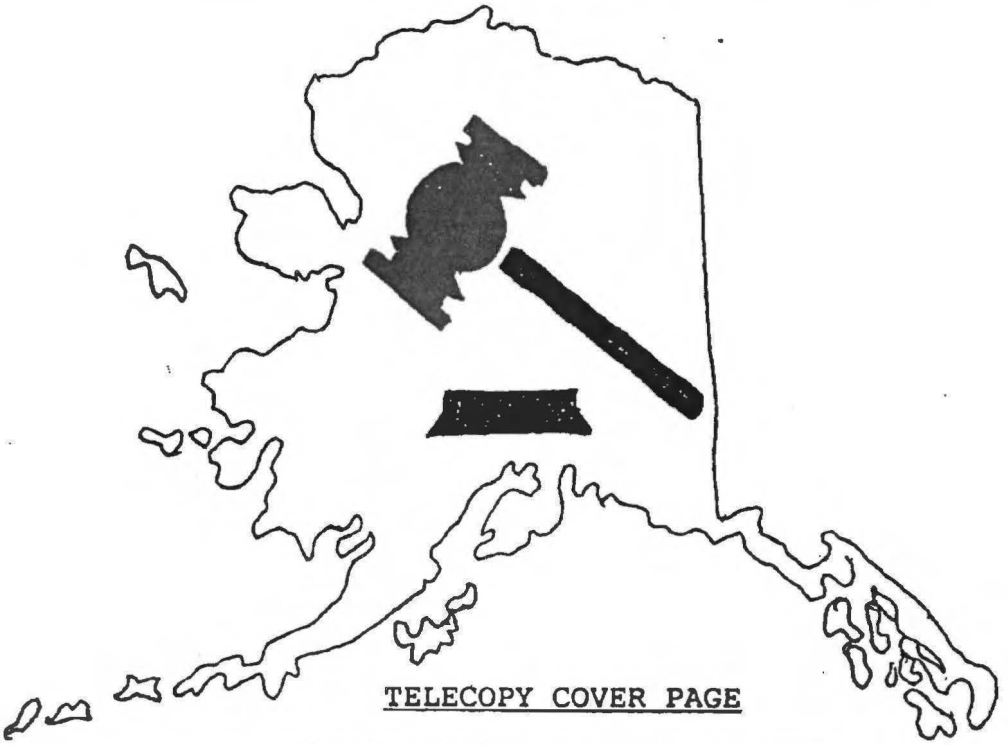
Restoration Objectives - Revisions
early drafts Nov-Dec '95

21.1.3



TELECOPY COVER PAGE

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TO: X Molly McCammon
Stan Senner

UNIT: _____

FAX: _____

FROM: Maria Lisowski

NUMBER OF PAGES (not including the cover sheet) 1

DATE: 1/8/96 TIME: 445

COMMENTS:

Please make sure each receives a copy. Thanks.

United States Department of Agriculture
Office of General Counsel

P.O.Box 21628
Juneau, Alaska
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January 8, 1996

CONFIDENTIAL ATTORNEY-CLIENT PRIVILEGED COMMUNICATION
ATTORNEY WORK PRODUCT/DO NOT RELEASE UNDER FOIA

TO: Molly McCammon
Executive Director
Exxon Valdez Oil Spill Trustee Council

FROM: Maria Lisowski ml
Attorney

SUBJECT: NEPA Compliance--Revised Restoration Plan

You have asked for comments regarding the Preliminary Revised Draft of Chapter 5 (Recovery Objectives) of the Restoration Plan (hereafter "Revised Draft"). While I have been unable to review the substance of this document in its entirety due to other workload, I am concerned with pursuing this revision of the Restoration Plan without also considering compliance with the National Environmental Policy Act (NEPA).

As you know, an environmental impact statement (EIS) was prepared for the Restoration Plan. The Council on Environmental Quality regulations provide that agencies shall prepare a supplement to a final EIS if, among other things, there are significant new circumstances or information relevant to environmental concerns that bear upon the proposed action or its impacts. 40 C.F.R. § 1502.9(c). It appears that the information contained in the Revised Draft may constitute significant new circumstances or information relevant to environmental concerns regarding restoration actions or their impacts.

Until appropriate agency NEPA analysis is undertaken to determine whether the Restoration Plan EIS must be supplemented and in what manner that supplementation is to occur, the proposed public release of the Revised Draft should not occur. The document may eventually be released as part of a public comment period pursuant to the NEPA process. However, until a determination is made regarding how NEPA will be complied with, no public release of the Revised Draft should occur.

cc: P.Janik, RF
J.Wolfe, EAM
D.Gibbons, EAM
S.Senner

Stan - keep in your file.

HUNTING-TRAPPING

Emergency Order

ALASKA DEPARTMENT OF FISH AND GAME

Under Authority of AS 16.05.060

Emergency Order No. 021595

Issued at Cordova, Alaska
November 14, 1995

Effective Date: 11:59 p.m.
November 16, 1995

Expiration Date: June 30, 1996
unless superseded by
subsequent emergency order

EXPLANATION:

This emergency order closes the State of Alaska land otter trapping season in the Knight Island Passage area of Game Management Unit 6(D) (Prince William Sound). All other portions of Game Management Unit 6 are not affected by this order.

REGULATION:

Therefore, the following regulations in 5 AAC 84.270, Furbearer Trapping are amended to read:

UNIT	OPEN SEASON	BAG LIMIT
(9) Otter, land		
Unit 6(D), that portion enclosed by a line extending from the Unit 6 boundary at the head of Kings Bay northeast along the center of Kings Bay and Port Nellie Juan, east to Pt. Eleanor, southeast to Little Smith Island, southwest to Pt. Helen, northwest to Verdant Island, southwest along the center of Icy Bay, and west along Tiger Glacier to the Unit 6(D) boundary	Nov. 10-Nov. 16	No limit.
Remainder of Unit 6	Nov. 10-Mar. 31	No limit.

Frank Rue
Commissioner

By delegation to: Roy A. Nowlin
Area Wildlife Biologist

JUSTIFICATION:

Oil contamination from the *Exxon Valdez* spill in 1989 caused injury to the land otter population in western Prince William Sound. Damage assessment studies during the three years following the spill showed otter food, body mass, movements and physiology were affected by oil pollution. Additional research over the next two years is essential to determine if the otter population is recovering and to help assess what role lingering effects from oil contamination might play in the overall health of the Prince William Sound ecosystem.

Closure of the land otter trapping season within the research area is necessary for successful completion of the study. Researchers must capture and release as many animals as possible to collect samples and take measurements. Continuing trapping activity could interfere with the research if otters are removed from the study area, or if otters become trap shy.

DISTRIBUTION:

This emergency order is distributed to the recipients listed below. Copies are available from Department of Fish and Game offices in Anchorage, Juneau, Cordova and Fairbanks.

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   - Regional Supervisors
   - Region II Area Biologists
   - Headquarters Senior Staff Biologist
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17. Village Councils: New Chenega, Tatitlek
18. Air Taxis: Cordova, Valdez, Anchorage, Yakutat

Frank Rue, Commissioner

Public Communications
Box 3-2000
Juneau, Alaska 99802-2000
(907) 465-4112

Alaska Department of Fish & Game

NEWS

November 14, 1995 Contact: Roy Nowlin 424-3215

Cordova -- Trapping for land otters in western Prince William Sound between Port Nellie Juan and Icy Bay on the mainland and in the Knight Island area will close at one minute before midnight on Thursday, November 16, by emergency order of the Alaska Department of Fish and Game.

Area Wildlife Biologist Roy Nowlin said the closure is necessary to help researchers determine if otters are recovering from the *Exxon Valdez* oil spill. He said oil contamination from the 1989 spill caused injury to the land otter population in western Prince William Sound. Damage assessment studies during the three years following the spill showed otter food, body mass, movements and physiology were affected by oil pollution.

Additional research over the next two years is essential to determine if otters are recovering and to help assess the overall health of the Prince William Sound ecosystem. Closure of the land otter trapping season within the research study area is important for successful completion of the research.

Researchers must capture and release as many animals as possible to collect samples and take measurements. Continuing trapping activity could interfere with the research if otters are removed from the study area, or if otters become trap shy.

21.1.3g

DATE: 1996-02-05 TIME: :
FROM: MHS:joes@fishgame.state.ak.us (Sullivan, Joe)

X-MHSFile: BEBJDLBI
TO: MHS:stans@evro.usa.com (Senner, Stan)
SUBJECT: FW: Cutthroat regulations
PRIORITY:

FYI

From: Hoffmann, Andrew
To: Sullivan, Joe
Cc: Hepler, Kelly
Subject: RE: Cutthroat regulations
Date: Monday, February 05, 1996 1:45PM

Joe,

I hope this is what you are looking for.

An Emergency Orders was issued in 1992 closing fishing for all species in oiled waters to protect cutthroat trout. Another Emergency Order was issued in 1993 closing oiled waters to fishing for cutthroat trout. At the 1994 Board of Fish meeting, regulations were changed to reduce the sport harvest of this species throughout PWS.

Andy

From: Sullivan, Joe
Sent: Monday, February 05, 1996 8:54 AM
To: Hoffmann, Andrew; Hepler, Kelly
Subject: FW: Cutthroat regulations

Does either of you know the answer to this? Please let me know what year if you do. thanks.

Joe

From: Stan Senner
To: Sullivan, Joe
Subject: Cutthroat regulations
Date: Sunday, February 04, 1996 10:08AM

Joe:

Do you know what year the Board of Fisheries adopted the sport fishing restrictions on cutthroats in PWS? My recollection is 1991? I need this to fill in a blank in the Chapter 5 revisions. Thanks.

Stan

from Andy Call D

22 Nov 95

DRAFT

Chapter 5
Goals, Objectives, and Strategies

This chapter presents goals, objectives, and strategies for restoration. The first part of this chapter discusses goals, objectives, and strategies in general. The second part describes the nature and extent of injury and recovery and ~~the~~ recovery objective~~, and the restoration strategy~~ for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives~~, and strategies~~ can be found on the following pages:

indent paragraphs.

~~Overview~~

~~The first part of this chapter discusses goals, objectives, and strategies in general.~~ A goal is the end toward which an endeavor is directed; objectives are descriptions of measurable outcomes; and strategies are plans of action. Taken together, the goals, objectives, and general strategies ~~produce a blueprint~~ that follow provide direction for restoring the spill area. To be funded, a project must be consistent with the goals and policies of the Restoration Plan and with restoration objectives and strategies as they change over time.

make this sentence a footnote?

GOAL: *The end toward which restoration is directed*

The goal of restoration is recovery of all injured resources and services. Recovery is to be sustained by healthy, productive ecosystems that maintain naturally occurring biodiversity. All restoration actions must be directed toward this goal.

OBJECTIVES: *Measurable outcomes of restoration*

The objectives of the restoration program are measurable conditions that signal the recovery of individual resources or services. They are the yardsticks against which the success of the program is measured.

In general, resources and services will have recovered when they return to conditions that would have existed had the spill not occurred. ~~In nature, however, populations often undergo large natural changes. Because~~ It is difficult to predict conditions that would have existed in the absence of the spill, and so recovery is often defined as a return to prespill conditions or to a level that falls within the bounds of natural variation. For resources that were in decline before the spill, like harbor seals ~~marbled murrelets~~, recovery may be achieved ~~consist of stabilizing the~~ when a population is stabilized, even if at a lower level than before the spill. For some resources, little is known about their injury and ~~recovery~~ current status, so it is difficult to define recovery.

Where ~~few little~~ prespill data exist, injury is inferred from comparison of oiled and unoiled areas, and recovery is usually defined as a return to conditions comparable to those of unoiled areas. Because the differences between oiled and unoiled areas may have existed before the spill, statements of injury and objectives based on these differences are often less certain than in those cases where prespill data exist. ~~Alternatively, injury may be evaluated based on the number of oiled carcasses picked up following the spill relative to the estimated size of the spill-area population. Even in cases where some prespill data are available, However,~~ there also is ~~can be some~~ uncertainty associated with interpreting the significance of prespill population data since populations undergo natural fluctuations. In all cases, indicators of recovery can include increased numbers of individuals, reproductive success, improved growth and survival rates, and normal age and sex composition of the injured population.

is this a new term?

Full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, are healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not occurred. A recovered ecosystem provides the same functions and services as would have been provided

had the spill not occurred.

STRATEGIES: *Plans of action*

A restoration strategy is a plan of action for achieving objectives. Each year, through its annual or multiyear work plan, the Trustee Council decides which strategies to implement. Restoration strategies reflect consideration of ecosystem relationships. For example, the strategy for some injured resources requires research into why they are not recovering, such as declining or contaminated food sources or disruption of ecosystem relationships. In this section, restoration strategies are presented under three headings: Biological Resources, Other Resources, and Services.

Biological Resources

Because restoration strategies for biological resources depend on whether the resource is recovering a resource's recovery status, strategies are subdivided into those for recovered resources, recovering resources, resources that are not recovering, and resources whose recovery for which the recovery status is unknown.

Recovered Resources. In general, once a resource has recovered, the Trustee Council no longer has a direct role with respect to that resource. The on-going management of recovered resources is the job of the state or federal agency to which such responsibilities have been assigned by law or regulation. Sustaining the health of recovered resources, however, will continue to receive consideration as the Trustee Council evaluates opportunities for habitat protection and acquisition and undertakes other measures to protect, restore, and enhance (?) the marine ecosystem in the oil-spill area. [NOTE TO REVIEWERS: I AM NOT ENTIRELY HAPPY WITH THIS PARAGRAPH, BUT IT GIVES US SOMETHING TO THINK ABOUT. IDEALLY, THIS WOULD BE THE PLACE TO INTRODUCE THE "E" WORD--I.E., ENHANCEMENT--BUT THAT MAY OR MAY NOT BE POLITICALLY CORRECT.]

Recovering Resources. The fact that a resource is recovering suggests that nature will restore it without intervention, Consequently, and restoration of recovering resources will rely primarily on natural recovery. Because these resources are if a resource is recovering, research into factors limiting recovery and general restoration projects to accelerate recovery may not be warranted. However, research that will lead to improved resource management and research on the health and recovery of the ecosystem in which that resource lives may be appropriate.

However Additionally, if a resource is not expected to recover fully on its own or if waiting for natural recovery will cause long-term harm to a community or service, appropriate alternative means of restoration would could be undertaken. Habitat protection and monitoring are encouraged, as are general restoration projects that protect the resource from other sources of further potential injury. (Restoration strategies under "Services" also apply to these resources.)

The restoration strategy for recovering resources has three four parts:

- Rely on natural recovery
- Monitor recovery
- Protect injured resources and their habitats
- Conduct limited research to benefit management and ecosystem recovery

investigate enhancement strategies?

Resources Not Recovering. Except for certain protective measures, attempts to restore these resources without knowing why they are not recovering may be ineffectual or even detrimental. For this reason, the restoration strategy for these resources emphasizes determining why they are not recovering, and eliminating threats to the remaining populations.

Also

Where sufficient knowledge about the nature of injury exists, the restoration strategy also encourages actions to promote recovery. The populations of some of these resources are in a steep decline and may not recover without help. Furthermore, some of these resources have subsistence or economic importance, and their recovery is linked to the recovery of these services. (Restoration strategies under "Services" also apply to these resources.)

Research is encouraged, provided it helps explain why a resource is not recovering. Habitat protection and monitoring are also encouraged. General restoration projects are allowed if they address factors limiting recovery or if they protect the resource from other sources of potential injury.

The restoration strategy for resources that are not recovering has four parts:

- Conduct research to find out why these resources are not recovering
- Initiate, sustain, or accelerate recovery
- Monitor recovery
- Protect injured resources and their habitats

Recovery Unknown. If specialists do not know whether a resource is recovering, it will be treated in much the same way as a recovering resource. Until more is known about the nature and extent of injuries and the degree of recovery of these resources, restoration will rely primarily on natural recovery, aided by ~~monitoring and~~ protective measures. Monitoring may be undertaken to determine a resource's recovery status.

Because the recovery of these resources is unknown, and, in some cases, the injury poorly understood, research into factors limiting recovery and general restoration projects to accelerate recovery may not be warranted. Habitat protection and monitoring are encouraged, as are general restoration projects that protect these resources from other sources of potential injury.

The restoration strategy for resources whose recovery is unknown has three parts:

- Rely on natural recovery
- Monitor recovery
- Protect injured resources and their habitats

Other Resources

Other injured resources include archaeological resources, designated wilderness areas and oiled sediment. The strategy for restoring archaeological resources seeks to repair and protect injured sites and artifacts. The strategy for sediment includes removal or reduction of residual oil and monitoring. Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas or wilderness study areas.

Services

Commercial fishing, passive use, recreation (including sport fishing) and tourism and subsistence are services that were reduced or lost because of the spill. Injured resources that support these services include clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. The primary way to restore services is to restore the resources on which they depend.

Additional restoration strategies for commercial fishing, recreation and tourism, and subsistence include promoting recovery of the service as soon as possible through such means as increasing the availability, reliability, or quality of the resource on which the service depends. For some resources, this may take the form of increasing availability in the long run through improved resource management or providing replacement resources. Strategies for recreation and tourism and subsistence also include removing or reducing residual oil if treatment is cost effective and less harmful than leaving the oil in place.

Injury Status and Objectives ~~and Strategies by Resource and Service~~

This section describes the nature and extent of injury and recovery and the recovery objectives ~~and the restoration strategy~~ for each injured resource and service. Specific strategies to achieve recovery objectives are described in annual work plans and restoration project invitations (e.g. *Invitation to Submit Restoration Projects for Federal Fiscal 1997 and Draft Restoration Program FY '97 and Beyond*). The information in this section is expected to change over time as the restoration program adapts to new information. For example, population decline or sublethal effects may be documented for new resources, some resources may begin to recover, and objectives and strategies may change in response to new conditions. Hypotheses for why resources are not recovering are particularly susceptible to change as prevailing hypotheses are tested and new ones are formed.

New scientific data will be incorporated into restoration decisions without the need to change the plan. However, changes will be reported in the Trustee Council's annual status report.

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION]

Archaeological Resources

Injury and Recovery

Twenty-four archaeological sites are known to have been adversely affected by cleanup activities, or looting and vandalism linked to the oil spill. Injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been

DRAFT

HARLEQUIN DUCKS

Injury and Recovery

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. As a result, harlequin ducks were severely affected by the oil spill in western Prince William Sound and, possibly, throughout the oil spill area. More than 200 carcasses of harlequin ducks were found in 1989, mostly in Prince William Sound, and it is estimated that about 1000 (?) actually died as a direct from the spill. In addition, in 1989 and 1990(?), elevated concentrations of hydrocarbons and their metabolites were found in the bile of 40% (?) of the harlequin ducks collected in western Prince William Sound, and many of them were in poor body condition. Evidence of exposure to hydrocarbons continued through at least 1993.

Baseline data on prespill populations and productivity of harlequin ducks are very poor. The resident prespill population of harlequin ducks in western Prince William Sound was estimated to be 2000 (?), and this population increases by about 10,000 with an annual influx of migrants during the winter season. Outside Prince William Sound, populations of harlequin ducks range from hudnreds to many thousands on the Kenai coast, Kodiak and Afognak islands, and along the Alaska Peninsula.

Since 1989, very few broods of harlequin ducks have been found in western Prince William Sound in comparison to the eastern sound, but it is not clear how much of this difference is due to the oil spill or to geographic differences in the availability of preferred nesting habitats. In addition, there is some evidence that numbers of molting harlequins, which gather in substantial numbers in the western part of the sound, have declined during post-spill surveys. Outside Prince William Sound there is little evidence of injury to harlequin ducks, but...

In the absence of strong baseline data, it is not clear whether and to what degree harlequin duck populations and productivity remain depressed. To the extent that injuries persist, there are at least two possible explanations: First, harlequin ducks may not yet have recruited a sufficient number of breeders into the population due to the initial loss of birds in the first year or two after the oil spill. Second, in some local populations, harlequins could continue to be exposed to hydrocarbon contamination by feeding on mussels at oiled beds. In this latter case, however, there is little information about how such exposure would affect the physiology and reproduction of harlequin ducks.

The Trustees continue to classify the harlequin duck as a nonrecovering injured species. This is a conservative assessment given the significant initial impact on the species and the potential that its populations and productivity remain depressed.

Recovery Objective

Harlequin ducks will have recovered when the populations in western (oiled) and eastern (unoiled) Prince William Sound exhibit similar structure (e.g., age and sex ratios) and behavior, or there is evidence that differences in the eastern and western parts of the sound are due to geography. Increasing trends in densities of breeding and molting harlequins or in numbers of broods in western Prince William Sound will be considered to be indications that recovery is underway.

Restoration Strategy

Research. Studies that explore the hypothesis that harlequin ducks continue to be exposed to and affected by hydrocarbon exposure are appropriate. There also is need to better understand the relationships and interchange among populations of harlequin ducks in the oil spill area.

Initiate, sustain, or accelerate recovery. If ingestion of oiled mussels is found to limit the recovery of

local populations of harlequin ducks, cleaning oiled mussel beds may hasten recovery. Information on relationships among regional populations would enhance future management of the species.

Monitor recovery. Monitor the size and structure of breeding and postbreeding populations in Prince William Sound, as well as numbers and distrubutions of young birds in broods.

Protect harlequin ducks and their habitat. Harlequin ducks are hunted for subsistence and sport. Since 1991 the Alaska Board of Game has shortenen the season for legal sport harvest of harlequins and reduced the daily bag limit to protect the resident population. The Trustees anticipate that such restrictions will continue until harlequin ducks are considered to be recovered.

Harlequin ducks nest in riparian habitats and forage and breed in coastal and estuarine habitats. Protection of habitats used by harlequin ducks will benefit their populations and is a prime consideration as the Trustees evaluate and acquire upland habitats through the large and small parcel habitat protection programs.

Cutthroat Trout & Dolly Varden Char

INJURY AND RECOVERY

A study to asses the injury to Dolly Varden char and cutthroat trout was conducted in 1989, 1990, and 1991. The study indicated that fish grew more slowly in oiled areas than in unoiled areas. Dolly Varden subadults and adults grew 24% and 22% slower in oiled areas than in unoiled. For Cutthroat trout it was 36% and 43%. This difference persisted through 1991 for cutthroat trout, but not for Dolly Varden (growth in the unoiled area decreased for this species in 1991). Although survival rates for both species were less in oiled areas than in oiled areas, the differences were not statistically significant.

Dolly Varden char and cutthroat trout feed extensively in the nearshore marine habitat. The scientists who conducted the study theorized that the slower growth may be due to a decline in nearshore food sources caused by the spill and cleanup, or due to direct exposure to oil itself.

There are no data more recent than 1991 to indicate whether these resources are recovering. In addition, the original study compared growth and survival rates in two oiled streams with those in three unoiled streams. This small study size makes it difficult to conclusively rule out the possibility that natural environmental conditions may have played a part in the study's conclusions.

RECOVERY OBJECTIVE

Because of questions concerning the degree and extent of injury, it is not possible to formulate a recovery objective. **[Note to reviewers: This is inconsistent with what I wrote above. Either we should decide we don't know if it was injured, and take it off the injured resources list, or we *can* formulate a recovery objective. But to say, "we know it was injured because it grew slowly but we don't know how to tell if it recovered" appears illogical. In addition, ADF&G, at the urging of EVOS, has spent 5 years restricting sport fishing for Cuts on the basis of this data. If we now say, "OOOOps, we were wrong. You were in error to rely on us. It was OK to go ahead and harvest." We better be SURE of ourselves.]**

Restoration Strategies: FY 97 and Beyond

Research to Improve Management. In FY 96, the Trustee Council authorized the first year of a three-year program to determine the relationship between resident and anadromous cutthroat tout. The results of this research will provide information to allow the Alaska Department of Fish and Game to better manage the species in Prince William Sound.

Past:	FY 96	96145, Relations bet Anadromous and Resident Populations	$200,000
Projected Future:	FY 97	\145, Relations bet Anadromous and Resident Populations	$200,000
	FY 98	\145, Relations bet Anadromous and Resident Populations	$100,000
			Total: $500,000

Monitoring Recovery. The FY 96 research project discussed above may provide additional information to help interpret the 1989-91 studies that documented the injury. If final or interim results of the project indicate that cutthroat trout and Dolly Varden char remain injured, recovery monitoring may be required. Thus, the decision to authorize recovery monitoring for cutthroat or Dolly Varden monitoring must await at least interim results of Project 96145. Thus, if a monitoring project is needed, it is unlikely to be funded before at least FY 98.

Supplementation to Protect Wild Stocks and Enhance Sport Fishing. Prince William Sound is the north- and west-most range of cutthroat trout, and the resource does not exist elsewhere in the spill area. Cutthroat stocks known to exist in the Sound are few, rarely number more than 1,000 fish, and are geographically isolated from each other. Cutthroat trout have a limited home range and do not migrate over great expanses of water. These small populations are vulnerable to exploitation, habitat alterations, and other natural- or human-induced changes.

In FY 94 and 95, the Trustee Council funded a program to increase the rearing and spawning habitat for cutthroat trout. By augmenting the small population on the edge of its range, the projects both enhance sport fishing and may make cutthroat trout populations less vulnerable to natural- or human-induced changes.

The habitat improvements were undertaken on five streams in Prince William Sound.

- Gumboot Creek, Eshamy Bay
- Otter Creek and Otter Lake, Knight Island
- Shrode Creek into Shrode Lake, Culross Island
- Sockeye Creek and Lake, Knight Island
- Rocky Creek and Bay, Montague Island

The Trustee Council authorized project monitoring in FY 96 to determine the success of the previous two years supplementation activities. Two additional years of monitoring is expected. The need and utility of future supplementation activities for cutthroat trout will be determined once this monitoring determines the success of past supplementation activities.

Past:	FY 94	96043, Cutthroat & Dolly Habitat Restoration in PWS	(See Note)
	FY 95	95043, Cutthroat & Dolly Habitat Restoration in PWS	$134,800
	FY 96	96043B, Cutthroat....	$40,400
Projected Future:	FY 97	\043B, Cutthroat...	$27,700
	FY 98	\043B, Cutthroat...	$27,700
	FY 99	\043B, Cutthroat...	$26,400
			Total: $257,000

Brachyramphus Murrelets

DRAFT

Injury and Recovery

The Brachyramphus murrelets include two species, marbled and Kittltitz's.

The Prince William Sound-northern Gulf of Alaska is a key center of abundance for Marbled Murrelets, which range from northern California to the Aleutians and in Asia south to Japan. Population size in Alaska, including in the southeast, is on the order of a few hundred thousand birds. Kittlitz's Murrelet is a little-known seabird found in the northern Gulf of Alaska, the Aleutian Islands, and on both sides of the Bering Sea. Its world population may number only a few tens of thousands, many of which are found in the oil spill area. The Kittlitz's murrelet is a candidate for federal listing as a Threatened or Endangered Species [check this]. The Marbled Murrelet is federally listed as Threatened in Washington, Oregon, and California; it is also listed as Threatened in British Columbia. Both murrelet species are highly vulnerable to contact with floating oil.

Carcasses of more than _____ murrelets were recovered following the oil spill. Of these, 612 were identified as marbled and __ as Kittlitz's. Undoubtedly many more murrelets were actually killed by the oil but not recovered on beaches. Given the importance of the oil region to Kittlitz's Murrelets and the small size of its world population, the oil spill may have had a greater effect on this species than on any other species. The current status of the Kittlitz's Murrelet population and the extent to which it may have recovered from the oil spill are not known.

The Marbled Murrelet population was in decline in Prince William Sound before the oil spill. Causes of the pre-spill decline are not known, but the oil spill probably increased the rate of its decline. It is estimated that the oil spill may have killed _-__% of its Prince William Sound population at the time of the oil spill. Population estimates for Marbled Murrelets in Prince William Sound are highly variable, and trend data do not yet indicate a statistically significant increase in post-spill numbers. Whatever factors accounted for the apparent pre-spill decline in the Marbled Murrelet population may compromise or mask any recovery from the effects of the oil spill.

Recovery Objectives

Marbled Murrelets will have recovered when population trends are increasing. No recovery objective can be identified for Kittlitz's Murrelets at this time.

Restoration Strategy

Monitor Recovery. Conduct boat surveys of marine birds in Prince William Sound in 1996 and possibly thereafter to detect a statistically significant increasing population trend for Marbled Murrelets.

Conduct Research. Continued research on the relationships of seabird production to the

availability of forage fish may shed light on the pre-spill decline of the Marbled Murrelet and suggest management actions to help reverse that decline and any lingering effects of the oil spill. Conduct study on the life history and ecology of Kittlitz's Murrelet and use to assess the status of the species and, if appropriate, identify a recovery objective.

Protection and Management. It has been suggested that the incidental deaths of murrelets in gillnet fisheries could be a factor in the deline and lack of recovery of Marbled Murrelets. Data from fishing boats in Prince William Sound in 1990 and 1991, however, suggest that gillnet mortalities are not significant. Additional information on the level and distribution of gillnet mortalities could enable a more thorough assessment of this factor potentially limiting recovery of murrelet recovery.

Clams

Monitor Recovery. There are no current plans to initiate or continue studies on the abundance and productivity of clams. If conducted, however, additional monitoring of coastal habitat index sites would yield insights about the status of clams. Some aspects of the Nearshore Vertebrate Predator project (96025) may shed light on the health of clams as prey for top predators in intertidal and nearshore habitats.

Accelerate Recovery or Enhance Population. In 1995 the Trustees supported initiation of a pilot project to raise little-neck and other clams in nurseries and to use them to reseed natural clam beds. The purpose of this work has been to restore services lost to subsistence users in oil-spill communities (see Subsistence). Given satisfactory progress and favorable economic analyses, this program could be extended and expanded.

Cutthroat Trout

Monitor Recovery. There are no current plans to initiate studies to monitor growth rates or numbers of Cutthroat Trout and Dolly Varden. Depending on the results of the study mentioned below (see Research), limited additional monitoring may be appropriate.

Conduct Research. In FY 1996 the Trustees are supporting a new study to explore relationships among resident and anadromous forms of Cutthroat Trout in streams in the oil-spill area. This study should yield insights that will enhance management of cutthroats at the northern extreme of their range, and may yield information that will aid interpretation of results on growth rates obtained during the Natural Resources Damage Assessment.

Protection and Management. Currently the Alaska Board of Fisheries has reduced creel limits on Cutthroat Trout in the oil-spill area. These restrictions will remain in place until the species is recovered or fisheries managers determine that the restrictions are no longer necessary.

Dolly Varden

Monitor Recovery. There are no current plans to initiate studies to monitor growth rates or numbers of Cutthroat Trout. Depending on the results of the study mentioned below (see Research), limited additional monitoring may be appropriate.

Conduct Research. In FY 1996 the Trustees are supporting a new study to explore relationships among resident and anadromous forms of Dolly Varden and Cutthroat Trout in streams in the oil-spill area. This study may yield information that will aid interpretation of results on growth rates obtained during the Natural Resources Damage Assessment.

Harbor Seals

Monitor Recovery. Continue surveys at index sites in Prince William Sound to detect trends in numbers of pups and molting adults.

Conduct Research. Continue studies to understand the Harbor Seal's pre- and post-spill population decline in Prince William Sound. Potential factors include changing food supplies (e.g., species composition and abundance), predation by killer whales, disease, and mortalities through subsistence take or incidental take associated with fisheries.

Accelerate Recovery or Enhance Populations. No direct means of restoring or enhancing numbers of Harbor Seals have been identified.

Protection and Management. Continue efforts to provide information on the status and conservation needs of Harbor Seals to subsistence hunters. [Say something about disturbance at glacier haulout sites?]

Intertidal Organisms

Monitor Recovery. Currently there are no plans for additional monitoring of at coastal habitat index sites. Such monitoring has been suggested, and, at the least, monitoring the recovery of Fucus species in the upper intertidal zone is probably desirable.

Conduct Research. Continue the Nearshore Vertebrate Predator project (96025), aspects of which address the status of key invertebrate prey of top predators in intertidal/nearshore habitats.

Accelerate Recovery or Enhance Populations. See Clams. Otherwise, no feasible ways to restore or enhance numbers of intertidal organisms have been identified.

Killer Whales

Monitor Recovery. Continue limited monitoring of AB pod until the disintegration of the AB is complete or it is determined that recovery is not likely. Long-term monitoring of Killer Whales is an on-going agency responsibility.

Conduct Research. [say something about predation on Harbor Seals?]

Mussels

Monitor Recovery. Aspects of the Nearshore Vertebrate Predator project concern the distribution, abundance, and structure of mussel populations in relation to top predators in intertidal/nearshore habitats. This study will give insight into the recovery status of mussels in Prince William Sound.

Accelerate Recovery or Enhance Populations. A final report on the pilot project to clean mussel beds is due in FY 1996. Any further clean-up efforts must follow a full evaluation of the results of the pilot effort.

Pacific Herring

Monitor Recovery. Continue surveys of spawning biomass, but phase out Trustee Council support to allow a transition to normal agency management. Monitor disease levels in herring population.

Conduct Research. Complete current projects aimed at identifying oceanographic and other factors that influence herring productivity (SEA Program, 96320 projects and 96166), on the effects of oil exposure on herring eggs and larvae (96074), on genetic stock identification (96165), and on the relationship between disease outbreaks and stress from exposure to oil (96162). Develop index of larval survival as an alternative to spawning biomass as a means of predicting population abundance (96166). Initiation of new studies, if any, must follow completion and evaluation of the results of existing projects.

Protection and Management. On-going surveys of spawning biomass provide a basis for managing (e.g., closures, as in 1993-95) the commercial fishery in Prince William Sound. The research now in progress will benefit future management and recovery efforts (e.g., better control of "pound" fisheries to diminish chances for disease outbreaks).

River Otters

Monitor Recovery. Continue to monitor exposure to contaminants and habitat use of River Otters in Prince William Sound through the Nearshore Vertebrate Predator project (96025).

Protection and Management. The Alaska Board of Game recently closed Montague and Knight island areas in western Prince William Sound to trapping of River Otters. This was done to ensure that trapping activities would not complicate recovery monitoring and research on this species. The restrictions will remain in place for the duration of the study and, depending on the what is learned about the status of River Otters, longer if necessary.

Pigeon Guillemot DRAFT

Injury and Recovery

Although the Pigeon Guillemot is widely distributed from California to the Chukchi Sea in North America and on the Siberian coast south to the Kamchatka Peninsula, nowhere does it occur in large numbers or concentrations. Boat surveys in Prince William Sound in 1972-73 indicated a population of about 14,600. Like the Marbled Murrelet, the pigeon guillemot was apparently declining in Prince William Sound before the oil spill. Fortunately, studies in the 1980s provide pre-spill data on breeding biology, diet, and numbers at Naked Island in Prince William Sound. Pigeon guillemots feed in shallow, nearshore waters and both the birds and their prey are vulnerable to oil pollution.

The pre-spill decline of the pigeon guillemot complicates interpretation of post-spill effects. However, more than 500 pigeon guillemot carcasses were found following the oil spill, and it is estimated that as much as 10-15% of the Gulf of Alaska population may have died. Declines along oiled shorelines in Prince William Sound were greater than along unoiled shorelines.

Numbers of pigeon guillemots on post-spill surveys in Prince William Sound have been highly variable, and there is not yet statistically significant evidence for a population increase. The factors responsible for the guillemot's pre-spill decline may compromise or mask recovery from the effects of the oil spill.

Recovery Objective

Pigeon guillemots will have recovered when its population in Prince William Sound is stable or increasing.

Recovery Strategy

Monitor Recovery. Continue boat surveys of marine birds in Prince William Sound in 1996 and possibly thereafter to document stable or increasing population of Pigeon Guillemots.

Conduct Research. Continue studies on the relationship of seabird productivity to the availability of forage fish to explore whether food is limiting recovery of guillemots. Also test guillemots to see whether there is on-going exposure to oil, perhaps through food obtained in nearshore habitats.

Accelerate Recovery or Enhance Populations. There are few, if any, feasible ways to directly accelerate recovery of this species. Under certain circumstances artificial nest boxes can augment natural nest sites used by guillemots, but nest boxes are not likely to be useful in the present situation.

Protection and Management. The results of studies on seabirds and forage fish may suggest management actions that benefit Pigeon Guillemots, but none have been identified to date.

DRAFT

Common Loons

Common Loons are present in the oil-spill area primarily as spring and fall migrants and as wintering birds. Seasonal populations of loons in the spill area are not known, but can be presumed to be a small, perhaps a few thousands at the most. Loons are highly vulnerable to oil on water.

More than ____ loon carcasses were recovered following the Exxon Valdez spill. Of these, at least ___ were Common Loons. Given that Common Loons are not numerous, the oil spill could have caused significant mortality at the population level. Because of the timing of the spill, both winter residents and spring migrants were probably affected, but the breeding grounds of the loons using Prince William Sound and the rest of the oil-spill area are not known.

The recovery status of the Common Loon is not known. Comparisons of pre- and post-spill surveys indicate that numbers in Prince William Sound...

There is no evidence that Common Loons were declining before the oil spill, but baseline data are few.

Recovery Objective

Common Loons will have recovered when the Prince William Sound population has returned to pre-spill levels.

Recovery Strategy

Monitor Recovery. Continue boat surveys for marine birds in 1996 and possibly thereafter in Prince William Sound to detect population trend and abundance. March surveys will be most appropriate, since this was the season in which the spill occurred and there is no information on the origins of loons in the sound at this or other seasons.

Black Oystercatcher

DRAFT

Injury and Recovery

Black Oystercatchers are widely distributed on the north Pacific coastline from Bristol Bay, Alaska to Baja California. An estimated 2,000 oystercatchers were in the oil-spill area prior to the Exxon Valdez Oil Spill. Some oystercatchers live in the spill zone year-round, while others migrate south during the winter. Since oystercatchers spend their entire annual cycle in or near intertidal habitats, they are highly vulnerable to oil pollution.

Only nine oystercatcher carcasses were recovered following the spill, but it is estimated that the oil spill may have killed as much as 20% of the spill-zone population. Population abundance in Prince William Sound has declined since the oil spill, as have numbers of breeding pairs. In addition to direct mortality from oil, there also were apparent sublethal effects, including slower growth rates of chicks on oiled versus unoiled shores in Prince William Sound. Hatching and fledging rates, however, have not differed between oiled and unoiled areas.

In the Restoration Plan the Trustees classified the Black Oystercatcher as an injured-but-recovering species. This judgement was based in part on information obtained from on the heavily-oiled Green Island, where the number of breeding pairs increased from 1989-1993. Since oystercatchers on Green Island may not be representative of a trend in Prince William Sound more broadly, it is prudent to consider the status of the Black Oystercatcher as "recovery unknown" until additional information is obtained.

Recovery Objective

The Black Oystercatcher will have recovered when there is an increasing trend for the Prince William Sound population and when reproductive success and chick growth rates in oiled areas are sustained within normal bounds.

Recovery Strategy

Monitor Recovery. Continue to use marine bird boat surveys in 1996 and possibly thereafter to detect an increasing trend in the Black Oystercatcher population in Prince William Sound. At present, there are no plans to monitor reproductive success is planned.

Research. Data gathered through the Nearshore Vertebrate Predator project (96025) will shed light on health of the intertidal ecosystem and its top predators, including oystercatchers. Depending on the results of the 1996 boat survey in Prince William Sound, it may be appropriate to consider additional research on the status and limitations on the recovery of oystercatchers.

DRAFT

COMMON MURRES

Injury and Recovery

There are about 12 million common and thick-billed murres in Alaska, including about 1.4 million in the Gulf of Alaska region. About _____ murres nest at colonies within the area directly affected by the Exxon Valdez oil spill. Murres spend much of their lives on the water and are highly vulnerable to floating oil. About 75% of the 30,000 oiled birds picked up following the oil spill were murres, and most of these were Common Murres.

Comparisons of pre- and post-spill surveys at the major colonies in the oil spill area--Chiswell and Barren islands, the Triplets, and at Puale Bay (Alaska Peninsula)--suggest that between 120,000 to 134,000 murres were killed by contact with the oil. The oil arrived in early April just as the murres were congregating at the colonies in anticipation of breeding. If the estimates of mortality at these colonies are adjusted to reflect the birds that were killed while feeding at sea and therefore not counted on the colony surveys, numbers of murres at these colonies declined by 35-70% following the spill.

In addition to direct mortalities of murres, there also was evidence that the timing and of reproduction was disrupted and productivity reduced at breeding colonies in the oil-spill area. For example, at the Barren Islands egg laying was about one month later than at the unoiled Semidi Islands during 1989-1991. At the Chiswell Islands, no egg laying was observed in 1989, and laying was late in 1990. Although pre-spill data on murre productivity at these colonies is weak, it appears that by 1993 reproductive timing and success were again within normal bounds.

Normal reproductive activity at oil-spill colonies is a sign that recovery is underway. There is need for additional surveys to document whether there are increasing populations of adult murres at index colonies. The complete recovery of murres following the oil spill could be compromised or masked due to environmental factors that influence such things as the availability of forage fish as prey for adult and young murres.

Recovery Objective

Common murres will have recovered when populations trends are increasing significantly at index colonies and productivity is sustained within normal bounds.

Restoration Strategy

Monitor Recovery. Conduct additional population surveys at the Chiswell and Barren islands and at Puale Bay during 1996-1999. Continue to monitor productivity at Barren Islands colonies in conjunction with related projects studying relationships between forage fish populations and seabird productivity.

Accelerate Recovery or Enhance Populations. There are few feasible ways to directly accelerate recovery of murres nesting at colonies where their populations were reduced by

the oil spill, but, given that recovery is underway naturally, no such measures are needed at this time. There are suggestions, however, that the Trustees should support additional efforts to enhance murre populations through removal of introduced predators on islands with murre colonies.

Conduct research. Studies of the genetic relationships among murres in the Gulf of Alaska region and Alaska more broadly could contribute information on the geographic extent of injury from the Exxon Valdez oil spill and guide management activities (such as removal of introduced predators) that will aid spill-area murre populations. Studies on murre productivity in relation to the availability of forage fish will contribute to the broader understanding of the Gulf of Alaska ecosystem.

21.1.3 G

Stan

Note #1: The first time I read thru, I thought you were taking strategies out altogether, so I crossed it out on the first few pages. Then when I was smart enough to read farther, I was mistaken, so I went back and crossed out (in red) my first cross-outs. Please ignore my confusion. Sorry.

Note #2: This is a minor point. I think this ¶ is the place to take note of the tremendous natural variability in the environment. You do note it at the end of the next paragraph, but its such an important point that I'd move it up. How about, "In general, resources and services ~~will have~~ are recovered when they return to conditions that would have existed had the spill not occurred. Nature, however, is not static. Wild populations may undergo large, natural population changes that are difficult to predict and understand. For that reason, recovery objectives for individual resources may be defined as a return to prespill conditions, or to within the bounds of natural variation. These are substitute measures required by our inability to precisely define the causes of natural population changes. For resources that were in decline before the spill, ...

BFD. Note #3: Strategies. I think the organization of strategies by recovering resources, non-recovering, recovery unknown, is an artifact of the past. You (Stan) don't think or talk about them that way. Instead, you think about them in terms of...Monitoring (when we monitor); Research (why we research), Management/Enhancement...That is the way we talk about it, so I'd write it that way. So, I didn't really edit this part.

Note #4, Archaeology. The 1995 Workshop asked for a change in restoration objective. I'm not sure its a good change, but we should explicitly consider it and accept, reject, or change it. Thus, you might add the following note: [**Note to reviewers:** Should we add the 1995 workshop recommendation? "Return artifacts to the spill area when facilities are adequate to receive them.']

Note #5, Bald Eagles. Two comments.

- 1st, I approve of putting short management intent in the recovery objectives, if it can be done *briefly*. Once we do, they are complete by themselves. Otherwise, once they are separated from the injury statement (which happens a lot), they appear sort of off the wall.
- 2nd, the word "considers to be recovered" means "we thought about it carefully and we believe". Its OK. I used the word appears which I (probably incorrectly) meant to mean "the data indicates that." My intent was to make it more fact-based and less value-based decision. If we put the facts into the sentence this problem goes away.
- So, I'd change it one of two ways. "Data indicates that bald eagles have recovered from the 3effects of the spill." Or, "Because population and productivity are at or above prespill levels, the Trustee Council considers..."

Note #6. Black Oystercatchers. I have no suggestions for changing the recovery objective, but as it reads now, it indicates 400 died, once normal birth rates are established and we get one more, its recovered. (By my calculations that means we're still down 399).

Note #7. Commercial Fishing. Change the objective as follows:

~~Commercial fishing will have recovered when the population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions that would have exited had the spill not occurred. Because of the difficult of separating spill related effects from other changes in fish runs, the Trustee Council may use prespill conditions as substitute for conditions that would have existed had the spill not occurred.~~ Commercial fishing will have recovered when the fish species they rely on have recovered from the spill.

Note #8. Common Murres.

Same problem as black oystercatchers. We lost 40% of the pop. They're breeding again so they're recovered. Doesn't ring any intuitive bells. That would be like saying if we had a major population loss without any breeding problems, recovery occurred almost instantaneously.

Note #9. Cutthroat Trout. The two sentences I'd add are: "Prince William Sound is the north- and west-most range of cutthroat trout, and the resource does not exist elsewhere in the spill area. Cutthroat stocks known to exist in the Sound are few, rarely number more than 1,000 fish, and are geographically isolated from each other."

Note #10. Designated Wilderness Areas. I'd add this paragraph (and possibly take out stuff in the first.)

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 continues. The massive intrusion of people and equipment associated with oil-spill cleanup has now ended.

If need to combine them together, How about:

"The oil spill delivered oil in varying quantities to the adjoining waters of the seven areas within the spill area designated as wilderness areas or wilderness study areas. ~~Oil was also deposited above the mean high tide line in many areas. During the intense clean up seasons of 1989 1990, hundreds of workers and thousands of pieces of equipment were at work in the spill area.~~ In addition, 1989 and 1990 cleanup activities imposed ~~This activity was~~ an unprecedented imposition of people, noise, and activity on the area's undeveloped and normally sparsely occupied landscape. As of 1995, 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 continues. The massive intrusion of people and equipment associated with oil-spill cleanup has now ended.

Note #11. Dolly V. The population model of R106 predicts recovery by 1999 with fishery closure, and approx 2005 without. (Figure 1, page 5). I don't know if there was a fishery closure, but we might check it out.

Note #12. The age/six stuff appears off-the-wall. I understand why its there, but no one else who isn't a Hadu scientist will. I'd introduce it as something like: "Harlequin ducks will have recovered when reproductive rates in oiled habitat are equivalent to those in similar unoiled habitat. However, scientists have difficulty determining the population or reproductive rates of harlequin ducks and may therefore use proxy indicators. For that reason, will be considered to be recovered when populations in similar habitat in eastern and western Prince William Sound have similar age and sex rations and breeding-season behavior."

Note #13. I don't like this write-up. It seems to say to me that the greatest oil is at 20m depth (untrue); that little evidence of oil is found (untrue), and that all surface oil is gone (untrue). The recovery objective essentially says its all recovered (untrue). I'll try to do a draft later today.

Note #14. Sockeye salmon. We need to say something about the recovery of Kodiak Salmon, and about the non-injury to other stocks. I've got stuff to add, but it may be too long.

> While low return-per-spawner for the Kenai River is expected following the peak escapement years of 1986-1989, the 1995 return was the lowest since ADF&G began keeping records in the early 1970s. However, the overall return was not unusually low, and the run has met escapement goals every year since the spill [Is this true?]. Because escapement goals were met in 1995 and appear likely to be met in the future, the run and return-to-spawner averages are eventually expected to return to normal levels. The time required for this recovery is not known.
>
> Analysis of the 1992 and 1993 data indicated that the Red Lake zooplankton communities and nutrient levels recovered to the level measured in 1986, before the oil spill. While Red Lake smolt counts appear to remain below optimum levels, the adult returns in 1994 met escapement goals. For Akalura Lake, 1990 zooplankton densities and low smolt numbers demonstrated a reduced nursery capacity in the lake. The 1994 return did not meet escapement requirements. [This needs to be updated.]
>
> The Frazier and Afognak lake systems on the Kodiak Archipelago, and the Chignik/Black Lake system on the Alaska Peninsula also experienced overescapement due to fisheries closures in 1989. However, for theses systems, post-spill data did not show evidence of injury.

Note #15. Subsistence. The 1995 Workshop asked for a change in restoration objective. I'm not sure its a good change, but we should explicitly consider it and accept, reject, or change it. Thus, you might add the following note:

[**Note to reviewers:** The subsistence work group at this year's Restoration Workshop

recommended that the recovery objective be revised to include: "Subsistence will have recovered when subsistence users' diet composition and harvest effort exist at pre-spill levels, and when the youth of the community have had the opportunity to learn subsistence skills first hand."]

from Veronica

Possible language for the third part of the recreation objective:

~~and facilities and management capabilities can accommodate changes in human use~~ public access to recreational resources is preserved, and public use of recreational resources is adequately managed.

Archaeological repositories:

None of the archaeological artifacts collected during spill response, damage assessment, or restoration is stored within the spill area. The artifacts are stored in the University of Alaska Museum in Fairbanks and the Federal Building in Juneau. Native communities in the spill area have expressed a strong interest in having these artifacts returned to the spill area for storage and display.

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by Trustee Council, is the only appropriate artifact storage facility in the spill area. In 1995 the Trustee Council authorized a comprehensive community plan for restoring archaeological resources in Prince William Sound and Lower Cook Inlet, including strategies for storing and displaying artifacts at appropriate facilities within the spill area.

Archaeological Resources Recovery Objective:

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered recovered when spill-related injury ends; looting and vandalism are at or below pre-spill levels; and the artifacts and scientific data which remain in vandalized sites are preserved (e.g., through excavation, site stabilization, or other forms of documentation). ~~Artifacts and data are typically preserved through excavation or other forms of documentation, or through site stabilization, depending on the nature of the injury and the characteristics of the site.~~

File: H:\home\bobl\transfer\morearch

OOOPS OK as is

See Note #1

Chapter 5
Goals, Objectives, ~~and Strategies~~

This chapter presents goals, objectives, ~~and strategies~~ for restoration. The first part of this chapter discusses goals, objectives, ~~and strategies~~ in general. The second part describes the nature and extent of injury and recovery and ~~the~~ recovery objective~~, and the restoration strategy~~ for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives~~, and strategies~~ can be found on the following pages:

Overview

The first part of this chapter discusses goals, objectives, and strategies in general. A goal is the end toward which an endeavor is directed; objectives are descriptions of measurable outcomes; and strategies are plans of action. Taken together, these goals, objectives, and strategies represent a plan produce a blueprint for restoring the spill area. To be funded, a project must be consistent with the goals and policies of the Restoration Plan and with restoration objectives and strategies as they change over time.

GOAL: *The end toward which restoration is directed*

The goal of restoration is recovery of all injured resources and services. Recovery is to be sustained by healthy, productive ecosystems that maintain naturally occurring biodiversity. All restoration actions must be directed toward this goal.

OBJECTIVES: *Measurable outcomes of restoration*

The objectives of the restoration program are measurable conditions that signal the recovery of individual resources or services. They are the yardsticks against which the success of the program is measured.

In general, resources and services will have recovered when they return to conditions that would have existed had the spill not occurred. Because it is difficult to predict conditions that would have existed in the absence of the spill, recovery is often defined as a return to prespill conditions. For resources that were in decline before the spill, like marbled murrelets, recovery may be achieved ~~consist of stabilizing the~~ when a population is stabilized at a lower level than before the spill. For some resources, little is known about their injury and ~~recovery~~ current status, so it is difficult to define recovery.

Where few ~~little~~ prespill data exist, injury is inferred from comparison of oiled and unoiled areas, and recovery is usually defined as a return to conditions comparable to those of unoiled areas. Because the differences between oiled and unoiled areas may have existed before the spill, statements of injury and objectives based on these differences are often less certain than in those cases where prespill data exist. Alternatively, injury may be evaluated based on the number of oiled carcasses picked up following the spill relative to the estimated ~~or presumed~~ size of the spill-area population. Even in cases where some prespill data are available, ~~However,~~ there also is ~~can be some~~ uncertainty associated with interpreting the significance of prespill population data since populations undergo natural fluctuations. In all cases, indicators of recovery can include increased numbers of individuals, reproductive success, improved growth and survival rates, and normal age and sex composition of the injured population.

Full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, are healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not occurred. A recovered ecosystem provides the same functions and services as would have been provided had the spill not occurred.

STRATEGIES: *Plans of action*

A restoration strategy is a plan of action for achieving objectives. Each year, through its annual or multiyear work plan, the Trustee Council decides which strategies to implement. Restoration strategies reflect consideration of ecosystem relationships. For example, the strategy for some injured resources includes research into why they are not recovering, such as declining or contaminated food sources or disruption of ecosystem relationships.

In this section, restoration strategies are presented under three headings: Biological Resources, Other Resources, and Services.

Biological Resources

Because restoration strategies for biological resources depend on ~~whether the resource is recovering~~ a resource's recovery status, strategies are subdivided into those for recovered resources, recovering resources, resources that are not recovering, and resources ~~whose recovery~~ for which the recovery status is unknown.

Recovered Resources. In general, once a resource has recovered, the Trustee Council no longer has a direct role with respect to that resource. The on-going management of recovered resources is the job of the state or federal agency to which such responsibilities have been assigned by law or regulation. Sustaining the health of recovered resources, however, will continue to received consideration as the Trustee Council evaluates opportunities for habitat protection and acquisition and undertakes other measures to protect, restore, and enhance [?] the marine ecosystem in the oil-spill area. [NOTE TO REVIEWERS: I AM NOT ENTIRELY HAPPY WITH THIS PARAGRAPH, BUT IT GIVES US SOMETHING TO THINK ABOUT. IDEALLY, THIS WOULD BE THE PLACE TO INTRODUCE THE "E" WORD--I.E., ENHANCEMENT--BUT THAT MAY OR MAY NOT BE POLITICALLY CORRECT.]

Recovering Resources. The fact that a resource is recovering suggests that nature will restore it without intervention, ~~Consequently,~~ and restoration of recovering resources will rely primarily on natural recovery.

~~Because these resources are~~ If a resource is recovering, research into factors limiting recovery ~~and general restoration projects to accelerate recovery~~ may not be warranted. ~~However,~~ research that will lead to improved resource management and research on the health and recovery of the ecosystem in which that resource lives may be appropriate.

~~However~~ Additionally, if a resource is not expected to recover fully on its own or if waiting for natural recovery will cause long-term harm to a community or service, appropriate alternative means of restoration ~~would~~ could be undertaken. Habitat protection and monitoring are encouraged, as are general restoration projects that protect the resource from other sources of potential injury. (Restoration strategies under "Services" also apply to these resources.)

The restoration strategy for recovering resources has ~~three~~ four parts:

- Rely on natural recovery

- Monitor recovery
- Protect injured resources and their habitats
- Conduct limited research to benefit management and ecosystem recovery

Resources Not Recovering. Except for certain protective measures, attempts to restore these resources without knowing why they are not recovering may be ineffectual or even detrimental. For this reason, the restoration strategy for these resources emphasizes determining why they are not recovering, and eliminating threats to the remaining populations.

Where sufficient knowledge about the nature of injury exists, the restoration strategy also encourages actions to promote recovery. The populations of some of these resources are in ~~a steep~~ decline and may not recover without help. Furthermore, some of these resources have subsistence or economic importance and their recovery is linked to the recovery of these services. (Restoration strategies under "Services" also apply to these resources.)

Research is encouraged, provided it helps explain why a resource is not recovering. Habitat protection and monitoring are also encouraged. General restoration projects are allowed if they address factors limiting recovery or if they protect the resource from other sources of potential injury.

The restoration strategy for resources that are not recovering has four parts:

- Conduct research to find out why these resources are not recovering
- Initiate, sustain, or accelerate recovery
- Monitor recovery
- Protect injured resources and their habitats

Recovery Unknown. If specialists do not know whether a resource is recovering, it will be treated in much the same way as a recovering resource. Until more is known about the nature and extent of injuries and the degree of recovery of these resources, restoration will rely primarily on natural recovery, aided by ~~monitoring and~~ protective measures. Monitoring may be undertaken to determine a resource's recovery status.

Because the recovery of these resources is unknown, and, in some cases, the injury poorly understood, research into factors limiting recovery and general restoration projects to accelerate recovery may not be warranted. Habitat protection and monitoring are encouraged, as are general restoration projects that protect these resources from other sources of potential injury.

The restoration strategy for resources whose recovery is unknown has three parts:

- Rely on natural recovery
- Monitor recovery
- Protect injured resources and their habitats

Other Resources

Other injured resources include archaeological resources, designated wilderness areas and oiled sediment. The strategy for restoring archaeological resources seeks to repair and protect injured sites and artifacts. The strategy for sediment includes removal or reduction of residual oil and monitoring. Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas or wilderness study areas.

Services
Commercial fishing, passive use, recreation (including sport fishing) and tourism and subsistence are services that were reduced or lost because of the spill. Injured resources that support these services include clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. The primary way to restore services is to restore the resources on which they depend.

Additional restoration strategies for commercial fishing, recreation and tourism, and subsistence include promoting recovery of the service as soon as possible through such means as increasing the availability, reliability, or quality of the resource on which the service depends. For some resources, this may take the form of increasing availability in the long run through improved resource management or providing replacement resources. Strategies for recreation and tourism and subsistence also include removing or reducing residual oil if treatment is cost effective and less harmful than leaving the oil in place.

Objectives and Strategies by Resource and Service

This section describes the nature and extent of injury and recovery and the recovery objective~~, and the restoration strategy~~ for each injured resource and service. Specific strategies to achieve recovery objectives are described in annual work plans and restoration project invitations (see for example *Invitation to Submit Restoration Projects for Federal Fiscal 1997 and Draft Restoration Program: FY 97 and Beyond).* The information in this section is expected to change over time as the restoration program adapts to new information. For example, population decline or sublethal effects may be documented for new resources, some resources may begin to recover, and objectives and strategies may change in response to new conditions. Hypotheses for why resources are not recovering are particularly susceptible to change as prevailing hypotheses are tested and new ones are formed.

New scientific data will be incorporated into restoration decisions without the need to change the plan. However, changes will be reported in the Trustee Council's annual status report.

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION]

Archaeological Resources

Injury and Recovery
Twenty-four archaeological sites are known to have been adversely affected by cleanup activities, or looting and vandalism linked to the oil spill. Injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been

disturbed, which has exposed sites to accelerated erosion. The effect of oil on soil chemistry and organic remains may reduce or eliminate the utility of radiocarbon dating in some sites.

Assessments of 14 sites in 1993 suggest that most of the archaeological vandalism that can be linked to the *Exxon Valdez* oil spill occurred in 1989 before adequate constraints were put into place over the activities of oil spill cleanup personnel. Most vandalism took the form of "prospecting" for high yield sites. In 1993, only two of the 14 sites visited showed signs of continued vandalism and the link between this recent vandalism and the *Exxon Valdez* oil spill remains highly problematical. Oil samples have not yet been analyzed, but oil was visible in the intertidal zones of two of the 14 sites. [Is this still True] include note

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data which remain in vandalized sites are preserved. Artifacts and data are typically preserved through excavation or other forms of documentation, or through site stabilization, depending on the nature of the injury and the characteristics of the site. ~~either speci~~ See Note # 4

Restoration Strategy

Repair spill-related injury to archaeological sites and artifacts. Injuries may be repaired to some extent through stabilizing eroding sites, or removing and restoring artifacts.

Protect sites and artifacts from further injury and store them in appropriate facilities. Archaeological sites and artifacts could be protected from further injury through the reduction of looting and vandalism, or the removal of artifacts from sites and storage in appropriate facilities. Opportunity for people to view or learn about the cultural heritage of people in the spill area would also provide protection by increasing awareness and appreciation of cultural heritage and would replace services lost as a result of irretrievable damage to some artifacts.

Monitor recovery. Monitor a small number of sites vulnerable to serious, commercial looting.

BALD EAGLES

Injury and Recovery

surveys in 1990, 1991 confirmed by

There are about __,000 bald eagles in Alaska, about _,000 of which breed in Prince William Sound and _,000 along the north Gulf of Alaska coast. ~~Two hundred to~~ An estimated 200-300 bald eagles died as a result of ~~may have been killed in~~ the spill, and productivity was reduced in oiled areas of Prince William Sound in 1989. However, productivity appeared to have recovered by 1990, and an aerial survey of adults in 1995 indicated that the population has returned to its prespill in Prince William Sound. ~~population estimates made in 1989, 1990, and 1991 indicate that there may have been an increase in the Prince William Sound bald eagle population since the previous survey conducted in 1984. Productivity decreased in 1989, but appeared to have recovered by 1990. Because population and productivity appear to have returned to prespill levels, bald eagles may have already recovered from the effects of the spill.~~

See Note #5

Recovery Objective

The Trustee Council considers the bald eagle to have recovered from the effects of the Exxon Valdez oil spill. ~~Bald eagles will have recovered when their population and productivity return to prespill levels.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the population and productivity of bald eagles in Prince William Sound until full recovery is confirmed and perhaps at intervals thereafter. The eagle population in Prince William Sound is expected to increase to its prespill level in 1994. There are not enough prespill data on eagle populations in other parts of the spill area to warrant surveys outside Prince William Sound.~~

~~*Protect bald eagles and their habitat.* With regard to bald eagles, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance in feeding and roosting areas.~~

BLACK OYSTERCATCHERS

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. An estimated 2,000 oystercatchers lived in the oil-spill area prior to the spill, and up to 20 percent of these died as a result of the spill. In addition, breeding activities were disrupted and there was reduced growth and survival of young oystercatchers in Prince William Sound. Productivity, however, has not been monitored since 199_, and the recovery status of the black oystercatcher is not known. ~~Within Prince William Sound, an estimated 120 to 150 black oystercatchers, representing 12-15 percent of the total estimated population, died as a result of the spill. Mortality outside of Prince William Sound is unknown. Black oystercatchers are recovering, although they may still be exposed to hydrocarbons when feeding in intertidal areas.~~

Note #6

Recovery Objective

Black oystercatchers will have recovered when there is an increasing trend in the Prince William Sound population ~~and attain prespill levels and~~ when reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor population abundance and distribution and the growth rates of chicks.~~

~~*Protect black oystercatchers and their habitat.* With regard to black oystercatchers, the objective of habitat protection is to reduce disturbance to feeding and nesting sites.~~

BRACHYRAMPHUS ~~MARBLED~~ MURRELETS

Injury and Recovery

There are two *Brachyramphus* murrelets: marbled and Kittlitz's. The Prince William Sound-northern Gulf of Alaska area is a key center of abundance for both species. The world population of Kittlitz's murrelet is believed to number only a few tens of thousands of birds, many of which are in the oil-spill area. The marbled murrelet is federally listed as a Threatened species in Washington, Oregon, and California; it is also listed as Threatened in British Columbia.

The Marbled murrelet populations ~~were~~ was in decline before the spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. The oil spill probably increased the prespill rate of decline for this species in the spill area, although the incremental injury is difficult to estimate. ~~The population of marbled murrelets may be stabilizing or even increasing since the spill.~~ Carcasses of more than 1,000 ~~*Brachyramphus*~~ murrelets were found after the spill, and it is estimated that as much as __ percent of the Prince William Sound marbled murrelet population were killed by the spill. Population estimates for murrelets are highly variable, and postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. The recovery status of Kittlitz's murrelet is not known.

Recovery Objective

Marbled murrelets will have recovered when population trends are stable or increasing. No recovery objective can be identified for Kittlitz's murrelet at this time.

~~Restoration Strategy~~

~~*Conduct research to find out why marbled murrelets are not recovering.* Likely causes include avian and mammalian predation, climatic/oceanographic features and prey limitation. Also of concern are the effects of resource exploitation (incidental gillnet catch) and upland development.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why marbled murrelets are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor the marbled murrelet population in Prince William Sound.~~

~~*Protect marbled murrelets and their habitat.* With regard to marbled murrelets, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.~~

CLAMS

Injury and Recovery

The magnitude of impacts on clam populations varies with the species, degree of oiling, and geographic area. However, data from the lower intertidal zone on sheltered beaches suggest that little-neck clams

and, to a lesser extent, butter clams ~~on sheltered beaches~~ were killed or suffered reduced growth ~~rates~~ as a result of the oil spill ~~by oiling~~ and clean-up activities. ~~In addition, growth appeared to be reduced by oil, but determination of sublethal or chronic effects is awaiting final analyses.~~ In communities on the Kenai Peninsula, Kodiak, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

Recovery Objective

Based on prespill data or comparisons of oiled and unoiled sites, clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill ~~(prespill data or unoiled control sites)~~.

~~**Restoration Strategy**~~

~~Clams are important for subsistence use and also serve as prey for sea otters and sea ducks such as harlequin ducks and pigeon guillemots. For additional restoration strategies, see *Subsistence, Sea Otters, Harlequin Ducks* and *Pigeon Guillemots*.~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the density and size of clams in select clam beds.~~

~~*Protect injured clam beds.* With regard to intertidal biota like clams, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Clams can also be protected by reducing marine pollution.~~

[NOTE TO REVIEWERS: I DIDN'T DO ANYTHING TO THE FOLLOWING SECTION.]

COMMERCIAL FISHING

Injury and Recovery

Commercial fishing was injured through injury to commercial fish species and also through fishing closures. Continuing injuries to commercial fishing may cause hardships for fishermen and related businesses. Each year that commercial fishing remains below prespill levels compounds the injury to the fishermen and, in many instances, the communities in which they live or work.

The Trustee Council recognizes the impact to communities and people of the Prince William Sound region resulting from the sharp decline in pink salmon and herring fisheries in past years. ~~In 1994, the Trustee Council committed over six million dollars to help address these issues through the development of an ecosystem-based study for Prince William Sound.~~ Some of the pink salmon and herring problems may be unrelated to the spill. However, the Council will continue to address these important problems.

Recovery Objective

Commercial fishing will have recovered when the population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions

that would have existed had the spill not occurred. Because of the difficulty of separating spill-related effects from other changes in fish runs, the Trustee Council may use prespill conditions as a substitute measure for conditions that would have existed had the spill not occurred.

Restoration Strategy

The primary method for restoring commercial fishing is to restore the species that are fished commercially, such as pink salmon, Pacific herring, and sockeye salmon. These species are discussed elsewhere in this chapter. Three additional parts of the strategy for restoring commercial fishing are the following:

Promote recovery of commercial fishing as soon as possible. Many communities that rely on commercial fishing will be significantly harmed while waiting for commercial fish resources to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of commercial fishing. This objective may be accomplished through increasing availability, reliability, or quality of commercial fish resources, depending on the nature of the injury. For resources that have sharply declined since the spill, such as pink salmon, and Pacific herring in Prince William Sound, this objective may take the form of increasing availability in the long run through improved fisheries management. Another example is providing replacement fish for harvest.

Protect commercial fish resources from further degradation. Further stress on commercial fish resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if a resource faces loss of habitat. The Trustee Council can also contribute to the protection of commercial fish species by providing information needed to improve their management.

Monitor recovery. Monitoring the recovery of commercial fishing will track the progress of recovery, detect major reversals, and identify problems with the resources and resource management that may affect the rate or degree of recovery. Inadequate information may require managers to unduly restrict use of the injured resources, compounding the injury to commercial fishing.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Population sizes are not known for any of these species, and, in general, however, loons are long-lived, slow-reproducing birds with small populations. Common loons in the oil-spill area may number only a few thousand, most of which are migrant and wintering birds. Neither the breeding grounds of the birds affected by the spill nor their recovery status are known.

Recovery Objective

Common Loons will have recovered when numbers of migrant/wintering (March) birds in

Prince William sound population have returned to prespill levels.

COMMON MURRES

Injury and Recovery murre carcasses

About 30,000 ~~oiled birds~~ were picked up following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres died than were actually recovered, and it is estimated that the spill-area population declined by about 40 percent, including at colonies at Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay. In addition to direct losses of murres, there was evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Postspill monitoring of productivity at index colonies indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed in 1994 [check] and, at that time, had not returned to prespill levels.

~~Productivity of common murres shows signs of recovery at some injured colonies (Barren Islands, Puale Bay) but postspill population counts are still lower than prespill estimates and show no sign of recovery.~~

Recovery Objective

Common murres will have recovered when population trends are increasing significantly at index colonies ~~in the spill area~~ and productivity is sustained ~~when reproductive timing and success are~~ within normal bounds. ~~(Normal bounds will be determined by comparing productivity data with information from other murre colonies in the Gulf of Alaska and elsewhere.)~~

Not tied to

~~**Restoration Strategy**~~

~~*Conduct research to find out why common murres are not recovering.* Suspected causes include avian predation and behavioral change which inhibits breeding productivity at some colonies.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why common murres are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor populations at index colonies such as the Chiswell Islands, Barren Islands, Triplets, Ungaiushak Island and Puale Bay. In addition, monitor the productivity of common murres at the Barren Islands.~~

~~*Protect common murres and their habitat.* With regard to common murres, the objective of habitat protection is to reduce disturbance in nearshore feeding areas and near nesting colonies.~~

CUTTHROAT TROUT

Injury and Recovery

Prince William Sound is at the northwestern limit of the range of cutthroat trout and the stocks known to exist within the sound are very small and, therefore, highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a small number of oiled index streams grew more slowly than in unoiled streams, possibly through reduced food supplies or exposure to oil. The difference in growth rates persisted through 1991. However, no studies have been conducted since then, and the recovery status of this species is not known. ~~Cutthroat trout have grown more slowly in oiled areas than in unoiled areas. Insufficient data are available to determine whether they are recovering.~~

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are comparable to those for unoiled areas. ~~This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.~~

~~Restoration Strategy~~

~~Cutthroat trout is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism*.~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect cutthroat trout and their habitat.* With regard to cutthroat trout, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning. The Trustee Council can also contribute to the protection of cutthroat trout by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION.]

DESIGNATED WILDERNESS AREAS

Injury and Recovery

The oil spill delivered oil in varying quantities to the waters adjoining the seven areas within the spill area designated as wilderness areas and wilderness study areas. Oil was also deposited above the mean high tide line in these areas. During the intense cleanup seasons of 1989 to 1990, thousands of workers and hundreds 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 Objective

Designated wilderness areas will have recovered when oil is no longer encountered in these areas and the public perceives them to be recovered from the spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas. No strategies have been identified that benefit only designated wilderness areas without also addressing injured resources.

DOLLY VARDEN

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden ~~have grown~~ grew more slowly in oiled streams ~~areas~~ than in unoiled streams ~~areas~~. ~~However,~~ no data have been gathered since 1991, and the recovery status of this species is not known. ~~Insufficient data are available to determine whether they are recovering.~~

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams ~~areas~~ are comparable to those ~~for~~ in unoiled streams ~~areas~~. ~~This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.~~

~~**Restoration Strategy**~~

~~Dolly Varden is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect Dolly Varden and their habitat.* With regard to Dolly Varden, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Dolly Varden by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

HARBOR SEALS

Injury and Recovery

Harbor seal numbers ~~were declining~~ in ~~the Gulf of Alaska, including~~ ~~Prince~~ William Sound, before the spill, ~~but an~~ estimated 300 seals died in the sound as a direct result of the spill. ~~Postspill surveys in 19__ showed that seals in the oiled area had declined by 43 percent, compared to 11 percent in the unoiled area.~~ Unfortunately, seals in both oiled and unoiled parts of Prince William Sound have continued to decline at an annual rate of about 6 percent. Possible factors for this long-term decline include disease and limitations in the abundance or quality of food. ~~Counts made during the molt at trend count sites in Prince William Sound from 1990 to 1993 indicate that numbers may have stabilized. However, counts during pupping have continued to decline. It is not known which counts are the best indicator of population status. If the conditions that were causing the population to decline before the spill have improved, normal growth may replace the animals that were lost. However, if conditions continue to be unfavorable, the affected population may continue to decline.~~ Harbor seals are a key subsistence resource in the oil-spill area ~~Prince William Sound~~. Subsistence hunting is ~~both~~ affected by the declining seal population and, in turn, may be affecting the recovery of harbor seals ~~status~~.

Recovery Objective

Recovery will have occurred when harbor seal population trends are stable or increasing.

~~Restoration Strategy~~

~~Harbor seals are important for subsistence use. For additional restoration strategies, see *Subsistence.*~~

~~*Conduct research to find out why harbor seals are not recovering.* Suspected causes include limited or changing availability of prey, particularly forage fishes; predation by killer whales; and resource exploitation through subsistence take or incidental take associated with fisheries.~~

~~*Initiate, sustain, or accelerate recovery of harbor seals.* Once scientists determine why harbor seals are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor trends in Prince William Sound during pupping and molting for comparison with previous years' data.~~

~~*Protect harbor seals and their habitat.* With regard to harbor seals, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites, and in nearshore feeding areas. Another way of protecting harbor seals is to provide information that will help subsistence hunters assess the effects of their harvest.~~

HARLEQUIN DUCKS

Injury and Recovery

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound, and many more than that actually died. In comparing oiled and unoiled areas of Prince William Sound, biochemical evidence of exposure to oil contined through 1993. Prespill data on harlequin populations and productivity are poor and complicated by possible geographic differences in habitat quality. However, the summer population in Prince William Sound is only a few thousand birds, and there continues to be concern about possible poor reproduction and a possible decline in numbers of molting birds in western Prince William Sound. ~~There are indications of reduced densities of harlequin ducks in the breeding season; a declining trend in the summer, postbreeding population; and very poor production of young in western Prince William Sound.~~

Recovery Objective

Harlequin ducks will have recovered when populations in eastern and western Prince William Sound have similar age and sex ratios and breeding-season behavior, provided that geographic differences are not shown to account for such differences as may now exist. ~~Lack of evidence~~ indicating exposure to hydrocarbons will be an indicator that recovery is underway. ~~breeding and postbreeding season densities and production of young return to estimated prespill levels, or when there are no differences in these parameters between oiled and unoiled areas.~~

~~Restoration Strategy~~

~~Harlequin ducks are hunted for subsistence and sport. For additional restoration strategies, see *Subsistence* and *Recreation and Tourism.*~~

~~*Conduct research to find out why harlequin ducks are not recovering.* Although the exact cause of reproductive failure among resident birds is unknown, it is believed to be related to ingestion of oil contaminated prey from foraging in oiled mussel beds.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why harlequin ducks are not recovering, efforts may be undertaken to accelerate recovery. If ingestion of oiled mussels is found to limit the recovery of harlequin ducks, cleaning oiled mussel beds may hasten recovery.~~

~~*Monitor recovery.* Monitor the breeding age population in Prince William Sound, as well as numbers of young, brood distribution, and abundance of postbreeding harlequins.~~

~~*Protect harlequin ducks and their habitat.* With regard to harlequin ducks, the objective of habitat protection is to ensure maintenance of adequate riparian habitat for nesting and brood rearing, and reduce disturbance to nearshore feeding, molting, brood rearing habitats. The Trustee Council can also contribute to the protection of harlequin ducks by providing information needed to improve their management. An example of protective management practices is the restriction on sport hunting of harlequin ducks imposed by the Alaska Board of Game in 1991.~~

INTERTIDAL ORGANISMS

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill, resulting in significant impacts to the flora and fauna of the intertidal zone, the area of beach between low and high tides. With tidal action, oil penetrated deeply into cobble and boulder beaches, and, even with intensive clean up activities, persists in some beaches today. Direct oiling and beach clean-up activities had a major impact on intertidal life. The most significant impacts occurred in middle and upper intertidal zones on sheltered rocky shores, which is where the greatest amounts of oil were stranded.

Small invertebrates like limpets, barnacles, and marine worms were less abundant at oiled versus unoiled index sites in Prince William Sound, Kodiak Island, and on the Kenai and Alaska peninsula coasts. The size, coverage, and reproductive potential of seaweed *Fucus gardneri* (known as rockweed or popweed) also was reduced following the spill. Although many numbers of many species of invertebrate fauna have increased following the spill, recovery of *Fucus* in the upper intertidal zone is lagging. Full recovery of *Fucus* is crucial for recovery of the intertidal ecosystem, since many invertebrates depend on the cover provided by this seaweed. Many intertidal resources are important to subsistence users, as well as to such "top predators" as sea and river otters, harlequin ducks, and pigeon guillemots.

~~The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult *Fucus* in large numbers.~~

Recovery Objective

~~Each intertidal elevation (lower, middle, or upper) will have recovered when community composition, population abundance of component species, age class distribution, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~ Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as *Fucus*, and provision of adequate, clean food supplies for top predators in intertidal/nearshore habitats.

Restoration Strategy

Conduct research to find out why some intertidal organisms are not recovering. Possible explanations include changes in the community structure resulting from spill induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).

Initiate, sustain, or accelerate recovery. Once scientists determine why some intertidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor matched oiled and unoiled intertidal sites, incorporating a variety of habitat types.

Protect intertidal organisms and their habitat. With regard to intertidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Intertidal organisms can also be protected by reducing marine pollution.

KILLER WHALES

Injury and Recovery

About ___ killer whales in _ "resident" pods regularly use Prince William Sound. Other whales in "transient" pods enter the sound occasionally. The rate of natural mortality in killer whales is very low, about 2 percent in the north Pacific. There has been particular concern in Prince William Sound about the resident AB pod, which numbered 36 animals prior to the spill. Since the spill, this pod has lost at least 11 whales, including 6 in 1989-1990 and 5 more in 1994-1995. No births were recorded in this pod in 1989 and 1990, and the pod fractured into subgroups for _ years following the spill. These losses are only circumstantially linked to the oil spill, particularly since there also were unusual losses in the AB pod in 1988, preceding the spill. It is now unlikely that the AB pod will ever regain its former size, although overall numbers of resident and transient killer whales in Prince William Sound are at prespill levels. Thirteen whales disappeared from one killer whale pod in Prince William Sound between 1988 and 1990. The injured pod is growing again. [NOTE TO REVIEWERS: THIS NEEDS CAREFUL FACT CHECKING.]

Recovery Objective

In general, the Trustee Council considers killer whales to have recovered in Prince William Sound. The AB pod has not returned to its prespill level of 36 whales, but, since it is unlikely to do so, no recovery objective is identified. Killer whales will have recovered when the injured pod grows to at least 36 individuals (1988 level).

Restoration Strategy

Rely on natural recovery. Natural processes aided by protective measures will be the main agents of restoration.

Monitor recovery. Monitor the injured pod (AB pod) of killer whales in Prince William Sound.

MUSSELS

Injury and Recovery

Mussels are hardy creatures, and there were increased densities but decreased sizes of mussels in oiled areas following the oil spill. During clean-up operations, mussel beds were purposely left alone. In 1991, high concentrations of relatively unweathered oil were found in the mussels and underlying byssal mats in certain dense mussel beds. In 1991, relatively high concentrations of oil were found in mussels and in the dense underlying mat (byssal substrate) of certain oiled mussel beds. The beds were not cleaned nor was oil removed after the spill. The The biological significance of oiled mussel beds is not known, but they Oiled mussel beds are potential local pathways of sources of fresh (unweathered) oil contamination for harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which feed to some extent on mussels and show some signs of continuing injury. The extent and magnitude of oiled mussel beds are unknown. At least 70 [?] mussel beds in Prince William Sound are known to still have oil residue, and 12 beds were cleaned on an experimental basis in 199_. Subsistence users also continue to be concerned about contamination from oil mussel beds.

Recovery Objective

they do not contain significantly elevated concentrations of oil.

Mussels will have recovered when there are no longer mussel beds with oil residues that have biologically significant potential as pathways of oil contamination to top predators in nearshore/intertidal habitats and to subsistence users. their populations and productivity are at prespill levels and they do not contain oil that contaminates higher trophic levels.

Restoration Strategy

Initiate, sustain, or accelerate recovery. Cleaning oiled mussel beds hastens their recovery and that of species that feed on them, such as harlequin ducks and juvenile sea otters.

Monitor recovery. Monitor the health of mussels and the concentration and degradation of oil in mussel beds identified as contaminated.

~~*Protect mussels and their habitat.* With regard to intertidal biota like mussels, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Mussels can also be protected by reducing marine pollution.~~

PACIFIC HERRING

Injury and Recovery

Pacific herring spawned in intertidal/subtidal habitats in Prince William Sound shortly after the oil spill. As much as 10 percent of the intertidal spawning habitat and 40 percent of the herring staging areas in the sound may have been contaminated by oil. ~~As a result,~~ studies conducted in 1989 and 1990 showed increased rates of egg mortality and larval deformities in oiled versus unoiled areas. These effects have been confirmed in laboratory studies, but their significance at a population level is not known. In 1992, herring biomass in Prince William Sound was at a record level. In 1993, however, when herring spawned in 1989 should have returned in large numbers, there was an unprecedented crash in numbers of adult herring. A viral disease and fungus were the probable agents of mortality, but the connection to the oil spill is ~~a matter of speculation~~. Numbers of spawning herring in Prince William Sound have remained depressed through the 1995 season. Pacific herring are extremely important ecologically as well as commecially. ~~Pacific herring studies have demonstrated egg mortality and larval deformities. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, the stocks and dependent fisheries in Prince William Sound are not healthy, as indicated by the low spawning biomass in 1993 and 1994 and the resultant elimination of the fisheries in those years.~~

The biomass decreased 75% from the record of the prev. yr.

Unknown ? less value-laden.

We have to say season closed early in 93 & remained closed in '94 & '95.

and the continuing closure affects the communities & people of PWS.

Recovery Objective

Pacific herring will have recovered when the Prince William Sound population is at prespill levels (allowing for normal variation). A normal age structure, disease levels, and spawning biomass will be indicators of recovery. ~~populations are healthy and productive and exist at prespill abundances.~~

Very Good!

~~Restoration Strategy~~

~~Pacific herring are important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why Pacific herring are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are disease, heritable genetic damage, oil toxicity, the impact of winter conditions on herring survival and reproductive success, and the advective transport of herring larvae from rearing areas in Prince William Sound.~~

~~*Initiate, sustain, or accelerate recovery of Pacific herring.* Once scientists determine why Pacific herring are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor fish health and spawning biomass.~~

~~*Protect Pacific herring and their habitat.* With regard to Pacific herring, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Pacific herring by providing information needed to improve their management. An example of protective management practices is the closure of the fishery by the Alaska Department of Fish and Game due to the failure of the herring run in Prince William Sound in 1993 and 1994.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

PASSIVE USE

Injury and Recovery

Passive use of resources includes 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. Injuries to passive uses are tied to public perceptions of injured resources.

Recovery Objective

Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of passive use values. No strategies have been identified that benefit only passive uses, without also addressing injured resources. Since recovery of passive uses requires that people know when recovery has occurred, the availability to the public of the latest scientific information will continue to play an important role in the restoration of passive uses.

PIGEON GUILLEMOT

Injury and Recovery

Although the pigeon guillemot is widely distributed, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, both the birds and the fish they prey on are vulnerable to oil pollution. Like the marbled murrelet, the pigeon guillemot population in Prince William Sound was in decline before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the Gulf of Alaska population may died in the spill, and declines along oiled shorelines in Prince William Sound were greater than along unoiled shorelines. Numbers of guillemots recorded on boat surveys are highly variable, and there is not yet any

statistically significant evidence of a postspill population increase. The factors responsible for the guillemot's prespill decline may compromise or mask recovery from the effects of the oil spill.

Recovery Objective

Pigeon guillemots will have recovered when its populations in Prince William Sound is are stable or increasing.

~~**Restoration Strategy**~~

~~*Conduct research to find out why pigeon guillemots are not recovering.* Likely causes include climatic/oceanographic features, prey limitation, and predation.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why pigeon guillemots are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor the pigeon guillemot population in Prince William Sound.~~

~~*Protect pigeon guillemots and their habitat.* With regard to pigeon guillemots, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.~~

PINK SALMON

Injury and Recovery

About 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams and were highly vulnerable to the effects of the oil spill. Salmon from intertidal habitats as well as those spawned higher or in streams or released from hatcheries had to swim through oiled waters and ingest oil particles or oiled prey as they foraged in the sound and emigrated to the Gulf of Alaska. As a result, two types of early life-stage injuries were documented: First, growth rates in juvenile salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams.

There is evidence that these two types of injury have resulted in reduced returns of adults from both wild and hatchery stocks (e.g., in 1990, 1992 and 1993). However, returns of adult salmon are highly variable, and it is difficult to separate oil effects from those of other factors.

Injuries to salmon eggs and juveniles remain the best indicators of injury. Although evidence of reduced juvenile growth rates was limited to the 1989 season, increased egg mortality in oiled persisted through 1993, reaching a high of 40-50 percent in 1991. The 1994 and 1995 seasons were the first since 1989 in which there were no statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery is underway, but fisheries biologists continue to explore hypotheses concerning possible genetic damage and increases in straying rates as a result of the spill.

~~Pink salmon studies have demonstrated egg mortality, fry deformities, and reduced growth in juveniles. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, there is evidence of continued damage in some stocks from exposure to oil, and there were unexpectedly poor runs of both wild and hatchery stocks of pink salmon in Prince William Sound in 1992 and 1993. In 1994, runs were still depressed but exceeded forecasts.~~

Recovery Objective

Pink salmon will have recovered when returns of wild adults are within the bounds of natural variation and there are no statistically significant differences in egg mortalities in oiled and unoiled streams for two years each of odd- and even-year runs in Prince William Sound. ~~populations are healthy and productive and exist at prespill abundance. An indication of recovery is when egg mortalities in oiled areas match prespill levels or levels in unoiled areas.~~

~~**Restoration Strategy**~~

~~Pink salmon is important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why pink salmon are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are heritable genetic damage and oil toxicity.~~

~~*Initiate, sustain, or accelerate recovery of pink salmon.* Once scientists determine why pink salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor egg mortality, escapement, and return per spawner productivity.~~

~~*Protect pink salmon and their habitat.* With regard to pink salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of pink salmon by providing information needed to improve their management. An example of protective management practices is restriction of the fishery by the Alaska Department of Fish and Game due to poor returns of pink salmon to Prince William Sound in 1992 and 1993.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

RECREATION AND TOURISM

Injury and Recovery

The spill disrupted use of the spill area for recreation and tourism. Resources important for wildlife viewing include killer whale, sea otter, harbor seal, bald eagle, and various seabirds. Residual oil exists on some beaches with high value for recreation and may decrease the quality of recreational experiences and discourage recreational use of these beaches.

Closures on sport hunting and fishing also affected use of the spill area for recreation and tourism. Sport fishing resources include salmon, rockfish, Dolly Varden, and cutthroat trout. Harlequin ducks are hunted in the spill area.

Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas increased management problems and facility use in unoiled areas. Some facilities, such as the Green Island cabin and the Fleming Spit camp area, were injured by cleanup workers.

Recovery Objective

Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, recreation use of oiled beaches is no longer impaired, ~~and facilities and management capabilities can accommodate changes in human use.~~

Restoration Strategy

Preserve or improve the recreational and tourism values of the spill area. Habitat protection and acquisition are important means of preserving and enhancing the opportunities offered by the spill area. Facilities damaged during cleanup may be repaired if they are still needed. New facilities may restore or enhance opportunities for recreational use of natural resources. Improved or intensified public recreation management may be warranted in some circumstances. Projects that restore or enhance recreation and tourism would be considered only if they are consistent with the character and public uses of the area. However, all projects to preserve and improve recreation and tourism values must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removal of residual oil from beaches with high value for recreation and tourism may restore these services for some users. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Monitor recovery. Monitor the recovery of resources used for recreation and tourism. Also monitor changes in recreation and tourism in the spill area.

RIVER OTTERS

Injury and Recovery

River otters have a low density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve otter carcasses were found following the spill. Studies conducted during 1989-1991 identified several differences between otters in oiled and unoiled areas in Prince William Sound, including biochemical evidence of exposure to hydrocarbons or other sources of stress, reduced diversity in prey species, reduced body size (length-weight), and increased territory size. However, sample sizes were small, and it is not clear that these differences are the result of the oil spill. The Nearshore Vertebrate Predator project, now underway, will shed new light on the status of the river otters. In 1995 the Alaska Board of Game used its emergency authority to restrict trapping of river otters in western Prince William Sound to ensure that the results of this study are not compromised by the removal of animals from study areas on Montague and Knight islands. ~~River otters in Prince William Sound have suffered sublethal effects from the spill and may continue to be exposed to hydrocarbons.~~

Recovery Objective

The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound (or shown not to be related to the oil spill). ~~Indications of recovery are when habitat use, food habitats and physiological indices have returned to prespill conditions.~~

odd. It's always true.

Why not say, "this Rec. Obj will be reviewed following results from NVP"

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the health and habitat use of river otters in Prince William Sound.~~

~~*Protect river otters and their habitat.* With regard to river otters, the objective of habitat protection is to ensure maintenance of adequate riparian and shoreline habitats for feeding and denning.~~

ROCKFISH

Injury and Recovery

20

Very little is known about rockfish populations in the northern Gulf of Alaska. Some dead adult rockfish were recovered following the oil spill, and chemical analysis of five specimens indicated that oil ingestion was the cause of death. ~~Other~~ rockfish ~~were~~ showed exposed to hydrocarbons and ~~showed~~ sublethal effects. ~~Furthermore~~ In addition, closures to salmon fisheries apparently increased fishing pressures on ~~alternative species, such as~~ rockfish, which may have affected ~~be affecting their~~ the rockfish population. However, the original extent ~~and mechanism~~ of injury and the current status of ~~to~~ this species are unknown.

We're only talkers about about Rockfish

Analysis of

Recovery Objective

Without further study, a recovery objective cannot be defined.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Determine if restoration is needed.* Synthesize Natural Resource Damage Assessment studies and other data on rockfish in Prince William Sound to define a restoration objective and develop strategies to monitor and protect the recovery of the species.~~

~~*Monitor recovery.* Once a recovery objective is defined, monitor the progress of natural recovery toward that objective.~~

SEA OTTERS

Injury and Recovery

Surveys of sea otters in the 1970s and 1980s indicate that the population was expanding and on the order of 10,000 animals in Prince William Sound prior to the spill. Based on the number of carcasses and other data, population models suggest that 3,500-5,500 otters died in the first few months following the spill. In 1990 and 1991, unusual numbers of prime-age adult otters were found dead and there was evidence of an increased death rate in recently weaned juveniles. By 1992-93, mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of Prince William Sound. Boat surveys conducted in March and July in 1993 and again in 1994 indicated a Prince William Sound of about 7,700 otters. There was no difference in rates of change in the populations of oiled and unoiled areas, but nor was there statistically significant evidence of a population increase following the spill (1990-1994). The Nearshore Vertebrate Predator project, which is expected to be completed in 199_, should greatly clarify the recovery status of the sea otter in Prince William Sound. ~~Sea otters do not appear to be recovering, but are expected to eventually recover to their prespill population. Exactly what population increases would constitute recovery is very uncertain, as there are no population data from 1986 to 1989, and the population may have been increasing in Eastern Prince William Sound during that time. In addition, only large changes in the population can be reliably detected with current measuring techniques. However, there are recent indications that the patterns of juvenile and mid-aged mortalities are returning to prespill conditions.~~

Recovery Objective

Sea otters will have recovered when the Prince William Sound population returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in oiled parts of the sound will indicate that recovery is underway. ~~Sea otters will be considered recovered when population abundance and distribution are comparable to prespill abundance and distribution, and when all ages appear healthy.~~

Restoration Strategy

Sea otters are harvested for subsistence. For additional restoration strategies, see *Subsistence.*

Conduct research to find out why sea otters are not recovering. One hypothesis is that exposure to hydrocarbons and ingestion of contaminated prey affected survival and reproductive success of sea otters in Prince William Sound. Another hypothesis is that the oil spill induced changes in the population of benthic prey species that have limited reoccupation of sea otter habitat and the recovery of sea otters in oiled areas.

Initiate, sustain, or accelerate recovery of sea otters. Once scientists determine why sea otters are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor abundance and mortality of sea otters in oiled areas.

Protect sea otters and their habitats. With regard to sea otters, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites and in nearshore feeding areas.

SEDIMENTS

Injury and Recovery

With tidal action, oil penetrated deeply into cobble and boulder beaches that are relatively common on the rocky islands of shores throughout the spill area zone, especially in sheltered areas. Cleaning removed much of the oil from the intertidal zone but subsurface oil persisted in many heavily oiled beaches and was transported to subtidal sediments. in mussel beds, which were avoided during the cleanup. Chemical analyses show that *Exxon Valdez* oil reached its greatest concentrations in sediments at depths of 20 meters, although elevated levels of hydrocarbon-degrading bacteria were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. apparently did not reach deeper than 20 to 40 meters, although elevated activities of hydrocarbon-degrading bacteria were seen somewhat deeper in some cases. By 1993, however, there was little evidence of *Exxon Valdez* oil and related microbial activity at index sites in Prince William Sound except at sites associated with sheltered beaches that were heavily oiled in 1989 and for which subsurface oil was still observable in 1993 (Herring, Northwest, and Sleepy bays). On most shorelines, Exxon Valdez oil is neither present much less biologically active. However, visits to selected shorelines in Prince William Sound and as far away as the Alaska Peninsula in 1995 indicate that subsurface oil is clearly present at some sheltered sites. [NOTE TO REVIEWERS: THERE WAS SOME SAMPLING OF SEDIMENTS IN 1994. WHAT WERE THE RESULTS?]

There is no such thing as a spill zone for use of undefined area for which we have a meaningful concept

See Note 13

Recovery Objective

Sediments will have recovered when contamination causes no negative effects to the spill ecosystem and residues of subsurface oil at sheltered sites that were previously heavily oiled are declining.

~~**Restoration Strategy**~~

~~*Monitor recovery.* Monitor concentrations of hydrocarbons in sediments and indices of petroleum exposure in flatfish.~~

~~*Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place.* Removal of residual oil may accelerate recovery of sediment where natural recovery is insufficient. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.~~

SOCKEYE SALMON

Injury and Recovery

Commericial fishing was closed in portions of Cook Inlet and in Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-usual returns (overescapement) of spawning fish to the Kenai River and to Red and Akalura lakes on Kodiak Island. Initially these high escapements may have produced more juvenile sockeye than could be supported by the planktonic food available in the nursery lakes. Whatever the mechanism, the result was reduced outmigration of smolts and, ultimately, returns of adults. The effects of the 1989 overescapement have clearly persisted in the Kenai River system through 1995. Although the overall escapement goal for that system was exceeded in 1995, there is still concern about the run strength of ~~certain~~ year-classes affected by the initial overescapement. ~~Sockeye salmon in Red Lake, Akalura Lake, and lakes in the Kenai River system declined in population because of adult overescapement in 1989. The Red Lake system may be recovering because the plankton has recovered and fry survival improved in 1993. However, Akalura Lake and the Kenai River lakes have not recovered: smolt production has continued to decline from these lakes. In the Kenai River lakes, for example, smolt production has declined from 30 million in 1989 to 6 million in 1990 and to less than 1 million in 1992 and 1993.~~

Recovery Objective

Sockeye salmon in the Kenai ~~River~~ ~~and~~ Red-Akalura ~~lake~~ systems when overall escapement goals are met and returns-per-spawner for key year classes are within normal bounds. ~~affected lakes will have recovered when populations are able to support overwinter survival rates and smolt outmigrations comparable to prespill levels.~~ [NOTE TO REVIEWERS: I AM UNCERTAIN ABOUT THIS OBJECTIVE, BOTH THE ORIGINAL AND THE REVISED VERSION.]

~~**Restoration Strategy**~~

~~Sockeye salmon is important for subsistence use, commercial fishing, and sport fishing. For additional restoration strategies, see *Subsistence, Commercial Fishing* and *Recreation and Tourism.*~~

~~*Rely on natural recovery for sockeye salmon in Red Lake.* Natural processes aided by protective measures will be the main agents of restoration for sockeye salmon in Red Lake. This population of sockeye salmon is expected to fully recover by 1996.~~

~~*Conduct research to find out why other populations of sockeye salmon are not recovering.* The most likely explanation is that overescapement of adults changed the community structure of sockeye lake rearing habitat. Possible changes in community structure include a reduction in zooplankton biomass; conversion of the zooplankton community structure to a predation resistant form; or a change in composition of zooplankton that demands increased foraging time for juvenile salmon and thereby makes them susceptible to increased predation.~~

~~*Initiate, sustain, or accelerate recovery of sockeye salmon.* Once scientists determine why sockeye salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor outmigrations of smolt from Red Lake and Akalura Lake. In Kenai River lakes, monitor fall fry abundance and smolt abundance to estimate overwinter survival and smolt production.~~

~~*Protect sockeye salmon and their habitats.* With regard to sockeye salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of sockeye salmon by providing information needed to improve their management.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

SUBSISTENCE

Injury and Recovery

Subsistence users say that maintaining their subsistence culture depends on uninterrupted use of resources used for subsistence. The more time users spend away from subsistence activities, the less likely they will return to the activities. Continuing injury to natural resources used for subsistence may affect the way of life of entire communities.

Residual oil exists on some beaches with high value for subsistence. Continued presence of hydrocarbons may contaminate resources used for subsistence or, at a minimum, create uncertainty about the safety of resources. Uncertainty about the safety of resources may reduce their use and value for subsistence.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels, and when people are confident that the resources are safe to eat. One indication that recovery has occurred is when the cultural values provided by gathering, preparing, and sharing food are reintegrated into community life.

Restoration Strategy

The primary way of restoring subsistence is to restore injured resources used for subsistence, such as clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. These are discussed elsewhere in this chapter. Four additional parts of the strategy to restore subsistence are the following:

Promote recovery of subsistence as soon as possible. Many subsistence communities will be significantly harmed while waiting for resources used for subsistence to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of subsistence use. This objective may be accomplished through increasing availability, reliability, or quality of resources used for subsistence, or increasing the confidence of subsistence users. Specifically, if subsistence harvest has not returned to prespill levels because users doubt the safety of particular resources, this objective may take the form of increasing the reliability of the resource through food safety testing. Other examples are the acquisition of alternative food sources and improved use of existing resources. However, all projects to promote subsistence must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removing residual oil from beaches with high value for subsistence may improve the safety of foods found on these beaches. This benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Protect subsistence resources from further degradation. Further stress on subsistence resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if important subsistence areas are threatened. Protective action could also include protective management practices if a resource or service faces further injury from human use or marine pollution.

Monitor recovery. Monitor the recovery of resources used for subsistence. Also monitor subsistence harvest.

SUBTIDAL ORGANISMS

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the size and species composition of plant and animal populations below lower tide levels. Different habitats, including eelgrass beds, kelp beds, and deep water, were compared at oiled and unoiled sites. The greatest effects were detected at oiled sites with sandy sea bottoms under eelgrass beds, at which there were reduced numbers and/or diversity of helmet crabs, amphipods, and other crustaceans and mollusks. There were sublethal effects on the eelgrass itself. Organisms living in sediment (i.e., infauna) at depths of 3-20 meters were especially affected. Some opportunistic, stress-tolerant species, such as *Musculus* mussels, a variety of polychaetes, and juvenile cod, increased in numbers at oiled sites. Differences in oiled and unoiled sites were less evident by 1993.

In 1989, divers in parts of heavily oiled Herring Bay found numerous dead organisms on the bottom at depths greater than 11 meters. Far fewer organisms were found in the same locations in 1990 and 1991. More systematic studies of organisms in deep waters (40, 100, and greater than 100 meters) in 14 bays in Prince William Sound showed no obvious effects 16 months after the spill. This is probably because the current speed within Prince William Sound was sufficient to flush out toxic fractions of the oil before there was injury to benthic fauna.

[NOTE TO REVIEWERS: ANY RESULTS MORE RECENT THAN 1993?]

~~Certain subtidal organisms, like eelgrass and some species of algae, appear to be recovering. Other subtidal organisms, like leather stars and helmet crabs, showed little signs of recovery through 1991.~~

Recovery Objective

Subtidal communities will have recovered when community composition in oil areas, especially in association with eelgrass beds, is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as _____, and reductions in the presence of opportunistic species, such as _____.

~~Subtidal communities will have recovered when the community composition, age class distribution, population abundance of component species, and ecosystem functions and services in each injured subtidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~

Restoration Strategy

Conduct research to find out why some subtidal organisms are not recovering. Possible explanations include changes in the community structure resulting from spill-induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).

Initiate, sustain, or accelerate recovery. Once scientists determine why some subtidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor subtidal organisms in Prince William Sound.

Protect subtidal organisms and their habitats. With regard to subtidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Subtidal organisms can also be protected by reducing marine pollution.

21.1.3F

Mundy comments 29 Nov '95

DRAFT

Injury Status and Objectives ~~and Strategies~~ by Resource and Service

This section describes the nature and extent of injury and recovery and the recovery objective~~, and the restoration strategy~~ for each injured resource and service. Specific strategies to achieve recovery objectives are described in annual work plans and restoration project invitations (e.g., *Invitation to Submit Restoration Projects for Federal Fiscal 1997 and Draft Restoration Program: FY 97 and Beyond*). The information in this section is expected to change over time as the restoration program adapts to new information. For example, population decline or sublethal effects may be documented for new resources, some resources may begin to recover, and objectives and strategies may change in response to new conditions. Hypotheses for why resources are not recovering are particularly susceptible to change as prevailing hypotheses are tested and new ones are formed.

New scientific data will be incorporated into restoration decisions without the need to change the plan. However, changes will be reported in the Trustee Council's annual status report.

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION]

Archaeological Resources

Injury and Recovery

Twenty-four archaeological sites are known to have been adversely affected by cleanup activities, or looting and vandalism linked to the oil spill. Injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been disturbed, which has exposed sites to accelerated erosion. The effect of oil on soil chemistry and organic remains may reduce or eliminate the utility of radiocarbon dating in some sites.

Assessments of 14 sites in 1993 suggest that most of the archaeological vandalism that can be linked to the *Exxon Valdez* oil spill occurred in 1989 before adequate constraints were put into place over the activities of oil spill cleanup personnel. Most vandalism took the form of "prospecting" for high yield sites. In 1993, only two of the 14 sites visited showed signs of continued vandalism and the link between this recent vandalism and the *Exxon Valdez* oil spill remains highly problematical. Oil samples have not yet been analyzed, but oil was visible in the intertidal zones of two of the 14 sites. [NOTE TO REVIEWERS: IS THIS STILL TRUE?]

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data which remain in vandalized sites are preserved. Artifacts and data are typically preserved through excavation or other forms of documentation, or through site stabilization, depending on the nature of the injury and the characteristics of the site. [NOTE TO REVIEWERS: SHOULD WE ADD THE 1995 WORKSHOP RECOMMENDATION, WHICH WAS TO "RETURN ARTIFACTS TO THE SPILL AREA WHEN FACILITIES ARE ADEQUATE TO RECEIVE THEM."]

Restoration Strategy

Repair spill-related injury to archaeological sites and artifacts. Injuries may be repaired to some extent

through stabilizing eroding sites, or removing and restoring artifacts.

Protect sites and artifacts from further injury and store them in appropriate facilities. Archaeological sites and artifacts could be protected from further injury through the reduction of looting and vandalism, or the removal of artifacts from sites and storage in appropriate facilities. Opportunity for people to view or learn about the cultural heritage of people in the spill area would also provide protection by increasing awareness and appreciation of cultural heritage and would replace services lost as a result of irretrievable damage to some artifacts.

Monitor recovery. Monitor a small number of sites vulnerable to serious, commercial looting.

BALD EAGLES

Injury and Recovery

There are about __,000 bald eagles in Alaska, about _,000 of which breed in Prince William Sound and _,000 along the north Gulf of Alaska coast. ~~Two hundred to~~ An estimated 200-300 bald eagles died as a result of ~~may have been killed in~~ the spill, and productivity was reduced in oiled areas of Prince William Sound in 1989. Productivity was back to normal in 1990 and 1991, and an aerial survey of adults in 1995 indicated that the population has returned to its prespill level in Prince William Sound. ~~However, population estimates made in 1989, 1990, and 1991 indicate that there may have been an increase in the Prince William Sound bald eagle population since the previous survey conducted in 1984. Productivity decreased in 1989, but appeared to have recovered by 1990. Because population and productivity appear to have returned to prespill levels, bald eagles may have already recovered from the effects of the spill.~~

Recovery Objective

Because the Prince William Sound population and productivity are at or above prespill levels, the bald eagle has recovered from the effects of the Exxon Valdez oil spill. ~~Bald eagles will have recovered when their population and productivity return to prespill levels.~~

~~Restoration Strategy~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the population and productivity of bald eagles in Prince William Sound until full recovery is confirmed and perhaps at intervals thereafter. The eagle population in Prince William Sound is expected to increase to its prespill level in 1994. There are not enough prespill data on eagle populations in other parts of the spill area to warrant surveys outside Prince William Sound.~~

~~*Protect bald eagles and their habitat.* With regard to bald eagles, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance in feeding and roosting areas.~~

BLACK OYSTERCATCHERS

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. An estimated 2,000 oystercatchers lived in the oil-spill area prior to the spill, and up to 20 percent of these died as a result of the spill. In addition, breeding activities were disrupted and there was reduced growth and survival of young oystercatchers in Prince William Sound. Productivity, however, has not been monitored since 1993 [?], and the recovery status of the black oystercatcher is not known. ~~Within Prince William Sound, an estimated 120 to 150 black oystercatchers, representing 12-15 percent of the total estimated population, died as a result of the spill. Mortality outside of Prince William Sound is unknown. Black oystercatchers are recovering, although they may still be exposed to hydrocarbons when feeding in intertidal areas.~~

Recovery Objective

Black oystercatchers will have recovered when there is an increasing trend in the Prince William Sound population and ~~attain prespill levels and~~ when reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor population abundance and distribution and the growth rates of chicks.~~

~~*Protect black oystercatchers and their habitat.* With regard to black oystercatchers, the objective of habitat protection is to reduce disturbance to feeding and nesting sites.~~

CLAMS

Injury and Recovery

The magnitude of impacts on clam populations varies with the species of clam, degree of oiling, and location. However, data from the lower intertidal zone on shelted beaches suggest that little-neck clams and, to a lesser extent, butter clams ~~on sheltered beaches~~ were killed or suffered slower growth rates as a result of the oil spill ~~by oiling~~ and clean-up activities. ~~In addition, growth appeared to be reduced by oil, but determination of sublethal or chronic effects is awaiting final analyses.~~ In communities on the Kenai Peninsula, Kodiak, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

Recovery Objective

Based on prespill data or comparisons of oiled and unoiled sites, clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill ~~(prespill data or unoiled control sites)~~. [NOTE TO REVIEWERS: SHOULD RECOVERY OBJECTIVE MENTION SUBSISTENCE?]

~~**Restoration Strategy**~~

~~Clams are important for subsistence use and also serve as prey for sea otters and sea ducks such as harlequin ducks and pigeon guillemots. For additional restoration strategies, see *Subsistence, Sea Otters, Harlequin Ducks* and *Pigeon Guillemots.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the density and size of clams in select clam beds.~~

~~*Protect injured clam beds.* With regard to intertidal biota like clams, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Clams can also be protected by reducing marine pollution.~~

[NOTE TO REVIEWERS: I DIDN'T DO ANYTHING TO THE FOLLOWING SECTION.]

COMMERCIAL FISHING

Injury and Recovery

Commercial fishing was injured through injury to commercial fish species and also through fishing closures. Continuing injuries to commercial fishing may cause hardships for fishermen and related businesses. Each year that commercial fishing remains below prespill levels compounds the injury to the fishermen and, in many instances, the communities in which they live or work.

The Trustee Council recognizes the impact to communities and people of the Prince William Sound region resulting from the sharp decline in pink salmon and herring fisheries in past years. In 1994, the Trustee Council committed over six million dollars to help address these issues through the development of an ecosystem-based study for Prince William Sound. Some of the pink salmon and herring problems may be unrelated to the spill. However, the Council will continue to address these important problems.

Recovery Objective

Commercial fishing will have recovered when the population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions that would have existed had the spill not occurred. Because of the difficulty of separating spill-related effects from other changes in fish runs, the Trustee Council may use prespill conditions as a substitute measure for conditions that would have existed had the spill not occurred. [NOTE TO REVIEWERS: A POSSIBLE REVISION HERE WOULD BE TO DELETE THE ABOVE AND ADD THE FOLLOWING - "COMMERICIAL FISHING WILL HAVE RECOVERED WHEN THE FISH SPECIES THEY RELY ON HAVE RECOVERED FROM THE SPILL.]

Restoration Strategy

The primary method for restoring commercial fishing is to restore the species that are fished commercially, such as pink salmon, Pacific herring, and sockeye salmon. These species are discussed elsewhere in this chapter. Three additional parts of the strategy for restoring commercial fishing are the following:

Promote recovery of commercial fishing as soon as possible. Many communities that rely on commercial fishing will be significantly harmed while waiting for commercial fish resources to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of commercial fishing. This objective may be accomplished through increasing availability, reliability, or quality of commercial fish

resources, depending on the nature of the injury. For resources that have sharply declined since the spill, such as pink salmon, and Pacific herring in Prince William Sound, this objective may take the form of increasing availability in the long run through improved fisheries management. Another example is providing replacement fish for harvest.

Protect commercial fish resources from further degradation. Further stress on commercial fish resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if a resource faces loss of habitat. The Trustee Council can also contribute to the protection of commercial fish species by providing information needed to improve their management.

Monitor recovery. Monitoring the recovery of commercial fishing will track the progress of recovery, detect major reversals, and identify problems with the resources and resource management that may affect the rate or degree of recovery. Inadequate information may require managers to unduly restrict use of the injured resources, compounding the injury to commercial fishing.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. The population sizes are not known for any of these species, but, in general, loons are long-lived, slow-reproducing, and have small populations. Common loons in the oil-spill area may number only a few thousand, most of which are migrant and wintering birds. Neither the breeding areas of the birds affected by the spill nor their recovery status are known.

Recovery Objective

Common Loons will have recovered when numbers of migrant/wintering (March) birds in Prince William sound population have returned to prespill levels.

COMMON MURRES

Injury and Recovery

About 30,000 carcasses of oiled birds were picked up following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres died than were actually recovered, and it is estimated that the spill-area population declined by about 40 percent, including at colonies at Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay. In addition to direct losses of murres, there was evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Postspill monitoring of productivity at index colonies indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed in 1994 [check] and, at that time, had not returned to prespill levels.

~~Productivity of common murres shows signs of recovery at some injured colonies (Barren Islands, Puale Bay) but postspill population counts are still lower than prespill estimates and show no sign of recovery.~~

Recovery Objective

Common murres will have recovered when population trends are increasing significantly at index colonies and productivity is sustained within normal bounds. ~~in the spill area and when reproductive timing and success are (Normal bounds will be determined by comparing productivity data with information from other murre colonies in the Gulf of Alaska and elsewhere.)~~

~~**Restoration Strategy**~~

~~*Conduct research to find out why common murres are not recovering.* Suspected causes include avian predation and behavioral change which inhibits breeding productivity at some colonies.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why common murres are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor populations at index colonies such as the Chiswell Islands, Barren Islands, Triplets, Ungaiushak Island and Puale Bay. In addition, monitor the productivity of common murres at the Barren Islands.~~

~~*Protect common murres and their habitat.* With regard to common murres, the objective of habitat protection is to reduce disturbance in nearshore feeding areas and near nesting colonies.~~

CUTTHROAT TROUT

Injury and Recovery

Prince William Sound is at the northwestern limit of the range of cutthroat trout, and few stocks are known to exist within the sound. Local cutthroat populations rarely number more than 1,000 each, and the fish have small home ranges and are geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a small number of oiled index streams grew more slowly than in unoiled streams, possibly as a result of reduced food supplies or exposure to oil. The difference in growth rates persisted through 1991. No studies have been conducted since then, and the recovery status of this species is not known. ~~Cutthroat trout have grown more slowly in oiled areas than in unoiled areas. Insufficient data are available to determine whether they are recovering.~~

growth = survival

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are comparable to those for unoiled areas. This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.

geographic patterns in growth are not related to geographic distribution of oiling

~~**Restoration Strategy**~~

~~Cutthroat trout is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism*.~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect cutthroat trout and their habitat.* With regard to cutthroat trout, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning. The Trustee Council can also contribute to the protection of cutthroat trout by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION.]

DESIGNATED WILDERNESS AREAS

Injury and Recovery

The oil spill delivered oil in varying quantities to the waters adjoining the seven areas within the spill area designated as wilderness areas and wilderness study areas. Oil was also deposited above the mean high tide line in these areas. During the intense cleanup seasons of 1989 to 1990, thousands of workers and hundreds 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 Objective

Designated wilderness areas will have recovered when oil is no longer encountered in these areas and the public perceives them to be recovered from the spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas. No strategies have been identified that benefit only designated wilderness areas without also addressing injured resources.

DOLLY VARDEN

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden ~~have grown~~ grew more slowly in oiled streams ~~areas~~ than in unoiled streams ~~areas~~. However, no data have been gathered since 1991, and the recovery status of this species is not known. ~~Insufficient data are available to determine whether they are recovering.~~

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams ~~areas~~ are comparable to those ~~for~~ in unoiled streams ~~areas~~. This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.

after adjustment for geographic effects

~~Restoration Strategy~~

~~Dolly Varden is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect Dolly Varden and their habitat.* With regard to Dolly Varden, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Dolly Varden by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the spill. An estimated 300 seals died in the sound as a direct result of the spill, and this was 6-15 percent of the prespill population. Postspill surveys in 19__ showed that seals in ~~the~~ oiled areas had declined by 43 percent, compared to 11 percent in ~~the~~ unoiled areas. Unfortunately, seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill at an annual rate of about 6 percent. Possible factors for this long-term decline include disease and the amount or quality of food. ~~Counts made during the molt at trend count sites in Prince William Sound from 1990 to 1993 indicate that numbers may have stabilized. However, counts during pupping have continued to decline. It is not known which counts are the best indicator of population status. If the conditions that were causing the population to decline before the spill have improved, normal growth may replace the animals that were~~

lost. However, if conditions continue to be unfavorable, the affected population may continue to decline. Harbor seals are a key subsistence resource in the oil-spill area Prince William Sound. Subsistence hunting is both affected by the declining seal population and, in turn, may be affecting the recovery of harbor seals status.

Recovery Objective

Recovery will have occurred when harbor seal population trends are stable or increasing.

Restoration Strategy

Harbor seals are important for subsistence use. For additional restoration strategies, see *Subsistence.*

Conduct research to find out why harbor seals are not recovering. Suspected causes include limited or changing availability of prey, particularly forage fishes; predation by killer whales; and resource exploitation through subsistence take or incidental take associated with fisheries.

Initiate, sustain, or accelerate recovery of harbor seals. Once scientists determine why harbor seals are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor trends in Prince William Sound during pupping and molting for comparison with previous years' data.

Protect harbor seals and their habitat. With regard to harbor seals, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites, and in nearshore feeding areas. Another way of protecting harbor seals is to provide information that will help subsistence hunters assess the effects of their harvest.

HARLEQUIN DUCKS

Injury and Recovery

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound, and many more than that actually died. From 1990 [?]-1993, there was biochemical evidence of exposure to hydrocarbons in harlequins from oiled versus unoiled areas. Prespill data on harlequin populations and productivity are poor and complicated by possible geographic differences in habitat quality. However, the summer population in Prince William Sound is small, only a few thousand birds, and there continues to be concern about possible poor reproduction and a possible decline in numbers of molting birds in western Prince William Sound. [NOTE TO REVIEWERS: IS THE REFERENCE TO BIOCHEMICAL EVIDENCE STATED CORRECTLY?] There are indications of reduced densities of harlequin ducks in the breeding season; a declining trend in the summer, postbreeding population; and very poor production of young in western Prince William Sound.

Recovery Objective

Harlequin ducks will have recovered when the population in western Prince William Sound has a normal age- and sex-composition and evidence of reproductive success that is appropriate for the type and quality of breeding habitat. One indicator of recovery will be when there is no longer biochemical evidence of exposure to oil among harlequins in western Prince William Sound. [NOTE TO REVIEWERS: THIS IS NOT WORDED PARTICULARLY WELL, BUT IS THE CONCEPT ON THE RIGHT TRACK? ALSO, THE REFERENCE TO BIOCHEMICAL EVIDENCE ASSUMES THAT WE ARE GOING TO COLLECT SOME SPECIMENS.]] ~~breeding and postbreeding season densities and production of young return to estimated prespill levels, or when there are no differences in these parameters between oiled and unoiled areas.~~

~~**Restoration Strategy**~~

~~Harlequin ducks are hunted for subsistence and sport. For additional restoration strategies, see *Subsistence* and *Recreation and Tourism*.~~

~~*Conduct research to find out why harlequin ducks are not recovering.* Although the exact cause of reproductive failure among resident birds is unknown, it is believed to be related to ingestion of oil contaminated prey from foraging in oiled mussel beds.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why harlequin ducks are not recovering, efforts may be undertaken to accelerate recovery. If ingestion of oiled mussels is found to limit the recovery of harlequin ducks, cleaning oiled mussel beds may hasten recovery.~~

~~*Monitor recovery.* Monitor the breeding age population in Prince William Sound, as well as numbers of young, brood distribution, and abundance of postbreeding harlequins.~~

~~*Protect harlequin ducks and their habitat.* With regard to harlequin ducks, the objective of habitat protection is to ensure maintenance of adequate riparian habitat for nesting and brood rearing, and reduce disturbance to nearshore feeding, molting, brood rearing habitats. The Trustee Council can also contribute to the protection of harlequin ducks by providing information needed to improve their management. An example of protective management practices is the restriction on sport hunting of harlequin ducks imposed by the Alaska Board of Game in 1991.~~

INTERTIDAL ORGANISMS

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill, and both the oil and intensive clean-up activities had significant impacts on the flora and fauna of the intertidal zone, the area of beach between low and high tides. With tidal action, oil penetrated deeply into cobble and boulder beaches, and, even with intensive clean up activities, persists in some beaches today. The most significant impacts occurred in middle and upper intertidal zones on sheltered rocky shores, which is where the greatest amounts of oil were stranded.

Small invertebrates like limpets, barnacles, and marine worms were less abundant at oiled versus unoiled index sites in Prince William Sound, Kodiak Island, and on the Kenai and Alaska peninsula coasts. The size, coverage, and reproductive potential of seaweed *Fucus gardneri* (known as rockweed or popweed) also was reduced following the spill. Although many numbers of many species of invertebrate fauna have increased following the spill, recovery of *Fucus* in the upper intertidal zone is lagging. Full recovery of *Fucus* is crucial for recovery of the intertidal ecosystem, since many invertebrates depend on the cover provided by this seaweed. Many intertidal resources are important to subsistence users, as well as to sea and river otters, black oystercatchers, harlequin ducks, and pigeon guillemots.

~~The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult *Fucus* in large numbers.~~

Recovery Objective

~~Each intertidal elevation (lower, middle, or upper) will have recovered when community composition, population abundance of component species, age-class distribution, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~ Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as *Fucus*, and provision of adequate, clean food supplies for top predators in intertidal/nearshore habitats.

~~Restoration Strategy~~

~~*Conduct research to find out why some intertidal organisms are not recovering.* Possible explanations include changes in the community structure resulting from spill induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).~~

Initiate, sustain, or accelerate recovery. Once scientists determine why some intertidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor matched oiled and unoiled intertidal sites, incorporating a variety of habitat types.

Protect intertidal organisms and their habitat. With regard to intertidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Intertidal organisms can also be protected by reducing marine pollution.

KILLER WHALES

Injury and Recovery

About ___ killer whales in _ "resident" pods regularly use Prince William Sound. Other whales in "transient" pods enter the sound occasionally. The rate of natural mortality in killer whales is very low, about 2 percent in the north Pacific. There has been particular concern in Prince William Sound about the resident AB pod, which numbered 36 animals prior to the spill. Since the spill, this pod has lost at least 11 whales, including 6 in 1989-1990 and 5 more in 1994-1995. No births were recorded in this pod in 1989 and 1990, and the pod fractured into subgroups for _ years following the spill. These losses are only circumstantially linked to the oil spill, particularly since there also were unusual losses in the AB pod in 1988, preceding the spill. It is now unlikely that the AB pod will ever regain its former size, although overall numbers of resident and transient killer whales in Prince William Sound are at prespill or higher levels. Thirteen whales disappeared from one killer whale pod in Prince William Sound between 1988 and 1990. The injured pod is growing again. [NOTE TO REVIEWERS: THIS NEEDS CAREFUL FACT CHECKING, ESPECIALLY THE MENTION OF PRESPILL DECLINE IN AB POD AND THAT OVERALL NUMBERS OF WHALES ARE NOW AT PRESPILL OR HIGHER LEVELS.]

Recovery Objective

Overall, killer whales have recovered in Prince William Sound, although the AB pod has not returned to its prespill level of 36 whales. Since it is now unlikely that the AB pod will return to 36 whales, no additional recovery objective is identified. Killer whales will have recovered when the injured pod grows to at least 36 individuals (1988 level).

Restoration Strategy

Rely on natural recovery. Natural processes aided by protective measures will be the main agents of restoration.

~~*Monitor recovery.* Monitor the injured pod (AB pod) of killer whales in Prince William Sound.~~

~~Marbled~~ Murrelets, Marbled and Kittlitz's

Injury and Recovery

Prince William Sound and the northern Gulf of Alaska are key areas in the distributions of two poorly studied seabirds, marbled and Kittlitz's murrelets. The world population of Kittlitz's murrelet is believed to number only a few tens of thousands of birds, many of which are in the oil-spill area. The marbled murrelet is federally listed as a Threatened species in Washington, Oregon, and California; it is also listed as Threatened in British Columbia.

The Marbled murrelet populations in Prince William Sound was ~~were~~ in decline before the spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. The oil spill probably increased the prespill rate of decline for this species in the spill area, although the incremental injury is difficult to estimate. ~~The population of marbled murrelets may be stabilizing or even increasing since the spill.~~ Carcasses of nearly 1,100 murrelets were found after the spill, and it is estimated that as much as __ percent of the Prince William Sound marbled murrelet population was killed by the spill. Population estimates for murrelets are highly variable, and postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. The recovery status of Kittlitz's murrelet is not known.

Recovery Objective

Marbled murrelets will have recovered when population trends are stable or increasing. No recovery objective can be identified for Kittlitz's murrelet at this time.

~~Restoration Strategy~~

~~*Conduct research to find out why marbled murrelets are not recovering.* Likely causes include avian and mammalian predation, climatic/oceanographic features and prey limitation. Also of concern are the effects of resource exploitation (incidental gillnet catch) and upland development.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why marbled murrelets are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor the marbled murrelet population in Prince William Sound.~~

~~*Protect marbled murrelets and their habitat.* With regard to marbled murrelets, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.~~

MUSSELS

Injury and Recovery

Mussels are hardy creatures, and there were increased densities but decreased sizes of mussels in oiled areas following the oil spill. During clean-up operations, mussel beds were purposely left alone. In 1991, high concentrations of relatively unweathered oil were found in the mussels and underlying byssal mats in certain dense mussel beds. ~~In 1991, relatively high concentrations of oil were found in mussels and in the dense underlying mat (byssal substrate) of certain oiled mussel beds. The beds were not cleaned nor was oil removed after the spill. The~~ The biological significance of oiled mussel beds is not known, but they ~~Oiled mussel beds~~ are potential ~~local pathways of sources of fresh (unweathered)~~ oil contamination for harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which feed to some extent on mussels and show some signs of continuing injury. ~~The extent and magnitude of oiled mussel beds are unknown.~~ At least 70 [?] mussel beds in Prince William Sound are known to still have oil residue, and 12 beds were cleaned on an experimental basis in 199_. Subsistence users also continue to be concerned about contamination from oil mussel beds.

Recovery Objective

Mussels will have recovered when they do not contain concentrations of oil that are harmful to people or predators. [NOTE TO REVIEWERS: ALTERNATIVELY, THIS MIGHT MAKE REFERENCE TO "SIGNIFICANTLY ELEVATED LEVELS," RATHER THAN REFERENCE TO BIOLOGICAL SIGNIFICANCE.] ~~their populations and productivity are at prespill levels and they do not contain oil that contaminates higher trophic levels.~~

~~Restoration Strategy~~

~~*Initiate, sustain, or accelerate recovery.* Cleaning oiled mussel beds hastens their recovery and that of species that feed on them, such as harlequin ducks and juvenile sea otters.~~

~~*Monitor recovery.* Monitor the health of mussels and the concentration and degradation of oil in mussel beds identified as contaminated.~~

~~*Protect mussels and their habitat.* With regard to intertidal biota like mussels, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Mussels can also be protected by reducing marine pollution.~~

PACIFIC HERRING

Injury and Recovery

Pacific herring spawned in intertidal/subtidal habitats in Prince William Sound shortly after the oil spill. As much as 10 percent of the intertidal spawning habitat and 40 percent of the herring staging areas in the sound may have been contaminated by oil. Field studies conducted in 1989 and 1990 showed increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Laboratory studies confirm that these

effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries in the field at a population level is not known. In 1992, herring biomass in Prince William Sound was at a record level. In 1993, however, when herring spawned in 1989 should have returned in large numbers, there was an unprecedented crash in numbers of adult herring. A viral disease and fungus were the probable agents of mortality, but the connection to the oil spill is not proven. Numbers of spawning herring in Prince William Sound have remained depressed through the 1995 season. Pacific herring are extremely important ecologically as well as commercially, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound. Pacific herring studies have demonstrated egg mortality and larval deformities. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, the stocks and dependent fisheries in Prince William Sound are not healthy, as indicated by the low spawning biomass in 1993 and 1994 and the resultant elimination of the fisheries in those years.

Recovery Objective

Pacific herring will have recovered when the Prince William Sound population is at prespill levels (allowing for normal variation). A normal age structure, disease levels, and spawning biomass will be indicators of recovery. ~~Populations are healthy and productive and exist at prespill abundances.~~

~~**Restoration Strategy**~~

~~Pacific herring are important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why Pacific herring are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are disease, heritable genetic damage, oil toxicity, the impact of winter conditions on herring survival and reproductive success, and the advective transport of herring larvae from rearing areas in Prince William Sound.~~

~~*Initiate, sustain, or accelerate recovery of Pacific herring.* Once scientists determine why Pacific herring are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor fish health and spawning biomass.~~

~~*Protect Pacific herring and their habitat.* With regard to Pacific herring, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Pacific herring by providing information needed to improve their management. An example of protective management practices is the closure of the fishery by the Alaska Department of Fish and Game due to the failure of the herring run in Prince William Sound in 1993 and 1994.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

PASSIVE USE

Injury and Recovery

Passive use of resources includes 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. Injuries to passive uses are tied to public perceptions of injured resources.

Recovery Objective

Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of passive use values. No strategies have been identified that benefit only passive uses, without also addressing injured resources. Since recovery of passive uses requires that people know when recovery has occurred, the availability to the public of the latest scientific information will continue to play an important role in the restoration of passive uses.

PIGEON GUILLEMOT

Injury and Recovery

Although the pigeon guillemot is widely distributed, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, both they and the fish they prey on are vulnerable to oil pollution. Like the marbled murrelet, the pigeon guillemot population in Prince William Sound was in decline before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the Gulf of Alaska population may have died in the spill, and declines along oiled shorelines in Prince William Sound were greater than along unoiled shorelines. Numbers of guillemots recorded on boat surveys are highly variable, and there is not yet any statistically significant evidence of a postspill population increase. The factors responsible for the guillemot's prespill decline may negate or mask recovery from the effects of the oil spill.

Recovery Objective

Pigeon guillemots will have recovered when the populations ~~are~~ in Prince William Sound is stable or increasing.

~~Restoration Strategy~~

~~*Conduct research to find out why pigeon guillemots are not recovering.* Likely causes include climatic/oceanographic features, prey limitation, and predation.~~

Initiate, sustain, or accelerate recovery. Once scientists determine why pigeon guillemots are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor the pigeon guillemot population in Prince William Sound.

Protect pigeon guillemots and their habitat. With regard to pigeon guillemots, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.

PINK SALMON

Injury and Recovery

About 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams and were highly vulnerable to the effects of the oil spill. Hatchery salmon and wild salmon from both intertidal and upstream spawning habitats had to swim through oiled waters and ingest oil particles or oiled prey as they foraged in the sound and emigrated to sea. As a result, two types of early life-stage injuries were documented: First, growth rates in juvenile salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams. A third effect was ~~indicated by studies~~ also identified as a possible effect of oiling genetic damage

There is evidence that these two types of injury have resulted in reduced returns of adults from both wild and hatchery stocks (e.g., in 1990, 1992 and 1993 [1994?]). Returns of adult salmon are highly variable, however, and it is difficult to separate oil effects from those of other factors. ↳ So it is desirable to measure basic population indicators growth + survival to measure effects of oil

Injuries to salmon eggs and juveniles remain the best indicators of injury. Although evidence of reduced juvenile growth rates was limited to the 1989 season, increased egg mortality in oiled persisted through 1993, reaching a high of 40-50 percent in 1991. The 1994 and 1995 seasons were the first since 1989 in which there were no statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery is underway, but fisheries biologists continue to explore hypotheses concerning possible genetic damage and increases in straying rates as a result of the spill.

streams

~~Pink salmon studies have demonstrated egg mortality, fry deformities, and reduced growth in juveniles. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, there is evidence of continued damage in some stocks from exposure to oil, and there were unexpectedly poor runs of both wild and hatchery stocks of pink salmon in Prince William Sound in 1992 and 1993. In 1994, runs were still depressed but exceeded forecasts.~~

Recovery Objective

Pink salmon will have recovered when returns of wild adults are within the bounds of natural variation and there are no statistically significant differences in egg mortalities in oiled and unoiled streams for two years each of odd- and even-year runs in Prince William Sound. ~~populations are healthy and productive and exist at prespill abundance. An indication of recovery is when egg mortalities in oiled areas match prespill levels or levels in unoiled areas.~~

population indicators growth, survival

~~**Restoration Strategy**~~

~~Pink salmon is important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing*.~~

~~*Conduct research to find out why pink salmon are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are heritable genetic damage and oil toxicity.~~

~~*Initiate, sustain, or accelerate recovery of pink salmon.* Once scientists determine why pink salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor egg mortality, escapement, and return per spawner productivity.~~

~~*Protect pink salmon and their habitat.* With regard to pink salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of pink salmon by providing information needed to improve their management. An example of protective management practices is restriction of the fishery by the Alaska Department of Fish and Game due to poor returns of pink salmon to Prince William Sound in 1992 and 1993.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

RECREATION AND TOURISM

Injury and Recovery

The spill disrupted use of the spill area for recreation and tourism. Resources important for wildlife viewing include killer whale, sea otter, harbor seal, bald eagle, and various seabirds. Residual oil exists on some beaches with high value for recreation and may decrease the quality of recreational experiences and discourage recreational use of these beaches.

Closures on sport hunting and fishing also affected use of the spill area for recreation and tourism. Sport fishing resources include salmon, rockfish, Dolly Varden, and cutthroat trout. Harlequin ducks are hunted in the spill area.

Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas increased management problems and facility use in unoiled areas. Some facilities, such as the Green Island cabin and the Fleming Spit camp area, were injured by cleanup workers.

Recovery Objective

Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, recreation use of oiled beaches is no longer impaired, and facilities and management capabilities can accommodate changes in human use.

Restoration Strategy

Preserve or improve the recreational and tourism values of the spill area. Habitat protection and acquisition are important means of preserving and enhancing the opportunities offered by the spill area. Facilities damaged during cleanup may be repaired if they are still needed. New facilities may restore or enhance opportunities for recreational use of natural resources. Improved or intensified public recreation management may be warranted in some circumstances. Projects that restore or enhance recreation and tourism would be considered only if they are consistent with the character and public uses of the area. However, all projects to preserve and improve recreation and tourism values must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removal of residual oil from beaches with high value for recreation and tourism may restore these services for some users. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Monitor recovery. Monitor the recovery of resources used for recreation and tourism. Also monitor changes in recreation and tourism in the spill area.

RIVER OTTERS

Injury and Recovery

River otters have a low density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve otter carcasses were found following the spill. Studies conducted during 1989-1991 identified several differences between otters in oiled and unoiled areas in Prince William Sound, including biochemical evidence of exposure to hydrocarbons or other sources of stress, reduced diversity in prey species, reduced body size (length-weight), and increased territory size. However, sample sizes were small, and it is not clear that these differences are the result of the oil spill. The Nearshore Vertebrate Predator project, now underway, will shed new light on the status of the river otters. In 1995 the Alaska Board of Game

used its emergency authority to restrict trapping of river otters in western Prince William Sound to ensure that the results of this study are not compromised by the removal of animals from study areas on Montague and Knight islands. [NOTE TO REVIEWERS: IS THE REFERENCE TO BIOCHEMICAL EVIDENCE OF EXPOSURE STATED CORRECTLY?] ~~River otters in Prince William Sound have suffered sublethal effects from the spill and may continue to be exposed to hydrocarbons.~~

Recovery Objective

The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound. ~~Indications of recovery are when habitat use, food habitats and physiological indices have returned to prespill conditions.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the health and habitat use of river otters in Prince William Sound.~~

~~*Protect river otters and their habitat.* With regard to river otters, the objective of habitat protection is to ensure maintenance of adequate riparian and shoreline habitats for feeding and denning.~~

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. Dead adult rockfish were recovered following the oil spill, and chemical analysis of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure ~~were exposed~~ to hydrocarbons and ~~showed~~ sublethal effects. ~~Furthermore~~ In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have affected ~~be affecting their~~ the rockfish population. However, the original extent ~~and mechanism~~ of injury and the current status of ~~to~~ this species are unknown.

Recovery Objective

Without further study, a recovery objective cannot be defined.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

Determine if restoration is needed. Synthesize Natural Resource Damage Assessment studies and other data on rockfish in Prince William Sound to define a restoration objective and develop strategies to monitor and protect the recovery of the species.

Monitor recovery. Once a recovery objective is defined, monitor the progress of natural recovery toward that objective.

SEA OTTERS

Injury and Recovery

Surveys of sea otters in the 1970s and 1980s indicate that the population was expanding and about 10,000 animals lived in Prince William Sound prior to the spill. Based on the number of carcasses and other data, population models suggest that 3,500-5,500 otters died in the first few months following the spill. In 1990 and 1991, unusual numbers of prime-age adult otters were found dead and there was evidence of an increased death rate in recently weaned juveniles. By 1992-93, mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of Prince William Sound. Boat surveys conducted in March and July in 1993 and again in 1994 indicated a Prince William Sound of about 7,700 otters, but there was no statistically significant evidence of a population increase following the spill (1990-1994). The Nearshore Vertebrate Predator project, which is expected to be completed in 199_, should greatly clarify the recovery status of the sea otter in Prince William Sound. Sea otters do not appear to be recovering, but are expected to eventually recover to their prespill population. Exactly what population increases would constitute recovery is very uncertain, as there are no population data from 1986 to 1989, and the population may have been increasing in Eastern Prince William Sound during that time. In addition, only large changes in the population can be reliably detected with current measuring techniques. However, there are recent indications that the patterns of juvenile and mid-aged mortalities are returning to prespill conditions.

Recovery Objective

Sea otters will have recovered when the Prince William Sound population returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in oiled parts of the sound will indicate that recovery is underway. Sea otters will be considered recovered when population abundance and distribution are comparable to prespill abundance and distribution, and when all ages appear healthy.

Restoration Strategy

Sea otters are harvested for subsistence. For additional restoration strategies, see *Subsistence.*

~~*Conduct research to find out why sea otters are not recovering.* One hypothesis is that exposure to hydrocarbons and ingestion of contaminated prey affected survival and reproductive success of sea otters in Prince William Sound. Another hypothesis is that the oil spill induced changes in the population of benthic prey species that have limited reoccupation of sea otter habitat and the recovery of sea otters in oiled areas.~~

~~*Initiate, sustain, or accelerate recovery of sea otters.* Once scientists determine why sea otters are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor abundance and mortality of sea otters in oiled areas.~~

~~*Protect sea otters and their habitats.* With regard to sea otters, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites and in nearshore feeding areas.~~

SEDIMENTS

Injury and Recovery

With tidal action, oil penetrated deeply into cobble and boulder beaches that are ~~relatively~~ common on ~~the rocky islands of~~ shorelines throughout the spill area, especially in sheltered habitats. Cleaning removed much of the oil from the intertidal zone but subsurface oil persisted in many heavily oiled beaches and associated subtidal sediments. ~~in mussel beds, which were avoided during the cleanup.~~ Subsurface oil persists at least at ___ locations in Prince William Sound and as far away as the Alaska Peninsula. While much of this oil is probably not biologically active, it is of great concern to residents in oil-spill communities, and there are sites where sheening still occurs.

Following the oil spill, chemical analyses of oil in sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in sediments reached its greatest concentrations at depths of 20 meters, although elevated levels of hydrocarbon-degrading bacteria (associated with elevated hydrocarbons) were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. ~~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.~~ By 1993, however, there was little evidence of *Exxon Valdez* oil and related microbial activity at most index sites in Prince William Sound, except at those associated with sheltered beaches that were heavily oiled in 1989. These index sites--at Herring, Northwest, and Sleepy bays--were among the ___ at which subsurface oiling is known to occur (see above).

Recovery Objective

Sediments will have recovered when ~~contamination causes no negative effects to the spill ecosystem~~ residues of subsurface oil at sheltered sites that were previously heavily oiled are declining or are biologically harmless. [NOTE TO REVIEWERS: THIS IS NOT VERY SATISFYING, BUT THIS IS A TOUGH ONE.]

~~**Restoration Strategy**~~

~~*Monitor recovery.* Monitor concentrations of hydrocarbons in sediments and indices of petroleum exposure in flatfish.~~

~~*Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place.* Removal of residual oil may accelerate recovery of sediment where natural recovery is insufficient. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.~~

SOCKEYE SALMON

Injury and Recovery

Commericial fishing was closed in portions of Cook Inlet and in Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-usual returns (overescapement) of spawning fish to the Kenai River, Red and Akalura lakes on Kodiak Island, and lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that consumed huge quantities of zooplankton, thus destroying planktonic food webs in the nursery lakes. ~~Whatever the mechanism,~~ the result was ~~reduced outmigration of smolts and, ultimately, returns of adults.~~ Lost sockeye production as shown by declines in the ~~[redacted]~~ fishery returns ~~per spawner~~ for each spawner in the escapement.

The effects of the 1989 overescapement have persisted in the Kenai River system through 1995. Although the overall escapement goal for that system was exceeded in 1995, there is concern that the initial overescapement will continue to affect post-spill year-classes and that sockeye returns are yet not sufficient to fulfill the commericial, recreational, and subsistence demands on sockeye salmon in the Kenai River system. [NOTE TO REVIEWERS: THE ABOVE NEEDS WORK, INCLUDING AN UPDATE ON THE STATUS IN RED/AKALURA LAKES.]

~~Sockeye salmon in Red Lake, Akalura Lake, and lakes in the Kenai River system declined in population because of adult overescapement in 1989. The Red Lake system may be recovering because the plankton has recovered and fry survival improved in 1993. However, Akalura Lake and the Kenai River lakes have not recovered: smolt production has continued to decline from these lakes. In the Kenai River lakes, for example, smolt production has declined from 30 million in 1989 to 6 million in 1990 and to less than 1 million in 1992 and 1993.~~

(fisheries have a lot to do with meeting esc goals)

Recovery Objective

Sockeye salmon in the Kenai River system and Red and Akalura lakes will have recovered when ~~overall escapement goals are met and~~ returns-per-spawner are within normal bounds. ~~affected lakes will have recovered when populations are able to support overwinter survival rates and smolt outmigrations comparable to prespill levels.~~

~~**Restoration Strategy**~~

~~Sockeye salmon is important for subsistence use, commercial fishing, and sport fishing. For additional restoration strategies, see *Subsistence, Commercial Fishing* and *Recreation and Tourism.*~~

~~*Rely on natural recovery for sockeye salmon in Red Lake.* Natural processes aided by protective measures will be the main agents of restoration for sockeye salmon in Red Lake. This population of sockeye salmon is expected to fully recover by 1996.~~

~~*Conduct research to find out why other populations of sockeye salmon are not recovering.* The most likely explanation is that overescapement of adults changed the community structure of sockeye lake rearing habitat. Possible changes in community structure include a reduction in zooplankton biomass; conversion of the zooplankton community structure to a predation resistant form; or a change in composition of zooplankton that demands increased foraging time for juvenile salmon and thereby makes them susceptible to increased predation.~~

~~*Initiate, sustain, or accelerate recovery of sockeye salmon.* Once scientists determine why sockeye salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor outmigrations of smolt from Red Lake and Akalura Lake. In Kenai River lakes, monitor fall fry abundance and smolt abundance to estimate overwinter survival and smolt production.~~

~~*Protect sockeye salmon and their habitats.* With regard to sockeye salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of sockeye salmon by providing information needed to improve their management.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

SUBSISTENCE

Injury and Recovery

Subsistence users say that maintaining their subsistence culture depends on uninterrupted use of resources used for subsistence. The more time users spend away from subsistence activities, the less likely they will return to the activities. Continuing injury to natural resources used for subsistence may affect the way of life of entire communities.

Residual oil exists on some beaches with high value for subsistence. Continued presence of hydrocarbons may contaminate resources used for subsistence or, at a minimum, create uncertainty about the safety of resources. Uncertainty about the safety of resources may reduce their use and value for subsistence.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels, and when people are confident that the resources are safe to eat. One indication that recovery has occurred is when the cultural values provided by gathering, preparing, and sharing food are reintegrated into community life.

Restoration Strategy

The primary way of restoring subsistence is to restore injured resources used for subsistence, such as clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. These are discussed elsewhere in this chapter. Four additional parts of the strategy to restore subsistence are the following:

Promote recovery of subsistence as soon as possible. Many subsistence communities will be significantly harmed while waiting for resources used for subsistence to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of subsistence use. This objective may be accomplished through increasing availability, reliability, or quality of resources used for subsistence, or increasing the confidence of subsistence users. Specifically, if subsistence harvest has not returned to prespill levels because users doubt the safety of particular resources, this objective may take the form of increasing the reliability of the resource through food safety testing. Other examples are the acquisition of alternative food sources and improved use of existing resources. However, all projects to promote subsistence must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removing residual oil from beaches with high value for subsistence may improve the safety of foods found on these beaches. This benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Protect subsistence resources from further degradation. Further stress on subsistence resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if important subsistence areas are threatened. Protective action could also include protective management practices if a resource or service faces further injury from human use or marine pollution.

Monitor recovery. Monitor the recovery of resources used for subsistence. Also monitor subsistence harvest.

SUBTIDAL ORGANISMS

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the size and species composition of plant and animal populations below lower tide levels. Different habitats, including eelgrass beds, kelp beds, and deep water, were compared at oiled and unoiled sites. The greatest effects were detected at oiled sites with sandy sea bottoms under eelgrass beds, at which there were reduced numbers and diversity of helmet crabs, amphipods, and other crustaceans and mollusks. There were sublethal effects on the eelgrass itself. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic, stress tolerant species, such as *Musculus* mussels, a variety of polychaetes, and juvenile cod, increased in numbers at oiled sites. Differences in oiled and unoiled sites were less evident by 1993.

In 1989, divers in parts of heavily oiled Herring Bay found numerous dead organisms on the bottom at depths greater than 11 meters. Far fewer organisms were found in the same locations in 1990 and 1991. More systematic studies of organisms in deep waters (40, 100, and greater than 100 meters) in 14 bays in Prince William Sound showed no obvious effects 16 months after the spill. This is probably because the current speed within Prince William Sound was sufficient to flush out toxic fractions of the oil before there was injury to deep-water fauna.

[NOTE TO REVIEWERS: ANY RESULTS MORE RECENT THAN 1993?]

~~Certain subtidal organisms, like eelgrass and some species of algae, appear to be recovering. Other subtidal organisms, like leather stars and helmet crabs, showed little signs of recovery through 1991.~~

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as _____, and reductions in the presence of opportunistic species, such as _____.

~~Subtidal communities will have recovered when the community composition, age class distribution, population abundance of component species, and ecosystem functions and services in each injured subtidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~

Restoration Strategy

Conduct research to find out why some subtidal organisms are not recovering. Possible explanations include changes in the community structure resulting from spill-induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).

Initiate, sustain, or accelerate recovery. Once scientists determine why some subtidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor subtidal organisms in Prince William Sound.

Protect subtidal organisms and their habitats. With regard to subtidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Subtidal organisms can also be protected by reducing marine pollution.

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DRAFT

Injury Status and Objectives ~~and Strategies~~ by Resource and Service

This section describes the nature and extent of injury and recovery and the recovery objective~~, and the restoration strategy~~ for each injured resource and service. Specific strategies to achieve recovery objectives are described in annual work plans and restoration project invitations (e.g., *Invitation to Submit Restoration Projects for Federal Fiscal 1997 and Draft Restoration Program: FY 97 and Beyond*). The information in this section is expected to change over time as the restoration program adapts to new information. For example, population decline or sublethal effects may be documented for new resources, some resources may begin to recover, and objectives and strategies may change in response to new conditions. Hypotheses for why resources are not recovering are particularly susceptible to change as prevailing hypotheses are tested and new ones are formed.

New scientific data will be incorporated into restoration decisions without the need to change the plan. However, changes will be reported in the Trustee Council's annual status report.

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION]

Archaeological Resources

Injury and Recovery

Twenty-four archaeological sites are known to have been adversely affected by cleanup activities, or looting and vandalism linked to the oil spill. Injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been disturbed, which has exposed sites to accelerated erosion. The effect of oil on soil chemistry and organic remains may reduce or eliminate the utility of radiocarbon dating in some sites.

Assessments of 14 sites in 1993 suggest that most of the archaeological vandalism that can be linked to the *Exxon Valdez* oil spill occurred in 1989 before adequate constraints were put into place over the activities of oil spill cleanup personnel. Most vandalism took the form of "prospecting" for high yield sites. In 1993, only two of the 14 sites visited showed signs of continued vandalism and the link between this recent vandalism and the *Exxon Valdez* oil spill remains highly problematical. Oil samples have not yet been analyzed, but oil was visible in the intertidal zones of two of the 14 sites. [NOTE TO REVIEWERS: IS THIS STILL TRUE?]

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data which remain in vandalized sites are preserved. Artifacts and data are typically preserved through excavation or other forms of documentation, or through site stabilization, depending on the nature of the injury and the characteristics of the site. [NOTE TO REVIEWERS: SHOULD WE ADD THE 1995 WORKSHOP RECOMMENDATION, WHICH WAS TO "RETURN ARTIFACTS TO THE SPILL AREA WHEN FACILITIES ARE ADEQUATE TO RECEIVE THEM."]

Restoration Strategy

Repair spill-related injury to archaeological sites and artifacts. Injuries may be repaired to some extent

through stabilizing eroding sites, or removing and restoring artifacts.

Protect sites and artifacts from further injury and store them in appropriate facilities. Archaeological sites and artifacts could be protected from further injury through the reduction of looting and vandalism, or the removal of artifacts from sites and storage in appropriate facilities. Opportunity for people to view or learn about the cultural heritage of people in the spill area would also provide protection by increasing awareness and appreciation of cultural heritage and would replace services lost as a result of irretrievable damage to some artifacts.

Monitor recovery. Monitor a small number of sites vulnerable to serious, commercial looting.

BALD EAGLES

Injury and Recovery

There are about __,000 bald eagles in Alaska, about _,000 of which breed in Prince William Sound and _,000 along the north Gulf of Alaska coast. ~~Two hundred to~~ An estimated 200-300 bald eagles died as a result of ~~may have been killed in~~ the spill, and productivity was reduced in oiled areas of Prince William Sound in 1989. Productivity was back to normal in 1990 and 1991, and an aerial survey of adults in 1995 indicated that the population has returned to its prespill level in Prince William Sound. ~~However, population estimates made in 1989, 1990, and 1991 indicate that there may have been an increase in the Prince William Sound bald eagle population since the previous survey conducted in 1984. Productivity decreased in 1989, but appeared to have recovered by 1990. Because population and productivity appear to have returned to prespill levels, bald eagles may have already recovered from the effects of the spill.~~

excellent ?

Recovery Objective

Because the Prince William Sound population and productivity are at or above prespill levels, the bald eagle has recovered from the effects of the Exxon Valdez oil spill. ~~Bald eagles will have recovered when their population and productivity return to prespill levels.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the population and productivity of bald eagles in Prince William Sound until full recovery is confirmed and perhaps at intervals thereafter. The eagle population in Prince William Sound is expected to increase to its prespill level in 1994. There are not enough prespill data on eagle populations in other parts of the spill area to warrant surveys outside Prince William Sound.~~

~~*Protect bald eagles and their habitat.* With regard to bald eagles, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance in feeding and roosting areas.~~

BLACK OYSTERCATCHERS

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. An estimated 2,000 oystercatchers lived in the oil-spill area prior to the spill, and up to 20 percent of these died as a result of the spill. In addition, breeding activities were disrupted and there was reduced growth and survival of young oystercatchers in Prince William Sound. Productivity, however, has not been monitored since 1993 [?], and the recovery status of the black oystercatcher is not known. ~~Within Prince William Sound, an estimated 120 to 150 black oystercatchers, representing 12-15 percent of the total estimated population, died as a result of the spill. Mortality outside of Prince William Sound is unknown. Black oystercatchers are recovering, although they may still be exposed to hydrocarbons when feeding in intertidal areas.~~

emphasis on sublethal - less so on numbers

indication of recovery

Recovery Objective

Black oystercatchers will have recovered when there is an increasing trend in the Prince William Sound population ~~and attain prespill levels and~~ when reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor population abundance and distribution and the growth rates of chicks.~~

~~*Protect black oystercatchers and their habitat.* With regard to black oystercatchers, the objective of habitat protection is to reduce disturbance to feeding and nesting sites.~~

CLAMS

Injury and Recovery

The magnitude of impacts on clam populations varies with the species of clam, degree of oiling, and location. However, data from the lower intertidal zone on shelted beaches suggest that little neck clams and, to a lesser extent, butter clams ~~on sheltered beaches~~ were killed or suffered slower growth rates as a result of the oil spill ~~by oiling~~ and clean-up activities. ~~In addition, growth appeared to be reduced by oil, but determination of sublethal or chronic effects is awaiting final analyses.~~ In communities on the Kenai Peninsula, Kodiak, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

Recovery Objective

Based on prespill data or comparisons of oiled and unoiled sites, clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill ~~(prespill data or unoiled control sites)~~. [NOTE TO REVIEWERS: SHOULD RECOVERY OBJECTIVE MENTION SUBSISTENCE?]

~~**Restoration Strategy**~~

~~Clams are important for subsistence use and also serve as prey for sea otters and sea ducks such as harlequin ducks and pigeon guillemots. For additional restoration strategies, see *Subsistence, Sea Otters, Harlequin Ducks* and *Pigeon Guillemots.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the density and size of clams in select clam beds.~~

~~*Protect injured clam beds.* With regard to intertidal biota like clams, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Clams can also be protected by reducing marine pollution.~~

[NOTE TO REVIEWERS: I DIDN'T DO ANYTHING TO THE FOLLOWING SECTION.]

COMMERCIAL FISHING

Injury and Recovery

Commercial fishing was injured through injury to commercial fish species and also through fishing closures. Continuing injuries to commercial fishing may cause hardships for fishermen and related businesses. Each year that commercial fishing remains below prespill levels compounds the injury to the fishermen and, in many instances, the communities in which they live or work.

The Trustee Council recognizes the impact to communities and people of the Prince William Sound region resulting from the sharp decline in pink salmon and herring fisheries in past years. In 1994, the Trustee Council committed over six million dollars to help address these issues through the development of an ecosystem-based study for Prince William Sound. Some of the pink salmon and herring problems may be unrelated to the spill. However, the Council will continue to address these important problems.

Recovery Objective

Commercial fishing will have recovered when the population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions that would have existed had the spill not occurred. Because of the difficulty of separating spill-related effects from other changes in fish runs, the Trustee Council may use prespill conditions as a substitute measure for conditions that would have existed had the spill not occurred. [NOTE TO REVIEWERS: A POSSIBLE REVISION HERE WOULD BE TO DELETE THE ABOVE AND ADD THE FOLLOWING - "COMMERICIAL FISHING WILL HAVE RECOVERED WHEN THE FISH SPECIES THEY RELY ON HAVE RECOVERED FROM THE SPILL.]

Restoration Strategy

The primary method for restoring commercial fishing is to restore the species that are fished commercially, such as pink salmon, Pacific herring, and sockeye salmon. These species are discussed elsewhere in this chapter. Three additional parts of the strategy for restoring commercial fishing are the following:

Promote recovery of commercial fishing as soon as possible. Many communities that rely on commercial fishing will be significantly harmed while waiting for commercial fish resources to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of commercial fishing. This objective may be accomplished through increasing availability, reliability, or quality of commercial fish

resources, depending on the nature of the injury. For resources that have sharply declined since the spill, such as pink salmon, and Pacific herring in Prince William Sound, this objective may take the form of increasing availability in the long run through improved fisheries management. Another example is providing replacement fish for harvest.

Protect commercial fish resources from further degradation. Further stress on commercial fish resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if a resource faces loss of habitat. The Trustee Council can also contribute to the protection of commercial fish species by providing information needed to improve their management.

Monitor recovery. Monitoring the recovery of commercial fishing will track the progress of recovery, detect major reversals, and identify problems with the resources and resource management that may affect the rate or degree of recovery. Inadequate information may require managers to unduly restrict use of the injured resources, compounding the injury to commercial fishing.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. The population sizes are not known for any of these species, but, in general, loons are long-lived, slow-reproducing, and have small populations. Common loons in the oil-spill area may number only a few thousand, most of which are migrant and wintering birds. Neither the breeding areas of the birds affected by the spill nor their recovery status are known.

Recovery Objective

Common Loons will have recovered when numbers of migrant/wintering (March) birds in Prince William sound population have returned to prespill levels.

COMMON MURRES

Injury and Recovery

About 30,000 carcasses of oiled birds were picked up following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres died than were actually recovered, and it is estimated that the spill-area population declined by about 40 percent, including at colonies at Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay. In addition to direct losses of murres, there was evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Postspill monitoring of productivity at index colonies indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed in 1994 [check] and, at that time, had not returned to prespill levels.

~~Productivity of common murres shows signs of recovery at some injured colonies (Barren Islands, Puale Bay) but postspill population counts are still lower than prespill estimates and show no sign of recovery.~~

Recovery Objective

Common murres will have recovered when population trends are increasing significantly at index colonies indicated by and productivity is sustained within normal bounds. ~~in the spill area and when reproductive timing and success are (Normal bounds will be determined by comparing productivity data with information from other murre colonies in the Gulf of Alaska and elsewhere.)~~

~~**Restoration Strategy**~~

~~*Conduct research to find out why common murres are not recovering.* Suspected causes include avian predation and behavioral change which inhibits breeding productivity at some colonies.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why common murres are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor populations at index colonies such as the Chiswell Islands, Barren Islands, Triplets, Ungaiushak Island and Puale Bay. In addition, monitor the productivity of common murres at the Barren Islands.~~

~~*Protect common murres and their habitat.* With regard to common murres, the objective of habitat protection is to reduce disturbance in nearshore feeding areas and near nesting colonies.~~

CUTTHROAT TROUT

Injury and Recovery

Suggestions of mechanisms

Prince William Sound is at the northwestern limit of the range of cutthroat trout, and few stocks are known to exist within the sound. Local cutthroat populations rarely number more than 1,000 each, and the fish have small home ranges and are geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a small number of oiled index streams grew more slowly than in unoiled streams, possibly as a result of reduced food supplies or exposure to oil. The difference in growth rates persisted through 1991. No studies have been conducted since then, and the recovery status of this species is not known. ~~Cutthroat trout have grown more slowly in oiled areas than in unoiled areas. Insufficient data are available to determine whether they are recovering.~~

growth related to survival

Geographic patterns in growth are not related to geographic pattern of oil

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are comparable to those for unoiled areas. This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.

after adjusting for geographic effects

~~**Restoration Strategy**~~

~~Cutthroat trout is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect cutthroat trout and their habitat.* With regard to cutthroat trout, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning. The Trustee Council can also contribute to the protection of cutthroat trout by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THE FOLLOWING SECTION.]

DESIGNATED WILDERNESS AREAS

Injury and Recovery

The oil spill delivered oil in varying quantities to the waters adjoining the seven areas within the spill area designated as wilderness areas and wilderness study areas. Oil was also deposited above the mean high tide line in these areas. During the intense cleanup seasons of 1989 to 1990, thousands of workers and hundreds 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 Objective

Designated wilderness areas will have recovered when oil is no longer encountered in these areas and the public perceives them to be recovered from the spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas. No strategies have been identified that benefit only designated wilderness areas without also addressing injured resources.

pick up from cutthroat

DOLLY VARDEN

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden ~~have grown~~ grew more slowly in oiled streams ~~areas~~ than in unoiled streams ~~areas~~. However, no data have been gathered since 1991, and the recovery status of this species is not known. ~~Insufficient data are available to determine whether they are recovering.~~

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams ~~areas~~ are comparable to those ~~for~~ in unoiled streams ~~areas~~. This objective will be changed if new information should indicate that the documented differences in growth rates were not related to the oil spill.

after adjusting for geographic effects

~~Restoration Strategy~~

~~Dolly Varden is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect Dolly Varden and their habitat.* With regard to Dolly Varden, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Dolly Varden by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the spill. An estimated 300 seals died in the sound as a direct result of the spill, and this was 6-15 percent of the prespill population. Postspill surveys in 19__ showed that seals in ~~the~~ oiled areas had declined by 43 percent, compared to 11 percent in ~~the~~ unoiled areas. Unfortunately, seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill at an annual rate of about 6 percent. Possible factors for this long-term decline include disease and the amount or quality of food. ~~Counts made during the molt at trend count sites in Prince William Sound from 1990 to 1993 indicate that numbers may have stabilized. However, counts during pupping have continued to decline. It is not known which counts are the best indicator of population status. If the conditions that were causing the population to decline before the spill have improved, normal growth may replace the animals that were~~

lost. However, if conditions continue to be unfavorable, the affected population may continue to decline. Harbor seals are a key subsistence resource in the oil spill area Prince William Sound. Subsistence hunting is both affected by the declining seal population and, in turn, may be affecting the recovery of harbor seals status.

Recovery Objective

Recovery will have occurred when harbor seal population trends are stable or increasing.

Restoration Strategy

Harbor seals are important for subsistence use. For additional restoration strategies, see *Subsistence.*

Conduct research to find out why harbor seals are not recovering. Suspected causes include limited or changing availability of prey, particularly forage fishes; predation by killer whales; and resource exploitation through subsistence take or incidental take associated with fisheries.

Initiate, sustain, or accelerate recovery of harbor seals. Once scientists determine why harbor seals are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor trends in Prince William Sound during pupping and molting for comparison with previous years' data.

Protect harbor seals and their habitat. With regard to harbor seals, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites, and in nearshore feeding areas. Another way of protecting harbor seals is to provide information that will help subsistence hunters assess the effects of their harvest.

HARLEQUIN DUCKS

Injury and Recovery

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound, and many more than that actually died. From 1990 [?]-1993, there was biochemical evidence of exposure to hydrocarbons in harlequins from oiled versus unoiled areas. Prespill data on harlequin populations and productivity are poor and complicated by possible geographic differences in habitat quality. However, the summer population in Prince William Sound is small, only a few thousand birds, and there continues to be concern about possible poor reproduction and a possible decline in numbers of molting birds in western Prince William Sound. [NOTE TO REVIEWERS: IS THE REFERENCE TO BIOCHEMICAL EVIDENCE STATED CORRECTLY?] There are indications of reduced densities of harlequin ducks in the breeding season; a declining trend in the summer, postbreeding population; and very poor production of young in western Prince William Sound.

indications

Recovery Objective

Harlequin ducks will have recovered when the population in western Prince William Sound has a normal age- and sex-composition and evidence of reproductive success that is appropriate for the type and quality of breeding habitat. One indicator of recovery will be when there is no longer biochemical evidence of exposure to oil among harlequins in western Prince William Sound. [NOTE TO REVIEWERS: THIS IS NOT WORDED PARTICULARLY WELL, BUT IS THE CONCEPT ON THE RIGHT TRACK? ALSO, THE REFERENCE TO BIOCHEMICAL EVIDENCE ASSUMES THAT WE ARE GOING TO COLLECT SOME SPECIMENS.]] ~~breeding and postbreeding season densities and production of young return to estimated prespill levels, or when there are no differences in these parameters between oiled and unoiled areas.~~

~~**Restoration Strategy**~~

~~Harlequin ducks are hunted for subsistence and sport. For additional restoration strategies, see *Subsistence* and *Recreation and Tourism*.~~

~~*Conduct research to find out why harlequin ducks are not recovering.* Although the exact cause of reproductive failure among resident birds is unknown, it is believed to be related to ingestion of oil-contaminated prey from foraging in oiled mussel beds.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why harlequin ducks are not recovering, efforts may be undertaken to accelerate recovery. If ingestion of oiled mussels is found to limit the recovery of harlequin ducks, cleaning oiled mussel beds may hasten recovery.~~

~~*Monitor recovery.* Monitor the breeding age population in Prince William Sound, as well as numbers of young, brood distribution, and abundance of postbreeding harlequins.~~

~~*Protect harlequin ducks and their habitat.* With regard to harlequin ducks, the objective of habitat protection is to ensure maintenance of adequate riparian habitat for nesting and brood-rearing, and reduce disturbance to nearshore feeding, molting, brood-rearing habitats. The Trustee Council can also contribute to the protection of harlequin ducks by providing information needed to improve their management. An example of protective management practices is the restriction on sport hunting of harlequin ducks imposed by the Alaska Board of Game in 1991.~~

INTERTIDAL ORGANISMS

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill, and both the oil and intensive clean-up activities had significant impacts on the flora and fauna of the intertidal zone, the area of beach between low and high tides. With tidal action, oil penetrated deeply into cobble and boulder beaches, and, even with intensive clean up activities, persists in some beaches today. The most significant impacts occurred in middle and upper intertidal zones on sheltered rocky shores, which is where the greatest amounts of oil were stranded.

Small invertebrates like limpets, barnacles, and marine worms were less abundant at oiled versus unoiled index sites in Prince William Sound, Kodiak Island, and on the Kenai and Alaska peninsula coasts. The size, coverage, and reproductive potential of seaweed *Fucus gardneri* (known as rockweed or popweed) also was reduced following the spill. Although many numbers of many species of invertebrate fauna have increased following the spill, recovery of *Fucus* in the upper intertidal zone is lagging. Full recovery of *Fucus* is crucial for recovery of the intertidal ecosystem, since many invertebrates depend on the cover provided by this seaweed. Many intertidal resources are important to subsistence users, as well as to sea and river otters, black oystercatchers, harlequin ducks, and pigeon guillemots.

~~The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult *Fucus* in large numbers.~~

Recovery Objective

~~Each intertidal elevation (lower, middle, or upper) will have recovered when community composition, population abundance of component species, age-class distribution, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~ Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as *Fucus*, and provision of adequate, clean food supplies for top predators in intertidal/nearshore habitats.

~~Restoration Strategy~~

~~*Conduct research to find out why some intertidal organisms are not recovering.* Possible explanations include changes in the community structure resulting from spill induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why some intertidal organisms are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor matched oiled and unoiled intertidal sites, incorporating a variety of habitat types.~~

~~*Protect intertidal organisms and their habitat.* With regard to intertidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Intertidal organisms can also be protected by reducing marine pollution.~~

KILLER WHALES

Injury and Recovery

About ___ killer whales in _ "resident" pods regularly use Prince William Sound. Other whales in "transient" pods enter the sound occasionally. The rate of natural mortality in killer whales is very low, about 2 percent in the north Pacific. There has been particular concern in Prince William Sound about the resident AB pod, which numbered 36 animals prior to the spill. Since the spill, this pod has lost at least 11 whales, including 6 in 1989-1990 and 5 more in 1994-1995. No births were recorded in this pod in 1989 and 1990, and the pod fractured into subgroups for _ years following the spill. These losses are only circumstantially linked to the oil spill, particularly since there also were unusual losses in the AB pod in 1988, preceding the spill. It is now unlikely that the AB pod will ever regain its former size, although overall numbers of resident and transient killer whales in Prince William Sound are at prespill or higher levels. ~~Thirteen whales disappeared from one killer whale pod in Prince William Sound between 1988 and 1990. The injured pod is growing again.~~ [NOTE TO REVIEWERS: THIS NEEDS CAREFUL FACT CHECKING, ESPECIALLY THE MENTION OF PRESPILL DECLINE IN AB POD AND THAT OVERALL NUMBERS OF WHALES ARE NOW AT PRESPILL OR HIGHER LEVELS.]

Recovery Objective

Overall, killer whales have recovered in Prince William Sound, although the AB pod has not returned to its prespill level of 36 whales. Since it is now unlikely that the AB pod will return to 36 whales, no additional recovery objective is identified. ~~Killer whales will have recovered when the injured pod grows to at least 36 individuals (1988 level).~~

~~Restoration Strategy~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

Monitor recovery. Monitor the injured pod (AB pod) of killer whales in Prince William Sound.

MARBLED MURRELETS, MARBLED AND KITTLITZ'S

Injury and Recovery

Prince William Sound and the northern Gulf of Alaska are key areas in the distributions of two poorly studied seabirds, marbled and Kittlitz's murrelets. The world population of Kittlitz's murrelet is believed to number only a few tens of thousands of birds, many of which are in the oil-spill area. The marbled murrelet is federally listed as a Threatened species in Washington, Oregon, and California; it is also listed as Threatened in British Columbia.

The Marbled murrelet populations in Prince William Sound was were in decline before the spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. The oil spill probably increased the prespill rate of decline for this species in the spill area, although the incremental injury is difficult to estimate. The population of marbled murrelets may be stabilizing or even increasing since the spill. Carcasses of nearly 1,100 murrelets were found after the spill, and it is estimated that as much as __ percent of the Prince William Sound marbled murrelet population was killed by the spill. Population estimates for murrelets are highly variable, and postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. The recovery status of Kittlitz's murrelet is not known.

Recovery Objective

Marbled murrelets will have recovered when population trends are stable or increasing. No recovery objective can be identified for Kittlitz's murrelet at this time.

Restoration Strategy

Conduct research to find out why marbled murrelets are not recovering. Likely causes include avian and mammalian predation, climatic/oceanographic features and prey limitation. Also of concern are the effects of resource exploitation (incidental gillnet catch) and upland development.

Initiate, sustain, or accelerate recovery. Once scientists determine why marbled murrelets are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor the marbled murrelet population in Prince William Sound.

Protect marbled murrelets and their habitat. With regard to marbled murrelets, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.

MUSSELS

focus on contamination

Injury and Recovery

Mussels are hardy creatures, and there were increased densities but decreased sizes of mussels in oiled areas following the oil spill. During clean-up operations, mussel beds were purposely left alone. In 1991, high concentrations of relatively unweathered oil were found in the mussels and underlying byssal mats in certain dense mussel beds. ~~In 1991, relatively high concentrations of oil were found in mussels and in the dense underlying mat (byssal substrate) of certain oiled mussel beds. The beds were not cleaned nor was oil removed after the spill. The~~ The biological significance of oiled mussel beds is not known, but they ~~Oiled mussel beds~~ are potential local pathways of ~~sources of fresh (unweathered)~~ oil contamination for harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which feed to some extent on mussels and show some signs of continuing injury. ~~The extent and magnitude of oiled mussel beds are unknown.~~ At least 70 [?] mussel beds in Prince William Sound are known to still have oil residue, and 12 beds were cleaned on an experimental basis in 199_. Subsistence users also continue to be concerned about contamination from oil mussel beds.

contaminate their predators

Recovery Objective

Mussels will have recovered when they do not contain concentrations of oil that are harmful to people or predators. [NOTE TO REVIEWERS: ALTERNATIVELY, THIS MIGHT MAKE REFERENCE TO "SIGNIFICANTLY ELEVATED LEVELS," RATHER THAN REFERENCE TO BIOLOGICAL SIGNIFICANCE.] ~~their populations and productivity are at prespill levels and they do not contain oil that contaminates higher trophic levels.~~

~~Restoration Strategy~~

~~*Initiate, sustain, or accelerate recovery.* Cleaning oiled mussel beds hastens their recovery and that of species that feed on them, such as harlequin ducks and juvenile sea otters.~~

~~*Monitor recovery.* Monitor the health of mussels and the concentration and degradation of oil in mussel beds identified as contaminated.~~

~~*Protect mussels and their habitat.* With regard to intertidal biota like mussels, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Mussels can also be protected by reducing marine pollution.~~

PACIFIC HERRING

Injury and Recovery

Pacific herring spawned in intertidal/subtidal habitats in Prince William Sound shortly after the oil spill. As much as 10 percent of the intertidal spawning habitat and 40 percent of the herring staging areas in the sound may have been contaminated by oil. Field studies conducted in 1989 and 1990 showed increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Laboratory studies confirm that these

under investigation

effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries in the field at a population level is not known. In 1992, herring biomass in Prince William Sound was at a record level. In 1993, however, when herring spawned in 1989 should have returned in large numbers, there was an unprecedented crash in numbers of adult herring. A viral disease and fungus were the probable agents of mortality, but the connection to the oil spill is not proven. Numbers of spawning herring in Prince William Sound have remained depressed through the 1995 season. Pacific herring are extremely important ecologically as well as commercially, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound. ~~Pacific herring studies have demonstrated egg mortality and larval deformities. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, the stocks and dependent fisheries in Prince William Sound are not healthy, as indicated by the low spawning biomass in 1993 and 1994 and the resultant elimination of the fisheries in those years.~~

indicators are growth + reproduction recruitment

Recovery Objective

Pacific herring will have recovered when the Prince William Sound population is at prespill levels (allowing for normal variation). A normal age structure, disease levels, and spawning biomass will be indicators of recovery. ~~populations are healthy and productive and exist at prespill abundances.~~

~~**Restoration Strategy**~~

~~Pacific herring are important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why Pacific herring are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are disease, heritable genetic damage, oil toxicity, the impact of winter conditions on herring survival and reproductive success, and the advective transport of herring larvae from rearing areas in Prince William Sound.~~

~~*Initiate, sustain, or accelerate recovery of Pacific herring.* Once scientists determine why Pacific herring are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor fish health and spawning biomass.~~

~~*Protect Pacific herring and their habitat.* With regard to Pacific herring, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Pacific herring by providing information needed to improve their management. An example of protective management practices is the closure of the fishery by the Alaska Department of Fish and Game due to the failure of the herring run in Prince William Sound in 1993 and 1994.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

PASSIVE USE

Injury and Recovery

Passive use of resources includes 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. Injuries to passive uses are tied to public perceptions of injured resources.

Recovery Objective

Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

Restoration Strategy

Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of passive use values. No strategies have been identified that benefit only passive uses, without also addressing injured resources. Since recovery of passive uses requires that people know when recovery has occurred, the availability to the public of the latest scientific information will continue to play an important role in the restoration of passive uses.

PIGEON GUILLEMOT

Injury and Recovery

Although the pigeon guillemot is widely distributed, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, both they and the fish they prey on are vulnerable to oil pollution. Like the marbled murrelet, the pigeon guillemot population in Prince William Sound was in decline before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the Gulf of Alaska population may have died in the spill, and declines along oiled shorelines in Prince William Sound were greater than along unoiled shorelines. Numbers of guillemots recorded on boat surveys are highly variable, and there is not yet any statistically significant evidence of a postspill population increase. The factors responsible for the guillemot's prespill decline may negate or mask recovery from the effects of the oil spill.

Recovery Objective

Pigeon guillemots will have recovered when the populations ~~in Prince William Sound is~~ ~~are~~ stable or increasing.

~~Restoration Strategy~~

~~*Conduct research to find out why pigeon guillemots are not recovering.* Likely causes include climatic/oceanographic features, prey limitation, and predation.~~

Initiate, sustain, or accelerate recovery. Once scientists determine why pigeon guillemots are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor the pigeon guillemot population in Prince William Sound.

Protect pigeon guillemots and their habitat. With regard to pigeon guillemots, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.

PINK SALMON

Injury and Recovery

About 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams and were highly vulnerable to the effects of the oil spill. Hatchery salmon and wild salmon from both intertidal and upstream spawning habitats had to swim through oiled waters and ingest oil particles or oiled prey as they foraged in the sound and emigrated to sea. As a result, two types of early life-stage injuries were documented: First, growth rates in juvenile salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams.

There is evidence that these two types of injury have resulted in reduced returns of adults from both wild and hatchery stocks (e.g., in 1990, 1992 and 1993 [1994?]). Returns of adult salmon are highly variable, however, and it is difficult to separate oil effects from those of other factors.

Injuries to salmon eggs and juveniles remain the best indicators of injury. Although evidence of reduced juvenile growth rates was limited to the 1989 season, increased egg mortality in oiled persisted through 1993, reaching a high of 40-50 percent in 1991. The 1994 and 1995 seasons were the first since 1989 in which there were no statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery is underway, but fisheries biologists continue to explore hypotheses concerning possible genetic damage and increases in straying rates as a result of the spill.

~~Pink salmon studies have demonstrated egg mortality, fry deformities, and reduced growth in juveniles. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, there is evidence of continued damage in some stocks from exposure to oil, and there were unexpectedly poor runs of both wild and hatchery stocks of pink salmon in Prince William Sound in 1992 and 1993. In 1994, runs were still depressed but exceeded forecasts.~~

population indicators, such as adjusted

population indicators, such as ... are normal,

Recovery Objective

Pink salmon will have recovered ~~when returns of wild adults are within the bounds of~~ natural variation and there are no statistically significant differences in egg mortalities in oiled and unoiled streams for two years each of odd- and even-year runs in Prince William Sound. ~~populations are healthy and productive and exist at prespill abundance. An indication of recovery is when egg mortalities in oiled areas match prespill levels or levels in unoiled areas.~~

~~**Restoration Strategy**~~

~~Pink salmon is important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why pink salmon are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are heritable genetic damage and oil toxicity.~~

~~*Initiate, sustain, or accelerate recovery of pink salmon.* Once scientists determine why pink salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor egg mortality, escapement, and return per spawner productivity.~~

~~*Protect pink salmon and their habitat.* With regard to pink salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of pink salmon by providing information needed to improve their management. An example of protective management practices is restriction of the fishery by the Alaska Department of Fish and Game due to poor returns of pink salmon to Prince William Sound in 1992 and 1993.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

RECREATION AND TOURISM

Injury and Recovery

The spill disrupted use of the spill area for recreation and tourism. Resources important for wildlife viewing include killer whale, sea otter, harbor seal, bald eagle, and various seabirds. Residual oil exists on some beaches with high value for recreation and may decrease the quality of recreational experiences and discourage recreational use of these beaches.

Closures on sport hunting and fishing also affected use of the spill area for recreation and tourism. Sport fishing resources include salmon, rockfish, Dolly Varden, and cutthroat trout. Harlequin ducks are hunted in the spill area.

Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas increased management problems and facility use in unoiled areas. Some facilities, such as the Green Island cabin and the Fleming Spit camp area, were injured by cleanup workers.

Recovery Objective

Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, recreation use of oiled beaches is no longer impaired, and facilities and management capabilities can accommodate changes in human use.

Restoration Strategy

Preserve or improve the recreational and tourism values of the spill area. Habitat protection and acquisition are important means of preserving and enhancing the opportunities offered by the spill area. Facilities damaged during cleanup may be repaired if they are still needed. New facilities may restore or enhance opportunities for recreational use of natural resources. Improved or intensified public recreation management may be warranted in some circumstances. Projects that restore or enhance recreation and tourism would be considered only if they are consistent with the character and public uses of the area. However, all projects to preserve and improve recreation and tourism values must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removal of residual oil from beaches with high value for recreation and tourism may restore these services for some users. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Monitor recovery. Monitor the recovery of resources used for recreation and tourism. Also monitor changes in recreation and tourism in the spill area.

RIVER OTTERS

Injury and Recovery

River otters have a low density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve otter carcasses were found following the spill. Studies conducted during 1989-1991 identified several differences between otters in oiled and unoiled areas in Prince William Sound, including biochemical evidence of exposure to hydrocarbons or other sources of stress, reduced diversity in prey species, reduced body size (length-weight), and increased territory size. However, sample sizes were small, and it is not clear that these differences are the result of the oil spill. The Nearshore Vertebrate Predator project, now underway, will shed new light on the status of the river otters. In 1995 the Alaska Board of Game

used its emergency authority to restrict trapping of river otters in western Prince William Sound to ensure that the results of this study are not compromised by the removal of animals from study areas on Montague and Knight islands. [NOTE TO REVIEWERS: IS THE REFERENCE TO BIOCHEMICAL EVIDENCE OF EXPOSURE STATED CORRECTLY?] ~~River otters in Prince William Sound have suffered sublethal effects from the spill and may continue to be exposed to hydrocarbons.~~

Recovery Objective

The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound. ~~Indications of recovery are when habitat use, food habitats and physiological indices have returned to prespill conditions.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the health and habitat use of river otters in Prince William Sound.~~

~~*Protect river otters and their habitat.* With regard to river otters, the objective of habitat protection is to ensure maintenance of adequate riparian and shoreline habitats for feeding and denning.~~

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. Dead adult rockfish were recovered following the oil spill, and chemical analysis of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure ~~were exposed~~ to hydrocarbons and ~~showed~~ sublethal effects. ~~Furthermore~~ In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have affected ~~be affecting their~~ the rockfish population. However, the original extent ~~and mechanism~~ of injury and the current status of ~~to~~ this species are unknown.

Recovery Objective

Without further study, a recovery objective cannot be defined.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

Determine if restoration is needed. Synthesize Natural Resource Damage Assessment studies and other data on rockfish in Prince William Sound to define a restoration objective and develop strategies to monitor and protect the recovery of the species.

Monitor recovery. Once a recovery objective is defined, monitor the progress of natural recovery toward that objective.

SEA OTTERS

Injury and Recovery

Surveys of sea otters in the 1970s and 1980s indicate that the population was expanding and about 10,000 animals lived in Prince William Sound prior to the spill. Based on the number of carcasses and other data, population models suggest that 3,500-5,500 otters died in the first few months following the spill. In 1990 and 1991, unusual numbers of prime-age adult otters were found dead and there was evidence of an increased death rate in recently weaned juveniles. By 1992-93, mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of Prince William Sound. Boat surveys conducted in March and July in 1993 and again in 1994 indicated a Prince William Sound of about 7,700 otters, but there was no statistically significant evidence of a population increase following the spill (1990-1994). The Nearshore Vertebrate Predator project, which is expected to be completed in 199_, should greatly clarify the recovery status of the sea otter in Prince William Sound. Sea otters do not appear to be recovering, but are expected to eventually recover to their prespill population. Exactly what population increases would constitute recovery is very uncertain, as there are no population data from 1986 to 1989, and the population may have been increasing in Eastern Prince William Sound during that time. In addition, only large changes in the population can be reliably detected with current measuring techniques. However, there are recent indications that the patterns of juvenile and mid-aged mortalities are returning to prespill conditions.

Recovery Objective

Sea otters will have recovered when the Prince William Sound population returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in oiled parts of the sound will indicate that recovery is underway. Sea otters will be considered recovered when population abundance and distribution are comparable to prespill abundance and distribution, and when all ages appear healthy.

Restoration Strategy

Sea otters are harvested for subsistence. For additional restoration strategies, see *Subsistence.*

Conduct research to find out why sea otters are not recovering. One hypothesis is that exposure to hydrocarbons and ingestion of contaminated prey affected survival and reproductive success of sea otters in Prince William Sound. Another hypothesis is that the oil spill induced changes in the population of benthic prey species that have limited reoccupation of sea otter habitat and the recovery of sea otters in oiled areas.

Initiate, sustain, or accelerate recovery of sea otters. Once scientists determine why sea otters are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor abundance and mortality of sea otters in oiled areas.

Protect sea otters and their habitats. With regard to sea otters, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites and in nearshore feeding areas.

SEDIMENTS

Injury and Recovery

With tidal action, oil penetrated deeply into cobble and boulder beaches that are relatively common on the rocky islands of shorelines throughout the spill area, especially in sheltered habitats. Cleaning removed much of the oil from the intertidal zone but subsurface oil persisted in many heavily oiled beaches and associated subtidal sediments. in mussel beds, which were avoided during the cleanup. Subsurface oil persists at least at ___ locations in Prince William Sound and as far away as the Alaska Peninsula. While much of this oil is probably not biologically active, it is of great concern to residents in oil-spill communities, and there are sites where sheening still occurs.

Following the oil spill, chemical analyses of oil in sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in sediments reached its greatest concentrations at depths of 20 meters, although elevated levels of hydrocarbon-degrading bacteria (associated with elevated hydrocarbons) were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. 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. By 1993, however, there was little evidence of *Exxon Valdez* oil and related microbial activity at most index sites in Prince William Sound, except at those associated with sheltered beaches that were heavily oiled in 1989. These index sites--at Herring, Northwest, and Sleepy bays--were among the ___ at which subsurface oiling is known to occur (see above).

Recovery Objective

Sediments will have recovered when ~~contamination causes no negative effects to the spill ecosystem~~ residues of subsurface oil at sheltered sites that were previously heavily oiled are declining or are biologically harmless. [NOTE TO REVIEWERS: THIS IS NOT VERY SATISFYING, BUT THIS IS A TOUGH ONE.]

~~**Restoration Strategy**~~

~~*Monitor recovery.* Monitor concentrations of hydrocarbons in sediments and indices of petroleum exposure in flatfish.~~

~~*Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place.* Removal of residual oil may accelerate recovery of sediment where natural recovery is insufficient. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.~~

SOCKEYE SALMON

Injury and Recovery

Commericial fishing was closed in portions of Cook Inlet and in Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-usual returns (overescapement) of spawning fish to the Kenai River, Red and Akalura lakes on Kodiak Island, and lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that consumed huge quantities of zooplankton, thus destroying planktonic food webs in the nursery lakes. Whatever the mechanism, the result was reduced outmigration of smolts and, ultimately, returns of adults.

The effects of the 1989 overescapement have persisted in the Kenai River system through 1995. Although the overall escapement goal for that system was exceeded in 1995, there is concern that the initial overescapement will continue to affect post-spill year-classes and that sockeye returns are yet not sufficient to fulfill the commericial, recreational, and subsistence demands on sockeye salmon in the Kenai River system. [NOTE TO REVIEWERS: THE ABOVE NEEDS WORK, INCLUDING AN UPDATE ON THE STATUS IN RED/AKALURA LAKES.]

~~Sockeye salmon in Red Lake, Akalura Lake, and lakes in the Kenai River system declined in population because of adult overescapement in 1989. The Red Lake system may be recovering because the plankton has recovered and fry survival improved in 1993. However, Akalura Lake and the Kenai River lakes have not recovered: smolt production has continued to decline from these lakes. In the Kenai River lakes, for example, smolt production has declined from 30 million in 1989 to 6 million in 1990 and to less than 1 million in 1992 and 1993.~~

Recovery Objective

Sockeye salmon in the Kenai River system and Red and Akalura lakes will have recovered when overall escapement goals are met and returns-per-spawner are within normal bounds. ~~affected lakes will have recovered when populations are able to support overwinter survival rates and smolt outmigrations comparable to prespill levels.~~

~~**Restoration Strategy**~~

~~Sockeye salmon is important for subsistence use, commercial fishing, and sport fishing. For additional restoration strategies, see *Subsistence, Commercial Fishing* and *Recreation and Tourism.*~~

~~*Rely on natural recovery for sockeye salmon in Red Lake.* Natural processes aided by protective measures will be the main agents of restoration for sockeye salmon in Red Lake. This population of sockeye salmon is expected to fully recover by 1996.~~

~~*Conduct research to find out why other populations of sockeye salmon are not recovering.* The most likely explanation is that overescapement of adults changed the community structure of sockeye lake rearing habitat. Possible changes in community structure include a reduction in zooplankton biomass; conversion of the zooplankton community structure to a predation resistant form; or a change in composition of zooplankton that demands increased foraging time for juvenile salmon and thereby makes them susceptible to increased predation.~~

~~*Initiate, sustain, or accelerate recovery of sockeye salmon.* Once scientists determine why sockeye salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor outmigrations of smolt from Red Lake and Akalura Lake. In Kenai River lakes, monitor fall fry abundance and smolt abundance to estimate overwinter survival and smolt production.~~

~~*Protect sockeye salmon and their habitats.* With regard to sockeye salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of sockeye salmon by providing information needed to improve their management.~~

[NOTE TO REVIEWERS: I DIDN'T TOUCH THIS SECTION.]

SUBSISTENCE

Injury and Recovery

Subsistence users say that maintaining their subsistence culture depends on uninterrupted use of resources used for subsistence. The more time users spend away from subsistence activities, the less likely they will return to the activities. Continuing injury to natural resources used for subsistence may affect the way of life of entire communities.

Residual oil exists on some beaches with high value for subsistence. Continued presence of hydrocarbons may contaminate resources used for subsistence or, at a minimum, create uncertainty about the safety of resources. Uncertainty about the safety of resources may reduce their use and value for subsistence.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels, and when people are confident that the resources are safe to eat. One indication that recovery has occurred is when the cultural values provided by gathering, preparing, and sharing food are reintegrated into community life.

Restoration Strategy

The primary way of restoring subsistence is to restore injured resources used for subsistence, such as clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. These are discussed elsewhere in this chapter. Four additional parts of the strategy to restore subsistence are the following:

Promote recovery of subsistence as soon as possible. Many subsistence communities will be significantly harmed while waiting for resources used for subsistence to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of subsistence use. This objective may be accomplished through increasing availability, reliability, or quality of resources used for subsistence, or increasing the confidence of subsistence users. Specifically, if subsistence harvest has not returned to prespill levels because users doubt the safety of particular resources, this objective may take the form of increasing the reliability of the resource through food safety testing. Other examples are the acquisition of alternative food sources and improved use of existing resources. However, all projects to promote subsistence must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removing residual oil from beaches with high value for subsistence may improve the safety of foods found on these beaches. This benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Protect subsistence resources from further degradation. Further stress on subsistence resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if important subsistence areas are threatened. Protective action could also include protective management practices if a resource or service faces further injury from human use or marine pollution.

Monitor recovery. Monitor the recovery of resources used for subsistence. Also monitor subsistence harvest.

SUBTIDAL ORGANISMS

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the size and species composition of plant and animal populations below lower tide levels. Different habitats, including eelgrass beds, kelp beds, and deep water, were compared at oiled and unoiled sites. The greatest effects were detected at oiled sites with sandy sea bottoms under eelgrass beds, at which there were reduced numbers and diversity of helmet crabs, amphipods, and other crustaceans and mollusks. There were sublethal effects on the eelgrass itself. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic, stress-tolerant species, such as *Musculus* mussels, a variety of polychaetes, and juvenile cod, increased in numbers at oiled sites. Differences in oiled and unoiled sites were less evident by 1993.

In 1989, divers in parts of heavily oiled Herring Bay found numerous dead organisms on the bottom at depths greater than 11 meters. Far fewer organisms were found in the same locations in 1990 and 1991. More systematic studies of organisms in deep waters (40, 100, and greater than 100 meters) in 14 bays in Prince William Sound showed no obvious effects 16 months after the spill. This is probably because the current speed within Prince William Sound was sufficient to flush out toxic fractions of the oil before there was injury to deep-water fauna.

[NOTE TO REVIEWERS: ANY RESULTS MORE RECENT THAN 1993?]

~~Certain subtidal organisms, like eelgrass and some species of algae, appear to be recovering. Other subtidal organisms, like leather stars and helmet crabs, showed little signs of recovery through 1991.~~

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as _____, and reductions in the presence of opportunistic species, such as _____.

~~Subtidal communities will have recovered when the community composition, age class distribution, population abundance of component species, and ecosystem functions and services in each injured subtidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~

Restoration Strategy

Conduct research to find out why some subtidal organisms are not recovering. Possible explanations include changes in the community structure resulting from spill-induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).

Initiate, sustain, or accelerate recovery. Once scientists determine why some subtidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor subtidal organisms in Prince William Sound.

Protect subtidal organisms and their habitats. With regard to subtidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Subtidal organisms can also be protected by reducing marine pollution.

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Note: This version has deletions in strike out and additions with background.

21 Dec '95
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Chapter 5
~~Goals, Objectives, and Strategies~~ Injury Status and Recovery Objectives

~~This chapter presents goals, objectives, and strategies for restoration.~~ The first part of this chapter discusses ~~goals,~~ recovery objectives~~, and strategies~~ in general. The second part describes the nature and extent of injury and recovery and ~~the~~ recovery objective~~, and the restoration strategy~~ for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives~~, and strategies~~ can be found on the following pages:

~~Overview~~

~~The first part of this chapter discusses goals, objectives, and strategies in general. A goal is the end toward which an endeavor is directed; objectives are descriptions of measurable outcomes; and strategies are plans of action. Taken together, goals, objectives, and strategies produce a blueprint for restoring the spill area. To be funded, a project must be consistent with the goals and policies of the Restoration Plan and with restoration objectives and strategies as they change over time.~~

~~**GOAL:** *The end toward which restoration is directed*~~

~~The goal of restoration is recovery of all injured resources and services. Recovery is to be sustained by healthy, productive ecosystems that maintain naturally occurring biodiversity. All restoration actions must be directed toward this goal.~~

OBJECTIVES: *Measurable outcomes of restoration*

The objectives of the restoration program are measurable conditions that signal the recovery of individual resources or services. They are the yardsticks against which the success of the program is measured.

In general, resources and services will have recovered when they return to conditions that would have existed had the spill not occurred. In nature, however, populations often undergo large natural changes. ~~Because~~ It is difficult to predict conditions that would have existed in the absence of the spill, and so recovery is ~~often~~ defined as a return to prespill conditions or to a level that falls within the bounds of natural variation. For resources that were in decline before the spill, like harbor seals ~~marbled murrelets~~, recovery may be achieved ~~consist of stabilizing the~~ when a population is stabilized, even if at a lower level than before the spill. For some resources, little is known about their injury and recovery status, so it is difficult to define recovery.

Where few ~~little~~ prespill data exist, injury is inferred from comparison of oiled and unoiled areas, and recovery is usually defined as a return to conditions comparable to those of unoiled areas. Because the differences between oiled and unoiled areas may have existed before the spill, statements of injury and objectives based on these differences are often less certain than in those cases where prespill data exist. Alternatively, injury may be evaluated based on the number of oiled carcasses picked up following the spill relative to the estimated size of the spill-area population. Even in cases where some prespill data are available, ~~However,~~ there also is ~~can be some~~ uncertainty associated with interpreting the significance of prespill population data since populations undergo natural fluctuations. In all cases, indicators of recovery can include increased numbers of individuals, reproductive success, improved growth and survival rates, and normal age and sex composition of the injured population.

Full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, are healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not occurred. A recovered ecosystem provides the same functions and services as would have been provided had the spill not occurred.

[NOTE: SINCE WE ARE ELIMINATING THE DISCUSSION OF RESTORATION STRATEGIES UNDER EACH RESOURCE OR SERVICE, WE MAY BE ABLE TO ELIMINATE THIS HERE. IF WE WANT TO KEEP IT IN SOME FORM, IT NEEDS QUITE A LOT OF WORK. FOR EXAMPLE, IT COULD BE REORGANIZED TO DISCUSS WHY WE MONITOR, DO RESEARCH, ETC. WE NOT NEED TO MAKE AN IMMEDIATE DECISION, BUT SOONER RATHER THAN LATER.]

STRATEGIES: *Plans of action*

A restoration strategy is a plan of action for achieving objectives. Each year, through its annual or multiyear work plan, the Trustee Council decides which strategies to implement. Restoration strategies reflect consideration of ecosystem relationships. For example, the strategy for some injured resources includes research into why they are not recovering, such as declining or contaminated food sources or disruption of ecosystem relationships.

In this section, restoration strategies are presented under three headings: Biological Resources, Other Resources, and Services.

Biological Resources

Because restoration strategies for biological resources depend on whether the resource is recovering a resource's recovery status, strategies are subdivided into those for recovered resources, recovering resources, resources that are not recovering, and resources whose recovery for which the recovery status is unknown.

Recovered Resources. In general, once a resource has recovered, the Trustee Council no longer has a direct role with respect to that resource. The on-going management of recovered resources is the job of the state or federal agency to which such responsibilities have been assigned by law or regulation. Sustaining the health of recovered resources, however, will continue to receive consideration as the Trustee Council evaluates opportunities for habitat protection and acquisition and undertakes other measures to protect, restore, and enhance [?] the marine ecosystem in the oil spill area. [NOTE TO REVIEWERS: I AM NOT ENTIRELY HAPPY WITH THIS PARAGRAPH, BUT IT GIVES US SOMETHING TO THINK ABOUT. IDEALLY, THIS WOULD BE THE PLACE TO INTRODUCE THE "E" WORD I.E., ENHANCEMENT BUT THAT MAY OR MAY NOT BE POLITICALLY CORRECT.]

Recovering Resources. The fact that a resource is recovering suggests that nature will restore it without intervention, Consequently, and restoration of recovering resources will rely primarily on natural recovery.

Because these resources are If a resource is recovering, research into factors limiting recovery and general restoration projects to accelerate recovery may not be warranted. However, research that will lead to improved resource management and research on the health and recovery of the ecosystem in which that resource lives may be appropriate.

However Additionally, if a resource is not expected to recover fully on its own or if waiting for natural recovery will cause long-term harm to a community or service, appropriate alternative means of restoration would could be undertaken. Habitat protection and monitoring are

encouraged, as are general restoration projects that protect the resource from other sources of potential injury. (Restoration strategies under "Services" also apply to these resources.)

The restoration strategy for recovering resources has three four parts:

- Rely on natural recovery
- Monitor recovery
- Protect injured resources and their habitats
- Conduct limited research to benefit management and ecosystem recovery

Resources Not Recovering. Except for certain protective measures, attempts to restore these resources without knowing why they are not recovering may be ineffectual or even detrimental. For this reason, the restoration strategy for these resources emphasizes determining why they are not recovering, and eliminating threats to the remaining populations.

Where sufficient knowledge about the nature of injury exists, the restoration strategy also encourages actions to promote recovery. The populations of some of these resources are in a steep decline and may not recover without help. Furthermore, some of these resources have subsistence or economic importance and their recovery is linked to the recovery of these services. (Restoration strategies under "Services" also apply to these resources.)

Research is encouraged, provided it helps explain why a resource is not recovering. Habitat protection and monitoring are also encouraged. General restoration projects are allowed if they address factors limiting recovery or if they protect the resource from other sources of potential injury.

The restoration strategy for resources that are not recovering has four parts:

- Conduct research to find out why these resources are not recovering
- Initiate, sustain, or accelerate recovery
- Monitor recovery
- Protect injured resources and their habitats

Recovery Unknown. If specialists do not know whether a resource is recovering, it will be treated in much the same way as a recovering resource. Until more is known about the nature and extent of injuries and the degree of recovery of these resources, restoration will rely primarily on natural recovery, aided by monitoring and protective measures. Monitoring may be undertaken to determine a resource's recovery status.

Because the recovery of these resources is unknown, and, in some cases, the injury poorly understood, research into factors limiting recovery and general restoration projects to accelerate recovery may not be warranted. Habitat protection and monitoring are encouraged, as are general restoration projects that protect these resources from other sources of potential injury.

The restoration strategy for resources whose recovery is unknown has three parts:

- ~~Rely on natural recovery~~
- ~~Monitor recovery~~
- ~~Protect injured resources and their habitats~~

~~**Other Resources**~~

~~Other injured resources include archaeological resources, designated wilderness areas and oiled sediment. The strategy for restoring archaeological resources seeks to repair and protect injured sites and artifacts. The strategy for sediment includes removal or reduction of residual oil and monitoring. Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas or wilderness study areas.~~

~~**Services**~~

~~Commercial fishing, passive use, recreation (including sport fishing) and tourism and subsistence are services that were reduced or lost because of the spill. Injured resources that support these services include clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. The primary way to restore services is to restore the resources on which they depend.~~

~~Additional restoration strategies for commercial fishing, recreation and tourism, and subsistence include promoting recovery of the service as soon as possible through such means as increasing the availability, reliability, or quality of the resource on which the service depends. For some resources, this may take the form of increasing availability in the long run through improved resource management or providing replacement resources. Strategies for recreation and tourism and subsistence also include removing or reducing residual oil if treatment is cost effective and less harmful than leaving the oil in place.~~

Injury Status and Recovery Objectives ~~and Strategies by Resource and Service~~

This section describes the nature and extent of injury and recovery and the recovery objective~~, and the restoration strategy~~ for each injured resource and service. Specific strategies to achieve recovery objectives are described in annual work plans and restoration project invitations (e.g., *Invitation to Submit Restoration Projects for Federal Fiscal 1997 and Draft Restoration Program: FY 97 and Beyond).* The information in this section is expected to change ~~over time~~ as the restoration program adapts to new information. For example, population declines or sublethal effects may be documented for new resources, some resources may begin to recover or never recover, and recovery objectives ~~and strategies may~~ will change in response to new information and conditions. Hypotheses for why resources are not recovering are particularly susceptible to change as prevailing hypotheses are tested and new ones are formed.

New scientific data will be incorporated into restoration decisions without the need to change the plan. However, changes will be reported in the Trustee Council's annual status report.

Archaeological Resources

Injury and Recovery

Twenty-four archaeological sites on public lands are known to have been adversely affected by cleanup activities, or looting and vandalism linked to the oil spill. Additional sites on private land may have been injured, but damage assessment studies were limited to public land.

Documented injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been disturbed, which has exposed sites to accelerated erosion. The effect of oil on soil chemistry and organic remains may reduce or eliminate the utility of radiocarbon dating in some sites.

Assessments of 14 sites in 1993 suggest that most of the archaeological vandalism that can be linked to the ~~*Exxon Valdez* oil~~ spill occurred in 1989 before adequate constraints were put into place over the activities of oil spill clean-up personnel. Most vandalism took the form of "prospecting" for high yield sites. In 1993, only two of the 14 sites visited showed signs of continued vandalism, ~~and the link between~~ but it is difficult to prove that this recent vandalism was related to the spill. ~~and the *Exxon Valdez* oil spill remains highly problematical~~. Oil ~~samples have not yet been analyzed, but oil~~ was visible in the intertidal zones of two of the 14 sites monitored in 1993, but because oil samples have not yet been analyzed, the *Exxon Valdez* oil spill cannot be confirmed as the source of the oil in these sites.

Monitoring of archaeological sites in 1994 and 1995 found no evidence of new damage from vandalism. The presence of oil is being determined in sediment samples taken from four sites in 1995.

[NOTE: VERONICA IS WORKING ON AN ADDITIONAL SHORT PARAGRAPH MENTION REPOSITORY IN KODIAK...]

[NOTE TO REVIEWERS: SHOULD WE ADD THE 1995 WORKSHOP RECOMMENDATION, WHICH WAS TO "RETURN ARTIFACTS TO THE SPILL AREA WHEN FACILITIES ARE ADEQUATE TO RECEIVE THEM."]

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data which remain in vandalized sites are preserved. (Artifacts and data are typically preserved through excavation or other forms of documentation, or through site stabilization, depending on the nature of the injury and the characteristics of the site.)

~~**Restoration Strategy**~~

~~*Repair spill-related injury to archaeological sites and artifacts.* Injuries may be repaired to some extent through stabilizing eroding sites, or removing and restoring artifacts.~~

~~*Protect sites and artifacts from further injury and store them in appropriate facilities.* Archaeological sites and artifacts could be protected from further injury through the reduction of looting and vandalism, or the removal of artifacts from sites and storage in appropriate facilities. Opportunity~~

~~for people to view or learn about the cultural heritage of people in the spill area would also provide protection by increasing awareness and appreciation of cultural heritage and would replace services lost as a result of irretrievable damage to some artifacts.~~

~~*Monitor recovery.* Monitor a small number of sites vulnerable to serious, commercial looting.~~

BALD EAGLES

Injury and Recovery

Prince William Sound provided year-round and seasonal habitat for about 5,000 bald eagles. ~~Two hundred to 300~~ About 250 bald eagles are estimated to have died as a result of ~~may have been killed in~~ the spill, and productivity was reduced in oiled areas of Prince William Sound in 1989. Productivity was back to normal in 1990 and 1991, and an aerial survey of adults in 1995 indicated that the population has returned to or exceeded its prespill level in Prince William Sound. ~~However, population estimates made in 1989, 1990, and 1991 indicate that there may have been an increase in the Prince William Sound bald eagle population since the previous survey conducted in 1984. Productivity decreased in 1989, but appeared to have recovered by 1990. Because population and productivity appear to have returned to prespill levels, bald eagles may have already recovered from the effects of the spill.~~

Recovery Objective

Because the Prince William Sound population and productivity are at or above prespill levels, the bald eagle has recovered from the effects of the Exxon Valdez oil spill. ~~Bald eagles will have recovered when their population and productivity return to prespill levels.~~

~~Restoration Strategy~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the population and productivity of bald eagles in Prince William Sound until full recovery is confirmed and perhaps at intervals thereafter. The eagle population in Prince William Sound is expected to increase to its prespill level in 1994. There are not enough prespill data on eagle populations in other parts of the spill area to warrant surveys outside Prince William Sound.~~

~~*Protect bald eagles and their habitat.* With regard to bald eagles, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance in feeding and roosting areas.~~

BLACK OYSTERCATCHERS

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. An estimated 1,500-2,000 oystercatchers live in south-central Alaska. Only 9 carcasses of adult oystercatchers were recovered following the spill, but estimated mortality may have been as high as, but probably did not exceed, 20 percent in the spill area. In addition, breeding activities were disrupted by the oil and clean-up activities. Hatching success at Green Island was reduced in 1989, and chicks raised at oiled nest sites gained weight more slowly than chicks at unoiled nest sites in Prince William Sound during 1991-93. Interpretation of these data on hatching success and chick growth, however, are confounded by lack of pre-spill data. Productivity and survival of black oystercatchers in Prince William Sound have not been monitored since 1993, and the recovery status of this species is not currently known. ~~Within Prince William Sound, an estimated 120 to 150 black oystercatchers, representing 12-15 percent of the total estimated population, died as a result of the spill. Mortality outside of Prince William Sound is unknown. Black oystercatchers are recovering, although they may still be exposed to hydrocarbons when feeding in intertidal areas.~~

Comparing Montague Breem small example too

Recovery Objective

Black oystercatchers will have recovered when the Prince William Sound population returns to ~~attain~~ prespill levels and reproduction is normal. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas will indicate that recovery is underway. ~~reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor population abundance and distribution and the growth rates of chicks.~~

~~*Protect black oystercatchers and their habitat.* With regard to black oystercatchers, the objective of habitat protection is to reduce disturbance to feeding and nesting sites.~~

CLAMS

Injury and Recovery

The magnitude of impacts on clam populations varies with the species of clam, degree of oiling, and location. However, data from the lower intertidal zone on sheltered beaches suggest that little-neck clams and, to a lesser extent, butter clams ~~on sheltered beaches~~ were killed or suffered slower growth rates as a result of the oil spill ~~by oiling~~ and clean-up activities. ~~In addition, growth appeared to be reduced by oil, but determination of sublethal or chronic effects is awaiting final analyses.~~ In communities on the Kenai Peninsula, Kodiak, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

?

Recovery Objective

Based on prespill data or comparisons of oiled and unoiled sites, clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence

of the oil spill ~~(prespill data or unoiled control sites)~~.

~~**Restoration Strategy**~~

~~Clams are important for subsistence use and also serve as prey for sea otters and sea ducks such as harlequin ducks and pigeon guillemots. For additional restoration strategies, see *Subsistence, Sea Otters, Harlequin Ducks* and *Pigeon Guillemots.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the density and size of clams in select clam beds.~~

~~*Protect injured clam beds.* With regard to intertidal biota like clams, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Clams can also be protected by reducing marine pollution.~~

COMMERCIAL FISHING

Injury and Recovery

Commercial fishing is a service that was injured through injury to commercial fish species (see individual resources) and ~~also~~ through fishing closures. In 1989, closures affected fisheries in Prince William Sound, lower Cook Inlet, upper Cook Inlet, Kodiak, and Chignik. These fisheries opened again in 1990. Since then, there have been no spill-related district-wide closures, except for the Prince William Sound herring fishery, which was closed in 1993 and has remained closed since then due to the collapse of the herring population. These closures, including the on-going closure of the herring fishery in Prince William Sound, harmed the livelihoods of persons who fish for a living and the communities in which they live. To the extent that the oil spill continues to be a factor that reduces opportunities to catch fish, there is on-going injury to commercial fishing as a service.

On this basis, the Trustee Council continues to make major investments in projects to understand and restore commerically important fish species that were injured by the oil spill. These projects include: spplementation work, such as fertilizing Coghill Lake to enhance its sockeye salmon run and construction of a barrier bypass at Little Waterfall Creek; development of tools that have almost immediate benefit for fisheries management, such as otolith mass marking of pink salmon in Prince William Sound and in-season genetic stock identification for sockeye salmon in Cook Inlet; and research such as the SEA Project and genetic mapping which will enhance the ability to predict and manage fisheries over the long-term.

~~Continuing injuries to commercial fishing may cause hardships for fishermen and related businesses. Each year that commercial fishing remains below prespill levels compounds the injury to the fishermen and, in many instances, the communities in which they live or work.~~

The Trustee Council recognizes the impact to communities and people of the Prince William Sound region resulting from the sharp decline in pink salmon and herring fisheries in past years. In 1994, the Trustee Council committed over six million dollars to help address these issues through the development of an ecosystem-based study for Prince William Sound. Some of the pink salmon and herring problems may be unrelated to the spill. However, the Council will continue to address these important problems.

Recovery Objective

Commercial fishing will have recovered when the commercially important fish species have recovered and opportunities to catch these species are not lost or reduced due to effects of the oil spill. population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions that would have existed had the spill not occurred. Because of the difficulty of separating spill related effects from other changes in fish runs, the Trustee Council may use prespill conditions as a substitute measure for conditions that would have existed had the spill not occurred.

Restoration Strategy

The primary method for restoring commercial fishing is to restore the species that are fished commercially, such as pink salmon, Pacific herring, and sockeye salmon. These species are discussed elsewhere in this chapter. Three additional parts of the strategy for restoring commercial fishing are the following:

Promote recovery of commercial fishing as soon as possible. Many communities that rely on commercial fishing will be significantly harmed while waiting for commercial fish resources to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of commercial fishing. This objective may be accomplished through increasing availability, reliability, or quality of commercial fish resources, depending on the nature of the injury. For resources that have sharply declined since the spill, such as pink salmon, and Pacific herring in Prince William Sound, this objective may take the form of increasing availability in the long run through improved fisheries management. Another example is providing replacement fish for harvest.

Protect commercial fish resources from further degradation. Further stress on commercial fish resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if a resource faces loss of habitat. The Trustee Council can also contribute to the protection of commercial fish species by providing information needed to improve their management.

Monitor recovery. Monitoring the recovery of commercial fishing will track the progress of recovery, detect major reversals, and identify problems with the resources and resource management that may affect the rate or degree of recovery. Inadequate information may require managers to unduly restrict use of the injured resources, compounding the injury to commercial fishing.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. The population sizes are not known for any of these species, but, in general, loons are long-lived, slow-reproducing, and have small populations. Common loons in the oil-spill area may number only a few thousand, including only hundreds in Prince William Sound. Common loons injured by the spill probably included a mixture of resident and migrant birds, and their recovery status is not known.

Recovery Objective

Without more information on injury to common loons and their recovery status, no recovery objective can be identified.

COMMON MURRES

Injury and Recovery

About 30,000 carcasses of oiled birds were picked up following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres died than were actually recovered, and it is estimated that the spill-area population declined by about 40 percent, including at colonies at Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay. In addition to direct losses of murres, there was evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Postspill monitoring of productivity at index colonies indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed in 1994 [check] and, at that time, had not returned to prespill levels.

~~Productivity of common murres shows signs of recovery at some injured colonies (Barren Islands, Puale Bay) but postspill population counts are still lower than prespill estimates and show no sign of recovery.~~

Recovery Objective

Common murres will have recovered when populations ~~trends are increasing significantly~~ at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. ~~in the spill area and when reproductive timing and success are (Normal bounds will be determined by comparing productivity data with information from other murre colonies in the Gulf of Alaska and elsewhere.)~~

Restoration Strategy

Conduct research to find out why common murres are not recovering. Suspected causes include avian predation and behavioral change which inhibits breeding productivity at some colonies.

Initiate, sustain, or accelerate recovery. Once scientists determine why common murres are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor populations at index colonies such as the Chiswell Islands, Barren Islands, Triplets, Ungaiushak Island and Puale Bay. In addition, monitor the productivity of common murres at the Barren Islands.

Protect common murres and their habitat. With regard to common murres, the objective of habitat protection is to reduce disturbance in nearshore feeding areas and near nesting colonies.

CUTTHROAT TROUT

Injury and Recovery

Prince William Sound is at the northwestern limit of the range of cutthroat trout, and few stocks are known to exist within the sound. Local cutthroat populations rarely number more than 1,000 each, and the fish have small home ranges and are geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a small number of oiled index streams grew more slowly than in unoiled streams, possibly as a result of reduced food supplies or exposure to oil, and there is concern that reduced growth rates may reflect reduced survival. The difference in growth rates persisted through 1991. No studies have been conducted since then, and the recovery status of this species is not known. Cutthroat trout have grown more slowly in oiled areas than in unoiled areas. Insufficient data are available to determine whether they are recovering.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are comparable to those for unoiled areas, after taking into account geographic effects.

Restoration Strategy

Cutthroat trout is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*

Rely on natural recovery. Natural processes aided by protective measures will be the main agents of restoration.

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect cutthroat trout and their habitat.* With regard to cutthroat trout, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning. The Trustee Council can also contribute to the protection of cutthroat trout by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

DESIGNATED WILDERNESS AREAS

Injury and Recovery

The oil spill delivered oil in varying quantities to the waters adjoining the seven areas within the spill area designated by Congress as wilderness areas and wilderness study areas. Oil also was deposited above the mean high-tide line in these areas. During the intense clean-up seasons of 1989 and 1990, thousands of workers and hundreds 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. Although activity levels on these wilderness shores have probably returned to normal, but at some locations there is still residual oil.

Recovery Objective

Designated wilderness areas will have recovered when oil is no longer encountered in these areas and the public perceives them to be recovered from the spill.

~~Restoration Strategy~~

~~Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of designated wilderness areas. No strategies have been identified that benefit only designated wilderness areas without also addressing injured resources.~~

DOLLY VARDEN

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden ~~have grown~~ grew more slowly in oiled streams ~~areas~~ than in unoiled streams ~~areas~~, and there is concern that reduced growth rates reflect reduced survival. However, no data have been gathered since 1991, and the recovery status of this species is not known. ~~Insufficient data are available to determine whether they are recovering.~~

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams ~~areas~~ are comparable to those ~~for~~ in unoiled streams ~~areas~~, after taking into account geographic effects.

~~**Restoration Strategy**~~

~~Dolly Varden is one of the species on which sport fishing in the spill area depends. For additional restoration strategies, see *Recreation and Tourism.*~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor growth rates in injured populations.~~

~~*Protect Dolly Varden and their habitat.* With regard to Dolly Varden, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Dolly Varden by providing information needed to improve their management. Examples of protective management practices are the conservative limits on sport fish harvests that have been adopted by the Alaska Board of Fisheries for parts of Prince William Sound.~~

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the spill. An estimated 300 seals died in the sound as a direct result of the spill, and this was 6-15 percent of the prespill population. Postspill surveys in 19__ showed that seals in ~~the~~ oiled areas had declined by 43 percent, compared to 11 percent in ~~the~~ unoiled areas. Unfortunately, seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill at an annual rate of about 6 percent. Possible factors for this long-term decline include disease and the amount or quality of food. ~~Counts made during the molt at trend count sites in Prince William Sound from 1990 to 1993 indicate that numbers may have stabilized. However, counts during pupping have continued to decline. It is not known which counts are the best indicator of population status. If the conditions that were causing the population to decline before the spill have improved, normal growth may replace the animals that were lost. However, if conditions continue to be unfavorable, the affected population may continue to decline.~~ Harbor seals are a key subsistence resource in the oil spill area ~~Prince William Sound~~. Subsistence hunting is ~~both~~ affected by the declining seal population and, in turn, may be affecting the recovery of harbor seals ~~status~~.

Recovery Objective

Recovery will have occurred when harbor seal population trends are stable or increasing.

~~**Restoration Strategy**~~

~~Harbor seals are important for subsistence use. For additional restoration strategies, see *Subsistence.*~~

~~*Conduct research to find out why harbor seals are not recovering.* Suspected causes include limited or changing availability of prey, particularly forage fishes; predation by killer whales; and resource exploitation through subsistence take or incidental take associated with fisheries.~~

~~*Initiate, sustain, or accelerate recovery of harbor seals.* Once scientists determine why harbor seals are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor trends in Prince William Sound during pupping and molting for comparison with previous years' data.~~

~~*Protect harbor seals and their habitat.* With regard to harbor seals, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites, and in nearshore feeding areas. Another way of protecting harbor seals is to provide information that will help subsistence hunters assess the effects of their harvest.~~

HARLEQUIN DUCKS

Injury and Recovery

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound, and many more than that actually died throughout the spill area. Bile samples from harlequin ducks collected in eastern and western Prince William Sound in 1989-90 had higher concentrations of hydrocarbon ~~derivatives [right words?]~~ than samples from harlequins collected at Juneau. Prespill data on harlequin populations and productivity are poor and complicated by possible geographic differences in habitat quality. However, the summer population in Prince William Sound is small, only a few thousand birds, and there continues to be concern about poor reproduction and a possible decline in numbers of molting birds in western versus eastern parts of the Sound. ~~There are indications of reduced densities of harlequin ducks in the breeding season; a declining trend in the summer, postbreeding population; and very poor production of young in western Prince William Sound.~~

metabolites

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to ~~estimated~~ prespill levels. ~~or when there are no differences in these parameters between oiled and unoiled areas.~~ A normal population age- and sex-structure and reproductive success appropriate to the habitat in western Prince William Sound will indicate that recovery is underway.

~~**Restoration Strategy**~~

~~Harlequin ducks are hunted for subsistence and sport. For additional restoration strategies, see *Subsistence* and *Recreation and Tourism*.~~

~~*Conduct research to find out why harlequin ducks are not recovering.* Although the exact cause of reproductive failure among resident birds is unknown, it is believed to be related to ingestion of oil contaminated prey from foraging in oiled mussel beds.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why harlequin ducks are not recovering, efforts may be undertaken to accelerate recovery. If ingestion of oiled mussels is found to limit the recovery of harlequin ducks, cleaning oiled mussel beds may hasten recovery.~~

~~*Monitor recovery.* Monitor the breeding age population in Prince William Sound, as well as numbers of young, brood distribution, and abundance of postbreeding harlequins.~~

~~*Protect harlequin ducks and their habitat.* With regard to harlequin ducks, the objective of habitat protection is to ensure maintenance of adequate riparian habitat for nesting and brood rearing, and reduce disturbance to nearshore feeding, molting, brood rearing habitats. The Trustee Council can also contribute to the protection of harlequin ducks by providing information needed to improve their management. An example of protective management practices is the restriction on sport hunting of harlequin ducks imposed by the Alaska Board of Game in 1991.~~

INTERTIDAL ORGANISMS

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill, and both the oil and intensive clean-up activities had significant impacts on the flora and fauna of the intertidal zone, the area of beach between low and high tides. With tidal action, oil penetrated deeply into cobble and boulder beaches, and, even with intensive clean up activities, persists in some beaches today. The most significant impacts occurred in middle and upper intertidal zones on sheltered rocky shores, which is where the greatest amounts of oil were stranded.

Small invertebrates like limpets, barnacles, and marine worms were less abundant at oiled versus unoiled index sites in Prince William Sound, Kodiak Island, and on the Kenai and Alaska peninsula coasts. The size, coverage, and reproductive potential of seaweed *Fucus gardneri* (known as rockweed or popweed) also was reduced following the spill. Although numbers of many species of invertebrate fauna have increased following the spill, recovery of *Fucus* in the upper intertidal zone is lagging. Full recovery of *Fucus* is crucial for recovery of the intertidal ecosystem, since many invertebrates depend on the cover provided by this seaweed. Many intertidal resources are important to subsistence users, as well as to sea and river otters, black oystercatchers, harlequin ducks, and pigeon guillemots.

~~The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult *Fucus* in large numbers.~~

Recovery Objective

~~Each intertidal elevation (lower, middle, or upper) will have recovered when community composition, population abundance of component species, age class distribution, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.~~ Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as *Fucus*, and provision of adequate, ~~clean~~ uncontaminated food supplies for top predators in intertidal/nearshore habitats.

~~Restoration Strategy~~

~~*Conduct research to find out why some intertidal organisms are not recovering.* Possible explanations include changes in the community structure resulting from spill-induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).~~

Initiate, sustain, or accelerate recovery. Once scientists determine why some intertidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor matched oiled and unoiled intertidal sites, incorporating a variety of habitat types.

Protect intertidal organisms and their habitat. With regard to intertidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Intertidal organisms can also be protected by reducing marine pollution.

KILLER WHALES

within their ranges

Injury and Recovery

less frequently

About ___ killer whales in _ "resident" pods regularly use Prince William Sound. Other whales in "transient" pods enter the sound occasionally. There has been particular concern in Prince William Sound about the resident AB pod, which numbered 36 animals prior to the spill. Fourteen whales disappeared from this pod in 1989 and 1990, during which time no young were recruited into the population. Although four calves were added to the AB pod during 1992-94, surveys in 1994 and 1995 indicate the loss of five more whales. The link between these losses and the oil spill is only circumstantial, but the apparent mortality of killer whales in Prince William Sound following the spill far exceeds rates documented for pods in British Columbia and Puget Sound over the last 20 years. The AB pod may never regain its former size, but overall numbers of resident killer whales in Prince William Sound are at or exceed prespill levels. Thirteen whales disappeared from one killer whale pod in Prince William Sound between 1988 and 1990. The injured pod is growing again.

Recovery Objective

there are as many now as pre-spill

Overall, killer whales have recovered in Prince William Sound, although the AB pod may never return to its prespill level of 36 whales. Pending further evaluation of the status of the AB pod, no additional recovery objective is identified. Killer whales will have recovered when the injured pod grows to at least 36 individuals (1988 level).

AB pod = nonrecovering

Restoration Strategy

Rely on natural recovery. Natural processes aided by protective measures will be the main agents of restoration.

Monitor recovery. Monitor the injured pod (AB pod) of killer whales in Prince William Sound.

~~Marbled~~ Murrelets, Marbled and Kittlitz's

Injury and Recovery

Prince William Sound and the northern Gulf of Alaska are key areas in the distributions of two poorly studied species of seabirds, marbled and Kittlitz's murrelets. The world population of Kittlitz's murrelet is believed to number only a few tens of thousands of birds, many of which are in the oil-spill area. The marbled murrelet is federally listed as a Threatened species in Washington, Oregon, and California; it is also listed as Threatened in British Columbia.

The Marbled murrelet population~~s~~ in Prince William Sound was ~~were~~ in decline before the spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. The oil spill probably increased the prespill rate of decline for this species in the spill area, although the incremental injury is difficult to estimate. ~~The population of marbled murrelets may be stabilizing or even increasing since the spill.~~ Carcasses of nearly 1,100 murrelets were found after the spill, and it is estimated that as much as __ percent of the Prince William Sound marbled murrelet population was killed by the spill. Population estimates for murrelets are highly variable, and postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. The recovery status of Kittlitz's murrelet is not known.

Recovery Objective

Marbled murrelets will have recovered when population trends are stable or increasing. No recovery objective can be identified for Kittlitz's murrelet at this time.

~~Restoration Strategy~~

~~*Conduct research to find out why marbled murrelets are not recovering.* Likely causes include avian and mammalian predation, climatic/oceanographic features and prey limitation. Also of concern are the effects of resource exploitation (incidental gillnet catch) and upland development.~~

~~*Initiate, sustain, or accelerate recovery.* Once scientists determine why marbled murrelets are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor the marbled murrelet population in Prince William Sound.~~

~~*Protect marbled murrelets and their habitat.* With regard to marbled murrelets, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.~~

Mussels

Injury and Recovery

Mussels are an important prey species in the nearshore ecosystem throughout the oil-spill area, and beds of mussels provide physical stability in the intertidal zone. For these reasons, mussel beds were purposely left alone during *Exxon Valdez* clean-up operations. In 1991, high concentrations of relatively unweathered oil were found in the mussels and underlying byssal mats in certain dense mussel beds. ~~In 1991, relatively high concentrations of oil were found in mussels and in the dense underlying mat (byssal substrate) of certain oiled mussel beds. The beds were not cleaned nor was oil removed after the spill. The~~ The biological significance of oiled mussel beds is not known, but they ~~Oiled mussel beds~~ are potential pathways of ~~sources of fresh (unweathered)~~ oil contamination for local populations of harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which to some extent feed on mussels and show some signs of continuing injury. ~~The extent and magnitude of oiled mussel beds are unknown.~~ At least __ [70 ?] mussel beds in Prince William Sound are known to still have oil residue; 12 beds were cleaned on an experimental basis in 1994. Subsistence users also continue to be concerned about contamination from oil mussel beds.

Recovery Objective

Mussels will have recovered when they do not contaminate their predators. ~~their populations and productivity are at prespill levels and they do not contain oil that contaminates higher trophic levels.~~

~~**Restoration Strategy**~~

~~*Initiate, sustain, or accelerate recovery.* Cleaning oiled mussel beds hastens their recovery and that of species that feed on them, such as harlequin ducks and juvenile sea otters.~~

~~*Monitor recovery.* Monitor the health of mussels and the concentration and degradation of oil in mussel beds identified as contaminated.~~

~~*Protect mussels and their habitat.* With regard to intertidal biota like mussels, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Mussels can also be protected by reducing marine pollution.~~

PACIFIC HERRING

Injury and Recovery

Pacific herring spawned in intertidal/subtidal habitats in Prince William Sound shortly after the oil spill. As much as 10 percent of the intertidal spawning habitat and 40 percent of the herring staging areas in the sound may have been contaminated by oil. Field studies conducted in 1989 and 1990 showed increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries in the field at a population level is not known. In 1992, herring biomass in

going from 120,000 tons to about 20,000 tons.

Prince William Sound was at a record level. In 1993, however, ~~when herring spawned in 1989 should have returned in large numbers~~, there was an unprecedented crash in ~~numbers~~ of adult herring. A viral disease and fungus were the probable agents of mortality, ~~but~~ the connection between the oil spill and the disease outbreak is under investigation. Numbers of spawning herring in Prince William Sound have remained depressed through the 1995 season. Pacific herring are extremely important ecologically as well as commercially, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound. ~~Pacific herring studies have demonstrated egg mortality and larval deformities. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, the stocks and dependent fisheries in Prince William Sound are not healthy, as indicated by the low spawning biomass in 1993 and 1994 and the resultant elimination of the fisheries in those years.~~

and

Recovery Objective

Pacific herring will have recovered when indicators of population health, such as reproduction, growth, and recruitment, are within normal bounds and free of oil-related effects within Prince William Sound. ~~populations are healthy and productive and exist at prespill abundances.~~

~~**Restoration Strategy**~~

~~Pacific herring are important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why Pacific herring are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are disease, heritable genetic damage, oil toxicity, the impact of winter conditions on herring survival and reproductive success, and the advective transport of herring larvae from rearing areas in Prince William Sound.~~

~~*Initiate, sustain, or accelerate recovery of Pacific herring.* Once scientists determine why Pacific herring are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor fish health and spawning biomass.~~

~~*Protect Pacific herring and their habitat.* With regard to Pacific herring, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of Pacific herring by providing information needed to improve their management. An example of protective management practices is the closure of the fishery by the Alaska Department of Fish and Game due to the failure of the herring run in Prince William Sound in 1993 and 1994.~~

PASSIVE USE

Injury and Recovery

Passive use of resources includes 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. Injuries to passive uses are tied to public perceptions of injured resources. [NOTE: THIS SAYS ALMOST NOTHING ABOUT INJURY. IS THERE ANYTHING TO SAY. PERHAPS A REFERENCE TO THE VALUATION SURVEYS DONE FOLLOWING THE SPILL.]

Recovery Objective

Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

~~Restoration Strategy~~

~~Any restoration strategy that aids recovery of injured resources, or prevents further injuries, will assist recovery of passive use values. No strategies have been identified that benefit only passive uses, without also addressing injured resources. Since recovery of passive uses requires that people know when recovery has occurred, the availability to the public of the latest scientific information will continue to play an important role in the restoration of passive uses.~~

PIGEON GUILLEMOT

Injury and Recovery

Although the pigeon guillemot is widely distributed, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, both they and the fish they prey on are vulnerable to oil pollution. Like the marbled murrelet, the pigeon guillemot population in Prince William Sound was in decline before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the Gulf of Alaska population may have died in the spill, and declines along oiled shorelines in Prince William Sound were greater than along unoiled shorelines. Numbers of guillemots recorded on boat surveys are highly variable, and there is not yet any statistically significant evidence of a postspill population increase. The factors responsible for the guillemot's prespill decline may negate or mask recovery from the effects of the oil spill.

Recovery Objective

Pigeon guillemots will have recovered when the populations in Prince William Sound is ~~are~~ stable or increasing.

Restoration Strategy

Conduct research to find out why pigeon guillemots are not recovering. Likely causes include climatic/oceanographic features, prey limitation, and predation.

Initiate, sustain, or accelerate recovery. Once scientists determine why pigeon guillemots are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor the pigeon guillemot population in Prince William Sound.

Protect pigeon guillemots and their habitat. With regard to pigeon guillemots, the objective of habitat protection is to ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.

PINK SALMON

Injury and Recovery

About 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams and were highly vulnerable to the effects of the oil spill. Hatchery salmon and wild salmon from both intertidal and upstream spawning habitats swam through oiled waters and ingested oil particles and oiled prey as they foraged in the sound and emigrated to sea. As a result, three types of early life-stage injuries were identified: First, growth rates in juvenile salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams. A possible third effect, genetic damage, is under investigation.

In the years preceding the spill, the total return of wild pink salmon in Prince William Sound varied from a maximum of 21.0 million fish in 1984 to a minimum of 1.8 million in 1988. Since the spill, returns of wild pinks have varied from a high of about 14.4 million fish in 1990 to a low of about 2.2 million in 1992. There is particular concern about the Sound's southwest district, where returns of both hatchery and wild stocks have been generally weak since the oil spill. Because of the tremendous natural variation in adult returns, however, it is difficult to attribute poor returns in a given year to injuries caused by oil. Injuries to salmon eggs and juveniles remain the best indicators of injury and recovery.

Evidence of reduced juvenile growth rates was limited to the 1989 season, but increased egg mortality persisted in oiled compared to unoiled streams through 1993. The 1994 and 1995 seasons were the first since 1989 in which there were no statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery from oil-spill effects is underway.

The Sound Ecosystem Assessment (SEA) Project is exploring physical and biological oceanographic factors that influence production of salmon and herring. These natural factors are likely to have the greatest influence over year-to-year returns in both wild and hatchery stocks of pink salmon.

~~Pink salmon studies have demonstrated egg mortality, fry deformities, and reduced growth in juveniles. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, there is evidence of continued damage in some stocks from exposure to oil, and there were unexpectedly poor runs of both wild and hatchery stocks of pink salmon in Prince William Sound in 1992 and 1993. In 1994, runs were still depressed but exceeded forecasts.~~

Recovery Objective

Pink salmon will have recovered when population indicators, such as growth and survival, are within normal bounds and there are no statistically significant differences in egg mortalities in oiled and unoiled streams for two years each of odd- and even-year runs in Prince William Sound. ~~populations are healthy and productive and exist at prespill abundance. An indication of recovery is when egg mortalities in oiled areas match prespill levels or levels in unoiled areas.~~

~~**Restoration Strategy**~~

~~Pink salmon is important for subsistence use and commercial fishing. For additional restoration strategies, see *Subsistence* and *Commercial Fishing.*~~

~~*Conduct research to find out why pink salmon are not recovering.* A leading hypothesis is that when the abundance of zooplankton is low, predatory fish and birds switch from a zooplankton diet to juvenile salmon and herring, thereby reducing survival of the juveniles. Other possible causes are heritable genetic damage and oil toxicity.~~

~~*Initiate, sustain, or accelerate recovery of pink salmon.* Once scientists determine why pink salmon are not recovering, efforts may be undertaken to accelerate recovery.~~

~~*Monitor recovery.* Monitor egg mortality, escapement, and return per spawner productivity.~~

~~*Protect pink salmon and their habitat.* With regard to pink salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of pink salmon by providing information needed to improve their management. An example of protective management practices is restriction of the fishery by the Alaska Department of Fish and Game due to poor returns of pink salmon to Prince William Sound in 1992 and 1993.~~

RECREATION AND TOURISM

Injury and Recovery

The spill disrupted use of the spill area for recreation and tourism. Resources important for wildlife viewing and which are still injured by the spill include killer whale, sea otter, harbor seal, ~~bald eagle,~~ and various seabirds. Residual oil exists on some beaches with high value for recreation, and its presence may decrease the quality of recreational experiences and discourage recreational use of these beaches.

Closures of sport hunting and fishing also affected use of the spill area for recreation and tourism. Sport fishing resources include salmon, rockfish, Dolly Varden, and cutthroat trout. The Alaska Board of Fisheries restricted sport harvest of cutthroat trout in Prince William Sound in 199_, and those restrictions remain in place. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1992 [?], and those restrictions remain in place.

Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas increased management problems and facility use in unoiled areas. Some facilities, such as the Green Island cabin and the Fleming Spit camp area, were injured by clean-up workers. [NOTE: CAN WE SAY ANYTHING TO UPDATE THIS? VERONICA IS LOOKING AT THIS.]]

Recovery Objective

Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, recreation use of oiled beaches is no longer impaired, and facilities and management capabilities can accommodate changes in human use.

~~**Restoration Strategy**~~

~~*Preserve or improve the recreational and tourism values of the spill area.* Habitat protection and acquisition are important means of preserving and enhancing the opportunities offered by the spill area. Facilities damaged during cleanup may be repaired if they are still needed. New facilities may restore or enhance opportunities for recreational use of natural resources. Improved or intensified public recreation management may be warranted in some circumstances. Projects that restore or enhance recreation and tourism would be considered only if they are consistent with the character and public uses of the area. However, all projects to preserve and improve recreation and tourism values must be related to an injured natural resource. See Policy 9 in Chapter 2.~~

~~*Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place.* Removal of residual oil from beaches with high value for recreation and tourism may restore these services for some users. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.~~

~~*Monitor recovery.* Monitor the recovery of resources used for recreation and tourism. Also monitor changes in recreation and tourism in the spill area.~~

RIVER OTTERS

Injury and Recovery

River otters have a low density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve otter carcasses were found following the spill. Studies conducted during 1989-1991 identified several differences between otters in oiled and unoiled areas in Prince William Sound, including biochemical evidence of exposure to hydrocarbons or other sources of stress, reduced diversity in prey species, reduced body size (length-weight), and increased territory size. However, sample sizes were small, and it is not clear that these differences are the result of the oil spill. The Nearshore Vertebrate Predator project, now underway, will shed new light on the status of the river otters. In 1995 the Alaska Board of Game used its emergency authority to restrict trapping of river otters in western Prince William Sound to ensure that the results of this study are not compromised by the removal of animals from study areas on Montague and Knight islands. ~~River otters in Prince William Sound have suffered sublethal effects from the spill and may continue to be exposed to hydrocarbons.~~

Recovery Objective

The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound, after taking into account any geographic effects. ~~Indications of recovery are when habitat use, food habitats and physiological indices have returned to prespill conditions.~~

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Monitor recovery.* Monitor the health and habitat use of river otters in Prince William Sound.~~

~~*Protect river otters and their habitat.* With regard to river otters, the objective of habitat protection is to ensure maintenance of adequate riparian and shoreline habitats for feeding and denning.~~

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. Dead adult rockfish were recovered following the oil spill, and chemical analysis of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure ~~were exposed~~ to hydrocarbons and ~~showed~~ sublethal effects. ~~Furthermore~~ In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have affected ~~be affecting their~~ the rockfish population. However, the original extent ~~and mechanism~~ of injury and the current status of ~~to~~ this species are unknown.

Recovery Objective

Without further study, a recovery objective cannot be defined.

~~**Restoration Strategy**~~

~~*Rely on natural recovery.* Natural processes aided by protective measures will be the main agents of restoration.~~

~~*Determine if restoration is needed.* Synthesize Natural Resource Damage Assessment studies and other data on rockfish in Prince William Sound to define a restoration objective and develop strategies to monitor and protect the recovery of the species.~~

~~*Monitor recovery.* Once a recovery objective is defined, monitor the progress of natural recovery toward that objective.~~

SEA OTTERS

Injury and Recovery

Surveys of sea otters in the 1970s and 1980s indicate that the population was expanding and about 10,000 animals lived in Prince William Sound prior to the spill. Based on the number of carcasses and other data, population models suggest that 3,500-5,500 otters died in the first few months following the spill. In 1990 and 1991, unusual numbers of prime-age adult otters were found dead and there was evidence of an increased death rate in recently weaned juveniles. By 1992-93, mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of Prince William Sound. Boat surveys conducted in March and July in 1993 and again in 1994 indicated a population of about 7,700 otters in the Sound, but there was no statistically significant evidence of a population increase following the spill (1990-1994). The Nearshore Vertebrate Predator project, which is expected to be completed ~~in 1999~~ [?], should ~~greatly~~ clarify the recovery status of the sea otter in Prince William Sound. ~~Sea otters do not appear to be recovering, but are expected to eventually recover to their prespill population. Exactly what population increases would constitute recovery is very uncertain, as there are no population data from 1986 to 1989, and the population may have been increasing in Eastern Prince William Sound during that time. In addition, only large changes in the population can be reliably detected with current measuring techniques. However, there are recent indications that the patterns of juvenile and mid-aged mortalities are returning to prespill conditions.~~

help

WOS started in 1995

Recovery Objective

Sea otters will have recovered when the Prince William Sound population returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in oiled parts of the sound will indicate that recovery is underway. ~~Sea otters will be considered recovered when population abundance and distribution are comparable to prespill abundance and distribution, and when all ages appear healthy.~~

Restoration Strategy

Sea otters are harvested for subsistence. For additional restoration strategies, see *Subsistence.*

Conduct research to find out why sea otters are not recovering. One hypothesis is that exposure to hydrocarbons and ingestion of contaminated prey affected survival and reproductive success of sea otters in Prince William Sound. Another hypothesis is that the oil spill induced changes in the population of benthic prey species that have limited reoccupation of sea otter habitat and the recovery of sea otters in oiled areas.

Initiate, sustain, or accelerate recovery of sea otters. Once scientists determine why sea otters are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor abundance and mortality of sea otters in oiled areas.

Protect sea otters and their habitats. With regard to sea otters, the objective of habitat protection is to reduce disturbance at haulout sites and pupping sites and in nearshore feeding areas.

SEDIMENTS

Injury and Recovery

With tidal action, oil penetrated deeply into cobble and boulder beaches that are relatively common on the rocky islands of shorelines throughout the spill area, especially in sheltered habitats. Cleaning removed much of the oil from the intertidal zone but subsurface oil persisted in many heavily oiled beaches and associated subtidal sediments. in mussel beds, which were avoided during the cleanup. Subsurface oil persists at least at ___ locations in Prince William Sound and as far away as the Alaska Peninsula. While much of this oil is probably not biologically active, it is of great concern to residents in oil-spill communities, and there are sites where sheening still occurs.

Following the oil spill, chemical analyses of oil in sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in sediments reached its greatest concentrations at depths of 20 meters, although elevated levels of hydrocarbon-degrading bacteria (associated with elevated hydrocarbons) were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. 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. By 1993, however, there was little evidence of *Exxon Valdez* oil and related microbial activity at most index sites in Prince William Sound, except at those associated with sheltered beaches that were heavily oiled in 1989. These index sites--at Herring, Northwest, and Sleepy bays--were among the ___ at which subsurface oiling is still known to occur (see above).

Recovery Objective

Sediments will have recovered when ~~contamination causes no negative effects to the spill ecosystem~~ residues of subsurface oil at sheltered sites that were previously heavily oiled are declining or are biologically harmless.

~~**Restoration Strategy**~~

~~*Monitor recovery.* Monitor concentrations of hydrocarbons in sediments and indices of petroleum exposure in flatfish.~~

~~*Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place.* Removal of residual oil may accelerate recovery of sediment where natural recovery is insufficient. However, this benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.~~

SOCKEYE SALMON

Injury and Recovery

Commericial fishing was closed in portions of Cook Inlet and near Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-usual ~~returns~~ (i.e., overescapement) of spawning fish to the Kenai River, Red and Akalura lakes on Kodiak Island, and lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that consumed huge quantities of zooplankton, thus destroying planktonic food webs in the nursery lakes. Although the exact mechanism is unclear, the result was lost sockeye production as shown by declines in the returns of adults per spawning sockeye ~~in the fishery escapement~~.

The effects of the 1989 overescapement have persisted in the Kenai River system through 1995. Although the overall escapement goal for that system was met in 1995, there is concern that the initial overescapement will continue to affect post-spill year-classes and that sockeye returns are yet not sufficient to fulfill the commericial, recreational, and subsistence demands on sockeye salmon in the Kenai River system.

Production of zoolplankton in both Red and Akalura lakes on Kodiak Island has returned to normal. There continues to be some problem in the rate of production of sockeye fry in Red Lake, which may or may not be linked to the overescapement at the time of the oil spill. Continuing low adult escapements at Akalura Lake are more likely the result of a mixed stock fishery harvest in the Kodiak vicinity than a result of the earlier overescapement.

~~Sockeye salmon in Red Lake, Akalura Lake, and lakes in the Kenai River system declined in population because of adult overescapement in 1989. The Red Lake system may be recovering because the plankton has recovered and fry survival improved in 1993. However, Akalura Lake and the Kenai River lakes have not recovered: smolt production has continued to decline from these lakes. In the Kenai River lakes, for~~

example, smolt production has declined from 30 million in 1989 to 6 million in 1990 and to less than 1 million in 1992 and 1993.

Recovery Objective

Sockeye salmon in the Kenai River system and Red and Akalura lakes will have recovered when adult returns-per-spawner are within normal bounds. affected lakes will have recovered when populations are able to support overwinter survival rates and smolt outmigrations comparable to prespill levels.

Restoration Strategy

Sockeye salmon is important for subsistence use, commercial fishing, and sport fishing. For additional restoration strategies, see *Subsistence, Commercial Fishing* and *Recreation and Tourism.*

Rely on natural recovery for sockeye salmon in Red Lake. Natural processes aided by protective measures will be the main agents of restoration for sockeye salmon in Red Lake. This population of sockeye salmon is expected to fully recover by 1996.

Conduct research to find out why other populations of sockeye salmon are not recovering. The most likely explanation is that overescapement of adults changed the community structure of sockeye lake rearing habitat. Possible changes in community structure include a reduction in zooplankton biomass; conversion of the zooplankton community structure to a predation resistant form; or a change in composition of zooplankton that demands increased foraging time for juvenile salmon and thereby makes them susceptible to increased predation.

Initiate, sustain, or accelerate recovery of sockeye salmon. Once scientists determine why sockeye salmon are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor outmigrations of smolt from Red Lake and Akalura Lake. In Kenai River lakes, monitor fall fry abundance and smolt abundance to estimate overwinter survival and smolt production.

Protect sockeye salmon and their habitats. With regard to sockeye salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat for spawning and rearing. The Trustee Council can also contribute to the protection of sockeye salmon by providing information needed to improve their management.

SUBSISTENCE

Injury and Recovery

Before the oil spill, the Alaska Department of Fish and Game had documented 15 Native Alaskan communities (with about 2,200 people) in Prince William Sound, lower Cook Inlet, Kodiak, and the Alaska Peninsula that relied heavily on subsistence resources, such as fish, shellfish, seals, deer, and waterfowl. Per capita subsistence harvest ranged from nearly 200 pounds to more than 600 pounds per year. Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for these declines included reduced availability of fish and wildlife to harvest, concern about possible health effects of eating contaminated or injured fish and wildlife, and disruption of lifestyles due to clean-up and other activities.

Subsistence foods were tested for evidence of hydrocarbon contamination during 1989-1994, and the results indicated that most resources contained no or very low levels of petroleum hydrocarbons. Eating foods with low ~~levels~~ of hydrocarbons posed no risk to human health, although subsistencers were advised not to eat shellfish from obviously contaminated areas. Samples of ducks from the Chenega Bay area in 1994 showed that exposure to crude oil had decreased significantly compared to the exposure levels documented since 1990.

Residual oil exists on some beaches near subsistence communities, and, in general, there continues to be concern or at least uncertainty about the safety of fish and wildlife resources. Uncertainty about the safety of resources reduces their use and value for subsistence.

Surveys by the Alaska Department of Fish and Game indicate that in some communities subsistence resources are again being harvested at prespill levels based on total pounds-per-person. It is important to note, however, that the composition of many diets has shifted to include more fish and fewer seals. Diet composition continues to be a serious concern to subsistence users.

Subsistence users say that maintaining their subsistence culture depends on uninterrupted use of fish and wildlife resources. The more time users spend away from subsistence activities, the less likely that they will return to these practices. Continuing injury to natural resources used for subsistence may affect the way of life of entire communities. There is particular concern that the oil spill disrupted opportunities for young people to learn subsistence culture, and that this knowledge may be lost to them in the future.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels. In addition, there is recognition that people must be ~~and when people are~~ confident that the resources are safe to eat. ~~One indication that recovery has occurred is when~~ and that the cultural values provided by gathering, preparing, and sharing food need to be ~~are~~ reintegrated into community life.

Restoration Strategy

The primary way of restoring subsistence is to restore injured resources used for subsistence, such as clams, harbor seals, Pacific herring, pink salmon, sea otters, and sockeye salmon. These are discussed elsewhere in this chapter. Four additional parts of the strategy to restore subsistence are the following:

Promote recovery of subsistence as soon as possible. Many subsistence communities will be significantly harmed while waiting for resources used for subsistence to recover through natural recovery alone. Therefore, an objective of restoration is to accelerate recovery of subsistence use. This objective may be accomplished through increasing availability, reliability, or quality of resources used for subsistence, or increasing the confidence of subsistence users. Specifically, if subsistence harvest has not returned to prespill levels because users doubt the safety of particular resources, this objective may take the form of increasing the reliability of the resource through food safety testing. Other examples are the acquisition of alternative food sources and improved use of existing resources. However, all projects to promote subsistence must be related to an injured natural resource. See Policy 9 in Chapter 2.

Remove or reduce residual oil if treatment is cost effective and less harmful than leaving the oil in place. Removing residual oil from beaches with high value for subsistence may improve the safety of foods found on these beaches. This benefit would have to be balanced against cost and the potential for further disruption to intertidal communities.

Protect subsistence resources from further degradation. Further stress on subsistence resources could impede recovery. Appropriate protection can take the form of habitat protection and acquisition if important subsistence areas are threatened. Protective action could also include protective management practices if a resource or service faces further injury from human use or marine pollution.

Monitor recovery. Monitor the recovery of resources used for subsistence. Also monitor subsistence harvest.

SUBTIDAL ORGANISMS

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the size and species composition of plant and animal populations below lower tide levels. Different habitats, including eelgrass beds, kelp beds, and deep water, were compared at oiled and unoiled sites. The greatest effects were detected at oiled sites with sandy sea bottoms under eelgrass beds, at which there were reduced numbers and diversity of helmet crabs, amphipods, and other crustaceans and mollusks. There also were sublethal effects on the eelgrass itself. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic, stress-tolerant species, such as *Musculus* mussels, a variety of polychaetes, and juvenile cod, apparently increased in numbers at oiled sites. Differences in oiled and unoiled sites were less evident by 1993.

Certain subtidal organisms, like eelgrass and some species of algae, appear to be recovering. Other subtidal organisms, like leather stars and helmet crabs, showed little signs of recovery through 1991.

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the return of keystone species, such as [illegible], and reductions in the presence of opportunistic species, such as [illegible]. Subtidal communities will have recovered when the community composition, age class distribution, population abundance of component species, and ecosystem functions and services in each injured subtidal habitat have returned to levels that would have prevailed in the absence of the oil spill.

certain crabs and others

Restoration Strategy

Conduct research to find out why some subtidal organisms are not recovering. Possible explanations include changes in the community structure resulting from spill induced changes in predators; changes in the population of benthic prey; and limitations in recruitment processes (the availability of new organisms to repopulate the area).

Initiate, sustain, or accelerate recovery. Once scientists determine why some subtidal organisms are not recovering, efforts may be undertaken to accelerate recovery.

Monitor recovery. Monitor subtidal organisms in Prince William Sound.

Protect subtidal organisms and their habitats. With regard to subtidal biota, the objective of habitat protection is to maintain water quality along the shoreline and reduce disturbance in nearshore areas. Subtidal organisms can also be protected by reducing marine pollution.

1

Andy
Bob
Steve

10-12 October

Andy's 3 things wrong

- counting animals to determine recovery w/o hard benchmarks
- agency management - how to avoid
- lack of a vision informed by recent decisions + results

- no new projects in '97?

Bald Eagles

* Recovering or Recovered? ✓
  - what happened in '95 population survey

* No further work by TC

Black Oystercatcher

* Recovering or Recovery Unknown? ✓

* Recovery objective — reproductive success is an indicator that recovery is occurring

* Strategy — change monitoring to indicate occasional? should "distribution" be deleted?

Clams

* Recovery Unknown - OK as status

Was there inquiry outside FWS

* Objective — Probably cannot ever know when recovery has occurred, ~~Strategy~~ * Strategy — should focus on enhancement @ near beaches important to people

Enhancement -?
where to bring in

(2)

Common Murres

* Change status from Not Recovery to Recovering on basis of productivity & timing
* Objective → timing & success are indicators of that recovery is occurring
* Strategy
  - kill 1st 2 item — research
    - accelerate
  - periodic monitoring

? - foxes — Sustain & Accelerate Recovery

Cutthroat Trout

ask Bob Sp.

* Recovery Unknown
  - Question degree of injury initially
* Recovery objective undefined because injury was fuzzy
* Strategy - research on life history gaps to enhance through management

are they going to some streams where NEPA work was done?

Dolly Varden

- same a cutthroat vis a vis status & objective
* Strategy - natural recovery & habitat protection only?

Wilderness Area

- eliminate 2nd sentence of strategy

Harbor Seal

OK — incorporate more uncertainty into discussion of status

Harlequin Duck

* Not recovering
* Objective — some version of Rosenberg + Bothe as per DPD [96-427]
* careful about use of oiled mussels as justification

Intertidal

* all "Recovering"
* Objective — - returns to "similar to" pre-spill levels
  - Indicators of recovery are
    - return of key spp
    - provision of food for top predators
* Strategy - eliminate 1st 2 item

Killer Whales

* Recovering or Recovered
* If Recovering, recast objectives to focus on overall numbers, not just A/B pod

Marbled Murrelet

- reconcile statements about lack of recovery under strategy w/statement about stabilizing or even increasing under injury & recovery
- objectives – "stable or increasing"
- eliminate "Initiate, sustain, or accelerate recovery."
- mention gillnets under protect murrelets
- get rid of reference to "disturbance" under protect marbled murrelets and their habitats

Mussels

* Objective – what is said about return to prepill populations + productivity doesn't seem to relate to injury
  - recovery when no abnormal concentration in mussel beds

21.1.3 B

DATE: 1995-10-17 TIME: 13:55
FROM: MHS:70724.2057@compuserve.com (Applied Marine Sciences)

X-MHSFile: AOACABEO
TO: MHS:stans@evro.usa.com
SUBJECT: Dave Bernard
PRIORITY:

ATTN: Stan Senner
Subject: Time:
10:14 AM
OFFICE MEMO Dave Bernard Date:
10/17/95
Stan:
Here's Dave's address and telephone number. Dave has a lot of experience with "big picture" issues relative to ecosystem management and restoration. In particular, he and I have discussed the issue of identifying benchmarks by which to judge the progress of oil spill restoration. This includes the idea of quantification of restoration objectives. He is currently working on restoration goals and objectives (benchmarks) for the Banff ecosystem for the Canadian government.

Dave is a peer reviewer, and one thing you might want to consider is having him examine an early draft of your re-write of Chapter 5, and then you spend a two hours with him discussing it. We could pay him for a few hours of his time. He may just be willing to meet with you, although I think we should be sensitive to using his expertise for free.

David Bernard
ESSA Technologies, Ltd
1765 West 8th Ave
Vancouver, BC V6J 5C6
CANADA
Wk: (604) 733-2996
Hm: (604)-947-0996
Fx: (604) 733-4657

Cheers.
Andy
(I'm in Livermore today and thursday, Oakland tomorrow and friday)

revisiting status of injured species

1. are some recovered? can we tell?
2. are we going to face a continuing barrage of amendments for pet species?
3. is there another paradigm for running the restoration program that fits w/in the settlement?

4 monitoring schedule

we don't have enough money to document the recovery of all species in a statistically significant manner.

what if we check once more before 2002 (a la coastal habitat)?

revisiting recovery objectives

1. are they worthwhile (see #1 above)?
2. quantify them?
3. process of changing them? reconvene the group that established them initially?

revisiting program objectives/directions

1. implicit in revising recovery objectives
2. revision (prioritization) of guiding principles in RPlan

to what

how?

by when?

3. what are the characteristics of the current program that need to be changed?
   a. counting animals to determine recovery w/o quantified benchmarks (unable to determine if we're meeting our goals)
   b. inability to determine if we're funding normal agency responsibilities
   c. lack of vision that is informed by recent findings/results (eg, late reports, funding before assimilating new data)
   d. inadequate synthesis, assessment, and conclusions about what the fuck happened
4. what characteristics are more appropriate?
   a. lasting benefit
   b. integrating post FY2002 planning into the present workplans
5. how do we make the change?

what if we fund no new projects in 97. just continuation/closeout, while we thing about all this?

Andy:

The following items could be the basis of a meeting of the core reviewers:

-refine recovery objectives to make them more realistic in terms of what reasonably can be achieved or known, given prior baseline data, etc.

-taking into account revised recovery objectives and the current work plan, map out objectives and priorities for '97 program. In doing so, we must-

-address question about how much more monitoring and to what ends, and

-define applied research questions that are fundamental to the legacy we want to leave

-this shaping of the '97 work plan should be done with the longer-term picture in mind, because it strongly influence the rest of the EVOS program

-this means that we must begin to think about uses of Restoration Reserve and the post-2001 program

The final day of the meeting should involve EVOS staff (e.g., Molly for sure, but also Bob, Eric, Sandra?).

At some point before the annual science meeting we need buy-in from work force and "team leaders" from among the PIs. Need to think about how to do.

In some form, the resulting ideas should be developed as discussion items for the annual science review. We can use the PIs as a sounding board on directions and priorities and to help flesh out areas of uncertainty.

The core reviewers and EVOS could reconvene following the science meeting and revisit the earlier thinking. The result should basically be the FY '97 (and beyond) Science Invitation

Sometime before that invitation goes out, however, we need buy-in from the Trustee Council.

Stan

DATE: 1995-07-21 TIME: 17:01
FROM: MHS:70724.2057@compuserve.com (Applied Marine Sciences)

X-MHSFile: BBCNAMEO
TO: MHS:stans@evro.usa.com
SUBJECT: a weak attempt...
PRIORITY:

ATTN: Stan Senner

	Subject:	Time: 4:53 PM
OFFICE MEMO	a weak attempt...	Date: 7/20/95

Here's a rough attempt to write down a rationale for why we need to have a meeting of staff and reviewers and what we propose to do there. I'm glad everybody seems to like the idea--now if we can only explain what we want to do_

The most effective way for the TC to achieve its mission is to undertake programs with the potential to provide lasting benefit to the resources, economy, and human population of the spill area. Projects that gather data on the population of a species with no other goal but counting and comparing to pre-spill levels really do provide much opportunity to generate lasting benefts, except in those instances where we can actually do something to influence those populations (e.g., hunting and fishing regulations). However, it can be cogently argued that in such instances the monitoring must be considered part of the agency mandate.

We are proposing to revise the restoration objectives, or possibly changing or prioritizing the "guiding principles" in the restoration plan. The rationale for this proposal is based on the propositions that (i) RP contains objectives that cannot be met because of lack of adequate baseline data, poor understanding of ecosystem processes, or inadequate opportunities for actual restoration (e.g., environmental manipulations), (ii) recovery of injured resources will go well beyond 2002, and we currently have no plan for managing the restoration reserve, (iii) inadequate priority has been given to processes that produce lasting/continuing benefits, therefore reducing the effectivness with which the TC can achieve its mission.

Now, after than weak presentation, a list of what we need to do:

1. revisit the guiding principles, and consider prioritizing them.
2. establish a set of draft principles for managing the restoration reserve.
3. establish a set of criteria for standard agency management functions.
4. do a lot of work on this memo.

DATE: 1995-06-26 TIME: 14:17
FROM: MHS:70724.2057@compuserve.com (Applied Marine Sciences)

X-MHSFile: AOBFDDCE
TO: MHS:stans@evro.usa.com
SUBJECT: Agenda
PRIORITY:

ATTN: Stan Senner
Agenda
Stan:

Here's my list of items for us to discuss on Friday. These are not in any order of priority.

1. Objectives, format, and schedule for annual meeting.
2. Restoration objectives:
   a. do we need to quantify them?
   b. do we need to revise some (eg, have killer whales recovered?)
3. Accepting journal articles as final reports; should we and how?
4. Monitoring schedule
   a. needs to be reviewed and blessed by peer reviewers
5. Residual oil workshop; a workshop to discuss
   a. shoreline assessment
   b. native claims of oiling; need to address oil spill residual
   c. mussel beds
   d. kodiak/AP shoreline issues
6. Interim funding of APEX through annual review
7. Scientific review sessions
   a. APEX
   b. SEA
   c. Genetics (requested by J. Seeb)
   d. when, how, where, who...
8. Restoration Program accomplishments
   a. need to summarize these for TC and public
   b. how to develop the list
9. The "big picture"
   a. Molly thinks we need to further develop a straightforward explanation of what we're doing and why.
   b. this can be developed out of the Pennoyer briefing

Let me know if you have other things to add to this.I'll need to drop you back at the airport on Friday around 6:30 pm

Andy

- Interim funding for APEX
  - who needs it

- Respond to Joe S re dates for Joint Science Review vis a vis hatchery matters

APPLIED marine SCIENCES

Stan - we should talk about this sometime. M.

May 3, 1995

TO: Molly McCammon
Executive Director

FROM: Andy Gunther
Assistant Chief Scientist

CC: Stan Senner
Bob Spies
Eric Myers
Bob Loeffler

RE: Quantifying Restoration Objectives for Assessing Success of EVOS Restoration Program

The purpose of this memorandum is to request your authorization to develop a proposal for quantifying the objectives of the Restoration Plan (the Plan). In FY02 the Trustee Council will have spent in excess of $700 million to restore the injuries caused by the oil spill. At that time, the success of the restoration program will be judged by whether the ecosystem has already recovered or is clearly recovering.

The Plan defines recovery objectives for each injured resource, and identifies these objectives as "...the yardsticks against which the success of the program is measured" (p.35). The recovery objectives in the Plan are not quantified, but instead take the form of semi-quantitative statements such as "return to pre-spill levels" or when "population trends are increasing significantly at index colonies" or "levels that would have prevailed without the oil spill." The only quantified recovery objective is for killer whales ("...when the injured pod grows to at least 36 individuals.")

Since the vast majority of recovery objectives are not quantified, determining whether injured resources or the ecosystem as a whole have recovered will be a subjective judgment. While scientific data will be available for consideration in this regard, there will be significant latitude for interpretation of this data relative to recovery. The obvious issues will be determining pre-spill populations given the lack of baseline data, and whether populations at unoiled control sites are representative of oiled locations. In addition, there are many other more subtle issues that will be part of judging recovery. For example, what sites should be used to determine if populations are recovering? What statistical procedures will be applied to determine if trends are significant? What is the influence of natural population fluctuations on recovery? Has the structure of ecosystem been altered due to natural or anthropogenic processes so that a return to pre-spill conditions is not possible or appropriate?

I recommend that the Restoration Program undertake an effort to quantify the restoration objectives. This will allow for objective determinations to be made of recovery, and will greatly facilitate preparation of the annual status report and revisions of the monitoring schedule. Quantified restoration objectives will also increase the accountability of the Restoration Program by establishing unambiguous benchmarks for judging the success of restoration, and should

make a major contribution toward establishing priorities for use of the restoration reserve. This effort will also put the Restoration Program at "the cutting edge" of environmental management. We would be able to draw on the experience of the States of Oregon (the Oregon Benchmarks program) and Minnesota (the Minnesota Milestones program), in addition to work underway in Canada. The process of establishing these objectives is likely to develop information useful to State and Federal agencies responsible for managing the natural resources of the spill area.

Obviously, quantifiable restoration goals cannot be established solely through objective scientific study, or consulting the scientific literature. We will in essence need to develop a "vision" for the ecosystem that is the result of consultations with stakeholders, scientists, and others to refine the goals and objectives in the restoration plan. We are already well along this path through the process of developing the Plan, and establishing quantifiable objectives (or benchmarks) is really the logical next step in the process of implementing the Plan. (These quantified objectives would be subject to revision as new information dictates.)

I would like request your approval to stop in Vancouver, British Columbia, on my way back from Alaska in late May to work with Dr. David Bernard of ESSA Technologies, Ltd., to develop a proposal for quantifying the objectives in the Plan. Dr. Bernard, who was the lead facilitator at the original SEA workshop in Cordova, is currently participating in an analogous effort in the Banff Valley for the Canadian Ministry of Parks. I believe Dr. Bernard's experience and expertise could be quite valuable in preparing a proposal. I would expect this proposal to include a brief description of the issue, a summary of the results of related efforts, a description of the methods to be used, and timeline with a budget. The timeline would place the project in the context of the FY96 Work Plan and other planned activities. For example, the Systematic Development of Informed Consent training you referred to in your recent memo could probably be fruitfully applied to an effort to draw together stakeholders, scientists, and natural resource managers to develop quantified restoration objectives.

MEMORANDUM State of Alaska

DEPARTMENT OF ENVIRONMENTAL CONSERVATION
EXXON VALDEZ OIL SPILL RESTORATION OFFICE

TO: Molly, Mark, Eric, Veronica, Sandra Byron, Bruce, Alex, Bob Spies

DATE: May 23, 1994

TELE: 278-8012

FROM: Bob Loeffler

FAX: 276-7178

SUBJECT: Recovery Status & Recovery Objective: Substantive Changes not in the *Invitation, Appendix A*

The letter distributing the *Invitation to Submit Restoration Projects* to the workshop participants included the following paragraph (underlining indicates my emphasis):

> You will probably notice that there are some differences between the workshop results and the information in the enclosure. Some participants suggested changes in the Recovery Status and Recovery Objective for a resource or service. (These are outlined in Appendix A of the *Invitation.*) These had previously been subjected to independent peer review. Most of the recommended changes clarified these objectives, and thus are included in the appendix. Those that substantively changed previous scientific conclusions are not included in this document but are being deferred pending further peer review. In some cases, you will receive a call asking for further information about your recommendation. This review process will be accomplished during the next several months.

This memo lists those objectives and status statements that we excluded (based on Bob Spies's recommendations). While no one has to do anything about them at this moment, I thought I'd better record them or I would lose track of which ones we excluded.

Recovery Objectives & Status Statements Needing Further Review
"Yes" means they were excluded from Appendix A of the *Invitation* that the PI version was

Resource or Service	Recovery Status	Recovery Objective
Archaeology	Yes	Yes
Bald Eagle	Yes	Yes
Black Oystercatcher	Yes	
Cutthroat Trout	Yes	
Dolly Varden	Yes	
Herring Bay Intertidal	See Note #1	See Note #1
Intertidal Organisms	Yes	Yes
Killer Whale	Yes	
Persistence of Oil	See Note #2	See Note #2
Persistence of Oil (Mussels)	See Note #2	See Note #2
Persistence of Oil (Subtidal)	See Note #2	See Note #2
Pigeon Guillemot		Yes
Pink Salmon		Yes
Sea Otters	Yes	Yes
Subtidal Organisms	Yes	

Note #1: Herring Bay Intertidal Organisms was submitted as a new recovery monitoring category and was not included in Appendix A.

Note #2: These were included in Appendix A, but they are new categories and have never been reviewed (or at least agreed-upon).

Archaeological Resources

Recovery Status: ~~Injury to archaeological resources stems from increased looting and vandalism of sites and artifacts, and erosion within and around the sites resulting from cleanup activities. In addition, archaeological artifacts may have been oiled. Injuries attributed to looting and vandalism still occur. These injuries diminish the availability or quality of scientific data and opportunities to learn about the cultural heritage of people in the spill area.~~ Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. The standard restorative approach to archaeological sites in federal law (e.g., ARPA) is through compensation of loss through data recovery combined with other mitigative actions (e.g., site stabilization, education, site patrols).

Recovery Objective: Archaeological resources will be considered recovered when spill-related injury ends; looting and vandalism are at or below pre-spill levels; and upon completion of the necessary compensatory data recovery (including analysis and report-writing in accordance with professional, federal, and state legal standards) and/or other mitigative actions. ~~Restoration cannot regenerate what has been destroyed, but it can prevent further degradation of both sites and the scientific information that would otherwise be lost.~~

Bald Eagles

Recovery Status: ~~Two hundred to 300~~ Up to 900 bald eagles may have been killed ~~in the spill~~ throughout the spill area. ~~However, p~~Population estimates made in 1989, 1990, and 1991 indicate that there ~~may have been an~~ was not a significant increase in the PWS bald eagle population since the previous survey conducted in ~~1984.~~1982. Productivity ~~decreased~~ of Prince William Sound eagles was low in 1989, but appeared to have recovered by 1990.

Recovery Objective: ~~Because population and productivity appear to have returned to pre-spill levels, bald eagles may have already recovered from the effects of the spill.~~ Bald eagles will have recovered when Prince William Sound population trends are stable or increasing compared to previous data and productivity is within normal bounds.

Black Oystercatcher

Recovery Status: ~~Black Oystereatchers are~~ The oiled population of black oystercatchers has not yet recovered. Productivity of black oystercatchers is recovering, although chick growth rates are still low in the oiled area. Oystercatchers may still be exposed to hydrocarbons when feeding in intertidal areas.

Cutthroat Trout

Recovery Status: Cutthroat trout have grown more slowly in oiled areas than in unoiled areas. ~~Insufficient data are available to determine whether they are recovering.~~

Dolly Varden

Recovery Status: Dolly Varden have grown more slowly in oiled areas than in unoiled areas. ~~Insufficient data are available to determine whether they are recovering.~~

"Herring Bay Intertidal Organisms" is a new category

Herring Bay Intertidal Organisms

Recovery Status: The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult Fucus in large numbers.

Recovery Objective: Intertidal communities in the upper intertidal zone will have recovered when community composition, population abundance of component species, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.

RECOVERY MONITORING STRATEGY: The strategy for this area represents a mix of recovery monitoring activities and activities to determine processes limiting recovery. The recovery monitoring component represents a minimal addition to the costs of the restoration research component which needs to be done on an annual basis. The recovery monitoring component should only be carried out if the restoration research component is conducted. The recovery monitoring provides a general control for the array of research activities.

Monitoring Schedule: Annual

Estimated Recovery Time: Unknown

Intertidal Organisms

Recovery Status: Some species showed evidence of recovery but intertidal as a whole had not recovered as of the last sampling in 1991, in any habitat or region studied.

Recovery Objective: ~~For each intertidal elevation (lower, middle, or upper)~~ Intertidal communities in the upper intertidal zone will have recovered when community composition, population abundance of component species, ~~age class distribution~~ and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.

Killer Whales

Recovery Status: ~~Thirteen whales disappeared from one pod in Prince William Sound between 1988 and 1990. The injured pod is growing again.~~ Fourteen killer whales disappeared from the resident AB pod in Prince William Sound between 1989 and 1991. In 1992 and 1993, no additional whales were reported as missing. No additional whales were reported as missing. No births occurred in 1989 and 1990. A total of four calves have been born into AB pod since 1991 (one in 1991, two in 1992, and one in 1993). In 1988, the pod contained 36 whales; in September 1993 the pod contained 26 whales. The injured pod is growing again.

All New

Persistence of Oil (Intertidal Sediments, Mussels)

Oil itself is not an injured resource or service. It is the cause of the injuries. Monitoring the fate and persistence of oil in the environment including location, concentration, and toxicity provides foundation monitoring for remaining oil contamination in the ecosystem. It also provides specific recovery monitoring for continued contamination in sediments and mussels.

Recovery Status:

- *Prince William Sound.* Limited shoreline surveys and limited clean-up work occurred in 1991, 1992, and 1993. The surveys indicated that subsurface oil remained at many sites that were heavily oiled in 1989.

  In 1993, shoreline assessment surveys were conducted at over 75 sites in Prince William Sound. They found that oil residue was present at most sites and sheening occurred at some. They also found that surface oiling has become very stable. There was no measurable reduction in surface asphalt and surface oil residue from 1992 to 1993. Subsurface oiling, on the other hand, has decreased substantially since 1991. Overall, the amount of subsurface oil found at the study sites in 1993 is about 45% of the amount found in the same areas in 1991.

- *Kodiak.* No sites have been surveyed on Kodiak Island since 1990.

- *Alaska Peninsula.* No general assessment work has been done since 1990. Five study sites were established in 1992 to examine the persistence and degradation of oil along national park coast lines. Those sites will be revisited in 1994. The 1992 observations indicate a continuing presence of oil at those sites.

- *Cook Inlet and Outer Kenai Coast.* Only limited assessment work has been done since 1990. A study site was established in 1992 to examine the persistence and chemical degradation of oil along national park coast lines. That site will be revisited in 1994. The 1992 observation indicates a continuing presence of oil at that site.

Recovery Objective: With respect to residual oil contamination, recovery has been achieved when remaining oil concentrations are reduced to a level comparable to pre-spill levels.

Persistence of Oil (Mussel Beds)

Recovery Status: Mussels themselves are an injured resource, both from the recreational and subsistence view plus possibly being the vehicle for transferring petroleum hydrocarbons to higher consumers. High concentrations of petroleum PAH's remain evident in some mussel beds within Prince William Sound (PWS), and preliminary results indicate contaminated beds outside PWS also.

Recovery Objective: Recovery will be complete when sediment PAH concentrations have declined to pre-spill concentrations.

RECOVERY MONITORING STRATEGY: Beds identified as contaminated should be monitored no more than once every three years. In order to maintain a level effort of work, one-third of these beds could be monitored each year.

Persistence of Oil (Subtidal Sediments)

Recovery Status: **All New** Subtidal organisms living in or on sediments and demersal fish that forage in subtidal sediment habitats maybe exposed to the petroleum hydrocarbons that may be contaminating the sediments. In 1991, shallow subtidal PAH composition patterns consistent with that of weathered *EXXON VALDEZ* oil (EVOS) were found mainly at Northwest Bay in the depth range 3 - 20 m. Reduced concentrations of EVO were found at some shallow water stations in Bay of Isles, Herring Bay, and Snug Harbor. Data in 1992 and 1993 on the fish exposed showed evidence of continued contamination.

Recovery Objectives: ~~Sediments whose contaminants, if any, causes no negative effects to the spill-affected ecosystem.~~ Subtidal sediments will have recovered when concentrations of petroleum hydrocarbons in shallow (0 - 20 m) sediments approximate the petrogenic background concentration that prevailed prior to the *EXXON VALDEZ* oil spill and petroleum exposure indices in biota from oiled sites are similar to indices in biota from non-oiled sites.

Pigeon Guillemot

Recovery Objective: Pigeon guillemots will have recovered when the Prince William Sound show an increasing trend. ~~populations are stable or increasing~~.

Pink Salmon

Recovery Objective: Pink salmon will have recovered when populations are healthy and productive. ~~and exist at prespill abundance (an indication of recovery is when egg mortalities in oiled areas match prespill level or levels in unoiled areas.)~~ Indicators of recovery are (1) egg survivals in oiled areas are equivalent to prespill levels or levels in unoiled areas; and (2) pink salmon escapement goals are met and returns per spawner equals or exceeds the prespill historic average.

Sea Otters

Recovery Status: ~~Sea otters do not appear to be recovering, but are expected to eventually recover to their prespill population. Exactly what population increases would constitute recovery is very uncertain, as there is no population data from 1986 to 1989, and the population may have been increasing in Eastern Prince William Sound during that time. In addition, only large changes in the population can be reliably detected with current measuring techniques. However, there are recent indications that the patterns of juvenile and mid-aged mortalities are returning to prespill conditions.~~ Sea otters do not appear to be recovering in all areas affected by the spill. They may have suffered sublethal effects and may be receiving continued exposure to residual oil. Although injuries appear to be subsiding (based on mortality rates and patterns), recovery has not been demonstrated. An additional concern is the apparent limited reoccupation by sea otters of heavily-impacted habitat.

Recovery Objective: ~~Sea otters will be considered recovered when population abundance and distribution are comparable to prespill abundance and distribution, and when all ages appear healthy.~~ Sea otter recovery will be assumed when no significant changes in abundance are detected over five surveys in the heavily oiled area and when densities do not differ between heavily oiled and non-oiled areas and when mortality patterns appear normal.

Subtidal Organisms

Recovery Status: Through 1991, certain subtidal organisms, like eelgrass and some species of algae, appeared to be recovering. Other subtidal organisms, like leather stars and helmet crabs showed little signs of recovery ~~through 1991~~. Recent observations suggest that eelgrass habitat may not be recovering.

Injured Resource: Harbor Seals

Lead Agency: ADF&G

Recovery Status: Harbor seal numbers were declining in Prince William Sound (PWS) before the spill. Following the spill, seals in the oiled area had declined 43%, compared to 11% in the unoiled area. Counts made during the molt at trend count sites in Prince William Sound during 1990-1993 indicate that numbers may have stabilized. However, counts during pupping have continued to decline. It is not known which counts are the best indicator of population status. If the conditions that were causing the population to decline before the spill have improved, normal growth may replace the animals that were lost. However, if conditions continue to be unfavorable, the affected population may continue to decline. Harbor seals are a key subsistence resource in PWS and subsistence hunting is both affected by and may be affecting harbor seal status.

Recovery Objective: Recovery will have occurred when harbor seals within the oiled area are at a population level comparable to that which would likely have occurred in the absence of the spill.

Recovery Monitoring Strategy: Aerial surveys of 25 trend count sites in PWS will be conducted during pupping and molting for comparison with previous years' data.

Monitoring Schedule: Aerial surveys will be conducted annually for the next 2 years. Periodicity of monitoring will be reevaluated after 1996, in light of population trend and indications of recovery. To date, it is not clear whether the population has stabilized in PWS or is continuing to decline. This species has declined more than 50% throughout the northern Gulf of Alaska and PWS in the last decade, and has a very high political profile. It is currently being considered for listing as depleted under the Marine Mammal Protection Act. Data on current population status are necessary to avoid unnecessary regulation of fisheries in PWS and to provide information to subsistence hunters that will allow them to make informed decisions about levels of harvest. This monitoring program is very inexpensive to conduct

Estimated Recovery Time: Unknown. If the ongoing decline was caused by food limitation or other unidentified factors that continue to be limiting, the population (including that segment that was damaged by the oil spill) may not recover.

From PIs, following publication of Chpt. 5

Injured Resource: Killer Whales

Lead Agency: NOAA

Recovery Status: Fourteen killer whales disappeared from the resident AB pod in Prince William Sound between 1989 and 1991. In 1992 and 1993, no additional whales were reported as missing. No additional whales were reported as missing. No births occurred in 1989 and 1990. A total of four calves have been born into AB pod since 1991 (one in 1991, two in 1992, and one in 1993). In 1988, the pod contained 36 whales; in September 1993 the pod contained 26 whales. The injured pod is growing again.

Recovery Objective: Killer whales will have recovered when the injured pod grows to at least 36 individuals (1988 level).

Recovery Monitoring Strategy: Photographs of individual killer whales occurring in AB pod will be collected to document natural recovery. Because AB pod whales frequently associate with other Prince William sound resident killer whale pods (approximately 80% of all encounters), it is necessary to photograph all killer whale pods/individuals encountered during field research in Prince William Sound.

Monitoring Schedule: Field research every two years will allow us to keep track of new births by year and record regrowth of the pod. Natality and mortality rates will be conservative biennial estimates, and missing whales will not be confirmed as dead until two years after they are first missing.

Estimated Recovery Time: Recovery of AB pod to pre-spill levels (36 whales) could take ten to fifteen years given the current age and sex structure of the population.

Injured Resource: Sea Otters

Lead Agency: USFWS

Recovery Status: Sea otters do not appear to be recovering in all areas affected by the spill. They may have suffered sublethal effects and may be receiving continued exposure to residual oil. Although injuries appear to be subsiding (based on mortality rates and patterns), recovery has not been demonstrated. An additional concern is the apparent limited reoccupation by sea otters of heavily-impacted habitat.

Recovery Objective: Sea otters will be assumed when no significant changes in abundance are detected over five surveys in the heavily oiled area and when densities do not differ between heavily oiled and non-oiled areas and when mortality patterns appear normal.

Recovery Monitoring Strategy: The recovery monitoring program will track abundance and mortality of sea otters in oiled areas.

Abundance: Aerial surveys of sea otter abundance in areas of Prince William Sound most heavily impacted by the oil spill (areas around northern Knight Island and Naked Island) and in non-oiled areas of western PWS will be conducted in 1995 and 1997 and thereafter only if the number of sea otters in oiled areas remains lower than anticipated. Data on sea otter abundance collected as part of the seabird boat surveys will continue to be collected in the process of monitoring seabirds (at no extra cost to either the seabird or sea otter projects), and will be used to augment the aerial survey data on sea otter abundance in oiled areas. However, the aerial surveys have been developed specifically to provide accurate counts of sea otters whereas the boat surveys have been shown to be biased in their estimates. Thus data collected in the boat surveys will be relied upon only as supplementary information.

Mortality: Sea otter carcasses will be collected in oiled areas of Prince William Sound (the Green Island area) in the spring of 1995 and 1996. Ages of the otters at the time of death can be determined from the skulls. Pre-spill data on carcasses from this area indicated the proportion of prime-age otters in the carcass sample is normally low. However, mortality of prime-age otters was high post-spill, through 1991. Since then, mortality patterns appear to be returning to normal. Two more seasons of carcass collection will allow us to confirm that mortality patterns in the population are similar to prespill. An advantage of assessing mortality through collection of carcasses is that the work can be completed in a short time at a relatively low cost.

Monitoring Schedule:

1995	Aerial surveys, Carcass collection
1996	Carcass collection
1997	Aerial surveys
1998	Only if data collected in 1996 suggests recovery is not occurring
1999	Aerial surveys, if needed

2001 Aerial surveys, if needed

Monitoring Schedule Justification:
Unusually low densities of sea otters have been observed in heavily oiled areas of PWS and no increases have been detected since the spill. Maximum annual growth rates in sea otter populations are 0.21. Based on an estimated annual increase of 0.10 and α and ß = 0.20, a significant difference between two bi-annual surveys could be detected. If the annual change is 0.05, three surveys (1995, 1997, 1999) would be required to detect statistical significance.

Estimated Recovery Time: Unknown. No increase in population size has been observed since the spill.

Injured Resource: River Otters

Lead Agency: ADF&G

Recovery Status: River otters have suffered sublethal effects from the spill and continuing exposure to hydrocarbons.

Recovery Objectives: Indications of recovery are when habitat use food habitats and physiological indices have returned to prespill conditions.

Recovering Monitoring Strategy: Monitor latrine sites for use by otters and reestablish use of abandon sites to indicate populations recovery. Monitor species composition in feces to document return to prespill composition.

Monitoring Schedule: Two field trips yearly early summer and late summer.

Estimated Recovery Time: River otters are long-lived species best case scenario - 15 years.

Injured Resource: Bald Eagles

Lead Agency: USFWS

Recovery Status: Up to 900 bald eagles may have been killed in the spill. However, population estimates made in 1989, 1990, and 1991 indicate that there may have been an increase in the PWS bald eagle population since the previous survey conducted in 1984. Productivity decreased in 1989, but appeared to have recovered by 1990.

Recovery Objective: Because population and productivity appear to have returned to prespill levels, bald eagles may have already recovered from the effects of the spill.

Recovery Monitoring Strategy: Aerial surveys of Prince William Sound were used before and after the spill to estimate population size and productivity. The PWS eagle population was expected to increase to its pre-spill level by 1994. Aerial surveys should be conducted in 1995 and at intervals of 5 years until the population and productivity reaches pre-spill levels. There were not enough pre-spill data on eagle populations in other parts of the spill area to warrant surveys outside PWS.

Monitoring Schedule: A PWS population survey should be conducted every 5 years starting in 1995

Estimated Recovery Time: 5 years.

Injured Resource: Black Oystercatcher

Lead Agency: USFWS

Recovery Status: The oiled population of black oystercatchers has not yet recovered. Productivity of lack oystercatchers is recovering, although oystercatchers may still be exposed to hydrocarbons when feeding in intertidal areas.

Recovery Objective: Black oystercatchers will have recovered when Prince William Sound populations attain prespill levels and when reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas.

Recovery Monitoring Strategy: Population abundance and distribution in Prince William Sound will be monitored during boat surveys for marine birds and mammals.

Monitoring Schedule: Population abundance and distribution will be monitored every three years during the boat surveys for marine birds.

Estimated Recovery Time: Unknown

Injured Resource: Common Murres

Lead Agency: USFWS

Recovery Status: Productivity of common murres show signs of recovery at the Barren Islands but numbers have not returned to pre-spill levels.

Recovery Objective: Common murres will have recovered when populations are increasing at index colonies and when reproductive timing and success are within normal bounds.

Recovery Monitoring Strategy: Populations at the Chiswell Islands, Barren Islands, Triplets, Ugaiushak Island and Puale Bay, all within the spill area, will be surveyed once every 3 years to determine if populations have recovered. Productivity will be monitored annually for five years at the Barren Islands to insure it is normal.

Monitoring Schedule: A complete population survey of injured colonies (see above) should be conducted every three years starting in 1996. Reproductive studies will be continued annually for five years, then terminated if productivity is normal.

Estimated Recovery Time: 15-70 years

Injured Resource: Harlequin Ducks

Lead Agency: ADF&G

Recovery Status: There are indications of population decline and possibly reproductive failure.

Recovery Objective: Harlequin ducks will have recovered when populations have returned to prespill levels, or when differences between oiled and unoiled areas are eliminated.

Recovery Monitoring Strategy: Breeding populations in the eastern a nd western PWS should be conducted in June and productivity surveys should be conducted in July.

Monitoring Schedule: Population surveys should be done every 3 years starting in 1995. Productivity surveys should be done annually for at least five years.

Estimated Recovery Time: 30-50 years

Injured Resource: Marbled Murrelet

Lead Agency: USFWS

Recovery Status: Marbled murrelet populations in Prince William Sound were in decline before the spill and may not attain pre-spill population levels. The causes of the pre-spill decline are unknown.

Recovery Objective: Marbled murrelets will have recovered when population trends are increasing.

Recovery Monitoring Strategy: Estimate the Prince William Sound marbled murrelet population in summer using boat surveys.

Monitoring Schedule: Boat surveys of Prince William Sound bird populations should be conducted in the summer every three years starting in 1996.

Estimated Recovery Time: Unknown.

Injured Resource: Pigeon Guillemot

Lead Agency: USFWS

Recovery Status: The pigeon guillemot population in Prince William Sound was in decline before the spill and may not attain prespill population levels. The causes of the prespill decline are unknown.

Recovery Objective: Pigeon guillemots will have recovered when populations are increasing.

Recovery Monitoring Strategy: Estimate the Prince William Sound pigeon guillemot population in winter and summer using boat surveys. Continue June counts of pigeon guillemots attending colonies on Naked, Peak, Storey, Smith and Little Smith islands. The Naked Island area supports >25% of Prince William Sound guillemots, and pre-spill and post-spill counts of the Naked Island area population provide excellent data for determining population trend. These data will provide an independent source of information to confirm trends found in the boat surveys.

Monitoring Schedule: Boat surveys of Prince William Sound bird populations should be conducted in winter and summer every three years starting in 1996. June counts of guillemots in the Naked Island area should be conducted every three years.

Estimated Recovery Time: Unknown.

Injured Resource: Cutthroat Trout

Lead Agency: ADF&G

Recovery Status: Cutthroat trout have grown more slowly in oiled areas than in unoiled areas.

Recovery Objective: Cutthroat trout will have recovered when growth rates within oiled areas are comparable to those for unoiled areas.

Recovery Monitoring Strategy: Monitor growth rates in injured populations to determine when the recovery objective has been met. Analysis of scale or otolith growth patterns may be a cost-effective approach to comparing current and past growth histories.

Monitoring Schedule: Every three years, continued at least one interval after the recovery objective has been met.

Estimated Recovery Time: Unknown.

Injured Resource: Dolly Varden

Lead Agency: ADF&G

Recovery Status: Dolly Varden have grown more slowly in oiled areas than in unoiled areas.

Recovery Objective: Dolly Varden will have recovered when growth rates within oiled areas are comparable to those for unoiled areas.

Recovery Monitoring Strategy: Monitor growth rates in injured populations to determine when the recovery objective has been met. Analysis of otolith growth patterns may be a cost-effective approaches to comparing current and past growth histories.

Monitoring Schedule: Every three years, continued at least one interval after the recovery objective has been met.

Estimated Recovery Time: Unknown

Injured Resource: Pacific Herring

Lead Agency: ADF&G

Recovery Status: Pacific herring studies have demonstrated egg mortality and larval deformities. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, the stocks and dependent fisheries in Prince William Sound are not healthy, as indicated by the low spawning biomass in 1993 and 1994 and the resultant elimination of the fisheries in those years.

Recovery Objective: Pacific herring will have recovered when populations are healthy and productive and exist at prespill abundances.

Recovery Monitoring Strategy: Monitor fish health and spawning biomass. Annual monitoring for fish health status will begin in 1994. Estimation of spawning biomass will require support of annual spawn deposition survey to supplement normal ADF&G data collection.

Monitoring Schedule: Annual monitoring until recovery objectives have been met, that is when a healthy, strong year-class has recruited into the spawning population. Continued annual monitoring for four additional years (one recruitment cycle) beyond meeting the recovery objectives to ensure recovery has been achieved.

Estimated Recovery Time: Unknown; no sooner than 1996 (1992 year-class), which will require annual monitoring until at least 2000.

Injured Resource: Pink Salmon

Lead Agency: ADF&G

Recovery Status: Pink salmon studies have demonstrated egg mortality, fry deformities, and reduced growth in juveniles. Populations may have declined, but there is uncertainty as to the full extent and mechanism of injury. However, there is evidence of continued damage in some stocks from exposure to oil, and there has been a precipitous decline to both wild and hatchery stocks of pink salmon in Prince William Sound since 1991.

Recovery Objective: Pink salmon will have recovered when populations are healthy and productive. Indicators of recovery are (1) egg survivals in oiled areas are equivalent to prespill levels or levels in unoiled areas; and (2) pink salmon escapement goals are met and returns per spawner equals or exceeds the prespill historic average.

Recovery Monitoring Strategy: (1) Annual monitoring of egg mortality in a standardized set of oiled and non-oiled streams. (2) Monitoring of escapements and return per spawner productivity. ADFG routinely monitors escapements throughout PWS as part of its management program; an additional increment of stock separation in the commercial fishery is necessary to accurately determine hatchery/wild stock fishery contributions, in order to estimate returns per spawner. This additional increment may be provided by higher-resolution management activities required as general restoration activity to ensure adequate escapement of impacted populations of pink salmon.

Monitoring Schedule: Annual monitoring until recovery objectives have been met, and for the subsequent generation (two years) after recovery objectives have been met to ensure recovery has been achieved.

Estimated Recovery Time: Unknown; at least two generations, depending on the mechanism of damage to reproductive success.

Injured Resource: Rockfish

Lead Agency: ADF&G

Recovery Status: Rockfish were exposed to hydrocarbons and showed sublethal effects. Furthermore, closures to salmon fisheries increased fishing pressures on rockfish which may be affecting their population. However, the extent and mechanism of injury to this species are unknown.

Recovery Objective: Without further study, recovery cannot be defined.

Recovery Monitoring Strategy: No monitoring strategy can be determined without definition of a recovery objective. Synthesis of NRDA studies and other data on PWS rockfish needed, with recommendations for recovery objective and monitoring approach a requirement of the synthesis project.

Monitoring Schedule: None.

Estimated Recovery Time: Unknown.

Injured Resource: Sockeye Salmon

Lead Agency: ADF&G

Recovery Status: Sockeye salmon in Red Lake, Akalura Lake, and lakes in the Kenai River system declined in population because of adult overescapement in 1989. The Red Lake system may be recovering because the plankton has recovered, and fry survival improved in 1993. However, Akalura Lake and Kenai River Lakes have not recovered ; smolt production has continued to decline from these lakes. In the Kenai River lakes, for example, smolt production has declined from 30 million in 1989 to 6 million in 1990, and to less than 1 million in 1992 and 1993.

Recovery Objective: Sockeye salmon in the impacted lakes will have recovered when populations are able to support overwinter survival rates and smolt outmigrations comparable to prespill levels.

Recovery Monitoring Strategy: In Red Lake and Akalura Lake, monitoring of smolt outmigrations. In Kenai River lakes, monitoring of fall fry abundance and smolt abundance to estimate overwinter survival and smolt production.

Monitoring Schedule: Annually until recovery objectives have been met, and for two subsequent years after smolt productivity has returned to normal. Thus two more years of monitoring at Red Lake are required to confirm recovery, while at least seven years of monitoring will be necessary at Kenai and Akalura Lake to monitor productivity through returns of year-classes damaged by spill-induced overescapements.

Estimated Recovery Time: For Akulara Lake and Kenai River lakes, recovery time is unknown, but is a minimum of seven years. Red Lake may be considered fully recovered in two years.

Injured Resource: Archeological Resources

Recovery Status: Archeological resources are nonrenewable: they cannot recover in the same sense as biological resources. The standard restorative approach to archeological sites in federal law (e.g., ARPA) is through compensation of loss through data recovery combined with other mitigative actions (e.g., site stabilization, education, site patrols).

Recovery Objective: Archeological resources will be considered recovered when spill-related injury ends; looting and vandalism are at or below prespill levels; and upon completion of the necessary compensatory data recovery (including analysis and report-writing in accordance with professional, federal, and state legal standards) and/or other mitigative actions.

Recovery Monitoring Strategy:
Background: The current evidence suggests that a majority of the archeological site vandalism that can be either directly or indirectly linked to the *Exxon Valdez* oil spill event occurred in 1989 before adequate constraints were put into place over the activities of oil spill cleanup personnel. Most of this vandalism took the form of prospecting for sites with high artifact yields. Numerous small holes, from 0.5 to 2.0 meters in size, were dug by vandals in 17 known sites (projections based on existing data suggests that about 100 additional sites were similarly vandalized).

Evidence of vandalism dropped dramatically after 1989, most probably reflecting the more effective archeological constraint system that had been put into place by the participating agencies, with the cooperation of Exxon Corp., by the late summer of 1989. This apparent drop in vandalism was unexpected and at first suggested that continued vandalism related to the *Exxon Valdez* spill event might not be a significant future concern. However, based on what we know about the behavior patterns of archeological looters, the activity focus of vandals may have shifted (or will shift) from general prospecting to a more focused pattern of looting at a select number of high-yield archeological sites that were identified by looters during the initial "prospecting" phase, or simply observed by more discrete potential looters engaged in cleanup operations in the post-1989 era. Artifact hunters are most likely to act on the opportunities presented by this knowledge in the next 15 years while their memories remain fresh; thereafter, the threat should gradually drop as the information loses "immediacy" and specificity.

A second oil-spill factor may greatly increase the likelihood that looter knowledge gained in the oil-cleanup period might be activated at any time at high-yield sites. The injury to commercial and subsistence species (e.g., harbor seals and herring) may create conditions of economic depression in several Gulf of Alaska communities that will increase the temptation to turn to commercial archeological looting as an alternative source of income to make up for the income loss in other sectors. (Note: Loss of subsistence species forces users to use limited cash to purchase food and other products.) Studies of the economics of archeological looting in Utah and elsewhere, such as St. Lawrence Island have shown that commercial digging increases in communities that are experiencing economic downturns.

Another compelling reason to be concerned is that demand for Alaskan archeological materials is at an all-time high by art dealers, jewelers, and even knife makers. The prices of single slate ulus now approach $500 at certain galleries; rare pieces of ivory and bone may be sold for over $100,000.

Strategy: Archeological monitoring of archeological sites injured by the spill or spill-related activities will target a small number of sites which are determined to represent those that are most vulnerable to serious, commercial looting. There will be two categories of sites scheduled for continued monitoring. The first group, or index group, will consist of 4 known sites that will be monitored on a yearly basis for signs of vandalism. The selection of these sites will be based on their potential vulnerability to pot hunting and will be independent of jurisdiction. That is, no attempt will be made to distribute index sites equally by political jurisdiction or agency jurisdiction. One or two of these sites will also be selected for continued hydrocarbon monitoring so the behavior and effect of oiling can be observed over the long term in archeological deposits. A second group of 4 sites will be selected for monitoring, but on a biannual basis. This second group of sites may vary over time in order to maintain flexible response to new information such as fresh reports of vandalism or new findings on patterns of looting. The second group of sites provides a cross-check to monitoring data collected at the index sites. By focusing annual monitoring on 4 index sites and using a 2-year monitoring schedule on the additional 4 "cross-check" sites, expenditures would be kept to a minimum, but at a level that would still provide adequate tracking of vandalism trends over the years.

Because baseline data have already been collected on the sites that would be monitored, local people and communities will be included in the monitoring effort whenever possible. Agency archeologists will serve as managers of the monitoring effort and conduct any specialized or difficult monitoring actions. This local involvement will also serve as a social mechanism for discouraging certain individuals from engaging in looting by encouraging the growth of cultural pride and heritage knowledge in the communities. Guidance for obtaining local participation will be sought in the results of the initial phase of the already funded "Community Archeological Site Protection Plans Project." The first phase of this project, which will outline an effective approach for the involvement of local communities in archeological protection, will be completed by the Office of History and Archaeology, State of Alaska, by September/October 1994. In order to avoid duplication of effort, every effort will be made to coordinate and integrate the archeological monitoring program with the community archeological protection activities.

Monitoring Schedule: Monitoring of index sites will occur on a yearly basis. This schedule is necessary to interdict vandalism before the damage has become severe and to insure that all signs of vandalism would be visible (e.g., unvegetated ground). The second group of sites will be monitored on a biannual basis which should be sufficient to identify at least the majority of vandalism indicators before they are hidden by vegetation. If monitoring indicates a strong recovery trend by the year 2000, the monitoring interval for index sites can shift to every two years and the interval for the second group to every four years.

Estimated Recovery Time: Recovery will have been achieved when all vandalism that was stimulated by the *Exxon Valdez* oil spill has ceased and any required data recovery actions (e.g., professional excavation of looted site areas) or other mitigative actions (e.g., stabilization of vandalized site areas) designed to address documented injury have been completed. The best professional judgement estimates the achievement of recovery by the year 2020. This period of time should see the present generation of archeological looters disappear, hopefully discouraged by local community education programs, site protection programs, and the social pressures created by a citizenry having a sense of "ownership" and pride in their archeological heritage. In addition, a thirty-year span should result in the dissipation of any remaining oil contamination in archeological deposits.

Injured Resource: Intertidal Organisms

Lead Agency: ADF&G

Recovery Status: Some species showed evidence of recovery but intertidal as a whole had not recovered as of the last sampling in 1991, in any habitat or region studied.

Recovery Objective: Intertidal communities in the upper intertidal zone will have recovered when community composition, population abundance of component species, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.

Recovery Monitoring Strategy: Monitor selected matched oiled and non-oiled (control) sites throughout the spill area, incorporating a variety of habitats in each region. To validate the inference of recovery for the matched-pair design, matched non-oiled sites should be monitored also.

Monitoring Schedule: Monitor Prince William Sound paired sites in 1995 and 1997. Monitor Cook Inlet/Kenai Peninsula and Kodiak/Alaska Peninsula in 1996 and 1998. Further monitoring cycles should be dependent upon results of initial four years. Approximately one-half of the site pairs would be within Prince William sound and the other one-half in the other two regions combined. Because of the matched-pair design and the need to make comparisons within regions, (which were shown to differ), a two-year monitoring cycle is necessary. This monitoring strategy provides continuity and level effort between years.

Estimated Recovery Time: Unknown

Injured Resource: Herring Bay Intertidal Organisms

Lead Agency: ADF&G

Recovery Status: The lower intertidal zone and, to some extent, the middle intertidal zone are recovering. However, injuries persist in the upper intertidal zone, especially on rocky sheltered shores. Recovery of this zone appears to depend, in part, on the return of adult Fucus in large numbers.

Recovery Objective: Intertidal communities in the upper intertidal zone will have recovered when community composition, population abundance of component species, and ecosystem functions and services in each injured intertidal habitat have returned to levels that would have prevailed in the absence of the oil spill.

Recovery Monitoring Strategy: The strategy for this area represents a mix of recovery monitoring activities and activities to determine processes limiting recovery. The recovery monitoring component represents a minimal addition to the costs of the restoration research component which needs to be done on an annual basis. The recovery monitoring component should only be carried out if the restoration research component is conducted. The recovery monitoring provides a general control for the array of research activities.

Monitoring Schedule: Annual

Estimated Recovery Time: Unknown

Injured Resource: Clams

Lead Agency: ADF&G

Recovery Status: Littleneck clams and butter clams on sheltered beaches were killed by oiling and clean-up activities. In addition, growth appeared to be reduced by oil, but determination of sublethal or chronic effects is awaiting final analyses.

Recovery Objective: Clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill (prespill data or non-oiled control sites).

Recovery Monitoring Strategy: Sample paired oiled and non-oiled (control) clam beds. Measures should be density and size-frequency distribution. Random sampling design within sites. Number and location of study sites to be determined from agency data and local subsistence usage. Consider sites throughout spill impact area.

Monitoring Schedule: Conduct one comprehensive study and then evaluate need for further monitoring.

Estimated Recovery Time: unknown

Injured Resource: Persistence of Oil (Intertidal Sediments, Mussels)

Lead Agency: ADEC

Oil itself is not an injured resource or service. It is the cause of the injuries. Monitoring the fate and persistence of oil in the environment including location, concentration, and toxicity provides foundation monitoring for remaining oil contamination in the ecosystem. It also provides specific recovery monitoring for continued contamination in sediments and mussels.

Recovery Status:

- *Prince William Sound.* Limited shoreline surveys and limited clean-up work occurred in 1991, 1992, and 1993. The surveys indicated that subsurface oil remained at many sites that were heavily oiled in 1989.

  In 1993, shoreline assessment surveys were conducted at over 75 sites in Prince William Sound. They found that oil residue was present at most sites and sheening occurred at some. They also found that surface oiling has become very stable. There was no measurable reduction in surface asphalt and surface oil residue from 1992 to 1993. Subsurface oiling, on the other hand, has decreased substantially since 1991. Overall, the amount of subsurface oil found at the study sites in 1993 is about 45% of the amount found in the same areas in 1991.

- *Kodiak.* No sites have been surveyed on Kodiak Island since 1990.

- *Alaska Peninsula.* No general assessment work has been done since 1990. Five study sites were established in 1992 to examine the persistence and degradation of oil along national park coast lines. Those sites will be revisited in 1994. The 1992 observations indicate a continuing presence of oil at those sites.

- *Cook Inlet and Outer Kenai Coast.* Only limited assessment work has been done since 1990. A study site was established in 1992 to examine the persistence and chemical degradation of oil along national park coast lines. That site will be revisited in 1994. The 1992 observation indicates a continuing presence of oil at that site.

Recovery Objective: With respect to residual oil contamination, recovery has been achieved when remaining oil concentrations are reduced to a level comparable to pre-spill levels.

Recovery Monitoring Strategy: To assess the persistence of oil, monitoring needs to record the location, concentration, and characterization of oil that remains from the *Exxon Valdez* oil spill. Monitoring the location means periodically determining the areal extent until it reaches "recovery" levels in most areas, and focusing more frequent monitoring on "hot spots" where significant concentrations remain.

Monitoring Schedule:

- *Kodiak and Alaska Peninsula.* Comprehensive surveys have not been conducted since 1990. A survey should be conducted in 1995 to determine the areal extent and location of significant concentrations of remaining oil. The monitoring should be designed to give a comprehensive look at the distribution of oil in order to satisfy scientific and public information needs. Needs for future monitoring, if any, on Kodiak and the Alaska Peninsula will be determined based on the results from 1995.

- *Prince William Sound.* Specific areas in Prince William Sound were monitored in 1993. Monitoring is not needed in 1995. It should be conducted in 1996 to determine the location of significant concentrations of remaining oil. Like that for Kodiak and the Alaska Peninsula, the monitoring should be designed to give a comprehensive look at the distribution of oil in order to satisfy scientific and public information needs. It should not focus on known "hot spots" monitored in 1993, but be a broader effort to give a comprehensive picture. Future monitoring of specific remaining areas of high oil concentration will be determined based on the results from 1996.

- *Cook Inlet and Outer Kenai Coast.* Monitoring needs for Cook Inlet and outer Kenai Coast need not drive the monitoring schedule; rather, they should be incorporated into the projects for Kodiak and Prince William Sound as logistics opportunities are available.

Estimated Recovery Time: Unknown.

Injured Resource: Persistence of Oil (Mussel Beds)

Recovery Status: Mussels themselves are an injured resource, both from the recreational and subsistence view plus possibly being the vehicle for transferring petroleum hydrocarbons to higher consumers. High concentrations of petroleum PAH's remain evident in some mussel beds within Prince William Sound (PWS), and preliminary results indicate contaminated beds outside PWS also.

Recovery Objective: Recovery will be complete when sediment PAH concentrations have declined to pre-spill concentrations.

Recovery Monitoring Strategy: Beds identified as contaminated should be monitored no more than once every three years. In order to maintain a level effort of work, one-third of these beds could be monitored each year.

Monitoring Schedule: Perform one cycle of monitoring, then re-evaluate.

Estimated Recovery Time: Unknown