Post Work shop Drafts

21.1.6

CHUGACH NATIONAL FOREST
FAX COVER SHEET

TO: STAN SEVNER FAX NO.: 276-7178

DEPT.: EVOS PHONE NO.:

FROM: RAY THOMPSON FAX NO.:

DEPT.: USFS PHONE NO.: 271-2536

REMARKS: As we discussed here's my suggestion on pg 2 of your letter.

Ray

TOTAL NUMBER OF PAGES (EXCLUDING COVER): 1

DATE SENT: 3-7-94 TIME: 1512

Your comments on the proposed changes to the List of Injured Resources and Services, summaries of Injury and Recovery, and Recovery Objectives are invited and encouraged. If you have questions about the proposed changes, or wish to request copies of the Chief Scientist's recommendations about additions to the list of injured resources and services, please call 1-800-478-7745 (inside Alaska) or 1-800-283-7745 (outside Alaska). Thank you.

Sincerely, (or other documents mentioned in this letter)

Molly McCammon
Executive Director

enclosures (2)

Stan:

add this suggestion and I will be happy. Dave stated that if this was ok with me he'll go along. Thanks for the extra effort.

Ray

Stan Senner

From: Bud Rice
To: Stan Senner
Cc: Peter Armato; Jeff Troutman; KATM Kodiak Office
Subject: EVOS Draft Update on Injured Resources:
Date: Friday, August 23, 1996 4:16PM

Original Subject:
EVOS Draft Update on Injured Resources: Cormorants

In reviewing the statements concerning the injury and recovery of cormorants following EVOS, I decided to review survey estimates of cormorant populations before and after EVOS on the Kneai Peninsula. Nishimoto and Rice (1987) surveyed the entire outer coast of the Kenai Peninsula from Gore Point to Cape Resurrection, and Bailey and Rice surveyed randomly selected segments two times during the summer of 1989. In comparing survey results for cormorants between 7/86 and 7/89 we detected population decreases for all cormorant groups: pelagic cormorants, red-faaced cormorants, double-crested cormorants and unidentified cormorants. Number and percent changes for these groups were as follows:

Species	1986	1989	Percent Change
Pelagic cormorant	593	330	-44%
Red-faced corm.	187	46	-75%
Double-crested c.	195	176	-10%
Unidentified cor.	65	58	-11%

I don't have handy at my fingertips the subsequent survey data obtained with FWS during spring and summer of 1990. At any rate, I wonder if anyone can state whether cormorants have recovered in the Gulf form effects of EVOS. I hope this information stimulates some debate and thought about impacts and restoration to these species that may have been overlooked with respect to EVOS.

Bud

this area

new (Counts on the outer Kenai Peninsula coast suggested that the direct mortality of cormorants due to oil resulted in fewer birds in ~~attendance at breeding colonies~~ in 1989 compared to 1986. In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in Prince William Sound based on pre- and postspill July boat surveys (1972-73 v 1989-91). There were fewer cormorants in oiled than in unoiled parts of the Sound. More recent surveys (1993-94) did not show an increasing population trend since the oil spill. With support from the Trustee Council, these boat surveys will be repeated in 1996.

and

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

FAX COVER SHEET

To: Bud Rice Number:

From: Stan Senner Date: 9 Sept '96

Comments: Total Pages: 2

Please let me know what you think of the new sentence in the cormorant injury account. By the way, I checked the original morgue data. By far, most cormorant mortality occurred in Prince William Sound.

HARD COPY TO FOLLOW _____

Document Sent By:

3/27/96

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*** ACTIVITY REPORT ***
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TX/RX NO.	8998
CONNECTION TEL	2572517
CONNECTION ID	B.RICE
START TIME	09/09 14:21
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RESULT	OK

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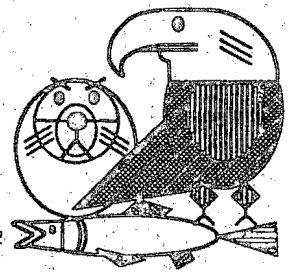

FAX COVER SHEET

FAXED

To: Lisa Thomas Number:

From: Stan Senner Date: 9 Sep '96

Comments: Total Pages: 2

Let me know if this new language for the Chpt. 5 PIGU account is okay. The brief mention of APEX and NVP does not do either of them justice, but it does make the connection for the public.

HARD COPY TO FOLLOW _____

Document Sent By:

3/27/96

The Alaska Predator Ecosystem Experiment (APEX) project is investigating the possible link between pigeon guillemot declines to the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin. The Nearshore Vertebrate Predator (NVP) project also addresses the possibility that exposure to oil continues to limit the guillemot's recovery. Both projects are supported by the Trustee Council. } new

Chapter 5
Injury Status and Recovery Objectives

The first part of this chapter discusses recovery objectives in general. The second part describes the nature and extent of injury and recovery and specific recovery objectives for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives can be found on the following pages:

Objectives

The recovery objectives described in the following section are the measurable conditions that signal the recovery of individual resources or services. 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, and it is difficult to predict conditions that would have existed in the absence of the spill. Recovery, therefore, is most realistically indicated by a return to prespill conditions, which may be assessed by comparisons of pre- and post-spill populations, by comparisons of populations or communities in oiled and unoiled areas, or, ideally, by both methods. For resources that were in decline before the spill, like harbor seals, recovery may be defined as the stabilization of a population, even if it is stabilized at a lower level than existed before the spill. In all cases, increased numbers of individuals, reproductive success sustained within normal bounds, improved growth and survival rates, and normal age and sex composition of the injured population, among others, are all indicators that recovery is underway.

Full ecological recovery will have been achieved when the populations 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.

Injury Status and Recovery Objective

This section describes the nature and extent of injury and recovery and the recovery objective for each injured resource and service. Specific strategies to achieve resource recovery objectives are described and updated in annual invitations (e.g., *Invitation to Submit Restoration Proposals for Federal Fiscal Year 1997*) and work plans. The information in this section is expected to change as the restoration program adapts to new information. For example, population declines or sublethal effects may be documented for new resources; other resources may recover or show signs that recovery is underway. Thus, the following descriptions of the injury and recovery status and recovery objectives for injured resources and lost or reduced services will change in response to new information, conditions, and scientific insights.

New scientific data will be incorporated into restoration decisions without the need to change the *Restoration Plan*. However, changes will be reported in the Trustee Council's annual status report, and, periodically, Chapter 5 of the *Restoration Plan* itself will be updated.

Resources

Archaeological Resources

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

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 spill occurred early 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. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was most probably from the *Exxon Valdez* spill. Hydrocarbon levels at the second sites were not sufficient to permit identification of the source or sources of the oil.

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.

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

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of 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.

Recovery Objective
Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered to have 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 (e.g., through excavation, site stabilization, or other forms of documentation).

BALD EAGLES

Injury and Recovery
The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Prince William Sound provided year-round and seasonal habitat for about 5,000 bald eagles. A total of 151 eagle carcasses was recovered following the oil spill, and, within Prince William Sound, it is estimated that about 250 bald eagles died as a result of the oil spill. There were no estimates of mortality outside the sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, 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.

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.

BLACK OYSTERCATCHERS

inconsistent type style w/ the rest of the document.

Injury and Recovery
Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but it has been estimated that actual mortalities may have been as high as, but probably did not exceed, 20 percent in the spill area.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill 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 known.

Recovery Objective
Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

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 were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, Prince William Sound, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

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, based on prespill data or comparisons of oiled and unoiled sites.

COMMON LOONS

Typestyle inconsistent w/ the rest of this document.

Injury and Recovery
Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current 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
No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

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 index 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 the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994, and, at that time, the local population had not returned to prespill levels.

Recovery Objective
Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be further indication that recovery is underway.

CORMORANTS

Injury and Recovery

Cormorants are large, fish-eating birds, that spend much of their time on the water or perched on rocks near the water. Three, and sometimes four, species are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The latest information from the U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog gives counts of 7161 pelagic cormorants, 8967 red-faced cormorants, and only 1558 double-crested cormorants in the oil-spill area. These are direct counts, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species) in Prince William Sound comparing boat pre- and post-spill surveys in July, including comparisons of oiled versus unoiled areas. Those surveys have not shown any increasing population trend since the oil spill.

Recovery Objective

Pelagic, red-faced, and double-crested cormorants when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

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 trout 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 have led to 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.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

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 by Congress. 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, 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.

DOLLY VARDEN

Inconsistant Typestyle

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams , and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991, and the recovery status of this species is not known.

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams , after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil impacted harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on comparisons of surveys in 1988 and then in 1989 after the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

When a population declines it means that deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline, adjusted for time of day and other factors, is about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

Harbor seals have long been and continue to be a key subsistence resource in the oil-spill area. Subsistence hunting is affected by the declining seal population, and lack of opportunities to hunt seals has changed the diets of subsistence users who traditionally had relied heavily on these marine mammals.

Recovery Objective

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

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; many more actually died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks and Barrow's and common goldeneye collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher

concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye 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.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

INTERTIDAL COMMUNITIES

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. 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. Intertidal resources are important to subsistence users, sea and river otters, and to a variety of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats through the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective
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 reestablishment of important species, such as *Fucus* at sheltered rock sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

KILLER WHALES

Injury and Recovery
More than 100 killer whales in 6 "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the sound less frequently. 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 the losses and the oil spill is only circumstantial, but the probable mortality of killer whales in Prince William Sound following the spill far exceeds rates 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 within the major resident killer whales pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective
Killer whales will have recovered when the number of individuals in the AB pod is stable or increasing relative to the status of other major resident pods in Prince William Sound.

KITTLITZ'S MURRELET

Injury and Recovery
The Kittlitz's murrelet is only found in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more

murrelets were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective
No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELET

Injury and Recovery
The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. 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 in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified were marbled murrelets. Many more murrelets were actually killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. Nor is there evidence of any further decline.

Recovery Objective
Marbled murrelets will have recovered when the population ~~trends are~~ is stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

Don't want a stable declining trend here either.

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 and habitat for other organisms 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 and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of 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.

At least 70 mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective

Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

Pacific Herring

Injury and Recovery

Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant fraction of these spawning habitats as well as herring staging areas in the sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In

1993, however, there was an unprecedented crash of adult herring. A viral disease and fungus were the probable agents of mortality, and 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. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of pollock as both competitors with and predators of herring, which may indicate that there in a connection between the lack of recruitment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically as well as commercially. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective
Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

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, there was evidence that the pigeon guillemot population in Prince William Sound had declined 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 population in Prince William Sound is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

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 pink 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, returns 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 management 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 *Exxon Valdez* oil. For pink salmon, mortalities of 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 oceanographic and ecological factors that influence production of pink salmon and Pacific 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.

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.

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, but the actual mortality is not known. 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. Since there were no prespill-data and sample sizes were small, 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 Jackpot and Knight islands.

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 differences.

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective

No recovery objective can be defined.

Inconsistent typestyle

SEA OTTERS

Injury and Recovery

By the late 1800s, sea otters had been eliminated from most of their historical range due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional otters probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-1994). This lack of a significant positive trend, however, may result from a lack of statistical power in the survey, which will be repeated in 1996.

Based on the insights of local observers, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western sound.

Recovery Objective

Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

Inconsistent typestyle

SEDIMENTS

Injury and Recovery

Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound was in 1993, and it included 45 areas of shoreline known from the clean-up to have had the most significant oiling. That survey indicated that heavy subsurface oil had decreased by 65 percent since 1991, and

that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the sound is relatively stable and, by this time, is likely to decrease only slowly.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings on the islands, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water 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. 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 few sites at which subtidal oiling is still known to occur.

Recovery Objective

Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and 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 numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other 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 altering 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.

The effects of the 1989 overescapement of sockeye salmon 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 commercial, recreational, and subsistence demands on sockeye salmon in the Kenai River system.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem with fry production may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

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.

Inconsistent Typestyle — SUBTIDAL COMMUNITIES

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. The concentration of oil in sediments in 1990 was more than twice as great at oiled sites. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced diversity and abundance of eelgrass shoots and flowers, worms, clams, snails, oil-sensitive amphipods (sand fleas), and helmet crabs. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, increased in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plant and animals. However, there were still some animals that were more abundant at oiled sites, like those observed in 1990. These included the opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod. Reconnaissance surveys indicated that there were more small green sea urchins at oiled sites.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. However, the abundance of small green sea urchins was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the sediment oil concentrations and organisms that live within the substrate are not yet complete.

Recovery Objective
Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

Services

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 and poor fishery recruitment since 1989. 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 commercially important fish species that were injured by the oil spill. These projects include: supplementation 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.

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 because of the effects of the oil 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.

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. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial lost passive use values resulting from the oil 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 information on the health and recovery status of injured resources, based on monitoring and research projects, will play an important role in the restoration of passive uses.

This looks like a different type size though the style is the same.

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, 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. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, 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.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. There are still locations within the oil-spill area, however, avoided by recreational users because of the presence of residual oil.

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.

They're not just predominantly Alaskan; they are Alaskan.

SUBSISTENCE

Injury and Recovery

Fifteen predominantly ~~Alaskan~~ Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include 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 from 1989-1994. No or very low concentrations of petroleum hydrocarbons were found in most resources. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to pre-spill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort

to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. 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 ways 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 confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be 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.

Increase involvement of subsistence users in the restoration process. Increasing participation of community residents will increase their confidence that injured resources will be and are being restored. Increased participation also will improve the results of restoration work, including research and monitoring projects, through the incorporation of traditional and local knowledge.

Exxon Valdez Oil Spill Trustee Council
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MEMORANDUM

To: Restoration Work Force

From: Molly McCammon
Executive Director

Subject: Update on Injury and Recovery Status

Date: September 27, 1996

We have completed the final draft of the Update on Injury and Recovery Status (i.e., Chapter 5 revisions). This version incorporates the changes discussed at the Trustee Council meeting on August 29.

My plan is to have these printed with a September 1996 date and to distribute them to the general mailing list sometime this fall or winter, probably in combination with the final FY 1997 work plan or some other document that needs wide distribution.

I will put this topic on the agenda for the Work Force meeting on October 2nd. If you have any comments or suggestions, please bring them up at that time.

enclosure (1)

United States Department of Agriculture | Forest Service | Alaska Region | P.O. Box 21628 Juneau, AK 99802-1628

August 21, 1996

Administrative Record - Injury Update

EXXON VALDEZ RESTORATION PLAN EIS SUPPLEMENTATION E

OBJECTIVES

This evaluation reviews the April 1996, Exxon Valdez Oil Spi Plan, Draft Update on Injured Resources and Services. A det made on the significance of proposed changes to Chapters 4 ((Goals, Objectives and Strategies) of the Exxon Valdez Oil Spill Restoration Plan (EVOS Restoration Plan). Relative to the Restoration Plan Environmental Impact Statement of September 1994, the Record of Decision of October 31, 1994, and the EVOS Restoration Plan of November 1994, the Forest Service, as lead Federal Trustee agency, will determine whether a supplement to the Final Environmental Impact Statement is warranted.

The National Environmental Policy Act (NEPA) implementing regulations (40 CFR 1502.9 [c]) and Forest Service Handbook direction (1909.15-92-1, section 18.2) provide that agencies:

(1) Shall prepare supplements to either draft or final environmental impact statements if:

(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

(ii) There are sufficient new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

(2) May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

The Final Environmental Impact Statement (FEIS) contains evaluations and findings regarding impacts of restoration actions on injured resources and services. The Record of Decision (ROD) provides Trustee agencies and the public restoration decisions to include direct restoration actions, habitat acquisition and protection, research and monitoring. These include long-term actions utilizing a restoration reserve, administration of restoration activities, public involvement and science management. These actions are pursuant to the use of the $900 million settlement between Exxon Corporation and its subsidiary companies, and the United States and the State of Alaska. The EVOS Restoration Plan provides long-term guidance to the Trustee Council for using these funds in restoring the resources and services injured by the oil spill.

This paper presents and analyzes circumstances presented in the April 1996 Exxon Valdez Oil Spill Restoration Plan Draft Update on Injured Resource and Services (hereafter referred to as the Draft Update). The Draft Update

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Alaska Region
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August 21, 1996

EXXON VALDEZ RESTORATION PLAN EIS SUPPLEMENTATION EVALUATION

OBJECTIVES

This evaluation reviews the April 1996, Exxon Valdez Oil Spill Restoration Plan, Draft Update on Injured Resources and Services. A determination will be made on the significance of proposed changes to Chapters 4 (Injury) and 5 (Goals, Objectives and Strategies) of the Exxon Valdez Oil Spill Restoration Plan (EVOS Restoration Plan). Relative to the Restoration Plan Environmental Impact Statement of September 1994, the Record of Decision of October 31, 1994, and the EVOS Restoration Plan of November 1994, the Forest Service, as lead Federal Trustee agency, will determine whether a supplement to the Final Environmental Impact Statement is warranted.

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provides current information for two parts of the Restoration Plan: 1) Table 2. Resources and Services Injured by the Spill, p.32, in Chapter 4, and 2) the summaries of Injury and Recovery and the Recovery Objectives in Chapter 5.

BACKGROUND

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

The ROD for the EVOS Restoration Plan Environmental Impact Statement was signed by the Federal Trustees and designates on October 31, 1994. The final EVOS Restoration Plan was completed in November 1994. It was modified to reflect the Trustees' decisions on restoration policies, strategies and actions.

The EVOS Restoration Plan is a programmatic document which the Trustee agencies and the public can use as long-term guidance for restoring the resources and services injured by the oil spill. It contains policies for making restoration decisions and describes how restoration activities will be implemented.

The EVOS Restoration Plan provides for information updates to be incorporated into the plan as acquired, reviewed and approved by the Trustee Council. More specifically, Chapter 4 of the Restoration Plan indicates that the list of injured resources and services (p.32, Table 2) would be reviewed as new information is obtained. The FEIS addressed injured resources and services provided by these resources by determining how restoration activities contribute to restoring injured resources and services, and how restoration actions directed at the injured resources and services affect other resources and services. It also provides for a restoration program which includes five categories of restoration activities. These are:

- General Restoration;
- Habitat Protection and Acquisition;
- Monitoring and Research;
- Restoration Reserve; and
- Public Information, Science Management, and Administration.

The decision reached in the ROD by the Trustees incorporates an ecosystem approach to restoration and provides for both scientific review and public participation in the process of defining restoration actions. Restoration is to be focused on the injuries to natural resources and the services provided by those natural resources.

The EVOS Restoration Plan calls for Chief Scientist's recommendations before adding injured species to the list, changing the status of a species on the list, and for removing species from the list. These peer reviewed recommendations are then acted upon by the Trustee Council.

Direction for changing the Restoration Plan (p.10, ch.1) is as follows:

> "The Trustee Council may change the plan if the Council determines the plan is no longer responsive to restoration needs. Changes may be made due to new scientific data, or to changing social and economic conditions. However, new scientific data will be incorporated into restoration decisions without the need to change the plan."

The ROD provides for an ecosystem approach to restoration. The Trustees may consider restoration activities for the injuries addressed by these specific excerpts from the ROD. They may consider restoration:

- for any injured resource or service;
- for resources and services not previously identified as injured ... if reasonable scientific or local knowledge obtained since the spill indicates a spill-related injury;
- for resources and services that have not recovered; and
- for resources for which there was no documented injury if these activities will benefit an injured resource or service.

PURPOSE AND NEED

The purpose of the EVOS Restoration Plan and FEIS is to "restore, insofar as possible, the injured natural resources and thereby the services they provide that were affected by the Exxon Valdez oil spill." Planning and decision guidance provides the Trustees with a broad platform from which to direct restoration actions. Through past and current restoration actions, research and monitoring of injured resources, the Trustees have determined which resources not previously, nor specifically, identified in planning documents should be considered for restoration, or their recovery status modified to update planning documents. This analysis will determine if there are extraordinary circumstances in these modifications which will cause the Forest Service to initiate a supplement to the FEIS.

The Draft Update provides for public review of the proposed changes and additions to the EVOS Restoration Plan. The information presented in the Draft Update is scientific in nature and appears not to substantially change the focus of the planned restoration actions. Although recovery objectives are presented in more detail than those in the EVOS Restoration Plan, the revised objectives are synonymous with current approved restoration objectives and actions.

DISCUSSION

The proposed revisions presented in the Draft Update include changing recovery status of some resources (for example, moving the bald eagle [Haliaeetus leucocephalus] from the "recovering" category to "recovered"), and adding to the list itself. In August 1995, the Trustee Council added Kittlitz's murrelet (Brachyramphus brevirostris) and common loons (Gavia immer) to the injured species list. In addition, the Council now proposes to add three species of cormorants (red-faced [Phalacrocorax urile], pelagic [P. pelagicus], and double-crested [P. auritus]). Requests to add scoters (Oidemia nigra and Melanitta sp.) and black-legged kittiwakes (Rissa tridactyla) to the list were not recommended by the Council's Chief Scientist.

As restoration activities occur, restoration managers and scientists have determined that the planned ecosystem approach to their work is very useful in understanding the injury and recovery status of resources and services. Annual peer-reviewed work plans are being incorporated into larger groupings (for example: Pink Salmon, Sound Ecosystem Assessment [SEA], Marine Mammals, Near-shore Ecosystem, Seabird/Forage Fish and Related Projects, Subsistence and others) to increase efficiency of effort and expenditures, and to accommodate collaborative understanding of research and monitoring results. These efforts have focused restoration needs. Incorporating the above mentioned resources into the restoration program does not materially change the recovery objective, the level of effort, or focus of the restoration activities being evaluated and approved by the Trustees from those anticipated in the EVOS Restoration Plan and FEIS. It does, however, accommodate understanding of species' predator/prey relationships, and hence is ecosystem based, and it corroborates the roles of restoration managers and scientists in defining injury, providing for effective restoration actions, and promoting recovery.

The Draft Update was sent to the Public Advisory Group, agencies and other publics in April 1996. Comments on the draft were solicited. When the June 15, 1996 due date for these comments arrived only five responses had been received. These are summarized as follows:

- an interest in having lake fertilization done in Eshamy Lake;
- an interest in having spot shrimp receive more attention to determine why the species remains in such low numbers in Prince William Sound;
- an interest in more restoration effort for pink salmon;
- an interest in splitting and studying components of the intertidal communities; and
- an interest in continuing monitoring programs.

These questions and concerns have been previously considered by the Chief Scientist for the Trustee Council. Additionally, the Executive Director of the Trustee Council has asked her science coordinator to respond to these

concerns. These responses summarize the Trustees' position on these issues. A summary of the science coordinator's comments include respectively:

1) There has been no injury linked to the EVOS that directly affected the Eshamy system, therefore no restoration actions have been approved for that system.

2) The spot shrimp population in western Prince William Sound was known to have declined prior to the 1989 oil spill. During damage assessment no injury from Exxon Valdez oil could be determined. No restoration actions have been approved for spot shrimp.

3) Salmon stocks, particularly pink salmon stocks within the spill area, are being studied in detail. Continuing studies, monitoring and data evaluation will produce a more complete picture of the pink salmon as a component of the oiled ecosystem.

4) The interrelationships of intertidal community components are currently being evaluated in a variety of studies. Splitting out and naming each component for individual study has not been deemed cost effective nor a good way to understand the intricate species interrelationships within the intertidal community.

5) Monitoring of recovery will continue.

CONCLUSION

The Trustee Council's desire to modify the listing of injured resources and services and to provide additional focus on recovery objectives for these injuries are within the current parameters of the EVOS Restoration Plan and FEIS. The public has had an opportunity to comment on the proposed changes. People have not expressed opposition to the proposed updates. They have not suggested other substantive changes. Public involvement continues on a regular basis to determine timely shifts in public desires. This is done through public notice of annual work plans, Public Advisory Group meetings, public comment periods at Trustee Council meetings, science workshops, and the Restoration Update newsletter. The proposed changes have been suggested as a result of these recurring processes, the need for scientific information, and restoration results.

As previously stated, the information presented in the Draft Update is scientific in nature and appears not to substantially change the focus of planned restoration actions. The proposed changes to the injury list and recovery objectives provide for non-substantive modifications to planning documents that are within the Trustees' decision authority and within the NEPA analysis completed for the EVOS Restoration Plan Final Environmental Impact Statement.

DETERMINATION

The Forest Service has reviewed National Environmental Policy Act and other requirements regarding supplementation of the Exxon Valdez Oil Spill FEIS. I have considered the proposed changes to the EVOS Restoration Plan in the Draft Update.

I have determined that supplementation of the EVOS FEIS is not warranted in relation to the changes proposed for Chapters 4 and 5 of the EVOS Restoration Plan in the Draft Update. The changes are primarily scientific in nature and do not substantially modify or restrict the Trustees' authority or scope of actions to effect restoration of injured resources and services. The purpose and need for restoration actions have not changed to a degree that warrants a supplement to the EVOS FEIS. The environmental consequences of the actions authorized by the ROD and displayed in the EVOS FEIS have not changed.

No further NEPA actions, including a supplement to the FEIS, are required to implement the changes proposed in the April 1996, Exxon Valdez Oil Spill Restoration Plan Draft Update on Injured Resources & Services.

PHIL JANIK
Trustee Council Member
USDA Forest Service

8/26/96
Date

$42,141. Seiners harvested $31.8 million worth of fish setting the average earnings for the 266 permit fleet at $119,670. The set gill net harvest is valued at $1.1 million, making the average earnings for each of the 29 active permit holders approximately $38,249.

Oil Spill Impacts on Management

Recognizing that the 1989 Exxon Valdez oil spill continued to have the potential to affect seafood quality within the Prince William Sound Management Area, the Department of Fish and Game and the Department of Environmental Conservation (D.E.C.) renewed the Memorandum of Understanding regarding seafood quality for the 1990 season (Appendix A.10.). The Department of Fish and Game conducted extensive beach surveys and collected fish that were provided to D.E.C. for inspection, prior to commercial openings in the affected areas of the Sound. Some minor beach areas continued to pose an appreciable likelihood for fouling of gear and adulterating of catch and were closed for the 1990 season. Two small beaches in the Eshamy District, 3.5 miles of shoreline on northern Latouche Island, and the shoreline of Eleanor, Ingot, and Knight Island north of 60°25.0 N. lat. were closed. These closures did not result in any reduction in the harvest of fish. Besides this, the lingering effects of the oil spill had little impact on the conduct of the 1990 salmon season.

SEASON SUMMARY BY DISTRICT

Copper River District

Pre-Season Outlook and Harvest Strategy

The 1990 harvest forecast for the Copper River District was 37,100 chinook, 658,100 sockeye, and 295,300 coho salmon. The harvest for the 1990 season was 844,778 sockeye, 200,000 or 28 percent above the anticipated. The chinook harvest was 21,702, almost 15,000 or 41 percent below the anticipated. Chum and pink salmon are also present with steelhead but comprise less than 1 percent of the catch. The Gulkana Hatchery was expected to contribute 139,226 in 1990. The actual hatchery contribution could not be verified as no smolt were tagged in 1987 and 88.

The early season management strategy in the Copper River District is based on the actual catch and effort compared to the anticipated catch and effort. This provides the most reliable method of evaluating early run strength. Two evenly spaced periods each week are optimum; however the fishing schedule is adjusted in-season as the situation dictates. Effort, tides and environmental conditions also enter into interpretation of the data. In late May, the upriver escapement data from Miles Lake sonar project becomes the primary factor governing the management of the fishery. By mid-June aerial estimates of sockeye escapement in the Copper River delta are available and are also considered when scheduling

Exxon Valdez Oil Spill Trustee Council
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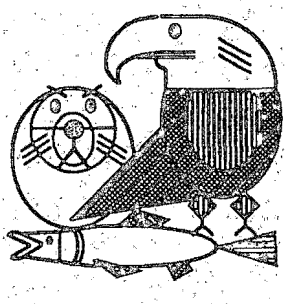

MEMORANDUM

To: Restoration Work Force

From: Molly McCammon
Executive Director

Subject: Update on Injury and Recovery Status

Date: September 27, 1996

We have completed the final draft of the Update on Injury and Recovery Status (i.e., Chapter 5 revisions). This version incorporates the changes discussed at the Trustee Council meeting on August 29.

My plan is to have these printed with a September 1996 date and to distribute them to the general mailing list sometime this fall or winter, probably in combination with the final FY 1997 work plan or some other document that needs wide distribution.

I will put this topic on the agenda for the Work Force meeting on October 2nd. If you have any comments or suggestions, please bring them up at that time.

enclosure (1)

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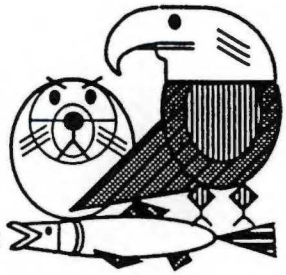

September 1996

Dear Reader:

The Trustee Council adopted the *Exxon Valdez Oil Spill Restoration Plan* in November 1994 with the intent that the plan would be updated as needed to incorporate new scientific information.

The enclosed documents update two parts of the *Restoration Plan*: the List of Injured Resources and Services in Chapter 4 and the summaries of Injury and Recovery and the Recovery Objectives in Chapter 5.

List of Injured Resources and Services
Chapter 4 of the *Restoration Plan* indicates that the list of injured resources and services (p. 32, Table 2) will be reviewed as new information is obtained. The approved revisions include changes to the recovery status of some resources (for example, moving Bald Eagles from the "recovering" category to "recovered") and additions to the list itself. In August 1995, the Council added Kittlitz's murrelets and common loons to the injured species list. In addition, the Council has now added three species of cormorants (red-faced, pelagic, and double-crested).

Chapter 5: Goals, Objectives & Strategies
Chapter 5 of the *Restoration Plan* (pp. 33-56) discusses general goals and strategies for restoring injured resources and services and also provides specific information on the status, recovery objectives, and restoration strategies for individual resources and services. In the attached document, the Council now provides updated information on the status of injured resources and services, as well as revisions to the Recovery Objectives for injured resources and services. Readers are referred to annual work plans and invitations to submit proposals (e.g., *Invitation to Submit Proposals for Federal Fiscal Year 1997*) for the most current information on the restoration strategies chosen by the Council to achieve its recovery objectives.

Thank you for your interest in restoration following the *Exxon Valdez* oil spill.

Sincerely,

Molly McCammon
Executive Director

enclosure

[Note to Readers: This document updates information on Injury and Recovery status and Recovery Objectives in Chapter 5 (pp. 33-56) and the List of Injured Resources and Services (p. 32) in the *Restoration Plan*.]

RESOURCES

ARCHAEOLOGICAL RESOURCES

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

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 spill occurred early 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. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was from the *Exxon Valdez* spill. Hydrocarbon levels at the second site were not sufficient to permit identification of the source or sources of the oil.

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.

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

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of 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.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological

resources. Archaeological resources will be considered to have recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data remaining in vandalized sites are preserved (e.g., through excavation, site stabilization, or other forms of documentation).

Bald Eagles

Injury and Recovery

The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Following the spill a total of 151 eagle carcasses was recovered from the oil-spill area. Prince William Sound provides year-round and seasonal habitat for about 5,000 bald eagles, and within the Sound it is estimated that about 250 bald eagles died as a result of the spill. There were no estimates of mortality outside the Sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, 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.

Recovery Objective

Bald eagles will have recovered when their population and productivity have returned to prespill levels. Based on the results of studies in Prince William Sound, this objective has been met.

Black Oystercatchers

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but the actual number of mortalities may have been considerably higher.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill 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 known.

Recovery Objective

Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

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 were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, and the Alaska Peninsula and in Prince William Sound concern about the effects of the oil spill on clams and subsistence uses of clams remains high. (see Subsistence)

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, based on prespill data or comparisons of oiled and unoiled sites.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current 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

No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

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 probably died than actually were recovered. Based on surveys of index colonies at such locations as Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay, the spill-area population may have declined by about 40 percent following the spill. In addition to direct losses of murres, there is 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 the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994. At that time, the local population had not returned to prespill levels.

The Alaska Predator Ecosystem Experiment (APEX project), funded by the Trustee Council, is investigating the linkages among murre populations and changes in the abundance of forage fish, such as Pacific herring, sand lance, and capelin.

Recovery Objective
Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be a further indication that recovery is underway.

CORMORANTS

Injury and Recovery
Cormorants are large fish-eating birds that spend much of their time on the water or perched on rocks near the water. Three species typically are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog, however, currently lists counts of 7,161 pelagic cormorants, 8,967 red-faced cormorants, and 1,558 double-crested cormorants in the oil-spill area. These are direct counts, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

Counts on the outer Kenai Peninsula coast suggested that the direct mortality of cormorants due to oil resulted in fewer birds in this area in the 1989 compared to 1986. In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in Prince William Sound based on pre- and postspill July boat surveys (1972-73 v 1989-91), and there were fewer cormorants in oiled than in unoiled parts of the Sound. More recent surveys (1993-94) did not show an increasing population trend since the oil spill. With support from the Trustee Council, these boat surveys will be repeated in 1996.

Recovery Objective
Pelagic, red-faced, and double-crested cormorants will have recovered when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

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 trout 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 have led to 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.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

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 by Congress. 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, 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.

DOLLY VARDEN

Injury and Recovery

Like the cutthroat trout, there is evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams, and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991. The recovery status of this species is not known.

Recovery Objective
Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams, after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil affected harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on surveys conducted before (1988) and after (1989) the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

In a declining population deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline ~~is~~ was about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

Harbor seals have long been a key subsistence resource in the oil-spill area. Subsistence hunting is affected by the declining seal population, and lack of opportunities to hunt seals has changed the diets of subsistence users who traditionally had relied heavily on these marine mammals.

Recovery Objective
Harbor seals will have recovered from the effects of the oil spill when their population is stable or increasing.

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. Many more than that number probably died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the immediate spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks (combined with samples from Barrow's and common goldeneye) collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye 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. 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.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

Intertidal Communities

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. 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. Intertidal resources are important to subsistence users, sea and river otters, and to a variety of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats throughout the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small species of barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective

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 reestablishment of important species, such as *Fucus* at sheltered rocky sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

KILLER WHALES

Injury and Recovery

More than 80 killer whales in six "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the Sound less frequently. 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 adult whales. The link between these losses and the oil spill is only circumstantial, but the likely mortality of killer whales in the AB pod in Prince William Sound following the spill far exceeds rates observed for other pods in British Columbia and Puget Sound over the last 20 years. In addition to the effects of the oil spill, there has been concern about the possible shooting of killer whales, perhaps due to conflicts with long-line fisheries.

The AB pod may never regain its former size, but overall numbers within the major resident killer whale pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective

Killer whales in the AB pod will have recovered when the number of individuals in the pod is stable or increasing relative to the trends of other major resident pods in Prince William Sound.

KITTLITZ'S MURRELETS

Injury and Recovery

The Kittlitz's murrelet is found only in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more murrelets probably were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective

No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELETS

Injury and Recovery

The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. 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 in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified to the species level were marbled murrelets. Many more murrelets probably were killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound, nor is there evidence of any further decline.

Recovery Objective

Marbled murrelets will have recovered when its population is stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

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 and habitat for other organisms 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 and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of 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.

About 30 mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak

Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective
Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

PACIFIC HERRING

Injury and Recovery
Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant portion of these spawning habitats as well as herring staging areas in the Sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In 1993, however, there was an unprecedented crash of the adult herring population. A viral disease and fungus were the probable agents of mortality, and the connection between the oil spill and the disease outbreak is under investigation. Numbers of spawning herring in Prince William Sound remained depressed through the 1995 season. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of walleye pollock as both competitors with and predators on herring, which may indicate that there is a connection between the lack of recruitment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically and commercially and for subsistence users. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective
Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

PIGEON GUILLEMOTS

Injury and Recovery

Although the pigeon guillemot is widely distributed in the north Pacific region, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, the guillemots and the fish on which they prey are vulnerable to oil pollution.

Like the marbled murrelet, there is evidence that the pigeon guillemot population in Prince William Sound had declined before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the spill-area population may have died following the spill. Guillemot nesting on the Naked Islands was well-studied in 1978-81. Postspill surveys using the same methods indicated a decline of about 40 percent in guillemots in the Naked Islands. Based on boat surveys, the overall guillemot population in the Sound declined as well.

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.

The Alaska Predator Ecosystem Experiment (APEX) project is investigating the possible link between pigeon guillemot declines to the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin. The Nearshore Vertebrate Predator (NVP) project also addresses the possibility that exposure to oil continues to limit the guillemot's recovery. Both projects are supported by the Trustee Council.

Recovery Objective

Pigeon guillemots will have recovered when their population is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

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 the sea. As a result, three types of early life-stage injuries were identified: First, growth rates in juvenile pink 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, returns 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 a particular concern about the Sound's southwest management 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 *Exxon Valdez* oil. For pink salmon, mortalities of 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 oceanographic and ecological factors that influence production of pink salmon and Pacific 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.

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.

River Otters

Injury and Recovery
River otters have a low population density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve river otter carcasses were found following the spill, but the actual mortality is not known. Studies conducted during 1989-91 identified several differences between river 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. Since there were no prespill data and sample sizes were small, 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 otter. 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 Jackpot and Knight islands.

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 differences.

Rockfish

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and probable sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective

No recovery objective can be identified.

Sea Otters

Injury and Recovery

By the late 1800s, sea otters had been eliminated from most of their historical range in Alaska due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional animals probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult sea otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the Sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-94). This lack of a significant positive trend, however, may result from low statistical power in the survey, which will be repeated in 1996.

Based on observations by local residents, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western Sound.

Recovery Objective
Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

SEDIMENTS

Injury and Recovery
Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning and natural degradation removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound, conducted in 1993, included 45 areas of shoreline known to have had the most significant oiling. Based on that survey, it was estimated that heavy subsurface oil had decreased by 65 percent since 1991 and that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the Sound is relatively stable and, by this time, is likely to decrease only slowly. Oil also persists under armored rock settings on the Kenai and Alaska peninsulas, and this oil has undergone little chemical change since 1989.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings in the Kodiak area, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water depths of 20 meters below mean low tide, 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. 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--are among the few sites at which subtidal oiling is still known to occur.

ignore

Recovery Objective
Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines (both tidal and subtidal) in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and 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-desirable numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that overgrazed the zooplankton, thus altering 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.

The effects of the 1989 overescapement of sockeye salmon 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.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

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.

SUBTIDAL COMMUNITIES

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. The concentration of oil in sediments in 1990 was more than twice as great at oiled sites. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced abundances of eelgrass shoots and flowers and helmet crabs. The abundance and diversity of worms, clams, snails, and oil-sensitive amphipods (sand fleas) also were reduced. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, were greater in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plants and animals. As was true in 1990, however, some opportunistic species still were more abundant at oiled sites. These included the

opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. The abundance of small green sea urchins, however, was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the recent oil concentrations in sediments and organisms that live within the substrate are not yet complete.

Recovery Objective
Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

SERVICES

COMMERCIAL FISHING

Injury and Recovery
Commercial fishing is a service that was reduced 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 and poor fishery recruitment since 1989. 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 commercially important fish species that were injured by the oil spill. These projects include: supplementation 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.

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 because of the effects of the oil spill.

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. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial losses of passive use values resulting from the oil 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.

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 still are injured by the spill include killer whales, sea otters, harbor seals, 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. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, 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.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. However, there are still locations within the oil-spill area which are avoided by recreational users because of the presence of residual oil.

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.

Injury and Recovery

Fifteen predominantly ~~Alaskan~~ Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include 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 from 1989-94. No or very low concentrations of petroleum hydrocarbons were found in most subsistence foods. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to prespill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. 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 ways 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 confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be reintegrated into community life.

[*Note: This table is modified from p. 32 of the* Restoration Plan.]

Table 2. Resources and Services Injured by the Spill

INJURED RESOURCES				LOST or REDUCED SERVICES
Recovered	**Recovering**	**Not Recovered**	**Recovery Unknown**	Commercial fishing
Bald eagle	Archaeological resources*	Cormorants (3 species)	Black oystercatcher	Passive uses
	Common murres	Harbor seal	Clams	Recreation and Tourism including sport fishing, sport hunting, and other recreation uses
	Intertidal communities**	Harlequin duck	Common loon	
	Mussels	Killer whale (AB pod)	Cutthroat trout	Subsistence
	Pink salmon	Marbled murrelet	Designated Wilderness areas	
	Sediments	Pacific herring	Dolly Varden	
	Sockeye salmon	Pigeon guillemot	Kittlitz's murrelet	
	Subtidal communities	Sea otter (in oiled west. PWS)	River otter	
			Rockfish	

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*Archaeological resources are not renewable in the same way that biological resources are, but there has been significant progress toward the recovery objective.

**Status of intertidal communities based largely on monitoring in sheltered rocky habitats in Prince William Sound; status of other intertidal habitats is less certain or unknown, though some recovery can be anticipated.

Amending the List of Injured Resources and Services. The list of injured resources and services will be reviewed as new information is obtained through research, monitoring, and other studies sponsored by the Trustee Council. In addition, information may be submitted to add to or otherwise change this list. This information can include research results, assessment of population trends, ethnographic and historical data, and supportive rationale. Information that has been through an appropriate scientific review process is preferable. If data have not been peer reviewed, they should be presented in a format that permits and facilitates peer review. Information to change the list will be reviewed through the Trustee Council's scientific review process.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

April 23, 1996

MEMORANDUM FOR: Molly McCammon
Executive Director

FROM: Bruce Wright
Program Manager

SUBJECT: Chapter 5

Chapter 5 of the Restoration Plan, Injury and Recovery and Recovery Objectives, has seen dramatic improvements by incorporating new scientific information, changes in organization, format and clearer presentation of the information. In the April 1996 version I found only one typo (although this was a quick review); in the killer whale section, page 10, paragraph 1, last line, misspelling of `perhaps'.

Thanks for considering my earlier comments. Keep up the good work.

cc: Stan Senner

Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

April 1996

Dear Reader:

The Trustee Council adopted the *Exxon Valdez Oil Spill Restoration Plan* in November 1994 with the intent that the plan would be updated as needed to incorporate new scientific information.

The enclosed documents provide information to update two parts of the *Restoration Plan*: the List of Injured Resources and Services in Chapter 4 and the summaries of Injury and Recovery and the Recovery Objectives in Chapter 5. The Council invites public comment on the changes to the List of Injured Resources and Services and to the updated Recovery Objectives. To be most helpful, **please submit written comments on these drafts to: *Exxon Valdez* Oil Spill Trustee Council, 645 G Street, Suite 401, Anchorage, Alaska 99501 by June 15, 1996.**

List of Injured Resources and Services
Chapter 4 of the *Restoration Plan* indicates that the list of injured resources and services (p. 32, Table 2) will be reviewed as new information is obtained. The proposed revisions include changes to the recovery status of some resources (for example, moving Bald Eagles from the "recovering" category to "recovered") and additions to the list itself. In August 1995, the Council added Kittlitz's murrelets and common loons to the injured species list. In addition, the Council now proposes to add three species of cormorants (red-faced, pelagic, and double-crested). Requests to add scoters (three species) and black-legged kittiwakes to the list were recommended against by the Council's Chief Scientist. If you would like a copy of the Chief Scientist's recommendations, please call the Trustee Council office (see telephone numbers on second page).

Chapter 5: Goals, Objectives & Strategies
Chapter 5 of the *Restoration Plan* (pp. 33-56) discusses general goals and strategies for restoring injured resources and services and also provides specific information on the status, recovery objectives, and restoration strategies for individual resources and services. In the attached document, the Council now provides updated information on the status of injured resources and services. Based on these updated status reports, the Council also proposes and invites comments on revisions to the Recovery

Objectives for injured resources and services. Readers are referred to annual work plans and invitations to submit proposals (e.g., *Invitation to Submit Restoration Proposals for Federal Fiscal Year 1997*) for the most current information on the restoration strategies chosen by the Council to achieve its recovery objectives.

Your comments on the proposed changes to the List of Injured Resources and Services and the Recovery Objectives are invited. If you have questions about the proposed changes, or wish to request any of the documents mentioned above, please call 1-800-478-7745 (inside Alaska) or 1-800-283-7745 (outside Alaska). Thank you.

Sincerely,

Molly McCammon
Executive Director

enclosure

[Note to Readers: This draft updates information on Injury and Recovery status and Recovery Objectives in Chapter 5 (pp. 33-56) and the List of Injured Resources and Services (p. 32) in the *Restoration Plan*.]

RESOURCES

ARCHAEOLOGICAL RESOURCES

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

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 spill occurred early 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. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was from the *Exxon Valdez* spill. Hydrocarbon levels at the second site were not sufficient to permit identification of the source or sources of the oil.

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.

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

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of 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.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological

resources. Archaeological resources will be considered to have recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data remaining in vandalized sites are preserved (e.g., through excavation, site stabilization, or other forms of documentation).

BALD EAGLES

Injury and Recovery

The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Following the spill a total of 151 eagle carcasses was recovered from the oil-spill area. Prince William Sound provides year-round and seasonal habitat for about 5,000 bald eagles, and within the Sound it is estimated that about 250 bald eagles died as a result of the spill. There were no estimates of mortality outside the Sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, 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.

Recovery Objective

Bald eagles will have recovered when their population and productivity have returned to prespill levels. Based on the results of studies in Prince William Sound, this objective has been met.

BLACK OYSTERCATCHERS

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but the actual number of mortalities may have been considerably higher.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill 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 known.

Recovery Objective

Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

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 were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, and the Alaska Peninsula and in Prince William Sound concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

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, based on prespill data or comparisons of oiled and unoiled sites.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current 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

No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

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 probably died than actually were recovered. Based on surveys of index colonies at such locations as Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay, the spill-area population may have declined by about 40 percent following the spill. In addition to direct losses of murres, there is 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 the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994. At that time, the local population had not returned to prespill levels.

The Alaska Predator Ecosystem Experiment (APEX project), funded by the Trustee Council, is investigating the linkages among murre populations and changes in the abundance of forage fish, such as Pacific herring, sand lance, and capelin.

Recovery Objective
Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be a further indication that recovery is underway.

CORMORANTS

Injury and Recovery
Cormorants are large fish-eating birds that spend much of their time on the water or perched on rocks near the water. Three species typically are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog, however, currently lists counts of 7,161 pelagic cormorants, 8,967 red-faced cormorants, and 1,558 double-crested cormorants in the oil-spill area. These are direct counts, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in Prince William Sound based on pre- and postspill July boat surveys (1972-73 v 1989-91). There were fewer cormorants in oiled than in unoiled parts of the Sound. More recent surveys (1993-94) did not show an increasing population trend since the oil spill. With support from the Trustee Council, these boat surveys will be repeated in 1996.

Recovery Objective
Pelagic, red-faced, and double-crested cormorants will have recovered when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

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 trout 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 have led to 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.

Recovery Objective
Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

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 by Congress. 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, 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.

DOLLY VARDEN

Injury and Recovery
Like the cutthroat trout, there is evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams, and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991. The recovery status of this species is not known.

Recovery Objective
Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams, after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery
Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil affected harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on surveys conducted before (1988) and after (1989) the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

In a declining population deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline is about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

Harbor seals have long been a key subsistence resource in the oil-spill area. Subsistence hunting is affected by the declining seal population, and lack of opportunities to hunt seals has changed the diets of subsistence users who traditionally had relied heavily on these marine mammals.

Recovery Objective
Harbor seals will have recovered from the effects of the oil spill when their population is stable or increasing.

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. Many more than that number probably died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the immediate spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks (combined with samples from Barrow's and common goldeneye) collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye 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. 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.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

INTERTIDAL COMMUNITIES

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. 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. Intertidal resources are important to subsistence users, sea and river otters, and to a variety of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats throughout the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small species of barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective

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 reestablishment of important species, such as *Fucus* at sheltered rocky sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

KILLER WHALES

Injury and Recovery

More than 80 killer whales in six "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the Sound less frequently. 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 adult whales. The link between these losses and the oil spill is only circumstantial, but the likely mortality of killer whales in the AB pod in Prince William Sound following the spill far exceeds rates observed for other pods in British Columbia and Puget Sound over the last 20 years. In addition to the effects of the oil spill, there has been concern about the possible shooting of killer whales, pehaps due to conflicts with long-line fisheries.

The AB pod may never regain its former size, but overall numbers within the major resident killer whale pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective

Killer whales in the AB pod will have recovered when the number of individuals in the pod is stable or increasing relative to the trends of other major resident pods in Prince William Sound.

KITTLITZ'S MURRELET

Injury and Recovery

The Kittlitz's murrelet is found only in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more murrelets probably were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective

No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELET

Injury and Recovery

The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. 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 in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified to the species level were marbled murrelets. Many more murrelets probably were killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound, nor is there evidence of any further decline.

Recovery Objective

Marbled murrelets will have recovered when its population is stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

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 and habitat for other organisms 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 and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of 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.

About 30 mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak

Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective
Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

PACIFIC HERRING

Injury and Recovery
Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant portion of these spawning habitats as well as herring staging areas in the Sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In 1993, however, there was an unprecedented crash of the adult herring population. A viral disease and fungus were the probable agents of mortality, and the connection between the oil spill and the disease outbreak is under investigation. Numbers of spawning herring in Prince William Sound remained depressed through the 1995 season. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of walleye pollock as both competitors with and predators on herring, which may indicate that there is a connection between the lack of recruitment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically and commercially and for subsistence users. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective
Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

PIGEON GUILLEMOT

Injury and Recovery

Although the pigeon guillemot is widely distributed in the north Pacific region, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, the guillemots and the fish on which they prey are vulnerable to oil pollution.

Like the marbled murrelet, there is evidence that the pigeon guillemot population in Prince William Sound had declined before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the spill-area population may have died following the spill. Guillemot nesting on the Naked Islands was well-studied in 1978-81. Postspill surveys using the same methods indicated a decline of about 40 percent in guillemots in the Naked Islands. Based on boat surveys, the overall guillemot population in the Sound declined as well.

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.

The Alaska Predator Ecosystem Experiment (the APEX project), supported by the Trustee Council, is investigating the possible link between pigeon guillemot declines to the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin.

Recovery Objective

Pigeon guillemots will have recovered when their population is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

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 the sea. As a result, three types of early life-stage injuries were identified: First, growth rates in juvenile pink 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, returns 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 a particular concern about the Sound's southwest management 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 *Exxon Valdez* oil. For pink salmon, mortalities of 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 oceanographic and ecological factors that influence production of pink salmon and Pacific 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.

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.

RIVER OTTERS

Injury and Recovery
River otters have a low population density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve river otter carcasses were found following the spill, but the actual mortality is not known. Studies conducted during 1989-91 identified several differences between river 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. Since there were no prespill data and sample sizes were small, 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 otter. 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 Jackpot and Knight islands.

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 differences.

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and probable sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective

No recovery objective can be identified.

SEA OTTERS

Injury and Recovery

By the late 1800s, sea otters had been eliminated from most of their historical range in Alaska due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional animals probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult sea otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the Sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-94). This lack of a significant positive trend, however, may result from low statistical power in the survey, which will be repeated in 1996.

Based on observations by local residents, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western Sound.

Recovery Objective
Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

SEDIMENTS

Injury and Recovery
Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning and natural degradation removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound, conducted in 1993, included 45 areas of shoreline known to have had the most significant oiling. Based on that survey, it was estimated that heavy subsurface oil had decreased by 65 percent since 1991 and that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the Sound is relatively stable and, by this time, is likely to decrease only slowly. Oil also persists under armored rock settings on the Kenai and Alaska peninsulas, and this oil has undergone little chemical change since 1989.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings in the Kodiak area, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water depths of 20 meters below mean low tide, 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. 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--are among the few sites at which subtidal oiling is still known to occur.

Recovery Objective
Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines (both tidal and subtidal) in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and 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-desirable numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that overgrazed the zooplankton, thus altering 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.

The effects of the 1989 overescapement of sockeye salmon 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.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

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.

SUBTIDAL COMMUNITIES

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. The concentration of oil in sediments in 1990 was more than twice as great at oiled sites. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced abundances of eelgrass shoots and flowers and helmet crabs. The abundance and diversity of worms, clams, snails, and oil-sensitive amphipods (sand fleas) also were reduced. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, were greater in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plants and animals. As was true in 1990, however, some opportunistic species still were more abundant at oiled sites. These included the

opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. The abundance of small green sea urchins, however, was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the recent oil concentrations in sediments and organisms that live within the substrate are not yet complete.

Recovery Objective
Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

SERVICES

COMMERCIAL FISHING

Injury and Recovery
Commercial fishing is a service that was reduced 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 and poor fishery recruitment since 1989. 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 commercially important fish species that were injured by the oil spill. These projects include: supplementation 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.

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 because of the effects of the oil spill.

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. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial losses of passive use values resulting from the oil 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.

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 still are injured by the spill include killer whale, sea otter, harbor seal, 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. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, 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.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. However, there are still locations within the oil-spill area which are avoided by recreational users because of the presence of residual oil.

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.

SUBSISTENCE

Injury and Recovery

Fifteen predominantly Alaskan Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include 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 from 1989-94. No or very low concentrations of petroleum hydrocarbons were found in most subsistence foods. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to pre-spill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. 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 ways 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 confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be reintegrated into community life.

Table 2. Resources and Services Injured by the Spill

INJURED RESOURCES				LOST or REDUCED SERVICES
Recovered	**Recovering**	**Not Recovered**	**Recovery Unknown**	Commercial fishing
Bald eagle	Archaeological resources*	Cormorants (3 species)	Black oystercatcher	Passive uses
	Common murres	Harbor seal	Clams	Recreation and Tourism including sport fishing, sport hunting, and other recreation uses
	Intertidal communities	Harlequin duck	Common loon	
	Mussels	Killer whale (AB pod)	Cutthroat trout	Subsistence
	Pink salmon	Marbled murrelet	Designated Wilderness areas	
	Sediments	Pacific herring	Dolly Varden	
	Sockeye salmon	Pigeon guillemot	Kittlitz's murrelet	
	Subtidal communities	Sea otter (in oiled west. PWS)	River otter	
			Rockfish	

---

*Archaeological resources are not renewable in the same way that biological resources are, but there has been significant progress toward the recovery objective.

Amending the List of Injured Resources and Services. The list of injured resources and services will be reviewed as new information is obtained through research, monitoring, and other studies sponsored by the Trustee Council. In addition, information may be submitted to add to or otherwise change this list. This information can include research results, assessment of population trends, ethnographic and historical data, and supportive rationale. Information that has been through an appropriate scientific review process is preferable. If data have not been peer reviewed, they should be presented in a format that permits and facilitates peer review. Information to change the list will be reviewed through the Trustee Council's scientific review process.

Exxon Valdez Oil Spill Trustee Council
645 G Street, Suite 401
Anchorage, AK 99501-3451

Dr. E.H. Williams
POB 908
LaJas, PR 00667

SENT BY: 2-14-96 ; 10:01 ; 21.1.6B

United States Department of the Interior

NATIONAL PARK SERVICE
Alaska Regional Office
2525 Gambell Street, Room 107
Anchorage, Alaska 99503-2892

IN REPLY REFER TO

FACSIMILE TRANSMITTAL

TO - FAX #	276-7178
ATTENTION	STAN SENNER
FROM	BUD RICE
DATE	2/14/96
	DIVISION of ENVIRONMENTAL QUALITY
NO. OF PAGES, Including this page	3

NOTE/SPECIAL INSTRUCTIONS: Attached are comments on the revised Chapter 5, Injury Status and Recovery Objectives, of the EVOS Restoration Plan. This document gets a little better with each review. I appreciate your efforts.

Bud

If you need more information or if there are problems with this fax, call the Division of Environmental Quality, National Park Service, Alaska Regional Office, Anchorage, AK, 1-907-257-2648 or fax 1-907-257-2517.

United States Department of the Interior

NATIONAL PARK SERVICE
Alaska Regional Office
2525 Gambell Street, Room 107
Anchorage, Alaska 99503-2892

IN REPLY REFER TO:

N36(AKSO-REQ)

February 14, 1996

Memorandum

To: Stan Senner, EVOS Restoration Office Science Coordinator

From: Bud Rice, NPS Liaison to EVOS Restoration Office

Subject: Comments on Revised Chapter 5 (Injury Status and Recovery Objectives) of the EVOS Restoration Plan

Thank you for the opportunity to comment of the proposed wording of the Exxon Valdez Oil Spill Restoration Plan revised chapter 5 on injury status and recovery objectives. I appreciate the consideration, and in some cases the incorporation, of previous comments submitted by the National Park Service. Additional comments and questions are given below.

Table 1. Injured Resources: The addition of "Designated Wilderness" to the column "Recovery Unknown", as suggested by Molly McCammon in her cover letter, has not yet been accomplished on the copy I have. Otherwise, the table looks fine, as modified. I appreciate the addition of "Passive Uses" to the lost services category.

Page 3, Archeological Resources: Though improved, this section fails to fully capture the magnitude of impact to archeological resources in the spill-affected area. Though 24 sites are known to have been adversely affected as a result of EVOS, it is estimated that about 100 sites were similarly affected on all lands, public or private. By stating "additional sites on both public and private lands were probably injured", the reader has no idea if this is a couple sites or hundreds, or none at all. Though we do not know exactly how many sites were injured throughout the spill-affected area, it seems that we ought to provide an educated guess at the magnitude of injury, as provided by archeologists. (Similar estimates of injury are noted for bald eagles and other resources.) Also, oil sampled at MR-1 on the Kenai Peninsula in 1994 and 95 has been positively identified as EVOS oil by Jeffrey Short of the Auke Bay Lab. Therefore, we can delete "most probably" from the phrase "most probably from the *Exxon Valdez* spill."

Page 4, Bald Eagles, Injury and Recovery: This section is still unclear. We are still mixing information in a single sentence that addresses injury to bald eagles throughout the spill-affected area and in Prince William Sound. I recommend placing the first phrase of the third sentence as the second sentence, and addressing impacts in PWS in the third sentence, as suggested below:

> The bald eagle is an abundant resident of coasts throughout the oil-spill area. Following the spill a total of 151 eagle carcasses was recovered from the spill-affected area. Prince William Sound provided(s) year-round and seasonal habitat for about 5,000 bald eagles, and within the Sound it is estimated that about 250 bald eagles died as a result of the oil spill....

Page 4, Bald Eagles, Recovery Objective: This recovery objective is a summary judgement, not a recovery objective, and it ignores areas outside the Prince William Sound. Does it make more sense to state a recovery objective, then follow with a sentence that states this recovery objective has already been met?

Page 5, Common Murres, Line 1: Civil Action No. A91-082, Table 1 of U.S. vs EXXON states that of September 25, 1989, 35,279 bird carcasses were recovered. Therefore, an estimate of 35,000 is better than "about 30,000".

Page 6, Cormorants, Line 2: What is the fourth cormorant species that may occur in the spill-affected areas, Brandt"s? I did not think it made it up here.

Page 6, Cormorants, Recovery Objective, Line 1: The sentence needs a verb after "cormorants" like "will have recovered".

Page 13, Pigeon Guillemot, Injury and Recovery: This section needs to specify what part of the Gulf of Alaska population died as a result of the spill. The Gulf of Alaska is a huge area, and the general public may not understand that we intend this to mean the spill-affected area in the Gulf outside of Prince William Sound. Does the 10-15 percent of the population include Prince William Sound or just outside of the Sound? I recommend using language like "10-15 percent of the population in the spill-affected area died in the spill."

Page 13, Pigeon Guillemot, Recovery Objective: Why are we limiting recovery to Prince William Sound when we state above that 10-15 percent of the population in the Gulf died in the spill? Also, EVOS-related studies support research on pigeon guillemots in Kachemak Bay. Seabird surveys along the coast of Kenai Fjords showed that pigeon guillemots sustained a considerable drop in population following the spill, over 20 percent, between 1986 and 1989.

Page 17, Sediments, Injury and Recovery: Somewhere in this section it should be noted that oil is persisting under armored rock settings on the Kenai Peninsula and Alaska Peninsula. This has been documented by Gail Irvine and Dan Mann.

Page 21, Recreation and Tourism, Injury and Recovery: Isn't the restriction on sport harvest of harlequin ducks limited to western Prince William Sound? As written the reader may get the impression that sport harvest is restricted throughout PWS. Also, isn't Fleming Spit in Cordova, and how did clean-up workers in PWS injure the camp area there? Is this a result of people seeking work in the spill-affected area, or were spill workers staged there?

I hope these comments are helpful.

[*Note: This table is modified from p. 32 of the* Restoration Plan.]

from Bruce Wright

see p. 31 in the Restoration Plan or change text in Rest. Plan p. 31, ¶3

1?

Table 2. Resources and Services Injured by the Spill

INJURED RESOURCES				LOST or REDUCED SERVICES
Recovered	**Recovering**	**Not Recovered**	**Recovery Unknown**	Commercial fishing
Bald eagle	Archaeological resources*	Cormorants (3 species)	Black oystercatcher	Passive uses
	Common murres	Harbor seal	Clams	Recreation and Tourism including sport fishing, sport hunting, and other
	Intertidal communities	Harlequin duck	Common loon	
	Mussels	Killer whale (AB pod)	Cutthroat trout	
	Pink salmon	Marbled murrelet	Dolly Varden	
	Sediments	Pacific herring	Kittl	
	Sockeye salmon	Pigeon guillemot	Rive	
	Subtidal communities	Sea otter (oiled west. PWS)	Rocl	
	---------- *Although archaeological resources are non-renewable, there has been significant progress toward the recovery objective.			

and designated Wilderness

Amending the List of Injured Resources and Services. The list of injured reso … v information is obtained through research, monitoring, and other studies sponsored by the Tr … y be submitted to add resources to the list. This information can include research results, ass … c and historical data, and supportive rationale. Information that has been through an appropria … f data have not been peer reviewed, they should be presented in a format that permits and facilitates peer review. Information to change the list will be reviewed through the Trustee Council's scientific review process.

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	Sediments	Pacific herring	Kittlitz's murrelet	
	Sockeye salmon	Pigeon guillemot	River otter	
	Subtidal communities	Sea otter (oiled west. PWS)	Rockfish	
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21.1.6A

Chapter 5
Injury Status and Recovery Objectives

The first part of this chapter discusses recovery objectives in general. The second part describes the nature and extent of injury and recovery and specific recovery objectives for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives can be found on the following pages:

Objectives

The recovery objectives described in the following section are the measurable conditions that signal the recovery of individual resources or services. 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, and it is difficult to predict conditions that would have existed in the absence of the spill. Recovery, therefore, is most realistically indicated by a return to prespill conditions, which may be assessed by comparisons of pre- and post-spill populations, by comparisons of populations or communities in oiled and unoiled areas, or, ideally, by both methods. For resources that were in decline before the spill, like harbor seals, recovery may be defined as the stabilization of a population, even if it is stabilized at a lower level than existed before the spill. In all cases, increased numbers of individuals, reproductive success sustained within normal bounds, improved growth and survival rates, and normal age and sex composition of the injured population, among others, are all indicators that recovery is underway.

Full ecological recovery will have been achieved when the populations 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.

Injury Status and Recovery Objective

This section describes the nature and extent of injury and recovery and the recovery objective for each injured resource and service. Specific strategies to achieve resource recovery objectives are described and updated in annual invitations (e.g., *Invitation to Submit Restoration Proposals for Federal Fiscal Year 1997*) and work plans. The information in this section is expected to change as the restoration program adapts to new information. For example, population declines or sublethal effects may be documented for new resources; other resources may recover or show signs that recovery is underway. Thus, the following descriptions of the injury and recovery status and recovery objectives for injured resources and lost or reduced services will change in response to new information, conditions, and scientific insights.

New scientific data will be incorporated into restoration decisions without the need to change the *Restoration Plan*. However, changes will be reported in the Trustee Council's annual status report, and, periodically, Chapter 5 of the *Restoration Plan* itself will be updated.

this corresponds to how these topics are presented on following pages

Resources

Archaeological Resources

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

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 spill occurred early 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. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was most probably from the *Exxon Valdez* spill. Hydrocarbon levels at the second sites were not sufficient to permit identification of the source or sources of the oil.

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.

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

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of 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.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered to have 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 (e.g., through excavation, site stabilization, or other forms of documentation).

Bald Eagles

Injury and Recovery

The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Prince William Sound provided year-round and seasonal habitat for about 5,000 bald eagles. A total of 151 eagle carcasses was recovered following the oil spill, and within Prince William Sound, it is estimated that about 250 bald eagles died as a result of the oil spill. There were no estimates of mortality outside the sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, 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.

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.

Black Oystercatchers

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but it has been estimated that actual mortalities may have been as high as, but probably did not exceed, 20 percent in the spill area.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill 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 known.

Recovery Objective

Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

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 were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, Prince William Sound, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

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, based on prespill data or comparisons of oiled and unoiled sites.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current 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

No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

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 index 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.

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the APEX (Apex Predator Ecosystem Experiment) project is investigating the possible link of murre declines to abundance of forage fish (herring, sand lance, and capelin). 13

prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be further indication that recovery is underway.

CORMORANTS

Injury and Recovery

Cormorants are large, fish-eating birds, that spend much of their time on the water or perched on rocks near the water. Three, and sometimes four, species are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The latest information from the U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog gives counts of 7161 pelagic cormorants, 8967 red-faced cormorants, and only 1558 double-crested cormorants in the oil-spill area. These are direct counts, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species) in Prince William Sound comparing boat pre- and post-spill surveys in July, including comparisons of oiled versus unoiled areas. Those surveys have not shown any increasing population trend since the oil spill.

Recovery Objective

Pelagic, red-faced, and double-crested cormorants when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

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 trout 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 have led to 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.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

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 by Congress. 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, 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.

Dolly Varden

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams, and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991, and the recovery status of this species is not known.

Recovery Objective
Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams , after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery
Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil impacted harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on comparisons of surveys in 1988 and then in 1989 after the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

When a population declines it means that deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline, adjusted for time of day and other factors, is about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

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the APEX (Apex Predator Ecosystem Experiment) project is investigating the possible link of harbor seal declines abundance of forage fish (herring, sand lance, and capelin).

13

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Recovery ... when harbor seal pop...

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; many more actually died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks and Barrow's and common goldeneye collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher

concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye 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.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

INTERTIDAL COMMUNITIES

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. 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. Intertidal resources are important to subsistence users, sea and river otters, and to a vareity of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats through the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockwood or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the covery provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective

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 reestablishment of important species, such as *Fucus* at sheltered rock sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

KILLER WHALES

Injury and Recovery

More than 100 killer whales in 6 "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the sound less frequently. 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 the losses and the oil spill is only circumstantial, but the probable mortality of killer whales in Prince William Sound following the spill far exceeds rates 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 within the major resident killer whales pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective

Killer whales will have recovered when the number of individuals in the AB pod is stable or increasing relative to the status of other major resident pods in Prince William Sound.

KITTLITZ'S MURRELET

Injury and Recovery

The Kittlitz's murrelet is only found in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

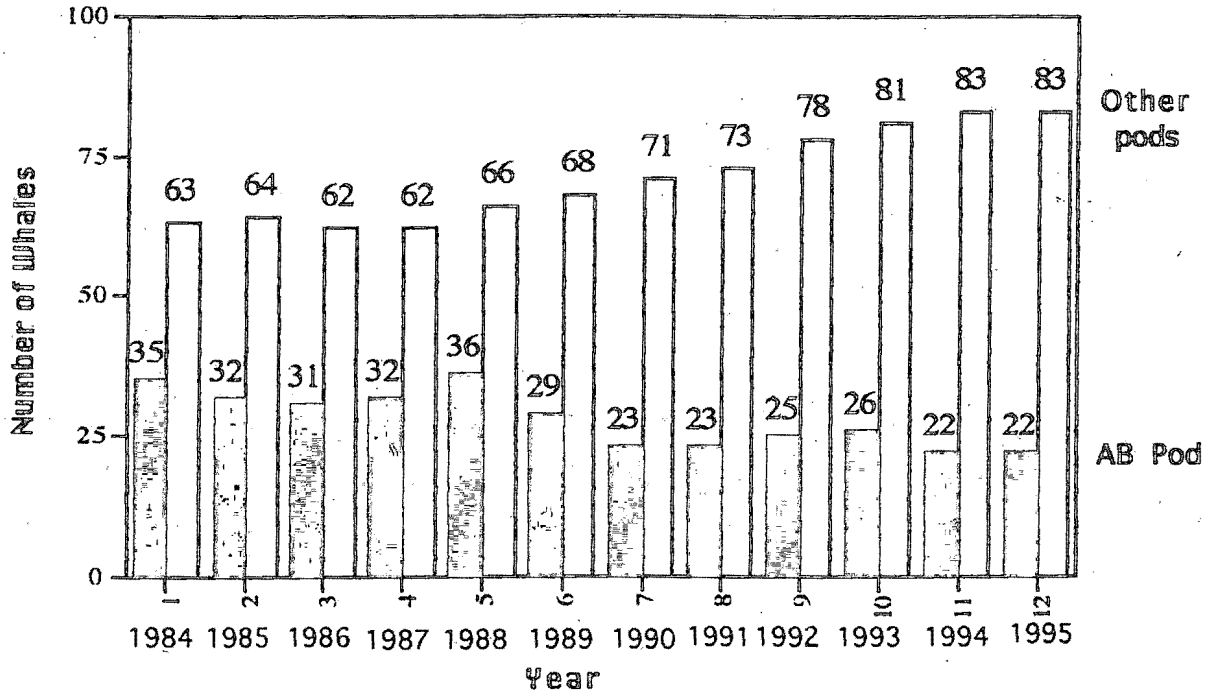
Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more

in many other years. Resident whales were not observed in October. August was the month with the most killer whale encounters (22), primarily resident pods. All encounters of three or more resident pods "superpods" occurred in late July or August.. [1]

Resident Pods

The total number of whales in well-documented resident pods other than AB pod has increased from 78 to 83 whales from 1992 to 1996, while AB pod has declined from 26 whales to 22 whales in that same time period (Figure 2)

Figure 2. Total number of whales in AB pod and in other resident pods by year, 1984-1994.



[1] Detailed analysis of occurance of resident and transient whales by month and year will be completed after data entry into GIS format is complete

murrelets were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective
No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELET

Injury and Recovery
The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. 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 in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified were marbled murrelets. Many more murrelets were actually killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. Nor is there evidence of any further decline.

Recovery Objective
Marbled murrelets will have recovered when population trends are stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

The APEX (Apex Predator Ecosystem Experiment) project is investigating the possible link of marbled murrelet declines abundance of forage fish (herring, sand lance, and capelin).

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 and habitat for other organisms 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 and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of 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.

Approximately 30 (from Molly Babcock)

~~At least 70~~ mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective

Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

PACIFIC HERRING

Injury and Recovery

Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant fraction of these spawning habitats as well as herring staging areas in the sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In

1993, however, there was an unprecedented crash of adult herring. A viral disease and fungus were the probable agents of mortality, and 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. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of pollock as both competitors with and predators of herring, which may indicate that there in a connection between the lack of recuritment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically as well as commercially. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective
Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

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, there was evidence that the pigeon guillemot population in Prince William Sound had declined 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 population in Prince William Sound is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

the APEX (Apex Predator Ecosystem Experiment) project is investigating the possible link of pigeon guillemot declines to abundance of forage fish (herring, sand lance, and capelin).

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 pink 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, returns 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 management 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 *Exxon Valdez* oil. For pink salmon, mortalities of 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 oceanographic and ecological factors that influence production of pink salmon and Pacific 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.

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.

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, but the actual mortality is not known. 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. Since there were no prespill data and sample sizes were small, 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 Jackpot and Knight islands.

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 differences.

ROCKFISH

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective

No recovery objective can be defined.

Sea Otters

Injury and Recovery

By the late 1800s, sea otters had been eliminated from most of their historical range due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional ~~otters~~ animals probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult sea otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-1994). This lack of a significant positive trend, however, may result from a lack of statistical power in the survey, which will be repeated in 1996.

Based on the insights of local observers, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western sound.

Recovery Objective

Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

Sediments

Injury and Recovery

Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning and natural microbial biodegradation removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound was in 1993, and it included 45 areas of shoreline known from the clean-up to have had the most significant oiling. That survey indicated that heavy subsurface oil had decreased by 65 percent since 1991, and

that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the sound is relatively stable and, by this time, is likely to decrease only slowly.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings on the islands, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water 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. 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 few sites at which subtidal oiling is still known to occur.

Recovery Objective

Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and 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 numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other 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 altering 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.

The effects of the 1989 overescapement of sockeye salmon 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 commercial, recreational, and subsistence demands on sockeye salmon in the Kenai River system.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem with fry production may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

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.

Subtidal Communities

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. The concentration of oil in sediments in 1990 was more than twice as great at oiled sites. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced diversity and abundance of eelgrass shoots and flowers, worms, clams, snails, oil-sensitive amphipods (sand fleas), and helmet crabs. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, increased in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plant and animals. However, there were still some animals that were more abundant at oiled sites, like those observed in 1990. These included the opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod. Reconnaissance surveys indicated that there were more small green sea urchins at oiled sites.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. However, the abundance of small green sea urchins was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the sediment oil concentrations and organisms that live within the substrate are not yet complete.

Recovery Objective
Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

Services

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 and poor fishery recruitment since 1989. 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 commercially important fish species that were injured by the oil spill. These projects include: supplementation 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.

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 because of the effects of the oil 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~~ Four 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

doesn't compute

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.

add Improved management - this allows for less conservative harvests of hatchery stocks while protecting injured wild stocks.

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. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial lost passive use values resulting from the oil spill.

nonconsumptive use

losses of

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 information on the health and recovery status of injured resources, based on monitoring and research projects, will play an important role in the restoration of passive uses.

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, 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. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, 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.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. There are still locations within the oil-spill area, however, avoided by recreational users because of the presence of residual oil.

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.

SUBSISTENCE

Injury and Recovery

Fifteen predominantly Alaskan Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include 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 from 1989-1994. No or very low concentrations of petroleum hydrocarbons were found in most resources. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to pre-spill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort

to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. 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 ways 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 confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be 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.

Increase involvement of subsistence users in the restoration process. Increasing participation of community residents will increase their confidence that injured resources will be and are being restored. Increased participation also will improve the results of restoration work, including research and monitoring projects, through the incorporation of traditional and local knowledge.

Scientific Research Opportunities

The EVOS has provided many scientific research opportunities ultimately leading to profound findings of the effects of a large oil spill on many species, marine habitats and a pristine ecosystem. Some referenced oiled study sites will be maintained to all further investigation and completion of these studies. . . . . .

Sten,
Just an idea.
What do you think?
Bruce

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

MEMORANDUM

To: Restoration Work Force, Liaisons, and Legal Counsel

From: Molly McCammon, Executive Director
Stan Senner, Science Coordinator
Dr. Robert Spies, Chief Scientist

Date: February 9, 1996

Subj: Revised Chapter 5 and List of Injured Resources

Attached are revised versions of Chapter 5 and the injured resources list. Our plan is to send final drafts of these documents out for public review by about February 26. With a few exceptions, which are outlined below, these are not substantively different from the versions you saw before the Restoration Workshop. However, we welcome any suggestions you or your Trustee may have for improving the documents. Also, let me or Stan Senner know if there is any concern in sending them out for public review.

The revised Chapter 5 is much like what it was before the workshop. We have continued to refine the discussions of injury and recovery status and the recovery objectives, but there are no major changes for the various resources. With respect to services, there are two changes:

(1) For Passive Uses, a sentence was added noting that the State of Alaska's contingent valuation studies following the oil spill document losses of passive uses. Previously, this section defined passive use but said nothing about injury following the *Exxon Valdez* oil spill. In the recovery strategy, we clarified that monitoring and research projects are one way that we can provide information to the public on the health and recovery status of injured resources and such information is a way to restore passive uses.

(2) For Subsistence, we added a strategy, "Increase involvement of subsistence users in the restoration process." We believe that this language will better reflect a growing emphasis on community involvement and traditional knowledge.

With respect to the other services, we reviewed the restoration strategies carefully and believe that they are sufficiently broad to cover the strategies being implemented through the annual work plan.

Finally, in regard to injured resources, we have enclosed a draft memorandum from the Chief Scientist with his recommendations in regard to scoters, cormorants, and kittiwakes. He recommends adding three species of cormorants to the list, but not scoters or kittiwakes. Accordingly, cormorants have been added to the revised draft Table 2.

In regard to Table 2, the other change you should be aware of is that we recommend removing the term "biological resources," and then integrating archaeological resources, designated wilderness areas, and sediments into the list of other injured resources. We propose that archaeological resources (with a footnote) and sediments be classified as "recovering," while designated wilderness areas be classified as "recovery unknown." These changes respond to suggestions by several reviewers. Please let us know if you have problems or questions with these changes.

Please try to return any comments to the Anchorage Restoration Office by close of business on Friday, February 16. Stan Senner is away from the office the 13th through the 16th, but he will work on a final version immediately after President's Day.

Thank you.

[*Note: This table is modified from p. 32 of the* Restoration Plan.]

Table 2. Resources and Services Injured by the Spill

INJURED RESOURCES				LOST or REDUCED SERVICES
Recovered	**Recovering**	**Not Recovered**	**Recovery Unknown**	Commercial fishing
Bald eagle	Archaeological resources*	Cormorants (3 species)	Black oystercatcher	Passive uses
	Common murres	Harbor seal	Clams	Recreation and Tourism including sport fishing, sport hunting, and other recreation uses
	Intertidal communities	Harlequin duck	Common loon	
	Mussels	Killer whale (AB pod)	Cutthroat trout	
	Pink salmon	Marbled murrelet	Dolly Varden	Subsistence
	Sediments	Pacific herring	Kittlitz's murrelet	
	Sockeye salmon	Pigeon guillemot	River otter	
	Subtidal communities	Sea otter (oiled west. PWS)	Rockfish	
	---------- *Although archaeological resources are non-renewable, there has been significant progress toward the recovery objective.			

Amending the List of Injured Resources and Services. The list of injured resources and services will be reviewed as new information is obtained through research, monitoring, and other studies sponsored by the Trustee Council. In addition, information may be submitted to add resources to the list. This information can include research results, assessment of population trends, ethnographic and historical data, and supportive rationale. Information that has been through an appropriate scientific review process is preferable. If data have not been peer reviewed, they should be presented in a format that permits and facilitates peer review. Information to change the list will be reviewed through the Trustee Council's scientific review process.

Chapter 5
Injury Status and Recovery Objectives

The first part of this chapter discusses recovery objectives in general. The second part describes the nature and extent of injury and recovery and specific recovery objectives for each injured resource and service discussed in Table 2 in Chapter 4. Detailed information on injury and recovery objectives can be found on the following pages:

Objectives

The recovery objectives described in the following section are the measurable conditions that signal the recovery of individual resources or services. 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, and it is difficult to predict conditions that would have existed in the absence of the spill. Recovery, therefore, is most realistically indicated by a return to prespill conditions, which may be assessed by comparisons of pre- and post-spill populations, by comparisons of populations or communities in oiled and unoiled areas, or, ideally, by both methods. For resources that were in decline before the spill, like harbor seals, recovery may be defined as the stabilization of a population, even if it is stabilized at a lower level than existed before the spill. In all cases, increased numbers of individuals, reproductive success sustained within normal bounds, improved growth and survival rates, and normal age and sex composition of the injured population, among others, are all indicators that recovery is underway.

Full ecological recovery will have been achieved when the populations 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.

Injury Status and Recovery Objective

This section describes the nature and extent of injury and recovery and the recovery objective for each injured resource and service. Specific strategies to achieve resource recovery objectives are described and updated in annual invitations (e.g., *Invitation to Submit Restoration Proposals for Federal Fiscal Year 1997*) and work plans. The information in this section is expected to change as the restoration program adapts to new information. For example, population declines or sublethal effects may be documented for new resources; other resources may recover or show signs that recovery is underway. Thus, the following descriptions of the injury and recovery status and recovery objectives for injured resources and lost or reduced services will change in response to new information, conditions, and scientific insights.

New scientific data will be incorporated into restoration decisions without the need to change the *Restoration Plan*. However, changes will be reported in the Trustee Council's annual status report, and, periodically, Chapter 5 of the *Restoration Plan* itself will be updated.

Resources

Archaeological Resources

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

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 spill occurred early 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. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was most probably from the *Exxon Valdez* spill. Hydrocarbon levels at the second sites were not sufficient to permit identification of the source or sources of the oil.

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.

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

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of 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.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered to have 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 (e.g., through excavation, site stabilization, or other forms of documentation).

Bald Eagles

Injury and Recovery

The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Prince William Sound provided year-round and seasonal habitat for about 5,000 bald eagles. A total of 151 eagle carcasses was recovered following the oil spill, and, within Prince William Sound, it is estimated that about 250 bald eagles died as a result of the oil spill. There were no estimates of mortality outside the sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, 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.

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.

Black Oystercatchers

Injury and Recovery

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but it has been estimated that actual mortalities may have been as high as, but probably did not exceed, 20 percent in the spill area.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill 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 known.

Recovery Objective

Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

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 were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, Prince William Sound, and Alaska Peninsula, concern about the effects of the oil spill on clams and subsistence uses of clams remains high.

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, based on prespill data or comparisons of oiled and unoiled sites.

COMMON LOONS

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current 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

No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

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 index 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 the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994 and, at that time, the local population had not returned to prespill levels.

Recovery Objective

Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be further indication that recovery is underway.

CORMORANTS

Injury and Recovery

Cormorants are large, fish-eating birds, that spend much of their time on the water or perched on rocks near the water. Three, and sometimes four, species are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The latest information from the U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog gives counts of 7161 pelagic cormorants, 8967 red-faced cormorants, and only 1558 double-crested cormorants in the oil-spill area. These are direct counts, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species) in Prince William Sound comparing boat pre- and post-spill surveys in July, including comparisons of oiled versus unoiled areas. Those surveys have not shown any increasing population trend since the oil spill.

Recovery Objective

Pelagic, red-faced, and double-crested cormorants when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

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 trout 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 have led to 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.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

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 by Congress. 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, 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.

Dolly Varden

Injury and Recovery

Like the cutthroat trout, there was evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams , and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991, and the recovery status of this species is not known.

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams , after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil impacted harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on comparisons of surveys in 1988 and then in 1989 after the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

When a population declines it means that deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline, adjusted for time of day and other factors, is about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

Harbor seals have long been and continue to be a key subsistence resource in the oil-spill area. Subsistence hunting is affected by the declining seal population, and lack of opportunities to hunt seals has changed the diets of subsistence users who traditionally had relied heavily on these marine mammals.

Recovery Objective

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

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; many more actually died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks and Barrow's and common goldeneye collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher

concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye 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.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

Intertidal Communities

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. 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. Intertidal resources are important to subsistence users, sea and river otters, and to a vareity of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats through the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockwood or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the covery provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective

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 reestablishment of important species, such as *Fucus* at sheltered rock sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

Killer Whales

Injury and Recovery

More than 100 killer whales in 6 "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the sound less frequently. 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 the losses and the oil spill is only circumstantial, but the probable mortality of killer whales in Prince William Sound following the spill far exceeds rates 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 within the major resident killer whales pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective

Killer whales will have recovered when the number of individuals in the AB pod is stable or increasing relative to the status of other major resident pods in Prince William Sound.

Kittlitz's Murrelet

Injury and Recovery

The Kittlitz's murrelet is only found in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more

murrelets were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective
No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELET

Injury and Recovery
The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. 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 in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified were marbled murrelets. Many more murrelets were actually killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound. Nor is there evidence of any further decline.

Recovery Objective
Marbled murrelets will have recovered when population trends are stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

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 and habitat for other organisms 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 and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of 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.

At least 70 mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective

Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

Pacific Herring

Injury and Recovery

Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant fraction of these spawning habitats as well as herring staging areas in the sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In

1993, however, there was an unprecedented crash of adult herring. A viral disease and fungus were the probable agents of mortality, and 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. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of pollock as both competitors with and predators of herring, which may indicate that there in a connection between the lack of recuritment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically as well as commercially. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1995 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective

Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

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, there was evidence that the pigeon guillemot population in Prince William Sound had declined 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 population in Prince William Sound is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

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 pink 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, returns 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 management 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 *Exxon Valdez* oil. For pink salmon, mortalities of 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 oceanographic and ecological factors that influence production of pink salmon and Pacific 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.

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.

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, but the actual mortality is not known. 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. Since there were no prespill data and sample sizes were small, 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 Jackpot and Knight islands.

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 differences.

Rockfish

Injury and Recovery

Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective

No recovery objective can be defined.

Sea Otters

Injury and Recovery

By the late 1800s, sea otters had been eliminated from most of their historical range due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional otters probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-1994). This lack of a significant positive trend, however, may result from a lack of statistical power in the survey, which will be repeated in 1996.

Based on the insights of local observers, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western sound.

Recovery Objective

Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

Sediments

Injury and Recovery

Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound was in 1993, and it included 45 areas of shoreline known from the clean-up to have had the most significant oiling. That survey indicated that heavy subsurface oil had decreased by 65 percent since 1991, and

that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the sound is relatively stable and, by this time, is likely to decrease only slowly.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings on the islands, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water 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. 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 few sites at which subtidal oiling is still known to occur.

Recovery Objective

Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and 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 numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other 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 altering 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.

The effects of the 1989 overescapement of sockeye salmon 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 commercial, recreational, and subsistence demands on sockeye salmon in the Kenai River system.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem with fry production may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

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.

Subtidal Communities

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. The concentration of oil in sediments in 1990 was more than twice as great at oiled sites. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced diversity and abundance of eelgrass shoots and flowers, worms, clams, snails, oil-sensitive amphipods (sand fleas), and helmet crabs. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, increased in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plant and animals. However, there were still some animals that were more abundant at oiled sites, like those observed in 1990. These included the opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod. Reconnaissance surveys indicated that there were more small green sea urchins at oiled sites.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. However, the abundance of small green sea urchins was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the sediment oil concentrations and organisms that live within the substrate are not yet complete.

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

Services

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 and poor fishery recruitment since 1989. 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 commercially important fish species that were injured by the oil spill. These projects include: supplementation 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.

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 because of the effects of the oil 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.

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. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial lost passive use values resulting from the oil 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 information on the health and recovery status of injured resources, based on monitoring and research projects, will play an important role in the restoration of passive uses.

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, 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. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, 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.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. There are still locations within the oil-spill area, however, avoided by recreational users because of the presence of residual oil.

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.

SUBSISTENCE

Injury and Recovery

Fifteen predominantly Alaskan Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include 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 from 1989-1994. No or very low concentrations of petroleum hydrocarbons were found in most resources. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to pre-spill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort

to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. 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 ways 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 confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be 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.

Increase involvement of subsistence users in the restoration process. Increasing participation of community residents will increase their confidence that injured resources will be and are being restored. Increased participation also will improve the results of restoration work, including research and monitoring projects, through the incorporation of traditional and local knowledge.

APPLIED marine SCIENCES

February 7, 1996

To: Molly McCammon, Executive Director

From: Robert B. Spies, Chief Scientist

DRAFT

Re: Further analysis of recent nominations to the injured species list

Recommendation

The Trustee Council's Restoration Plan allows for amending the list of injured species published in the plan by nomination and review of the pertinent information through the council's scientific review process. This memo reviews the available information on three species or groups of birds that have been nominated: black-legged kittiwakes, cormorants and scoters. I have examined, with the help of Mr. Stan Senner, available data on the extent and severity of injury, including the results of Exxon-funded boat surveys. As a result, I recommend adding to the list double-crested, red-faced, and pelagic cormorants. I find that the available information on black-legged kittiwakes and scoters (which includes white-winged, surf and black) does not indicate that these species were significantly affected by the spill.

Background

During the August 11, 1995 meeting of the *Exxon Valdez* Trustee Council staff was directed to consider in more detail the nominations of scoters and cormorants to the injured species list. In addition, a recommendation from the Chief Scientist on black-legged kittiwakes had been deferred until more data could be gathered and more analyses undertaken. At your request, I present in this memo a further analysis of data on injury of black-legged kittiwakes, as well as scoters (which includes white-winged, surf and black) and cormorants (which includes double-crested, red-faced, and pelagic cormorants).

We all realize that there are many more species injured by the *Exxon Valdez* oil spill than are listed in Table B-1 of the Restoration Plan. This list reflects those species for which there is evidence that the spill-area populations were particularly hard hit by the spill. Placing additional species on this list should not imply any commitment on the part of the Trustee Council to allocate additional resources for research on, or restoration of, these species.

The recommendations herein are based on the best available information about the relative severity of the injuries. This includes results of boat surveys funded by both the Trustee Council (Klosiewski and Laing 1994, Agler et al. 1994, 1995), other Trustee Council or agency-funded studies,

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and carcasses in the morgue, taking into account probable population sizes. Of course, our recommendations would be reconsidered if significant new information or alternative analyses were to come to light.

There are several criteria that were considered in making recommendations for addition of species to this list: 1) the severity of injury to the population, 2) whether recovery from injury is apparent, and 3) the strength of the evidence. With regard to this last criterion, we generally considered the estimated mortality, based on the number of carcasses recovered, relative to the total population size in the region as a threshold criterion. If the severity of injury appeared to be significant in terms of the population, then the government- or Exxon-funded population surveys were used as corroborating evidence when available.

Black-legged kittiwakes

Black-legged kittiwakes have been nominated to the injured species list by Dr. David Irons of the USFWS (letter of June 24, 1994) based on the recovery of carcasses after the spill and on the results of studies of kittiwake reproductive success. We have received data and opinions from Dr. Irons in support of the nomination. Dr. Scott Hatch, of the National Biological Service, has provided an alternative view. The following analysis is based on an estimate of kittiwake mortality immediately after the spill relative to the total population in the spill area and an evaluation of the chick productivity data supplied by Dr. Irons.

There were 1225 black-legged kittiwakes received at the spill-area morgues in 1989. An analysis of conditions for sea birds in 1989 led Piatt et al. (1990) to partition this mortality by whether it occurred before or after August 1, 1989. Prior to that date most mortalities were due to the spill. Subsequent to that date most mortalities were probably due to natural causes. Two hundred and forty-one of the black-legged kittiwake carcasses were received before August 1, 1989; the balance, 984, were received after that date and were mainly from the Gulf of Alaska. Based on an expansion factor of 5 to 10 actual mortalities for every carcass recovered, we estimate that 1,205 to 2,410 black-legged kittiwakes were killed by the spill. To put this mortality in perspective, there have been 100,579 nesting black-legged kittiwakes counted in colonies within the path of the spill and 268,512 nesting kittiwakes in the wider oil spill area (US Fish and Wildlife Service, Alaska Seabird Colony Catalog). These counts of kittiwakes at colonies are not population estimates, which would be still higher. However, based on this range of kittiwakes at risk and the range of estimated mortalities, it appears that the mortalities are on the order of 1 to 2% of the population. One could argue that the date used to separate oil-spill attributable deaths from natural mortality, August 1, 1989 is arbitrary, but Dr. Piatt and colleagues made a strong case for such a separation in this period since dead sea birds received at the morgues after this date had

very little oil on them and many showed indications of starvation, most likely due to natural causes.

As noted in the background section above, we have generally considered the estimated mortality in relation to the total population size as a threshold criterion. In this case, the kittiwake mortality is not consequential at the population level.

Dr. Irons has also presented data indicating that kittiwake colonies in the path of the oil spill in 1989 had poor productivity compared to colonies in the unoiled areas (Irons, 1996). While there clearly was poorer productivity at colonies in the path of the spill, I do not find these productivity data per se are sufficient evidence of injury, particularly given the pre-spill differences seen in these same colonies and the tremendous variability of kittiwake productivity, both geographically and temporally. Since the evidence for the oil contamination of birds and their eggs after the spill has not been finalized and accepted through the review process, perhaps the issue of the effects on chick productivity can be considered further when that report is available.

Finally, the overall kittiwake population in Prince William Sound in 1989-1991 was significantly less than in 1972-73. However, the number of kittiwakes in oiled and unoiled areas were not different after the spill (Klosiewski and Lang, 1994). The Exxon-funded boat surveys also did not find evidence of impacts on kittiwakes.

Based mainly on the insignificant mortality of black-legged kittiwakes and, to a lesser extent, that the evidence from productivity studies and populations survey is not yet compelling , I cannot recommend adding black-legged kittiwakes to injured species list at this time.

Cormorants

Carcasses of 838 cormorants were recovered, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. If the unidentified cormorants are allocated proportionately to the three species, and multiplied by a factor of 5 as a conservative estimate of actual mortality, then the estimated mortalities are: 2840 pelagic, 1095 red-faced, and 255 double-crested cormorants.

These estimated mortalities need to be considered in the context of the regional populations of these species. No regional population estimates are available, nor are the existing data such that any rigorous estimate can be made. There are some data, however, which shed light on the numbers of cormorants in the oil-spill area:

(1) The Alaska Seabird Colony catalog maintained by the U.S. Fish and Wildlife Service includes the following direct counts of cormorants at nesting colonies (presented as a range: number in oiled areas-number in general oil-spill area): pelagic, 5529-7161; red-faced, 8696-8967; double-crested, 823-1558; unidentified, 3030-3667). These numbers should not be interpreted to represent all cormorants in the region, nor even all breeding cormorants.

(2) U.S. Fish and Wildlife Service boat surveys conducted in Prince William Sound since the oil spill (Agler et al. 1995) have resulted in the following ranges of population estimates for both oiled and unoiled areas in the sound (values presented are low and high estimates for March surveys, 1990-1994): pelagic, 5,431-10,959; red-faced, 6-8; double-crested, 124-1041; and unidentified, 278-3,477. Since these are March estimates, these include some combination of wintering and migrant birds from unknown breeding areas.

(3) Forsell and Gould (1981) estimated that 18,500 cormorants of all three species were wintering in the bays and coasts of Kodiak, Sitkalidak, and southern Afognak islands. They also estimated that pelagic cormorants outnumbered red-faced on a 10:1 basis and that there were very few double-crested cormorants in the Kodiak area.

It is important not to make too much of any of these data, which have their own limitations and which were gathered by different methods, seasons, etc. It appears, however, that pelagic cormorants have regional populations at least in the low 10s of thousands (e.g., 20,000-30,000). The red-faced cormorant is less abundant, perhaps 10,000-20,000. Double-crested cormorants perhaps number only 1,000-2,000. These are only crude estimates of population sizes, but, on these bases, the estimated mortalities due to the oil spill appear to be significant at the population level.

There are some additional data which can be brought to bear: There were statistically-significant declines in the estimated numbers of cormorants (all species) in Prince William Sound comparing boat surveys in July 1972-73 and 1989-91, including comparisons of oiled versus unoiled areas (Klosiewski and Laing 1994). In addition, Exxon's boat surveys indicated "strong" evidence of initial negative impacts on pelagic cormorants in Prince William Sound and for double-crested cormorants on the Kenai coast (Day et al. 1995). Given the evidence (and uncertainties) outlined above, I recommend listing all three cormorants--pelagic, red-faced, and double-crested--as injured resources as a result of the Exxon Valdez oil spill.

Scoters

Carcasses of 811 scoters were recovered following the oil spill, including 342 white-winged, 175 surf, 132 black and 162 unidentified scoters. If the unidentified scoters are assigned to the three species in proportion to their

numbers in the morgue and the species totals are increased by a factor of five as a conservative estimate of actual mortalities, the following died as a result of the oil spill: 2140 white-winged, 1095 surf, and 120 black scoters.

The direct mortalities of scoters should be compared with their population sizes, but there are no regional population estimates for any of the scoter species in the oil-spill area. There are some data, however, that shed some light on the population sizes.

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The data cited above present, at best, a piecemeal picture of scoter populations in the oil-spill area. Taken together, however, these data suggest a total oil-spill area scoter population of more than 100,000 birds, and, possibly, considerably more. White-winged scoters appear to be the most abundant species overall, although the proportions of the three species vary geographically and seasonally. Therefore I estimate a total mortality of about 4,000 scoters out of 100,00 individuals at risk.

Comparisons of pre-and post-spill boat surveys in Prince William Sound in March, July and August (1972-73 vs. 1989-91) showed significantly fewer scoters post-spill but these trends did not hold when populations in oiled areas were compared to those in unoiled areas (Kloseiwski and Lang, 1994).

Finally, Exxon's boat surveys, 1989-91, revealed no evidence of negative impacts for surf and white-winged scoters either in Prince William Sound or on the Kenai coast. There was "weak" evidence of initial impacts on black scoters in the Sound (Murphy et al., 1995)

Therefore, it appears that the injury to scoters is not sufficiently severe to warrant the special recognition of being placed on the injured species list.

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CC: D. Williams
D. Irons

DRAFT

APPLIED
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SCIENCES

April 1, 1996

TO: Molly McCammon
Executive Director

FROM: Robert B. Spies
Chief Scientist

CC: Stan Senner
Science Coordinator

RE: Changes to the Injured Species List

The purpose of this memo is to provide a recommendation regarding alterations to the injured species list. These alterations are based upon recent data from the Restoration Program, and the proposed changes would affect the recovery status for certain species as listed in Table 2 of the Restoration Plan.

This memo is organized by the type of change being proposed (e.g., changing from "recovering" to "recovered'), and then the species of concern are considered as appropriate.

Changing from Recovering to Recovered

Bald Eagles. Following the spill a total of 151 eagle carcasses was recovered from the oil-spill area, and within the Sound it is estimated that about 250 bald eagles died as a result of the spill. In addition to direct mortalities, productivity was reduced in oiled areas of Prince William Sound in 1989.

Studies conducted under the auspices of the Trustee Council indicate that 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.

Recommendation: I recommend that bald eagles now be considered Recovered.

Changing from Not Recovering to Recovering

Common Murres. 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). Based on surveys of index colonies at such locations as Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay, the spill-area population declined by about 40 percent. 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 the colonies in the Barren Islands indicates that reproductive timing and success were within normal bounds in 1993. Numbers of adult murres were last surveyed at those same colonies in 1994. At that time, the local population had not returned to prespill levels.

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Recommendation: Given that productivity is now normal, I recommend that common murres be reclassified from Not Recovering to Recovering.

Subtidal Communities. Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there was reduced diversity and/or abundance of eelgrass shoots and flowers, worms, clams, snails, oil-sensitive amphipods (sand fleas), and helmet crabs. Organisms living in surface sediments at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, were more numerous at oiled sites.

By 1993, the eelgrass habitat (the only habitat examined in 1993), revealed fewer differences in abundances of plants and animals. However, as was true in 1990, some opportunistic species still were more abundant at oiled sites. Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites.

The abundance of small green sea urchins, however, was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the recent oil concentrations in sediments and organisms that live within the substrate are not yet complete.

Recommendation: Based upon these results, I recommend that the status subtidal communities be changed from Not Recovering to Recovering.

Pink Salmon. Three types of early life-stage injuries were identified in pink salmon. First, growth rates in juvenile pink salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams. Evidence for a third effect, genetic damage, has also been gathered, and investigations are underway to determine if this injury has occurred.

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. The tremendous natural variation in adult returns makes it difficult to attribute poor returns in a given year to injuries caused by the *Exxon Valdez* oil spill. 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 not statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery from oil-spill effects is underway.

Recommendation: Based upon these results, I recommend that the status of pink salmon be changed from Not Recovering to Recovering.

Changing from Recovering to Not Recovered

Killer Whale (AB Pod). More than 80 killer whales in six "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the Sound less frequently. 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 restoration studies documented that four calves were added to the AB pod during 1992-94, surveys in 1994 and 1995 indicate the loss of five more adult whales. The link

between the losses and the oil spill is only circumstantial, but the probable mortality of killer whales in the AB pod in Prince William Sound following the spill far exceeds rates observed for other pods in British Columbia and Puget Sound over the last 20 years. In addition to the effects of the oil spill, there has been concern about the possible shooting of killer whales, perhaps due to conflicts with long-line fisheries.

The AB pod may never regain its former size, but overall numbers within the major resident killer whales pods in Prince William Sound are at or exceed prespill levels.

Recommendation: I recommend that the killer whale be changed from Recovering to Not Recovered, but that it be specified that only the AB Pod is not recovered.

Changing from Recovering to Recovery Unknown

Black oystercatcher. Only nine carcasses of adult oystercatchers were recovered following the spill, but it has been estimated that actual mortalities may have been much higher. In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill data.

Early restoration studies (1993) indicated that productivity of black oystercatchers in Prince William Sound was recovering, but these measurements have not been made since that time. Moreover, the measurements in 1993 were limited in number and geographic scope.

Recommendation: I recommend that the recovery status of black oystercatchers be changed from Recovering to Recovery Unknown.

Changing from Other to Recovering

Archaeological Resources. 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 both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites. Monitoring of archaeological sites in 1994 and 1995 found no evidence of new damage from vandalism.

Archaeological resources are nonrenewable; the cannot recover in the same sense as biological resources. However, there has been significant progress toward achieving the recovery objective identified in the Restoration Plan.

Recommendation: To reflect progress in achieving the recovery objective, I recommend that archaeological resources be reclassified from Other to Recovered.

APPLIED marine SCIENCES

February 7, 1996

To: Molly McCammon, Executive Director

From: Robert B. Spies, Chief Scientist

Re: Further analysis of recent nominations to the injured species list

Recommendation

The Trustee Council's Restoration Plan allows for amending the list of injured species published in the plan by nomination and review of the pertinent information through the council's scientific review process. This memo reviews the available information on three species or groups of birds that have been nominated: black-legged kittiwakes, cormorants and scoters. I have examined, with the help of Mr. Stan Senner, Science Coordinator for the Trustee Council, available data on the extent and severity of injury, including the results of Exxon-funded boat surveys. As a result, I recommend adding to the list double-crested, red-faced, and pelagic cormorants. I find that the available information on black-legged kittiwakes and scoters (which includes white-winged, surf and black) does not indicate that these species were significantly affected by the spill.

Background

During the August 11, 1995 meeting of the *Exxon Valdez* Trustee Council staff was directed to consider in more detail the nominations of scoters and cormorants to the injured species list. In addition, a recommendation from the Chief Scientist on black-legged kittiwakes had been deferred until more data could be gathered and more analyses undertaken. At your request, I present in this memo a further analysis of data on injury of black-legged kittiwakes, as well as scoters (which includes white-winged, surf and black) and cormorants (which includes double-crested, red-faced, and pelagic cormorants).

We all realize that there are many more species injured by the *Exxon Valdez* oil spill than are listed in Table B-1 of the Restoration Plan. This list reflects those species for which there is evidence that the spill-area populations were particularly hard hit by the spill. Placing additional species on this list should not imply any commitment on the part of the Trustee Council to allocate additional resources for research on, or restoration of, these species.

The recommendations herein are based on the best available information about the relative severity of the injuries. This includes results of boat surveys funded by both the Trustee Council (Klosiewski and Laing

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1994, Agler et al. 1994, 1995), other Trustee Council or agency-funded studies, and carcasses in the morgue, taking into account probable population sizes. Of course, my recommendations would be reconsidered if significant new information or alternative analyses were to come to light.

There are three criteria that were considered in making recommendations for addition of species to this list: 1) the severity of injury to the population, 2) whether recovery from injury is apparent, and 3) the strength of the evidence. With regard to this last criterion, I generally considered the estimated mortality, based on the number of carcasses recovered, relative to the total population size in the region as a threshold criterion. If the severity of injury appeared to be significant in terms of the population, then the government- or Exxon-funded population surveys were used as corroborating evidence when available.

Black-legged kittiwakes

Black-legged kittiwakes have been nominated to the injured species list by Dr. David Irons of the USFWS (letter of June 24, 1994) based on the recovery of carcasses after the spill and on the results of studies of kittiwake reproductive success. We have received data and opinions from Dr. Irons in support of the nomination. Dr. Scott Hatch, of the National Biological Service, has provided an alternative view. The following analysis is based on an estimate of kittiwake mortality immediately after the spill relative to the total population in the spill area and an evaluation of the chick productivity data supplied by Dr. Irons.

There were 1225 black-legged kittiwakes received at the spill-area morgues in 1989. An analysis of conditions for sea birds in 1989 led Piatt et al. (1990) to partition this mortality by whether it occurred before or after August 1, 1989. Prior to that date most mortalities were due to the spill. Subsequent to that date most mortalities were probably due to natural causes. Two hundred and forty-one of the black-legged kittiwake carcasses were received before August 1, 1989; the balance, 984, were received after that date and were mainly from the Gulf of Alaska. Based on an expansion factor of 5 to 10 actual mortalities for every carcass recovered, we estimate that 1,205 to 2,410 black-legged kittiwakes were killed by the spill. To put this mortality in perspective, there have been 100,579 nesting black-legged kittiwakes counted in colonies within the path of the spill and 268,512 nesting black-legged kittiwakes in the wider oil spill area (US Fish and Wildlife Service, Alaska Seabird Colony Catalog). These counts of kittiwakes at colonies are not population estimates, which would be still higher. However, based on this range of kittiwakes at risk and the range of estimated mortalities, it appears that the mortalities are on the order of 1 to 2% of the population. One could argue that the date used to separate oil-spill attributable deaths from natural mortality, August 1, 1989 is arbitrary, but Dr. Piatt and colleagues made a strong case for such a

separation in this period since dead sea birds received at the morgues after this date had very little oil on them and many showed indications of starvation, most likely due to natural causes.

As noted in the background section above, we have generally considered the estimated mortality in relation to the total population size as a threshold criterion. In this case, the kittiwake mortality is not consequential at the population level.

Dr. Irons has also presented data indicating that kittiwake colonies in the path of the oil spill in 1989 had poor productivity compared to colonies in the unoiled areas (Irons, 1996). While there clearly was poorer productivity at colonies in the path of the spill, I do not find these productivity data per se are sufficient evidence of injury, particularly given the pre-spill differences seen in these same colonies and the tremendous variability of kittiwake productivity, both geographically and temporally. Since the evidence for the oil contamination of birds and their eggs after the spill has not been finalized and accepted through the peer review process, perhaps the issue of the effects on chick productivity can be considered further when that report is available.

Finally, the overall black-legged kittiwake population in Prince William Sound in 1989-91 was significantly less than in 1972-73. However, the number of kittiwakes in oiled and unoiled areas was not different after the spill (Klosiewski and Lang, 1994). The Exxon-funded boat surveys also did not find evidence of impacts on kittiwakes.

Based mainly on the insignificant mortality of black-legged kittiwakes and, to a lesser extent, that the evidence from productivity studies and populations survey is not compelling , I cannot recommend adding black-legged kittiwakes to injured species list at this time.

Cormorants

Carcasses of 838 cormorants were recovered following the spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. If the unidentified cormorants are allocated proportionately to the three species, and multiplied by a factor of 5 as a conservative estimate of actual mortality, then the estimated mortalities are: 2840 pelagic, 1095 red-faced, and 255 double-crested cormorants.

These estimated mortalities need to be considered in the context of the regional populations of these species. No regional population estimates are available, nor are the existing data such that any rigorous estimate can be made. There are some data, however, which shed light on the numbers of cormorants in the oil-spill area:

(1) The Alaska Seabird Colony catalog maintained by the U.S. Fish and Wildlife Service includes the following direct counts of cormorants at nesting colonies (presented as a range: number in oiled areas-number in general oil-spill area): pelagic, 5529-7161; red-faced, 8696-8967; double-crested, 823-1558; unidentified, 3030-3667). These numbers were gathered over a period of years should not be interpreted to represent all cormorants in the region, nor even all breeding cormorants.

(2) U.S. Fish and Wildlife Service boat surveys conducted in Prince William Sound since the oil spill (Agler et al. 1995) have resulted in the following ranges of population estimates for both oiled and unoiled areas in the sound (values presented are low and high estimates for March surveys, 1990-1994): pelagic, 5,431-10,959; red-faced, 6-8; double-crested, 124-1041; and unidentified, 278-3,477. Since these are March estimates, these include some combination of wintering and migrant birds from unknown breeding areas.

(3) Forsell and Gould (1981) estimated that 18,500 cormorants of all three species were wintering in the bays and coasts of Kodiak, Sitkalidak, and southern Afognak islands. They also estimated that pelagic cormorants outnumbered red-faced on a 10:1 basis and that there were very few double-crested cormorants in the Kodiak area.

It is important not to make too much of any of these data, which have their own limitations and which were gathered by different methods, in different seasons, etc. It appears, however, that pelagic cormorants have regional populations at least in the low 10s of thousands (e.g., 20,000-30,000). The red-faced cormorant is less abundant, perhaps 10,000-20,000. Double-crested cormorants perhaps number only 1,000-2,000. These are only crude estimates of population sizes, but, on these bases, the estimated mortalities due to the oil spill appear to be significant at the population level.

There are some additional data which can be brought to bear: There were statistically-significant declines in the estimated numbers of cormorants (all species) in Prince William Sound comparing boat surveys in July 1972-73 and 1989-91, including comparisons of oiled versus unoiled areas (Klosiewski and Laing 1994). In addition, Exxon's boat surveys indicated "strong" evidence of initial negative impacts on pelagic cormorants in Prince William Sound and for double-crested cormorants on the Kenai coast (Day et al. 1995). Given the evidence (and uncertainties) outlined above, I recommend listing all three cormorants--pelagic, red-faced, and double-crested--as injured resources as a result of the Exxon Valdez oil spill.

Scoters

Carcasses of 811 scoters were recovered following the oil spill, including 342 white-winged, 175 surf, 132 black and 162 unidentified scoters. If

the unidentified scoters are assigned to the three species in proportion to their numbers in the morgue and the species totals are increased by a factor of five as a conservative estimate of actual mortalities, the following died as a result of the oil spill: 2140 white-winged, 1095 surf, and 120 black scoters.

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Therefore, it appears that the injury to scoters is not sufficiently severe to warrant the special recognition of being placed on the injured species list.

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