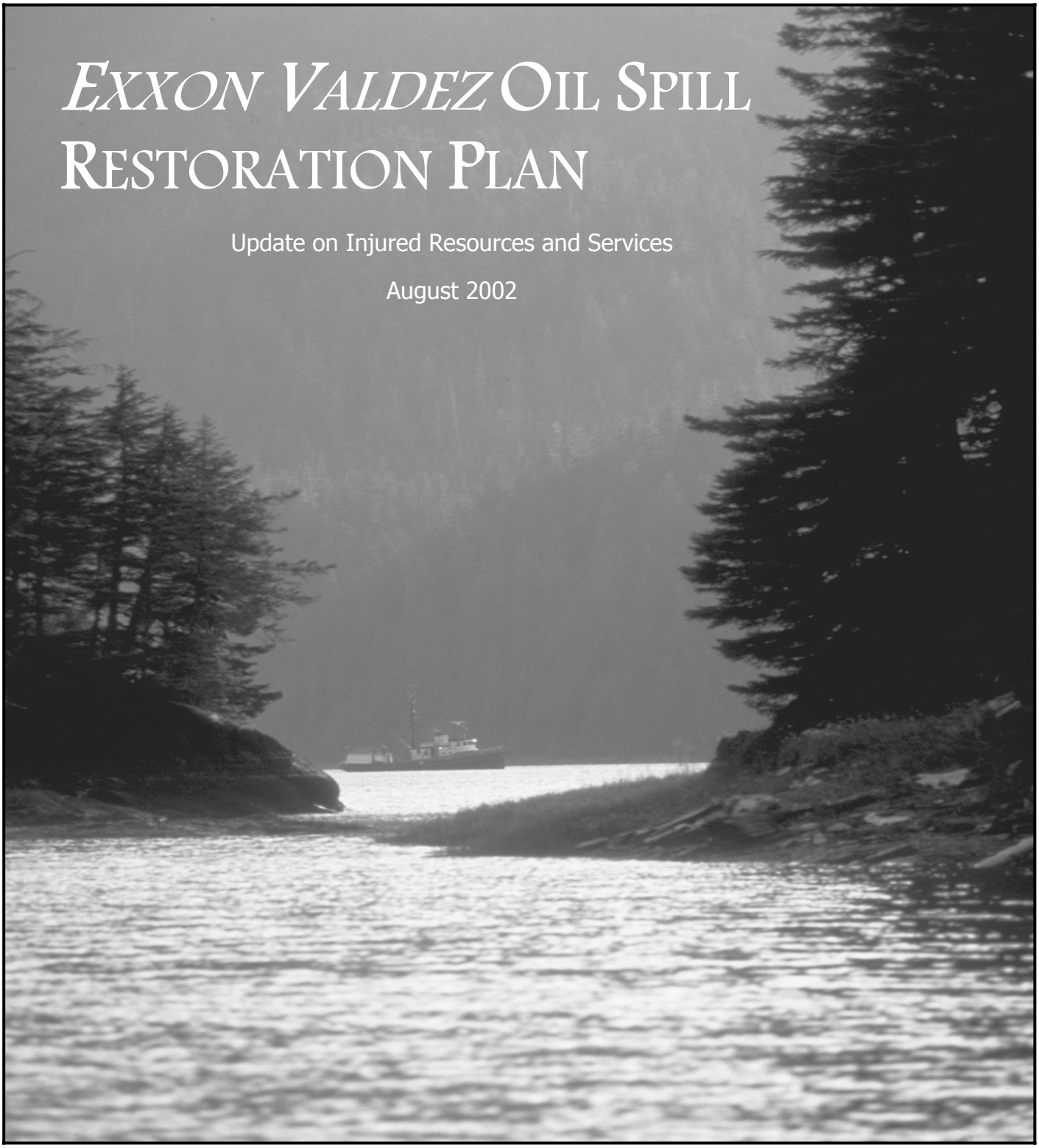
Exxon Valdez Oil Spill Restoration Plan

Update on Injured Resources and Services

August 2002



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UPDATE ON INJURED RESOURCES AND SERVICES
AUGUST 2002

INTRODUCTION

History and Purposes of the List

In November 1994, the *Exxon Valdez* Oil Spill Trustee Council adopted an official list of resources and services injured by the spill as part of its *Restoration Plan*. This list has served three main purposes in the Restoration Program:

1. It has highlighted injuries caused by the oil spill and cleanup efforts and helped the Trustees and the public track the status of important fish, wildlife, and other resources and services. The fish and wildlife on this list are thought to have suffered population-level or sublethal injuries, but the list does not include every species or resource that suffered some degree of injury. For example, carcasses of about 90 different species of oiled birds were recovered in 1989, but only 10 species of birds are on the list of injured species.

2. It has helped guide the *Restoration Plan*. This was especially important in 1994 when the plan was first adopted, but the list still serves to highlight resources that are in need of consideration.

3. Finally, taken as a whole, the list of injured resources has helped the Trustees and the public track recovery of the overall ecosystem and the functions and human services that it provides.

It should be noted that the analysis of these resources and their recovery status only pertains to recovery from the effects of the 1989 oil spill. Many of these resources are also experiencing the effects of other natural and human factors resulting in significant population declines. Where these species lie on the continuum of recovery from the oil spill should not be taken to reflect their overall status and health. In addition, many of the species that may be "recovered" or "recovering" from the effects of the oil spill are vital parts of the oil-impacted ecosystem that will be the focus of the Trustee Council's long-term monitoring program – GEM – the Gulf of Alaska Ecosystem Monitoring and Research Program.

The *Restoration Plan* states that the Injured Resources and Services list will be reviewed periodically and updated to reflect results from scientific studies and other information. With each review, a resource's progress toward a recovery objective is evaluated. The recovery objectives have been set to be as concrete and measurable as possible. However, they may be changed to reflect new insights about the nature of the injury and the best – or more accurate - ways to evaluate recovery status.

The Injured Resources and Services list was first updated in September 1996. At that time the bald eagle was upgraded from recovering to recovered. In March 1999, a major review of recovery objectives and status occurred and several more changes were made. River otters were then considered to be recovered, and five resources—black oystercatchers, clams, marbled murrelets, Pacific herring, and sea otters—were upgraded to recovering. One resource, the common loon, was moved from recovery unknown to not recovering. Five resources remained as recovery unknown. All four human services were classified as recovering.

In 2002, more than 13 years after the spill, recovery continues to progress and more changes have been made to the list. Five more species or resources have been moved to the recovered category: archaeological resources, black oystercatchers, common murres, sockeye salmon and pink salmon. In addition, designated wilderness areas have been moved from the recovery unknown to the recovering category; Pacific herring have been moved back from the recovering to the not recovering category; subtidal communities have been moved from the recovering to recovery unknown category; and killer whales have been moved from not recovering to recovering. In all, seven resources are considered fully recovered from the effects of the oil spill; 16 resources and all four human services have still not fully recovered; and the recovery of five resources is still considered unknown.

The 1994 *Restoration Plan* provides that the Injured Resources and Services list can be updated any time new information becomes available. The next major evaluation of changes in recovery status for all injured resources and lost or reduced services likely will be in 2006, 15 years after the 1991 settlement between the governments and Exxon and initiation of the restoration program.

How to Interpret this List

The assignment of resources to various categories continues to be based on judgements made after weighing the available evidence, including:

- estimates of population sizes and trajectories in the spill area;

- comparisons of population estimates in oiled and unoiled areas of the northern Gulf of Alaska;
- whether there has been continued exposure to residual oil in the spill area; and
- whether sublethal or chronic injuries persist or show improvement.

Some of the factors involved in making judgments about recovery status include:

1. *Uncertainties in population estimates*. Because of the variability in animal distributions and the challenges of getting accurate counts, especially of highly mobile fish, birds and marine mammals, most estimates of population size have wide ranges. For example, ranges that are between 40% greater or smaller (or even more) than the true population size will result from many census techniques. This range can be narrowed, but costs escalate with the increasing effort to obtain greater accuracy.
2. *Lack of prespill data*. Many of the resources affected by the spill had limited or no recent data on their status in 1989. In addition, some of the available pertinent data was the result of limited sampling and had wide ranges in the population estimates. Having such patchy data on resources made it difficult to accurately assess initial injury. In turn, any uncertainties in injury inevitably lead to uncertainties in estimating recovery.
3. *Interaction of spill and natural factors*. It is increasingly difficult to separate what may be lingering effects of the spill from changes that are natural or caused by factors unrelated to the oil spill. In fact, what is often observed appears to be an interaction between oil effects and natural changes, such as the effects of the 1998 *El Niño* on common murres in the Barren Islands which were recovering from oil spill impacts. We now understand much more about long-term changes in climate in the northern Gulf of Alaska and how these changes affect marine species.
4. *Emergence of new effects*. Since the *Exxon Valdez* oil spill affected an area rich in wildlife and was so well studied, it would not be surprising that there are findings without precedent in the scientific literature on oil effects. One example of such an unprecedented effect is the sensitivity of Pacific herring and pink salmon to low concentrations of weathered oil. We cannot discount evidence for an injury just because it had never been encountered in the aftermath of other spills.

Ecosystem Perspective and Recovery

The List of Injured Resources consists mainly of single species and resources, but, as noted above, it provides a basis for evaluating the recovery of the overall ecosystem, its functions, and the services that it provides to people. In fact, through the *Restoration Plan*, the Trustee Council adopted an ecological approach to restoration, and the studies and projects the Trustee Council sponsors have been ecological in character.

Page 35 of the *Restoration Plan* defines ecosystem recovery as follows:

> *Full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, 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.*

Using this definition, the coastal and marine ecosystems in the oil spill region have not fully recovered at this time from the effects of the oil spill. For example, harlequin ducks and sea otters still show signs of oil exposure and may be negatively affected by such exposure. A number of other species and communities are showing signs of recovery, but are still not fully recovered from the effects of the oil spill. Although full ecological recovery has not been achieved, the spill area ecosystem is still largely intact and functioning and on its way to recovery 13 years after the *Exxon Valdez* oil spill.

It is desirable to have injured resources obtain a state that would have occurred in the absence of the spill. However, it also is important to understand that ecosystems are dynamic and would have changed even in the absence of the oil spill. Given our present ability to predict multi-year changes in marine ecosystems—which is extremely limited—it is very difficult to know how the ecosystem would have changed in the absence of the spill. For that reason, it is also sometimes necessary to consider other measures (return to prespill status or attaining equivalent status in oiled and unoiled areas) in order to have more concrete objectives. Also, as mentioned above, baseline data describing fish and wildlife populations, to say nothing of complex intertidal and subtidal communities, were generally poor in 1989. Therefore, in revising this list

Resources and Services Injured by the Spill

NOT RECOVERING

Species are showing little or no clear improvement from oil spill injuries.

Common loon
Cormorants (3 spp.)
Harbor seal
Harlequin duck
Pacific herring
Pigeon guillemot

RECOVERING

Substantive progress is being made toward recovery objective. The amount of progress and time needed to achieve recovery vary depending on the resource.

Clams
Designated Wilderness Areas
Intertidal communities
Killer whale (AB pod)
Marbled murrelets
Mussels
Sea otter
Sediments

Resources in boldface have been recategorized on this Recovery Line during the most recent update (August 2002).

RECOVERED

Recovery objectives have been met.

Archaeological resources
Bald eagles
Black oystercatcher
Common murres
Pink salmon
River otter
Sockeye salmon

RECOVERY UNKNOWN

Limited data on life history or extent of injury; current research inconclusive or not complete.

Cutthroat trout
Dolly Varden
Kittlitz's murrelet
Rockfish
Subtidal communities

Photo by Roy Corral

HUMAN SERVICES

Human services that depend on natural resources were also injured by the oil spill. These services are each considered to be recovering until the resources on which they depend are fully recovered.

Recreation & tourism
Commercial fishing
Passive uses
Subsistence

judgments have been made in the face of increasing knowledge—but also, great uncertainty—of how natural changes have occurred in the northern Gulf of Alaska.

The following goals and objectives are used in assessing the status of the resources and services injured by the oil spill:

Restoration Goal: Recovery of all injured resources and services, including the ecosystem as a whole.

Recovery Goal of Injured Resources and Services: A return to conditions that would have existed had the spill not occurred.

Recovery Objective: A specific, measurable parameter that is used to signal the recovery status of an injured resource or service. In most cases the recovery objective reflects the type of injury that occurred from the spill.

Since it is difficult to predict conditions that would have existed in the absence of the spill, recovery objectives use measurable and biologically substantive parameters as proxies for these conditions. For some species, multiple objectives are used to assess recovery.

Comparisons of these parameters between oiled and unoiled areas are sometimes used where little or no prespill data exist. Geographic comparisons of this nature should take into account differences, such as those that may exist naturally between eastern and western Prince William Sound, if these can be determined. For some resources, so little is known about the original or current injury or status, that identifying a recovery objective is not possible.

The following objectives are used:

Return to prespill levels: Used where population estimates or indices were available prior to 1989. For species that are highly variable, these numbers could reflect a range of values. These numbers do not account for the effects of other influences on injured populations, such as from climate change, although thee other effects may interact with oil spill effects.

Hydrocarbon exposure: Used where hydrocarbon exposure itself was part of the original basis for injury, where hydrocarbon exposure may limit recovery, or where hydrocarbon exposure in an injured resource may be a pathway to injury in other resources. Oil exposure may refer to background concentrations, which takes into account hydrocarbon exposure from natural oil seeps, natural coal deposits, and oil released from the Valdez petroleum plant as a result of the 1964 earthquake.

Stable or increasing population: Used where resources were in decline before the spill or there are ongoing declines that may be unrelated to the spill.

Measures of productivity: Used in lieu of or to supplement data on population sizes. Includes such indicators as eggs produced or young successfully reared, returns-per-spawner, or growth rates. These include measures of reproductive success and demographics.

- Productivity means an increase in the biomass of a species, or the number of individuals of one species, as a function of time and geographic unit.
- Reproductive success means the reproduction of viable individuals, and may not be related to overall biomass. For seabirds however, productivity and reproductive success are used interchangeably by biologists and usually refer to eggs hatched or chicks per nest.
- Demographics refer to the distribution of individuals in a population or in some geographic area with respect to age and sex or other characteristics of a population.

Photo by Roy Corral

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INJURED RESOURCES

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ARCHAEOLOGICAL RESOURCES

Injury
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 included 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, residual oil may have contaminated sites.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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).

Recovery Status
Assessments of 14 sites in 1993 suggested 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 cleanup personnel. Most vandalism took the form of "prospecting" for high yield sites. Once these problems were recognized, protective measures were implemented and successfully limited additional injury. Although some cases of vandalism were documented in the 1990s, there appears to be no spill-related vandalism at the present time.

From 1994-1997, two sites in Prince William Sound were partly documented, excavated, and stabilized by professional archaeologists because they had been so badly damaged by oiling and erosion. The presence of oil in sediment samples taken from four sites in 1995 did not appear to have been the result of re-oiling by *Exxon Valdez* oil. Residual oil does not appear to be contaminating any known archaeological sites.

In 1993, the Trustee Council provided part of the construction costs for the Alutiiq Archaeological Repository in Kodiak. This facility now houses Kodiak area artifacts that were collected during spill response. In 1999, the Trustee Council approved funding for an archaeological repository and local display facilities for artifacts from Prince William Sound and lower Cook Inlet. These are currently in various stages of contruction.

Based on the apparent absence or extremely low rate of spill-related vandalism and the preservation of artifacts and scientific data on archaeological sites and artifacts, archaeological resources are considered to be recovered.

BALD EAGLES

Injury
The bald eagle is an abundant resident of marine and riverine shoreline throughout the oil spill area. Following the oil spill, a total of 151 eagle carcasses was recovered from the spill area. Prince William Sound provides year-round and seasonal habitat for about 6,000 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 spill area. In addition to direct mortalities, productivity was reduced in oiled areas of Prince William Sound in 1989.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Bald eagles will have recovered when their population and productivity (reproductive success) have returned to prespill levels.

Recovery Status
Productivity (or reproductive success as measured by chicks per nest) was back to normal in 1990 and 1991, and

an aerial survey of adults in 1995 indicated that the population had returned to or exceeded its prespill level in the sound. **In September 1996, the Trustee Council classified the bald eagle as recovered from the effects of the oil spill.**

BLACK OYSTERCATCHERS

Injury
Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. 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 several times higher.

In addition to direct mortalities, breeding activities were disrupted by the oil and cleanup activities. When comparing 1989 with 1991, significantly fewer pairs occupied and maintained nests on oiled Green Island, while during the same two years the number of pairs and nests remained similar on unoiled Montague Island. Nest success on Green Island was significantly lower in 1989 than in 1991, but Green Island nest success in 1989 was not lower than on Montague Island. In 1989, chicks disappeared from nests at a significantly greater rate on Green Island than from nests on Montague Island. Disturbance associated with cleanup operations also reduced productivity on Green Island in 1990. In general, the overt effects of the spill and cleanup had dissipated by 1991, and in that year productivity on Green Island exceeded that on Montague Island.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Black oystercatchers will have recovered when the population returns to prespill levels and reproduction and productivity are 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.

Recovery Status
Boat-based surveys of marine birds in Prince William Sound indicate that there are increases in numbers of oystercatchers in both the oiled and unoiled areas through 2000 (Stephenson et al., 2001). Given the fact that only 9 carcasses of this species were recovered in 1989 after the spill, it is likely that the population of the sound is probably as large or larger than previous to the spill.

In 1998 the Trustee Council sponsored a study to reassess the status of this species in Prince William Sound. The data indicated that oystercatchers have fully reoccupied and are nesting at oiled sites in the sound. The breeding phenology of nesting birds was relatively synchronous in oiled and unoiled areas, and no oil-related differences in clutch size, egg volume, or chick growth rates were detected. A high rate of nest failures on Green Island are likely attributed to predation, not lingering effects of oil. **Given general agreement between these results and those of the earlier work, which indicated that the effects of the spill on black oystercatchers had largely dissipated by 1991, black oystercatchers are considered to be recovered from the effects of the oil spill. This does not mean that oystercatchers are still not exposed to some oil in the intertidal zone, but the amounts are so insignificant that it would not cause an effect on this species.**

CLAMS

Injury
The magnitude of immediate impacts on clam populations varied with the species of clam, degree of oiling, and location. Some littleneck clams and some butter clams were probably killed and may have suffered slower growth rates as a result of the oil spill and cleanup activities.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Clams will have recovered when population and productivity measures (such as size and distribution) at oiled sites are comparable to populations and productivity measures at unoiled sites, taking into account geographic differences.

Recovery Status
Studies by the NOAA Hazardous Materials Division and others have been conducted on intertidal and subtidal communities in relation to oiling and shoreline treatments. In general, these studies indicated that intertidal fauna dwelling in soft sediments, including various clam species, had recovered to some extent within one to three years after 1989 on oiled-but-untreated shorelines. As of 1997, full recovery had not been achieved, especially on shorelines that were oiled and treated by hot-water washes. One study found that densities of littleneck and butter clams

were depressed through 1997 on oiled, treated mixed-sedimentary shores where fine sediments had been washed downslope during pressured water treatments.

Comparing oiled study sites on Knight Island with unoiled sites on Montague Island, researchers in the Nearshore Vertebrate Predator Project found a full range of size classes of clams at the oiled sites, as well as more large clams. However, oiled sites also had fewer juvenile clams and lower numbers of several species. **Based on all of the evidence summarized above, clams continue to be recovering, but are not yet fully recovered from the effects of the oil spill.** The Trustee Council is sponsoring a study of clam populations in FY02 to determine if the populations of clams on treated beaches have improved since 1997.

COMMON LOONS

Injury
Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current population sizes in the spill area are not known for any of these species. Common loons in the 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 wintering and migrating birds. The specific breeding areas used by the loons affected by the spill are not known.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Common loons will have recovered when their population returns to prespill levels in the oil spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

Recovery Status
Boat-based surveys of marine birds in Prince William Sound give at least some insight into the recovery status of the loons affected by the oil spill. Prespill counts of loons exist only for 1972-1973 and 1984-1985. After the spill, contrasts between oiled and unoiled areas of the sound indicate that loons as a group are generally doing better in unoiled areas than in oiled areas. Thus, the survey data suggest that the oil spill had a negative effect on numbers of loons (all species combined) in the oiled parts of the sound. It is not known what the populations of loons may have been had the spill not occurred.

Based on the surveys carried out through 2000, there are indications of recovery, but only in 2000. In 2000 the highest counts ever recorded for common loons occurred in March surveys of Prince William Sound; however, these counts likely included some early migrants as well as wintering birds. In addition, July counts in 2000 were the third highest of the 11 years since 1972 with data. These increases were limited to the unoiled portion of the sound. Since loons are a highly mobile species with widely variable population numbers and the prespill data were limited, one year of high counts in the unoiled areas is insufficient to indicate that recovery has started. **Thus the common loon is considered still not to have recovered from the effects of the spill.**

COMMON MURRES

Injury
About 30,000 carcasses of oiled birds were picked up in the first four months 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 breeding colonies at such locations as the barren Islands, Chiswell Isalnds, Triplet Islands, Puale Bay, and Ugiaushak Island, the spill area populations 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.


Photo by USFWS

Recovery Goal
A return of conditions that would have existed had the spill not occurred.

Recovery Objective
Common murres will have recovered when populations at indez colonies have returned to prespill levels and

when reproductive success (productivity) is sustained within normal bounds. Increasing population trends at index colonies will be an indication that recovery is underway.

Recovery Status
Postspill monitoring at the breeding colonies in the Barren Islands indicated that productive success was within normal bounds by 1993, and it has stayed within these bounds each breeding season since then. During the period 1993-1997, the murres nested progressively earlier by 2-5 days each year, suggesting that the age and experience of nesting birds were increasing, as might be expected after a mass mortality event. By 1997, numbers of murres at the Barren Island had increased, probably because 3-and 4-year old nonbreeding subadult birds that were hatched there in 1993 and 1994 were returning to their natural nesting colony. **Although there were low counts in 1996, the counts in 1997 at this index site bring the colony size to presill levels. That, coupled with normal reproductive success (productivity), indicate that recovery has been achieved for common murres.**

CORMORANTS

Injury
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. In 1996, the U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog, however, listed 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 at colonies, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species was 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 1989 compared to 1986. In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in the oiled portion of Prince William Sound based on pre- and postspill boat surveys in July 1984-85 compared to 1989-91. It is not known what the counts and trends of comorants would have been in the absence of the oil spill.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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

Recovery Status
More recent surveys (through 2000) have not shown a significant increasing population trend since the oil spill, and for that reason **these species are considered to be not recovering.**

CUTTHROAT TROUT

Injury
Prince William Sound is at the northwestern limit of the range of cutthroat trout. Local cutthroat trout populations are believed to be small, 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 in Prince William Sound grew more slowly than in unoiled streams.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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.

Recovery Status
The apparent difference in growth rates between trout in oiled versus unoiled streams persisted through 1991. It was hypothesized that the slower rate of growth in oiled streams was the result of reduced food supplies or exposure to oil, and there was concern that reduced growth rates would result in reduced survival. However, preliminary data from a Trustee Council sponsored study of resident and anadromous forms of cutthroat trout in Prince William Sound suggest that there is significant genetic variation among trout from different locations across the sound. These data are consistent with the idea that cutthroat populations are small and isolated and effects other than oil, such as gentic variations in growth

rates and variable water temperatures, could be causing the differences seen in the growth rates. The report on this work has experienced significant delays, but is near completion. **Pending the completion and review of this additional work, the recovery status of the cutthroat trout remains unknown.**

DESIGNATED WILDERNESS AREAS

Injury

The oil spill delivered oil in varying quantities to the waters and tidelands adjoining eight areas designated as wilderness areas and wilderness study areas by Congress or the Alaska State Legislature. Oil also was deposited above the mean high-tide line at these locations. During the intense cleanup seasons of 1989 and 1990, thousands of workers and hundreds of pieces of equipment were at work in the spill zone. 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 returned to normal, at some locations there is still residual oil.

Photo by Roy Corral

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

Recovery Objective

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

Recovery Status

Among the affected areas were designated wilderness in the Katmai National Park, wilderness study areas in the Chugach National Forest and Kenai Fjords National Park, and Kachemak Bay Wilderness State Park. Six moderately to heavily oiled sites on the Kenai and Katmai coasts were last surveyed in 1994, at which time some oil mousse persisted in a remarkably unweathered state on boulder-armored beaches at five sites. These sites were visited again in 1999. The data from these sites indicate that there is still oil along park shorelines on the Katmai coast. Surveys carried out in 2001 to determine the surface and subsurface distribution of oil in Prince William Sound found significant quantities of oil on shorelines within designated wilderness study areas. The amount of oil on shorelines in designated wilderness study areas in Prince William Sound has probably decreased since the early 1990s, and natural processes will lead to further reductions. **Therefore, designated wilderness areas are recovering but have not recovered from the oil spill.**

DOLLY VARDEN

Injury

Dolly Varden are widely distributed in the spill area. In spring, anadromous forms of Dolly Varden migrate to the sea from the lakes and rivers where they spend the winter. Summers are spent feeding in nearshore marine waters. Thus, some Dolly Varden in Prince William Sound and perhaps at other locations were exposed to *Exxon Valdez* oil in 1989 and possibly beyond. In fact, concentrations of hydrocarbons in the bile of Dolly Varden were some of the highest of any fish sampled in 1989. Like the cutthroat trout, there is evidence from 1989-90 that Dolly Varden in a small number of oiled index streams in Prince William Sound grew more slowly than in unoiled streams. It was hypothesized that the slower rate of growth in oiled streams was the result of reduced food supplies or exposure to oil, and there was concern that reduced growth rates would result in reduced survival.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

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.

Recovery Status

The growth differences between Dolly Varden in oiled and unoiled streams did not persist into the 1990-91 winter. No growth data have been gathered since 1991. In addition, by 1990 the concentrations of hydrocarbons in bile had dropped substantially.

In a 1991 restoration study sponsored by the Trustee Council, some tagged Dolly Varden moved considerable distances among streams within Prince

William Sound, suggesting that mixing of overwintering stocks takes place during the summer in saltwater. This hypothesis is supported by preliminary data from another Trustee Council sponsored study, which indicates that Dolly Varden from different locations across the sound are genetically similar. The final report on this genetics study has been delayed, but should be completed soon. If this preliminary conclusion is born out, it would suggest that the Dolly Varden population in the sound should have little difficulty in recovering from any initial growth-related effects. **Pending completion and review of the genetics work, however, it is prudent to continue classifying the Dolly Varden as recovery unknown.**

HARBOR SEALS

Injury

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 aerial surveys conducted at trend-count haulout sites in central Prince William Sound before (1988) and after (1989) the oil spill, seals in oiled areas declined by 43 percent, compared to 11 percent in unoiled areas.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

Recovery Objective

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

Recovery Status

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. It is not known what harbor seal populations would have been had the spill not occurred.

Environmental changes in the late 1970s may have reduced the amount or quality of prey resources, including such forage fishes as Pacific herring and capelin, available to harbor seals in the northern Gulf of Alaska ecosystem. These changes may have been responsible for or contributed to the initial prespill harbor seal decline, and the ecosystem may now support fewer seals than it did prior to the late 1970s. Recent studies, however, indicate that the seals in the sound, especially pups and yearlings, are in very good condition and do not show evidence of nutritional stress. Ongoing sources of mortality include killer whale predation, possible shark predation, subsistence hunting, and commercial fishery interactions (e.g., drowning in nets). The relative roles of oil and various natural factors are not known.

Satellite tagging studies sponsored by the Trustee Council and genetic studies carried out by the National Marine Fisheries Service indicate that harbor seals in the sound are largely resident throughout the year and have limited movement and interbreeding with other subpopulations in the northern Gulf of Alaska. This suggests that recovery must come largely through recruitment and survival within resident populations.

For the period 1989-1997, the average estimated annual rate of decline of harbor seals in Prince William Sound was about 4.6 percent. **The population showed some signs of stabilizing in the 1990s, but surveys in 2000 and 2001 indicate that the decline is continuing. Therefore, harbor seals continue to be considered not recovering from the effects of the oil spill.**

HARLEQUIN DUCKS

Injury

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 in the sound and perhaps thousands throughout the spill area. Because the spill occurred in early spring before wintering harlequins migrated from the sound to inland breeding sites, the initial effects of the spill likely affected harlequin duck productivity beyond the immediate spill zone. The geographic extent and magnitude of these extended impacts are not known.

Prespill data on harlequin populations and reproductive success are limited and difficult to interpret, but after the spill there was concern about poor reproductive success in the western (oiled) versus eastern (unoiled) parts of Prince William Sound. This concern was based on observations of 7-15 broods in the eastern sound and few-to-no reports of broods in the western sound when comparable numbers of streams were surveyed.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Harlequin ducks will have recovered when breeding- and nonbreeding-season demographics return to prespill levels and when biochemical indicators of hydrocarbon exposure in harlequins in oiled areas of Prince William Sound are similar to those in harlequins in unoiled areas.

Recovery Status
The current overwintering population of harlequin ducks in Prince William Sound is on the order of 18,000 ducks, while the summer population is about half that number. Surveys designed specifically to count harlequin ducks have been carried out in the fall, winter and spring in various years since the spill. Fall boat surveys to monitor molting-wintering harlequin ducks indicate a significant declining trend in the oiled western sound from 1995-1997, but no trend in the unoiled eastern sound. The spring harlequin duck surveys have only two years of data (1999 and 2000)—too little on which to draw conclusions, but increases in all areas of the sound in 2000 are promising. Spring surveys were also conducted in 2001 and 2002, but the results are not yet published. Other boat surveys designed to monitor an entire suite of marine birds in the sound have shown mixed results: an increasing trend in March surveys in unoiled areas; no trend in oiled areas between 1997 and 2000; and an increasing trend in both oiled and unoiled areas in July of these same years.

Postspill research shows mixed results with respect to age- and sex-structure of harlequin populations in the eastern and western parts of the sound. ADF&G fall surveys from 1995-1997 indicate similar age ratios between the two areas, suggesting that recruitment is similar. In addition, some harlequins remain in the sound to nest in the spring and summer, mostly on the eastern side, but it is now suspected that most harlequins of breeding age and condition probably leave the sound altogether to nest in inland drainages. Thus, conclusions of reproductive failure based on lack of broods in the oiled area do not now seem warranted.

Winter surveys from 1995-1998 found that adult female survival was lower in oiled versus unoiled areas, and a similar survival scenario is suggested from data collected in 2000 to 2002. Oil remained in the subsurface of the intertidal zone through 2001, including under some mussel beds where harlequin ducks could be feeding. Biopsies from harlequin and Barrow's goldeneye ducks continue to show differences in an enzyme indicative of exposure to hydrocarbons between birds from oiled versus unoiled parts of the sound. These differences are consistent with the possibility of continued exposure to spill-derived hydrocarbons in the western sound. The biological effect of this possible exposure has not been established, but the declining trend of female survivability in the oiled areas may be continuing. Although this result cannot be attributed unequivocally to oil exposure, there is reason for concern about possible oil exposure and reduced survival for harlequin ducks in the western sound.

Trustee Council sponsored studies give insight into prospects for recovery of harlequin ducks. Although some harlequin ducks make major seasonal movements, they exhibit high site fidelity to summer breeding sites and to molting and wintering sites during non-breeding seasons. Strong site fidelity may limit population recovery by immigration, but a genetic analysis of harlequin ducks indicates that the spill area population is homogeneous (i.e., very similar throughout). Taken together, these data are consistent with a low rate of dispersal, perhaps at the subadult stage, or a rapid expansion of the population in recent geological time. To the extent that there is subadult dispersal from adjacent expanding populations, such dispersal would enhance recovery. It is likely, however, that recovery will largely depend on recruitment and survival from within injured populations. This recovery may be compromised if exposure to lingering hydrocarbons reduces fitness and survival of harlequin ducks.

Although some of the indicators show signs of recovery, the majority of the indicators do not indicate recovery. Taken together, the population census trends, survival measures and indicators of exposure suggest that the harlequin duck has not recovered from the effects of the oil spill.

INTERTIDAL COMMUNITIES

Injury
Portions of 1,400 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 cleanup activities had significant impacts on the flora and fauna of the intertidal zone. Intertidal communities are intrinsically important and are resources for subsistence users, sea and river otters, and a variety of birds, including black oystercatchers, harlequin ducks, and pigeon guillemots.

Initial impacts to intertidal organisms occurred at all tidal levels and in all types of habitats throughout the oil spill area. Many species of algae and invertebrates were less abundant at oiled sites than at unoiled reference sites. Some, more opportunistic species, including a small species of

barnacle, oligochaete worms, and filamentous brown algae, colonized shores affected by the oil spill and cleanup activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), also was reduced following the spill.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Intertidal communities will have recovered when such important species as *Fucus* have been reestablished at sheltered rocky sites, the differences in community composition and organism abundance on oiled and unoiled shorelines are no longer apparent after taking into account geographic differences, and the intertidal and nearshore habitats provide adequate, uncontaminated food supplies for top predators.

Recovery Status
In the lower and middle intertidal zones on oiled rocky shores, algal coverage and invertebrate abundances had returned by 1991 to coverages and abundances similar to those observed in unoiled areas. However, large fluctuations in the algal coverage have taken place in the oiled areas since the spill. This pattern is consistent with continued instability due to the original spill impact and the subsequent cleanup. However, instability of *Fucus* populations during the last 12 years probably results from a combination of spill- and naturally-induced changes, with a greater influence of natural events in the later years.

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. As of 1997, *Fucus* had not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities had been substantial. 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. In studies of the effects of cleanup activities on beaches, invertebrate molluscs and annelid worms on oiled and washed beaches were still much less abundant than on comparable unoiled beaches through 1997.

More recent data should soon be available, including results of a study in the summer of 2002 to determine if intertidal clam populations on oiled shorelines are comparable to those on unoiled shorelines. **Based on substantial progress, but the lack of full recovery of some soft-sediment intertidal invertebrates, as well as the continued presence of residual oil and the role of oil in initiating *Fucus* population instability, the intertidal communites are considered to be recovering, but not fully recovered from the effects of the oil spill.**

KILLER WHALES

Injury
More than 115 killer whales in eight "resident" pods regularly use Prince William Sound/Kenai Fjords as part of their ranges. Other whales in "transient" groups are observed in the sound less frequently. There has been particular concern about the resident AB pod, which numbered 36 animals prior to the spill. Fourteen whales disappeared from this pod in 1989 and 1990, and no young were recruited into the population. The original link between the AB pod losses and the oil spill was largely circumstantial, although the pod was observed surfacing in an *Exxon Valdez* oil slick following the spill in 1989. The rate of disappearance and likely mortality of killer whales in this well-studied pod far exceeded rates observed for other pods in British Columbia and Puget Sound over the last 30 years, and in the northern Gulf of Alaska over the last 18 years. Another possible cause for the disappearance


Photo by Craig Matkin

of the whales in the AB pod was the shooting of killer whales due to conflicts with long-line fisheries prior to the oil spill. Although the original shootings may not have immediately resulted in death for some animals, it is possible the injuries weakened them over time and contributed to premature mortality. In this way it is possible that the effects from the conflicts in the 1980s were still apparent in the 1990s.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
The original recovery objective for killer whales was a return to prespill numbers for the AB pod. The objective was changed in 1999, but upon further reflection and public comment, the recovery objective is once again a return to prespill numbers for the AB pod – 36 individuals.

Recovery Status
By 1993 the AB pod had increased to 26 individuals as births outpaced deaths. In 1995 mortalities, including animals orphaned in 1989-90, reduced the pod to 22 whales. Since 1995 the pod again has increased steadily in size to 26 individuals in 2001. Thus, social disintegration has not happened and an apparently stable structure has been achieved. Overall numbers within the other major resident killer whale pods in Prince William Sound are at or exceed prespill levels. **Since AB pod has not regained its prespill size of 36 individuals, killer whales are considered to be recovering, but not fully recovered from the effects of the oil spill.**

In addition to the AB pod, there is concern that a decline in resightings of individuals within the AT1 group of transient killer whales has accelerated following the oil spill. Although there is no evidence linking the oil spill to the AT1 group, this update also reports on its status. Recent genetic analyses show that resident and transient killer whales in Prince William Sound are genetically distinct. Since 1990 and 1991, 11 individuals have been missing from the AT1 group and are now almost certainly dead. During that same period there has been no recruitment of calves into this pod of transients. Transient killer whales largely prey on marine mammals, and there has been a 60 percent decline in the harbor seal population in the sound over the last two decades. Changes in the availability of such an important prey species could influence killer whale distribution and reproduction. Trustee Council sponsored research on contaminants in killer whales in Prince William Sound indicates that some transient whales, including the AT1 group, are carrying high concentrations of PCBs, DDT, and DDT metabolites in their blubber. The presence of such contaminants is not related to the oil spill. The high concentrations of contaminants found in the transient whales are comparable to those found to cause reproductive problems in other marine mammals.

KITTLITZ'S MURRELETS

Injury
The Kittlitz's murrelet is found only in Alaska and portions of the Russian Far East. 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, but they are known to 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. It is likely that about 500 individuals died as an acute effect of the oil spill, which would represent a substantial fraction of the world population.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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

Recovery Status
Because so little is known about this species, the Trustee Council funded an exploratory study on the ecology and distribution of the Kittlitiz's murrelet in Prince William Sound starting in 1996. This project found that this species has an affinity for tidewater glaciers in the northern and northwestern parts of the sound. It also appears that reproductive output in 1996 and 1997 was extremely low or absent, and some Kittlitz's murrelets were apparently paired with marbled murrelets. There appear to be about 1,200-1,400 Kittlitz's murrelets during summer in the four bays studied in northern and northwestern sound. Another, more extensive marine bird boat survey conducted in 2001 suggests a sound-wide summer population of about 2,500 murrelets. These estimates are consistent with what is believed to be a small Alaska and world population.

The population data, indications of low reproductive success, and affinity to tidewater glaciers (of which the lower elevation glaciers are receding rapidly) are reasons for concern about the long-term conservation of Kittlitz's murrelets. **Specifically, with reference to the effects of the oil spill, however, the original extent of the injury and its recovery status are still unknown and may never be resolved. Therefore, this species is in the recovery unknown category.**

MARBLED MURRELETS

Injury
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 also is 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 not known for certain, but environmental changes in the late 1970s probably reduced the availability or quality of prey resources. There is, nonetheless, clear evidence that oil caused injury to marbled murrelets in the sound. 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. Since they are a small bird and not easily seen, many more murrelets probably were killed by the oil than were found, perhaps as much as 7 percent of the spill area population, based on the 1989-1990 population counts.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Marbled murrelets will have recovered when their populations are stable or increasing. Sustained or increasing productivity within normal bounds (based on adults and juveniles on the water) will be an indication that recovery is underway.

Recovery Status
The recovery of the marbled murrelet population in Prince William Sound is assessed primarily through standard marine bird boat-based surveys. As a result of boat surveys carried out in July for seven years from 1989-2000, densities of marbled murrelets decreased in both the oiled and unoiled areas of Prince William Sound. However, for the March surveys carried out in most years between 1990 and 2000, there have been no significant trends in the population size, although the counts have increased in both oiled and unoiled areas. The reason for the summer time declines in both oiled and unoiled areas is probably due to some factor other than the oil spill. The Trustee Council's Alaska Predator Ecosystem Experiment (APEX) project has investigated the relationship between marbled murrelet declines and the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin. It appears that there is a direct correlation between the availability of forage fish and production of young murrelets, based on the presence of juvenile murrelets on the water in Prince William Sound.

The summer time marbled murrelet population is not stable nor increasing, but the March population is stable over time. Marbled murrelet productivity, as measured by surveys of adults and juveniles on the water in Prince William Sound, appears to be within normal bounds. **Based on these results, it appears that the marbled murrelet is at least recovering from the effects of the oil spill, but clearly has not yet recovered.**

MUSSELS

Injury
Mussels are an important prey species in the nearshore ecosystem throughout the spill area and are locally important for subsistence. Beds of mussels provide physical stability and habitat for other organisms in the intertidal zone and were purposely left alone during *Exxon Valdez* cleanup operations. In 1991, high concentrations of relatively unweathered oil were found in the mussels and in underlying byssal mats and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known precisely, but they are potential pathways of oil contamination for bird and mammal populations (e.g., harlequin ducks and sea otters) which include mussels and other prey in and around mussel beds in their diets.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Mussels will have recovered when concentrations of oil in the mussels reach background concentrations and mussels do not contaminate their predators.

Recovery Status
The Trustee Council's NearshoreVertebrate Predator project has found evidence of hydrocarbon exposure in sea otters, river otters, harlequin ducks, and Barrow's

goldeneyes in oiled parts of Prince William Sound in 1996 and 1997. Again in 2000 both sea otters and harlequin ducks showed evidence of oil exposure, but the pathway of such exposure has not been established. Both of these species include mussels in their diets.

About 30 mussel beds in Prince William Sound still contained *Exxon Valdez* oil residue when last sampled in 1995. Twelve of these beds had been cleaned on an experimental basis in 1993 and 1994. In 1995, oil hydrocarbon concentrations in mussels at half the treated beds were lower than would have been expected if the beds had not been cleaned. In 1996, however, limited sampling indicated that several of the cleaned beds had been recontaminated from surrounding or underlying oil residue.

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. In 1995, hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites were generally lower than for sites in Prince William Sound, but at some sites substantial concentrations persisted. While several sites in Prince William Sound still contained high concentrations of oil in 1995, over half the sites surveyed demonstrated significant natural declines that suggest background concentrations should be reached in the next few years. Oil contamination in mussels, however, will likely persist for many years at certain sites that are well protected from wave action or where oil penetrated deeply into underlying sediments.

The latest available data, taken in 1999, indicates that oil is still being accumulated in mussels, but more data will be available soon on samples taken in the summer of 2001. Since the latest available data indicates that *Exxon Valdez* oil remains in mussels, they are considered to be recovering from the oil spill, but not yet recovered.

PACIFIC HERRING

Injury

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.

Photo by Roy Corral

Herring populations are dominated by occasional, very strong year classes that are recruited into the overall population. 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 very high. Despite the large spawning biomass in 1992, the population exhibited a density-dependent reduction in size of individuals, and in 1993 there was an unprecedented crash of the adult herring population. A viral disease and fungus may have been the immediate agents of mortality or a consequence of other stresses, such as a reduced food supply and increased competition for food. There have been no "very strong" year classes recruited into the Prince William Sound herring population since 1988.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

Recovery Objective

Pacific herring will have recovered when the next highly successful year class is recruited into the population and when other indicators of population health (such as biomass, size-at-age, and disease expression) are within normal bounds in Prince William Sound.

Recovery Status

Laboratory investigations since the 1993 population crash have shown that exposure to very low concentrations of *Exxon Valdez* oil can compromise the immune systems of adult herring and lead to expression of the viral disease. The extent to which the exposure to oil contributed to the 1993 disease outbreak is uncertain. Using closed pounds in the commercial sac roe fishery may also have increased expression of the disease. There is also evidence that plankton production in the 1990s was less than in the 1980s, and so food limitation at the time of a peaking population may have contributed to the 1993 population crash. In addition, the average size-at-age of herring had been decreasing since the mid-1980s as the population was rising.

The Trustee Council's Sound Ecosystem Assessment has resulted in new understanding of the importance of body condition in determining overwintering survival of herring and in the influences of the Gulf of Alaska on herring productivity within Prince William Sound. Ongoing research on herring disease in relation to commercial fishing practices, such as the enclosed "pound" fisheries, have direct implications for management of the herring fishery.

Numbers of spawning herring in Prince William Sound remained depressed through the 1995 season. In 1997 and 1998 the spawning biomass was about double that of 1994, the season following the crash, and there were limited commercial harvests for herring in the sound. The increased biomasses in 1997 and 1998 were signs that recovery had begun. For that reason, in 1999, Pacific herring were considered to be recovering from the effects of the oil spill. Unfortunately, in the last several years the recovery has stalled and the population has yet to recruit a highly successful year-class, which is fundamental to recovery of this species. There is evidence from limited collections in the spring of 2002 that a large proportion (over 70%) of the Pacific herring population in Prince William Sound is now composed of young, 3-year old fish. If this preliminary trend holds up, it is possible that the next large year class has moved into the population, which would once again signal that recovery is underway. **However, until that happens, the Pacific herring can only be considered to be not recovering from the effects of the oil spill.**

PIGEON GUILLEMOTS

Injury

Although pigeon guillemots are widely distributed in the north Pacific region, they do not occur anywhere in large concentrations. Because guillemots feed in shallow, nearshore waters, guillemots and the fish and invertebrates 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 declined before the oil spill. The causes of the prespill decline are not known for certain, but environmental changes in the late 1970s probably reduced the availability or quality of prey resources. There is, nonetheless, clear evidence that oil caused injury to the guillemot population in the sound. An estimated 10-15 percent of the spill area population died immediately following the spill. Boat-based surveys of marine birds before (1984-85) and after the oil spill indicated that the guillemot population declined throughout the oiled portion of the sound. It is not known what pigeon guillemot populations would be had the oil spill not occurred.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

Recovery Objective

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

Recovery Status

Boat surveys have indicated that numbers of guillemots in the summer time continue to decline along both oiled and unoiled shorelines in the Prince William Sound through 2000. March surveys reveal no significant trends in abundance although the data appear to suggest a decline at this time of year as well. **For these reasons the pigeon guillemot is still considered to be not recovering from the effects of the oil spill.**

The Trustee Council's Alaska Predator Ecosystem Experiment (APEX) has investigated the possible link between pigeon guillemot declines and the availability of high-quality forage fish, such as Pacific herring and sand lance. This work has revealed a strong connection between the availability of certain prey fishes, especially sand lance, and guillemot chick growth rates, fledging weights, and nesting population size. The APEX project and the Nearshore Vertebrate Predator (NVP) project, also sponsored by the Trustee Council, addressed the possibility that exposure to oil is limiting the guillemot's recovery. The biochemical data indicated that adult guillemots were experiencing greater hydrocarbon exposures in western Prince William Sound than in the eastern portion of the sound as recently as 1999. However, guillemot chicks, which are restricted to the nest and are fed only fish, are not being exposed to hydrocarbons.

PINK SALMON

Injury

Certain features of the life history of pink salmon made this species highly vulnerable to damage from the oil spill. As much as 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams, where eggs deposited in the gravel and developing embryos were chronically exposed to hydrocarbon contamination in the water column or leaching from oil deposits on adjacent

beaches. When juvenile pink salmon migrate to saltwater, they spend several weeks foraging for food in nearshore habitats. Thus, juvenile salmon entering seawater from both wild and hatchery sources could have been exposed to oil as they swam through oiled waters and fed along oiled beaches. Trustee Council sponsored studies have documented two primary types of injury due to the exposure of these early life stages: 1) growth rates in both wild and hatchery-reared juvenile pink salmon from oiled parts of the sound were reduced; and 2) there was increased embryo mortality in oiled versus unoiled streams.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Pink salmon will have recovered when population indicators, such as juvenile growth and survival, are within normal bounds and when ongoing oil exposure, which may cause injury to pink salmon embryos (eggs), is negligible.

In addition to the population indicators, the Trustee Council's recovery objective in 1999 required a sequence of two years each of odd- and even-year runs without differences in embryo mortality. Differences were detected in 1990-1993, none in 1994, 1995 and 1996, but in 1997 there was again a difference. The cause of this difference could not categorically be attributed to oil exposure. A Trustee Council sponsored study showed that hatchery-spawned embryos showed the same effects as those displayed by embryos in their native streams. However, the only way to sustain such an injury over time would be a continuing genetic effect from the original injury or continuing exposure of the embryos in the originally oiled streams. Laboratory experiments have shown a continuing genetic effect for only one generation of pink salmon (two years). There is also a well-known phenomenon of lethality for most mutations that would lead to extermination of the genetic defects in a generation. That leaves continued exposure to oil as the remaining pathway for any continuing embryo mortality. For that reason, a more precise way to assess continued embryo mortality is based on hydrocarbon exposure of pink salmon embryos. Given the expense of the embryo mortality field studies ($1.7 million over four years) and the inability to attribute a direct cause to any potential differences, this data is no longer gathered by the Alaska Department of Fish and Game. Accordingly, this objective was modified.

Recovery Status
In the years preceding the spill, returns of wild pink salmon in Prince William Sound varied from a maximum of 23.5 million fish in 1984 to a minimum of 2.1 million in 1988. Throughout Alaska there is increasing recognition of the importance of changes in marine ecosystems on the growth and survival of salmon. The Sound Ecosystem Assessment (SEA) project explored oceanographic and ecological factors that influence production of pink salmon and Pacific herring in Prince William Sound. These factors include such things as the timing of spring plankton blooms and changes in circulation patterns that link the sound to the Gulf of Alaska, and are likely to have the greatest influence on year-to-year returns in both wild and hatchery stocks of pink salmon.

Since the spill, returns of wild pinks have varied from a high of about 12.7 million fish in 1990 to a low of about 1.9 million in 1992. In 2001 the return of wild stock fish was estimated to be 6.7 million fish. The decade preceding the oil spill was a time of very high productivity for pink salmon in the sound, and, given the tremendous natural variation in adult returns, it is impractical to measure directly the extent to which wild salmon returns since 1989 were influenced by the oil spill. Based on intensive studies and mathematical models carried out following the spill, wild adult pink salmon returns to the sound's Southwest District in 1991 and 1992 were most likely reduced by a total of 11 percent. However, such an approach is unlikely to produce reliable multi-generational injury estimates. In addition, an analysis of escapement data from 1968-2001 showed no apparent time trends in annual escapements in either the oiled or unoiled parts of the sound. Therefore, there appear to be no observable effect at the population level at this time.

Population levels appear to be within normal bounds. In addition, reduced juvenile growth rates in Prince William Sound occurred only in the 1989 season. Since then, juvenile growth rates have been within normal bounds.

Higher embryo mortality persisted in oiled compared to unoiled streams through 1993. No statistically significant differences in mbryo mortalities in oiled and unoiled streams were detected in 1994 through 1996, but in 1997 there was again a difference. It is not clear whether the 1997 difference was due to the effects of lingering weathered oil, perhaps newly exposed by storm-related disturbance of adjacent beaches, or due to other natural factors such as differences in the physical environment. Although patches of weathered oil still persist in or near intertidal spawning habitats in a few of the streams used by pink salmon in southwestern Prince William Sound, the amounts are considered negligible based on 1999 and 2001 studies. In 1999 dissolved oil measurements were made in six pink salmon streams in the oil spill area, chosen because they were the most likely to show residual oiling. Methods were used that were extremely sensitive. Only one of the six streams had clearly measurable

concentrations of oil, and that was about a thousand times lower than the concentration established through Trustee Council sponsored studies to be toxic to developing pink salmon embryos. In 2001 a Trustee Council study assessed those intertidal areas in western Prince William Sound considered to be most heavily oiled in 1993. There were no pink salmon streams located near any of those sites determined to have the most extensive subsurface oil deposits. Based on these results, the biological impact of exposure of pink salmon embryos to lingering oil is negligible and unlikely to limit pink salmon populations. **It is highly unlikely that oil is now accumulating in pink salmon embryos and having any significant effects. On this basis and given the fact that pink salmon population levels and indicators such as juvenile growth and survival are within normal bounds, pink salmon are considered recovered from the effects of the oil spill.**

RIVER OTTERS

Injury
River otters have a low population density in Prince William Sound. Twelve river otter carcasses were found following the spill, but the actual total 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 alterations, reduced diversity in prey species, reduced body size (length-weight), and increased home-range size. Because there were few prespill data, it is not certain that these differences are the result of the oil spill.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
The river otter will have recovered when biochemical indicators 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.

Recovery Status
Although some of the differences (e.g., values of blood characteristics) between river otters in oiled and unoiled areas in Prince William Sound persisted through 1996, there were few differences documented in 1997 and 1998. **Thus, there are no indications of possible lingering injury from the oil spill, and the Trustee Council's recovery objective has been met. River otters were considered to be recovered in 1999.**

ROCKFISH

Injury
Very little is known about rockfish populations (of several species) 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 had the effect of increasing fishing pressure on rockfish, which, in turn, may have adversely affected local rockfish populations.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
No recovery objective can be identified.

Recovery Status
The original extent of injury and the current recovery status of this species are unknown. Because little is know about rockfish abundance and species composition in the spill area and because rockfish are harvested commercially, even basic information about these species could provide a basis for improved management or, at least, the identification of priorities for more targeted research.

SEA OTTERS

Injury
By the late 1800s, sea otters had been eliminated from most of their historical range in Alaska due to excessive harvesting by Russian and American fur traders. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population in most of Alaska, including Prince William Sound. Today the only harvests of sea otters are for subsistence purposes. About 1,000 sea otter carcasses were recovered following the spill, and 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.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

Recovery Objective
Sea otters will have recovered when the population in oiled areas returns to its prespill levels and distribution, and when biochemical indicators of hydrocarbon exposure in otters in the oiled areas are similar to those in otters in unoiled areas. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

Recovery Status
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 both aerial and boat surveys conducted in western Prince William Sound, there is statistically significant evidence of a population increase following the oil spill (1993-98). Observations by local residents bear out this general increase. However, within the most heavily oiled bays in the western sound, such as those on northern Knight Island, the aerial surveys indicate that recovery is not complete.

The Trustee Council's Nearshore Vertebrate Predator project addressed the lack of recovery in sea otters in these heavily oiled bays. The lack of recovery may reflect the extended time required for population growth for a long-lived mammal with a low reproductive rate, but it also could reflect the effects of continuing exposure to hydrocarbons, or a combination of both factors. Through 2000, researchers have continued to find biochemical evidence of oil exposure in sea otters around northern Knight Island. Biochemical samples from 2001 are now being analyzed. An additional hypothesis is that food supplies are limiting recovery, but the evidence does not fully support this idea.

It is clear that sea otter recovery is underway for much of the spill-affected area, with the exception of populations at the most heavily oiled bays in western Prince William Sound. For this reason, sea otters continue to be in the recovering category.

SEDIMENTS

Injury
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.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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

Recovery Status
A comprehensive survey of shorelines in Prince William Sound was conducted in 1993, but that survey has been repeated in the summer of 2001 with revised methods for better quantifying the oil remaining in intertidal sediments. The 2001 surveys indicate that about 20 acres of continuously oiled intertidal habitat now persist in Prince William Sound. While it appears that natural weathering processes are gradually reducing the amount of remaining oil in sediments, the amount estimated in 2001 is about twice the amount estimated to be in the sediments in 1993 (using methods that were designed in 1989 more for cleanup decisions than for quantitative estimates of remaining oil). The shorelines of the outer Kenai and Alaska Peninsula coasts get more wave action than most shorelines within Prince William Sound. These Gulf of Alaska sites tended to be contaminated with oil in the form of mousse, a stable emulsion of oil in water, which can persist for long periods in a largely unweathered state. Five of six index beaches on the gulf coast have a heavy boulder "armor" and were last visited in 1993 and 1994. At that time, surface and subsurface oil mousse persisted in a remarkably unweathered state.

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 carried out in 1995 around Kodiak Island found no oil or only trace amounts, so oiling in the Kodiak area has not persisted as it has in 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 was mostly confined to the uppermost 20 meters water depths (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 elevated 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 substantial subsurface oiling is still known to occur.

Based on the information above, sediments are considered to be recovering. However, the presence of surface and subsurface oil continues to compromise wilderness and recreational values, expose and potentially harm living organisms, and offend visitors and residents, especially those who engage in subsistence activities along still-oiled shorelines.

SOCKEYE SALMON

Injury

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 and also Red and Akalura lakes on Kodiak Island. Research carried out following the spill demonstrated that initially these high escapements produced an overabundance of juvenile sockeye that then overgrazed the zoo-plankton, thus altering planktonic food webs in the nursery lakes. The result was lost sockeye production as shown by reduced growth rates during the freshwater part of the sockeye life history and declines in the returns of adults per spawning sockeye.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

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**.**

Recovery Status

Although sockeye freshwater growth tended to return to normal within two or three years following the overescapement, there are indications that these systems are less stable for several years after an initial overescapement event. The negative effects of the 1989 overescapement on sockeye productivity, as measured by return per spawner, in the Kenai River watershed were readily apparent for returns from the brood years 1989-92. 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. By 1997, Red Lake had responded favorably in terms of smolt and adult production and was at or near prespill production of adult sockeye. At Akalura Lake there were low juvenile growth rates in freshwater during the period 1989-92, and these years of low growth correspond to low adult escapements during the period 1994-97. Starting in 1993, however, the production of smolts per adult increased sharply and the smolt sizes and age composition suggested that rearing conditions have improved. There also was concern about overescapement effects in lakes on Afognak Island and on the Alaska Peninsula. However, analysis of sockeye freshwater growth rates of juveniles from Chignik Lake on the Alaska Peninsula did not identify any impacts associated with a 1989 overescapement event. On the basis of catch data through 2001 and in view of recent analyses of return per spawner estimates presented to the Alaska Board of Fisheries in 2001, the return-per-spawner in the Kenai River system is within historical bounds. **Therefore, it is highly unlikely that the effects that reverberated from the overescapements in 1989 continue to affect sockeye salmon (e.g., cause abnormal returns per spawner), and this species is considered to be recovered from the effects of the oil spill.**

SUBTIDAL COMMUNITIES

Injury

Shallow subtidal habitats of Prince William Sound, from the lower intertidal zone to depths of about 20 meters, typically have dense stands of kelp or eelgrass and contain numerous polychaete worms, snails, clams, sea urchins, and other invertebrate life. These subtidal communities provide shelter and food for an array of nearshore fishes, birds, and marine mammals. Oil that was transported down to subtidal habitats, as well as subsequent cleanup activities involving extensive vessel traffic, apparently caused changes in the abundance and species composition of

plant and animal populations below lower tides.

Biologically, negative effects of the oil were most evident for oil-sensitive species of amphipods, which were consistently less abundant at oiled than at unoiled sites. Reduced numbers of eelgrass shoots and flowers may have been due to increased turbidity associated with cleanup activities (e.g., boat traffic). Two species of sea stars and helmet crabs also were less abundant at oiled sites. Some invertebrates living in the sediment, including species in eight families of polychaete worms, two families of snails, and one family of mussels, were greater in numbers at oiled sites. These species are more tolerant of oil exposure and may have also responded to the organic enrichment associated with oil. Some of the species that showed increased numbers also may have benefited from reduced competition or predation due to the effects of the spill. It is also is to be expected that when comparing any two sets of bays that measuring a large number of species will turn up differences just on the basis of chance.

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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 or consistent with natural differences between sites such as proportions of mud and sand.

Recovery Status
Different habitats, emphasizing eelgrass beds and adjacent areas of soft sediment, were compared at oiled and unoiled sites from 1990-1995. It is difficult to draw firm conclusions from this study, because it is hard to distinguish between natural site differences (e.g., percent sand and mud) and those differences actually resulting from the oil spill or cleanup. Concentrations of hydrocarbons in subtidal sediments were significantly higher at oiled sites than at unoiled reference sites, but never very high by comparison with concentrations known to cause community responses in the scientific literature. These oil concentrations dropped sharply by 1991, but evidence of oil contamination due to *Exxon Valdez* oil persisted at some locations through 1995 at very low concentrations. By 1995, based on postspill comparisons of oiled and unoiled sites, there was recovery of most constituents of the eelgrass community. In 1999 an article was published in the peer reviewed literature that acknowledged the role that natural factors may be playing in the remaining differences in subtidal communities between oiled and unoiled bays. **Since the study results show that the remaining faunal differences could be due to the influence of natural factors or to oil effects or some combination, and since additional study will not likely bring more certainty to question, the recovery status of subtidal communities is judged to be unknown.**

HUMAN SERVICES

COMMERCIAL FISHING

PASSIVE USE

RECREATION AND TOURISM

SUBSISTENCE

COMMERCIAL FISHING

Injury
Commercial fishing is a service that was reduced through injury to commercial fish species (see individual resource accounts) and also through fishing closures. In 1989, closures affected fisheries in Prince William Sound, Cook Inlet, the outer Kenai coast, Kodiak, and Chignik. These closures harmed the livelihoods of persons who fish for a living. The period before the oil spill was a time of relative prosperity for many commercial fishermen. The years 1987-88 saw some of the highest ever per pound prices for salmon and increased capitalization of the fishery. Thus, fishermen's expectations for income in 1989 were very high, making the fishery closures and other spill effects even more disruptive.


Photo by Roy Corral

Recovery Goal
A return to conditions that would have existed had the spill not occurred.

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.

Recovery Status
Although pink salmon and sockeye salmon are considered to be recovered from the oil spill, recovery is still not complete for Pacific herring (see individual resource accounts), one of the injured resources that is commercially fished. The recovery status of rockfish is still unknown and will likely never be known. No spill-related district-wide fishery closures related to oil contamination have been in effect since 1989. However, the Prince William Sound herring fishery was closed from 1993-96 due to a disease outbreak that may be related to the oil spill, was open to limited commercial harvest in 1997 and 1998, and has remained closed since then. **For these reasons, commercial fishing, as a lost or reduced service, is in the process of recovering from the effects of the oil spill, but full recovery has not been achieved.**

For a variety of reasons, as discussed below, disruptions to income from commercial fishing continue today, as evidenced by changes in average earnings, ex-vessel prices, and limited entry permit values. For example, for the period 1981-2000, fishermen's average earnings in the Prince William

Sound salmon seine fishery peaked in 1987 ($176,500), dropped in 1989 by more than half, rebounded in 1990, hit a new low in 1992-93 (runs in 1992-93 were the lowest in 15 years), then hovered somewhat below the 1989 level until 1999-2000, when average earnings climbed to the $130,000 level. Average per-fisher harvests have varied widely during this period, with the three highest years being 1996, 1999, and 2000. Ex-vessel prices were highest in the period 1987-90, and have been below prices of the early 1980s ever since. Limited entry permit prices in this fishery reached a peak in 1989-91, nearly double the price in any earlier year in this period, and have declined since to currently ten percent of their peak price (from $236,000 in 1989 to $22,000 in 2000). The number of permits fished, roughly 250 each year 1981-91, had declined to 130 in 2000.

Natural variability in fish returns and a number of economic changes in the commercial fishing industry since 1989 probably mean that many of these changes in income are not directly attributable to the spill. However, these factors also make discerning spill-related impacts difficult. Economic changes confronting the industry include the increased world supply of salmon (due primarily to farmed salmonids) and corresponding reduced prices, entry restrictions in certain fisheries (such as Individual Fishing Quotas, IFQs, for halibut and sablefish), allocation changes (e.g., a reduction in the allocation of Cook Inlet sockeye salmon to commercial fishermen), changes in processing capacity (closure of major processors in Cordova and Kenai, and a recently announced closure in Larsen Bay on Kodiak Island), and new measures imposed by the North Pacific Fishery Management Council on offshore groundfish fishing to protect the declining number of Steller sea lions.

Although a number of studies aimed at allocating financial impacts to the oil spill versus other factors have been carried out, the federal jury's compensatory award (as opposed to the $5 billion in punitive damages) in the private lawsuit against Exxon is the current legal determination of the liability and damages regarding commercial fishermen (including permit holders, fishing crew, spotter pilots, and vessel owners). The jury award was less than the damage claimed by commercial fishermen and more than that acknowledged by Exxon. In brief, the jury determined that any financial effects on fishermen after 1989, with the exception of the salmon seine fishery in Prince William Sound in 1992-93 and the herring fishery in Prince William Sound in 1993, are not attributable to the spill. The jury considered damage claims for the period 1989-95, including claims related to size of harvest, fish prices, limited entry permit values, and vessel values.

PASSIVE USE

Injury

Passive use encompasses nonuse values, such as the appreciation of the aesthetic and intrinsic values of undisturbed areas and the value derived from simply knowing that a resource exists. Injuries to passive use are tied to public perceptions of injured resources. Immediately following the oil spill, the State of Alaska, using a contingent valuation approach, measured substantial losses of passive use values resulting from the spill. This approach involved surveying a sample of U.S. households to elicit how much people would be willing to pay in additional taxes to fund a program designed to prevent future spills. Prior to answering the survey questions, respondents were provided information about the spill's impact, including the number of miles of shoreline oiled, an estimate of the number of birds, sea otters, and harbor seals killed, and the conclusion that few fish were harmed, as well as projections of when recovery would occur (typically three to five years).

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

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.

Recovery Status

Because recovery of a number of injured resources is incomplete and in some cases has not begun, the Trustee Council considers passive use, as a lost or reduced service, to be recovering from the spill but not yet recovered. In updating the status of passive uses, the Trustee Council has chosen not to repeat the contingent valuation study, which was very expensive and time consuming. However, the key to recovery of passive use is knowing that restoration of injured resources has occurred. Toward this end, in the years since the settlement between Exxon Corporation and the state and federal governments, the Trustee Council has undertaken a comprehensive program to restore injured resources and has made a deliberate and consistent effort to inform the public about the status of restoration.

The two key components of the Trustee Council's restoration effort are the research, monitoring, and general restoration program and the habitat protection and acquisition program. The research, monitoring, and general restoration program,

which is funded each year through the annual work plan, focuses mostly on knowledge and stewardship as the best tools for long-term health of the marine ecosystem. It also includes development of tools to benefit fisheries management and some direct enhancement activities, such as improving access to spawning habitat. Projects to monitor the status of injured resources, including resources such as killer whales for which no active restoration may be possible, have also been funded through the annual work plan. The habitat protection program preserves habitat important to injured resources through the acquisition of land or interests in land. As of March 2002, the Council has protected more than 643,600 acres of habitat, including more than 1,400 miles of coastline and over 300 streams valuable for salmon spawning and rearing. A summary of the Council's public information efforts follows.

Each year the Trustee Council prepares a number of documents for distribution to the public including; annual work plans, which describe the work underway to restore the injured resources and services; the *Annual Status Report*, which reports to the public on the progress of restoration; and updates to the Restoration Plan (1996, 1999). The Council's annual restoration workshop, which is open to the public, provides another venue for reporting on the progress of restoration. The Council has also published its Restoration Notebook series, which tells the story of injury and recovery from the spill of select injured species.

In addition, from 1996 through early 1999 the Council aired a weekly radio series, "Alaska Coastal Currents", throughout the state. Since 1997, the Trustee Council has had a web site (www.oilspill.state.ak.us) that offers detailed information about restoration efforts.

Project final reports, are also available to the public through the Alaska Resource Library and Information Services (ARLIS) in Anchorage as well as at several other libraries in the state, at the Library of Congress, and through NTIS (National Technical Information Service). In addition, the Council supports researchers in publishing their project results in the peer-reviewed scientific literature, which expands their audience well beyond Alaska. Nearly 500 such papers have been published as of April 2002.

The 17-member Public Advisory Group (PAG), is an important means of keeping stakeholders and others informed of the progress of restoration. In addition to holding quarterly meetings with the Trustee Council staff, in many years the PAG has held an open house in one or more communities in the spill area. Additional public meetings have been held throughout the spill area. All meetings of the Council are widely advertised and opportunity for public comment, is always provided.

RECREATION AND TOURISM

Injury

The oil spill disrupted use of the spill area for recreation and tourism. In addition, resources important to recreation were injured and beaches used for recreational activities were oiled.

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, particularly in the years immediately following the spill, increased management problems and facility use in unoiled areas.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

Recovery Objective

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

Recovery Status

In the years since the spill, there has been a marked increase in the number of visitors to Alaska. Preliminary data for the summer of 2001 indicate over 1.2 million visitors, compared to approximately 600,000 visitors in the summer of 1989. Visitation to the spill area has experienced a similar increase. For example, since 1993 the annual number of visitors to the Kenai Fjords National Park Visitor Center has been nearly double what it was in 1988. In 2000, the number of visitors to the USFS Crooked Creek Visitor Information Center in Valdez was nearly 70 percent greater than in 1989. From 1989 to 1997, the number of sportfishers increased by 65% in Prince William Sound, by 25% in the Kodiak Region, and by 15% in the Kenai Peninsula region. In 2000, the numbers were up slightly for Prince William Sound and Kodiak, and had decreased slightly for the Kenai Peninsula region.

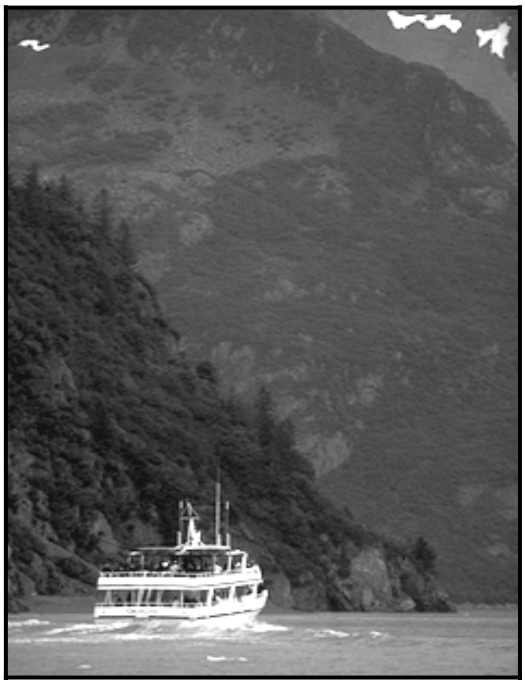
Even though visitation has increased since the oil spill, however, the Trustee Council's recovery objective requires that the injured resources important to recreation be recovered and recreational use of oiled beaches not be impaired, and this objective has not been met. **Therefore, the Council finds recreation to be recovering from the effects of the spill, but not yet recovered.**

Several resources important for wildlife viewing still are not

recovering from the spill or their recovery is unknown, including harbor seal, common loon, cormorant (three species), Kittlitz's murrelet, and pigeon guillemot. Other resources, including sea otter and marbled murrelet, are recovering. The bald eagle, another resource important for wildlife viewing, has recovered from the effects of the spill. (See individual resource accounts for more information on recovery status.)

Telephone interviews were conducted in early 1999 with key informants who recreated extensively in the oil spill area before the spill and currently. Contacted again in 2002, nearly all of the informants commented on increased visitation to the area since the spill. Informants with experience in Prince William Sound continued to report diminished wildlife sightings in the sound, particularly in heavily oiled areas such as around Knight Island. They reported seeing fewer seabirds, killer whales, sea lions, seals, and sea otters than were generally sighted before the spill, but also reported observing increases in the number of seabirds over the last several years. Key informants with experience along the outer Kenai coast reported diminished sightings of seabirds, seals, and sea lions. Changes in the amount of wildlife observed could be due to the oil spill or to other factors

Sportfishing resources for which the recovery status is unknown are cutthroat trout, Dolly Varden, and rockfish. In 1992-93, in response to evidence of injury to cutthroat trout, emergency closures were put in place in some locations in Prince William Sound. In addition, bag limits have been reduced since 1991 and a closure during the April 15-June 15 spawning season has been in effect since 1994. These measures reflect the management goals for a potentially vulnerable species at the edge of its range. The salmon species that were injured (pink and sockeye salmon) are recovered from the effects of the spill.



Wildlife tours in Kenai Fjords National Park

Harlequin ducks, which are hunted in the spill area, are still not recovered. The Alaska Board of Game restricted sport harvest of harlequin ducks in western Prince William Sound and Kenai Fjords in 1991. Those restrictions were removed in the 1999-2000 hunting season when sea duck limits were changed statewide to have different limits for resident and non-resident hunters. There are currently no special restrictions for harlequins in Prince William Sound or Kenai Fjords.

Trustee Council sponsored surveys of oiled shorelines indicate that residual oil is still present on some beaches. The results of the most recent survey in Prince William Sound (2001) indicate approximately 20 acres of shoreline are still contaminated with oil. Oil was found at 58 percent of the 91 sites assessed and is estimated to have the linear equivalent of 5.8 kilometers of contaminated shoreline. The most recent survey of the Kenai outer coast and the coast of Katmai National Park (1999) found oil mousse persisting in a remarkably unweathered state on five moderately-to-heavily-oiled boulder-armored beaches (the oil is chemically similar to 11-day old *Exxon Valdez* oil). A survey of 30 oiled sites in the Kodiak Archipelago in 1995 found no oil or only trace amounts.

Key informants telephoned in early 1999 indicated that some beaches in Prince William Sound, particularly in the western portion of the sound, continue to be avoided by some recreational users, particularly kayakers and campers, because of the presence of residual oil. Contacted again in early 2002, informants commented that visitors to the sound routinely inquire about the existence of oil on beaches, either in planning visits or while on tours. They also commented that experienced users of the sound can readily find oil on certain beaches and continue to avoid those areas. Since 1999, informants have indicated that the possible presence of residual oil has no effect on recreational activities along the outer Kenai coast, the Kodiak Archipelago, and the Lake Clark and Katmai national park coastlines.

In 1997, the Trustee Council provided funding for the residents of Chenega Bay, working with the Department of Environmental Conservation, to use PES-51, a citrus-based chemical agent, to clean some of the most heavily-oiled sites near their village. One year later, a statistical analysis showed that the cleanup method reduced the amount of oil remaining on these beaches by a factor of three compared with reductions observed on untreated beaches. However, considerable subsurface oil remains

that was inaccessible at the time of treatment, but was uncovered during storms the following winter. NOAA's Auke Bay Lab found no biological injury due to the cleanup.

The State of Alaska dedicated over $10 million of its criminal settlement with Exxon to restoring recreational facilities and use in state parks in the spill area. Improvements include trails, cabins, boat launches, interpretive displays, and campsites. In addition, the Trustee Council funded U.S. Forest Service development of a human use model for western Prince William Sound, which is intended to aid planning for and mitigation of human uses so that injured species continue to be protected. The model may also assist in planning for future recreation needs in the sound.

SUBSISTENCE

Injury

Fifteen predominantly Alaskan Native communities (with a total population of about 2,200 people) in the oil spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, and waterfowl. Many families in other communities also rely on the subsistence resources of the spill area.

Household interviews conducted with subsistence users in communities throughout the spill area in 1989 indicated that subsistence harvests of fish and wildlife in most of the communities declined substantially following the spill. Key factors in the reduced harvests included reduced availability of fish and wildlife, concern about possible health effects of eating oiled fish and wildlife, and disruption of the traditional lifestyle due to cleanup and related activities.

Recovery Goal

A return to conditions that would have existed had the spill not occurred.

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.

Recovery Status

Household interviews were repeated each year 1990-93 and again in 1998. By 1993, the estimated size of the subsistence harvest and participation in subsistence activities appeared to have returned to prespill levels in some communities, with the harvest rebounding first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula and lagging behind a year or more in the Prince William Sound communities.

Many subsistence resources injured by the spill, including clams, mussels and harbor seals, have still not recovered from the effects of the spill. In addition, in 1998, household interviews indicated that subsistence users continued to feel the effects of the spill. For these reasons, subsistence continues to recover from the effects of the oil spill, but has not yet recovered. The percentage of those interviewed who reported that subsistence uses are lower than before the spill has declined. Concerns about food safety and effects on the traditional lifestyle have lessened. Concerns about resource availability and greater harvest effort remain, but harvest levels in all communities interviewed are at or approaching prespill levels. Subsistence harvests in 1998 varied among communities from 250-500 pounds per person usable weight, indicating continued strong dependence on subsistence resources.

Regarding resource availability, subsistence users continued to report scarcity of a number of important subsistence resources, including harbor seals, herring, clams, and crab. These observations are generally consistent with scientific studies funded by the Trustee Council that continue to find that some subsistence species (e.g., harbor seals, Pacific herring, clams) are not recovered from the effects of the spill (see individual resource accounts).

According to those interviewed, the 1998 increase in pounds harvested at a time of continued reduced resource availability reflects greater harvest effort (traveling farther, spending more time and money) than would have been required before the spill to achieve a similar harvest. It also reflects increased reliance on fish in the subsistence diet. Increased fish harvests and decreased marine mammal and shellfish harvests occurred in most communities where

interviews were conducted. The cultural and nutritional importance of each resource varies, and these changes in diet composition remain a serious concern to subsistence users.

The decline in shellfish consumption reflects food safety concerns as well as reduced availability of shellfish. From 1989-94, subsistence foods were tested for evidence of hydrocarbon contamination, with no or very low concentrations of petroleum hydrocarbons found in most subsistence foods. However, because some shellfish can readily accumulate hydrocarbons, subsistence users have been advised not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. By 1998, a large majority of those interviewed expressed confidence about most foods except certain shellfish, such as clams, and concerns about the presence of PSP (paralytic shellfish poisoning) in clams outweighed concerns about lingering hydrocarbon contamination from the oil spill.

Subsistence users continue to emphasize that the value of subsistence cannot be measured in pounds alone. Harvest levels do not encompass the cultural value of traditional and customary use of natural resources. Following the oil spill, there was concern that the spill disrupted opportunities for young people to learn cultural subsistence practices and techniques, and that this knowledge may be lost to them in the future. In 1998, the number of subsistence users reporting a decline in the influence of elders in teaching subsistence skills and values had decreased and the number reporting that young adults are learning enough subsistence skills had increased. Also, the number reporting less sharing of subsistence resources, another integral aspect of subsistence culture, had decreased. However, many of those interviewed continue to express concern about these elements of the traditional lifestyle, with more than 50 percent responding that the traditional way of life has not recovered since the spill.

In the 1998 household interviews, a number of subsistence users commented that some of the current influences on subsistence may not be attributable to the oil spill. Factors such as demographic changes in village populations, ocean warming, increased competition for subsistence resources by other people (e.g., sport fishing charters) and predators (e.g., sea otters), and increased awareness of PSP and other contaminants may play a role in resource availability, food safety, and participation in traditional practices. The Trustee Council will likely repeat the household interviews with subsistence users in communities through the spill area in 2004 or 2005.

Exxon Valdez Oil Spill Restoration Plan

Update on Injured Resources and Services
August 2002

Exxon Valdez Oil Spill Trustee Council

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