KAREN

TO: RPWG members

From: Sanford P. Rabinowitch, RPWG

Subject: Review of Chapter III: Draft Restoration Plan

Date: April 13, 1993

Attached is version two of Chapter III, now 9 pages instead of 70 and Appendix ___ "Injury Tables and Natural Resource Damage Assessment and Restoration Studies."

In my absence I recommend comments be sent to Bob Loeffler.

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Chapter III - Injury

The *Exxon Valdez* oil spill occurred in March, just before the most biologically active season of the year. It affected the migration of birds, and the primary breeding season for most species of birds, mammals, fish, and marine invertebrates in the spill's path. Much of southcentral Alaska's intricate coastline was oiled, frequently with devastating impact to intertidal and shallow subtidal resources. It also affected human use of the spill area, including subsistence, recreation, commercial fishing, and other uses. Some resources and services remain exposed to oil persisting below high tide.

Oil affected each resource and use differently. For some resources, the population measurably declined. By measurably declined, we mean a measurable decline in abundance that will persist for more than one generation. For example, an estimated 3,500 to 5,000 sea otters were killed by the spill, and the population will not recover for many generations. Other species were killed or otherwise injured by the spill, but the injury did not measurably lower the overall population. Deaths by individual animals or sublethal injuries, which do not result in death, may not be reflected in a lower population because the natural variability of the species may mask the injury, or the resource may have some mechanism to compensate for the injury.

Some species, such as marbled murrelets, pigeon guillemots, and harbor seals were declining before the spill. Their rate of decline was accelerated by the spill, but other factors such as variations in climatic conditions, habitat loss, or increased competition for food may also influence long-term trends in the health and populations of these and other species.

Add another couple sentences for Archaeological & Wilderness Areas.

The spill also directly affected human uses of the spill area including commercial fishing, commercial tourism, recreation, passive use, and subsistence. The nature and extent of the injury varied by user group and by area of use. Table 3.1 summarizes injuries caused by the spill.

Table 3.1
Resources and Services Injured by the Oil Spill

RESOURCES			SERVICES (Human Uses)
Population Decline	Injured, but No Population Decline	Other	
Black oystercatcher Common murre Harbor seal Harlequin duck Intertidal organisms Marbled murrelet Pigeon guillemot Sea otter Sockeye salmon Subtidal organisms	Bald eagle * Cutthroat trout * Dolly Varden * Killer whale Pacific herring * Pink salmon River otter Rockfish	Air, water, and sediments Archaeological resources Designated wilderness areas	Commercial fishing Commercial tourism Passive use Recreation including sport fishing, sport hunting, and other recreation use Subsistence

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

Let's pull "Air" off of this list.

What Was Injured By the Spill and Is It Recovering?

MAMMALS

HARBOR SEALS: The oil spill caused population declines and sublethal injuries in harbor seals. Many were directly oiled and an estimated 345 died. Oil residues found in seal bile were 5 to 6 times higher in oiled areas than unoiled areas in 1990. The population was declining prior to the oil spill which makes it difficult to determine the effects of the spill. There are some recent indications that the population may be stabilizing, but there is no indication of any increase.

KILLER WHALES: Population decline and other injuries have been documented in one of the pods (extended family group) in the oil spill area. There is debate about whether the oil spill caused these injuries. Thirteen whales out of 36 in one whale pod in Prince William Sound are missing and presumed dead. Circumstantial evidence links the whale disappearance to the oil spill. Additionally, several adult males have collapsed dorsal fins and social disruption of family units has been observed. In that pod, no new births were recorded in 1989 or 1990; one birth was recorded in 1991; and two births were recorded in 1992. These births suggest that the pod is beginning to recover.

RIVER OTTERS: There are differences in some indicators of health, feeding habits, and other aspects of river otter biology between oiled and unoiled areas. These differences may indicate an effect of the spill. Lacking prespill data and a measure of the population, there is great uncertainty about the nature of the injury. River otters feed in the intertidal and shallow subtidal areas and may still be exposed to oil persisting in the environment.

SEA OTTERS: The oil spill caused population declines and sublethal injuries in sea otters. It is estimated that 3,500 to 5,000 otters died. The total sea otter population in the Gulf of Alaska is estimated at around 20,000. Surveys in 1989, 1990 and 1991 showed measurable differences in population and survival rates between oiled and unoiled areas. In 1992, lower juvenile survival rates and higher than normal numbers of dead, prime-age otters indicate that the populations in Prince William Sound continue to be stressed. Sea otters feed in the lower intertidal and subtidal areas and may still be exposed to oil persisting in the environment. Little or no evidence of recovery has been detected.

BIRDS

BALD EAGLES: A minimum of 200 to 300 eagles were estimated to have been killed by the spill. However, because population census techniques are not accurate enough to detect population changes this small, no measurable population decline has been recorded. Productivity in Prince William Sound was disrupted in 1989, but returned to normal in 1990. Exposure to oil and some sublethal injuries were found in 1989 and 1990, but no continuing effects were observed on populations. Bald eagles are recovering, and may have recovered, from the effects of the oil spill.

BLACK OYSTERCATCHERS: The oil spill caused population declines and sublethal injuries in black oystercatchers. In 1989, smaller eggs and lighter weight chicks were found in oiled areas. Black oystercatchers feed in the intertidal areas and may still be exposed to oil persisting in the environment. The population is recovering although evidence of sublethal injuries persisted in

1992.

COMMON MURRES: The oil spill caused population declines and sublethal injuries at murre colonies within the oil spill area. In 1989, between 175,000 to 300,000 murres were killed. Measurable impacts on populations were recorded in 1989, 1990 and 1991. Breeding was still inhibited in some colonies in the Gulf of Alaska in 1992. The degree of recovery varies between colonies and some colonies show little evidence of recovery.

HARLEQUIN DUCKS: The oil spill caused population declines and sublethal injuries in harlequin ducks. In 1989, approximately 400 birds were killed. In the three years since the oil spill, it appears that harlequin ducks still are not successfully breeding in oiled areas of Prince William Sound. Harlequin ducks feed in the intertidal and shallow subtidal areas and may still be exposed to oil persisting in the environment.

MARBLED MURRELETS: The oil spill caused population declines, but it is unknown if there were sublethal injuries. It is estimated that 8,000 to 12,000 birds died. Measurable population effects were recorded in 1989, 1990 and 1991 as a result of the oil spill. In 1989, oil contamination was found in livers of adult birds. Marbled murrelet populations were declining prior to the oil spill. In 1992, recovery was uncertain and no signs of an increasing population have been observed, but the decline may have stabilized.

PIGEON GUILLEMOTS: The oil spill caused population declines in pigeon guillemots. In 1989, between 1,500 to 3,000 birds were estimated to have been killed. In 1989, oil contamination was found in birds and on eggs. The recovery status in 1992 is uncertain. There is no evidence of an increase in the population. Pigeon guillemot populations were declining prior to the spill.

FISH

CUTTHROAT TROUT AND DOLLY VARDEN: The oil spill caused sublethal injuries and possibly population declines in these two species. Between 1989 and 1991, survival and growth in adult populations in oiled areas differed from those in unoiled areas. This difference persisted even though indications of exposure to oil decreased over these years. The persistence of different rates of survival and growth may have been due to continuing injury to the food base. However, scientists disagree as to whether these differences in survival and growth existed before the spill. It is unknown whether these species are recovering.

PACIFIC HERRING: The oil spill caused sublethal injuries to Pacific herring. It is presently unknown whether these injuries will result in a population decline. Measurable differences in egg mortality between oiled and unoiled areas were found in 1989. Eggs and larvae were injured or killed in 1989 and, to a lesser extent, in 1990. In 1991 there were no differences between oiled and unoiled areas. Injuries to the 1989 year class may result in reduced recruitment to the adult population. If so, an adult population decline will not become apparent until 1993. Overall recovery status is unknown.

PINK SALMON: The oil spill caused sublethal injuries to wild stock populations, and there is debate on whether the wild stock population has declined. Abnormal fry were observed in 1989 and egg mortality continued to be higher than expected in 1990 and 1991. The debate about

population declines focuses on whether the observed injuries will result in reduced adult returns. Reduced growth of juveniles, which correlates with reduced survival, was found in 1989 and 1991. In 1992, there was continued evidence of sublethal injuries. Overall recovery status is unknown.

ROCKFISH: The oil spill caused at least sublethal injuries; however, it is unknown whether or not population declines also occurred. Twenty dead fish were found in 1989, but only a few were in condition to be analyzed. Those analyzed showed exposure to oil with some sublethal injuries. Closures to salmon fisheries increased the fishing pressure on rockfish and the increasing catch may be affecting the population. It is unknown if the population has recovered from sublethal injuries, or from any population decline.

SOCKEYE SALMON: Kenai River and Red Lake sockeye salmon stocks both suffered population declines as well as sublethal injuries. Smolt survival continues to be poor in both systems due to overescapements that occurred at Red Lake in 1989 and in the Kenai system in 1987, 1988, and 1989. In 1992, the estimated number of Kenai River smolt was only 3% of average. As a result of overescapement, adult returns are expected to be low in 1994 and successive years. Overall recovery status is unknown.

COASTAL HABITAT

COASTAL HABITAT - INTERTIDAL ZONE: The oil spill caused population declines and sublethal injuries in the populations of plants and animals that live in the area between low and high tide. The lower intertidal and, to some extent, the mid intertidal zones are recovering. However, in the upper intertidal zone, some species have not recovered, and oil persists in and under mussel beds. Intertidal organisms were affected by both oiling and clean-up, particularly the high pressure hot water washing. Recovery varies by species largely based on their position within the intertidal zone.

COASTAL HABITAT - SUBTIDAL ZONE: The oil spill caused population declines and sublethal injuries in the populations of plants and animals found below low tide. Eelgrass and some species of algae appear to be recovering. Amphipods in eelgrass beds recovered to pre-spill densities in 1991. Leather stars and helmet crabs showed little sign of recovery through 1991. Overall recovery is variable by species.

OTHER SPECIES STUDIED

In addition to the resources described other species were studied as part of the damage assessment process but are not believed to have suffered notable injuries. These include sea lions, brown bears, Sitka black-tailed deer, black-legged kittiwakes, some sea birds, crab, shrimp, and many others.

OTHER NATURAL RESOURCES

ARCHAEOLOGICAL RESOURCES: Twenty-four archaeological sites are known to have been harmed by oiling, clean-up activities, or looting and vandalism linked to the oil spill. An additional 113 sites are estimated to have been similarly affected. Injuries attributed to increased looting and vandalism linked to the oil spill are still occurring. Archaeological sites and artifacts cannot

recover. They are finite, non-renewable resources.

DESIGNATED WILDERNESS AREAS: Many miles of coastlines were oiled in designated wilderness areas and wilderness study areas. Some oil remains embedded in the sediments of these areas. Until oil is completely removed or degrades naturally, injuries to these areas will continue.

SERVICES (HUMAN USES)

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

COMMERCIAL TOURISM: Although the nature and extent of injury varied, approximately 43 percent of the tourism businesses surveyed in 1990 felt they had been significantly affected by the oil spill. Millions of dollars were lost in 1989 due to reduced visitor spending in Southcentral and Southwest Alaska. By 1990, only 12 percent felt that their businesses were affected by the spill.

PASSIVE USE: In 1991, over 90% of those surveyed nation-wide were aware of the oil spill. Over 50% believed that the oil spill was the largest environmental accident caused by humans anywhere in the world. There was also a perception that the value of wild areas had diminished. Some respondents reported that their perception of lost value was recovering as they sensed some recovery was occurring. The feelings of others have not changed as they did not believe recovery was occurring.

RECREATION: The nature and extent of injury varied by user group and by area of use. About one quarter of respondents to a recreation survey in 1992 reported no change in their recreation experience, but others reported avoiding the spill area, reduced wildlife sightings, residual oil and more people. They also reported changes in their perception of recreation opportunities in terms of increased vulnerability to future oil spills, erosion of wilderness, a sense of permanent change, and concern about long-term ecological effects. However, some respondents reported a sense of optimism. There are indications that declines in recreation activities reported in 1989 appear to have reversed in 1990, but there is no evidence that they have returned to prespill levels.

RECREATION - SPORT FISHING AND HUNTING: Between 1989 and 1990, a decline in sport fishing (number of anglers, fishing trips and fishing days) was recorded for Prince William Sound, Cook Inlet, and the Kenai Peninsula. In 1992, an emergency order restricting cutthroat trout fishing was issued for western Prince William Sound due to low adult returns. The closure is expected to continue at least through 1993. Sport hunting of harlequin ducks was reduced by restrictions imposed in 1991 and 1992 in response to damage assessment studies. It is likely that these restrictions will continue until the species shows signs of recovery. Kenai River sockeye overescapements may severely affect sport fishing as early as 1994.

SUBSISTENCE: Subsistence harvests of fish and wildlife in 9 of 15 villages surveyed declined from 4 to 78 percent in 1989 when compared to prespill averages. Seven of the 15 villages show continued decline in use in 1990 and 1991. This decline was particularly noticeable in the Prince William Sound villages of Chenega and Tatitlek. In 1989, chemical analysis indicated that most resources tested, including fish, marine mammals, deer, and ducks, were safe to eat, but that shellfish from oiled beaches should not be eaten. However, villagers believe that contamination of subsistence food sources continues to be dangerous to their health and that some subsistence species continue to decline.

NATURAL RECOVERY

Table 3.2 presents estimated natural recovery rates for injured biological resources. Predicting the amount of time needed for a species to recover is extremely difficult. Scientists often use models based on factors such as population numbers and growth rates. However, for many of the injured biological resources, the background information was not available to develop these predictive models. For those resources, peer reviewers and agency scientists based their estimates on the best available information.

For example, for black oystercatchers there have been no studies to determine a population growth rate anywhere within the species' range. In this case, the experts are forced to rely on information from a related species, the Eurasian oystercatcher, to estimate a recovery time. Under certain circumstances, a population of Eurasian oystercatchers would be capable of growing at 6.25% annually . If the injured black oystercatcher population grows at the same rate, it could recover to prespill numbers in 15 years. The amount of time could be considerably less if the growth rate is higher, or if animals from adjacent areas move to the oiled area. On the other hand, the recovery time could be considerably longer if the growth rate is less than that of the Eurasian oystercatcher, or if the habitat quality is low. Where oil persists in the environment, habitat quality is likely to be low.

Recovery estimates for services are not provided in the Table 3.2. Recovery is linked, in part, to the resources that support the service, and can vary widely between user groups.

ESTIMATED NATURAL RECOVERY RATES OF INJURED BIOLOGICAL RESOURCES. These estimates contain a great deal of uncertainty. For some species there is substantial disagreement within the scientific community. The estimates are likely to change as recovery continues, more information is provided through monitoring, and scientists learn more about the species.

Table 3.2
Estimated Natural Recovery Rates of Injured Biological Resources

	Resources	Natural Recovery Estimates (Yrs. from 1989)	Comments
	Black oystercatcher	15 to 30 years	Recovering. To recover the estimate # last.
	Common murre	50 to 120 years	Recovery varies by colony. Pre-spill population
	Harbor seal	Unknown	In decline before spill. Population may have stabilized. In absence of spill
	Harlequin duck	10 to 50 years	Still no reproduction within oiled areas studied in Prince William Sound. #'s & reproductive status
	Intertidal organisms	10 to 25 years	Recovery estimates are combined for all organisms in the upper intertidal zone. Recovery in lower and mid-intertidal zones is expected to be faster than that in the upper intertidal zone.
	Marbled murrelet	Unknown	In decline before spill. Estimates vary widely on when the population may stabilize. It may be stable now, or may take about 50 years to stabilize at lower population size.
	Pigeon guillemot	Unknown	In decline before spill. Probably still declining. Should stabilize in less than 50 years.
	Sea otter	15 to 40 years	Population stable, but not recovering.
	Sockeye salmon	10 to 50 years	Estimates are for attaining a 10-year average similar to prespill populations for Kenai River and Red Lake sockeye salmon.
	Subtidal organisms	Less than 10 years	Recovering in most places.
	Bald eagle	4 to 6 years	Back to prespill population between 1993 and 1995.
	Cutthroat trout	10 to 20 years	
	Dolly Varden	10 to 20 years	
	Killer whale	10 to 20 years	Estimates are for the injured pod to return to its prespill size. Currently recovering.
	Pacific herring	Unknown	Population decline may be documented after 1993.
	Pink salmon	Less than 20 years	Estimates represent recovery of wild stocks to a population level that may be less than 100% of the prespill population.
	River otter	Unknown	Injury and actual population size are difficult to assess.
	Rockfish	Unknown	

ADDITIONAL INFORMATION

For additional technical information regarding injury and information about natural resource damage assessment and restoration studies see appendix _____.

APPENDIX ___

INJURY TABLES
&
NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION STUDIES

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
MARINE MAMMALS										
Harbor Seals (c)	YES (200)	YES	YES	POSSIBLY STABLE, BUT NOT RECOVERING (a)	UNKNOWN	YES	YES (d)	UNKNOWN	UNKNOWN	Many seals were directly oiled . There was a measurable difference in populations between oiled and unoiled areas in PWS in 1989 and 1990. Population was declining prior to the spill and no recovery evident in 1992. Oil residues found in seal bile were 5 to 6 times higher in oiled areas than unoiled areas in 1990.
Humpback Whales	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Other than fewer animals being observed in Knight Island Passage in summer 1989, which did not persist in 1990, the oil spill did not have a measurable impact on the north Pacific population of humpback whales.
Killer Whales	YES (13)	YES	UNKNOWN	RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	13 Adult whales of the 36 in AB pod are missing and presumed dead. The AB pod has grown by 2 whales since 1990. Circumstantial evidence links whale disappearance to oiling.
Sea Lions (c)	UNKNOWN	UNKNOWN	NO	CONTINUING DECLINE	(e)	(e)	(e)	(e)	(e)	Several sea lions were observed with oiled pelts and oil residues were found in some tissues. It was not possible to determine population effects or cause of death of carcasses recovered. Sea lion populations were declining prior to the oil spill.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Sea Otters	YES (3,500 TO 5,000)	YES	YES	STABLE, BUT NOT RECOVERING	YES, POSSIBLY	YES	YES	YES (d)	YES (d)	Post-spill surveys showed measurable difference in populations and survival between oiled and unoiled areas in 1989, 1990 and 1991. Survey data have not established a significant recovery. Prime-age animals were still found on beaches in 1989, 1990 and 1991. Carcasses of sea otters feed in the lower intertidal and subtidal areas and may still be exposed to hydrocarbons in the environment.
TERRESTRIAL MAMMALS										
Black Bear	NO	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	No field studies were done.
Brown Bear	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Hydrocarbon exposure was documented on Alaska Peninsula in 1989 including high hydrocarbon levels in the bile of one dead cub. Brown bear feed in the intertidal zone and may still be exposed to hydrocarbons in the environment.
River Otters	YES (NUMBER UNKNOWN)	UNKNOWN	YES	UNKNOWN	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	Exposure to hydrocarbons and sub-lethal effects were determined, but no effects were established on population. Sub-lethal indicators of possible oil exposure remained in 1991. River otters feed in the intertidal and shallow subtidal areas and may be still be exposed to hydrocarbons in the environment.
Sitka Black-tailed Deer	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Elevated hydrocarbons were found in tissues in some deer in 1989.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
BIRDS										
Bald Eagles	YES (614-902)	YES	YES	RECOVERING	UNKNOWN	YES	YES	YES (d)	YES(d)	Productivity in PWS was disrupted in 1989, but returned to normal in 1990. Exposure to hydrocarbons and some sub-lethal effects were found in 1989 and 1990, but no continuing effects were observed on populations.
Black-legged Kittiwakes	YES (NUMBER UNKNOWN)	NO	NO	NO CHANGE	NO	YES	YES (d)	YES (d)	YES (d)	Total reproductive success in oiled and unoiled areas of PWS has declined since 1989. Hydrocarbon contaminated tissues were detected in 1989. Hydrocarbon contaminated stomach contents were detected in 1989 and 1990. This species is known for great natural variation and reproductive failure may be unrelated to the oil spill.
Black Oyster-catchers	YES (129 ADULTS; UNKNOWN FOR CHICKS (f)	YES	YES	RECOVERING	YES	YES	YES (d)	YES (d)	YES (d)	Differences in egg size between oiled and unoiled areas were found in 1989. Exposure to hydrocarbons and some sublethal effects were determined. Populations declined more in oiled areas than unoiled areas in post-spill surveys in 1989, 1990 and 1991. Black oystercatchers feed in the intertidal areas and may be still be exposed to hydrocarbons in the environment.
Common Murres	YES (175,000 to 300,000)	YES	YES	DEGREE OF RECOVERY VARIES IN COLONY	YES	NO	YES	YES	YES	Measurable impacts on populations were recorded in 1989, 1990 and 1991. Breeding is still inhibited in some colonies in the Gulf of Alaska.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Glaucous-winged gulls	YES (NUMBER UNKNOWN)	NOT DETECTED	NO	NO CHANGE	NO	YES (d)	YES (d)	YES (d)	YES (d)	While dead birds were recovered in 1989, there is no evidence of a population level impact when compared to historic (1972, 1973) population levels.
Harlequin Ducks	YES (423)	YES	YES	STABLE OR CONTINUING DECLINE	YES	YES	YES (d)	YES (d)	YES (d)	Post-spill samples showed hydrocarbon contamination and poor body conditions. Surveys in 1990-1992 indicated population declines and near total reproductive failure. Harlequin ducks feed in the intertidal and shallow subtidal areas and may still be exposed to hydrocarbons in the environment.
Marbled Murrelets (c)	YES (8,000 TO 12,000)	YES	UNKNOWN	STABLE OR CONTINUING DECLINE	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Measurable population effects on were recorded in 1989, 1990 and 1991. Marbled murrelet populations were declining prior to the spill. Hydrocarbon contamination was found in livers of adult birds.
Peale's Peregrine Falcons	UNKNOWN	UNKNOWN	NO	(e)	(e)	(e)	(e)	(e)	(e)	When compared to 1985 surveys a reduction in population and lower than expected productivity was measured in 1989 in the PWS. Cause of these changes are unknown.
Pigeon Guillemots (c)	YES (1,500 TO 3,000)	YES	NO	STABLE OR CONTINUING DECLINE	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Pigeon guillemot populations were declining prior to the spill. Hydrocarbon contamination was found in birds and, externally, on eggs.
Storm Petrels	YES (NUMBER UNKNOWN)	NO	AWAITING RESULTS	NO CHANGE	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Few carcasses were recovered in 1989 although petrels ingested oil and transferred oil to their eggs. Reproduction was normal in 1989.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Other Seabirds	YES (375,000-435,000)	VARIES BY SPECIES	UNKNOWN	VARIES BY SPECIES	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Seabird recovery has not been studied. Species collected dead in 1989 include common, yellow-billed, pacific, red-throated loon; red-necked and horned grebe; northern fulmar; sooty and short-tailed shearwater; double-crested, pelagic, and red-faced cormorant; herring and mew gull; arctic and Aleutian tern; Kittlitz's and ancient murrelet; Cassin's, least, parakeet, and rhinoceros auklet; and horned and tufted puffin.
Other Sea Ducks	YES (875) (b)	NO	UNKNOWN	UNKNOWN	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include Stellar's, king and common eider; white-winged, surf and black scoter; oldsquaw; bufflehead; common and Barrow's goldeneye; and common and red-breasted merganser. Sea ducks tend to feed in the intertidal and shallow subtidal areas which were most heavily impacted by oil.
Other Shorebirds	YES (NUMBER UNKNOWN)	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include golden plover; lesser yellowlegs; semipalmated, western, least and Baird's sandpiper; surfbird; short-billed dowitcher; common snipe; red and red-necked phalarope.
Other Birds	YES (NUMBER UNKNOWN)	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include emperor and Canada goose; brant; mallard; northern pintail; green-winged teal; greater and lesser scaup; ruddy duck; great blue heron; long-tailed jaeger; willow ptarmigan; great-horned owl; Stellar's jay; magpie; common raven; northwestern crow; robin; varied and hermit thrush; yellow warbler; pine grosbeak; savannah and golden-crowned sparrow; white-winged crossbill.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
FISH										
Cutthroat Trout	YES, SEE COMMENTS	POSSIBLY	YES	STABLE, BUT NOT RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	Differences in survival and growth between anadromous adult populations in the oiled and unoiled areas persisted in 1991 despite the decrease in exposure indicators. This could be due to continuing injury to the food base.
Dolly Varden	YES, SEE COMMENTS	POSSIBLY	YES	STABLE, BUT NOT RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	Differences in survival between anadromous adult populations in the oiled and unoiled areas persisted in 1991 despite the decrease in exposure indicators. This could be due to continuing injury to the food base.
Pacific Herring	YES, TO EGGS AND LARVAE	UNKNOWN	YES	UNKNOWN	NO	YES	UNKNOWN	UNKNOWN	UNKNOWN	Measurable difference in egg counts between oiled and unoiled areas were found in 1989 and 1990. Lethal and sublethal effects on eggs and larvae were evident in 1989 and to a lesser extent in 1990; in 1991 there were no differences between oiled and unoiled areas. It is possible that the 1989 year class was injured and could result in reduced recruitment to the fishery.
Pink Salmon (Wild) (c)	YES, TO EGGS	POSSIBLY	YES	SEE COMMENTS	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	There was initial egg mortalituy in 1989. Egg mortality continued to be high in 1991, possibly due to genetic damage to spawners. Abnormal fry were observed in 1989. Reduced growth of juveniles was found in the marine environment, which can be correlated with reduced survival.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Rockfish	YES (20) (f)	UNKNOWN	YES	UNKNOWN	UNKNOWN	YES	YES	UNKNOWN	UNKNOWN	Few dead fish were found in 1989 in condition to be analyzed. Exposure to hydrocarbons with some sub-lethal effects were determined in those fish, but no effects established on the population. Closures to salmon fisheries increased fishing pressures on rockfish which may be impacting population.
Sockeye Salmon	UNKNOWN	YES	YES	SEE COMMENTS	YES	UNKNOWN	YES	YES	NO	Smolt survival continues to be poor in the Red Lake and Kenai River systems due to overescapements in Red Lake in 1989, and in the Kenai River in 1987, 1988, 1989. As a result, future adult returns are expected to be low in 1994 and successive years. Trophic structures of Kenai and Skilak Lakes have been altered by overescapement.
SHELLFISH										
Clam	YES (NUMBER UNKNOWN)	UNKNOWN	POSSIBLY, FINAL ANALYSES PENDING	UNKNOWN	UNKNOWN	YES	YES	YES	YES	Native littleneck and butter clams were impacted by both oiling and clean-up, particularly high pressure, hot water washing. Littleneck clams transplanted to oiled areas in 1990 grew significantly less than those transplanted to unoiled sites. Reduced growth recorded at oiled sites in 1989 but not 1991.
Crab (Dungeness)	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Crabs collected from oil areas were not found to have accumulated petroleum hydrocarbons.
Oyster	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Although studies were initiated in 1989, they were not completed because they were determined to be of limited value.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Sea Urchin	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Studies limited to laboratory toxicity studies.
Shrimp	UNKNOWN	UNKNOWN	NO	(e)	(e)	(e)	(e)	(e)	(e)	No conclusive evidence presented for injury linked to oil spill.
INTERTIDAL/SUBTIDAL COMMUNITIES										
Intertidal Organisms/ Communities	YES	YES	YES	VARIABLE BY SPECIES, SEE COMMENTS	YES	YES	YES	YES	YES	Measurable impacts on populations of plants and animals were determined. The lower intertidal and, to some extent, the mid intertidal is recovering. Some species (Fucus) in the upper intertidal zone have not recovered, and oil may persist in and mussel beds.
Subtidal Communities	YES	YES	YES	VARIABLE BY SPECIES, SEE COMMENTS	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	Measurable impacts on population of plants and animals were determined in 1989. Eel grass and some species of algae appear to be recovering. Amphipods in eel grass beds recovered to pre-spill densities in 1991. Leather stars and helmet crabs show little sign of recovery through 1991.

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

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

RPWG draft 3/18/93

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Passive Use	In 1991, over 90% of those surveyed (nation-wide) said they were aware of the *Exxon Valdez* oil spill. People report that values have been lost; their feelings about the spill area have changed. There is a wide-spread feeling that something has been lost.	Recovery status is unknown.	YES	YES	YES	YES	Over 50% of those surveyed believed that the spill was the largest environmental accident caused by humans anywhere in the world. The median household willingness to pay for future prevention was $31. Multiplying this by the number of U.S. household results in a damage estimate of $2.8 billion.
Recreation (e.g., hunting, fishing, camping, kayaking, sailboating, motorboating, environmental education)	The nature and extent of injury varied by user group and by area. About a quarter of key informants interviewed reported no change in their recreation experience, but others reported avoidance of the spill area, reduced wildlife sightings, residual oil, and more people. Overall, recreation use declined significantly in 1989. Between 1989 and 1990 a decline in sport fishing (number of anglers, fishing trips and fishing days) were recorded for PWS, Cook Inlet and the Kenai Peninsula. In 1992 an emergency order restricting cutthroat trout fishing was issued for western PWS due to low adult returns. Sport hunting of harlequin duck was affected by restrictions imposed in 1991 in response to damage assessment studies.	Declines in recreation activities reported in 1989 appear to be recovering for some user groups, but the degree of recovery is unknown. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in sport fishing closures or harvest restrictions during these and perhaps in subsequent years. The 1992 sport fishing closure for cutthroat trout is expected to continue at least through 1993. Harvest restrictions are expected to continue for harlequin duck through 1993.	YES	YES	YES	YES	Survey respondents also reported changes in their perception of recreation opportunity in terms of increased vulnerability to future oil spills, erosion of wilderness, a sense of permanent change, concern about long-term ecological effects, and, in some, a sense of optimism.

(a) There may have been an unequal distribution of injury within each region, see map for location of regions.

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Commercial Fishing	During 1989, emergency commercial fishery closures were ordered in PWS, Cook Inlet, Kodiak and the Alaska Peninsula. This affected salmon, herring, crab, shrimp, rockfish and sablefish. The 1989 closures resulted in sockeye over-escapement in the Kenai River and in the Red Lake system (Kodiak Island). In 1990 a portion of PWS was closed to shrimp fishing.	Currently there are no area-wide oil spill-related commercial closures in effect. Management actions to try to compensate for the spill are still in effect. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in closure or harvest restrictions during these and perhaps in subsequent years.	YES	YES	YES	YES	Injuries and recovery status of rockfish, pink salmon, shellfish and herring are uncertain. Therefore, future impacts on these fisheries is unknown.
Commercial Tourism	Approximately 43% of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill in summer 1989. The net loss in visitor spending in the oil spill area in 1989 was $19 million.	By 1990, 12% of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill.	YES	YES	YES	YES	

(a) There may have been an unequal distribution of injury within each region, see map for location of regions.

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Subsistence	Subsistence harvests of fish and wildlife in 10 of 15 villages surveyed declined from 4 - 78% in 1989 when compared to pre-spill levels. At least 4 of the 10 villages showed continued lower than average levels of use in the period 1990-1991; this decline is particularly noticeable in the Prince William Sound villages of Chenega and Tatitlek. In 1989-1991, chemical analysis indicated that most resources tested, including fish, marine mammals, deer, and ducks, were safe to eat. In 1989-1991, health advisories were issued indicating that shellfish from oiled beaches should not be eaten.	Many subsistence users believe that continued contamination to subsistence food sources is dangerous to their health. In addition, village residents believe that subsistence species continue to decline or have not recovered from the oil spill.	YES	YES	YES	NO	For detailed information on village subsistence use see table _, page__.

a) There may have been an unequal distribution of injury within each region, see map for location of regions.

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

RPWG draft 3/18/93

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

a) There may have been an unequal distribution of injury within each region, see map for location of regions.

b) This page has not yet been reviewed by the Chief Scientist.

NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION STUDIES

The most up to date list of interium and final damage assessment reports can be found at the Oil Spill Public Information Center (OSPIC). Some computerized information is available.

Oil Spill Public Information Center (OSPIC)
645 G Street, Anchorage, Alaska 99501
(907) 278-8008
Inside Alaska (800) 478-7795 * Outside Alaska (800)283-7745

Gorbicc's comments

Chapter III - Injury

The *Exxon Valdez* oil spill occurred in March, just before the most biologically active season of the year. It affected the migration of birds, and the primary breeding season for most species of birds, mammals, fish, and marine invertebrates in the spill's path. Much of southcentral Alaska's intricate coastline was oiled, frequently with devastating impact to intertidal and shallow subtidal resources. It also affected human use of the spill area, including subsistence, recreation, commercial fishing, and other uses. Some resources and services remain exposed to oil persisting below high tide up the four years following the spill.

Oil affected each resource and service differently. For some resources, the population measurably declined. By measurably declined, we mean a measurable decline in abundance that will persist for more than one generation. For example, an estimated 3,500 to 5,000 sea otters were killed by the spill, and the population will not recover for many generations. Other species were killed or otherwise injured by the spill, but the injury did not measurably lower the overall population. Deaths of individual animals or sublethal injuries, which do not result in death, may not be reflected in a lower population because the natural variability of the species may mask the injury, or the resource may have some mechanism to compensate for the injury.

Some species, such as marbled murrelets, pigeon guillemots, and harbor seals were declining before the spill. Their rate of decline was accelerated by the spill, but other factors such as variations in climatic conditions, habitat loss, or increased competition for food may also influence long-term trends in the health and populations of these and other species.

The spill also directly affected human uses of the spill area including commercial fishing, commercial tourism, recreation, passive use, and subsistence. The nature and extent of the injury varied by user group and by area of use. Table 3.1 summarizes injuries caused by the spill.

Individual animals murdering other individual animals is a cause of death not previously considered !!

Table 3.1
Resources and Services Injured by the Oil Spill

RESOURCES			SERVICES (Human Uses)
Population Decline	Injured, But No Population Decline	Other	
Black oystercatcher	Bald eagle	Air, water, and sediments	Commercial fishing
Common murre	* Cutthroat trout	Archaeological resources	Commercial tourism
Harbor seal	* Dolly Varden	Designated wilderness areas	Passive use
Harlequin duck	* Killer whale		Recreation including sport fishing, sport hunting, and other recreation use
Intertidal organisms	Pacific herring		Subsistence
Marbled murrelet	* Pink salmon		
Pigeon guillemot	River otter		
Sea otter	Rockfish		
Sockeye salmon			
Subtidal organisms			

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

What Was Injured By the Spill and Is It Recovering?

MAMMALS

HARBOR SEALS: The oil spill caused population declines and sublethal injuries to harbor seals. Many were directly oiled and an estimated 345 died. Oil residues found in seal bile were 5 to 6 times higher in oiled areas than unoiled areas in 1990. The population was declining prior to the oil spill which makes it difficult to determine the effects of the spill. There are some recent indications that the population may be stabilizing, but there is no indication of any increase.

KILLER WHALES: Population decline and other injuries have been documented in one of the pods (extended family group) in the oil spill area. There is debate about whether the oil spill caused these injuries. Thirteen whales out of 36 in one whale pod in Prince William Sound are missing and presumed dead. Circumstantial evidence links the whale disappearance to the oil spill. Additionally, several adult males have collapsed dorsal fins and social disruption of family units has been observed. In that pod, no new births were recorded in 1989 or 1990; one birth was recorded in 1991; and two births were recorded in 1992. These births suggest that the pod is beginning to recover.

RIVER OTTERS: There are differences in some indicators of health, feeding habits, and other aspects of river otter biology between oiled and unoiled areas. These differences may indicate an effect of the spill. Lacking prespill data and a measure of the population, there is great uncertainty about the nature of the injury. River otters feed in the intertidal and shallow subtidal areas and may still be exposed to oil persisting in the environment.

SEA OTTERS: The oil spill caused population declines and sublethal injuries in sea otters. It is estimated that 3,500 to 5,000 otters died. The total sea otter population in the Gulf of Alaska is estimated at around 20,000. Surveys in 1989, 1990 and 1991 showed measurable differences in population and survival rates between oiled and unoiled areas. ~~In 1992~~ lower juvenile survival rates and higher than normal numbers of dead, prime-age otters indicate that the populations in Prince William Sound continue to be stressed. Sea otters feed in the lower intertidal and subtidal areas and may still be exposed to oil persisting in the environment. Little or no evidence of recovery has been detected.

Post-spill study results showing

BIRDS

BALD EAGLES: A minimum of 200 to 300 eagles were estimated to have been killed by the spill. However, because population census techniques are not accurate enough to detect population changes this small, no measurable population decline has been recorded. Productivity in Prince William Sound was disrupted in 1989, but returned to normal in 1990. Exposure to oil and some sublethal injuries were found in 1989 and 1990, but no continuing effects were observed on populations. Bald eagles are recovering, and may have recovered, from the effects of the oil spill.

BLACK OYSTERCATCHERS: The oil spill caused population declines and sublethal injuries in black oystercatchers. In 1989, smaller eggs and lighter weight chicks were found in oiled areas. Black oystercatchers feed in the intertidal areas and may still be exposed to oil persisting in the environment. The population is recovering although evidence of sublethal injuries persisted in

SUBSISTENCE: Subsistence harvests of fish and wildlife in 9 of 15 villages surveyed declined from 4 to 78 percent in 1989 when compared to prespill averages. Seven of the 15 villages show continued decline in use in 1990 and 1991. This decline was particularly noticeable in the Prince William Sound villages of Chenega and Tatitlek. In 1989, chemical analysis indicated that most resources tested, including fish, marine mammals, deer, and ducks, were safe to eat, but that shellfish from oiled beaches should not be eaten. However, villagers believe that contamination of subsistence food sources continues to be dangerous to their health and that some subsistence species continue to decline.

NATURAL RECOVERY

Table 3.2 presents estimated natural recovery ~~rates~~ times for injured biological resources. Predicting the amount of time needed for a species to recover is extremely difficult. Scientists often use models based on factors such as population numbers and growth rates. However, for many of the injured biological resources, the background information was not available to develop these predictive models. For those resources, peer reviewers and agency scientists based their estimates on the best available information.

For example, for black oystercatchers there have been no studies to determine a population growth rate anywhere within the species' range. In this case, the experts are forced to rely on information from a related species, the Eurasian oystercatcher, to estimate a recovery time. Under certain circumstances, a population of Eurasian oystercatchers would be capable of growing at 6.25% annually . If the injured black oystercatcher population grows at the same rate, it could recover to prespill numbers in 15 years. The amount of time could be considerably less if the growth rate is higher, or if animals from adjacent areas move to the oiled area. On the other hand, the recovery time could be considerably longer if the growth rate is less than that of the Eurasian oystercatcher, or if the habitat quality is low. Where oil persists in the environment, habitat quality is likely to be low.

Recovery estimates for services are not provided in the Table 3.2. Recovery is linked, in part, to the resources that support the service, and can vary widely between user groups.

ESTIMATED NATURAL RECOVERY ~~RATES OF~~ TIMES FOR INJURED BIOLOGICAL RESOURCES. These estimates contain a great deal of uncertainty. For some species there is substantial disagreement within the scientific community. The estimates are likely to change as recovery continues, more information is provided through monitoring, and scientists learn more about the species.

Also replace in title of Table 3.2
"Estimated Natural Recovery ~~Rates of~~ Times for Injured Bio...

United States Department of the Interior

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

IN REPLY REFER TO:

TAKE PRIDE IN AMERICA

TO: RPWG members

From: Sanford P. Rabinowitch, RPWG

Subject: Review of Chapter III: Draft Restoration Plan Comments due to Sandy Rabinowitch COB April 5, 1993

Date: March 26, 1993

As you all know, chapter III has been written by many authors and began as a very long section. As directed by RPWG and with continuing coordination with our co-chairs, I have cut approximately 25 pages from the total length of the material I originally received. After my editing Steve Levi was given the chapter and he again edited it in it's entirety. Steve's has made some formatting changes and has made the language more user friendly. Thereafter I again went through the entire document this time making only small changes.

At this time I can see several things:

* The document is close, but not perfect in terms of consistent formatting. Some sections are too long and others are probably too short. In a few places we need material. All the section titles do not match - but we are close.

* A section titled "Comments" has been added to retain material that seemed important but did not fit well beneath other headings. I would like to shorten these comment sections down - or even make them disappear - can you suggest where this text fits or if it can be deleted?

* Because of changes the RT has made over the past eight weeks, to the three summary of injury tables and to the brochure, some things in the chapter need to be changed. For example, some terminology has been switched and some things, like archaeology, have been re-catorgorized. These changes need to be routed out in the text and marked so they are all found. Some areas will need re-writes.

* We have decisions to make. Should the "option" material stay in this section?

* We need to insure that important things have not been inadvertently deleted.

* We need to continue to delete text that goes beyond what is needed - so the chapter is shorten as much as possible.

* We need to ensure that the summary of injury tables and the text are consistent. Please compare tables and text for areas that you are most familiar and recommend corrections.

With this in mind the draft chapter is now in your hands for review. I expect their to be many comments. I would appreciate paper copies of your comments **(by March 5)** and for those of you that have substantial re-writes getting these on disk would be especially beneficial.

If you have any questions while reviewing please give me a call.

d:\sandy\dplan\covmemo.III

CHAPTER III. Injured Resources and Services

A. Background

This chapter answers the three basic questions involving restoration:

- *What was injured by the spill?*
- *What is the present status of recovery?*
- *What, if anything, can be done to aid recovery?*

INJURY TO NATURAL RESOURCES

The civil settlement specifies that restoration funds will be used to restore injuries resulting from the *Exxon Valdez* oil spill. The settlement requires that the funds be spent to "restore...natural resources injured as a result of the oil spill and the reduced or lost services provided by such resources..."

Natural Resources are defined in the settlement as the "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to [or] managed by...the state or federal governments." For example, any injury to pink salmon is an injury to a natural resource.

A natural resource fits this category if it has experienced injury -- or it has sustained a loss of quality -- due to exposure to oil spilled by the *Exxon Valdez*, or which otherwise can be attributed to the oil spill and cleanup.

Population-Level Injury. The most serious injuries are those that have reduced the population of a natural resource. For plant and animal species the injuries from the oil spill have resulted in a lower population of that species. For example, murres were the most severely affected bird species because several large colonies in the Gulf of Alaska lost 35 - 70% of the breeding adults. The population of murres in the oil spill area remains depleted. Thus, murres have suffered a population-level injury, IE., an injury that can be measured by comparing present day population with that prior to the oil spill.

Chronic or Sublethal Injury. A chronic or sublethal injury is an effect on one or more life stages of a species. An example would be the reduced survival of eggs or larvae. In many cases, such an injury may not be reflected in an overall population loss to the species. That is, the injury may be apparent but is statistically insignificant. However, injuries currently considered to be

sublethal may decrease long-term survival for enough individuals to result in population reductions.

There are a number of reasons why a sublethal or chronic injury may not result in a lower population. These include: the chronic or sublethal injury may not affect the productivity of the species, or the species may have some natural compensating mechanism for the injury. There may also be enough variability in the natural abundance of the species to mask the effect of the injury, or scientific measurement techniques may not be sensitive enough to measure the aberration.

Degradation of Habitat. The oil spill and cleanup altered and contaminated the flora, fauna, and physical components of the habitats of many species. This is most pronounced in intertidal and subtidal areas. The ongoing injury to plants and animals that live below high tide continues to affect the many natural resources that use these habitats.

Direct Mortality. Thousands of birds and lesser numbers of marine mammals, fish, shellfish, birds and organisms to the bottom of the food chain were found dead after the spill. While this direct mortality is the most obvious injury caused by the oil spill, it is not always the most serious. Some species endured significant mortality without causing a long-term effect on the population, such as loons or grebes.

Our knowledge of the pre- or post-spill populations is still coming into focus, and, in many cases, ecological relationships are unknown or unproven. The full impact of the oil spill will not be known for decades.

INJURY TO NATURAL RESOURCE SERVICES

In addition to restoring natural resources to their pre-spill population levels or qualities, the settlement requires restoration funds to restore reduced or lost **services.** For example, recreation that was damaged by injuries to fish and wildlife must be restored. Other damaged services include subsistence, commercial and sport fishing, tourism, designated wilderness and passive use values of the spill-affected areas.

A natural resource service has experienced injury if the *Exxon Valdez* oil spill or clean up:

- has significantly reduced the physical or biological functions performed by natural resources, including loss of human uses; or
- has significantly reduced aesthetic, intrinsic, or other indirect uses provided by natural resources; or, in

combination with either of these,

- has resulted in the continued presence of oil on lands integral to the use of special-purposes lands. (Special-purposes lands are those designated by the State of Alaska or the United States for the protection and conservation of natural resources and services. Examples are National or State Parks.)

This definition covers a wide range of injured natural resources and services. Some examples are commercial fishing, subsistence hunting, fishing, and gathering. Some recreation examples include kayaking and backcountry camping, sport fishing and hunting and designated wilderness areas.

CONCEPTS CRITICAL TO UNDERSTANDING RECOVERY

Natural Recovery. Many resources and services will recover to pre-spill levels without intervention. Others that were declining before the spill will continue to decline if present trends continue.

In a scientific sense, full ecological recovery will have been achieved when the pre-spill population of flora and fauna are again present, healthy and productive, and there is a full complement of age classes. Additionally, air, ground water and drinking water in the oil spill area must be brought back to its pre-spill quality. A fully recovered ecosystem is one which provides the same functions and services as were provided by the pre-spill, uninjured system.

Rate and Degree of Recovery. The rate of recovery is the number of years that a resource or service will require to return to its pre-spill level and quality. The degree of recovery is the target population size and quality of the recovery. Since the population of some species, such as the harbor seal, was in decline prior to the oil spill, it will not be possible to return to a population that is equivalent to the pre-spill model. Thus the degree of recovery for the harbor seals will not approach 100 percent. The degree of recovery varies from species to species and the rate of recovery varies from a few years to more than a century.

Some restoration options (presented in this plan, see chapter ___) will affect the rate of recovery. That is, they are not intended to alter the long-term population level of the species. Instead, they are designed to shorten the number of years it takes to reach the pre-spill population level. For example, if it were possible to eliminate the residual oil in mussel beds that are being consumed by harlequin ducks, it would speed the duck's recovery. However, the population of ducks will only return to its pre-spill level, cleaning mussel beds will not increase the population level beyond

its natural limit. Thus, cleaning mussel beds may change the rate but not the degree of recovery for harlequin ducks.

Other options include creating salmon spawning and rearing areas and have the potential to enhance population levels. They change the actual number of fish or animals in the long-term population. These options change the degree of recovery.

B. Conclusions

1. MARINE MAMMALS

Harbor seals, humpback whales, killer whales, sea lions, and sea otters were studied following the spill.

a. Harbor Seals (Genus species)

DESCRIPTION:

A harbor seal is an aquatic marine mammal. Adults average four feet in length and 200 pounds in weight. Seals are graceful swimmers and swim with an undulating, side-to-side motion. They are excellent divers, have been known to dive to depths of 1,000 feet and can stay submerged for half an hour at a time. They feed on fish, crab, shrimp, and squid and, in turn, are preyed upon by sea lion (?) and killer whale. Alaska Natives are allowed to take harbor seal for subsistence purposes. Prior to the oil spill, the harbor seal population was estimated at 2,000 to 5,000 in Prince William Sound [and perhaps double that for the entire oil spill area.?]

INJURY:

An estimated 200 harbor seals were killed by the oil spill in Prince William Sound alone. It is not known how many harbor seals in the spill area were affected. However, it is estimated that an additional 100 seals were killed by the spill at sites that were not monitored. A loss of harbor seal in this magnitude may be critical as the harbor seal population was in the midst of a severe decline before the oil spill. The fall 1989 survey showed that about 100 seals were missing from the 25 haul outs that were monitored.

[An examination of the carcasses of harbor seals indicated that death was caused by hypothermia. Oil from the spill fouled the seal's body's natural ability to insulate itself from the frigid waters which average 35 degrees (?).?] Harbor seal tissues from carcasses found in Prince William Sound showed many times the concentrations of oil than those

in the Gulf of Alaska in 1989. This disparity persisted into 1990 when surprisingly high concentrations of oil [continued to be ?] found in the bile of seals from the Sound.

The high concentrations of oil in the bile of surviving seals would be consistent with aromatic hydrocarbon exposure [suffocation?] causing death. In addition, there was damage to nerve cells in the thalamus of the brain, which would also be consistent with exposure to low molecular weight aromatic hydrocarbons. [What is "low molecular weight aromatic hydrocarbons?]

Following the spill, harbor seals were studied in Prince William Sound because major haul outs in the central part of the Sound were heavily oiled and pre-spill population counts were available for these haul outs. In the 25 haul outs in Prince William Sound that have been regularly surveyed since 1984, 86% of the seals seen in April of 1989, survey were extensively oiled and another 10% were lightly oiled -- including many pups. By late May, the percentage of heavily oiled animals had jumped to 74%.

RECOVERY

Because harbor seal populations have declined precipitously since 1984 -- for unknown reasons -- it is difficult to predict recovery from the oil spill. Since the oil spill there has been a decrease in the subsistence harvest which is expected to speed population recovery though no definitive time frame can be assigned to the recovery.

RESTORATION OPTIONS

There are few methods of actively aiding harbor seal recovery. The only effective restoration options are protective: protecting harbor seal haul outs from disturbance, cooperative programs with commercial fishing groups to protect harbor seals from fishing-related interactions, and cooperative programs with subsistence users to provide information, and if needed, develop voluntary guidelines for subsistence harvest.

Option #4.2 - Reduce Disturbance at Harbor Seal Haul-out Sites

The nature and frequency of disturbance at harbor seal haul outs in Prince William Sound is not recorded but appears to be minimal. However, recovery could be slowed if disturbance increases enough to affect major haul-out and pupping areas. This option would fund interagency coordination to ensure that harbor seal haul-out sites are considered and protected when

permitting coastal and marine activities require state or federal permits. Should monitoring detect poor recovery and significant disturbance, it may be effective to increase protection of harbor seal haul outs. In this case, funds would be used to develop protective measures.

Option #46 - Cooperative program with Commercial Fishermen

This option would initiate a cooperative observer program to investigate the interaction, and, if necessary, to develop cooperative guidelines with fishermen to protect harbor seals.

Option #47 - Cooperative with Subsistence Users

This option funds agency personnel to work with subsistence users to assess the levels of the local population of subsistence resources. If necessary, the managers would then work with villagers to agree on cooperative guidelines for harvest levels for seals.

Comments:

It is not known whether seals in the Gulf of Alaska were affected by the spill. Since there was a severe decline in the harbor seal population before the spill, it is difficult to determine when natural recovery will occur. However, the population may have stabilized in some areas within Prince William Sound but no growth is being reported.

b: Humpback Whales (Megaptera versabilis)

Found worldwide, the humpback varies in length from 25 to 53 feet. The whale is predominantly black with a white portion on its belly. It feed primarily on krill and can be found from southeast Alaska to as far west as Attu, the last island of the Aleutians. The humpback are a favorite of maritime tourists as they can be identified easily because of their flippers, which can grow to one-third of their body's length and are usually white.

INJURY:

The only known effect of the spill on humpback whales was displacement of some of the animals from Lower Knight Island Passage during 1989. Humpbacks returned the next year.

RESTORATION:

No restoration is proposed for humpback whales, although any

measure to minimize disturbance to marine mammals in the spill area might benefit this species.

COMMENTS:

Humpback whale studies, carried out in 1989 and 1990, included photo-documentation of individual whales, estimates of reproductive success and possible displacement from preferred habitats in Prince William Sound.

c. Killer Whales (Orcinus orca)

Killer whales, often called by the species name Orcas, may reach a length of 30 feet and weigh as much as 10 tons. The mammal can be visually identified by its high dorsal fin, which reaches six feet for the males, and the black body with a white area on the belly and two other white spots on either side of the head. Each animals also has a light gray "saddlemark" behind their dorsal fin. Killer whales range from the Arctic Ocean to the North Pacific, often traveling in groups, called "pods," of 25 to 30 individuals. With a top speed of 25 knots, killer whales have no difficulty catching a wide variety of prey including cod, flatfish, sardines, salmon, tuna, octopus, squid, seal, and other species of whale.

INJURY:

Thirteen killer whales disappeared from one pod of resident killer whales between 1988 and 1990. They are presumed dead. Circumstantial evidence points to the spill as the cause.

Approximately 140 killer whales forming nine pods regularly use Prince William Sound and there are some transient pods as well. The rate of natural mortality in killer whales in the North Pacific is about 2% per year, the equivalent of 3 or 4 whales per year. Pre-spill mortality was higher, however, for the resident AB pod, ranging from 3.1 - 9.1% from 1984 to 1988. In the summer of 1989 there were 9 whales missing from resident pods. The next fall, the AB pod was composed of 36 killer whales which was a loss of seven in a year, an unprecedented 19.4% mortality rate or 19.4%. In 1990 an additional 6 individuals were missing from AB pod, an annual mortality rate of 20.7% for this pod. Missing whales were either females or immature animals, and in several cases calves were orphaned. Due to loyalty of killer whales to their group and mothers to calves, the missing whales are most certainly dead. The bodies, which

almost always sink after death, have not been found.

RESTORATION:

Killer whales have started to recover from 1989-1990 losses. Recovery may take as long as 20 years. There is little that humans can do, except to protect the species from further stress and let the species recover on their own.

COMMENTS:

Despite the losses, AB pod is growing again. From a low point of 23 animals in 1991, there are now 25 animals in the pod. The AB pod is expected to fully recover to its pre-spill level of 32 to 36 individuals within 10 to 20 years from 1989.

Option #4.2 - Reduce Disturbance at Rubbing Beaches and Concentration Areas

Disturbance is not known to be a problem for killer whales in the AB pod. Initiating a program to reduce disturbance will only be useful if the AB pod does not recover, and if disturbance hinders reproductive success.

This option would fund research to determine the nature and extent of disturbance and develop protective measures.

Option #45.0 - Reduce Fisheries Interactions by Facilitating Changes in the Black Cod Fishery

This option would examine the feasibility of subsidizing [salmon?] fishermen who voluntary shift [to?] the black cod fishery to reduce interaction. Although these interactions have not been serious in recent years, there is potential that they may once again become significant -- if individual fishing quotas (IFQs) are instituted.

d. Sea Lions (Eumetopias jubatus)

DESCRIPTION:

Also known as the Steller sea lion, the males of this species reach 13 feet in length and can weigh up to 2,400 pounds. The sea lion's body is covered with short hair which ranges in color from yellowish-brown to black. Found

from Southeast Alaska as far north as the Pribilof Islands, sea lions prefer to forage for food in clear water that is less than 300 feet deep. Sea lions prey on rockfish, smelt, herring, salmon, halibut, octopus, shrimp and crab.

INJURY:

Ten sea lions were found dead in oiled areas, mainly on rocky beaches, but it is not known if any mortality was due to oil [even though some oil was found in the tissue samples of the carcasses?]

RESTORATION:

No effective restoration measures specific to sea lions are available, but general habitat protection measures could benefit sea lions.

COMMENTS:

Sea lions have experienced a severe population decline over the last 30 years in the north Pacific Ocean--as great as 93%. This decline combined with seasonal movements presented great obstacles to determining if the sea lion population in the Gulf of Alaska had been affected by the spill. Sea lions were counted at 8 oiled haul-out sites, located mainly in the Gulf of Alaska. Sea lions were observed swimming through oil.

e. Sea Otters (Enhydra lutris)

Because of their human-like face with frost white whiskers, the sea otter is known as the "Old Man of the Sea." This marine mammal grows to a length of 4 1/2 feet and can weigh up to 80 pounds. Found throughout Prince William Sound and the length of the Aleutian Islands, the sea otter feeds on clams, mussels, snails abalone, crab and octopus. The otter's appetite is voracious, requiring about 25 pounds of food per day for an adult, the highest known food requirement for an animal that size. It is estimated that there were 150,000 sea otters in Alaskan waters; 10,000 in Prince William Sound and 20,000 along the shores of the Gulf of Alaska.

INJURY:

Sea otters were particularly vulnerable to the effects of

the spill, as they rely on their fur for insulation. This was the most abundant marine mammal in the path of the oil. Calculations indicate that 3,500 to 5,500 sea otters died from acute exposure to oil. Not only were many sea otters killed in the spring of 1989, there is evidence that post-spill mortality continued for at least another year.

Sea otters spend most of their time on the surface of the water, often in large numbers, making them susceptible to floating oil. Since they do not have much fat, they depend on rapid metabolism to generate heat. Their luxurious fur and an entrapped air layer with dense, water-resistant underfur prevent heat loss to the cold Alaskan waters. To maintain the insulating properties of their fur, otters must groom constantly. When sea otters became fouled with oil, grooming because obsessive, resulting in ingestion of oil.

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

Data indicates that in 1990 and 1991, sea otters were still being affected by the spill. Carcasses found in these years included an unusually large proportion of dead prime-age adult otters, 2-8 year olds, rather than mainly juvenile and old otters, as found before the spill. And a study of survival of young sea otters just after weaning showed a 22% higher death rate during the winter of 1990-1991 and spring of 1991 in areas affected by the spill.

One possible cause of the apparently higher mortalities of weanling and prime-age animals would be eating oil-contaminated prey. During 1992 surveys fresh oil was found in protected dense beds of mussels. Since mussels form a large part of the diet of young otters, they are potentially at risk from foraging in these beds. It is not known to what extent young otters forage on mussels in the dense beds which have been oiled and to what extent they forage on more isolated mussels, which would be expected to be less of a risk.

RESTORATION:

Sea otters are expected to recover to 80 - 100% of their pre-spill population. Under ideal conditions, sea otters can increase their population at more than 10% per year. Sea otter populations already established in an area probably have a current growth rate of 2 - 3% per year. However, if the habitat remains degraded, the sea otter population may not recover for 35 to 40 years. If the habitat recovers rapidly, and there are no chronic or sublethal effects on the sea otter population, recovery may occur within 7 - 15 years from 1993.

Nature will play the largest role in recovery of sea otters, but there are a number of restoration actions that may help.

Option #47 - Cooperative Program with Subsistence Users

Subsistence hunting of sea otters is allowed only for Natives under the Marine Mammal Protection Act of 1972. The size of the harvest before the spill is unknown but it was probably been less than 20 animals per year in Prince William Sound. The utility of this option depends on current and anticipated harvest trends.

This option would fund agency personnel to work with subsistence users to assess the health of the local population of subsistence resources. If necessary, managers would then work with villagers to develop cooperative harvest guidelines for sea otters.

Option #4.2 - Reduce Disturbance at Sea Otter Haul-out Sites

Currently, disturbance at sea otter haul-out and pupping sites in Prince William Sound appears to be minimal and not to be affecting this species. [Therefore, reducing disturbance is not expected to significantly aid the rate or degree of recovery. Additionally, there is little information on how sea otters react to disturbance.?] However, should disturbance increase enough to affect major haul-out and pupping areas in the next 5 years, recovery could be slowed. Thus, it may be prudent to increase the level of protection at haulouts and pup-rearing sites. This option would fund research to determine the level and importance of human disturbance at sea otter haul-out and pupping sites, and to develop appropriate methods to protect those sites.

Option #13 - Cleanup of Oiled Mussel Beds

Mussels in the spill area are widely scattered. Some, however, are in dense aggregated beds. Some of these dense beds contain significant concentrations of unweathered oil. The exposure of young otters to oil from these oiled mussel beds is not known, nor is there information on how much oiled food can been eaten before the toxin levels cause an effect. Although mussels form a large part of the diet of juvenile sea otters, it is not known if they forage extensively in these dense, contaminated beds.

COMMENTS:

While scientists are unsure whether the populations in the oil spill area are stable, it is clear that they have not recovered to their pre-spill levels and recovery appears to be proceeding slowly, if at all.

[With specific regard to the benefits of cleaning the mussel beds, (Option 13,) could be substantial (25% to over 50% improvement in weanling survival and recruitment rates) for the rate of recovery if the connection between the dense mussel beds and poor weanling survival exists.

However, there is not an established means of cleaning mussel beds that will effectively remove the oil and not harm the mussel bed. Several types of clean-up techniques are being tried on a small scale in 1992. Because of the uncertain feasibility of this option, and the fact that it is potentially very effective, this option is recommended for special study to test its feasibility and effectiveness.

2. TERRESTRIAL MAMMALS

Some terrestrial mammals were exposed to oil through foraging in intertidal habitats. These included brown bear, river otters, Sitka black-tailed deer, and mink. There was a great deal of difficulty in deriving data on the spill on black bears because of the difficulty of finding, tagging or otherwise studying this species in dense vegetation. Further, unless the carcasses were found near the intertidal areas, there was no way to determine mortality.

a. Brown Bear (Ursus arctos)

DESCRIPTION:

Ranging throughout Alaska, the brown bear is the largest of the terrestrial mammals and can grow to a length of 9 feet and weighing as much as 1,500 pounds. Omnivorous, it eats

fruits, berries, shrubs, salmon, mice, caribou, moose, clams, insect larvae and carrion. It is also a cannibal.

INJURY:

On all the islands around Kodiak and down the Alaska Peninsula, brown bears forage in the intertidal zone, where clams are plentiful. After the spill, brown bears scavenged the carcasses of spill-killed sea otters and birds that washed ashore. Analyses of fecal material and some samples of bile show that brown bears were exposed to oil. High concentrations of oil were found in the bile of one yearling brown bear found dead in 1989. Since the mortality rates for cubs is close to 50% for the first two years, it is uncertain if this death was related to the exposure to hydrocarbons. There is no evidence that indicates a population level, sublethal or chronic effects from the oil spill occurred.

RESTORATION: No restoration options are proposed for brown bears.

b. River Otters (Lutra canadensis)

Growing to as large as five feet in length and weighing up to 25 pounds, the river otters can be found in all parts of Alaska except the extreme reaches of the Arctic. Though they prefer to live on fish, they will also eat shellfish, frogs, insects, birds, and even some vegetable matter.

INJURY:

Following the oil spill, eleven carcasses of river otters were found on beaches. Total mortality was impossible to estimate. An autopsy of the carcasses [?] revealed oil in their tissues, and there were differences in body weights, some blood parameters, and diversity of diet that may indicate continuing sublethal effects from oil exposure. Due to the lack of pre-spill data, the secretive nature of these animals and difficulties in live-trapping animals over a large geographical area, it was not possible to determine if the spill has reduced populations of river otters in the affected areas.

There is evidence that chronic oil exposure may be having effects on river otters in Prince William Sound. The river

otters captured in oiled areas after the winter of 1989-1990 weighed less than those captured in unoiled areas with the same overall length. Further blood samples taken in 1991 indicate that river otters from oiled areas may continue to suffer chronic effects from petroleum hydrocarbon exposure. These effects may include liver damage and anemia.

[Only a small number of oiled river otters were observed. Two live otters were captured in the spill area and their bile was analyzed and found to contain elevated [???] concentrations of oil, probably from eating contaminated food. Is this paragraph necessary?]

COMMENTS:

A reduction in the number of prey species was noted in the scat. Otters from unoiled habitat did not exhibit this differential. Further, river otter scat in latrine locations indicated that estimated populations sizes were not different between the study areas, but there is also considerable uncertainty about this conclusion since the sizes of the samples were relatively low and a number of assumptions were made in the study design. [Staff suggest a re-thinking of this paragraph as there were only 11 carcasses found.]

RESTORATION:

Without a reliable way to detect small changes in populations, it is difficult to tell when recovery will occur.

Option #8.0 - Develop Sport and Trapping Harvest Guidelines for River Otters

This option would provide funding for research to develop trapping harvest guidelines for river otters. While it would likely have limited benefit to river otter recovery, it would provide better information to agency managers which might allow the harvest to reopen sooner.

c. Sitka Blacktail Deer (Odocoileus hemionus sitkensis)

Found throughout Southeast Alaska and on Kodiak Island, the Sitka Blacktail deer has a reddish brown coat in summer which turns blue-during the winter. The deer feed on vegetation and berries during the summer and any vegetation they can find, including seaweed, during the winter. Its

primary predator is the wolf.

INJURY:

Deer often forage in the intertidal zone on seaweed. Deer taken by subsistence hunters and analyzed for oil contamination showed slightly elevated concentrations of oil. But the deer were determined to be safe to eat.

COMMENTS:

No evidence was found that Sitka blacktail deer were affected by the spill. Deer carcasses found after the spill in Prince William Sound were determined to have died from natural causes.

d. Mink (Mustela vison)

DESCRIPTION:

With the exception of the most northern reaches of the Arctic, the mink is found throughout Alaska. Though an adult mink only weighs about 5 pounds, it is voracious eater dining on whatever it can catch including fish, insects, ducks, birds, and crustaceans. Minks are solitary animals, except during breeding, and have musk which has a smell that rivals that of a skunk.

INJURY:

Mink often forage in the intertidal zone and were exposed to oil on their pelts and in their food. However, due to the lack of information on the populations of these animals before the spill and the difficulties of tabulating its population after the spill, it was impractical to assess the potential effects on these mammals through field studies. A laboratory study of mink was carried out to determine if oil-contaminated food might affect their reproduction. No reproductive effects were documented, even when high concentrations of weathered oil were added to the food.

RESTORATION: No restoration options are proposed for mink.

3. BIRDS

Birds were among the most vulnerable animals to the effects of the spill. Sea birds, which spend much of their time on the water, did little to avoid the spreading oil. Once their plumage became coated with oil, it lost its buoyancy and insulating properties. Birds died as a result of hypothermia and from oil

ingested while preening. There were more than 36,000 bird carcasses recovered. Large numbers of murres, sea ducks and bald eagles were recovered after the spill. Carcasses of loons, cormorants, pigeon guillemots, marbled murrelets, grebes and other species were also recovered from beaches in the spill area. This total was only a small portion of the birds killed by the spill. Other dead birds were washed out to sea, sunk, scavenged onshore, buried in the beach by wave action, decomposed or landed on a beach that was not searched. The results of a computer simulation based on recovered birds indicates that between 300,000 and 645,000 birds were killed by the spill with the best approximation being between 375,000 and 435,000.

a. Bald Eagles (Haliaeetus leucocephalus)

The symbol of the United States of America, there are more bald eagles in Alaska than in the rest of the nation combined. Found in all parts of Alaska except the Arctic, the bald eagle can reach 40 inches in height and have a wingspread of eight feet. Eagles are primarily scavengers and prefer fish but will also eat small mammals. There were an estimated 27,000 bald eagles in Alaska with 2,000 of them in Prince William Sound and 6,000 along the northern coast of the Gulf of Alaska.

INJURY:

About 150 eagles were killed by the oil spill, but the number of dead birds is uncertain and may be several times this number. It is possible that the number of eagles killed in Prince William Sound may have been as high as 430.

Bald eagles encountered oil while feeding on fish and heavy oiling of the plumage led to loss of body heat and the inability to fly. Preening caused the eagles to ingest oil. There is uncertainty as to the total number killed. Seventy-four percent of radio-tagged eagles that died of natural causes ended up in forest and other inland areas.

There was also a sharp decrease in productivity of eagles in 1989, with a greater rate of nest failure in oiled as opposed to unoiled areas.

RECOVERY:

Since the number of eagles lost appears to be less than the change that could be detected by common aerial survey techniques, it is not possible to measure the recovery of the eagle population to pre-spill numbers. Similarly, it

appears unlikely that the lost chick production in 1989 will have a measurable impact on the population. Bald eagles are expected to be fully recovered to their pre-spill population level between 4 to 6 years after the oil spill.

The only restoration options available to help eagle populations are protective.

COMMENTS:

The bald eagle population in Prince William Sound is believed to be at or near the habitat's carrying capacity. Loss of suitable, unused nesting habitat for additional or replacement eagle nests would likely constitute a corresponding decrease in the population. Agency and peer review experts indicated that habitat loss could result in natural recovery proceeding only to 85% of the pre-spill level. The effects may be greater in regions where nesting habitat is already limited by human activity, such as Afognak Island.

Option #37 - Habitat Protection and Acquisition

Purchase of additional habitat could afford protection beyond existing statutes and regulations.

b. Black Oystercatchers (Haematopus bachmani)

A jet-black bird with a flat, red bill, the black oystercatcher is about the size of a crow. A short-legged shorebird, it nests in beach gravel near the grass line. Approximately 950 black oystercatchers lived in Prince William Sound prior to the spill with another 2,000 in the rest of the spill area.

INJURY:

Nine black oystercatcher carcasses were recovered from beaches after the spill. It is somewhat uncertain how many additional birds may have been killed but it is estimated that 120 to 150 birds in Prince William Sound died as a result of the spill.

RECOVERY

Black oystercatchers are expected to recover to their pre-spill levels in 30 years. There is uncertainty regarding the rate of recovery because the actual impact of the injury

will not be known until the 1993 breeding season when chicks hatched during 1989 will become sexually mature. It is also unknown how much movement there is between areas so the effect of immigration into the oiled area may greatly accelerate the recovery.

Three restoration options will have effect on multiple species, but would also benefit black oystercatchers.

Option #13 - Eliminate of Oil from Mussel Beds

This option would provide funds to eliminate oil from dense mussel beds. The option is expected to increase the rate of recovery of the overall population by a little less than 10%. This option may be more effective in localized areas where breeding pairs feed more on the more densely aggregated and contaminated mussel beds.

Option #14 - Accelerate Recovery of the Upper Intertidal Zone

This feasibility option will test whether it is possible to re-establish *Fucus* which was the dominant intertidal species before the oil spill. (*Fucus* is the dominant seaweed which grows throughout the spill area. *Fucus* was destroyed in the upper intertidal areas by the spill and cleanup. Re-establishing *Fucus* could be instrumental in accelerating recovery of the upper intertidal zone.)

If feasible, this option could be locally effective for oystercatchers. Because this technique would have to be applied over at least 10% of the breeding area in order to produce a notable response in the injured black oystercatcher population, it is not practical to use it to recover the overall population.

Option #37 - Habitat Protection and Acquisition

Because black oystercatcher are concentrated along the intertidal zone already government owned, habitat acquisition will not significantly affect the rate or degree of population increase.

COMMENTS:

In addition to mortality there are differences in some reproductive parameters between black oystercatchers in oiled and unoiled environments. The egg volume and the weight gained by chicks raised in oiled areas were different in 1989 than in the unoiled area; however, there is no pre-

spill data for these areas and it is not known if these conditions existed before the spill.

c. Murres (Uria aalge)

A seabird which nests in colonies, the murre can grow to 16 inches in length. It is dark brown with white belly feathers and has small, narrow wings which it uses to swim underwater. Out of an estimated 12 million common and thick-billed murres in Alaska, there are 1.4 million in the Gulf of Alaska. Of these, 1.2 million live in the Semidi Islands which were not affected by the oil spill.

INJURY:

Murres were the most severely affected bird species, with several large colonies in the Gulf of Alaska loosing from 35 - 70% of breeding adults. With non-breeding birds possibly also affected, total mortality may have been as high as 300,000. Some colonies have lost so many breeding adults that there are not enough remaining individuals to fend off predators.

Murres are very susceptible to floating oil. Very few murres are found in Prince William Sound, so they were not affected until the oil entered the Gulf of Alaska and reached major breeding colonies. At the major colonies which were studied (Chiswell Islands, Barren Islands, Puale Bay, and the Triplets), it is an estimated 120,000 to 134,000 adult breeders were killed by contact with oil. If the rate of mortality is adjusted for birds not counted on the colonies, but feeding at sea, it is estimated that 170,000 to 190,000 breeding birds were killed. In general, it is estimated that between 35% and 70% of the breeding adults at the above colonies were killed by the spill. It is not known where pre-breeding juveniles were at the time of the spill, or if many were killed.

Since the spill the timing of reproduction has been abnormal in oil-impacted colonies. At the Barren Islands and at Puale Bay, egg laying has been about a month late in 1989, 1990 and 1991.

At the Chiswell Islands there was no egg laying in 1989, and laying was late in 1990. Due to the decimated nature of these colonies, it is likely that the [rate of predation? or the percentage of loss?] was much greater than normal, since these colonies rely on sheer numbers of birds to discourage predation by gulls and eagles. Further, the delay of egg

laying for a month in most affected colonies is likely to produce chicks that cannot survive. It has been estimated there has been a loss of 300,00 murre chicks due to the disruption of reproduction.

There were preliminary indications of recovery at the Barren Islands in 1991 and 1992, but it is not yet known when normal timing of reproduction will start again. Peer review and agency scientists estimate that *eventually* the injured common murre populations will return to between 80 - 100% of their pre-spill level. The degree of recovery may vary from pre-spill levels because of natural population fluctuations. Because recovery rates for this species are very slow and because of the current breeding problems, the scientists estimate that recovery will require between 50 and 120 years from 1989.

RESTORATION

Option #4.1 - Reduce Human Disturbance at Murre Colonies

Murres are sensitive to disturbance during the nesting period, especially loud noise. Sudden loud noises, such as gun shots, will scare murres off their nests, allowing gulls and other predators access to eggs and young chicks. There appears to a potential problem near the Barren Islands with disturbance. Halibut fisherman catch large halibut near the Barren Island murre colony and routinely shoot the fish before landing them. This appears to occur frequently during the summer nesting season. While such disturbance may not be a problem for a healthy population, it could delay the recovery of an affected colony, such as that at the Barren Islands. There is a good chance that elimination of gunshot noise within about a half mile of the Barren Island murre colonies would help aid recovery of this colony.

This option would fund a public education program to contact fisherman, party boat and charter boat captains and seek voluntary reduction of disturbance. If voluntary actions are not effective, formal regulations could be considered to control disturbance at the colonies. If regulations were promulgated, some increased enforcement may also be necessary.

This option could increase the rate of recovery by 10 - 24%. It is most likely to have its greatest affect at the Barrens Island or Puale Bay. It is thought that the Chiswell Islands colonies have habituated to the tour boats that frequent the Chiswell Islands, so protective measures aimed

at the Chiswells where gunshots are infrequent would have limited effectiveness.

Option #16.1 - Increase Murre Productivity through Enhanced Social Stimuli

This option has been classified as a "special study" because there are too many unknowns to evaluate its effectiveness. Seabird scientists believe that it could be effective at stimulating synchronized breeding on small portions of the injured colonies, however, they do not believe it can be implemented on a large enough scale to influence a large colony.

Option #16.1 - Improve Physical Characteristics of Nest Sites

Some scientists suggested modifying nests to minimize the loss of eggs. Examples could include placing sills around nesting ledges or adding partitions to reduce the number of eggs knocked off the ledges. This option would be used to "jump start" severely injured murre colonies.

Both agency staff and experts agree that while there is potential to effect the rate of recovery, it is unlikely that modification could be made over a large enough area to cause a colony-wide effect. In addition, the effectiveness of this technique is uncertain. Experts suggested that testing this option may be appropriate on a healthy colony to document the change in productivity.

Options #17.2 - Reduce Predator Access to Marine Bird Colonies

Predation can have a significant affect on the nesting productivity of murres. Gulls, ravens and eagles are known predators of murres and this option would temporarily reduce predation until the murres have returned to successful breeding patterns. Because this option injures predator populations, it should be terminated after a few years.

Agency and peer review experts indicated that if predation is lowered at the injured colonies, this option could improve the rate of recovery by 15 - 20 years. Documentation of the current predation levels is necessary before this option would be implemented.

Option #37 - Habitat Protection and Acquisition

Most murre colonies are under public ownership so purchasing private land will have limited application for their recovery. One exception is Gull Rock in Kachemak Bay, which

is privately owned. It continues to have a healthy colony but the ability to ensure the continued health of the colony would be enhanced if it were publicly managed.

Comments:

There are some signs that recovery may be beginning in 1991 in isolated parts of the Barren Islands, but the threshold to reproductive success has not been passed and recovery is expected to take many decades.

d. Glaucous-winged Gulls (Laurus glaucescens)

The traditional sea gull, the glaucous-winged gull can reach 26 inches in height, has grey wings with a white head and chest. It nests in colonies and has a habitat which includes tidal flats, garbage dumps, canning facilities, salmon streams and coastal communities.

INJURY:

RESTORATION:

e. Harlequin Ducks (Histrionicus histrionicus)

The male harlequin duck lives up to his name, taken from the "harlequin" or clown of Old England. Growing to a height of 17 inches, the male is slate-blue with white spots and stripes on his head, shoulders and wings with chestnut wings. The female is brown with three white spots on either side of her head.

INJURY:

Harlequin ducks appear to be the most affected of the six species of sea duck in the oil spill area. Both acute and sublethal effects have been documented. An estimated 600 harlequin ducks were killed by the spill. With few exceptions, neither breeding ducks nor fledgling chicks have been located within the oiled area of Prince William Sound since 1989. Breeding activity in the unoiled eastern Prince William Sound appears to be normal. The lack of reproductive activity of harlequin ducks in the oil spill area since 1989 appears to be the most lingering effect of the spill.

Elevated concentrations of oil in the bile of harlequin

ducks was collected in western Prince William Sound in 1989 indicates an oil-related effect on reproduction. However, there is so little known about the causes of reduced breeding, physiological changes induced by feeding on oiled invertebrate prey that recovery time cannot be predicted.

Of the six species of affected sea ducks, the harlequin feed highest in the intertidal zone where most of the stranded oil was initially deposited. Some oil still persists in many of these areas. Because they are most susceptible to accumulating oil from their feeding and preening activities in the upper intertidal zone, post-spill studies of sublethal effects focused mostly on harlequins.

Analysis of bile from harlequins from Prince William Sound in 1989 indicated that oil concentrations were five-times greater in the spill area. A 1989 comparison of body condition indicated that harlequins from eastern Prince William Sound had better body condition than those from western Prince William Sound which was oiled.

In 1991, mist netting of streams in oiled and unoiled areas provided an index of the reproductive activity because brooding ducks make frequent trips between their streamside nests and the saltwater forage areas. In the eastern Prince William Sound, 12 streams were netted for 149.5 hours and 23 ducks were captured. In the western Prince William Sound, 16 streams were netted for [132 hours 254 hours?] and no ducks were captured. In 1992, the comparable data were: 20 streams were netted in the eastern Sound for 485 hours, 44 ducks were captured; and 37 streams in the western Sound were netted for 254 hours, and only two ducks were captured. This data indicates a large difference in numbers of brooding birds between oiled and unoiled areas.

There is also data on the numbers of broods seen at end of summer molt surveys. These data indicate that in 1991 in eastern Prince William Sound, 1,234 ducks were sighted, 16 of which were hens with broods. In western Prince William Sound 666 birds were seen of which 5 were hens with broods. Of the 5 broods seen, only one was within the oil spill area -- in the Bay of Isles. Molting surveys carried out in 1992 show that in eastern Prince William Sound there were 1,050 harlequin ducks seen, 5 of which were hens with broods, and in western Prince William Sound there were 1,503 harlequin ducks seen which 3 were hens with broods. Again, only one of the broods was within the oil spill area of western Prince William Sound -- in Drier Bay. There are some data previous to 1989 that indicate that there was successful reproduction within the area that is now affected by the spill.

RECOVERY

Recovery has not begun. If oiled food is affecting the harlequins reproduction, fecundity should increase once the toxicity threshold is reached. [There should be another sentence here. This is the first time toxicity is mentioned.]

Experts disagree on the time it will take harlequin duck populations to recover to their pre-spill levels. Estimates range between 10 and 50 years from 1989. Experts expect harlequin ducks to *eventually* recover within 80 - 100% of their pre-spill levels (with the range being due to the natural variation in the population).

RESTORATION

There are three options that may aid natural recovery: protection of the streamside habitat to prevent further stress, maintaining existing hunting closures, and eliminating oil from mussel beds which may be the pathway through which oil is continuing to contaminate the harlequins.

Option #8 - Develop Sport-harvest Guidelines

During the late summer and early fall, the oil-spill area population of harlequins consists of the local breeding population. During the late fall, the breeding population is joined by a huge number of migrants on their way south.

The Alaska Board of Game closed the September hunting season in Prince William Sound and the outer Kenai Coast (Game Management Unit 6D and 7) to taking harlequin ducks by issuing an emergency closure in (1990?). Agency and peer review experts believe that maintaining the September closure will increase the population levels during recovery by 10 - 24%. However, additional late-season closures are expected to provide only minor benefits to recovery population levels because the migrants vastly outnumber the breeding harlequins at that time. Hunting at that time takes mostly the migrant harlequin rather than the oil-spill area's breeding population.

This option would fund research necessary to provide the Game Board with information concerning the impact of closure on the recovery of the harlequin duck population. It would also provide the game board with information necessary to make the decision to reopen the harvest, once recovery becomes imminent.

Option #13 - Eliminate Oil from Mussel Beds

Mussels are an important part of a harlequin's diet. Unfortunately, it is unknown whether cleaning widely scattered beds of these oiled mussels beds would substantially reduce the oil intake for harlequin ducks. For this and other reasons, there was wide disagreement between agency and peer review experts on the effectiveness of cleaning mussel beds. On a localized basis it may provide substantial improvement to the rate of recovery (25 - 50%), and it may allow the ducks to begin breeding again in the oil-spill area.

Because of the link between the mussel beds and the harlequin duck injury, and the toxicity level of oil in the harlequins is unknown, it is not possible to apply this option on a large enough scale to significantly accelerate recovery over the entire area. More information on the link between oiled mussels and harlequin duck feeding habits is needed before this option can be properly evaluated.

Option 37 - Habitat Protection and Acquisition

Studies in the Lower 48 have shown that harlequins are easily disturbed by nearby logging or other development activities. This option proposes to acquire land near nesting habitat to ensure that breeding will not be disrupted by loud noises. Protecting the shoreline and stream corridor habitat was recommended by agency and peer review scientists as the most effective option. It is a method of protecting the maximum natural recovery rate.

f. Marbled Murrelets (Brachyramphus marmoratus)

A small sea bird, the marbled murrelet grows up to 9 inches in length. It is a mottled brown in summer and, during the winter, has a black back and cap with a white chest. There were between 60,000 and 120,000 marbled murrelets in the oil spill area prior to March of 1989.

INJURY:

Approximately 600 marbled murrelets were killed because of the spill. Statistically this represents about 6,000 killed, between 5 and 10 percent of the population of the spill affected area. Unfortunately, baseline data is lacking to determine pre-spill population levels. Data from the early 1970s and mid-1980s indicate that marbled murrelets were in decline in Prince William Sound.

Marbled murrelets have a low reproductive rate and are unlikely to recover from the mortality of the spill. However, due to the [highly variable?] population counts made since the spill, it is not possible to determine population trends in the spill area. [Reference books dispute this? Armstrong's A GUIDE TO THE BIRDS OF ALASKA. Thus, protection of stands of old growth timber close to where this species is known to occur is a reasonable precaution for any continuing healthy population of marbled murrelets.??]

RECOVERY

Marbled murrelet population is not expected to return to pre-spill population levels. Estimates on when the population may stabilize vary widely between experts. Estimates of further declines range from an additional 20 to 50% loss with the population stabilizing at that reduced level between 11 to 50 years.

Option #9 - Minimize Incidental Take of Marbled Murrelets by Commercial Fisheries

Studies estimate that in 1991 there was no mortality of murres due to set nets in the spill area, but approximately 300 marbled murrelets died due to entanglement in drift nets. This option would study the extent of marine bird mortality in the oil-spill area coastal gillnet fishery to develop new strategies for reducing mortality and incorporation of reliable techniques into State regulation.

Agency and peer-review experts indicate substantial uncertainty over the effectiveness of this option. Most experts believe it would increase the likelihood that the population would stabilize at a larger population: closer to a 30% loss from existing levels rather than a 50% loss. Experts disagreed whether there would be any effect on the rate of stabilization. They felt that the option could generate substantial improvement in the rate of stabilization in local areas where mortality is high, but it would likely have a much smaller improvement on the time to stabilization for the population as a whole.

Option #37 - Habitat Protection and Acquisition

This option provides the greatest benefit in ensuring that the population can recover and that prime habitat is not developed in a way to adversely affect the marbled murrelet population. If this species is to recover, nesting habitat

and food supply must be protected. Since this species has been shown to favor old-growth timber protection of this habitat is a prudent step to ensuring recovery and continued protection.

Option #40 - Special Designations

Special designations that include both upland and marine habitats could provide substantial protection to marbled murrelet habitat. A large designation area that would limit development activities and pollution sources may have a positive effect on the marbled murrelets food sources. This added protection would also increase the confidence in a more rapid stabilization period. There is wide disagreement between experts on the benefit these designations may provide.

COMMENTS:

In the Pacific Northwest, marbled murrelets are a threatened species under the federal Threatened and Endangered Species Act. They are not listed under the act in Alaska.

Post-spill data indicate that there has been a decline in this species since the last censuses in the middle 1980s. However, it is not possible to separate the decline due to the spill from that due to other causes. Post-spill studies also confirmed the presence of oil in marbled murrelets collected near Naked Island in Prince William Sound. It is not known if there are sublethal effects of the oil on this species.

Population estimates in Prince William Sound since the spill show an uncertain pattern of recovery. The estimates for marbled murrelets were 107,000 in 1989, 81,000 in 1990, and 106,000 in 1991. The data taken in the 1970s and 1980s indicate a population decline occurring during this decade. Though there is great uncertainty about the decline, scientists expect it to continue.

In addition, the long-term declines in populations of other sea birds in the spill area indicate that there may be some sort of large-scale changes in food supply or predation that deserve careful study if the natural resources are to be wisely managed. Whether these changes might be related to the apparent growth of populations of predators or fishery interactions, bear examination.

g. **Pigeon Guillemot** (Cepphus grylle)

Black and plump-bodied with a reddish-orange feet, the pigeon guillemot turns grey and black in the winter. Growing to a length of 13 inches, it nests in cliffs and crevices high above the tide line. It forages along the shore and congregates on rocky beaches.

INJURY:

Five hundred and sixteen guillemot carcasses were recovered after the spill for an estimated total mortality of 1,500 to 3,000. The results of boat surveys in Prince William Sound indicate that the population of this species was 14,600 in 1973. After the spill the populations were 4,000, in 1989, 3,000 in 1990 and 6,600 in 1991. The survey data, however, indicate that the decline in the oiled areas were greater than in the unoiled areas of the Sound.

RECOVERY

Pigeon guillemots are not expected to return to their pre-spill population levels. The population was declining prior to the spill and the decline is expected to continue. The reasons for the long-term decline are unknown which makes predictions of future population trends extremely difficult. The population is expected to stabilize sometime in the next 50 years, but estimating the population size when it stabilizes is uncertain.

Option 17.2 - Reduce Predator Access to Marine Bird Colonies

Pigeon guillemots nest on the ground and are preyed upon by small mammals such as weasels and mink, and by large birds such as seagulls and ravens. This option would temporarily reduce local predator population until the pigeon guillemot populations have begun to recover. Because this option entails killing predator populations, it could only be continued for a few years and would only be used to "jump start" severely injured pigeon guillemot colonies. Before the option could be implemented, additional research would be necessary to determine the extent of the predation at the colonies, and to more fully evaluate its effectiveness.

Agency and peer review experts indicate that if predation is high at the injured colonies, this option could improve the degree of recovery by 25 - 50%. This decrease in predation would reap an increase in the productivity of the colony and thus slow the rate of population decline.

Option 37 - Habitat Protection and Acquisition

Pigeon guillemots are tolerant of human activity near nesting areas. However, it is important to protect the nesting sites from erosion or other degradation. Protecting upland habitat immediately adjacent to the coast would prevent the population decline from accelerating due to lost nesting habitat.

4. OTHER BIRDS

SUMMARY

There were numerous other birds affected by the spill. The most direct evidence of injury comes from the carcasses of birds found on the beaches in 1989. Some of the other species include ducks, sandpipers, phalaropes, gulls, terns, auklets, puffins, various passerines, loons, grebes, shearwaters, petrels, cormorants, and geese. Other data comes from boat surveys carried out after the spill using similar techniques to those used in 1972-1973 and 1984-1985 surveys. The following species declined more in oiled than in non-oiled areas since the early 1970s: harlequin duck, black oystercatcher, pigeon guillemots, northwest crow and cormorants. A similar comparison based on the 1984-1985 surveys showed declines in harlequin duck, black oystercatcher, murre, pigeon guillemots, cormorant, Arctic tern and tufted puffin.

There is a great deal of uncertainty about the recovery of populations of these species. Habitat protection may prevent further damage to these populations, although large-scale interactions in the marine ecosystem that may be linked to fishery and hatchery practices during the last ten years needs more study in relation to the high potential of having affected populations of marine birds dependent on the pelagic food web.

Injuries to murres, eagles, marbled murrelets, and sea ducks are discussed individually above; however, these are only three of the approximately 90 species of birds represented in the collections of dead birds recovered after the spill. In Table xx the species with more than yy bodies recovered after the spill are listed. In general, these numbers statistically represent about 10 - 15% of the total numbers of individuals killed. For most of these species there is not an available population census of the affected area at the time of the spill that will allow accurate assessment of the significance of these estimated losses.

5. FISH

In spite of the fact that few fish carcasses were recovered after

the spill, the broad spectrum of marine and estuarine species were affected. The egg and larval stages of fish are more sensitive to the effects of oil than adults and thus the oiling of habitat affected the fecundity of some streams and estuaries.

As an example, there were differences in mortality of pink salmon and herring eggs between oiled and unoiled areas. In addition, comparison of larval growth and abnormalities suggest that oil affected this life stage in both species. [However, there is disagreement in some cases as to whether egg and larval mortalities have resulted in declines in adult populations. Both pink salmon and herring reproduce along oiled shorelines and their eggs were exposed directly to oil, resulting in injuries to eggs and juveniles.

Further, the oil spill caused mortality to the bottom of the food chain which, in turn, affected the availability of food in the habitat. Dolly Varden and cutthroat trout, which use the intertidal and subtidal zones for foraging, both show differences in growth and survival between populations in oiled and unoiled areas.

Sockeye salmon were unique in that their primary injury was caused by overescapement in the Kenai River and Red Lake System (Kodiak) which resulted from closing commercial fisheries due to the spill. Unusually large numbers of overwintering sockeye fry apparently depleted available food sources, resulting in poor survival and very low numbers of outmigrating smolt. Impacts on rockfish are uncertain, although exposure and mortality were demonstrated.

There were no large fish kills observed at the time of the spill, as sometimes occur when fish are exposed to oil in confined habitats.

a. Cutthroat Trout and Dolly Varden

Salmo clarki Richardson and Salvelinus malma (Walbaum)

DESCRIPTION:

The cutthroat trout and Dolly Varden are anadromous game fish which live in fresh and estuarine waters. The Dolly Varden is the larger of the two species, growing to 3 feet in length and upwards of 40 pounds. Some cutthroats reach this size but most range between 1 and 4 pounds. Prince William Sound is the northern limit for cutthroat trout. Both Dolly Varden char and cutthroat trout feed extensively in the nearshore marine habitat during warmer months but return to freshwater in the autumn to overwinter.

INJURY:

Both cutthroat trout and Dolly Varden feed extensively in the shallow, estuarine waters which were affected by the spill.

Survival of adult Dolly Varden returning to oiled streams in 1989-90 was 40% [32% is used in another source] less than those returning to unoiled areas. Survival [appeared?] to be 28% less for adult cutthroat trout returning to oiled areas. In addition, in 1989-90 adult Dolly Varden grew 22% less in oiled areas. Measurement of hydrocarbons in the bile of Dolly Varden following the spill in 1989 showed that this species had the highest oil concentration of any fish species studied.

Adult cutthroat trout returning to oil areas grew 43% [57% is used in another source] less than those returning to unoiled streams.

The exact reason for these injuries is unclear. They may be due to exposure to oil, or to less abundant or damaged food supply in oiled areas. Sampling of water, sediment, and prey species all revealed [continued?] oil contamination in the oiled areas of Prince William Sound.

Recovery is expected to occur in 9 to 19 years. This estimate is largely dependent on the continued restriction of sport fishing for these species in western Prince William Sound.

RECOVERY:

Option #2.1 - Intensify Cutthroat and Dolly Varden Management to Protect Injured Stocks

This option would fund research to provide the Alaska Board of Fish with information to enact more detailed management of the cutthroat and Dolly Varden sport fisheries and study lakes and drainages in Prince William Sound as alternate sites to replace fishing opportunities lost as a result of the spill. Scientists estimate this option would enhance stocks 5 - 10% above pre-spill levels.

Option #19 - Update and Expand the State's Anadromous Waters Catalog and Atlas (This option applies primarily to cutthroat trout.)

This option would fund the Department of Fish and Game to update the State of Alaska's Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes and its associated atlas. Anadromous streams listed in the catalog are automatically afforded legal protection under Title 16 of Alaska Department of Fish and Game statutes. Many new streams were found during the spill response, others listed were never or incompletely surveyed. Implementing this option would result in a 10% increase in confidence that populations would fully recover to pre-spill levels, although it would not increase the rate of recovery.

Option #37 - Habitat Protection and Acquisition

Cutthroat trout may be especially sensitive to upland disturbance since they are at the northern end of their range. Undisturbed uplands and riparian vegetation provide important habitats and natural buffers that protect the quality of watersheds and the ecosystem as a whole. This option would not effect the rate of recovery, but could help ensure that full recovery to pre-spill levels is achieved.

COMMENTS:

b. Pacific Herring (Clupea harengus)

DESCRIPTION:

Pacific herring grow to 15 inches in length, they are found in such abundance that the fishing season is limited to hours. Herring spawn in intertidal and subtidal waters, the reason their eggs are so easily retrieved.

INJURY:

In 1989, herring spawned in Prince William Sound shortly after the oil spill. Comparing the 1989 class with those of later years, significant differences were found in the rates of egg fertilization and abnormalities in developing larvae. Larval abnormalities continued to be elevated in 1990, but not in 1991.

Although none of the herring spawning areas were heavily oiled, over 40% of areas used by herring to stage, spawn, or deposit eggs and 90% of the areas used for summer rearing and feeding were exposed to oil.

Studies carried out in 1989 and 1990 showed a slight but statistically significantly higher rate of egg mortality in the oiled areas, compared to unoiled areas. In addition,

rates of larval mortality, lethal and sublethal genetic damage, and physical deformities were greater in oiled than unoiled areas of Prince William Sound in 1989. All differences between herring sampled at oiled and unoiled study sites were less pronounced in 1990 and were not observed in 1991.

The lack of difference in egg and larval mortality between oiled and unoiled areas in 1991 may indicate that recovery has occurred. However, the complex population dynamics of Pacific herring make it impossible to predict the extent of injury or estimate natural recovery rates until fish spawned in 1989, and in subsequent years, are fully recruited into the adult spawning population. Population level injuries could take up to fifty years to recover, although there is a high level of uncertainty associated with this figure.

RECOVERY

Option #2.2 - Intensify Herring Management to Protect Injured Stocks

The Alaska Department of Fish and Game may want to recommend restricting fishing or redirecting it to an alternate stocks or sites. This option would fund the research to support those recommendations.

This option could improve the rate and degree of population recovery by over 50%. However, successful management will depend on determining if discrete stocks of herring spawn in Prince William Sound and if they can be separately fished in staging areas or on historic fishing grounds. This option develops stock-specific information such as age and size composition, natural mortality rates, seasonal movements, stock abundance and recruitment, and genetic identity, on which changes in management may be based.

COMMENTS:

Reproduction has probably recovered, but further study may confirm a very weak 1989 year class in the population.

Due to the large natural variability of herring populations, further evaluation and study would be needed to be able to conclude that the adult population has been significantly affected by the spill. There is also some evidence that four-year-old herring, which spawned in 1988, may have suffered some reproductive impairment.

c. Pink Salmon (Oncorhynchus gorbuscha)

DESCRIPTION:

Also known as a "humpback," the pink salmon is a highly prized commercial fish. Growing to a length of 30 inches it is found in most Alaskan waters.

INJURY:

The most apparent injury is to egg mortality. The difference in mortality rates between oiled and unoiled streams persists. For at least the first three years after the spill, the rate appears to be worsening, both in oiled and unoiled areas. While there is disagreement among experts on whether population level injuries exist, those who do believe that the spill reduced the adult population estimate that recovery should occur within 20 years of 1989. Estimates for recovery from population level injuries range from 50 to 100 years. Factors which may delay recovery include possible genetic damage to wild spawners and the impact of hatchery fish straying into wild streams.

Since 1989, significant differences have been found in the rate of egg mortality between oiled and unoiled streams in Prince William Sound. Some deformed embryos were found in heavily oiled intertidal spawning areas. Also, in 1989 the exposure of pink salmon fry to oil in Prince William Sound was correlated with decreases in their rate of growth. Impacts on natural, environmental variation and hatchery-wild stock interactions complicate conclusions.

About 75% of the wild pink salmon in Prince William Sound spawn in the intertidal zone. There was no apparent change in the use of this habitat in the summer of 1989, and many salmon deposited their eggs in the intertidal portion of oiled streams. Eggs incubated in oiled streams had mortalities 67% greater in 1989 than eggs incubated in unoiled streams, 51% greater in 1990, and 96% greater in 1991. In 1989 and 1990, increased egg mortality was confined to oil-contaminated areas. Additionally, in 1991, egg mortalities were also associated with unoiled areas leading experts to conclude that spawning populations suffered genetic damage which reduced the viability of their eggs.

Further, pink salmon fry released from hatcheries and left their natal streams in the spring of 1989 were also exposed to oil in the open water. Pink salmon larvae were exposed

to sufficient amounts of oil to induce the enzymes that metabolize oil. Also, juveniles that were exposed to oil in Prince William Sound coastal waters were shown to have a 25% slower rate of growth in 1989 than those unexposed, even after accounting for the effects of food supply and temperature. Reduced growth is generally correlated with reduced survival.

RESTORATION OPTIONS

Option 2.3 - Intensify Pink Salmon Management to Protect Injured Stocks

Restricting existing fisheries or directing other fisheries to alternate sites, while attempting to minimize impacts to human uses is the objective of this option.

This option could help ensure 100% population recovery and accelerate recovery up to 50% over the natural rate. The potential for enhancing wild populations up to 25% above pre-spill levels also exists. This would be the most effective method for restoring population level injuries.

Option #11.1 - Construct Salmon Spawning Channels

This option could accelerate recovery of wild pink salmon stocks by the installation and operation of artificial spawning channels. Since there are relatively few areas where this option could be implemented, the overall population would be increased by less than 10%. On a single stream, adult returns could be increased by up to 20%.

Option #11.3 - Improve Access to Fish Spawning Areas, Fish Passes, Remove Instream Barriers

This option will accelerate recovery of injured wild salmonids by construction of fish passes or removing instream barriers (log-jams) to provide access to unexploited spawning habitat. Because there are few sites where this option would benefit injured pink salmon populations, it could provide less than 10% gain in overall population recovery. However, the option could be more effective in restoring in individual salmon runs. The option has potential to raise populations above pre-spill levels.

Option #19 - Update and Expand the State's Anadromous Waters Catalog and Atlas

This option would fund the Department of Fish and Game to update the State of Alaska's Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes and its associated atlas. Anadromous streams listed in the catalog are automatically afforded legal protection under Title 16 of Alaska Department of Fish and Game statutes.

Updating these documents through additional stream surveys, particularly smaller tributaries, would increase protection of anadromous salmonids including wild pink salmon, their habitat, species that feed on them or rely on their nutrient contribution, and the services they provide. Anadromous streams listed in the catalog are automatically afforded legal protection under Alaska Department of Fish and Game statutes. Many new anadromous streams were found during the spill response, others listed were incompletely surveyed. This option could provide some degree of protection for recovering populations, especially outside the Sound where a larger percentage of pink salmon spawn above the intertidal zone.

Option #37 - Habitat Protection and Acquisition

Populations of salmonids, including wild pink salmon, are especially dependent upon anadromous streams and their adjacent riparian lands. Undisturbed uplands and riparian lands provide important habitats that protect the quality of watersheds and the ecosystem as a whole. By acquiring strategic areas, injured species can be safeguarded during recovery and various resources and services can be restored and enhanced. This option could protect 10 - 30% of the population from disturbances which would delay recovery. It is especially applicable in areas outside the Sound where a larger percentage of pink salmon spawn above the intertidal zone. Added protection has the potential to increase populations 10% above pre-spill levels.

Option #40 - Designate Protected Areas

Uplands used by wild pink salmon can be placed into special State or Federal designations which provide increased levels of regulatory protection. An important feature of special designations is that they can provide a regulatory basis for managing an area on an ecosystem level, with the primary objective of restoring spill injuries. This option would not increase the rate or degree of recovery but could protect up to 30% of the population from habitat degradation which would slow recovery.

Option #48 - Improve Survival Rates of Salmon Eggs and Fry

(This option should not be implemented without taking into account the ecological and fisheries management impacts of releasing additional fish.)

This option focuses on the implementation of proven fishery enhancement techniques to increase the rate of survival of egg and larvae of stocks of wild pink salmon injured by the oil spill. This includes remote fry rearing and artificial spawning techniques. This option also includes the provision to collect outmigrating fry and rear them in net pens and the hatchery rearing of wild eggs. This option would be expensive to implement on a wide scale. Localized efforts would help ensure recovery to pre-spill levels at a faster rate. However, the option could not be implemented until fish recover from all chronic injuries. There is also potential to enhance local population 10 -25% above pre-spill levels.

Option #51 - Relocate Existing Hatchery Runs

This option would relocate hatchery runs of salmon which overlap in timing or geography with runs of wild-stock pink salmon. Better separation of wild and hatchery runs will allow more precise management of fisheries and potentially decrease harvest pressures on injured fish, without closing or restricting fisheries. The option could apply to hatchery pink or sockeye salmon which support Prince William Sound fisheries that have historically intercepted significant numbers of wild salmon. This option could provide substantial localized benefits and reduce interception of runs by 25 - 50%.

COMMENTS:

Successful implementation of the management of pink salmon will depend on the ability to control stock-specific exploitation rates, for both wild and hatchery runs. Restoration based on stock-specific management will, in turn, depend upon better information on stock characteristics such as age and size composition, natural mortality rates, season movements, stock abundance and recruitment. Separation of discrete stocks using genetic markers is also needed. On the basis of this information, the Alaska Department of Fish and Game will recommend to the Alaska Board of Fish various changes to fishing regulations to further protect wild pink salmon stocks injured by the oil spill.

d. Rockfish

Unfortunately, little is known about rockfish populations, injury, or recovery. The spill did kill some rockfish and exposed others to oil. In addition, the commercial fishing salmon closures during the spill increased fishing for rockfish. Rockfish harvest is not currently limited by the Alaska Board of Game. There is concern that without limits, overfishing may be occurring.

Without knowledge of rockfish populations, injury, or recovery, there are few options available to address the species. However, more intensive fisheries management may prevent any overfishing resulting from the spill.

INJURY

Many (19) dead rockfish were reported after the spill, but only 5 were in good enough condition to analyze. All 5 fish died from oil ingestion. Other rockfish collected from oiled areas in Prince William Sound and the outer Kenai coast in 1989, 1990 and 1991 indicated exposure to oil and higher than normal incidence of oil-associated organ lesions. Population impacts are unknown.

Post-spill increases in fishing pressure may also be affecting rockfish. Partially due to numerous spill-related fishing closures in 1989, fishing pressure shifted to rockfish, and harvest levels increased. Rockfish harvests in Prince William Sound increased from approximately 93,000 pounds in 1989 to over 489,000 pounds in 1990. While harvest has decreased somewhat since 1990, it is still higher than the historic average. The increased harvest has caused concern because rockfish do not reproduce until they are ___ years old, produce relatively few young, and would not recover rapidly from overfishing.

RECOVERY

Option #2.4 - Intensify Rockfish Management to Protect Injured Stocks

> Increased research and changes in management practices, would determine whether harvest limits or other fishing techniques are needed to sustain rockfish populations. If so, the option will fund research to allow the Alaska Department of Fish and Game to recommend regulation changes to the Alaska Board of Fish. Research will focus on quantifying stock characteristics such as age and size composition, natural mortality rates, season movements, rockfish abundance and recruitment, and rockfish bycatch in other fisheries.

If rockfish populations have been reduced because of exposure to oil or overfishing, this is the only option which could provide significant benefit to rockfish.

COMMENTS:

e. Sockeye Salmon (Oncorhynchus nerka)

A highly-prized commercial and sport fish, it ranges from Southeast Alaska to Point Hope. It can grow as large as three feet in length and weigh 15 pounds. It is anadromous.

INJURY:

In 1989, the decision not to allow commercial fishing in portions of Cook Inlet resulted in too many spawning salmon returning to certain sockeye rearing lakes in the Kenai River system. The problem was compounded by the fact that too many fish returned in 1987 and 1988.

The Kenai River watershed is managed for an average return of 600,000 spawning salmon. Over 1,400,000 fish returned in 1987 and 1989. The cumulative effect of large numbers of spawning fish in the Kenai River system has been a decline in smolt production. This was probably caused by overgrazing of plankton by fry overwintering in Kenai and Skilak lakes. Smolt production fell as follows:

Year	Smolt Production
1987	30 million smolts
1988	6 million smolts
1989	2.5 million smolts
1990	<1 million smolts

Outmigration of smolt from the Kenai River system have been on the decline since 1990 and the forecasted returns in 1994 and 1995 are below minimum goals for returning salmon. If minimum goals are not met, at least some of the Kenai River fisheries will be closed.

Low juvenile survival may, in turn, cause all or part of the Kenai River fishery to be closed until it can regain its natural balance. Without intervention, Kenai River sockeye populations will not regain their long-term average population until at least 1999.

Overescapement also occurred in Red Lake in Kodiak in 1989 and resulted in similar problems. Two and five-tenths times

the average number of fish returned to spawn in 1989. Overgrazing by fry is assumed to have occurred and fry survival to have been reduced. Low adult returns are anticipated in 1993, 1994 and 1995.

RECOVERY

There are no indications of recovery in the Kenai River system. Estimates of population recovery vary between experts and ranges from 10 to 50 years after 1989.

Natural recovery of the Red Lake system on Kodiak Island is expected to be [more?] rapid since overescapement occurred only in 1989 and the food base may not have been seriously damaged. Without intervention, the Red Lake Sockeye are not expected to recover to pre-spill levels until 1996 or 1997.

RESTORATION OPTIONS

Option #2.5 - Intensify Sockeye Management to Protect Injured Stocks

A change in management practices could accelerate recovery of injured Kenai River sockeye stocks. Examples of possible changes are restricting existing fisheries, or directing other fisheries to alternate sites. Successful changes requires additional information on the way in which different fisheries exploit injured Kenai sockeye runs and information on population size, movements, and genetic composition.

This option will fund research to allow the Alaska Department of Fish and Game to recommend regulation changes to the Alaska Board of Fish. Agency and peer review scientist believe this option could reduce the risk of future overescapements from 25% to 10%. [This percentage is not consistent with others in **format**, not in substance.]

Option #11.3 - Improve Access to Fish Spawning Areas, Fish Passes, Remove Instream Barriers (Kodiak Only).

This option will accelerate recovery of injured sockeye salmon in the Red Lake system. It will fund a survey to locate sites for fishes passes, and then fund their construction, or fund removing instream barriers such as log-jams to provide access to unexploited spawning habitat. Although there are not many sites where this is known to be applicable, it could enhance sockeye populations in the Red

Lake by 25% above pre-spill levels.

This restoration option is only applicable to Kodiak since these activities are not permitted in the Kenai River drainage. The option should not be implemented without taking into account the ecological and management implications of increasing fish populations.

Option #37 - Habitat Protection and Acquisition

Sockeyes are especially dependent upon anadromous streams and their adjacent riparian lands. Undisturbed uplands provide important habitats and natural buffers that protect the quality of watersheds and the ecosystem as a whole. This option would not effect the rate of recovery, but could help ensure that full recovery to pre-spill levels is achieved.

Option #48 - Improve Survival Rates of Salmon Eggs and Fry

This option would fund implementation of proven fishery enhancement techniques to increase the survival sockeye egg and larvae in the Kenai River and Red Lake systems. Examples of these techniques include the use of egg boxes to increase survival of wild salmon eggs, net pens to collect outmigrating fry and rear them until conditions are optimal for their survival, or hatchery rearing of wild eggs.

This option would not be implemented without taking into account the ecological and fisheries management impacts of releasing additional fish. In addition, the option can be implemented only when the plankton populations in the lake systems returned to normal. Otherwise, increased numbers of fry would merely aggravate the injury. When plankton recover, the option has the potential to achieve recovery of the adult sockeye population in one generation by improving fry production up to 80%. One generation would be five years from 1995. However, this would require that the option be undertaken on a very large scale.

6. SHELLFISH

SUMMARY

Shellfish include clams, mussels, crab, oysters, sea urchins and shrimp. Intertidal clams and mussels, however, are dealt with in the section on intertidal communities. Injuries to crabs, shrimp, sea urchins and oysters were not documented and no restoration options are currently proposed.

INJURY

Dungeness crabs and shrimp studies ceased early in the damage assessment process because these species were scarce in Prince William Sound. No field studies were conducted on sea urchins, and oyster studies (on farmed oysters) were terminated after they were determined to be of limited value. However, since oil is known to have impacted subtidal sediments and communities, it is possible that undocumented exposure and injury occurred for several shellfish species.

RECOVERY

There is no information on recovery.

RESTORATION OPTIONS

There are no options proposed for shellfish.

7. INTERTIDAL COMMUNITIES

a. Intertidal Communities

DESCRIPTION:

Intertidal communities include the many plants and small animals that live in the area between low and high tide. Because so many other species feed and live in this area, the health of the intertidal community is important to the entire ecosystem.

Most of the documented damage to intertidal communities is in the middle and upper intertidal zones of sheltered rocky shores. These locations were the most heavily oiled, are where oil persists longest, and where most of the clean-up efforts occurred. The damage has been found mainly to the most common species: rockweed or popweed (*Fucus*), limpets, barnacles and periwinkles. Other damage includes an apparent transient effect on intertidal fishes and fewer clams in the lower intertidal zone.

INJURY:

Many hundreds miles of shoreline [over 1000?] were oiled including many national and state parks, refuges and forests. With tidal action, oil penetrated deeply into cobble and boulder beaches that are relatively common in the spill area. Cleaning removed much of the oil from the intertidal zone, but subsurface oil persisted in many

heavily oiled beaches, and in mussel beds, which were not cleaned during the clean-up efforts. Direct oiling killed many organisms, but beach cleaning, particularly high pressure, hot water washing, had a devastating effect on intertidal life.

The greatest damage was observed in the upper and middle intertidal zones of sheltered rocky shores, where the largest amounts of oil persisted and recovery is relatively slow. In the upper and middle intertidal zones of these rocky shores the seaweed *Fucus gardneri*, limpets, periwinkles, and barnacles were less abundant at oiled than unoiled sites. However, the ecological imbalances created by the spill damage apparently also resulted in increases of ephemeral algae after the spill and of limpets in 1991. The magnitude of the measured differences varied with degree of oiling and geographic area. In sheltered beaches the data on abundance of clams in the lower intertidal zone suggests strongly that little neck clams and, to a lesser extent, butter clams were negatively affected by the spill. Also, in 1990 contrasts of abundance of intertidal fishes indicated fewer fish in oiled areas, but such differences were not found in 1991.

RECOVERY

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

Recovery in the upper intertidal appears to depend on the return of adult *Fucus* in large numbers to this zone. *Fucus* is the most common seaweed found throughout the spill area. It provides cover and stability for the many small plants and animals that inhabit the intertidal area. Agency and peer review scientists estimate that it may take as long as 6 to 15 years for *Fucus* to recover. Full recovery of the intertidal community may take from 8 to 25 years, since it may take several years for other species to return after the *Fucus* has recolonized an area.

RESTORATION OPTIONS

Option #14 - Accelerate Recovery of the Upper Intertidal Zone

This option provides funds to test and implement the most

effective method(s) for accelerating the rate of recovery of the upper intertidal zone, particularly the *Fucus* community.

Techniques being considered are largely experimental and will be initiated as a feasibility study. At specific locations, this option could increase the rate of recovery by 25 - 50%. This recovery rate would apply in areas showing few signs of Fucus recovery.

Option 30D - Bivalve Shellfish Hatchery and Research Center

The option would provide funds is to assess the feasibility of establishing a shellfish hatchery and mariculture technical center in the oil spill area to restore, replace, or enhance injured bivalve shellfish species native to Alaska. While initially aimed at restoration and enhancement of subsistence shellfish species, this option also could aid in the recovery of injured wild stocks, particularly native littleneck and butter clams.

COMMENTS:

In addition to the direct effect of the oil and cleanup on plants and animals of the intertidal zone, there may be indirect effects on animals feeding on the intertidal zone. Some data indicates that sea otter pups, harlequin ducks, and, to a lesser extent, river otters and black oystercatchers may still be affected by the spill by feeding on contaminated intertidal organisms, such as mussels

b. Subtidal Communities

SUMMARY

Subtidal communities include the plants and animals that live below low tide.

INJURY

Oil deposited intertidally was washed off the beaches by tidal and wave action, and by the massive cleanup. Much of it sank, associated with particles into the subtidal zone. This exposed the intertidal communities to oil for several years after the spill.

Several subtidal environments were studied after the spill: eel grass beds, *Laminaria* (kelp) beds, fjords and the deep benthos (40 to 100 meters). All these studies relied on contrasts between oiled and unoiled environments without the benefit of pre-spill data on populations of organisms. In

many cases several sites were contrasted with several unoiled sites and sites were matched for conditions likely to affect the abundance of organisms. The greatest differences were seen for small organisms living in the sandy sea bottom below eelgrass beds --they were less abundant in oiled environments. Among the affected groups were crustaceans known from previous studies to be sensitive to oil. In addition, there were larger organisms that showed differences in abundance, most notably the crab *Telemesus*. Two separate studies found that eelgrass in oiled areas did not bloom as well after the spill as in unoiled areas. Some organisms were more abundant in oiled areas, notably small mussels that live on eel grass and juvenile cod. [juvenile cod?]

The results of other subtidal studies produced much less certain information on injury. The results of chemical analyses show that oil did not penetrate deeper than about 20 to 40 meters, although elevated activities of hydrocarbon-degrading bacteria were seen somewhat deeper in some cases. Differences were noted between abundance of organisms at 300 feet in several bays, but the exact cause of these differences is not clear. Some flatfish had elevated amounts of oil in their bile in 1989 and 1990, and slightly elevated occurrences of gill damage.

RECOVERY

Analysis of samples of invertebrates associated with eelgrass beds taken in 1991 indicated that differences noted in 1990 between oiled and unoiled areas had started to converge. Another year of study in 1993 may indicate if this trend has continued.

Because recovery has been observed in shallow (<20m) subtidal habitats, and because full recovery is expected in most cases in less than 10 years, there also is little that can be done to accelerate recovery. While transplantation of eel grass, seaweeds and invertebrates is technically possible, recovery has proceeded to where this approach is not now necessary. However, there is need to continue periodic monitoring of subtidal resources.

RESTORATION OPTIONS

No restoration options are proposed.

III. X. Resources: Summary of Results of Injury Assessment Studies

Table X summarizes the results of the injury assessment studies for all resources studied after the *Exxon Valdez* oil spill. Under "Description of Injury," columns focus on injury that took place during 1989 -- just after the spill. The table also shows whether there was initial mortality caused by the spill, whether the spill caused a population-level injury, and whether there is evidence of sublethal or chronic effects on the resource. For some resources, an estimate is available for the total number of animals initially killed by the spill. If available, that estimate is shown in parentheses under the initial mortality column. For many resources, the total number killed will never be known.

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

The "Geographic Extent of Injury" shows whether the injury occurred in the geographic areas shown in Figure X. (Though the injury may have been more extensive in some regions than others.)

Chapter III.B.(7)(a) Injured Services

a. Archaeological Sites and Artifacts

SUMMARY

The oil spill area has been occupied by Native peoples for at least 11,000 years. The oil spill area has also provided a geographical backdrop to much of Alaska's early history in the post-European contact era (Mobley 1990:55). Although rarely studied when compared to other areas and eras of Alaska, a draft cultural resource assessment study by Dekins et al. (1992:v) estimated that the oil spill area contains between 2,600 and 3,137 historic properties, including 1,287 known sites that have been recorded in the Alaska Heritage Resources Survey.

At least 155 archaeological sites were exposed to some degree of oiling with an estimated 60 more sites subjected to moderate to heavy oiling. A conservative projection by McAllister (1992:43), based on the pattern of known injury to archaeological sites documented by Jesperson and Griffin

(1992:7-8), indicated that another 130 to 150 archaeological sites had been adversely affected by oiling, clean-up activities, or looting and vandalism linked to the *Exxon Valdez* oil spill. Of these, an estimated 113 suffered substantive injury as a consequence of either beach clean-up actions or vandalism (McAllister 1992:43).

INJURY

Injuries to archaeological sites include theft of surface artifacts and masking of subtle clues that archaeologists depend upon to identify and classify sites. Key diagnostic artifacts have been illegally taken, ancient burials have been violated and potholes dug by looters have destroyed critical evidence contained in the layered sediments. Additionally, vegetation has been disturbed which has exposed sites to accelerated erosion. The effect of oil on the soil chemistry and organic remains has reduced or eliminated the ability of radiocarbon dateability (Dekins et al. 1992; Mifflin and Associates 1991; Reger et al. 1992). Other injuries to archaeological sites have not yet been reported and the actual extent of damage will not be known for decades.

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

RECOVERY

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

RESTORATION OPTIONS (For detailed description of applicable restoration options, see Appendix A).

Option #1.0 - Site Stewardship

This option involves the recruitment, training, coordination, and maintenance of a corps of citizens to safeguard archaeological sites near their residence. This option best addresses the injuries sustained as a result of looting and vandalism. Citizen groups, Native villages and local

corporations can be brought into the program. The Trustee Council initiated this option by approving the Site Stewardship Program in February, 1992. This is a long term project which is expected to last for several years. Thereafter, it is expected to continue under the leadership of local, state and/or federal auspices.

Option #10.0 - Preservation of Archaeological Sites and Artifacts

This option has three components. First, it will be critical to conduct site-specific restoration assessments at sites with documented injury. This is particularly important where there is insufficient information upon which to determine appropriate treatment.

Second, restorative action must be taken either in the form of physical repair or data recovery. The initial focus includes the 24 archaeological sites for which there is clear evidence of injury and time is critical to prevent further degradation of the resource.

Third, after responding to known injuries, the option would expand to identify other injured sites. This restoration effort will be on a priority basis with those sites most likely to suffer irrevocably to be restored first. It is important to emphasize that the bulk of injury data was derived from a study of the oil spill response records and a comprehensive, independent assessment of injury has never been conducted.

The last component of this restoration option will be to resolve the impact of long-term injury from oiling. Ten sites exposed to oiling will be monitored for a period of 10 years to determine the effect of the oil on soil chemistry, radiocarbon dating, and the recovery of protective vegetation.

Option #35.0 - Replacement of Archaeological Artifacts

This option will identify institutions and individuals with archaeological artifacts from the oil spill region who would be willing to donate their artifacts to the *Exxon Valdez* Oil Spill Trustees member agencies. In turn, the Trustees would transfer acquired artifacts to appropriate public institutions within the oil spill area for public display and appropriate scientific uses and study. This will serve to replace artifacts lost to looting and return them to their region of origin.

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b. Subsistence

SUMMARY

Surveys conducted by the State of Alaska in 15 Native villages before the spill and in 7 of those villages in 1990 indicated that subsistence use in the oil spill area was significantly reduced (injured) in 1989, primarily because of concern over health effects associated with use of contaminated resources. While subsistence harvests began to recover in some Native communities (Ouzinkie, Port Graham, Nanwalek (English Bay), Larsen Bay, and Karluk) in 1990 and 1991, other Native communities (Chenega and Tatitlek) had continued, below-average harvests. Based upon chemical analyses of a spectrum of subsistence resources (fish, shellfish, deer, ducks, marine mammals), most resources (with the exception of mussels and clams from oiled beaches) were determined to be safe for human consumption.

Proposed restoration options address the need to restore the confidence of subsistence users. Testing subsistence foods for the prepense of oil will identify those areas and resource still injured. Restoration also assumes that recovery will be gradual and that there is a need to exploit alternative subsistence resources, either by providing access to subsistence areas not impacted by the spill, or by providing

assistance in the development of shellfish mariculture to replace contaminated shellfish. The duration of the injury restoration will depend on the rate of recovery of subsistence services and perception of food safety.

INJURY

The Alaska Department of Fish and Game, Division of Subsistence, determined before the *Exxon Valdez* oil spill, that 15 Native Alaskan communities (with about 2,200 people) of Prince William Sound, Lower Cook Inlet and the Alaska Peninsula relied heavily on subsistence resources. These subsistence resources included salmon, halibut, rockfish and Dolly Varden; marine invertebrates such as clams, crabs, and octopus; marine mammals (harbor seals and sea lions); land mammals such as deer (Prince William Sound and Kodiak Island), black bear and goats (Prince William Sound and Lower Kenai Peninsula); birds including ptarmigan, waterfowl, and gulls eggs; and wild plants. The statistical mean number of resources categories used ranged from 10 to 25, and generally every household participated in subsistence harvests. The per capita subsistence harvest ranged from nearly 200 pounds to over 600 pounds per household per year.

Table 1 illustrates changes in harvest levels in the first year (April 1989 to March 1990) following the spill. Subsistence harvests of fish and wildlife in 9 of these villages (Chenega Bay, Tatitlek, Nanwalek (English Bay), Port Graham, Karluk, Old Harbor, Ouzinkie, Port Lions, and Chignik Lagoon) declined by poundage from 4 to 78% compared to pre-spill averages (Fall 1991). The reason for this decline varied from community to community and household to household. But most declines were attributed to perceived consequences of the oil spill, particularly the concern for potential health effects as a result of consuming contaminated foods.

Chemical studies conducted by the U.S. Food and Drug Administration (ADHSS 1989a) and the National Oceanic and Atmospheric Administration (Varanasi et al. 1990) measured levels of oil and metabolites in the bile and edible tissues of subsistence foods. These studies discovered that most of the resources tested (fish, shellfish, deer, ducks, marine mammals) contained no or very low levels of oil-related contamination and that eating foods with those levels posed no health risk. Exposure to oil did not necessarily render organisms unsafe to consume. However, some samples of shellfish had unacceptably high levels of oil prompting an advisory that shellfish should not be collected from oil-contaminated areas (ADHSS 1989b).

RECOVERY

Table 1 also summarizes changes in harvest levels in 7 Native villages following the oil spill. The finding that subsistence harvests had increased in 5 villages during the 1990-1991 timeframe suggested increased confidence in using some subsistence resources. However, the continued low levels of harvest at Chenega Bay, Tatitlek, Nanwalek (English Bay) and Ouzinkie, and the continued concern in some households in the 7 villages suggested that the injury persisted through the second year following the spill (Fall 1992).

While data is not yet available for the period of April, 1991, to present, resource managers suggest that subsistence harvests have not returned to pre-spill levels in all affected Native communities -- particularly Chenega Bay and Tatitlek. Concern over long-term health effects of consuming contaminated resources, a loss of confidence on the part of subsistence users, and the real or perceived reduction in available resources, are all factors likely to affect recovery of subsistence use.

TABLE 1. Subsistence Harvests Before and After the ***Exxon Valdez*** Oil Spill: Per Capita Harvest in Pounds (Fall, 1991, 1992; Page, 1991). (see footnote a)

COMMUNITY	PRE-SPILL YEAR ONE	PRE-SPILL YEAR TWO	OIL SPILL YEAR	% CHANGE (see footnote b)	POST-SPILL YEAR ONE
Prince William Sound					
Chenega	308.8	374.2	148.1	-60.4	143.1
Tatitlek	351.7	643.5	214.8	-66.6	155.2
Lower Cook Inlet					
Nanwalek (English Bay)	288.8	(c)	140.6	-51.3	181.1
Port Graham	227.2	(c)	121.6	-46.5	213.5
Kodiak Island					
Akhiok	519.5	159.3	297.7	+86.9	(d)
Karluk	863.2	381.0	250.5	-34.3	395.2
Larsen Bay	403.5	200.9	209.9	+4.5	340.4
Old Harbor	491.1	419.3	271.1	-35.2	(d)
Ouzinkie	369.1	405.7	88.8	-78.1	204.9
Port Lions	279.8	328.3	146.4	-55.4	(d)
Alaska Peninsula					
Chignik Bay	187.9	(c)	208.6	+11.1	(d)
Chignik Lagoon	220.2	(c)	211.4	-3.7	(d)
Chignik Lake	279.0	(c)	447.6	+60.1	(d)
Ivanof Bay	455.6	(c)	489.8	+8.4	(d)
Perryville	391.2	(c)	394.2	+1.0	(d)

(a) Pre-spill study years are: Tatitlek 1987-88 and 1988-89; Chenega, 1984-85 and 1985-86; Nanwalek (English Bay) and Port Graham, 1987; Kodiak Island Borough, 1982-83 and 1986; Alaska Peninsula, 1984. The "spill year" is 1989 for all communities, except Chenega and Tatitlek, for which it is April 1989-March 1990. "Post spill year one" is April 1990-March 1991.
(b) Based on most recent previous year.
(c) Only one previous measurement.
(d) Not determined.

RESTORATION OPTIONS (For detailed description of applicable restoration options, see Appendix A).

Some of the service restoration options focus on injured species because population increases will re-establish the subsistence services. These restoration options are described under the species injury summaries for intertidal areas, harbor seals, sea otters, harlequin ducks, pink and sockeye salmon, herring and rockfish.

Five options are proposed which could be used to mitigate lost subsistence opportunities and speed recovery of harvest levels. The mariculture and shellfish hatchery options primarily benefit subsistence users by providing an alternative source of shellfish, but also could be used to speed recovery of injured shellfish populations. Alternative sources of subsistence food could also be provided by starting new [and invigorating existing] salmon runs in subsistence harvest areas. These options are summarized below.

Option #18.0 - Replace Fisheries Harvest Opportunities by Creating New Salmon Runs

New subsistence harvest opportunities could be provided by establishing new hatchery runs or stocking streams. Salmon is a traditional subsistence food and the runs could compensate for reduced harvest salmon. These invigorated runs would also temporarily replace harvest of marine mammals, shellfish, ducks and other species not currently fully utilized due to spill-related injuries or perceptions.

Subsistence use could take the form of terminal harvests at remote hatchery release sites or new, self-perpetuating runs in streams adjacent to subsistence communities. Both of these actions must be implemented with great care, especially in Prince William Sound, to avoid disruption of existing commercial and sport fisheries and to comply with ADF&G policies and guidelines on fish genetics. This option is applicable in harvest areas utilized by Native communities whose harvest levels remain low, such as Tatitlek, Chenega, Nanwalek (English Bay), and Ouzinkie.

Option #30.0 - Test Subsistence Foods for Residual Hydrocarbon Contamination

This option will help to restore the confidence of subsistence users in subsistence foods. Samples of mussels, clams, ducks, rockfish and other resources will be collected from the harvest areas of: Chenega, Tatitlek, Nanwalek (English Bay),

Port Graham, Ahkiok, Karluk, Old Harbor, Ouzinkie, Port Lions, Chignik Lagoon, Kodiak City(?), Cordova(?), Valdez(?), Seldovia, Kenai(?), and Seward(?). Community representatives will be used in the collection of samples.

Additionally, bile and blubber samples will be taken from seals harvested by subsistence hunters in the spill area. The samples will be analyzed for residual oil and the results will be reported to the communities in an informational letter and on going community visits which will continue until the pre-spill subsistence activity level has been re-established.

The program would be expected to continue for 3 years. At the end of this period, the degree of recovery of the resources, as well as the subsistence economy, will be evaluated to determine if the program should continue. The Trustee Council began work on this option by approving a subsistence testing program in January, 1993.

Option #49.0 - Provide Access to Alternative Subsistence Foods

This option seeks to minimize interruption of subsistence lifestyle at those Native communities affected by the oil spill. Some resource populations have declined, while others (notably shellfish) suffer ongoing injury from buried oil. Funds will be provided for subsistence hunters from Chenega to travel to un-impacted areas to harvest traditional subsistence resources. Funding will also be provided to subsistence hunters in other Native communities to assist the Chenegans by gathering, preserving and sending subsistence foods to Chenega. This support will continue until the resources in the subsistence area used by the Chenegans have recovered to pre-spill population levels.

Option #50.1 - Develop Subsistence Mariculture Sites

This program will provide the villages of Chenega, Tatitlek, Port Graham, Nanwalek (English Bay), Ouzinkie, and Ahkiok with a means to develop an alternative bivalve resource for both subsistence and commercial harvest. The basic strategy for the village mariculture program is to initially concentrate on oyster culture, and subsequently test the feasibility of culturing species native to Alaska, e.g., clams, mussels and scallops. The feasibility of culturing Alaskan species is largely dependent on developing a reliable source of spat, which is addressed in Option 50.2.

For those villages which already have mariculture permits (Eyak, Tatitlek, Chenega), settlement funds will be used to establish new oyster culture operations or increase existing

operations to commercial production levels. A mariculture specialist will be hired to organize village operations, help initiate and sustain a training program, and prepare and implement mariculture development plans. For those villages without permits (Port Graham, Nanwalek (English Bay), Ouzinkie, Ahkiok), initial efforts will focus on identification of potential mariculture sites and the development of permit applications. Activities in ensuing years will include preparation of mariculture development plans, training, establishing production, and development of markets.

Option #50.2 - Develop Bivalve Shellfish Hatchery and Research Center

This option proposes the construction of a hatchery and a research facility which will provide a reliable, local source of shellfish spat. The hatchery would be operated by the private sector, using technology developed at a State-operated research center.

The first step of this option would be to complete a study designed to identify which Alaskan shellfish species best lend themselves to hatchery propagation, what types of facilities will be required, where the hatchery and resource center will be located, and what potential benefits and costs are associated with the project.

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c. Recreation and Tourism

SUMMARY

Published studies of the impact of the *Exxon Valdez* oil spill on recreation and tourism address the economic effect on tourism and recreation fishing during 1989. Both industries suffered significant declines in 1989 and improved markedly in 1990. However, residual effects linger.

In 1992, a key informant study was conducted to discover public awareness on a broad range of recreation issues. The study found that about one-quarter of informants reported no change in their recreation experience, but others reported avoidance of the spill area, reduced wildlife sightings, and residual oil. It was also noted that there were more people. Further, they reported changes in their perception of recreation opportunity. Informants also reported a concern for the increased vulnerability of the area to future oil spills, erosion of wilderness [values] and a concern about long-term ecological effects.

INJURY

About 1/2 of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill. The net loss in visitor spending in Southcentral and Southwest Alaska in 1989 was $19 million (McDowell 1990). An estimated 124,185 lost recreational fishing days were lost due to closures, fear of contamination of the resource, and lack of availability of boats. (Carson and Hanemann 1992).

The study canvassed 92 users in ten user categories: air taxi operators, camping/kayaking, conservation/education, lodgeowner, Native corporations, public recreation managers, sailing/motorboating, sportfishing/hunting, tour operators, and tourism associations. The response rate was 45%.

Informants were asked how their recreation business had changed. About a quarter of the respondents reported no change in their income. Others reported the following changes: (1) avoidance of [areas which were heavily oiled in 1989] and displacement to less affected areas, primarily northern Prince William Sound; (2) reduced wildlife sightings; (3) fewer fish; (4) visual sighting of residual oil in the form of tar balls and sheens that affected the enjoyment of coastal areas and raised concern about tainted fish; and (5) more interest in the spill area and more people visiting it (RPWG 1993). Recreational use of Prince William Sound and the

Outer Kenai Coast, including Kenai Fjords National Park and Kachemak Bay State Wilderness Park, appeared to be most severely impacted; less severe impacts were reported in Kodiak and Kachemak Bay.

Informants were also asked whether there were changes not reflected in their experiences that concern the way they think about the area or perceive their recreation opportunities. Most of the respondents (80%) said their perceptions had changed. This group included at least half of each user group except air taxi operators. Those indicating a change in perception of recreation opportunities cited the following changes: (1) increased sense of vulnerability with regard to future oil spills, the fragility of the ecosystem, and threats to archaeological resources; (2) intrusion of cleanup and restoration activities; (3) a sense of permanent change; (4) a sense of unknown or unseen ecological effects that will alter the environment in the future; and (5) a sense of optimism about the future (RPWG 1993).

RECOVERY

By 1990 only 12% of the tourism businesses surveyed felt their livelihood had been significantly affected by the oil spill (McDowell, 1990). Many of the conditions that had contributed to the severe decline in recreation fishing had changed and the situation had improved (Carson and Hanemann 1992).

Although the status of recovery of recreation was not asked in the key informant interview, respondents volunteered information. They reported seeing less oil now than in 1989 and subsequent years; a slow, but discernible increase in wildlife sightings; and each year a slight increase in people using the spill area for recreation activities (RPWG 1993).

RESTORATION OPTIONS (For detailed description of applicable restoration options, see Appendix A).

Restoration options to restore fish and wildlife to pre-spill population levels will also help restore recreation and tourism services. In addition, a well-designed and executed public information program will improve management of the spill area and help to restore recreational opportunities. Seven options are being considered that are specifically targeted to restore or enhance recreation.

Option #37.0 - Habitat Protection and Acquisition

Private lands (Inholdings) in various size tracts exist in

parks and refuges throughout the spill area. Purchase of inholdings in parks and refuges, and key camping or fishing areas would provide long-term protection of recreation resources and instill confidence that recreation opportunities and wilderness values will be preserved.

Option #40.0 - Special Designation

Setting aside some public lands and waters for special management will protect recreation areas from future dramatic changes. Some key informants thought there were already enough special designations in the spill area; others supported additional special designations and cited certain areas that warrant such treatment. These included designation of the College Fjord/Nellie Juan Wilderness Study Area as wilderness with the additions proposed by the Chugach Forest Study Group; consideration of Harris Bay (Kenai Fjords National Park) and the area from Pt. Freemantle to the eastern side of Esther Passage (Prince William Sound) as a national marine sanctuary; and protection of Nuka Island. Although the Trustees could initiate a special designation and fund initial expense, the areas of special treatment are usually established through the state or federal legislative processes.

Option #44.0 - Spill Prevention and Contingency Planning

Several informants conveyed their sense of vulnerability because of the likelihood of future oil spills. Assurance that another spill will be averted or at least contained faster would instill a measure of trust to counteract this perception. Laws, funding, and local involvement abound in the area of spill prevention and contingency planning. Restoration funds could complement spill prevention and contingency planning activities being undertaken through other programs.

Option #34.0 - Marine Environmental Institute

A Marine Environmental Institute would benefit recreation and tourism in two ways: 1) the research program would improve knowledge about the effects of the oil spill and preparedness for future spills and 2) the facility and its educational programs could serve as a visitor attraction. A research program could be undertaken through many different vehicles. Two possibilities are a research foundation and a marine environmental institute.

Option #12A - New Public Recreation Facilities

Construction of recreation facilities such as mooring buoys, boat ramps, picnic areas, outhouses, caches, cabins, campsites, and trails will create opportunities for public use and direct access to specific areas. Well managed use could reduce resource damage, improve safety, and divert activity away from the spill area while it heals. On the other hand, construction of new public facilities will also attract more people and increase use of a damaged ecosystem.

Most respondents in the study believe that new public recreation facilities were inappropriate for wilderness areas. Among those who supported new public recreation facilities in the spill area, conditions of support varied. Because these are fundamentally land use decisions, some recommended that the decision to fund recreation facilities with restoration funds be tied to a comprehensive plan. Finally, concern was raised that facilities be patrolled and maintained and that the decision to fund construction be complemented with a commitment to long-term maintenance and enforcement.

Option #33.0 - Visitor Centers

Visitor centers would be convenient outlets for educating the public about recreation opportunities, low-impact camping, various land use regulations and guidelines and other measures to protect the spill area. They would also complement other visitor attractions in the area. Visitor centers exist in most communities in the spill area.

Option #12B - Planning and Marketing for New Commercial Facilities on Public Land

This option consists of making public land available for commercial recreation facilities such as fuel stops, docks, campgrounds, and lodges, and also providing seed money for planning and marketing these sites. This proposal offers advantages similar to those of option 12A. Furthermore, this option changes a use but does not restore an injured use. In addition, private landowners throughout the spill area could supply the land for commercial recreation facilities.

Among respondents who favored this option, support varied with the type of facility (fuel stops and private campgrounds were favored over lodges) and location (inappropriate in wilderness areas) and was conditioned on good siting and design.

REFERENCES

Carson, Richard T. and W. Michael Hanemann. 1992. A Preliminary Economic Analysis of Recreational Fishing Losses Related to the *Exxon Valdez* Oil Spill.

McDowell Group. 1990. An Assessment of the Impact of the *Exxon Valdez* Oil Spill on The Alaska Tourism Industry. Juneau, Alaska.

Restoration Planning Work Group. 1993. Recreation Key Informant Study. *Exxon Valdez* Oil Spill Office, Anchorage, Alaska.

d. Wilderness and Intrinsic Values

SUMMARY

The oil spill area consists of relatively undeveloped uplands[3] which are generally perceived to be "wilderness" by the public. Some areas have been formally designated as wilderness by either the United States or State of Alaska. Two federal areas are currently being formally considered for wilderness designation. The legislated areas include: Katmai National Park, Becharof National Wildlife Refuge, and Kachemak Bay State Wilderness Park. Study areas include: Kenai Fjords National Park, and the Nellie Juan/College Fjord area of the Chugach National Forest. Federal areas are managed according to the 1964 Wilderness Act and the Alaska National Lands Conservation Act (ANILCA) of 1980. State areas are managed according to enabling legislation and subsequent management plans. Generally, the areas are managed to maintain their natural landscape, a sense of solitude, and their wild character. Evidence of human presence is generally limited to temporary uses for short periods of time. Various state and federal lands not legislatively designated as wilderness are managed according to each agencies enabling legislation and subsequent regulations. These areas allow a broader range of uses and increased human development and thus have increased human presence.

INJURY

The oil spill delivered oil in varying quantities to the adjoining waters of all the designated and un-designated wilderness areas and oil was deposited above the mean high tide line in many areas. The national media covered the event and broadcast the disaster to every corner of the globe. As a result, the *Exxon Valdez* oil spill is now the event against which subsequent spills are measured. Many people, within Alaska and throughout the United States, believe that wilderness and other intrinsic values were lost or injured as a result of the oil spill.

During the intense cleanup seasons of 1989-1990, hundreds of workers and thousands of pieces of equipment were at work in the spill area. This activity was an unprecedented imposition of people, noise and activity on the area's undeveloped and normally sparsely occupied landscape.

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[3]Wilderness designations include uplands generally above the mean high tide line.

RECOVERY

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

RESTORATION OPTIONS (For detailed description of applicable restoration options, see Appendix A).

Option # 37.0 - Habitat Protection/Acquisition

This restoration option is designed to respond to both potential, long-term threats and to threats to injured resources and services. The intent of habitat protection/acquisition is to prevent additional injury to resources and services and to acquire lands that contain resources equivalent to those injured by the spill.

Option # 40.0 - Designate Protected Areas

This option provides the Trustees the ability to designate government-owned lands into management regimes which provide an increased level of resource protection. Different designations provide for alternative mixes of emphasis on public use, resource protection and scientific study. Special designations under consideration include: Alaska State Parks, Alaska Department of Fish & Game Special areas, National Marine Sanctuaries, National Estuarine Research Reserves, Research Natural Areas, National Recreation Areas, and federal wilderness areas.

REFERENCES

e. Sport and Commercial Fishing

SUMMARY

Damages to fisheries consisted of several emergency closures, most of them occurring in 1989. Sport fishing decreased due to actual and perceived contamination of fishing areas. Perhaps the greatest impact may be reductions in the number of sockeye returning to the Kenai River and Red Lake systems. Reduced returns of cutthroat trout to western Prince William Sound resulted in a 1992 closure of the area. Fisheries targeting pink salmon, herring and rockfish are not currently

impacted, although these species are known to have been injured to some extent. Restoration focuses on restoring the species which support services.

INJURY

During 1989, emergency commercial fishery closures were ordered in Prince William Sound, Cook Inlet, and the waters surrounding Kodiak Island and the Alaska Peninsula. Harvests were closed or restricted for salmon, herring, crab, shrimp, rockfish and sablefish. In 1990, a portion of Prince William Sound was closed to shrimp fishing for the same reason. All of the 1989 and 1990 closures were to prevent harvest of oiled species and were not triggered by population reductions in these species. There are currently no spill-related commercial fishery closures in effect.

While there were no sport fishery closures until 1992, ADF&G data documented a significant decline in sport fishing from 1989 to 1990 and quantified the losses at $31 million. Declines in the number of anglers, fishing trips and fishing days were noted for saltwater fisheries in Prince William Sound, Cook Inlet and the Kenai Peninsula areas. Public perception of the spill zone, primarily with out-of-state sport fishermen, may have been largely responsible for reductions in sport fishing activities. This aspect of injury is more fully discussed in the sections on injuries to wilderness and recreational activities.

The only spill-related sport fish closure resulted from a 1992 State of Alaska emergency order restricting cutthroat trout fishing in western Prince William Sound due to low adult returns. This closure will remain in effect until runs return to a sustainable level. Damage assessment from 1991 studies indicate that growth and survival rates of both species [Dolly Varden and cutthroat trout continue to be lower in previously oiled areas which could be because of injuries to the food chain.

Significant impacts on fisheries may have resulted from too many fish returning to the Kenai River and Red Lake (Kodiak Island) systems in 1989. Since 1989 commercial sockeye fisheries have been closed and large numbers of fish escaped harvest to spawn. This resulted in an unusually large number of fry moving into the lakes to feed. It is hypothesized that the fry overgrazed the zooplankton available to them in the lakes and were not able to maintain sufficient growth and survival rates. As a result, fry survival in the Kenai system was very poor for two years in a row and Red Lake fry may have stayed in the lake an extra year to feed. This will probably

result in reduced adult returns to these systems starting in 1994. It is also likely that 1995 returns to the Kenai River will also be very low. Closure of Kenai River sockeye fisheries would have major impacts on multiple user groups.

The extent of injury to rockfish is not fully understood. Although mortalities were caused by exposure to oil, few carcasses have bene found primary because rock fish are bottom dwellers and their bodies would not be easily recovered. Additional injury may have been inflicted by significantly increased commercial fishing pressures. Following the spill-induced, commercial fishery closures, many fishermen purchased new gear and re-directed harvest efforts towards rockfish. Little is known about current population levels and how well they will be able to withstand this increased pressure. However, rockfish are known to have low rates of reproduction and growth and have been seriously damaged by overfishing in other places. Thus, the possibility exists that population-level injuries caused by overfishing could necessitate closures of commercial and sport fishing for rockfish.

While injuries to pink salmon and herring were documented, there are no clear indications that these injuries will impact commercial or sport fishermen.

RECOVERY

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

Cutthroat trout fishing will probably remain closed in the western Sound in 1993, and will not reopen until populations recover.

Insufficient data exists to determine whether rockfish continue to be impacted by oil or if they are being harmed by increased harvest pressure. The lack of population data could result in additional damage to the species due to overfishing.

RESTORATION OPTIONS (For detailed description of applicable restoration options, see Appendix A).

Many of the options for restoring sport and commercial fishing injuries focus on restoring injured species population. These options are described under the species injury summaries for sockeye and pink salmon, cutthroat trout, Dolly Varden, rockfish and herring. Species restoration strategies include adjusting fishery management, improving or creating new salmon spawning and rearing habitat, improving salmon egg and fry survival, and acquiring and protecting fish habitat (Options 2, 11, 19, 37, 40 and 48).

However, two options are proposed which are solely intended to mitigate lost fishing opportunities. These options do not restore injured fish populations. Instead, they provide new sport and commercial fishing opportunities or provide new access routes for sport fishermen. The user groups which benefit would be determined by the species targeted by the option.

Option #18.0 - Replace Fishing Harvest Opportunities by Establishing New Salmon Runs

This option entails starting new salmon runs to replace opportunities lost due to fishing closures or reduced harvests. New salmon runs could take the form of terminal runs returning to hatcheries and remote release sites. All returning adults would be harvested every year or used for brood stock for the next year's run. Alternatively, self-perpetuating runs could be started in streams not currently used by spawning salmon. Spawning habitat could be created to make stream stocking applicable on a significant scale. Either of these alternatives would have to be implemented with great care, especially within Prince William Sound, to avoid disruption of existing fisheries and to comply with ADF&G policies and guidelines on fish genetics and disease control.

[The runs would be maintained] until wild-stocks recover. If the option is continued beyond this time, it will be in the context of enhancing the service above pre-spill levels. The option is applicable as direct restoration to all areas where fishermen are anticipated to be impacted by spill-related fishery closures or restrictions. This currently includes the Cook Inlet and Kodiak areas where sockeye runs are anticipated to decline drastically. However, it will not be possible to implement this option in time to mitigate the effects of a 1994 sockeye closure.

Option #28.0 - Acquire Access to Sport Fishing and Recreational Areas

Injuries to sport fishing can be restored by acquiring access to sport fishing and recreational areas. While much of the land in the spill area is publicly owned, some private lands exist where access is denied. Access could be created through fee simple purchase of lands. This option could be associated with other options to construct small-scale recreation facilities such as boat ramps, parking lots and sanitation facilities.

Access corridors will relieve fishing pressure on streams with injured fish stocks. For instance, if Kenai River sockeye fisheries are closed or restricted, sport fishing could be diverted to unaffected areas by providing access. This option could be used to directly restore fishing opportunities in areas where there are existing or anticipated spill-related sport fishing closures, i.e., Prince William Sound, Kenai Peninsula and Kodiak. If these access points were maintained after the sport fishery was fully recovered, it would constitute an enhancement of fishing opportunities above pre-spill levels.

REFERENCES

Michael Mills, Sport Fish Division ADF&G Special Publication #92-5 titled, Alaska Sport Fishing in the Aftermath of the *Exxon Valdez* Oil Spill, December, 1992.

III. XX. Services: Summary of Results of Injury Assessment Studies

Table XX summarizes information about services injured by the spill. Much of the damage to services and the information about those damages is not quantitative. The information used for this table is taken from injury assessment studies, information from state and federal agency studies, agency managers, and, for recreation, a Key Informant Interview study conducted by the Restoration Planning Working Group in December 1992. The "Description of Injury" column recounts the situation for each service in the year(s) following the spill. The "Status of Recovery in 1992" shows the situation for that service at the end of 1992.

The "Geographic Extent of Injury" column shows whether the injury occurred in the geographic areas shown in figure X. (Injury may have been more extensive in some regions than others.)

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
MARINE MAMMALS										
Harbor Seals (c)	YES (200)	YES	YES	POSSIBLY STABLE, BUT NOT RECOVERING (a)	UNKNOWN	YES	YES (d)	UNKNOWN	UNKNOWN	Many seals were directly oiled . There was a measurable difference in populations between oiled and unoiled areas in PWS in 1989 and 1990. Population was declining prior to the spill and no recovery evident in 1992. Oil residues found in seal bile were 5 to 6 times higher in oiled areas than unoiled areas in 1990.
Humpback Whales	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Other than fewer animals being observed in Knight Island Passage in summer 1989, which did not persist in 1990, the oil spill did not have a measurable impact on the north Pacific population of humpback whales.
Killer Whales	YES (13)	YES	UNKNOWN	RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	13 Adult whales of the 36 in AB pod are missing and presumed dead. The AB pod has grown by 2 whales since 1990. Circumstantial evidence links whale disappearance to oiling.
Sea Lions (c)	UNKNOWN	UNKNOWN	NO	CONTINUING DECLINE	(e)	(e)	(e)	(e)	(e)	Several sea lions were observed with oiled pelts and oil residues were found in some tissues. It was not possible to determine population effects or cause of death of carcasses recovered. Sea lion populations were declining prior to the oil spill.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Sea Otters	YES (3,500 TO 5,000)	YES	YES	STABLE, BUT NOT RECOVERING	YES, POSSIBLY	YES	YES	YES (d)	YES (d)	Post-spill surveys showed measurable difference in populations and survival between oiled and unoiled areas in 1989, 1990 and 1991. Survey data have not established a significant recovery. Prime-age animals were still found on beaches in 1989, 1990 and 1991. Carcasses of sea otters feed in the lower intertidal and subtidal areas and may still be exposed to hydrocarbons in the environment.
TERRESTRIAL MAMMALS										
Black Bear	NO	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	No field studies were done.
Brown Bear	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Hydrocarbon exposure was documented on Alaska Peninsula in 1989 including high hydrocarbon levels in the bile of one dead cub. Brown bear feed in the intertidal zone and may still be exposed to hydrocarbons in the environment.
River Otters	YES (NUMBER UNKNOWN)	UNKNOWN	YES	UNKNOWN	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	Exposure to hydrocarbons and sub-lethal effects were determined, but no effects were established on population. Sub-lethal indicators of possible oil exposure remained in 1991. River otters feed in the intertidal and shallow subtidal areas and may be still be exposed to hydrocarbons in the environment.
Sitka Black-tailed Deer	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Elevated hydrocarbons were found in tissues in some deer in 1989.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
BIRDS										
Bald Eagles	YES (614-902)	YES	YES	RECOVERING	UNKNOWN	YES	YES	YES (d)	YES(d)	Productivity in PWS was disrupted in 1989, but returned to normal in 1990. Exposure to hydrocarbons and some sub-lethal effects were found in 1989 and 1990, but no continuing effects were observed on populations.
Black-legged Kittiwakes	YES (NUMBER UNKNOWN)	NO	NO	NO CHANGE	NO	YES	YES (d)	YES (d)	YES (d)	Total reproductive success in oiled and unoiled areas of PWS has declined since 1989. Hydrocarbon contaminated tissues were detected in 1989. Hydrocarbon contaminated stomach contents were detected in 1989 and 1990. This species is known for great natural variation and reproductive failure may be unrelated to the oil spill.
Black Oyster-catchers	YES (129 ADULTS; UNKNOWN FOR CHICKS (f)	YES	YES	RECOVERING	YES	YES	YES (d)	YES (d)	YES (d)	Differences in egg size between oiled and unoiled areas were found in 1989. Exposure to hydrocarbons and some sublethal effects were determined. Populations declined more in oiled areas than unoiled areas in post-spill surveys in 1989, 1990 and 1991. Black oystercatchers feed in the intertidal areas and may be still be exposed to hydrocarbons in the environment.
Common Murres	YES (175,000 to 300,000)	YES	YES	DEGREE OF RECOVERY VARIES IN COLONY	YES	NO	YES	YES	YES	Measurable impacts on populations were recorded in 1989, 1990 and 1991. Breeding is still inhibited in some colonies in the Gulf of Alaska.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Glaucous-winged gulls	YES (NUMBER UNKNOWN)	NOT DETECTED	NO	NO CHANGE	NO	YES (d)	YES (d)	YES (d)	YES (d)	While dead birds were recovered in 1989, there is no evidence of a population level impact when compared to historic (1972, 1973) population levels.
Harlequin Ducks	YES (423)	YES	YES	STABLE OR CONTINUING DECLINE	YES	YES	YES (d)	YES (d)	YES (d)	Post-spill samples showed hydrocarbon contamination and poor body conditions. Surveys in 1990-1992 indicated population declines and near total reproductive failure. Harlequin ducks feed in the intertidal and shallow subtidal areas and may still be exposed to hydrocarbons in the environment.
Marbled Murrelets (c)	YES (8,000 TO 12,000)	YES	UNKNOWN	STABLE OR CONTINUING DECLINE	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Measurable population effects on were recorded in 1989, 1990 and 1991. Marbled murrelet populations were declining prior to the spill. Hydrocarbon contamination was found in livers of adult birds.
Peale's Peregrine Falcons	UNKNOWN	UNKNOWN	NO	(e)	(e)	(e)	(e)	(e)	(e)	When compared to 1985 surveys a reduction in population and lower than expected productivity was measured in 1989 in the PWS. Cause of these changes are unknown.
Pigeon Guillemots (c)	YES (1,500 TO 3,000)	YES	NO	STABLE OR CONTINUING DECLINE	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Pigeon guillemot populations were declining prior to the spill. Hydrocarbon contamination was found in birds and, externally, on eggs.
Storm Petrels	YES (NUMBER UNKNOWN)	NO	AWAITING RESULTS	NO CHANGE	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Few carcasses were recovered in 1989 although petrels ingested oil and transferred oil to their eggs. Reproduction was normal in 1989.

(a) There may have been an unequal distribution of injury within each region, see map for location of regions;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
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Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Other Seabirds	YES (375,000-435,000)	VARIES BY SPECIES	UNKNOWN	VARIES BY SPECIES	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Seabird recovery has not been studied. Species collected dead in 1989 include common, yellow-billed, pacific, red-throated loon; red-necked and horned grebe; northern fulmar; sooty and short-tailed shearwater; double-crested, pelagic, and red-faced cormorant; herring and mew gull; arctic and Aleutian tern; Kittlitz's and ancient murrelet; Cassin's, least, parakeet, and rhinoceros auklet; and horned and tufted puffin.
Other Sea Ducks	YES (875) (b)	NO	UNKNOWN	UNKNOWN	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include Stellar's, king and common eider; white-winged, surf and black scoter; oldsquaw; bufflehead; common and Barrow's goldeneye; and common and red-breasted merganser. Sea ducks tend to feed in the intertidal and shallow subtidal areas which were most heavily impacted by oil.
Other Shorebirds	YES (NUMBER UNKNOWN)	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include golden plover; lesser yellowlegs; semipalmated, western, least and Baird's sandpiper; surfbird; short-billed dowitcher; common snipe; red and red-necked phalarope.
Other Birds	YES (NUMBER UNKNOWN)	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	YES (d)	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include emperor and Canada goose; brant; mallard; northern pintail; green-winged teal; greater and lesser scaup; ruddy duck; great blue heron; long-tailed jaeger; willow ptarmigan; great-horned owl; Stellar's jay; magpie; common raven; northwestern crow; robin; varied and hermit thrush; yellow warbler; pine grosbeak; savannah and golden-crowned sparrow; white-winged crossbill.

(a) There may have been an unequal distribution of injury within each region, see map for location of regions;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
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Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
FISH										
Cutthroat Trout	YES, SEE COMMENTS	POSSIBLY	YES	STABLE, BUT NOT RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	Differences in survival and growth between anadromous adult populations in the oiled and unoiled areas persisted in 1991 despite the decrease in exposure indicators. This could be due to continuing injury to the food base.
Dolly Varden	YES, SEE COMMENTS	POSSIBLY	YES	STABLE, BUT NOT RECOVERING	UNKNOWN	YES	UNKNOWN	UNKNOWN	UNKNOWN	Differences in survival between anadromous adult populations in the oiled and unoiled areas persisted in 1991 despite the decrease in exposure indicators. This could be due to continuing injury to the food base.
Pacific Herring	YES, TO EGGS AND LARVAE	UNKNOWN	YES	UNKNOWN	NO	YES	UNKNOWN	UNKNOWN	UNKNOWN	Measurable difference in egg counts between oiled and unoiled areas were found in 1989 and 1990. Lethal and sublethal effects on eggs and larvae were evident in 1989 and to a lesser extent in 1990; in 1991 there were no differences between oiled and unoiled areas. It is possible that the 1989 year class was injured and could result in reduced recruitment to the fishery.
Pink Salmon (Wild) (c)	YES, TO EGGS	POSSIBLY	YES	SEE COMMENTS	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	There was initial egg mortalituy in 1989. Egg mortality continued to be high in 1991, possibly due to genetic damage to spawners. Abnormal fry were observed in 1989. Reduced growth of juveniles was found in the marine environment, which can be correlated with reduced survival.

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

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Rockfish	YES (20) (f)	UNKNOWN	YES	UNKNOWN	UNKNOWN	YES	YES	UNKNOWN	UNKNOWN	Few dead fish were found in 1989 in condition to be analyzed. Exposure to hydrocarbons with some sub-lethal effects were determined in those fish, but no effects established on the population. Closures to salmon fisheries increased fishing pressures on rockfish which may be impacting population.
Sockeye Salmon	UNKNOWN	YES	YES	SEE COMMENTS	YES	UNKNOWN	YES	YES	NO	Smolt survival continues to be poor in the Red Lake and Kenai River systems due to overescapements in Red Lake in 1989, and in the Kenai River in 1987, 1988, 1989. As a result, future adult returns are expected to be low in 1994 and successive years. Trophic structures of Kenai and Skilak Lakes have been altered by overescapement.
SHELLFISH										
Clam	YES (NUMBER UNKNOWN)	UNKNOWN	POSSIBLY, FINAL ANALYSES PENDING	UNKNOWN	UNKNOWN	YES	YES	YES	YES	Native littleneck and butter clams were impacted by both oiling and clean-up, particularly high pressure, hot water washing. Littleneck clams transplanted to oiled areas in 1990 grew significantly less than those transplanted to unoiled sites. Reduced growth recorded at oiled sites in 1989 but not 1991.
Crab (Dungeness)	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Crabs collected from oil areas were not found to have accumulated petroleum hydrocarbons.
Oyster	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Although studies were initiated in 1989, they were not completed because they were determined to be of limited value.

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(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Resource	Description of Injury			Status of Recovery in December, 1992		Geographic Extent of Injury (a)				Comments/Discussion
	Oil Spill Mortality (total mortality estimate)(b)	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
Sea Urchin	UNKNOWN	UNKNOWN	UNKNOWN	(e)	(e)	(e)	(e)	(e)	(e)	Studies limited to laboratory toxicity studies.
Shrimp	UNKNOWN	UNKNOWN	NO	(e)	(e)	(e)	(e)	(e)	(e)	No conclusive evidence presented for injury linked to oil spill.
INTERTIDAL/SUBTIDAL COMMUNITIES										
Intertidal Organisms/ Communities	YES	YES	YES	VARIABLE BY SPECIES, SEE COMMENTS	YES	YES	YES	YES	YES	Measurable impacts on populations of plants and animals were determined. The lower intertidal and, to some extent, the mid intertidal is recovering. Some species (Fucus) in the upper intertidal zone have not recovered, and oil may persist in and mussel beds.
Subtidal Communities	YES	YES	YES	VARIABLE BY SPECIES, SEE COMMENTS	YES	YES	UNKNOWN	UNKNOWN	UNKNOWN	Measurable impacts on population of plants and animals were determined in 1989. Eel grass and some species of algae appear to be recovering. Amphipods in eel grass beds recovered to pre-spill densities in 1991. Leather stars and helmet crabs show little sign of recovery through 1991.

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

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

RPWG draft 3/18/93

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Passive Use	In 1991, over 90% of those surveyed (nation-wide) said they were aware of the *Exxon Valdez* oil spill. People report that values have been lost; their feelings about the spill area have changed. There is a wide-spread feeling that something has been lost.	Recovery status is unknown.	YES	YES	YES	YES	Over 50% of those surveyed believed that the spill was the largest environmental accident caused by humans anywhere in the world. The median household willingness to pay for future prevention was $31. Multiplying this by the number of U.S. household results in a damage estimate of $2.8 billion.
Recreation (e.g., hunting, fishing, camping, kayaking, sailboating, motorboating, environmental education)	The nature and extent of injury varied by user group and by area. About a quarter of key informants interviewed reported no change in their recreation experience, but others reported avoidance of the spill area, reduced wildlife sightings, residual oil, and more people. Overall, recreation use declined significantly in 1989. Between 1989 and 1990 a decline in sport fishing (number of anglers, fishing trips and fishing days) were recorded for PWS, Cook Inlet and the Kenai Peninsula. In 1992 an emergency order restricting cutthroat trout fishing was issued for western PWS due to low adult returns. Sport hunting of harlequin duck was affected by restrictions imposed in 1991 in response to damage assessment studies.	Declines in recreation activities reported in 1989 appear to be recovering for some user groups, but the degree of recovery is unknown. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in sport fishing closures or harvest restrictions during these and perhaps in subsequent years. The 1992 sport fishing closure for cutthroat trout is expected to continue at least through 1993. Harvest restrictions are expected to continue for harlequin duck through 1993.	YES	YES	YES	YES	Survey respondents also reported changes in their perception of recreation opportunity in terms of increased vulnerability to future oil spills, erosion of wilderness, a sense of permanent change, concern about long-term ecological effects, and, in some, a sense of optimism.

(a) There may have been an unequal distribution of injury within each region, see map for location of regions

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Commercial Fishing	During 1989, emergency commercial fishery closures were ordered in PWS, Cook Inlet, Kodiak and the Alaska Peninsula. This affected salmon, herring, crab, shrimp, rockfish and sablefish. The 1989 closures resulted in sockeye over-escapement in the Kenai River and in the Red Lake system (Kodiak Island). In 1990 a portion of PWS was closed to shrimp fishing.	Currently there are no area-wide oil spill-related commercial closures in effect. Management actions to try to compensate for the spill are still in effect. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in closure or harvest restrictions during these and perhaps in subsequent years.	YES	YES	YES	YES	Injuries and recovery status of rockfish, pink salmon, shellfish and herring are uncertain. Therefore, future impacts on these fisheries is unknown.
Commercial Tourism	Approximately 43% of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill in summer 1989. The net loss in visitor spending in the oil spill area in 1989 was $19 million.	By 1990, 12% of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill.	YES	YES	YES	YES	

(a) There may have been an unequal distribution of injury within each region, see map for location of regions

TABLE XX Services: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

Service	Description of Injury	Status of Recovery in December, 1992	Geographic Extent of Injury (a)				Comments/Discussion
			PWS	Kenai	Kodiak	Alaska Penin.	
Subsistence	Subsistence harvests of fish and wildlife in 10 of 15 villages surveyed declined from 4 - 78% in 1989 when compared to pre-spill levels. At least 4 of the 10 villages showed continued lower than average levels of use in the period 1990-1991; this decline is particularly noticeable in the Prince William Sound villages of Chenega and Tatitlek. In 1989-1991, chemical analysis indicated that most resources tested, including fish, marine mammals, deer, and ducks, were safe to eat. In 1989-1991, health advisories were issued indicating that shellfish from oiled beaches should not be eaten.	Many subsistence users believe that continued contamination to subsistence food sources is dangerous to their health. In addition, village residents believe that subsistence species continue to decline or have not recovered from the oil spill.	YES	YES	YES	NO	For detailed information on village subsistence use see table _, page__.

(a) There may have been an unequal distribution of injury within each region, see map for location of regions

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

RPWG draft 3/18/93

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

(a) There may have been an unequal distribution of injury within each region, see map for location of regions.

(b) This page has not yet been reviewed by the Chief Scientist.

RESTORATION PLANNING WORKING GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 "G" STREET
ANCHORAGE, ALASKA 99501

TO: Restoration Planning Work Group

FROM: Ray Thompson

SUBJECT: Review of Chapter III, Draft Restoration Plan, and Discussion of Coordination with Walcoff on Chapters 1 and 2 of the Draft EIS.

Draft Plan Chapter III has been dutifully rewritten and edited. There are mixed feelings about the product content and location in the Plan. Several of us have some concern over the length of the chapter relative to what we have envisioned for other plan chapters. Maybe most of this material should be in the appendix or Chapter 3, Affected Environment, of the Draft EIS? Please bring your copies and be prepared to discuss these issues Friday, 4/9/93, at 0830 in the RPWG meeting room.

I have also enclosed Draft EIS Chapters 1 and 2 (outline) from Walcoff. I have not reviewed them yet but I think it is worth our time to review them now and discuss their content. Early next week I will prepare a response to Walcoff for Ken Rice's review and forwarding.

By the way, GOOD WORK on the Brochure! We are receiving a trickle of comment on the product - not its content yet - and they are all good. Distribution to papers and the mailing list is nearly complete. By this time next week we will have it in the hands of many interested persons.

enclosures

cc: Rice

To: RPWG
From: Sandy Rabinowitch
Date: April 9, 1993

Subject: Chapter III

Enough info to get content of plan -

Review Comments

Many, but not all, feel the text is far too lengthy. There is much, but not yet unanimous, consensus on three detailed points:

* Dramatically shorted the "description" section;

* Move the "comments" text into the injury or recovery sections and delete what does not fit into those categories (option sections disappear);

* Reduce the bulk of text associated with the options by having only a brief connecting paragraph (injury-option) and a list of option titles only.

Proposed New Approach

* Consider the current chapter III as an appendix, make appropriate changes (need to agree on details of the changes).

* Replace chapter III with text from brochure specifically, injury text from page 3, page 6 and natural recovery text on page 7.

description
injury
options

injury Table is appendix

Special Guest - effectiveness will link ~~there~~ injury to alt/options

questionnaire - print & bind in document