

State/Federal Natural Resource Damage Assessment Plan for the Exxon Valdez Oil Spill August 1989

Public Review Draft



Dear Reviewer:

We have prepared this draft Natural Resource Damage Assessment Plan and Restoration Strategy in response to the spilling of approximately eleven million gallons of crude oil that resulted from the March 24, 1989, grounding of the tanker Exxon Valdez in Prince William Sound.

The document describes the studies necessary to determine the extent and magnitude of injury to natural resources of Prince William Sound and the adjacent Gulf of Alaska. The studies to assess injury are designed to support: 1) the development of restoration plans to promote the long-term recovery of natural resources, and 2) the determination of damages to be claimed for the loss of services of the natural resources.

The plan was prepared through the cooperation of the State of Alaska, the U.S. Departments of Agriculture and Interior, the National Oceanic and Atmospheric Administration, and the U.S. Environmental Protection Agency under the general provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation and Liability Act.

The draft plan is provided for public review. In your review, please keep in mind that the plan is focused on those studies necessary to determine injury to natural resources and to determine damages resulting from the loss of public use of those resources, and on the strategy for restoration of natural resources. While related long-term research may be desirable and may build on the studies in the plan, it falls outside the scope and intent of the plan.

Your comments must be received by September 30, 1989, at the following address:

Trustee Council
P. O. Box 20792
Juneau, AK 99802

Questions concerning the draft plan, its distribution, and the means by which you may participate in the public review process should be directed to Mary Fitzgerald-Jones or Barbara Hyder at (907)276-3550.

We appreciate your interest and look forward to your comments.

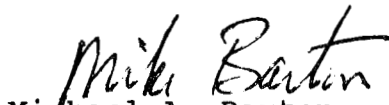
Sincerely,



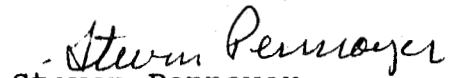
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EXECUTIVE SUMMARY

The March 24, 1989, grounding of the tanker Exxon Valdez in Alaska's Prince William Sound caused the largest oil spill in U.S. history. Approximately 11 million gallons of North Slope crude moved through the southwestern portion of the Sound and along the coast of the western Gulf of Alaska, causing extensive harm to natural resources. Because of intrinsic, social, and economic values of the public natural resources and uses impacted by the Exxon Valdez oil spill, restoration is important. Restoration is the primary objective of the state and federal Trustees and EPA and will be undertaken expeditiously.

This plan, in addition to laying out an approach to achieve restoration, describes the process by which harm will be evaluated so that money to restore the injured resources can be sought from those responsible for the spill. The State of Alaska and three federal agencies (the Departments of Agriculture, Commerce, and Interior) are acting together as trustees to protect and assess injuries to natural resources, as provided by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Water Act (CWA). EPA is assisting the Trustees in damage assessment and coordinating the restoration effort with the State of Alaska. The Trustees and EPA have prepared this Damage Assessment Plan, and following review by the public, the Trustee Council will implement it. Exxon has provided an initial \$15 million for these assessment activities. The total cost for the assessment studies described in this plan is estimated to be \$35 million through February 28, 1990.

The studies have been designed to assess the injury to natural resources. The damage assessment document is essentially a one-year plan. No further studies will be conducted after February 28, 1990, except those approved by the Trustees upon recommendation of the Trustee Council and scientific and legal review groups as being necessary to promote restoration and to support assessment of legally recoverable natural resource damages.

To manage the assessment, the trustees have established a Trustee Council headquartered in Alaska. Each Trustee has one representative on the Council. The U.S. Environmental Protection Agency is acting as an advisor to the Council to promote restoration and long-term recovery of the ecology of Prince William Sound and the Gulf of Alaska.

The assessment has three major components: 1) determination and quantification of injury, 2) determination of damages, and 3) development of a restoration strategy. Determination of injury involves documenting the exposure of the resources to oil from the Exxon Valdez, and identifying which resources were adversely

affected by that exposure. Quantification of the injury involves measuring the amount of adverse effect upon each resource. Determination of damages involves putting a price tag on those adverse effects.

The Trustee Council will also begin to develop a restoration plan. This document describes the strategy and scope of the process for initiating and developing this plan. The recovered damages will be used to restore, replace or acquire the equivalent of the injured natural resources as described in the restoration plan.

The studies described in this plan fall into nine categories: 1) Coastal Habitat, 2) Air/Water, 3) Fish/Shellfish, 4) Marine Mammals, 5) Terrestrial Mammals, 6) Birds, 7) Economic Uses, 8) Technical Services (including chemistry, histopathology, and an integrated geographic information system, complete with mapping) to support the resource studies, and 9) Restoration. The studies will be performed in accordance with the quality assurance/quality control plan described in Appendix A. The studies are coordinated within each group and across groups to determine and quantify injury and to support the damage determination and restoration effort in the most cost-effective way.

The Coastal Habitat study measures spill-related changes in the supratidal, intertidal, and shallow subtidal zones. This study is designed to document injury to resources that rely on these habitats, and to determine damages for the loss of services provided by these habitats.

The Air/Water studies determine the distribution and composition of petroleum hydrocarbons in the water, sediments, and living resources. The distribution of hydrocarbons provides a basis for documenting exposure and for estimating potential injury to resources. The combined results of the Coastal Habitat and Air/Water studies also are useful in estimating the natural rates of recovery of natural resources and the potential for accelerating early recovery.

The Fish/Shellfish studies focus on comparing the number of certain fish and shellfish (at all life stages) in oiled and non-oiled areas throughout the spill area. Species were selected for study based on their role in major fisheries and/or their merit as indicators of broader effects. Determination of injury to fishery resources will be substantiated by information on the distribution and composition of petroleum in the environment, the presence of hydrocarbons and metabolites in tissues, and the occurrence of petroleum-related effects.

Studies on marine mammals include not only carcass counts, but also studies of pathology and toxicology, especially in sea otters and

seals. Injury also will be determined by surveying the number and distribution of marine mammals throughout the affected area.

Terrestrial mammals near the coast were exposed to hydrocarbons by breathing fumes and eating oiled carcasses or vegetation. The studies will determine the presence of hydrocarbons in tissues of dead animals, and will determine the effects, if any, of oil exposure on the local populations of terrestrial mammals, including black and brown bears, Sitka black-tailed deer, river otters and mink, and on reproduction in laboratory mink (as a model for other species).

The plan for assessing injury to migratory birds is organized into five units: 1) surveys and censuses, 2) raptors, 3) sea birds, 4) waterfowl, shorebirds, and passerines, and 5) toxicology. The surveys and censuses will provide an overview of mortality, population changes, and distribution. Studies proposed for particular types of birds focus on collecting data regarding reproductive success, survival, effects of hydrocarbons, and other information needed to supplement the surveys and censuses. These data will be gathered for birds potentially most affected by the spill or best serving as indicators for larger groups.

The economic value of the lost or injured natural resources is based on the goods and services they provide humans. The damages which form the basis of the Trustees' claim against the potentially responsible parties are calculated by considering 1) the reduction of these goods and services (lost-use value) resulting from the spill, and 2) the cost of restoring these goods and services to their pre-spill level, replacing them or acquiring their equivalent (restoration).

The Trustees have not yet decided whether to use the Natural Resources Damage Assessment regulations. Nor have they decided whether, or to what extent, potentially responsible parties should participate in the damage assessment.

When the assessment is completed, a claim will be presented to the potentially responsible parties. That claim will include both damages and any unreimbursed cost of the assessment. The unreimbursed costs recovered will be returned to the individual trustee agencies incurring them. Damages collected will be used to restore, replace, or acquire the equivalent of the injured natural resources and reimburse agencies for relevant costs already incurred.

State/Federal
Natural Resource Damage Assessment
and
Restoration Strategy
for the Exxon Valdez Oil Spill

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INTRODUCTION

This document describes damage assessment and restoration activities to be undertaken jointly by the State of Alaska and three federal agencies (the Departments of Agriculture, Commerce, and Interior). Authority for this action is provided by the federal Clean Water Act (33 U.S.C. 1321), and the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9601 et seq.). Under those laws, the three departments and the state share trusteeship for the natural resources, living and non-living, that were injured by the Exxon Valdez oil spill. The trustees (in cooperation with the U.S. Environmental Protection Agency, the State of Alaska's Department of Law, and the Department of Justice) have developed this plan to assess the natural resource damage resulting from the spill. Because of the intrinsic, social, and economic values of the public natural resources and uses impacted by the Exxon Valdez oil spill, restoration is important. Based upon injury determination and damage assessment, the Trustee Council will identify opportunities for restoration and will expeditiously pursue appropriate restoration actions.

BACKGROUND

At 12:04 a.m., March 24, 1989, the tanker Exxon Valdez, carrying more than 50 million gallons of North Slope crude oil, ran aground and ruptured its tanks on Bligh Reef in Alaska's Prince William Sound. What followed was the largest oil spill in U.S. history; approximately eleven million gallons of crude oil poured into one of the Nation's most sensitive ecosystems in less than five hours. To date oil has moved across nearly 10,000 square miles of water in Prince William Sound and the Gulf of Alaska. More than 700 miles of shoreline have been oiled.

Initially, the oil brought death to thousands of wild animals. Oil and its complex breakdown products are expected to linger in some areas for many years. Natural resources affected or potentially affected include:

- . Air
- . Surface water, sediments, and groundwater
- . Land managed by natural resource trustees, including submerged land, wetlands, shoreline, soil, geologic resources, and other features of that land
- . Marine and terrestrial plants and microorganisms
- . Fish of many species, shellfish, and other marine invertebrates

- . Marine mammals, including sea otters, seals, sea lions, porpoises and whales
- . Terrestrial animals, including big game and other wildlife
- . Birds, including seabirds, waterfowl, shorebirds, and raptors

The Geographic Setting:

Prince William Sound lies near the top of the 850-mile arc of the Gulf of Alaska, which extends from the Aleutian Islands on the west to the islands of southeast Alaska (Fig. 1a and 1b). The Gulf coast is remote, rugged country of great natural beauty. Much of the region was pristine before the spill.

Prince William Sound (Fig. 2) is one of the largest undeveloped marine ecosystems in the United States. It has one of the continent's largest tidal estuary systems, a rich environment teeming with life where rivers meet and mingle with the tides. In terms of water surface alone, the Sound is about the size of Chesapeake Bay. Its many islands, bays, and fiords give it a shoreline more than 2,000 miles long.

The Sound lies within the boundaries of the Chugach National Forest. To the southwest is the Kenai Peninsula, home of Kenai Fiords National Park and the western portion is within the Nellie Juan-College Fiord Wilderness Study Area. Both the National Forest and National Park are accessible by air and boat from Anchorage, Alaska's major population center, making the area popular with recreationists. State ferries that run among the larger communities make it easy for people to visit the heart of the Gulf coast. In recent years, there has been a steady increase in the number of cruise ship and other tourist visits.

The maritime climate nourishes a lush, green landscape. Bears, whales, bald eagles, puffins, seals, sea lions, and sea otters are among the wildlife people come to see. Glaciers that carved the intricate fiords still send icebergs floating out to sea. These are the largest glaciers outside Antarctica and Greenland. They descend from permanent icefields capping the coastal mountain range.

The Kenai Peninsula points southwest to Shelikof Strait, and is bordered on the north by the Alaska Peninsula. Along the Alaska Peninsula's coast is Katmai National Park. South of the strait lies Kodiak Island, once the base of Russia's Alaskan fur trade. The hunting born of that trade all but destroyed the native sea otters. Their numbers, coaxed back from the edge of extinction, finally had begun to grow again along the Gulf coast. The Alaska Peninsula tapers, then scatters into the islands of the Aleutian

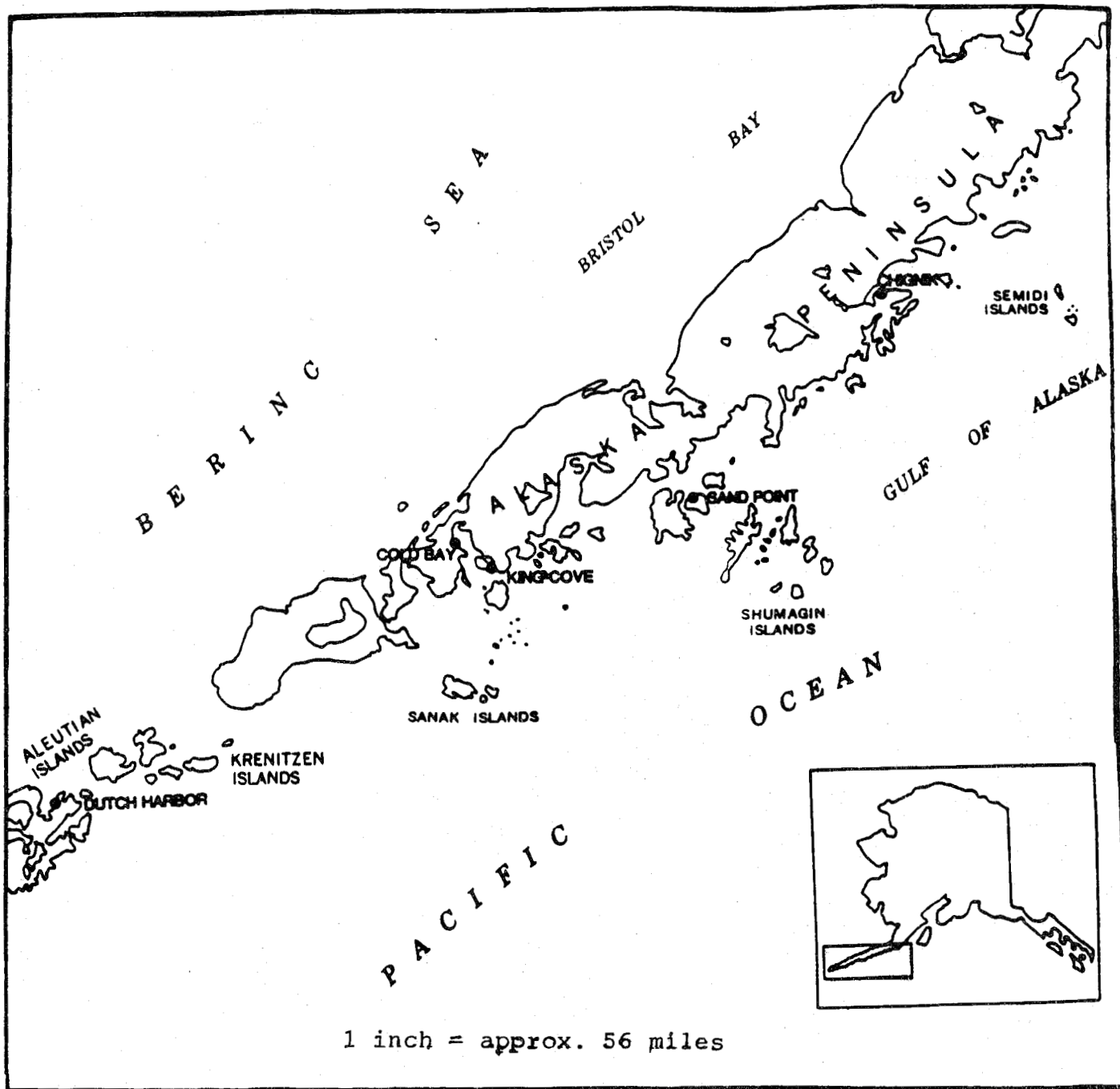


Figure 1b. Map of Western Gulf of Alaska

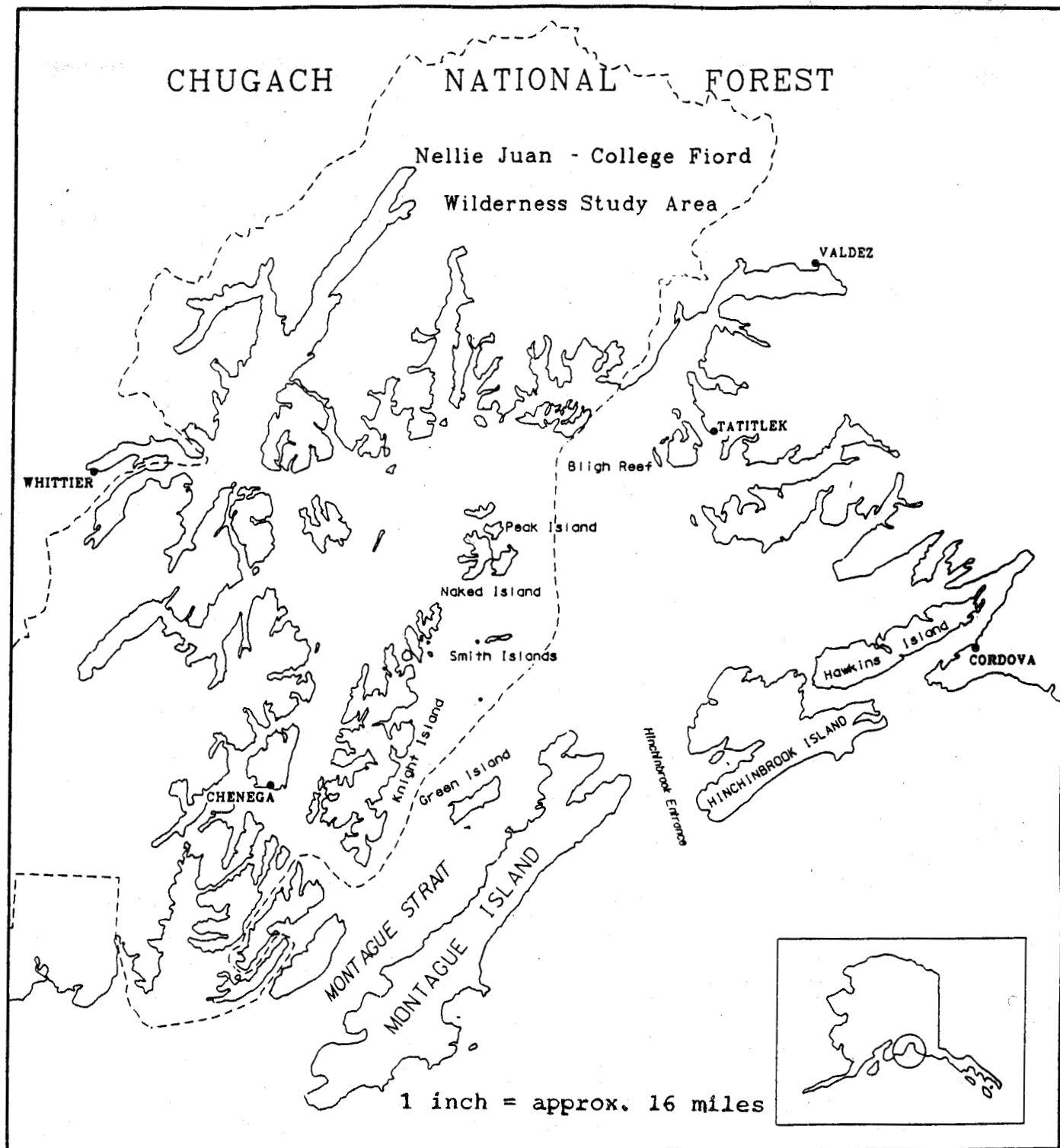


Figure 2. Map of Prince William Sound

chain. Just north of the Aleutians are the rich fishing grounds of the Bering Sea.

The Gulf of Alaska's weather is primarily caused by storm systems passing along the Aleutian storm track. Throughout the year, offshore winds blow predominantly from the south in the eastern Gulf, from the east in the northcentral region, and from the west (but are highly variable) near the Aleutian Islands. Wind intensity is greatest from October through April. Storms that cross the Gulf drop as much as 300 inches of rain and snow annually in the high coastal mountains.

The weather affects the regional oceanography. There are both wind-induced currents and coastal currents driven by differences in water density from the large runoff of fresh water in southeast Alaska.

Major currents in the northern Gulf of Alaska flow from east to west (Fig. 3). They enter Prince William Sound through Hinchinbrook Entrance and lesser openings to the east, then sweep counterclockwise through the Sound, exiting mainly through Montague Strait. Surface water temperatures in Prince William Sound range from about 33 to 54 degrees Fahrenheit. Surface salinity fluctuates, especially in the north where glacial runoff pours into saltwater.

The coastal current moves southwest along the Kenai Peninsula to the Chugach and Barren Islands. There, the current splits, with some water entering Cook Inlet and the rest moving into a system of gyres along the east and south shores of Kodiak Island. Currents in lower Cook Inlet move generally northward along the east side, rotating counterclockwise into Kachemak Bay, and across the inlet to Kamishak Bay. The currents then flow southwest through Shelikof Strait, along the coast of the Alaska Peninsula toward the Aleutian chain. That is the path being followed by the oil.

Chronology of the Spill:

Based upon current information, the chronology of events regarding the spill is as follows:

The Exxon Valdez is a tanker of single-skin, high-strength steel construction. It is 987 feet long and 166 feet wide, about the size of an aircraft carrier. At the time of the grounding, it was loaded to a draft of 56 feet. The grounding upon the reef tore open eight of 11 cargo tanks. Three saltwater ballast tanks also were pierced.

The enormous damage sent crude oil pouring into the Sound. Within five hours, approximately 11 million gallons had been spilled. But

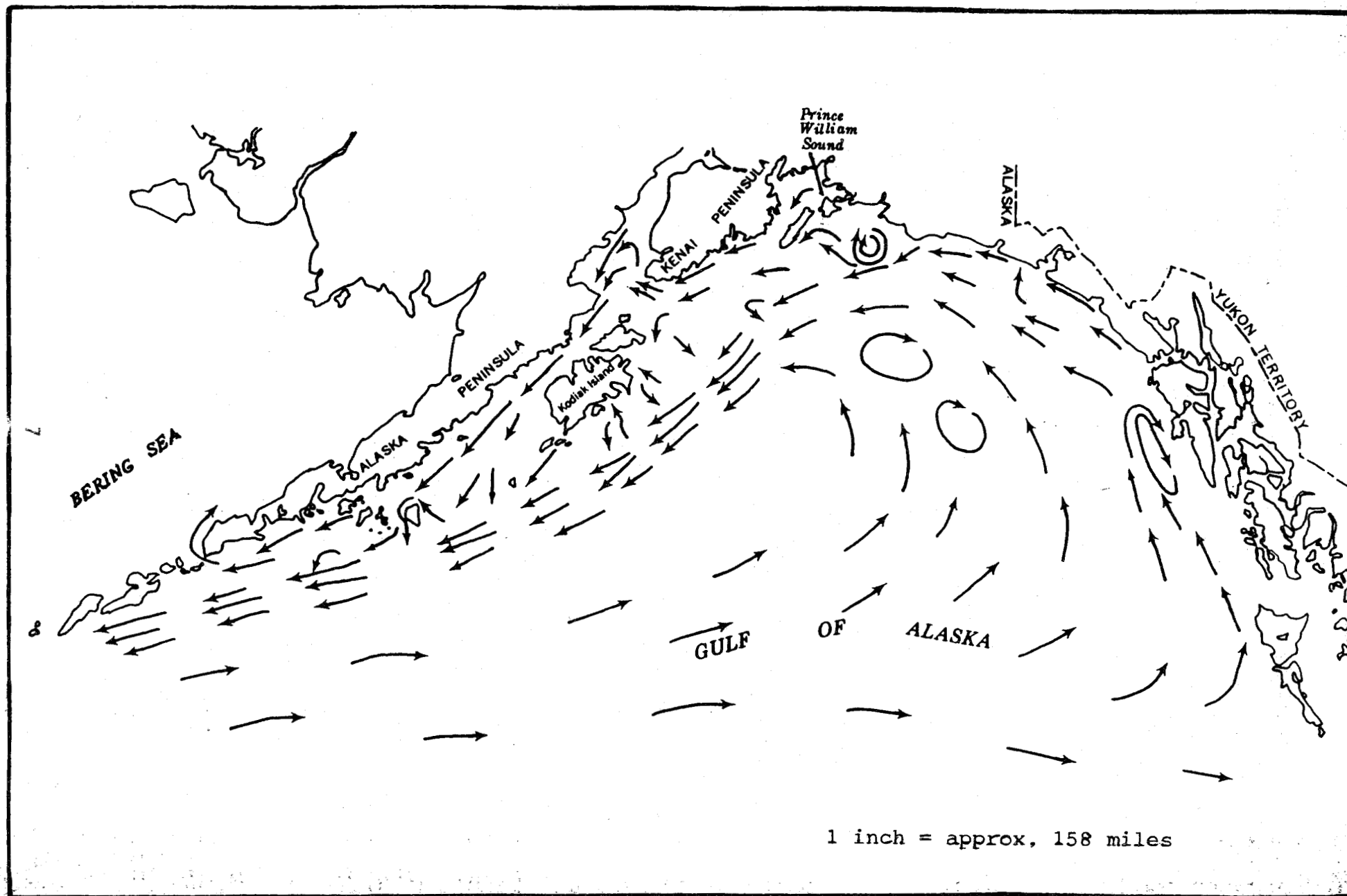


Figure 3. Major Currents in the Gulf of Alaska (schematic representation)

about 80 percent of the ship's cargo—43 million gallons—remained on board. Simultaneously, there were three top priorities: to contain the initial spill, to prevent the spilling of more crude oil, and to remove oil remaining on the ship. The actions that unfolded are described below:

- . The Port of Valdez was closed 24 minutes after the grounding. The port remained closed to all traffic for four days.
- . Shortly after the accident, Alyeska, the consortium of oil companies using the North Slope pipeline, was notified to activate its oil spill response contingency plan.
- . It was not until 7:30 a.m. that Alyeska had a helicopter aloft with a Coast Guard investigator aboard. Videotape recorded during that overflight shows an oil slick about 1,000 feet wide and 4 miles long.
- . But major problems had begun to arise. Alyeska's spill response equipment was not deployed quickly. A barge that was supposed to provide containment equipment at a spill within five hours had been stripped of its gear. Reloading the barge was time-consuming and further delayed when cranes loading the equipment on the barge were redirected to load a tug bound for the stricken ship. The barge left ten hours after the oil spill, and arrived on scene two hours after that.
- . The number and size of booms available for immediate use were insufficient to contain the spill. Few skimmers were put to work during the first 24 hours. Alyeska did not have a tank barge into which the skimmers could discharge recovered oil.
- . Environmentally sensitive areas needed protection. The National Oceanic and Atmospheric Administration (NOAA) had identified those areas before the spill. In addition, Alyeska's contingency plan identifies those areas and requires protective booming. When Alyeska failed to protect these areas, a group composed of DEC personnel and fishermen's groups identified the four key hatchery sites and equipment was deployed to protect them. This action was successful, but there was not enough equipment left to contain the oil or to protect other sensitive areas.
- . Exxon Shipping Company began clean-up on the second day after the spill. The Exxon Baton Rouge was directed to the scene to offload the remaining cargo. This critical work had begun within several days of the grounding. The last of the liquid oil cargo remaining on the Exxon Valdez was removed by April 4. The following day, the vessel was refloated and towed to a sheltered harbor on Naked Island for temporary repairs.

- . Exxon also attempted to burn the oil on the water, using fireproof booms to contain it. An estimated 15,000 gallons of oil were burned.
- . Shortly after the spill, the International Bird Rescue Research Center was contacted. Center personnel arrived on scene March 25 and began to set up a bird cleaning and rehabilitation center in Valdez. A specialist from the Hubbs Marine Research Institute in San Diego arrived in Valdez to set up a sea otter facility. Exxon hired these animal rescue specialists.
- . Sea otter collection began March 29. At the request of Exxon, the U.S. Fish and Wildlife Service assisted in this effort. The first sea otter cleaning and rehabilitation center opened March 30 in Valdez. Sea otter facilities also were established in Seward and Homer.
- . Bird collection, supervised by the U.S. Fish and Wildlife Service, began March 29. The first cleaning and rehabilitation center opened March 31 in Valdez. As the oil moved south, more centers were established in other cities.
- . On April 2, the Alaska Department of Fish and Game closed Prince William Sound's herring roe fisheries. Other fisheries were later closed as the oil moved through the Sound into the Gulf of Alaska and the entrance to Cook Inlet.
- . Prevailing currents and winds were moving the oil (now in the form of mousse and tar balls) out of Prince William Sound, into the Gulf of Alaska, and along the coast of the Kenai Peninsula toward Kodiak Island and the Alaska Peninsula (see Fig. 4). By April 11, oil had reached the Barren Islands and the entrance to Cook Inlet, 250 miles from Bligh Reef. It then entered Shelikof Strait between Kodiak Island and the Alaska Peninsula, reaching the southern end of the Strait by mid-May.
- . To date more than 700 miles of shoreline along the oil's path are known to have been oiled with the degree of oiling ranging from light to heavy. The degree of oiling will change as natural cleansing takes place and as tidal and storm action moves oil off and onto beaches, and from one to another.
- . Exxon initiated shoreline clean-up on April 2, placing work crews on Naked, Peak, and Smith Islands. The rocky shoreline, with cobbled beaches, makes clean-up extremely difficult and labor-intensive. Exxon temporarily suspended its clean-up efforts on April 13 while it developed a comprehensive shoreline clean-up plan for approval by the Federal On-Scene

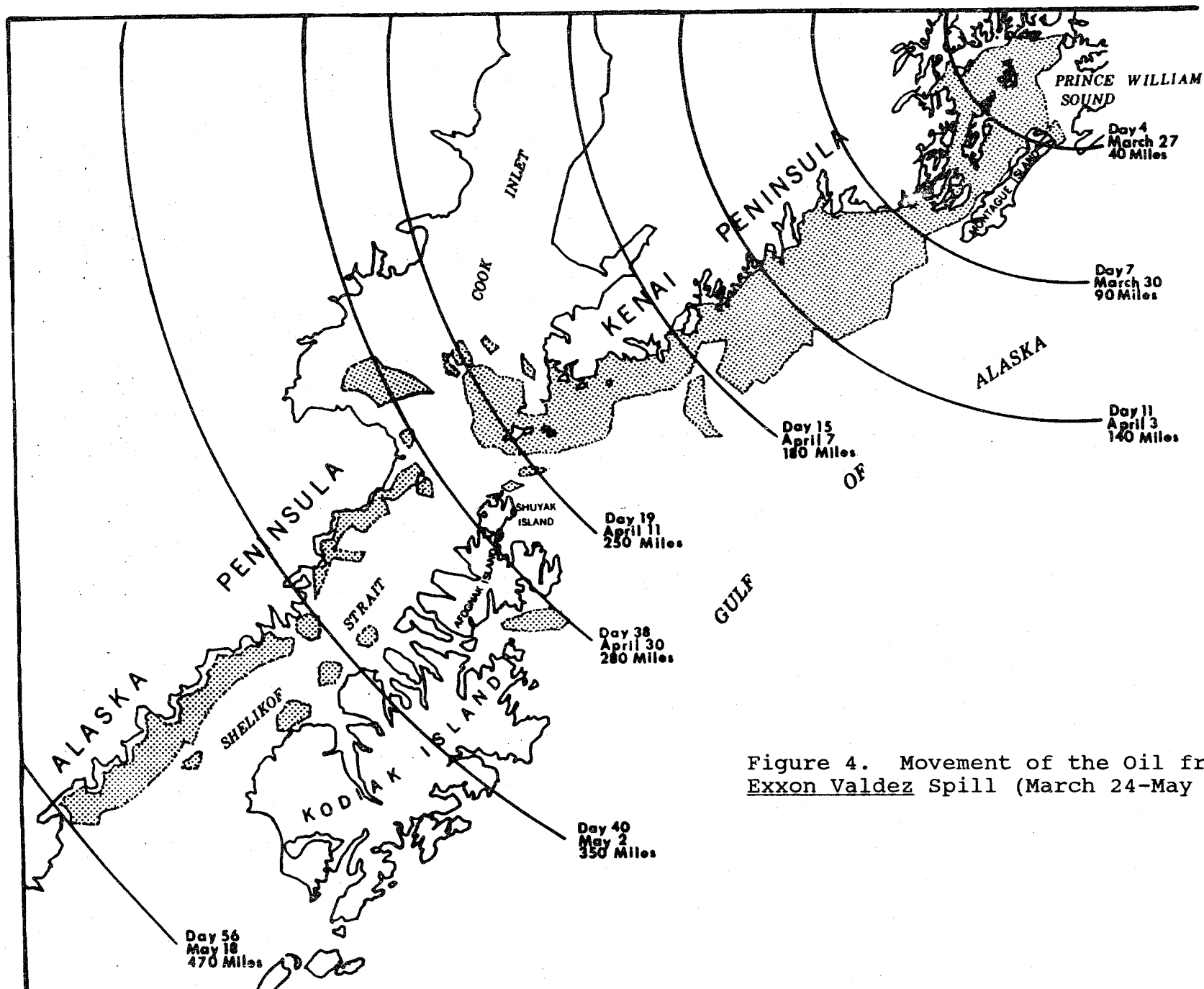


Figure 4. Movement of the Oil from the Exxon Valdez Spill (March 24-May 18, 1989)

Coordinator. Approval was granted on April 17 after Exxon agreed to hire more workers and speed up the work. Interagency Shoreline Clean-up Committees (whose membership includes the trustee agencies and other federal, state and local experts) were formed to advise on areas requiring priority attention and on clean-up techniques that would minimize environmental harm. Despite these efforts, progress continues to be slow, handicapped by the nature of the shoreline and by re-oiling as the tides bring in more oil.

FATE AND EFFECTS OF THE SPILLED OIL

The effect of an oil spill on the environment depends greatly on conditions at the time and place it occurs. The geographic location, weather, and time of year influence both the kind and number of living organisms there, and the transport and weathering (and thus the toxicity) of the oil itself. This section describes the behavior of spilled oil and the effects that have been seen or can be expected to occur in the spill zone (Fig. 5).

Transport and Fate of Spilled Oil:

Immediately after an oil spill at sea, floating slicks are transported by currents and winds. The oil's more volatile and soluble components evaporate into the atmosphere or dissolve into the water. Where there is high wave energy, especially near shore, small droplets of oil may be beaten into the surface water, thereby increasing both the speed with which it is accommodated in the water and the potential toxicity to plankton and fish.

The floating slick spreads as it is carried along the surface, emulsifying with increasing quantities of water along the way. After several days at sea, the oily mousse may contain as much as 75 percent water; the slick then begins to break up into floating masses. Later, these masses are broken up further by wave energy. They turn into tar balls that, because of continued evaporation and dissolving of lighter components, may float semi-submerged or completely under water.

When the floating oil or mousse contacts land, it may be stranded in the intertidal zone. In high-energy environments, the stranded oil coats the rocks and hardens into a tough, tarry "skin." Waves gradually erode the oil. As much as half of the oil may be washed away within the first 18 months, although pools of oil are likely to collect in hollows among the rocks, where it may remain for years. On cobble or coarse sand beaches, the oil may sink deeply into the sediments. Wave erosion is less effective in these environments, and slow biodegradation assumes a more important role in removal of the oil. However, because the oil is mobile in these porous beaches, some of it may gradually return to the water, and once again affect the life there. In muddy sediments, penetration

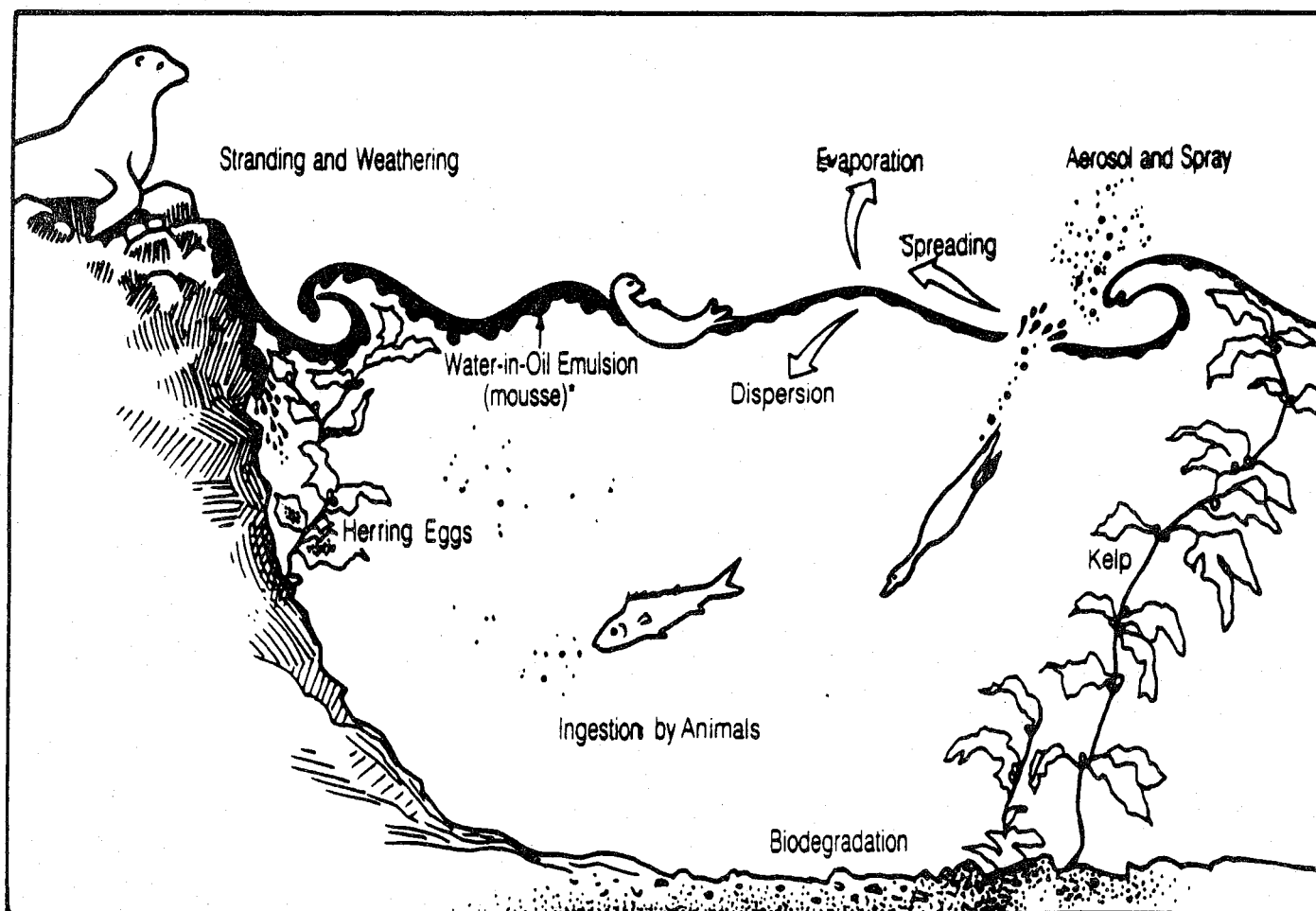


Figure 5. Behavior of Oil in the Alaskan Environment (schematic representation)

is minimal, and only the upper few centimeters are affected. But because muddy bottoms usually are found in low-energy environments (such as wetlands), the stranded oil may persist for decades. Once oil is beached, the wind and wave action may mix in sediments. Weighted down with sand and gravel it has collected, the oil is likely to end up on the bottom near shore.

After an extended period of floating at sea, patches of mousse and tar balls may collect small amounts of dense material, which can make them neutrally buoyant, or even cause them to sink. In some areas, oil that has reached the bottom, either by sinking at sea or by way of a beach, may interfere with fishing by fouling the gear. Tar balls also may be eaten by bottom-feeding fish, possibly tainting their flesh.

Prince William Sound, is generally a fiord/estuary system, and not a high energy, open coastal environment. Oil is likely to be moved deeper into the fiords rather than being flushed out. In general, this results in an oiling of increasingly sensitive environments, since the higher-risk, lower-energy environments are located deeper in fiords and bays. The entrances to the fiords are sheltered, rocky headlands, where oil may stick to rocks in the intertidal zone. With little abrasive wave action, oil could remain in such areas for years, with only slow chemical and biological processes to degrade it. Gravel beaches, another extremely vulnerable habitat, are common near these headlands. Since the oil was relatively fresh and unweathered when it first contacted the coastal areas in western Prince William Sound, it flowed and penetrated deeply into the gravel and cobble beaches. The potential exists for the oil released in the Exxon Valdez incident to persist in and on these Prince William Sound coastlines for many years.

The fiords along the outer Kenai Peninsula and the coasts of Kodiak Island generally are much more exposed to wave action than those in Prince William Sound. The rocky headlands and exposed beaches in these areas will undergo self-cleansing much more rapidly than in the Sound. As oil is transformed into mousse and tar balls, it becomes less likely to penetrate into sediments, so the effects decrease in relation to distance from the origin of the spill.

Toxicity of the Oil:

In general, petroleum hydrocarbons are more stable in cold climates than in warmer ones. Lower temperatures lead to slower rates of physical weathering and biodegradation of the oil. At any temperature, however, the aromatic constituents of petroleum tend to be acutely poisonous. These same components (benzene, toluene, xylene, naphthalene) also are among the first to dissipate. As they evaporate and dissolve, the acute toxicity of the remaining oil diminishes.

Oil usually is most toxic during the early stages in a spill, when the toxic aromatic components are most concentrated in the upper few meters of the water. Oil also is especially damaging to intertidal areas when it comes ashore soon after its release, as it did on Naked and Knight Islands, and the other nearby islands and mainlands along the coast of Prince William Sound.

Selected Environmental Effects of the Spill:

The immediate spill effects were most visible on marine birds and sea otters. Sea otters are extremely sensitive to oiling (pups even more than adults), as are seabirds that dive through the surface of the water to feed. The insulating quality of fur and feathers is reduced by oiling, and these creatures quickly succumb to hypothermia or drowning. The pre-spill population of sea otters in the affected portions of Prince William Sound was estimated at approximately 2,500 animals, with similar or greater numbers along the Kenai and Alaska Peninsulas.

Mammals and birds in the vicinity of the initial slick within the first week of the spill also were exposed to the fumes of volatile hydrocarbons in the air. That can lead to respiratory damage and death.

Terrestrial mammals near the spill in the early days also were exposed to strong petroleum vapors. These animals, including river otters, mink, bears, and deer, may also be affected through scavenging of oiled carcasses on the beaches or by browsing on oiled vegetation in the intertidal zone.

Those marine mammals that do not rely on hair or fur for thermal regulation (whales, porpoises, and harbor seals as opposed to sea otters) appear to be less sensitive to oiling. However, their overall vulnerability is not well known. For example, the ability of whales and porpoises to detect and avoid oil on the water's surface is a hotly contested topic. Pupping of harbor seals began in May, and the pups are picking up oil in the nursery areas. Some already have died.

The Fish and Wildlife Service counted more than 91,000 seabirds (mostly diving ducks, grebes, and loons) in Prince William Sound immediately after the spill. About half of these birds were in areas later reached by floating oil. Many of the birds were killed as the result of direct exposure to the oil. Others may be affected indirectly through loss of habitat or food. Seabirds were just returning to breeding and nesting colonies in the Sound and along the coast. Their success in breeding could be diminished by loss of habitat, loss of food, and the death of eggs and chicks. Large numbers of waterfowl and shorebirds stop each year to feed in Prince William Sound during spring migration in April and May.

These birds also were exposed to spilled oil, and may have been injured through loss of habitat or food.

In oiled coastal areas of western Prince William Sound and the nearby Gulf, intertidal organisms have died due to smothering and the acute toxicity of the oil. Clean-up activities in these areas also will affect them. Even after clean-up, some oil is likely to remain, deeply buried in the gravel and among the rocks. Recovery of intertidal populations may take many years.

Pacific herring are second in importance only to salmon among the fishery resources in Prince William Sound. Herring spawn in the lower intertidal and shallow subtidal zones in the Sound and elsewhere in the affected area. The roe are highly vulnerable and sensitive to oil, which may kill them outright or cause abnormalities in the developing embryos. As a result of the spill, both the herring and roe fisheries have been closed in Prince William Sound, and restrictions have been placed on the herring fisheries of Kodiak and lower Cook Inlet. Herring do not return to their natal areas to spawn until they are at least three years old. So the full effects of the spill may not become evident this year.

Prince William Sound accounts for about half of Alaska's total commercial harvest of pink salmon. Several state-owned and private hatcheries, along with wild stocks, support the pink salmon fishery in the Sound. Approximately one half of the wild pink salmon in Prince William Sound spawn in the intertidal zone. Hatchery-raised fry normally are released in early April and spend up to three months feeding in the shallow, nearshore areas before migrating into the Gulf of Alaska. Because of the spill, the release of fry was delayed in some areas. The salmon fry may be affected directly by hydrocarbons in these shallow nursery areas, or they may suffer from food shortages. That could result in lower returns of adult fish in 1991.

Four other species of salmon are found in the Sound. These fish spawn mainly in the rivers and streams, but some of the chum salmon spawn in intertidal gravel where there is some flow of fresh water. The production and survival of the 1989 fry from all of these species are at risk, as is the spawning success of adults returning in the fall of 1989.

The eggs and larval forms of many species of fish and shellfish were in near-surface waters at the time of the spill. The concentrations of hydrocarbons in the water beneath the floating slicks in Prince William Sound probably were sufficient to kill many of them, raising the possibility of delayed population effects in some species.

In addition to the injuries sustained by resource organisms and habitat, the spill affects important human activities. The great natural beauty of the area is the basis of a growing tourist industry and for outdoor recreation, such as hiking, camping, kayaking, hunting, and fishing. Several coastal communities rely on the impacted area for subsistence hunting and fishing. Archaeological sites with cultural and historical significance lie in submerged, intertidal and upland areas affected by the spill. The spectacular wilderness and beauty of the Kenai Fjords National Park, Katmai National Park, and the Chugach National Forest are of great intrinsic value to Americans throughout the nation. These areas have been fouled by spilled oil.

STATUTORY AUTHORITIES AND PROCEDURES FOR NATURAL RESOURCE DAMAGE ASSESSMENTS

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Water Act (CWA) together authorize a legal and procedural framework for damage claims for the injury or destruction of natural resources resulting from oil or hazardous substance spills. CERCLA defines natural resources broadly to include non-living resources (air, land, sediments, surface and ground water) as well as living resources (fish, wildlife, and other biota), 42 U.S.C. 9601(16). It authorizes the designation of federal and state officials to act as trustees to protect public interests in these resources by assessing damages for injuries to natural resources and submitting claims to recover damages from potentially responsible parties. Sums recovered through such damage claims are to be used only to "restore, replace, or acquire the equivalent" of the injured natural resources, 42 U.S.C. 9607(f). Trustees also may recover the costs of the assessments to determine injury to the resources and the dollar value required as compensation for that injury, 42 U.S.C. 9607(a)(4)(c).

CERCLA called for federal regulations to establish procedures for assessing damages resulting from the injury to or destruction or loss of natural resources. The regulations were to specify standard procedures for simplified assessments requiring minimal field observation (Type A), and alternative protocols to determine the type and extent of short- and long-term injury, destruction, or loss (Type B). These regulations were issued by the U.S. Department of the Interior in 1986 and 1987 and located at 43 CFR Part II. The Type B regulations outline the scientific methods to determine: 1) the pathway through which pollutants reach the resources of concern, 2) the adverse effects of the pollutants on the resources, and 3) the extent of those injuries, the estimated time required for the resources to recover to pre-spill condition, and the loss of services during that time.

Information derived from this quantification of the injury is then used by the trustees to estimate the amount of money to be sought as compensation. In addition to restoration costs, trustees also can claim lost use value during the period of time required for restoration or replacement of the injured resources.

The natural resource provisions of CERCLA have been extended to the CWA, an earlier statute that provides authority for federal response and clean-up of oil spills and for recovery of any costs associated with these actions. Under the CWA, federal or state officials are authorized to act on behalf of the public to recover the costs of replacing or restoring resources injured or destroyed by a discharge of oil. Sums recovered must be used by the appropriate federal or state agencies to restore, rehabilitate or acquire the equivalent of the injured or destroyed natural resources.

Management Structure for the Exxon Valdez Damage Assessment:

The oil that spilled from the Exxon Valdez has affected natural resources under the trusteeship of the State of Alaska and three federal departments (Departments of Agriculture, Commerce, and the Interior). The Secretary of Agriculture, the Secretary of Commerce, the Secretary of the Interior, and the Commissioner of the Alaska Department of Fish and Game (for the State) are working together to develop a joint assessment plan and to initiate the studies required for the assessment. As the assessment studies proceed, the restoration plan will be developed and implemented to facilitate resource recovery. Restoration efforts will begin as soon as practical after information is obtained on the extent of resource injury.

To facilitate the process, they have established a Trustee Council based in Alaska consisting of a single representative of each Trustee agency. The U.S. Environmental Protection Agency is participating in the Council's activities as an advisor to promote the long-term revival of the ecology of Prince William Sound. In addition, the U.S. Departments of Justice and Transportation, the U.S. Office of Management and Budget, the Alaska Department of Environmental Conservation and other federal and state agencies deemed appropriate by the Trustee Council each may provide one consultant to the Council.

The Trustee Council members will coordinate the assessment of damages to the resources. They also will evaluate the Natural Resource Damage Assessment regulations and consider whether, and to what degree, the procedures in those regulations should be utilized to assess damages caused by the Exxon Valdez oil spill. To assist in the work, the Council has appointed a Management Team, Legal Team, and Budget Control Team.

The Management Team is composed of a representative of each Trustee and a representative of EPA. Under the guidance of the Trustee Council, the Management Team will coordinate all aspects of the assessment of natural resource damages resulting from the Exxon Valdez spill. Included are the preassessment screen, preparation of the assessment plan, conduct of the assessment, and determination of the damage claim. The Management Team will prepare cost estimates for implementing the assessment, and forward these estimates to the Budget Control Team for review.

Each of the four Trustees has different responsibilities for resources injured by the spill. The studies outlined in the assessment plan are designed to quantify adverse effects that may be reimbursed—regardless of who might be reimbursed—by the potentially responsible parties. As soon as possible after quantification of injury, restoration plans will be developed for the affected resources and funds provided by the responsible party will be employed to effect natural resource restoration.

The four trustee agencies have worked closely with the U.S. Coast Guard, which is overseeing Exxon's response and clean-up efforts, to protect their trust resources as much as is possible during the clean-up. The Trustees are, for example, represented on all of the Interagency Shoreline Clean-up Committees. These groups provide advice to the Federal On-Scene Coordinator to assist that official in approving Exxon's clean-up proposals for the different types of oiled shoreline.

The Trustees have determined that the Exxon Valdez spill, because of its size and geographic scope, does not meet the criteria established in the Natural Resource Damage Assessment regulations for the use of the Type A simplified damage assessment procedures. While the proposed damage assessment plan is generally consistent with the federal regulations for Type B full-field assessments, the Trustees have not yet decided whether, or to what extent, to utilize these regulations in conducting the assessment. Nor have the Trustees determined whether the potentially responsible parties should participate in the damage assessment or the extent of that participation.

Phases Of The Damage Assessment Process:

Major steps in the damage assessment process are diagramed in Figure 6. The grounding of the Exxon Valdez and the release of its cargo set into motion the preliminary confirmation of exposure and the planning process leading to this Damage Assessment Plan. The results of the studies described in the plan will support an assessment report, on which the claim for damages will be based. In concert with the studies, the Trustees will begin preliminary restoration planning so that final restoration can begin as soon as possible after recovery of the claim.

THE DAMAGE ASSESSMENT AND RESTORATION PROCESS

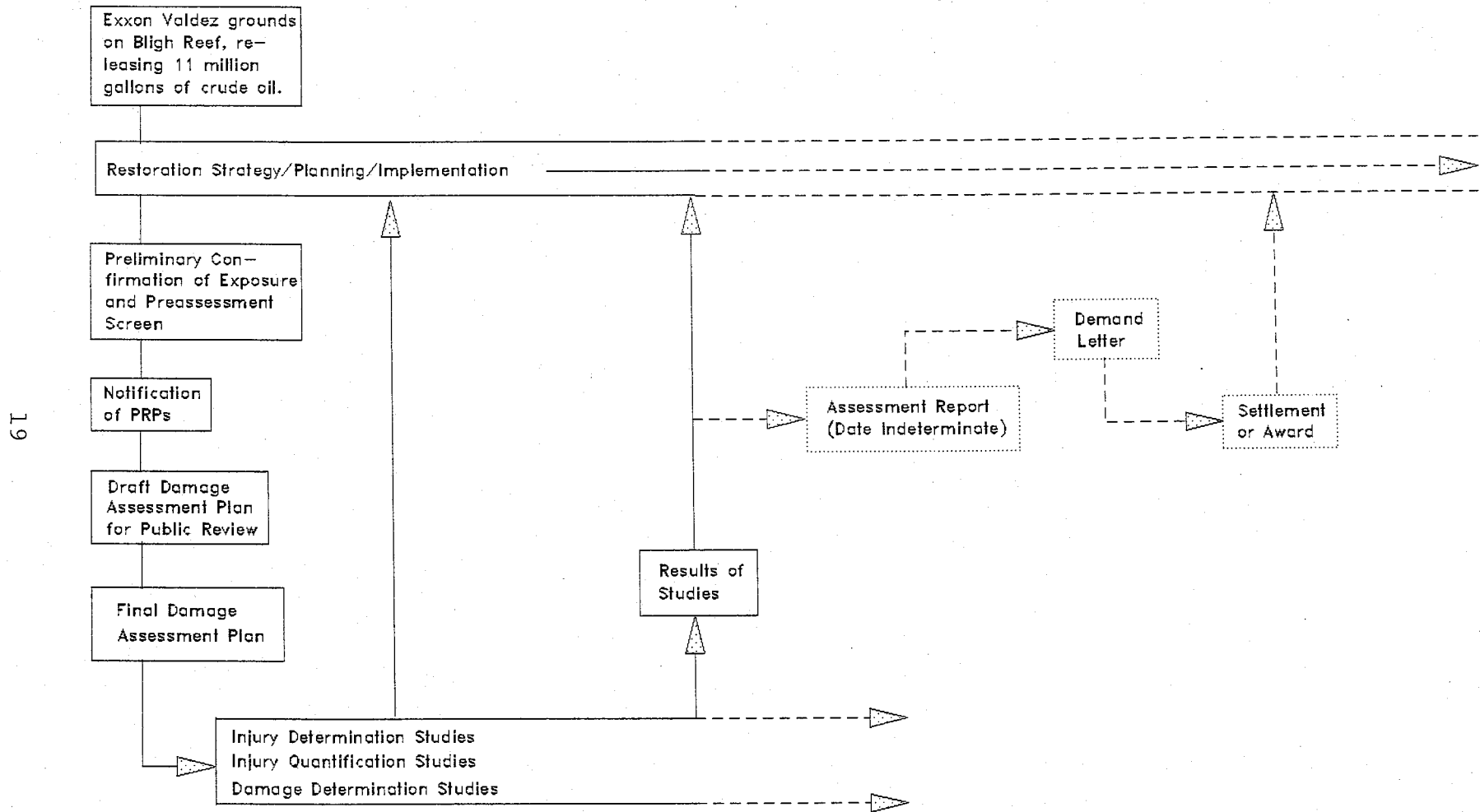


Figure 6

NATURAL RESOURCE DAMAGE ASSESSMENT STRATEGY

The overall strategy for the damage assessment represented in this plan is diagramed in Figure 7. Several categories of information are ultimately required. To support the estimates of economic damage for lost or injured resources, scientific information is needed: 1) to verify the nature and magnitude of the injury sustained, 2) to provide proof that the injury was caused by the spill, and 3) to identify potential needs and approaches for restoring the resources. The studies described in this plan are designed as an integrated set to provide all information needed to support a claim for damages, and ultimately, lead to resource restoration.

In accord with the Natural Resource Damage Assessment Regulations, the overall damage assessment consists of three major components: 1) determination and quantification of injury, 2) determination of damages (Fig. 7), and 3) development of a restoration strategy. The injury determination phase documents the exposure of the resources to Exxon Valdez oil and determines whether that exposure harmed them. The injury quantification process determines the magnitude of the adverse effects on each resource through time. Determination of damages involves the assignment of economic values, or damages, that may be claimed for the cumulative injury sustained by all resources.

Determination and Quantification of Injury:

While certain kinds of injury are apparent immediately, other kinds are not. They can only be derived based on information about: 1) the distribution, transport, and persistence of spilled oil, 2) the distributions of various resources, and 3) their sensitivities to oil exposure. Such impact hypotheses have been derived, where necessary, from a combination of historical information and new data gathered at the Exxon Valdez oil spill site. Demonstration of injury amounts to verification of hypothesized effects. Injury demonstration depends on confirmation of exposure of the resource to petroleum and detection of a change in the distribution, productivity, or quality of the resource.

Exposure can be demonstrated by information on the distribution and chemical composition of spilled oil in space and time, along with information on the actual presence of petroleum residues or their metabolites in the tissues of resource organisms. In those organisms where petroleum residues or metabolites are measured, subcellular effects also may be detected. Such information can be instrumental in demonstrating injury and in supporting claims for damages to the injured resource.

Although the Natural Resource Damage Assessment regulations suggest that determination and quantification of injury are separate and sequential activities, they frequently must be conducted

TRUSTEE COUNCIL APPROACH TO THE Exxon Valdez Natural Resource Damage Assessment

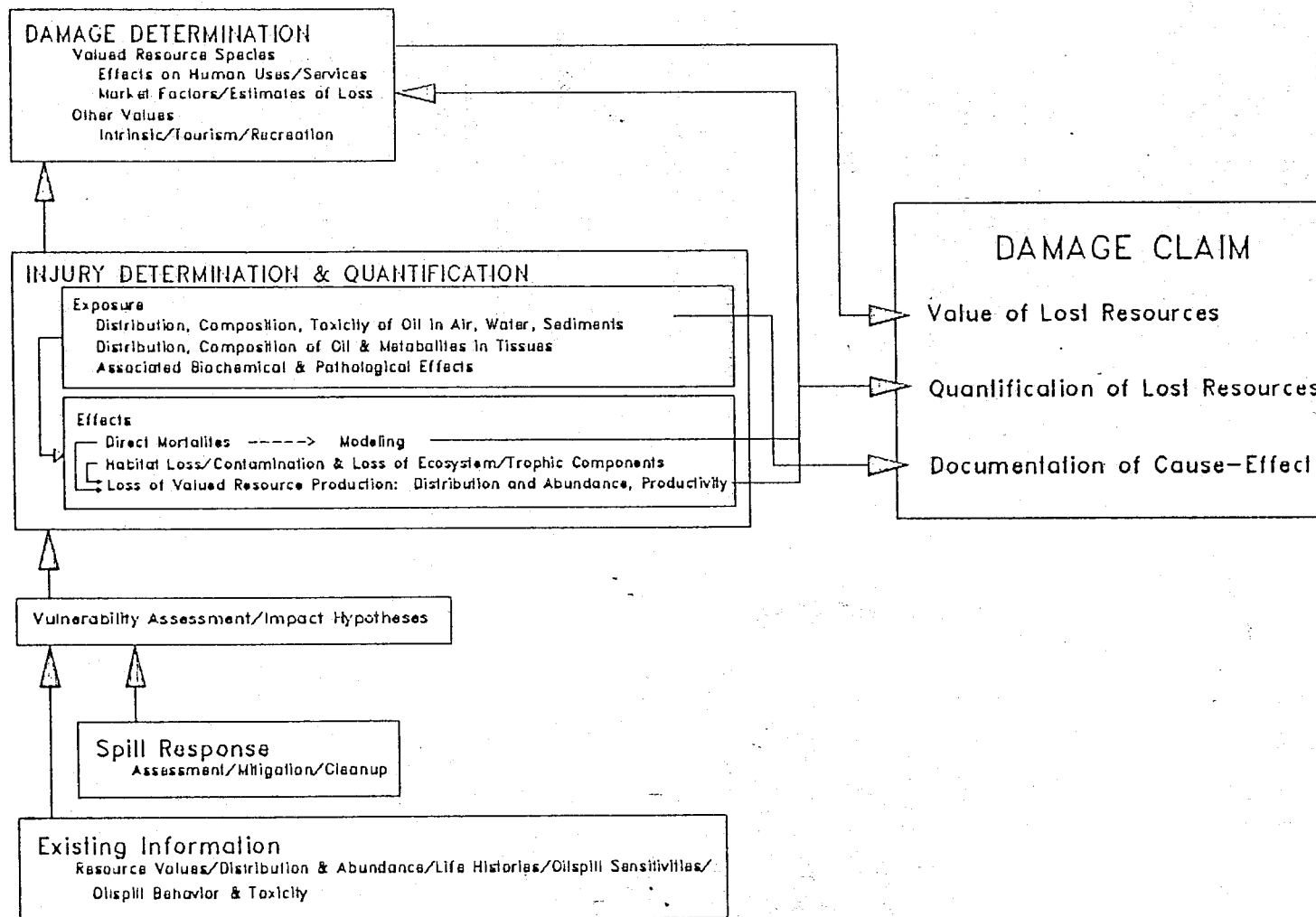


Figure 7. The overall approach adopted by the Trustee Council for the Exxon Valdez natural resource damage assessment

simultaneously. Injury to a natural resource may be manifested either by an adverse change in the quality of that resource or by a reduction in the quantity or productivity of the resource. In the latter case, resource surveys and population dynamics studies may be used to determine whether the spill has had a significant effect. Since populations often undergo fluctuations as a result of natural processes, spill-related injury may not be detectable without substantial and simultaneous emphasis on quantifying the injury. As a result, many of the studies included in this plan address both objectives together.

Use of existing information: Where possible, the basic approach of the injury determination/quantification phases is to compare conditions following the spill with base line (pre-spill) conditions. These are available through historical data on the productivity of commercial fisheries in the impacted region, and on the numbers of birds, mammals, fish, and invertebrates that are known to inhabit the Sound and adjacent Gulf of Alaska. Historical data also are available for the subsistence use of birds, fish, shellfish, and mammals, and for recreational use. Economic values can be developed from these data.

Pre-spill conditions have been documented for some ecosystems and sites in the Sound. Monitoring sites established previously by various federal and state agencies have been sampled over the years and were re-sampled just ahead of the advancing oil by a team of NOAA, U.S. Fish and Wildlife Service, and Alaska Department of Fish and Game personnel. Post-spill conditions will be documented through the collection and analysis of samples of sediment, water, and biota; the counting of selected biota at severely impacted, lightly impacted, and non-impacted sites, and repeated sampling of the relevant resources and locations. The studies in this plan have been designed to make maximum use of information generated during the emergency response to the spill. For those resources or locations lacking adequate historical data, the assessment will be based on comparison of impacted areas with unimpacted, but otherwise similar, areas nearby. This approach also substantiates the cause-effect relationship between the observed injuries, the spill, and its associated response/clean-up activities.

An extensive data base concerning the effects of oil, specifically North Slope crude oil, exists for Alaskan marine organisms and ecosystems. The use of these data and associated physical and biological models will provide estimates of food chain effects, long-term ecosystem losses, and recovery rates. These estimates will be validated with measurements made as part of the damage assessment.

Criteria for study evaluation: To be included in this Damage Assessment Plan, each study was determined to be acceptable (either

on the merits of the individual study alone, or in combination with other studies) according to the following criteria:

1. Likely Validity of Impact Hypothesis

- The hypothesized injury is based on sound scientific evidence.
- The expected magnitude of injury or loss in services will be detectable and quantifiable.

2. Soundness of Scientific Approach

- The study design ensures high probability that resulting data will be conclusive.
- Observation/measurement methods have appropriate sensitivity and resolution.
- The study provides for appropriate quality assurance/quality control.

3. Cost-Effectiveness

- The study is conducted in the most efficient, cost-effective manner.
- Study costs are reasonable in relation to the damage they are likely to document.

4. Coordination with Related Work

- The study does not re-create existing data, information, and models, and takes advantage of these where appropriate.
- The study does not duplicate other studies and is coordinated with other studies for maximum effect.

Scope and integration of study design: The injury determination and injury quantification studies are categorized into seven major groups: 1) Coastal Habitat, 2) Air/Water, 3) Fish/Shellfish, 4) Marine Mammals, 5) Terrestrial Mammals, 6) Birds, and 7) Technical Services. The general objectives of each category are described in Part I of this plan, along with descriptions of each study to be performed. These studies are to be performed in accordance with the requirements of the quality assurance/ quality control plan (shown as Appendix A). The technical services unit provides direction and support for all chemical analyses and histopathological observations, and establishes a centralized and integrated geographical information system and mapping function for the overall damage assessment process. The studies are coordinated within each group and across all groups to determine and quantify in the most effective manner possible the injury to each category of natural resource, and to support the damage determination and subsequent restoration process.

Because of their expertise and experience in assessing injury to a population, habitat, or use, damage assessment project leaders will be asked to provide in their reports an assessment of 1) the feasibility of restoring or replacing an injured resource, population, or use, and 2) alternative strategies or methods for restoration or replacement. These assessments and alternatives will be evaluated by restoration specialists. Feasibility of restoring or replacing the resource, use, or habitat will be determined, the approximate cost of restoration alternatives will be determined and a strategy for restoration or replacement will be recommended.

Together, the Coastal Habitat and Air/Water studies support an integrated assessment of exposure, in turn, that supports many of the other resource-oriented studies (Fig. 8). These studies document the occurrence of petroleum in all compartments of the environment that are major pathways of exposure for valued resource species: air, water, sediments, and, to a limited extent, food. For each of the resource-oriented study categories, this exposure assessment enables: 1) delineation of the potential area and duration of exposure to oil, 2) documentation of the cause-and-effect relation between the observed injury and the oil pollution or ensuing response/clean-up activities, and 3) quantification of the recovery rates of the affected habitat or resource species.

Determination of Damages -- Economic Valuation Methodologies:

The methods used to measure the damages caused by the spill are expected to largely parallel those outlined in the Natural Resource Damage Assessment regulations. Several items related to economic methodology are elaborated below.

Basis of damage calculations: Economic damages may be calculated as the cost of restoring or replacing the resources, or resource services, injured by the spill in addition to the value of the goods and services reduced or lost as a result of the spill (also referred to as the "diminution of use values").

Services or uses are basis of economic studies: The non-economic studies performed in support of this assessment determine injury to specific natural resources in the affected areas. For example, studies are being conducted to determine the direct effects of the spill on certain species of birds and fish. The purposes of these studies are to establish that injury has occurred, quantify the amount of injury, and identify mechanisms by which the injuries are transmitted throughout the ecosystem.

A resource-by-resource approach is logical for documenting injury to natural resources. The economic value of resources stems primarily from the services those resources provide to humans. In order to quantify economic damage, it is necessary to determine how

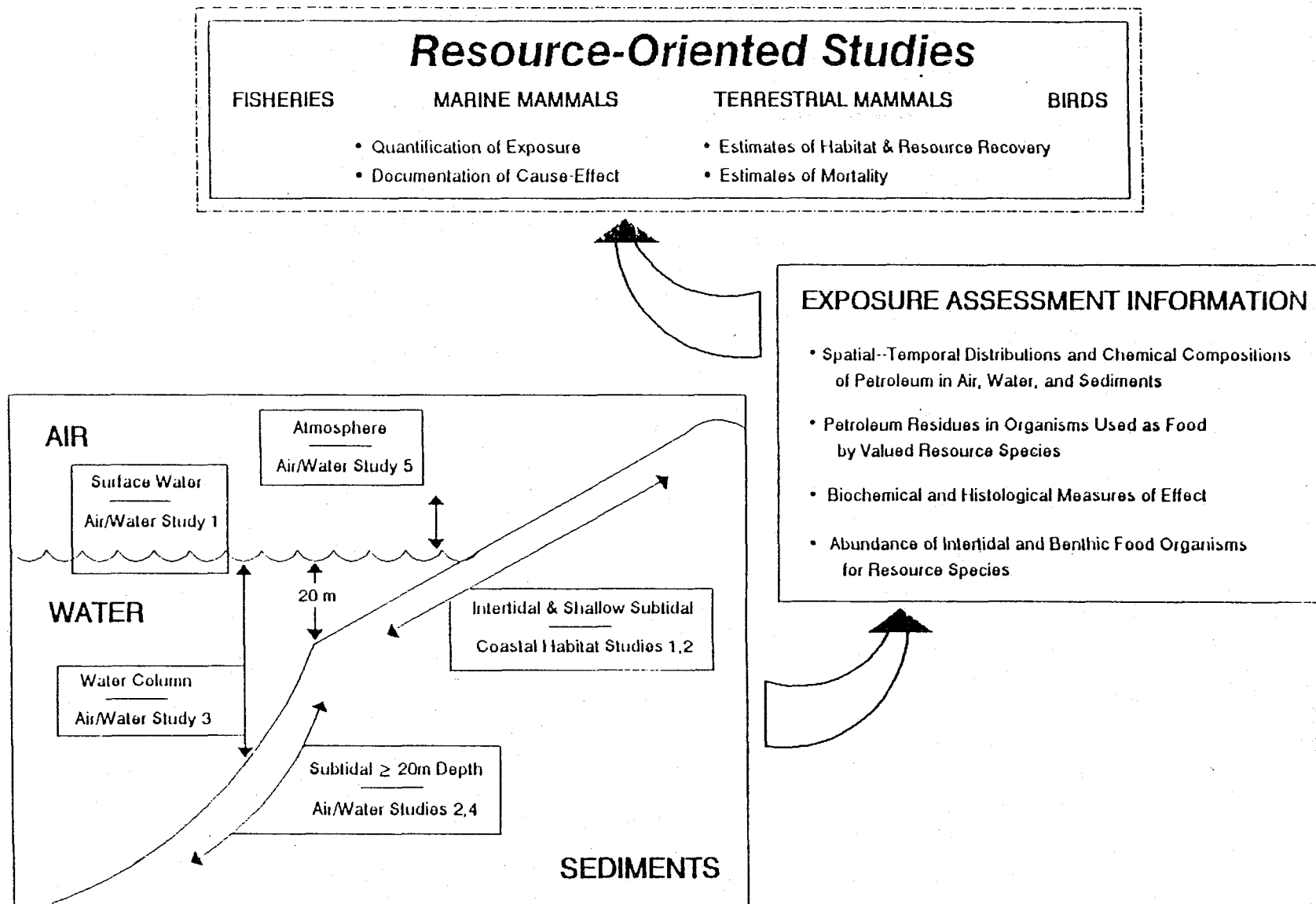


Figure 8. The resource-oriented studies depend heavily on information generated by the coordinated set of Coastal Habitat and Air/Water studies.

the injury to the natural resource affected human activities. The total economic damage caused by the spill can be determined by adding up the damages caused to all of the human uses (including intrinsic value) of the injured resources. Care has been (and will be) taken to avoid double counting of economic damages.

Base line services: To the degree feasible, the assessment will encompass the principles outlined in the Natural Resource Damage Assessment Regulations where damages are calculated relative to the pre-spill base line level of human uses of the resources. Under this principle, one measure of economic damages caused by the spill are the difference in the economic value of the human uses of the resources occurring with and without the spill.

Discount rate: The Natural Resource Regulations specify that a 10 percent real rate of discount shall be used to calculate the net present value of the economic damages. The rate to be used as a basis for calculating the final damage claim against the potentially responsible parties has not yet been determined by the Trustee Council.

Determination for continuation of studies: All studies are designed for early detection and determination of injury. They will be terminated on February 28, 1990, except those approved by the Trustees upon recommendation of the Trustee Council and scientific and legal review groups as being necessary to promote restoration and to support assessment of legally recoverable natural resource damages.

NATURAL RESOURCE RESTORATION PLAN

Restoration includes actions undertaken to restore an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided. Recognizing the necessity for an expeditious determination of the feasibility of and methodology to be used in restoring injured natural resources and public uses, the restoration planning process will begin immediately under the direction of the Trustee Council. A restoration plan will be written, and restoration activities may commence as soon as injuries to resources are sufficiently evaluated.

Due to the magnitude of the injuries associated with this oil spill, and the need to begin restoration work as soon as practicable, specific elements of a restoration plan for discrete habitats or species may be written when injury is sufficiently evaluated for that particular habitat or species. The actual number of elements to be developed will likely change as new information becomes available. The various elements will be combined into a restoration plan which will form the basis for the

natural resource restoration or replacement activities to be done under statutory authorization of CERCLA and the CWA.

In developing a restoration plan, the natural resource injury assessment reports will be reviewed to identify the areas where restoration may be appropriate. Restoration techniques and strategies will be evaluated and an assessment of the feasibility and costs of each will be made. A recommendation of the most appropriate and cost-effective methodology will be made and, following public review, a final restoration plan, including restoration strategies and schedules, will be adopted.

Restoration Plan Development Process:

Under the direction of the Trustee Council, and with the federal effort being coordinated with the Washington, D.C., restoration subgroup, the following approach in developing the restoration plans will be utilized:

1. Restoration literature, injury assessment reports, and recommendations of principal investigators to identify restoration methods and strategies will be reviewed. Other types of injury assessment information will also be reviewed and evaluated as appropriate;
2. Public agency and scientific input on natural resource injuries and restoration or replacement methods and strategies will be considered;
3. Alternatives to restore injured resources and services to pre-spill conditions will be evaluated. Techniques available in biological and physical sciences to restore and replace resources will be considered. The impacts of restoration or replacement on other resources and uses will also be considered;
4. Public review in development of restoration plans will be provided.

The Restoration Plan:

The restoration plan for Prince William Sound and other areas impacted by the Exxon Valdez oil spill will focus on the injuries identified by injury assessment studies and on the long-term recovery of the ecosystem. Recognizing the importance of reestablishing ecological health, resource- and/or habitat-specific restoration plan elements will be developed, as soon as practical, after specific natural resource injuries have been sufficiently evaluated. Plan elements will present resource/habitat-specific restoration alternatives, recommend restoration activities, and will emphasize the recovery of the ecosystem.

Implementation of the restoration activities will begin as soon as possible after public review and approval by the Trustees. This approach will provide the flexibility to accommodate and evaluate all the results and recommendations of the assessment studies as they are completed, while avoiding undue delay in the implementation of critical restoration activities.

The restoration plan elements will include consideration of a range of restoration and/or replacement alternatives intended to restore lost or injured resources and uses to their pre-spill level. All alternatives, ranging from direct replacement to no action, will be evaluated. The types of activities to be considered will vary for each affected resource/species/habitat and could include, for example:

- no or minimal active restoration, with the natural resources recovering to pre-spill conditions over time;
- reestablishing the food base for a certain species and then introducing individuals of that species into the affected area;
- building and operating a salmon hatchery to enhance the number of salmon present in a particular area; and
- allowing natural populations to expand.

Restoration alternatives will consider techniques available in the biological, physical, and other sciences, and will consider the long-term and indirect impacts of restoration or replacement on other resources and uses.

Part I

Studies: Injury Determination/Quantification

NOTE

Each of the following studies contain a description of one year costs. These are projected obligations accrued from the onset of the project through February 28, 1990, and includes all field and analysis activities. Budgets are presented in 1,000's of dollars.

COASTAL HABITAT INJURY ASSESSMENT

More than 700 miles of coastal habitat (including the shallow subtidal, intertidal, and portions of the supratidal zones) in three geographic regions (Prince William Sound, Cook Inlet and the Kenai Peninsula, and Kodiak and the Alaska Peninsula) had received light to heavy oiling from the Exxon Valdez oil spill by late May 1989. These coastal habitats may sustain additional injury from the ensuing clean-up activities. Assessment of injuries to coastal habitat resources and of their rates of recovery require consideration of the various categories of coastal morphology, the degree of oiling, the specific biotic assemblages affected, and their trophic interactions. Assessment of clean-up effects is another component of the injury assessment.

These coastal habitats are used by many organisms important to people, including fish, shellfish, birds, and mammals. These habitats also are used for human activities including recreation, fishing, and mining. Clean-up procedures may not only reduce the adverse effects of oil, but also may cause additional injury to the coastal habitat. Assessment of clean-up effects is an essential component of overall injury assessment. The Coastal Habitat studies are designed to estimate the effects of the spill and associated clean-up activities in terms of 1) abundance of intertidal and subtidal organisms used as food by valued resource species, 2) contamination of these same food resources by oil, 3) quantification of injury over the entire affected area, and 4) recovery of various habitat types after clean-up treatments.

This portion of the Damage Assessment Plan is useful in documenting the potential for effects of oil spilled in coastal habitats to enter the food chain and affect higher order organisms of economic importance. These Coastal Habitat studies are closely coordinated with related studies of higher order organisms throughout the Damage Assessment Plan.

A statistically valid design for sampling coastal habitat injury will provide a basis for determining the extent of injury to the entire area affected by the oil spill. These studies will provide supporting data for determining and quantifying injury to the species of fish and shellfish, mammals, and birds that provide services directly to humans and which therefore can be valued in monetary terms. In addition, these studies will serve as the basis for estimating rate of recovery, and the need and potential for assisting recovery of the natural resources through restoration or replacement.

COASTAL HABITAT STUDY NUMBER 1

Study Title:

Comprehensive Assessment of Injury to Coastal Habitats

Concern/Justification:

Coastal habitats are particularly vulnerable to oil spill impacts because of the grounding of oil in the intertidal zone, the persistence of oil in intertidal and subtidal sediments, and the effects of associated clean-up activities. Assessment of injuries to coastal habitat resources and determination of rates of recovery requires consideration of the various coastal geomorphologic types, the degree of oiling, the affected biotic assemblages, and their trophic interactions. Different categories of coastal habitats will be targeted for intensive study based on importance of ecological and human use, sensitivity to oiling, and likely persistence of oil. Guidance for the use of control areas is provided in 43 CFR § 11.72.

During phase one, the affected coastline will be categorized into five representative coastal habitat types, each subdivided further into areas that were unoiled, or received light or moderate/heavy oiling. Selection of study sites within each category will be based on a statistically valid sampling strategy ground-truthed through a reconnaissance survey. The statistical design, in accordance with the Quality Assurance Program, will permit extrapolation to the entire affected area of the injuries determined through analysis of the study sites. During phase two, an intensive evaluation of study sites will be conducted to determine the extent of injury to natural resources.

Objectives:

Phase One

- A. Establish a statistically valid site selection and sampling strategy and identify potential study sites using an existing coastal morphology classification scheme and shoreline impact survey maps.
- B. Ground-truth and establish approximately 150 study sites as determined to be necessary in paragraph A.

Phase Two

- A. Assess changes in critical trophic levels and interactions, and assess changes in terms of quantity (biomass and productivity/activity of population), quality (vigor, and

utility to other trophic levels), and composition (composition of communities, diversity and standing crop of key species).

- B. Assess injury to beach sediments and soils.
- C. Establish the response of these parameters to varying degrees of oiling and subsequent clean-up procedures.
- D. Quantify and extend impact results to the entire spill affected area.
- E. Estimate the rate of recovery of these habitats and their potential for restoration.
- F. Provide linkages to other studies by demonstrating the relationships between oil, trophic level impacts, and higher organisms.
- G. Determine levels of toxicity resulting from hydrocarbon contamination in water/sediment columns along the shoreline.
- H. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with Air/Water Studies 1 through 5 to provide a comprehensive assessment of potential resource exposure to petroleum via air, surface water, the water column, and intertidal/subtidal sediments. Many of the other studies (including Fish/Shellfish Studies 1, 7, 11, and 12; Marine Mammals Studies 5 and 6; Terrestrial Mammals Studies 1 through 5; and Birds Studies 2 through 4 and 8 through 12) rely on this study for information on abundance of food organisms, and on potential petroleum exposure either from contaminated food or through direct uptake from the environment.

Methods and Analyses:

Phase I

Using a geographic information system, potential study sites will be identified by overlaying shoreline impact maps on coastal morphology maps. Replicate study sites (tentatively 3 each) will be selected for each of 45 categories of coastline (3 Regions: Prince William Sound, Kenai Peninsula-Lower Cook Inlet, and Kodiak-Alaska Peninsula X 5 habitat types X 3 degrees of oiling: none, light, and moderate to heavy). Up to fifteen additional study sites representing light and moderate to heavy oiling in Prince William Sound will be added, bringing the approximate total number

of sites to 150. Candidate study sites will be visited, marked, and photographed to define boundaries and prepare site descriptions.

Phase II

Four vertical transects will be established on each of the 150 sites through all three zones (subtidal, intertidal, and supratidal). Chemical/physical characteristics of areas will be determined including salinity, soil/sediment texture, degree of oiling (percent covered, depth, hydrocarbon composition), volatile organic compounds, etc. Changes over time in oil distribution and composition will be documented. Community composition, cover, and standing crop by trophic level will be estimated. Key species (dominant producers and food sources) will be determined and studied to estimate the quantity, quality, and composition at each trophic level, and to collect samples for determination of hydrocarbon contamination. Additional species will be studied to meet requirements of other injury assessment studies. Using a geographic information approach, the impact by habitat type and degree of oiling over the entire area affected by the spill will be integrated and field verified. On-site amphipod LC50 bioassays will be performed using ASTM STP 854 protocol.

Lead Agencies: Alaska Department of Fish and Game and U.S. Forest Service

Cooperating Agency(ies): Federal: EPA, NOAA, USDI
State: DEC, DNR

Budget: Alaska Department of Fish and Game

Phase I

Salaries	\$66.0
Travel	20.0
Contracts	420.0
Supplies	15.0
Equipment	<u>15.0</u>

TOTAL \$536.0

U.S. Forest Service

Phase II

Salaries	\$412.0
Travel	32.0
Contracts	3330.0
Supplies	270.0
Equipment	<u>856.0</u>
<u>TOTAL</u>	\$4900.0*

* Includes \$218.0 to be contracted to NOAA.

AIR/WATER RESOURCES INJURY ASSESSMENT

The evaluation of injury to the air and water resources is a critical component in assessing the overall damage to natural resources. Five studies have been developed: four on water, and one on air.

WATER RESOURCES

Assessment of the concentrations of petroleum hydrocarbons in the water column of Prince William Sound and the Kenai Fiords region began within the first few weeks of the Exxon Valdez spill. Oil has impacted pelagic and nearshore waters; benthic sediments, intertidal habitats, and adjoining habitats above high tide. Quantifying hydrocarbon levels in the water column is most critical during the first few weeks following an oil spill, when dissolution of soluble components is most rapid and the likelihood of toxic exposure is highest. Marine water quality is protected under state and federal water quality standards (including use classes for growth and propagation of fish and wildlife, aquaculture, and human uses such as recreation). Moreover, State of Alaska water quality standards for petroleum hydrocarbons establish three criteria for "receptors" (habitats) that are broadly defined as "water":

1. Water column concentrations of aromatic hydrocarbons shall not exceed 10 ug/liter (parts per billion).
2. No visible sheen, film, floating oil, or discoloration shall occur on the surface of the water.
3. Concentrations of hydrocarbons in sediments shall not have deleterious effects on aquatic life.

The four water proposals found in this package are designed to reveal violations of any or all of these three criteria. Documenting these violations will assist in demonstrating injury to the water resource; and chemical exposure of marine mammals, birds, intertidal and shallow subtidal communities, fisheries, and terrestrial mammals dependent on beach habitats.

Initial estimates of the extent of floating oil and water column concentrations demonstrate the need to assess areas outside the Sound as part of a comprehensive damage assessment. Necessary sampling in geographic areas that have been or will likely be affected by oil is reflected in the water studies.

The Air/Water studies are integrated with the Coastal Habitat studies to serve many other projects, in that injury to air and water habitat clearly relates to injury of biological resources.

These studies also will assist in establishing the need and method for restoration of air and water resources.

The four water quality studies focus on:

1. Geographic extent and temporal persistence of floating oil from the Exxon Valdez.
2. Geographic and temporal distribution of dissolved and particulate petroleum hydrocarbons in the water column.
3. Petroleum hydrocarbon-induced injury to subtidal marine sediment resources.
4. Injury to deep water (>20 meters) benthic infaunal resources from petroleum hydrocarbons.

Air/Water Study 1 will confirm, to the extent necessary, that oil collected is from the Exxon Valdez, will document the extent of surface oiling, and will map the results of injury for use by other study teams. Consolidating and interpreting the results of aerial surveys and satellite imagery is the primary task.

Air/Water Study 2 will document hydrocarbon concentrations in the water column at a range of depths and locations. Trends in ambient water quality will be determined using the blue mussel as a biological indicator to supplement chemical measurements.

Air/Water Study 3 will document the presence, persistence, and chemical composition of petroleum hydrocarbons in subtidal marine sediments. These data will assist in quantifying injury to the sediment and will provide the chemical linkage needed to assess biological injury. Shallow subtidal oil concentrations will be compared with oil concentrations in adjacent intertidal areas to better understand the fate of oil. Sampling stations will extend outside Prince William Sound to include the Kenai Fiords, Katmai, Cook Inlet, Kodiak, and the Aleutian Chain.

Air/Water Study 4 will determine the degree of injury to the benthic infaunal resource and the duration of any documented injury. Benthic infaunal samples will be collected from agency vessels at the same stations sampled for subtidal marine sediments to ensure that both fate and effect of subtidal oiling are examined. Additionally, microbial screening techniques of subtidal sediments will be employed initially to determine the presence or absence of oil.

AIR RESOURCES

Exposures to high levels of volatile organic compounds (VOCs) released into the atmosphere from the Exxon Valdez oil spill may adversely affect mammals and birds in the spill zone. The Air/Water study in this plan will model the VOC concentrations emitted into the atmosphere from the oil spill as a function of distance from Bligh Reef over time using a reconstructed meteorological history from March 24 onward. Loss rates of VOCs from crude oil will assist in calculating mass balance and in verifying the ambient air models. The ambient concentrations predicted will be used to assess whether federal health standards for VOCs were exceeded and for how long, as a basis for documenting and quantifying injury to mammals and birds.

AIR/WATER STUDY NUMBER 1

Study Title:

Geographic Extent and Temporal Persistence of Floating Oil from the Exxon Valdez

Concern/Justification:

The presence of floating oil (continuous slicks, sheens, mousse, or tar balls) violates state and federal laws. Demonstrating a violation of water quality criteria is de facto evidence that uses of the water protected by law have been jeopardized. Documenting the temporal and spatial patterns of floating oil will provide information for determining injury to the water resource and for quantifying services lost due to the injury. The time series of the geographic extent of floating oil also is needed for calculating exposures of fish, birds, and marine mammals.

Objectives:

- A. Confirm, as needed, that floating oil is from the Exxon Valdez.
- B. Document temporal and spatial patterns of floating oil.
- C. Provide information to other study teams for use in injury assessments.

Relationships with Other Studies:

This study is coordinated with the other Air/Water studies and the Coastal Habitat study to provide an integrated exposure assessment for all natural resources. The information on distribution of floating oil will support estimates of direct mortality to sea otters (Marine Mammals Study 6) and seabirds (Birds Studies 1, 2).

Methods and Analyses:

The Alaska Department of Environmental Conservation will consolidate and interpret interagency data on floating oil over time, gathered from aerial surveys. Oil spill models will be used to estimate the extent and the volume of floating oil in the environment through time. Base maps will be generated to show extent and persistence of floating oil over time. Newly oiled surface waters will be added as data become available. Information on oiled beaches will be used to corroborate or verify reported sightings, thereby ensuring credibility of observations. Satellite images and interpretation will be provided by the University of Alaska. Mapping methods will be compatible with

guidelines provided by the Geographic Information System Technical Team.

National Oceanic and Atmospheric Administration staff will collect samples of floating oil and beached oil to verify the source and to determine the extent of Exxon Valdez oiling. A variety of analytical methods may be used in accordance with the quality assurance/quality control guidelines.

Lead Agencies: National Oceanic and Atmospheric Administration and Alaska Department of Environmental Conservation

Cooperating Agency(ies): Federal: EPA, USFS, USDI
State: DNR, IMS - UAF

Budgets:

Alaska Department of Environmental Conservation

Salaries	\$139.5
Travel	13.5
Contracts	27.0
Supplies	36.0
Equipment	<u>15.0</u>

TOTAL \$231.0*

* Includes \$103.5 reimbursible services agreement (RSA) to IMS - UAF

National Oceanic and Atmospheric Administration

Salaries	\$ 75.0
Travel	12.5
Contracts	0.0
Supplies	12.5
Equipment	<u>12.5</u>

TOTAL \$112.5

AIR/WATER STUDY NUMBER 2

Study Title:

Petroleum Hydrocarbon-Induced Injury to Subtidal Marine Sediment Resources

Concern/Justification:

Hydrocarbon contamination of marine sediments violates state and federal water quality criteria where concentrations result in deleterious effects on aquatic life. Benthic infauna and epifauna are food for fish, marine mammals, and birds. Documenting injury to subtidal sediments is a useful step in quantifying damages to these resources. Determining the extent of subtidal oiling is helpful in evaluating whether this environment will serve as a long-term repository for hydrocarbons, contributing to chronic toxicity through remobilization of oil into the water column. Evaluating the extent of oiling in key sediments will establish possible contamination pathways (for example, salmon fry feeding on benthic copepods).

Objectives:

- A. Determine occurrence, persistence, and chemical composition of petroleum hydrocarbons in subtidal marine sediments.
- B. Provide marine sediment data to assist agencies in mass balance calculations on the fate of oil.
- C. Relate subtidal oil concentrations with adjacent intertidal concentrations and other studies.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with the other Air/Water studies and with the Coastal Habitat study to provide an integrated exposure assessment for all natural resources. Distribution of subtidal oil is of particular importance for estimating exposure to crabs (Fish/Shellfish Studies 14 and 22), spot shrimp (Fish/Shellfish Study 15), benthic infauna (Air/Water Study 4), and demersal fish (Fish/Shellfish Studies 18 and 24).

Methods and Analyses:

Sampling stations will be chosen based on 1) existing baseline work, 2) established deep and shallow subtidal stations (DEC, NOAA,

UAF), 3) projected likelihood of oil deposition, 4) sensitive area selection (hatcheries and key estuaries), and 5) proximity to oiled intertidal habitats.

The number of samples collected will vary as a function of expected contamination. In accordance with the Quality Assurance Program, three replicate core samples per station will be collected with analysis on the upper 2 cm of sediment. A manned submersible will be used in Prince William Sound during the 1989 field season to visually check for oil in bottom sediments. Sediment grab sampling will be conducted in geographic areas that have been or will likely be affected by oil.

Sites for the damage assessment include: Prince William Sound, Kenai Fiords, the Kodiak Island area, and other locations extending to the Aleutian Chain. Guidance for the selection of control stations is provided in 43 CFR § 11.72. Nearshore sites will be coordinated with intertidal sampling sites established by the Coastal Habitat study.

Analyses will include 1) TPH/GC and PNA/SIM characterization of oil in marine sediments, 2) total organic carbon on selected samples, and 3) size fraction analysis on representative samples. Prescreening analyses of collected samples will occur prior to full GC/MS analysis in areas with low likelihood of oiling.

Lead Agencies: National Oceanic and Atmospheric Administration and Alaska Department of Environmental Conservation

Cooperating Agency(ies): Federal: EPA, USDI
State: ADF&G, DEC, DNR, IMS - UAF

Budgets:

Alaska Department of Environmental Conservation

Salaries	\$127.5
Travel	9.0
Contracts	391.5
Supplies	15.0
Equipment	<u>10.0</u>

TOTAL \$553.0*

* Includes RSA of \$452.0 to UAF, including 42 days of the R/V Alpha Helix for support of various Air/Water and Fish/Shellfish projects.

National Oceanic and Atmospheric Administration

Salaries	\$125.0
Travel	10.0
Contracts	160.0
Supplies	25.0
Equipment	<u>10.0</u>
<u>TOTAL</u>	\$330.0

AIR/WATER STUDY NUMBER 3

Study Title:

Geographic and Temporal Distribution of Dissolved and Particulate Petroleum Hydrocarbons in the Water Column

Concern/Justification:

State of Alaska water quality criteria establish a 10 ug/liter (ppb) limit on allowable levels of total aromatic hydrocarbons in the water column. Quantifying hydrocarbon levels in the water column is most critical during the first few weeks following an oil spill, when dissolution of soluble components is highest. Exceeding state water quality criteria constitutes de facto evidence that water uses protected under regulation have been jeopardized. This study provides the necessary evidence of chemical exposure to support determination of injury to biological and geological resources.

Objectives:

- A. Document water column hydrocarbon concentrations at a range of depths, locations, and times.
- B. Quantify injury to water resources.
- C. Relate water injury to biological injury.
- D. Evaluate trends in ambient water quality through measurements of hydrocarbons in a biological indicator (*Mytilus*) as a surrogate for chemical measurements.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with the other Air/Water studies and with the Coastal Habitat study to provide an integrated exposure assessment for all natural resources. Modeling of oil distribution in the water column will be coordinated with Air/Water Study 1. The data on oil in the water column will support injury determination for all pelagic and demersal resources, including salmon, herring, shrimp, larval fishes, and crabs. Most of the Fish/Shellfish studies will make use of this information in determining injury.

Methods and Analyses:

Shipboard sampling of the water column at 1, 3, 5, and 9 meter depths already has occurred through efforts of the National Oceanic and Atmospheric Administration, University of Alaska, Alaska Department of Environmental Conservation, and National Park Service at numerous stations in Prince William Sound and Kenai Fiords and Katmai National Parks. Mussel cages will be deployed at 12 sites in the Sound and 18 sites outside the Sound to serve as indicators of water quality over time. Mussels will be transplanted to the cages from control sites in Southeast Alaska. Additionally, a selected number of stations will be occupied by DEC for future water column hydrocarbon sampling (including bottom water) to corroborate the results of mussel tissue burden analysis by NOAA. Analyses will include volatile aromatic hydrocarbons, total petroleum hydrocarbons/GC, and polynuclear aromatics/SIM.

Lead Agencies: Alaska Department of Environmental Conservation and National Oceanic and Atmospheric Administration.

Cooperating Agency(ies): Federal: EPA, USDI (NPS)
State: DNR, UAF

Budgets:

Alaska Department of Environmental Conservation

Salaries	\$ 112.0
Travel	29.0
Contracts	82.0
Supplies	20.0
Equipment	<u>10.0</u>

TOTAL \$253.0*

* Includes \$10.9 RSA to IMS - UAF

National Oceanic and Atmospheric Administration

Salaries	\$ 65.0
Travel	11.5
Contracts	231.0
Supplies	20.0
Equipment	<u>15.0</u>

TOTAL \$342.5*

* Includes \$62.5 contract to NPS

AIR/WATER STUDY NUMBER 4

Study Title:

Injury to Deep Water (>20 meters) Benthic Infaunal Resources from Petroleum Hydrocarbons

Concern/Justification:

Deepwater benthic infaunal communities may be adversely affected. They also provide prey for demersal fish and some marine mammals. Such communities also have been documented to be useful indicators of pollution. If injury to these communities is demonstrated in conjunction with elevated levels of petroleum hydrocarbons in subtidal sediments, violation of state and federal water quality criteria is conclusive. Benthic infaunal communities have historically served as useful indicators of subtidal health in polluted areas.

Objectives:

- A. Determine injury to the benthic infaunal resource.
- B. Quantify injury to the deep water benthic infaunal resource.
- C. Determine persistence of injury to benthic resources.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with the other Air/Water studies and with the Coastal Habitat study to provide an integrated exposure assessment for all natural resources. Along with Coastal Habitat Study 1, this study documents the abundance of species used as food by valued resources (including otters, harbor seals, and demersal fishes) and quantifies the extent of contamination of these food resources.

Methods and Analyses:

In accordance with the Quality Assurance Program, five replicates per station will be collected using Van Veen grab samplers. Previous OCSEAP data will be considered in selecting open water stations. On-site shipboard screening of marine sediments will be used to determine the necessity of additional chemical or biological sampling on cruise transects. Archiving of a considerable number of infaunal samples is expected pending receipt of subtidal sediment hydrocarbon results. Sampling of benthic

infauna and marine sediments will occur concurrently at each station. Station locations are as identified in the study of subtidal marine sediments.

Marine sediments will be examined using microbial techniques. Species composition, abundance, and biomass will be determined for benthic infauna.

Lead Agencies: National Oceanic and Atmospheric Administration and Alaska Department of Environmental Conservation

Cooperating Agency(ies): Federal: EPA, USDI
State: ADF&G, DNR, IMS - UAF

Budgets:

Alaska Department of Environmental Conservation

Salaries	\$ 41.3
Travel	3.8
Contracts	45.0
Supplies	7.5
Equipment	<u>0.0</u>

TOTAL \$ 97.6*

* This study will be conducted by IMS - UAF in its entirety

National Oceanic and Atmospheric Administration

Salaries	\$ 75.0
Travel	6.3
Contracts	187.5
Supplies	12.5
Equipment	<u>0.0</u>

TOTAL \$281.3

AIR/WATER STUDY NUMBER 5

Study Title:

Injury to the Air Resource from the Release of Oil - Generated Volatile Organic Compounds

Concern/Justification:

The high levels of VOCs released into the atmosphere by oil from the Exxon Valdez have adverse health implications for mammals and birds in the spill zone. Modeling the expected ambient VOC concentrations against distance and time will allow prediction of possible unhealthful conditions as measured by standards established by the National Institute of Occupational Safety and Health. VOC concentration results may be applicable to assessing injury to a variety of other organisms ranging from marine mammals with documented lung damage to vascular plants.

Objectives:

- A. Model the ambient VOC concentrations as a function of time and distance from Bligh Reef.
- B. Establish "zones of concentration," areas with predicted VOC concentrations exceeding federal health standards.
- C. Model loss rates of VOCs from crude oil to assist in mass balance calculations and to verify ambient air models.

Relationships with Other Studies:

This study is coordinated with the other Air/Water studies and with the Coastal Habitat study to provide an integrated exposure assessment for all natural resources. The concentration field for VOCs in the atmosphere is required to verify injury through inhalation by terrestrial and marine mammals and birds.

Methods and Analyses:

Existing air dispersion models will be run using existing wind vector data available from NOAA, U.S. Coast Guard vessels, and land stations, to reconstruct the climatological history and ambient atmospheric VOC concentrations throughout the Prince William Sound area from March 24, 1989, until the VOC concentrations become insignificant through decay. Concentration isopleths will be mapped and used as a basis for calculating exposures for populations at risk. Concentrations of VOC in fresh and weathered North Slope crude oil will be determined and used to help verify the ambient VOC model.

Analyses will include 1) models of ambient air VOC concentrations over time and space, 2) models of toxic exposure probability, and 3) VOC concentration in weathered crude over time.

Lead Agency: Alaska Department of Environmental Conservation.

Cooperating Agency(ies): Federal: EPA, NMFS, NOAA, USDI (NPS),
USCG

Budget: Alaska Department of Environmental Conservation

Salaries	\$ 22.5
Travel	7.5
Contracts	75.0
Supplies	1.5
Equipment	<u>0.0</u>
<u>TOTAL</u>	\$106.5

FISH/SHELLFISH INJURY ASSESSMENT

The Exxon Valdez discharged crude oil into one of the richest fisheries belonging to the United States. The communities of Cordova, Homer, Seward, Valdez, Whittier, Kodiak, and Sandpoint, as well as numerous other communities, depend in part or in whole on these commercial, subsistence, and recreational fisheries for their existence. All commercial, recreational, and subsistence fisheries in Prince William Sound, Cook Inlet, Kodiak Island, and the Alaska Peninsula from Cook Inlet to Unimak Island may have been affected by the oil spill. The exvessel value of commercial catches in the Sound alone in 1988 was over \$110 million. The exvessel value of the salmon fisheries in the affected areas outside the Sound in 1988 was \$308 million. The exvessel value of groundfish and shellfish fisheries of the western and central Gulf of Alaska and Bering Sea in 1988 was \$869 million. Kodiak had the highest value of landed catch of any port in the United States during that year. The largest recreational fisheries in the state for rockfish, halibut, and salmon center on Homer and Seward. Anglers from Alaska, all other 49 states, and many countries of the world spent 300,000 angler days participating in these recreational fisheries in 1987. Communities, such as Tatitlek, Chenega Bay, and English Bay depend on subsistence fisheries in the Sound and Cook Inlet for the very existence of their residents.

The fisheries impacts of the oil spill were immediate. Commercial fisheries for herring, shrimp, and groundfish in the Sound were closed. Bookings with fishing guides, charter boat operators, and fishing lodges were cancelled. A fishing industry that depended on the reputation of quality born of a pristine Alaska found that reputation potentially tarnished; markets for Alaska seafood were placed in jeopardy.

Beyond these initial impacts, economic losses to the United States from any degradation to its fisheries from the oil spill will occur through effects on the death, birth, and growth of the animals upon which these fisheries depend. Most fish and deep-water shellfish die unseen within the water. But no matter how unseen, the potential effects of crude oil on individual fish and shellfish are real. Bioassays using crude oil from Prudhoe Bay and elsewhere have shown that exposure to concentrations as low as a few parts per billion in seawater will cause loss of limbs in Tanner crab, immediate death of eggs and larvae of herring, and death of Dungeness crab and shrimp. How those deaths of fish and shellfish affect the commercial, recreational, and subsistence values of fisheries is the crux of the assessment of injury to fishery resources.

A series of studies was developed into a program of injury assessment to document and quantify the effects of the oil spill

on fishery resources. Species were selected for study based on their value as indicators or their role in major fisheries. Comparison of the abundance of fish larvae, juveniles, and adults between oiled and non-oiled waters was chosen as the basic experimental design. In some studies, oiled and non-oiled waters will relate to different areas; in other studies, these terms will relate to the same area or population before and after the spill; and in the remaining studies, oiled and non-oiled will refer to different areas and populations with comparisons before and after the spill. Guidance for selection of control areas is provided in 43 CFR § 11.72. The presence of oil in the vicinity of fish and shellfish will be documented by the suite of Coastal Habitat and Air/Water studies. Contamination of individual fish and shellfish will be documented by analysis of their tissues. The "effect" described in the impact assessment will be reflected as changes in harvest or use as reflected by programs presently in place in the agencies. Adverse changes in viability, as described in 43 CFR § 11.62(f)(1), will be documented.

FISH/SHELLFISH STUDY NUMBER 1

Study Title:

Injury to Salmon Spawning Areas in Prince William Sound

Concern/Justification:

Wild stocks of salmon provide a major fishery in Prince William Sound. In 1988, the value of the commercial catch of salmon (wild and hatchery stocks combined) was \$76 million to the fishermen. Salmon also are very important to sport, subsistence, and personal use fisheries. Freshwater survival of Prince William Sound salmon may be adversely affected by higher than optimal levels of escapement as a consequence of the inability to harvest salmon in traditional fishing areas because of oil in those areas. Marine survival may be adversely impacted because the oil spill reached intertidal spawning areas as well as rearing areas. Therefore, the oil spill may have a deleterious impact on the future abundance of salmon. This study will identify affected streams and document oil impacts on spawning wild salmon.

Objectives:

- A. Determine presence or absence of oil on intertidal habitat used for salmon spawning.
- B. Document the physical extent of oil distribution on intertidal spawning areas.
- C. Estimate the numbers of spawning pink, chum, and sockeye salmon by species, and by intertidal and upstream areas for approximately 100 streams in the Sound.
- D. Produce a catalog of aerial photographs and detailed maps of spawner distribution for each stream sampled.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Fish/Shellfish Studies 1 through 4 support a comprehensive and integrated determination of injury to Prince William Sound salmon stocks, from adult spawning success to juvenile survival. Fish/Shellfish Studies 7 through 9 provide related information outside of the Sound. Information on the extent and persistence of oil in the intertidal zone will be supplemented by Coastal Habitat Study 1. The results of Fish/Shellfish Studies 1 through

4 will be used by Economic Uses Study 3 to determine the extent of damage to the Sound's salmon resource.

Methods and Analyses:

All intertidal spawning habitat identified in the Anadromous Stream Catalog in that portion of the Sound directly contacted by oil will be visually inspected, mapped, and photographed. Photographs will include standard reference markers, and maps will document the distribution of oil contamination, including the presence of pooled oil, the thickness of oil on the substrate, and the penetration of oil into the substrate. This information, in concert with the standard mapping of oil contamination provided by other studies, will enable stratification (none, light, and moderate to heavy) according to the oil contamination on intertidal spawning areas and nearshore rearing areas.

Of the 211 aerially surveyed index streams in the Sound, a statistically significant number (tentatively 100) will be surveyed in this study. Each survey will include counts of live and dead salmon by species and location in the river above mean low water, stage of spawning, evidence of prespawning mortality, tide stage, and comments on visibility. A subset (46 streams) of the 100 streams will be sampled by Fish/Shellfish Study 2 for pink and chum salmon egg and preemergent fry. For the 46 streams, detailed maps of spawner distribution in the intertidal and upstream zones will be recorded. These data will be the basis of expansion of egg and preemergent fry densities to estimates of total abundance of eggs and preemergent fry.

Information from this study, in concert with that from other studies, as well as the ongoing programs of the Alaska Department of Fish and Game and the Prince William Sound Aquaculture Corporation, will indicate abundance of and mortality between life-history stages: spawners, preemergent fry/smolts, and returning adult salmon. This study, along with information from the Coastal Habitat study and the early marine salmon studies, will determine whether salmon have suffered abnormal mortality or changes in abundance as a result of the degree of oiling in the spawning and rearing habitat, and deviation from preferred levels of escapement attributed to oil.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 52.2
Travel	5.5
Contracts	58.1
Supplies	17.9
Equipment	<u>11.1</u>
<u>TOTAL</u>	\$144.8

FISH/SHELLFISH STUDY NUMBER 2

Study Title:

Injury to Salmon Eggs and Preemergent Fry in Prince William Sound

Concern/Justification:

Wild stocks of salmon provide a major fishery in Prince William Sound. The freshwater survival of Prince William Sound salmon could be adversely affected as a consequence of the presence of oil. This study will document oil impacts on salmon eggs and fry survival.

Objectives:

- A. Assess abundance of pink and chum salmon eggs and preemergent fry in study streams.
- B. Assess overwinter mortality (eggs to preemergent fry) of pink and chum salmon eggs.
- C. Assess tissue concentrations of hydrocarbons in alevins collected in April 1989 from oiled and non-oiled sites.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 1.

Methods and Analyses:

Of the 100 pink and chum salmon streams assessed for spawner distribution, 46 streams will be selected for preemergent fry sampling. Of these streams, 25 have a historical data base, and the remainder (21) are new sites selected to increase sampling in known oiled areas. During the spring of 1989, two replicates of preemergent fry sampling will be conducted: the first during the first two weeks of April and the second during the last two weeks of April. Four zones (1.8 m-2.4 m, 2.4 m-3.0 m, 3.0 m-3.7 m above mean low water and upstream) per stream will be sampled. A linear transect of ten circular digs (0.3 m²) will be conducted per transect. During the spring, counts of live and dead eggs and live and dead preemergent fry by species will be done for each dig. During autumn, egg sampling will be conducted. Sampling procedures for eggs are the same as for preemergent fry sampling.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 82.2
Travel	5.0
Contracts	16.2
Supplies	5.7
Equipment	<u>40.0</u>

TOTAL \$149.1

FISH/SHELLFISH STUDY NUMBER 3

Study Title:

Salmon Coded-Wire Tag Studies in Prince William Sound

Concern/Justification:

Wild stocks of salmon and salmon from five hatcheries provide a major fishery in Prince William Sound. The marine and estuarine survival of salmon may be adversely impacted due to exposure of intertidal spawning areas, along with nearshore and offshore rearing areas, to crude oil. Because of these factors, operating singularly or in concert, the Exxon Valdez oil spill may have a major deleterious impact on the future productivity of salmon stocks.

Before a loss in production due to the oil spill can be measured, 1) young salmon must be shown to be exposed to contaminated waters; and 2) the subsequent return (harvest and escapement) of these salmon must be known. The former information indicates cause, while the latter shows the extent of the damage. Fish/Shellfish Study 4 ("Early Marine Salmon Injury Assessment") will document the presence or absence of young salmon from various coded-wire tagged stocks in oiled water. Salmon stocks in heavily impacted areas may be in serious jeopardy, and there is concern about the impact on the many unique populations of these fish. Survival rates of selected stocks will be measured in this study.

Objectives:

- A. Assess the marine survival rates and harvests of wild pink salmon from three streams with oil-contaminated estuaries and two streams with uncontaminated estuaries.
- B. Assess the marine survival rates and harvests of sockeye salmon from two watersheds with estuaries contaminated with oil and one with an estuary that is not contaminated.
- C. Assess the marine survival rates and harvests of pink, chum, coho, sockeye, and chinook salmon released from five hatcheries in the Sound. Two of these facilities have heavily oiled estuaries, while three do not.
- D. Assess the abundance of sockeye salmon smolts emigrating from the study streams.
- E. Assess the extent of straying of returning salmon in outlying areas.

- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 1.

Methods and Analyses:

In all situations, a subsample of fry or smolt will be tagged with a coded-wire tag. Total returns (catch and escapement) will be assessed to document the marine survival of the tagged stocks. A subsample of the harvests from all fisheries will be inspected for those tagged fish as they return as adults. Statistics on the percent of a group marked, percent of harvest with a particular tag lot, and the harvest itself will be used according to standard procedures to estimate the harvest by group in each fishery. These same procedures will be used to plan the number of juveniles to tag and adults to inspect and obtain estimates with the desired accuracy and precision. The percent of a group marked will be estimated by sampling at hatcheries and on the spawning grounds. Returns of fish to their respective spawning grounds and hatcheries will be assessed. These fish plus the catch represent the total return allowing for determination of marine survival by tag lot. In accordance with the Quality Assurance program, sufficient samples will be taken to make the sampling error around these estimates as small as practical. The results from this study will be integrated with the results from Fish/Shellfish Studies 1, 2, and 4 to estimate the impact of the oil spill on Prince William Sound salmon.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA, USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 898.9
Travel	20.7
Contracts	528.8
Supplies	87.9
Equipment	<u>407.1</u>

TOTAL \$1943.4

FISH/SHELLFISH STUDY NUMBER 4

Study Title:

Early Marine Salmon Injury Assessment in Prince William Sound

Concern/Justification:

Some estuarine and intertidal nursery areas for wild and hatchery stocks were heavily impacted by the oil spill. It is anticipated that these impacts may have detrimentally affected the viability of salmon production in Prince William Sound and the resultant viability of present fisheries and the related economy.

Before any loss in production from the oil spill can be estimated: 1) young salmon must have been exposed to contaminated habitat; and 2) the subsequent return (harvest and escapement) must be known. The former information indicates cause, while the latter shows extent of the damage. This study will address the question of exposure. Also, residence time within the area impacted by the oil spill is of concern, as is the extent to which estuarine and nearshore rearing habitat has been degraded by the oil spill.

Objectives:

- A. Determine whether and how oil contamination has adversely changed the abundance, growth, and feeding habits of juvenile salmon during their early nearshore marine residence.
- B. Determine whether oil contamination in critical habitats used by juvenile salmon during their early marine residence has adversely affected those juvenile salmon.
- C. Determine migration patterns of juvenile salmon relative to oiled and non-oiled areas in western Prince William Sound and the residence time of fish in the oil-impacted areas.
- D. Measure hydrocarbon levels in tissues of juvenile salmon in oiled and non-oiled areas and document oil-related mortalities. (Histopathology will be used to document sublethal effects on fish physiology.)
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 1.

Methods and Analyses:

Oiled and non-oiled nearshore rearing habitat of juvenile salmon will be examined, as will the associated abundance, growth, feeding habits, and behavior of juvenile salmon in these habitats. Coded-wire-tagged juvenile salmon (see Fish/Shellfish Study 3) will be recovered at selected points along their migration route through the oil-impacted area. The tissues of juvenile coded-wire tagged salmon will be sampled to assess hydrocarbon content. Any fish kills within the study area will be documented.

Three basic approaches will be used to determine impacts of the oil spill on juvenile salmon and their habitats: 1) direct pairwise comparisons of oiled and non-oiled habitats, and the abundance, growth, feeding habits, and behavior of juvenile salmon in these habitats; 2) comparisons with historical data on juvenile salmon ecology in the Sound; and 3) evaluation of differences in abundance, growth, feeding habits, and food resources of juvenile salmon relative to the geographic distribution of oil contamination. Recovered coded-wire tags will provide information on the speed, route, and residence time of specific labeled groups. Catch-per-unit-effort data will be used to determine the relative use of different migration corridors. Hydrocarbon contamination of tissues of juvenile salmon will be assessed by pairwise comparisons between oiled and control areas.

Lead Agencies: Alaska Department of Fish and Game and National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USFS
State: DNR, UAF

Budgets: Alaska Department of Fish and Game

Salaries	\$184.8
Travel	17.1
Contracts	305.2*
Supplies	32.7
Equipment	<u>50.9</u>

TOTAL \$590.7

* Includes \$141.3 funding for IMS - UAF.

National Oceanic and Atmospheric Administration

Salaries	\$ 65.0
Travel	25.0
Contracts	76.0*
Supplies	35.0
Equipment	<u>37.5</u>

TOTAL \$238.5

* Includes \$12.0 to be contracted to USFS.

FISH/SHELLFISH STUDY NUMBER 5

Study Title:

Injury to Dolly Varden Char and Cutthroat Trout in Prince William Sound

Concern/Justification:

Crude oil has contaminated the nearshore and estuarine waters in Prince William Sound inhabited by juvenile and adult Dolly Varden char and cutthroat trout. Bioassays have shown that the presence of crude oil in low concentrations can affect the survival of the prey of these species. High concentrations may directly impair reproduction, growth, and survival rates of Dolly Varden char and cutthroat trout as well.

Dolly Varden char and cutthroat trout in the Sound are caught in recreational fisheries. Recreational fishers in Prince William Sound expended over 81,000 angler-days in 1987. Reduction in abundance of these species could seriously jeopardize unique stocks of fish. Any reduction in abundance due to the oil spill could cause loss of catch and, ultimately, losses in revenue related to these resources.

Since all Dolly Varden char and cutthroat trout in the Sound were in fresh water when the spill occurred, the earliest impacts of the oil spill on these species would occur as the fish feed in oiled areas during the summer. These two species may be particularly susceptible since they reside in nearshore areas for months during the summer and will be in close proximity to oiled habitat for extended periods of time. Any impacts would affect the survival rates of those fish frequenting oiled waters.

Objectives:

- A. Compare survival rates of juvenile and adult Dolly Varden char and cutthroat trout within oiled and non-oiled areas of the Sound during 1989-90.
- B. Compare survival rates of smolting Dolly Varden char and cutthroat trout from spawning streams within oiled and non-oiled areas of the Sound.
- C. Assess exploitation rates in recreational fisheries of Dolly Varden char and cutthroat trout overwintering in oiled and non-oiled areas.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Sampling of some streams for this study will be coordinated with sampling for Fish/Shellfish Studies 2 and 4. Sampling of tagged fish in the recreational fishery will be done under Fish/Shellfish Study 6. Related work on Dolly Varden char outside of Prince William Sound will be conducted under Fish/Shellfish Study 10. Information on the extent and persistence of oil in the intertidal zone will be supplied by Coastal Habitat Study 1. Results will be used by Economic Use Studies 3, 5, and 6, relating to bioeconomic modeling, recreation and subsistence values, respectively.

Methods and Analyses:

Dolly Varden char and cutthroat trout that are spawned in streams with overwintering lakes will smolt, return annually to the lake in their natal watershed to overwinter, and then return to their natal stream to spawn. Dolly Varden char and cutthroat trout spawned in streams without lakes will smolt, search out a stream with a lake, annually return to this lake to overwinter, and then return to their natal stream to spawn. All watersheds in this study have spawning populations of Dolly Varden char and cutthroat trout, and overwintering lakes.

Prior to the spring emigration, weirs will be placed on four streams. Two of these streams have oiled estuaries (Otter Lake on Knight Island and Green Island Lake on Green Island), while two do not (on the southern shores of Hitchenbrook and Hawkins Islands). Emigrant fish will be counted, and each one ≥ 200 mm will be tagged. Marked fish will be recovered in the recreational fishery through another study.

In addition, all smolting, overwintering, and spawning Dolly Varden char and cutthroat trout will be counted at weirs on the outlets to the Coghill (non-oiled) and Eshamy Rivers (oiled). Dolly Varden char and cutthroat trout will be counted and tagged at Coghill and Eshamy Rivers. A large percentage of smolts leaving all six rivers will be marked in the same way in all watersheds. The same percentage will be marked from each lake.

Since Dolly Varden char and cutthroat trout from natal streams with overwintering lakes return to their natal streams to overwinter, their survival rates will be calculated by mark-recapture methods.

Any immediate impacts of the oil spill on the harvest of Dolly Varden char and cutthroat trout in recreational fisheries will be determined for study populations overwintering in streams and lakes in oiled and non-oiled areas. Numbers of tagged fish recovered in the fishery will be expanded by the number of fish sampled.

Estimated harvest of these overwintering populations will be prorated by the distribution of fishing effort across oiled and non-oiled waters. Since Dolly Varden char and cutthroat trout from natal streams with overwintering lakes always return to their natal streams to overwinter, survival rates of char during their first exposure to oil will be calculated as described above after discounting effects of the sport fishery.

Lead Agency: Alaska Department of Fish and Game.

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$218.1
Travel	7.0
Contracts	65.0
Supplies	79.4
Equipment	<u>67.9</u>
<u>TOTALS</u>	\$437.4

FISH/SHELLFISH STUDY NUMBER 6

Study Title:

Prince William Sound and Gulf of Alaska Sport Fishery Harvest and Effort

Concern/Justification:

Areas adjacent to oil-contaminated waters support significant marine sport fisheries. During 1987 a total of approximately 215,000 angler days of recreational fishing effort were sustained in the following locations: Prince William Sound (81,000); Resurrection Bay (31,000); Kachemak Bay (88,000); and Chiniak Bay (15,000). Access to these marine fisheries is limited and funnels through Valdez, Whittier, Cordova, and Anchorage for Prince William Sound; Seward for Resurrection Bay; Homer for Kachemak Bay; and Kodiak for Chiniak Bay. Transportation from nearly all of these locations is by boat. The only exception is Anchorage, which has a large seaplane base. Halibut, rockfish, Dolly Varden char, cutthroat trout, and all five species of salmon are caught. All of these recreational fisheries depend in part upon maintaining the wild and pristine character of the area. Any loss of fish abundance, shifts in seasonal distribution of fish, and loss of the pristine character of the area from the oil spill could result in substantial reduction in participation in these recreational fisheries and a serious loss of revenue to the local communities and to the state.

Objectives:

- A. Determine recreational catch and harvest of salmon, rockfish, halibut, cutthroat trout, and Dolly Varden char.
- B. Determine angler effort and identify the temporal and spatial distribution and location of origin of angling effort.
- C. Determine percentage of oil-contaminated fish in the sport harvest.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic distribution and persistence of oil in areas visited by anglers and other recreationists will be obtained from the suite of Air/Water and Coastal Habitat studies.

Methods and Analyses:

Stratified random creel surveys will be conducted in Valdez, Cordova, Whittier, Eshamy Lagoon, Seward, Homer, and Kodiak from May 1 through September 15. Anglers and other recreationists will be interviewed as they return from boat or fly-out trips and as they are encountered during surveys of shoreline fisheries. Information on anglers flying out of the seaplane base in Anchorage will be obtained through logbooks maintained by fishing guides and air taxis. Recreationists encountered at sampling stations or during transits of the shoreline will be counted and interviewed. Names, addresses, and telephone numbers will be obtained from recreational participants. Anglers will also be asked where they fished, how long, what they caught, and how many fish they kept. Sport catches will be examined for signs of oil contamination, including unpalatable flesh and residues of oil in the digestive tracts.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA, NPS, USFS, USFWS
State: DEC, DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 84.5
Travel	7.0
Services	54.9
Supplies	9.5
Equipment	<u>20.0</u>

TOTAL \$175.9

FISH/SHELLFISH STUDY NUMBER 7

Study Title:

Injury to Pink/Chum Salmon Spawning Areas Outside Prince William Sound

Concern/Justification:

Wild stocks of pink and chum salmon provide major fisheries in areas outside Prince William Sound where extensive oiling has occurred. In 1988, the value of the commercial catch of wild and hatchery stocks of salmon from the oiled lower Cook Inlet to the south Alaska Peninsula/Aleutians area was more than \$210 million to fishermen. Salmon also are very important to sport, subsistence, and personal use fisheries. The marine survival of wild stocks may be adversely impacted because intertidal spawning areas as well as nearshore and offshore rearing areas were affected by the oil spill. In addition, the freshwater survival of salmon may be affected by levels of escapement as a consequence of the inability to harvest salmon in traditional fishing areas due to the presence of oil in those areas. Because of these factors, operating singly or in concert, the Exxon Valdez oil spill may have a major deleterious impact on the future abundance of pink and chum salmon.

Objectives:

- A. Count the numbers of spawning salmon by species and by intertidal and upstream areas for 109 pink/chum salmon streams outside the Sound where historical fry density data exist. These include 20 streams in the lower Cook Inlet/Kenai Fiords area, 40 streams in the Kodiak Island/Shelikof Strait mainland area, 18 streams in the Chignik/Katmai coast area, and 31 streams in the South Alaska Peninsula/Aleutian Islands area.
- B. Produce a catalog of aerial photographs and detailed maps of spawner distribution for each stream sampled.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Fish/Shellfish Studies 7 through 9 support a comprehensive and integrated determination of injury to salmon stocks outside of Prince William Sound, from adult spawning success to juvenile survival. Information on the extent and persistence of oil in the intertidal zone will be provided by Coastal Habitat Study 1. The

results of the salmon studies will be evaluated under Economic Use Study 3.

Methods and Analyses:

Replicate surveys on-site will be conducted on each of the 109 streams selected. Each survey will include counts of live and dead salmon by species and location in the river (at least four strata will be selected based on the spawner distribution), stage of spawning, evidence of prespawning mortality, tide stage, and comments on visibility will be recorded. Detailed maps of spawner distribution in the intertidal and upstream zones will be recorded. This detail will provide the basis of expansion of egg and preemergent fry densities to estimates of total abundance of eggs and preemergent fry.

Information from this study, in concert with other injury assessment studies and ongoing Alaska Department of Fish and Game escapement and fishery monitoring programs, will be used to estimate abundance of and mortality between life-history stages. Stages for pink and chum salmon include spawners, preemergent fry, and returning adults. Information from this study, along with information from the Coastal Habitat study and early marine salmon injury assessment, will be used to post-stratify the response (mortality and abundance) by differential oiling of spawning and rearing habitat, and by deviations from preferred levels of escapement attributed to oil.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NPS, USFS, USFWS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$132.6
Travel	4.2
Contracts	147.2
Supplies	23.0
Equipment	<u>13.3</u>
<u>TOTAL</u>	\$320.3

FISH/SHELLFISH STUDY NUMBER 8

Study Title:

Injury to Pink and Chum Salmon Egg and Preemergent Fry in Areas Outside Prince William Sound

Concern/Justification:

Wild stocks of pink and chum salmon provide major fisheries in areas outside Prince William Sound where extensive oiling has occurred. The marine survival of salmon may be adversely impacted because intertidal spawning areas as well as nearshore and offshore rearing areas were affected by the oil spill. Lower marine survival could result in lower harvests. In addition, the freshwater survival of salmon may be affected by lower- or higher-than-desired levels of escapement as a consequence of the inability to harvest salmon in traditional fishing areas due to the presence of oil in those areas. Because of these factors, operating singly or in concert, the Exxon Valdez oil spill may have a major deleterious impact on the future abundance of stocks of pink and chum salmon. This study will document oil impacts on salmon egg and fry survival.

Objectives:

- A. Determine abundance of pink and chum salmon eggs and preemergent fry.
- B. Determine overwinter mortality (egg to preemergent fry) of pink and chum salmon eggs.
- C. Determine reductions, if any, in pink and chum salmon preemergent fry abundance due to oiling.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 7.

Methods and Analyses:

The 109 pink/chum salmon streams outside the Sound assessed for spawner distribution will be included in the pink and chum salmon preemergent fry sampling program and up to 80 of the streams will be included in the egg sampling program, as needed for statistical significance and as control streams.

Preemergent egg and fry sampling will be conducted in the fall and spring. At least four strata will be selected for each stream, based on the mapping of spawner distribution to provide the best estimate of abundance. For each of the strata selected, a linear transect of ten circular digs (0.3 m²) will be conducted per transect. Counts of live and dead eggs and live and dead preemergent fry by species will be done for each dig.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NPS, USFS, USFWS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 44.4
Travel	1.4
Contracts	49.1
Supplies	7.7
Equipment	<u>8.8</u>
<u>TOTAL</u>	\$111.4

FISH/SHELLFISH STUDY NUMBER 9

Study Title:

Early Marine Salmon Injury Assessment for the Kenai Peninsula and Kodiak/Shelikof Strait

Concern/Justification:

Some estuarine and intertidal nursery areas important to salmon stocks were heavily impacted by the oil spill. It is anticipated that these impacts may have detrimentally affected the viability of salmon production from the Kenai Peninsula and points west, and the resultant viability of the present fisheries and related economy. Areas outside Prince William Sound have been affected differently from areas inside the Sound due to varying amounts of oil and changes in chemical composition, toxicity, and consistency over time.

Objectives:

- A. Determine the effects of oil contamination on abundance, growth, and feeding habits of juvenile salmon during their early nearshore marine residence.
- B. Determine hydrocarbon levels in tissues of juvenile salmon in oiled and control areas and document any oil-related mortalities and other adverse changes in viability.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 7.

Methods and Analyses:

Study areas along the Kenai Peninsula and Kodiak/Shelikof Strait will be selected. A site in Resurrection Bay has been selected since base line data exist. These oiled and non-oiled nearshore rearing areas of juvenile salmon will be examined, as well as the associated abundance, growth, feeding habits, and behavior of juvenile salmon. Any fish kills within the study area will be documented. This study is an extension of the pairwise early marine salmon habitat comparison studies in the Sound. Pairwise comparisons of oiled and non-oiled habitats, and the abundance, growth, feeding habits, and behavior of juvenile salmon in these habitats will be made. Hydrocarbon contamination of tissues of

juvenile salmon will be assessed by pairwise comparisons between oiled and non-oiled areas.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NMFS, NPS, NOAA, USFWS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$115.5
Travel	3.5
Contracts	182.5
Supplies	7.0
Equipment	<u>40.0</u>

TOTAL \$348.5*

* Includes a \$150.0 contract to USFWS.

FISH/SHELLFISH STUDY NUMBER 10

Study Title:

Injury to Dolly Varden Char and Sockeye Salmon in the Lower Kenai Peninsula

Concern/Justification:

Crude oil has contaminated nearshore and estuarine waters important to both Dolly Varden char and sockeye salmon. Bioassays have shown that the presence of crude oil in low concentrations can affect the survival of prey (such as pink salmon and copepods) of these species. High concentrations may directly impair reproduction, growth, and survival rates of Dolly Varden char and sockeye salmon as well.

Dolly Varden char and sockeye salmon are caught in sport, commercial, and subsistence fisheries in lower Cook Inlet. A reduction in abundance due to the oil spill could therefore reduce the catch. Any impacts of oil could affect the survival rates of fish frequenting oiled waters. There is concern that the oil spill may have seriously jeopardized unique populations of these two species outside of Prince William Sound.

Objectives:

- A. Compare survival rates of smolting Dolly Varden char from spawning streams within oiled and non-oiled areas of the lower Kenai Peninsula.
- B. Determine the extent of migration by Dolly Varden char from non-oiled into oiled areas to overwinter.
- C. Compare marine survival rates of sockeye salmon smolt in oiled areas of the lower Kenai Peninsula with known survival rates prior to the oil spill.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic extent and persistence of oil in coastal and intertidal areas will be provided by the suite of Air/Water and Coastal Habitat studies. Fish/Shellfish Study 5 will examine oil-spill effects on Dolly Varden char inside of the Sound. Information from this study will support Economic Uses Study 3.

Methods and Analyses:

Dolly Varden char spawned in streams with overwintering lakes will smolt, return to the lake in their natal watershed to overwinter, and return to their natal stream to spawn. Char spawned in streams without overwintering lakes will smolt, search for a stream with a lake, return to this lake to overwinter, and return to their natal stream to spawn.

Based upon this life history knowledge, all smolting, overwintering, and spawning Dolly Varden char will be counted at weirs at Desire Lake, English Bay, and Packers Lake; adults will be counted on the Anchor River. All four watersheds have spawning char, but only the first three have overwintering lakes. (There is no lake on the Anchor River.) English Bay and Desire Lake are in oiled areas; Packers Lake and the Anchor River are in non-oiled areas. English Bay and Desire Lake offer the opportunity for coordinated and efficient evaluation of both Dolly Varden and sockeye salmon at a single location. Cook Inlet Aquaculture Association currently operates smolt and adult weirs at Packers Lake; Alaska Department of Fish and Game currently operates an adult fish weir on the Anchor River. A large percentage of Dolly Varden smolts leaving Desire Lake, English Bay, and Packers Lake will be marked in the same way in all watersheds, but differently in different years. The same percentage will be marked from each lake. Each spent adult Dolly Varden leaving the Anchor River will be marked and measured.

Since Dolly Varden char from natal streams with overwintering lakes return to their natal streams to overwinter (i.e., English Bay, Desire Lake, and Packers Lake), their survival rates will be calculated as the number of marked fish recaptured, divided by the number previously marked. Numbers of marked adults from the Anchor River overwintering in either Packers Lake (non-oiled area) or English Bay (oiled area) will be a direct measure of migration of char through oiled and non-oiled waters, since Packers Lake and English Bay are the two watersheds closest to the Anchor River with overwintering lakes. If adults from Anchor Lake overwinter in these areas, so do smolt from this river. Mature char, immature char, and smolt will be identified by length frequency and examination of external sexual characteristics.

Smolting and returning sockeye salmon will be counted at weirs on English Bay and Desire Lake. Both smolt and adults will be sampled to determine age and length composition. Marine survival rates of sockeye salmon will be calculated as returns of adults divided by smolt. Since fish from these stocks are taken in terminal fisheries, harvests will be known. After apportioning harvests and escapements by age composition, returns will be determined. Marine survival rates for both stocks will be compared with data collected before the oil spill.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NPS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 84.0
Travel	0.7
Contracts	16.5
Supplies	45.0
Equipment	<u>6.4</u>

<u>TOTAL</u>	\$152.6
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FISH/SHELLFISH STUDY NUMBER 11

Study Title:

Injury to Prince William Sound Herring

Concern/Justification:

The Prince William Sound herring stock supports commercial fisheries with a 1988 exvessel value of \$12 million, and subsistence harvests. Direct mortality of adult herring, eggs, and larvae due to oil contamination of nearshore spawning and rearing areas may reduce the future abundance of herring. Hydrocarbons may also interfere with growth and reproduction during the spring and summer of 1989 and possibly longer. Herring impact studies are designed to assess lethal and sublethal effects of the oil spill on juvenile and adult herring survival, growth, and reproduction. There is concern that the oil spill may have seriously jeopardized unique populations of herring, particularly in heavily oiled areas.

Objective:

- A. Expand the normal data base for herring to increase the precision of the estimated abundance of herring using expanded spawn deposition surveys of the number of eggs deposited, combined with age, weight, sex, and fecundity sampling.
- B. Document the occurrence of herring spawn in oiled and non-oiled areas.
- C. Determine hydrocarbon contamination of, and physiological impacts on, adult herring by analyzing tissue samples for hydrocarbon and histopathological analyses from herring in oiled and non-oiled areas.
- D. Determine the proportion of dead herring eggs in oiled and non-oiled areas.
- E. Determine the hatching success, viable hatch, and occurrence of abnormal larvae by collecting herring eggs from oiled and non-oiled areas and rearing them under laboratory observation.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic extent and persistence of petroleum hydrocarbons in herring spawning areas will be provided by Coastal Habitat Study 1. Related studies on herring outside of Prince

William Sound are conducted under Fish/Shellfish Study 12. Information from these studies will be used in bioeconomic models under Economic Uses Study 3.

Methods and Analyses:

Spawn deposition surveys will be used to estimate herring abundance. Up to 160 transects will be randomly located in areas of herring spawn, with divers systematically subsampling along the transect to estimate egg densities, as required to be statistically significant. From estimates of egg densities and spawning bed dimensions, the total number of eggs deposited will be determined. Estimates of fecundity, average weight, and sex ratio will be used to convert numbers of eggs deposited to spawning biomass. The average weight, fecundity, and sex ratio of the spawning population will be assessed using nonsize-selective fishing gear during periods of herring spawning. The ratio of live to dead herring eggs in oiled and non-oiled herring spawning areas will be assessed by enumerating live and dead eggs every four days until hatching. Herring eggs will be collected for hydrocarbon analysis. There will be 180 small batches of herring spawn collected from oiled and non-oiled spawning areas for laboratory rearing in salinities and temperatures similar to surface waters during April and May. For each batch, the ratio of live to dead eggs, number of newly hatched larvae, presence of visible abnormalities, length, yolk sac dimensions, and dry weight of newly hatched larvae will be measured.

Herring impact studies are designed to assess lethal and sublethal effects of the oil spill on juvenile and adult herring growth, survival and reproduction. In addition, changes in the abundance of adult herring will be assessed using biomass estimates and further refined by catch-age analysis which incorporates biomass estimates as auxiliary information. Estimates of herring recruitment and adult biomass will be available through the Alaska Department of Fish and Game's ongoing Prince William Sound herring stock assessment program. Changes in growth and fecundity relationships during the spring and summer 1989 oil-impacted growing season will not be detectable until the spring of 1990. Observed changes in growth and fecundity will be compared to the amount of variability present in historical and future growth and fecundity data. Historical data on age, weight, and length are available back to 1972, and historical fecundity data are available for 1983, 1984, 1988, 1989.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA, OCSEAP/MMS, USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 85.0
Travel	9.5
Contracts	148.0
Supplies	19.0
Equipment	<u>113.0</u>
<u>TOTAL</u>	\$374.5

FISH/SHELLFISH STUDY NUMBER 12

Study Title:

Injury Assessment to Kodiak and Alaska Peninsula Herring

Concern/Justification:

Kodiak and Alaska Peninsula herring stocks support commercial fisheries with 1988 exvessel values of \$2.8 million and \$0.5 million, respectively, as well as subsistence harvests. Direct mortality of adult herring, eggs, and larvae due to oil contamination of nearshore spawning and rearing areas may reduce the future abundance of herring. Hydrocarbons may also interfere with growth and reproduction. Herring impact studies are designed to assess lethal and sublethal effects of the oil spill on egg survival and adult herring growth and reproduction. There is concern that the oil spill may have seriously jeopardized unique populations of herring, particularly in areas that were heavily oiled.

Objectives:

- A. Document the occurrence of herring spawn in oiled and non-oiled areas.
- B. Compare growth increments of adult herring during 1989 with those for other years.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 11.

Methods and Analyses:

Aerial surveyors will record milt locations and prepare maps showing the distribution of milt along the shoreline. The extent of hydrocarbon impact on herring eggs and larvae will be assessed from herring egg and larval survival field and laboratory work at similar hydrocarbon exposure levels found in the Sound. The average weight, age, and sex ratio of the spawning population will be assessed from a sampling program using nonsize-selective fishing gear during periods of herring spawning.

Herring impact studies are designed to determine lethal and sublethal effects of the oil spill on egg survival and adult herring growth and reproduction. Impacts of the oil spill on adult

herring survival cannot be directly assessed using absolute abundance measures because of the large number of relatively small, discrete stocks involved. Aerial survey mapping projects will assess the amount of herring spawning areas contaminated by oil. Changes in growth relationships during the spring and summer 1989 oil-impacted growing season would first be detectable during the following spring. Observed growth will be compared with historical and future growth data.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): None

Budget: Alaska Department of Fish and Game

Salaries	\$15.0
Travel	0.0
Contracts	45.0
Supplies	0.0
Equipment	<u>0.0</u>
<u>TOTAL</u>	\$60.0

FISH/SHELLFISH STUDY NUMBER 13

Study Title:

Injury to Prince William Sound Clams

Concern/Justification:

Bivalve mollusks are an important component of the food chain, and they support subsistence and sport fisheries in Prince William Sound. The principal species examined during this study will include the cockle, littleneck clam, and butter clam. This study is designed to determine injury to Prince William Sound bivalve resources and their habitats.

Objectives:

- A. Determine level of hydrocarbons in bivalves at beach sites with no oiling, moderate oiling, and heavy oiling.
- B. Determine the effects of oil contamination on tissue and organs of bivalves.
- C. Determine bivalve mortality at each site.
- D. Determine growth rates of littleneck clams.
- E. Document adverse changes in numbers of young-of-the-year clams.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with Coastal Habitat Study 1, and will be completely integrated upon full implementation of Coastal Habitat Study 1. Fish/Shellfish Study 21 addresses similar objectives outside of Prince William Sound. The results of these studies will support Economic Uses Studies 3, 5, and 6, on bioeconomic modeling and recreation and subsistence uses, respectively.

Methods and Analyses:

This study will be conducted by the Alaska Department of Fish and Game, the objectives of this study will be combined with the Coastal Habitat study. During April and May of 1989, nine beach sites will be surveyed that represent: no oil contamination (Olson Bay, Siwash Bay, and Simpson Bay); moderate oil contamination (Port

Chalmers, Outside Bay, and West Bay) and heavy oil contamination (Gibbon Anchorage, Herring Bay, and Horse Shoe Bay). Seven 0.5 m² quadrants will be sampled along three transects at each beach site (21 quadrants per site), perpendicular to the water's edge. Live and any recently dead specimens of cockles, littleneck clams, and butter clams will be collected, sorted, and enumerated, and the data recorded. An additional 30 meter transect along the high tide line will be sampled at each site to count the number of recently dead bivalves washed ashore. For each species, three samples of specimens will be collected from each site for hydrocarbon analysis (one sample per transect).

Samples for determining the effects of oil contamination on tissues and organs of bivalves will be collected at each site. Only littleneck clams will be collected for growth and age estimation. A total of 100 littleneck clams will be collected from each transect at each site. After all nine sites are sampled, one heavily oiled beach will be monitored biweekly from May through September. If sudden changes in the proportion of dead clams or cockles occur, all nine sites will be revisited immediately to determine hydrocarbon levels in sediments and bivalves, to collect necropsy samples, and to determine bivalve mortality. If sudden changes in the proportion of dead clams do not occur, sites will be revisited once during the fall. Repeat sampling will monitor growth and any changes in relative abundance in young-of-the-year clams.

An analysis of variance (ANOVA) will be used to test for significant differences in the hydrocarbon content of cockles and clams among sites. Hydrocarbon concentrations in bivalves will be related to the level of beach contamination (no, intermediate, and high) and hydrocarbon concentrations in sediments (from the sediment sampling program) to assess the oil spill impacts to Prince William Sound bivalves. ANOVA tests also will be used to test for significant differences in the proportion of dead clams among sites and with time. Necropsy analysis will establish cause of death. An ANOVA on growth parameters obtained after the oil spill will be compared with growth parameters for littleneck clams prior to the oil spill to resolve effects of oil contamination on growth. Changes in recruitment will be determined for each species from the relative abundances of bivalves between two and four years old.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$20.5
Travel	3.5
Contracts	50.5
Supplies	8.7
Equipment	<u>3.0</u>
<u>TOTAL</u>	\$86.2

FISH/SHELLFISH STUDY NUMBER 14

Study Title:

Injury to Prince William Sound Crabs

Concern/Justification:

The diverse marine habitats of Prince William Sound support a variety of crab species. Two of these, the brown king crab and Dungeness crab, cannot be assessed with trawls. Brown king crabs, which occur in very deep waters, currently support a commercial fishery. Dungeness crabs, which occur in more shallow water, currently support subsistence and sport fisheries, and have supported a commercial fishery in the past. Crabs are known to be very sensitive to hydrocarbons. Crabs are known to lose legs, suffer egg loss, and have molting difficulty as a result of hydrocarbon exposure. It is suspected that Dungeness crabs may be particularly susceptible due to their shallow-water ecology.

Objectives:

- A. Assess the levels of hydrocarbons in Dungeness crabs at four oiled and four non-oiled sites in the Sound.
- B. Assess the levels of hydrocarbons in brown king crabs at nine sites in the Sound.
- C. For both crab species, assess the incidence of limb loss and abnormalities in newly formed crab shells, and assess such reproductive factors as fecundity, egg loss, condition, and development; and for Dungeness crabs, assess larval production from ovigerous females collected in oiled and non-oiled areas.
- D. Determine whether these observations demonstrate any adverse changes in viability.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic extent and persistence of oil in crab habitats will be provided by the suite of Air/Water and Coastal Habitat studies, especially Air/Water Study 2, and by Fish/Shellfish Study 20, Undersea Observations. Related observations will be made on crabs outside the Sound under Fish/Shellfish Study 22. The results of these two crab studies will be used in Economic Use Studies 3, 5, and 6.

Methods and Analyses:

Dungeness crab samples were collected immediately after the oil spill. Similar samples will be collected in the autumn prior to egg hatch. Eight sites, four in oiled and four in control areas, will be sampled by diver transects and pot gear. Fecundity and egg condition will be determined from examination of pleopod collections. Fecundity will be compared among females of similar size, and parameters of fecundity-size relationships will be tested for differences. Ovigerous crabs from oiled and non-oiled areas will be held in the laboratory until larval release and larval production are estimated.

For brown king crab, samples will be collected in August. Nine sites will be selected based upon pre-survey examination for oil contamination in crab habitat by the "Undersea Observations" study. Crabs will be collected with commercial king crab pots systematically deployed in nine areas. Sediment samples obtained through air-water studies will be used to post-stratify the statistical analysis according to the severity of oil contamination. Data on fecundity and egg condition will be determined from examination of pleopod collections. Fecundity will be compared among females of similar size and parameters of fecundity-size relationships will be tested for differences.

For both species, necropsy and hydrocarbon samples will be collected based upon standard procedures. Statistics for analysis of variance will be computed to determine differences in hydrocarbon content in crabs and sediment, incidence of leg loss, abnormalities in shells of newly molted crabs, necropsy, and estimated reproductive parameters among areas.

Lead Agencies: Alaska Department of Fish and Game (king crab) and National Oceanic and Atmospheric Administration (Dungeness crab)

Cooperating Agency(ies): None

Budgets:

Alaska Department of Fish and Game

Salaries	\$20.6
Travel	1.5
Contracts	38.0
Supplies	4.8
Equipment	<u>0.0</u>

TOTAL \$64.9

National Oceanic and Atmospheric Administration

Salaries	\$30.0
Travel	4.0
Contracts	20.0
Supplies	2.0
Equipment	<u>22.0</u>
<u>TOTAL</u>	\$78.0

FISH/SHELLFISH STUDY NUMBER 15

Study Title:

Injury to Prince William Sound Spot Shrimp

Concern/Justification:

In 1988 the commercial harvest of spot shrimp in Prince William Sound amounted to over \$500,000, which was approximately one-third of the statewide total. Spot shrimp also support subsistence and personal use fisheries in the Sound. Spot shrimp are relatively long-lived (seven to nine years) and are known to be very sensitive to oil contamination. Impacts to spot shrimp populations may occur, since spot shrimp eggs (which hatched immediately before the oil spill) and early life-stages are known to be very sensitive to oil contamination.

Objectives:

- A. Measure hydrocarbon concentrations in spot shrimp from oiled and non-oiled areas.
- B. Determine the relative abundance of spot shrimp in oiled and control areas.
- C. Analyze egg fecundity, mortality, and sublethal effects for oiled and non-oiled areas, and determine whether those effects result in adverse changes in viability.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic extent and persistence of oil in spot shrimp habitats will be provided by Air/Water Study 2 and by Fish/Shellfish Study 20. The results of the shrimp study will be used in Economic Use Studies 3, 5, and 6.

Methods and Analyses:

Spot shrimp will be sampled using standardized commercial shrimp pot gear in oiled (Unakwik Inlet, Port Wells, Culross Passage) and non-oiled (adjacent to Eleanor, Knight, and Green Islands) areas. For both the fall and spring sampling periods, up to 264 pots will be fished in a stratified pattern incorporating depth and location within oiled and non-oiled areas. Biological data to be collected include enumeration of catch by species and the weight, size, sexual stage, and fecundity by species by pot. Other data to be

collected include station location, depth, water temperature and salinity (profiles), and catch-per-unit-effort. Shrimp samples will be collected for hydrocarbon analysis. Statistics for analysis of variance will be calculated to contrast differences in hydrocarbon content and relative abundance in oiled and non-oiled areas. Analyses of biological factors to contrast potential differences among areas also will be performed. These factors include fecundity and stage of egg development, egg fouling and predators, size frequency distributions, species catch composition, and sex ratios.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): None

Budget: Alaska Department of Fish and Game

Salaries	\$ 25.4
Travel	1.5
Contracts	20.3
Supplies	2.3
Equipment	<u>11.0</u>

<u>TOTAL</u>	\$ 60.5
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FISH/SHELLFISH STUDY NUMBER 16

Study Title:

Prince William Sound Oysters

Concern/Justification:

Oysters have been used as an indicator species in oil spill impact assessments elsewhere in the world. Oysters accumulate petroleum hydrocarbons in their tissues; however, they do not possess the enzyme system necessary to metabolize hydrocarbons. Therefore, depuration and return to control levels may extend over a long period of time, as observed seven years after the grounding of the Amoco Cadiz.

There are three oyster farms in the Sound, one of which produces 1.5 million animals annually. One farm, at Perry Island, is within the oil spill. Another, at Fairmont Island, is near the spill area. Oyster tissues from these sites will serve as good indicators of oil contamination.

Objectives:

- A. Determine the effects of oil contamination on Pacific oyster growth and survival.
- B. Determine the effect of oil contamination on physiology of Pacific oysters.
- C. Measure rates of depuration and recovery of the site(s) impacted by the oil spill.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationship to Other Studies:

Exposure information for the oyster-growing areas will be obtained in part from Air/Water Studies 1 and 3, and Coastal Habitat Study.

Methods and Analyses:

Biological parameters will be collected at each of these three oyster farm sites. Existing growth data from the farms will be used as a base line.

Once per month, each population will be sampled to determine mortality, growth, and condition. Two lots of 200 animals will be marked at each site to track growth and survival. Hydrocarbon

samples will be collected at each site on a monthly basis for the six months following the spill (April-September 1989). Pairwise comparison of growth and survival will be drawn between the oysters in the oiled area and those outside oil-impacted areas. Differences will be evaluated relative to the characteristics of each of the three sites.

Lead Agencies: Alaska Department of Fish and Game and National Oceanic and Atmospheric Administration

Cooperating Agency(ies): None

Budgets:

Alaska Department of Fish and Game

Salaries	\$ 5.0
Travel	7.5
Contracts	2.0
Supplies	5.0
Equipment	<u>6.0</u>

TOTAL \$ 25.5

National Oceanic and Atmospheric Administration

Salaries	\$ 0.0
Travel	0.0
Contracts	3.0
Supplies	2.0
Equipment	<u>0.0</u>

TOTAL \$ 5.0

FISH/SHELLFISH STUDY NUMBER 17

Study Title:

Injury to Prince William Sound Rockfish

Concern/Justification:

Rockfish semi-pelagic and associated with reefs and pinnacles. Oil contamination of these reefs could kill rockfish outright or continue to taint them due to persistence of oil in the substrate or in their food. Dead rockfish have been recovered floating in areas where surface waters had been oiled inside the Sound. A decline in rockfish populations due to the oil spill could harm sport, commercial, and subsistence fisheries by reducing harvest.

Objectives:

- A. Sample rockfish populations from both oiled and control sites in previously studied areas of the Sound.
- B. Document the presence or absence of oiled rockfish, non-oiled rockfish, and oiled substrate in areas of fish kills.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on occurrence and persistence of oil in rockfish habitats will be obtained from Air/Water Studies 2 through 4, and from Fish/Shellfish Study 20. Injury to rockfish and other demersal species outside of Prince William Sound is being determined under Fishery Study 23. The results of the rockfish studies will be used in Economic Use Studies 3, 5, and 6, which address bioeconomic modeling, recreational and subsistence values, respectively.

Methods and Analyses:

Ten reefs (six in oiled and four in non-oiled areas) have been selected for study. Rockfish populations near all ten reefs were studied during August in 1977-79. Fish will be collected with commercial longline gear set for two hours over each reef with 360 hooks per set during May. Tissues will be removed from all captured fish and used for organoleptic testing for petroleum hydrocarbons. These areas will be fished again in August with longline gear. In addition, the substrate in each area will be inspected for oil using a remotely operated vehicle, as described in another study ("Undersea Observations").

Where direct or anecdotal evidence of a fish kill is observed, the area in question will be visited and rockfish obtained by collecting a sample of any dead fish on the surface or fishing for live fish with hook and line. All fish found dead on the surface will be necropsied, all moribund fish will be subjected to hydrocarbon analysis, and all live fish will be tested organoleptically as described above. At sites with documented fish kills, reefs and pinnacles will be searched for oil with a remotely operated vehicle in August.

Information on harvests and catch-per-unit-of-effort (CPUE) in the ten study areas and in areas investigated during fish kills will be obtained through another study ("Sport Fishery and Harvest Study"). Occurrence of rockfish during this study will be compared with distributions noted in historical surveys.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA
State: DEC

Budget: Alaska Department of Fish and Game

Salaries	\$12.0
Travel	3.6
Contracts	23.0
Supplies	6.0
Equipment	<u>1.0</u>
<u>TOTAL</u>	\$45.6

FISH/SHELLFISH STUDY NUMBER 18

Study Title:

Prince William Sound Trawl Assessment

Concern/Justification:

Prince William Sound supports bottom fisheries worth several million dollars annually for species such as Tanner crab, king crab, sidestripe shrimp, halibut, pollock, sablefish, Pacific cod, and others. A multispecies stock assessment survey permits estimation of abundance. A drop in abundance of those stocks previously surveyed (e.g., Tanner crab) would show that sustainable harvests have declined. Data from this study will allow detection of missing year-classes consistent with the timing of the oil spill. Data from this study will permit quantification of any harvest foregone due to the oil spill.

Objectives:

- A. Determine abundance of Tanner crab, sidestripe shrimp, halibut, sablefish, and other commercially important species.
- B. Determine age composition for primary species.
- C. Determine the incidence of abnormalities in tissues and organs in fish and shellfish captured in oiled and non-oiled areas and whether such abnormalities result in adverse changes in viability for the resource.
- D. Determine the incidence of tar balls in the demersal environment and in stomachs of groundfish captured in oiled and non-oiled areas.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationship to Other Studies:

This study is coordinated with Fish/Shellfish Study 24, the trawl survey outside of Prince William Sound. Both studies will examine demersal fish to ascertain the extent of exposure in this environment. Related information on geographic distribution and persistence of petroleum will be provided by Air/Water Studies 2-4. Resource abundance information from these surveys will be used in Economic Use Study 3.

Methods and Analyses:

Stratified random surveys will be conducted using methods consistent with previous trawl surveys. Surveys will first be conducted from mid-May to mid-June, and again in August. The survey in mid-May to mid-June is planned to provide the best information on immediate impacts of the oil spill. The August survey forms the basis for determining changes in annual abundance. Catch-sampling methods will follow standard procedures for trawl surveys. Otoliths of primary groundfish species will be collected for age determinations. To permit pairwise comparisons, four sites each in oiled and non-oiled areas will be identified for intensive study. Tissue and organ samples of fish and shellfish will be collected from these eight sites to permit analyses for hydrocarbons and physical injuries. Stomachs from groundfish will be examined aboard the vessel for tar balls.

Area-swept methods will be used to estimate abundance. Confidence intervals for abundance estimates will be used to document changes in abundance. Statistics for analysis of variance will be computed to assess any differences in hydrocarbon content and incidence of tissue abnormalities to assess differences between oiled and non-oiled areas. Catch-age analyses for principal species will be conducted to detect potential recruitment failures associated with the oil impact.

Lead Agencies: Alaska Department of Fish and Game and National Oceanic and Atmospheric Administration

Cooperating Agency(ies): None

Budgets:

Alaska Department of Fish and Game

Salaries	\$127.3
Travel	13.0
Contracts	0.0
Supplies	7.0
Equipment	<u>52.0</u>
<u>TOTAL</u>	\$199.3

National Oceanic and Atmospheric Administration

Salaries	\$125.0
Travel	5.0
Contracts	282.0*
Supplies	37.5
Equipment	<u>90.0</u>

TOTAL \$539.5

* Includes all costs of R/V Cobb for 123 days for this and other studies.

FISH/SHELLFISH STUDY NUMBER 19

Study Title:

Injury to Larval Fish in Prince William Sound

Concern/Justification:

Larvae of pollock, halibut, Pacific cod, black cod, herring, flathead sole, starry flounder, yellowfin sole, Tanner crab, spot shrimp, pink shrimp, and king crab are vulnerable to oil contamination. All of these species are important to commercial, sport, subsistence, and personal use fisheries. Larvae of these species may have been present in Prince William Sound at the time of the spill and may have been affected by hydrocarbons known to have been in the water column at that time. Residual oil, even in low concentrations, in the water column will kill larvae after the principal slick has passed. The position in the water column of many of these species is unknown. Also, abundance of some of these species can be assessed only at the larval stage in their life history.

Objectives:

- A. Determine the spatial and temporal presence of larval finfish and shellfish in the Sound.
- B. Determine larval distribution of finfish and shellfish in relation to distribution of hydrocarbons in the Sound.
- C. Estimate loss of larval finfish and shellfish production during 1989 as a result of the oil spill with assistance from literature data on toxicity.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Temporal distribution of petroleum in near-surface waters will be estimated under Air/Water Studies 1 and 3, and will be used as a basis for evaluating injury to larval fish. Results of this study will support analysis of oil-spill effects under Fish/Shellfish Studies 14, 15, 18, 22, and 24.

Methods and Analyses:

Using the R/V Alpha Helix, R/V Cobb, and vessel charters, sampling will be conducted one week per month from March through October, collecting larvae of commercially important finfish and shellfish

at specific stations in oiled and non-oiled areas. These samples will represent the first data collected on the relative abundance of larvae of shellfish and groundfish in the Sound (some samples were taken in areas in advance of the arrival of crude oil by starting this study in April). A 1-m² NIO (Tucker trawl) net with 505-u or 1,000-u mesh net will be used along with a MOCHNESS, which allows up to ten discrete depth or oblique tows per deployment.

Three analyses will be performed. First, observations of larval density will be ordered in sequence by time, area, and depth. Data on hydrocarbon concentrations and physical oceanographic conditions collected in the Sound by other ongoing programs will be similarly ordered to determine those species exposed to hydrocarbon contamination. Published laboratory studies on effects of hydrocarbons on larvae will be used to infer impacts of the oil spill on those species exposed to hydrocarbon contamination in the Sound. Second, changes in spawning biomass of commercially important species from ongoing trawl surveys and changes in the density of their larvae (this study) will be used to assess possible lethal effects of oil contamination as inferred from analysis 1. Third, for species with protracted spawning periods, data concerning larval size and growth will be compared with the dates of elevated hydrocarbon contamination of the Sound (from the water sampling program) to detect any missing components of larval length distributions associated with possible increases in larval mortality coincident with the oil spill.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA
State: UAF

Budget: Alaska Department of Fish and Game

Salaries	\$198.5
Travel	24.3
Services	66.8
Supplies	23.8
Equipment	<u>100.0</u>

TOTAL \$413.4*

* Includes RSA to UAF for \$382.0.

FISH/SHELLFISH STUDY NUMBER 20

Study Title:

Undersea Observations

Concern/Justification:

Information exists about the distribution of spilled oil from the Exxon Valdez on the water surface and in intertidal areas of Prince William Sound and the Gulf of Alaska. However, the extent, distribution, and patchiness of oil and oil byproducts on the seafloor is unknown. Information concerning subsurface oil distribution is needed to establish sampling areas for damage assessment studies of bottom-dwelling (demersal) species. It is also important for directing the detailed sampling designs for many of the individual groundfish and shellfish damage assessment studies. Direct observation by remote-operated vehicle (ROV), coupled with limited ground-truthing, will support the overall resource damage assessment by 1) confirming the extent of oil on the seafloor in the study areas for several studies; and 2) guiding selection of specific study sites so that paired study areas are representative of oiled and non-oiled conditions. Direct observation of seafloor conditions will increase the efficiency and cost-effectiveness of the overall groundfish and shellfish studies both inside and outside of the Sound.

Objectives:

- A. Through direct observation, identify appropriate sample areas for the brown king crab, spot shrimp, and rockfish/halibut studies.
- B. Direct selection of specific sites within oiled and control areas for pairwise evaluation.
- C. Provide direct support to the rockfish injury assessment study in Resurrection Bay.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study directly supports Fish/Shellfish Studies 14, 15, 17, and 23, which are designed to determine injury to brown king crab, spot shrimp, and rockfish, respectively. Observations from the ROV will be complemented in Prince William Sound by observations from a manned submersible, under Air/Water Study 2.

Methods and Analyses:

Visual (video tape) records will be collected along transects within potential brown king crab, spot shrimp, halibut, and rockfish sampling areas in the Sound and the northwestern Gulf of Alaska to a maximum 1,500-foot depth using ROVs. ROVs will be controlled from surface vessels that, in most cases, already are deployed for other aspects of the overall damage assessment. Presence of oil, general distribution and abundance of demersal fish and shellfish, depth, substrate type, turbidity, temperature, and salinity will be recorded. Transect density will be increased where evidence of oil is found. Ground truth sampling along ROV transects generally will be accomplished with samples already being collected. Observations from a manned submersible (the use of which is described in the study entitled "Petroleum Hydrocarbon-Induced Injury to Subtidal Marine Sediment Resources") will complement the ROV observations, especially within Prince William Sound. It is expected that ROVs will be tethered, maneuverable, and will support video camera, lights, and water quality measurement equipment. Precise subsea positioning and tracking capability may be added, and broader-scale substrate mapping also can be accomplished by including sidescan sonar. (These have not been assumed in the budget.) Approximately 60 days of ROV deployment will be needed to specifically support the fishery studies. That time will be divided roughly equally between Prince William Sound and areas outside (including Resurrection Bay and the southern Kenai Peninsula, lower Cook Inlet, the Alaska Peninsula, and Shelikof Strait).

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: EPA, NOAA
State: UAF

Budget: Alaska Department of Fish and Game

Salaries	\$ 60.0
Travel	22.5
Contracts	218.8
Supplies	18.8
Equipment	<u>230.0</u>
<u>TOTAL</u>	\$550.1

FISH/SHELLFISH STUDY NUMBER 21

Study Title:

Injury to Clams Outside Prince William Sound

Concern/Justification:

Bivalve mollusks are an important component of the food chain and support subsistence and sport fisheries in Resurrection Bay, lower Cook Inlet, Kodiak Island/Shelikof Strait, and the Alaska Peninsula. The principal species examined in this study will include the cockle, littleneck clam, butter clam, and razor clam. This study is designed to assess the effects of the Exxon Valdez oil spill on bivalve resources in selected areas outside Prince William Sound.

Objectives:

- A. Determine level of hydrocarbons in bivalves at oiled and non-oiled beach sites (paired samples).
- B. Determine the effects of oil contamination on tissues and organs of bivalves.
- C. Determine and compare any bivalve mortality between oiled and control sites.
- D. Determine and compare annual growth rates of bivalves between oiled and control areas.
- E. Document any changes in numbers of young-of-the-year clams.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 13.

Methods and Analyses:

During June-September, ten locations outside the Sound will be selected for monitoring. Representative locations in Resurrection Bay, lower Cook Inlet, Kodiak, and the Alaska Peninsula will be sampled during low tides. At each location, an oiled and a nearby non-oiled beach site will be selected for paired samples.

Seven quadrants will be sampled along three transects at each beach site. Live and any recently dead specimens of bivalves will be

collected, sorted, and enumerated, and the data recorded. An additional 30-meter transect along the high tide line will be sampled at each site to assess the number of any recently dead bivalves washed ashore.

For each species, three samples of specimens will be collected from each site for hydrocarbon analysis (one sample per transect). Necropsy samples will be collected from each species at each site (20 specimens/site). Specimens for hydrocarbon analysis and necropsy will be randomly selected. A total of 100 of either littleneck clams or razor clams will be collected from each transect at each site for growth and age estimation. All five locations will be re-sampled to monitor changes in hydrocarbon levels, mortality, and recruitment.

Analysis of variance tests will be used to test for significant differences in the hydrocarbon content of bivalves and the proportion of dead clams. Hydrocarbon levels in bivalves will be related to the level of beach contamination (oiled versus non-oiled) and hydrocarbon concentration in sediments (from the sediment sampling program) to assess the oil spill impacts on bivalves. Necropsy analysis will establish cause of death. Growth parameters and the abundance of bivalves two to four years old will be statistically tested for temporal changes in growth rates and recruitment between oiled and non-oiled beaches.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USDI (NPS), USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$30.4
Travel	2.6
Contracts	67.5
Supplies	6.0
Equipment	<u>2.3</u>
<u>TOTAL</u>	\$108.8

FISH/SHELLFISH STUDY NUMBER 22

Study Title:

Injury to Crabs Outside Prince William Sound

Concern/Justification:

The diverse marine habitats of Kodiak Island, Cook Inlet, and the Aleutian Islands support a wide variety of commercial, sport, and subsistence crab species. Dungeness crab support commercial fisheries in Cook Inlet and near Kodiak Island valued at \$4 million annually. The commercial values, when included with the subsistence and sport harvests, make this species extremely valuable. Crabs are known to be very sensitive to hydrocarbon contamination. They are known to lose legs, suffer egg loss, and have difficulty molting. Dungeness crab may be particularly susceptible to oil contamination due to their shallow water existence.

Objectives:

- A. Determine the levels of hydrocarbons in Dungeness crabs in oiled and non-oiled sites in Cook Inlet and near Kodiak Island.
- B. Determine the incidence of limb loss, abnormalities in newly formed crab shells, and assess such reproductive factors as fecundity, egg loss, condition, and development; and assess larval production from ovigerous females collected in oiled and non-oiled areas.
- C. Determine whether the observed effects are adverse changes in the viability of the resource.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 14.

Methods and Analyses:

Dungeness crab samples from sites in oiled and non-oiled areas will be sampled in the fall by subtidal transects using divers and pot gear. Fecundity and egg condition will be determined from examination of pleopod collections. Fecundity will be compared among females of similar size and parameters of fecundity-size relationships will be tested for differences. Ovigerous crabs from

oiled and non-oiled areas will be held in the laboratory until larval release, and larval production is estimated. Necropsy and hydrocarbon samples will be collected based upon standard procedures.

Statistics for analysis of variance will be computed to determine differences in hydrocarbon content in crabs, incidence of leg loss, abnormalities in shells of newly molted crabs. Necropsy of crabs will take place and reproductive parameters among areas will be estimated.

Lead Agencies: Alaska Department of Fish and Game and National Oceanic and Atmospheric Administration

Cooperating Agency(ies): State: UAF

Budgets:

Alaska Department of Fish and Game

Salaries	\$10.0
Travel	1.0
Contracts	0.0
Supplies	0.0
Equipment	<u>0.0</u>

TOTAL \$11.0

National Oceanic and Atmospheric Administration

Salaries	\$ 30.0
Travel	7.5
Contracts	25.0
Supplies	31.0
Equipment	<u>7.0</u>

TOTAL \$100.5

FISH/SHELLFISH STUDY NUMBER 23

Study Title:

Injury to Rockfish, Halibut, and Lingcod Along the Lower Kenai Peninsula

Concern/Justification:

The recreational fisheries for halibut based in Homer and for halibut, rockfish, and lingcod based in Seward are the largest of their kind in Alaska. These species are also harvested by commercial and subsistence fishermen. Rockfish in these fisheries are semi-pelagic and associated with reefs and pinnacles. Lingcod are benthic, sedentary, and associated with reefs. Halibut are benthic and migratory. Oil contamination of reefs could kill these fish outright or continue to chronically taint them due to persistence of oil in the substrate or in the food web.

Objectives:

- A. Assess contamination of rockfish and lingcod from oiled and non-oiled populations in and offshore of Resurrection Bay.
- B. Document the presence or absence of oiled rockfish and lingcod, non-oiled rockfish and lingcod, and oiled substrate in areas of fish kills.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Fish/Shellfish Study 17.

Methods and Analyses:

Several locations in oiled and non-oiled waters in and near Resurrection Bay will be observed. Each location will be an area known to have had rockfish, lingcod, and/or halibut in 1988; charter boat operators and fishing guides will be surveyed to identify these areas. Fish will be caught in these areas with commercial longline gear set for two hours over each reef with 360 hooks per set. Tissues will be removed from all captured fish and organoleptically tested for petroleum hydrocarbons. In addition, the bottom in each area will be inspected for oil with a remotely operated vehicle (ROV), as described in another study.

Where direct or anecdotal evidence of a fish kill is obtained, rockfish or lingcod will be obtained by collecting a sample of any

dead fish on the surface or fishing for live fish with hook and line. Up to ten fish found dead on the surface will be necropsied, all moribund fish will be subjected to hydrocarbon analysis, and all live fish will be tested organoleptically as described above. Reefs and pinnacles at any site with documented fish kills will be searched for oil with an ROV.

Information on harvest will be obtained through an ongoing project of the Alaska Department of Fish and Game based in Seward to monitor recreational fisheries. For halibut fisheries based in Homer, information on changes in harvest and fishing effort will be obtained from the Statewide Harvest Survey, an ongoing project of the Alaska Department of Fish and Game.

Lead Agency: Alaska Department of Fish and Game.

Cooperating Agency(ies): Federal: NOAA, USDI (NPS)
State: DEC

Budget: Alaska Department of Fish and Game

Salaries	\$ 34.2
Travel	5.0
Contracts	52.7
Supplies	3.5
Equipment	<u>13.0</u>

TOTALS \$108.4

FISH/SHELLFISH STUDY NUMBER 24

Study Title:

Shellfish and Groundfish Trawl Assessment Outside Prince William Sound

Concern/Justification:

In lower Cook Inlet, Shelikof Strait, waters off Kodiak Island, and Alaska Peninsula bays, both sediments and prey items of groundfish and crab have likely been affected by the Exxon Valdez oil spill. Groundfish and crab fisheries yield multi-millions of dollars annually for species such as Tanner crab, red king crab, shrimp, halibut, pollock, sablefish, Pacific cod, flatfish, and others. A multispecies stock assessment permits estimation of abundance. Decreases in abundance of those stocks previously surveyed would show that sustainable harvests have declined. Data from this project will allow detection of reduced year-class strength consistent with the timing of the oil spill. Data from this project will permit quantification of any harvest foregone due to the oil spill.

Objectives:

- A. Measure abundance of Tanner crab, red king crab, halibut, pollock, sablefish, and other commercially important species.
- B. Determine age composition for primary species.
- C. Determine the incidence of abnormalities in tissues and organs in fish and shellfish captured in oiled areas and whether such abnormalities result in adverse changes in the viability of the resource.
- D. Catalog specific areas from the outer Kenai Peninsula to the Aleutian Islands where fishery resources show the bioaccumulation of petroleum compounds and their metabolite derivatives.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study is coordinated with Fish/Shellfish Study 18, the multispecies trawl survey inside of Prince William Sound. Objectives C and D are being undertaken on the NOAA vessel R/V Fairweather in close coordination with Air/Water Studies 2-4. Together these studies provide exposure information for studies of

other deep-water resources. Results of this study will be used in Economic Use Study 3.

Methods and Analyses:

Stratified random surveys will be conducted using methods consistent with previous and other planned trawl surveys. Existing survey programs include the triennial National Marine Fisheries Service coastwide trawl survey, Kodiak (Alaska Department of Fish and Game) trawl surveys for king and Tanner crabs, and annual National Marine Fisheries Service hydroacoustic surveys for pollock in Shelikof Strait. However, major gaps in the existing survey coverage exist, including lower Cook Inlet (Kachemak and Kamishak Bays), bays along the Alaska Peninsula, and coastal waters of the Aleutian Islands. This study will include areas such as these and will be fully integrated with these existing trawl surveys.

Surveys will be conducted during June and August. Catch-sampling methods will follow standard procedures. Otoliths of groundfish species will be collected for age determinations. Stomach, muscle, liver, and bile samples will be collected and analyzed for indication of exposure to oil and potential damage to reproductive potential.

Area-swept methods will be used to estimate abundance. Confidence intervals for abundance estimates will be used to document changes in abundance. Exposure to oil will be determined from analyses of tissues for hydrocarbon components and their metabolites. Potential reproductive damage will be determined through standard biochemical analyses. Catch-age analyses will be conducted to detect potential recruitment failures associated with the oil impact.

Lead Agencies: Alaska Department of Fish and Game and National Oceanic and Atmospheric Administration

Cooperating Agency(ies): None

Budgets:

Alaska Department of Fish and Game

Salaries	\$ 34.5
Travel	2.3
Contracts	196.5
Supplies	10.5
Equipment	<u>52.0</u>

<u>TOTAL</u>	\$ 295.8
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National Oceanic Atmospheric Administration

Salaries	\$ 45.0
Travel	40.0
Contracts	1900.0*
Supplies	200.0
Equipment	<u>15.0</u>

TOTAL \$2200.0

* Includes all costs of R/V Fairweather for this and other studies and trawl charter contract for annual groundfish and shellfish assessment on Continental Shelf.

FISH/SHELLFISH STUDY NUMBER 25

Study Title:

Injury to Scallop Resources in Kodiak Waters

Concern/Justification:

Weathervane scallops form the basis of a commercial fishery based primarily out of Kodiak. This resource may have been exposed to petroleum as a result of the Exxon Valdez oil spill.

The State of Alaska, the Japanese National Government (Overseas Fishery Cooperation Foundation), and the Kodiak Area Native Association have cooperated in the implementation of a scallop mariculture feasibility and demonstration project at Kodiak for the past three years. The project includes sites around Kodiak Island and has been conducted in cooperation with communities, villages, and the Kodiak City and Borough. The Japanese government, the State of Alaska, and various federal agencies have invested approximately \$2 million. The Exxon Valdez oil spill has put this program at risk and also has generated significant concerns about the biological impacts upon the commercial concentrations of scallops that live in nearby waters.

Objectives:

- A. Assess the effects of oil contamination on scallop growth and survival.
- B. Assess the effects of oil contamination on hydrocarbon content and physiology.
- C. Monitor rates of depuration and recovery by scallops.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the distribution and persistence of oil in scallop-producing areas will be provided by Air/Water Studies 2 through 4 and Fish/Shellfish Studies 20 and 24. Results of this study will be used by Economic Use Studies 1 and 3.

Methods and Analyses:

Existing growth data from the two scallop sites will be used as a base line. Pink, spiny, and weathervane scallops are involved. Mortality, growth, and condition factors of scallops at an oiled

and a non-oiled site will be sampled monthly. Samples for hydrocarbon determination will be collected once every two months following the spill through October. Pairwise comparison of growth, survival, and hydrocarbon content will be drawn between the scallops in the oiled and non-oiled site. Results will be analyzed to estimate the effects of the spill on the stocks of wild scallops that support active commercial fisheries in this area.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USDI

Budget: Alaska Department of Fish and Game

Salaries	\$18.4
Travel	4.3
Contracts	20.0
Supplies	11.1
Equipment	<u>0.0</u>

<u>TOTAL</u>	\$53.8
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FISH/SHELLFISH STUDY NUMBER 26

Study Title:

Injury to Impacts on Sea Urchins off Kodiak Island

Concern/Justification:

Green sea urchins support a rapidly growing commercial fishery in Kodiak with an exvessel value of \$152,000 in 1988. Urchins are shipped live via air freight to markets in Japan and provide a high-quality roe product. Sea urchins occupy intertidal and subtidal habitats which may become heavily contaminated by hydrocarbons from the oil spill. The oil spill could cause concentrations of hydrocarbons lethal to urchins, render the roe product unmarketable, smother, or contaminate their primary food source (kelp and algae on rocks), or result in reproductive failures due to injury to ovaries, lowered egg production, or developmental deformities in the eggs. Furthermore, oil may be toxic to larvae, and result in fewer recruits to the fishery in the future. Data from this study will permit quantification of any harvest foregone due to the oil spill.

Objectives:

- A. Measure relative abundance of green sea urchins in oiled and non-oiled areas.
- B. Determine roe production of urchins in oiled and non-oiled areas.
- C. Determine the incidence of abnormalities in ovarian development in urchins in oiled and non-oiled areas.
- D. Determine recruitment of young urchins in oiled and non-oiled areas.
- E. Determine the toxicity of crude oil to urchin larvae.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the geographic distribution and persistence of oil in sea urchin-producing areas will be provided by the suite of Coastal Habitat and Air/Water studies. Results of this study will be used by Economic Use Studies 1 and 3 to calculate damages occurring to the sea urchin fishery resource.

Methods and Analyses:

In accordance with the Quality Assurance Program, four oiled and four non-oiled areas of green sea urchin habitat will be selected for study. Five transects will be surveyed in each of the eight study areas at high tide in both September and November during the egg maturation period. At least three transects will traverse kelp beds. A cable, marked at 1 m intervals, will be laid from mean high water in a line perpendicular to shore to a total depth of 20 m. Floats will be anchored along the cable at depths of 5, 10, 15, and 20 m. A team of divers will survey each transect within 3 m on either side of the cable. The depth, presence of oil and kelp, and kelp condition (alive/dead, oiled/non-oiled, etc.) will be recorded every 1 m interval along each transect. Also, the sex, health (live or dead), size (diameter), depth, and position of every urchin encountered along each transect will be recorded. Along each transect, a random sample of 10 mature female urchins will be collected, and the diameter, live weight, and roe weight of these animals will be determined in the laboratory. A random sample of ovaries of 10 animals per sample area will be prepared for histological examination for abnormalities. Lastly, three random composite samples of ovaries from each area will be prepared for hydrocarbon analyses. Twenty live urchins will be shipped to a contractor for laboratory bioassay experiments on toxicity of oil to urchin larvae.

Statistics for analysis of variance will be computed to assess any differences in hydrocarbon content, incidence of ovary abnormalities, oil toxicity to larvae, changes in relative abundance, and any differences in parameters describing relationships between ovary weight and urchin diameter or ovary weight and total weight. Trend analyses of the relative abundance of young-of-the-year urchins will be used to detect potential recruitment failures associated with the oil impact. Multivariate statistics (e.g., log linear models) may be used to identify more complex associations among the biological and physical parameters between oiled and non-oiled areas.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: NPS, USFWS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$14.0
Travel	1.0
Contracts	21.0
Supplies	6.0
Equipment	<u>3.0</u>
<u>TOTAL</u>	\$45.0

MARINE MAMMALS INJURY ASSESSMENT

There are more than 25 species of marine mammals in Prince William Sound, the Gulf of Alaska, and adjoining waters. Most abundant and conspicuous are sea otters, Steller sea lions, harbor seals, and killer whales. Total populations of these and other marine mammals are not precisely known. However, recent population estimates suggest that about 40,000 sea otters, 60,000 sea lions, 90,000 harbor seals, 3,000 harbor porpoises, 150,000 Dall's porpoises, and 300 killer whales seasonally reside in the Gulf of Alaska. A large proportion of these marine mammals are in areas affected by the oil spill.

In addition, the entire population of eastern Pacific gray whales migrates through the area. Killer whales and harbor and Dall's porpoises breed within Prince William Sound. Humpback whales, an endangered species, use the Sound as a summer feeding area, and several other cetacean species use Prince William Sound and adjoining waters intermittently. Several important pinniped mating and pupping locations are in the Sound and just outside. Both harbor seals and sea lions are declining in abundance in the Sound and in much of Alaska; they may be given additional protection under the Marine Mammal Protection Act. The area impacted by the Exxon Valdez oil spill provides a variety of marine habitats that are seasonally critical for significant numbers of marine mammals that are of state, national, and international importance.

Marine mammals are a resource of considerable cultural, aesthetic, and economic significance. Alaskans at Tatitlek, Cordova, Chenega, and other villages harvest sea otters, sea lions, and harbor seals for subsistence and to use in traditional Native handicrafts. A multimillion dollar tourist industry depends, in part, on the ability to show visitors sea otters, killer whales, and other marine mammals. Sea otters are captured in the Sound for public display in aquaria throughout the world. Alaskan residents who use the Sound and other impacted areas also enjoy seeing these and other unique marine mammals in the wild. Media throughout the world feature photos and stories about these marine mammals.

During the first month and a half after the oil spill, many sea otters, pinnipeds, and cetaceans were seen surfacing in oil. Killer whales were observed near oiled areas. Many sea otters have died despite efforts to capture, clean, and rehabilitate them. Several hundred heavily-oiled harbor seals have been observed within the Sound and near Kodiak Island, and harbor seal mortalities have occurred. Short-term laboratory studies have shown that exposure to crude oil damages eyes and skin, while oil ingestion leads to liver and kidney damage and central nervous system degeneration. Effects of prolonged exposure by marine mammals to large quantities of oil, such as is now occurring, are unknown, but could include reproductive failure, reduced growth and

survival rates, displacement, and behavioral changes. The most severe long-term impacts could occur to those marine mammals dependent upon prey contaminated by oil.

The sea otter, harbor seal, sea lion, killer whale, humpback whale, and gray whale are the species most likely to be affected by the oil spill. These species will be used to represent other cetaceans and pinnipeds where appropriate, and to determine and quantify acute and chronic injury and duration of impact.

Sea otter studies will include determination of injury through carcass counts and studies of pathology and toxicology. Injury will be quantified by comparing historical and pre-impact survey data on distribution and abundance to similar surveys conducted during and after the spill. Population effects will be quantified by comparative studies of vital life-history parameters and individual growth data from oiled and non-oiled areas.

Cetacean studies will determine injury and possibly cause of death by analyzing beached carcasses and comparing the overall abundance and distribution of killer whales and humpback whales in the Sound and adjacent areas to historical data and pre- and post-spill surveys. For both killer whales and humpback whales, individual animals can be identified by coloration or natural marks. Comparison of the presence, movements, and behavior of these individuals to existing data will document injury and quantify the level of impacts. Changes in vital life history parameters will be documented to determine changes in natality or fecundity.

Pinniped studies will document injury by assessing levels of mortality to adult, juvenile, and young-of-the-year harbor seals and Steller sea lions through intensive surveys of known birthing, mating, and resting locations during reproductive and molting periods. Injury will be quantified by determining the relative abundance and distribution of each species throughout the affected area, conducting aerial and shipboard surveys and comparing those data to historical and pre- and post-spill survey data. Appropriate samples will be collected from animals exposed to oil and compared with tissues obtained from unexposed animals. These analyses will document the pathway, timing, and location of hydrocarbon concentrations in various organ systems.

MARINE MAMMALS STUDY NUMBER 1

Study Title:

Effects of the Exxon Valdez Oil Spill on the Distribution and Abundance of Humpback Whales in Prince William Sound, Southeast Alaska, and the Kodiak Archipelago

Concern/Justification:

The humpback whale is the third most depleted endangered whale in the North Pacific. Two populations have been identified in the eastern Gulf of Alaska, including one that uses Prince William Sound and the Kodiak area, and another that uses Southeast Alaska. The two populations are somewhat distinct; animals from the Sound and Kodiak are rarely seen in Southeast Alaska, and Southeast animals are not known frequent the Sound. Individual whales are identified by tail coloration and natural marks. Approximately 40-50 animals appear annually in the Sound (not necessarily the same animals from year-to-year). Following the Exxon Valdez oil spill, humpback whales may abandon the Sound for other feeding areas. Comparative data exist for overall abundance and distribution. These data can be used to determine if humpback whales are no longer using the Sound or have altered their behavior in direct or indirect response to the oil spill.

Objectives:

- A. Determine the numbers and distribution and identify individual humpback whales and their movements in the Sound during and after the oil spill.
- B. Survey the two other major feeding areas for humpback whales in Alaska (near Kodiak Island and in Southeast Alaska) to determine if individuals known to use the Sound on a regular basis are now feeding elsewhere.
- C. Quantify the extent of injury to the Humpback Whale population resulting from the oil spill.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information generated by this study will support determination of damages under Economic Uses Studies 5 and 7, recreation and intrinsic values, respectively.

Methods and Analyses:

Numbers and distribution will be determined by line-transect surveys using boats and airplanes. Individual animals will be identified by photographing animals from small boats. Transect data and individual identifications will be compared to historical data and pre- and post-spill surveys.

Distributional surveys in southeast Alaska will be conducted from ships (aided by airplane surveys), and individual humpback whales will be identified to document whether animals from the Sound have moved into Southeast.

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USFS, USDI
State: DNR

Budget: National Oceanic and Atmospheric Administration

Salaries	\$ 46.0
Travel	6.0
Contracts	153.0
Supplies	13.0
Equipment	<u>8.0</u>
<u>TOTAL</u>	\$226.0

MARINE MAMMALS STUDY NUMBER 2

Study Title:

Assessment of Injuries to Killer Whales in Prince William Sound, the Kodiak Archipelago, and Southeast Alaska

Concern/Justification:

Killer whales in Prince William Sound have been studied extensively over the past 12 years and are known to have very low rates of mortality and natality. These studies have identified individuals and pods that belong to family groups, which stay together over many years. Studies are needed to document both the lethal and sublethal impact of the spill on the integrity of these family units, natality and mortality, continuity of habitat usage, and seasonal distribution and abundance. Any changes in the life history or ecology of killer whales as a result of the oil spill could have a dramatic effect on their survival in the Sound.

Objectives:

- A. Determine the abundance, distribution, and pod structure of killer whales in and adjacent to the Sound.
- B. Identify changes in distribution, abundance, pod structure, and integrity of the family unit pre- and post- spill.
- C. Determine whether killer whale natality/mortality rates have changed.
- D. Quantify the extent of injury to killer whale populations from the Exxon Valdez oil spill and related activities.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Marine Mammals Study 1.

Methods and Analyses:

Principal areas will be surveyed by plane and ship. Photographic documentation of all animals observed from ship will be made and compared with previous data to identify individuals and pods. Cow/calf pairs will be identified and missing individuals from pods will be determined. Sampling will occur bimonthly during April-October.

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USDI, USFS
State: DNR

Budget: National Oceanic and Atmospheric Administration

Salaries	\$ 31.0
Travel	8.0
Contracts	153.0
Supplies	6.0
Equipment	<u>2.0</u>
<u>TOTAL</u>	\$200.0

MARINE MAMMALS STUDY NUMBER 3

Study Title:

Cetacean Necropsies to Determine Injury from the Exxon Valdez Oil Spill

Concern/Justification:

Nineteen species of cetaceans occupy marine habitats in the Gulf of Alaska. Of these, fin, sei, minke, humpback, gray, and killer whales, and Dall's and harbor porpoises are routinely encountered in waters affected by the Exxon Valdez oil spill. Humpback whales, although frequently observed in Prince William Sound, are an endangered species. Nearly the entire population of eastern Pacific gray whales migrates along Alaska's coast each spring on route to summer feeding grounds in the Bering and Chukchi Seas. Some gray whales are thought to feed in Alaskan waters during migration, and others are known to remain in the Gulf of Alaska throughout the summer. Along the north coast of the Alaska Peninsula, gray whale carcasses are routinely seen each spring, a presumed result of natural mortality. By mid-May 1989, four carcasses were found at Tugidak Island (near Kodiak) following the oil spill; the cause of death for these animals has not yet been determined. Because gray whales and other cetaceans are known to feed in the Gulf, they may be affected by the oil spill. This project will locate and necropsy beached cetaceans to determine if contact with or exposure to Exxon Valdez oil was the cause of death.

Objectives:

- A. Locate cetaceans stranded from Kayak Island through Unimak Pass and conduct necropsies on each animal to determine if the cause of death is a result of the oil spill.

Relationships with Other Studies:

This study provides substantiation of causality and mortality in support of Marine Mammals Studies 1 and 2. The information will be used under Economic Uses Studies 5 and 7 to determine damages to recreation and intrinsic values.

Methods and Analyses:

Aircraft will be used to survey beaches for stranded cetaceans. Where feasible, each will be examined for evidence of oil-related mortality and/or other possible causes of death. Necropsies will be performed by qualified veterinary pathologists. Tissues will be analyzed for hydrocarbons and appropriate histological and pathological examinations will be performed. Surveys of the area from Unimak Pass to the Sound will be conducted to determine if

strandings have occurred in or near the oil spill. As a control, dead cetaceans observed southeast of the oil spill area will be sampled and tested for hydrocarbons.

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USDI, USFS
State: DNR

Budget: National Oceanic and Atmospheric Administration

Salaries	\$ 15.0
Travel	4.0
Contracts	50.0
Supplies	2.0
Equipment	<u>2.0</u>
<u>TOTAL</u>	\$ 73.0

MARINE MAMMALS STUDY NUMBER 4

Study Title:

Assess the Oil Spill's Impact on Steller Sea Lions in Prince William Sound and the Gulf of Alaska

Concern/Justification:

Several thousand Steller sea lions were present in Prince William Sound and adjoining areas at the time of the oil spill, and remained in the area of contamination. Specific effects of oil on sea lions are unknown but are hypothesized to include mortality, disturbance, displacement, increased stress, behavioral changes, and/or loss or reduction of prey. Sublethal effects could be very subtle. Mortality could occur immediately or be delayed, both among animals that use the Sound and in the rest of the population across the entire northern Gulf of Alaska. Many sea lions use the Sound in winter and early spring, then move to rookeries in other locations in the northern Gulf in late April and May for pupping and breeding. Sea lions are highly mobile and are known to move throughout the entire northern Gulf. Far more animals could be exposed to contamination than might be counted at one time within the spill-impact area. This study is designed to investigate sea lions from Cape St. Elias, east of the Sound, to Chowiet Island in the Semidi Islands Group, south of Shelikof Strait. Steller sea lions in the Gulf are currently in a state of decline and have been proposed as depleted under the Marine Mammal Protection Act. Any additional mortality or reduction in productivity is of great concern.

Objectives:

- A. Estimate the number of sea lions using rookeries and haulouts between Cape St. Elias and Chowiet Island.
- B. Document premature birthing rate at study sites.
- C. Estimate pup production and mortality on rookeries in the northern Gulf.
- D. Determine presence of hydrocarbon contamination and histopathological effects in Steller sea lions.
- E. Determine if presence of oil affects haulout and rookery use.
- F. Determine effects of spill on growth and survival of Steller sea lions.

- G. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the spatial-temporal distribution of oil will be provided by the suite of Air/Water and Coastal Habitat studies. Information on abundance and contamination of sea lion prey organisms will be provided by a combination of several Fish/Shellfish studies. Results of this study will support the determination of damage to recreation and intrinsic values under Economic Uses Studies 5 and 7.

Methods and Analyses:

Periodic photosurveys will be flown of all haulouts and rookeries from Cape St. Elias to Outer Island. Pup counts will be conducted at all pupping areas from Chowiet Island to the Canadian border. Rookeries and hauling areas will be searched for aborted fetuses and sick or dead adults. Sick, dead, and a few control sample animals will be collected and examined for hydrocarbon contamination, reproductive status, food habits, diseases, and body condition. Tissue samples will be collected for histopathological examination and to determine levels of hydrocarbon contamination. Observers will be stationed at key rookeries and haulouts for observation of numbers, old and new visual-marked animals, behavior, and condition.

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USDI
State: ADF&G, DNR

Budget: National Oceanic and Atmospheric Administration

Salaries	\$ 92.5
Travel	21.5
Contracts	133.0
Supplies	12.0
Equipment	<u>11.0</u>

TOTAL \$270.0*

* This study will be conducted by ADF&G under contract to NMFS.

MARINE MAMMALS STUDY NUMBER 5

Study Title:

Assess the Injury to Harbor Seals in Prince William Sound and Adjacent Areas

Concern/Justification:

Harbor seals are one of the most abundant species of marine mammals in Prince William Sound. They are used for subsistence and handicraft purposes by Native residents in the area. Oil introduced into the marine environment may injure harbor seals directly or alter the biological and physical suitability of their habitat. There is potential for individual and population impacts through toxicologic and food-chain mechanisms. Responses of seals to oiling of haulout sites and consequences of haulout behavior changes are unknown. Seal pups, born in May and June, may be particularly susceptible to injury or death upon exposure to oil. Seals that have contacted oil or eaten oil-contaminated prey may not be suitable for human consumption.

Periodic counts have been used to provide trends in harbor seal numbers. These trend counts are available for the Sound and Tugidak Island on the south end of Kodiak. In the Sound, 25 sites were surveyed in 1984 and 1988 to provide an index of the population. Of those 25 sites, 9 are within the area impacted by oil. In 1984, approximately 50 percent of the harbor seals were found at these 9 locations. The trend counts in the Sound indicate a 40 percent decline in the number of seals at major haulouts between 1984 and 1988. The oil spill may exacerbate the decline by causing the loss of animals through exposure to oil that causes premature birth or abortions or, indirectly, by contamination or loss of the prey base.

Objectives:

- A. Evaluate effects of the oil spill on the distribution of harbor seals at haulouts within the Sound during pupping and molting seasons.
- B. Evaluate trends in harbor seal numbers in oiled and non-oiled parts of the Sound.
- C. Determine whether contact with oil affects reproductive success and pup survival in harbor seals.
- D. Examine tissues of seals for contamination and histopathologic effects.

- E. Determine the degree and persistence of oiling of harbor seals and their haulouts at selected sites within the Sound and adjoining areas.
- F. Determine fate of rehabilitated seals.
- G. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the distribution and persistence of oil will be provided by the suite of Air/Water and Coastal Habitat Studies, as will data on the abundance and contamination of harbor seal prey organisms. Tracking of radio-tagged seals will be coordinated with tracking of similarly tagged sea otters under Marine Mammals Studies 6 and 7. Results of this study will be analyzed under Economic Uses Studies 5, 6, and 7 to evaluate damage to recreational, subsistence, and intrinsic values.

Methods and Analyses:

Shoreline surveys will be conducted for several months using boats and helicopters to determine if direct mortalities result from the spill. Tissue samples from dead and moribund animals will be collected to determine cause of death. Levels of hydrocarbons in tissues of non-oiled animals taken in subsistence hunts will be compared to those oiled animals. Reproductive success will be evaluated by searching haulout sites for aborted fetuses and by conducting pup counts on haulout sites. Aerial surveys of trend-count haulout sites in both oiled and non-oiled areas will be conducted to determine if oil exposure has affected distribution. Established trend-count surveys will be conducted, during pupping and molting, to evaluate the effects of the oil spill on population trends. Selected haulout sites will be visited periodically and classified as to degree of oiling of seals and substrate. Rehabilitated seals will be tagged with visual and radio-tags, and their movements monitored.

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: USDI, USFS
State: ADF&G, DNR

Budget: National Oceanic and Atmospheric Administration

Salaries	\$ 71.0
Travel	15.0
Contracts	126.5
Supplies	23.0
Equipment	<u>9.5</u>
<u>TOTAL</u>	\$245.0*

* This study will be conducted by ADF&G under contract to NMFS.

MARINE MAMMALS STUDY NUMBER 6

Study Title:

Assess the Magnitude, Extent, and Duration of Oil Spill Impacts on Sea Otter Populations in Alaska

Concern/Justification:

Several hundred sea otters are known to have died as a result of contamination by oil. Death has occurred from hypothermia and from severe liver, kidney, and lung damage as a result of ingestion of oil, and emphysema from inhaling toxic aromatic compounds present during the early period of the spill. Long-term or chronic effects of oil on sea otters is unknown. Potential effects may occur as the result of debilitating or sublethal injury, accumulation of toxins, and loss or contamination of the food supply.

Objectives:

- A. Determine the magnitude of the injury to sea otter populations including number, age, sex, reproductive status, geographic extent, and duration as a result of the spill.
- B. Determine long-term effects of the spill on sea otters.
- C. Document presence/persistence of hydrocarbon/toxins in live and dead sea otters.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the distribution and persistence of oil in intertidal and nearshore subtidal habitats will be provided by the Coastal Habitat studies, along with data on the abundance and contamination of benthic organisms used by sea otters as food. Tracking of radio-tagged animals under Marine Mammals Studies 5, 6, and 7 will be coordinated to the extent possible. Results of the sea otter studies will support determination of damage to recreation and intrinsic values under Economic Uses Studies 5 and 7.

Methods and Analyses:

All dead sea otters brought to depositories will be counted, sexed, and aged. Female reproductive tracts will be analyzed to determine reproductive status. Boat and aircraft surveys will be conducted to count live and dead sea otters on a monthly basis. A comparison of live and dead sea otters in oiled and non-oiled areas will be made. A population estimate of live sea otters will be calculated.

Pup-ratio counts will be made in oiled and non-oiled areas to provide a measure of productivity. Up to 100 mature females in oiled areas and up to 100 females in non-oiled areas will be instrumented with radio transmitters to document movement patterns and to estimate reproduction and survival for comparison with existing data. Up to 50 dependent pups in oiled areas and up to 25 dependent pups in non-oiled areas will be instrumented with radio transmitters to document survival and dispersal. Food habits of sea otters will be monitored visually in oiled and non-oiled areas. Dependent pups with radio transmitters will be weighed and measured and subsequently recaptured to calculate growth rates.

Sea otter carcasses will be salvaged, cause of death will be determined through necropsy and histopathology, and representative tissues will be sampled for hydrocarbon analysis. Blood, milk, fat, and other tissue biopsies from live sea otters will be sampled for histopathology and hydrocarbon analysis.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI (NPS and BIA), USFS
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$186.0
Travel	31.0
Contracts	120.0
Supplies	31.0
Equipment	<u>395.0</u>
<u>TOTAL</u>	\$763.0

MARINE MAMMALS STUDY NUMBER 7

Study Title:

Assess the Fate of Sea Otters Oiled and Rehabilitated as a Result of the Exxon Valdez Oil Spill

Concern/Justification:

Much time and money has been invested in the capture, rehabilitation, and holding of sea otters contaminated with oil from the Exxon Valdez oil spill. Severity of oiling and internal injuries suffered by many affected sea otters have been so great that only about 50 percent of those reaching the cleaning facilities have survived. It is likely that some of those surviving the ordeal may suffer long-term effects.

Objectives:

- A. Determine the effects of oiling and subsequent rehabilitation on survival, movement, and behavior of sea otters captured and released in the Sound.
- B. Identify potential alternative methods and strategies for rehabilitation.

Relationships with Other Studies:

See Marine Mammals Study 6.

Methods and Analyses:

Sea otters captured in the Sound will be held in captivity until they are healthy enough for release. Thirty-six rehabilitated sea otters will be surgically implanted with radio transmitters or will be outfitted with flipper radio transmitters prior to release into the wild. These transmitters will be used to evaluate survival and success of the rehabilitation effort. Relocation will be frequent enough to provide estimates of survival. Survival rates will be compared with those from other studies. Adult females will be monitored for reproductive success.

Carcasses of radioed sea otters will be salvaged and necropsied by a veterinary pathologist to determine cause of death. Results will be compared with those from other animals killed during the oil spill.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI (NPS and BIA), USFS
State: DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$40.0
Travel	3.0
Contracts	35.0
Supplies	5.0
Equipment	<u>25.0</u>
<u>TOTAL</u>	\$108.0

TERRESTRIAL MAMMAL INJURY ASSESSMENT

A great variety of terrestrial mammals inhabits the area impacted by the Exxon Valdez oil spill. Many of them utilize the intertidal areas, especially in the spring. These mammals occupy an important niche in the coastal ecosystem and are important to humans for recreational viewing, sport and subsistence hunting, and commercial and subsistence trapping. Dead mammals have been observed on beaches impacted by the oil.

Nineteen terrestrial mammal species have been identified as potentially impacted. Five species have been selected for intensive study and nine species for a general assessment. The studies generally will determine what, if any, lethal or sublethal impacts on terrestrial mammals have occurred, focusing on the identification of adverse changes in viability. Guidance for such determinations is provided in 43 CFR sec. 11.62(f). Information gathered will assist in both the calculation of any loss of use value and the need and methods for restoration or replacement of the resources. Studies are proposed for mink and river otters, deer, and black bears in Prince William Sound, brown bears on the Alaska Peninsula, and carnivores and small mammals on the Alaska Peninsula. The latter study will include an assessment on foxes, coyotes, wolves, wolverines, weasels, ermine, marten, voles, and shrews. Scientists will conduct an intensive effort to determine if deer were injured and the degree of injury over the next five months. This study will then end unless injury can be documented. If a significant level of injury is discovered, a more extensive study will be developed.

Also proposed is a laboratory study to determine the influence of hydrocarbons on reproduction in domestic mink. That study is essential to learn whether sublethal doses of hydrocarbons will influence reproduction in mammals. Mink will be used as the mammalian model for other terrestrial and marine mammal species. Feeding trials with other species will not be required.

TERRESTRIAL MAMMAL STUDY NUMBER 1

Study Title:

Assessment of the Exxon Valdez Oil Spill on the Sitka Black-Tailed Deer in Prince William Sound

Concern/Justification:

Sitka black-tailed deer occur throughout Prince William Sound and number approximately 15,000 to 20,000 animals. Services associated with deer in the Sound include intrinsic value of existence, opportunity to view and photograph deer, and an annual harvest of about 2,000 animals. Most of the deer live on Hinchinbrook and Montague Islands. Beaches on Hinchinbrook Island were not contaminated by oil, whereas the northwestern portion of Montague Island was lightly oiled. Deer also occur and feed on smaller islands where beaches were heavily impacted by oil.

During late winter and early spring, most deer in the Sound are distributed along coastal beaches and in the coastal fringe forest where they forage on seaweeds and grasses. Some of the forage has been oiled. Deer could be injured if they consume seaweed or grasses contaminated by oil. Small to moderate amounts of crude oil consumed by deer and other ruminants could cause direct mortality due to disruption of the rumen fermentation process and aspiration of rumen fluid into the lungs. Sublethal injury also could occur, reducing animal health and affecting reproduction.

Objectives:

- A. Quantify the number of dead deer per unit area on both a heavily oiled and non-oiled island in the Sound.
- B. Determine if tissue and rumen contents of deer on heavily oiled islands have been contaminated by oil.
- C. Determine if deer found dead have rumen contents in the lungs.
- D. Determine any adverse changes in viability in the deer. Guidance for such determinations is provided in 43 CFR sec. 11.62(f).
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on distribution and persistence of oil in the intertidal zone will be provided by the Coastal Habitat studies and

Air/Water Study 1. Exposure of terrestrial mammals via the atmosphere will be quantified by Air/Water Study 5. Results of this study will support the estimation of damages to recreational, subsistence use, and intrinsic values under Economic Uses Studies 5, 6, and 7.

Methods and Analyses:

Systematic surveys for dead deer will be conducted on a heavily oiled island and a control island of similar size, topography, and deer density. (Guidance for selection of control island is provided in 43 CFR sec. 11.72(d)). Transects extending 500 meters into the forest will be established perpendicular to the beach at 25 meter intervals along selected 1-km lengths of beach. Up to 300 transects may be conducted on each island in accordance with the Quality Assurance Program. The carcass of each dead deer that is found will be examined in the field by a pathologist. Pellet group counts on each island will be done to correct for different deer densities. This procedure will provide an estimate of deer mortality per unit area on each island.

During August 1989, tissue samples from up to 25 deer from oil-contaminated islands will be analyzed for hydrocarbons and pathological abnormalities. Tissue samples from uncontaminated areas will be analyzed for base line data.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$20.0
Travel	4.0
Contracts	63.0
Supplies	0.0
Equipment	<u>0.0</u>
<u>TOTAL</u>	\$87.0

TERRESTRIAL MAMMAL STUDY NUMBER 2

Study Title:

Assessment of Exxon Valdez Oil Spill on Black Bear in Prince William Sound

Concern/Justification:

There is a dense population of black bears in Prince William Sound. The bears are omnivorous, opportunistic feeders near the top of the food chain. Black bears may ingest oil directly by eating sludge washed ashore, grooming oiled hair, feeding on intertidal organisms, or scavenging carcasses of mammals and birds killed by oil offshore and deposited on beaches. They also may consume plants and animals contaminated by sublethal doses of oil. Effects of oil ingestion are varied and could range from death from acute toxic effects to long-term suppression of reproduction. Experimental work with oiled polar bears in Canada indicated two of three animals died from organ failure after grooming. Population effects could range from sharp, immediate declines to subtle, long-term reductions as chronic effects of hydrocarbons stored in fat are expressed. Lost services resulting from direct mortality of black bears and/or reduced reproduction include reduced intrinsic values, reduced opportunities to see and photograph bears, and reduced opportunities to hunt bears.

Objectives:

- A. Determine mortality rates of black bears in heavily oiled habitats in the Sound.
- B. Determine changes in productivity of female black bears in the oil-contaminated areas.
- C. Document use of oiled foods by black bears through scat examination and direct observation.
- D. Determine cause of death of bears in oil-contaminated habitat.
- E. Calculate the decline of black bear populations due to adverse changes in viability, resulting from oil contamination.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Terrestrial Mammals Study 1.

Methods and Analyses:

Data will be acquired through 30 radio-collared black bears and from collections of scat and tissue samples. Comparisons of mortality and productivity rates of bears in the impact area will be made with similar data currently available for the Kenai Peninsula. Bear scats collected on contaminated and uncontaminated beaches will be chemically compared for evidence indicating ingestion of petroleum residues. Direct observations of bears on beaches will provide documentation of feeding on oil-contaminated forage. Carcasses of bears will be necropsied by a veterinary pathologist for evidence of cause of death. Tissues of bears found dead in the study area will be chemically analyzed for evidence of petroleum residues.

Changes in the black bear population will be inferred from a population model incorporating mortality and productivity data from the radio-collared bears. This model also will be used to simulate changes in black bear populations elsewhere in the Sound and on the Kenai Peninsula, using densities estimated from sport harvest or other appropriate data.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS, USDI
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$34.9
Travel	10.0
Contracts	80.8
Supplies	14.0
Equipment	<u>0.0</u>
<u>TOTAL</u>	\$139.7

TERRESTRIAL MAMMAL STUDY NUMBER 3

Study Title:

Assess the Effect of the Exxon Valdez Oil Spill on River Otter and Mink in Prince William Sound

Concern/Justification:

River otter and mink are expected to be the terrestrial mammals most affected by the oil spill. Both species feed in the intertidal zone, where much of the oil has accumulated. Both species were abundant in Prince William Sound prior to the oil spill. Both species rely on marine fishes, crabs, and other intertidal invertebrates for food; they capture this food in the water. Oiling will cause direct mortality and population declines. Oiling may cause long-term changes in forage fish and invertebrate populations that will directly and indirectly impact these two mammals. Lost services resulting from direct mortality of river otter and mink and/or reduced reproduction include reduced intrinsic values, reduced opportunities to see and photograph river otter and mink, and reduced opportunities to trap these two valuable furbearers.

Objectives:

- A. Determine mortality and document any declines of river otter and mink populations.
- B. Determine changes in distribution of river otter and mink, and changes in their food habits in oiled and non-oiled habitats.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Terrestrial Mammals Study 1. The effects of oil exposure on reproduction in mink will be determined under Terrestrial Mammals Study 6.

Methods and Analyses:

Immediate mortality and population decline will be documented by direct body counts and by comparing scat deposition rates at latrine sites. Sites will be cleared and checked periodically to determine usage. Comparisons will be made between oiled and control habitats. Population density of river otter will be assessed by radio-labeling the feces of 10 to 15 otter per study site. Ratios of labeled to unlabeled scats will be used to

estimate population abundance. Scats collected will be analyzed for food habits using standard techniques. Mink density will be estimated using mark-recapture techniques that accommodate capture heterogeneity.

Tissue samples from both river otter and mink will be collected from oiled and control areas to assess changes and accumulations of crude-oil compounds. Approximately four animals of each species from each area will be collected monthly. Movements, distribution, and habitat selection of radio marked otters and mink will allow assessment of changes in habitat selection as it relates to beach oiling. Available habitat will be estimated using aerial photographs and on-site examinations.

Extrapolations from intensive study areas will be made to other areas impacted by oil to determine overall impacts to the otter and mink populations. Study sites are located in the Knight Island group (oiled areas) and in Esther Passage and Eaglek Bay (control areas). Other sites on the Kenai Peninsula and on the Alaska Peninsula will be monitored for mink and otter sign in another study (Terrestrial Mammals Study 5, Effects of Oil on Carnivores and Small Mammals Outside Prince William Sound). Results in these areas will be linked with intensive studies in Prince William Sound so that impacts can be extrapolated.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USFS
State: UAF (IAB), DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 84.6
Travel	13.3
Contracts	157.0
Supplies	18.8
Equipment	<u>\$ 14.0</u>

TOTAL \$287.7*

* Includes \$36.0 contract to UAF (IAB).

TERRESTRIAL MAMMAL STUDY NUMBER 4

Study Title:

Assessment of Exxon Valdez Oil Spill on Brown Bear Populations on the Alaska Peninsula

Concern/Justification:

Brown bears occur along a section of shoreline on the southern edge of the Alaska Peninsula impacted by the Exxon Valdez oil spill. In the affected area, brown bear densities are relatively high. Brown bears are omnivorous, opportunistic feeders, and they could ingest oil directly by eating sludge washed ashore, grooming oiled hair, and scavenging carcasses of mammals and birds killed by oil. Effects of oil ingestion could range from immediate death to other adverse changes in viability including long-term suppression of reproduction. For bear populations, effects could range from sharp, immediate declines to subtle, long-term reductions.

People value the presence of brown bears and visit areas expressly to view brown bears. Brown bears are hunted in many areas.

Objectives:

- A. Determine mortality of brown bears in an oil-contaminated area of the Alaska Peninsula.
- B. Determine the cause of brown bear mortalities.
- C. Document the extent of use of oiled foods by brown bears.
- D. Estimate population density of brown bears in the oil-contaminated study area.
- E. Determine if productivity of female brown bears in the oil-contaminated area is depressed.
- F. Estimate brown bear population declines due to adverse changes in viability.
- G. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Terrestrial Mammals Study 1.

Methods and Analyses:

Mortality, productivity, and use of oil-contaminated foods will be determined from a sample of 30 radio-collared brown bears. The bears' location will be determined at two- to three-day intervals until winter denning, monthly during the denning period, and at two-week intervals. Survival and productivity of collared bears will be compared to parameters estimated in a prior study of brown bears at Black Lake. Use of oil-contaminated organisms and vegetation will be determined from observations recorded on tracking flights, from stomach samples of recovered bear carcasses, and from scat samples. Tissue samples will be collected from carcasses of marked animals and hunter-killed bears. Chemical analyses for petroleum residues will be performed on scats and from tissues of bears found dead. These samples will be compared with samples collected from uncontaminated sites. Bear carcasses will be necropsied for evidence of cause of death. A population estimate for the oil-contaminated area will be derived.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USDI (USFWS and NPS)

Budget: Alaska Department of Fish and Game

Salaries	\$ 38.7
Travel	13.0
Contracts	85.1
Supplies	14.8
Equipment	<u>11.1</u>
<u>TOTAL</u>	\$162.7

TERRESTRIAL MAMMAL STUDY NUMBER 5

Study Title:

Effects of Oil on Carnivores and Small Mammals Outside Prince William Sound

Concern/Justification:

Oil spilled by the Exxon Valdez has washed ashore on portions of the Kenai Peninsula, Kodiak Archipelago, and Alaska Peninsula. The degree of oiling differs from that in Prince William Sound in that the oil was more weathered and has reached shore in patches. Oil on shore ranges from scattered tar balls to heavy patches of emulsified oil. By mid-May, the southwestern tip of the Kenai Peninsula, the east side of Shuyak Island, and portions of the Alaska Peninsula in the vicinity of the Katmai National Park and Preserve and Becharof National Wildlife Refuge had received moderate-to-heavy concentrations of oil. A wide variety of carnivores, including bears, river otters, mink, foxes, wolverine, coyotes, wolves, marten, and weasels, forage on these beaches. A variety of other small mammals occupy the beach fringe and may use oiled areas. The potential mechanisms of impact on these species include direct oiling of fur, ingestion of oil while scavenging, and ingestion of oil during grooming.

Objectives:

- A. Determine the direct effects of oil on carnivores and small mammals.
- B. Determine changes in abundance of carnivores and small mammal populations.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Terrestrial Mammals Study 1.

Methods and Analyses:

The approach will be to place crews in several selected study areas. Emphasis will be on heavily and moderately oiled areas where concentrations of dead oiled animals have been found, but some slightly oiled sites will be studied. In each area, the crew will document species present and search for evidence of animals coming in contact with and being injured by oil. Where significant

evidence of injury is found, more intensive efforts will be made to document the injury and quantify changes in animal density.

Direct observation of animals, tracks, scats, runs, dens, etc., will be made. Scent stations will be established to determine the presence of predators and scavengers. Observations of animals foraging in oil and tracks indicating contact with oil will be noted. Scavenged carcasses and nearby sign will be examined to determine the species of scavenger. Scats will be collected and tested for presence of oil. Searches for dead mammals will be made. When possible, they will be necropsied and tissues will be saved for hydrocarbon analysis. In selected areas, small mammals will be collected, necropsied, and their tissues tested. Abundance of selected species will be assessed. Techniques will include direct counts, location of active latrine sites for river otter, scent stations for foxes and other carnivores, location of active dens, and limited systematic trapping of small mammals. These procedures will be repeated up to several times during the field season. Where a decrease in abundance is demonstrated, they will be repeated until recovery is observed. In conjunction with the Coastal Habitat study, changes in abundance of small mammals will be extrapolated to other areas on the basis of habitat type and degree of habitat oiling. Where a major impact on river otter or mink is indicated, a rigorous assessment will be coordinated with Terrestrial Mammals Study 5 (river otter and mink).

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): Federal: USDI
State: DNR

Budget: Alaska Department of Fish and Game

Salaries	\$ 93.8
Travel	26.9
Contracts	108.7
Supplies	41.5
Equipment	<u>31.5</u>

<u>TOTAL</u>	\$302.4
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TERRESTRIAL MAMMAL STUDY NUMBER 6

Study Title:

Influence of Oil Hydrocarbons on Reproduction of Mink

Concern/Justification:

Aside from outright death, it is likely that the most important influence of a pollutant or toxicant on animal populations is its impact on reproduction. Detrimental effects on the reproductive cycle of mammals are well documented for a toxic chemical group of hydrocarbons, the PCBs. Using mink as a model species, this study will determine if oil hydrocarbons have had deleterious effects on reproduction.

The mink is an excellent model, as it is well studied reproductively, known to be affected reproductively by PCBs, and is available commercially for experimentation. Wild mink populations in Prince William Sound are being impacted by exposure to oil, and the findings of this study will have direct application to the assessment of environmental damage to them, as well as to other mammals that have similar reproductive biology (including otters and bears). The data collected in this study will provide a basis for making an economic assessment of reproductive loss to mammalian species.

Objectives:

- A. Determine the effect of ingested oil hydrocarbons on mink reproduction.
- B. Determine the phase(s) in the reproduction cycle most sensitive to hydrocarbon effects. (Female: estrous, dispause, early pregnancy, late pregnancy, lactation. Offspring: pubertal development. Male: spermatogenesis, sperm viability.)
- C. Determine the likely injury to mink populations using the impacts to reproduction observed in the laboratory studies.

Relationships with Other Studies:

This study will document causality of oil exposure on reproductive success in mink and, by inference, other mammals. In conjunction with results from Terrestrial Mammals Studies 2, 3, 4, and 5, population effects on these species will be modeled as a basis for determination of damages to recreational, subsistence, and intrinsic values under Economic Uses Studies 5, 6, and 7.

Methods and Analyses:

The effect of oil ingested at sublethal levels will be assessed in both chronic and acute studies. In the chronic study, male and female mink (laboratory-bred animals) will be housed outdoors under natural light and temperature conditions and will ingest oil-contaminated food for a period of two years. A control group of males and females also will be studied. Breeding behavior, number of offspring, their birth weights, survivorship, and growth rates will be determined.

In the acute study, groups of female mink will be subjected to a seven-day ingestion of oiled food at three levels of contamination. Untreated controls will be compared with eight treatment groups: 1) pre-estrus: treated for seven days immediately prior to estrus; 2) post-estrus: treated for seven days in the diapause period (20 days); 3) post-implantation: treated for seven days in early pregnancy (30 days); 4) late gestation: treated for the last seven days of pregnancy; 5) lactation: treated for seven days immediately after birth; 6) late lactation: treated for seven days pre-weaning; and 7) and 8) weaned: treatment of male and female offspring for seven days.

Estrus and mating activity will be monitored to determine insemination success, number born, birth weight, survival rate, and growth rate of offspring. Groups of males will be treated for seven days at or just prior to the onset of seasonal recrudescence and for seven days during peak reproductive activity. Copulation/insemination success and male effect on pregnancy rate and birth rate of females, testis development, and sperm motility/viability/morphology will be measured, as will oil hydrocarbon presence in tissues. Tissue and blood samples will be collected from estrus through lactation. The blood samples will be assayed by radioimmunoassay for progesterone, estradiol, cortisol, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) in females; testosterone, cortisol, LH and FSH in males. Tissue and fluid samples will be collected for both histopathology and hydrocarbon analyses. From the results of this study, a determination will be made of the dose and time at which deleterious effects occur.

Lead Agency: Alaska Department of Fish and Game

Cooperating Agency(ies): State: UAF (IAB)

Budget: Alaska Department of Fish and Game

Salaries	\$ 0.0
Travel	0.0
Contracts	192.2
Supplies	0.0
Equipment	<u>0.0</u>

TOTAL \$192.2*

* This study will be conducted by UAF (IAB) under contract to
ADF&G

BIRD INJURY ASSESSMENT

More than 140 species of birds could be affected by the Exxon Valdez oil spill. There are more than 157 seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, and the Barren Islands. One hundred twenty-five of the colonies most directly affected contain 670,000 breeding birds of 18 different species. The Kodiak Archipelago supports about 215 colonies containing 435,000 birds. The area affected by the oil spill also supports about 60 pairs of breeding Peale's peregrine falcons, which nest close to seabird colonies. The total numbers of marine birds in the Sound are approximately 500,000 in summer and 300,000 in winter. During summer, this includes approximately 120,000 colonial seabirds, 100,000 murrelets, 15,000 pigeon guillemots, 44,000 waterfowl, and 3,000 bald eagles. In winter, the Sound supports more than 100,000 waterfowl and 115,000 seabirds. Intertidal flats in the eastern portion of the Sound and the contiguous Copper River Delta are used in spring as a staging area by over 10 million migrating shorebirds of 32 species. Clearly, the Sound and other areas affected by the spill provide a variety of marine habitats seasonally critical for significant numbers of birds that are of state, national, and international importance.

All of these birds are used by the public in a variety of ways. Recreational uses include hunting, bird watching, casual viewing as a contribution to the overall aesthetic experience of outdoor uses in general, attraction for tourism, and falconry. These uses of birds occur both within and outside Alaska on four continents. Some birds are used for subsistence purposes. Intrinsic human uses and values include the role of birds in maintaining the ecological integrity of a wilderness environment, in maintaining the biological diversity of such an area, and in serving as an important element in the feelings of many Americans for Alaska as the last pristine frontier in the Nation. Many birds also are important to base line research in a largely undisturbed ecosystem. Ongoing studies have been disrupted; educational values have been compromised. Eagles and peregrines in the affected area are valuable as potential sources of birds for relocation to reestablish populations.

Although more than 25,000 dead birds have been collected thus far, this represents only a small portion of total mortality. Mortality caused by direct contact with the oil is an incomplete measure of injury. More subtle and delayed impacts also are expected. These could cause large population reductions. The birds most affected may be those with specialized diets of invertebrates or fishes that suffered population reduction or were contaminated by oil. Direct contact or ingestion of oil could be significant for shorebirds and other species feeding on contaminated beaches, intertidal zones,

and nearshore waters. Eagles and other birds scavenging on dead and incapacitated birds, fish, mollusks, and other animals will receive particularly large doses of oil residues.

It is not practical to study all of the bird species potentially affected by the oil spill. Therefore, these studies focus on species that best represent larger bird groups with similar life cycles, habitat needs, and foraging strategies. Other selection factors include the availability of base line data, feasibility of establishing experimental controls, and ability to determine injury in a reasonable, cost-effective manner. Data on injury to indicator species will be related by inference to the larger groups they represent.

Whenever possible, studies will be conducted and data will be analyzed to detect changes by direct comparison with previous information on the status and productivity of the populations of concern. Surveys conducted from aircraft and boats will be used in comparing seasonal distribution and abundance of most birds with historic data. For example, bald eagle surveys have been conducted in selected plots throughout the entire oil spill area. Surveys to locate peregrine falcon nesting sites have been conducted in Prince William Sound, the southern Kenai Peninsula coast, and a portion of lower Cook Inlet. Seabird colonies have been censused in the past throughout the affected area, and seabird reproductive success has been studied at selected colonies and other areas. Shorebird migration surveys have been conducted to estimate the numbers of birds passing through the Sound and to identify bird staging areas within the Sound. Limited beached bird surveys have been conducted at locations throughout and beyond the affected area. Studies of food habits and food availability have been conducted for some species at selected sites in the Sound, and limited information is available on pre-spill levels of contaminants in prey species and eggs of some marine birds in the Sound.

Many studies will use unaffected, control areas for comparison with data from oiled areas. Studies also will include replicate collection of data in different geographic areas characterized as having received heavy to moderate, light, or no oiling. However, birds are transient, and true controls are difficult to establish for some species. Controlled experiments will be conducted to determine what percentage of birds killed by oil are actually being recovered. Linkage of oil to injury of birds will be made by 1) direct observations of birds, prey, eggs, and young, 2) necropsies and histopathological examinations, 3) analysis of hydrocarbon contaminants in birds, eggs, and prey, 4) measures of productivity, and 5) loss or contamination of food. In this way adverse changes in viability of the resource as described in 43 CFR § 11.62(f)(1) will be established.

For many of the birds killed or otherwise injured by oil, assessment--beyond an incomplete body count--is impractical or is not cost-effective. For example, relatively little habitat used by concentrations of dabbling ducks, such as pintails and teals, has been directly impacted by the spill. In total, however, these and birds from other species numbering in the hundreds of thousands will encounter oil during their migration to widely-dispersed areas throughout Alaska and other states and countries. This injury generally will go undocumented. Other injury will be documented inadequately because of such factors as uncoordinated but well-meaning bird pickup efforts, weather, geography, and other logistical considerations. Assessment of injury to birds, therefore, will be understated.

The proposed plan for assessing injury to migratory birds is organized into five units: 1) surveys and censuses; 2) raptors; 3) seabirds; 4) waterfowl, shorebirds, and passerines; and 5) toxicology. The surveys and censuses will provide an overview of mortality, population changes, and distribution of birds in general. Studies proposed for particular species or species groups focus primarily on collecting more detailed data regarding reproductive success, survival, linkage to hydrocarbons, and other information needed to supplement the surveys and censuses. These data will be gathered for species potentially most affected by the oil spill or best serving as indicators for species otherwise impractical to investigate. Comparison of data to existing baseline information, or between experimental (oiled) and control (non-oiled) areas, will provide a basis for quantifying injury beyond the initial count of recovered dead birds.

BIRD STUDY NUMBER 1

Study Title:

Beached Bird Survey to Assess Injury to Waterbirds from the Exxon Valdez Oil Spill

Concern/Justification:

Because marine bird carcasses float and are relatively durable, they frequently are washed ashore after dying at sea. The accumulation of oiled bird carcasses on beaches is often the most visible biological impact of an oil-pollution incident.

Systematic surveys of beached birds were first conducted in Alaska in 1977 by the U.S. Fish and Wildlife Service. These surveys continued sporadically in several geographic areas of Alaska, providing pre-oil data on bird mortality. However, interpretation of these historic data in relation to post-spill data is confounded by several variables. Among those are carcass flotation times, carcass longevity on beaches, and the percentage of total mortality represented by the number of beached birds. Hence, experiments to quantify these variables are needed to provide a more reliable estimate of total waterbird mortality resulting from the oil spill.

Objectives:

- A. Determine the number and location of dead and dying waterbirds in Prince William Sound and the Gulf of Alaska, as reported to receiving centers in Valdez, Seward, Homer, and Kodiak.
- B. Determine the mortality of waterbirds observed on site in the Sound, the Gulf, and along the southern coast of the Alaska Peninsula.
- C. Calculate what proportion of waterbirds killed by oil was actually found on beaches.
- D. Compare present mortality with the mortality found in beached bird surveys conducted in Alaska from 1977 to 1988.
- E. Calculate overall mortality in conjunction with bird population surveys and seabird colony censuses.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Results of the beached bird survey will be analyzed along with population data from Birds Studies 2 through 13 to calculate the total mortality resulting from the spill. These results will then

be used in Economic Uses Studies 5, 6, and 7 to estimate damage to recreational, subsistence, and intrinsic values.

Methods and Analyses:

Minimum mortality for each species will be estimated by analyzing numbers and origin of dead birds collected at all waterbird depository centers, and information provided from other agencies.

A systematic survey using general methods described in the literature will be used. Appropriate numbers of randomly selected beaches within three shoreline strata will be determined using variances from surveys conducted in April 1989. In addition to the randomly selected beaches, some beaches known for their large amount of drift also will be selected.

Different experiments will be monitored to arrive at correction factors for the three stated variables that affect the percentages of dead birds detected on the beaches: 1) flotation times, 2) longevity on beaches, and 3) drift experiments.

The estimated overall mortality of waterbirds in Prince William Sound and the northern Gulf of Alaska related to the oil spill will be determined by correlating numbers of beached birds with population estimates (incorporating correction factors for flotation times, longevity on beaches, and the percentage of birds appearing on each beach type).

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI, USFS
State: ADF&G

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 133.0
Travel	9.0
Contracts	30.0
Supplies	8.0
Equipment	<u>78.0</u>
<u>TOTAL</u>	\$258.0

BIRD STUDY NUMBER 2

Study Title:

Surveys to Determine Distribution and Abundance of Migratory Birds in Prince William Sound and the Northern Gulf of Alaska

Concern/Justification:

The shorelines of Prince William Sound and the southern Kenai Peninsula support abundant waterfowl and waterbird populations throughout the year. According to bird surveys initiated soon after the oil spill, nearly half of the late winter bird population in Prince William Sound was in or near oiled areas. Surveys of oiled shorelines show a dramatic decline in numbers of sea ducks, loons, grebes, and cormorants. Repeated surveys of non-oiled shorelines suggest that birds either died or were displaced from oil-impacted areas. Base line data on migratory birds (collected from both aircraft and boats) are available for comparison with post-spill distribution and abundance data from the Sound and the southern coast of the Kenai Peninsula. Data collected from boats also exist for Kodiak Island. Additional surveys are needed to identify changes in distribution and abundance that have occurred since the oil spill.

Objectives:

- A. Determine distribution and abundance of waterfowl and waterbirds in shoreline and selected marine habitats of Prince William Sound and the northern Gulf of Alaska.
- B. Compare data on the distribution and abundance of waterfowl and waterbirds in areas affected by the oil spill, areas unaffected by the spill, and comparable historic data.
- C. Determine the recovery rates of populations that were reduced by the spill.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Results of these surveys will be integrated with data from the beached bird surveys (Bird Study 1) and with population and reproduction studies (Bird Studies 3 and 6 through 11) to estimate the total mortality to migratory waterfowl and waterbirds. Results will be used to determine damage to recreational, subsistence, and intrinsic values under Economics Uses Studies 5, 6, and 7.

Methods and Analyses:

The numbers and distribution of migratory birds in coastal and marine habitats will be determined using four aerial surveys (spring, summer, fall, and winter) and by conducting shoreline surveys from boats using techniques developed during previous censuses. A new aerial survey will count birds observed in a quarter-mile-wide strip along the shoreline and in transects over open water. Plots for sampling will be established both in shoreline and pelagic areas to facilitate even more cost-effective and logistically practical surveys. Three surveys using boats will be conducted this summer and one this winter on a randomly selected subsample of transects previously established in the Sound. The entire south coast of the Kenai Peninsula and selected areas in the Kodiak Archipelago will be surveyed to allow comparisons with historic data and to make comparisons between oiled and unaffected areas. Paired shoreline surveys using boats and aircraft will be conducted to develop visibility correction factors for avian species. Population estimates and associated variances will be calculated for each species using established double-sampling procedures.

Shoreline habitats have been characterized in previous studies. Changes in distribution and numbers of birds will be evaluated by comparing avian use of similar habitat types in oiled and non-oiled areas. Differences within and between years will be evaluated using ANOVA or other appropriate statistical procedures.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI, USFS
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 146.0
Travel	15.0
Contracts	79.0
Supplies	37.0
Equipment	<u>288.0</u>
<u>TOTAL</u>	\$565.0

BIRD STUDY NUMBER 3

Study Title:

Population Surveys of Seabird Nesting Colonies in Prince William Sound, the Outside Coast of the Kenai Peninsula, the Barren Islands, and Other Nearby Colonies Likely to be Impacted

Concern/Justification:

There are 157 seabird colonies in the regions of concern. At least 125 of these colonies, not counting the Semidi Islands, lie within the area affected by the oil spill. These 125 colonies contain 670,000 breeding seabirds. Some of these colonies are among those most visited by tourists. Cliff-nesting seabirds are an important part of this human use/tourism. Certain species, such as diving waterbirds, are more vulnerable than others to mortality from oil. This project will evaluate what changes may have occurred with some species in relation to numbers of adult birds at selected colony sites. Most of these colonies have been censused at least twice in the last 17 years, which provides a base line for determining injury caused to the colonies by the oil spill.

Diving seabirds are known to be easily injured in oiled waters. In addition, these species are long-lived with low reproductive rates, making any adult mortality a critical factor in these species' ability to recover from loss. The oil spill moved through colony areas just prior to breeding, a time when many species, such as murres, concentrate on the water in large rafts near the colonies. Although there are many species breeding at these sites, the monitoring strategies have been to select certain species, (primarily cliff-nesting) based on a variety of factors.

Objectives:

- A. Determine if the numbers of selected species of breeding colonial seabirds within the oiled area have decreased compared to numbers previously censused at these sites. Non-oiled nesting colonies will be surveyed as a control.
- B. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the distribution and persistence of oil will be provided by the suite of Air/Water and Coastal Habitat studies, as will data on the abundance and contamination of prey organisms. This study will be coordinated with Bird Studies 1, 2, 8, 9, and 10 to estimate total spill-related mortality to colonial nesting

seabirds. The sensitivity of these birds to oil exposure will be documented experimentally under Bird Study 14. Results of these studies will support determination of damages to recreational and intrinsic values under Economic Uses Studies 5 and 7, respectively.

Methods and Analyses:

The assessment of injury to population numbers of selected seabirds will be conducted in four general regions: 1) Prince William Sound, 2) Kenai Fiords (Chiswell and Pye Islands), 3) Barren Islands, and 4) Semidi Islands/Alaska Peninsula. The study in each area will look at changes in numbers of adults at colony sites with primary emphasis on cliff nesters (murres, cormorants, and kittiwakes) and secondary emphasis on the other selected species (tentatively pigeon guillemots and large gulls). A plot system will be established, and a total count will be made for comparison with past estimates. Once eggs have been laid, at least three replicate counts will be made of colonies or plots. Counts will be treated by the standard statistical methods.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI, USFS
State: DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$184.0
Travel	59.0
Contracts	40.0
Supplies	30.0
Equipment	<u>127.0</u>
<u>TOTAL</u>	\$440.0

BIRD STUDY NUMBER 4

Study Title:

Assessing the Injury of the Exxon Valdez Oil Spill to Bald Eagles

Concern/Justification:

More than 5,000 bald eagles are associated with intertidal habitats in the area affected by the oil spill. Serious impacts to bald eagles could result from ingestion of oil, physical oiling, decreases in nesting success, and reductions in the amount of available food. This study will document the extent of these impacts and identify the causal pathways.

Objectives:

- A. Determine numbers of resident and wintering bald eagles and their rate of decline or recovery.
- B. Determine bald eagle productivity in areas affected by the oil spill and in non-oiled control areas.
- C. Determine winter survival of bald eagles in the affected area.
- D. Determine the prevalence of contaminated foods in the diet.
- E. Determine physical effects of oiling on eagles and eggs.
- F. Determine toxic effects of oil on eagles.
- G. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Information on the distribution and persistence of oil in intertidal areas foraged by eagles will be provided by the Coastal Habitat study. Total mortality of eagles will be estimated from this study in concert with data on dead eagles from Bird Study 1. These results will support damage estimates under Economic Use Studies 5 and 7.

Methods and Analyses:

Surveys of stratified random plots will be conducted to estimate the number of bald eagles in areas affected by the oil spill. These data will be compared with previously collected data. Two extensive surveys will be conducted to determine productivity in the impacted area: one in mid-May to estimate nest occupancy, and

another in mid-July to estimate productivity. Nest selection will be stratified by the degree of impact near the nest and compared among the strata to detect significant changes. Data from a remote nesting site will be compared with data from previous years. Weekly surveys will be conducted to assess the timing and causes of nest failure. The Knight Island sites will be used for these intensive surveys. Nests that fail will be climbed to collect dead eggs or nestlings and to search for the cause of failure. This more intensive work will allow a more accurate interpretation of the extensive surveys. To evaluate oil-related winter mortality, 30 adults and 30 fledgling eagles will be tagged with visual marks and radios. Weekly surveys will be conducted to relocate the transmitters and to document eagle numbers, distribution, and causes of mortality. Direct observations of foraging eagles will indicate the amount of time eagles spend on oiled substrates. Prey remains will be collected for visual evidence of oil contamination. Dead eagles will be collected, necropsied, and the extent of oiling recorded. Eaglets and eggs will be examined for oil. The presence of oil on the heads and tails of adult eagles will be noted during surveys to provide an estimate of the population that has come in contact with oil.

Adult, immature, fledgling, and nestling eagles found dead will be necropsied. Addled eggs will be analyzed for oil contamination and fertility. Blood samples from eagles will be collected and analyzed to determine contaminant concentrations, identify trends in these contaminants, and evaluate sublethal impacts.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS, USDI
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 100.0
Travel	20.0
Contracts	230.0
Supplies	20.0
Equipment	<u>75.0</u>
<u>TOTAL</u>	\$445.0

BIRD STUDY NUMBER 5

Study Title:

Impact Assessment of the Exxon Valdez Oil Spill on Peale's Peregrine Falcons

Concern/Justification:

Surveys in Prince William Sound and along the outside coast of the Kenai Peninsula have documented a considerable population of Peale's peregrine falcons. These falcons, thought to be year-round residents of the area foraging on seasonally abundant prey ranging in size from warblers to ducks, could receive direct and indirect injury from exposure to spilled oil. Birds of prey that become oiled could be taken by falcons. Oil transferred to peregrine falcons could affect individuals and the population through 1) coating of feathers and the resultant loss of insulation and flight capabilities, 2) reduced reproduction due to ingestion and the resultant effects on the physical condition of adults, 3) reduced reproduction due to transfer of oil from feathers of incubating adults to eggs, and 4) mortality of individuals due to toxicity. The ingestion of small amounts of crude oil are known to have effects on reproductive hormones of birds, adversely affecting courtship and nesting behavior, egg viability, and other reproduction factors.

Objectives:

- A. Survey known and suspected nesting territories to determine status and productivity. Compare these data with historic data and information from other populations of peregrine falcons.
- B. Collect eggs, feathers, and blood samples from nestlings and adults for contaminant and trace-element analysis.
- C. Collect prey remains at nest sites to determine extent of contamination.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Results on exposure of peregrine falcons to oil and the subsequent mortality will be used in Economic Uses Studies 5 and 7 to estimate damages to recreational and intrinsic values.

Methods and Analyses:

The study area will include the mainland shore and islands of Prince William Sound from Cape Hinchinbrook along the southern

coast of the Kenai Peninsula to Kachemak Bay, and the Alaska Peninsula from Kamishak Bay to Wide Bay. Fifty or more potential peregrine nest sites have been identified in this area.

Two surveys of the area will be conducted. The initial survey, to determine presence or absence of peregrines at coastal bluffs and to collect 10 fresh egg samples for contaminant analysis, will take place in early and mid-May. A helicopter will be used for the survey and to provide access to potential nesting habitats. At sites with large concentrations of cliff-nesting seabirds, the helicopter will land far enough away from bluffs to minimize disturbance. Observers will approach on foot to survey potential nesting habitat.

The latter survey, in late June and early July, will embrace the same area but focus on the sites which were determined to be occupied by peregrine falcons during the initial survey. Nests will be located by observers on the ground and then reached by standard climbing techniques to collect feather and blood samples and to band nestlings. Approximately 20 adults will be trapped near nests to take feathers and collect 5-ml blood samples from each bird, while approximately 30 young will be sampled for feathers and 3-ml of blood. Prey remains and addled or broken eggs will be collected at the nest sites. During both surveys, staff will document oil on falcons and look for bands on adults to learn where they were banded. If the birds were not previously banded, they will be banded with lock-aluminum bands.

Approximately 50 feather samples will be collected for trace-metal analysis, and a similar number of blood samples will need to be examined by gas chromatography for the presence of aliphatic hydrocarbons. Thirty prey remains will be examined for hydrocarbon content.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): State: ADF&G

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 9.0
Travel	1.5
Contracts	30.0
Supplies	1.5
Equipment	<u>1.5</u>

TOTAL \$43.5*

* Study to be conducted by ADF&G under contract to USFWS.

BIRD STUDY NUMBER 6

Study Title:

Assessment of the Abundance of Marbled Murrelets at Sites Along the Kenai Peninsula and Prince William Sound

Concern/Justification:

Available information suggests that the marbled murrelet will suffer significant injury from the oil spill. Small diving seabirds that frequent nearshore areas, marbled murrelets have the highest oil vulnerability index of any bird. One way to document injury to this species is to compare pre- and post-oil abundance at selected sites with consistent, historic data, and to collect adults for evidence of contamination. An estimated 103,000 murrelets are widely distributed throughout Prince William Sound during the summer. The area affected by the oil spill has a large proportion of the Alaskan breeding population. This species is of particular concern because it is on the U.S. Fish and Wildlife Service's Candidate List of Threatened and Endangered species.

Objectives:

- A. Determine if populations of marbled murrelets at oiled sites have declined compared with populations at non-oiled sites.
- B. Determine if there is evidence of marbled murrelet breeding activity at sites in oiled areas.
- C. Determine if adult marbled murrelets at oil-affected and non-oil-affected sites contain petroleum hydrocarbons.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Results of this study will be integrated with those of Bird Studies 1 and 2 to provide estimates of overall mortality of marbled murrelets, and (by inference) of other birds with similar distributions and feeding behavior. These results will support determination of damages to recreational and intrinsic values under Economic Uses Studies 5 and 7.

Methods and Analyses:

Marbled murrelet censuses conducted in 1989 will be compared with pre-oil censuses conducted in areas that have been oiled and with one non-oiled site in Prince William Sound serving as a control

site. Marbled murrelet breeding activities will be determined by on-land watches and by collection of adult murrelets. Watches will be replicated five times in early June with two observers stationed at appropriate lookout sites from one hour prior to one hour after both sunrise and sunset. Ten marbled murrelets will be collected from a heavily oiled site, Naked Island, and a non-oiled site for contaminant analyses. (The same birds will be used for determination of breeding activity.)

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI, USFS
State: DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 67.0
Travel	12.5
Contracts	0.0
Supplies	6.2
Equipment	<u>30.0</u>

TOTAL \$115.7

BIRD STUDY NUMBER 7

Study Title:

Assessment of the Effects of Petroleum Hydrocarbons on Reproductive Success of the Fork-Tailed Storm Petrel

Concern/Justification:

The population of forked-tailed storm petrels has been estimated at 65,000 pairs at East Amatuli Island in the Barren Island group. The storm petrel is the only plankton-feeding seabird that can be easily monitored in areas affected by this oil spill. Storm petrels at East Amatuli Island have been monitored from 1976 to 1988, making this one of the longest studied storm-petrel colonies in Alaska. These studies were initiated, in part, to provide base line data on seabird populations as a result of the outer continental shelf oil and gas lease sale program. This species generally represents the shearwaters and fulmars.

Adult storm petrels are highly pelagic and wide ranging. They feed on surface zooplankton, and historically have fed in the areas now impacted by the oil spill. The formation of stomach oils by the concentration and retention of dietary lipids in the proventriculus provides a unique potential for monitoring the consumption of petroleum hydrocarbons at sea. Because of the repeated transfer of crude oil ingested by adults to their young, chicks act as a sink for petroleum hydrocarbons. The chicks provide a good model for investigating the impact of exposure on seabird reproduction.

Objectives:

- A. Determine if reproductive success of storm petrels is lower than in previous years.
- B. Assess the impact of crude-oil exposure on storm petrel reproduction by measuring relationships between exposure, breeding adult foraging efficiency, chick physiological condition, and nesting success.
- C. Determine if adults have been contaminated externally or internally by oil.
- D. Determine persistence of crude oil in the marine environment by using storm petrels as indicator species and monitoring temporal changes in exposure and sublethal effects.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

Results of this study will be integrated with those of Bird Studies 1 and 2 to estimate overall mortality of fork-tailed storm petrels and (by inference) other species with similar distributions and feeding behavior. These results will support determination of damages under Economic Uses Studies 5 and 7.

Methods and Analyses:

Eight storm petrel subcolonies at East Amatuli island will be searched, and burrow contents and degree of oiling will be determined. Reproductive success will be checked from the fourth week of August to the second week of September. Dead birds and addled eggs will be collected for analysis. Active nests will be located and marked during early incubation. Fresh eggs will be collected for gas chromatographic analyses of pristane and phytane. Hatching success will be monitored to determine the potential effects of petroleum transferred from adult plumage to eggshell surfaces. Individual variation in exposure of chicks (and adults) will be monitored by periodically collecting stomach oils from chicks and adults.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): None

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 72.0
Travel	1.0
Contracts	48.0
Supplies	4.0
Equipment	<u>10.0</u>
<u>TOTAL</u>	\$135.0

BIRD STUDY NUMBER 8

Study Title:

Assessment of Injuries to Waterbirds from the Exxon Valdez Oil Spill on the Reproductive Success of Black-legged Kittiwakes in Prince William Sound

Concern/Justification:

Black-legged kittiwakes are the most abundant colonial seabird in Prince William Sound. The kittiwake is one of the chief indicator species of seabirds, studied extensively by the U.S. Fish and Wildlife Service. This species generally represents the non-scavenging gulls (for example; mew gulls and Sabines). Kittiwakes also are a seabird species nesting in Prince William Sound for which reproductive success can be quantified easily and quickly. Kittiwakes nesting at 26 colonies in Prince William Sound have been studied for the last five years. Base line data are available on these colonies for numerous other years since 1972. Eleven of these colonies are in the area that was oiled, and 15 colonies are outside the oiled area.

Kittiwake reproductive success could be reduced as a result of the oil spill by several means. Adults could die of oil contamination. Contaminated adults might not lay eggs, incubate eggs, or feed chicks. Adults with oil on their breast feathers may oil and thereby kill their eggs during incubation. Adults may feed contaminated prey to their chicks and thereby cause them to become deformed, grow slowly, or die.

Objectives:

- A. Determine if kittiwake reproductive success is lower at colonies in oiled areas than at colonies in non-oiled areas, as compared with pre-spill levels.
- B. Determine if adult kittiwakes at oil-affected colonies have been and continue to be contaminated by oil, either externally or internally.
- C. Determine if unhatched eggs and prey delivered to chicks in oiled and non-oiled areas contain petroleum hydrocarbons.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Birds Study 3.

Methods and Analyses:

Nests at colonies will be counted in early to mid-June as an index of reproductive effort. Chicks will be counted in early to mid-July, just before they fledge. Nests and chicks will be counted three times to determine the variation inherent in counting. The numbers of oiled and non-oiled birds at colonies will be recorded weekly. Internal contamination will be determined by analyzing tissues (livers) for petroleum hydrocarbons. Eggs collected from colonies within and outside the oil-affected areas will be used for hydrocarbon analyses. Prey samples also will be analyzed for hydrocarbons.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 62.0
Travel	6.0
Contracts	12.0
Supplies	25.5
Equipment	<u>85.5</u>

TOTAL \$190.0

BIRD STUDY NUMBER 9

Study Title:

Assessment of Injury to Waterbirds Based on the Population and Breeding Success of Pigeon Guillemots in Prince William Sound

Concern/Justification:

The pigeon guillemot is a common colonial nesting seabird in Prince William Sound. Many colonies are located in the areas affected by the oil spill. As a diving seabird, it is highly susceptible to oiling. Pigeon guillemots represent one of the largest groups of colonial nesting seabirds in the area, and prior studies indicate that they comprise one-third of all seabirds nesting on Naked, Storey, Peak, Smith, and Little Smith Islands. These islands were the first shorelines to be impacted by the oil spill.

This study generally represents the puffins, auklets, and murre. A catastrophic oil spill has the potential to affect the local seabird population through 1) direct mortality of adult birds, 2) increased nest desertion by adults due to physiological effects or poor foraging conditions, 3) reduced hatching success due to oil transfer from adults to eggs, and 4) increased chick mortality due to low food availability or contaminated prey. Pigeon guillemots were chosen as study subjects in 1978 because they are good indicators of the nearshore marine environment. They forage near shore on a variety of bottom fish, invertebrates, and surface fish. They also have relatively stable colony populations and are widely distributed around Naked Island and throughout the Sound. The availability of pre-spill data makes possible comparisons before and after the spill, and provides a direct link to diminished populations. It also provides the opportunity to conduct concurrent studies at sites with varying degrees of oil exposure.

Objectives:

- A. Determine if reproductive success of pigeon guillemots in oiled areas is lower than it was from 1978 to 1981.
- B. Determine if reproductive success of pigeon guillemots is lower in oiled areas than in non-oiled areas.
- C. Determine if prey is less abundant in oiled areas than in non-oiled areas by comparing chick-feeding rates, prey use, and foraging habitat use among colonies.
- D. Determine if petroleum hydrocarbons are present in adult pigeon guillemots, unhatched eggs, dead chicks, or prey items in oiled areas.

- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.
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Relationships with Other Studies:

See Birds Study 3.

Methods and Analyses:

Seabird colonies will be censused as they were in 1978-1980, by circumnavigating the islands from 100 meters offshore in good weather. Nest sites used in previous years will be checked from early to late June for the presence of eggs and for clutch size. Nests with eggs will be checked weekly to determine hatching success. Colony areas will be surveyed for degree of oiling. Chick-feeding observations will be made for a minimum period of five hours, with feeding watches distributed evenly throughout the nestling phase. At both the oiled study site and the control site, birds, eggs, and chicks will be examined for the incidence of direct oiling. Samples will be taken of adults, unhatched eggs, dead chicks, and regurgitated prey items for petroleum hydrocarbon analyses.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS
State: DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$65.0
Travel	4.5
Contracts	2.0
Supplies	8.0
Equipment	<u>30.0</u>

<u>TOTAL</u>	\$109.5
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BIRD STUDY NUMBER 10

Study Title:

Assessment of Injury to Glaucous-Winged Gulls using Prince William Sound

Concern/Justification:

Glaucous-winged gulls are among the most numerous birds in Prince William Sound. About 50,000 birds use Prince William Sound in the summer, and lesser numbers are present year round. They survive primarily by scavenging and foraging in littoral and intertidal areas. Since the Exxon Valdez oil spill, a high percentage of glaucous-winged gulls observed have been oiled. Existing literature indicates that small amounts of ingested crude oil inhibit growth and affect osmoregulation (salt gland), hepatic, and adrenal gland activity. Existing literature also demonstrates that minute quantities (LD50=50 microns) of North Slope crude oil are toxic to egg embryos. Transfer of oil from adult gull breast feathers to eggs will likely cause embryo mortality and a significant decline in population productivity.

Previous research has verified that most of the glaucous-winged gulls frequenting the Sound come from Egg Island and smaller colonies within the Sound. The Egg Island colony, located about 15 miles from the Sound, is the largest glaucous-winged gull colony in the world (with 10,000 breeding pairs).

This species generally represents the scavenging birds such as herring gulls, and scavenging passerines. Glaucous-winged gulls have intrinsic value, and are an important part of the food chain, serving as a major scavenger. They are among the most visible birds in Prince William Sound, thereby contributing to the overall quality of life and visitor experience. The Egg Island colony has research value because it is the world's largest colony and because extensive research has been conducted there in the past. Future research will likely be compromised by oil-spill effects.

Objectives:

- A. Determine the number of breeding glaucous-winged gull pairs and nests in 1989 in the Egg Island colony, and compare these data to historical data.
- B. Compare previously determined productivity indices with productivity observed in 1989.
- C. Determine the cause of egg-hatching failure by direct observation and contaminant analysis.

- D. Determine chick mortality rates and those portions attributable to oil contamination.
- E. Determine losses in colony productivity attributable to oil.
- F. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Birds Study 3.

Methods and Analyses:

Standard methods as previously used in this colony will be used to measure nest density, clutch size, egg success, and numbers of breeding pairs. The presence of oil on incubating adults and eggs will be noted for nests in sample plots located throughout the colony. Unhatched eggs, both from oiled and non-oiled incubating adults, will be collected and used for contaminant analysis, as will a sample of chicks found dead in the colony. Based upon chick mortality and egg and clutch success determinations from sample plots, colony production will be determined and compared with production in years prior to the oil spill.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$37.2
Travel	4.0
Contracts	8.5
Supplies	8.3
Equipment	<u>15.0</u>

TOTAL \$73.0*

* Study to be conducted by ADF&G under contract to USFWS

BIRD STUDY NUMBER 11

Study Title:

Injury Assessment of Hydrocarbon Uptake by Sea Ducks in Prince William Sound and the Kodiak Archipelago

Concern/Justification:

Prince William Sound is the wintering area for over 125,000 sea ducks, primarily Barrow's goldeneyes, three species of scoters, harlequins, and oldsquaws. More than 160,000 sea ducks, consisting mainly of these same species, winter in the nearshore waters of Kodiak and neighboring islands. In the spring, the Sound is a major migration area for sea ducks. In the summer in both areas, the numbers of some species are low, while remaining high to moderate for others. Sea ducks are heavily dependent on intertidal and subtidal marine invertebrates. Oldsquaws take a wide variety of foods and use invertebrates in the water column as well as bottom-dwelling animals. Scoters and goldeneyes utilize blue mussels and, like harlequins, consume a wide variety of clams, snails, and limpets. Bivalves, particularly blue mussels, are well-known for their ability to concentrate pollutants at high levels. The crude oil spilled from the Exxon Valdez may cause severe damage to marine invertebrates that support sea ducks year round, and bioaccumulation of pollutants in this food chain may result in uptake of hydrocarbons by sea ducks over a long period of time. Through integration with other studies, this study will determine the levels of hydrocarbons taken in by sea ducks, and will predict resultant physiological and life-history effects.

The study emphasized will be in Prince William Sound, where oil impacts have been the greatest. Sea ducks are harvested in northern Gulf of Alaska coastal waters by both sport and subsistence hunters. Hunters travel from outside Alaska to hunt specifically for these species, some of which are found mostly or solely in Alaska. As well as having intrinsic value, their abundance, size, and color provide significant viewing and photographic enjoyment for both residents and tourists.

Objectives:

- A. Develop a data base describing food habits of sea ducks.
- B. Synthesize data on hydrocarbon levels in local marine invertebrates and in gut samples from sea ducks.
- C. Determine total hydrocarbon intake by sea ducks by measuring concentrations in tissues and fluids, and determine physiological and histological effects observed in collected birds.

- D. Evaluate and quantify hydrocarbon intake effects on health, survival, and reproductive potential of sea ducks, and relate this information to other studies, identifying changes in abundance and distribution within the affected area.
- E. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

The Coastal Habitat Study will provide data on the extent and persistence of oil in coastal areas, and on the abundance and contamination of prey species for sea ducks. Results of this study will be analyzed with those of Birds Studies 1 and 2 to estimate mortality of sea ducks. These results will then be used under Economic Uses Studies 5 through 7 to estimate damage to recreational, subsistence, and intrinsic values.

Methods and Analyses:

Food habits of sea ducks will be determined from previous collections in Port Valdez, studies in southeast Alaska, and collections of birds throughout the year from oiled and control areas of Prince William Sound and Kodiak. Collections will focus on harlequin ducks and scoters year round, and goldeneyes during winter. Hydrocarbon intake will be evaluated from concurrent impact assessments on marine invertebrates related to diet composition of sea ducks, and from laboratory analysis of food items in gut samples. Measures of physiological effects will be examined and histological information noted during necropsies. Results will be combined with a literature review and data from seasonal waterfowl surveys conducted in other studies to evaluate and quantify overall effects on health, survival, and reproductive potential of sea duck populations.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$67.0
Travel	7.0
Contracts	24.0
Supplies	7.5
Equipment	<u>40.5</u>

TOTAL \$146.0*

* Study to be conducted by ADF&G under contract to USFWS.

BIRD STUDY NUMBER 12

Study Title:

Assessment of Injury to Shorebirds Staging and Nesting in Rocky Intertidal Habitats of Prince William Sound and the Kenai Peninsula

Concern/Justification:

Coastal habitats of Prince William Sound and the southern Kenai Peninsula are used regularly by at least 23 species of shorebirds throughout the year. The most intensive use occurs in spring when an estimated 11 million shorebirds stage in the region. Rocky intertidal habitat, which is abundant throughout the area, is particularly important to a few species whose entire world populations breed in the vicinity of the Bering Sea. Those species include the black turnstone, surfbird, and rock sandpiper. Other species, such as black oystercatchers and semipalmated plovers, commonly breed throughout the Sound and along the coast of the Alaska Peninsula. All of these species are highly vulnerable to being oiled and to feeding on contaminated prey.

Up to a half-million shorebirds stage in rocky intertidal habitats of Prince William Sound in areas heavily affected by oil. The potential injury to these populations is a function of the proportion of the population directly and indirectly exposed to oil, the duration of exposure, and the severity of physiological responses affecting individual survival and reproduction. Likelihood of injury is particularly high for species that usually breed and forage throughout the summer in areas now impacted by oil.

Objectives:

- A. Estimate the amount of time individual shorebirds are exposed to contaminated beaches, and estimate the total number of shorebirds of each species that are exposed to contaminated beaches.
- B. Determine the proportion of shorebirds that become directly contaminated with oil on plumage, feet, or bills.
- C. Determine the minimum proportion of shorebirds that ingest oil by preening oiled plumage, foraging or roosting in oil-contaminated areas, or ingesting contaminated prey.
- D. Assess the degree to which oiled substrates interfere with feeding behavior of shorebirds.

- E. Document direct mortality, indicators of adverse physiological effects, and presence of petroleum hydrocarbons in shorebirds using oil-contaminated habitats.
- F. Quantify population and reproductive success of shorebirds breeding and foraging throughout summer in oiled and non-oiled areas of Prince William Sound.
- G. Determine reproductive success of a sample of shorebirds that stage in the affected area and nest in Bering Sea coastal habitat (a sample for which comparative base line data is available).
- H. Determine comparative levels of hydrocarbon contamination in birds using oiled and non-oiled, control areas.
- I. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

The Coastal Habitat study will provide information on the extent and persistence of oil in intertidal areas, and on the abundance and contamination of potential prey species. Damage to recreational and intrinsic values will be estimated under Economic Uses Studies 5 and 7, respectively.

Methods and Analyses:

The number of shorebirds directly affected by oil contamination will be estimated from the following: 1) replicated censuses of primary affected areas throughout the annual cycle, 2) an estimate of the rate of turnover of individuals during migration, and 3) an estimate of the proportion of birds that ingest oil or become externally contaminated with oil. Aerial surveys will be flown to delineate concentrations of shorebirds in relation to the degree of oil contamination of the shoreline. A complete survey of the study area coastline will be conducted during peak spring migration in early May. Surveys from the beach and from boats will be conducted along selected sections of shoreline used in past years for staging by large numbers of shorebird migrants. The frequency of feeding, walking, and agonistic interactions of foraging birds will be recorded. Surfbirds will be captured and marked with dye and colored leg bands.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USDI, USFS
 State: ADF&G, DEC, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$128.0
Travel	7.0
Contracts	14.0
Supplies	7.0
Equipment	<u>10.0</u>
<u>TOTAL</u>	\$166.0

BIRD STUDY NUMBER 13

Study Title:

Impact Assessment of the Exxon Valdez Oil Spill on Passerines and Other Nongame Birds in Prince William Sound

Concern/Justification:

Several year-round resident passerine species are heavily dependent upon shoreline and intertidal areas in the Sound, and will likely become oiled and die from contact with dead and dying oiled wildlife and oiled shores. These species include the gray jay, Steller's jay, black-billed magpie, common raven, northwestern crow, great blue heron, and others. These birds are known to occur in the tens of thousands in Prince William Sound. Other migratory passerines that use intertidal and shoreline areas also may be similarly affected by oil contamination. These passerines include swallows, thrushes, several species of sparrows, water pipits, and rusty blackbirds. These birds occur in the hundreds of thousands. Also, resident belted kingfishers and dippers may be affected by oil contamination of shoreline areas. In addition to direct lethal effects of oiled plumage, birds may be subject to sublethal effects of oil contamination, which could affect overall health and reproductive potential. Passerine species have major intrinsic and recreational (viewing) value. For example, birdwatching is among the top ten outdoor activities in the United States, far surpassing hunting in number of participants. The total numbers and species diversity of birds are a significant factor in the overall enjoyment of both residents and visitors to the Sound.

Objectives:

- A. Document passerine scavenging of oiled carcasses.
- B. Document relative numbers of passerine and other nongame bird species that are subject to oil contamination, and compare these data to relative numbers in non-oiled areas.
- C. Evaluate and quantify hydrocarbon levels in tissue relative to effects on health, survival, and reproductive potential of passerines, and relate these data to changes in relative abundance and distribution of birds in the Sound.
- D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

See Birds Study 12.

Methods and Analyses:

Oiled and non-oiled shores will be selected for surveys, with selection cognizant of available data, ease of logistical support, and recommended statistical methods. Observations of passerines and other nongame birds will be recorded along oiled and non-oiled beaches, including documentation of scavenging on dead and dying oiled wildlife (primarily coordinated with field observations in other studies). Passerines on oiled shorelines will be live-trapped for examination. Histopathological analyses of the effects of oil contamination will be conducted by examining tissues of collected birds that are obviously contaminated and/or have been observed feeding on contaminated food items.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: USFS
State: ADF&G, DNR

Budget: U.S. Fish and Wildlife Service

Salaries	\$46.5
Travel	1.5
Contracts	3.5
Supplies	5.0
Equipment	<u>2.5</u>

TOTAL \$59.0

* Study to be conducted by ADF&G under contract to USFWS.

BIRD STUDY NUMBER 14

Study Title:

Effects on Migratory Birds of Exposure to North Slope Crude Oil

Concern/Justification:

The Exxon Valdez oil spill will expose large numbers of numerous species of birds to varying amounts of crude oil. Effects on these birds will range from direct mortality to sublethal contamination with less easily defined impacts. Ingestion, oil on plumage, and oil on eggs may cause both short- and long-term effects, including indirect mortality and reduced productivity. A number of laboratory experiments and field tests have been conducted in the past to determine toxicity of North Slope crude oil to birds. Results of these studies will be summarized and gaps in understanding of effects will be examined further to assure adequate linkage between the Exxon Valdez oil spill and injury to bird resources.

Objectives:

- A. Review and synthesize relevant information regarding toxicological effects of North Slope crude oil on birds.
- B. Determine adequacy of past studies in representing the current situation involving a wide range of taxonomically different birds.
- C. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

These experimental results will be analyzed in concert with field results from Birds Studies 3 through 13 to document causality between the spill and estimates of mortality.

Methods and Analyses:

Based on review and evaluation of existing information, staff will devise and implement laboratory or field experiments necessary to document the effects of North Slope crude oil on raptors, waterfowl, and seabirds. Laboratory experiments will focus on captive-bred birds, but will include wild-strain animals as necessary and practical. Field studies, although less controlled, may be used. All studies will involve use of experimental (oiled) and control (non-oiled) birds.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency(ies): None

Budget: U.S. Fish and Wildlife Service

Salaries	\$ 0.0
Travel	0.0
Contracts	10.0
Supplies	0.0
Equipment	<u>0.0</u>
<u>TOTAL</u>	\$ 10.0

TECHNICAL SERVICES

In each of the preceding categories of natural resources, the determination and quantification of injury require appropriate information on the exposure of the resource to hydrocarbon residues from the Exxon Valdez oil spill. Exposure can be demonstrated by detailed information on the distribution and evolving chemical composition of the spilled oil through time, in concert with analyses of petroleum hydrocarbons or their metabolites in the tissues of resource organisms. In those organisms where exposure is indicated, oil-related injury can be substantiated by measuring enhancement of petroleum-biodegrading enzyme systems, disruption of the normal balance of reproductive hormones, presence of DNA adducts with petroleum-related contaminants, and elevated incidence of histopathological and external lesions.

Under the direction of the resource-oriented studies, samples of water, sediments, and tissues are being collected throughout the entire region impacted by the spilled oil. Those samples finally selected for chemical analysis will be analyzed by a team of participating laboratories in accord with a centralized quality assurance/quality control program (described in detail in Appendix A of this plan) which will help ensure that all data are of known, defensible, and verifiable quality. The QA/QC program also will provide appropriate instrument calibration standards and standard reference materials that will demonstrate the accuracy, precision, and comparability of all chemical data generated by the damage assessment program.

Many of the studies described under Fish/Shellfish, Birds, Marine Mammals, and Terrestrial Mammals also require information on the incidence of oil-induced histopathological conditions. These observations will be performed under strict guidelines (detailed procedures are described in Appendix B of this plan) by a small team of histopathologists to ensure compatibility of results and evaluations throughout the State/Federal Damage Assessment Program.

The chemistry project and histopathology project described here are designed to provide quality-controlled technical services to studies described in other portions of the plan. The investigators performing these analyses will work very closely with the personnel conducting those studies, and in many cases, the data will be evaluated jointly. Major objectives of these analyses and the subsequent evaluations include:

- Measure the post-spill concentrations of petroleum hydrocarbons in sediments, tissue samples, and water, and compare these concentrations with those available from pre-spill historical data and from non-impacted locations.

- Conduct an exposure assessment of marine animals through systematic determinations of the variations of the oil-in-water and oil-in-sediment concentrations over time after the spill. In selected locations, estimate exposure more directly through analyses of bile from hydrocarbon metabolites and liver tissue for aryl hydrocarbon hydroxylase (AHH) activity, prevalence of DNA adducts, and occurrence of histopathological and external lesions.
- Characterize the chemistry of the petroleum hydrocarbons in terms of weathering, fate, and effects.

TECHNICAL SERVICES STUDY NUMBER 1

Study Title:

Hydrocarbon Analytical Support Services and Analysis of Distribution and Weathering of Spilled Oil

Concern/Justification:

A large number of water, sediment, shellfish, finfish, bird, mammal, and other samples are expected to be collected during the State/Federal Damage Assessment Program. Appropriate laboratory procedures must be used to analyze them for petroleum hydrocarbon contamination. Most of the damage assessment studies involve collection of hydrocarbon samples. None of those studies includes costs for analyzing the samples to be collected; all hydrocarbon analytical costs are included in this project.

Objectives:

- A. Measure petroleum hydrocarbons, hydrocarbon metabolites, and other appropriate chemical/biochemical measures of hydrocarbon exposure in water, sediment, and tissue samples collected through the Exxon Valdez oil spill damage assessment projects.
- B. Prepare a quality assurance/quality control (QA/QC) plan that establishes detailed procedures and protocols for sample collection, sample identification, chain of custody, and shipping.
- C. Establish a coordinated group, the Analytical Chemistry Group, to oversee and develop a centralized QA/QC program to assist the analytical laboratories in providing quality data, and demonstrate the accuracy, precision, and comparability of all data developed by the program.
- D. Provide technical on-site system audits of field and laboratory data collection activities by Analytical Chemistry Group members.
- E. Develop appropriate instrument calibration standards and natural matrix control materials (National Institute of Standards and Technology).
- F. Develop an integrated synthesis of the distribution and chemical composition of spilled oil, as it weathered through time, to provide a detailed basis for final exposure assessment.

- G. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

This study provides chemical and analytical support to all of the resource-oriented studies.

Methods and Analyses:

Procedures set forth for generating analytical data of acceptable quality are included in the QA/QC document listed as Appendix A. Analytical precision and accuracy will be determined and demonstrated by the periodic analysis of reference materials provided by the National Institute of Standards and Technology and by participation in intercomparison exercises. Any changes in analytical methodology from that proposed in the original QA/QC plan shall be validated statistically, to the satisfaction of the Analytical Chemistry Group, and tested through the blind analysis of an accuracy-based material. A series of three intercomparison exercises utilizing blind analyses of gravimetrically prepared materials, extracts of environmental matrices (tissues, sediment, and water), or the matrices themselves will be conducted annually. Participation in these exercises is mandatory. The Analytical Chemistry Group will review and provide written comments on the QC data, including control charts and the results of intercomparison exercises for further study. In close coordination with Air/Water Studies 1 through 3, the results of the chemical analyses will be evaluated and synthesized in interim and final reports to document the spatial extent and timing of oil distribution in water and sediments and the evolution of chemical composition of the oil through time.

Lead Agencies: National Oceanic and Atmospheric Administration and
U.S. Fish and Wildlife Service

Coordinating Agency(ies): None

Budgets: National Oceanic and Atmospheric Administration

Salaries	\$ 50.0
Travel	10.0
Contracts	1050.0
Supplies	40.0
Equipment	<u>150.0</u>
<u>TOTAL</u>	\$1300.0

U.S. Fish and Wildlife Service

Salaries	\$ 50.0
Travel	10.0
Contracts	750.0
Supplies	40.0
Equipment	<u>150.0</u>
<u>TOTAL</u>	\$1000.0

TECHNICAL SERVICES STUDY NUMBER 2

Study Title:

Histopathology: Examination of Abnormalities in Tissues from Birds, Mammals, Finfish, and Shellfish Exposed to the Spilled Oil

Concern/Justification:

Histopathology is an important tool used in determining mechanisms of death and sublethal effects caused by infectious agents and toxic substances. A number of histopathological conditions are known to result from exposure to oil. Evidence of these conditions will be documented in tissue samples taken from selected species of birds, mammals, finfish, and shellfish as one means of demonstrating spill-related injury in those organisms. Since tissues deteriorate (autolyze) rapidly, samples taken for histological evaluation as part of the damage assessment will be collected, preserved, and processed under strict guidelines, as determined by the quality assurance program.

Objectives:

- A. Measure the incidence of histopathological conditions and external lesions in selected species of birds, mammals, finfish, and shellfish collected in collaboration with relevant biological field investigations.
- B. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

Relationships with Other Studies:

The incidence of histopathological abnormalities will be determined on tissues collected in many studies related to Fish/Shellfish, Marine Mammals, Terrestrial Mammals, and Birds.

Methods and Analyses:

Standard histological methods for collection, preservation, processing, and interpretation will be used for animal tissues collected at oiled and non-oiled sites. (See Appendix B for procedures to be used.) Pairwise comparisons of animal tissues collected at oiled and non-oiled sites will be made regarding cellular degenerative or necrotic changes caused by oil exposure. Reports will be prepared to document the incidence and characteristics of histopathological conditions observed in the various groups of organisms, and determining their relationship with exposure of the organisms to the oil spilled from the Exxon Valdez.

Lead Agencies: U.S. Fish and Wildlife Service and Alaska
Department of Fish and Game

Cooperating Agency(ies): Federal: NOAA, USFS

Budgets:

Alaska Department of Fish and Game

Salaries	\$ 85.0
Travel	20.0
Contracts	197.0
Supplies	4.8
Equipment	<u>12.0</u>

TOTAL \$318.8

U.S. Fish and Wildlife Service

Salaries	\$ 86.9
Travel	13.5
Contracts	16.0
Supplies	3.0
Equipment	<u>2.0</u>

TOTAL \$121.4

TECHNICAL SERVICES STUDY NUMBER 3

Study Title:

Mapping of Damage Assessment Data and Information

Concern/Justification:

The Trustee agencies need a series of maps that depict oil impact data and shore types over the geographic area involved. These maps will be used to identify categories of oil impacts for different shoreline types, and to direct field operations in relation to that information.

These maps will be updated periodically and used as a common basis for presenting information and results from each of the damage assessment study categories. A geographic information system will be selected and implemented to facilitate the management and presentation of all information.

Objectives:

- A. Develop a single map format depicting the degree of onshore oiling and shore type for the entire region affected by the oil spill.
- B. Produce at least one set of these maps for each of the participating agencies by June 19, 1989.
- C. Create and maintain, throughout the damage assessment process, a data base of data pertinent to the overall damage assessment process, in a way that is accessible to all of the participating agencies.

Relationships with Other Studies:

The initial maps generated under this study are critical to the planning and implementation of Coastal Habitat Study 1. The geographic information mapping system will support the generation of information products from most of the resource-oriented studies throughout the entire course of activities under the Damage Assessment Plan.

Methods and Analyses:

A single map format will be provided. The format chosen will include four data layers: 1) shoreline, 2) upland land status, 3) ESI shore type, and 4) DEC oil impact. The upland land status data will be entered through cooperative efforts of the participating agencies. The ESI shore types will be entered under contract. Oversight on data structuring and accuracy will be

provided. The oil impact data will be transferred to the data base from the DEC Autocad data base maintained in Valdez. The geoprocessing group will logically structure this data in an accessible data base. All data sources, capture methods, and data base structuring will be documented. The data base will be available to the participating agencies. All transmittals of digital or hard copies will be documented.

Lead Agencies: Alaska Department of Natural Resources and U.S. Fish and Wildlife Service

Cooperating Agency(ies): Federal: EPA, USDI (NPS), NOAA, USFS,
USGS/EROS
State: ADF&G, DEC

Budgets:

Alaska Department of Natural Resources

Salaries	\$134.0
Travel	11.5
Contracts	58.0
Supplies	45.0
Equipment	<u>239.5</u>

TOTAL \$488.0

U.S. Fish and Wildlife Service

Salaries	\$100.0
Travel	0.0
Contracts	32.0
Supplies	0.0
Equipment	<u>0.0</u>

TOTAL \$132.0

U.S. Forest Service

Salaries	\$30.0
Travel	0.0
Contracts	20.0
Supplies	0.0
Equipment	<u>0.0</u>

TOTAL \$50.0

Part II

Development of the Restoration Plans

RESTORATION PLANS

Restoration plans are designed to identify specific actions that will be taken to restore the ecological health of Prince William Sound, and other affected areas, to the conditions that existed prior to the Exxon Valdez oil spill.

RESTORATION STUDY NUMBER 1

Study Title: Development of a Restoration Plan

Concern/Justification:

This project proposal summarizes the rationale and potential costs associated with developing a restoration plan for Prince William Sound and the Gulf of Alaska. This proposal does not reflect the costs of the actual restoration work.

As the injuries associated with the Exxon Valdez oil spill are determined, activities to restore the natural resources of the affected areas to the pre-spill conditions will be evaluated and initiated. Individual restoration plan elements should be developed as soon as practical after specific natural resource injuries have been sufficiently evaluated.

Objectives:

1. Incorporate ecological concepts and ecosystems perspectives in the overall restoration recommendations;
2. Review natural resource (injury) assessment reports and make an assessment of feasibility and cost of restoration and/or replacement of injured natural resources;
3. Evaluate restoration techniques and strategies and recommend the most appropriate and cost-effective methodologies; and
4. Develop restoration strategies, schedules, and plans.

Methods and Analyses:

The Trustee Council in cooperation with the restoration subgroup will direct the development of the initial and final restoration plans.

The Trustee Council will seek the input of expert scientists, agency representatives, the concerned public and others before specific restoration activities are selected for implementation.

Lead Agencies: EPA and the State of Alaska

Cooperating Agencies: USFS, NOAA, USDI

Budget: Trustee Agencies

Salaries	\$380.0
Travel	50.0
Contracts	20.0
Supplies	20.0
Equipment	<u>30.0</u>

<u>TOTAL</u>	\$500.0
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Part III

Damage Determination: Economic Value of Resource Use

DAMAGE DETERMINATION:
ECONOMIC VALUE OF RESOURCE USE

The studies described in Part I are designed to document for each resource category (Coastal Habitat, Fish/Shellfish, Birds, etc.) the magnitude of harm or injury caused by the spill. However, changes in resource numbers are not always directly amenable to economic valuation. The assignment of economic values usually is based on the loss of services provided by the resource to humans. Determination of damages, therefore, relies heavily on the collection of economic information through techniques not directly related to the determination or quantification of injury.

The economic use studies do not fit neatly into discrete resource categories for the most part. These studies will be supervised directly by the interagency economic and legal teams which serve the Trustee Council and are expected to be jointly funded by all Trustee agencies. The estimated budget is approximately \$2.8 million. No lead agency has been designated for these studies.

ECONOMIC USES STUDY NUMBER 1

Study Title:

Estimated Price Effects on Commercial Fisheries

Concern/Justification:

Media exposure of the Exxon Valdez oil spill has been substantial. Closures of entire fisheries and various fishing districts are occurring as a result of the oil spill. Catches may be affected through reductions in the size of fish stocks in the short term and long term. These factors may affect the prices of fish products for producers and to consumers.

Objectives:

- A. Measure the effects of the spill in terms of changes in consumer surplus prices and product prices.
- B. Analyze the competitiveness of output markets for commercial fisheries affected by the spill.

Methods and Analyses:

Demand functions will be estimated using established econometric techniques. Existing models will be used where appropriate. For example, price response models will be estimated for representative products (frozen sockeye salmon, canned pink salmon, halibut, herring roe, etc.) This study will track and compare 1989 grounds prices (using fish ticket information from affected and unaffected areas) and information collected in previous years.

ECONOMIC USES STUDY NUMBER 2

Study Title:

Fishing Industry Costs

Concern/Justification:

The seafood harvesting sector already has seen significant impacts, such as labor costs, tender availability, and movement of fishermen into unaffected areas. Changes in fishing patterns as a direct result of the oil spill also will affect the flow of seafood products within the economy and the costs of production in various regions of Alaska. Additionally, a substantial number of vessels that normally would be engaged in fishing and tendering are involved in the clean-up effort. These shifts of effort will have economic implications that are not yet clear. For example, lack of adequate tender capacity may mean that the quality of fish delivered to processors is reduced, delivery costs may go up, and available resources may go unharvested. Lack of tender capacity also could cause shifts in fish processing location.

Objectives:

- A. Identify the effects of the oil spill on fish harvesting, processing, and marketing costs.
- B. Analyze the competitiveness of input markets important to the commercial fisheries affected by the oil spill.

Methods and Analyses:

Cost and production data will be collected from the fishing industry and secondary sources. These data will be used to estimate cost functions or changes in costs resulting from the oil spill.

ECONOMIC USES STUDY NUMBER 3

Study Title:

Bioeconomic Models for Damage Assessment

Concern/Justification:

The linkages between effects of the oil spill on fishery resources and the commercial fisheries may best be quantified through the development of bioeconomic models. Some economic effects must be estimated simultaneously, using other models that incorporate relevant ecological factors.

Objectives:

Measure the interactions between the fishery resources and the commercial fisheries, evaluating the direct cost of the oil spill on the use value of these commercial fisheries.

Methods and Analyses:

Biological and economic models will be developed and integrated using established techniques. Such models will incorporate much of the information generated by the other economic and biological studies.

ECONOMIC USES STUDY NUMBER 4

Study Title:

Effects of the Oil Spill on the Value of Public Land

Concern/Justification:

Direct and indirect impacts of the oil spill may reduce the economic value of public lands and resources. For example, the Alaska Department of Natural Resources, Bureau of Indian Affairs, and the U.S. Forest Service are concerned that the market value of uplands and submerged lands could be reduced for uses such as mining, logging, mariculture, gravel extraction, grazing, shore fisheries, and sales of land for recreation and settlement.

Objectives:

Determine the change in market values of public lands.

Methods and Analyses:

To determine the lost market land values, this study will 1) estimate the acres of uplands and submerged lands directly and indirectly affected by the oil spill, 2) project market demands for leases and sales in the area affected by the oil spill, and 3) project changes in total value of leases and sales through demand information.

ECONOMICS USES STUDY NUMBER 5

Study Title:

Economic Damages to Recreation

Concern/Justification:

The Exxon Valdez oil spill has impacted natural resources that support a wide range of recreational activities including fishing, hunting, boating, hiking, camping, and sightseeing. Because of their unique attributes, these resources attract recreationists from throughout the United States and other countries to Prince William Sound and the Gulf of Alaska coast.

The oil spill may result in economic damage to those resources' recreational services in two principal ways: 1) some recreationists who otherwise would have gone to the area will choose a substitute activity and/or area, thereby potentially suffering a loss in personal satisfaction and possibly incur increased costs, and 2) recreationists who visit the area may suffer reduced satisfaction because of the oil spill's adverse impacts on recreational services that the natural resources otherwise would have provided.

Objectives:

Develop estimates of economic injuries to recreationists.

Methods and Analyses:

The study will look at all types of consumptive and nonconsumptive recreational activities. A variety of techniques may be used for estimating economic injuries to recreation activities including travel cost models, contingent valuation, and unit-day values. The travel cost method uses a model to statistically estimate a demand curve for a recreation site(s) by analyzing the relationship between the number of visits to a site(s) and the costs of making those trips, including the opportunity cost of time. Estimates of changes in consumer surplus are derived from the demand curve and form the basis for the economic damage estimate. The contingent valuation method makes use of a survey questionnaire to ask individuals how much they value, in dollar terms, the recreational activities in question. The unit-day value approach makes use of standardized values per unit of recreational use (appearing in the economics literature).

This study will obtain demographic, attitudinal, behavioral, and perceptual data, using 1) household and on-site surveys, 2) post-spill and historic pre-spill resident and nonresident recreation use data for areas directly affected by the oil spill

as well as for areas outside of the spill zone, 3) post-spill and pre-spill data on tourism (prices and quantities) in Alaska, and 4) post-spill and pre-spill data on hunting and fishing licenses, and other types of licenses and permits issued to recreation businesses and users in the state.

ECONOMICS USES STUDY NUMBER 6

Study Title:

Losses to Subsistence Households

Concern/Justification:

Several communities on the shores of Prince William Sound, lower Cook Inlet, Kodiak Island, and the Alaska Peninsula, and in or near the Exxon Valdez oil spill area, are highly dependent upon noncommercial fishing, intertidal food gathering, marine mammal hunting, and land mammal hunting for subsistence uses. Among the smaller subsistence communities are Tatitlek, Chenega Bay, English Bay, Port Graham, Ouzinkie, Port Lions, Larsen Bay, Karluk, Akhiok, Old Harbor, and Chignik Bay. Larger subsistence communities include Cordova, Valdez, Seldovia, and Kodiak. Subsistence uses are defined as rural Alaska residents' customary and traditional uses of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade. Those uses are designated as the priority public consumptive use of wild resources in both federal and state law.

Following the oil spill, subsistence harvests were reduced in several communities because of health concerns. This could have important ramifications in the economy and social order of the communities, and could lead to increased dependencies on the government and increased social pathologies. Potentially important economic losses to the communities include 1) subsistence losses, 2) local inflation affecting harvests and food procurement, and 3) damage to subsistence property.

Objectives:

- A. Conduct a literature review and compile base line information.
- B. Document extent of oil contact and clean-up on or near historic harvest sites.
- C. Document changes in subsistence use through time (i.e., species selection; harvest timing, quantities, areas, methods, and efficiency; and household participation rates in harvest, use, sharing, barter, and exchange).
- D. Document local social and economic changes that affect subsistence use, including wage/labor patterns, income levels,

inflation rates in the villages for goods and services, clean-up work, outside agency demands, and industry demands.

E. Assign monetary values to losses to subsistence households.

Methods and Analyses:

Field observations and interviews will be used to collect information. Changes in subsistence use and socioeconomic changes will be determined by conducting systematic household surveys and interviews, and comparing these data to historic information. Market prices and price imputation will be used to estimate increased costs to subsistence users. Survey methods will be used to study losses associated with the oil spill. Information on prices and markets for commercial goods purchased will be used to prepare consumer price-index analogues and to estimate the economic costs of the spill to subsistence communities.

ECONOMICS USES STUDY NUMBER 7

Study Title:

Study of Loss of Intrinsic Values Due to the Exxon Valdez Oil Spill

Concern/Justification:

Intrinsic values include option value, existence value, quasi-option value, and bequest value. This type of value is independent of economic value arising from direct use of the resource. The public may perceive a loss reaching beyond the direct use of resources impacted by the oil spilled into Prince William Sound and the movement of this oil to hundreds of miles of shoreline outside the Sound. Resources with intrinsic value include fish, birds, and mammals, along with the wilderness character of the areas including ecological integrity and scenic quality. It is probable that designated types of public stewardship such as wilderness, national park, state park, and state or national wildlife refuge influence intrinsic values. Extensive investigations are needed to determine the value the public would place on maintaining the existence of the now-soiled lands, waters, and wildlife in their pristine state.

Objectives:

Determine the loss of intrinsic value of the natural resources resulting from the oil spill.

Methods and Analyses:

This study will use surveys designed to document an individual's intrinsic valuation of the resources in question.

ECONOMIC USES STUDY NUMBER 8

Study Title:

Economic Damage Assessment of Research Programs Affected by the Exxon Valdez Oil Spill

Concern/Justification:

The oil spill affected research programs in the vicinity of the spill, resulting in damage to, or loss of, various research and resource monitoring studies. Opportunities to study natural resource systems in the affected area may have been lost as a result of the spill. Research studies conceived before the spill by federal, state, other government agencies, and private groups, could have been impacted. An example is a study involving tagging fish that was in progress in an affected area of Prince William Sound. Determination of the extent or degree of damage to research studies will require careful evaluation and study.

Objectives:

Assess damage and economic loss of research investigations, and account for the cost of resources expended in affected studies, focusing on research-based expenditures made or committed to before the oil spill.

Methods and Analyses:

Research studies directly impacted by the oil spill will be calculated. Costs of resources already expended and costs of delays and disruptions of the affected research programs will be calculated. The economic valuation is to be based on an opportunity-cost approach. This study will focus on the economic valuation of delayed or foregone research results, including lost unique research opportunities involving the affected area.

ECONOMIC USES STUDY NUMBER 9

Study Title:

Survey of Archaeological Sites Impacted by the Exxon Valdez Oil Spill

Concern/Justification:

Archaeological sites may be physically damaged by oil. Approximately 900 identified sites, along a coastline of approximately 1700 miles, lie in the currently known path of the spill. Many coastal archaeological sites are within or partially within the intertidal zone—some because they were built there, and others through subsidence of the land. Direct coating of intertidal sites may have occurred with varying impacts, depending on the type of site (petroglyph, pictograph, beach gravel, weir, submerged stratigraphy, etc.). Upland sites may be damaged by erosion caused by destruction of site vegetation. Additionally, the oil may be transported inland and permeate site sediments. The scientific value of sites may be adversely affected by contamination of artifacts, faunal remains, sediments, radiocarbon materials, and other data.

Objectives:

- A. Determine the number of cultural resources that have been impacted by the oil spill.
- B. Determine the type and extent of injury to the archaeological sites.
- C. Assess the economic damages to the sites.

Methods and Analyses:

A data base will be established through literature search and field survey of the oil impacted areas, emphasizing those sites with high potential as cultural resources. A model will be established for the kinds of cultural resources impacted, the degree of impact, and the physical setting in which it occurred. A representative sample of each type of cultural resource affected will be researched, and archaeological tests will be conducted.

Analysis of the cultural resources will concentrate on the effect of the oil on the physical stratigraphy (soils) of the site and particularly its organic component to determine changes in preservation. Attention also will be given to changes in soil compaction, stratification, or obscuring of the stratigraphy. Artifact movement or loss within the soil column from changes in chemical breakdown and leaching away of the constituents over time

or inundation (pavement formation and conglomeration) also will be considered. Development of specialized data recovery techniques may be necessary.

Key factors important in determining the economic value of the injured sites include the number of sites affected, the extent of injury, the types of information lost, and the uniqueness of that information. These and other factors will be used to help estimate the economic value of the injured sites as well as the cost of restoration or replacement.

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Part IV

Summary of Fiscal Needs

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
Fiscal Data Are In 1000's of Dollars

*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Coastal Habitat	CH1	Comprehensive Assessment	ADF&G	\$ 536.0
			USFS	4900.0
Air/Water	AW1	Geographical Extent in Water	DEC	231.0
			NOAA	112.5
	AW2	Injury to Subtidal	DEC	553.0
			NOAA	330.0
	AW3	Hydrocarbons in Water	DEC	253.0
			NOAA	342.5
	AW4	Injury to Deep Water	DEC	97.6
			NOAA	281.3
	AW5	Injury to Air	DEC	106.5
Fisheries	F1	Salmon Spawning Area Injury	ADF&G	144.8
	F2	Egg and Preemergent Fry Sampling	ADF&G	149.1
	F3	Coded-Wire Tagging	ADF&G	1943.4
	F4	Early Marine Salmon Injury	ADF&G	590.7
			NOAA	238.5
	F5	Dolly Varden Injury	ADF&G	437.4

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
Fiscal Data Are In 1000's of Dollars
Page 2

*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Fisheries	F6	Sport Fishery Harvest & Effort	ADF&G	175.9
	F7	Salmon Spawning Area Injury, Outside PWS	ADF&G	320.3
	F8	Egg & Preemergent Fry Sampling, Outside PWS	ADF&G	111.4
	F9	Early Marine Salmon Injury, Outside PWS	ADF&G	348.5
	F10	Dolly Varden & Sockeye Injury, Lower Cook Inlet	ADF&G	152.6
	F11	Herring Injury	ADF&G	374.5
	F12	Herring Injury, Outside PWS	ADF&G	60.0
	F13	Clam Injury	ADF&G	86.2
	F14	Crab Injury	ADF&G NOAA	64.9 78.0
	F15	Spot Shrimp Injury	ADF&G	60.5
	F16	Injury to Oysters	ADF&G NOAA	25.5 5.0

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
Fiscal Data Are In 1000's of Dollars
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Fisheries	F17	Rockfish Injury	ADF&G	45.6
	F18	Trawl Assessment	ADF&G	199.3
			NOAA	539.5
	F19	Larvae Fish Injury	ADF&G	413.4
	F20	Underwater Observations	ADF&G	550.1
	F21	Clam Injury, Outside PWS	ADF&G	108.8
	F22	Crab Injury, Outside PWS	ADF&G	11.0
			NOAA	100.5
	F23	Rockfish Injury, Outside PWS	ADF&G	108.4
	F24	Trawl Assessment, Outside PWS	ADF&G	295.8
			NOAA	2200.0
	F25	Scallop Mariculture Injury	ADF&G	53.8
	F26	Sea Urchin Injury	ADF&G	45.0
Marine Mammals	MM1	Humpback Whale	NOAA	226.0
	MM2	Killer Whale	NOAA	200.0

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Marine Mammals	MM3	Cetacean Necropsy	NOAA	73.0
	MM4	Sea Lion	NOAA	270.0
	MM5	Harbor Seal	NOAA	245.0
	MM6	Sea Otter Injury	USDI	763.0
	MM7	Sea Otter	USDI	108.0
Terrestrial Mammals	TM1	Injury to Sitka Black- Tail Deer	ADF&G	87.0
	TM2	Injury to Black Bear	ADF&G	139.7
	TM3	Injury to River Otter and Mink	ADF&G	287.7
	TM4	Injury to Brown Bear	ADF&G	162.7
	TM5	Injury to Small Mammals	ADF&G	302.4
	TM6	Reproduction of Mink	ADF&G	192.2
Birds	B1	Beached Bird Survey	USDI	258.0

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
Fiscal Data Are In 1000's of Dollars
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Birds	B2	Censuses & Seasonal Distribution	USDI	565.0
	B3	Seabird Colony Surveys	USDI	440.0
	B4	Bald Eagles	USDI	445.0
	B5	Peal's Peregrine Falcons	USDI	43.5
	B6	Marbled Murrelets	USDI	115.7
	B7	Storm Petrels	USDI	135.0
	B8	Black-legged Kittiwakes	USDI	190.0
	B9	Pigeon Guillemots	USDI	109.5
	B10	Glaucous-winged Gulls	USDI	73.0
	B11	Sea Ducks	USDI	146.0
	B12	Shorebirds	USDI	166.0
	B13	Passerines	USDI	59.0

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Birds	B14	Exposure to North Slope Oil	USDI	10.0
Technical Services	TS1	Chemistry	NOAA	1300.0
			USDI	1000.0
	TS2	Histopathology	ADF&G	318.8
			USDI	121.4
	TS3	Mapping	DNR	488.0
			USDI	132.0
			USFS	50.0
Restoration Planning	RP1	Restoration Planning	ALL	500.0
Economics	ALL	Economic Studies	ALL	2800.0

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

Study Category	Number	Title	Agency	Budget
Overhead	01	State of Alaska	ADF&G	2011.0
	02	Dept. of Agriculture	USFS	874.5
	03	Dept. of Interior	USDI	800.0
	04	Dept. of Commerce	NOAA	981.0
	05	Environmental Protection Agency	EPA	450.0
TOTALS				\$35420.9

Summary of the Exxon Valdez Oil Spill Damage Assessment Program
Fiscal Data Are In 1000's of Dollars
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*Budgets are projected obligations accrued from the onset of the project through 2/28/90

SUMMARY	Agency	Budget
	STATE OF ALASKA	\$12643.5
	NOAA	7522.8
	USFS	5824.5
	USDI	5680.1
	EPA	450.0
	ALL TRUSTEES	3300.0
	TOTAL	\$35420.9

Appendices

APPENDIX A
STATE/FEDERAL DAMAGE ASSESSMENT PLAN
ANALYTICAL CHEMISTRY
QUALITY ASSURANCE/QUALITY CONTROL

TABLE OF CONTENTS

1. QUALITY ASSURANCE FOR ANALYTICAL CHEMISTRY
 - 1.1 Study-Specific QA Plans
 - 1.2 Technical System Audits
 - 1.3 Standards and Quality Control Materials
 - 1.4 Analytical Performance Evaluations
 - 1.5 Data Reporting and Deliverables
2. MINIMUM REQUIREMENTS: SAMPLING AND SAMPLING EQUIPMENT
 - 2.1 Sample Collection
 - 2.2 Sample Identification
 - 2.3 Sample Preservation and Holding Times
 - 2.4 Sample Shipping
3. MINIMUM REQUIREMENTS: ANALYSIS
4. MINIMUM REQUIREMENTS: REPORTING AND DATA DELIVERABLES

Appendix A (continued)

This document describes the Quality Assurance for the analytical chemistry portions of the Exxon Valdez Damage Assessment Process. It is to be used in conjunction with the Analytical Chemistry Quality Assurance Programs of the Trustee Agencies. It describes only those minimum requirements necessary to validate the data generated by analytical chemistry laboratories. Quality assurance requirements for other types of measurements are not addressed.

For instructions in meeting the requirements described in this document, please consult "Collection and Handling of Samples," which was prepared by the Analytical Chemistry Group for use in training field personnel or the following Agency representatives:

Carol-Ann Manen, National Oceanic and Atmospheric Administration,
(907) 789-6014.

Everett Robinson-Wilson, U.S. Fish and Wildlife Service,
(907) 786-3493.

Rolly Grabbe, Alaska Department of Environmental Conservation,
(907) 364-2155.

John Moore, U.S. Fish and Wildlife Service, (301) 497-0524.

Appendix A (continued)

This Analytical Chemistry QA Plan was developed by and has the concurrence of:

Chris Brodersen, National Oceanic and Atmospheric Administration

Christine Brodersen 10 July 89

Carol-Ann Manen, National Oceanic and Atmospheric Administration

Carol Ann Manen 7/3/89

William D. MacLeod, National Oceanic and Atmospheric Administration

William D. MacLeod 7/12/89

Stanley D. Rice, National Oceanic and Atmospheric Administration

Stanley D. Rice

Susan Haseltine, U.S. Fish and Wildlife Service

Susan Haseltine 7/26/89

John Moore, U.S. Fish and Wildlife Service

John F. Moore 7-24-89

Everett Robinson-Wilson, U.S. Fish and Wildlife Service

Everett F. Robinson-Wilson 7/5/89

Gregory Smith, U.S. Fish and Wildlife Service

Gregory J. Smith 25 JUL 1989

Pages 1-9 of State/Federal Damage Assessment Plan, Quality Assurance/Quality Control

Rolly Grabbe 7-18-89

Rolly Grabbe, Alaska Department of Environmental Conservation

Ursula Spannagel 7/18/89

Ursula Spannagel, Alaska Department of Environmental Conservation

W.B. Towns

Barry Towns, Environmental Protection Agency

Bruce Woods, Environmental Protection Agency

Bruce G. Woods 7 Aug 89

Appendix A (continued)

1. Quality Assurance for Analytical Chemistry

Each Trustee agency through their individual standard documented QA programs and guidances shall ensure that all data generated by or for that agency and their contractors, in support of the Exxon Valdez Damage Assessment, are of known, defensible, and verifiable quality.

These documented QA programs and guidances include but are not limited to:

- NOAA National Status and Trends Program, Mussel Watch Phase 4 Work/QA Project Plan
- Quality Assurance of Chemical Analyses Performed Under Contract With the USFWS
- EPA SW-846, Chpt. 1, QA/QC Requirements
- EPA Guidelines and Specification for Preparing Quality Assurance Project Plans, QAMS-005
- EPA Handbook for Sampling and Sample Preservation of Water and Wastewater

In addition, an interagency team of leading scientists from the Trustee agencies and the Environmental Protection Agency, hereafter referred to as the Analytical Chemistry Group (ACG), shall develop and oversee a centralized program which will demonstrate the quality and comparability of the chemical data obtained by the Trustee agencies.

The major components of this centralized QA program will be:

1. Development of study-specific analytical chemistry QA plans.
2. Technical on-site system audits of field and laboratory data collection activities.
3. Development and provision of appropriate instrument calibration standards and control materials.
4. Laboratory performance evaluations by means of intercomparison exercises.
5. Review of data deliverables and all supportive documentation to evaluate data quality.

Appendix A (continued)

1.1 Study-Specific Quality Assurance Plans

Prior to the initiation of each study, the study manager must prepare and submit a study-specific analytical chemistry QAP to the ACG for review and concurrence. This plan shall specify each study's goals, sampling procedures, analytical procedures, and all quality control measures and acceptance criteria associated with those procedures.

The QAP must be study-specific, however any documented QA guidance and/or appropriate Standard Operating Procedures (SOP's) used by the Trustee agencies may form the basis of individual study QA plans.

A Quality Assurance Plan must address the following:

- * Title Page - Includes the signatures of the individuals responsible for the project and ACG concurrence.
- * Project Description and Sampling Objectives - Briefly describes the what, where, and why of the project.
- * Data Needs - Describes what elements, compounds, classes of compounds, and/or physical data are required. Must describe the desired detection limits, precision and accuracy of the data for the study.
- * Sampling and Labelling Procedures - Describes sample collection, including field QC and preservation. Estimates the number and kind of samples to be collected. Minimum requirements for sample collection are described in Section 2.
- * Chain of Custody - Describes Chain-of-Custody and documentation procedures. Minimum requirements are described in Section 2.
- * Analytical Procedures - References or describes in detail proposed method(s).
- * Internal Quality Control - Describes type and frequency of internal quality control. Minimum requirements are described in Section 3.
- * Calibration Procedures and Frequency - Describes the methods and frequency for calibrating field and laboratory instruments. These must be specified in SOP's.

Appendix A (continued)

- * Data Verification - Describes the data verification in SOP form and includes; (1) the methods used to identify and treat outliers, and (2) the data flow from generation of raw data through storage of verified results.
- * Data Deliverables - Specifies reporting needs additional to the minimum requirements described in Section 4.
- * Technical System and Performance Audits - Specifies field or intra-laboratory audits planned by the responsible Agency.

1.2 Technical System Audits

On-site system audits may be performed without prior notification by the ACG after consultation with the responsible agency.

1.3 Standards and Quality Control Materials

The National Institute of Standards and Technology (NIST) will develop and provide appropriate standards and quality control materials.

1.4 Analytical Performance Evaluations

Prior to the initiation of work, each analytical laboratory will be required to demonstrate its capability. This will be accomplished by providing laboratory documentation on the performance of the proposed methods and through the analysis of an accuracy based material. The results of this analysis must be within +/- 15% of the value of each analyte or measurement parameter.

Any changes in analytical methodology from that proposed in the original QA plan shall be validated under agency procedures and documented to the ACG.

A series of three intercomparison exercises, utilizing the blind analysis of gravimetrically prepared materials, extracts of environmental matrices (tissue, sediment and water) or the matrices themselves, will be conducted annually. Participation in these exercised is mandatory. Materials will be prepared by, and data

Appendix A (continued)

returned to the NIST for statistical analysis. The NIST will report to the chairperson of the ACG. Unacceptable performance will result in the discarding of the associated data.

The ACG will review and provide written reports on the results of intercomparison studies to the Management Team.

1.5 Data Reporting and Deliverables

Data deliverables will be reviewed by the generating Agency to verify the quality and useability of the data. A QC report on each data set will be provided to the ACG for review.

All data and associated documentation will be held in a secure place under chain-of-custody procedures until the Trustees indicate otherwise.

2. Minimum Requirements: Sampling and Sampling Equipment

Sample collection activities must be described in SOP's. References to existing documents are acceptable.

The method of collection should not alter the samples.

Sample collection and storage devices shall not alter the sample.

Samples shall be held in a secure place under appropriate conditions and under chain-of-custody until the Trustees indicate otherwise.

2.1 Sampling Identification and Labelling

An SOP will be in place for each study which describes procedures for the unique identification of each sample. A sample tag or label will be attached to the sample container. A waterproof (indelible) marker must be used on the tag or label. Included on the tag are the sample identification number, the location of the collection site, the date of collection and signature of the collector.

The information above will also be recorded in a field notebook along with other pertinent information about the collection and signed by the collecting scientist.

Appendix A (continued)

2.2 Field Chain-of-Custody

The field sampler will be personally responsible for the care and custody of the samples collected until they are transferred to another responsible party.

Samples will be accompanied by a chain-of-custody record or field sample data record. When samples are transferred from one individual's custody to another's, the individuals relinquishing and receiving will sign, date and note the time on the record.

Shipping containers will be custody-sealed for shipment. Whenever samples are split, a separate chain-of-custody record will be prepared for those samples and marked to indicate with whom the samples are being split.

Samples shall be maintained in a manner that preserves their chemical integrity from collection through final analysis.

Sample shipper will arrange for sample receipt.

After analysis, any remaining sample and all sample tags, labels and containers shall be held under chain-of-custody procedure until the Trustees indicate otherwise.

3. Minimum Requirements: Analysis

The applicable methodology must be referenced or described in detail in the SOP's for each measurement parameter.

Method limits of detection must be calculated by matrix and analyte.

Control of the analytical method in terms of accuracy and precision must be demonstrated.

Calibration must be verified at the end of each analysis sequence.

Samples must be quantified within the demonstrated linear working range for each analyte.

Standard curves must be established with at least 3 points besides 0.

Field blanks, procedural blanks, reference materials, replicates and analyte recovery samples must be run at a minimum frequency of 5 percent each per sample matrix batch.

Appendix A (continued)

A minimum list of the petroleum hydrocarbon compounds which are to be considered for identification and quantification in water, tissue and sediment include the volatiles, i.e., benzene, toluene, xylene and the polynuclear aromatic and aliphatic hydrocarbons listed below:

Naphthalene	n-dodecane
2-Methylnaphthalene	n-tridecane
1-Methylnaphthalene	n-tetradecane
Biphenyl	n-pentadecane
2,6-Dimethylnaphthalene	n-hexadecane
Acenaphthylene	n-heptadecane
Acenaphthene	pristane
2,3,5-Trimethylnaphthalene	n-octadecane
Fluorene	phytane
Phenanthrene	n-nonadecane
Anthracene	n-eicosane
1-Methylphenanthrene	
Fluoranthene	
Pyrene	
Benz(a)anthracene	
Chrysene	
Benzo(b)fluoranthene	
Benzo(k)fluoranthene	
Benzo(a)pyrene	Benzo(e)pyrene
Indeno(1,2,3-c,d)pyrene	Perylene
Dibenz(a,h)anthracene	
Benzo(g,h,i)perylene	

4. Minimum Requirements: Reporting and Data Deliverables

Measurement results, including negative results, as if three figures were significant must be reported.

Results of quality control samples analyzed in conjunction with the study samples must be reported.

Documentation demonstrating analytical control of precision and accuracy on an analyte and matrix specific basis must be reported.

APPENDIX B

EXXON VALDEZ OIL SPILL DAMAGE ASSESSMENT PLAN HISTOPATHOLOGY GUIDELINES

Histopathology is an important tool used in determining mechanisms of death and sublethal effects caused by infectious agents and toxic substances. A definitive diagnosis often does not result from histological examination, but can give strong support to other positive measurements. Tissues deteriorate (autolyze) rapidly after an animal dies; therefore, to be of value, any samples taken for histological evaluation as part of the damage assessment of the Exxon Valdez oil spill must be collected, preserved, and processed under strict guidelines.

Sample Collection and Preservation Protocols

Standard protocols for necropsy and preservation of tissue samples for histopathology shall be used throughout the oil spill assessment studies. Different protocols have been designed to accommodate the different groups of animals to be encountered in the assessment studies. Necropsy procedures have been established and provided to study managers under separate cover for a variety of different animal groups including finfish, bivalve mollusks, brachyuran and crab-like anomurans (i.e., king crabs), shrimp, marine and terrestrial mammals, and migratory and nonmigratory waterfowl.

Paired sampling of animals from oiled versus non-oiled sites will be done for comparative purposes. Histopathological sampling should be done during any observed acute episodes of mortality or morbidity to determine the cause of death or abnormality. These types of samples are the most valuable in assessing acute toxicity affects and will be the most likely samples collected for birds and mammals due to their high visibility in the impacted areas. Because of the low visibility of fish and shellfish, many histology samples will consist of random collections in impacted and control areas with little prior obvious indication of morbidity or mortality.

Any histological processing of samples collected from apparently normal shellfish will be performed after results of parallel hydrocarbon sampling are known; i.e., positive hydrocarbon results may merit further histopathology studies. This would not be advisable for fish and other higher animals that possess an active mixed function oxidase (MFO) liver enzyme system which could metabolize hydrocarbons to other compounds providing negative hydrocarbon results, while potentially still exhibiting toxicological lesions. Analyses of enzyme function may show an activated MFO system in exposed fish and higher animals.

Appendix B (continued)

Consequently, histology and hydrocarbon samples, as well as other appropriate samples, such as liver and bile, will be taken from the same animal when possible for analyses of metabolites and enzyme function. If certain fish and shellfish are too few or small, subsampling other animals from the same site at the same time will be necessary.

Processing and Interpretation Protocols

Histopathology assessment of birds and mammals will be done primarily on tissues from clinically affected animals using established criteria of cellular degenerative and necrotic changes recognized by a board certified veterinary pathologist.

Histopathological analysis of finfish and shellfish tissues will include the criteria above as well as indices established in the Amoco Cadiz oil spill studies (Haensly, et al., 1982; Berthou, et al., 1987) to allow some quantification of potentially subtle degenerative changes in tissue histology of otherwise clinically normal animals. Briefly, these indices include mean concentration of mucus cells per mm² of gill lamellae (fish); mean concentration of mucus cells per mm of epidermis in 10 fields (fish); average epidermal thickness in mm measured in 10 fields (fish); mean concentration of macrophage centers per mm of liver; mean concentration of hepatocellular vacuolation due to fatty degeneration (fish); a mean and total tissue necrosis index (invertebrates); histological gonadal index (invertebrates); and differences in prevalences and intensities of incidental lesions caused by infectious agents (fish and invertebrates).

Quality Assurance in Field Collection of Samples and in Interpretation of Results

Field Collection:

Veterinary personnel trained in sample taking will be utilized for onsite necropsies of birds and mammals in order to ensure adequate quality control and standardized sample collection. The same high standards will be attainable in fish and invertebrates in that sample collection will be done by trained finfish and shellfish biologists. A fish pathologist and technician are available to train field personnel and assist in necropsy and preservation of finfish and shellfish samples at collection sites.

Sample collection from migratory birds and sea otters will be coordinated with the U.S. Fish and Wildlife Service National Wildlife Health Laboratory in Madison, Wisconsin. Collection of

Appendix B (continued)

samples from nonmigratory birds and other marine mammals will be coordinated with the Alaska State Veterinary Laboratory in Anchorage. Finfish and shellfish samples can be coordinated through the onsite fish pathologist and the ADF&G, Fisheries Rehabilitation, Enhancement and Development Division Fish Pathology Laboratory in Juneau.

Interpretation of Results:

Quality control of all processed work will require independent blind reading of subsampled histology slides by two different laboratories. Tissues with known lesions will be included periodically in groups of tissue samples for blind reading and determination of competency in interpretation.

Repository For Samples And Inventory Procedures

A common repository for storage of all histology samples awaiting processing will be established at Anchorage in a secured building in compliance with chain-of-custody requirements. Samples received will be given a unique accession number to be cross-referenced with the project and original numbering assigned by the collector.

Chain of Custody Guidelines

Due to the evidentiary nature of sample collecting investigations, the possession of samples will be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. To maintain and document sample possession, chain of custody procedures will be followed.

The field sampler will be personally responsible for the care and custody of the samples collected until they are transferred. All samples will be accompanied by a chain of custody record and will be custody-sealed. This procedure includes use of a custody seal such that the only access to the package is breaking the seal. When samples are transferred from one individual's custody to another's, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person and, ultimately, to a specified analytical laboratory.

Shipping containers will also be custody-sealed for shipment. The seal shall be signed before the sample is shipped. The chain of custody record will be dated and signed to indicate transfer. The original record will accompany the shipment and a copy will be retained by the sample collector. Whenever samples are split, a

Appendix B (continued)

separate chain of custody record will be prepared for those samples and marked to indicate with whom the samples are being split. If samples are being sent by common carrier, copies of all bills of lading or air bills must be retained as part of the permanent documentation.

Subcontracting for Histological Work

Subcontracting work for histopathology processing and interpretation will be under the control of an interagency team referred to as the Histology Technical Group which will determine if potential contractors are qualified to do the work. Qualifications for mammal and avian samples will require a board certified veterinary pathologist. Finfish and shellfish work will require individuals with a demonstrated publication record in the field of histopathology.

Finfish and Shellfish Mortality Assessments

Estimates of finfish and shellfish mortalities will be according to guidelines established for estimating fish kills contained in Part II (Fish Kill Counting Guidelines) of the Monetary Values of Freshwater Fish and Fish-Kill Counting Guidelines, American Fisheries Society Special Publication Number 13, 1982, including use of appropriate random sampling methods and tagged carcasses.

References

- Bell, T. A. and D. V. Lightner. 1988. A Handbook of Normal Penaeid Shrimp Histology. The World Aquaculture Society, Baton Rouge, LA.
- Berthou, F., G. Balouet, G. Bodennec, and M. Marchand. 1987. The occurrence of hydrocarbons and histopathological abnormalities in oysters for seven years following the wreck of the Amoco Cadiz in Brittany (France). Mar. Environ. Res. 23:103-133.
- CERCLA. 1988. Natural Resource Damage Assessments. 53 Federal Regulation 5166 and 9769.
- Haensly, W. E., J. M. Neff, J. R. Sharp, A. C. Morris, M. F. Bedgood, and P. D. Boem. 1982. Histopathology of *Pleuronectes platessa* L. from Aber Wrac'h and Aber Benoit, Brittany, France: long-term effects of the Amoco Cadiz crude oil spill. J. Fish Dis. 5:365-391.

Appendix B (continued)

Johnson, P. T. 1980. Histology of the Blue Crab, *Callinectes sapidus*: A Model for the Decapoda. Praeger Publ., New York.

Sparks, A. K. 1985. Synopsis of Invertebrate Pathology Excluding Insects. Elsevier Publ., New York.

APPENDIX C

PREASSESSMENT SCREEN AND DETERMINATION

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Frank J. Iarossi
President
Exxon Shipping Company
P.O. Box 1512
Houston, TX 77252-1512

Re: Notice of Intent to Perform an Assessment
M/T Exxon Valdez

Dear Mr. Iarossi:

On March 24, 1989, the M/T Exxon Valdez ran aground on Bligh Reef in Prince William Sound, Alaska. As a result, approximately eleven million gallons of Alaska North Slope crude oil were discharged into the marine environment, subsequently spreading throughout southwest Prince William Sound and westward along the Kenai Peninsula. Significant quantities of oil covered thousands of square miles of ocean, and further impacts have occurred or are anticipated in the Kodiak Island archipelago and adjacent mainland, Cook Inlet, areas along the Alaska Peninsula, Aleutian Islands, and the Bering Sea, including Bristol Bay, as well as in previously unaffected areas within the original area of distribution.

Exxon Shipping Company has been identified as a potentially responsible party for that discharge. On or about April 13, 1989, the Exxon Shipping Company and the natural resource trustees signed a Memorandum of Agreement regarding the payment by Exxon Shipping Company of fifteen million dollars to fund the activities of the natural resource trustees. This letter further notifies the potentially responsible parties of the intent of the below-signed authorized officials, representing the natural resource trustees, to perform a natural resource damage assessment, as provided for by the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act, as amended. It should be noted that no final decision has been made as to whether the damage assessment will be conducted under the Natural Resource Damage Assessment regulations, 43 C.F.R. Part 11. Liability may also arise under other laws.

Exxon Shipping Company is invited to respond to this letter and to participate, under the direction of the natural resource trustees, in that process. After 30 days following your receipt of this letter, we intend to complete a draft assessment plan. Because of the timing of the discharge and the short season available for collection of data, we are proceeding with initial data and sample collections.

The resources potentially at risk are described in the preassessment determination and general information supporting that determination, a copy of which is enclosed. A considerable body of background information supports the summary statements provided in the enclosed documentation, including reports of the incident by the Coast Guard and other agencies, as well as many other reports both published and internal. The screen is intended only to determine whether there is sufficient cause to pursue a natural resource damage assessment; omission of any information here does not preclude consideration of such information in the course of the assessment.

Michael A. Barton
Regional Forester
Authorized Official
U.S. Forest Service
Department of Agriculture
Date 5/25/89

Walter D. Stiglitz
Regional Director
Authorized Official
U.S. Fish and Wildlife Service
Department of the Interior
Date 5/31/89

Steve Pennoyer
Regional Director
Authorized Official
National Marine Fisheries
Service
Department of Commerce
Date 5/26/89

Orin W. Beensworth
Commissioner
Authorized Official
Alaska Department of Fish and Game
State of Alaska
Date 5.26.89

Enclosures

Appendix C (continued)

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. L. R. Raymond
President
Exxon Corporation
1251 Avenue of the Americas
New York, NY 10020-1198

Re: Notice of Intent to Perform an Assessment
M/T Exxon Valdez

Dear Mr. Raymond:

On March 24, 1989, the M/T Exxon Valdez ran aground on Bligh Reef in Prince William Sound, Alaska. As a result, approximately eleven million gallons of Alaska North Slope crude oil were discharged into the marine environment, subsequently spreading throughout southwest Prince William Sound and westward along the Kenai Peninsula. Significant quantities of oil covered thousands of square miles of ocean, and further impacts have occurred or are anticipated in the Kodiak Island archipelago and adjacent mainland, Cook Inlet, areas along the Alaska Peninsula, Aleutian Islands, and the Bering Sea, including Bristol Bay, as well as in previously unaffected areas within the original area of distribution.

Exxon Corporation has been identified as a potentially responsible party for that discharge. On or about April 13, 1989, the Exxon Shipping Company and the natural resource trustees signed a Memorandum of Agreement regarding the payment by Exxon Shipping Company of fifteen million dollars to fund the activities of the natural resource trustees. This letter further notifies the potentially responsible parties of the intent of the below-signed authorized officials, representing the natural resource trustees, to perform a natural resource damage assessment, as provided for by the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act, as amended. It should be noted that no final decision has been made as to whether the damage assessment will be conducted under the Natural Resource Damage Assessment regulations, 43 C.F.R. Part 11. Liability may also arise under other laws.

Exxon Corporation is invited to respond to this letter and to participate, under the direction of the natural resource trustees, in that process. After 30 days following your receipt of this letter, we intend to complete a draft assessment plan. Because of the timing of the discharge and the short season available for collection of data, we are proceeding with initial data and sample collections.

The resources potentially at risk are described in the preassessment determination and general information supporting that determination, a copy of which is enclosed. A considerable body of background information supports the summary statements provided in the enclosed documentation, including reports of the incident by the Coast Guard and other agencies, as well as many other reports both published and internal. The screen is intended only to determine whether there is sufficient cause to pursue a natural resource damage assessment; omission of any information here does not preclude consideration of such information in the course of the assessment.

Michael A. Barton

Regional Forester
Authorized Official
U.S. Forest Service
Department of Agriculture

Date

5/25/89

Walter O. Stiglitz

Regional Director
Authorized Official
U.S. Fish and Wildlife Service
Department of the Interior

Date

5/31/89

Steven Pennoyer

Regional Director
Authorized Official
National Marine Fisheries
Service
Department of Commerce

Date

5/26/89

Onne W. Cullenworth

Commissioner
Authorized Official
Alaska Department of Fish and Game
State of Alaska

Date

5-26-89

Enclosures

Appendix C (continued)

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. George M. Nelson
President
Alyeska Pipeline Service Company
1835 S. Bragaw
Mail Station 528
Anchorage, AK 99512

Re: Notice of Intent to Perform an Assessment
M/T Exxon Valdez

Dear Mr. Nelson:

On March 24, 1989, the M/T Exxon Valdez ran aground on Bligh Reef in Prince William Sound, Alaska. As a result, approximately eleven million gallons of Alaska North Slope crude oil were discharged into the marine environment, subsequently spreading throughout southwest Prince William Sound and westward along the Kenai Peninsula. Significant quantities of oil covered thousands of square miles of ocean, and further impacts have occurred or are anticipated in the Kodiak Island archipelago and adjacent mainland, Cook Inlet, areas along the Alaska Peninsula, Aleutian Islands, and the Bering Sea, including Bristol Bay, as well as in previously unaffected areas within the original area of distribution.

Alyeska Pipeline Service Company has been identified as a potentially responsible party for that discharge. On or about April 13, 1989, the Exxon Shipping Company and the natural resource trustees signed a Memorandum of Agreement regarding the payment by Exxon Shipping Company of fifteen million dollars to fund the activities of the natural resource trustees. This letter further notifies the potentially responsible parties of the intent of the below-signed authorized officials, representing the natural resource trustees, to perform a natural resource damage assessment, as provided for by the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act, as amended. It should be noted that no final decision has been made as to whether the damage assessment will be conducted under the Natural Resource Damage Assessment regulations, 43 C.F.R. Part 11. Liability may also arise under other laws.

Alyeska Pipeline Service Company is invited to respond to this letter and to participate, under the direction of the natural resource trustees, in that process. After 30 days following your receipt of this letter, we intend to complete a draft assessment plan. Because of the timing of the discharge and the short season available for collection of data, we are proceeding with initial data and sample collections.

The resources potentially at risk are described in the preassessment determination and general information supporting that determination, a copy of which is enclosed. A considerable body of background information supports the summary statements provided in the enclosed documentation, including reports of the incident by the Coast Guard and other agencies, as well as many other reports both published and internal. The screen is intended only to determine whether there is sufficient cause to pursue a natural resource damage assessment; omission of any information here does not preclude consideration of such information in the course of the assessment.

Michael A. Barton

Regional Forester
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Stuart Pennoyer

Regional Director
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National Marine Fisheries
Service
Department of Commerce

Date 5/26/89

Orin Callmanson

Commissioner
Authorized Official
Alaska Department of Fish and Game
State of Alaska

Date 5-26-89

Enclosures

PREASSESSMENT SCREEN AND DETERMINATION

Determination

The listed natural resource trustees or their delegates are responsible for managing and protecting natural resources and have made the following determination:

On March 24, 1989, the M/T Exxon Valdez ran aground on Bligh Reef in Prince William Sound, Alaska. As a result, approximately eleven million gallons of Alaska North Slope crude oil were discharged into the marine environment, subsequently spreading throughout southwest Prince William Sound and westward along the Kenai Peninsula. Significant quantities of oil remain at sea covering thousands of square miles, and further impacts have occurred or are anticipated in the Kodiak Island archipelago and adjacent mainland, Cook Inlet, areas along the Alaska Peninsula, the Aleutian Islands, and the Bering Sea, including Bristol Bay, as well as in previously unaffected areas within the original area of distribution.

Numerous natural resources under the trusteeship of state and federal agencies under CERCLA have been and will be injured as a result of this discharge. The response actions taken and planned to be taken will not sufficiently remedy the injury to those natural resources without further action. Sufficient information can be obtained at a reasonable cost to justify initiation of a natural resource damage assessment. General information supporting this determination is enclosed. A considerable body of background information supports the summary statements provided in the enclosed documentation, including reports of the incident by the Coast Guard and other agencies, as well as many other reports, both published and internal. This screen is intended only to determine whether there is sufficient cause to pursue a natural resource damage assessment; omission of any information here does not preclude consideration of such information in the course of the assessment.

Michael A. Barton
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Date 5/31/89

Appendix C (continued)

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Service
Department of Commerce

Date 5/26/89

Enclosures

Donnell Callenworth
Commissioner
Authorized Official
Alaska Department of Fish and Game
State of Alaska

Date 5.26.89

Appendix C (continued)

INFORMATION ON THE SITE AND ON THE DISCHARGE

1. Time, quantity, duration, and frequency of the discharge

As a result of the grounding of the Exxon Valdez, starting at 12:30 a.m., March 24, 1989, and continuing for several weeks, approximately eleven million barrels of Alaska North Slope crude oil were discharged from the region of Bligh Reef in Prince William Sound, Alaska. The bulk of that oil was discharged within the first days following the grounding, and smaller amounts continued to be discharged in the course of removing the taker from the reef, inspecting the damage, and making temporary repairs in preparation for movement to a repair facility. The main body of the oil was transported by wind and currents throughout the southwestern portion of Prince William Sound, then westward along the south shore of the Kenai Peninsula toward Kodiak Island and the entrance to Cook Inlet. Hundreds of miles of coastlines and islands along this route have received oil from this discharge, and large quantities of oil remain at sea. Additional areas have been or are likely to be impacted, including parts of Kodiak and Afognak Islands, mainland areas in Shelikof Strait, elsewhere on the Alaska Peninsula, Aleutian Islands, areas within Cook Inlet, and the Bering Sea, including Bristol Bay. Shifting winds and currents, coupled with the volume of oil discharged and remaining in the marine system, are expected to result in additional oil also coming ashore within the area already impacted. Final disposition of the oil and its products cannot be determined at this time, but sufficient information is known to demonstrate the need for a damage assessment.

2. The name of the hazardous substance

Although oil and oil products are not considered hazardous substances under CERCLA, their discharge is prohibited under the Clean Water Act. The oil discharged is Alaska North Slope crude oil, which naturally contains significant quantities of toxic metals including vanadium, nickel, chromium, and zinc. The oil is also highly toxic because it is about 25 percent aromatics, which are generally considered the most toxic hydrocarbon components. As it degrades through physical, chemical, photochemical, and biological processes, additional toxic materials are likely to be generated.

Appendix C (continued)

3. History of the site of the discharge

Bligh Reef is located in the northeast section of the Prince William Sound in southcentral Alaska. Prince William Sound and the other impacted areas are some of the most pristine environments in the world. They support one of the largest commercial fisheries in the world, extensive tourism based on wildlife viewing, camping, boating, and other outdoor activities, as well as significant subsistence and sport fisheries. The areas of impact include several state parks, national parks, national wildlife refuges, national forest, Native allotments, wilderness study areas, and state critical habitat areas, all of which are known for their spectacular resource values, scenic beauty, and high value natural resources. Impacted areas also include public and private aquaculture sites, including some of the largest salmon hatcheries in the world. The final extent of the impacted area is now yet known, but those areas already impacted and expected to be impacted, as described above, have also been minimally impacted by man, with the exception of a number of small communities including Valdez, Cordova, Whittier, Seward, Homer, Seldovia, Kodiak, and other smaller communities, which depend in whole or part on the natural resources affected by the discharge of oil. The areas of impact have had substantial prehistoric and historic use by Native cultures.

4. Relevant operations occurring at or near the site

Bligh Reef is an obstacle to navigation that has been marked by navigational aids for many years. The main shipping channel for oil tankers loading at the Port of Valdez, which is the southern terminus of the Trans-Alaska Pipeline, is located about twenty-five miles northeast of the initial site of the discharge. Other fishing or shipping ports in the general area impacted or potentially impacted include Cordova, Seward, Homer, and Kodiak.

5. Additional oil or hazardous substances potentially discharged from the site

The oil discharged from the Exxon Valdez may have contained one or more additives to facilitate its movement through the pipeline. These additives are also toxic, but their contribution to the effects of the discharge have not yet been evaluated. Additional toxic materials can be expected to appear as the oil breaks down due to physical, chemical, photochemical, and biological processes.

Appendix C (continued)

6. Potentially responsible parties

The Coast Guard has identified the following as potentially responsible parties; this list may be expanded upon further investigation.

Exxon Corporation, and its managers and representatives

Exxon Shipping Corporation, and its managers and representatives

Alyeska Pipeline Services Company, and its managers and representatives.

7. Damages excluded from liability

The trustees are not aware at this time of any defenses or exclusions of liability under applicable laws.

Appendix C (continued)

PRELIMINARY ASSESSMENT CRITERIA

1. Discharge or release

On March 24, 1989, at 12:30 a.m., the Exxon Valdez ran aground on Bligh Reef in Prince William Sound, approximately twenty-five miles southwest of Valdez, Alaska. During the following days, approximately eleven million gallons of crude oil were discharged into marine waters, which spread throughout much of western and southwestern Prince William Sound and the southern coast of the Kenai Peninsula. Oil has been deposited on hundreds of miles of shorelines throughout this area. Significant quantities of oil remain at sea covering thousands of square miles, and further impacts have occurred or are anticipated in the Kodiak Island archipelago and adjacent mainland, Cook Inlet, other areas along the Alaska Peninsula, the Aleutian Islands, and the Bering Sea, including Bristol Bay, and in previously unaffected areas within the original area of distribution. Further spread of oil is likely to occur.

2. Affected natural resources

Natural resources affected or potentially affected include but are not limited to the following. They are listed without regard to specific natural resource trustees, but all fall within the jurisdiction of one or more of those trustees.

- Marine and anadromous fishes of many species
- Marine mammals, including sea otters, pinnipeds of several species, and cetaceans
- Birds, including seabirds, waterfowl, shorebirds, raptors, and other species
- Shellfish, including both mollusks and crustaceans of many species
- Marine invertebrates other than shellfish
- Lands managed by natural resource trustees, including wetlands, shorelines, soil, geologic resources, and other features of those lands
- Marine and terrestrial plants and microorganisms
- Surface waters, including sediments

Appendix C (continued)

- Ground water
- Submerged lands
- Terrestrial wildlife, including big game species
- Air resources

3. Sufficient quantity and concentration of oil

Approximately eleven million gallons of Alaska North Slope crude oil were discharged. Initially, a large quantity of undiluted oil spread over a considerable area causing widespread deaths and injuries to numerous species of wildlife, both aquatic and terrestrial. Thousands of dead animals have been collected and are continuing to be found, and many animals with sublethal injuries are also being observed. Counts of dead animals are regularly updated in Coast Guard and other agency reports; these counts represent only a small fraction of the number of animals actually being killed or otherwise injured. Reproductive, physiological, and behavioral injuries in affected species are anticipated. Oil and its complex breakdown products will persist for a long time; the nature and degree of toxicity of that oil will vary over time, and will require considerable study to determine its ultimate fate and effects.

4. Availability of data for a reasonable cost damage assessment

Many natural resources in parts of Prince William Sound and southwest Alaska have been studied in the past, both as to abundance and values. Other areas and resources, especially on and near the Kenai and Alaska Peninsulas, will require additional studies to determine base line conditions and services. Sufficient base line data exist for beginning an assessment; additional data will be needed in other areas. Further studies needed will be described in the assessment plan. The massive and obvious extent of natural resource injuries, as well as the high value of those resources for which values are known, give little doubt that a natural resource damage assessment can be performed at reasonable cost.

5. Response actions

The continuing response action being carried out by Exxon and coordinated with the Coast Guard and other agencies, although it contains elements attempting to prevent further injuries, will not sufficiently restore or compensate for lost or injured natural resources. Certain preassessment activities, such as surveys, have

Appendix C (continued)

been started and are essential both to the response action by determining sensitivity of areas potentially impacted as well as to assessment by providing current base line data. Significant quantities of oil and its breakdown products will remain in the environment following the response action, and many presently undocumented effects can be reasonably anticipated.

Appendix C (continued)

PRELIMINARY IDENTIFICATION OF RESOURCES POTENTIALLY AT RISK

1. Preliminary identification of pathways

The oil was discharged into marine waters of Prince William Sound and has been distributed extensively by currents, wind, and wave action. Much of the oil remains in the marine system. During that period, weather ranged from calm to heavy storms. Substantial quantities volatilized into the air and dissolved into the water column, and degradation of the oil will result in additional breakdown products being physically and chemically dispersed. Wave action has deposited oil well above the high tide line in many areas, and well below the surface of the substrate on many shorelines. Pathways into which oil or its products have entered include direct contact, surface water, ground water, air, food chains, and particulate movement.

2. Exposed areas

The main body of the oil was transported by wind and currents through the southwestern portion of Prince William sound, then westward along the south shore of the Kenai Peninsula toward Kodiak Island and the entrance to Cook Inlet. Hundreds of miles of coastlines and islands along this route have received oil from this discharge, and large quantities of oil remain at sea. Additional areas have been or are likely to be impacted, including parts of Kodiak and Afognak Islands, mainland areas in Shelikof Strait, elsewhere on the Alaska Peninsula, Aleutian Islands, and the Bering Sea including Bristol Bay, and areas within Cook Inlet. Shifting winds and currents, coupled with the volume of oil discharged and remaining in the marine system, are expected to result in additional oil coming ashore within the area already impacted. Large numbers of migratory birds are beginning to move through the area, resulting in likely indirect impacts on breeding grounds elsewhere, primarily farther north within Alaska. Salmon and other fish rely on Prince William Sound as breeding or rearing habitat, and indirect impacts on these fish are likely to be found over large areas of the North Pacific and in upstream breeding habitats.

3. Exposed water estimates

The total area of water that will be impacted directly by this discharge cannot be estimated accurately at this time, but several thousand square miles are already known to have been affected.

4. Estimates of concentrations

Appendix C (continued)

Concentrations range from 100 percent at the site and time of discharge to 0 percent in unaffected areas. The oil is a complex mixture and will change composition significantly over time due to physical, chemical, photochemical, and biological processes. Different components of both the original oil and of its breakdown products will vary in solubility and toxicity.

5. Potentially affected resources

Natural resources affected or potentially affected include but are not limited to the following. They are listed without regard to specific natural resource trustees, but all fall within the jurisdiction of one or more of those trustees.

- Marine and anadromous fishes of many species
- Marine mammals, including sea otters, pinnipeds of several species, and cetaceans
- Birds, including seabirds, waterfowl, shorebirds, raptors, and other species
- Shellfish, including both mollusks and crustaceans of many species
- Marine invertebrates other than shellfish
- Lands managed by natural resource trustees, including wetlands, shorelines, soil, geological resources, and other features of those lands
- Marine and terrestrial plants and microorganisms
- Surface waters, including sediments
- Groundwater
- Submerged lands
- Terrestrial wildlife, including big game species
- Air resources

Services provided by these natural resources include, but are not limited to the following:

- Habitat for trustee species, including food, shelter, breeding areas, and other factors essential to long-term survival

Appendix C (continued)

- Commercial, subsistence, personal use, and sport fisheries
- Aquaculture
- Subsistence and sport hunting and trapping
- Other subsistence, sport, and commercial uses
- Other recreational uses, including tourism, camping, boating, contract recreation, wildlife viewing, and other activities
- Wilderness
- Scientific assessment and research, including archeological
- Mining
- Drinking
- Marine transportation
- Cultural use
- Option and existence values

APPENDIX D

PARTICIPANTS IN THE NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS

TRUSTEES

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State of Alaska
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Manual Lujan
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Appendix D (continued)

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John H. Clark
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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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Appendix D (continued)

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* And many other people who may not be listed but their contributions are acknowledged.

APPENDIX E
KEY TO ABBREVIATIONS

State Agencies

ADF&G	Alaska Department of Fish and Game
CFEC	Commercial Fisheries Entry Commission
DCED	Alaska Department of Commerce & Economic Development
DEC	Alaska Department of Environmental Conservation
DHSS	Alaska Department of Health and Social Services
DNR	Alaska Department of Natural Resources
UAF	University of Alaska, Fairbanks
	IAB - UAF, Institute of Arctic Biology
	IMS - UAF, Institute of Marine Science
	SFOS - UAF, School of Fisheries and Ocean Science

Federal Agencies

BIA	Bureau of Indian Affairs
DOC	U.S. Department of Commerce
EPA	Environmental Protection Agency
MMS	Minerals Management Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OCSEAP	Outer Continental Shelf Environmental Assessment Program
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

Federal Laws

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act