The 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill

Volume I: Assessment and Restoration Plan

Appendices A, B, C

April 1991

Dear Reviewer:

This document describes studies proposed to be conducted jointly by the State of Alaska and the United States during the third year since the *Exxon Valdez* oil spill. The purpose of these studies is to determine injury to natural resources resulting from that spill. This document also describes restoration planning activities proposed for 1991.

The 1991 proposed plan has greatly benefitted by incorporation of many of the public comments on the "State/Federal Natural Resources Damage Assessment Plan and Restoration Plan for the *Exxon Valdez* Oil Spill, August 1990." This proposed plan was assembled through the cooperative efforts of the State of Alaska acting through the Departments of Fish and Game, Environmental Conservation, Natural Resources, and Law, and the United States acting through the Federal Departments of Justice, Agriculture and Interior, the National Oceanic and Atmospheric Administration, and the U.S. Environmental Protection Agency.

At this printing an agreement has been reached between the State and Federal Trustees, and Exxon, regarding a judicially supervised settlement of claims. Ratification of the settlement agreement may result in modification of plans and projects currently proposed to be conducted.

Public comment on this document will assist the Trustee Council in developing future injury assessment and restoration efforts and may also result in modification of plans and projects proposed to be conducted in 1991. Questions concerning the plan and its distribution should be directed to U.S. Department of Agriculture, Forest Service Public Affairs Office (907) 586-8806.

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Comments should be received by June 3, 1991, at the following address:

Trustee Council
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We appreciate your interest and look forward to your participation in this important process.

Sincerely,

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VOLUME I: THE 1991 STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION PLAN FOR THE *EXXON VALDEZ* OIL SPILL AND APPENDICES A, B, C

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INTRODUCTION

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 (see map, Fig. 1). The spill injured fish, birds, mammals, and a variety of other forms of marine life, habitats, and resources.

The State of Alaska acting through the Alaska Departments of Fish and Game (ADF&G), Environmental Conservation (ADEC), and Law (Attorney General), and the United States acting through the federal Departments of Agriculture (DOA), Interior (DOI) and through the National Oceanic and Atmospheric Administration (NOAA), are acting together as Natural Resource Trustees as provided by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Clean Water Act (CWA), and other state and federal authorities. The Environmental Protection Agency (EPA) is assisting in damage assessment and is coordinating the federal restoration efforts with the State of Alaska.

This plan, which describes the proposed 1991 studies, continues or modifies certain 1989 and 1990 damage assessment studies. These studies are designed to determine the nature and extent of the injuries, losses or destruction of resources, and lost uses of the resources. These data provide a base for developing a restoration plan.

Funds received as the result of litigation or settlement will be used to restore, replace, or acquire the equivalent of the injured natural resources and services and to reimburse agencies for relevant costs incurred. The U.S. Department of Justice and Alaska Department of Law represent the federal and state governments, respectively, in pursuit of these claims.

In 1989, the Trustees developed a damage assessment plan incorporating 72 studies in 10 categories. In 1990, 50 studies were undertaken. The proposed 1991 damage assessment plans incorporates 42 studies in 10 categories.

Damage assessment is a dynamic process and it will continue to evolve. In order to identify studies that should be continued, terminated or new studies that should be initiated, the Trustees considered the extensive public comments on the first two years of work and consulted damage assessment investigators, other agency scientific staff, legal counsel, and independent outside expert reviewers. The studies were evaluated from five perspectives: (1) immediate injury, (2) long-term alteration of populations, (3) sublethal or latent effects, (4) ecosystem-wide effects, and (5) habitat degradation.

Studies were discontinued for a variety of reasons, such as the determination that field work had been completed or that there was no practicable way to measure injury. The mere fact that a study was discontinued does not indicate that the resource was uninjured by the spill. Funds are provided to conclude data analysis and report preparation for certain studies that are not being continued in 1991.

The studies described in this plan fall into ten categories: (1) Marine Mammals, (2) Terrestrial Mammals, (3) Birds, (4) Fish/Shellfish, (5) Coastal Habitat, (6) Subtidal Habitat, (7) Technical Services (including chemistry and an integrated geographic information system, complete with mapping) to support the resource studies, (8) Archaeological Resources, (9) Economic Studies, and (10) Restoration. The cost for all activities described in the 1991 State/Federal Natural Resource Damage Assessment and Restoration Planning for the *Exxon Valdez* Oil Spill is approximately $35 million.

Marine Mammal studies include direct observations of injury (e.g., through carcass counts) as well as estimates of population effects based on censuses or pathologic and toxicologic indicators (as is being undertaken with otters and seals). In addition, the direct observational data allow for inferences to be made about injuries to populations.

Terrestrial mammals near the coast may have been exposed to hydrocarbons by breathing fumes or eating oiled carcasses or vegetation. The studies will determine the presence of hydrocarbons in tissues of dead animals and the effects, if any, of oil exposure on local populations of brown bears and river otters.

The 1991 effort to determine injury to birds will focus on seabirds, bald eagles, and waterfowl. Surveys and censuses, radio telemetry, and documentation of sublethal and physiological impacts will be used as means to determine injury. The information obtained will contribute to an understanding of mortality, population changes, and other factors essential for the damage assessment process. Studies proposed for birds focus on the collection of data on survival and reproductive success in relation to initial and continuing exposure to hydrocarbons and conversion products.

The Fish/Shellfish studies focus on identifying potential injury to the various life stages of fish and shellfish in areas affected by the oil spill. Species were selected for study based on their respective niche or overall importance within the ecosystem, ability to be sampled, and the existence of an historic data base.

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

The Subtidal Habitat studies determine the distribution and composition of petroleum hydrocarbons or their environmental conversion products in water, sediments, and living resources. Information gathered on the distribution and nature of the hydrocarbons and their conversion products provides a basis for documenting exposure and for determining injury to resources. The combined results of the Coastal Habitat and Subtidal Habitat studies also form a basis for estimating rates of recovery of natural resources and the potential for accelerating recovery.

The Technical Services category includes activities that provide process support or information services to all studies in the areas of analytical chemistry and an integrated geographic information system, complete with mapping.

Studies on archaeological resources will proceed in two steps: (1) inventory, description, and classification; and (2) qualitative and quantitative descriptions and measurements of changes detrimental to the archaeological resources related to the spill.

The value of lost or injured natural resources, and the goods and services they provide humans, are based on results from economic studies. In this regard, damages forming the basis of the Trustees' claim against the potentially responsible parties are calculated by considering (1) the reduction of these goods and services, including intrinsic values, 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.

The restoration planning component describes the strategy and scope of the restoration process planned for the third oil spill year. Restoration measures will be implemented as appropriate methods are identified and funds are available.

TABLE ONE. STUDIES AUTHORIZED IN 1989, 1990 AND 1991

X = Initiated or Continued

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Marine Mammals (MM)					
	1	Humpback Whale	X	X	
	2	Killer Whale	X	X	X
	3	Cetacean Necropsy	X		
	4	Sea Lion	X	X	*
	5	Harbor Seal	X	X	X
	6	Sea Otter Injury	X	X	X
	7	Rehabilitated Sea Otters	X	X	moved to MM 6
Terrestrial Mammals (TM)					
	1	Sitka Black-Tail Deer	X	X	
	2	Black Bear	X	X	
	3	River Otter & Mink	X	X	X
	4	Brown Bear	X	X	X
	5	Small Mammals	X		
	6	Mink Reproduction	X	X	*
Birds	1	Beached Bird Survey	X	X	X
	2	Census/Seasonal Distribution	X	X	X
	3	Seabird Colony Surveys	X	X	X
	4	Bald Eagles	X	X	X
	5	Peale's Peregrine Falcons	X	X	
	6	Marbled Murrelets	X		
	7	Storm Petrels	X		
	8	Black-Legged Kittiwakes	X		

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Birds, continued					
	9	Pigeon Guillemots	X		
	10	Glaucous-winged Gulls	X		
	11	Sea Ducks	X	X	X
	12	Shorebirds	X		
	13	Passerines	X	X	
	14	Exposure North Slope Oil	X		
Fish/Shellfish (F/S)					
	1	Salmon Spawning Area Injury	X	X	X
	2	Eggs/Pre-emergent Fry Sampling	X	X	X
	3	Coded-wire tagging	X	X	X
	4	Early Marine Salmon Injury	X	X	X
	5	Dolly Varden Injury	X	X	X
	6	Sport Fishing Harvest & Effort	X		
	7	Salmon Spawning Area Injury, Outside PWS	X	X	*
	8	Egg & Pre-emergent Fry, Sampling Outside PWS	X	X	*
	9	Early Marine Salmon Injury Outside PWS	X		
	10	Dolly Varden & Sockeye Injury, Lower Cook Inlet	X		
	11	Herring Injury	X	X	X
	12	Herring Injury Outside PWS	X		
	13	Clam Injury	X	X	X
	14	Crab Injury	X		
	15	Shrimp Injury	X	X	moved to subtidal

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Fish/Shellfish, continued					
	16	Oyster Injury	X		
	17	Rockfish Injury	X	X	moved to subtidal
	18	Trawl Assessment	X	X	*
	19	Larval Fish Injury	X		
	20	Underwater Observations	X		
	21	Clam Injury Outside PWS	X	(combined with F/S 13)	
	22	Crab Injury Outside PWS	X	X	
	23	Rockfish Injury Outside PWS	X	(combined with F/S 17)	
	24	Dermersal Fish Injury	X	X	moved to subtidal
	25	Scallop Mariculture Injury	X		
	26	Sea Urchin Injury	X		
	27	Sockeye Salmon Overescapement		X	X
	28	Run Reconstruction		X	X
	29	Life History Modeling		(combined with F/S 28)	
	30	Database Management		X	X
Coastal Habitat (CH)					
	1	Intertidal Studies	X	X	X
Air/Water (A/W)					
	1	Geographic Extent of Oil in Water	X		
	2	Injury to Subtidal Sediments and Benthos	X	X	moved to subtidal
	3	Hydrocarbons in Water	X	X	moved to subtidal
	4	Injury to Deep Water	X	(combined with A/W 2)	
	5	Injury to Air	X		
	6	Oil Fate and Toxicity		X	moved to subtidal

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Subtidal					
	1	Hydrocarbon Exposure, Microbial and Meiofaunal Community Effects (A/W2)			X
	2	Injury to Benthic Communities (CH 1 and A/W 2)			X
	3	Bio-availability and Transport of Hydrocarbons (A/W 3)			X
	4	Sediment Toxicity Bioassays (A/W 6)			X
	5	Injury to Shrimp (F/S 15)			X
	6	Injury to Rockfish (F/S 17)			X
	7	Injury to Demersal Fish (F/S 24)			X
Technical Services					
	1	Hydrocarbon Analysis	X	X	X
	2	Histopathology	X	X	
	3	Mapping	X	X	X
Archaeology					
	1	Archaeological	Part of Econ 9	X	X
Economics					
	1	Commercial Fisheries Losses	X	X	X
	2	Fishing Industry Costs	X	(combined with Econ 1)	
	3	Bioeconomic Models	X	(combined with Econ 1)	
	4	Public Land Effects	X	X	
	5	Recreational Losses	X	X	X
	6	Subsistence Losses	X	X	X
	7	Intrinsic Values	X	X	X

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Economics, continued					
	8	Research Program Effects	X	X	X
	9	Archaeological Damage Quantification	X		
	10	Petroleum Products Price			X
Restoration Planning			X	X	X

* These studies are being funded for the completion of data analysis and final report preparation.

PART I: INJURY DETERMINATION/QUANTIFICATION

MARINE MAMMAL ASSESSMENT

Although the most visible impact of the EVOS on marine mammals was the large number of dead sea otters, other marine mammal species were potentially injured by the spill, including Steller sea lions, harbor seals, killer whales, and humpback whales.

In 1989, seven studies were assembled and implemented to gather information on injury to marine mammals. Aerial surveys for stranded cetaceans were also conducted. Additional data on injuries to sea otters were gathered at the sea otter rehabilitation centers.

In 1990, most of these studies were continued to further refine the information documenting injury resulting from the spill.

Three of these studies will be continued in 1991 including studies on killer whales, harbor seals and sea otters. In addition, the study on sea lions conducted during 1989 and 1990 will be completed with final data analysis and report preparation.

In many cases, the 1989 and 1990 studies have been expanded and modified in response to knowledge gained during the two years following the spill, as well as, comments from reviewers and the public. The ongoing study on killer whales is intended to provide information on changes in killer whale use of the spill zone, to assess long-term impacts, and to corroborate information on injury to killer whales gathered during the 1989 and 1990 studies. Data from studies on harbor seals will provide information on toxicological effects of the EVOS. The sea otter study will continue to look at population effects and possible physiological and toxicological impacts that could result in long-term, sublethal injuries.

MARINE MAMMAL STUDY NUMBER 2

Study Title: Assessment of Injuries to Killer Whales in PWS

Lead Agency: NOAA

INTRODUCTION

During the first two years of the killer whale damage assessment work, photographs of individual killer whales in PWS were collected from May to September 1989 and 1990 to assess the impact of the EVOS on killer whale life history and ecology. In PWS, research vessels traversed over 20,000 nautical miles in search of whales or while photographing whales, reflecting 507 days of field research. This effort represents the most complete study accomplished to date on killer whales in PWS. An unusually high number of killer whales have been reported missing from the PWS area. The assessment of the overall effects of the EVOS on killer whale populations in PWS will be enhanced with photographic evidence that the whales missing in 1989/1990 are confirmed missing in 1991.

The purpose of this study is to obtain photographs of individual killer whales in PWS from May to late September 1991. Calves of the year will be documented. Photographs collected will be compared to the Alaskan photographic database for the years 1977 to 1990 to determine if changes have occurred in whale abundance, seasonal distribution, continuity of habitat usage, pod integrity, and mortality or natality rates. Results of this research will aid in the determination of the extent of displacement or reduction in numbers of killer whales as a result of the EVOS.

OBJECTIVES

A. To count the number and individually identify killer whales within PWS.

B. To test the hypothesis that killer whale distribution within PWS and adjacent waters is similar to that reported for previous years (1984-1990).

C. To test the hypothesis that pre- and post-spill killer whale pod structure and integrity have remained constant.

D. To test the hypothesis that killer whale natality rates within PWS have not changed since the EVOS.

E. To test the hypothesis that killer whale mortality rates within PWS have not changed since the EVOS.

METHODS

Personnel from the National Marine Mammal Laboratory (NMML), Seattle, Washington (Alaska Fisheries Science Center, NMFS/NOAA/DOC) will develop and coordinate all killer whale research activities associated with the *Exxon Valdez* damage assessment. Field studies will be conducted by contractors that have recognized expertise in the study areas of concern.

Shore-based camps will be established in PWS to conduct photo-identification studies on killer whales from small boats (May through September 1991). Camp locations will be similar to those set up in 1990. Camps may be moved during the field season based on whale distribution data collected during the study. All camps are fully self-contained with necessary items for camp and vessel safety. Camps will be resupplied with food and essentials at least twice a month by a vessel chartered specifically for this reason. Each camp is staffed by at least two biologists and one small boat. Camp personnel will communicate among themselves via marine radios. For consistency in data collection, key personnel remain in the field throughout the 5-month period.

Weather permitting, field personnel will spend an average of 8 to 10 hours per day conducting boat surveys searching for whales. Effort must be comparable to the 1989 and 1990 seasons. Specific areas, known for whale concentrations, are investigated first. However, if reports of whales are received from other sources (e.g, sighting network described below), those areas are examined. If whales are not located in "known" areas and opportunistic sighting reports are not available, a general search pattern is developed and implemented. Travel routes typically taken by whales are surveyed. When whales are sighted, researchers stop further search efforts and approach the whales to collect photo-identification information. When whales are encountered, researchers select a vessel course and speed to approximate the animals' course and speed to facilitate optimal photographic positioning.

To obtain a high-quality photograph, an approach within 30-60 meters is required. Photographs are taken of the left side of the whale's dorsal fin and saddle patch. Any high-performance camera system can be used to collect the data. Motor drives (5 frames/sec) and 300 mm fixed lenses are optimal. The camera shutter speed is set to 1/1000th second, or the highest speed possible. The film type should allow for a high shutter speed and good depth of field. For this project black and white ASA 400 film is used and developed at ASA 1600. The camera should be held steady and be supported by a shoulder brace if possible. All exposed film during this study will be developed by the same photographic laboratory. Film will be processed throughout the season to allow field personnel to obtain necessary feedback within two weeks of encounters. Proper labelling of exposed film includes date, roll number, photographer's initials, location, species code, and ASA setting. A new roll of film is used for each encounter.

Daily effort logs are maintained each day which will permit 1) quantification of the amount of time searching for whales vs photographing whales, 2) quantification of search effort under different weather conditions, 3) daily vessel trackline, and 4) an estimation of number of vessels/aircraft encountered in the study area.

To increase the sighting effort within PWS to ensure that all whales are being seen and photographed, a marine mammal sighting network will be organized throughout the PWS area. This network will record all opportunistic sightings of whales collected from Alaskan State Ferries and private aircraft and boats. Whale sightings are reported directly to the whale research vessels. Field teams respond by searching out the area where whales were reported in order to collect photographic data.

All exposed film of killer whales collected during the 1991 field season will be analyzed for individual identification. Each negative (or print as needed) is placed under a dissection microscope for identification purposes and notes and sketches are made. Sub-standard photographs (not showing enough detail or improper angle/side) are discarded, thus reducing the probability of mis-matching photographs. Photographs are then grouped by individuals. Each identified whale is then visually compared to the historical photographic database available. Once an individual whale is properly identified, it is relatively easy to identify the pod to which it belongs. When all photographs are properly entered and evaluated, it is then possible to determine 1) if all members of the pod were present, and 2) if pod structure/integrity is similar to previous years. Missing animals are noted. It is imperative that 1991 studies be done to verify the missing individuals described in 1990. The stability of resident pods over time is such that if an individual is listed as missing for at least one year, that missing whale is considered dead.

To avoid biases in data interpretation, it is important that the amount of effort in searching for and photographing whales in 1991 is at least equal to (but not less than) that completed in previous years. For a large pod (>12 animals), the likelihood of obtaining photographs of all individuals is increased as the number of encounters is increased. Some individuals, and certain pods, are more likely to approach vessels, making photographic documentation easier, while others remain considerably distant, making for more difficult conditions. Whale behavior also plays a role when attempting to obtain photographs of individuals. If the pod is resting (typically grouped together), it is easier to obtain photographs of all whales versus when the pod is travelling (spread out through an area). Researchers with prior killer whale experience in a particular area, who are capable of recognizing individuals, will also enhance the likelihood of accounting for all whales within a pod.

Calves of the year will be noted and their mothers identified. Natality (number of calves per adult female) will be calculated for each pod for each year and comparisons made between resident and transient groups using descriptive statistics. Mortality rates through 1990 will also be calculated for resident groups. Mortality for transient pods will be calculated when necessary data are available.

General location of whales will be recorded each time photographs are taken, allowing comparisons of pod distributions among years. Changes in normal distribution patterns will be reported.

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BUDGET

Salaries	$ 48.0
Travel	8.0
Contracts	110.0
Supplies	10.0
Equipment	10.0
Total	186.0

MARINE MAMMAL STUDY NUMBER 5

Study Title: Assessment of Injury to Harbor Seals in PWS, GOA and Adjacent Areas

Lead Agency: ADF&G

Cooperating Agency: NOAA

INTRODUCTION

Harbor seals (*Phoca vitulina richardsi*) are one of the most abundant species of marine mammals in PWS. They are resident throughout the year, occurring primarily in the coastal zone where they feed and haul out to rest, bear and care for their young, and molt (Hoover 1988). Some of the largest haulouts in PWS, and waters adjacent to these haulouts, were directly impacted by substantial amounts of oil during the EVOS. Oil that moved into the GOA impacted harbor seal habitat at least as far to the southwest as Tugidak Island. The impacts of the EVOS on harbor seals are of particular concern since trend surveys indicate that the number of harbor seals in PWS declined by 40% from 1984 to 1988, and similar declines have been noted in other parts of the northern GOA (Pitcher 1989).

During the EVOS, harbor seals were exposed to oil both in the water and on land. In the early weeks of the spill they swam through oil and inhaled aromatic hydrocarbons as they breathed at the air/water interface. On haulouts in oiled areas, seals crawled through and rested on oiled rocks and algae throughout the spring and summer. Pups were born on haulouts in May and June, when some of the sites still had oil on them, resulting in pups becoming oiled. Also, many pups nursed on oiled mothers. At haulouts throughout the oiled areas, seals were exposed to greatly increased human activity in the form of air and boat traffic and cleanup activities.

Following the EVOS, field observations were made of seals in oiled and unoiled areas of PWS. Carcasses of 47 seals were necropsied and sampled; 19 were found dead or died in captivity, and 28 were collected specifically for sampling. Preliminary histopathological and toxicological analyses are almost complete.

In 1989 and 1990, aerial surveys were conducted during June to count the number of harbor seal pups and non-pups on 25 oiled and unoiled haulouts in PWS. Results from the two years have been compared to determine whether the number of pups/non-pups is similar in oiled and unoiled areas and whether the proportion changed from 1989 to 1990. Aerial surveys were also conducted at the same 25 haulouts during the fall molt. Results of fall 1989 and 1990 surveys have been compared to results of surveys flown in 1984 and 1988 to determine whether trends in numbers are similar in oiled and unoiled areas.

This project proposes to complete histopathological and toxicological analyses of harbor seal tissues and to provide counts of harbor seals on haulouts in oiled and unoiled parts of PWS during pupping and molting in 1991. Data from this third year of aerial surveys following the spill will be used to evaluate whether 1990 data were indicative of a normal year and whether changes that occurred in the distribution and abundance of harbor seals following the EVOS coincided with the presence or absence of oil in the area or on haulouts. Toxicological analyses of tissues from oiled seals will allow an assessment of how hydrocarbons were assimilated by seals and how contaminant levels changed with time; analysis of tissues from control seals will provide baseline data for comparison with results from seals collected in oiled areas. Final analysis and interpretation of histopathology slides will provide thorough documentation of toxic damage to tissues. Survey and laboratory data, in combination with historical data for PWS, will be used to evaluate whether the EVOS caused a reduction in pup productivity at oiled sites, and whether changes in abundance during the fall molt were due to the EVOS. This information will be used to make recommendations regarding restoration of lost use, populations, or habitat where injury is identified.

OBJECTIVES

A. Test the hypothesis that harbor seals found dead in the area affected by the EVOS died due to oil toxicity.

B. Test the hypothesis that seals exposed to oil from the EVOS assimilated hydrocarbons to the extent that harmful pathological conditions resulted.

C. Test the hypothesis that pup production was lower in oiled than in unoiled areas, or than in years not affected by the EVOS.

D. Test the hypothesis that the number of harbor seals on the trend count route during pupping and molting decreased in oiled areas of PWS as compared to unoiled areas.

METHODS

In 1991, aerial surveys will be conducted during pupping in June and molting in September along a previously established trend count route (Calkins and Pitcher 1984; Pitcher 1986, 1989) that covers 25 haulout sites and includes 6 sites impacted by the EVOS (Agnes, Little Smith, Big Smith, Seal, and Green islands, and Applegate

Rocks), 16 unoiled sites, and 3 intermediate sites that were not physically oiled but were adjacent to oiled areas. Visual counts will be made of seals at each site and photographs taken of large groups for later verification.

During June, separate counts will be made of pups and non-pups. Pupping surveys are needed in 1991 since there are no historical data available from PWS during the pupping season with which to compare the 1989 results, and a single year of post-spill data from 1990 is not enough to establish what is normal in a non-oil-spill year.

Surveys during the molt in 1991 are necessary to determine whether observed changes in the number of seals on oiled sites between 1988 and 1990 persist.

All statistical tests for significance will use alpha = 0.05. Statistical testing is not appropriate for all objectives. The assessment of cause of death of animals found in areas impacted by the EVOS (Objective A) will require expert evaluation of limited and varying toxicology and histopathology data sets.

Toxicological results for each seal collected will be entered into a database along with information on date and location of collection; presence of oil in the area; degree of external oiling of the seal; and age, sex, size, and reproductive condition. Hydrocarbon levels in the tissues will be tabularized. Differences between groups will be tested where possible using ANOVA (Neter and Wasserman 1974).

Types of pathology detected will be listed for each specimen and will be grouped into tables by sex, age, collection location, and/or degree of oiling. Incidence of pathology will be expressed as the percentage of the total number of animals in the group that exhibited a particular type of anomaly. Incidence of pathology will be evaluated in light of toxicological results for each specimen.

Harbor seal surveys must be conducted within biological time windows imposed by the pupping and molting periods. While results of previous harbor seal trend counts have indicated that it is desirable to obtain 7-10 counts during a survey period (Pitcher 1986, 1989), the actual number of counts is frequently limited by the number of days suitable for flying. During pupping, the survey window cannot be extended to accommodate sample size needs since, as pups grow and are weaned, they become increasingly difficult to differentiate from the air. Similarly, during the molt it is necessary to confine surveys to the period when maximum numbers are hauled out.

Aerial surveys of harbor seals do not estimate the total number of seals present since they do not account for seals that are in the water or seals hauled out at locations not on the trend count route. Surveys provide indices of abundance based on the number of hauled out seals counted. Interpretation of trend count surveys relies on the assumption that counts of harbor seals on select haulout sites are valid linear indices of local abundance. We assume that within a given biological window, such as the pupping or molting period, haulout behavior remains the same from one year to the next, and counts can thus be compared. Standardization of procedures minimizes the affects of variables such as tide and weather that could influence the number of seals hauled out on a given day.

The trend count route includes haulouts impacted by the EVOS, as well as haulouts that are north, east, and south of the primary areas impacted by oil. There is an adequate sample of both oiled and unoiled areas.

Data from 1991 pupping surveys will be used in a retrospective analysis comparing counts of non-pup seals in oiled and unoiled sites between years (1989-91) and using the same statistical techniques employed for fall molting surveys (Frost 1990).

In order to compare pup production at oiled and unoiled sites (Objective C), a one-way analysis of co-variance (Neter and Wasserman 1974) will be performed on the square roots of the trimeans (Hoaglin et al. 1985) of pup counts, using the square roots of non-pup trimean counts as the covariate. The square root transformation will be used to correct for non-constant variation of the count data (Snedecor and Cochran 1980). Linear contrasts (Neter and Wasserman 1974), where the average number of pups is adjusted to a common number of non-pups, will be used to test working hypotheses.

Data collected during the molt in 1984, 1988, 1989, and 1990 will be used for comparisons with data collected in 1991. A repeated measures ANOVA (Winer 1971) will be performed on the trimean (Hoaglin et al. 1985) of the site count data in order to examine trends in abundance at oiled versus unoiled sites. The trimean statistic will be used as a measure of central tendency because sets of counts at a single location sometimes show bimodal distributions or include extreme variations. This analysis assumes random samples, constant variance, and normality of the differences. If necessary, transformations (Snedecor and Cochran 1980) will be used to ensure constant variance and normality. The test assumes that the mean proportion of the population hauled out on the trend count route is constant over years. Hypotheses addressing Objective D will be tested using orthogonal contrasts derived from the ANOVA.

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BUDGET

Salaries	$ 54.6
Travel	8.3
Contracts	28.5
Supplies	2.8
Equipment	0
Total	$ 94.2

MARINE MAMMAL STUDY NUMBER 6A

Study Title: Boat Surveys to Determine Sea Otter Abundance in PWS Following the EVOS

Lead Agency: FWS

INTRODUCTION

In the first year following the EVOS, hundreds of sea otters are known to have died as a result of contamination by oil. The capacity of the population to recover to pre-spill levels is not known. This study will assess the impacts of the oil spill on Alaska sea otter populations through surveys of wild populations living in oiled and unoiled areas.

OBJECTIVES

A. To test the hypothesis that sea otter densities are not significantly different between oiled and unoiled areas.

B. To test the hypothesis that sea otter densities are not significantly different between pre- and post-spill surveys in oiled and unoiled areas.

C. To estimate the magnitude of any change between pre- and post-spill sea otter population estimates in PWS.

D. To estimate post-spill population size of sea otters in PWS.

E. To estimate winter 1991 offshore densities of sea otters in oiled and unoiled areas to estimate otter density values at the time of the oil spill in March 1989.

METHODS

An original boat-based survey of PWS consisted of a complete sea otter census of 718 shoreline transects totalling 4,062 km of shoreline (Irons et al. 1988). This initial survey was conducted using a single vessel over a period of two field seasons (June, July, and August of 1984 and 1985). A random sample of approximately 25 percent of the transects was surveyed in June, July, and August of 1989. In addition, offshore areas were surveyed in July and August 1989. These same transects, plus an additional 25 shoreline transects, were again sampled in June, July, and August of 1990. A slightly reduced sample of shoreline and offshore transects were surveyed in March 1990. Surveys proposed for 1991 include replication of the March and July surveys.

To insure that project design and standard operating procedures are followed, (1) all crew members will read and discuss the observer guidelines handbook, (2) all crew members will partake in trial surveys prior to actual surveys, (3) one person on each boat will have responsibility for maintaining consistent data collection procedures, (4) standardized forms will be used during data collection, and (5) data forms will be checked by the project leaders at the end of each day to insure the integrity of the data.

Post-stratification of shoreline and offshore transects by presence or absence of oil has been based on data collected by the Coastal Habitat Study, the Air/Water Studies, and the Technical Services Study Number 3.

Prior to the start of each survey, transect and environmental data are collected and recorded on a standard data sheet. Transect data consist of observer names, transect number, date, and start time of transect. Environmental data include air temperature, water temperature, sea state, wind direction and velocity, weather, presence of ice on transect, and tidal state. In addition, an overall observation condition is recorded, and notes on human activity and presence of oil within the transect are taken. Surveys are postponed or aborted in unsuitable conditions (visibility less than 100 m, or wave heights greater than 2 ft).

Shoreline transects from Irons et al. (1988) are surveyed at a speed of 5-10 knots from 100 m offshore. Distance to shore is periodically checked using a rangefinder. One observer surveys from the shoreline to the boat, while a second observer surveys from the boat seaward an additional 100 m. The survey window extends approximately 100 m ahead of, and 100 m above the boat while travelling. Sightings of marine mammals, birds, and boats within this window are recorded on the standard data sheet as being within the "inside" strip (0-100 m) or the "outside" strip (100-200 m). In addition to species, strip, and quantity, information is collected on the disposition of the sighting (object was in the water, in the air, on land, or following the boat). Deviation from the transect due to rocks, ice, or other obstructions is noted in the comments section of the data sheet.

Offshore transect lines are oriented along north/south axes, and steered by a combination of compass heading and LORAN-C interpolator. Boat speed for offshore surveys is slightly faster than for shoreline surveys, ranging from 15-25 knots, dependent upon sighting conditions. Transect and environmental data are collected as in shoreline surveys. The sampling window is essentially the same as well, with observers sampling a strip 100 m in width on each side of the boat, and forward approximately 100 m. By definition, shoreline surveys sample the 200 m strip adjacent to shore. For the purposes of this study, the offshore environment is therefore defined as any area greater than 200 m from shore. Objects further than 200 m from shore are recorded within the "offshore" strip on the data sheet. Where offshore transect lines intersect land, objects sighted within 200 m of shore are recorded within the "nearshore" strip.

DATA ANALYSIS

Statistical assumptions pertinent to these analyses have been outlined in the previous study plans. Data collected during 1989 and 1990 suggest that these assumptions are being met.

Abundance estimates will be calculated independently for shoreline, coastal and pelagic environments using ratio estimator techniques according to Cochran (1977). Estimates calculated from third-year surveys will be compared to earlier estimates for the determination of injury to the sea otter population within PWS. Differences in otter densities will be tested using two sample t-tests and/or ANOVA, dependent upon post-stratification of oil condition.

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BUDGET

The costs of this study are included in the budget for Bird Study Number 2 and totals $220.0. The budget breakout is not repeated here.

MARINE MAMMAL STUDY NUMBER 6B

Study Title: Intersection Model of Sea Otter Mortality

Lead Agency: FWS

INTRODUCTION

Following the release and subsequent movement of oil from the EVOS, live and dead oiled sea otters were observed within PWS and along the KP. Oiled sea otter carcasses were retrieved and live oiled otters were captured for transport to rehabilitation centers in Valdez, Seward, and Homer. The number of dead oiled otters retrieved may include some otters that were dead before the spill. It is likely that additional otters became oiled and died and their carcasses were not recovered, while others may have become oiled and survived.

Three approaches are currently under investigation to estimate the number of sea otter mortalities that resulted from acute exposure to oil. One method estimates the number of unrecovered carcasses based on the probability of carcass recovery. Another method compares estimates of sea otter abundance before and after the spill. The third approach uses an analytical model to relate oil exposure to subsequent mortality of sea otters. The purpose of this study is to develop such a model for application along the KP. This model may be extended for application throughout the spill zone to provide an estimate of the total acute mortality.

This approach involves: 1) estimating the abundance and distribution of sea otters in near-shore and off-shore habitat along the KP at the time of the spill, 2) estimating the level of exposure of each otter, 3) estimating the degree of oiling received by otters at each exposure level, and 4) estimating the mortality rate associated with each degree of oiling. Sea otter oiling and population data along with the oil distribution data will be integrated by the model to provide an estimate of the total spill induced mortality for this area.

OBJECTIVES

To develop an analytical model capable of estimating rates of exposure of sea otters to oil, degree of oiling, and mortality along the KP following the EVOS.

METHODS

Oil Distribution

A hind-cast computer model developed by NOAA (on-scene spill model, OSSM) will be used to simulate the distribution of oil particles as they traveled through PWS and along the KP. The OSSM model traces the movement of 10,000 particles (Lagrangian elements, each representing about 1,100 gallons of oil) from their origin at Bligh reef, at three hour intervals. Under this model, about 1,250 (12%) of the oil particles moved out of PWS and along the KP.

Sea Otter Abundance

The abundance and distribution of sea otters in near-shore and off-shore habitat along the KP at the time the oil passed through will be estimated based on the spring 1989 helicopter survey that was conducted during the spill response. The location of each observed otter was recorded during the survey on large scale maps. These locations and numbers of otters will be used as an estimate of the distribution and abundance of otters at the time of the spill.

Exposure to Oil

In order to measure exposure, an exposure region will be defined for each otter or group of otters, as a circle with radius 1.4 km centered at the otter's location during the survey. Any portion of this circle that overlaps land will be excluded from the exposure region. The 1.4 km radius represents the average distance sea otters were observed to move between successive radio relocations recorded between 18 and 36 hours apart in California (Ralls et al. 1988). The Ralls et al. (1988) data include movements of adult and sub-adult male and female sea otters.

The number of gallons per day times the number of days that oil was within an exposure region divided by the area of the exposure region (gallon*days/km^2) will be used as a measure of the exposure of that location to oil. The proportion of the observed otters at each location will be used to estimate the proportion of the population with that location's level of exposure.

Study Areas

Data for relating exposure levels to oiling and mortality of otters were collected within two areas of PWS. The first of these areas was Herring Bay on the north end of Knight Island where heavy oiling was observed to persist over time, all otters were oiled, the degree of oiling was heavy and mortality rates were high. The second site comprised the northeast third of Prince of Wales Passage, including Iktua Bay between Evans and Bainbridge Islands. This area was lightly oiled along most of the shoreline and oil appeared to pass through in a short time. Most sea otters were either non-oiled or lightly oiled and mortality was relatively low.

Mortality rate calculations exclude pups born in captivity, otters with an undetermined oiling status and otters exhibiting obvious non-oil related pathology (eg., paralysis or blindness). Bodkin and Weltz (1990) describe a pattern of declining degree of oiling and resultant mortality as the time interval between exposure and capture increased in PWS. This pattern led to diminishing sea otter capture efforts in PWS on April 21, 1989, and a shift in the effort to the KP where initial oiling occurred on or about April 1, 1989.

Sea Otter Capture

During the first 3 weeks of April 1989, otters in Herring Bay and Prince of Wales Pass were captured with dip-nets and tangle-nets (Bodkin and Weltz 1990). Each otter was classified into 1 of 4 categories based on the quantity of oil observed on its pelage at the time of capture. The degree of oiling categories were defined as follows: heavy = complete or nearly complete coverage of the pelage with visible oil, moderate = partial oiling of about 25-50% of the pelage with visible oil, light = oil not easily visible or detectable, or a small proportion (<10%) of the pelage containing visible oil, and none = oil not visually or tactically evident on the pelage.

Relating Mortality to Degree of Oiling

Oiled otters were transported to rehabilitation centers, where they were cleaned and held. Mortality rates for each of the oiling categories following capture and holding were recorded. Mortality was considered spill related if it occurred within 30 days of capture. Mortality usually occurred within 5 (65%) days of arrival (mean = 7.1 days; range 0 to 34 days) at a rehabilitation center.

Mortality rates used in the model are based on the mortality rates observed in the rehabilitation centers and on a study of experimentally oiled captive sea otters (Kooyman and Costa 1979).

Relating Degree of Oiling to Exposure

The relationship between the degree of oiling and the exposure will be estimated by calculating the exposure in gallon*days using the OSSM and relating that to oiling which occurred in the study areas. Values defining high exposure, moderate exposure, and low exposure will be defined for each area.

The proportion of the estimated total near-shore and off-shore KP sea otter population in high, moderate, and low exposure categories will be determined based on their estimated exposure values and the scale developed for the study areas. The total mortality will be estimated by taking each of the products of the total population estimate, the exposure level proportion, a corresponding degree of oiling proportion and its associated mortality rate, and then summing over the degree of oiling categories. Overall mortality rates for each exposure category will be estimated based on the mortality rate and the size of each portion of the population. The total mortality for the KP otters will be estimated as the sum of the totals for the three exposure categories for the near-shore and off-shore habitats.

DATA ANALYSIS

A point estimate of sea otter mortality resulting from acute exposure to oil along the KP will be obtained as described in the Methods section.

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BUDGET

Salaries	$70.0
Total	$70.0

MARINE MAMMAL STUDY NUMBER 6C

Study Title: Radiotelemetry Studies on Sea Otters in PWS

Lead Agency: FWS

INTRODUCTION

On March 24, 1989, over 11 million gallons of crude oil were spilled in PWS due to the EVOS. Thousands of sea otters were potentially affected. Exposure of sea otters to components of crude oil may have caused acute illness and mortality or chronic illness which may cause population damage either due to eventual mortality, reduced production or both.

Within months of the spill, research was initiated to determine both the acute and the chronic consequences of exposure to crude oil from the EVOS on sea otters that were not treated and remained in the affected habitat, as well as on otters that were treated at otter rehabilitation centers following exposure. From the wild population, 100 adult and 64 dependent sea otters were captured, examined, instrumented with radio-transmitters, and monitored in PWS beginning in October 1989 to the present. Additionally, of the large number of sea otters that were captured and brought into otter rehabilitation centers, 45 were radio-instrumented during June 1989, released in eastern PWS during July, and continuously monitored until the present. The goal of this research effort was to provide data on the survival, reproduction, and behavior of the sea otters following release from these centers, and by doing so, to gain insights into both the damage done to the PWS sea otter population and in the efficacy of the "rehabilitation" strategy.

The studies proposed herein represent a continuation of the research effort briefly described above. These studies were designed to permit comparisons of certain characteristics of the sea otters in the oil spill zone not only with those of sea otters from eastern PWS, but also to information about sea otters throughout PWS available from previous studies dating back to the mid-1970's. This approach provides both a coincident baseline for the data gathered on sea otters in the spill zone and a way to address the question whether the spill may have directly or indirectly caused damage over a larger geographic area than has usually been assumed. Additionally, it provides a way to gauge what is normal for this population, and in so doing, establishes both a measure and a goal for recovery efforts.

In addition to the general goals described above, the information gathered during these studies will provide information crucial to formulating restoration policy for sea otters throughout the oil spill zone, including information on habitat utilization, and more specifically, identification of critical habitats, recolonization rates, predicting and monitoring population growth rates during the recovery phase, and the formulation of future response and restoration policies for sea otters throughout their range.

OBJECTIVES

Weanlings

A. To test the hypothesis that weanling survival at various age intervals is not different between oiled and unoiled areas.

B. To document the movements of weanling sea otters with respect to areas in PWS that have been affected by the EVOS.

Adult Females

A. To test the hypothesis that pup survival pre-weaning is not different between oiled and unoiled areas.

B. To test the hypothesis that survival of adult female sea otters is not different in oiled and unoiled areas.

C. To test the hypothesis that pupping rates of adult female sea otters are not different between oiled and unoiled areas.

D. To document the movements of adult female sea otters with respect to areas in PWS that have been affected by the oil spill.

Otters from Rehabilitation Centers

A. To test the hypothesis that survival of sea otters that underwent oiling, cleaning, treatment, and release is not different from that of sea otters that were not affected by the EVOS.

B. To test the hypothesis that reproductive rates of female sea otters that underwent oiling, cleaning and treatment does not differ significantly from that of female sea otters that were not affected by the EVOS.

C. To document the movements of sea otters from treatment centers relative to impacted habitats in western PWS and the KP.

METHODS

No additional capture or examination of sea otters is proposed for this study. Capture, instrumentation, and biological sampling of study otters has been well described in the 1989 and 1990 study plans.

Radio-instrumented sea otters will be monitored by observers in aircraft and skiffs. Aircraft and skiffs will be equipped with right-and left-mounted Yagi antennas and programmable, scanning FM receivers. Aircraft will be flown at variable heights depending upon whether observers are attempting to locate radio signals or make visual observations on individual sea otters. An attempt will be made to find and visually examine each otter at least biweekly until 30 September, 1991. After that date, we will locate and determine the status of each otter once per month until 15 February, 1992. Data will be recorded directly on xeroxed topographical maps and on data sheets for later data entry into computers.

Information on presence or absence of oil will come from data collected in the Coastal Habitat Study, Subtidal Studies, Technical Services Study Number 3, and response data sets.

DATA ANALYSIS

A. Tests

It is assumed that control animals, from unoiled portions of PWS, are healthy and relatively uncontaminated, and that their survival is representative of that of wild populations. It is also assumed that sea otters captured in the treated areas have been either directly or indirectly exposed to the spilled oil.

B. Analytical Methods

Survival analyses will be conducted using the Kaplan-Meier product limit estimator (Kaplan and Meier 1958, White and Garrott 1990) programmed in a simple Lotus 123 spreadsheet and plotted using Lotus Freelance graphics software. Significance of differences between control and treatment groups will be tested following the procedure described by Cox and Oakes (1984).

Reproductive data will be compared between treatment and control groups using contingency tables and tests of independence. Two-way contingency tables will be used except when interactions among age, sex, treatment type or location are of interest. In that case, three-way or multi-way contingency tables based on log-linear models will be used (Sokal and Rohlf 1981).

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BUDGET

Salaries	$ 146.0
Travel	14.0
Contractual	149.0
Commodities	41.0
Total	$ 350.0

MARINE MAMMAL STUDY NUMBER 6D

Study Title: Sea otter prey selection and foraging success in Western PWS

Lead Agency: FWS

INTRODUCTION

Sea otters commonly prey on a variety of benthic marine invertebrates that inhabit coastal waters ranging in depth from the intertidal to approximately 20 fathoms (Kenyon 1969). Principal prey species identified in PWS in the past include crab, clam, and mussel (Calkins 1978; Garshelis 1986; Johnson 1987). Damages to the nearshore benthic community resulting from the EVOS may influence the recovery of affected sea otter populations. Probable mechanisms of influence include (1) decreased food availability and (2) consumption of prey contaminated by hydrocarbons.

Sea otters require a relatively high amount of energy to maintain their body temperature in cold North Pacific waters (Costa and Kooyman 1984). Juvenile and adult sea otters consume between 20-30% of their body weight per day (Kenyon 1969). In western PWS, sea otters spend approximately 50% of a 24 hr period foraging, and during the winter months (November-April) foraging activity increases (Garshelis 1986).

To evaluate hydrocarbon contamination in PWS, certain shellfish and coastal sediments have been systematically sampled in portions of the sea otter range by the Coastal Habitat and Fish/Shellfish damage assessment studies. Additional taxa of shellfish of sea otter prey will be collected as needed.

There are at least two functional responses to a contaminated prey base. Prey selection may continue as prior to contamination, resulting in ingestion of hydrocarbons by sea otters. The consumption of contaminated prey may increase the metabolic demands on the sea otters' energy budget, which in turn may retard recovery of the population. Alternatively, sea otters may reduce or eliminate, through prey selection, contaminated prey from their diet. If sea otter populations are limited by food resources in PWS, as suggested by Johnson (1987), a decline in abundance or a lack of recovery of the sea otter population may result. These injuries may occur over a time scale longer than previous damage assessment studies considered.

The purpose of this study is to describe the species composition and relative frequency of occurrence of prey selected by sea otters in three locations in western PWS, following the EVOS. The results of this study will quantify the extent to which sea otters are foraging on contaminated prey in these areas and allow evaluation of the need for the collection of additional sea otter prey for hydrocarbon analysis. Additionally, this study may provide data necessary to quantify the site specific exposure rate of sea otters to dietary hydrocarbons.

OBJECTIVES

A. To describe prey species and the relative frequency that each prey species is consumed by sea otters in 3 areas affected by the EVOS.

B. To collect tissue samples of key sea otter prey (indicated by frequency of occurrence > .10) for toxicological analysis if not currently sampled by coastal habitat and fish\shellfish studies.

C. To determine foraging success rates in each of three study areas.

D. To compare prey species and foraging success rates from the Green Island area to historic data from the same region.

E. To estimate mean size and determine approximate caloric value per prey item.

METHODS

Sea otter prey will be determined at three sites within western PWS. Study sites will be near Green Island, Herring Bay, and Drier Bay (the latter two on Knight Island). Study sites were selected based on several criteria: (1) the location of intertidal and subtidal sampling sites for sediments and tissues, (2) the locations from which sea otter tissue samples were collected following the spill, (3) the capture location of radio telemetered sea otters, and (4) the relative degree of oiling at each site as quantitatively evaluated by an oil exposure model developed by the NOAA (OSSOM). In general, the Herring Bay site exhibited the heaviest degree and persistence of oiling, the Green Island area had a patchy distribution of heavy shoreline oiling, and the Drier Bay site exhibited intermediate oiling. The benthic contours of the Knight Island sites are similar to one another; the Green Island area has a more extensive shallow water area. Hydrocarbon contamination is assumed to be relatively uniform within the study sites, and levels of hydrocarbons observed in sampled prey to be representative of those prey species being consumed by sea otters.

The primary method of data collection will be observational. Observations will be made with the aid of high resolution Questar telescopes and 10X binoculars. Data recorded will include sex, age class of focal animal (adult or juvenile), number of prey and relative prey size (A: < 3 cm, B: ≥ 3 to < 6 cm , C: ≥ 6 cm to < 9 cm, D: ≥ 9 to < 12 cm and E: ≥ 12 cm), dive time, surface time, success rate and prey item to lowest taxon. Repeated dives will be recorded for a focal animal until a maximum of 50 identifiable prey items are observed per individual or until the animal is lost or discontinues foraging. Radio-implanted sea otters from damage assessment studies will be used as focal animals when feasible. Focal animal selection, when more than one otter is feeding at an observation site, will be random. A minimum sample of 500 identifiable prey items will be recorded at each of the three selected geographic areas. An attempt will be made to distribute foraging observations from all vantage points within each study area. Compiled foraging data will be compared to species sampled by the Coastal Habitat and Fish\Shellfish studies. If an observed prey species constitutes more than 10% overall of the sea otter's prey at any site and has not been sampled in supporting studies, samples will be collected. Sea otter prey will be collected from forage areas with the aid of SCUBA, and hydrocarbon levels of the collected prey will be determined by standard analytical laboratory procedures. Sampling protocols for identified prey will be determined as necessary, depending on species, but will follow accepted methodologies.

Data from radio-marked animals which are of known age and reproductive status will be collected as a priority. However, the majority of observations will likely be collected on unmarked animals. Marked and unmarked animals will be distinguished in the data set. Adult animals will be categorized as male, independent female, or female with a pup. Juveniles will be identified as small dark-headed otters estimated to be less than 24 months of age. Dependent otters will be classified as such.

Data will be collected only during daylight hours, during as many tidal cycles as possible. Tidal state will be recorded for all observations.

Information regarding the species, their density (when available), number of species, sample location, and results of toxicological analysis of tissue of marine invertebrates identified as sea otter prey species within the foraging study sites will be required from the Coastal Habitat and Fish\Shellfish damage assessment studies.

DATA ANALYSIS

Initial analysis will consist of listing prey by species and determining the frequency of occurrence for each prey type, by site. Mean success rates, dive times and surface intervals will be estimated by site and prey type. Differences between sites will be tested with ANOVA. Prey selection and foraging success can be compared to historic data collected at Green Island (Johnson 1987) as comparable techniques will be used to gather data. ANOVA or chi-square contingency table analyses, as appropriate, will be used to detect differences among dive times, success rates, mean Kcal/unit effort, relative frequency of prey items, among areas, and/or between times. A significance level of .05 will be used for all tests.

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BUDGET

Salaries	\$48.0
Travel	5.3
Commodities	8.0
Equipment	8.9
Total	\$70.2

MARINE MAMMAL STUDY 6E

Study Title: Sea Otter Mortality in PWS Following the *Exxon Valdez* Oil Spill

Lead Agency: FWS

INTRODUCTION

Much of the initial work to assess damages to sea otters caused by the EVOS focused on sea otter mortality as a result of acute exposure to oil following the spill. Additional studies have been directed at identifying possible longterm effects due to acute or chronic exposure to hydrocarbons in the environment. Systematic surveys for beach cast marine mammals and sea birds have been identified as valuable for describing patterns of mortality over time (Bodkin and Jameson, in press). Changes in the characteristics of mortality (i.e., carcass recovery rates, age-class and sex composition of dying animals) from pre- to post-spill time periods may be indicative of groups of animals compromised by exposure to oil or hydrocarbon residues in the environment.

Kenyon (1969) and Johnson (1987) documented patterns of mortality for sea otter populations within areas at various stages of reoccupation. Findings indicate extremely low levels of mortality for prime age otters in habitat recently occupied. Levels of mortality for young of the year and old animals increase with length of occupation of an area. Recovery rates of prime age beach cast carcasses remains low, regardless of length of occupancy. These studies are based on information gained from carcasses collected on beaches, and while they do not provide mortality rates, they do provide an age class distribution and carcass recovery rates that can be used to evaluate annual changes and regional differences in mortality characteristics.

The Green Island area, in southwestern PWS, has a long established sea otter population and is within the oil spill zone. Green Island was the site of much of Johnson's work, which provided 10 years of baseline mortality data for that area, as well as 10 years of mortality data for the more recently established northeastern portion (Port Gravina) of the Sound which was not directly affected by oil.

One year of post-spill data has already been collected on mortality patterns in oiled areas (Green, Knight, Naked and Perry islands) and a control area in the eastern Sound (Port Gravina). Continuing the beach surveys will provide additional information on post-spill characteristics of mortality and the persistence of changes that may be occurring relative to pre-spill mortality patterns. Additionally, fresh carcasses will be collected for necropsy and samples taken for histopathology and toxicology studies.

OBJECTIVES

The overall objective of this study is to conduct beach surveys in three areas of PWS and collect sea otter carcasses to determine (1) if mortality patterns (age class and sex distributions, and rates of carcass deposition) are similar to previous years, and (2) post-spill trends in mortality. Specific hypotheses to be tested for each area are:

A. The proportion of prime age carcasses found in 1991 is not significantly different from proportions found in previous beach surveys in PWS.

B. The proportion of female carcasses found in 1991 is not significantly different from proportions found in previous beach surveys in PWS.

C. Post-spill levels of carcass deposition (number of carcasses per linear kilometer of beach surveyed) are not significantly different from pre-spill levels of mortality in PWS.

METHODS

Beaches will be surveyed in three areas: 1) Green Island in southwestern PWS, 2) Knight and Naked Islands in western PWS, and 3) Port Gravina in northeastern PWS. These beaches include those surveyed pre-spill by Johnson (1987). Control beaches will include those in the Hell's Hole, Olsen Bay area of Port Gravina. These beaches will be walked once in the spring, after the snow melts from the supratidal zone but before summer revegetation occurs, which may hide old carcasses washed high on the beach.

Skulls will be taken from carcasses and a tooth extracted for aging (Garshelis 1984). Fresh carcasses will be collected and necropsied as soon as possible. Tissue samples will be collected for toxicology and histopathology. Badly decomposed carcasses or partial remains may have no evidence indicating the sex of the individual. In these cases, if a canine is present and the carcass is that of an adult, sex may be determined by canine diameter (Lensink 1962, Johnson 1987).

All teeth will be sectioned and prepared according to standard procedures. Readings of age will be done by two qualified individuals. Necropsies will be performed by personnel at the University of Alaska-Fairbanks, Institute of Arctic Biology, whenever feasible. Samples taken for histopathology will be sent to the Armed Forces Institute of Pathology. Tissue samples will be taken for toxicological analysis according to protocols established by the Analytical Chemistry Working Group.

DATA ANALYSIS

Three variables will be analyzed: 1) the proportion of prime age carcasses, 2) the proportion of female carcasses, and 3) the rate of carcass deposition (carcasses per kilometer of beach). Analysis of each of these three variables will be run separately.

The proportion of prime age carcasses will be the most sensitive indicator of abnormal change in mortality. This variable is not influenced by many of the confounding variables associated with the other two, and a significant change in this parameter is the most meaningful biologically. Prime age in this study refers to those age groups with uniformly high survival rates as measured by pre-spill data, and, based on Johnson (1987), is defined as those animals between 2 and 8 years old for the western PWS and 2 to 10 years old for the eastern PWS.

Changes in the proportion of female carcasses recovered could reflect changes in the proportions of males and females in the area due to immigration/emigration or initially high mortality of one group at the time of the spill. Changes may also reflect differential levels of continuing mortality between sexes due to unequal levels of susceptibility to hydrocarbon toxins or unequal levels of exposure to toxins because of spacial segregation. Proportions (age-classes and sex) will be tested with a Chi-square contingency table (Zar, 1984). Initially, data collected in 1991 will be compared to 1990 data for each area. If significant differences are not found, data from 1990 and 1991 will be combined and compared to pre-spill data (1974-1984).

The number of carcasses recovered for a given year is variable and may be influenced by a number of variables (e.g., weather and current patterns, yearly changes in otter distribution and abundance). For example, from 2 to 34 carcasses were found annually on Green Island area beaches between 1974 and 1984. However, examining rates of carcass deposition may be of some value for describing patterns of mortality over time. For the Green Island and Port Gravina areas, a t-test using years as replicates will be used to compare rates of carcass deposition on transects surveyed in 1990-91 to comparable transects surveyed in 1974-84.

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BUDGET

Salaries	$19.7
Travel	3.3
Contractual	5.0
Commodities	8.8
Equipment	3.0
Total	$39.8

MARINE MAMMAL STUDY NUMBER 6F

Study Title: Bioindicators of Damage to Sea Otters From Exposure to Oil

Lead Agency: FWS

INTRODUCTION

During 1989 and 1990, damage assessment studies on sea otters included research on populations living in oiled areas in western PWS. Sea otters in eastern PWS have served as a control group. Assays on blood components, sperm and testicular cells, and hydrocarbon levels in tissue samples have all been evaluated as bioindicators of injury to the sea otters.

Adult female and juvenile sea otters with radio transmitters are being monitored in PWS as part of the NRDA studies. By summer 1991, they will have been monitored for over a year. Data are being collected on survival and reproductive rates, and on movements. Previous blood data, collected at the time of capture and instrumentation, are available. It is anticipated that monitoring of these animals will continue through 1991. Recapture and collection of a second blood sample as well as a urine sample from these sea otters would provide the opportunity for further physiological and toxicological monitoring of these animals. Samples from the instrumented sea otters would be of particular interest because of the opportunity to relate results to the known history and continuing observations on the animals.

Many of the adult females are expected to have dependent pups in the summer of 1991. Capture and examination of these pups would provide an opportunity to further investigate the incidence of physical abnormalities observed in 1990 captures.

Eastern portions of PWS were not directly oiled, and otters living there have generally been considered a valid control for otters found in western PWS. However, given the critical importance of establishing reliable baseline values for Alaskan sea otters, capture efforts on sea otters in a second control area are necessary.

OBJECTIVES

The overall objective of this study is to evaluate bioindicators of sea otters exposed to oil from the EVOS. Specific objectives are:

A. To collect blood samples from sea otters in western PWS and southeast Alaska. Samples from western PWS will be compared to those from southeast Alaska. In western PWS, instrumented sea otters will be targeted because of their known history.

B. To relate blood analyses on sea otters in western PWS (instrumented otters) with outcome (survival and reproductive rates) and to compare blood samples collected in 1991 to previous samples collected on the same otters.

C. To measure pre-weaning growth rates of sea otter pups born in 1991 in western PWS.

D. To conduct physical examinations of all sea otters captured and sedated for evaluation of health and detection of developmental abnormalities.

METHODS

Capture activities will be conducted in June and July 1991 in western PWS and southeast Alaska.

In PWS, adult female sea otters were instrumented with radio transmitters in the fall of 1989 and spring of 1990, and sea otter pups were instrumented in the fall of 1990. Blood samples were collected at the time of capture. Since instrumentation, they have been monitored to measure survival and reproduction rates (for the adult females). Due to the advantage of obtaining blood samples on individuals of known history, instrumented sea otters in the western Sound will be targeted for sample collection in the summer of 1991. An attempt will be made to capture up to 30 of these otters. If sufficient numbers of instrumented sea otters cannot be recaptured, additional non-instrumented sea otters from western PWS will be captured and sampled. The sea otters will be sedated, blood collected by jugular venipuncture and, when possible, urine samples will also be collected.

Locations of the instrumented otters will be known from ongoing radio tracking efforts. Capture methods will include divers using Wilson traps so that specific individuals can be targeted. Tangle nets and dip nets will be used as a supplementary capture method as needed.

Most of the adult females will be accompanied by a dependent pup, which will also be captured and physically examined by a veterinarian experienced in handling and treating sea otters. Approximately 60 days after the initial capture, pups will be recaptured, and weights and lengths again taken to estimate growth rates. Previous studies (Monnett, unpublished data) provide information on pre-spill growth rates for comparison.

In southeast Alaska (Sitka control area), sea otters will be caught using tangle nets. Adult otters of either sex will be targeted. Animals will be sedated, physical examinations will be done, and blood and urine collected.

Approximately 4 cc of whole blood will be put in a chemically clean jar and frozen for toxicology analysis. Whole blood (in a EDTA tube) and serum will be air-expressed to a qualified laboratory for analysis of complete blood counts and blood chemistries. Fresh blood smears will be made at the time of collection. Urine will be collected by expression of the bladder and analyzed in the field with reagent strips, and for specific gravities and sediment levels.

Procedures for drugging the sea otters and collecting blood samples will be as outlined in previous study plans (MM 6, 1989 and 1990).

Capture and handling techniques will be similar to procedures used in previous studies in Alaska and California. For veterinary panels, blood samples will be sent to the same laboratory used in 1989 and 1990 NRDA studies; a subset of samples will be sent to a second laboratory, located in Alaska, for comparison purposes. Toxicology assays will be done by the same laboratory as in previous years, following established protocols from 1989 and 1990 studies.

Information on locations of instrumented sea otters will be obtained from ongoing telemetry studies on these otters. A clinical pathologist will be required for a interpretation of the blood results. Mapped data on shorelines and offshore areas affected by oil will be available for correlation with sea otter capture locations and blood results.

DATA ANALYSIS

Blood values (veterinary panels and toxicology) from southeast Alaska (control area) and western PWS will be compared in an exploratory data analysis, using t-tests to test for differences among the two areas. All variables will be examined for normality and homogeneity of variance and transformed as appropriate. Toxicology values of blood samples from western PWS will be compared to values for the samples collected in 1989-90 using a paired t-test. Additionally, for samples from western PWS, blood values will be related to the history and outcome of the individual sea otter. For example, values of sea otters that survive through the end of 1991 will be compared to those of otters that die with chi-square contingency table analysis. These types of comparisons will also be used to relate outcomes to specific locations (and degree of oiling thereof) where the otters have been residing.

BUDGET

Salaries	$ 0.0
Travel	12.5
Contracts	27.9
Commodities	22.0
Equipment	26.0
Total	$ 88.4

MARINE MAMMAL STUDY 6G

Study Title: Assessment of Pathological Processes and Mechanisms of Toxicity in Sea Otters that Died Following the EVOS

Lead Agency: FWS

INTRODUCTION

Following the EVOS, a massive effort was undertaken to capture, clean, and medically treat sea otters exposed to crude oil. Following the spill, 329 sea otters were brought into rehabilitation centers in Valdez and Seward. Approximately half of these animals died during rehabilitation, a few were sent to aquaria, and the remainder were released to the natural environment in August, 1989. Approximately 18 million dollars were spent by Exxon to rehabilitate affected otters. Studies on released sea otters are providing evidence that a high percentage of these animals may have died following release (Monnett et al., 1990). There is concern that capture and rehabilitation may not be an effective alternative for preservation of the sea otter population following exposure to crude oil.

The subset of animals that died in captivity should provide crucial information regarding mechanisms of toxicity associated with exposure to crude oil and pathological processes that caused death following contamination with this toxic substance. Analysis of data from these animals will provide critical information to determine if rehabilitation is a useful alternative for the preservation of sea otter populations exposed to crude oil.

Although numbers of recovered carcasses were highest in the months immediately following the oil spill, efforts to recover sea otter carcasses from PWS have continued through 1990 and are planned for 1991. Recovered carcasses may provide valuable clues to the factors involved in the death of these animals. Work conducted under this study will continue efforts that have been ongoing since the spill.

OBJECTIVES

A. To determine the efficacy of sea otter medical treatment and rehabilitation as a viable method for the restoration of the Alaskan sea otter population following exposure to crude oil.

B. To evaluate chronic effects of residual oil in the environment through examination of sea otter carcasses recovered in the oil spill zone in 1991. Work conducted under this study will continue efforts that have been ongoing since the spill.

METHODS

A. Sea Otters from Rehabilitation Centers

In the six months following the EVOS, pathologists from Environmental Protection Agency and the Armed Forces Institute of Pathology were on site and performed complete gross necropsies on all sea otters that died at rehabilitation centers. Histopathology of samples collected from these animals will be integrated with the clinical records, hematology, clinical chemistries, and chemical residue analyses. The specific objectives of this study are:

- to describe the gross anatomical and histopathological lesions in sea otters that died at rehabilitation centers;
- to develop a model to describe the toxic effects and pathological processes that caused death in sea otters following exposure to crude oil; and
- to test whether the necropsy, histopathology, toxicology, and hematology results are statistically related to the geographic location of capture, severity of oiling, date of exposure, duration of exposure, or the changing composition of oil.

B. Recovered Sea Otter Carcasses

In 1991, carcass recovery efforts will be continued. Ages will be determined for recovered carcasses. Necropsies of these carcasses, with sampling for histopathology and toxicology, will further our understanding of pathological processes associated with long-term exposure to residual oil in the environment. In addition, 1991 studies of sea otter foraging behaviour will determine prey composition and hydrocarbon levels of prey for sea otters in western PWS, which can be related to body hydrocarbon levels.

BUDGET

Salaries	$ 0.0
Travel	20.0
Contractual Analysis	22.0
Administrative Support	5.0
Equipment	14.0
Total	$ 61.0

MARINE MAMMAL 6H

Study Title: Sea Otter Damage Assessment Studies: Database Management and Data Analysis

Lead Agency: FWS

INTRODUCTION

Two years of oil spill response efforts and NRDA studies have produced large amounts of data on sea otters affected by oil. To date, most of these data have had only a preliminary analysis. NRDA studies on sea otters, with the full or part-time involvement of over 10 scientists, will continue to generate new data in 1991.

OBJECTIVES

The objectives of the work outlined in this proposal are:

A. To provide database support, including data entry, editing, and record management, for ongoing sea otter studies.

B. To support statistical analyses and write-up of data generated in previous and ongoing sea otter studies.

METHODS

The objectives of this proposal will be met by support of one scientist, one database manager, and one biotechnician. All three individuals will be full time. The majority of their time will be spent in Anchorage working on data; however, a portion of the time of all three will be spent in the field assisting with 1991 damage assessment studies, as needed. Studies or data sets requiring support and analysis are listed below.

DATA ANALYSIS

1. Morgue/carcass recovery: Almost 900 carcasses were recovered within 6 months of the oil spill, and recovery efforts are still continuing. Carcassses are maintained in frozen storage. Necropsies have been done on most animals and, as feasible, samples collected for histological analysis and toxicology. Additionally, teeth have been collected and submitted for aging and reproductive tracts of females have been examined. Identification numbers are now being cross-checked and all data compiled in one database. Biological samples collected are stored or shipped, as required for analyses.

2. Sea otters from rehabilitation centers: Following the spill, 329 sea otters were captured in the oil spill zone and placed in otter rehabilitation centers in Seward and Valdez. One hundred and seventeen of those otters died in the centers. In addition, sea otters that were not considered able to survive in the wild following the rehabilitation process were sent to aquaria, and their health is being monitored. Records on condition and health, medical treatments, blood collections, and behavior were kept for all otters. A thorough study is ongoing to evaluate pathological processes contributing to death following exposure to oil, and evaluating the success of the rehabilitation effort (see MM 6H). Clinical data are currently being coded by veterinarians who worked with the otters on a daily basis, and this information will be combined with histopathology, clinical pathology, necropsy, and toxicology information. Portions of this database are not yet in digital format, and thus support is required to organize and maintain all records on the sea otters from the rehabilitation centers, and to provide data as required to the cooperating pathologists involved in this study.

3. Blood data: Since the oil spill, blood samples have been collected on approximately 200 sea otters in PWS (not including sea otters that had blood samples drawn at the rehabilitation centers). Additional blood samples will be collected in the summer of 1991. Analyses of these data will include relationships between blood panels (CBC's and chemistries) and toxicology (hydrocarbon levels), geographic locations, and reproductive and survival information on the otters.

4. Toxicology data: Tissue samples from carcasses (depending on condition) have been collected for analysis of hydrocarbon levels. Additionally, blood and fat samples have been collected from live animals caught in PWS since the fall of 1989. Several thousand samples are now in frozen storage pending analysis of hydrocarbon levels. Results have been received for approximately 150 tissue samples; 250 more are currently being tested. Analysis of the toxicology data set will require input from a biostatistician and toxicologist as well as direction from the scientists who have been involved in the studies to date. Prioritization will be done on additional samples to submit for analysis. Relationships with other information available on the animals will be investigated.

5. Survey data: In 1989, helicopter surveys were done on the KP and the KAP to determine sea otter abundance and distribution prior to the arrival of oil (April and May), and again after the oil had affected these areas (August and September). Analysis of these data will be undertaken.

	BUDGET
Salaries	$107.6
Travel	11.3
Contract	10.0
Commodities	2.5
Total	$131.4

TERRESTRIAL MAMMAL INJURY ASSESSMENT

Terrestrial mammals are an important part of the ecosystem in the area affected by the EVOS. A wide variety of species are present, many of which use intertidal habitats that were heavily impacted by oil. They are important to humans for recreational viewing, sport and subsistence hunting, and commercial and subsistence trapping.

In the 1989 damage assessment plan, 14 species were selected for study from a total of 19 species that were identified as potentially being impacted by the oil spill. In 1990, studies were continued for four species: deer, mink, river otter, and brown bear. A literature review on the importance of intertidal habitat use by black bear was also done. During the coming year, work will continue on river otter and brown bear only.

River otter work will continue to examine lethal and sublethal injury within the oiled and unoiled study areas established last year. This includes examination of animals found dead and assessment of oil impacts on populations, food habits and habitat use. In addition, several aspects of sublethal injury will be investigated on a broad scale by expansion of data collection to oiled and unoiled areas of PWS that are outside the established study areas.

Brown bear investigations will be limited to monitoring female bears that were radio-collared during 1989 and 1990. Any mortalities will be noted and the cause of death will be investigated.

TERRESTRIAL MAMMAL STUDY NUMBER 3

Study Title: Assessment of the effect of the EVOS on River Otters in PWS

Lead Agency: ADF&G

INTRODUCTION

River otter (*Lutra canadensis*) populations in PWS rely on intertidal and subtidal environments for food. Studies of similar coastal populations in southeastern Alaska documented that marine fishes, crabs, and other invertebrates dominated food habits (Larsen 1983, Woolington 1984). Because critical habitats for otters were heavily contaminated by oil, otter populations are at risk by direct contact with oil or by environmental changes to other components of their habitats in response to oil. Data regarding population density prior to the oil spill are lacking, but otters were probably abundant. The goal of this study is to determine if the VOS had measurable effects on river otter populations. The approach is (1) to examine carcasses to determine direct effects of oil, (2) compare pre- and post-spill dietary information from scats, (3) continue comparison of population density and various biological aspects between oiled and control study areas, and (4) relate biological aspects of river otters in different areas of PWS to the degree of oil contamination and environmental impacts identified for these areas in other oil-impact studies.

This study will employ extensive sampling of river otters through live-capture techniques throughout PWS. Work already accomplished in the two intensive study areas (Esther Passage control area and Herring Bay/Lewis Bay oiled-area) has provided data on body mass-length relationships and blood values for otters. Extensive sampling will provide data on these relationships in all components of the otter population. Additionally, the study will relate this data to varying levels of oil contamination and environmental impacts, by sampling study sites established by other impact studies (e.g., intertidal invertebrates and fish). A larger sample size of otters than can be obtained from the intensive study areas is necessary to identify population level impacts for river otters in PWS.

Continued work in the intensive study areas will monitor changes in population levels, activity patterns, and home range size of the previously documented otter populations. These data will be related to 1990 data to identify trends that may be important to proper interpretation of data from the extensive sampling effort and for long-term trends. This work will continue to use radio-telemetry, radioisotope labeling of feces, home range determinations, and activity patterns to provide parallel data.

Additionally, animals will be live-captured and released throughout the summer to provide comparable blood and body measurements with the extensive program.

OBJECTIVES

Direct Effects

A_1. Determine cause of death for river otters recovered from oiled areas via necropsy and histopathological procedures.

A_2. Test ($\alpha = 0.05$) for higher hydrocarbon levels in river otters in oiled versus unoiled areas.

A_3. Determine sub-lethal effects of exposure to oil on river otters.

Population Change

B_1. Estimate population sizes of river otters with 10% of the true value 95% of the time, on representative oiled and control study areas using mark-recapture methods, and test ($\alpha = 0.05$) for lower population levels in oiled versus control areas.

B_2. Estimate the rate of fecal deposition for river otters within 10% of the true value 95% of the time. This rate will be used as an index to population size to test ($\alpha = 0.05$) for lower rate of deposition in oiled versus control study areas.

B_3. Test ($\alpha = 0.05$) for lower survivorship of river otters in oiled versus control study areas.

Food Habits

B_4. Test ($\alpha = 0.05$) for differences in food habits of river otters before and after the oil spill on the oiled study area.

B_5. Test ($\alpha = 0.05$) for differences in food habits of river otters on oiled and control study areas.

Habitat Use

B_6. Test ($\alpha = 0.05$) for differences in activity patterns (foraging) of river otters between oiled and control study areas.

B_7. Use home range size and use patterns to test ($\alpha = 0.05$) for differences in habitat selection in river otters between oiled and control study areas.

METHODS

Methods used in 1990 will be continued in 1991. Trapping areas for the extensive live-capture program will be selected to provide data from differing levels of oil contamination and to allow the greatest use of site-specific data from other appropriate oil-impact studies. The intensive study areas will be utilized to provide continued data on trends in otter populations and to provide continuity for interpretation of data from the extensive program.

The following are methods for collecting data by objective.

Direct Effects

A_1. Necropsy and histopathology procedures will be performed according to standard protocols.

A_2. Hydrocarbon protocols are established. No additional animals will be collected but hydrocarbon and histological samples will be taken from all suitable carcasses that become available.

A_3. River otters will be live captured at latrine sites in both study areas and at pre-selected areas of PWS. The techniques will be the same as used in 1990. The modified Hancock live traps and drugging boxes to hold otters, as described by Melquist and Hornocker (1979), will be used. Weather permitting, traps will be monitored morning and evenings, and traps will be equipped with a trap transmitter that signals a sprung trap. Otters will be held only as long as necessary to obtain body measurements, draw a blood sample, and extract a premolar for age determination. Animals will then be released at their original capture site.

Standard procedures will be used to collect and process blood in the field. Obtaining blood values and morphometrical data from the same animals should increase the power of our analysis and allow a more complete understanding of the relationship between these values and their relationship to oil contamination.

Population Change

B_1. In May, river otters will be captured in both study areas for this objective. These animals will be surgically implanted with a standard implantable transmitter encapsulated in biologically inert materials, and with radioactive isotopes by a licensed veterinarian. Techniques for implantation of radio transmitters will be those utilized in 1990 and originally described by Woolington (1979). Animals will be held only as long as necessary to complete the marking process and recover from surgery. Animals will then be released at their original capture site.

The radioisotope implants will provide the basis for estimating the population density in the oiled and control study areas using a mark-recapture method. Marking of feces will occur as the polylactic acid (PLA) tablets containing the isotope are absorbed by the body and the long-lasting tracer released (Crabtree et al. 1989). Feces will be recovered from latrine sites to provide both early and late summer population estimates. This mark-recapture technique was employed successfully in 1990.

A closed population model, employing the radio transmitters to determine exactly how many marked animals are resident in the study area while scats are being sampled, will be used. Mark-recapture models for closed populations are well established.

B_2. Data to assess the rates of fecal deposition as a means of estimating river otter population size will continue to be gathered. These data will be used to assess population trend and habitat use patterns in the intensive study areas.

B_3. Estimates of survival will depend on data obtained from otters instrumented with radio transmitters. Each transmitter is equipped with a "mortality mode" so the fate of individual study animals can be determined. Data collection for this objective will coincide with data collected for objectives B_1, B_6, and B_7.

Food Habits

B_4 and B_5. Food habits of river otters will be described from prey remains in their feces. Such procedures have been used successfully in past studies of these species (Gilbert and Nancekivell 1982). A large sample of scats has been gathered but those scats gathered for objective B_2 and B_3 will be preserved and used if additional food habit analyses are necessary. Laboratory analysis of prey remains in feces of river otters will follow procedures outlined by Bowyer et al. (1983).

Because of differential digestibility of prey and variable rates of passage through the gut, volumetric measures of prey remains in mustelid feces are meaningless. Consequently, the analysis will be confined to the occurrence of prey items in latrines and will be expressed in terms of percent of latrines with food items, and percent of total food items (Bowyer et al. 1983). To ensure that subsamples from a latrine are representative of that site, all feces from that site will be mixed and a series of subsamples (about the volume of an individual scat) will be drawn and analyzed separately. Sampling will continue until the function between number of prey items and number of samples becomes asymptotic. All latrines included in the analysis, however, will contain at least five scats per sampling period.

Because sample variance is unknown, it is not possible to specify the total number of samples necessary to describe food habits adequately at this time. However, monitoring reduction in variation of the mean was addressed in 1990 by increasing sample size (of latrines) for important food items to ensure that all proportions are estimated within 0.05 of their true value 95% of the time (Kershaw 1964:29). In the control area, 113 latrines are established and in the oiled area there are 131 sample sites. Additionally, a sample of scats excess to the food habit studies will be submitted for hydrocarbon analysis.

HABITAT USE

B_6. Otter activity will be monitored by recording the apparent activity pattern when the radio signal is first picked up during telemetry relocations. In 1991, emphasis will be placed on obtaining visual observation of otters in the intensive study areas to obtain parallel data on foraging areas and durations.

B_7. Habitat data for description of the two study areas was completed in 1990. Data on home range and habitat selection of individuals will be collected daily, weather permitting, by monitoring telemetered animals. Radio tracking will be conducted from a small boat, and the entire coastline of both study areas will be surveyed. Because river otters are distributed immediately along coastal areas (Larsen 1983), telemetry "fixes" will be made over relatively short distances, and multiple "legs" can be used in triangulation. Consequently, error polygons should be small and biases from animal movements during triangulation will be minimal. Starting time of telemetry surveys will be randomized each day to help minimize any bias from diel activities of otters on estimates of home range size and habitat selection. Further, aerial telemetry may be conducted if needed to determine locations of individuals that cannot be located by boat. Telemetry transmitters will be equipped with a mortality signal that will allow the speedy recovery of dead animals. The recovery of isotope-labeled scats from latrine sites will also confirm individual home ranges determined by VHF radio telemetry.

Methods for analyzing data are detailed below for each objective.

Direct Effects

A_1. A cause of death will be assigned to each river otter carcass based upon necropsy report and lab analysis of tissue specimens. Hydrocarbon levels will be presented for all usable samples.

A_2. A one-tailed Z test for proportions (Snedecor and Cochran, 1980) will be used to test this hypothesis.

A_3. Blood samples and standard body measurements were taken from otters live captured in 1990. Differences in selected blood values of otters from the oiled and nonoiled study areas will be tested with multi-response permutation procedures using "Blossom" statistical software (Biondini et al. 1988, Zimmerman et al. 1985). Regression lines of length-mass relationships will be compared according to Neter et al. (1985).

POPULATION CHANGE

B_1. Analysis for river otters will follow methods described by Seber (1982: 120-121) for sampling a closed population with replacement. Population size and 95% confidence intervals for both control and oil affected areas will be estimated. A one-tailed Z statistic will be used to determine if the population density is lower in the oiled area versus the control area. This test assumes that the population estimates are normally distributed and have equal variance (Seber 1982: p 121-123).

B_2. Differences in rates of scat deposition between oiled and control study areas will be tested ($\alpha = 0.05$) with a single factor covariance analysis model (Neter et al. 1985: 848). The response variable will be rate of scat deposition and the covariate will be the number of latrine sites (to control for any differences in population size between study areas). Main effects will include oiling and months of study. Since a one-tailed hypothesis is being tested with regard to the oiling main effect, the critical region for this section of the ANOVA table will be one-tailed. If variances are not homogeneous, either a ranked ANOVA procedure will be employed or the data will be transformed to obtain homogeneous variance or normality.

B_3. Estimation and analysis of survival distributions for radio marked individuals will follow procedures of Pollock et al. (1989). This method controls for censored observations due to transmitter failure, animals leaving the study area, and individual animals living longer than the study period. Depending upon the structure of data, we will use either a parametric likelihood function or nonparametric Kaplan-Meier procedure coupled with log-likelihood test to examine differences ($\alpha = 0.05$) in survivorship (by sex and age class) of individuals inhabiting the two study areas. Model assumptions include a random sample of animals, that survival times are independent for different animals, and that censoring mechanisms are random (Pollock et al. 1989). An additional year of sampling may be necessary to obtain a sample size large enough to make valid comparisons between the oiled and unoiled areas.

FOOD HABITS

B_4 and B_5. Statistical analysis will include only food items that compose at least 10% of the diet. Comparisons of food habits, pre- and post-spill, between oiled and control areas, and among months will be made with the Quade test, including multiple comparisons of food items (Conover 1980:296-299).

HABITAT USE

B_6. It is hypothesized that if availability of forage species in the subtidal zone were reduced due to oil, otters would spend more time foraging to obtain a diet equivalent to that in the control area. Additionally, changes in the density of otters in the two study areas could influence activity patterns. Simultaneous reductions in otter populations and forage species could result in change in individual activity patterns.

Differences in activity of river otters (stratified by sex and age class) between oiled and unoiled study areas will be tested ($\alpha = 0.05$) with a two-tailed Mann-Whitney test (Conover 1980: 216).

B_7. The procedures of Swihart and Slade (1985a,b) will be used to correct for auto-correlation among home range locations and to determine the time interval to achieve independence of observations. An adequate number of relocations to assess the seasonal home range of an individual will be determined by obtaining an asymptotic relationship between home range size and increasing number of relocations. Once the proper time interval and sample size have been determined, the method of Dixon and Chapman (1980) will be used to calculate 25%, 50%, 75% and 95% isoclines of home range use.

Isoclines of home range use will be overlayed on detailed maps of coastal habitats. The 95% use isocline will be employed to determine the habitats available for a particular animal. Proportional weighing by 25%, 50% and 75% isoclines within each habitat will determine use. Thus, habitat use and availability will allow a determination of habitat selection for each telemetered individual. Testing for differences in habitat selection (rather than use) between oiled and control areas is essential because a difference in habitat use may occur as a result of differential availability of habitats independent of effects of oiling. A knowledge of habitat selection by river otters is essential for extrapolating from our study areas to effects on habitat oiled in other areas. Consequently, habitat selection (by sex) will be inferred from a significant difference ($\underline{P} < 0.05$) in use and availability matrices compared simultaneously with Hotelling's T^2 statistic; *a posteriori* comparisons of individual habitat types will be accomplished using Bonferroni multiple tests (Johnson and Wichern 1988:188). Similarly, comparisons of habitat selection in oiled and control areas will be made with a multivariate analysis of variance (MANOVA), again using Bonferroni multiple contrasts.

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BUDGET

Personnel	$ 122.1
Travel	19.6
Contract	165.9
Supplies	39.2
Equipment	30.5
TOTAL	$ 377.3

TERRESTRIAL MAMMAL STUDY NUMBER 4

Study Title: Assessment of EVOS on Brown Bear Populations on the AP

Lead Agency: ADF&G

Cooperating Agencies: DOI, NPS, FWS

INTRODUCTION

Brown bears reside along a section of shoreline on the southern edge of the AP that was impacted by the EVOS. Brown bears may be exposed to oil by eating tar balls, grooming oiled fur, consuming oiled carcasses, and as top level consumers, through accumulation of toxins in the food chain. Bears in the area reproduce on an average of every four to five years and may live 25 years or longer. Effects of oil exposure may be immediate, or more likely would occur over longer periods of time. The effects of short term exposure to high concentrations of petroleum hydrocarbons may not become evident for many years.

Aerial surveys and radio-telemetry were used during 1989 and 1990 to study population density, female mortality and exposure to hydrocarbons in an oiled area within Katmai National Park, and in an unoiled area near Black Lake. In 1991, the study will focus only on the continuation of radio-telemetry to obtain additional mortality information.

OBJECTIVES

A. Test the hypothesis that the survival (excluding hunting mortality) of female brown bears near oiled areas of the coast of Katmai National Park are lower than in other coastal brown bear populations that were not exposed to oil.

B. Determine the cause of death of dead brown bears located during monitoring flights in Katmai National Park. Obtain tissues for hydrocarbon analysis if suitable to determine if death can be attributed to the physiological effects of ingesting hydrocarbons.

METHODS

A maximum of 34 previously radio-collared brown bears will be located during monitoring flights between den emergence (May) and den entrance (October). Monitoring will be conducted 3 to 4 times per month during critical periods and twice per month during mid-summer. The presence or absence of dependent offspring will be noted when possible.

The radio transmitters fitted to females were equipped with a mortality indicating mode. When the animal is motionless for a predetermined period (usually 6 hours) the signal transmits at a slower (or in some cases, faster) interval. When movement occurs (as when the animal was resting but not dead), the signal returns to normal from mortality mode. During monitoring flights, bears whose radios transmit on mortality mode will be visually located to determine if they are dead. If visual location from the air is not possible, a ground search will be conducted. Survival rates will be calculated using the Kaplan-Meier technique.

If accessible, dead bears will be necropsied to determine the cause of death and suitable tissues will be collected for hydrocarbon and histological analysis.

BUDGET

Salaries	$ 41.5
Travel	4.7
Services	28.1
commodities	0.7
Equipment	1.0
Total	$ 76.0

BIRD INJURY ASSESSMENT

The EVOS resulted in the death of a large number of migratory birds, especially seabirds, waterfowl, and bald eagles. In the months following the spill it became apparent that the vast populations of numerous bird species that inhabit or utilize the spill zone remained at risk to direct mortality, as well as sublethal, long-term injuries.

Fourteen studies were developed and conducted during 1989 and 1990 to document injury to migratory birds. It was recognized early in the process that it was not possible to study all the bird species potentially affected by the oil spill nor the full scope of effects to any species. Therefore, efforts were concentrated on studying key species or groups of species where injury was most evident and could be determined in a cost-effective manner.

Five of these studies will be continued in 1991. Studies on peregrine falcons and passerines were not continued because it was determined that all data pertinent to assessing injuries had been gathered.

Continuing studies have been expanded and/or modified in response to comments from reviewers and the public. The eagle study will provide information on losses to breeding populations, chronic injury, and carcass recovery rate. The seabird colony and waterfowl surveys will provide a means to compare pre- and post-spill populations as well as determine recovery rates and mechanisms for impacted species. The seabird colony work will emphasize documentation of injury to murre colonies. The sea duck study will provide important information on sublethal effects of the spill on various species of ducks that feed in the intertidal and subtidal habitats affected by the spill. Finally, an additional effort will be made in 1991 to more completely catalogue and more efficiently store the numerous bird carcasses that were collected during the spill response. This will facilitate the future distribution of these birds to interested universities or museums.

BIRD STUDY NUMBER 1

Study Title: Further Examination of Bird Carcasses from the EVOS

Lead Agency: FWS

INTRODUCTION

Following the EVOS, thousands of dead birds were recovered from beaches and nearshore waters by clean-up crews and stored in freezer vans. It is important that these birds are put to their best scientific use. Interest in obtaining these birds has been expressed by various museums and universities for use in scientific research and education.

Given the difficulties that field workers faced in identifying large numbers of heavily oiled birds and managing the storage of the carcasses during and after the field operations, it is necessary to re-examine and organize the many birds presently being stored in the freezer vans. The storage system for the carcasses will be reorganized for quick and easy retrieval of specific carcasses in the future. The re-examination of the unidentified birds, partial carcasses, and refinement of some identifications from a broad to a more specific category will serve to provide a better basis for future disbursement of the carcasses. Additionally, data important to other studies will also be gathered from carcasses as they are examined.

OBJECTIVES

A. Re-examine carcasses for the refinement of bird numbers and refine identification from a broad to a more specific level.

B. Classify carcasses according to the amount and distribution of oil on the plumage.

C. Reorganize the storage system for the birds to allow for quick and easy retrieval of specific birds.

D. Update log sheets with the best available information.

E. Gather data that are of value to other bird studies.

METHODS

Initially, the 9,000 carcasses in the Seward and Homer freezer vans will be examined, followed by the remaining carcasses in the Kodiak/Alaska freezer vans and the Valdez freezer van (about 23,000 carcasses).

The carcasses in the Seward and Homer vans are stored in totes (4′ x 4′ x 3′) that will be lifted by fork-lift from the freezer van, placed in a pickup truck and transported to the warehouse facility, where they will be thawed and inspected. Bags of carcasses in the other three vans are not stored in totes, but are simply piled on the floor. These vans will be thawed to allow removal of the bags.

At the warehouse, totes of carcasses from the Seward and Homer vans will be thawed and the contents removed. The following information will be updated on log sheets for each carcass:

(1) taxa (to species level where possible);
(2) state of decomposition;
(3) proportion of plumage oiled;
(4) distribution of oil on plumage; and
(5) completeness of specimen material (some carcasses are represented by only a sternum or a wing).

In some cases, data on age class and other parameters will be gathered to assist other bird studies. The bags of carcasses will be repackaged, as necessary, and will retain their original number and data sheet. After examination, birds will be individually bagged (when possible), returned to the freezer van, refrozen in a compact mass, organized and stored so that specific bags can be quickly retrieved. By this process, the inventory of the contents of each bag in the Seward and Homer vans will be updated.

The Kodiak/Alaska Peninsula vans and the Valdez van will be examined following the Seward and Homer vans. Because of the way the carcasses are stored, it will be necessary to thaw these vans entirely to remove the bags. Additionally, it is probable that there are too many birds in the Kodiak/Alaska Peninsula vans to store on shelves. It may be necessary to store a portion of these in the Seward and Homer vans if space is unavailable.

DATA ANALYSIS

Data collected during the process of carcass examination will be recorded on standard forms, photocopied, and entered into a computer database for analysis. Most analyses will focus on number of carcasses, species, and degree of oiling.

At the end of the study, a report will be prepared. This report will provide a complete and comprehensive description of all carcass material and the complete results of analyses. Additionally, photocopies of all data sheets will be provided as an Appendix to the report.

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BUDGET

Personnel	$105.0
Travel and Other Costs	50.0
Contractual	158.0
TOTAL	$313.0

BIRD STUDY NUMBER 2

Study Title: Surveys to Determine Distribution and Abundance of Migratory Birds in PWS and the Northern GOA

Lead Agency: FWS

INTRODUCTION

This study is a continuation of a similar study undertaken in 1989 and 1990 to examine whether the EVOS caused a decline in the distribution and abundance of waterbirds in the waters and shorelines affected by the spill, including PWS, Kodiak Island and the northern portion of Shelikof Strait. These waters support abundant waterfowl and seabird populations throughout the year (Dwyer et al. 1976, Forsell and Gould 1981, Hogan and Murk 1982, Irons et al. nd., Nishimoto and Rice 1987). Potential injuries to waterbirds from exposure to the EVOS include, but are not limited to, death, changes in behavior, and decreased productivity. Using surveys by small boats, this project will collect information on the summer and winter distribution and abundance of waterbirds in PWS. These post-spill data will be compared to data collected, using similar methods, in pre-spill surveys to determine whether the oil spill affected and continues to affect waterbird distribution and abundance in 1991.

This proposal describes the boat survey work that will be accomplished in the third year of this study. (The aerial survey portion of Bird Study No. 2 has been discontinued.) PWS will be surveyed in March and July 1991. This field effort will be conducted in concert with the Marine Mammal Study No. 6 (Sea Otters). Surveys will not be conducted on Naked Island in Prince William Sound, on the southern Kenai Peninsula or on Kodiak Island waters in 1991.

OBJECTIVES

A. To determine distribution and estimate abundance (with 95% confidence limits) of waterbirds in PWS.

B. To test the hypothesis that estimates of waterbird relative abundances, using new and comparable historic data, are not significantly lower ($\alpha = 0.05$) in oiled than non-oiled areas in PWS.

C. To estimate the long- and short-term trends of populations that were determined in previous objectives to be reduced by the oil spill.

METHODS

A. Boat Survey Sampling Methods

Damage Assessment Surveys. Surveys will be conducted jointly with the sea otter survey component of Marine Mammal Study No. 6 using three 25-foot boats each manned with an operator and two observers. Observers will record all birds and sea otters within 100 m on each side of the boat within survey transects, and whether the animal is in the water, on land, or in the air. The survey window will extend approximately 40-50 m ahead of and 100 m above the moving boat, but will be extended for animals that exhibited strong avoidance behavior when the boat was more than 50 m away (e.g. scoters, murrelets, harlequin ducks, harbor seals). Surveys will be conducted only when seas are less than 2 feet. Date and time of survey, and environmental variables including wind velocity and direction, air and water temperature, weather, observation conditions, sea state, tide, presence of oil on water or on shoreline, and presence of human activity will also be recorded for each transect.

A stratified random sampling design using shoreline, coastal/ pelagic and pelagic strata will be used to meet Objectives A-C. Surveys will be conducted in March and July 1991. Fewer transects will be sampled in March than in July because winter weather conditions make it difficult to complete a longer survey.

The shoreline stratum was divided into 742 transects used in surveys by Irons et al. (1988, nd) (see Pre-Oil Spill Surveys below). For the March 1991 survey, the same 100 randomly selected transects (covering approximately 13% of the shoreline) used in March 1990 will be surveyed. The July 1991 survey will include the same 212 transects (covering approximately 30% of the shoreline) sampled in June, July and August 1990 surveys. These include 187 transects randomly selected to be surveyed in 1989, plus 25 additional transects randomly selected from the population of transects surveyed by Irons et al. (1988, nd) in 1984.

The shoreline stratum includes all water within 200 m of shoreline. Transects will be surveyed by travelling 100 m offshore, parallel to the coast, at 5-10 knots. One observer will record all animals seen between the coast and the boat while the other will record all animals between 100-200 m offshore.

Pelagic and coastal/pelagic strata consist of plots of water delineated by 5-minute intervals (latitude and longitude) on NOAA charts. Forty-six of 206 coastal/pelagic plots and 25 of 86 pelagic plots randomly selected to be surveyed in June, July and August 1989 and 1990 will be surveyed in July 1991. The same 86 pelagic plots previously used in all surveys and the same 29 coastal/pelagic plots used in March 1990 will be surveyed in March 1991. Plots exclude any water within 200 m of the coast. The two strata differ in that coastal/pelagic plots intersect more than approximately 1 nm (nautical mile) of shoreline, whereas pelagic plots intersect less than 1 nm of shoreline. For plots that are 5 minutes wide (east to west), two north-south transect lines located 1 minute inside the east and west boundaries of the plot will be surveyed. For plots that are less than 5 minutes wide due to intersection with land, either one or two transect lines will be surveyed, depending on plot size. In cases where a plot would be very small, it was combined with an adjacent plot, so that some plots contain three transect lines.

Transects in pelagic and coastal/pelagic plots will be steered by a combination of compass heading and LORAN-C coordinates. Boat velocity for pelagic and coastal/pelagic plots will be higher than for shoreline surveys, ranging from 15-20 knots, depending on observation conditions.

<u>Pre-Oil Spill Surveys</u>. Two major survey efforts by the FWS were made prior to 1989. Original data from these efforts were located for this study for pre- and post-spill comparisons.

The first effort was a series of 4 boat surveys conducted in March/April 1972, July 1972, March 1973 and August 1973 (Dwyer et al. 1975). These surveys randomly selected approximately 13% of transects in pelagic and shoreline strata in 1972, and randomly selected transects within subgroups of these strata in 1973 ("open water" and "coastal" subgroups within the pelagic stratum and "outer exposed beaches", "inner exposed beaches" and "inner bays and fjords" within the shoreline stratum). Observation methods were comparable to those used in Damage Assessment Surveys, with transect width 100 m on either side of the boat, except that small bays were included in the shoreline stratum, and were surveyed in their entirety as part of shoreline transects. Although individual transects used in these surveys were different from those used in Damage Assessment Surveys, methods were similar and population estimates can be compared.

During July and August of 1984 and 1985, a complete survey of the PWS shoreline was conducted, using observation methods similar to those used for Damage Assessment Surveys (Irons, Nysewander and Trapp nd).The shoreline was divided into 742 transects. (These transects were subsequently sampled for the shoreline portion of Damage Assessment Surveys). The western half of the Sound was surveyed in 1984, and the eastern half was surveyed in 1985. No surveys of pelagic strata were attempted in either 1984 or 1985.

B. Quality Assurance and Control Plans

To ensure that project design and procedures are followed, 1) all crew members will partake in training surveys prior to initial surveys, 2) one person on each boat will be responsible for maintaining consistent data collection procedures, 3) standardized forms will be used during data collection, and 4) data forms will be checked at the end of each day to ensure the integrity of the data.

C. Information Required From Other Investigators

Shoreline and pelagic boat-based surveys in PWS will be conducted in conjunction with sea otter surveys outlined in Marine Mammals Study No. 6. Field data collection, computer data entry, and quality control will be performed by biologists and technicians from both the Marine Mammal Project and the Marine and Coastal Bird Project.

Post-stratification of shoreline and pelagic transects based on presence or absence of oil will be based on data compiled by the Coastal Habitat Study, the Air/Water (Subtidal) Studies, and the Technical Services Study No. 3. Oiling information was collected by the Alaska Department of Environmental Conservation (ADEC) in early summer 1989 (ADEC Summer 1989 Shoreline Assessment Data), fall 1989 [ADEC Fall 1989 Shoreline Assessment Data ("Fall Walk-a-thon")] and spring 1990 [Multi-agency Spring 1990 Survey ("SSAT Survey")]. These 3 datasets will be used together to compile the maximum extent of shoreline oiling. The area of water covered by oil was estimated from a map based on ADEC aerial observations, from a shoreline oiling map and from a NOAA HAZMAT hindcast model of the movement of spilled oil (J.A. Galt and D.L. Payton, National Oceanic and Atmospheric Administration, Hazardous Materials Response Branch, Seattle, WA). The shoreline oiling dataset and our estimated area of oil on the water were automated onto FWS Geographic Information System (GIS) using ArcInfo software, and were used to produce datasets describing the extent of oiling in each transect.

DATA ANALYSIS

Population estimates and variances (Objective A). Estimates for oiled and non-oiled areas of PWS (as defined by "oil on water" datasets, above), as well as estimates for the entire Sound, will be produced by adding estimates generated for each stratum within a survey. For the shoreline stratum, these will be computed using a ratio estimator as follows (Sheaffer, Mendenhall and Ott 1986: 131):

Population estimate: $\hat{\tau}_y = r\hat{\tau}_x$

Variance: $\hat{V}(\hat{\tau}_y) = (\hat{\tau}_x)^2\hat{V}(r) = \hat{\tau}_x^2 (\frac{N-n}{nN}) (\frac{1}{\mu_X^2}) (\Sigma\frac{(Y_i - rx_1)^2}{(n-1)})$

Bound on the error of estimation (EE): $EE = 2\sqrt{\hat{V}\ (\hat{\tau}_y)}$

where $\hat{\tau}_y$ = *population estimate for the shoreline stratum*

$r = \frac{\Sigma Y_1}{\Sigma X_1}$

Y_i = *number of birds counted on the shoreline transect*

X_i = *area of the shoreline transect in* km^2

τ_x = *total area of all shoreline transects in* km^2

$\hat{V}(\hat{\tau}_y)$ = *estimated variance of* $\hat{\tau}_y$

$\hat{V}(r)$ = *estimated variance of r*

N = *total number of shoreline transects*

n = *number of sampled shoreline transects*

μ = *mean area of all shoreline transects*

The formulas will be the same for pelagic strata except that 1) Y_i will be estimated as the density of animals counted in transects multiplied by the area of the block sampled, and 2) the finite population correction (fpc=(N-n)/N) will not be included.

Using ratio estimators is appropriate if the number of birds counted is positively correlated with transect length. The extent of such a correlation will be determined. Simple totals and variances will be calculated if the correlation between counts and transect length is poor.

Statistical tests (Objective B). To examine whether oiled and non-oiled populations changed in the same way between the Irons 1984 shoreline survey and surveys conducted after the spill, the change in population size in oiled shoreline areas compared to non-oiled shoreline areas will be computed as follows (after log transformation) for transects surveyed within a given month (July or August):

Change in population in oiled compared to non-oiled area $= [(R_1 - R_2)_{oiled} - (R_1 - R_2)_{non\text{-}oiled}]\ X_{oiled}$

$$\textit{Variance of change} = \left[\frac{\hat{var}(\hat{\tau}_{1oiled} - \hat{\tau}_{2oiled})}{X^2_{oiled}} + \frac{\hat{var}(\hat{\tau}_{1non} - \hat{\tau}_{2non})}{X^2_{non\text{-}oiled}}\right] X^2_{oiled}$$

where
$\hat{\tau}_1$ = *estimated population total in* 1984
$\hat{\tau}_2$ = *estimated population total in* 1989 (*or* 1990)
y_1 = 1984 *counts transects surveyed in* 1984 *and* 1989 (*or* 1990)
y_2 = 1989 (*or* 1990) *counts from transects surveyed in* 1984 *and* 1989 (*or* 1990)
w = *counts transects surveyed in* 1984 *only*
z = *counts transects surveyed in* 1989 (*or* 1990) *only*
x = *transect area for* $y(x)$, $w(x')$ *and* $z(x^*)$

$$R_1 = \frac{y_1 + w}{x + x'}$$

$$R_2 = \frac{y_2 + z}{x + x^*}$$

$$\hat{var}(\hat{\tau}_1 - \hat{\tau}_2) = X^2 \left[\left(\frac{1}{(n_1+n_2)} - \frac{1}{N}\right) \frac{(s^2_{1counts} + R^2_1\, s^2_{1area} - 2R_1\, s_{1counts,area})}{\left(\frac{x + x'}{n_1 + n_2}\right)^2} + \left(\frac{1}{n_1 + n_2} - \frac{1}{N}\right) \frac{s^2_{2counts} + R^2_2 s^2_{2area} - 2R_1 s_{2counts,area}}{\left(\frac{x + x^*}{n_1 + n_3}\right)^2} - \frac{2\left(\frac{n_1}{(n_1 + n_2)(n_1 + n_3)} - \frac{1}{N}\right) s_{(y_{i1} - R_1x_i)(y_{i2} - R_2x_i)}}{\frac{(x + x')}{(n_1 + n_2)} * \frac{(x + x^*)}{(n_1 + n_3)}} \right]$$

The western half of PWS was surveyed in 1984, and the eastern half in 1985. Transects surveyed in 1985 were not combined with those sampled in 1984 because few transects affected by oil were sampled in 1985; this meant that variation due to year surveyed could not be distinguished from variation due to oiling. A separate test using 1985 data could not be conducted because there were not enough transects sampled in oiled areas in 1985 to perform statistical tests.

The above formulas allow the use of transects that were sampled in either pre- or post-spill surveys, as well as transects that were sampled in both survey periods. T-values and their associated probabilities can be derived from them. If possible, both oiling definitions (shoreline and "oil on water") will be applied.

Two-sample t-tests will be performed on datasets consisting of population estimates from each survey in a given month prior to and after the spill. For example, population estimates for all strata combined for the month of March 1972, 1973 and 1991 will be compared.

Post-stratification of PWS into habitats for various species is currently underway using previously collected data on shoreline types, bathymetry data and examination of each species' distribution. Such stratification may make statistical tests more sensitive to spill-related population changes. All statistical treatments may be revised after such stratification.

Maps indicating distribution and abundance of birds will be produced for each survey to illustrate differences between surveys and oiled and non-oiled areas. Graphs of bird abundance will be produced and updated with each survey to show population trends and differences. Bird density and abundance estimates will also be presented in tabular form.

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BUDGET

Personnel	$141.0
Travel	10.0
Contractual	30.0
Supplies	33.0
Equipment	6.0
Total	$220.0

BIRD STUDY NUMBER 3

Study Title: Population Surveys of Seabird Nesting Colonies in PWS, the Outside Coast of the KP, Barren Islands, and Other Nearby Colonies, with Emphasis on Changes of Numbers and Reproduction of Murres

Lead Agency: FWS

INTRODUCTION

The 1989 EVOS prompted resurvey of seabird colonies in PWS and other areas westward along the spill trajectory. Most of these colonies were censused at least two and up to six different years out of the previous 17 years prior to the oil spill. Murres and kittiwakes on one nearby colony site, Middleton Island, were censused 11 of the 17 years before the spill. Cliff-nesting species such as the black-legged kittiwake and common murre were the primary emphasis of the 1989-90 censuses. Timing of egg laying and productivity (numbers of fledgling chicks) were also noted for these species. In 1990 the major effort was placed on replicate counts of murres. Semidi Islands and Middleton Island monitoring continued as the main control sites for murres.

There are approximately 320 seabird colonies, not including the Semidi Islands, that occur within the area affected by the oil spill. Before the spill they contained about 1,121,500 breeding seabirds of which 319,130 were murres (FWS, Catalog of Alaskan Seabird Colonies--Computer Archives 1986). The Semidi Islands contained an additional 1,133,000 murres of both species (FWS computer archives 1986). Diving seabirds are known to be easily impacted by oil spills (King and Sanger, 1979). In addition, these species are long-lived and have low reproductive rates, thus making any mortality of adults a critical factor in these species' ability to recover from loss.

This study will continue this year to look at changes in numbers of adult murres at the breeding colonies selected: (1) Chiswell Islands, (2) Barren Islands, (3) Puale Bay/Cape Unalishagvak, and (4) Semidi Islands. Productivity and phenology will be measured from land-based plots in the Semidis and compared with that recorded similarly at the Puale Bay colony to develop estimates of productivity and phenology at the other colonies where land-based plots are not feasible.

OBJECTIVES

A. Determine whether 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. Compare reproductive chronology and productivity for murres and kittiwakes at colony sites within the oiled area with those found at nearby colonies in the GOA not affected directly by the EVOS.

METHODOLOGY

This study will continue to look primarily at changes in numbers of breeding adult murres at the previously mentioned sites. In some areas there will be a secondary emphasis on counts of other selected species such as black-legged kittiwakes, cormorant species, and parakeet auklets if weather, logistics, timing, and geography allow. Total counts are not feasible at large colonies like the Semidi and Barren Islands and hence previously established plots will be used of certain subcolonies.

Specifically, the two strategies used in 1989 and 1990 will continue to be utilized: (1) counts of adult seabirds on plots from land-based observation points; (2) counts from boat-based observation vantage points where land-based observations are not possible. If plots or subdivisions are not possible, then total counts or photography from boats will be the sole option. Aerial photography will not work at this time because the murre colonies were highly asynchronous, and will not stay on the colony. The above strategies, in combination with the widespread distribution and number of colonies to be examined, determined that the sample plan would have two basic applications for 1991:

(1) A combination of total counts and establishment/review of plots counted from boats will occur at colony sites like the Barren Islands and Chiswell Islands because the colonies are much larger, in very exposed waters, have a poor history of censusing, and require counts from boats. Sample plots were established in 1989 and 1990 on the basis of accessibility and visibility.

(2) Land-based plots will be continued at the Semidi Islands because these colonies are too large for total counts. Land plots are feasible and have been used for over 10 years. Sample plots were previously selected on the basis of accessibility.

The AP murre colonies have required a combination of both applications in the past and will continue to do so since some portions of the colonies are visible from land, but most aspects of the colony required boat counts.

Colonies will be recensused using the standard FWS methodology for either land-based or boat-based counts of seabirds (Byrd 1989; Hatch and Hatch 1988 and 1989; Irons et al. 1987; Nishimoto and Rice 1987). This will vary depending on the topography of each area. At least three replicate counts will be conducted, between 1000 and 1700 hours, of colonies or plots after eggs are laid. These three replicate counts will be on three separate days. Plots and photographs (using 6x7 cm format cameras) will again be utilized for establishment of correction factors of total counts, comparisons with past plots, and for evaluation of future recovery or change. Survey units are subcolonies for cliff nesters and islands for other species.

During boat censuses, seas must be less than 3 feet and rain should not be more than a light drizzle. At least three observers including skiff operator make the counts by binoculars from the boat. Each observer counts each section of the cliff at least two times and all counts are compared to see if sections of the plot were missed (differences in counts by two observers cannot be greater than 5%) and need more replicate counts.

Nesting phenology and reproductive performance on land-based plots will be determined by viewing nests at regular intervals of approximately 3 days. Nest sites will be numbered on plot photographs and/or drawings and then followed throughout the field season. Attendance of adults, nest starts, and the presence or absence of eggs or chicks are recorded. For murres, it is frequently not possible to see the contents of a site because the birds remain motionless for long periods of time. Thus distinctive behavior (e.g. wings held over the back so that tips do not cross, tail down, back slightly humped) is used to indicate that a murre is incubating an egg. Because it is possible to misinterpret a bird's posture, we will use the convention that a site has to have a bird in "incubating posture" on at least three consecutive checks to consider the site as having an egg. In a similar fashion, wing mantling will be used to indicate that a murre has a chick. However, only one sighting of wing mantling is necessary to consider a murre to have a chick or to be in a "brooding posture." The conventions of murre monitoring used by the Alaska Maritime National Wildlife Refuge will be used to resolve any questions of interpretation.

Phenology and productivity data cannot be gathered as intensively at areas where murre colonies can only be reached and observed from boats. Instead, phenology will be determined indirectly by the change in degree of murre attendance at the cliffs since murre attendance is highly variable on a daily basis before egg laying and becomes more consistent after that. As in 1990, some portions of the rugged islands will be climbed occasionally whenever sea conditions permit a landing and portions of murre colonies will be scanned for eggs or chicks. Productivity will be evaluated by number of chicks present on plots or subcolonies near fledgling times.

DATA ANALYSIS

The standard procedures and assumptions used by the FWS on colonies in the Alaska Maritime National Wildlife Refuge are described by Garton 1988 and Byrd 1989. Several key assumptions are: (1) plots, by necessity, are not random and selection is based on accessibility; hence this study makes the assumption that counts within plots are representative of the way the counts varied on the entire colony; (2) counts of plots or entire colonies from boats are very difficult for large colonies and replications of counts by several observers on the same day and different days illustrate the need to refine the accuracy and the variation recorded. This means that even counts of entire colonies are considered a form of index, but this study assumes that changes in these indices represent the changes occurring in the colony; (3) counts are unlikely to be normally distributed and are more likely to be skewed and clumped. This type of data requires either very large sample sizes, or the use of a non-parametric test, or the data needs to be transformed logarithmically and then tested by the appropriate parametric test. This transformation normalizes the data and is required for valid application of statistical tests on small sample sizes (Fowler and Cohen 1986, D. Robson pers. comm.).

The standard FWS procedures mentioned prefer to compare trends between years using numerous replicate counts where all plots are censused each count day and these counts are replicated on successive days. The average of daily counts on the Semidi Islands will be used to calculate a confidence interval for the estimate as was done on the Semidi Islands data in the past (Hatch and Hatch 1988; Hatch and Hatch 1989; Dragoo and Bain 1990). At other sites where there are fewer replicate counts, the procedure used in the past, which was usually an average of the available counts, will be followed.

Data for 1991 will be treated similarly to 1990 data using standard t-tests on logarithmically transformed data for all colonies except the Barrens where an analysis of variance for the comparison of change in murre numbers (also log transformed) was used for the Barrens versus the Semidis between 1979 and post-oiling years.

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BUDGET

Personnel	$124.4
Logistics	140.8
Equipment	18.0
Miscellaneous	
Supplies/Services	35.3
Travel/Per Diem	17.0
Contractual	194.5
Total	$530.0

BIRD STUDY NUMBER 4

Study Title: Assessing the Effects of the EVOS on Bald Eagles

Lead Agency: FWS

INTRODUCTION

The area affected by the EVOS provides year-round habitat for approximately 5000 adult bald eagles and seasonal habitat for an estimated additional 2500 immature bald eagles. An unknown number of bald eagles from breeding areas in southcentral Alaska may also winter in the spill area.

Bald eagles are closely associated with intertidal habitats that were heavily impacted by the EVOS. Nearly all nests in the spill area occur within 100 meters of the beach where eagles commonly forage in intertidal habitats on fish and marine invertebrates. Eagles that breed elsewhere, but spend winters in the spill area, also use the impacted intertidal habitats for foraging.

This study is a continuation of work designed to document the magnitude and duration of impacts to bald eagles caused by the EVOS. Estimates for the number of eagles occupying the spill area after the spill will be compared with historical data to identify changes in the population. Nestling and adult bald eagles from oiled and non-oiled areas will be monitored to estimate survival rates, distribution and exposure to oiled areas, and determine causes of mortality. Estimates of acute mortality will be improved through assessment of the number of dead birds found in relation to the number of birds that were killed, but never found. Blood samples will be collected to monitor the health of eagles within the spill area.

Because eagles mature slowly and are long-lived, impacts to the population may not be readily apparent. Furthermore, the long-term impacts of oil contamination on bald eagles are unknown.

OBJECTIVES

A. Estimate numbers of resident bald eagles such that the estimate is within 10% of the actual size 95% of the time; determine whether changes in population size have occurred in the oil-impacted areas since 1982 and test whether the change in number of eagles in oil-impacted areas is different than changes in non-oiled areas.

B. To test the hypothesis that survival rates are the same for bald eagles in oiled and non-oiled areas.

C. Determine the proportion of eagles that die on beachfront relative to the number that die in areas away from the beachfront.

D. Determine the toxic and sublethal effects of oiling on eagles and eggs.

METHODS

Population Surveys (Objective A). Surveys of randomly selected plots will be conducted from Malaspina Glacier to Cape Elizabeth in early May, following methodology discussed in Hodges et al. (1984). All shorelines in each selected plot will be flown at an altitude of about 200 feet and an airspeed of 90 to 100 knots using fixed-winged aircraft. Eagles will be classified as either white-headed or immature. "White-headed" eagles will include sexually mature adults and near-adults that have predominantly white heads. This survey will not directly estimate the number of immatures, therefore, we will assume that ability to detect all age classes is equal for birds in flight, and a ratio of adults to immatures observed flying will be used to estimate the number of immatures.

Survival Studies (Objectives B). During the winter, food resources for bald eagles are at the lowest availability of the year and eagles are presumably under the greatest nutritional stress. Mortality due to inadequate food will most likely occur during the winter period. Furthermore, some contaminants stored in fat tissues are mobilized during periods of nutritional stress. To estimate survival rates, 135 eagles (64 adults and 71 nestlings from oil and non-oiled areas) were tagged with radio transmitters. Bi-weekly aerial flights will be made to relocate the transmitters using standard telemetry techniques (Gilmer et al. 1981) and to document eagle numbers, distribution, and mortality within the study area. Dead eagles will be retrieved and necropsied to determine the cause of death. Survival rates will be estimated using the Kaplan-Meier (1958) procedure (Pollock et al. 1989). Survival functions will be tested for significant differences between eagles marked in oiled and in unoiled areas, and between age classes. Long-term monitoring will allow calculation of seasonal and annual survival rates and a better interpretation of the long-term effects of oil contamination on bald eagle populations through population modelling.

Carcass Recovery Study (Objective C). Data from the telemetered birds in the survival study will also provide information on the number of birds that die on the beachfront relative to the number that die in wooded areas where they are unlikely to be found. This will provide an index to estimate the total number of eagles killed by the EVOS in 1989 relative to the number of eagle carcasses recovered during 1989.

Toxic and Sublethal Effects of Oiling (Objective D). All eagles found dead will be collected and necropsied to substantiate the cause of death and look for signs of oil contamination. Tissue samples from the collected specimens will be analyzed for contaminants. All histopathology work will be accomplished through the FWS National Wildlife Health Laboratory. All samples collected in the field will be properly labelled and chain of custody procedures followed.

Blood samples from birds which are caught and released will be collected and analyzed to determine concentrations of hydrocarbons and other contaminants associated with oil contamination. Approximately equal numbers of bald eagles will be sampled from oil and non-oiled areas. Blood samples will also be analyzed for standard blood chemistry profiles, which will help identify sublethal impacts. Blood chemistry of eagles will be compared between oiled areas and non-oiled areas, and tested (2-sample t-test, a = 0.05) for significant differences. Blood chemistry results will also be interpreted by a veterinary clinical pathologist.

DATA ANALYSIS

Population surveys (Objective A). Analytical methods and tests: Surveys will be conducted using a random plot design, as discussed in Hodges et al. (1984). This survey technique will allow estimation of the changes in numbers of adult eagles and occupied nests when compared with the previous surveys of PWS in 1982 and 1989, trying to obtain a confidence interval of ± 10%. It will be assumed that no major changes in habitat quality or quantity that may affect the breeding population have occurred since 1982, other than the EVOS. The following hypotheses will be tested (2-sample t-test or analysis of variance, a = 0.05): (1) that the number of adult bald eagles in the entire survey area in 1989, 1990 and 1991 is the same as the number of adult bald eagles in 1982; (2) that the number of adult bald eagles within the oil-impacted area is the same for 1982, 1989, 1990 and 1991; and (3) that the change in numbers of adult bald eagles in the oiled areas is the same as the change in numbers in non-oiled areas among and between years.

A parametric two-sample t-test (Steel and Torrie, 1960) will be used which does not require equal variances to test the above hypotheses. Analysis of variance will be used for multiple comparisons. Assumptions necessary for valid application of the t-test will be checked (e.g., test for normality). If assumptions are violated, either an appropriate transformation or an equivalent non-parametric test will be used.

Survival Studies (Objective B). Analytical Methods and Tests: It will be assumed that all eagles in the study area have an equal chance of being captured and that all transmitters have a negligible effect on the eagles behavior and do not influence the bird's chance of survival. Survival data will be analyzed using the methods of Kaplan and Meier (1958) which accommodate infrequent visitation (i.e., relocations) of birds, and censusing of lost birds. This is an appropriate method because it is expected that eagles will move from the study area where they cannot be relocated during every survey. Furthermore, the Kaplan-Meier method does not assume constant survivorship during the period of observation.

A Z-test (Bart and Robson, 1982) will be used to test for significant differences in survival rates between eagles marked in oiled areas and eagles marked in unoiled areas. This Z-test requires the transformation of the survival rate and standard error to normalize its distribution and allow use of a Z statistic to test for differences in survival rates. The potential exposure of individual radio-marked eagles in oiled areas based on frequent, accurate relocations will be substantiated allowing a more appropriate classification of eagles into treatment groups based on the proportional amount of time they were located in oiled or unoiled areas.

<u>Toxic and Sublethal Effects of Oiling (Objective D)</u>. Analytical Methods and Tests: Blood samples will be collected from eagles captured in PWS and will be tested for significant differences in levels of contaminants and blood characteristics between bald eagles from oiled and non-oiled areas using a 2-sample t-test (a = 0.05). Assumptions necessary for valid application of the t-test will be checked (e.g., for normality). If assumptions are violated, an appropriate transformation or an equivalent non-parametric test will be used. Information on blood characteristics will also be interpreted by a veterinary clinical pathologist to access impacts on bird health.

The spring population surveys will be conducted between April and May, 1991. The radio-marked eagles will be monitored bi-weekly between February and June 1991. Dead eagles will be collected as available between February and June 1991. Blood will be sampled between late August and October 1991.

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BUDGET

Salaries	$ 83.0
Travel	17.0
Contracts	137.0
Commodities	14.0
Equipment	4.0
Total	$255.0

BIRD STUDY NUMBER 11

Study Title: Injury Assessment of Hydrocarbon Uptake by Sea Ducks in PWS

Lead Agency: FWS

Cooperating Agency: ADF&G

INTRODUCTION

This study will focus on the effects of petroleum hydrocarbon ingestion by harlequin ducks (*Histrionicus histrionicus*), Barrow's goldeneyes (*Bucephala islandica*), common goldeneyes (*Bucephala clangula*), black scoters (*Oidemia nigra*), surf scoters (*Melanitta perspicillata*), and white-winged scoters (*Melanitta deglandi*) in PWS as a result of the EVOS. PWS is a major wintering area for these sea duck species (Isleib and Kessel, 1973). It is also an important migration area for sea ducks in spring and fall, and a breeding site for resident harlequin ducks during the summer (Hogan, 1980). Harlequin ducks in particular, because of their resident status and intertidal foraging habits, are considered substantially at risk to effects of the EVOS (King and Sanger, 1979). Goldeneyes and scoters, although migratory, are also at risk because of their intertidal and subtidal foraging habits.

The six sea duck species included in this study are heavily dependent on intertidal and subtidal marine invertebrates (Vermeer and Bourne, 1982). Harlequins consume a wide variety of intertidal clams, snails, small blue mussels, and limpets (Koehle, Rothe and Dirksen, 1982; Dzinbal and Jarvis, 1982). Surf scoters and goldeneyes utilize larger blue mussels (*Mytilus*sp.) obtained by diving. Bivalves, particularly blue mussels (*Mytilus*sp.), and small clams (*Macoma*sp.), are well known for their ability to concentrate pollutants at high levels (Shaw et al, 1976). The crude oil spilled from the EVOS may injure marine invertebrates that support sea ducks throughout the year (Stekoll, Clement, and Shaw, 1980). Hydrocarbons may bioaccumulate in the food chain and result in uptake of petroleum hydrocarbons by sea ducks over a long period (Dzinbal and Jarvis, 1982; Sanger and Jones, 1982). This study is designed to determine levels of petroleum hydrocarbon ingestion by sea ducks and document resultant physiological and life history effects (Gay, Belisle and Patton, 1980; Hall and Coon, 1988). A predictive model may be constructed for harlequin duck reproductive losses based upon physiological effects of petroleum contamination resulting from the EVOS. Pre-oil spill baseline data are available on petroleum contaminant levels in harlequin ducks tissue from PWS (Irons, FWS, pers. comm.).

OBJECTIVES

A. Develop a data base describing food habits of the six species of sea ducks in PWS.

B. Obtain data from other NRDA studies on petroleum hydrocarbon levels in marine invertebrates, particularly blue mussels, from the PWS area; relate these data to the levels of petroleum hydrocarbons found by chemical analysis of invertebrates in gut samples from sea ducks collected in oil spill and control areas; and test the hypothesis (at $\alpha = 0.05$) that the incidence of petroleum hydrocarbons in gut samples from collected sea ducks is higher in the oil spill areas than in the control areas.

C. Estimate by chemical analysis petroleum hydrocarbon levels in collected sea duck tissues and body fluids within 10% of the actual value 95% of the time.

D. Test the hypothesis (at $\alpha = 0.05$) that the incidence of petroleum hydrocarbons in tissues of collected sea ducks is significantly higher in 1989-91 in the oil spill areas than in the control area.

E. From evidence of histopathology, estimate the ingested petroleum hydrocarbon effects on morbidity and mortality of sea ducks. This information may be related to other studies to identify changes in abundance and distribution within the affected areas.

F. Test the hypothesis that productivity of harlequin ducks in the oil spill area of PWS is the same as productivity in control areas of PWS.

METHODS

This study compares levels of petroleum hydrocarbons in tissues of six species of ducks collected in four study areas. The areas exposed to petroleum are western PWS and southwestern Kodiak Island. The control sites are southeastern PWS and southeastern Alaska (north of Juneau). Tissues were collected for evidence of both histopathological changes and chemical contamination. Analysis of chemical and histopathological samples from these ducks continues in 1991.

Female harlequin ducks are secretive and nests difficult to find. Therefore, females will be mist-netted and radio-tagged at stream mouths in oiled and unoiled areas of PWS in spring 1991 and radio-tracked along streams to locate nesting sites. Clutch size, hatching success, and brood size (a productivity index) will be obtained from sample nest sites in oiled and unoiled areas.

ANOVA (Snedecor and Cochran, 1980) will be used to test the hypothesis that prevalence of petroleum hydrocarbons in gut samples from collected sea ducks is higher in the oil spill areas than in the control areas.

Cumulative logit loglinear models (William and Grizzle, 1972; Agresti, 1984) will be used to model the incidence of petroleum hydrocarbons using area collected and species as explanatory variables. Hypotheses concerning differences by area in incidence of petroleum hydrocarbons will be tested with a conditional likelihood ratio statistic for nested models (Agresti, 1984). A Bonferroni (Snedecor and Cochran, 1980) Z-statistic (Agresti, 1984) will be used to determine the nature of the differences among areas if the main effect is significant.

Exposure of sea ducks to hydrocarbon contaminated prey may result in physiological effects, such as changes in the amount of body fat. Sea ducks were weighed and fat tracts photographed. Fat deposition was classified by condition as: excellent, good, fair, poor, or none. Adipose tracts scored were: throat, flank, subcutaneous, heart and mesenteric. Loglinear models (Agresti, 1984) will be used to model the distribution of physiological classification (fat tract scores) by area and species. A conditional likelihood ratio statistic for nested models will be used to test the hypothesis that physiological classification is independent of area. If area and physiological classifications are dependent, a Bonferroni (Snedecor and Cockran, 1980) Z-statistic (Agresti, 1984) will be used to determine differences among areas while controlling for physiological effect.

Tissues were collected for either chemical analysis (presence, absence, or degree of petroleum residue) or histopathology. Results are being compared to unexposed specimens from "clean" (unexposed control) areas. Choice of materials and tissues, handling, and discussion of results are according to published guidelines for interpreting residues of petroleum hydrocarbons in wildlife tissues (Hall and Coon, 1988).

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BUDGET

Salaries	$ 87.9
Travel	30.0
Contracts	40.0
Supplies	12.0
Equipment	9.0
Total	$178.9

FISH/SHELLFISH INJURY ASSESSMENT

The grounding of the tanker *Exxon Valdez* discharged crude oil into one of the richest marine fisheries communities of the United States. Although oil contamination was most severe within PWS, the oil spread into large portions of the Gulf of Alaska (GOA), Lower Cook Inlet (LCI), Shelikof Strait, and other North Pacific Ocean waters off the coasts of Kodiak and the Alaska Peninsula. The fish and shellfish populations inhabiting these marine and estuarine waters form integral parts of a vast and complex ecosystem, which also includes various other invertebrate species, birds, and mammals (including humans).

For example, the various life history stages of Pacific herring are important forage species for various piscivorous fishes (e.g. Pacific salmon, halibut, etc.), birds (gulls, cormorants, eagles, loons, etc.), mammals (sea lions, seals, whales, etc.), invertebrates (crabs), and are used for subsistence and commercial purposes. Outmigrating smolts of Pacific salmon are important seasonal prey items for a variety of predatory fish and marine birds. Maturing salmon in the high seas and adult salmon returning to inland waters, are the major portion of the diet of marine mammals such as sea lions, seals, and killer whales. Salmon are also the summer mainstay for eagles and many species of gulls. Spawning adults in the streams constitute almost 100% of the summer diet for bear and some river otter and are a very important link between the marine and terrestrial ecosystems. Salmon carcasses in streams, estuaries, and lakes are a crucial source of nutrients for planktonic communities and benthic organisms, which represent the bottom rungs of the food chain for a wide variety of animals.

Various fish and shellfish species are also important components of subsistence, commercial, and sport fishery harvests. Communities such as Tatitlek, Chenega Bay, and English Bay depend upon subsistence fisheries in PWS and LCI for the very existence of their residents. The ex-vessel value of commercial fish and shellfish catches within PWS and other affected areas was estimated to be $1.3 billion. The largest recreational fisheries in Alaska for salmon, halibut, and rockfish center in Homer and Seward; a total of 300,000 angler days was recorded from these areas in 1987. Finally, many non-consumptive users of fish and wildlife also utilize the waters affected by the oil spill. Injury to fish and shellfish populations and resulting alterations to ecological communities would certainly diminish the value of the area to this group of people.

Bioassays prior to EVOS using crude oil from Prudhoe Bay and other areas 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 various shrimp species. To assess the type and extent of injury to marine fish and shellfish communities by the

EVOS, a series of Fish/Shellfish (F/S) studies was developed by investigators from various State and Federal agencies. Species were selected for study based on their value as indicators of injury, their role as key species within the ecosystem, or their direct importance to man as components of subsistence, commercial, or sport harvests.

Comparisons of the abundance of larvae, juveniles, or adults between oiled and unoiled waters were chosen as the basic experimental units. In some studies, oiled and unoiled waters pertain to different geographic areas; in other studies these terms relate to the same area or populations before and after the oil spill; in the remaining studies these terms refer to different areas and populations before and after the spill. Contamination of individual fish and shellfish is determined by analysis of tissue samples, bile samples, or testing for induction of specific enzymes associated with hydrocarbon exposure. Injuries to fish and shellfish populations resulting from the oil spill may be expressed as lethal (e.g., mortality to specific life history stages) or sublethal (e.g., decreased growth, reproduction potential, etc.). Such injuries to populations could cause losses in harvests and use of these species by man, and result in undesirable alterations of natural communities.

Project proposals were reviewed and modified through comments provided by State and Federal agency staff members, State and Federal attorneys, various experts retained by the State and Federal governments, and many corporate and private individuals. Based on these comments and results from 1989 and 1990 studies, a number of changes were made for the 1991 fisheries program. Salmon studies F/S 1, 2, 3, 4, 27, 28 and 30 were continued another year. That portion of F/S 3 relating to tagging of hatchery and wild stock salmon was recommended to be accomplished through the restoration program while tag recovery from adult salmon and analysis would be continued within this damage assessment F/S 3 project. Salmon studies F/S 7 and 8 were funded as necessary to conclude these projects in 1991. Dolly Varden and cutthroat trout study F/S 5, herring study F/S 11 and clam study F/S 13 were approved for continuation in 1991. The injury to shrimp study F/S 15, injury to rockfish study F/S 17 and injury to demersal fish study F/S 24 became subtidal studies ST 5, 6, and 7 respectively and were recommended for continuation in 1991. Trawl assessment study F/S 18 was funded only as necessary to conclude this project in 1991. The crab study outside PWS (F/S 22) was not approved for continuation in 1991.

FISH/SHELLFISH STUDY NUMBER 1

Study Title: Injury to Salmon Spawning Areas in PWS

Lead Agency: ADF&G

INTRODUCTION

The recent annual production of wild stock pink salmon in PWS has ranged from 10 to 15 million fish. Chum salmon returns have ranged from 0.8 to 1.5 million fish. Much of the spawning for pink and chum salmon occurs in intertidal areas (up to 75% in some years). Intertidal spawning areas are susceptible to marine contaminants and the March 24, 1989, EVOS may adversely affect spawner distribution and success in PWS. To detect injury to pink and chum salmon stocks, intertidal contamination will be documented and correlated with trends in adult returns. Return estimates are based on accurate appraisals of catch and escapements. This project is designed to document oil contamination of intertidal spawning habitat; provide accurate estimates of wild stock escapements; and provide estimates of intertidal and upstream areas available for spawning. F/S Study 3 provides estimates of the wild stock component of the commercial catch. Results from F/S Study 3 and this study will be combined to estimate total return of wild stocks. F/S Study 2 estimates eggs and fry per square meter and egg to fry survival by tide zone in a subset of the streams in this study. Egg and fry density and survival data from F/S Study 2 will be combined with spawner density data by tide zone from this study and historic average fecundity data to estimate total egg deposition and egg to fry survival by tide zone in 138 streams.

The ADF&G has performed spawning ground surveys of the major salmon spawning streams in PWS since the late 1950's. An aerial survey program provides weekly estimates of fish numbers in 218 spawning streams. A ground survey program has provided corresponding estimates of fish numbers on a subset of approximately 116 streams during the peak of spawning. During 1987 and 1988, funding for the ground survey program was severely curtailed and only 58 streams were walked. F/S Study 1 includes a thorough and extensive ground escapement survey program on salmon spawning streams for which there are past ground survey data and includes additional oiled and unoiled streams in western PWS. The study also includes ground surveys of salmon streams to document the presence of oil in intertidal spawning habitat and the presence or absence of oil in the tissues of adult salmon returns, and from fry outmigration during and subsequent to the EVOS.

A total of 411 streams were surveyed in 1989 for the presence of oil in intertidal spawning areas and 138 streams from among the 218 in the historic aerial survey program were included in a ground census of pink and chum salmon escapements. In 1990 the oil survey was limited to 138 streams in the escapement censusing portion of the project. Mussel samples for hydrocarbon analysis were collected in the intertidal portions of the 138 streams in the ground censusing program in both 1989 and 1990. The total area of intertidal spawning habitat was estimated for each of the 138 streams and the area of upstream spawning habitat was estimated for 100 of the 138 streams. Total pink salmon spawning escapement at four streams was estimated through weirs in 1990 and stream residence time (stream life) estimates were made for pink salmon in 22 streams. Tissue samples for hydrocarbon analysis were collected from spawning adult pink salmon in 12 oiled and 10 unoiled streams in the ground survey program.

Based on results of the 1989 and 1990 studies, the program in 1991 will emphasize more detailed and intensive data collection on fewer streams. Weirs will be installed on seven streams; the four streams weired in 1990 and three additional streams. The six streams in the wild stock tagging portion of F/S Study 3 will be among the weired systems and adults will be sampled for coded-wire tags (CWT) applied during the 1990 field season. Ground surveys and stream life studies will be continued at each weired stream and approximately 20 additional streams. Oil surveys as well as mussel and adult salmon tissue sampling will continue on all surveyed streams in 1991.

Results of this study will provide accurate estimates of pink and chum salmon escapement to each stream surveyed; will correlate escapement estimates based on aerial counts with weir and ground counts to estimate past and current year escapements for 218 streams included in the ADF&G aerial survey program; will provide estimates of post oil spill distribution of spawning within stream zones and among streams; will estimate total available intertidal and upstream spawning habitat for each stream; will estimate average stream life for pink and chum salmon in PWS; will provide coded-wire tag data for F/S Study 3; will document physical presence or absence of oil in intertidal salmon spawning and rearing habitat and presence or absence of oil in tissues of mussels and salmon that rear or live there; and will provide an atlas of aerial photographs and detailed maps of important spawning sites.

OBJECTIVES

A. Determine the presence or absence of oil on intertidal habitat used by spawning salmon through visual observation, aerial photography, and hydrocarbon analysis of tissue samples from intertidal mussels at stream mouths.

B. Document the physical extent of oil distribution on intertidal spawning areas.

C. Document the presence or absence of hydrocarbons from the EVOS in the tissues of adult salmon originating from the fry outmigrations in 1989 and subsequent years in oiled and unoiled areas.

D. Estimate the number of spawning salmon, by species, within standardized intertidal and upstream zones for 27 streams in PWS.

E. Enumerate the total intertidal and upstream escapement of pink and chum salmon through weirs installed on seven streams that are representative of streams in the aerial and ground escapement survey programs.

F. Estimate the accuracy of aerial counts for the 218 aerial index streams by comparison of paired ground and aerial counts from the same streams on the same or adjacent survey dates and by comparison of aerial, ground, and weir counts on seven streams.

G. Estimate average stream life of pink and chum salmon in at least 27 streams in PWS using a variety of techniques.

H. Estimate pink and chum salmon escapements from 1961 through 1988 for the 218 aerial index streams using the average observed error in the aerial survey method and stream life data from 1989, 1990, and 1991.

I. Estimate the stream area available for spawning within standardized intertidal and upstream zones for the 138 streams surveyed.

J. Produce a catalog of aerial photographs and detailed maps of spawner distribution for the more important pink and chum salmon streams of PWS for use in designing sampling transects in the egg deposition and preemergent fry studies.

K. Enumerate adult returns to streams where coded-wire tags were applied to wild pink salmon stocks and assist in the spawning ground sampling for tag recovery.

METHODS

This project is an integral part of the study of impacts of the EVOS on Pacific salmon populations in PWS. Streams examined by this project are a subset of the anadromous salmon streams monitored by the ongoing ADF&G aerial survey program. Two additional F/S studies in PWS, pink and chum salmon egg deposition and preemergent fry studies (F/S Study 2) and salmon coded-wire tagging studies (F/S Study 3), will rely on information about salmon spawning and distribution data and coded-wire tag recovery data obtained from this project.

Streams to be surveyed will be selected according to the following criteria:

1. Stream is included in the ADF&G aerial survey program.
2. Stream is included in the pink and chum salmon egg deposition and pre-emergent fry project (F/S Study 2).
3. Stream is included in the CWT project for wild stocks of pink salmon (F/S Study 3).
4. Stream has been included in stream life studies conducted by this project in 1989 and 1990.
5. Stream was enumerated in prior spawning ground foot survey programs.
6. Stream is representative of the early, middle, and late run pink and chum salmon stocks in PWS.
7. Stream is representative of the spatial distribution of pink and chum salmon stocks in PWS and include streams from oiled and unoiled areas.

Maps of all streams in the program prepared from aerial photographs prior to the 1989 field season were modified and corrected during the three survey circuits in 1989 and 1990 and will be used and updated during the 1991 field season.

A pre-season survey to mark tide zones will be conducted in June, prior to the return of the pink and chum salmon. The location of tide levels 1.8, 2.4, 3.0, and 3.7 m above mean low water will be measured from sea level using a surveyors's level and stadia rod. Sea level at each site will be referenced to mean low water with site specific, computer generated tide tables which predict tides at five minute intervals. Tide zone boundaries will be delineated with color coded steel stakes. The linear length of the stream within each intertidal zone will be measured with a surveyor's chain or range finder. The linear length of the stream in the upstream zone will be measured similarly on short streams and estimated from accurately scaled aerial photos on long streams. The average stream width will be determined from systematic width measurements taken in each zone. The number of measurements in each zone will depend on the length of the zone. Each measurement will be recorded at the appropriate location on the stream maps prepared in 1989 and 1990.

Crews marking, measuring, and mapping tide zones will also conduct foot surveys of the intertidal stream bed and adjacent beaches to document, map, and classify oiling. A composite sample of mussels will be collected at the mouth of each stream for hydrocarbon analyses. Results of the analyses will be used to document oil impact that the stream sustained. Each sample will consist of enough mussels to provide 10 grams of tissue (approximately 30 mussels) for analysis. The mussels will be collected from 0-2 m above mean low water in the immediate vicinity of each stream mouth and above water to avoid contamination by hydrocarbons on the water surface. The samples will be stored separately in properly cleaned, glass jars with teflon lined lids.

Weirs for total escapement enumeration will be installed on seven streams in 1991. These seven streams include the four weired in 1990 as well as the six streams in the coded-wire tagging project for wild stocks of pink salmon (F/S Study 3). The weirs will be installed at or as near as possible to the 1.8 m tide level or the lower level of intertidal spawning. Weir crews will record daily passage through the weir and perform daily ground surveys of intertidal and upstream portions of the weired systems as well as the 20 other pink and chum salmon spawning streams. Live and dead pink and chum salmon will be enumerated in standardized intertidal and upstream zones in each stream. During each stream survey the following data will be recorded:

1. anadromous stream number and name (if available);
2. latitude and longitude of the stream mouth;
3. date and time (24 hour military time);
4. tide stage;
5. observer names;
6. counts of live and dead salmon by species and tide zone (0.0-1.8 m, 1.8-2.4 m, 2.4-3.0 m, and 3.0-3.7 m above mean low water and upstream); and
7. weather and comments on visibility, lighting, and other survey conditions.

All data will be recorded on pre-printed mylar data sheets which will overlay a map of the stream. Maps will be improved and modified during the survey to show spawner distribution within each zone and the upstream limit of spawning. Particular attention will be given to spawner density and distribution observations for streams which are also sampled during F/S Study 2.

Counts of live and dead salmon will be made for the five tide zones (the intertidal zones < 1.8 m, 1.8-2.4 m, 2.4-3.0 m, 3.0-3.7 m above mean low water and the upstream zone) from the 1.8 m tide level to the limit of upstream spawning on all 138 streams. Tide stage will be monitored continuously and survey times and direction will be adjusted accordingly. If the tide stage is at or below the 1.8 m level the stream walk will begin at the mouth of the stream and progress upstream. The mouth or downstream limit of the stream will be defined as the point where a clearly recognizable stream channel disappears or is submerged by salt water. Fish seen below the downstream limit will be included as an estimate of fish off the stream mouth and noted as a comment on the data form. If portions of the stream above the 1.8 m tide level are submerged, the crew will proceed to the upstream limit of the walk, walk downstream, and coincide the end of the walk with the time predicted for the tide to be at or below the 1.8 m level. The upstream limit of a walk will be determined by the presence of natural barriers to fish passage (i.e. waterfalls), by the end of the stream, or by the upstream limit of spawning. The upstream limit of spawning will be marked on U.S. Geological Survey color aerial photos of each stream following each survey.

Crew members will walk together but independently count live fish in each intertidal zone on moderate size streams with a single channel. Crew members will individually enter their count on mechanical hand tallies. A maximum of three replicate counts may be made for each zone at the request of either observer. Upstream counts in a single channel will be similarly conducted at convenient stopping points (i.e., log jams or other clear counting delineators). For large braided or branched streams, each crew member will count separate channels or upstream forks. To avoid confusion with counts of live fish, counts of dead fish will be recorded on the return leg of the stream walk. Only fish that have died since the previous count will be tallied as dead in the daily surveys. To prevent duplicate counts between surveys, tails and tags of all dead pink and chum salmon observed will be removed. To avoid perpetuating counting biases within a counting crew, personnel will be rotated daily. When possible, crew members will not be assigned to the same streams on succeeding days.

Tests for variability among observers and among counting crews (observer pairs) will be conducted on all streams on a minimum of three separate occasions. During each test, all observers will estimate numbers of live and dead pink salmon by zone and will record their counts independently. Counts will be compared after all test streams have been surveyed. Three crews of randomly paired observers will also replicate counts on 10 streams and results among observed pairs will be compared.

All streams in the daily foot survey program will be included in a stream life study. Stream life studies will be modeled in part after previous studies in PWS (Helle et al. 1964; McCurdy 1984). Fish will be captured at the stream mouths with beach seines and tagged with individually numbered Peterson disk tags color coded for day of capture. Tagging will be conducted at weekly intervals. During each tagging episode 120 fish per stream will be tagged. If fewer than 120 fish are available, all fish captured will be tagged. At weired streams, tagged fish will be enumerated by tag color as they pass through the weir. Live and dead fish bearing tags will be enumerated separately by color code and tag number during daily counts of live and dead pink and chum salmon.

Stream life will be estimated using three methods. The first estimate is the mean difference between date of tag recovery from dead fish and the tagging date. A separate estimate will be made for each tag lot at each stream to examine changes in stream life through time. The second estimate will be based on daily and cumulative weir counts and daily carcass counts. Daily weir and carcass counts will be used to estimate total fish days. Total fish days will then be divided by the cumulative weir count to obtain mean stream life. The third method will be based on the difference in days between peak live count and the peak dead count from the ground surveys.

The 22 streams where adult salmon tissue samples were taken for hydrocarbon analysis in 1990 will be sampled again in 1991. Twenty males and 20 females will be captured at the weir on each stream. The fish will be iced and flown immediately to the Cordova ADF&G laboratory where tissues will be excised, labeled, catalogued, and preserved.

Changes in numbers and distribution of salmon escapements as a result of the EVOS will be examined by dividing streams into categories based on levels of hydrocarbon contamination. Categorical data analysis techniques such as log linear models using chi-square statistics will be used to compare differences in spawning among streams and tide zones. Count and spawner distribution data will also be compared with historical stream survey data and related to the level of hydrocarbon impact.

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BUDGET

Salaries	$119.0
Travel	2.0
Contractual	116.0
Commodities	31.0
Equipment	20.0
Total	$288.0

FISH/SHELLFISH STUDY NUMBER 2

Study Title: Injury to Salmon Eggs and Preemergent Fry in PWS

Lead Agency: ADF&G

INTRODUCTION

Much of the spawning for pink and chum salmon (up to 75% in some years) occurs in intertidal areas. Moles, Babcock, and Rice (1987) have shown the adverse effects of oil on pink salmon alevins, particularly in salt water. The EVOS in PWS occurred immediately prior to emergence of pink and chum salmon from stream and intertidal spawning areas. These areas may have been severely impacted by the oil spill.

This study, along with F/S Studies 1, 3, and 4, support a comprehensive and integrated determination of injury to PWS salmon stocks. Results will include documentation of oil in intertidal salmon spawning habitat, pre-spill and post-spill estimates of total adult returns of wild and hatchery stocks, wild stock spawning success, wild stock egg to fry survival, and early marine survival of wild and hatchery stocks. Information on the extent and persistence of oil in the intertidal zone will be supplemented by Coastal Habitat Study 1. The results of F/S Studies 1 through 4 will be used by Economic Uses Study 1 to determine the extent of injury to the PWS salmon resource.

The ADF&G has sampled pink and chum salmon preemergent fry since the 1960's in order to predict the magnitude of future salmon returns. The fry sampling program has operated at a reduced level since 1985. The oil spill has the potential to cause mortality to the critical egg and fry life stages, and thus an increased and more comprehensive fry sampling program is necessary. This project is designed to meet this need by assessing the effect of the oil spill on egg and fry of wild stock pink and chum salmon.

OBJECTIVES

A. Estimate the density, by tide zone, of preemergent fry in 48 streams, and eggs in 31 streams using numbers of live and dead eggs and fry.

B. Estimate egg mortality and overwinter survival of pink and chum salmon eggs in both oiled and unoiled (control) streams.

C. Document hydrocarbon contamination in preemergent fry using tissue hydrocarbon analysis, and eggs and preemergent fry using mixed-function oxidase (MFO) analysis.

D. Assess any loss in adult production from changes in overwinter survival using the results of F/S Studies 1, 2, 3, and 4.

METHODS

There are approximately 900 anadromous fish streams in PWS. Preemergent fry sampling from some of these streams has historically provided an abundance index for pink salmon that is used to forecast future returns. In recent years, 25 index systems considered representative of pink and chum salmon producing streams in PWS have been sampled. Prior to 1985, sampling had been performed on as many as 45 streams. This study is designed to compare rates of mortality and abundance among areas with various levels of oil impacts and with data from sampling prior to the oil spill.

Sampling will consist of egg deposition surveys performed from late September to mid-October and preemergent fry sampling conducted from mid-March to mid-April. Preliminary sampling was performed on two occasions during the spring of 1989 in an effort to assess fry abundance prior to and immediately after oil impact. On the first occasion all 25 streams in the ongoing ADF&G preemergent index program were sampled along with 14 additional streams. During the second event (approximately two weeks after the oil spill), 14 of the streams were resampled (representing both oiled and unoiled areas), and an additional 16 streams were surveyed to assess their potential as egg and preemergent study streams. During September and October of 1989 and 1990 egg sampling was conducted on 31 of these streams. Preemergent fry sampling was completed on 48 streams from mid-March to early May in 1990.

Spring fry sampling in 1991 will be conducted on 48 streams. These will include the 25 streams in the ongoing ADF&G preemergent index program plus 23 additional streams. The additional streams are located in central and southwest PWS where most the oiling occurred. New study streams were selected using the following criteria:

1. Adult salmon returns were expected to be great enough to indicate a high probability of success in egg and fry sampling.

2. Egg and fry sampling had been done in past years.

3. Streams with low to no oil impact, i.e., controls, were selected in the immediate vicinity of high oil impact streams to help account for possible variability in egg and fry survival due to different environmental conditions.

Most of the streams with suspected or obvious oil impact were not sampled prior to the EVOS. The 30 streams in low impact areas include 27 with a history of sampling; six suspected of having received some impact including four with a history of sampling; and 12 streams with oil visibly present in the intertidal zone, including five with a history of sampling.

As in 1989 and 1990, egg sampling will be conducted in the fall on 31 of the 48 streams sampled for preemergent fry. Streams included in the fry sampling program, but not in the egg program are traditional fry sampling streams located on the eastern and northern shore of PWS. These streams are outside the area studied for oil impact effects. The 13 streams in low impact areas left in the egg sampling program include four with a history of sampling. Streams suspected of having some oil impact and streams that had visible impact are included in both the egg and fry sampling programs.

Sampling methods are identical for the preemergent fry and egg sampling and are modeled after procedures described by Pirtle and McCurdy (1977). On each sample stream, four zones, three intertidal and one above tidal influence, will be identified and marked during preemergent fry sampling. The zones are 1.8-2.4 m, 2.4-3.0 m, 3.0-3.7 m above mean low water, and upstream of tidal influence. Separate linear transects 30.5 m in length will be established for egg and preemergent fry samples in each zone (one transect for each type dig in each zone). The transects will run diagonally across the river with the downstream end located against one bank and the upstream end against the opposite bank. Overlapping of transects will be minimized to control the influence of fall egg sampling on perceived abundance of fry during spring sampling. Fourteen 0.3 m^2, circular digs (56 per stream) will be systematically made along each transect using a high pressure hose to flush eggs and fry from the gravel. Eggs and fry will be caught in a specially designed net.

Numbers of live and dead fry by species, as well as numbers of live and dead eggs by species, will be recorded from each 0.3 m^2 dig. Additional information such as date, time, zone, and a subjective estimate of overall percent absorption of the fry egg sacs in the sample will also be noted.

Preemergent pink salmon fry will be collected from the intertidal channels of streams. Fry samples will be analyzed for the presence of hydrocarbons characteristic of those found in oil from the *Exxon Valdez*.

Fry sampled for hydrocarbon analysis will be collected from the intertidal stream bed at a level approximately 2.5 m above mean low water. Samples will be collected when the tide is below that level to avoid contamination from any surface oil film. A shovel or clam rake will be used to dislodge the fry from the gravel. A stainless steel strainer, pre-rinsed in dimethylchloride and dried, will be used to catch fry as they are swept downstream. Captured fry will be placed in jars with teflon lined lids and frozen.

Fry from each tide zone will also be collected for MFO analysis. These samples will be selected randomly from the digs in each transect. Fry collected for MFO analysis will be preserved in buffered formalin solution in glass jars.

Numbers of live and dead preemergent fry and eggs will be summarized by date, stream, level of hydrocarbon impact, and stream zone. A mixed effects analysis of variance will be used to test for differences in egg to fry mortality due to oiling using the 31 streams sampled for both eggs and preemergent fry. Hydrocarbon results and degree of oiling as visually assessed by the mapping portion of the assessment of intertidal spawning areas will be used to post-stratify streams. Degree of oiling and height in the tidal zone will be treated as fixed effects. Height in the tidal zone is nested within stream, a random effect. Analysis of covariance will be used if an ordinal measure of hydrocarbon impact can be obtained from the analysis of mussel tissue collected during F/S Study No. 1.

Power of the test was estimated for the analysis of variance using data from the 1975 and 1976 egg and preemergent fry samples in PWS. These data indicated the ability to detect an increase of 15% in egg to fry mortality (e.g. 10% mortality to 25% mortality) at $\alpha = 0.05$, 95% of the time.

Specific statistics to be estimated are:

1. number of dead and viable eggs per square meter by salmon species, stream, and stream zone;

2. number of dead and live fry per square meter by salmon species, stream, and stream zone; and

3. egg to fry survival by salmon species, stream, and stream zone.

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Pirtle, R.B. and M.L. McCurdy. 1977. Prince William Sound general districts 1976 pink and chum salmon aerial and ground escapement surveys and consequent brood year egg deposition and preemergent fry index programs. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 9, Juneau.

BUDGET

Salaries	$ 82.0
Travel	4.0
Contractual	144.0
Commodities	10.0
Equipment	19.0
Total	$ 259.0

FISH/SHELLFISH STUDY NUMBER 3

Study Title: Salmon Coded-Wire Tag Studies In PWS

Lead Agency: ADF&G

INTRODUCTION

Two questions must be answered to measure a loss in salmon production due to EVOS: 1) which stocks were exposed to contaminated waters and 2) to what extent did exposure reduce survival and production (catch plus escapement)? This study will contribute to estimates of survival and production for hatchery and wild stocks in oiled and unoiled areas by quantifying fry outmigration, the wild and hatchery stock components of the catch, and the hatchery escapements.

Wild stock returns of pink salmon in PWS have ranged from 10 to 15 million fish in recent years. Chum salmon returns have ranged from 0.8 to 1.5 million. Additionally, returns of pink salmon to four PWS hatcheries now average more than 20 million fish and hatchery chum salmon returns in excess of 1.4 million fish are expected.

Catch and escapement data for wild pink salmon in PWS have been collected since 1961. Hatchery production became a significant part of the total salmon return in 1985. Consequently, pink salmon fry tagging was initiated at three area hatcheries in 1986 to estimate hatchery contributions to the 1987 catch. Similar estimates were made for a fourth facility in 1987 and 1988. F/S Study 3 estimated catch and survival rates of pink salmon released from these four PWS hatcheries based on tags applied in 1988 and 1989 and recovered in the commercial, cost recovery and hatchery brood stocks in 1989 and 1990. Tags were also applied to chum, sockeye, coho, and chinook salmon released from PWS area hatcheries and to smolts from two wild stocks of sockeye salmon in 1989. A similar multi-species tagging program was conducted again in 1990; however, tags were also applied to smolts from one additional wild stock of sockeye salmon and fry from six wild stocks of pink salmon including three from oiled areas and three from unoiled areas. Tagging in 1991 is being transitioned from damage assessment to restoration.

Pink salmon tag recoveries are expected from all four hatcheries in 1991. Recoveries are expected for chum salmon released from Main Bay Hatchery in 1986, Main Bay and Solomon Gulch Hatcheries in 1987, and Solomon Gulch in 1989. Tagged sockeye salmon will be recovered from Main Bay Hatchery releases in 1988 and 1989, and releases of coho salmon from Wallace H. Noeremberg (WHN) and Solomon Gulch Hatcheries in 1990.

OBJECTIVES

A. Estimate catch, escapement, and survival rates of pink, chum, sockeye, coho, and chinook salmon released from five hatcheries in PWS. Outmigrating smolt and returning adults from these facilities are potentially exposed to oil in the environment.

B. Estimate catch of the combined wild stocks of pink salmon in PWS and using escapement data from F/S Study 1, estimate differences in relative survival rates between pre- and post-spill brood years.

C. Estimate survival rates of wild pink salmon from three streams with contaminated estuaries and three with uncontaminated estuaries.

D. Estimate survival rates of wild stocks of sockeye salmon, two from oiled areas, one from an unoiled area.

METHODS

Under a separate proposed restoration project, a subsample of fry or smolt from all hatcheries releasing salmon into PWS will be tagged with a coded-wire tag (Appendix A). Wild pink fry and sockeye salmon smolt from both oiled and non-oiled areas of the Sound will also be tagged (Appendix B). Tags will be applied at rates that insure sufficient numbers can be recovered in the commercial fishery, hatchery cost recovery harvests, and hatchery brood stock collections to allow researchers to estimate the contribution of each tag release group by district, week, and processor stratum.

Four hatcheries released 615 million pink salmon fry in 1990. Each of 32 release groups were tagged at a rate of approximately one tag per 580 fish released (1 in 580). The tag rate was held constant across release groups to prevent confusion of differential tag mortality with variation in survival between release groups (Peltz and Geiger, 1988; Geiger and Sharr, 1989).

In 1989, chum salmon were tagged at the rate of approximately one tag per 60 fish released at the Solomon Gulch Hatchery near Valdez. Tagging of Solomon Gulch chum salmon continued at the same level in 1990 and the WHN hatchery release of 20.6 million chum salmon fry was also tagged at a rate of approximately one tag per 480 fish.

Wild pink salmon were tagged from six stocks examined in F/S Study 2 in 1990; three from oil contaminated streams and three from uncontaminated streams. Inclined plane traps were used to capture fry as they emerged. Trapped fry were manually enumerated in 1990. Manual enumeration will continue in 1991 but electronic fry counters will also be tested. A portion of the daily outmigration were anesthetized and tagged. The anesthesia and associated trauma required the tagged fish to be held separately from the untagged fish, until they appeared to have recovered fully from the effects of tagging. The extent to which the survival and behavior of the tagged fish can be extrapolated to other groups of salmon will be assessed at the time of recovery. Approximately 40,000 fry were tagged for each stock at tagging rates ranging from 1 in 4 to 1 in 17 fish released.

Smolt in the 2.6 million fish release of sockeye salmon from the Main Bay Hatchery were tagged at a rate of 1 in 21 in 1990.

Recovery samples are stratified by district, processor, and discrete time segments (Cochran 1977; Peltz and Geiger 1988). Fifteen percent of the pink salmon catch and a minimum of 20% of other salmon species catches will be scanned for fish with a missing adipose fin in each time and area specific stratum. Catch sampling will be done in four fish processing facilities in Cordova, one facility in Seward, and three facilities in Valdez. When feasible, sampling will occur at facilities in Kodiak, Kenai, Anchorage, and Whittier and on large floating processors. All deliveries by fish tenders to these facilities will be monitored by radio and by daily contact with processing plant dispatchers to ensure the deliveries being sampled are district specific.

In addition to catch sampling at the processing facilities, approximately 15% of the fish in the hatchery terminal harvest areas will be scanned for missing adipose fins. There will be a brood stock tag recovery effort at each of the three hatchery facilities where tags were initially applied. A minimum of 50% of the daily brood stock requirements of each facility will be scanned for fish with missing adipose fins.

The recovery of tags from wild stocks of sockeye and pink salmon will coincide with recoveries of hatchery stocks in the commercial catch, terminal harvest, and brood stock sampling programs. Tags will also be recovered in the escapements of each tagged wild stock. At each of these streams, crews will enumerate the daily escapement through a weir. As escapement passes through the sockeye salmon weirs, a portion will be scanned daily for missing adipose fins. At pink salmon weirs, daily foot surveys will be conducted to enumerate fresh carcasses and the surveyors will scan them for missing adipose fins. Carcasses enumerated each day will be marked daily to prevent duplicate counting on subsequent days.

In the catch, terminal harvest, brood stock, and wild stock escapement surveys, the total number of fish scanned and the total number of fish with missing adipose fins will be recorded. The heads will be removed from fish with missing adipose fins. Each head will be tagged with uniquely numbered strap tags. Recovered heads will be assembled and pre-processed in the Cordova area office. Heads will then be sent to the ADF&G FRED Division Coded-Wire Tag Laboratory in Juneau for decoding and data posting.

Coded-wire tag sampling forms will be checked by the tag lab for accuracy and completeness. Sampling and biological data will first be entered onto the laboratory's database. The heads will then be processed by removing and decoding the tags, and entering the tag code and the code assigned in the recovery survey into the database. Samples will be processed within five working days of receipt.

The first step in the coded-wire tag analysis will be to estimate the harvest of salmon from each tag lot in units of adult salmon. For hatchery stocks, a modification of the methods described in an ADF&G technical report by Clark and Bernard (1987) will be used. The specific methods, estimators, and confidence interval estimators are described in ADF&G technical reports for two previous studies of pink salmon in PWS (Peltz and Geiger 1988), (Geiger and Sharr 1989). Additional references on methods of tagging pink salmon in PWS can be found in Peltz and Miller (1988). In the case of wild stocks, the methods, estimators, and necessary assumptions are described by Geiger (1988).

The contribution of a tag lot, to a fishery stratum, is estimated by multiplying the number of tags recovered in the structured recovery survey, by the inverse of the proportion of the catch sampled (the inverse sampling rate) and the inverse of the proportion of the tag lot that was actually tagged (the inverse tag rate). The escapement (brood stock) of each tag lot is estimated using methods unique to the particular situation. After the contribution to each fishery is estimated by tag lot, marine survival is estimated by summing the estimated harvest of the tag lot in each fishery, and the estimated escapement (brood stock), and dividing by the estimated number of fish represented by the tag code.

Total catches stratified by week, district, and processor were obtained from summaries of fish sales receipts (fish tickets) issued to each fisherman. The total hatchery contribution to the commercial and hatchery cost recovery harvest is the sum of the estimates of contributions in all week, district, and processor strata:

$$\hat{C}_t = \Sigma_i X_{ti} (N_i / S_i) p_t^{-1}$$

where:
$\hat{C}_t$ = catch of group *t* fish,
X_{ti} = number of group *t* tags recovered in *i*th strata,
N_i = number of fish caught in *i*th strata,
S_i = number of fish sampled in *i*th strata,
p_t = proportion of group *t* tagged.

For sampled strata, we used a variance approximation which ignores covariance between release groups (Geiger 1988):

$$V\ (\hat{C}_t) = \Sigma_i X_{ti} (N_i/S_i p_t)^2 [1 - (N_i/S_i p_t)^{-1}].$$

The average tag recovery rate for all processors in a week and district will be used to estimate hatchery contribution in catches delivered to processors not sampled for that district and week. Variances associated with unsampled strata will not be calculated.

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BUDGET

Salaries	$ 558.0
Travel	18.0
Contracts	442.0
Supplies	39.0
Equipment	18.0
Total	$1,075.0

Appendix A. Coded-wire tagging goals for hatchery releases of salmon in PWS, 1991.

Hatchery	Species	Projected Release	Valid Tag Goal	Number Tags to Order	Total Release /Marked Ratio Goal	Number of Tag Codes	Tag Length
Armin F. Koernig	Pink	116,000,000	193,000	218,000	600	16	Half
Cannery Creek	Pink	140,000,000	234,000	261,000	600	14	Half
Solomon Gulch	Pink	140,000,000	233,000	252,000	600	10	Half
Wally Norenburg	Pink	225,000,000	375,000	422,000	600	18	Half
GRAND TOTAL	Pink	621,000,000	1,035,000	1,153,000	600	58	Half
Solomon Gulch	Chum	1,600,000	20,000	20,000	80	2	Half
Wally Norenburg	Chum	78,000,000	156,000	173,000	500	4	Half
GRAND TOTAL	Chum	79,600,000	176,000	193,000	450	6	Half
Solomon Gulch	Coho	1,000,000	30,000	30,000	33	2	Full
		20,000	10,000	10,000	2	1	Full
Wally Norenburg	Coho	2,300,000	73,500	73,500	40	2	Full
Whittier	Coho	100,000	10,000	20,000	10	1	Full
Cordova	Coho	50,000	10,000	10,000	5	1	Full
GRAND TOTAL	Coho	3,470,000	133,500	143,500	26	7	Full
Main Bay	Sockeye	3,575,000	125,000	125,000	29	8	Full
GRAND TOTAL	Sockeye	3,575,000	125,000	125,000	29	8	Full
W. Noerenburg	King	600,000	30,000	30,000	20	1	Full
Cordova	King	60,000	10,000	10,000	6	1	Full
GRAND TOTAL	King	660,000	40,000	40,000	17	2	Full
GRAND TOTAL	All	708,305,000	1,509,500	1,654,500	470	81	Both

Appendix B. Coded-wire tagging goals for wild stocks of salmon in PWS, 1991.

System	Treatment	Species	Projected Outmigration	Valid Tag Goal	Total Release /Marked Ratio	Number of Tag Codes	Tag Length
Upper Herring B.	Oiled	Pink	210,000	40,500	5	3	Half
Hayden Ck.	Oiled	Pink	360,000	40,500	9	3	Half
Loomis Ck.	Oiled	Pink	210,000	40,500	5	3	Half
Cathead Ck.	Clean	Pink	150,000	40,500	5	3	Half
O'Brien Ck.	Clean	Pink	300,000	40,500	7	3	Half
Totemoff Ck.	Clean	Pink	720,000	40,500	18	3	Half
GRAND TOTAL	All	Pink	1,950,000	243,000	8	18	Half
Coghill	Clean	Sockeye	600,000	27,000	22	2	Half
Eshamy	Oiled	Sockeye	600,000	27,000	22	2	Full
Jackpot	Oiled	Sockeye	600,000	27,000	22	2	Full
GRAND TOTAL	All	Sockeye	1,800,000	81,000	22	6	Both
GRAND TOTAL	All	All	3,750,000	323,000	30	24	Both

FISH/SHELLFISH STUDY NUMBER 4

Study Title: Early Marine Salmon Injury Assessment in PWS

Lead Agencies: ADF&G, NMFS

INTRODUCTION

Recruitment to adult salmon populations appears to be strongly affected by mortality during the early marine period, because mortality at this time is typically very high (Parker 1968; Ricker 1976; Hartt 1980; Bax 1983). During this period, slow-growing individuals sustain a higher mortality because they are vulnerable to predators for a longer time than fast-growing individuals (Parker 1971; Healey 1982; West and Larkin 1987). In the laboratory, sublethal hydrocarbon exposure has been shown to cause reduced growth of juvenile salmon (Rice et al. 1975; Schwartz 1985). Thus, in the wild, sublethal hydrocarbon exposure is expected to cause reduced growth resulting in increased size-selective predation.

Oil contamination may also cause reduced survival by decreasing prey populations or disrupting migration patterns. Oil can be toxic to littoral and pelagic macroinvertebrates (Caldwell et al. 1977; Gundlach et al. 1983). Hydrocarbon exposure can damage olfactory lamellar surfaces (Babcock 1985) and cause an avoidance reaction (Rice 1973).

During the past decade, five salmon hatcheries have been established within PWS. These facilities, operated by private non-profit corporations, produced approximately 535 million juvenile salmon in 1989. Approximately one million of these fish were marked with a coded-wire tag (CWT). Recoveries of these marked fish in PWS has played a major role in our assessment of the impact of the oil spill.

In 1991, the impact assessment will be conducted by ADF&G and NMFS. Studies conducted by ADF&G will focus on the impact of the oil on fry growth, fry migratory behavior, and fry-to-adult survival. Studies conducted by NMFS will focus on fry abundance, growth, and behavior and oil contamination in the fish and their prey. Also, an experiment will be conducted to determine the effects of ingestion of whole oil on the growth and survival of pink salmon fry.

GOALS

A. Determine the effects of oil contamination on abundance, distribution, growth, feeding habits, and behavior of pink salmon fry during their early marine residency.

B. Describe the apparent effect of oil contamination on the migration patterns of pink salmon fry in western PWS.

C. Quantify hydrocarbon contamination in tissues of juvenile salmon collected in oiled and unoiled areas.

D. Determine the relationship between pink salmon fry growth and fry-to-adult survival.

E. Determine if hydrocarbon contamination affected the abundance of primary prey species of pink salmon fry.

F. Determine the effects of ingestion of whole oil on survival and growth of pink salmon fry.

PART I: Impacts of Oil Spill on Migratory Behavior and Growth

Lead Agency: ADF&G

Further studies are needed to determine whether oil contamination caused reduced growth and survival of juvenile pink salmon migrating into heavily-oiled areas near Armin F. Koenig (AFK) Hatchery in PWS. This effort will involve (1) estimating fry growth when the fish were near the areas where they were released and recaptured, (2) examining the effects of other factors that may have caused growth differences in oiled and unoiled areas, (3) acquiring additional measures of the level of oil exposure of fry in oiled and unoiled areas, (4) quantifying the relationship between fry growth and fry-to-adult survival, and (5) collecting additional data on fry growth and migration in oiled and unoiled areas of western PWS. F/S Study No. 4 will focus on pink salmon, because evidence of injury to this species has been collected in previous years.

Otolith microstructure analysis will be used to estimate the short-term growth of CWT fry. The locations where the CWT fry were released and recaptured are known. The growth of CWT fry when they were near these locations will be estimated by measuring otolith growth between increments that are formed each day (Volk et al. 1984). This approach will enable a relatively clear logical association between oil contamination, environmental conditions, and fry growth in specific areas.

An association between low fry growth and oil contamination is not sufficient evidence of injury. Water temperature (Martin 1966; Kepshire 1976), prey density, and prey species composition (Ivlev 1961; Parsons and LeBrasseur 1973) strongly affect the feeding and growth rates of pink salmon fry. High densities of chum salmon fry may cause declines of epibenthic prey populations (Healey 1979); however, it is not clear whether this is true for pink salmon that feed more on pelagic zooplankton (Cooney et al. 1981). A quantitative examination of these factors is needed to determine whether oil exposure caused reduced fry growth in 1989. Theoretical and empirical techniques will be used to address this problem. A bioenergetics model will be used to estimate the relative effects of water temperature, prey density, and prey species composition on fry growth given the conditions in 1989. The feeding rate of pink salmon fry is strongly affected by prey size (Parsons and LeBrasseur 1973). Additional measurements of prey size composition will be made on samples of fry collected from oiled and unoiled areas in 1989. Multiple regression analysis will be used to estimate relationships between environmental conditions and CWT fry growth. Residuals analysis and other diagnostic tests will be used to determine whether the growth of fry in oiled areas was different than expected given the environmental conditions in 1989.

The amount of mixed-function oxidase (MFO) activity in fish tissues is a measure of hydrocarbon exposure (Kloepper-Sams and Stegeman 1989). MFO analyses will be conducted on selected samples of untagged fry to establish the degree of oil exposure of fish in oiled and unoiled areas.

The scientific literature and experience at hatcheries suggest that pink salmon fry growth is related to fry-to-adult survival (Parker 1968; Parker 1971; Ricker 1976; Hartt 1980; Bax 1983; Nichelson 1986; Taylor et al. 1987); however, no quantitative relationship between these variables exists for PWS pink salmon. A regression equation relating mean fry growth to the fry-to-adult survival of pink salmon from specific tag lots will be estimated using data from the 1988 and 1989 broods. Data from the 1990 brood will be incorporated in the regression after the adult return in 1992. The regression equation will be used to estimate the survival of fish in oiled and unoiled areas.

OBJECTIVES

(Letters refer to goals described above)

A-1. Estimate pink salmon fry growth in oiled and unoiled areas of western PWS in 1991.

A-2. Complete an otolith microstructure analysis on all CWT fry collected in 1989, 1990, and 1991. Use the analysis to estimate fry growth during the two week time periods immediately after the fish were released and immediately prior to recapture. Estimate the 95% confidence intervals on all growth estimates.

A-3. Determine the amount of MFO activity in selected samples of fry collected in 1989, 1990, and 1991. Use the results from this analysis in conjunction with data on beach oil contamination to group samples in an analysis of variance.

A-4. Conduct an analysis of variance on fry growth during the two week time period immediately after release using otolith growth estimates from fry collected in 1989, 1990, and 1991. If significant differences (p=0.05) in fry growth are found among tag lots or years, a multiple comparison of means test will be performed.

A-5. Conduct a repeated measures analysis of variance on fry growth during the two week time period immediately prior to recapture using otolith growth estimates from fry collected in 1989, 1990, and 1991. If significant differences (p=0.05) in fry growth are found among areas or years, a multiple comparison of means test will be performed.

A-6. Conduct a multiple regression analysis to estimate the effects of oil exposure and environmental conditions on fry growth during the two week time period immediately after release. Conduct residuals analysis and other diagnostic tests to determine whether the growth of fry in oiled areas was significantly different (p=0.05) from the expected value give the environmental conditions in 1989.

A-7. Conduct a multiple regression analysis to estimate the effects of oil exposure and environmental conditions on fry growth during the two week time period immediately prior to recapture. Conduct residuals analysis and other diagnostic tests to determine whether the growth of fry in oiled areas was significantly different (p=0.05) from the expected value given the environmental conditions in 1989.

A-8. Test for differences (p=0.05) in prey composition between oiled and unoiled areas using chi-square analysis.

A-9. Test for differences (p=0.05) in stomach content weights between oiled and unoiled areas using repeated measures analysis of variance.

A-10. Use a bioenergetics model to estimate the relative effects of water temperature, prey density, and prey composition on fry growth in 1989.

B-1. Describe CWT fry migration patterns in western PWS in 1991.

B-2. Qualitatively compare CWT fry migration patterns in 1989, 1990, and 1991.

D-1. Conduct a linear regression analysis to estimate ($p=0.05$) the relationship between mean fry growth and the fry-to-adult survival of pink salmon from specific tag lots released in 1989 and 1990.

METHODS

Field Studies:

Pink salmon fry will be collected using beach and purse seines deployed from a 6 m long aluminum skiff. Sampling will begin the first week of May and extend to the end of June. A 40 m long beach seine and 70 m long purse seine will be used to capture the fish. Methods used to isolate, handle, and preserve CWT fry in 1989 and 1990 will be employed again in 1991 (Raymond and Wertheimer 1990). Samples (n=100) of untagged fry will be retained from sites where CWT fry are recovered. These samples will be preserved in 70% ethanol for later otolith analysis.

Coded-wire tags will be extracted and interrogated as they are recovered in the field. This will enable specific tag lots to be targeted. Methods developed by the ADF&G F.R.E.D. Division Tag Laboratory for extracting and interrogating coded-wire tags will be employed. Damage to the fishes' head will be kept to a minimum when dissecting coded-wire tags. The remains of the head and the body will be placed in a pre-weighed vial and frozen. The vials will be weighed later on shore when accuracies of .01 g can be obtained.

The following criteria (listed in order of priority) will be employed in making sampling decisions in the field:

1) Recover a minimum of 30 tagged fish from each tag lot.
2) Recover fish from each tag lot in at least three different areas during a single sampling period. Sampling sites where fry were collected in 1989 will be receive priority (Raymond et al. 1990).
3) Recover fish from each tag lot during at least three different sampling periods.

Approximately 60 tag codes will be used in 1991. Therefore, it will not be possible to meet each of the sampling objectives for each of the tag lots. To circumvent this problem, tag lots from the same hatchery with similar fry size and time of release characteristics will be treated as a group. Sampling criteria will initially be applied to these groups then to individual lots if time permits. Tag lots or groups having characteristics similar to important tag lots in the 1989 database will receive priority (Raymond et al. 1990).

Water temperature at 1 m depth will be measured at all sample sites using a YSI temperature meter. Temperature measurements will also be made at stations 100 m apart along 1 km long transects perpendicular and parallel to shore near important fry nursery areas (Raymond et al. 1990). A range finder and compass will be used to estimate the position of each station. At each station, measurements will be made at 1 m intervals from the surface to 10 m depth using a YSI meter. The YSI meter will be calibrated weekly with a mercury thermometer. Mercury thermometers will be calibrated in an ice bath at the beginning and end of the season. Temperature transects will be run after an extended period of calm weather and after a storm to determine the effect of wind mixing on temperature variability.

Samples of fry (n=60) will be collected from each tag lot at the Wally Noerenberg and AFK hatcheries immediately before the fry are released to estimate the mean and variance of fry body weight. These samples will be placed in 10% formalin and later weighed to an accuracy of .01 g in the laboratory. At both hatcheries, samples of CWT (n=30) and untagged fry (n=30) will be taken from each of two netpens at the same time. These samples will be used to determine if the mean and variance of fry body weight are different between CWT and untagged fry in the same netpen. Each sample taken from the netpens will be made from at least three subsamples taken at various places in the pen.

Laboratory Studies:

Otolith microstructure analysis will be used to estimate fry growth during the two week time periods immediately after release and prior to recapture. Thin sections of sagittal otoliths will be prepared using methods developed by Volk et. al. (1984). A computer image analysis system will be used to measure otolith microstructures. The number of increments and the diameter of the marine zone will be measured along at least two radius lines in the posterodorsal quadrant of each otolith. The mean of these measurements will be used in subsequent analyses.

Measurements of prey composition and stomach content weights will be taken from 16 additional samples of untagged fry collected in oiled and unoiled areas where important CWT fry samples were obtained in 1989. Thirty stomachs will be examined from each sample of untagged fry. Prey items in the following categories will be enumerated: large calanoid copepods (>2.5 mm), small calanoid copepods (<2.5 mm), harpacticoid copepods, and other. The prey biomass in each category will be estimated by multiplying the number of individuals in each category by the mean dry weight of the individuals in that category (Raymond, unpublished data). Fish used for stomach analysis will be weighed to an accuracy of .01 g before dissection.

Data Analysis:

Otolith increment formation and growth may provide a more direct assessment of effects of environmental conditions and oil exposure on fish somatic growth over time. Otolith growth analysis assumes that otolith increment formation is related to time, and that otolith growth is related to fish growth (Campana and Neilson 1985). Linear regression analyses will be conducted first to ensure that increment formation is functionally related to time and that otolith growth is related to fish somatic growth. If these relationships are significant, differences in increment formation and otolith growth among tag lots will be tested using an analysis of covariance (Neter et al. 1990). This analysis examines differences in both mean response and slope among the tag lots. The analyses will use data from all CWT fry collected in 1989, 1990, and 1991. Data from tag lots with similar means and slopes ($p=0.05$) will be combined and regression equations developed to estimate growth of CWT fry over two week time periods. Ninety-five percent confidence bands will be calculated for all growth estimates obtained from otoliths.

Analysis of variance will be used to test the hypothesis of no difference ($p=0.05$) in fry otolith growth between oiled and unoiled areas. Analyses of fry growth over the two week time period immediately after release will focus on differences among tag lots and oil exposure. Fry released from AFK Hatchery in 1989 entered oiled water while those released from other hatcheries and in other years entered unoiled water. Repeated measures analysis of variance (Winer 1971) will test differences in growth during the two week time period immediately prior to recapture. Variables in the analysis include tag lot, treatment (oil, non-oil), time period, and year. MFO analyses and other data will be used to categorize oiled and unoiled areas. Repeated measures analysis of variance is necessary because fry are recovered from the same sample sites over time. Significant differences in fry otolith growth will be examined further with a multiple comparison of means test (Zar 1974). Growth estimates from otoliths for all CWT fry collected in 1989, 1990, and 1991 will be used in this analysis.

A multiple regression analysis will be performed to determine effects of oil exposure and release conditions on fry otolith growth during the two week time period immediately after release. Data from tag lots released in 1989, 1990, and 1991 will be used in the analysis. The effects of size of release, size of fry at release, timing of release, zooplankton abundance, water temperature, and oil exposure on fry growth will be examined. Examination of residuals and other diagnostic tests will assess adequacy of the fit of the model and any violation of assumptions. Fry from AFK Hatchery in 1989 were released into oiled areas while all other fry were released into unoiled areas. Influence of data from AFK Hatchery in 1989 on regression parameter estimates will also be investigated using dummy variables (Draper and Smith 1981).

A bioenergetics model (Kimmerer et al. 1991) will be used to evaluate the relative effects of prey density, water temperature, and fry density on fry growth. Model parameters will be taken from studies on pink salmon; however, when model parameters are not available for pink salmon, parameters from other salmonids will be used. The effect of parameter uncertainty will be investigated by producing model growth estimates for the probable range of parameter values. A range of growth estimates will then be produced for the probable range of water temperature, prey density, and prey composition encountered by pink salmon fry in oiled and unoiled areas of PWS in 1989.

A linear regression analysis (Zar 1974) will be conducted to estimate ($p=0.05$) the relationship between mean fry growth and the fry-to-adult survival of fish from specific tag lots. Data from tag lots released in 1989, 1990, and 1991 will be used in the analysis. The regression equation will be used to examine possible differences between estimated and predicted survival of fry in oiled and unoiled areas in 1989.

Prey composition in the diet in 1989 will be examined using separate chi-squared tests on the proportion of stomach content weights in each of four prey categories. The analysis will test for differences ($p=0.05$) in the proportion of stomach content weights in each prey category between oiled and unoiled areas. Analysis of covariance will be used to test for differences ($p=0.05$) in stomach content weights between oiled and unoiled areas. Variables in the analysis will include treatment (oil, non-oil) and time-of-day, with fish weight as a covariate. Stomach weight will be examined to determine if a transformation of the data is needed.

Part II. Impact of the Oil Spill on Juvenile Pink and Chum Salmon and their Prey in Critical Nearshore Habitats

Lead Agency: NMFS

INTRODUCTION

Preliminary results from F/S Study No. 4 have documented effects of the EVOS on juvenile pink salmon, including exposure and hydrocarbon tissue burden, reduced growth in oiled areas, and changes in migratory behavior (Cooney 1990; Raymond 1990; Wertheimer et al. 1990). The hydrocarbon profiles of juvenile pink salmon contaminated in 1989 indicate ingestion of whole oil was the primary route of contamination. Hydrocarbons dissolved in the water column following the spill were low or undetectable (Short 1990), and thus were unlikely to have been a significant source of contamination, while sheen and mousse were common in nearshore waters of western PWS in 1989.

Zooplankton and epibenthic crustaceans are the primary prey of juvenile pink and chum salmon fry during their initial marine residency (Kaczynski et al. 1973; Cooney et al. 1981; Wertheimer et al. 1990). Oil could be ingested either directly as small particles, or indirectly via contaminated prey. Oil particles from 0.1 - 1.0 mm diameter were observed as deep as 80 m following the wreck of the tanker *Arrow* in Chedabucto Bay (Forrester 1971). In that spill, Conover (1971) found that zooplankton ingested oil particles and estimated that 20% of the oil spilled was sedimented to the bottom as zooplankton feces. Epibenthic crustaceans, such as harpacticoid copepods, may also bioaccumulate hydrocarbons from contaminated sediments.

Proposed research for continuation in 1991 is divided into two phases. The first is to complete the analysis of the data collected for juvenile salmon in 1989 and 1990 on exposure and contamination by hydrocarbons; distribution, abundance, and habitat utilization; size and growth; feeding habits; and prey abundance. Results and conclusions regarding extent and effects of oil contamination to juvenile salmon are preliminary and tentative at this time because of incomplete processing and analyses of 1990 and some 1989 data. The objectives of this phase of the project are essentially reiterations of the objectives previously defined for the NMFS component of F/S Study No. 4.

The second phase will examine the effects of ingestion of whole oil on juvenile pink salmon under controlled conditions. Most research on the effects on hydrocarbon exposure to juvenile salmon has focused on exposure to water-soluble fraction (Rice et al. 1975; Rice et al. 1984) or prey contaminated with water-soluble fraction (Schwartz 1985). There is little information on the effects of whole oil exposure to pink and chum salmon. Laboratory data on the toxicity of whole oil is needed to link evidence of ingestion with observed or speculated effects in pink salmon. Such information also will be valuable in assessing the potential for injury to other fish species utilizing the nearshore habitats and food resources exploited by juvenile pink salmon during their initial marine residency.

OBJECTIVES

(Letters refer to goals described above)

Section 1: Completion of 1989/1990 Analysis

A-1. Compare the abundance of juvenile pink and chum salmon between oiled and non-oiled areas in 1989 and 1990.

A-2. To compare distribution and habitat utilization by juvenile salmon between 1989 and 1990.

A-3. Compare sizes and growth rates of juvenile salmon between oiled and non-oiled areas in 1989 and 1990.

A-4. Quantify the feeding habits of juvenile pink and chum salmon in terms of fullness, frequency of occurrence, biomass, and Index of Relative Importance, and to compare oiled and non-oiled areas in 1990 and between 1989 and 1990.

C-1. Compare tissue contamination of juvenile pink salmon in relation to the degree of environmental contamination in the area of capture in 1989 and 1990.

C-2. Compare MFO induction in juvenile pink and chum salmon in relation to the degree of environmental contamination in the area of capture in 1989 and 1990.

E-1. Compare the abundance of epibenthic and zooplankton prey species of juvenile salmon between oiled and unoiled areas.

E-2. Compare the abundance of epibenthic prey species of juvenile salmon in relation to the degree of contamination in sediments of beaches in contaminated embayments in 1990.

Section 2. Effects of oil ingestion.

F. Determine the effects of oil ingestion on juvenile pink salmon in terms of degree of contamination (hydrocarbon tissue burden and MFO induction), survival, and growth (measured by weight gain, otolith increment, and RNA/DNA ratio).

METHODS

Phase 1: Completion of 1989/1990 Analysis

1. Sample Processing

Sample series that are incompletely processed include hydrocarbon samples of pink salmon tissue, sediments, mussels, and water; otolith increment analysis from pink salmon juveniles; epibenthic pump samples from lightly oiled and heavily oiled transects in Herring Bay; and MFO analysis of pink and chum salmon juveniles. The hydrocarbon samples have been released to the analytical laboratories through Technical Services 1, and should be complete by spring of 1991. The otolith samples are being processed by the Washington Department of Fish, and are scheduled for completion in February, 1991. The epibenthic samples are contracted for completion by August, 1991. An additional contract for completing the appropriate MFO samples will be let in March, 1991.

2. Data Analysis

The univariate approach to analysis of variance (ANOVA) of a repeated measures design (Frane 1980) will be used to analyze temperature, salinity, hydrocarbon contamination data, systematic catch data, pelagic zooplankton, and epibenthic sled and pump collections. The factors in the environmental data ANOVA are time, oil, bay/corridor, and location, with location nested in oil and bay/corridor. Three replicate observations of temperature and salinity were taken for each cell. The same design will apply to the hydrocarbon data. In the systematic catch data, the factors considered are time, oil, bay/corridor, location, and habitat, with location nested in oil and bay/corridor.

A second analytical approach to test the hypothesis of no difference in abundance of juvenile pink and chum salmon between oiled and unoiled locations will be to use the nonparametric Wilcoxon paired-ranks test (Daniel 1978). Differences in abundance between matched cells of the *a priori* pairs of oiled and unoiled locations will be compared; 56 such comparisons are possible for each species. For pink salmon, differences in abundance will also be tested separately in bays and corridors.

Based on Box-Cox diagnostic plots (Dixon et al. 1988), the biomass of zooplankton and epibenthos will be transformed prior to the ANOVA procedure by natural logarithms (ln) in order to normalize distribution and maximize variance homogeneity. For pelagic zooplankton, the factors considered in the ANOVA will be time, oil, bay/corridor, and location, with location nested in oil and bay/corridor. For the systematic epibenthic sled samples, the factors considered will be time, oil, bay/corridor, location, and habitat, with location nested in oil and bay/corridor. For the tidal transect epibenthic sled sampling, the factors are time, oil, location, habitat, and tide level, with location nested in oil. The number of species or species groups of zooplankton and epibenthic crustaceans will be used as a simple measure of diversity (Pielou 1975), and also compared using ANOVA.

Abundance, percent gravid females, and percent total harpacticoids for primary prey species of juvenile salmon will be compared using ANOVA for epibenthic pump samples from heavily oiled and lightly oiled beaches within contaminated embayments. Data from each embayment sampled with the epibenthic pump will be analyzed separately, with the transects sampled nested within contamination level. When hydrocarbon sediment data are available, the abundance of the prey will be examined as a function of the amount of oil actually found in the sediment samples.

Size and growth of juvenile salmon will be examined by comparing mean sizes, apparent growth rates, and the weight/length relationship between oiled and unoiled areas. Mean sizes of pink salmon will be also analyzed using ANOVA and the nonparametric

Wilcoxon paired-ranks test. The nonparametric approach will test only the null hypothesis that there was no difference between fish size in oiled and unoiled locations.

Apparent growth rates (change in size over time) will be calculated for each habitat type within a location using the regression of natural logarithm weight over time. Analysis of covariance will be used to determine if fish can be pooled over habitats within a sampling locations. Comparisons between oiled and unoiled locations will then be made using ANOVA, where sufficient data exists. The weight/length relationship will be used to compare the condition of juvenile pink and chum salmon between oiled and unoiled areas, as recommended by Cone (1989).

For each prey category, dry weight, dry weight as a percent of total prey weight in a stomach, standardized dry weight (dry weight as a percentage of fish dry weight), numbers, and numbers as a percent of total numbers in a stomach will be calculated for each fish. Weight of stomach contents will also be calculated as a percent of total weight for each fish. Index of relative importance (IRI, where IRI = % frequency of occurrence x (%number + %weight)) will be calculated for each habitat type by oil and bay/corridor. Minimum variance clustering of standardized dry weights will be used to identify associations among habitats, bays and corridors, and oiled and unoiled areas. Wilcoxon signed-rank test will be used to compare diet parameters between paired sets in oiled and unoiled areas.

<u>Phase 2: Oil ingestion experiment</u>

Pink salmon (*Oncorhynchus gorbuscha*) fry will be obtained from the Auke Creek Hatchery after emergence. Fry will be reared in 800 l cylindrical tanks receiving 20 lm^{-1} single-pass filtered seawater. Fry will be grown to a mean size of approximately 0.6 g on BioDiet starter feed then switched to 1 mm pellets. At this time they will be randomly allocated into three oiled treatments groups, a dichloromethane control, and untreated controls, and placed in rectangular (30 x 41 x 53 cm) tanks receiving 1 lm^{-1} seawater. There will be 3 replicate tanks per treatment, for a total of 18 tanks. Initial numbers in each tank will be 1000 fry. Feeding rates will be updated weekly, based on the estimated fry biomass in each tank. Food will be delivered by automatic feeders, supplemented by hand feeding. Lighting will be natural, and temperature will be ambient seawater: tanks will be located outdoors.

A preliminary experiment will start after the fry begin feeding to determine palatability of oiled food and how the oil behaves when the food is added to seawater. Fry size will be approximately 0.3 g, and the experiment will last one week. Observations will include feeding behavior, mortality, and slick characteristics (if any). Contamination levels of food in the preliminary test will be 0.1, 1, and 10% oil.

Food for the treatment groups will be contaminated with Prudhoe Bay crude oil. Food pellets plus oil dissolved in dichloromethane will be placed in glass flasks, then rotovaped to remove the dichloromethane. Samples will be contaminated with 0.5, 1.0, and 2.0%, perhaps up to 10% oil by weight, depending on the outcome of the preliminary experiment. Food for the dichloromethane controls will be similarly treated, except no oil will be added: other control food will not be treated. Food will be thawed shortly before use as needed to minimize possible evaporative hydrocarbon loss. Contaminated food will be analyzed periodically for hydrocarbon levels.

Lethal and sublethal effects of contamination will be evaluated. Mortality will be routinely monitored; dead fish will be removed at least daily. Sublethal effects will be measured as growth in terms of changes in mean length and weight and in terms of otolith growth and the ratio of ribonucleic acid (RNA) to deoxyribonucleic acid (DNA). Otolith increment widths and RNA/DNA ratios are growth processes that may be more sensitive over short time spans than total somatic growth (Volk et al. 1984; Barron and Adelman 1984). Formalin preserved fry tissues will be examined histologically for mixed function oxidase (MFO) induction. Tissues examined will include gills, anterior intestine/cecal epithelium, kidney, liver, heart, vertebral cord, and skeletal muscle. Condition factor will be calculated.

Before distribution to the experimental tanks, 110 fry will be subsampled randomly to establish baseline characteristics at the beginning of the experiment. Subsequent subsamples of 110 fry will be collected weekly from each replicate. To avoid oiled food in the hydrocarbon analysis, 60 fry will be collected before first feeding in the morning to ensure that food and fecal material has been voided from the gut. These fry will be frozen immediately in hydrocarbon free jars with Teflon lids for later hydrocarbon analysis. The remaining 50 fry will collected in the early afternoon (circa 1:00 pm), narcotized in MS-222, measured, blotted dry, and weighed. Twenty of these fish will be randomly selected for MFO analysis (n=10) or for possible histological/pathological examination (n=10) and placed in 10% buffered formaldehyde. Stomachs will be excised from the other 30 fry in the length-weight sample, and weighed to determine fullness as a percentage of body weight. Fifteen of these fry from each sample will also be randomly selected, white muscle will be removed from just posterior to the dorsal fin and frozen for RNA/DNA analysis, and the heads removed and stored in 95% reagent-grade ethanol for otolith analysis. Each sample will be labeled with a code identifying treatment, replicate, and fish number. Samples from week 0, 1, 3, 6 will be processed for hydrocarbons, otolith increments, and RNA/DNA; samples from week 2, 4, 5 will be held in reserve.

Concentrations of hydrocarbons in preserved fry will be analyzed by GC-MS and GC-FID using standard protocols established by Technical Services 1. Fry will be thawed and viscera will be dissected from the body. Viscera and carcasses will be analyzed separately for hydrocarbon content. MFO samples will be processed by contract with Woods Hole Oceanographic Institute.

Sagittal otoliths will be used for analysis of otolith size and increments. Using the method described by Winter (1985), the sagittal otoliths will be removed from each of the preserved pink salmon heads by removing the lower jaw and gill rakers and extracting the sagittal otoliths (visible through the clear wall of the neurocranium) with no. 5 fine-tipped forceps. The medial side of the right otolith from each of the fish will be attached to an acetate sheet and imbedded in casting resin (Schultz and Taylor, 1987). The otolith within the resin pellet will be thin-sectioned via a diamond cut-off saw to expose the plane containing the focus. The thin section of the otolith will then be lapped and polished to remove excess resin and extraneous scratches and cutting marks (Neilson and Geen 1981; Schultz and Taylor 1987). The section of otolith will either be viewed directly under a transmitted-light compound microscope or the image from the microscope will be transferred to an image enhancement and analysis system for viewing and analysis. A standard axis between the saltwater transition check and the edge of the otolith will be measured in the posterodorsal quadrant and the number of rings bisected by this axis will be counted (Wilson and Larkin 1982; Volk et al. 1984; Deegan and Thompson 1987). Incremental increase in the size of the otolith along the standard axis, the number of increments and their respective widths will be used as parameters to test for treatment effects.

The measurement of RNA and DNA will follow the methods described by Bentle et al. (1981). White muscle will be macerated with protease and incubated at 37° C with ethidium bromide for 1 hr. The sample will then be placed in a cuvette in a thermal-jacketed holder and analyzed for fluorescence intensity in a fluorometer. RNAase will then be added to the sample, the sample will be incubated for 45 minutes and then re-evaluated for fluorescence. DNAase will then be added to the sample, the sample incubated for 30 minutes, and again re-evaluated for fluorescence. The fluorescence intensities will be compared to standard curves for RNA and DNA to determine content of the nucleic acids.

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BUDGET

	ADF&G	NOAA	TOTAL
Salaries	$ 37.5	$ 65.0	$ 102.5
Travel	2.1	10.0	12.1
Contractual	76.1	40.0	116.1
Supplies	16.5	27.0	43.5
Equipment	4.2	30.0	34.2
Total	$ 136.4	$ 172.0	$ 308.4

FISH/SHELLFISH STUDY NUMBER 5

Study Title: Injury to Dolly Varden Char and Cutthroat Trout In PWS

Lead Agency: ADF&G

INTRODUCTION

The goal of this study is to compare the survival and growth of populations of Dolly Varden char (char) and cutthroat trout (trout) differentially affected by the oil spill in PWS. This will be the third year of this project. Trout and char are estuarine anadromous species that inhabit PWS (Morrow 1980). Unlike anadromous Pacific salmon, trout and char utilize nearshore and estuarine areas for feeding. Their marine migrations are not as extensive as those of Pacific salmon (Morrow 1980). Some of the most important stocks of these species inhabit areas that have been severely impacted by direct contact with oil including Green and Montague Islands and Eshamy Bay (Mills 1988). Since these species commonly live to age 8 (Morrow 1980), the potential exists for both short-term and long-term effects from exposure to oil. Study of these species is crucial in that they represent finfish species that inhabit the most oil-affected areas throughout most of their lives.

The experimental design for this program is based upon the model developed by Armstrong (1970, 1974, 1984) and Armstrong and Morrow (1980) to explain the migratory behavior of anadromous char. This model identifies two patterns of life history, fish spawned in lake systems and fish spawned in non-lake systems. For both groups, juvenile char remain in freshwater residence in their natal stream for up to four years. During their last spring of freshwater residence, they smolt to sea. During late summer or early fall, fish that were spawned in lake systems return to their natal stream to overwinter in the freshwater lake. During the spring, they again emigrate into marine waters and annually return to their natal lake system during late summer or early fall to spawn and overwinter. Fish that were spawned in non-lake systems exhibit a more complex migration. Upon smolting, juvenile char search for a lake system to overwinter. These fish then behave in the same manner as do fish that originate in a lake system except that they return to their natal stream to spawn and then return to their selected lake system to overwinter.

The migratory habits of anadromous cutthroat trout are less well understood than those of anadromous char in Alaska although it appears that they exhibit similar migratory habits to char (Jones 1982). Trout, however, spawn in the spring as opposed to fall for char.

It is hypothesized that two detrimental impacts on these species could result from the presence of large amounts of crude oil in marine waters: (1) reduced survival; and (2) reduced growth. To test whether there was a measurable impact, three stocks of trout and char that overwinter in watersheds that issue into a marine environment which has been directly exposed to oil (oiled group) and two stocks of trout and char that overwinter in watersheds that issue in unoiled areas (control group) were selected for study.

Significant changes in stock abundance, composition, or dynamics from the initial emigration of stocks within the treatment group as compared to stocks from the control group is assumed to be due to contact with the oiled marine waters. Evidence from the literature indicates that marine migrations can range up to 116 kilometers for char (Armstrong 1974) and 80 kilometers for trout (Jones 1982). Armstrong's model of migratory behavior provides the basic framework for this study. First, each of the study streams represents a stock of fish that annually homes to that specific overwintering stream. Second, since overwinter residency occurs entirely in freshwater, fish sampled during the 1989 spring emigration had not yet encountered oiled waters. Given this, the first sample from each stream (the emigration during 1989) provides the baseline data for stocks in control and treatment.

OBJECTIVES

A. Test if there is no difference in annual survival rates of char and cutthroat trout between oiled and control groups during 1989-91 and 1990-91 (the test will be done given a level of significance of alpha = 0.05).

B. Test if there is no difference in annual growth rates of char and cutthroat trout between oiled and control groups during 1989-91 and 1990-91 (the test will be done given a level of significance of alpha = 0.05).

METHODS

Trout and char were still in freshwater residence at the time of the spill, and the opportunity existed to sample these fish during their 1989 emigration prior to any potential exposure to an oiled marine environment. Data collected during 1989 became the baseline for each system. Therefore, in addition to comparisons between treatment and control, comparisons are also possible for each stream within oiled and control groups between subsequent years' data and the 1989 baseline.

Each study stream consists of a freshwater lake-river system that: (1) is a tributary to marine waters that were either impacted by large quantities of oil (oiled) or received virtually no oil (control); and (2) contains stocks of anadromous trout and char.

A weir will be installed and completely block each study stream prior to the initiation of the 1990 spring emigration. A smolt weir for sockeye salmon will operate at the outlet of Eshamy Lake as part of F/S 3. Sampling for char and trout will be conducted in conjunction with this project.

During the spring sampling, weirs will be used to count and sample the emigration of trout and char from study streams. Weirs will be installed approximately 0.5 km upstream from the saltwater terminus of the streams. The weirs will be operated by a two-person crew from mid-April to early-July. Downstream live traps will be installed.

All fish captured in the trap will be examined for presence or absence of tags, tag scars, and adipose fins. Each fish containing a tag from 1989, a tag scar, or missing its adipose fin will be considered one recapture event. Recaptured fish with missing tags will be retagged. Fish with no visible tag scar and containing their adipose fin (not tagged in 1989) will also be tagged. Each fish captured will be identified, counted, and measured (tip-of-snout to fork-of-tail to the nearest mm). Scale smears will be collected from the preferred area from all cutthroat trout and placed individually on acetate slides in coin envelopes. Date, species, sex (if identifiable from external maturation characteristics), and length will be recorded for each fish. Recapture events will be recorded separately for fish containing tags and fish with missing tags. Tag numbers will be recorded for each recapture and each fish tagged.

All fish found dead impinged on the weir or in the live box will be examined for presence of tags and adipose fins, identified, and measured as outlined above. Sex and maturity will be determined by internal examination, and sagittal otoliths will be collected. Date, species, sex, length, maturity, and tag number will be recorded. Fish containing tags, tag scars or missing adipose fins will be recorded as recaptures.

Estimates of annual survival will be computed for each study site through analysis of tag returns. If all emigrating fish can be examined for marks, the estimates of annual survival (S) can be simply computed as:

$$S = m_2/R_1$$

where:

m_2 = number of fish recovered in year y+1
R_1 = number of fish tagged in year y.

If the weir holds, the hypothesis of equal survival between oiled and control sites will be tested using contrast within a multinomial analysis of variance (Woodward et al. 1990). Char and trout of different sizes suffer different mortality rates (Armstrong 1974; Sumner 1953) so the size structure of different populations will be examined and controlled in the analysis if necessary.

Jolly-Seber three-sample method (Seber 1982) will be used in the event that each emigrating fish cannot be examined at the weirs. Buckland's program RECAP (1980) will be used to generate the estimates and variances. The 95% confidence intervals around the survival estimates will be compared to tests for significant differences between oiled and control sites.

Annual individual growth will be calculated from the tag data as the difference between length at time of release and length at time of recovery. At each site, a box plot will be constructed for the growth values, and observations more than 1.5 interquartiles away from the box edge will be considered recording errors and not used in the analysis. An analysis of variance will be used to test for significant differences in growth between fish from control and oiled groups. Variation due to differences in years and initial length can be controlled through the use of a block and covariate in the linear model if necessary. The power to detect a 5% difference in the growth rate of fish from treatment and control areas is estimated to be 90%.

The assumptions of analysis of variance are:

1. random sample,

2. normal distribution, and

3. homogeneity of variance.

The assumption of normality will be tested using Kolomogorov's D statistic. If the data is not normally distributed then a logarithmic or a rank transformation will be necessary.

The homogeneity of variance assumption will be tested with a Bartlett's test. Again, if the assumption is not valid, a transformation will be used.

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BUDGET

Salaries	$ 230.9
Travel	10.4
Contracts	55.8
Supplies	28.0
Equipment	0.0
Total	$ 325.1

FISH/SHELLFISH STUDY NUMBER 11

Study Title: Injury to PWS Herring

Lead Agency: ADF&G

INTRODUCTION

The oil spill in PWS coincided with the annual migration of Pacific herring (*Clupea harengus pallasi*) to near-shore spawning areas. In 1989, a significant portion of the spawning area in PWS was located within areas contaminated by oil. Additionally, adult spawning herring and newly hatched juveniles traversed areas impacted by oil and beach cleaning activities.

It was hypothesized that the oil spill would adversely impact adult fish through direct mortality, food shortages, slowed growth, and a possible reduction in fecundity. In addition, herring eggs have been shown to be particularly susceptible to hydrocarbon contamination due to the affinity of hydrocarbon compounds for yolk sac material. Impacts on egg mortality, egg hatching success, and percent viable hatch have the capacity to reduce the abundance and availability of herring. Adult and juvenile herring, as well as herring eggs, often form an important item in the diet of marine fishes (e.g. salmon and halibut), mammals (e.g. sea lions, seals, and whales), and birds (e.g. cormorants, ducks, puffins, gulls). Herring also support an important commercial fishery within PWS, worth approximately 12 million dollars in 1988 and 9 million dollars in 1990.

The goal of this project is to determine whether the EVOS will have a measurable impact on populations of herring in PWS. Accurate and precise estimates of population abundance, age structure, weight, and length composition data are needed to accomplish this goal. In addition, the direct effects of oil contamination on spawning success and egg and larval survival will be determined.

OBJECTIVES

A. Expand the normal sampling of the herring population in PWS to increase the precision of herring abundance, age composition, weight, sex ratio, and fecundity estimates. Specifically we intend to:

   1. Estimate the biomass of the spawning stock of herring in PWS during 1991 such that the estimate is within ± 25% of the true value 95% of the time.

2. Estimate the age, weight, length, and sex (AWLS) composition of herring in PWS during 1991 such that age composition estimates are within ± 10% of their true values 95% of the time.

B. Document the occurrence of herring spawn in oiled and unoiled areas, validating the sites with quantified oil level information obtained from shoreline survey maps and hydrocarbon analyses of 1989, 1990, and 1991 herring eggs and mussel tissue.

C. Estimate hydrocarbon contamination of, and physiological impacts on, adult herring by analyzing tissue samples.

Test the hypothesis that the level of hydrocarbons in herring tissues is not related to the level of oil contamination of the area from which the herring were sampled. The experiment is designed to detect a difference of 1.6 standard deviations in hydrocarbon content with the probability of making a type I and type II error of 0.05 and 0.1, respectively.

D. Estimate the presence and type of damage to tissues and vital organs of herring sampled from oiled and unoiled areas.

Test the hypothesis that the level of hydrocarbons in herring eggs is not related to the level of oil contamination of the area from which the herring were sampled. The experiment is designed to detect a difference of 1.6 standard deviations in hydrocarbon content with the probability of making a type I and type II error of 0.05 and 0.1, respectively.

E. Estimate the proportion of dead herring eggs in oiled and unoiled areas from a subsample of study sites that were utilized in the 1989 and 1990 egg mortalities study, expanding the data base and providing sample sites for sample collection of live and preserved eggs.

Test the hypothesis that the proportion of dead herring eggs is not related to the level of oil contamination of the area from which the herring were sampled.

F. Estimate the hatching success, viable hatch, occurrence of abnormal larvae, and collect embryonic and larval tissue for sublethal testing including cytogenetics, MFO analysis, and histopathological analyses by collecting herring eggs and rearing them in field and under laboratory observation.

Test the hypothesis that hatching success, viable hatch, and occurrence of abnormal larvae are not related to the level of oil contamination of the area from which the herring were sampled.

G. Estimate the number (proportion) of eggs removed from the spawning areas (due to wave action or predation) between the time of egg deposition (spawning) and the time of hatching.

METHODS

This project will be conducted in three parts: (1) herring spawn deposition estimation, (2) herring age, weight, length, growth, and fecundity estimation, and (3) herring egg survival and egg loss estimation.

Herring Spawn Deposition Estimation

The management of the PWS herring stock is based on a harvest policy established by the Alaska Board of Fisheries which specifies a maximum 20% exploitation rate for the combined harvest of all herring fisheries. The allowable harvest is based on biomass estimates established the previous year modified by the expected growth and survival over the year. While aerial surveys were used to estimate biomass from 1973-87, spawn deposition surveys were performed in 1983 (Jackson and Randall 1983) and 1984 (Jackson and Randall 1984), and were the primary biomass estimate starting in 1988 (Biggs and Funk 1988). Aerial surveys are easier to perform than spawn deposition surveys, but aerial survey biomass estimates are not as reliable because of the varying visibility of herring schools from the air and the unknown residence time of herring schools on the spawning grounds. In addition, estimates of precision are not available for aerial survey biomass estimates. The ADF&G continues to conduct an annual aerial survey of spawning biomass to provide in season indicators of run timing and distribution of spawning activity. This information is used for planning the spawn deposition survey.

This project represents an augmented program to assess the PWS herring stock's response to the EVOS. The original goal of the 1989 herring spawn deposition survey was to estimate the spawning biomass with a precision such that the biomass estimate would be within ± 25% of the true biomass estimate 95% of the time under optimal survey conditions. Fishery managers determined that this level of precision was acceptable for estimating exploitation rates and forecasting future abundance. If weather or other logistic problems hampered the spawn deposition survey sampling effort, fishery managers were willing to tolerate reduced precision. The EVOS introduced a potentially new and unknown level of mortality on herring stocks. The accuracy and precision of estimates of stock abundance need to be assured from both oiled and unoiled areas (as reflected in objectives A1 and A2). The opportunity to estimate herring biomass with spawn deposition surveys is only available during a relatively narrow two week window. After the oil spill, the number of divers involved in the survey was increased to assure that even if weather problems restricted the available sampling time, sufficient numbers of transects could still be performed. The number of transects was also increased to provide a level of precision such that the biomass estimate would be within ± 25% of the true biomass 95% of the time.

The aerial survey project will provide a map indicating the general location of herring spawning areas. Transects will be placed perpendicular to the shoreline at locations selected randomly from the shoreline maps of spawning areas. Divers will swim along the transects and systematically place 0.1 m^2 quadrants at 5 m intervals. Divers will estimate the total number of eggs in each quadrant. All egg-containing vegetation will be removed from a subset of the quadrants for later enumeration of the number of eggs in a laboratory procedure. These enumerated egg counts will be used to correct bias in diver-estimated egg counts and estimate the precision of the diver estimates. The survey design is described in detail by Biggs and Funk (1988), and follows closely the two-stage sampling design of similar surveys in British Columbia (Schwiegert et al. 1985), and in southeast Alaska (Blankenbeckler and Larson 1982, 1987). The surveys use random sampling at the first stage (transects), and systematic sampling at the second stage (quadrants within transects). Random sampling in the second stage is not feasible because of underwater logistical constraints (Schwiegert et al. 1985). In addition to the two-stage design, the survey is stratified by five areas within PWS (southeast, northeast, North Shore, Naked Island, and Montague Island) because of the geographic separation of these areas and the potential for herring in these areas to be discrete stocks.

Mean egg densities along each transect will be combined to estimate an overall average egg density. The observed widths of the spawning bed along each of the transects will be used to estimate the average spawning bed width. The average width, average density, and total spawning bed shoreline length will be used to estimate the total number of eggs deposited in each of five area strata established within PWS. Using the average fecundity and sex ratio derived from the AWLS sampling portion of this project, the total number of eggs deposited will be converted into population numbers and biomass. Based on the variances obtained during the 1989 and 1990 surveys, 160 transects will be needed to insure that the estimated biomass would have a 95% chance of being within 25% of the true biomass. (161 and 160 transects were conducted in 1989 and 1990 and the resulting biomass estimates had a 95% chance of being within 19% and 23%).

Sampling Procedure:

The general locations of spawning activity will be derived from visible milt observed in the water column during scheduled aerial surveys. This information will be compiled and summarized on maps showing spawning locations and the number of days on which milt was observed.

Using this information, skiff surveys will be conducted in season, by members of the spawn deposition dive team, to verify the accuracy of spawning area maps derived from aerial survey data. Diving where herring have spawned is not recommended for at least 5 days after spawning activity has ceased because of water visibility problems caused by milt and because large numbers of sea lions are usually present.

The shoreline area containing herring spawn on the map, verified by skiff survey, will be divided into the smallest segments resolvable on the scale of the map (0.1 mile). A total of 160 of the shoreline segments will be proportionally allocated to each of five major areas (southeast, northeast, North Shore, Naked Island, and Montague Island) based upon the number of miles of spawn in each major area. For example, if the northeast area contains approximately 25% of the spawn in all five areas, then 25% or 40 of the 160 transects will be placed in the northeast area. Transects will be selected at random from all of the spawn-containing shoreline segments within each area. Each transect will be assigned a number and its location drawn on waterproof field maps that can be taken out in the dive skiff. The dive team leader will determine the exact transect location within the randomly selected shoreline segment by identifying a shoreline feature (tree, rock, cliff, etc.) located above the high tide line as the dive skiff approaches the shore, but before bottom profiles, bottom vegetation, or herring spawn are visible from the skiff.

A 0.1 m^2 quadrant constructed of PVC pipe will be used for the sampling frame. A depth gauge and compass will be fastened to the quadrant. Data will be recorded on pre-printed single matte mylar forms attached to PVC clipboards, using a large weighted carpenter's pencil attached to the clipboard. Normally the dive team leader will make egg density estimates and record data while the assistant diver sets and follows the compass course, measures distances, and carries and places the quadrant.

Sampling along the transects will occur in the following manner:

1. A compass course perpendicular to the shoreline at the transect location will be set on the compass attached to the sampling quadrant.

2. The first quadrant will be placed within the first 5 m of spawn by tossing the quadrant.

3. The lead diver will estimate and record the number of eggs in the quadrant. The number of eggs is normally

recorded in units of thousands. The vegetation type, percent cover, substrate, and depth are also recorded.

4. The assistant diver will measure four complete 1 m hand-spans offshore, along the compass course. Halfway through the fifth hand-span, the assistant diver will gently toss the quadrant ahead approximately one-half meter and allow it to come to rest. The lead diver then makes another estimate at the new quadrant location.

5. This process continues every 5 m until the apparent end of the spawn is found. Divers will verify the end of the spawn by swimming at least an additional 20 m past the end of the spawn, unless a steep drop-off is encountered.

Data codes have been developed for the vegetation types and species that are encountered in PWS. If more than one is present in the quadrant sampled, the three most common are recorded on the data forms. Percent cover is a simple estimate of the percentage of plant cover that exists within the quadrant sampled (e.g., if half the area is covered, the cover is 50%).

Approximately every fifth quadrant will be used as a special diver calibration sample. Both divers will estimate the number of eggs in the quadrant in a manner such that neither can see the other's estimate. Divers will attempt to remove all egg-containing vegetation and scrape eggs off rock substrate, placing the material in numbered mesh bags. A sample size goal of 80 calibration samples per diver was established, including 20 in each of four vegetation categories (eelgrass, fucus, large brown kelp, hair kelp), based on 1988, 1989, and 1990 survey results. Calibration samples should also be spread over a wide range of egg densities. The spawn deposition project leader will track the number of samples collected by each diver by vegetation group and density to ensure that sufficient calibration samples are taken in each category. Upon completing a dive shift, calibration sample material will be removed from the numbered mesh bags and placed in Nalgene Ziploc bags. Gilson's solution will be poured over the sample so that all material is completely immersed. A label will be made for each sample (preferably in pencil on mylar) containing the transect number, both diver's estimates, date, and vegetation type. Five or 6 calibration sample bags can be stored in a 5 gallon plastic bucket. Samples should not be stacked over one another to prevent spilling and mixing. Procedures for the enumeration of the number of eggs in each calibration sample are described, including the formulas used to prepare Gilson's solution and the other chemicals used for sample processing.

Data Analysis:

Biomass Estimation

The 1991 spawn deposition survey will conform with the 1988-1990 spawn deposition surveys in PWS (Biggs and Funk 1988). The overall biomass estimator is:

$$B = \frac{(T \cdot B')}{(1 - R)}, \tag{1}$$

where,

B = estimated spawning biomass in tonnes,
T = estimated total number of eggs (billions) deposited in an area,
B′ = estimated tonnes of spawning biomass required to produce one billion eggs, and
R = estimated proportion of eggs disappearing from the study area from the time of spawning to the time of the survey (egg loss).

The estimates for T and B′ are derived from separate sampling programs and are thus independent. Ignoring the unknown variability in R, the estimated variance for the product of the independent random variables T and B′, conditioned on R is:

$$\mathrm{Var}(B|R) = \frac{[T^2\mathrm{Var}(B') + B'^2\mathrm{Var}(T) - \mathrm{Var}(T)\cdot\mathrm{Var}(B')]}{(1-R)^2}, \tag{2}$$

where,

Var(B′) = an unbiased estimate of the variance of B′, and
Var(T) = an unbiased estimate of the variance of T (Goodman 1960).

The total number of eggs deposited in an area is estimated from a two-stage sampling program with random sampling at the primary stage, followed by systematic sampling at the secondary stage, using a sampling design similar to that described by Schwiegert et al. (1985). In computing variances based on the systematic second stage samples it is assumed that eggs are randomly distributed in spawning beds with respect to the 0.1 m^2 sampling unit. While this assumption was not examined, in practice the variance component contributed by the second sampling stage was much smaller than that contributed by the first stage, so that violations of this assumption would have little effect on the overall variance. The total number of eggs (T), in billions, in an area is estimated as:

$$T = N \cdot \hat{y} \cdot 10^{-6}, \tag{3}$$

where,

N = $L/\sqrt{0.1}$ = the total number of possible transects,
L = the shoreline length of the spawn-containing stratum in meters,
$\sqrt{0.1}$ = 0.3162 m = width of transect strip,
$\hat{y}$ = average estimated total number of eggs (thousands) per transect, and
10^{-6} = conversion from thousands to billions of eggs.

The average total number of eggs per transect strip (in thousands) is estimated as the mean of the total eggs (in thousands) for each transect strip using:

$$\hat{y} = \frac{\sum_{i=1}^{n} \hat{y}_i}{n}, \tag{4}$$

where,

$\hat{y}_i = M_i \cdot \bar{y}_i$,

$\bar{y}_i$ = average quadrant egg count in transect i (in thousands of eggs),
i = transect number,
M_i = $w_i/\sqrt{0.1}$ = number of possible quadrants in transect i,
w_i = transect length in meters, and
n = number of transects actually sampled.

The average quadrant egg count within a transect, $\bar{y}_i$, is computed as:

$$\bar{y}_i = \frac{\sum_{j=1}^{m_i} y_{ij}}{m_i}, \tag{5}$$

where,

j = quadrant number within transect i,
m_i = number of quadrants actually sampled in transect i, and
y_{ij} = adjusted diver-estimated egg count (in thousands of eggs) from the diver calibration model for quadrant j in transect i.

The variance of T is similar to that given by Cochran (1963) for three stage sampling with primary units of equal size, although in this case the expression is modified because the primary units (transects) do not contain equal numbers of secondary units (quadrants), and the variance term for the third stage comes from the general linear model used in the diver calibration samples:

$$Var(T) = N^2(10^{-6})^2[\frac{(1-f_1)}{n} \cdot s_1^2 + \frac{f_1(1-f_2)}{\sum_{i=1}^{n} m_i} \cdot s_2^2 + \frac{f_1 f_2}{\sum_{i=1}^{n} m_i} \cdot s_3^2], \qquad (6)$$

where,

$$s_1^2 = \frac{\sum_{i=1}^{n}(\hat{Y}_i - \hat{Y})^2}{n-1} = \text{variance among transects},$$

$$s_2^2 = \sum_{i=1}^{n} M_i^2 \sum_{j=1}^{m_i} \frac{(y_{ij} - \bar{y}_i)^2}{n(m_i-1)} = \text{variance among quadrants},$$

$s_3^2 = \sum_{i=1}^{n} \sum_{j=1}^{m_i} Var(y_{ij})$ = sum of the variances of the individual predicted quadrant egg counts from the diver calibration model,

$f_1 = \frac{n}{N}$ = proportion of possible transects sampled, and

$f_2 = \frac{m_i}{M_i}$ = proportion of quadrants sampled within transects (same for all transects).

Diver Calibration:

Diver observations of vegetation species will be aggregated into four vegetation categories based on structural and phylogenetic similarities of plants in the quadrant: eelgrass, fucus, hair kelp, and large brown kelp. Diver estimates of egg numbers are approximately proportional to laboratory-enumerated counts, but systematic biases in the diver estimates can be accounted for by vegetation type and density (Biggs and Funk 1988). Individual diver effects were not significant in the 1988 and 1989 survey, but potential differences among individual divers will be examined. The basic form of models used to account for biases in diver observations is:

$$Y_{ijk} = e^{\alpha} \cdot e^{D_j} \cdot e^{V_k} \cdot X_{ijk}^{\beta_{jk}} \cdot e^{\epsilon}, \qquad (7)$$

where,

α = a constant,
D_j = parameters representing the effect of j^{th} diver,
V_k = parameters representing the effect of the k^{th} vegetation type,
β_{jk} = parameters controlling the functional form of the relationship between the diver estimate and laboratory-enumerated egg count for diver j in vegetation type k,
Y_{ijk} = the i^{th} laboratory egg count in the vegetation-diver stratum jk,
X_{ijk} = the i^{th} diver estimate in vegetation-diver stratum jk, and
ϵ = a normally distributed random variable with mean 0 and variance σ^2.

A multiplicative-effect model is chosen because relative estimation errors are expected to change with egg density. The distribution of laboratory-enumerated egg counts for a given diver estimate was positively skewed in the 1988 and 1989 surveys (Biggs and Funk 1988, Biggs in press), so that the logarithmic transformation used to estimate the parameters of the multiplicative-effect model also stabilized the variance and corrected the skewness of the egg density estimates. After a logarithmic transformation, model 7 becomes:

$$\log_e(Y_{ijk}) = \alpha + D_j + V_k + \beta_{jk}\cdot\log_e(X_{ijk}) + \epsilon \qquad (8)$$

where, β_{jk} = the slope of the relationship between the logarithm of the diver estimate and the logarithm of the laboratory-enumerated egg count.

In logarithmic form, the model comprises a linear analysis of covariance problem with two factor effects (vegetation and diver) and one covariate (diver-estimated egg number). The SAS Institute Inc. (1987) procedure for general linear models will be used to obtain least squares estimates of parameters and evaluate variance components. In addition to the two factor effects and one covariate, terms for diver-vegetation group interactions, density-vegetation group interactions and density-diver interactions will be considered in the analysis of covariance. Three-way and higher level interaction effects will not be considered because the objective is to derive a simple model with a relatively small number of parameters. Backward stepwise procedures will be used to determine subsets of the six effects that explain the maximum amount of variability in the data with the smallest number of parameters. During the backward stepwise procedures, effects will be included or eliminated from the model based on the probability level of F ratios for partial sums of squares.

Translation of the predicted values from the logarithmic model, equation (8), back to the original scale, equation (7), requires a correction for bias. The bias in the expected value of Y_{ijk} is $\exp(\frac{1}{2}\sigma^2)$ when the true variance of Y_{ijk}, σ^2, is known. Laurent (1963) gives an exact expression for the bias correction that incorporates additional terms when σ^2 is estimated from a sample. For the diver calibration data, the biases in estimating σ^2 from a sample were less than 0.05% (Biggs and Funk 1988), so expected values for Y_{ijk} are estimated from:

$$E(Y_{ijk}) = e^{\alpha} \cdot e^{D_j} \cdot e^{V_k} \cdot X_{ijk}^{\beta_{jk}} \cdot e^{\frac{1}{2}s^2}, \qquad (9)$$

where, s = the mean squared error from the general linear model. The variance of individual predicted Y_{ijk} is estimated from:

$$Var(Y_{ijk}) = [e^{(2Y_{ijk} + \sigma^2)}] \cdot [e^{\sigma^2} - 1] . \qquad (10)$$

Although the above expression is appropriate when σ is known (Laurent 1963), s is assumed to be an unbiased estimate of σ for the 1990 study since only a small bias was introduced into estimates of the mean when s was used to estimate σ in past years (Biggs and Funk 1988).

Spawning Biomass per Billion Eggs (B′)

Catch sampling programs will be used to estimate the relationship between spawning biomass and egg deposition. The tonnes of spawning biomass required to produce one billion eggs (B′) will be estimated as:

$$B' = \frac{\overline{W} \cdot \overline{S}}{F(\overline{W}_f)} \cdot 10^3 , \qquad (11)$$

where,

$\overline{W}$ = estimated average weight in grams of all herring (male and female) in the spawning population in an area,

S = estimated ratio of total spawning numbers (male and female) to female spawning numbers,

$\overline{F}(W_f)$ = estimated fecundity at the average weight of females in the spawning population in an area, in numbers of eggs, and

10^3 = conversion factor = $\dfrac{10^{-6}}{10^{-9}} = \dfrac{\text{grams to tonnes}}{\text{eggs to billions}}$.

Estimates of average weight, sex ratios, and fecundities are not independent. The variance of B′ is approximately:

$$\begin{aligned}\mathrm{Var}(B') = (10^3)^2 \{ & [S/F(\overline{W}_f)]^2 \,\mathrm{Var}(\overline{W}) \\ & + [\overline{W}/F(\overline{W}_f)]^2 \,\mathrm{Var}(S) \\ & + [\overline{W}S/F(\overline{W}_f)^2]^2 \,\mathrm{Var}(F(\overline{W}_f)) \\ & + 2\mathrm{Cov}(\overline{W},S)\; [S/F(\overline{W}_f)]\; [\overline{W}/F(\overline{W}_f)] \\ & - 2\mathrm{Cov}[\overline{W},F(\overline{W}_f)]\; [S/F(\overline{W}_f)]\; [\overline{W}S/F(\overline{W}_f)^2] \\ & - 2\mathrm{Cov}[S,F(\overline{W}_f)]\; [\overline{W}/F(\overline{W}_f)]\; [\overline{W}S/F(\overline{W}_f)^2] \}. \qquad (12)\end{aligned}$$

The covariance terms containing S, $\mathrm{Cov}(\overline{W},S)$ and $\mathrm{Cov}[S,F(\overline{W}_f)]$, will not be included in the estimate for 1990. These terms were not included in the estimate of Var(B′) in 1988, 1989, and 1990 because S was estimated from either the same pooled AWL samples or from a single AWL sample. However, $\mathrm{Cov}(\overline{W},S)$ and $\mathrm{Cov}[S,F(\overline{W}_f)]$ probably contribute a small amount to Var(B′) since the term involving $\mathrm{Cov}[\overline{W},F(\overline{W}_f)]$ was very small in 1988, 1989, and 1990.

Correction for Egg Loss:

The only component needed for the biomass estimate that has not been estimated within the present study is egg loss (the proportion of eggs disappearing from spawning areas between the time of spawning and the time of surveys). Before the extensive use of SCUBA diving to survey herring egg deposition, estimates of egg loss were considered to be relatively high. Montgomery (1958) estimated that egg loss was 25 to 40% for southeast Alaska, and Blankenbeckler and Larson (1987) used similar estimates in their early egg deposition surveys in southeast Alaska. However, Haegele et al. (1981), conducting diving surveys in British Columbia, argued that egg loss was only about 10%. They based this assumption on the fact that most spawn was deposited in the subtidal zone where egg loss, primarily due to predation and wave loss, was probably less than had been observed in the intertidal zone. Presently, egg loss is assumed to be 10% in British Columbia, southeast Alaska and PWS since the timing of diving surveys in relation to spawning has been standardized among these areas (W. Blankenbeckler, ADF&G, Ketchican, pers. comm.; Biggs and Funk 1988).

Herring Age, Weight, Length, Growth and Fecundity Estimation

Mean Weight and Sex Ratio:

Mean weight and sex ratio will be estimated from AWLS samples collected from the commercial catch and ADF&G test fishing conducted before or after commercial openings. AWLS samples will be collected from the spawning population in each of the spawn deposition summary areas (southeast, Valdez Arm, North Shore, Naked Island, and Montague Island). The approximate timing of peak herring spawning in each summary area will be determined from aerial survey sightings of milt and herring schools. All herring AWLS samples taken during the time of peak spawning in each area will be pooled to obtain estimates of mean weight and sex ratio for each summary area. Mean weights and sex ratios for all of PWS will be estimated as the average of the estimates from each of the areas weighing by the spawn deposition biomass estimate in each area.

The estimated sex ratio, S, is expressed as the ratio of the number of herring of both sexes in the AWL samples to the number of females. The binomial distribution will be used to estimate the proportion of females, p, in samples, where $S = 1/p$. The variance of S is then given by:

$$Var(S) = \frac{S^2(S-1)}{n}, \tag{13}$$

where, n is the number of herring in the AWL sample.

Commercial and test fishing catches will be sampled for AWLS, fecundity, and roe maturity information. These data will be used to estimate spawning biomass and spawn deposition, forecast herring returns, and evaluate effects of the oil spill on survival. Information on fecundity, mean weight of females, and sex ratio are also important components of the spawn deposition biomass estimator. AWLS sampling will be intensified in 1991 to increase the precision of biomass estimates and, therefore, enhance the possibility of detecting oil spill impacts upon herring stocks.

Sampling will begin as soon as concentrations of herring appear in nearshore areas that can be sampled with purse seine gear. Efforts will be made to sample major concentrations of herring throughout PWS at periodic intervals throughout the spawning period. The major objective of this portion of the study will be to determine the age, sex, and size composition of all major herring concentrations in the general areas including southeast area, northeast area, North Shore area, Naked Island, and Montague Island. Results of the aerial survey program will be used to direct test fishing efforts within each area.

Each week during the sampling period, early April through early May, six to eight samples of herring will be collected through test fishing or from the commercial catch. A sample of 403 herring is needed to simultaneously estimate the proportion of at age of a multinomial population such that 95% of the time the estimated proportions will be within ± 10% of the true proportions (Thompson 1987). Therefore, efforts will be made to obtain samples consisting of approximately 450 herring to allow for the occurrence of unreadable scales (usually less than 5% of the sample). Herring samples will be flown from the fishing grounds each day to Cordova for processing. Augmentation of the standard AWL sampling program will be needed to collect sufficient samples for hydrocarbon analyses, fecundity estimates, and oocyte loss measurements. All AWL data will be collected using personnel and funding from the standard (i.e. non-oil spill related) AWL sampling program conducted by ADF&G within PWS.

The following data will be collected for each herring sampled:

1. sex (determined by examination of gonads);
2. standard length (in mm);
3. weight (in grams);
4. age (determined by examination of scales);
5. capture information (date of capture, fishing district, subdistrict, local name for the location, fishing vessel name, gear type);
6. herring number on data form; and
7. data form number.

Fecundity:

Additionally, a subsample of herring will be collected to estimate fecundity. The average fecundity at the average female weight ($F(W_f)$) from expression (11) is a component of the spawn deposition survey biomass estimator. The spawn deposition survey attempts to estimate spawning biomass so that the 95% confidence interval is within ± 25% of the actual biomass estimate. If fecundity sampling is to contribute no more than 1% to the confidence interval width, a sample of 85 females of exactly the average weight of females in the spawning population is needed. Since average female weight is unknown at the time of sampling, more herring must be sampled over a range of sizes. Based on the precision of 1989 fecundity sampling, a sample size of 130 herring would be needed to provide the desired level of precision. An additional 100 samples clustered around the mean size of females in 1991 will be taken to compare with the past year's data. The mean weight of a female in the fecundity sample in 1990 was 131 grams. The predicted average weight for the population in 1990 is 155 grams, which translates to an average predicted length of 230 to 240 mm. Therefore, sampling clustered about the 220 mm to 240 mm length classes is desirable.

Effects of the oil spill on fecundity will also be examined by testing for differences in fecundity among five areas: (1) southeast shore including Simpson and Sheep Bays, Port Gravina, and Port Fidalgo; (2) northeast shore including Valdez Arm and Tatitlek Narrows; (3) North Shore; (4) Naked Island; and (5) Montague Island. While extensive mortality of adult herring from the oil spill has not been documented, it is possible that sublethal stresses could result in reduced fecundity.

Herring fecundity samples will be collected concurrently with AWL samples. To accomplish this, at least five individual test purse samples will be subsampled. Females within these purse seine samples will be randomly selected within 10 mm length classes until stratum goals are reached. The roe sacs from each selected female herring will be removed and placed in a Ziploc bag labeled with the AWL number corresponding to that female. Each individually packaged roe sample will then be placed in a larger plastic bag labeled with the sample date and location. Standard laboratory procedures have been developed to process fecundity samples.

Samples for hydrocarbon analyses will also be obtained from herring collected at each of the four locations (Naked Island, Galena Bay, Cedar Bay, and Stockdale Harbor):

1. three gut samples for hydrocarbons;
2. three viscera samples for hydrocarbons;
3. three muscle samples for hydrocarbons; and
4. three gonad samples for hydrocarbons.

General observations on the prevalence of nematodes, liver and gall bladder condition, and fullness of gut will also be made for each herring collected for hydrocarbon analyses. Standard protocol, including sample sizes and collection strata, for collecting herring eggs for hydrocarbon analyses will be followed.

In addition to the 500 ovaries collected for fecundity analysis, 50 ovaries will be collected and preserved in a buffered formalin solution for oocyte loss measurements. An additional 25 preserved ovaries will be obtained from Sitka Sound, southeast Alaska, for use as a control. Atretic eggs and histopathological damage in the sac roe of the adult herring will be recorded during oocyte loss observations.

A linear relationship was found between fecundity and weight for herring samples collected in 1988, 1989, and 1990 (Biggs and Funk 1988). In 1991, the fecundity-weight relationship will again be examined using data pooled across all areas. Average fecundity for each area will be estimated from the fecundity-weight relationship using the average female weight from each area. The average fecundity for each area will then be applied to the spawn deposition biomass estimator ($F(\overline{W}_f)$) in expression (11). The variance of estimated average fecundities will be approximated using the variance of predicted means from the fecundity-weight linear regression (Draper and Smith 1981):

$$Var[F(\overline{W}_f)] = s_2[\frac{1}{n} + \frac{1}{q} + \frac{(\overline{W}_f - \overline{WF})^2}{\sum(W_i - \overline{WF})^2}], \qquad (14)$$

where,

s^2 = residual mean square from the fecundity-weight linear regression,
$\overline{W}_f$ = average weight of female fish in the spawning population,
$\overline{WF}$ = average weight of females in the fecundity sample,
W_i = weight of individual females in the fecundity sample,
n = total number of females in the fecundity sample, and
q = total number of females in the AWL sample.

General Linear Model (GLM) extensions of linear ANOVA techniques will be used to test for year and area effects in growth and fecundity.

Egg Survival Study:

Oil contamination of herring spawning sites and exposure of spawning herring to oil may cause mortality to herring eggs, decrease hatching success, reduce larval viability, and impair larval growth. The major objective of this portion of the study will be to measure immediate, easily observable mortality of herring eggs in a subsample of the sites used in 1989. In 1991, nine sites will be used to conduct the egg loss study, collect hydrocarbon samples, collect live eggs for the laboratory portion of the study, and gather samples for sublethal impact testing.

Three study transects will be re-established in each of three areas used during 1989 and 1990 (assuming those areas receive spawn in 1991): Naked Island, Fairmont Bay, and Rocky Bay on north Montague Island. The ratio of live to dead eggs will be determined along each transect from subsamples of 100 eggs. Dead eggs turn an opaque white color and are easily identified with low power magnification under a binocular microscope. Mussel tissue samples will also be collected for hydrocarbon analysis.

Divers will establish the location of mean lower low water (MLLW) at the start of each dive. Each dive team will attempt to sample three transects each day. Each transect will be sampled every two days until most herring eggs have hatched (about 20 May). A total of twelve to sixteen dives will be made along each transect over the course of egg development.

The location of each transect will be marked. Divers will work along transects by following a compass course set perpendicular to shore. During the first dive, five sample stations at the +1, 0, -5, -15, and -30 foot depths will be marked underwater with weighted floats anchored by a spike. Station depths, corrected for tide stage, will be determined using diver's depth gauges. Three samples of vegetation containing at least 100 eggs will be collected at each depth along the transect whenever possible.

The following data will be recorded the first time each transect is sampled:

1. transect number;
2. site description (location, exposure, plant community);
3. number of depth strata from which herring eggs were obtained; and,
4. original treatment category (high, medium, low, or no oil-impact).

The following data will be recorded every time each transect is sampled:

1. transect number and location;
2. date;
3. dive time;
4. treatment level;
5. air and water temperature;
6. maximum depth; and,
7. number of live, dead, and other eggs per sample.

Herring eggs and mussels will be collected at each site for hydrocarbon analysis on the first day. Three samples each of eggs and mussels (six per transect) will be collected from each sampling location, including the three control sites in Sitka Sound, at the lowest tide stage at which mussels occur (usually about 5 ft below MLLW). Collection methods will follow established protocol, including chain of custody forms.

During one of the sampling trips to each transect, herring eggs and associated vegetation will be collected for the laboratory incubation project. Herring eggs will be collected at nine sites within PWS and three sites within Sitka Sound. At each site, three samples of vegetation containing at least 300 eggs will be collected at three depths (MLLW, -5 ft, and -15).

Herring eggs will also be collected and preserved in a phosphate buffered formalin solution, using seawater, for biochemical analysis. Results of these analyses may help determine the extent of oil exposure from determination of sublethal effects.

Finally, herring egg samples will be collected from each of the 12 study sites for cytogenetic analysis. Ten egg patches consisting of approximately 1000 eggs each (5 ml) will be preserved in a buffered formalin solution from each study site (i.e. a total of 120 samples). A subsample of eggs will be taken from each sample jar and analyzed for mitotic aberrations in the embryonic and yolk cells. Detailed methodology will be provided by the lab contracted to perform the service.

Egg survival data will be summarized by level of hydrocarbon impact, transect, depth, date of sample collection, and proportion of live eggs. Several different analyses will be conducted to test for differences in egg survival due to the level or amount of oil. The first analysis will be a nested mixed factor ANOVA incorporating all possible factors and interaction effects like:

$$Y_{ijkl} = u + A_i + B_j(A_i) + C_k + D_l + AC_{lk} + AD_{il} + CD_{kl} + ACD_{ikl} + \epsilon_{ijkl}, \qquad (15)$$

where,

Y_{ijkl} = the arc sin transformed proportion of live eggs,
u = grand mean,
A_i = oil impact level (treatment; fixed effect),
B_j = transect (random effect; nested within treatment),
C_k = depth (fixed effect),
D_l = time interval (days) between spawning and sample collection (random effect),
ACl k + AD_{il} + CD_{kl} + ACD_{ikl} = interaction terms, and
ϵ_{ijkl} = error terms, which, after arcsine transformation are assumed to be normally distributed with mean 0 and variance σ^2.

The second analysis will be an analysis of covariance (ANCOVA) where both treatment (A_i) and time (D_l) will be treated as covariates. Treatment and depth will be treated as fixed effects, while transect (nested within treatments) and time will be treated as random effects. This model will describe the decrease in the proportion of live eggs over time, using time as a covariate, and will reduce the number of parameters that must be estimated for the model.

Egg Loss Study:

Egg loss is the only component of the spawn deposition biomass estimator that has not been measured. In the past, a 10% egg loss factor was applied to all transect data to adjust the total spawned biomass estimate. In 1990 a preliminary egg loss study was conducted in conjunction with the egg survival study to determine whether the 10% egg loss factor is appropriate for use at PWS study locations. The egg loss study will be continued in 1991.

The same three transects used in each of three areas for the egg survival study will be used in the egg loss study: Naked Island, Fairmont Bay, and Rocky Bay on north Montague Island. Egg loss will be estimated by observing changes in egg density over time at these locations.

To avoid sampler bias in selecting samples a marked leadline, 20 m or less in length, will be used to select samples. The leadline will be placed parallel to shore and to the left of each transect station. Egg density estimates will be taken within 0.1 m^2 sample quadrants using the same procedures described for spawn deposition diver transects. For each transect, five egg density estimates will be made at each of five depths (+1, 0, -5,-15,-30 ft depths). Divers making egg density estimates for the egg loss study will be calibrated in a similar manner used for divers assisting in spawn deposition surveys. One egg count calibration sample will be collected at each transect and at each depth level. For the calibration sample, all herring eggs and vegetation will be removed from a 0.1 m^2 sample quadrant. Counts of eggs within the calibration sample will be made in the laboratory at a later time. Egg density estimates and egg counts will be conducted every other day from the time of spawning in each area until the time of hatching (a period of approximately 20-25 days). It should be possible to obtain egg density estimates and egg counts for about eight days during the study. This would result in a total of approximately 1,800 egg density estimates (three areas; 3 transects per area; five depths per transect; five egg density estimates per depth; eight days) and 540 egg counts (three areas; three transects per area; five depths per transect; one egg count per depth; eight days) for the season.

Egg loss data will be summarized by area, transect, depth, date of sample collection, and estimated egg density. Egg density estimates will be adjusted for observer (diver) biases, following procedures set forth for diver calibration in the spawn deposition survey, prior to analyses. The change in egg density over time for each transect and depth will be examined.

Egg Incubation Experiment:

A much smaller laboratory egg incubation experiment will be carried out by a private consultant contracted by ADF&G. This experiment will estimate the survival of herring eggs and larvae collected in PWS in 1991. The preliminary results of the 1989 and 1990 egg incubation experiment can be found in McGurk et al. (1990).

The objective of the 1991 experiment is to replicate the experiment done in 1989 and 1990 but on a much smaller scale. The eggs and larvae will be reared under the same conditions as they were in 1989 and 1990. The eggs and herring collected during this experiment will be sent to another independent contractor for sublethal testing. The results from the sublethal testing will allow us to compare sublethal effects in 1989, 1990, and 1991 under the same laboratory conditions.

Oil Exposure Study (Dose-Response):

The major addition to the 1991 herring study is an oil exposure study that will measure the effects of oil exposure on herring eggs and larvae.

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BUDGET

Salaries	$ 238.5
Travel	5.5
Contracts	299.3
Supplies	9.7
Equipment	5.0
Total	$ 558.0

FISH/SHELLFISH STUDY NUMBER 13

Study Title: Effects of Hydrocarbons on Bivalves

Lead Agency: ADF&G

INTRODUCTION

Bivalve mollusks are an important component of the food chain, existing as prey for bear and sea otters, and support subsistence and sport fisheries in PWS. Because they are relatively sedentary and occupy nearshore areas, bivalves may be particularly susceptible to contamination by oil. Bivalves metabolize hydrocarbons at a slow rate and are therefore likely to bioaccumulate hydrocarbons. It is hypothesized that increased hydrocarbons in nearshore sediments could affect bivalves for a long period of time by increasing mortality, decreasing growth, or causing sublethal injuries. The effects of oil on the growth and survival of littleneck clams (*Protothaca staminea*) in particular and other bivalves in general have been well documented (Anderson et al. 1982; Anderson et al. 1983; Augenfeld et al. 1980; Dow 1975; Dow 1978; Keck et al. 1978).

This study is a continuation of work which was conducted during 1989 and 1990. During 1991 field work will be conducted only in PWS. Clam aging, data entry and analysis from 1989 and 1990 will continue.

OBJECTIVES

A. Test if the level of hydrocarbons in bivalves and in sediments is not related to the level of oil contamination of a beach.

B. Document the presence and type of damage to tissues and vital organs of bivalves sampled from beaches such that differences of ± 5% can be determined between impact levels 95% of the time.

C. Test if the growth rate of littleneck clams is the same at beaches of no oil impact, intermediate or high levels of oil impact.

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

METHODS

The 1991 field portion of this study will be conducted by the ADF&G. Field work will be limited to a reciprocal transplant involving littleneck clams. A similar transplant study was conducted in 1990. During April 1991, clams will be tagged and transplanted between the same oiled and unoiled sites utilized in 1990. These sites are located in the vicinity of bear and sea otter habitat.

Six study sites for littleneck clams in PWS representing two levels of oil contamination (no contamination and intermediate or high contamination) will be sampled.

For each sample site, the following site description information will be recorded: site orientation (N-NW etc.), latitude, longitude, low tide height, temperature and salinity of the water, weather and wave action. Temperature and salinity of the water will be measured at a distance of approximately 5 m offshore from the sampled beach at the daily low slack tide.

To quantify oil impacts on clam growth and to discount site effects, littleneck clams will be transplanted from oiled to unoiled areas and from unoiled to oiled areas. Three oiled beaches and three unoiled beaches were chosen for this purpose. Criteria for selecting paired oiled/unoiled beaches, to the extent possible, will include similarity in profile, drainage and length-frequency distribution of bivalves.

Two tidal heights will be utilized, each of which has an adequate number of specimens at paired beaches. Clams will be transplanted to the same tidal height from which they originated. At each tidal height, three stations will be established creating triplicate sampling stations at each height. Each location will consist of three adjacent clearly marked 0.25 m^2 plots. One plot will be marked, but will not be disturbed until clams are sampled for growth. Another plot will be dug to a depth of 0.3 m and all of the removed clams and sediment will be replaced in the plot. Clams from this plot will have a small notch filed into the ventral edge of the valves to mark the time of disturbance. All clams will be removed from the third plot which will be dug to a depth of 0.3 m and the transplanted clams will be placed in this plot along with the original sediment.

Clams to be transplanted will be obtained by digging a trench along the prescribed tidal height of the donor beach until 150 clams between 15 mm and 35 mm in length have been collected. Fifteen millimeters is considered to be the smallest size which can effectively be tagged. Clams less than 35 mm are selected to narrow the range of ages for which differences in growth are being determined and because the maximum growth rate appears to occur within this size range. A sample of 50 specimens from each of three plots will provide 150 samples from each tidal height at each beach and 450 clams for each tidal height and level of beach impact. Sample size for growth is based on the difference between mean shell height for age i and age i+1 clams, variance in shell height for age i+1 clams, probability of making a type I error equal to 0.01 and probability of making a type II error equal to 0.05 (Netter and Wasserman 1985). The sample size was determined after comparing data for mean shell height and variance in shell height taken from Paul and Feder (1973) and Nickerson (1977). The sample size for detecting between impact level differences in growth at age of clams in the size range of 15 mm to 35 mm was estimated at 133 clams from the Paul and Feder data and at 85 clams from the Nickerson data for each impact level. The higher estimate was rounded up to 150 clams by including the next smaller size group (age 5-6). The purpose of 3 sites for each impact level is to provide replicates at each impact level.

Transplanted clams will be identified by marking each clam with a numbered Floy tag secured with a quick-drying adhesive. All marked clams will have a small notch filed into the ventral edge of the valves to mark the time of transplantation. Individual clams will be measured at the beginning and end of the experiment. In September of 1991, near the end of the growing season, clams will be removed from each of the plots described above and analyzed for growth. Wet and dry weights of clams will also be recorded so that clam condition can be compared in terms of a weight to length ratio. Hydrocarbon and histopathology samples will be taken during the experiment.

A total of six sediment samples will be collected from each site for hydrocarbon analysis. The triplicate sediment samples from each tide height will be composite samples which will be collected by scooping one tablespoon of sediment to a depth of 2 to 3 cm from each of the nine sample quadrates at a tide height. The small subsamples of sediment taken from each sampling quadrate will provide a representative mixture of sediment composition and contamination along the tide height.

Two hydrocarbon tissue samples will be obtained from each sampling station. Each hydrocarbon sample will be composed of 10 to 20 clams. Specimens with a shell length of 2 - 5 cm will be collected from the donor beach concurrent with the collection of clams for tagging to form a hydrocarbon sample at the time of transplantation. During transplantation 10 to 20 additional clams will be collected from the donor beach for placement with tagged clams in quadrate "A" at each sample station. These clams will comprise the hydrocarbon sample during fall recovery.

Combined tissue samples from each sampling station will provide a representative mixture of bivalve tissue composition and contamination across the site. The desired size of each composite tissue sample is 15 grams. The number of bivalves to provide this sample from each transect was estimated based on the average size of individuals of each species.

Collection of specimens for necropsy will begin after all hydrocarbon samples have been taken. Total sample size is 20 live or moribund specimens taken at random from each beach site. Noticeable numbers of moribund animals will be documented and sampled separately.

To address Objective A (hydrocarbons in sediments and bivalve tissues), an ANOVA will be used to test for differences in hydrocarbon content in sediment between sites. Differences in sediment hydrocarbon content will verify that control sites (areas of no oil impact) are in fact "controls". These differences will also permit post-stratification of sample sites according to level of impact. An analysis of variance will be performed on the hydrocarbon content of clam samples among sites. The results of this test will be related to the level of sediment impact.

Objective B will be met through ANOVA contingent upon the processing of necropsy samples. These samples will be processed if hydrocarbon analysis is positive.

To provide baseline (pre-impact) information on variance in growth at age among sites, an analysis of variance on growth parameters from clams taken during 1989 between areas will be conducted. Growth parameters will be determined for various growth curves, such as Gompertz, von Bertalanffy, or polynomial equations. Growth parameters will be presented for the most appropriate growth models only. A similar ANOVA will be conducted on growth parameters from clams taken during 1990 between areas. Those beach sites which are resampled in 1990 will be subjected to an analysis of variance on growth parameters obtained from fitting algorithms for clam growth after impact (1990 and beyond) and will be compared to growth parameters for clam growth prior to impact (approximately 1979-1989) to resolve impact of oil contamination on growth (Objective C). Graphics will be used to display differences in growth among areas over time, including growth curves (size at age) and growth increment at age by year for each beach.

To address Objective D, all data will be analyzed to determine degree of damage to stocks. Appropriate suggestions will be made for restoration or mitigation measures. This may include restrictions on human usage to reduce exposure to carcinogenic levels of hydrocarbons or to protect threatened clam populations. Other actions may include the need for continued monitoring of stocks.

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BUDGET

Salaries	$ 88.0
Travel	5.0
Contracts	50.0
Supplies	2.0
Equipment	2.0
Total	$ 147.0

FISH/SHELLFISH STUDY NUMBER 27

Study Title: Sockeye Salmon Overescapement

Lead Agency: ADF&G

INTRODUCTION

Commercial fishing for sockeye salmon in 1989, was curtailed in upper Cook Inlet (CI), the outer Chignik districts, and the Kodiak areas due to presence of oil in the fishing areas from the EVOS. As a result, the number of sockeye salmon entering four important sockeye producing systems (Kenai/Skilak, Chignik/Black, Red, and Frazer Lakes) and two less important lake systems (Akalura and Afognak or Litnik lakes) greatly exceeded levels that are thought to be most productive. Sockeye salmon spawn in lake-associated river systems. Adult salmon serve an extremely important role in the ecosystem, providing food for marine mammals, terrestrial mammals, and birds. Additionally, carcass decomposition serves to charge freshwater lake systems with important nutrients. Juvenile salmon which rear in lakes for one or two years serve as a food source for a variety of fish, birds and mammals. Sockeye salmon are also an important subsistence, sport, and commercial species. The ex-vessel value of the commercial catch of sockeye from these lake systems has averaged about $42 million per year since 1979, with the 1988 catch worth $115 million. Sockeye salmon returns to the Kenai River system support some of the largest recreational fisheries in the State.

Overly large spawning escapements may result in poor returns by producing more rearing juvenile sockeye than can be supported by the nursery lake's productivity (Kyle et al. 1988). In general, when rearing fish abundance greatly exceeds the lake's carrying capacity, prey resources are altered by changes in species and size composition (Mills and Schiavone 1982; Koenings and Burkett 1987; Kyle et al. 1988) with concomitant effects on all trophic levels (Carpenter et al. 1985). Because of such changes, juvenile sockeye growth is reduced, mortality increases, larger percentages holdover for another year of rearing, and the poor quality of smolts increases marine mortality. Where escapements are two to three times normal levels, the resulting high juvenile densities crop the prey resources to the extent that more than one year is required to return to normal productivity. Rearing juveniles from subsequent brood-years suffer from both the poor quality of forage and from the increased competition for food by holdover juveniles (Townsend 1989). This is the brood-year interaction underlying cyclic variation in the year class strength of anadromous fish.

This project will examine the effects of large 1989 spawning escapements on the resulting progeny for a select subset of the above mentioned sockeye nursery lakes. Three impacted lake systems where the 1989 escapements were more than twice the desired levels (Kenai/Skilak in Upper CI; Red and Akalura lakes on Kodiak Island) were selected. Upper Station Lake which is near the two impacted lakes on Kodiak did not receive a large escapement and will be examined as a control.

This study is necessary to obtain a more timely assessment of impact, as adult sockeye produced from the 1989 escapement will not return until the 1994/1995 season. Further, total return data are not available for individual Kodiak sockeye systems due to the complex mixed-stock nature of the commercial fisheries and the inability to estimate stock-specific catches.

OBJECTIVES

A. Estimate the number, age, and size of sockeye salmon juveniles rearing in selected freshwater systems.

B. Estimate the number, age, and size of sockeye salmon smolts migrating from selected freshwater systems.

C. Determine effects of large escapements resulting from fishery closures caused by the EVOS on the rearing capacity of selected nursery lakes through:

   1. analysis of age and growth of juveniles and smolts
   2. examination of nursery area nutrient budgets and plankton populations.

METHODS

Numbers of adult sockeye salmon that entered selected spawning systems outside PWS prior to and during 1989 have been estimated at weir stations or by sonar. This information was collected during projects routinely conducted by the ADF&G as part of their resource management program. Optimal escapement levels, which on the average should produce maximum sustained yield, have been based on either past relationships between spawners and returning progeny or the extent of available spawning and rearing habitat. The baseline program will continue at each site, including but not limited to estimates of adult sockeye escapement and collection of scales for age analysis.

For each of the 4 lake systems identified, the response (abundance, growth, and freshwater age) of rearing juveniles from the 1989 escapement will be studied through its likely period of freshwater residence, early summer 1990 to spring 1992.

The total number of juvenile sockeye in each lake will be estimated through hydroacoustic surveys conducted during the summer (late

June) and fall (September-October) of 1990, 1991, and possibly 1992. Age and size information as well as diet items will be obtained from samples of juvenile sockeye collected from concurrent mid-water trawl netting surveys. Survey transect designs for hydroacoustic sampling and tow-netting have been established for Kenai and Skilak lakes (Tarbox and King 1989), and will be developed for each additional lake in the study. The basic survey design will be a stratified random sample where each lake is subdivided into areas and survey transects randomly selected in each area. Such programs, funded through other studies, are already in place for Tustumena and Afognak lakes. Depending on densities of rearing juvenile sockeye, estimates of fish densities will be made for each transect either by echo integration or by echo counting. Total fish population estimates will be computed, by summing transect populations, along with 95% confidence intervals (Kyle 1989).

Freshwater growth and age of sockeye salmon rearing juveniles from all study systems will be determined from scale and otolith measurements made either by direct visual analysis of scales or on an Optical Pattern Recognition system. In cases where data are available (e.g., Kenai and Skilak Lakes), growth of progeny from the 1989 spawning escapements will be compared with growth (size) of progeny produced from spawnings within these systems during prior years.

The total number of smolt migrating from each system will be estimated with a mark-recapture study during 1990, 1991, and possibly 1992 using inclined plane traps after Kyle (1983), and Tarbox and King (1989). Smolt will be captured in traps, sampled for age and size information, marked with Bismark Brown Y (a biological dye), and transported upstream of the traps and released for subsequent recapture (Rawson 1984). Periodic retesting will determine the capture efficiency of the traps under changing river conditions during the spring. Total population estimates (with 95% confidence intervals) will be made using catch efficiencies. Weekly number weighted smolt size and age information will be calculated using a computer spreadsheet developed by Rawson (per. comm. 1985). Size and ages of sockeye smolts from the 1989 spawning escapements will be compared with smolt information from spawnings within these systems during prior years. Finally, smolt programs consistent to those for the study lakes are planned, under separate funding, for Tustumena and Afognak Lakes.

Limnological studies will monitor the response of the lakes to the high juvenile rearing densities and to estimate the carrying capacity parameters of euphotic volume, nutrient budgets (carcass enrichment), and zooplankton biomass, body-sizes, and population shifts. Approximately six limnology surveys will be conducted at two stations, during 1990, 1991, and possibly 1992, to determine zooplankton species abundance and body-sizes, nutrient chemistry, and phytoplankton abundance for Kenai/Skilak, Red, Akalura, and

Upper Station lakes. Carrying-capacity parameters exist for Afognak and Tustumena lakes based on ongoing studies by ADF&G FRED and Commercial Fisheries Divisions.

In cases where seasonal data are available (e.g., Akalura, Kenai, and Skilak lakes), limnological parameters taken during residence of the juveniles from the 1989 spawning escapements will be compared to parameters within these systems during prior years.

The holistic approach proposed here involves several evaluation procedures to assess the effects of sockeye salmon overescapement.

First, freshwater production from the 1989 escapements will be assessed in Kenai/Skilak, Red, Akalura, and Upper Station lakes. This will be accomplished through analysis of growth, freshwater survival (in particular overwinter survival), and freshwater age of sockeye smolt populations. Any anomalies will be determined by analysis of freshwater growth recorded on archived scales, historical freshwater age composition, and modelled freshwater survivals; and from results of previous studies as well as the 1991 smolt characteristics from each of the study systems. Also, planktonic food sources will be assessed through estimation of abundance of zooplankton prey biomass and numbers of species.

Second, future sockeye salmon production from the 1989 parent year and subsequent parent years will be estimated based on spawner/recruit relationships incorporating a brood-year interaction term. Losses of adult sockeye production from subsequent parent years may result from negative effects of progeny of the 1989 escapement on the lake's carrying capacity. The spawner/recruit relationships will be estimated from historical stock specific return data (where available), and generalized spawner/recruit data scaled to the carrying capacity parameters (i.e., euphotic volume and zooplankton biomass) of the nursery lakes where stock specific return data are not available (Geiger and Koenings 1991).

Third, experimental and empirical sockeye life history/production models (Koenings and Burkett 1987; Koenings et al. 1989) will be used to compare salmon production by life-stage at escapement levels consistent with management goals to the 1989 escapements.

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	BUDGET
Personnel Services	$189.7
Travel	11.2
Contractual	101.4
Supplies	29.6
Equipment	2.4
Total	$334.3

FISH/SHELLFISH STUDY NUMBER 28

Study Title: Salmon Oil Spill Injury Model and Run Reconstruction

Lead Agency: ADF&G

INTRODUCTION

This study integrates results obtained from Fish/Shellfish Studies 1-10 to determine damages to wild Pacific salmon (*Oncorhynchus* spp.) resources exposed to crude oil from the EVOS which spread through portions of PWS, CI, Kodiak, and Chignik. Damages to Pacific salmon populations in these areas would have profound impacts on both aquatic and terrestrial ecosystems since Pacific salmon are an important food source for many fish, bird, and mammal species and cycle significant amounts of nutrients from marine to estuarine, freshwater, and terrestrial environments. Also, the economies and culture of many communities in this portion of Alaska rely heavily on harvesting Pacific salmon in commercial, sport, and subsistence fisheries.

Two different procedures may be used in this study to assess damages to wild Pacific salmon populations resulting from crude oil contamination. The first, based on reconstructing salmon runs will use total adult returns (harvests and spawning escapements) to determine stock specific returns and production to oiled and unoiled areas. The second, based on life history modeling, will use spawning escapements and subsequent estimates of survival at various life history stages to project future adult returns to oiled and unoiled areas. Both approaches will use data from F/S studies 1-10, as well as information from the scientific literature, to set parameter values in computational models.

OBJECTIVES

Run Reconstruction

A. Develop a computational framework for estimating stock specific abundance over time in the eight commercial fishing districts in PWS.

B. Analyze the historical data to develop estimates of the model parameters, including estimates of hatchery stock contributions.

C. Reconstruct the 1990 and 1991 PWS pink salmon run and develop estimates of salmon production (number of adult returns per spawner) for oiled and unoiled areas.

Life History Modeling

A. Develop a computational framework to account for specific effects of oiling on species, stock, and life history stages of wild Pacific salmon (*Oncorhynchus* spp.) populations in PWS, CI, Kodiak, and the Chignik areas.

B. Estimate "status quo" (i.e. in absence of oil contamination) values for all parameters implicit in the computational framework.

C. Estimate the "oil impact" values for all parameters implicit in the computational framework.

D. Develop estimates of salmon injury by comparing simulations of future Pacific salmon production using "status quo" and "oil impact" model parameter values.

METHODS

Run Reconstruction

This portion of the study will develop techniques for reconstructing stock specific pink salmon abundance by fishing district in PWS. The study will consist of three activities, data synthesis, model development, and parameter estimation.

Data Synthesis. Historical catch, effort, escapement, and tagging data will be synthesized and an RBASE data base management system developed to provide easy access to this data. Details of this data are as follows:

A. Catch data will be summarized by species, district, daily or biweekly time periods, separated into hatchery and wild stock components for the years 1960 to 1991. Hatchery contributions from 1987 - 1991 will be based on CWT tagging. Hatchery contributions prior to 1986 will be based on assumption of equal exploitation rate within and relative escapement magnitudes by district.

B. Effort data will be summarized by district on daily or biweekly time periods for the years 1960 to 1991.

C. Timing curves describing the entry of escapement into the stream will be estimated by stream within district for years 1960 - 1991. The parameters of the timing curve will be estimated by fitting the stream life model of live fish in the stream to the escapement counts expanded to areas not counted by aerial survey. The stream specific expansion factors will be based on comparison of on-ground counts to aerial counts.

D. Extensive and comprehensive tagging studies have been conducted in PWS since 1957. A database management system will be developed to summarize those data. A database will be used to estimate parameters of stock specific migration models (see model development section below).

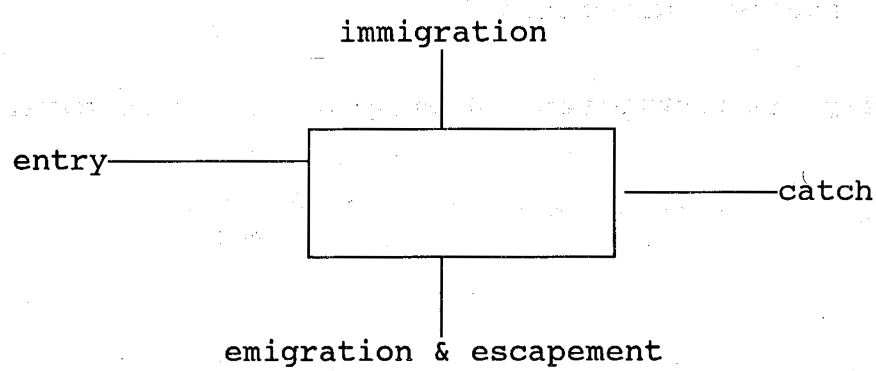
Model Development

The model below is developed in full generality. In estimating model parameters it may be necessary to simplify the model. The following definitions and relationships apply:

indices:

a	=	fishing district, (eight districts)
s	=	stock, (eight wild stocks, four hatcheries)
t	=	time
$N_{s,a,t}$	=	abundance of stock s in district a
$X_{s,t}$	=	number of stock s entering PWS
$Y_{s,t}$	=	number of stock s entering the spawning stream
$C_{a,t}$	=	catch of fish in district a
$p^{s}_{i,j}$	=	transition probability that a fish of stock s having left district i migrates to district j
$e_{s,a}$	=	probability stock s enters PWS through district a
$\tau_{s,a}$	=	residence time of stock s in district a
q	=	catchability coefficient
$E_{a,t}$	=	fishing effort in district a

Movement of fish into and out of the district is as follows:



$$N_{s,a,t} = \text{entry} - \text{catch} - \text{emigration} + \text{immigration}$$

Entry is the number of fish entering the district from outside PWS and is given by:

$$x_{s,t} \circ e_{s,a}$$

Catch is the number of fish removed by the fishery and is known:

$$C_{a,t} = q \circ E_{a,t} \circ \sum N_{s,a,t}$$

The catch can be apportioned to stock specific catch ($C^{s}_{a,t}$) by the relative stock specific abundance:

$$C^{s}_{a,t} = c_{a,t} \left[N_{s,a,t} \; / \sum_{\text{stocks}} N_{s,a,t} \right]$$

Emigration is the number of fish migrating from the district to other districts or to the bay of the spawning stream and is given by:

$$\sum_{\text{stocks}} (1 / \tau_{s,a}) \quad N_{s,a,t}$$

Immigration is the number of fish migrating into the district from other fishing districts and is given by:

$$\sum_{\text{stocks}} \sum_{\text{districts}} (1 / \tau_{s,a}) \quad N_{s,a,t} \quad p^{s}_{a,t}$$

Escapement is a component of emigration and is given by:

$$(1 / \tau_{s,a}) \quad N_{s,a,t} \quad (1 - \sum_{j \neq a} p^{s}_{a,t})$$

A normal probability distribution timing function f(•) will be assumed for both the entry ($x_{s,t}$) and for escapement ($y_{s,t}$):

$$x_{s,t} = f(x^{\infty}_{s}, \sigma^{s}_{1}, \mu^{s}_{1})$$

$$y_{s,t} = f(y^{\infty}_{s}, \sigma^{s}_{2}, \mu^{s}_{2})$$

Where x^{∞}_{s}, σ^{s}_{1}, μ^{s}_{1} are the total run, standard deviation, and mean of the timing function for entry, respectively; and y^{∞}_{s}, σ^{s}_{2}, μ^{s}_{2} are the total run, standard deviation, and mean of the timing function for escapement, respectively. Note that the escapement timing function will be estimated directly from the escapement data.

Fitting the Model

The migration parameters ($p^{s}_{i,j}$, $e_{s,a}$, $\tau_{s,a}$) will be estimated by analysis of historical tagging data. The method of estimation will be based on Hilborn (1990). Both the forward and backward methods of run reconstruction (Schnute and Sibert 1983; Starr and Hilborn 1988) with the forward method parameters of the model (q, x^{∞}_{s}, σ^{s}_{1}, μ^{s}_{1}) will be estimated by fitting the model ($q \Sigma N_{a,s}$) to catch per unit effort (C_a / E_a). With the backward method, the escapements are lagged back to the districts based on a migration model derived from the tagging data.

DISCUSSION

The life history and run reconstruction models will accommodate harvest in existing mixed stocks fisheries and will enable the comparison of alternative commercial fisheries harvest policies. This will facilitate the evaluation of fisheries restoration strategies that attempt to rebuild damaged stocks by reducing catch in fisheries that exploit stocks damaged and stocks not damaged by the oil spill.

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BUDGET

Personnel	$ 58.9
Travel	5.2
Contractual	100.0
Supplies	1.0
Equipment	10.0
Total	$175.1

FISH/SHELLFISH STUDY NUMBER 30

Study Title: Data Base Management

Lead Agency: ADF&G

INTRODUCTION

Large quantities of data are being analyzed in order to demonstrate the extent of injury to natural resources due to oiling. The purpose of this study is to make original data readily available in electronic form to agency and non-agency personnel so that data analyses can be conducted in an efficient and cost effective manner. The data to be placed under the database management system (DBMS) will be drawn from two categories:

1. historical data necessary to the interpretation and implementation of the results of NRDA studies,
2. data resulting from NRDA studies.

OBJECTIVES

A. To construct a cost effective DBMS to readily retrieve and order data from original selected data in electronic form according to user specified criteria of time, space, and other variables. The DBMS should be constructed to meet the following criteria, in order of priority:

   1. completeness of contents
   2. speed of retrieval
   3. ease of use in assembling primary data into datasets for further analysis by other software.

   Furthermore, the DBMS will take advantage of existing DBMS applications currently available in the ADF&G.

B. To develop the structural facilities for individuals to access data that is physically located at different sites. To accomplish this, a Local Area Network (LAN) facility must be developed in the Cordova and Anchorage ADF&G offices, along with a system for linking these with existing LANs in Juneau and Kodiak. Note that Objective B, although necessary for this project, will be met by a concurrent and separately funded "statewide database system" project currently being implemented by ADF&G using non-oil spill related funding.

METHODS

A relational database management application will be developed. It will be based in standard structured analysis and structured design methodologies. Development will employ the industry standard SQL language for relational databases. The system will be accessible by authorized IBM-compatible personal computers. It will be made available through a linked system of LANs covering offices in Kodiak, Anchorage, Cordova and Juneau. The end-user interface software allowing non-programmer access to the database information will be developed in Windows and made available to individuals.

The scope of data involves commercial species from PWS, Kodiak, CI, and Chignik areas. Specific discussions with assessment researchers have prioritized the type of observations to be incorporated. They are, in order of priority:

1. Commercial fisheries catch and effort data by area, species, and gear type.
2. Salmon escapement data, including aerial survey counts, stream counts, weir counts, and sonar counts.
3. NRDA project data of global interest.
4. Preemergent and egg density counts.
5. Biological data including age composition, size, sex, growth, and stock composition.
6. Groundfish and shellfish survey data.

This project will make use of an ADF&G statewide database network infrastructure being separately developed with State of Alaska general funds. This project will not develop the network.

BUDGET

Personnel Services	$149.5
Travel	5.4
Contractual	7.8
Supplies	2.6
Equipment	10.5
Total	$175.8

COASTAL HABITAT - INTERTIDAL STUDIES

More than 1000 miles of coastal shoreline received light-to-heavy oiling from the EVOS. Assessment of injuries to intertidal resources and 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 shorelines are used by many organisms which are important to people, including fish, shellfish, birds and mammals. These shorelines are also used for human activities such as recreation, fishing, mining, and for documenting past activities through invaluable archaeological resources. The intertidal studies are designed to estimate the effects of the spill and associated clean-up activities in terms of: (1) the abundance of intertidal organisms and the corresponding health of the ecosystem; (2) contamination of these same resources by oil; (3) quantification of injury from PWS to the KAP; and (4) natural recovery of these resources.

These studies document the potential pathways of oil spilled in the coastal environment as it moves through the food chain. Thus, the studies will provide data for determining ecological effects as well as other supporting data for determining and quantifying injury to fish, shellfish, mammals, and birds that provide services directly to humans. In addition, these studies serve as the basis for estimating rates of natural recovery, and the need and potential for assisting natural recovery of the resources through restoration.

Lastly, clean-up procedures may not only reduce the adverse effects of oil, but may also induce injury to intertidal resources. The assessment of clean-up effects by these studies is an important component of the overall injury assessment.

COASTAL HABITAT INTERTIDAL STUDY NUMBER 1A

Study Title: Comprehensive Assessment of Injury to Coastal Habitats

Lead Agency: USFS

INTRODUCTION

The purpose of the Coastal Habitat Injury Assessment is to document and quantify injuries to biological resources found in the intertidal zone throughout the shoreline areas affected by EVOS. Field work in the supratidal zone was concluded in 1990 and will not be conducted in 1991, while the subtidal portion was integrated into the formation of a 1991 suite of studies.

Study sites were selected and ground-truthed during Phase I. Phase II is an intensive evaluation of the study sites to determine the extent of injury to natural resources. The objective of this study is to estimate the effects of various degrees of oiling on the quantity (abundance and biomass), quality (reproductive condition and growth rate), and composition (diversity and proportion of standing stock) of key species in the critical trophic levels of coastal communities. These data are expected to provide evidence of injury to the overall health and productivity of these critical coastal habitats, and provide information necessary to the more species-specific studies on the effects of the oil spill on affected mammals, birds and fish that use these habitats.

PHASE I

Selection and ground truthing of study sites were concluded during 1990. No further Phase I work will be conducted during 1991.

PHASE II

Injury Determination

Coastal habitats are unique areas of high productivity supporting a diverse array of organisms, including many commercially and ecologically important species. These habitats are particularly vulnerable to oil spill impacts because of the grounding of oil in the intertidal zone, the persistence of oil in intertidal sediments, and the effects of associated clean-up activities.

Oil may affect coastal organisms directly by coating or ingestion, with toxic effects leading to death or reproductive failure. Indirectly, oiling may cause decreased productivity, accumulation of toxic effects through the food chain, and loss of microhabitat such as algae beds. Assessment of injuries to coastal habitat resources and determination of rates of recovery require consideration of the various coastal geomorphologic types, the degree of oiling, the affected habitat, and their trophic interactions. Ninety-seven study sites comprised of 59 sites retained from 1989 and 38 sites added in 1990 were selected for the intertidal component of the Coastal Habitat Injury Assessment (CHIA). These study sites are representative of the broad range of coastal habitat types including exposed rocky shores, fine textured beaches, coarse textured beaches, sheltered rocky shores and sheltered estuarine shores, oiling characteristics, and clean-up techniques found in the spill area.

Control sites were carefully paired with oiled sites to closely match physical and biological characteristics while maintaining a statistically valid site selection strategy. The current site selection scheme will strengthen the ability of the CHIA to detect injuries while maintaining the ability to extrapolate these results to the universe of other oiled shorelines. From the original set of 97 sites chosen in 1989-90, a total of 57 sites will be studied in 1991.

Coastal intertidal animals may use multiple habitats, necessitating a coordinated study of the effects of oiling over the entire intertidal habitat. The complexity of this system requires expertise in many disciplines. Therefore, an interdisciplinary team with the appropriate expertise, including plant and systems ecology, marine biology, and statistical analysis, has been established.

The first year of field studies was completed on November 1, 1989. In 1990, field studies were conducted from approximately May 1 to September 30. In 1991, a May 1 to July 31 reduced field sampling schedule is proposed. Processing of samples and data analysis is being conducted to determine the variance and magnitude of changes between unoiled and moderately and heavily oiled sites.

OBJECTIVES

A. Estimate the quantity (abundance and dry weight biomass), quality (reproductive condition and growth rate), and composition (diversity and proportion of standing crop) of critical trophic levels (and subsequent impact on trophic interactions) in moderately and heavily oiled sites relative to unoiled sites.

B. Estimate hydrocarbon concentrations in sediments and biological samples.

C. Establish the response of these parameters to varying degrees of oiling and subsequent clean-up procedures.

D. Extrapolate impact results to the entire spill-affected area.

E. Estimate the rate of recovery of the habitats studied and their potential for restoration.

F. Provide linkages to other studies by demonstrating the relationships between oil, trophic level impacts, and higher organisms.

METHODS

Vertical transects will be established at 57 of the study sites selected in Phase I. Work will be conducted along transects in the intertidal zone. For this study, the intertidal extends from the "0" tide mark to Mean Higher High Water (MHHW). Work in the supratidal zone was concluded in 1990. Work in the subtidal zone is being conducted within the context of the subtidal studies. Community composition, cover, and standing crop by trophic level will be estimated. Key species (dominant producers and food sources) will be determined and studied according to the methods listed below, to estimate the quantity, quality, and composition at each trophic level, and to collect samples for determination of hydrocarbon contamination. Using a geographic information approach, the impact (by habitat type and degree of oiling) over the entire area affected by the oil spill will be integrated and field-verified.

Specific methods for each component of the study were developed as follows:

Coastal
1. Initial Site Survey
2. Locating Transects
3. Sample Identification and Chain-of-Custody

Intertidal
- Invertebrates
  1. Locating 1 Quadrats
  2. Swath Surveys
  3. Reproductive Condition
  4. Growth and Survivorship
  5. Hydrocarbon Sampling Procedures
  6. Experimental Work
  7. General Laboratory Sorting Procedures
  8. Subsampling of Intertidal Samples
  9. Processing of Histological Samples

Fish

1. Locating Transects
2. Locating Quadrats
3. Sampling Quadrats
4. Minnow Trap Sampling
5. Sample Storage and Identification
6. Fish for Hydrocarbon Analysis

Plants

1. Introduction
2. Study Plan
   a. Stratified Sampling
   b. Site Experiments at Selected Habitats
   c. Field Experiments

Analysis of samples obtained in 1990 is still underway and will continue as additional 1991 samples are collected. Samples from 1991 will be processed as rapidly as possible after they are returned from the field. The reduced sampling scheme in 1991 should allow for complete sorting of 1990 and 1991 field samples before commencement of any further field work. The data from all of the component studies are being entered into a computer database management system. This system is widely used, and has good data security features. Use of this database system will therefore maximize both internal integration and availability of the data to related damage assessment projects.

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BUDGET

Services	$
Travel	
Contractual	5,100.0*
Commodities	
Equipment	
Total	$5,100.0

*University of Alaska

COASTAL HABITAT INTERTIDAL STUDY 1B

Study Title: Pre-spill and post-spill concentrations of hydrocarbons in sediments and mussels at intertidal sites within PWS and the Gulf of Alaska

Lead Agency: NOAA

INTRODUCTION

Damage assessment of the oil spill in PWS and GOA requires information on hydrocarbon contamination levels in water, sediment and biota prior to the spill (baseline) and at various times after the spill occurred, to determine the potential impact and duration of impact. Hydrocarbon baseline information is available for several sites in PWS prior to oil transport and for the first four years of oil shipment. The intertidal baseline for hydrocarbon levels in mussels, sediment, water, and fish were established at 10 sites from 1977 to 1981. Ten additional sites were established in the path of the spill in 1989. All sites are located on low energy, low gradient beaches, often associated with eel grass. All sites have adjacent bands of mussels (*Mytilus trossulus*).

Because of the potential persistence of hydrocarbons in sediments in temperate and subarctic intertidal and subtidal environments, sampling will be continued to document depuration and recovery rates. Concentrations of the full range of individual aliphatic and aromatic hydrocarbons in sediments and mussels from intertidal sites will be reported. Abundance of mussels and other epifauna along sediment and mussel transects will be photographically recorded during each sampling period. These data will provide a basis for estimating temporal and spatial impact to other biota of the nearshore environment and support other NRDA studies of fish, birds, and mammals.

OBJECTIVES

A. To sample and estimate hydrocarbon concentrations in mussels and sediments from 20 sites within 10% of the actual concentration 95% of the time, when total aromatic concentrations are greater than 200 ng/g dry wt. We will compare these with 1989-90 data.

B. To test the hypothesis that hydrocarbon contamination of sediments and mussels is the same for the pre-spill and post-spill period.

C. To document changes in abundance and distribution of intertidal epifauna and test the hypothesis that no differences occur at oiled and unoiled sites.

METHODS

Ten intertidal sites in PWS and Port Valdez were sampled for sediments, mussels, water, and fish annually from 1977 to 1981 to establish a baseline against which future changes in hydrocarbon concentrations can be compared. Sites were initially sampled in spring, summer and fall to determine if short-term changes occurred during the warm season. These sites were resampled in March 1989 immediately before several of them were impacted by the EVOS.

Immediately after the spill, and in some cases prior to the arrival of oil, ten additional sites were established to sample beaches within the trajectory of the oil path. Four of these sites were on the KP and the remaining six were in PWS. Sediment and mussel samples were taken. Photo-documentation was initiated along mussel and sediment transects at each site. These sites were re-sampled several times during the summers of 1989 and 1990 to document the appearance of and changes in hydrocarbon contamination from the EVOS. In 1991, only the 16 sites in PWS will be sampled and sampling frequency will be reduced to once or twice during the warm season.

<u>Sediments:</u> Transect lines thirty meters (m) in length are located parallel to the water line at the -0.75 m to +0.75 m tide level (depending on specific site). Sediment samples are collected in triplicate at each site. Each sample consists of a composite of 10 cores (dia 3.2 cm x depth 1.25 cm) taken at random along the 30-meter transect. Composite sediment samples are placed in chemically clean 4 oz. jars, placed in an ice chest with artificial ice and transported. These are frozen within 2-3 hours of collection. One blank sample is taken at each site.

<u>Mussels</u>: Transects for mussel collections are located parallel to the water line, usually immediately above the sediment transects at approximately the +1 m tide level. Triplicate mussel samples are collected and each sample contains approximately 30 2-5 cm. mussels (enough to produce $\geq$10 gms tissue) taken at random along the 30-meter transect. Samples in 16 oz. jars are cooled, transported and frozen in the same manner as the sediment samples. All samples are handled and stored according to established protocols to maintain quality assurance and control at all times.

<u>Photo-Documentation</u>: Close-range views of the strata, macroflora, and epifauna are photographed. Photos are taken every 4 or 8 m along the sediment transect and every 2 or 4 m along the mussel transect line beginning at one meter. Macrophyte cover as well as epifaunal occurrence and density are recorded from photographs taken of 625 cm^2 quadrants placed along the sediment and mussel transect lines. A grid of 100 random dots projected on each slide

is used to estimate occurrence and percentage of surface area covered by macrophytes and epifauna. Macrophytes and epifauna are identified to species where possible.

DATA ANALYSIS

Random sample and subsample collection prior to the analysis procedure will ensure that hydrocarbons present in the sample represent the average concentration at each site. "Hot spots" of hydrocarbon concentration over the 30 meter transects will be cancelled out by this procedure. Selected triplicate samples will be analyzed, the mean concentrations and deviations from these means determined, and appropriate statistical tests applied. Digital tables of individual hydrocarbons will be reported.

Macrophyte and epifauna occurrence and cover will be analyzed using one way ANOVA or paired comparisons (oiled vs unoiled where strata are similar). They will be tested at the .05 level of significance.

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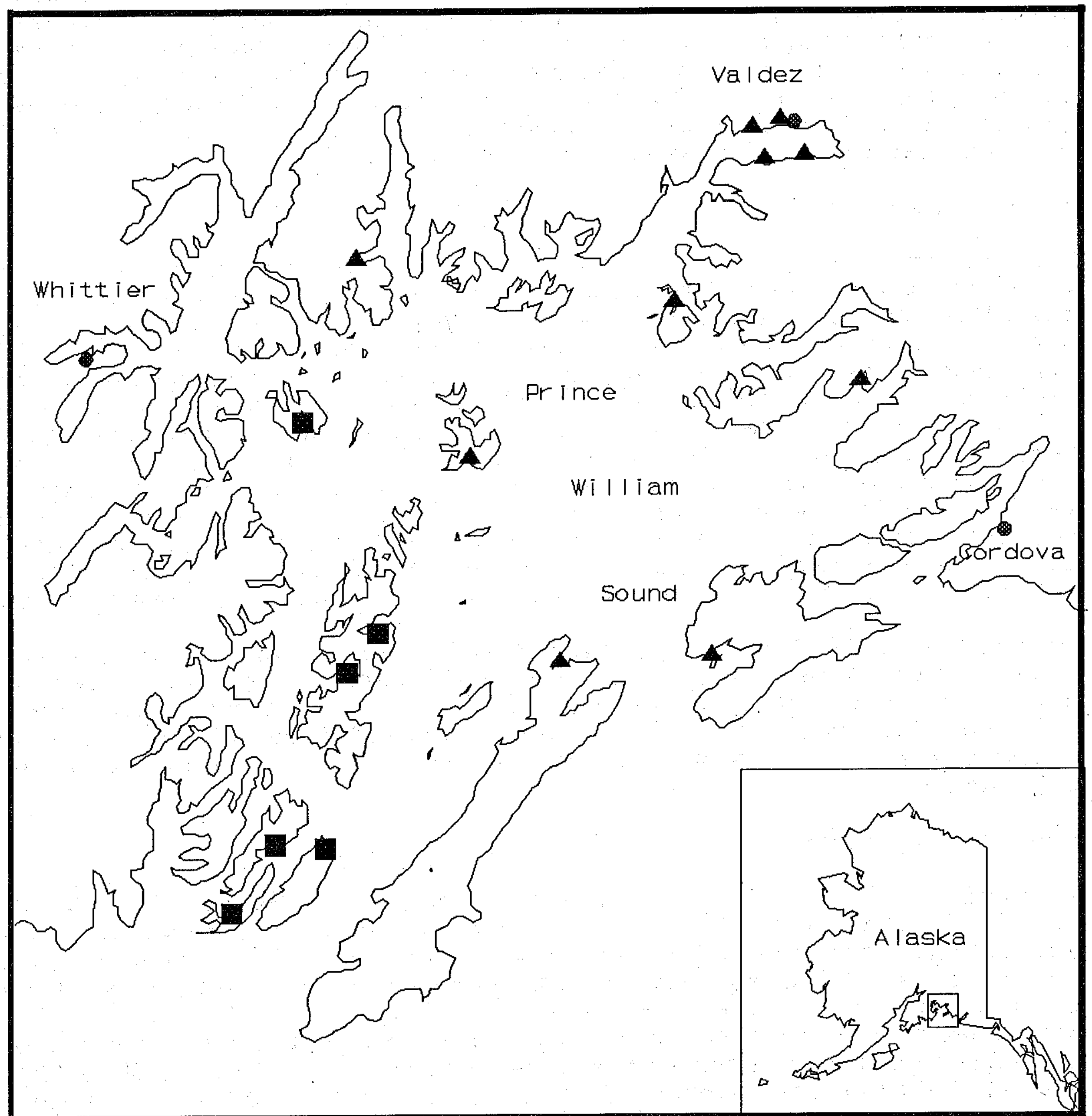
BUDGET

Labor		$	31.0
Travel			13.0
Contracts:	Helicopter		22.0
Supplies			2.0
Equipment			0.0
Total		$	68.0

Figure 1. Intertidal baseline sampling sites.
▲ = historical sites ■ = established in 1989.



SUBTIDAL RESOURCES INJURY ASSESSMENT

The subtidal regions of PWS and the GOA represent a vast and complex ecosystem. The oil from the EVOS is known to have reached portions of this ecosystem. This subset of the NRDA studies have the objectives of documenting the geographical extent, persistence, and toxicity of the EVOS oil in this environment and examining effects of oil on select marine organisms. As the natural resources and their habitats in the subtidal region are closely related, the studies on them have been placed together in a new Subtidal category for the 1991 NRDA study planning process. This category of studies includes the former Air/Water studies, including studies of benthic infaunal communities, and studies of various species of demersal fish and shellfish.

Water Resources

Monitoring of the concentrations of petroleum hydrocarbons in the water column of PWS and portions of the GOA began immediately after the EVOS. This monitoring was most critical during the first few weeks following the spill when the dissolution of soluble components was most rapid and the likelihood of toxic exposure was highest. As dilution of the EVOS oil in the water column continued below the levels that can be detected using direct measurements, the strategy for long-term documentation of the locations and concentrations of hydrocarbons available to marine organisms shifted to the use of alternate means of detection. This involved the study of bioaccumulators and measurements of the settling rates of oil contaminated sediments settling out from the water column. Subtidal Study No. 3 is dedicated to carrying out this monitoring.

Marine water quality is protected under state and federal water quality standards which include classifications for such uses as 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 criteria for water habitats.

Sediment Resources

A portion of the EVOS oil reached the marine sediments in PWS and in portions of the GOA. The extent of this contamination, its persistence and toxicity, and its direct effect on the benthic communities living in contact with sediments are studied by three of the studies in this category. Subtidal Study No. 1 will investigate the occurrence, persistence, and chemical composition of petroleum hydrocarbons in marine sediments. Subtidal Study No. 2 will document the effects of EVOS oil in marine sediments on deep and shallow water benthic communities. Subtidal Study No. 4 will investigate the fate of EVOS oil and determine its long-term toxicity.

These studies will document the injury level to a large ecosystem which contains a large number of organisms that are in the food chain of many higher trophic level animals that are the subject of other NRDA studies.

Demersal Fish and Shellfish Resources

Subtidal studies 5, 6, and 7 have the goal of documenting exposure to EVOS oil and injury for a number of demersal fish and shellfish resources. These studies combine elements of 1990 Fish/Shellfish studies 15, 17, 18, and 24. The large number of demersal species potentially affected by the EVOS and the vast extent of the available habitat that they occupy has resulted in these 1991 studies being primarily focused on representative species in areas of PWS where the potential for injury is believed to be the greatest.

The demersal fish/shellfish resources of PWS and the GOA, in addition to being utilized by commercial, sport, and subsistence fishermen, are a key food source for other fish, marine mammals, river otters, and for various species of birds.

SUBTIDAL STUDY NUMBER 1

Study Title: Hydrocarbon Exposure, Microbial and Meiofaunal Community Effects

Lead Agency: NOAA, DEC

INTRODUCTION

A substantial proportion of the approximately 11 million gallons of Prudhoe Bay crude oil released into the marine environment following the grounding of the tanker *Exxon Valdez* became stranded on the shoreline of PWS and northeastern GOA. Some of the oil that entered the water (the original crude oil derived from the spill, oil leaching from contaminated shorelines, and/or oil dispersed into the water by shoreline cleanup activities) reached the subtidal region as a result of physical and biological processes (Boehm et al. 1987). The proportion of the original volume of crude oil spilled from the *Exxon Valdez* that has reached subtidal sediments in PWS remains to be determined.

NOAA

A primary objective of the present study is to synthesize the data on hydrocarbon contamination of subtidal sediments collected by all NRDA studies. This will allow an estimate of the amount of crude oil that contaminated subtidal sediments in PWS and GOA and define the geographic and bathymetric extent of subtidal hydrocarbon contamination. Sampling of subtidal sediments in PWS will continue on a reduced scale in order to resolve the dynamics of hydrocarbon contamination of subtidal sediments influenced by additional contamination resulting from 1990 cleanup activities and the persistence of petroleum hydrocarbons in previously contaminated sediments.

DEC

The DEC portion of this study will conduct microbiological assays to measure the response of microbial populations to the EVOS. The intertidal and subtidal sediments for this portion of the study will be collected at the same sites where the NOAA sediment samples are taken.

Assessment of microbial populations is important since the ultimate fate of spilled oil depends on the ability of microorganisms to use it as a source of carbon and energy (Leahy and Colwell 1990). The microbial hydrocarbon oxidation potential assays are designed to measure microbial activity under optimized environmental conditions and independent of "in situ" hydrocarbon concentrations. Thus, they are an indicator of the microbial communities' acclimation to particular hydrocarbon fractions, implying exposure to these petroleum components "in situ." The observation of microbial communities acclimated to hydrocarbon oxidation in intertidal and subtidal sediments only implies exposure to hydrocarbons in general. Definitive characterization of the hydrocarbons as originating from the *Exxon Valdez* will depend on detailed chemical analysis of the sediment samples collected in parallel to the microbiological samples.

The sediment sampling will be coordinated closely with benthic infaunal studies (Subtidal Study No. 2). The benthic study will examine the effects of the oil spill on infaunal communities below a depth of 20 m. The sampling for this study will be conducted from the same vessel simultaneously (June/July 1991) as the deepwater sediment sampling. The second study will examine the effects of the oil on infaunal communities associated with eelgrass and *Laminaria* beds. Sediment and microbiological samples will be collected at the same sites where infauna of the eelgrass community will be taken. The benthic infaunal studies will be described in detail in a separate plan. The sediment and benthic infaunal studies were combined in the Air/Water Study No. 2 in 1990.

OBJECTIVES

A. Synthesize the analytical results on the concentrations of petroleum hydrocarbons in subtidal marine sediments collected under this study and all other NRDA studies under which sediments have been collected.

B. Determine occurrence, persistence, and chemical composition of petroleum hydrocarbons in all subtidal marine sediments analyzed to date.

C. Provide marine sediment data to generate in mass balance calculations on the fate of oil in the marine environment.

D. Enumerate populations of hydrocarbon-oxidizing microbes in intertidal and subtidal sediments collected at oiled and unoiled sites within PWS.

E. Assess the maximum potential for "in situ" biodegradation of selected hydrocarbon substrates in subtidal sediments at oiled and unoiled sites within PWS.

METHODS

NOAA

Sediments will be sampled at 20 sites in PWS (10 reference sites and 10 contaminated sites). Fourteen sites will be sampled in June/July. Sediment sampling will be coordinated with the microbiological and deep benthos projects at these 14 sites. Nine sites will be sampled in May and September.

Three samples, each a composite of eight subsamples collected randomly along 30 m transects laid parallel to the shoreline, will be taken at each intertidal site. Samples will be collected at low tide or by divers. Intertidal collections will be made at a single tidal height in the range of +1 to -1 m relative to mean lower low water (MLLW) depending on the distribution of fine sediments.

Subtidal sediment collections will be made at 6 m below MLLW in May and September and at 3, 6, 20, 40 and 100 m in June/July. Collections at 3, 6 and 20 m will be made by divers on transects laid along the appropriate isobath and sampled in the same way as described above for the intertidal transects. The eelgrass community project will sample sediments, infauna and epifauna in the same depth range at six of the PWS sites. Samples taken at depths below 20 m will be collected with a Smith-McIntyre grab. Three grabs will be taken at each depth. Four subsamples will be removed at randomly selected points within each grab. The subsamples will be combined to form one sample per grab. The samples will be taken at the same sites as the benthos (see deep benthos sampling in the Subtidal Study No. 2 plan), however sediments will not be taken from the same grab as the benthos samples because the volume needed for sediment hydrocarbon analysis.

DEC

Sediment samples for the microbiological work will be obtained from sediment chemistry samples taken during the June cruise. Samples will be taken at all 14 sites and at all depths where the sediment chemistry samples are taken. The samples taken by divers at the 3 m, 6 m and 20 m depths will be generated by placing approximately 1 kg of surface sediment in sterile whirlpack bags, and sealed at the sampling depth. The 40 m and 100 m samples will be obtained by composite subsampling into a sterile whirlpack bag of the surface sediment contained in the sampling device. The intertidal microbiological samples are composites of eight subsamples collected at random intervals along a 30 m transect parallel to the shoreline in the low intertidal zone. All microbiology samples will be collected as triplicate composites from the transect sampled.

Care will be taken to avoid contamination of samples by the sampling personnel and cross-contamination between different sediment samples. Sampling apparatus will be thoroughly rinsed with water between samples and disinfected with alcohol or alternate disinfectant. Samples obtained from the deepwater grabs will be collected from the center of the core to avoid surface contamination incidental to sample handling. All microbiological samples will be placed in coolers for transport to the support vessel for processing within three hours of collection.

Hydrocarbon biodegradation potential associated with sediment microbes will be assayed by adding radiolabelled aliphatic (^{14}C-hexadecane) and aromatic (^{14}C-phenanthrene) substrates to sediment samples. Each substrate will be monitored for biodegradation by the evolution of radio-CO_2 from the samples after two incubation periods.

A total of 20 gm of sediment from each sample will be needed for this assay. Each sediment sample assayed for hydrocarbon biodegradation will first be mixed 1:10 with sterile seawater augmented with mineral nutrients (Difco marine Bushnell-Haas broth). Ten ml aliquots of the resulting slurry will then be placed in sterile 40 ml incubation vials fitted with silicone septa. The substrate of interest will be added at a 10 ppm (ug/ml slurry) concentration by injection via syringe through the septa. The substrates will then be added in an acetone carrier (Baur and Capone 1988). Two replicate vials for each substrate/sediment sample/incubation time combination will be prepared with a "time zero" killed control also prepared for each substrate and triplicate set. All vials will be placed on a rotary shaker for 24 hours and then incubated at ambient temperatures for the duration of the incubation period.

Following incubation of the sample for the appropriate period (or initially in the case of the controls), substrate biodegradation in the sample vials will be halted by the addition of 1 ml 10N NaOH through the septum. This will result in a pH greater than 13, killing the culture of degraders and sequestering any evolved CO_2 in the form of carbonates in solution. The extent of hydrocarbon degradation will be monitored by measuring the radio-CO_2 evolved from each vial (Foght et al. 1988). After transport to the analytical facility at the University of Alaska, the sample vial contents will be purged of radio-CO_2 and the effluent gas will be passed first through an organic vapor trap and then through phenethylamine scintillation cocktail to trap the evolved CO_2 (Fedorak et al. 1982). The mean of each set of biodegradation samples for each substrate, concentration and incubation period will be compared the "time zero" killed controls to assess for losses due to volatization in transit or any possible abiotic CO_2 evolution. The extent of biodegradation will be expressed as a percentage of the total radiocarbon activity added to the sample after correction for abiotic losses.

In addition to the biooxidation potential assay, all microbiology samples will be analyzed using the Sheen Screen Most Probable Number technique for the presence of surfactant producing, hydrocarbon-degrading microorganisms (Brown and Braddock 1990).

While no technique to enumerate specific metabolic types of microorganisms in marine systems is absolute, the Sheen Screen technique provides consistent results that are appropriate for relative comparisons among stations and depths.

DATA ANALYSIS

NOAA

Synthesis of Sediment Analyses

Sediment samples collected for 12 studies included in the NRDA process have been catalogued in the damage assessment database of Technical Services Study No. 1 and some of those samples were submitted for analyses. The principal goal of the present proposal will be to synthesize the results from the sediment hydrocarbon analysis as they become available from Technical Services Study No. 1. Mapping of the geographic and bathymetric distribution of hydrocarbon contamination of sediments in PWS and the northeastern GOA will be carried out in coordination with the DNR. The combined sediment data will also be used to test specific hypotheses about the distribution of *Exxon Valdez* oil in sediments throughout the study area.

Statistical Analysis

In general, for sediment analyses the null hypothesis states that the concentration of petroleum hydrocarbons at particular depths or the distribution of petroleum hydrocarbons with depth at oiled sites does not differ from that at reference sites. All data will be tested for heteroscedasticity with Bartlett's test or equivalent. Data will be reported as means and 95% confidence intervals calculated according to a standard formula (Sokal and Rohlf 1981). Parametric statistics (Model I analysis of variance with site and depth as fixed factors and Scheffe's *a posteriori* test) will be used to test for differences in hydrocarbon concentrations between sites and depths if underlying assumptions of the parametric procedures are met (with data transformation if required), otherwise nonparametric tests (eg. the Kruskal-Wallis test) will be employed. Key petroleum weathering and source ratios will be calculated (Boehm et al. 1987).

DEC

Data on microbial activity levels and hydrocarbon degrader numbers will be subjected to non-parametric analyses (e.g. Mann-Whitney U test) to demonstrate any significant statistical differences in microbial community responses at oiled and reference sites.

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BUDGET

	NOAA	DEC	Totals
Salaries	$123.0	$28.0	$151.0
Travel	18.0	3.5	21.5
Contracts	20.0	107.5	127.5
Supplies	6.0	0.8	6.8
Equipment	8.0	0.0	8.0
Vessel	120.0	0.0	120.0
Total	$295.0	$139.8	$434.8

SUBTIDAL STUDY NUMBER 2

Study Title: Injury to Benthic Communities

Lead Agency: ADF&G

Cooperating Agencies: DEC and NOAA

INTRODUCTION

Benthic organisms (both meiofauna and infaunal macrofauna) associated with subtidal sediments generally represent good *in situ* monitors for measuring effects of oil fluxing to the bottom (for example see Cabioch et al. 1978; Kineman et al. 1980; and Sanders *et al*. 1980). These organisms typically remain close to or at the site of larval settlement, and, consequently, represent good monitoring organisms. The composition of the marine benthic fauna has been successfully used at various locations throughout the industrial world as a basis for measuring effects of pollutants on the bottom (e.g., see Pearson 1975; Cabioch et al. 1978; Pearson and Rosenberg 1978; Gray and Mirza 1979; Sanders et al. 1980; Kineman et al. 1980; Gray and Pearson 1982; Warwick 1986; Boesch and Rabalais 1987; Warwick et al. 1987; and Gray 1989), and should prove useful for assessing biological effects of the EVOS in PWS.

Subsequent to the crude oil spill from the EVOS, it was expected that a certain proportion of oil in the water column (either the original crude oil derived from the spill, oil leached from contaminated shorelines, and/or oil dispersed into receiving waters via shoreline remediation procedures) would reach the bottom by physical and biological processes. Benthic data collected in polluted waters elsewhere indicate that changes in species number, abundance, biomass, and diversity occur if sizable quantities of oil flux to the bottom. Changes in composition of benthic fauna can have serious trophic implications since many subtidal benthic invertebrates are important food resources for bottom-feeding species such as pandalid shrimps, crabs, bottomfishes, sea ducks and sea otters (see review in Feder and Jewett 1981, 1987; Hogan and Irons 1988; McRoy 1988). Further, the larvae of most benthic organisms in PWS move into the water column (March through June) and are utilized as food by large zooplankters and larval and juvenile stages of pelagic fishes, small salmon fry, and herring. Thus, damage to the benthic system by hydrocarbon contamination could affect feeding interactions of important species on the bottom as well as in the water column.

Shallow (<20 m) subtidal studies were initiated in PWS in the fall of 1989 and continued during the summer of 1990 under the Coastal Habitat Study. Deep (>20 m) benthos studies were initiated in PWS in July 1990 under Air/Water Study 2 (Injury to Deep Water [>20 m] Benthic Infaunal Resources from Petroleum Hydrocarbons). Six of the deep benthos sites sampled in 1990 were adjacent to eelgrass sites sampled by the shallow benthic program.

Sampling (for at least five years) of subtidal benthic populations should be continued as a method for assessing possible effects of oil on benthic communities as related to redistribution of oil-laden sediments from adjacent contaminated onshore sites. Oil that initially coated sediments onshore may eventually be transported offshore, thereby contributing to long-term effects on deep subtidal benthic fauna. Examples of such effects were observed following the *Amoco Cadiz* crude oil spill of 1978, in the Bay of Morlaix off the Brittany coast of France (Cabioch et al. 1978) and following the *Florida* No. 2 fuel oil spill of 1969 in Buzzards Bay near West Falmouth, Massachusetts (Sanders et al. 1980).

OBJECTIVES

Shallow Benthos

A. Determine the temporal and spatial effects of the EVOS on the infaunal invertebrate communities within selected PWS embayments where eelgrass (*Zostera*) and the brown algae (*Laminaria*) dominate.

Deep Benthos

A. Determine if changes occurred in the benthos following the EVOS by comparing taxon (primarily determined at the family level: see Methods) richness and diversity, general abundance and biomass, and trophic composition of benthic biota living on similar substrata at stations at depths of approximately 40 and 100 m below eelgrass beds in oiled and unoiled bays.

B. Determine if changes occurred in the benthos, as estimated temporally, by comparing taxon (see objective above) richness and diversity, general abundance and biomass, and the trophic composition of benthic biota at stations within oiled and unoiled bays on an annual basis for at least five years.

C. If changes are detected in the infaunal components of the benthic system, determine how much time is required for the benthos to recover to a relatively stable assemblage of taxa.

D. If changes are detected in the infauna, examine the relationship between the accumulation and retention of hydrocarbons in sediments and the effect on the benthic biota (this will be accomplished in conjunction with the subtidal project assessing hydrocarbon levels in sediments at the sampled stations).

METHODS

Shallow Benthos

General

Shallow subtidal sampling efforts will concentrate on infaunal invertebrate communities in eelgrass and *Laminaria* habitats within bays in PWS. These habitats were also sampled in 1990. They were chosen based on their relative ecological importance, the history of prior damage, and on their proportion of total habitat in the oiled area. Six of the sites within the eelgrass habitat were in common with the Deep Benthos sites. All studies will be conducted at oiled sites (selected at random when possible) and control sites that are matched to the oiled sites with regard to geomorphology, degree of freshwater input, substrate type, and general circulation and wave exposure regimes.

The shallow subtidal sampling for 1991 will occur in concert with the rockfish studies to be conducted by ADF&G (Subtidal Study 6). Both studies will utilize the same divers on the same platform to sample the shallow waters in western PWS. Some of the sampling sites for the two studies are in common.

Stratified Sampling - Rationale

A stratified sampling design, modified from the design used in our 1990 survey, will be employed in order to obtain estimates of basic population parameters (density and biomass) for infaunal invertebrates. These estimates will be used to indicate the effects of the EVOS on this community by comparing density (and other parameters) at oiled vs. control sites. The data will also be used in support of other studies (e.g., otters and birds) since the animals within the subtidal habitats are major food sources for these other species.

Strata to be sampled

In the 1990 sampling, the shallow subtidal communities within PWS was stratified into three major habitat types based on the dominant plants within the habitat: *Nereocystis* beds, eelgrass beds, and *Laminaria* beds (areas where either *Laminaria saccharina* or *Agarum cribrosum* dominate). For the *Laminaria* habitat (the most widely distributed), we further stratify into 3 oceanographic regions: islands, mainland, and outer sound and into three physiographic types: bays, points, and runs (straight shore line). This stratification scheme resulted in 9 potential strata within the *Laminaria* habitat, 1 within the *Nereocystis* habitat, and 1 within the eelgrass habitat, for a total of 11 potential strata in all. Another strata, silled fjords, was added in 1990 based on preliminary finding from our 1989 survey.

In 1990, we sampled 5 of the 12 potential strata: *Nereocystis*, eelgrass, *Laminaria* in island bays, *Laminaria* on island points and silled fjords. In 1991, we will sample only in the eelgrass and *Laminaria* bay habitats.

Selection of sites within strata

Sites to be sampled in 1991 are a subset of those visited in 1990. These were selected based on the summer 1989 oil maps and the September 1989 "walkathon" data. Areas that were moderately to heavily oiled in both surveys will be used as oiled sites. From these oiled areas for each strata (i.e., island bays or eelgrass beds), a section of shore line was selected to be sampled. The selection of the sampling locations was based on the following hierarchy for order of preference: sites for which there were pre-spill biological data, sites previously sampled in NMFS or DEC hydrocarbon surveys, sites sampled by Coastal Habitat intertidal crews, randomly selected sites within the habitat, and sites sampled in the deep benthos study.

Control sites were selected that were unoiled in both the summer oil survey and the "walkathon." Controls were matched with selected oiled sites with regard to aspect, proximity to sources of freshwater input, slope, wave exposure, and water circulation. A matched site will be selected randomly if more than one exists.

Initial site selections were made based on oiling maps and input from scientists familiar with habitats within PWS, as well as from fishermen familiar with PWS. Final selections were made in a reconnaissance survey conducted in April, 1990.

A total of 3 to 5 oiled sites and 3 to 5 control sites were selected from each habitat. Three of the oiled/control pairs within the eelgrass habitat are also sites for the Deep Benthos Component. In 1990, shallow and deep benthic sampling occurred at the following oil/control paired sites: Bay of Isles (O)/Drier Bay (C); Herring Bay (O)/Lower Herring Bay (C); and Sleepy Bay (O)/Moose Lips Bay (C).

Data Analysis

All taxonomic identifications for the 1991 sampling period will only be taken to the family level to accelerate processing time. Data analysis will be coordinated with analyses performed under the Deep Benthos component.

The general form of analysis for all data gathered will be a comparison of oiled vs. control sites using t-tests or nested analyses of variance. In studies where more than one site is sampled, sites will be the primary sampling unit, with various degrees of subsampling within a site.

Deep Benthos

Sampling

The sampling plan for the project calls for collection of five replicate samples at each of two stations within seven bays identified as oil-exposed sites and two stations within seven bays determined to have been uncontaminated (control) sites. All stations sampled will be at approximate depths of 40 and 100 m on a transect extending below seagrass beds within each of the identified bays. Shallow subtidal stations on the transects for at least eight of the bays will be sampled for biota for the Shallow Benthic Studies. A total of 28 deep stations x 5 replicates will be collected on a single cruise in July 1991 in conjunction with microbiological and hydrocarbon sampling projects that will be underway from the same ship platform. Shallow subtidal benthos (<20 m) will be sampled at approximately the same time period from a different ship platform, a circumstance necessitated by the need for a special ship-diving platform. Deep benthic samples at oil-exposed and unexposed sites will be collected on bottoms that are as physically similar as possible. The seven oil-exposed sites to be sampled for deep benthos are Northwest Bay, Disk Island, Herring Bay, Bay of Isles, Snug Harbor, Sleepy Bay, and Chenega. The seven unexposed (control) sites to be sampled for deep benthos are West Bay, Rocky Bay, Zaikof Bay, MacLeod Harbor, Mooselips Bay, Lower Herring Bay, and Drier Bay.

Deep benthic biological samples at stations at approximately 40 and 100 m will be collected with a 0.1 m^2 van Veen grab weighted with 31.7 kg of lead to facilitate penetration. Five replicate samples will be taken at all stations. Material from each grab will be washed on nested 1.0 and 0.5 mm stainless steel screens and preserved in 10% formalin-seawater solution buffered with hexamine.

Analysis and Processing Data

Organisms that will be collected by grab and subsequently used in analyses include infaunal macrofauna, slow-moving macrofaunal surface dwellers, and small sessile epifauna. Highly motile epifauna such as large gastropods, shrimps, crabs, and sea stars (except the infaunal sea star, *Ctenodiscus crispatus*) are not adequately collected by grab and will not be analyzed. Since 0.5 mm mesh fractions were collected and sorted, larger representatives of the meiofauna that are retained quantitatively by this screen will be analyzed. Thus, the following organisms are included in the analyses: nematodes, tardigrades, ostracods, harpacticoid copepods, tanaids and cumaceans. Although Foraminifera were common at some stations, most specimens examined were dead at the time of collection. Additionally, the sorting time necessary to sort samples required that (up to 60 hours per 0.5 mm replicate) this group be deleted from the analyses. Thus, Foraminifera are not included in the analyses; however, all samples containing large numbers of Foraminifera are archived.

All organisms will be identified primarily to Family or an appropriate higher taxonomic level. Generic and specific determinations for organism will be made whenever these categories are known and will be recorded on the data sheets. The decision to use higher taxonomic categories is expected to increase the speed of processing samples. Earlier analyses of benthic samples obtained at study sites shortly after the EVOS indicated that species diversity was typically high. It was estimated that the time necessary to determine taxa to generic and species levels would result in a multifold increase in hours spent in sorting and taxonomic identifications. Additionally, a recent paper by Warwick (1988) and other papers (Rosenberg 1972; Heip *et al.* 1988) indicate that better resolution of multivariate and other data emerges when higher taxonomic levels are used. However, availability of generic and specific names for common organisms allows an examination of station data in more detail if any of these taxa are particularly abundant at a site. All individuals are counted and weighed by taxonomic group. Approximate carbon values for all wet-weights will be calculated.

All data will be recorded on data sheets, entered on magnetic tape and processed with the VAX computer at the University of Alaska Fairbanks. Previously written programs at the University of Alaska for comparison of rank abundance and biomass will be applied to the PWS data. A diversity program will also be used to examine differences and similarities between stations.

Numerical Analysis

Station groups and taxon assemblages for each year, and for the combined data collected on subsequent cruises in future years, will be identified using the technique of hierarchical cluster analysis. Principal coordinate analysis will be used as an aid in the interpretation of the cluster analysis of the data and to identify the misclassification of stations by cluster analysis. Use of both of these multivariate techniques will make it possible to examine similarities (or dissimilarities) between groups of stations, and should be useful when comparing oiled vs unoiled bays.

A Kruskal-Wallis and a multiple comparison test for significance will be used to test for differences in the total abundance and biomass between stations sampled each year and in multi-year data sets. These tests will be made on the abundance and biomass of selected, dominant taxa at stations between years. Taxa will be chosen from the rank abundance and biomass printouts for each station; taxa selected will generally be those commonly present within bays being compared. However, taxa that are common at stations within unoiled bays, but rare or missing at stations within oiled bays, will also be tested. Analysis of variance

(ANOVA) will also be used to test differences in abundance and biomass between dominant taxa for stations at similar depths within unoiled and oiled bays.

Various measures of diversity will be calculated, and compared between stations at similar depths within unoiled and oiled bays. The indices to be calculated and presented are: Shannon Diversity (measures total diversity), Simpson Dominance (useful for identifying dominance by one or a few taxa at a station), Evenness, and Species Richness.

The K-dominance curves (Warwick 1986) that relate abundance and biomass data will be used in an attempt to assess the effect of hydrocarbons on benthic organisms in oiled bays. This is a recent technique designed to detect pollution-induced disturbance on marine benthic communities. However, there are problems of interpretation of the output of this technique that must be considered before environmentally-related conclusions can be drawn (Gray 1989; Beukema, In press). Distributions of geometric classes of abundance of species will also be calculated (Gray and Pearson 1982). Assessment of the distribution of taxa in these abundance classes is often useful to identify indicator species within a disturbed area.

Methodologies, rationale, and problems with the use of diversity indices, K-dominance curves, and geometric abundance classes as measures of pollution-induced disturbance are discussed in Bayne *et al*. (1988), Gray *et al*. (1988) and Appendix C.

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BUDGET

Salaries	$467.7
Travel	19.6
Contracts	90.8
Supplies	11.9
Equipment	2.5
Total	$592.5

SUBTIDAL STUDY NUMBER 3

Study Title: Bio-availability and Transport of Hydrocarbons

Lead Agencies: NOAA, DEC

INTRODUCTION

This study will continue to assess the geographic and temporal distribution of dissolved and particulate hydrocarbons in the water column resulting from the EVOS. Caged mussels will be used to determine the bio-availability of suspended hydrocarbons. Sediment traps provide a measure of suspended load as storms and clean up activities expose remaining shoreline oil deposits to weathering.

Analysis of caged mussels at impacted sites will compare levels of petroleum hydrocarbons with levels in mussels at unimpacted sites. Levels of hydrocarbons in mussel tissue will demonstrate that hydrocarbons are biologically available to biota in nearshore waters.

In 1991, NOAA/NMFS will continue caged mussel deployments. Field efforts will be reduced by placing mussels at ten sites in PWS for two one month exposures, in addition to collection of indigenous mussels at transplant sites.

In 1991, NOAA/NMFS will also begin the synthesis and interpretation of hydrocarbon contamination data for mussels and seawater from seven NRDA projects. This synthesis will provide information on hydrocarbon exposure over a broad geographical area and temporal duration.

DEC conducted two retrieval cruises in 1990 for the original set of five sediment traps. Ten additional traps deployed in August 1990 will be retrieved in March 1991 after winter storms and before the spring plankton bloom. Work in 1991 will concentrate all fifteen traps at five sites to allow more intensive monitoring. The traps will be retrieved again in June after the plankton bloom and removed in September before winter storms.

OBJECTIVES

A. Evaluate trends in ambient water quality using bioaccumulators *Mytilus trossulus* as surrogates for chemical measurements. Estimate concentrations of petroleum derived hydrocarbons accumulated by mussels transplanted for 1 or 2 months along the oil spill trajectory such that the estimate is within 25% of the actual concentrations 95% of the time.

B. Synthesize all water and mussel hydrocarbon data in the Technical Services 1 database to provide a comprehensive geographic and temporal picture of trends in petroleum hydrocarbon concentrations in the near shore water column.

C. Determine if sediments settling out of the water column in nearshore subtidal environments contain adsorbed hydrocarbons.

D. Decipher subtidal oiled sediment transport mechanisms through analysis of benthic sediments and stratigraphic analysis of bottom cores.

METHODS

NOAA/NMFS

Experimental Design

Prior to a new deployment cruise, bay mussels, *Mytilus trossulus*, will be collected from a hydrocarbon free site on Admiralty Island in southeast Alaska. The mussels will be transported to Auke Bay Lab and held in living stream tanks that have been rinsed with dichloromethane and flushed with ambient unfiltered seawater at the rate of 2 liters per minute at least overnight. Since mussel size may influence hydrocarbon uptake (Bayne et al. 1981), only mussels with shell length of 45-50 mm will be selected for deployment. At least 30 animals from each collection will be sampled to determine the population's base hydrocarbon level and condition.

Mussels will be kept aboard the deployment vessel in coolers and the blue ice changed daily for up to 6 days. A mussel "cage" is a nylon mesh diver collecting bag. For deployment, 20 mussels will be placed on a rigid perforated polypropylene sheet fitted into the bottom of each cage. Assuming some mortality during exposure, this number was selected to provide at least triplicate samples of 10 g of tissue for hydrocarbon analysis. On site, a cage will be attached to an anchored mooring line at 1 m, 5 m, and 25 m depths. The 2 shallower cage depths were selected to correspond to water column depths sampled by this study in the first 6 weeks after the spill; mussels at the third depth will be exposed to the water column about 10 m above the bottom at low tide. Mussels will be exposed for approximately 30 days. At the conclusion of each deployment cruise another baseline mussel sample will be taken.

Details of deployment, exposed mussel collection, and sample handling are provided in Air/Water 3 Study Plans 1989 and 1990.

Sampling 1991

Mussels will be deployed at ten 1990 sites within PWS. Eight sites were in the spill trajectory and subject to maximum original oiling as indicated by preliminary analysis of water column samples (Air/Water 3), sediment pore water samples (Air/Water 4), and by DEC Shoreline Impact Composite Maps. All sites coincide with Air/Water 2 sites and five coincide with Air/Water 3 sediment trap locations. There are two reference sites. Deployment in 1991 will indicate changes in hydrocarbon concentrations at these sites since deployed mussels were last collected in September 1990. Additional mussels may be collected in 1991 at specific sites in PWS where hydrocarbon data is needed.

Data Synthesis

The geographic and temporal extent of water and mussel samples collected, and of those submitted for hydrocarbon analysis will be determined. Samples that have not yet been selected for analysis, but that may be needed to provide a more complete documentation of overall exposure levels, will be identified. Additional mussels may be collected in 1991 at specific sites in PWS where hydrocarbon data is needed.

Data Analysis

Analysis of variance (ANOVA) will be used to determine the statistical differences of hydrocarbons found in samples. ANOVA will also be used to examine differences among water and mussel samples in the data synthesis process.

Draft graphic presentations of the data synthesis of all NRDA mussel samples will be prepared at Auke Bay Lab with Munmap and Autocad. Final maps will be prepared by Technical Services No. 3.

DEC

Experimental Design

The sediment trap design incorporates guidelines developed from previous sediment trap work with open-ocean moored traps and laboratory flume studies (Woods Hole 1989). The original design of the traps was only intended to capture sediments in the nearshore subtidal habitat to show presence or absence of adsorbed hydrocarbons, without quantification of flux rates. This is a result of presence of the traps being deployed in the complex, multidirectional, oscillatory current and wave environment of PWS making control of variables difficult. The sedimentary processes occurring in the area of a trap may be difficult or exorbitantly expensive to monitor.

Theoretically, estimation of trapping efficiencies in the field may be determined by use of three parameters:

(1) Reynolds Number, a function of current speed and the ratio of fluid viscosity to fluid density,

(2) aspect ratio (A) of height (H) to diameter (D), and
(3) the ratio of flow speed to particle fall velocities.

In short, the direction and velocity of any currents and the geometry of the trap (aspect ratio and axial symmetry) will determine if the trap disrupts the flow field and results in turbulent eddies within and around the trap that will change any naturally occurring sedimentation patterns. The spacing of the traps determine whether they affect each other's trapping efficiencies.

Based on the lack of data regarding currents, the traps were designed so that the aspect ratio, symmetry, and spacing would be adequate for a variety of conditions. The trapping cylinders are constructed of Schedule 40, high chemical resistance PVC, (6" inside diameter and 48" tall). A baffle of 0.5" square grid, 0.5" deep fits flush with the top of each trap. These cylinders are mounted on a 20" x 20" square base, with rebar extending 24" on which the cylinders are clamped. Each trap suite contains three cylinders. Design considerations follow the Woods Hole report (1989) including:

(1) a cylindrical geometry for axial symmetry which promotes trapping efficiency;

(2) an 8:1 aspect ratio to minimize eddies, reduce in-trap flow, and allow for a tranquil layer within the trap for current velocities to 20 cm/sec (0.39 knots). (In the sheltered bays where most traps are deployed, currents are probably within this range);

(3) a base in a triangular configuration that is oriented to wave-induced shore-normal currents. Cylinders are spaced at 18" centers and aligned to reduce chances any cylinder would be downstream of another; and

(4) leveling after deployment to maintain orientation to currents and the water column.

<u>Sampling 1991</u>

The 1991 sampling plan will locate traps along a transect to the shore at three different depths. Fifteen sediment traps will be deployed at five sites in 1991. At each site, divers will place a suite of traps at 10, 15 and 20 meters below MLLW.

The sediment traps are designed and located to collect sediments settling from the water column at single points throughout PWS. Coordination with other studies provides for result extrapolation both spatially and temporally. The trap sites have been matched with sites used by Coastal Habitat previous DEC subtidal sampling, Subtidal 2, and NOAA caged mussels. Sediment chemistry data will thus be available over time and from a larger area.

Knowledge is derived of current directions and velocity at the sediment trap sites from qualitative observations of sedimentation structures and drift patterns by the field team. Particle size, settling velocities, and current measurements will aid in the differentiation of bed-load movement versus resuspension (Visher 1969; Middleton 1976), delineation of erosional and depositional events (Sundborg 1956), as well as allowing calculations of trap efficiency. Differentiating between new sediment input to the subtidal and cycling of previously deposited sediments will give a better understanding of localized transport processes. Due to the great distances fine sediment particles can travel before settling out of the water column (in a current flow of 10cm/sec, a 0.06mm silt particle may travel as far as 10 km before settling at 100 m.), coordination with Subtidal No. 1 deepwater sampling is emphasized.

Data Analysis

Particulate samples from the sediment traps will be screened for hydrocarbon content by ultraviolet fluorescence spectrophotometry after methylene chloride extraction of samples. UVF is a semiquantitative method of analysis for hydrocarbons (ASTM 1982). Samples showing significant quantities of petroleum hydrocarbons will be further analyzed for polynuclear aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (TPH) according to procedures established by Technical Services Study No. 1.

Particle size analysis will be performed by sieving the sample in a stacked set of Wentworth grade sieves to 62 um. Analysis of the silt-clay fraction will be obtained by pipette analysis. Sediments will be inspected for composition, and cores for sedimentary structures.

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BUDGET

	NOAA	DEC	Totals
Salaries	$ 110.0	$69.0	$179.0
Travel	21.0	10.3	31.3
Contractual	0.0	11.5	11.5
Supplies	19.0	2.2	21.2
Vessel	0.0	103.2	103.2
TOTAL	$ 150.0	$196.2	$346.2

SUBTIDAL STUDY NUMBER 4

Study Title: Fate and Toxicity of Spilled Oil From the *Exxon Valdez*

Lead Agency: NOAA

INTRODUCTION

Overview and Relation to other Studies

This study is designed: a) to assess the toxicity of weathered *Exxon Valdez* oil and its degradation products to selected test organisms; and b) to integrate the results from selected other projects, both within and outside the NRDA, into an overall budget for the distribution, transport, transformation, and persistence of spilled oil in Alaskan coastal environments. The study is very closely coordinated with Subtidal Study No. 1 for its field work and toxicity studies, and will require close interaction with all of the present and past Air/Water studies, the Coastal Habitat studies, and with related spill response studies for completion of the spilled oil budget.

Toxicity of Prudhoe Bay Crude Oil and its Products of Weathering

Very limited information is available on the significance of either the polar constituents of crude oil or the intermediate oxidation products of petroleum hydrocarbons (whether from photooxidation or biodegradation) in terms of their potential for bioaccumulation and toxicity to resource organisms in the marine environment. Since these compounds have undergone preliminary oxidation and (sometimes) conjugation, they are more polar than their parent hydrocarbons, and will as a result generally be more subject to excretion or depuration, less subject to bioaccumulation, more susceptible to further oxidation (or biodegradation if accumulated), and more susceptible to dilution and dispersion in the water column. A detailed review of the literature on these topics was included as part of the study plan for this project last year. Under this project very limited studies were initiated during 1990 to determine whether such polar constituents pose a significant risk of toxicity or mutagenicity to Alaskan marine organisms as a result of the EVOS.

Acute Toxicity of Ambient Spilled Oil to Marine Organisms

Last year's study plan provided a review of the very considerable body of literature that exists on the toxicity of Alaskan crude oil to Arctic and subarctic marine organisms. The data base is probably adequate for assessing the relative sensitivities of different marine species to exposure and for estimating the range of potential responses (at the organism level) that may result from a particular level of exposure in the environment. Very little of this prior research on toxicity was directed, however, at the specific contribution of either hydrocarbon metabolites or other oxidation products of oil that may be produced by the processes of biological or chemical weathering in the environment.

Much of the early work in this area focused on the acute toxicities (generally 96-hour exposures) of water-soluble fractions (WSF) of fresh Cook Inlet crude oil and Prudhoe Bay crude oil to a variety of species and life stages of commercially or recreationally important Alaskan marine organisms. Data on the acute toxicities of crude oil to marine organisms of interest have been summarized by Brodersen et al. (1977), Craddock (1977), Moles et al. (1979), Rice et al. (1976, 1977, 1979, 1984), and National Academy of Sciences (1985). Rice et al. (1981) demonstrated that the compositions of the water-soluble fractions of Cook Inlet and Prudhoe Bay crude oils were very similar both to one another and to that of the discharge from the ballast treatment facility at Valdez.

Sublethal effects of oil exposure have also been studied extensively, through the use of long-term exposures (e.g., up to 40 days) to WSF of Alaskan crude oil, or of prolonged exposure to oiled food or oiled sediments. Earlier work (which focused primarily on temperate organisms and crude oils from sources other than Alaska) was summarized by Anderson (1977), Johnson (1977), and Patten (1977). During the late 1970's and early 1980's, increased attention was given to arctic and subarctic organisms, especially relative to Alaskan and Canadian oils, and some of this more recent work has been reviewed by Rice et al. (1984), Rice (1985), Wolfe (1985), National Academy of Sciences (1985), and Karinen (1988).

In conjunction with Subtidal Study No. 1, work was undertaken under this project in 1990 to test the ambient toxicity of marine sediments from PWS and the nearby GOA to two bioassay organisms: the marine amphipod *Ampelisca abdita* and the oyster *Crassostrea gigas*. Although results of this work have not been analyzed completely, preliminary results indicate that sediments from oiled sites in PWS were significantly more toxic to the bioassay species than were sediments from unoiled or lightly oiled reference sites.

Fate of Spilled Oil: Budgets and "Mass Balance"

An accurate and complete mass balance is difficult to assemble for a major oilspill in the marine environment. The quality of estimates of the quantities and locations of oil affected by different processes of transport or transformation have varied from spill to spill, depending on the local circumstances of the spill and the level of effort devoted to any particular process. Selected observations at past spills have been summarized by Mackay (1981), Gundlach et al. (1983), Jordan and Payne (1980), National

Academy of Sciences (1985), and Wolfe (1985, 1987). Information especially pertinent for summarizing the fate of oil from the EVOS has been and is still being gathered by the Interagency Response Team and the DEC, and by certain projects under the NRDA Program: especially Coastal Habitats Studies 1&2, A/W Studies 1-5, Fish/Shellfish Study 24 and Technical Services Study 1. Oil weathering models (Payne 1983, 1984) and transport/fate models (Galt and Torgrimson 1979; Spaulding et al. 1983), constructed to predict the distribution and fate of spilled oil, should also provide valuable insight and assistance in preparation of a budget for the oil spilled by the *Exxon Valdez*.

OBJECTIVES

A. Document the toxicity of contaminated sediments and related environmental samples to selected marine biota

B. At selected sites, document and quantify the occurrence of oxidized derivatives of *Exxon Valdez* oil; and determine the extent to which the observed toxicity of oil-contaminated environmental samples may be attributable to oxidation products of petroleum.

C. Construct a summary budget or "mass balance" summarizing the fate of the spilled oil.

METHODS

A. Toxicity of Oil-Contaminated Sediments And Other Environmental Samples

A boat-based survey of surficial sediment toxicity was carried out in 1989 under A/W Study No. 4, at all stations sampled during June to August, 1989 (Leg II). The toxicity bioassay used in that study was the standard Microtox assay, in which a composite of the replicate sediment samples obtained at each depth from each sampling site is analyzed for sediment toxicity based on the inhibition of bioluminescence in *Photobacterium phosphoreum* (15-min Microtox assay). Organic extracts of the sediments were prepared and assayed for toxicity by the methods of Schiewe et al (1985). The Microtox assay is rapid, simple, inexpensive, and sensitive; and the bioassay results have correlated well in other studies with the results of other standard bioassays that use fish, amphipods or bivalve larvae as test organisms (Chang 1981, Williams et al. 1986, Giesy et al. 1988). Results of the 1989 survey also correlated with UV fluorescence analyses of oil in the sediment samples.

Under A/W 6, toxicity tests were performed in 1990 on sediment samples taken at selected sites sampled by A/W Study No. 2 from the

NOAA ship *Davidson*. Two specific tests, both following well-established protocols, were used: a sediment elutriate test using larval oysters, and a whole sediment test using *Ampelisca abdita*. *Crassostrea* is a standard bioassay species used to represent intertidal and subtidal bivalve species whose larval recruitment is vulnerable to interruption by toxic oil residues remaining in intertidal sediments. *Ampelisca* inhabits soft nearshore sediments that are possible sinks for petroleum. Subtidal ampeliscid amphipods exhibited considerable sensitivity to oil in the aftermath of the *Amoco Cadiz* spill (Cabioch et al. 1982). Use of these two species was intended to provide a direct measure of the toxicity of the residual oil to actual marine species. Preliminary test results from the 1990 samples indicated that sediments from oiled sites were more toxic to both bioassay organisms than were sediments from unoiled reference sites, and both bioassays are proposed to be repeated in 1991 to determine whether the toxicity has persisted and how its levels may have changed.

Detailed methods for both of the proposed tests have been described previously: for the oyster larvae bioassay (Chapman and Morgan 1983; Chapman and Becker 1986); and for the *Ampelisca* test (Long, Buchman et al. 1989; Scott and Redmond 1990).

Sediment samples will be collected during one or more of the sampling cruises described under Subtidal Study No. 1. Sampling sites have been selected to represent the more heavily oiled areas and a set of unoiled (or very lightly oiled) reference sites for comparison. At each of 15 of the sites, eight one-liter samples of surficial sediments (top 5 cm) will be collected (2 each at the intertidal, 6-meter, 20-meter, and 100-meter depths) for toxicity testing with *Crassostrea* and *Ampelisca*. These samples will be stored at 0-4° C, and offloaded from the vessel at regular intervals for shipment to a testing laboratory to be selected through a competitive contracting procedure. Bioassays will be initiated within 10 days of the collection of the samples.

B. Oxidation Products of Petroleum

Two contracts were initiated under this study (A/W 6) in 1990 to determine the presence and significance of polar oxidation products of petroleum in the marine environment of PWS.

At two heavily oiled sites and one lightly or unoiled site in PWS, special samples were taken by a team of researchers from Science Applications International Corporation, to assess the concentrations and compositions of petroleum oxidation products, and their toxicity, in intertidal sediments and interstitial water. Large quantities of sediments and interstitial water were required to support the necessary development of suitable techniques for bulk fractionation of samples for chemical characterization and quantification of the polar metabolites and for toxicity testing.

The intertidal sediments and interstitial water were extracted with methylene chloride, and the extracts were subjected to toxicity testing with a suite of bioassays, including the standard Microtox bioassay (Schiewe et al. 1985), the Ames mutagenicity test (Ames et al. 1975), the SOS Chromotest assay for genotoxicity (Quillardet and Hofnung 1985, Quillardet et al. 1985), and the *Mytilus* larval toxicity bioassay. The extracts were then fractionated to separate polar from non-polar constituents, and the toxicity of the polar fractions will be compared with the better known toxicities of aromatic fractions and reference compounds. Those fractions that demonstrate significant toxicity will be analyzed by GC-MS to identify the composition of polar constituents.

A second contract was let to Bermuda Biological Station for the analysis of selected mussel (*Mytilus trossulus*) tissue samples for polar oxidation products to ascertain whether these compounds were present in, and bioaccumulated from, the oiled PWS environment.

At the time of this plan, results were not available from either of these contracts. During 1991, the contractors' reports will be received and evaluated, and final recommendations will be developed on how to assess the probable toxicity of polar constituents arising from the EVOS. These studies may lead also to recommendations for analyses of polar constituents to supplement the traditional hydrocarbon analyses being performed on environmental samples taken by other projects within the overall NRDA.

C. Budget for Fate of Spilled Oil

This task is primarily a synthesis function. Information on the distribution and fates of *Exxon Valdez* oil needs to be assembled from a number of sources, interpreted in the light of existing information and models, and presented in a way that will support a region-wide assessment of the potential effects of the spill.

During 1990, a small Steering Group of spill experts met to identify the compartments and processes that should be included in the FATES budget. The Steering Group identified the following compartments for initial analysis and inclusion in the budget: 1. Water Surface (floating oil), 2. Intertidal Zone (stranded oil), 3. Water Column (dissolved and accommodated oil), 4. Subtidal Sediments (sunken and settled oil, or oil otherwise transported to bottom sediments), 5. Atmosphere (evaporated oil). The actual masses of oil in these different compartments are quite different, and because of transfers among compartments as the spill was transported through and out of PWS, the pertinent time and space scales are also quite different. As a result, very different estimation methods have been used (by different people) for the various compartments. The Steering Group concluded therefore that information for these five compartments would best be synthesized separately, with appropriate effort to reconcile both the separate compartmental estimates as well as any estimates of fluxes between compartments . For each compartment and its associated major fluxes, the Steering Group identified and discussed important sources of data, historical information, and modeling expertise, and suggested preliminary courses of action, as summarized in the report of the steering group meeting.

Potential sources of data, historical information, and modeling expertise were identified for:

1. Floating oil (distribution in Time & Space)
2. Evaporation and atmospheric dispersion
3. Photooxidation in the atmosphere
4. Mousse formation
5. Beaching of oil & mousse (T&S)
6. Water column accommodation (T&S)
7. Photooxidation in water column, in slicks and on beaches
8. Biodegradation in water column
9. Transport to subtidal sediments
10. Biodegradation in sediments

Representatives of the above noted activities, along with other recognized experts on oil weathering and fates, will be consulted for recommendations on appropriate approaches to synthesis, and for their judgments on the suitability and adequacy of existing information for development of the FATES model. Timely progress on the FATES budget will depend on the availability of suitable information from other sources and projects. Chemical data, i.e., from TS No. 1, will be of utmost importance to the completion of this project. Where existing information is found to be deficient, means will be explored for gathering of improved information. The reliability of all estimates will be assessed and qualified in the final analysis.

To the extent practical, lead individuals will be designated for coordination and completion of the synthesis related to each of the identified compartments, especially where those compartments and processes are included explicitly in the NRDA. For example, initial assessment of the hydrocarbon levels and weathering in intertidal and subtidal sediments will be conducted under Subtidal No. 1 (A/W 2), while the assessment of water column data will be done under Subtidal No. 3 (A/W 3). Effort should be made to identify all sources of relevant data and information for each of the individual compartments in the Fates budget. The synthesis for each of the compartments should include estimates of the rates of transport and transformation processes ongoing within and/or between compartments, including such processes as mousse formation, photooxidation, biodegradation, evaporation, dissolution, accommodation, chemical weathering and compositional change, "bleeding" of sheen, adsorption-sedimentation, sinking, down-slope transport of oiled sediments, etc. Following this initial synthesis at the compartmental level, the results will be brought together at a summary review and workshop to examine, explain, and eliminate inconsistencies among data sets; and to encourage and promote development of a single, complete, and accurate consensus synthesis product for all components together. Every effort should be made in advance of the workshop to compare and reconcile the independent estimates of inter-compartmental transfers, however, these will be scrutinized in detail at the workshop itself. The final synthesis will include detailed assessments of the quality of the data and information, including analytical confidence limits, sampling adequacy in time and space, and model reliability. As part of this analysis, the reliability of all estimates will be assessed and qualified. Efforts will also be made to present estimates of oil distribution in a form amenable to comparison with existing information on toxicity to facilitate any subsequent assessments of the potential effects on biological resources.

D. Quality Assurance and Control

All samples will be taken with careful adherence to Chain-of-Custody requirements. All of the intertidal and subtidal sediment samples analyzed under this study will be retained in the custody of the laboratories performing the analyses, as called for in the guidelines provided by the Technical Services No. 1 Analytical Committee. The detailed protocols for collection of intertidal and subtidal sediment samples are given in past proposals for Air/Water Study No. 2.

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BUDGET

Salaries	$ 24.0
Travel/shipping	11.0
Contracts	85.0
Supplies	5.0
Total	$125.0

SUBTIDAL STUDY NUMBER 5

Study Title: Injury to PWS Spot Shrimp

Lead Agency: ADF&G

INTRODUCTION

This project will continue to determine possible damage to spot shrimp, *Pandalus platyceros*, due to the EVOS. Spot shrimp are a representative species of the deepwater nearshore benthic ecosystem, serving as a food source for a variety of fish. They are a commercially important species and also support subsistence and personal use fisheries in PWS. This project is a continuation of F/S Study No. 15 which was conducted during 1990-91.

Spot shrimp are known to be sensitive to oil contamination in both the larval and adult phase, and the effects of oil on spot shrimp in particular and shrimp in general are well documented (Anderson et al. 1981; Brodersen et al. 1977; Brodersen 1987; Mecklenburg, Rice and Karinen 1977; Sanborn and Malins 1980; Stickle et al. 1987; Vanderhorst 1976). To determine the impacts that hydrocarbons from the spill may have had on spot shrimp, samples will again be collected from the three oiled and three non-oiled sites in western PWS which had been surveyed in 1990. An additional site will be used in 1991 to increase the sample size for fecundity and modal analysis in the oiled area. The data collected from the samples will be analyzed to determine tissue hydrocarbon levels and tissue damage. The collected data will also be tested to confirm or reject the hypothesis that there is no significant difference in hydrocarbon levels between the oiled and non-oiled areas. Relative abundance, in terms of catch per unit effort, at each study site and changes in relative abundance over time will be tested to determine possible relationships with the level of oiling. A comparison with historical records will also be made. The size composition of the stock at each site will be estimated and, dependent upon recruitment to the fishing gear, analyzed to determine whether the 1989 year class suffered a high mortality rate in areas of high oil impact relative to other year classes in non-oiled areas. Spot shrimp fecundity will also be determined and tested for significant interannual differences between oiled and non-oiled sites.

OBJECTIVES

A. Estimate the relative abundance by weight and sex of spot shrimp and the relative abundance by weight of incidentally caught pink and coonstripe shrimp in oiled and unoiled areas and compare these values to those obtained during surveys in 1989 and 1990.

B. Compare size and age frequencies of spot shrimp (by sex and depth stratum) between sites using mixture modal analysis.

C. Estimate fecundity, egg mortality, and other sublethal effects between oiled and unoiled areas over time, and determine whether those effects result in adverse changes in reproductive viability.

D. Analyze tissue and egg samples for presence of hydrocarbons and compare differences between oiled and unoiled sites. Test the hypothesis that the level of hydrocarbons is not related to the level of oil contamination present at a site.

E. Document injury to tissues and compare differences between oiled and unoiled sites if warranted by results from tissue hydrocarbon analysis.

F. Provide information on stock status, hydrocarbon concentration and other indicators of stock condition for restoration of damages and management of the spot shrimp resource for subsistence, personal and commercial user groups.

METHODS

This project uses commercial spot shrimp pots of a standardized size to catch spot shrimp in oiled and unoiled areas. Shrimp specimens will be analyzed for Prudhoe Bay crude oil levels and necropsied to determine if damage has occurred to tissues as a result of oil contamination. Only one sampling period will occur during the winter of 1991-92. The sampling period will take place in early November (1991) following the fall molt and egg extrusion. Relative abundance estimates of spot shrimp will be made using a stratified pot deployment based on depth and location. Size distribution, species composition, and reproductive data will also be collected. Previous spot shrimp research in PWS is documented by Kimker and Donaldson (1987), Donaldson (1989), Donaldson and Trowbridge (1989), and Kruse and Murphy (1989).

This project will be carried out in two general areas. One will be an area of little apparent impact, the northwestern portion of PWS. This area includes Unakwik Inlet, the site of previous ADF&G research on abundance and growth of spot shrimp. The second area will be central and southwestern PWS, an area of generally high oil impact. This area includes Green Island where ADF&G test fishing occurred in 1981. Within each of these two areas, fishing will take place at three sites. In the northwestern sound, test fishing will occur in Unakwik Inlet, Port Wells, and Culross Passage. In the central and southwestern sound, test fishing will take place near Herring Bay, Chenega Island, and Green Island. An additional oiled site will be located at Elrington Passage to increase the sample size for mixture modal analysis in 1991. Shrimp distribution in these areas has been established by surveying the commercial fleet.

Fishing will take place at seven sites - four in oiled areas and three in unoiled areas. Each site will be stratified by depth. Stratum 1 will be shallow waters - 20 to 70 fathoms. Stratum 2 will be deep waters - 70 to 120 fathoms. Based on past research, spot shrimp are not abundant below those depth ranges. Because of the difficulty of placing the gear at precise depths, it is impractical to divide the depth into more than two strata. Strata span 50 fathoms in depth or approximately 65 to 85 fathoms in width along the bottom at slopes of 75 to 100 percent. Fishing a 100 fathom string will span the width of each strata and allow for a complete placement of gear over the strata.

Eleven pots spaced 10 fathoms apart will be fished on a long line so that each string of pots is 100 fathoms long. One 100 fathom string of gear constitutes a sampling station. Two stations will be fished in each stratum at each site for a total of 22 pots per stratum per site, or 44 pots per site. Forty-four pots is the most that can be fished in a day while collecting all of the various samples and data. If necessary, pots will be redeployed an additional day at each site and at each depth until a minimum of 500 shrimp are captured per depth stratum. A total of 264 pots will be fished during each time period.

Water temperature, salinity, and dissolved oxygen concentration by depth will be recorded using a CTD, transferred from the CTD to a micro-computer and stored on diskette. CTD casts will be at one station in the deep stratum every day. The CTD will be lowered at a rate of 60 meters per minute. Because of the configuration of the CTD, only readings from the downcast will be used.

Total weight of catch, sub-sample weight, and the weight of each species in a sub-sample will be recorded for each pot on a paper form at the time the pot is retrieved. The total weight of shrimp per pot will be determined by weighing the contents of each pot on an electronic scale. Spot shrimp that are removed as hydrocarbon samples will be accounted for in the total weight by adding weight representative of the number and size of shrimp removed. The average number of shrimp per kilogram will be determined. If less than 500 shrimp are estimated to be contained in all of the pots, all of the shrimp will be sampled. If the pots are estimated to contain more than 500 shrimp, a constant proportion by weight of each pot will be sampled for a total sample of 500 shrimp.

Each sub-sample will be sorted by species. Weight and number of animals will be recorded for each species. Only spot shrimp will be retained for further data collection. All spot shrimp in the sub-sample will be measured for carapace length to the nearest 0.1 millimeter using a digital caliper and sex will be determined as juvenile, male, transitional, or female. For female spot shrimp, egg color and stage of development (eyed or uneyed); relative clutch size; presence of breeding dress and egg parasites or parasitic externa will be noted. Each female retained for fecundity analysis will be identified with a code number to allow cross reference of fecundity and other data.

Specimens for necropsy analysis will be taken after the catch is weighed and processed. Twenty shrimp from a single station in each stratum will be selected randomly to make up a necropsy sample. Necropsy samples will be labeled with the date, station number, latitude and longitude, sample number, project leader's name, species, and agency.

To prevent contamination, specimens for hydrocarbon testing will be taken from the pot immediately after removal from water and before contents are weighed. Three spot shrimp will form one composite sample. Each composite will be taken from a different pot. Two replicates of the composite will be taken randomly from one station in the stratum and the third replicate will come from the other station. Three samples per site per depth stratum result in 12 samples per depth stratum (four sites X three samples) for the oiled area, and nine samples (3 sites x 3 samples) per depth stratum in the unoiled area. Twenty four samples (12 samples x 2 depth strata) will be taken in the oiled area and 18 samples (9 samples x 2 depth strata) in the unoiled area. This will allow hypothesis testing to detect differences in hydrocarbon levels of 1.2 standard deviations with the probability of a type I or type II error being 0.05 and 0.10, respectively.

The number of specimens for one hydrocarbon analysis is dependent on the size of the specimens collected. Tissue volume based on the average size of the species was estimated and the number of specimens needed to provide 15 gm of tissue was calculated to be three spot shrimp. It is estimated that three hydrocarbon samples from each treatment level are needed for detecting contamination between levels.

Twenty five egg-bearing females will be taken at random from each station to estimate fecundity and egg mortality. A total of 28 stations will yield a total sample size of 700 females. Specimens from each station will be individually labeled. Each sample bag will be labeled with project leader's name, species name, "eggs", date, station, and agency name.

Fecundity will be determined by removing the eggs from the pleopods, drying each egg mass to a constant weight, weighing a sub-sample of a known number of eggs, and expanding the sub-sample weight to the weight of the entire clutch. Carapace length will be taken for each specimen at the time of subsampling and assigning a fecundity number.

A minimum number of five shrimp from each station will be sampled for fecundity which will allow an adequate sample (30 per depth strata per oil impact level) to test for differences in fecundity between depth strata and oil impact level.

Objective A will be addressed by estimating the average catch per pot by weight, sex, and species. ANOVA will be used to test for significant differences in each of these categories between strata (depth), sites, and oiled versus unoiled areas. To define the relationship between hydrocarbon levels and changes in relative abundance, statistics for analysis of covariance or an appropriate multivariate technique will be calculated to contrast differences in hydrocarbon content and relative abundance in oiled and unoiled areas. Changes in average catch per pot over time will also be analyzed between different depth strata, sites, and oiled and unoiled areas.

A size frequency distribution will be made by sex to address Objective B. The hypothesis that there is no significant difference between strata, and oil impact levels for size frequency distribution will by tested using quantile-quantile plots, chi-square tests or other appropriate methods. A t-test or a similar non-parametric test will be used to test for similarity in means.

To meet Objective C, the relationship between size and fecundity will be examined. The percentage of spot shrimp females bearing eggs; the stage of spot shrimp egg development (color and presence or absence of eyes); the percentage of spot shrimp egg fouling and egg mortality; the fecundity by size; and the relative clutch size will be determined for each station. Chi-square tests will be used to test for differences in strata, sites and levels in data which involve percentages and proportions. Differences between strata, sites, and impact levels for fecundity and relative size of clutch will be tested for using analysis of variance.

To address Objectives D and E, the average levels of oil present in spot shrimp tissue by strata and site will be estimated. Significant differences in hydrocarbon concentrations between oiled and unoiled sites will be tested by analysis of variance. To further define the impact of hydrocarbon levels on the stock, the percentage of animals with abnormal tissues in oiled and unoiled areas will be determined. A chi-square test will be utilized to test for significant differences in percentage of animals with abnormal tissues between strata, sites, and impact levels.

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BUDGET

Personnel Services	$ 35.0
Travel	1.5
Contractual	12.0
Supplies	1.5
Equipment	0.0
Total	$ 50.0

SUBTIDAL STUDY NUMBER 6

Study Title: Injury to Demersal Rockfish and Shallow Reef Habitats in PWS and Along the Lower KP

Lead Agency: ADF&G

INTRODUCTION

In light of the findings of potential impacts on rockfish populations continued study of demersal rockfish populations and shallow reef habitats is warranted for 1991. Unlike many species of marine fish, demersal rockfish complexes are relatively sedentary, residing near rocky reefs and boulder fields. The potential impact of the oil spill on various nearshore assemblages is dependent upon location of various rockpiles. The potential uptake of various contaminants will be related to the level of oil contamination and food web characteristics of these reefs. Of primary importance are questions of transport of oil to subsurface habitats and the potential for residual persistence of this contamination. Khan (1987) reports that crude oil can contaminate sediments and persist for long periods of time in the environment.

Under these conditions, the petroleum hydrocarbons can exert a broad range of effects on animals, from impaired feeding, growth, reproduction, and changes in behavior; to tissue and organ damage, damage to blood cells, changes in enzyme activity and changes in parasite densities (Khan 1986; Khan 1987; Kiceniuk and Khan 1986; Rice 1985; Wennekens et al. 1975; Malins et al. 1977; Rice et al. 1977; Gundlach et al. 1983; Hose et al. 1987; Spies et al. 1982). These possible affects are especially critical to demersal rockfish since they are long-lived, recruitment is low, and the potential for long-term stock decline due to chronic exposure to crude oil is high. Continuation of this study will help determine long term histopathological effects on the fish and will quantify the extent to which hydrocarbons persist in the environment.

Only limited baseline data are available for rockfish populations in PWS and along the lower Kenai Peninsula (LKP). Rockfish were studied as part of a study of nearshore fish assemblages during the years 1977-1979 in PWS (Rosenthal 1980) and Morrison studied select reefs along the LKP during 1980 through 1984. These investigations provided descriptions of selected rockfish populations including estimates of species and prey composition, density, length and age composition.

OBJECTIVES

A. Determine the presence or absence of hydrocarbons in demersal rockfish, benthic suspension feeders, and sediments from two control and two treatment sites in PWS and two control and two treatment sites along the LKP.

B. Determine the physiological effects resulting from oil contamination through histopathological examination of six organs, enzyme activity, and the examination of developing embryos.

C. Determine the feasibility of using otolith microstructure to evaluate depressed growth as a result of oil contamination.

METHODS

Eight sites (four oiled and four control) in PWS and along the LKP will be sampled in 1991. Demersal species of rockfish, unconsolidated benthic sediments and sessile suspension feeders will be collected at each sample location for analysis of hydrocarbons. From the results of these analyses the mechanism of hydrocarbon uptake in demersal rockfish and the extent to which hydrocarbons persist in reef ecosystems may be determined. The effects of sublethal hydrocarbon contamination in demersal rockfish will be determined through histopathological examination of six organs; evaluation of enzyme activity; examination of developing embryos; and examination of otolith microstructure. Results will be compared between oiled and control sites.

Sample sites will be the same as those established in 1990. A systematic sampling design will be used to identify sampling sites within each reef. Transects will be established at discrete depths by deploying an anchor line along specific contours of the reef and each end will be marked by anchored flag pole assemblies. Coordinates, length, depth, and orientation of the transect will be recorded. The actual number of sample sites will depend on the length of the transect and the orientation of the reef in the ocean currents. Sampling will be conducted during late July and early August which is the time frame that consistent with 1990 sampling and also the time frame that Rosenthal (1980) identified as near the peak abundance of rockfish in nearshore areas. Collection methods for finfish, sediment, and sessile invertebrates are outlined below.

Fifteen adult demersal rockfish (target primarily yelloweye rockfish *Sebastes ruberrimus*) will be collected at each sample site using hook and line jigging techniques. Baited lures will be lowered to the substrate and raised enough to allow for adequate jigging action. When a fish is on the line it will be retrieved slowly in order to allow the air bladder to equilibrate and prevent extrusion of the stomach and regurgitation of its contents. Where hook and line techniques do not yield results, divers will verify the presence or absence of demersal rockfish assemblages, and if present, collect them using spear guns. Stomach contents will be collected to determine composition of the prey species and for analysis of hydrocarbons. Species identification of adult rockfish will be accomplished using the methods of Kramer and O'Connell (1988) and Hart (1973).

Fifty juvenile demersal rockfish will be collected using variable mesh, monofilament gillnets set in the shallow areas of the reef and in intertidal zones adjacent to the reefs. Given estimated proportions of 0.6 and 0.2 respectively, sample size was determined (Zar 1984) to be 50, where a =.05. Species identification of juvenile rockfish species will be accomplished using the methods of Matarese et al. (1989).

Nine sediment samples will be collected at each sample site by divers outfitted with SCUBA equipment prior to the collection of air-lift samples outlined above. Each sample will be collected from the upper two centimeters of substrate and stored in hydrocarbon-free four ounce jars. Each jar will be filled approximately one-third full. Excess water will be poured off at the surface and the sample will be frozen. Three sediment samples will be collected at each reef.

Three samples of sessile filter feeders will be collected from each reef by divers outfitted with SCUBA equipment. Each sample will consist of pieces of two or three sessile filter feeders. Enough samples will be collected to at least half fill a 4 oz. hydrocarbon sampling jar.

Samples collected will be handled differently depending upon the data required and type of analysis being conducted. The following sections explain each type of preparation that will be used. Most samples collected will be used for only one type of analysis; however, each rockfish captured will be used or prepared for a variety of purposes. Rockfish will be processed in the following specific order: 1) rockfish will be measured to the nearest millimeter (fork length) and weighed to the nearest gram for calculation of condition factor; 2) tissue will be sampled for hydrocarbon analysis and histopathological evaluation according to procedures outlined in proceeding sections; and, 3) otoliths will be removed for later age determination.

Length (fork length), to the nearest millimeter, and weight, to the nearest gram, will be used to calculate a relative condition factor. Condition factors will be calculated for all rockfish captured.

Ten of the 15 rockfish (Rice 1990) collected at each reef will be prepared for hydrocarbon analysis. All samples will be collected from live fish. Bile samples will be collected first by removing the whole gall bladder and emptying the bile into 0.5 oz. amber sampling jars. Ten grams each of stomach, pyloric caeca, liver, and muscle tissue will be collected from each rockfish. Each tissue type will be stored in separate 4 oz. sampling jars.

Fifteen live demersal rockfish, including the ten sampled for hydrocarbons, will be collected at each reef for histopathological analysis and processed under the guidelines outlined by the Histopathology Technical Group (Meyers 1989). One centimeter sections of tissue will be removed from the following organs: liver, spleen, kidney, gills, gonads, and eyes. All developing embryos will be collected and preserved in a neutral buffered formalin solution.

Sagittal otolith pairs will be collected from 50 juvenile yelloweye rockfish (measuring less than 200 mm) from each reef. Age validation studies involving daily growth increments, such as Boehlert and Yoklavich (1987), typically utilize otoliths from juveniles because growth is deposited more rapidly, and physiological checks and daily growth increments are more visible. Upon collection, otoliths will be rinsed and stored dry in pairs in coin envelopes.

Juvenile otoliths will be prepared for examination following methods outlined by Boehlert and Yoklavich (1987). Otoliths will be viewed under transmitted light with a compound microscope at 400X magnification. Presence and location of hyaline zones comprising annuli, daily growth increments, and checks resulting from physiological factors including a reduction in growth will be examined. The feasibility of distinguishing differences in the type of zones will be explored by measuring the width of growth zones deposited over consecutive periods of time (days and years). Where physiological checks are clearly discernible from annuli, the presence of checks will be determined with respect to annuli. Checks deposited within the growth zone of the previous year will be noted. The proportion of otoliths containing checks within this growth zone will be compared between control and treatment groups.

DATA ANALYSIS

Data analysis will consist primarily of the comparison of results between control and treatment groups for each of the following:

LeCren's relative condition factor (K_n) (Anderson and Gutreuter 1983) will be calculated for each adult and juvenile rockfish. The mean condition factor for adult and juvenile rockfish for each reef will be calculated and differences between control and treatment groups will be tested using ANOVA.

Rockfish tissues, sessile filter feeders, and sediments will be analyzed for the presence of hydrocarbons. Proportions of contaminated samples in each category will be compared between control and treatment groups.

For each species the proportion of treatment sites containing contaminated samples will be compared to the proportion of control sites with contaminated samples using a two-sampled z-test from Zar (1984).

Tissues will be examined for histopathological abnormalities and enzyme activity by a qualified laboratory. The proportion of samples showing evidence of histopathological abnormalities will be compared between control and treatment groups for each tissue type using the z-test from Zar (1984).

Otoliths from juvenile demersal rockfish will be examined as described in the methods section. Proportion of otoliths containing checks between the last two annuli will be compared between control and treatment groups using the z-test from Zar (1984). Age composition and mean length-at-age will be calculated for each species of rockfish.

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BUDGET

Personnel	$ 40.9
Travel	2.7
Services	63.6
Supplies	11.8
Equipment	1.0
Total	$ 120.0

SUBTIDAL STUDY NUMBER 7

Study Title: Assessment of Oil Spill Impacts on Fishery Resources: Measurement of Hydrocarbons and Their Metabolites, and Their Effects

Lead Agency: NOAA

INTRODUCTION

Because petroleum and its components may cause severe injury to fishery resources, monitoring of the nearshore fisheries resources of PWS. Such monitoring will include measurement of petroleum exposure and short-term effects, as was done in the summer and fall of 1989 and the summer of 1990. This study will continue to encompass a selected assessment of long-term biological effects, including measurements of reproductive dysfunction and histopathological lesions of liver, gill, kidney, and gonad, as was done in the summer of 1990 (Varanasi et al. 1990, 1991). However, the scope of the 1991 study is reduced substantially compared to studies done in 1989 and 1990, in that the primary study area will be limited to PWS, and fewer species will be examined. This narrowing of focus reflects findings of the previous two years, and is aimed at continuing only those portions of the study which are most likely to assist in documentation of injury. This study will also include the measurement of petroleum exposure and possible effects in pollock from PWS and the Shelikof Strait.

Certain petroleum components [e.g. AHs] may cause reproductive toxicity and teratogenicity in rodents (Shum et al. 1979; Gulyas and Mattison 1979; Mattison and Nightingale 1980). Similarly, reproductive impairment has been noted in benthic fish residing in contaminated areas of San Francisco Bay (Spies and Rice 1988) and southern California (Cross and Hose 1988). Moreover, English sole from areas of Puget Sound having high sediment concentrations of AHs showed inhibited ovarian maturation (Johnson et al. 1988), and fish from these areas that did mature often failed to spawn after hormonal treatment to induce spawning (Casillas et al. 1991). In general, reproductive impairment (including reduced plasma levels of the sex steroid, estradiol) was found in English sole which showed evidence of exposure to aromatic compounds. Moreover, laboratory studies have shown that plasma levels of estradiol are reduced in gravid female English sole exposed to chemical contaminants extracted from urban sediments (Stein et al. 1991). More importantly, our preliminary laboratory studies have shown that exposure to Prudhoe Bay crude oil reduced plasma levels of estradiol in gravid female rock sole. The continued assessment of possible reproductive dysfunction in animals from impacted areas will be very important in determining biological damage to living marine resources as a result of the EVOS. Histological examination of ovaries of selected species will be performed to determine if ovarian maturation is being affected in animals from oil-impacted areas. Fecundity and levels of plasma estradiol in these same animals will be determined. Combined with measurements of petroleum exposure (e.g. metabolites in bile and enzyme activities in liver, these studies will allow estimation of the degree of reproductive dysfunction which may be occurring in oil-exposed fish.

Exposure of animals to crude oil may also result in changes at the tissue and cellular levels (National Academy of Sciences 1985). Examples of such changes after exposure of fish to oil-contaminated sediments include liver hypertrophy and fatty liver in winter flounder (Payne et al. 1988) and the occurrence of hepatocellular lipid vacuolization in English sole (McCain et al. 1978). Certain AHs (e.g., benzo[a]pyrene) are known carcinogens in rodents and fish (Lutz 1979; Bailey et al. 1989), and studies with several bottomfish species show that, of the xenobiotic chemicals in sediments, AHs are most strongly associated with high prevalences of liver lesions, including neoplasms (Myers et al. 1987; Varanasi et al. 1987; Baumann 1989). Generally, histopathological lesions of the types noted above do not become manifest until at least several months after exposure. However, by the summer of 1991, fish in and around oil impacted sites will have potentially been exposed to petroleum components for more than two years. Moreover, there are some published data which suggest that histopathological changes have occurred in some fish species as a result of exposure to oil spilled from the *Exxon Valdez* (Khan et al. 1990).

Preliminary studies in 1990 suggested that pollock were being exposed to petroleum both inside and outside PWS. This study has been expanded to cover assessment of exposure and possible associated biological effects in pollock, both inside and outside PWS.

Briefly, this study will continue to measure exposure to oil and oil components in the biota of PWS and other areas affected by the oil spill, by determining levels of hydrocarbon metabolites in bile and by measuring hepatic AHH activities. Additionally, the study will measure a range of biological effects, especially indicators of reproductive dysfunction and histopathological effects. Only by employing such a broad spectrum of state-of-the art chemical, biochemical and biological methods will analytical data be obtained to document the degree of exposure and resultant biological effects of petroleum hydrocarbons on economically and ecologically important fish species. This information for important Alaskan fish species will be incorporated into models for use in estimating oil spill impacts on fishery resources.

OBJECTIVES

A. To sample selected fish species (e.g. pollock, yellowfin sole, rock sole, flathead sole, Pacific cod) from several sites inside and outside PWS, with emphasis on sites inside PWS. Site selection is primarily based on data from the last two years of sampling and analyses. Representative sediment samples will also be taken from each benthic sampling site for subsequent chemical analysis.

B. To estimate the exposure to petroleum hydrocarbons by measuring levels of hydrocarbon metabolites in bile of the above species from oiled and unoiled habitats such to detect significant differences in bile concentrations with a = 0.05. Additionally, stomach contents of fish showing high levels of hydrocarbon metabolites in bile will be analyzed for hydrocarbons, such to detect significant differences in concentrations with a = 0.05.

C. To estimate the induction of hepatic aryl hydrocarbon hydroxylase activity or increased levels of cytochrome P-450IA1 in the above species from oiled and unoiled habitats such to detect statistical differences in levels of effects with a = 0.05.

D. To estimate the prevalence of pathological conditions in the above species from oiled and unoiled habitats such to detect statistical differences in levels of effects with a = 0.05.

E. To estimate the levels of plasma estradiol, the degree of ovarian maturation, and fecundity in adult females of two of the above species (yellowfin sole and pollock) from oiled and unoiled habitats such to detect statistically significant differences with a = 0.05.

F. To estimate temporal changes in the parameters described in Objectives B&C, by comparing data obtained in 1991 to data obtained in 1989 and 1990. In order to assess either recovery or increased damage of habitats from the oil spill, trends in these parameters must be statistically significant at a = 0.05.

G. Using the above data, as appropriate, construct simulation models similar to those of Schaaf et. al. (1987) for important Alaskan fish species for use in estimating oil spill impacts on fishery resources. These models will incorporate pre-spill information from the fisheries literature on mortality and fecundity together with information on reproductive impairment, pathological conditions, and biochemical effects in fish exposed to petroleum hydrocarbons as a result of the spill.

METHODS

A. General Strategy and Approach

Samples of benthic fish (yellowfin sole, rock sole, flathead sole, and to a lesser extent, Pacific cod) will be collected from five sites during 1991, from mid-May to mid-June. Sites proposed for sampling are Olsen Bay, Rocky Bay, Snug Harbor, Sleepy Bay, and Squirrel Bay. As feasible, the sample locations will be coordinated with Subtidal Study 1. The selection of species is based primarily on results obtained in 1990 and 1989 under Fish/Shellfish Study 24, and to a lesser extent, Fish/Shellfish Study 18. Surficial sediment samples for establishing levels of petroleum hydrocarbon residues will be collected at these sites, with analyses projected to be done under Subtidal Study 1. Pollock will be collected in March, 1990, at several sites inside PWS and in the Shelikof Strait. Because of the schooling nature of this species, and the dependence on assistance from other federal and state groups for use of sampling platforms, sites cannot be predetermined. Efforts will be made to sample sites representing a spatial gradient away from the spill's occurrence and path.

Petroleum exposure of fish will primarily be assessed by measuring (a) concentrations of metabolites of aromatic petroleum compounds in bile, and (b) AHH activities in liver. These types of measurements are necessary because petroleum hydrocarbons in fish are rapidly metabolized to compounds that are not detectable by routine chemical analyses. AHH activity in fish is due primarily to a single cytochrome, P-450IA1 (Varanasi et al. 1986; Buhler and Williams 1989). Measurement of hepatic AHH activity will provide a very sensitive indicator of contaminant exposure of sampled animals (Collier and Varanasi 1987; Collier and Varanasi 1991). Moreover, the induction of AHH activity indicates not only that contaminant exposure has occurred, but also that biological changes have occurred as a result of the exposure. In addition to measuring AHH activity, cytochrome P-450IA1 will be directly quantitated in selected liver or tissue samples by an immunochemical method recently developed at the University of Bergen (Collier et al. 1989; Goksøyr 1991). Direct quantitation of cytochrome P-450IA1 has the advantage of using archived samples frozen at non-cryogenic temperatures (> -80° C). Thus future comparisons may be made between data collected in this program and data from other sample collection programs, if samples from the other programs are subjected to the same immunochemical quantitation techniques.

Other biological effects in fish will be estimated by examining selected species for pathological conditions and by assessing reproductive impairment in suitably mature female fish. Pathological conditions will include grossly visible abnormalities (e.g., fin erosion) and other lesions diagnosed by histological procedures (e.g., gill necrosis, liver cell necrosis).

Reproductive capacity will be estimated by examining the developmental stages of ovaries and by measuring plasma levels of certain reproductive hormones (Johnson et al. 1988), in addition to measuring fecundity (Cross and Hose 1988). The two primary species for assessing reproductive impairment are yellowfin sole and pollock. It is anticipated that, during the respective sampling periods (May/June and March), these two species will be at an appropriate stage in their reproductive cycle for such assessments. Laboratory studies will also be conducted to determine the effects of known doses of oil and oil components on reproductive processes in these or related species.

Samples of sediment, and selected stomach contents of fish (whose bile had evidence of oil exposure) will be analyzed (sediment under Subtidal Study 1) for hydrocarbons by recently developed, scientifically sound and cost-effective analytical procedures involving high-performance liquid chromatography, gas chromatography and mass spectroscopy (Krahn et al., 1988).

Environmental damage will be assessed using statistical and simulation models, which will be developed as part of these proposed studies, as well as from other investigations with related fish species. The bile and tissue chemistry data will be used to establish relationships between biological damage and estimated exposures to petroleum hydrocarbons.

B. Sampling Methods

Sampling activities will be conducted at several sites in PWS, including unoiled sites in Rocky Bay and Olsen Bay and petroleum-exposed sites in Snug Harbor, Sleepy Bay and Squirrel Bay/Fox Farm. Sample collection will be performed from a charter vessel for the three flatfish species and cod, at water depths of approximately 0 to 100 meters. At each site, sediment samples will be collected with a box corer, VanVeen or Smith-McIntyre grab. Sediments will be stored at - 20° C. The coordinates and depths of each station will be recorded. For pollock, samples will be collected at sites within the oil spill area.

Fish will be collected with a bottom trawl, long-line gear, or midwater trawl. Bottom trawls will be performed with an otter trawl (7.5 m opening, 10.8 m total length, 3.8 cm-mesh in the body of the net, and 0.64 cm-mesh in the liner of the cod end). Tows will be of 5 to 15 minutes duration. In order to reduce contamination of the catch by free oil, trawling will avoid areas of surface films or slicks. If a net is fouled by subsurface or bottom oil, it will be replaced (or cleaned, if possible) and a new area for trawling will be selected. Other fish sampling gear appropriate to the species and conditions will also be deployed. Individuals of selected target fish species will be sorted and examined for externally visible lesions; up to 30 fish of selected species will be measured, weighed, and necropsied; and tissue samples will be excised and preserved in fixative for histopathological examination or frozen for chemical analyses.

C. Laboratory Analyses

1. Bile Metabolite Assay (analyses done under Technical Services 1)

Samples of bile will be injected directly into a liquid chromatograph and a gradient elution conducted using a Perkin-Elmer HC-ODS with a gradient of 100% water (containing 5μL acetic acid/L) to 100% methanol (Krahn et al. 1984, 1986 a, b, c). Two fluorescence detectors are used in series. The excitation/emission wavelengths of one detector are set to 290/335 nm, where metabolites of naphthalene (NPH) fluoresce. Excitation/emission wavelengths of the other detector are set to 260/380 nm, where metabolites of phenanthrene (PHN) fluoresce. The total integrated area for each detector is then converted (normalized) to units of either NPH or PHN that would be necessary to give that integrated area.

2. Liver Aryl Hydrocarbon Hydroxylase (AHH) Activity and Cytochrome P-450IA1 Analysis

Hepatic microsomes are prepared essentially as described by Collier et al. (1986) and microsomal protein is measured by the method of Lowry et al. (1951), using bovine serum albumin as the standard. AHH activity is assayed by a modification of the method of Van Cantfort et al. (1977) as described by Collier et al. (1986), using ^{14}C-labeled benzo[a]pyrene as the primary substrate. All enzyme assays will be run under conditions in which the reaction rates are in the linear range for both time and protein. Cytochrome P-450IA1 will be measured by an ELISA utilizing rabbit antibodies to cytochrome P-450c isolated from Atlantic cod (Goksoyr 1991).

3. Histopathology

Histopathological procedures to be followed are described in the report from the Histopathology Technical Group for Oil Spill Assessment Studies in Prince William Sound, Alaska. Briefly, the procedures will involve the following: (a) tissues preserved in the field will be routinely embedded in paraffin and sectioned at five microns (Preece 1972); and (b) paraffin sections will be routinely stained with Mayer's hematoxylin and eosin, and for further characterization of specific lesions, additional sections will be stained using standard special staining methods (Thompson 1966; Preece 1972; Armed Forces Institute of Pathology 1968). All slides will be examined microscopically without knowledge of where the fish were captured. Hepatic lesions will be classified according to the previously described diagnostic criteria of Myers et al. (1987). Ovarian lesions will be classified as described in Johnson et al. (1988).

4. Reproductive Indicators

Reproductive activity will be assessed by examining the ovaries of the sampled fish histologically to determine their developmental stage, and for the presence of ovarian lesions that would be indicative of oocyte resorption (Johnson et al. 1988). Other parameters associated with reproductive activity will also be measured, including fecundity (Bagenal and Braum 1971), plasma vitellogenin (Gamst and Try 1980; DeVlaming et al. 1984) and estradiol (Sower and Schreck 1982) levels, and gonadosomatic index (ovary wt/gutted body wt x 100). Relationships between ovarian maturation, fecundity, plasma estradiol, plasma vitellogenin, and petroleum hydrocarbon exposure will then be evaluated.

D. Quality Assurance and Control Plans

1. Bile Analytes

Quality assurance procedures for bile analyses will include NPH and PHN calibration standards and the calibration standard will be analyzed after every 6 samples and the RSD will be reported. In addition, one blank sample and one reference material (control material) will be analyzed daily. The concentrations of analytes should be within 2 SD of the established concentrations in control material. Replicate analyses will be performed on 10% of the samples, if a sufficient amount exists.

2. AHH Activity and Cytochrome P-450IA1

Quality assurance procedures for AHH measurements include duplicate zero-time and boiled enzyme blanks for each set of assays. Each sample will be run in duplicate and those samples showing > 20% absolute difference between duplicates and >10 units (pmoles benzo[a]pyrene metabolized/mg microsomal protein/minute) difference between duplicates will be repeated. ELISAs for cytochrome P-450IA1 will be run in triplicate, and if the resulting coefficient of variation (CV) is > 10%, the outlying replicate will be omitted from the calculations. If the CV still exceeds 10%, the analysis of that sample will be repeated.

3. Histopathology

Pathologists on this project will use consistent, standard diagnostic criteria to be strictly adhered to by those who will also be examining slides in this project. These criteria will be established using color photographs of external lesions and standard reference slides containing tissues with the major lesion types expected in the study. Unusual or atypical lesions will be referred to specialists for confirmation. The accuracy of the histopathologic diagnosis also will be assured by consulting with and sending sections of tissues with representative lesion types to the Registry of Tumors in Lower Animals, National Museum of Natural History at the Smithsonian Institution in Washington, D.C.

4. Reproductive Indicators

Quality assurance for the measurement of plasma estradiol and vitellogenin include analysis of standards to confirm linearity and calibrate the assays. Blank analyses will be conducted to eliminate matrix effects. Analyses of pooled plasma from vitellogenic female English sole and winter flounder containing known levels of estradiol and vitellogenin will also be done. Duplicate analyses of each sample to evaluate performance of the assays will also be conducted. These quality checks are run daily with each set of samples. Fecundity measurements will be done in triplicate on each individual.

DATA ANALYSIS

A. Statistical Tests

The relative concentrations of contaminants in sediment and fish tissues at the study sites will be compared statistically using the Kruskal-Wallis test (ANOVA by ranks; see Sokal and Rohlf 1981, Zar 1984). Where significant differences among chemical concentrations are found, the a-value will be understood to be < 0.05. To determine whether the prevalence of histopathological effects noted in each of the fish species is statistically uniform among the sites, the G test for heterogeneity (Sokal and Rohlf 1981) will be performed.

B. Analytical Methods

Where possible, non-parametric statistical tests will be employed to avoid assumptions that the data are normally distributed. Non-parametric tests give highly reliable results. The principal non-parametric tests that will be used are Spearman rank correlation, which has about 91% of the power of product-moment correlation when the parametric assumptions are met (Zar 1984), and the heterogeneity-G statistic. Spearman rank correlation will be used for estimating uptake and metabolism of petroleum hydrocarbons from oiled and unoiled habitats when an independent measure of contamination (e.g., levels of AHs in sediment) is available.

The heterogeneity-G statistic (Sokal and Rohlf 1981) will be used to study prevalence of pathological conditions at oiled and unoiled habitats. In addition, logistic regression (appropriate where the outcome variable is binomial) will be used to model the prevalences of pathological conditions in relation to contamination.

The Kruskal-Wallis test (a non-parametric form of ANOVA) will be used for supporting statistical analyses of variation in sediment PAH levels at sites sampled. If the null hypothesis of no differences among sites is rejected at a = 0.05, a non-parametric multiple comparison test (Dunn 1964; Hollander and Wolfe 1973; Zar 1984) will be used to determine differences between sites at a = 0.05. Principal components analysis and LOWESS (Chambers et al. 1983) will also be employed for this purpose; both are methods of exploratory data analysis rather than inferential statistical methods. Cohen (1977) will be used for computations of statistical power.

C. Products

Status reports will contain information on the distribution and concentrations of petroleum hydrocarbons and their metabolites in fish tissues and in sediments obtained from sites in Alaska; the hepatic activities of AHH and levels of cytochrome P-450IA1 in fish from sites in Alaska; and the distribution and prevalence of histopathological disorders and reproductive impairment among selected species from those sites. Chemistry data will be submitted in the form of data tables and distribution maps, and all data will be stored in computerized data management programs. Fish pathology data will be reported in the form of distribution maps, tables describing disease frequencies of each species examined, photographs of gross and microscopic properties of abnormalities, figures representing various types of biological data (e.g., length-weight, age-weight) and discussions of the relative importance of the types of abnormalities found. Comparisons of the characteristics of these abnormalities will be made with similar conditions previously reported in other marine areas of the world. The data management formats were designed in cooperation with the National Oceanographic Data Center (NODC), and are compatible with the NODC data storage systems. In addition, articles describing the results of these studies will be published in peer-reviewed scientific journals.

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BUDGET

	NOAA	ADF&G	TOTAL
Salaries	$122.7	$20.8	$143.5
Travel	10.5	3.5	14.0
Supplies	18.9	8.7	27.6
Equipment (disposable)	7.9	7.0	14.9
Vessel support	75.0	40.0	115.0
Total	$235.0	$80.0	$315.0

TECHNICAL SERVICES

The hydrocarbon analysis and mapping projects described in this section are designed to provide high quality technical services to studies described in other portions of the NRDA plan. Hydrocarbon analytical services includes the generation, archival, and retrieval of all chemical analytical data. Mapping includes implementing and managing a geographic information system to record and process data collected by NRDA studies.

Appropriate information on exposure of the resource to hydrocarbon residues from the spill is required to determine and quantify injury. 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 organisms will provide essential information to other NRDA studies to demonstrate the relationship of injury to hydrocarbon exposure.

Samples of water, sediments and tissues for chemical analysis are being collected by individual studies throughout the entire region impacted by the EVOS. Selected samples are being analyzed by a team of participating laboratories in accordance with a centralized QA/QC program (Appendix A) which will help ensure that all data are of known, defensible, and verifiable quality and comparability.

The mapping project continues to develop the damage assessment geographic information system. The primary data layers have been collected and verified and large scale production and transmittal of map products has begun. Specific data analyses and map product will continue to be generated to support the analytical and interpretive needs of NRDA studies.

Although the processing of histopathology samples and information is no longer being supported by a separate technical service program, samples, analyses, and data continue to be generated within the context of specific NRDA studies. Oil-induced histopathological data are required by many of the studies described under Fish/Shellfish, Birds, Marine Mammals, and Terrestrial Mammals. This information continues to be gathered under strict quality assurance guidelines (Appendix B) by expert histopathologists to ensure compatibility of results and evaluations throughout the NRDA program.

TECHNICAL SERVICES STUDY NUMBER 1

Study Title: Hydrocarbon Analytical Support Services and Analysis of Distribution and Weathering of Spilled Oil

Lead Agency: FWS, NOAA

INTRODUCTION

In order to document the exposure of natural resources in the PWS and GOA ecosystems to spilled oil, NRDA projects are collecting sediment, water and biota samples to be analyzed for petroleum hydrocarbons. The data resulting from the analysis of these samples is used to define the exposure of that resource to spilled oil, to indicate the possible effect of the oil on the resource and to produce an integrated synthesis of the distribution of the oil in space and time. The analytical data must be accurate, precise and comparable across projects and throughout the time of the NRDA process. To this end, TS 1, a cooperative project between NOAA and the FWS, coordinates the chemical analysis of all samples collected by the NRDA projects. NOAA manages those samples from federal or state studies involving water, sediment, fish, shellfish, marine mammals - with the exception of sea otters, and intertidal areas. FWS manages those samples from studies involving birds, sea otters and terrestrial mammals. Samples are being analyzed at FWS-contract Texas A&M University (TAMU), and at NOAA/NMFS laboratories. NOAA has lead responsibility for implementing the Quality Assurance programs, updating and maintaining the sample inventory and analytical databases, and data interpretation and synthesis. FWS bears the main responsibility for Quality Control of the analytical data and assists in the maintenance of analytical databases and interpretation and synthesis of data.

OBJECTIVES

A. Measure petroleum hydrocarbons, hydrocarbon metabolites and other appropriate chemical/biochemical indicators of hydrocarbon exposure in the water, sediment and biota collected through the NRDA.

B. Assist Project Leaders and field personnel in implementing appropriate sample collection, identification, shipping and chain of custody procedures.

C. Manage sample tracking and archival.

D. Oversee a Quality Assurance program to assure and demonstrate the accuracy, precision and comparability of all chemical analytical data developed by the NRDA.

E. Provide analytical data to the Project Leaders in a timely and useful fashion. Assist in the interpretation of these data.

F. Develop an integrated synthesis of the distribution and chemical composition of spilled oil, as it weathers through time, to provide a detailed basis for final exposure assessment.

METHODS

All measures of petroleum hydrocarbons and hydrocarbon metabolites generated in support of the NRDA are being made in agreement with the QA/QC plan. The majority of the samples are being analyzed by TAMU through a FWS contract. The remainder of the analyses are being preformed by NOAA/NMFS laboratories. NOAA and FWS are each responsible for the analysis costs for their managed samples.

A field manual, "Analytical Chemistry: Collection and Handling of Samples" written in cooperation with all of the Trustee agencies has been provided to all identified project leaders and used by NOAA and FWS in a series of training sessions. Copies of this manual and continued training sessions will be available in 1991.

A centralized sample inventory and tracking system utilizing a customized MS/DOS R-BASE program resides at NOAA/NMFS, Auke Bay Laboratory. Each sample or subsample is assigned a unique identification code, defined in terms of the material collected or subsampled and documented to an exact field collection location and time. The parent database is updated and maintained by NOAA. FWS provides updated information on their samples and archives a read-only copy of the parent database.

The quality of the analytical data developed for the NRDA is assured and demonstrated through the mechanisms described in the QA plan. For hydrocarbon analyses, laboratory performance is:

- assisted through the provision of NIST calibration standards, control materials and Standard Reference Materials,

- monitored through the inspection of the results of the analysis of the QC samples (calibration standards, blanks, matrix spikes, replicates, SRMs and control materials) and

- tested through the blind analysis of accuracy-based fully-matrixed samples.

The program is similar for those laboratories measuring hydrocarbon metabolites in bile with the exception that because this is a semi-quantitative assay, there are no standards or reference materials.

NOAA/NMFS, Northwest Center has developed calibration and control materials and distributes them to participating laboratories for this measurement.

All analytical data, bulk parameters and supporting QC data are archived in a customized MS/DOS R-BASE program at NOAA/NMFS, Auke Bay Laboratory. For NOAA and FWS-managed samples, the project leader receives all data in hard copy accompanied by a simple summary sheet indicating whether or not the sample contains petroleum hydrocarbons. Programming has been completed to develop a series of ratios and indices indicating the quantity and composition of the oil in the samples. All data presently in the database will be subjected to this review and the results provided to the Project Leaders. All data are also available to Project Leaders in electronic form.

Synthesis has been initiated with TS 3 using the recently completed ratios and indices indicating the quantity and composition of the oil in samples. It is anticipated that this cooperation will result in a series of maps showing changes in the composition and concentration of the oil with time.

BUDGET

	NOAA	FWS	TOTAL
Salaries	$ 80.0	$ 85.0	$ 165.0
Travel	17.0	10.0	27.0
Contracts	1,868.0	430.0	2,298.0
Supplies	5.0	5.0	10.0
Equipment	30.0	20.0	50.0
Total	$2,000.0	$ 550.0	$2,550.0

TECHNICAL SERVICES STUDY NUMBER 3

Study Title: Implement and Manage a Geographic Information System (GIS) to Record and Process NRDA Data

Lead Agency: DNR and FWS

Cooperating Agency: DEC

INTRODUCTION

The purpose of Technical Services No. 3 (TS 3) remains unchanged: the group is charged with implementing and managing the geographic information system (GIS) to record and process data collected in NRDA studies. Primary data layers have been collected and verified. Additionally, TS 3 has begun large scale production and transmittal of NRDA map products.

OBJECTIVES

A. Produce and disseminate maps and analytical products for participants in the NRDA process.

B. Create and maintain, throughout the NRDA process, a database pertinent to the overall damage assessment process, which is accessible to all participating agencies.

METHODS

Methods are the same as described in the 1990 study plan. In addition to the data layers described in the 1990 study plan, data layers have been or will be prepared for study site locations, sampling locations, beach segment locations and multi-thematic atlases of pre-spill data from various sources. Additional data layers will be added as needed by investigators and the Trustee Council to enable geographic-based compilation of study results and other pertinent data.

BUDGET

	DNR	FWS	TOTAL
Salaries	$ 434.6	$ 185.0	$ 619.6
Travel	8.6	6.0	14.6
Contracts	84.7	16.0	100.7
Supplies	52.4	10.0	62.4
Equipment	76.0	83.0	159.0
Total	$ 656.3	$ 300.0	$ 956.3

DETERMINATION OF INJURY TO CULTURAL RESOURCES

Lead Agencies: USFS and DNR

Cooperating Agencies: ADF&G, FWS, NPS

INTRODUCTION

Holocene richness and diversity of resources resulted in the development of the largest prehistoric populations in Alaska along the Pacific mainland and island coasts. Kodiak Island had the largest, most dense prehistoric population of Eskimo peoples in the world. Similar ecological abundance suggests PWS and mainland coasts also supported major human populations. The region of oiled beaches includes large areas where few archaeological surveys have been done. To determine injury, specific information is needed on the location, number, and character of historic sites within the EVOS area. This information is obtainable through intensive on-the-ground sample surveys and direct testing.

OBJECTIVES

This study includes activities designed to identify and quantify injury to cultural resources from a scientific standpoint and to develop the foundation for a meaningful program to restore and rehabilitate archaeological resources. To determine the injury caused by the spill, the study will focus on the following:

A. Impacts on soil chemistry (pH, calcium, phosphate);

B. Impacts on soil structure and inclusions (stratigraphy; charcoal);

C. Impacts on artifacts including petroglyphs, bone, wood, ceramic, fiber and shell;

D. Impacts on vegetative cover of sites, including new or increased erosion on the sites;

E. Occurrence of theft or vandalism on sites, including new or increased incidences.

METHODS

1. Activities will be performed in a manner consistent with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Fed. Reg. 44716-44740, September 29, 1983).

2. Through a literature search and in-field surveys, an estimate of the number, type, character, and the significance of archaeological sites in the area affected by the oil spill will be determined.

3. Develop typologies based on site type, time period, and location.

4. Using the typologies developed, a representative sample of archaeological site types and locations to be investigated for impacts, will be selected. The sample will include sites in unoiled areas to serve as control sites.

5. Conduct archaeological investigations at the selected sites and locations.

6. Oil spill response workers and government employees will be interviewed concerning impacts to archaeological resources.

7. A laboratory analysis of the effects of the oil on the physical characteristics of the soil column will be performed. Attention will be given to its component parts to determine changes in preservation, soil compaction, stratification, and obscuration of the stratigraphy, as well as leaching and the chemical breakdown of organic materials.

8. Radiocarbon age determinations and soil sample analyses for pH, calcium, and phosphate will be performed.

9. Pre- and post-spill vandalism and erosion data will be compiled and evaluated to establish rates and effects of vandalism and erosion.

DISCUSSION

To assess the potential injury to archaeological sites along the coast, three physical zones can be established: submerged (below the lowest low tide), intertidal (between the lowest low and the highest high tides), and shore margin uplands (above the highest high tide). The greatest potential for injury exists through direct deposition of oil in the intertidal zone. Secondary transport into adjacent submerged areas and uplands may also injure archaeological sites. Upland archaeological sites are also subject to contamination from transportation of oil by wind, storm tide inundation, migration of contaminants in ground water, oiled bird and animal movement from the feeding/travel corridor of the intertidal zone, and their death and decomposition on archaeological deposits. Theft of artifacts and vandalism to archaeological resources are potential dangers in the intertidal and upland zones. The intertidal zone contains archaeological sites of great variety, numbers, and susceptibility to oil injury.

Shipwrecks, eroded/scattered artifacts, inundated stratified archaeological deposits, prehistoric rock art, prehistoric fish weirs, and remnants of structures or objects deliberately placed in the intertidal zone are among the site types known to exist. The shore margin uplands may contain all the previously mentioned site types, plus burials, above-ground structures, and recognizable resource collection locations such as culturally modified trees.

In the two higher elevation zones, a major potential injury resulting from oil contamination is interference with traditional archaeological dating techniques. Radiocarbon dating depends on comparison of the ratio of radioactive carbon 14 to carbon 12 in the sample being analyzed. Because petroleum contains abundant radioactively-inert carbon from organisms dead for millions of years, and the use of radiocarbon dating for dates up to 35,000 years ago, contamination by even a small amount of ancient carbon is expected to result in age determinations that are significantly older than the archaeological event being dated. This would seriously compromise radiocarbon dating as a technique for dating human activities and paleoenvironmental events and conditions. The potential for affecting age determination may be significant even in areas where only a sheen exists and may be investigated in assessing injury. In cases of oil contamination in stratified archaeological deposits, masking of the visibility and alteration of the chemical components of the microstratigraphy may also affect archaeologists' ability to trace strata.

Both direct and indirect injuries to archaeological sites may have occurred from response and treatment activities, as well as from increased activities in the resource areas. Further, increased access of personnel to remote areas may have increased the knowledge of site locations and potentially may accelerate vandalism, theft of heritage resources, and damage to the scientific value of the sites.

Field study activities did not occur in 1990, but will be performed during the 1991 field season. Funds to perform the study were obligated but not spent. The budget described below reflects the cost of including additional study sites and the anticipated cost of completing follow-up work once data are received.

BUDGET

	USFS	DNR	Total
Personnel	$ 85.0	$157.3	$242.3
Travel	18.0	6.3	24.3
Contracts	0.0	522.4	522.4
Supplies	0.0	1.6	1.6
Equipment	0.0	1.0	1.0
TOTAL	$ 103.0	$688.6	$791.6

PART II: PEER REVIEWERS/CHIEF SCIENTIST

SCIENTIFIC PEER REVIEWS/CHIEF SCIENTIST

Lead Agency: DOJ, DOA, DOI, NOAA

INTRODUCTION

Acceptable scientific procedures contemplate a process through which study plans, methodologies and data supporting conclusions are subjected to objective, rigorous review by peers. The government has identified a number of biologists, ecologists, chemists and statisticians to perform this function in connection with the natural resource damage assessment studies described in this plan. These scientists also may serve the government as expert witnesses, testifying regarding damages resulting from the EVOS.

OBJECTIVES

A. Ensure that the government's damage assessment studies follow acceptable science procedures and produce valid conclusions supported by accurate data.

B. Produce an integrated assessment of the damages resulting from the EVOS based on the many individual and disparate science and economic analyses.

METHODS

A Chief Scientist will be charged with coordination and direction of all scientific damage assessment studies, including synthesis and peer review efforts. Certain of the peer reviewers will focus on the primary areas of scientific damage assessment, i.e., coastal habitat, marine mammals, birds, fish, shellfish, terrestrial mammals, air and water, subtidal areas and archaeologic sites. Others, ecologists and biostatisticians, will compare and link data and findings among the groups.

BUDGET

The federal trustee agencies will reimburse the Department of Justice and NOAA in equal shares.

Department of Agriculture	$772.0
Department of Interior	772.0
National Oceanic and Atmospheric Administration	772.0
Total	$2,316.0

PART III: ECONOMICS

ECONOMIC STUDIES

The studies in this section are federal studies designed to assess the economic value of injury to natural resources associated with the EVOS. The following study descriptions are very similar to those for 1990 because the studies are ongoing. An additional study, estimating the economic damages to consumers of petroleum products, may be initiated if a relationship between the EVOS and the observed petroleum market price increases can be established. State studies designed to assess the economic value of injury to natural resources resulting from the EVOS are not discussed in this document. Litigation concerns continue to prevent disclosure of detailed progress to date and preliminary results.

The federal studies cover eight major areas: (1) commercial fishing, (2) public land values, (3) recreation, (4) subsistence, (5) intrinsic values, (6) research programs, (7) archaeological resources and (8) petroleum price impacts.

ECONOMICS STUDY NUMBER 1

Study Title: Commercial Fisheries Losses Caused by the EVOS

INTRODUCTION

This study will continue to build upon the results of the previous years' efforts.

The EVOS may have resulted in substantially reduced seafood production at several ports including Cordova, Seward, Kodiak, Kenai, and Homer, which are some of the most important commercial fishing ports in the United States. Both short-term impacts, through closure of certain fisheries, and long-term effects, such as reductions in population that will not become apparent for several years, may occur. These impacts may affect both the supply of and demand for seafood.

For example, changes in quality (both real and perceived) may have occurred, which could adversely affect seafood markets. In the case of several important commercial salmon fisheries, the spill resulted in harvests being confined to "terminal" areas, thus restricting traditional fishing patterns and timing of the harvest.

Terminal area harvests occur in close proximity to the salmon's spawning grounds. The result can be a significant reduction in quality, as compared to salmon harvested in more typical circumstances, i.e., more distant from, but en route to, spawning sites. The reduction in quality may affect the salmon's overall marketability and/or its appropriateness and acceptability for specific product forms. In either case, seafood consumers at every market level incur losses.

Salmon is one of several commercial species group which may have been adversely affected. Others may include Pacific herring, shellfish, and groundfish.

OBJECTIVES

Measure the economic loss to seafood consumers caused by the EVOS.

METHODS

The investigators are in the process of determining which species were injured by the spill. Conceptual models of consumer preferences and market characteristics for certain seafood products are being developed. A methodology to assess statistically significant changes in the level and quality of harvest is also under development. Data collection and analyses will also continue. The models will be used to estimate the demand for various seafood products, the price changes associated with the spill, and the effects of seafood quality and quantity changes on consumers.

BUDGET

Total:	$265.5

ECONOMICS STUDY NUMBER 4

Study Title: Effects of the EVOS on the Value of Public Land

INTRODUCTION

The EVOS affected subtidal, intertidal, and uplands areas on the shore of PWS and the GOA. This study will assess the lost market value of publicly held lands attributable to the oil spill. It will estimate market demand for leases and sales of land in the impacted areas, and project changes in total value of public lands.

OBJECTIVES

Determine the change in market values of public lands.

METHODS

Land appraisals are a common method of assessing the market value of land. Appraisers usually estimate the market value of land parcels from the selling price of similar parcels. Because no two parcels are identical, adjustments are required to achieve comparability. For the purposes of appraisal, market value is generally defined as the amount in cash, or in terms reasonably equivalent to cash, for which, in all probability, the property obligated to sell to a knowledgeable purchaser, who desires the property but is not obligated to buy. Using this definition of market value, the effect of the oil spill on land values will be estimated as the difference between the pre- and post-spill selling prices.

BUDGET

At present, no additional funds have been requested for this study. There may not have been sufficient land transactions to employ as the basis for determining any changes in the value of public lands affected by the spill. If it is determined that there were adequate land sales to support and economic valuation of the impacted lands, then this study will be continued and funded with the amount needed to determine the extent of the lost values to public lands.

ECONOMICS STUDY NUMBER 5

Study Title: Economic Damages to Recreation

INTRODUCTION

This study will continue to build upon the results of the previous years' efforts.

The EVOS 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 PWS and the GOA coast.

The EVOS 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 choose a substitute activity and/or area, thereby potentially suffering a loss in personal satisfaction and possibly incurring 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. These types of losses may have been experienced by sea kayakers, users of charterboat services/recreational fishers, users of air charters, hunters, cruise ship patrons and general tourists.

While relatively few in number, sea kayakers may have been significantly affected by the oil spill. Kayaking trips are taken from Valdez, Kodiak, Homer, Whittier and Seward to the western portion of PWS and the bays along the Kenai peninsula and Kodiak Island. A typical trip involves charter boat transportation to a site some distance from port. Most trips last more than one day and thus include both kayaking and wilderness camping. Southcentral Alaska includes some of the premier kayaking areas in the world.

The potential effect of the oil spill on kayakers could take several forms:

- beaches used for wilderness camping are oiled and unusable;
- wilderness scenery is despoiled and sense of pristine environment is lost;
- wildlife viewing opportunities are reduced;
- unoiled areas suffer from increased congestion;
- clean-up activities make boats for transport expensive or impossible to charter; and
- clean-up activities spoil the wilderness nature of the experience.

All of these potential effects may have occurred during the 1989 season and in subsequent years.

Recreational activities that use the services of charterboats and other private boats for hire are typically less intense than sea kayaking, but are far more numerous. Vessels for hire and charterboats range from the standard six passenger charterboats to large tour boats carrying over a hundred passengers. All types of vessels for hire have been impacted by cleanup activity. For brevity in this proposal, this entire group is referred to as "charterboats". Charterboat related recreational activities include salmon and halibut fishing, sightseeing and viewing marine wildlife and ferrying for wilderness camping in the PWS, KP, and Kodiak areas. Charterboats go out of Valdez, Whittier, Homer, Kodiak, Seward and the smaller villages in southcentral Alaska.

Because access to the general area is not easy, there are potentially substantial impacts which can be measured through a careful study of the charter fleet. The purpose of such a study would be to determine the reduction in the use of the PWS environment through the charter fleet as a consequence of the oil spill.

The level of participation in recreational fishing among the residents of Alaska is far greater than among the residents of any other state in the United States. Marine recreational fishing originates in all major towns on the PWS as well as Cook Inlet, Kodiak Island and the KP and the AP. Fishing trips are taken in several ways - from shore, from private boats and from charter vessels. Because access by car from Anchorage is relatively easy, shore fishing and private boat fishing on the Kenai is quite popular. All kinds of fishing draw large numbers of tourists to Alaska.

The study of charterboats will address only part of the potential recreational fishing effects. It is possible that the oil spill had detrimental effects on shore and private boat recreational fishing, as well. For example,

a) fishing trips in the potentially oiled areas may have declined due to fear of contaminated fish and waters;
b) anglers may not have been able to find accommodations in areas where they wanted to fish because of cleanup related activities;
c) the value of particular fishing trips out of the potentially oiled zones may have declined because sites became more congested.

Each season, a number of cruise ships pass through PWS on their way from Seattle or Juneau to Whittier where they discharge their passengers for the train trip to Anchorage. The likelihood that these individuals were directly affected by the oil spill is small, but many have canceled their trips because of fear that the oil spill would spoil the experience.

The general tourist activity sub-component of the proposal differs from the others in that it is not directed toward one specific recreational activity. Here the goal is to determine, from aggregate level data, the extent to which general tourist activity in the area of the spill may have been dislocated because of clean-up activities. There will have been losses to recreationists if these activities were diverted away from areas thought to be contaminated by the spill or affected by the congestion and lost services associated with clean up. Some of the marine related part of this damage will be captured in the investigation of the charterboats and kayaking. However, those people who do not plan to use boats but rather state parks or other facilities will not have been covered.

OBJECTIVES

Develop estimates of economic damages to recreationists.

METHODS

The study will continue to look at the impact of the EVOS on various consumptive and nonconsumptive recreational activities.

Sea kayaking: This study contains several stages: (1) the relevant sea kayaking population will be identified; (2) a survey instrument which will contribute to both recreational demand and simple contingent valuation analysis will be created; (3) the survey instrument will be pre-tested; (4) the survey will be administered; and (5) the survey results will be analyzed.

Charterboat activities: Data for this study will also be collected through a survey. After development of a theoretical framework for damage measurement, the sample size will be defined. A survey will be designed to determine the periodic recreational and cleanup activities undertaken by each charter vessel, the number of recreationists served, the extent of cancellations and the amount of time the vessel was involved in clean up activity. Vessel owners may also be interviewed in person. Finally, the data will be analyzed.

Recreational fishing: There is an existing model for recreational fishing in the KP area. This model will be investigated to determine its applicability to the EVOS.

Cruise ship tours: Cruise ship firms will be contacted to determine whether demand for cruise ship tours to PWS was affected by the EVOS. If there is evidence of substantial reductions in demand, methods of estimating the actual losses to recreationists will be explored.

General tourist activity: Assuming that aggregate effects on tourism may be accurately estimated, this study will compare those aggregate effects with the results of the activity-directed substudies to determine whether important categories of losses have been missed.

Additional substudies: The recreational losses study may be revised to include economic analysis of the impacts of the EVOS on other recreational activities such as hunting and use of air charters to gain access to areas used for recreation.

BUDGET

Total: $ 390.4

ECONOMICS STUDY NUMBER 6

Study Title: Losses to Subsistence Households

INTRODUCTION

This study will continue to build upon the results of the previous years' efforts.

Several communities on the shores of PWS, LCI, KAP are highly dependent upon noncommercial fishing, intertidal food gathering, marine mammal hunting, and land mammal hunting for subsistence uses. Among the small 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.

Following the EVOS, subsistence harvests were reduced in several communities. This could have important ramifications in the economy and social order of the communities. Potentially important economic losses to the communities include: (1) subsistence losses; (2) local inflation affecting harvests and food procurement; (3) damage to subsistence property; and (4) loss of intrinsic value to subsistence users.

OBJECTIVES

A. Conduct a literature review and compile base-line information.

B. Document the extent of oil contact and clean-up on or near historic harvest sites.

C. Document the 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, cleanup work, outside demands, and industry demands.

E. Assign monetary values to losses to subsistence households.

METHODS

Field observations and interviews will be used to collect information. Changes in subsistence use and socioeconomic patterns will be determined by conducting systematic household surveys and interviews, and comparing these data to historic information. Where applicable, market prices and price imputation will be used to estimate damages. For marketed goods, the cost of replacing the goods injured by the spill will normally be the measure of economic damage. However, the adverse effects of the spill extended beyond marketed goods. A number of methodologies are being considered for the estimation of economic damages to non-market goods and services.

BUDGET

Total: $ 532.1

ECONOMICS STUDY NUMBER 7

Study Title: Total Value of Natural Resources Injured by the EVOS

INTRODUCTION

This study was formerly titled "Loss of Intrinsic Values Due to the EVOS." The study title has been changed to reflect the scope of this study more accurately. This study will assess both use and intrinsic values of the injured natural resources. The study will continue to build upon the results of the previous years' efforts.

Intrinsic values include existence value, option value, and bequest value. These values are independent of the economic values arising from direct use of natural resources and cannot be measured by observing use of the area affected by the EVOS. Resources with intrinsic values include fish, birds and mammals, along with the wilderness character, ecological integrity and/or scenic quality of certain areas. These values are only imperfectly captured by the prices of goods traded in markets. Accordingly, non-market methods must be used to calculate intrinsic values. This study is designed to use the contingent valuation method to determine the loss in both intrinsic and use values resulting from the oil spill.

OBJECTIVES

Determine the loss in the value of natural resources injured by the EVOS.

METHODS

The contingent valuation method involves use of surveys to determine the values that people place on goods. This study will require development of a conceptual framework for contingent valuation survey design and analysis of survey results. Next, research will be conducted to determine the most accurate survey instrument for assessing intrinsic values. This research will involve consultation with economists and survey design experts. Substantial preliminary testing of survey formats will be conducted among small groups of people to verify the accuracy of the survey instrument. A nationwide survey will be conducted using a professional survey research firm. Econometric analysis will be used to interpret the results of the survey.

BUDGET

Total: $1,964.6

ECONOMICS STUDY NUMBER 8

Study Title: Economic Damage Assessment of Injury to Research Programs Affected by the EVOS

INTRODUCTION

The EVOS 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 or diminished as a result of the EVOS. Research studies underway before the spill and conducted, permitted, cooperatively participated in, sponsored or funded by the federal government likely were impacted. One example is a study involving tagging of fish that was in progress in an affected area of PWS. Determination of the set of studies affected and the extent or degree of damage will require careful evaluation and study.

OBJECTIVES

Assess damage to 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

The first step in this study is to identify the universe of studies that were underway in the affected area at the time of the spill. The next step requires a determination of which studies were negatively impacted by the spill. Some of those impacts may have been so significant that the entire study was discontinued. Other studies may have been able to continue, but only at an increased cost caused by the impacts of the spill. For example, sample sets may have been destroyed or the study may have been moved to another area. Once the universe of affected research programs is identified, this study will value the destroyed and damaged research studies by looking first to total project costs, extra funds expended and amounts spent on each study prior to being impacted by the spill.

BUDGET

Total: $104.9

ECONOMICS STUDY NUMBER 9

Study Title: Quantification of Damage to Archaeological Resources

INTRODUCTION

Archaeological sites along the many miles of oiled coastline and intertidal zones may have been physically injured by oil. Upland sites may have been injured by erosion caused by destruction of site vegetation or transportation of the oil inland. Loss to archaeological resources includes direct and indirect oiling. Determination of the number of cultural resources impacted by the oil spill as well as the type and extent of injury to the archaeological sites has been moved to a separate science study. The economics study is now limited to quantifying the loss to archaeological resources.

OBJECTIVES

Assess the economic damages to archaeological sites.

METHODS

The archaeological science study will create a database containing listings of the oil impacted areas and a model for the kinds of cultural resources impacted, the degree of the impact and the physical setting of the injured resource. Both use and intrinsic values of archaeological resources may have been impacted.

Use Value

1. Effects of the scientific value of the archaeological resource. The magnitude of this damage depends on the uniqueness of the affected site, the original quality of information available at the site, the nature of the impacts, and the willingness of the scientific community to pay for the lost information. If the site is unique and substitute sources of similar information do not exist, the value of the damage may be large.

2. Loss of value as tourist and educational attractions. Unique or spectacular archaeological sites have value as tourist attractions. All significant archaeological sites have educational value as the focus of field trips and published descriptions. Archaeological information and artifacts have value for museum interpretation and display. Oil impacts could substantially reduce these values.

Intrinsic Value

1. Impacts on the religious, cultural or symbolic values for native groups.

2. Loss of intrinsic value for the general, non-native population.

BUDGET

This study has not yet begun due to the delay in receiving results from the archaeological science study. At present, no additional funds have been requested for this study. When results from the archaeological resources science study are received, this study will be continued and funded with the amount needed to determine the extent of both the lost use and intrinsic values of archaeological resources.

ECONOMIC STUDY NUMBER 10

Study Title: Petroleum Products Price Impacts

INTRODUCTION

Retail prices for gasoline on the West Coast of the United States increased immediately after the EVOS. This increase is observed both relative to earlier periods in 1989 and relative to prices in other parts of the country immediately after the spill. Similar increases in other petroleum products may also have occurred.

OBJECTIVES

Estimate economic damages to consumers of petroleum products.

METHODS

This study will conduct a statistical analysis of the relationship between the EVOS and the observed petroleum market price increases. If it appears that a connection between the two events can be shown, the damage to consumers of petroleum products will be estimated. Investigators will use existing data and models as well as improved data and methods they develop to value the injury.

BUDGET

Total:	$ 271.3

PART IV: OIL SPILL PUBLIC INFORMATION SUPPORT

OIL SPILL PUBLIC INFORMATION SUPPORT

Lead Agency: DOJ, DOA, DOI, NOAA

INTRODUCTION

The Federal trustee agencies are committed to making as much information about the EVOS available to the public as possible.

OBJECTIVES

A. Provide a central facility for collecting information about oil spills in general and the EVOS in particular.

B. Gather scientific data from each of the government agencies involved in the spill response or natural resource damage assessment.

C. Answer Freedom of Information Act requests from the public about the EVOS.

METHODS

The Oil Spill Public Information Center (OSPIC) is located in Anchorage, Alaska, and was opened on September 27, 1990. The OPSIC serves the public by providing access to information about oil spills in general and the *Exxon Valdez* oil spill in particular. The current collection includes technical reports, newspaper clippings, maps, slides, photographs, books, periodicals, audio recordings, and video tapes. The OSPIC has received requests from corporate entities, students, college faculty, the legal community, and members of the public. The OPSIC will begin to catalog scientific data from the EVOS during 1991. OSPIC staff will also continue to process documents collected in response to Freedom of Information Act (FOIA) requests for inclusion in the OSPIC collection.

BUDGET

The trustee agencies will reimburse the Department of Justice in equal shares for the operation of the OSPIC and according to agency activity for FOIA processing.

Department of Agriculture	$ 614.0
Department of Interior	1,739.0
National Oceanic and Atmospheric Administration	599.0
Total	$2,952.0

PART V: RESTORATION PLANNING

RESTORATION PLANNING

OBJECTIVES

The goal of the restoration planning effort is to identify appropriate measures that can be taken to restore natural resources injured by the EVOS. Specific objectives are:

A. Identify or develop technically feasible restoration options for natural resources and services potentially injured by the EVOS;

B. Determine the nature and pace of natural recovery of injured resources, and identify where direct restoration measures may be appropriate;

C. Incorporate an approach to restoration that where appropriate, focuses on recovery of ecosystems rather than on the individual components of those systems;

D. Identify costs associated with implementing restoration activities, in support of the overall natural resource damage assessment process; and

E. Encourage, provide for, and be responsive to public participation and review during the restoration planning process.

DEFINITION

For any injury, there are three types of possible restoration activities:

1. direct restoration refers to measures in addition to response actions, usually taken on site, to directly rehabilitate an injured, lost, or destroyed resource;

2. replacement refers to substituting one resource for an injured, lost, or destroyed resource of the same or similar type; and

3. acquisition of equivalent resources means to compensate for an injury to a resource by substituting another resource that provides the same or substantially similar services as the resource injured, lost, or destroyed.

   Determining the adequacy of natural recovery is fundamental to the choice of a restoration activity. In some cases the Trustees maydetermine that it is most appropriate to allow natural recovery to proceed without further intervention.

1990 RESTORATION ACTIVITIES

The Trustee agencies and EPA initiated several small-scale field studies to evaluate the feasibility of restoration techniques. Results from these studies will help to determine the costs and effectiveness of full-scale restoration projects. Several technical support studies were also initiated to provide information needed to evaluate or carry out some potential restoration activities. These studies were described in the 1990 State/Federal Natural Resources Damage Assessment and Restoration Plan for the *Exxon Valdez* Oil Spill, August 1990 (available at the OSPIC) and preliminary results are summarized below.

1990 RESTORATION FEASIBILITY STUDIES

1. Reestablishment of *Fucus* in Rocky Intertidal Ecosystems

   Lead Agency: EPA

Early observations indicated that *Fucus*, a marine plant (rockweed) found on rocky shorelines in the intertidal zone throughout the oil spill area, was extensively damaged by both the spilled oil and cleanup efforts. If the natural recovery of *Fucus* could be significantly accelerated or enhanced, it would benefit the recovery of associated flora and fauna on intertidal rocky shores.

Specific objectives of this study were to identify the causes of variation in *Fucus* recovery at and near Herring Bay, Knight Island in PWS; to document the effects of alternative cleaning methods on *Fucus*; and to test the feasibility of enhancing the reestablishment of *Fucus*. Although results are preliminary it appears that *Fucus* recovers most slowly at intensively cleaned sites and almost no recovery occurs where tar cover persists.

2. Reestablishment of Critical Fauna in Rocky Intertidal Ecosystems

   Lead Agency: USFS

This feasibility study was designed to compare the rates of faunal recovery in rocky intertidal communities, and to demonstrate the feasibility of restoration of these communities by enhancing recolonization rates for such key species as limpets and starfish. Recolonization rates for these organisms and for the rockweed, *Fucus*, may limit the natural rates of recovery for the entire community. Parameters examined included the presence or absence ofcommon intertidal species on impacted and reference sites, population dynamics of several species of invertebrates, larval settlement on oiled versus unoiled surfaces, and differences in algal grazing by limpets between oiled and reference sites. One of the preliminary results indicates that heavy predation of several species of transplanted invertebrates was probably due to the lack of cover usually provided by *Fucus*.

3. Identification of Potential Sites for Stabilization and Restoration with Beach Wildrye

   Lead Agency: DNR

This study was designed to identify sites with injury to beach wildrye grass and to recommend restoration measures. Beach wildrye grass is important in the prevention of erosion in the coastal environment and is a key component of supratidal habitats in locations throughout the oil spill area. Erosion resulting from loss of beach wildrye can lead to the destabilization and degradation of wildlife habitats and of cultural and recreational sites. Results from survey work conducted in 1990 in PWS indicate injury to several beach wildrye communities.

4. Identification of Upland Habitats Used by Wildlife Affected by the Oil Spill

   Lead Agency: FWS, ADF&G

A diversity of birds, mammals, and other animals were killed by the spill or injured by contamination of prey and habitats. Many of these species are dependent on aquatic or intertidal habitats for activities such as feeding and resting, buy many also use upland habitats. Protection of upland habitats from further degradation may reduce the effects of the oil on injured fish and wildlife populations, and thereby speed their recovery. This study focused specifically on marbled murrelets and harlequin ducks, two species known to have been affected by the spill and known to use upland habitats.

Based on surveys of 140 streams, preliminary results of the harlequin duck study indicate that this species nests along larger-than-average anadromous fish streams, with moderate gradients and clear waters. Preliminary results on murrelets suggest that murrelets use north facing slopes, and inland areas at the heads of bays. Open bog meadows, especially at the heads of bays, appear to be used as flight corridors to upper wooded areas.

5. Land Status, Uses, and Management Plans in Relation to Natural Resources and Services

   Lead Agency: DNR

The objective of this study is to locate, categorize, evaluate, and determine the availability of maps, management plans, and other resource documents relevant to restoration planning throughout the oil spill region. Resource materials identified will assist in planning for implementing site-specific restoration activities, including direct restoration, replacement, and the acquisition of equivalent resources.

To date, a variety of documents, maps, and management plans have been identified and are being evaluated; other resource materials are being located. This preliminary project will be completed in Spring 1991. A second phase is under consideration.

1990 Technical Support Projects

1. Peer Reviewer Process for Restoration Feasibility Studies

Lead Agencies: ADF&G, DEC, DNR, DOI, DOA, NOAA, EPA

This project provided funds to ensure that scientists with expertise on natural resource restoration were available to provide peer review of restoration feasibility projects and other restoration planning studies and activities.

2. Assessment of Beach Segment Survey Data

Lead Agency: DNR

The objective of this project is to review and summarize beach survey information (obtained through oil spill response activities) to assist in planning for and implementing site-specific restoration activities, particularly in the area of direct restoration. This study was initiated late in 1990 and continues.

A master database is being created from that portion of the beach surveys relevant to restoration. The primary sources of this information are DNR and DEC. Data from local and regional governments as well as non-governmental sources will also be reviewed and integrated into the system as appropriate. This preliminary project will be completed in Spring 1991.

3. Development of Potential Feasibility Studies for 1991

Lead Agencies: ADF&G, EPA

This project provided for the orderly development of additional feasibility studies including: a) monitoring "natural" recoveries; b) pink salmon stock identification; c) herring stock identification/spawning site inventory; d) artificial reefs for fish and shellfish; e) alternative recreation sites and facilities; f) historic sites and artifacts; and g) availability of forage fish. Feasibility study proposals are currently under consideration including the above topics.

1991 RESTORATION PLANNING ACTIVITIES

The fundamental purpose of restoration planning is to identify, evaluate, and then recommend potential restoration implementation activities, in consultation with technical experts and the public.

The NRDA studies and other sources (e.g., Shoreline Assessment Program, and other agency surveys not connected with the oil spill) provide information on species, habitats, and ecosystems in need of restoration. In 1991, as damage assessment results are synthesized, the RPWG will consult with the principal investigators, agency experts, and outside peer reviewers to review the nature and extent of oil spill injuries in relation to the biology and ecology of the injured resources. A key goal in this process will be to identify life history requirements, limiting factors, and environmental processes that are especially sensitive or that may be enhanced. In turn, this will lead to the identification of potential restoration activities.

Once potential restoration implementation activities have been identified, they must be evaluated in terms of technical feasibility, environmental benefit, cost, and other factors. In 1991, the RPWG will continue to evaluate the restoration options identified thus far (e.g., those presented in RPWG's <u>Restoration Planning Following the *Exxon Valdez* Oil Spill: August 1990 Progress Report</u>), as well as new options that are suggested through public and technical consultations.

While some potential restoration implementation activities are readily evaluated, others require more detailed review and study. In some cases, the RPWG will recommend that restoration science studies (feasibility, monitoring, or technical support) be conducted to test the efficacy of particular options or to gather basic information necessary to evaluate or implement an option (e.g., biological or resource assessment data). Several such studies were carried out in 1990. Subject to additional technical review and availability of funds, some restoration science studies and implementation projects are being considered in 1991. If these studies or projects are carried forward they will be outlined in a <u>Federal Register</u> notice later this spring. Additional information on the Trustees' plan to implement restoration projects in 1991 was provided in the March 1, 1991, <u>Federal Register</u>, (56 FR 8898).

The RPWG also expects to further evaluate restoration approaches. For example, the RPWG will review different management systems for protecting marine habitats (e.g., National Marine Sanctuary Program, Alaska Marine Parks). Another example would be to carry out economic and environmental analyses of restoration alternatives.

As information about injuries becomes available, and as potential restoration actions are evaluated, further implementation activities may be recommended.

Literature Review

The scientific literature and information from other oil spills will provide background information that is helpful in restoration planning. In 1991, the RPWG expects to synthesize previously identified literature on restoration (see Appendix B, August 1990 Progress Report). The RPWG will also complete previously initiated syntheses of literature on species and ecosystem recoveries following natural and human-induced environmental disturbances.

Monitoring

Information on the adequacy of natural recovery is central to determining whether to implement restoration activities or to allow injured resources to recover on their own. The literature reviews described above will provide background information for such considerations, while damage assessment studies will provide current data on the status of resources injured by the EVOS. In 1991 the RPWG expects to recommend several monitoring studies to be carried out in the field in 1991 and to develop protocols for evaluating the effectiveness of any restoration projects that are implemented. The RPWG also will continue efforts to develop a comprehensive plan for long-term ecological monitoring that could be implemented in the oil spill environment following resolution of damage claims.

Public Participation

In 1990, the RPWG emphasized broad scoping activities to invite suggestions from the public about potential restoration activities and priorities. Public participation will continue to be important in 1991, with increased emphasis on evaluating and determining the importance of restoration alternatives. The RPWG is interested in, and available for, meetings with individuals or constituency groups. There also will be consideration of additional activities, such as publications and workshops in 1991. Requests and suggestions from the public are invited.

Scientific Review

Technical review is essential to the scientific integrity of the restoration planning process. As needed, the RPWG draws upon experts from academic institutions, public agencies, and private organizations (e.g., consulting firms, non-profit organizations) as sources of advice and criticism in planning feasibility and technical support studies, and in evaluating and recommending restoration activities. In 1991, the RPWG will continue to place emphasis on scientific review, including participation by peer reviewers.

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Restoration Planning Work Group. 1990. Restoration Planning Following the *Exxon Valdez* Oil Spill; August 1990 Progress Report. 80 pp.

BUDGET

The following restoration planning budget does not include the 1991 costs of any potential restoration implementation projects.

Salaries:	$835.0
Travel:	250.0
Supplies:	20.0
Equipment/Office:	75.0
Contractual Services:	
Literature Review	125.0
Scientific Review	100.0
Public Participation	30.0
Restoration Options Analysis	200.0
Report Publications	25.0
Restoration Science Studies:	3,875.0
Total Planning Activities Budget:	$5,485.0

PART VI: BUDGET

Budget Summary for the *Exxon Valdez* Oil Spill Damage Assessment - 1991

Budgeted costs for projects from 3-1-91 through 2-29-92.

STUDY NO.	STUDY TITLE	LEAD AGENCY	BUDGET
Marine Mammals			
2	Killer Whale	NOAA	$186,000
4	Sea Lion	ADF&G	24,000*
5	Harbor Seal	ADF&G	94,200
6	Sea Otter Injury	DOI	810,800
		subtotal	$1,115,000
Terrestrial Mammals			
3	River Otter & Mink	ADF&G	$377,300
4	Brown Bear	ADF&G	76,000
6	Mink Reproduction	ADF&G	8,500*
		subtotal	$461,800
Birds			
1	Beached Bird Survey	DOI	$313,000
2	Census/Seasonal Distribution	DOI	220,000
3	Seabird Colony Surveys	DOI	530,000
4	Bald Eagles	DOI	255,000
11	Sea Ducks	DOI	178,900
		subtotal	$1,496,900

Budget Summary for the *Exxon Valdez* Oil Spill Damage Assessment - 1991
(continued)
Budgeted costs for projects from 3-1-91 through 2-29-92.

STUDY NO.	STUDY TITLE	LEAD AGENCY	BUDGET
Fish/Shellfish			
1	Salmon Spawning Area Injury	ADF&G	$288,000
2	Eggs/Pre-emergent Fry Sampling	ADF&G	259,000
3	Coded-wire Tagging	ADF&G	1,075,000
4	Early Marine Salmon Injury	ADF&G NOAA	136,400 172,000
5	Dolly Varden Injury	ADF&G	325,100
7	Salmon Spawning Area Injury, Outside PWS	ADF&G	15,000*
8	Egg & Pre-emergent Fry Sampling, Outside PWS	ADF&G	15,000*
11	Herring Injury	ADF&G	558,000
13	Clam Injury	ADF&G	147,000
15	Injury to Shrimp	ADF&G	moved to Subtidal
17	Injury to Rockfish	ADF&G	moved to Subtidal
18	Trawl Assessment	NOAA	40,000*
24	Injury to Demersal Fish	NOAA	moved to Subtidal
27	Sockeye Salmon Overescapement	ADF&G	334,300
28	Run Reconstruction	ADF&G	175,100
30	Database Management	ADF&G	175,800
		subtotal	$3,715,700

Budget Summary for the *Exxon Valdez* Oil Spill Damage Assessment - 1991
(continued)
Budgeted costs for projects from 3-1-91 through 2-29-92.

STUDY NO.	STUDY TITLE	LEAD AGENCY	BUDGET
Coastal Habitat			
1A	Intertidal Studies	USFS	$5,100,000
1B	Intertidal Studies	NOAA	68,000
		subtotal	$5,168,000
Air/Water			
2a	Injury to Subtidal	DEC	moved to Subtidal
		NOAA	moved to Subtidal
2b	Deep Water Benthos	ADF&G	moved to Subtidal
3	Hydrocarbon in Water	DEC	moved to Subtidal
		NOAA	moved to Subtidal
6	Oil Fate and Toxicity	NOAA	moved to Subtidal
Subtidal			
1	Hydrocarbon Exposure, Microbial and Meiofaunal Community Effects (A/W 2a)	DEC	$139,800
		NOAA	295,000
2	Injury to Benthic Communities:	ADF&G	592,500
3	Bio-availablity and transport of hydrocarbons (A/W 3)	DEC	196,200
		NOAA	150,000
4	Sediment Toxicity Bioassays (A/W 6)	NOAA	125,000
5	Injury to Shrimp (F/S 15)	ADF&G	50,000
6	Injury to Rockfish (F/S 17)	ADF&G	120,000
7	Injury to Demersal Fish (F/S 24)	ADF&G	80,000
		NOAA	235,000
		subtotal	$1,983,500

Budget Summary for the *Exxon Valdez* Oil Spill Damage Assessment - 1991
(continued)
Budgeted costs for projects from 3-1-91 through 2-29-92.

STUDY NO.	STUDY TITLE	LEAD AGENCY	BUDGET
Technical Services			
1	Hydrocarbon Analysis	DOI	$550,000
		NOAA	2,000,000
3	Mapping	DOI	300,000
		ADNR	656,300
		subtotal	$3,506,300
Archaeology			
1	Archaeological	ADNR	$688,600
		USFS	103,000
		subtotal	$791,600
	SUBTOTAL FOR SCIENCE PROJECTS		**$18,238,800**
Peer Reviewers/Chief Scientist			
	Department of Agriculture		$772,000
	Department of Interior		772,000
	National Oceanic and Atmospheric Administration		772,000
	SUBTOTAL FOR PEER REVIEWERS/CHIEF SCIENTIST		**$2,316,000**
Economics			
1	Commercial Fisheries Losses	FEDERAL	$265,500
5	Recreation Uses Damage	FEDERAL	390,400
6	Subsistence Losses	FEDERAL	532,100
7	Intrinsic Value Loss	FEDERAL	1,964,600
8	Research Program Damage	FEDERAL	104,900
10	Petroleum Products Price	FEDERAL	271,300
	SUBTOTAL FOR ECONOMICS		**$3,528,800**
Restoration Planning			
	State of Alaska		$2,968,000
	Environmental Protection Agency		1,267,000
	Department of Interior		300,000
	Department of Agriculture		525,000
	National Oceanic & Atmospheric Administration		425,000
	SUBTOTAL FOR RESTORATION		**$5,485,000****

Budget Summary for the *Exxon Valdez* Oil Spill Damage Assessment - 1991
(continued)
Budgeted costs for projects from 3-1-91 through 2-29-92.

STUDY NO.	STUDY TITLE	LEAD AGENCY	BUDGET
	Oil Spill Public Information Support		
	Department of Agriculture		$614,000
	Department of Interior		1,739,000
	National Oceanic and Atmospheric Administration		599,000
	SUBTOTAL FOR OIL SPILL PUBLIC INFORMATION SUPPORT		**$2,952,000**
	Overhead		
	State of Alaska		$1,037,200
	Department of Agriculture		600,000
	Department of Interior		300,000
	National Oceanic and Atmospheric Administration		900,000
	Environmental Protection Agency		200,000
	SUBTOTAL FOR OVERHEAD		**$3,037,200**

GRAND TOTAL $35,557,800

* These studies are being funded for the completion of data analysis and final report preparation.

** Restoration implementation projects may be conducted this summer depending on resource availability. (See FR 88, 98, March 1, 1991.)

BUDGET SUMMARY FOR THE *EXXON VALDEZ* OIL SPILL BY AGENCY

State of Alaska	$10,612,300
Department of Agriculture	7,714,000
Department of Interior	6,268,700
National Oceanic and Atmospheric Administration	5,967,000
Environmental Protection Agency	1,467,000
All Federal Agencies (Economics)	3,528,800
GRAND TOTAL	**$35,557,800**

APPENDICES A, B AND C

APPENDIX A

STATE/FEDERAL DAMAGE ASSESSMENT PLAN

ANALYTICAL CHEMISTRY

QUALITY ASSURANCE/QUALITY CONTROL

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

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

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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

The principal investigators for Technical Services Study 1, in consultation with expert scientists developed and oversee a centralized program to 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.

1.1 Study-Specific Quality Assurance Plans

Prior to the initiation of each study, the principal investigator must prepare and submit a study-specific analytical chemistry QAP to Technical Services 1 principal investigators and scientific experts 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:

* <u>Title Page</u> - Includes the signatures of the individuals responsible for the project and Technical Services 1 concurrence.

* <u>Project Description and Sampling Objectives</u> - Briefly describes the what, where, and why of the project.

* <u>Data Needs</u> - 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.

* <u>Sampling and Labelling Procedures</u> - 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.

* <u>Chain of Custody</u> - Describes Chain-of-Custody and documentation procedures. Minimum requirements are described in Section 2.

* <u>Analytical Procedures</u> - References or describes in detail proposed method(s).

* <u>Internal Quality Control</u> - Describes type and frequency of internal quality control. Minimum requirements are described in Section 3.

* <u>Calibration Procedures and Frequency</u> - Describes the methods and frequency for calibrating field and laboratory instruments. These must be specified in SOP's.

* <u>Data Verification</u> - 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.

* <u>Data Deliverables</u> - Specifies reporting needs additional to the minimum requirements described in Section 4.

* <u>Technical System and Performance Audits</u> - 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 Technical Services 1 principal investigators 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 Technical Services 1 principal investigators and expert scientists.

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 exercises is mandatory. Materials will be prepared by, and data returned to the NIST for statistical analysis. The NIST will report to the Technical Services 1 principal investigators. Unacceptable performance will result in the discarding of the associated data.

The Technical Services 1 principal investigators 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 usability of the data. A QC report on each data set will be provided to the Technical Services 1 principal investigators 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.

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. <u>Minimum Requirements: Analysis</u>

The applicable methodology shall be referenced or described in detail in the SOP's for each measurement parameter.

Method limits of detection shall be calculated by matrix and analyte.

Control of the analytical method in terms of accuracy and precision shall be demonstrated.

Calibration shall be verified at the end of each analysis sequence.

Samples shall be quantified within the demonstrated linear working range for each analyte.

Standard curves shall be established with at least 3 points besides 0.

Field blanks, procedural blanks, reference materials, replicates and analyte recovery samples shall be run at a minimum frequency of 5 percent each per sample matrix batch.

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
2-Methylnaphthalene
1-Methylnaphthalene
Biphenyl
2,6-Dimethylnaphthalene
Acenaphthylene
Acenaphthene
2,3,5-Trimethylnaphthalene
Fluorene
Phenanthrene
Anthracene
1-Methylphenanthrene
Fluoranthene
Pyrene
Benz(a)anthracene
Chrysene

n-dodecane
n-tridecane
n-tetradecane
n-pentadecane
n-hexadecane
n-heptadecane
pristane
n-octadecane
phytane
n-nonadecane
n-eicosane

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. <u>Minimum Requirements: Reporting and Data Deliverables</u>

Measurement results, including negative results, as if three figures were significant shall be reported.

Results of quality control samples analyzed in conjunction with the study samples shall be reported.

Documentation demonstrating analytical control of precision and accuracy on an analyte and matrix specific basis shall be reported.

APPENDIX B

EVOS 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 EVOS shall 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 NRDA 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 unoiled 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 <u>after</u> 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. 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 mm^2 of gill lamellae (fish); mean concentration of mucus cells per mm of epidermis 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.

Finfish and shellfish samples can be coordinated through an ADF&G fish pathologist, Fisheries Rehabilitation, Enhancement and Development Division.

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.

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 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.

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 histophatological 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.

Sparks, A.K. 1985. Synopsis of invertebrate pathology excluding insects. Elsevier Publ., New York.

APPENDIX C

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ADF&G	Alaska Department of Fish and Game
AFK	Armin F. Koernig Fish Hatchery
AHs	Aromatic Hydrocarbons
AHH	Aryl Hydrocarbon Hydroxylase
ANOVA	Analysis of variance
AP	Alaska Peninsula
A/W	Air/Water
AWL	Age, Weight, Length
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CH	Coastal Habitat
CI	Cook Inlet
CIK	Cook Inlet/Kenai
CTD	Conductivity/temperature/depth
CWA	Clean Water Act
CWT	Coded wire tag
DEC	Alaska Department of Environmental Conservation
DNR	Alaska Department of Natural Resources
DOA	Department of Agriculture
DOC	Department of Commerce
DOI	Department of the Interior
DOJ	Department of Justice
DBMS	Database Management System
EPA	Environmental Protection Agency
ES	Economic Study
EVOS	Exxon Valdez Oil Spill
FRED	Fisheries Rehabilitation, Enhancement and Development Division, ADF&G
F/S	Fish/Shellfish
FWS	U.S. Fish and Wildlife Service
GC-MS	Gas chromatography-mass spectrometry
GOA	Gulf of Alaska
KAP	Kodiak Archipelago/Alaska Peninsula
KP	Kenai Peninsula
LCI	Lower Cook Inlet
LKP	Lower Kenai Peninsula
MFO	Mixed function oxidase
MLLW	Mean lower low water
MM	Marine Mammal
NIOSH	National Institute of Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPH	Naphthalene
NPS	National Park Service

APPENDIX C

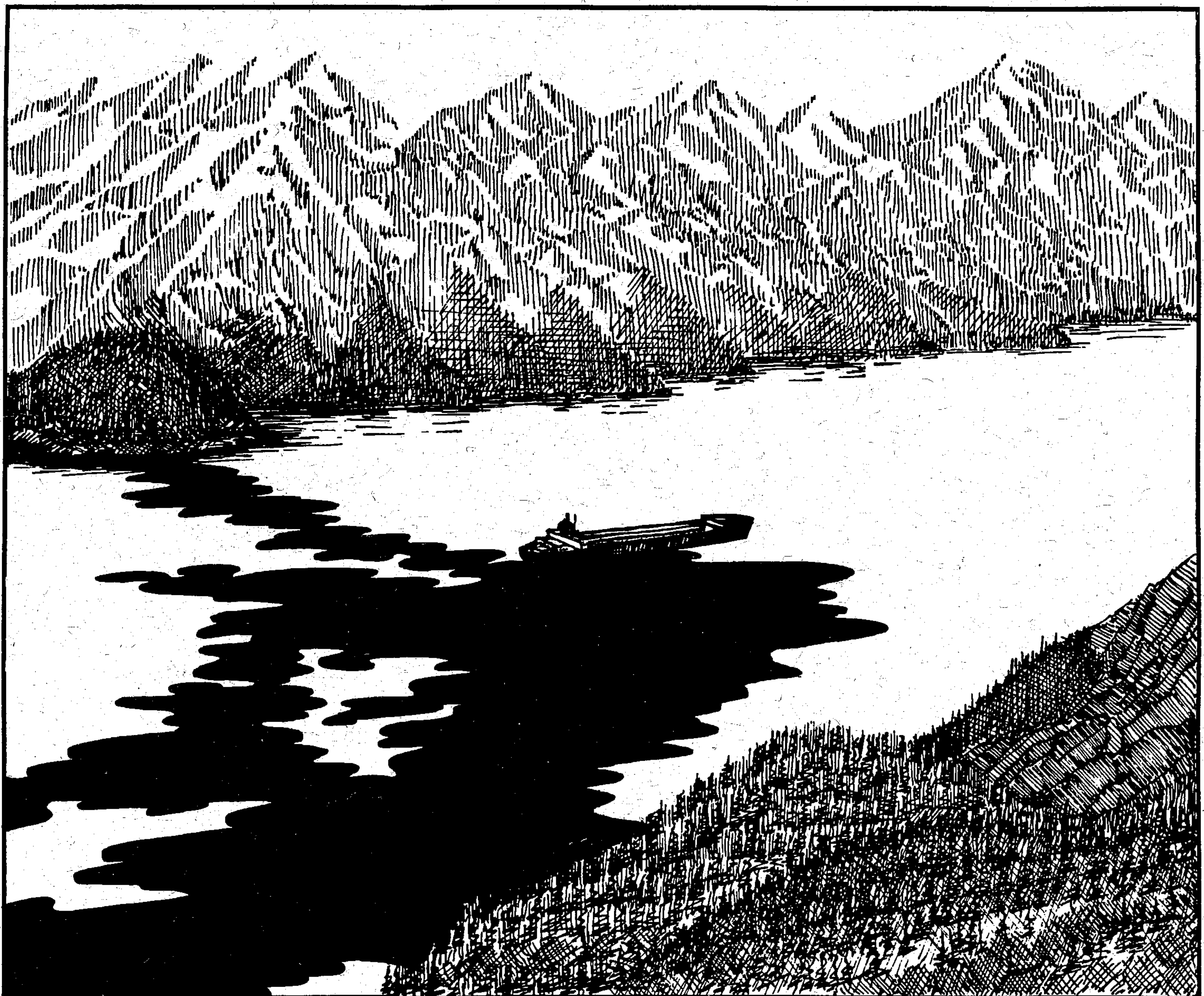
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

NRDA	Natural Resource Damage Assessment
NSO	Nitrogen-sulphur-oxygen
OSSM	On-Scene Spill Model
PED	Potential egg deposition
PHN	Phenanthrene
PI	Principal Investigator(s)
PWS	Prince William Sound
PWSAC	Prince William Sound Aquaculture
QA/QC	Quality Assurance/Quality Control
RPWG	Restoration Planning Work Group
SCAT	Shoreline Cleanup Advisory Team
SSAT	Spring Shoreline Assessment Team
TM	Terrestrial Mammals
TS	Technical Services
USFS	United States Forest Service
VFDA	Valdez Fisheries Development Association

The 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill

Volume II: Response to Public Comment

Appendix D



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VOLUME II

GENERAL

COMMENTS AND RESPONSES CONCERNING THE 1990 STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION PLAN FOR THE EVOS

The 1990 plan was made available to the public for review and comment. Five reviewers representing industry and environmental groups submitted comments on the plan. The reviewers included: Alyeska Pipeline Service Company (APSC), American Petroleum Institute (API), Exxon Shipping Company (ESC), National Wildlife Federation (NWF), and Natural Resources Defense Council (NRDC). (Ann McElroy of the University of Massachussets, Boston (UM) submitted technical comments on behalf of the NRDC and is identified separately in the comments.) Reviewers commented on the overall nature and content of the Plan and provided technical remarks concerning many of the individual studies. All comments were considered by the Trustees during their evaluation of the 1990 data and the formulation of the current plan.

This section provides a synthesis of the comments and their respective responses. The comments and responses are organized into two categories -- those dealing with the general nature of the plan and those concerning a specific category of studies or individual studies. For the information of the reader, the reviewers are identified with their comments.

Comments concerning individual studies that have been discontinued or completed are not addressed.

General Comments on the Plan

Comment: The Trustees failed to include the public in their deliberations concerning the studies to be undertaken in 1990. In these deliberations, federal budget priorities overrode the nation's interest in understanding the *Exxon Valdez* oil spill and fully restoring PWS. Consequently, the likelihood that the United States will be able to recover the damage assessment costs from the responsible parties is diminished since "skimping" on the studies may make proof of damages legally insufficient. (NWF)

Response: Owing to the litigation-sensitive nature of the damage assessment process, the Trustees have attempted to solicit public input in a manner that would not compromise their ability to pursue damage claims in a judicial forum. To the extent that public comments on the 1989 NRDA Plan addressed continuing elements of the Plan in 1990, those comments were taken into account in formulating the 1990 Plan. Given that there has been only minimal funding by potentially responsible parties for the conduct of the damage assessment, the Trustees are legally obligated to work within the constraints of the federal budget and monies made available by the State of Alaska. The Trustees are making every effort, in light of these budget constraints, to ensure that the studies that have been undertaken will meet the legal standards for recovery of damage assessment costs.

Comment: The Trustees have failed to include the potentially responsible parties (PRP) in the assessment process and refused to provide either the PRP's or the public with a meaningful opportunity to comment. This action is contrary to the Clean Water Act, the Ohio v. Department of the Interior decision and the NRDA regulations. Under the regulations, the PRP's are accorded a higher degree of participation than the general public. Their involvement is necessary to ensure the integrity of the process: they can perform replicate studies; oversee study activities; obtain and analyze splits of samples; and perform other validating activities. (APS, ESC)

Response: Under the NRDA regulations, the degree of participation of PRP's in the damage assessment process is within the discretion of the Trustees. See 43 C.F.R. § 11.32. In this damage assessment, PRP's were given a full opportunity to review and comment upon the damage assessment plan. The assertion that the Trustees are legally obligated to allow PRP's greater participation than the public is incorrect.

Comment: The Trustees may not pick and choose from the NRDA regulations on an issue-by-issue basis. (ESC)

Response: The Trustees disagree. The NRDA regulations are optional, and their use is within the discretion of the Trustees. See 43 C.F.R. § 11.10. There is no requirement that the Trustees must choose to employ the regulations on an all-or-nothing basis.

Comment: Because the assessment is not consistent with the NRDA regulations, the Trustees will be deprived of the rebuttable presumption of validity. This will undermine the credibility and enforceability of the final assessment. (APSC)

Response: The Trustees have not made a final decision on the extent to which they will apply the NRDA regulations. Those aspects of the assessment conducted in accordance with the regulations are entitled to a rebuttable presumption of accuracy. At the same time, the regulations recognize that Trustees may need to use innovative assessment methods not specified in the regulations. Where such methods are shown to be accurate and valid, their use enhances the credibility and enforceability of the assessment.

Comment: Failure to follow the NRDA regulations is contrary to statutory mandate. The Trustees do not have the discretion to waver from the dictates of these regulations. Alternative assessment procedures cannot be used unless compliance with the regulations would produce a clearly erroneous result and the alternative procedures chosen by the Trustees are scientifically and economically valid. Failure to follow the regulations, which under CERCLA are required to be the "best available procedures", will result in a determination that the assessment is scientifically invalid and legally indefensible. (APSC)

Response: This comment is incorrect. The regulations explicitly provide that they are optional. See 43 C.F.R. § 11.10. The regulations recognize that the accuracy and validity of the assessment may be enhanced by use of methods in addition to those specified in the regulations.

Comment: The Plan fails to document the Trustees' decision not to allow the PRPs to implement the damage assessment plan. This is contrary to 43 C.F.R. § 11.32(d). (ESC)

Response: The Trustees believe that their decision to conduct the damage assessment themselves is adequately documented in the Plan.

Comment: Failure of the Trustees to issue the 1990 Plan for public review and comment until after most of its studies had begun violates 43 C.F.R. § 11.32(c), which provides that the assessment plan is to be made available for review for 30 days before the performance of any of the methodologies contained in the NRDA regulations. (APSC)

Response: In order to conduct an adequate assessment, the Trustees determined that it was necessary to begin collection of data before completing the public comment process. This procedure is consistent with 43 C.F.R. § 11.22. To the extent possible, the Trustees have incorporated public comments into implementation of the studies. In addition, the 1990 Plan was based upon the 1989 studies, so comments on the 1989 studies were evaluated by the Trustees before the 1990 field season.

Comment: The 1990 Plan did not allow the PRPs and others to comment on the assessment projects before they were implemented, as the NRDA regulations require. Nor have the Trustees recognized the special role the PRPs are given by the regulations in developing the design and scope of the assessment process, prior to public involvement. This failure to cooperate with PRPs is contrary to the Department of the Interior's position in its promulgation of the regulations, the Department of Justice's position in defending the regulations and the decision in Ohio v. Department of the Interior. (ESC)

Response: In order to conduct an adequate assessment, the Trustees determined that it was necessary to begin collection of data before completing the public comment process. This procedure is consistent with 43 C.F.R. § 11.22. To the extent possible, the Trustees have incorporated public comments into implementation of the studies. (See previous response.) Under the NRDA regulations, the degree of participation of PRP's in the damage assessment process is within the discretion of the Trustees. See 43 C.F.R. § 11.32. In this damage assessment, PRP's were given a full opportunity to review and comment upon the damage assessment plan.

Comment: The Trustees have violated 43 C.F.R. § 11.32(a)(2)(iii), which requires that the Trustees invite PRP's to participate in the assessment process and to give them thirty days to respond before proceeding with the development of the assessment plan or any other assessment actions, by announcing the availability of the Plan in September of 1990, after most of the 1990 studies had been completed. (APSC, ESC)

Response: See Response above.

Comment: Contrary to the assertions of the Plan, the natural resource damage provisions of CERCLA do not authorize the undertaking of the damage assessment for the *Exxon Valdez* oil spill since CERCLA expressly excludes crude oil from its coverage. (APSC)

Response: While spills of crude oil are not subject to liability under CERCLA, CERCLA provides the legal framework for conducting natural resource damage assessments under both CERCLA and § 311 of the Clean Water Act, which does impose liability for oil spills.

Comment: Contrary to the Plan's assertion that "restoration is a broad term," restoration is defined precisely in decisions interpreting the Clean Water Act and the NRDA regulations as actions undertaken to return an injured resource to its baseline services. (ESC)

Response: The NRDA regulations, which are optional, define restoration as actions undertaken to return injured resources to their baseline physical, chemical, or biological properties or the services they provided. The 1990 Plan's description of restoration is in accordance with this regulatory definition. See 43 C.F.R. § 11.14(ll).

Comment: The Trustees' sole objective should be restoration of the area impacted by the spill. The Plan therefore should identify impacted resources in need of restoration and develop cost-effective methods of carrying out those restoration needs. The

Plan's failure to do this is illegal. (ESC)

Response: The ultimate objective of the Trustees is to restore, replace, or acquire the equivalent of the resources injured by the spill, and the damage assessment is directed toward that objective.

Comment: The Clean Water Act's provision for assessment of damage to natural resources focuses on restoration costs. It does not impose liability for natural resources damages apart from the cost of restoration or replacement, so only costs of those measures are recoverable. Hence lost use and non-use values are not compensable. The only relevance of the loss of use value of resources is in ensuring that in choosing among restoration alternatives, the Trustees can evaluate whether particular alternatives can be performed at a cost that is not grossly disproportionate to the use value of the resource and whether they will be cost-effective. (APSC)

Response: In Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989), the D.C. Circuit held that natural resource trustees are entitled to recover lost use and non-use values as well as the costs of restoration. That case dealt with the natural resource damage provisions of both CERCLA and the Clean Water Act. Furthermore, the Clean Water Act is not the sole legal authority for recovery of natural resource damages arising out of the oil spill; other authorities provide for recovery of lost use and non-use values.

Comment: The Plan includes economic studies designed to assess damages that are not compensable under the Clean Water Act, such as those estimating non-use losses, use value effects, commercial fishery losses, private damages, research losses, archaeological resource damages, hypothetical effects on the value of public lands, recreation values, subsistence values and "natural resource slander." (APSC)

Response: See Response to previous comment.

Comment: The Plan continues to include studies relating to losses to the commercial fishing and tourism industries, which are not recoverable in the NRDA process. Archaeological resources are man-made and therefore not covered by the NRDA process. (ESC)

Response: Commercial fishing and tourism are services provided by natural resources, damage to which is recoverable in the NRDA process. A valuation of the committed use of the cultural attributes of natural resources, as well as, the natural components of cultural sites, is properly within the NRDA process.

Comment: There is no authority in either the Clean Water Act or the NRDA regulations for inclusion of "natural resource slander" in a claim for natural resource damages. Consideration of such a claim in the damage assessment is inappropriate. (ESC)

Response: The services provided by natural resources may be impaired by the perception that the resources have been tainted or contaminated by an oil spill. The determination of whether such impairment is compensable must be made on a case-by-case basis.

Comment: The 1990 Plan contains no economic methodology determination, no resource recoverability analysis, and no restoration methodology plan, as required by 43 C.F.R. §§ 11.35, 11.73 and 11.82, respectively. (APSC)

Response: The regulations provide that the economic methodology determination may be postponed. See 43 C.F.R. § 11.35(d) (2). An evaluation of resource recoverability is one of the elements of the assessment. The Trustees, alone with EOA, are in the process of developing a restoration planning process consistent with the objectives of 43 C.F.R. § 11.82.

Comment: Relevant law requires that the anticipated costs of the assessment be less than the anticipated damage amount in order for the assessment costs to be reasonable. Many of the studies, notably those regarding Terrestrial Mammals, violate this requirement. (ESC)

Response: The NRDA regulations, which are optional, indicate that the anticipated cost of the assessment should be less than the anticipated amount of damages. See 43 C.F.R. § 11.14(ee). There is no requirement that each individual element of the assessment meet this test. Rather, individual elements need only lead to an increase in accuracy and precision in the assessment that outweighs their costs. See Id. The Trustees believe that the assessment meets these standards.

Comment: Many specific comments made on the 1989 Plan concerning alternative methods of analysis to be included were met with blanket responses such as "this was not feasible" or "this is now included in the study." Yet the basis for these decisions is unstated. (UM)

Response: This comment is too general to answer without a comprehensive review of all comments on 1989 studies and the relevant 1990 studies. In some cases, alternative methods of analysis were considered and incorporated into study design. In other cases, even though the alternative method may have been another appropriate method, it was decided that the value of retaining multi-year consistency outweighed the benefit in changing to an alternative method.

Comment: The studies do not appear to be integrated with respect to consistency of methods used, habitats or species sampled, or in the timely generation of data and summary reports. (UM)

Response: Studies were designed and executed by scientists with expertise in those fields. Efforts were made to ensure first that the methods used were appropriate to meet the objectives of the study for the resource in question. There is an ongoing process to integrate results of different studies. Data are being generated on an ongoing basis.

Comment: Several studies include sediment sampling from the same areas. One set of samples should be sufficient. The uncoordinated collection of samples from the same sites may lead to inconsistent and conflicting data. (API)

Response: We agree with this concern and are coordinating submission of samples for analysis. Sometimes sediment samples are analyzed for different factors and multiple samples are necessary.

Comment: A small number of samples (10 per study) were submitted for the preliminary evaluation of the first year's work in preparation for the 1990 plan. The Plan indicates that many hundreds of additional samples were submitted later, but it is not known what, if any, bearing these additional samples had on the 1990 work plan. There is a need for better project coordination, timely data analysis, report generation, and distribution. (UM)

Response: Any problems created by the limited amount of hydrocarbon analysis data available during preparation of the 1990 plan have been resolved. Principal investigators are receiving results in a timely and consistent fashion.

Comment: Although the Plan states that results from 1989 dictated study efforts in 1990, those results are not presented. The 1990 studies were more microscopic than those of 1989 without identifying the need to intensify study. Instead, the Plan should have been broadened to consider the viability of the ecosystem as a whole. (ESC)

Response: Because of potential litigation, 1989 results were not presented. The 1990 Plan focused efforts on a number of areas where more data were needed, both from a "microscopic" and ecosystem perspective.

<u>Comment</u>: The 1990 damage assessment plan demonstrates that the Trustees have not been following the Department of the Interior's Natural Resource Damage Assessment regulations. The purpose of damage assessment cases, as shown in <u>Ohio v. Department of the Interior</u>, is to restore the environment. Some 1990 studies aim to assess low levels of damage, which is the only impact discernible, and which will not be useful in the processes of restoration and rehabilitation. (API)

<u>Response</u>: Use of the natural resource damage assessment regulations is optional. While the Trustees agree that the goal of the natural resource damage assessment process is to restore the environment, every effort should be made to identify and quantify all injuries to natural resources as a result of EVOS. Quantified "low levels" of injury will result in recoverable damages based upon use and non-use values. As indicated in <u>Ohio v. Department of the Interior</u>, recoverable damages include restoration costs plus use and non-use values of the affected resource. Meaningful and responsible restoration cannot be effected without fully understanding the scope and degree of resource injury.

<u>Comment</u>: The studies will not determine whether biological changes were the result of oiling or human intervention. This evaluation is not possible due to a lack of reliable baseline data, and vagueness in definitions of oiling. (API)

<u>Response</u>: Recoverable damages for injuries to natural resources include both the effects of EVOS and the detrimental "human" cleanup activities. While multi-year baseline information on specific natural resources is desirable, it is not necessary in this damage assessment process, where adequate control areas can be identified.

<u>Comment</u>: Studies should not have been dropped due to lack of evidence of impacts early on in the NRDA process. Lack of discernible impacts at early stages would not necessarily indicate that there will be no effects in later years. Discontinuation of studies fails to take into account such factors as bioaccumulation and biomagnification, or genetic and reproductive impacts. (NRDC)

<u>Response</u>: Where possible, the delay in detectability of injuries was taken into account in determining which studies should continue. Certain studies will continue to assess such factors as bioaccumulation and biomagnification and genetic and reproductive impacts.

<u>Comment</u>: Although some studies were discontinued, forty additional sites will be investigated, many of which were not affected by the spill. The plan does not explain the reasons for this increase.

(API)

<u>Response</u>: The forty sites that are referenced are not additional sample sites, but represent improved sampling sites from the 1989 season for the Coastal Habitat Study. The total number of coastal habitat sites selected for 1990 did not increase. The new sites were intended to provide for the full array of spatial and habitat sites to meet the study design. The sites selected that were "unaffected" by oil represent control sites to match the physical and biological characteristics of the existing inductively selected oiled sites. This paired design will be used to determine the effects of oil or the subsequent beach cleaning activities on the intertidal ecosystem.

<u>Comment</u>: The 1990 Plan fails to provide the potentially responsible parties and the public with sufficient information to evaluate the scientific validity or the cost-effectiveness of the damage assessment. (APSC 1, 2, NWF 9) Although the 1990 Plan contains greater detail than the 1989 Plan, it does not contain sufficient information to allow meaningful comment. (APSC, NWF) It lacks information concerning: number and representative nature of sampling sites; number and quality of samples to be collected and analyzed; description of methods for collecting, preserving, shipping, identifying, preparing, analyzing, and reporting of samples; and details of the statistical design for interpretation of results. This violates the NRDA regulations. (ESC)

<u>Response</u>: The objective of the 1990 Plan was to provide adequate information for reviewers to understand the scope and methods of the assessment. The Trustees believe the information provided is sufficient for this purpose.

<u>Comment</u>: The lack of detail in the Plan permits the Trustees to avoid publication of the budget cuts affecting the assessment and risking potential recoveries of damages from the potentially responsible parties. (NWF)

<u>Response</u>: <u>See</u> response to the first comment in this section. Further, there is no obligation on the part of the Trustees to include within the Plan any statements regarding increases or decreases in budgets affecting the damage assessment.

<u>Comment</u>: In the 1990 Plan, the interrelationships among studies still is not adequately addressed. (UM)

<u>Response</u>: Although not directly addressed in the 1990 Plan, the Trustees have implemented a synthesis and integration process that is providing a clear understanding of the interrelationships among studies and providing specific recommendations on how this

integration can be improved. This should be more evident in the 1991 Plan.

Comment: 43 C.F.R. § 11.22 does not authorize the implementation of the studies described in the 1989 and 1990 Plans prior to review and comment. It does not contemplate that vast sums of monies might be spent to survey injury to all resources possibly affected by the spill or the analysis of data from such surveys or that injury determination might be based upon this work. It permits only the preliminary collection of field samples and site visits in order to preserve data and material that might otherwise be lost. (ESC)

Response: The purpose of 43 C.F.R § 11.22 is to allow the Trustees to obtain data on an expedited basis that might be lost if all of the procedural requirements of the regulations were followed. The provision authorizes collection of perishable data and materials. The extent of collection is within the discretion of the Trustees.

Comment: The 1990 Plan describes 51 studies, most of which are being conducted without first identifying that they are related to an injury that has been determined pursuant to the regulations (43 C.F.R. §§ 11.61 -.64). Some of the studies are designed to determine that no damage has been done to a particular resource. Other studies use non-specific methods or methodologies for determining injury, testing, and sampling that do not comply with the guidance of 43 C.F.R. §§ 11.62 -.64. (APSC)

Response: All studies are directly related to documenting injury to natural resources as a result of the EVOS. It is a standard scientific procedure to use the null hypothesis as a statement of the study objective. The most appropriate methodologies were used for each study.

Comment: The Plan improperly combines the injury determination and injury quantification phases of the assessment process so that there are studies attempting to quantify resource levels for which no injury has been documented. This is contrary to the regulatory mandates to conduct the assessment at a reasonable cost (43 C.F.R. § 11.13(c)) and to quantify only for injuries found in the damage determination phase (43 C.F.R. § 11.71(a)). The Plan also is going forward with damages determination before the injury and quantification phases have been completed, in violation of 43 C.F.R. §§ 11.81-.84. (APSC, ESC)

Response: The Trustees are unaware of any studies that involve quantification of injury where no injury has been demonstrated. Damage determination for a particular resource is appropriate where the underlying injury information is available. There is no requirement that damage determination with respect to a resource await completion of injury determination and quantification with respect to all other resources. Furthermore, the Trustees are not required to avoid collecting data relevant to injury quantification and damage determination at the same time that injury determination data is being collected where this is the most cost-effective procedure, and relevant data otherwise would be lost.

Comment: The Trustees should have performed a pre-assessment injury screening to determine which resources potentially had been injured by the oil spill. This would have eliminated many of the 1989 studies. The Trustees then should have evaluated 1989 data before authorizing studies for 1990 and allowed only those studies to go forward where it had been determined, in accordance with the regulations, that injury had in fact occurred and that the studies would be necessary to achieving cost-effective restoration. (APSC)

Response: The Trustees did conduct a pre-assessment screen before beginning the assessment process. A copy of this preassessment screen was included as Appendix C in the August 1989 State/Federal Natural Resource Damage Assessment Plan for the *Exxon Valdez* Oil Spill. Data collected from the 1989 studies were evaluated when determining the studies to go forward in 1990. Studies that were not deemed necessary to continue in 1990 were discontinued.

Comment: The 1990 Plan does not use a proper baseline for assessing the difference between the pre- and post-spill level of services rendered by the injured resources: many studies fail to take into account natural causes for differences in resource levels between and oiled and non-oiled areas; fail to consider contamination of resources by sources other than *Exxon Valdez* oil spill; ignore historic data showing natural variations in resource levels; or compare resources at oiled and non-oiled areas without using the regulatory criteria (43 C.F.R. § 11.72) for selecting "control" areas. (APSC)

Response: Proper baselines, when available, are used for assessing differences between pre- and post-spill resource values. In many cases baseline data did not exist, in which case treatment (oiled) and control (unoiled) data sets were gathered to make comparisons. Every effort is being made to account for other sources of variation or contamination. Control areas were established in accordance with regulatory criteria.

Comment: The 1990 studies do not distinguish between reductions in baseline services provided by the natural resources and changes in the resources themselves. According to the regulations, restoration or replacement measures are limited to those necessary to restore or replace the resources services to their baseline level. But the Trustees have not attempted to determine reductions in baseline services. This will invalidate the results of the assessment. (APSC)

<u>Response</u>: By determining injury to resources it will be possible to distinguish between the reductions in baseline services and changes in the resource. In addition, the regulations indicate that restoration may be achieved by restoring a resource to its baseline condition, either in terms of services or its physical, chemical, or biological properties.

<u>Comment</u>: The Plan does not provide the level of detail specified by the regulations regarding the scientific and economic methodologies used in the studies, especially as concerns sampling and data sharing. (APSC)

<u>Response</u>: The Plan provides that level of detail necessary to apprise the public of the damage assessment studies being undertaken and the applicable methodologies. As time allows, further detail is incorporated into the study plans for public review. The Trustees disagree with the assertion that there has been a regulatory violation; sufficient information has been provided to allow adequate public review. In addition, use of the damage assessment regulations is optional, although the Trustees have acted in a manner consistent with the regulations.

<u>Comment</u>: No justification is given for the discontinuance of studies, including the larval fish injury, crab injury, and whale necropsy studies. Public comment was not allowed prior to the Trustees' decision to drop these studies. This constitutes a significant modification of the assessment plan. (NRDC)

<u>Response</u>: Numerous studies have been discontinued or modified; others remain as originally implemented. The damage assessment process is dynamic with results being continually evaluated. If it is appropriate to modify or discontinue studies, given the purpose for which the studies were undertaken, their modification or termination is effected. Studies were evaluated on their likelihood to provide additional data from five perspectives: (1) immediate injury, (2) long-term alteration of populations, (3) sublethal or latent effects, (4) ecosystem-wide effects, and (5) habitat degradation. The fact of modification or termination is communicated through the next iteration of the Plan. Regardless of whether the termination of a study or group of studies may be a significant modification of the Plan, the public has been informed of those terminated studies and has been given the opportunity to comment on that action.

<u>Comment</u>: The Plan appears to shift resources to restoration

activities before an adequate analysis of the impacts from the spill is completed. (NWF)

Response: The Trustees believe that it is important to begin restoration of certain resources where there is adequate information to do so and where early restoration may prevent further injury. This policy will not interfere with an adequate analysis of the impacts of the spill.

Comment: The Trustees do not state any support for their supposition that the data obtained from studying particular species can be extrapolated to other species. (NWF)

Response: Leading scientists are working with the Trustees to determine when results from studies of particular resources can be extrapolated to other species or groups of species.

Comment: The Plan does not address the adverse effects of the spill on the interactions among different species and different elements of the ecosystem. It lacks a fully integrated ecosystem study. Although the coastal habitat study professes to undertake this type of study, it is unclear how this will be accomplished. (NWF, NRDC)

Response: An active and ongoing study synthesis process has been instituted to integrate the results of different studies. This will provide a broader, ecosystem wide understanding of injuries.

Comment: The Plan fails to acknowledge that recovery is taking place and focuses instead on microscopic examination of selected aspects of the affected area. As a result, many of the studies are not legally justified and are of little relevance to the Trustees' restoration goals. There is convincing evidence that fishery resources are vital and productive, that mature otters and pups are repopulating areas that were affected by the spill, and that density and diversity of bird species are returning to pre-spill norms. These observations should have been used to formulate a restoration-based Plan rather than embarking on a microscopically-focused set of studies. The Trustees should have followed the guidance of the NRDA regulations and commenced intensive scientific studies only if observations from cleanup and natural recovery warranted them. (ESC)

Response: The assessment is designed to provide a comprehensive analysis of the effects of the oil spill on the environment. The analysis of natural recovery is an important component of this assessment. On the other hand, the Trustees cannot ignore injury to certain populations or resources simply because other populations or resources appear to be recovering from the effects of the spill. Nor can the Trustees ignore continued toxic contamination of marine food chains simply because some aspects of the ecosystem are gradually recovering from the grosser impacts of the spill. If the commenter wishes to provide scientific data supporting its statements regarding recovery of natural resources, the Trustees will consider this data in conducting the assessment.

Comment: The Plan contains studies that focus on basic scientific research, traditional agency studies or management activities, and on preparation for litigation. These are unnecessary in a process that is intended to identify and measure cost-effective restoration requirements (e.g., salmon run surveys, humpback and killer whale censuses, bird and sea lion surveys, and gathering of recreational use data). (ESC)

Response: The assessment is designed to determine the nature and extent of injury to natural resources resulting from the spill, and to provide sufficient information to develop methods for restoring injured resources. The assessment does not include basic scientific research or traditional management activities. In some cases, of course, assessment of the effects of the spill requires studies similar to those commonly conducted by resource managers, but beyond the scope of normal agency management activities in an area unaffected by an oil spill. One of the purposes of the assessment is to determine the amount of natural resource damages in order to present a claim to the parties responsible for the spill. Until the parties responsible for the spill voluntarily assume responsibility for the effects of the spill on the environment, the Trustees cannot ignore the need for information sufficient to support a claim in litigation.

Comment: The Plan's studies that involve "takes" of birds, otters, seals, sea lions, mink, and deer are unjustified given the apparent health and vitality of these species. The following studies have no bearing on restoration requirements: laboratory research on mink reproduction and toxicity of polar compounds; radio-tracking of eagles, bears, and sea otters; premature pupping of sea lions in areas outside the impacted area; and measurement of insecticides in peregrine falcon eggs. (ESC)

Response: The actual health and vitality of birds, otters, seals, sea lion, mink, and deer cannot be determined without study. Some injuries may be sublethal and can only be documented by "take" of specimens. All of the listed studies have a direct bearing on restoration planning by providing a more complete picture of the total injury, both lethal and sublethal, to the resource.

Comment: Studies use unnecessarily invasive techniques, including the killing of animals from PWS. (API)

Response: Animals were collected only after careful review by leading scientists and agency experts and the take was in each case kept to a minimum.

Comment: The technical programs are aimed at finding evidence that some biological parameter is statistically different between oiled and non-oiled areas, but there is no indication how such findings will relate to restoration or how the differences can be linked to the presence of oil. (API, ESC)

Response: Each study includes provisions to link documented injury to oil. All information on injury is important to enable resource managers to understand the impact on a resource so that appropriate restoration planning can occur.

Comment: The Plan does not explain how the information gained from the various studies will be used to answer questions about the relative benefits of various restoration alternatives. (ESC)

Response: The NRDA studies provide essential information concerning the nature and extent of oil-spill injuries in relation to the biology and ecology of the injured resources. Before restoration alternatives can be adequately evaluated, it is necessary to have an understanding of the degree and nature of the injury of the resource. Once potential restoration implementation activities are identified, they will be evaluated in terms of technical feasibility, environmental benefit, cost, and other factors.

Comment: There is no connection between the restoration alternatives set forth in the Plan and the economic work evaluating the need for restoration and determining whether any of these projects are supportable in light of natural recovery. (ESC)

Response: An integral component of the restoration planning process is to determine the nature and pace of natural recovery of injured resources, and identify where direct restoration measures may be appropriate. All proposed restoration alternatives will undergo economic and environmental analyses to determine whether these projects are justified in light of natural recovery.

Comment: Restoration studies are only necessary if technical studies show that a resource will be adversely affected for a long period of time. Restoration studies that are being conducted before the results of the assessment studies are available assumes that all resources are injured and will require restoration measures. While this approach may shorten implementation time of restoration once the damage assessment process is over, it unwisely expends resources for feasibility studies and literature searches concerning resources that are later determined not to require active restoration measures. (ESC)

Response: The Trustees disagree that restoration studies are only necessary if a resource will be adversely affected for a long period of time. Restoration studies may concern any degree of injury to a natural resource in order to determine whether to enhance natural recovery. During the course of the NRDA studies, where the nature of the resource injury is reasonably clear, and where no alternatives would be foreclosed, it may be desirable to begin implementation of certain restoration activities prior to the conclusion of the NRDA studies and a final restoration plan.

Comment: The Trustees are responsible for selecting a cost-effective restoration program; the public's participation in this process is unproductive since the public does not have any independent knowledge about injuries or restoration needs. Public meetings held to develop lists of restoration ideas create expectations in the public that are not justifiable given the actual state of the environment. The restoration project's emphasis on public involvement is contrary to the regulatory requirements since it is not cost-effective and distracts the Trustees from focusing on the technical information needed to identify whether specific restoration measures are needed. (ESC)

Response: The Trustees believe that public involvement is an important part of the restoration process. The commenter's desire to increase the influence of responsible parties while excluding the public is inconsistent with the goals of the restoration process.

Comment: The Plan fails to take into account that oil exposure may have affected various species from sources other than the *Exxon Valdez* oil spill, such as those of biogenic (plant waxes) and petrogenic (shoreline oil seeps) as well as human (vessel traffic) origins. (ESC)

Response: If there is any indication that the hydrocarbon contamination in the spill area was caused by sources other than the oil spill, the assessment will address this issue. Hydrocarbon analysis is designed to differentiate between different sources of hydrocarbon exposure.

Comment: Many of the studies in the Plan violate the requirement that the anticipated costs of the assessment be less than the anticipated damage amount in order for the assessment costs to be reasonable. (ESC)

Response: As noted above, the Trustees believe that the studies in the assessment plan are consistent with the reasonable cost requirement in the NRDA regulations.

Comment: The Plan does not make clear that sampling programs, especially those in the Fish/Shellfish and Terrestrial Mammals studies, will produce information necessary to prove that a statistically significant portion of the expected biological variability is a function of hydrocarbon contamination as opposed to other natural factors. (ESC)

Response: These studies are designed to compare different parameters in oiled and unoiled areas and to measure exposure and injury from hydrocarbons.

Comment: In general the 1990 Plan still does not provide sufficient detail on statistical design to ensure that the studies will produce unbiased data for use in modelling efforts. (ESC)

Response: Sufficient information is provided in the 1990 Plan to facilitate an understanding of methodology and statistical testing. Modelling is not being considered for all studies.

Comment: The normal histology of most of the species being studied is not known. Sufficient information will not be gained by examining a few control specimens. Thus, a determination that a particular condition is abnormal and linking this abnormality to the spill will be difficult, if possible at all. (ESC)

Response: Histology samples are being interpreted by leading experts and are based, where possible, on known normal histology, for example, for sea otters. Proper precautions are being taken to ensure accurate interpretation of histology samples.

Comment: Many of the 1990 studies rely on non-specific or non-standard indicators to correlate evidence of hydrocarbon exposure to presume population impacts, which will not bear technically conclusive results. (ESC)

Response: This comment is difficult to respond to because it does not specify what indicators are considered non-standard. Generally, the techniques, analyses, and selected indicators in the studies are well documented in the literature and scientifically sound. In one study (brown bears), a well accepted hydrocarbon analysis is used, but applied to a sample (fecal) not previously tested. In no event do studies attempt to jump directly from hydrocarbon exposure to population impacts.

Comment: The criteria for determining oil-induced lesions in invertebrates and fish were developed for the *Amoco Cadiz* spill and may not be applicable to PWS species. (ESC)

Response: It is appropriate to use information in the literature to assist in measuring injury, including oil-induced lesions in invertebrates and fish. Any differences in these lesions between those impacted by the *Amoco Cadiz* oil spill and the EVOS will be evaluated as a part of the injury assessment efforts.

Comment: The Plan inadequately documents the ecological similarity of control sites and test sites. (ESC)

Response: Every effort was made to select control sites that are ecologically similar to test sites; the Plan generally describes this process.

Comment: Many studies are designed to show that there is no damage to the subject resource(s). Such studies should not have been included in the Plan given the probability that no damages will be uncovered. Their inclusion violates 43 C.F.R. §§ 11.23(b) and 11.61(e)(3). (ESC)

Response: The null hypothesis identified in many of the studies is a well established, objective starting point for scientific evaluation. Other hypotheses could have served equally well. The Trustees disagree there has been a violation of the natural resource damage assessment regulations.

Comment: The Trustee Council did not issue study plans for the 1989 and 1990 assessments far enough in advance of the public comment deadlines making the comment process meaningless. (NRDC, NWF, API)

Response: The Trustees have extended the deadlines for response to public comment in both years and received extensive and detailed comments on both plans. Comments on the 1989 and 1990 Plans have been taken into consideration in subsequent development of the study plans. The Trustees have made extraordinary efforts to ensure publication of the 1991 Plan earlier in the year and will consider public comments received thereon prior to commencement of the 1991 studies. Comments concerning ongoing studies will be considered as well.

Comment: As public comment has not been allowed prior to commencement of the studies, it has been difficult for responsible parties to call duplicative studies to the attention of the State or the Trustees. (API)

Response: The Trustees are endeavoring to avoid any unnecessary duplication of efforts in the joint State/Federal science study plans and have taken into account comments on the 1989 and 1990 plans.

Comment: Release of the Plan constituted a "major federal action" for which an environmental impact statement was required to be done. Even assuming, however, that the Trustees are taking steps that are the "functional equivalent" of an EIS, their "after-the-fact" publication of the studies does not meet the NEPA requirement that there be procedural standards for thorough consideration of the issues and judicial review. (NWF)

Response: The Trustees do not believe that NEPA is applicable to the damage assessment and restoration planning processes, but they will consider its applicability to future restoration projects on a project-by-project basis.

Comment: Repeated comments citing the need for an on-going review process were met with blanket statements indicating review was being done. However, this review process was never adequately described. If the Trustees had the Plan adequately reviewed by outside experts, these experts should be named and their comments made public. There is no guarantee that these comments were adequately addressed in the new Plan unless full disclosure is made. In response to comments on the 1989 Plan suggesting that the names of investigators involved in the damage assessment would aid in determining the adequacy of the plan, the Trustees stated that names are not necessary for evaluation of the study. Yet in most grant and contract evaluation processes, the "track record" of the investigator is taken into account. Particularly here, where few details of the actual investigations are given, naming the scientists involved would provide information valuable to assessment of the adequacy of the study. (UM)

Response: Given the litigation-sensitive nature of the damage assessment, the Trustees are not making public the internal workings of the process they have chosen for independent review. For the same reason it is not appropriate to make known the names or comments of those undertaking such review. The Trustees have taken into account "the track record", i.e., the professional qualifications, of these persons in selecting them for this process.

Comment: Without access to the results from the first year's studies and an independent review of the Plan, it is impossible to assess the propriety of the Trustees' decisions respecting (dis)continuation of each study. (API, UM, NRDC)

Response: To date the Trustees have opted not to release results of the studies undertaken in the damage assessment process owing to the litigation-sensitive nature of those results. As indicated in the 1990 Plan, the Trustees have attempted to formulate a method for mutual release of their data with those of the potentially responsible parties into a public repository. The Trustees are also preparing a protocol for review of scientific information before release to the public.

Comment: On page 336 of the Plan the Trustees state that a summary document on results of the first year's study was to be ready for public distribution in July, 1990. Yet the status of efforts to make this information available to the concerned public is not known. (UM)

Response: The document referred to concerned Phase I of the literature review undertaken by the Restoration Planning Work Group to identify references relevant to restoration. The Progress Report "scheduled for public distribution in July 1990" was issued by that group in August of 1990.

Comment: Since the discussions with Exxon regarding the deposition of data into a public repository have yielded no visible results, the Trustees should make their data available to the public immediately. (NWF, UM, NRDC) The regulations do not permit the Trustees to condition their release of data into a public repository on similar commitments by the potentially responsible parties. (APSC)

Response: Because the data acquired by both the Trustees and Exxon are litigation-sensitive, these parties have endeavored to arrive at a mutual agreement for release of data to the public. In the event that this effort is not successful, the federal and state governments will consider making public the results of damage assessment studies once the quality of the data has been assured, the results have been scientifically reviewed, and legal considerations are taken into account. The regulations leave to the discretion of the Trustees the manner in which data are shared/released and the timetable for the same.

Comment: The NRDA regulations require that the Trustees release to the potentially responsible parties all data results and documentation from the 1989 and 1990 studies. Without these data, the public cannot assess the propriety of modifying a particular study or initiating a new one. Nor can the scientific community peer review the Plan. (APSC)

Response: The Trustees are not required to follow the NRDA regulations in performing this damage assessment, but are acting in consonance with the regulations. The regulations permit the Trustees to exercise their discretion insofar as the manner by which data and results are released and the schedule for their release are concerned. 43 C.F.R. § 11.31(a)(4).

Comment: The Trustees' failure to make public the results of the scientific studies is a breach of the public trust. It prevents the scientific community from understanding the implications of the spill for future cleanup efforts and from having the most current information about the interaction of oil with arctic waters and ecosystems. This impedes scientists' ability to advise the state of Alaska as it is considering oil and gas exploration issues. (NWF)

Response: The Trustees disagree. The timeline for release of results from the damage assessment studies is dictated in large measure by professional scientific practices and litigation concerns. There is no obligation to have these data available for public review by any particular date or for consideration in resolving any particular political issues.

Comment: Studies being conducted by the State of Alaska and the federal Trustees are similar and in some cases the same. The lack of coordination between the State of Alaska and the federal Trustees may result in a doubling of assessment costs and damages. Double recovery of such costs is statutorily prohibited. Differences between the Trustees should be resolved before the commencement of unnecessary studies. (API)

Response: The state and federal governments are conducting the damage assessment jointly. There is full coordination between the two, and the Trustees have made efforts to avoid duplication of studies in approving the damage assessment studies.

Comment: The Trustees provided insufficient explanation in the Plan for their budgetary cutbacks and curtailment of certain studies as well as their decision not to implement certain studies proposed by the public. The deleted studies were necessary to performing a complete evaluation of damage assessment, and studies not initiated were necessary to form a comprehensive restoration plan. (NWF) Without explanations for discontinuation of studies undertaken in 1989, the public is constrained in its ability to comment on these decisions. (NWF)

Response: The Trustees have made every effort to ensure that the requisite budgets are available for studies necessary to assess damage from the EVOS. They are obligated, however, to conduct the assessment within budgetary constraints and have acted in a manner consistent with the NRDA regulations so as to achieve a cost-effective assessment. To the extent that these standards have required discontinuation of certain studies or non-implementation of others, the Trustees believe they have acted reasonably.

Comment: There is no commitment beyond the 1990 field season to carry out studies to assess long-term damage. The Trustees are obligated to conduct such studies. All scientists consulted believe several years of studies are needed to understand the impacts of the spill on the marine ecosystem. As the plan states, the effects may not become evident for three to four or more years. The Trustees should make clear their commitment to long-term studies. (NRDC, UM)

Response: Many factors affect the determination whether, and which, studies will be continued beyond the publication of the damage assessment plan each year. The absence of any commitment within the 1990 Plan to extend the damage assessment beyond that year's field season does not connote the end of scientific study. In fact, the Trustees, concurrent with this Response to Comments, are publishing the 1991 Plan. The Trustees will continue to consider the recommendations from the scientists working on their behalf regarding continuation of the assessment process. They are mindful that some damage may not be known for many years; to the extent that resources are available to them for that purpose, the Trustees will continue scientific study of the oil spill's impacts on the ecosystem.

Comment: Many of the resources that are the subject of the 1990 Plan either are recovering rapidly through natural recovery or exhibit no injury, and additional study of these resources is neither cost-effective nor necessary and violates the regulations. (APSC)

Response: The Trustees do not agree. There may be some resources for which natural recovery is the best restoration option, but this conclusion is not necessarily applicable to all the affected resources. In some instances, appearances of recovery may belie long-term and sublethal impacts to the ecosystem's resources.

Comment: The Trustees have no authority to conduct a damage assessment under any statutes other than the Clean Water Act. (ESC)

Response: The Clean Water Act (CWA) and other state and federal authorities provide the basis for a natural resource damages claim. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes the procedural framework for conducting the damage assessment under section 311 of the CWA.

MARINE MAMMALS

Comments on Marine Mammals Studies - General

Comment: Data collected for whale, seal, and sea lion studies is not from impacted areas. (API)

Response: In some cases the location of study sites is outside the spill zone. Those sites were chosen because the species of concern tends to concentrate at that site and has a broad geographic range that includes the spill zone. Also, historical data is often available from these locations, which allows pre- versus post-spill comparisons.

Comment: Several of the marine mammals studies rely on new and unproven methods for injury detection, including capture of animals, surgical procedures, and implantation of radio devices. These methods may cause additional stress or mortality. Justification for such activities is lacking. Reliance on these techniques will produce poorly formed conclusions that associate low-level hydrocarbon exposures to observed biological effects. This is true of the cetacean distribution data being gathered in Marine Mammals 1, the reproductive data gathered in Marine Mammals 4 and 5, and the sublethal data concerning sea otters being obtained in Marine Mammals 6. (API, ESC)

Response: Methods being used are all well established techniques. In some cases, however, they are being applied in new and innovative ways. These applications are carefully considered by contracted experts and are expected to yield reliable conclusions.

Comment: Significant impacts on marine mammals such as drift net mortality are ignored in these studies. (ESC)

Response: All significant sources of mortality are considered in design of the studies.

Comment: The sublethal or chronic endpoints proposed for use as indicators of hydrocarbon exposure are non-specific at best. Any observed changes could be correlated with a number of sources such as diesel fuel or hydraulic oil spills, and not necessarily EVOS. In addition, the endpoints are subject to a high degree of natural variability such as nutrition, sex, and non-specific stress. (ESC)

Response: In most cases sublethal and chronic endpoints are quite specific. They are significant changes in populations as a result of impacts on survival or reproduction. All studies are designed to deal with natural variation and oil contamination from other sources.

Comment: The intensity of the Trustees' efforts to meet the objectives of Marine Mammals 1, 2, 4, 5, and 6 is neither warranted nor cost-effective since it is unlikely that population impacts, other than those on sea otters, will be found because of deficiencies in baseline data and natural variations in population parameters being evaluated. Even with respect to Marine Mammals 7, literature suggests that sea otters have a remarkably rapid rate of natural recovery. (API, ESC)

Response: Efforts on marine mammals are both warranted and cost effective because impacts are likely and studies are well designed. Marine mammals are a highly valued resource. All these species were potentially exposed to hydrocarbon contamination. Significant historical data is available for comparison, and studies are designed to deal with natural variation. Sea otters have never been studied following an oil spill the size of the EVOS, therefore the rate of natural recovery is still unknown.

Comment: The design and application of statistical models for testing effects are vague. It is not clear how EVOS effects are to be estimated in many of the marine mammal studies. For marine mammals that are especially mobile, the field sample observations cannot distinguish effects of oiling, location, and timing. Therefore it will not be possible to tell whether any statistically significant effect was EVOS-induced. (ESC)

Response: Study plans provide sufficient detail to evaluate design and application of statistical models. For additional detail on methods, references are listed.

Comment: Historical population trends and estimates of variability are largely unavailable for the parameters being measured in the Marine Mammals studies: humpback whale distribution (Marine Mammals 1), killer whale natality and mortality (Marine Mammals 2), pathological examination of pinnipeds and otters (Marine Mammals 4, 5, and 6) and population sex/age structure of sea otters (Marine Mammals 6). The lack of adequate pre-spill baseline data will severely limit the Trustees' ability to detect post-spill differences, and attributing measurable differences to the spill will not be technically possible. (ESC)

Response: All desirable historical data is not available for all studies. However, this will not preclude detection of injury. Comparative data is being developed in control areas over a period of several years.

Comment: Whale, seal, and sea lion studies are not based on sufficient evidence of the presence of injury. Expenditures are not justifiable. (API, ESC)

Response: Indications of potential injury among these species are sufficient to justify these studies.

Comment: The location, timing, and level of oiling are important variables in all of the studies, yet the criteria for selecting study sites are not given in the Plan. (ESC)

Response: Selection of study sites was based upon one or more sources of oiling information which included observations of: oil at NRDA study sites, oil on water, and shoreline oiling.

Comments on Marine Mammals Studies - Specific

Marine Mammal Study No. 2 - Killer Whales

Comment: Marine Mammals 2 will provide data that may be useful for long-term goals of managing PWS, but are not directly related to oil spill impacts, e.g., distribution data for killer whales. (ESC)

Response: The focus of the study is to determine injuries to whales in PWS. We agree that some useful collateral data may result from this study that is not directly related to oil spill impacts. However, these data are expected to address injuries and may be useful in determining restoration activities.

Comment: Marine Mammals 2 lacks evidence of exposure of killer whales to oil, and it is unlikely that an exposure pathway can be established given the rapid return of Prince William Sound waters to background levels of oil and the lack of substantive contamination of fish or other prey species. (ESC)

Response: Cetaceans were observed in PWS on the day of the oil spill. Killer whales were observed swimming in oil slicks. Investigations are taking place regarding the effect of direct contact of oil to cetacean skin/eyes, inhalation, and ingestion.

Comment: Marine Mammals 2 is designed to show that killer whale mortality rates have not changed since the spill, i.e., that there has been no damage to this species. This type of study should not be included in a damage assessment. (ESC)

Response: The null hypothesis is a well established scientific procedure for conducting studies. This comment restates an objective. Changes in mortality rates may be a finding of the study.

Comment: The quantification of field search efforts for killer whales is not clear. (ESC)

Response: Within the limits of weather, the field crews search for whales daily during the field season. The amount of data collected will determine the adequacy of statistical comparisons/analyses.

Comment: This study will not achieve its objectives because historical killer whale movements and population dynamics are too poorly understood for meaningful comparisons with post-spill data. Also, the normal distribution pattern for killer whales in PWS has not been established. (ESC)

Response: The study does consider and has access to all existing historical information for PWS killer whales. Population dynamics, including distributional patterns, are well known for several pods of killer whales in PWS.

Comment: Collection of data only from PWS makes this study technically deficient. (ESC)

Response: Studies were also conducted in S.E. Alaska. Also, over 20 years of killer whale research on the west coast are available to establish pod behavior and population dynamics.

Comment: The assumption that the absence of a killer whale for one year indicates its mortality has not been established as a valid one. (ESC)

Response: Based on over 20 years of research, scientists who work with killer whales agree that if an animal is missing from a resident pod for over a year, it is dead.

Comment: Sampling locations are inadequately described only as areas "known for whale concentrations." (ESC)

Response: Known whale concentration areas are surveyed first. However, researchers routinely search all areas within PWS. Reports are also available from the sighting network throughout PWS.

Comment: The Plan does not indicate whether data concerning age, sex, or activity will be gathered other than through photographs.

Disturbance and harassment created in the efforts to take photographs may bias results. (ESC)

Response: The age of whales (other than calves) cannot be determined from field observations and subadult males and females appear the same. Females can be identified if they are with a calf and adult males can be identified by the large size of their dorsal fin.

Comment: The change in methodology resulting from the addition of the non-professional sighting network will make comparison of the 1990 data to that of previous surveys of questionable value. (ESC)

Response: There is no change in methodology between 1989 and 1990. A sighting network was in place during the 1989 season. Dedicated effort is similar between both years.

Comment: Analytical methods are not well-described: there is no definition of "pod integrity" or any description of how distribution data will be analyzed; the numbers and types of analyses are not given and QA/QC issues are not addressed; and the methods for determining mortality and natality rates are not included. (ESC)

Response: Analytical methods are described in the text. We state specifically that distributional data will be evaluated subjectively. Mortality is based on the number of missing animals from resident pods over a two year period and the number of stranded animals found on the beach. Natality rates are based on the number of new calves observed with their mothers for each season.

Comment: Objectives A, B, and D appear to depend on probabilities of whales sightings being constant over the whole survey route when, in reality, such probabilities are highly variable because they depend on environmental factors such as bathymetry and local prey densities. (ESC)

Response: The survey design does not rely on sightings being consistent over any particular area. When whale sightings occur, all environmental factors are recorded and these observations are considered during analysis.

Comment: It is unlikely that the results of this study can be used to link any measurable impact on killer whales with the spill because: 1) the study implies that any change from the pre-spill conditions represents spill damage whereas other environmental factors such as fishery conflicts are not being examined; 2) killer whales are highly mobile, so the assumption that the absence of particular whales from Prince William Sound is due to mortality is invalid; and 3) baseline natality and mortality data, which are neither sufficient nor well understood, are essential to the success of this study. (ESC)

Response: A large effort is being made to examine the impacts of all factors on killer whales, including non-oil environmental factors and fishery conflicts. Although killer whales are highly mobile, much research has been conducted on the stability of killer whale pods/membership over time.

Marine Mammal Study No. 5 - Harbor Seals

Comment: Marine Mammals 5 does not distinguish between oil spill effects and natural factors, such as ecological succession, natural cyclical changes and human activities, that may account for the difference in resource levels between oiled and non-oiled areas. (APSC)

Response: This study does distinguish between natural changes and those caused by oil. Historical abundance data from before the spill clearly indicate that oiled and unoiled population trends and rate of decline were the same. Ecological succession is not relevant to harbor seals in this context.

Comment: Marine Mammals 5 inadequately deals with the declining populations trends of harbor seals. (ESC)

Response: The study design adequately deals with declining population trends. We recognize this trend and have historical data indicating that it is the same in oiled and unoiled parts of PWS. We reference a source of detailed information in the study plan. This study is not designed to investigate this ongoing decline, but is intended to look at differences between oiled and unoiled areas.

Comment: It will be difficult to establish causal relationships for chemical residue data and pathologic observations in the investigation of tissue hydrocarbon levels or histologic changes in Marine Mammals 5. (ESC)

Response: Histopathology experts indicate that they can establish causal relationships for certain pathological observations.

Comment: Objectives A and B of this study will be impossible to achieve through the methods described in the Plan. Because the link between petroleum residues in tissues and pathological conditions often is not clear, the cause of death will be difficult to establish. Oil spills can cause pathologic changes that are not associated with increased residue levels. On the other hand, residue levels can be elevated in the absence of any pathologic conditions. (ESC)

Response: Objectives A and B are difficult to achieve but certainly not impossible. Determining that harmful pathological conditions resulted does not require that residue levels be elevated. Pathological changes may or may not be associated with elevated residues depending on what residues are tested, time and duration of exposure to oil, length of time after exposure that samples were taken, etc.

Comment: The collections of additional seals in 1990 was unwarranted in light of the fact that the impact on seal populations demonstrated in 1989 was minimal and that there are difficulties with the program design. (ESC)

Response: The collection of additional seals was warranted and was supported by marine mammal experts throughout the scientific community. The data obtained were valuable in determining persistence of hydrocarbons and whether or not pathological changes persisted.

Comment: Differences between oiled and unoiled areas cannot be attributed to oil as opposed to natural variability. The study is part of ongoing research into the cause of the declining harbor seal populations in the Gulf of Alaska and is not appropriately part of the NRDA program. (ESC)

Response: Design of the study will allow for detection of differences between oiled and unoiled areas that can be attributed to EVOS. This study is certainly not part of ongoing research.

Comment: The field methods for this study will not detect distribution changes. Any changes in distribution will appear to be changes in abundance. (ESC)

Response: The study will detect changes in abundance between oiled and unoiled areas. Changes in distribution are not expected to be a problem because harbor seals demonstrate a strong site fidelity and haulout sites are highly traditional.

Comment: QA/QC issues are not addressed in the description of this study. (ESC)

<u>Response</u>: Standard, scientifically accepted, QA/QC procedures are followed in all studies.

<u>Comment</u>: The analytical descriptions are not sufficiently detailed. Sample sizes for the exposure/pathology work are inadequate and the use of reference seals from southeast Alaska is inappropriate. (ESC)

<u>Response</u>: Methods are described in sufficient detail. Additional information can be found in referenced publications. Use of reference seals from southeast Alaska is considered appropriate because they were clearly unoiled, but taken from comparable habitat.

<u>Comment</u>: The analysis strategy appears to assume that sample locations are analogous to home ranges and that pathologic findings will correlate to tissue residue, but these assumptions are not valid. (ESC)

<u>Response</u>: The physical presence of oil marked seals collected in 1989 clearly indicated their exposure to oil. It is not necessary to assume that they were from the oiled areas, it was physically apparent. Seals in unoiled areas were clean and seals from oiled areas were discolored. Also, it is well known that harbor seals are relatively sedentary and show marked site fidelity.

<u>Comment</u>: Statistical procedures are defined in vague terms. It is not clear how the oil spill effects will be estimated and statistically tested. The level of the effect being tested and the effort needed to detect that effect are not provided. (ESC)

<u>Response</u>: Statistical methodology is clearly stated. It is also clear that the level of statistical significance is 0.05.

<u>Comment</u>: The sampling effort is not appropriate to meet the study's objectives. The probability of declaring an effect when there really is not one is not given. Nor is the probability of failing to find an effect when there really is one given. Thus, it may be impossible to ascertain whether a statistically significant effect was linked to the oil spill. Criteria for choosing impact and control sites were not given. (ESC)

<u>Response</u>: Sampling effort is appropriate to meet the objectives. Probability levels for the relevant tests are given. Choice of oiled and unoiled sites was based upon presence of oil on the

shoreline.

Comment: The forty percent decline in abundance observed in the trend counts was based strictly on two years' data. This is not sufficient to establish any meaningful baseline, trends, or natural variation. Since the cause of these declines has not been pinpointed, it is not likely that any impact of the spill can be detected by this study. (ESC)

Response: Historical data in combination with data collected at the control site will provide a basis for evaluating the ongoing population decline and any natural variation in the population. It is not necessary to pinpoint the cause of the ongoing decline in numbers in order to determine injury from EVOS.

Marine Mammal Study No. 6 - Sea Otter Impacts

Comment: Mature otter and pups are again repopulating areas that were affected by the spill. This evidence should be taken into account in the Plan. (ESC)

Response: We recognize there is some reoccupation of oiled habitat, and will be able to evaluate population distributions through surveys and by monitoring radio-instrumented adults and pups. Occupation of an area does not, however, necessarily imply that those otters or the habitat into which they move are in pre-spill condition.

Comment: None of the sea otter studies is likely to produce useful information since this species is recovering rapidly and uncovering minor differences between area populations will not contribute to defining a restoration need or a restoration strategy. (ESC)

Response: We know of no basis for the statement that there is an "obviously rapid recovery process" ongoing in oiled areas. The extent of certain differences between areas will be determined by the study, and it is not reasonable to determine that they will be minor prior to execution of the studies.

Comment: The description of the DNA content, sperm morphology, and haptoglobin binding analyses in Marine Mammals 6 is inadequate for technical review. Further, the endpoints for detecting hydrocarbon exposure are non-specific and are subject to a high degree of natural variability. (ESC)

Response: Detailed descriptions could not be included in the Marine Mammals 6 study plan due to space constraints; however, references providing thorough descriptions of these analyses were provided in the bibliography. The natural variability in these measures has been examined in other mammals, including some wildlife species, and has been accounted for in the statistical design of the study.

Comment: Any post-spill differences detected in distinct sea otter populations will not be attributable to the oil spill since sea otters typically have site-specific age, sex, and growth characteristics. (ESC)

Response: There are pre-spill population data on sea otters in eastern and western PWS, including information on sex, age, and growth characteristics. This information will be used in interpretation of findings from the present study.

Comment: It will be difficult to establish causal relationships for chemical residue data and pathologic observations in the investigation of tissue hydrocarbon levels and/or histologic changes in Marine Mammals 6. (ESC)

Response: Studies on otters that were known to be oiled and died in the spring and summer of 1989 will provide evidence on associations between exposure, pathologic changes, and hydrocarbon burdens. Similar studies on unoiled controls will provide baseline information. Results from this work will provide a basis for interpretation of data from additional carcasses found in areas affected by the oil spill.

Comment: The objectives for assessing spill impacts on otters are largely unattainable given the design and analyses of this study. There is no reference to the magnitude of the physical and ecological differences between the impacted and non-impacted study areas. Sea otter densities will be different generally between any two sites owing to natural factors, independent of oiling. This will affect the aspects of the study concerning population, sex, and age structure and reproductive history from carcass evaluations. (ESC)

Response: The sea otter damage assessment studies were reviewed by a qualified biostatistician and guidance will be provided during the data analysis phase. Distributions and abundance of sea otters in PWS are available from historical data. We agree there can be natural factors influencing study areas; however, existing data on basic demographic parameters of both eastern and western PWS are available and will be utilized in analysis and interpretation of results.

Comment: Study 6A lacks adequate description of the sampling locations and site selection criteria. Oiled sites are not well identified. Time of day of surveys is not indicated. Feeding behavior can vary significantly between subpopulations. There is no indication how sexes of the adult animals will be determined. (ESC)

Response: Sampling locations were selected based on sites examined in historical surveys, and were supplemented with additional, randomly selected sites. Surveys are done during daylight hours. Sexes of adults are not determined in the surveys. NRDA review of oiling data has ensured consistency and most accurate identification of oiled areas.

Comment: The methods proposed fail to distinguish between distribution effects and populations declines. Movement patterns of otters in the spill area are too poorly understood to be of value in making comparisons between oiled and reference sites. (ESC)

Response: Distributions of sea otters can be estimated from historical data and repeated post-spill surveys. Previous and ongoing telemetry studies address detailed movement patterns on a seasonal and annual basis.

Comment: Boat survey sampling frequencies are too low to detect differences in density over time. Since there is only one pre-spill estimate of population size, trends or variance cannot be determined. (ESC)

Response: Boat surveys will estimate distribution and abundance over time. Although there is only a single pre-spill boat survey, an estimate of variance of survey data can be obtained from post-spill results.

Comment: There is no pre-spill hematology for otters in the study area for use in comparing hematology data between areas. And historical differences in hematology have been attributed to variations in habitat quality. (ESC)

Response: Sea otters from unoiled areas will provide control values for blood samples collected from otters in areas affected by the oil spill. Hematology of California sea otters is also available and can be used to supplement the Alaskan control values. Interpretation of the hematology values will be done by a highly qualified clinical pathologist who is familiar with differences that may be associated with variations in habitat quality.

Comment: Many of the sublethal parameters being evaluated are not standard methodologies for wildlife, for assessing oil impacts, or assessing population impacts, so they are simply research. (ESC)

Response: The fact that these techniques may not be standard for wildlife in no way negates their value for the present studies, which are unprecedented in scope. The methods have been evaluated in other mammalian species, including several wildlife studies. It is fully appropriate to apply the most advanced scientific techniques to assess damages from the oil spill.

Comment: The population modelling technique of Study 6A is inappropriate because it requires a far better knowledge and understanding of population status and trends than are currently available for sea otters in PWS. (ESC)

Response: Sea otters in PWS and other parts of Alaska have been the subject of numerous studies including population modelling efforts. Given pre-spill studies and the large numbers of carcasses collected after the spill, there are ample data on which to base a population modelling effort.

Comment: The baseline data for Study 6A are too limited; the sample sizes are too small; the assumptions regarding population status are insupportable; and the clinical laboratory and residue analysis data will be inconclusive and have little bearing on effects of the spill. (ESC)

Response: A considerable amount of data exist from pre-spill studies on sea otters in PWS and will be utilized in the present study as baseline information and to support assumptions made regarding population status. Sample sizes were estimated to be adequate for statistical testing. Clinical laboratory data and hydrocarbon residue analyses will be related to reproduction and survival of the otters from which samples were collected. It is inappropriate to state, prior to the study, that results will be inconclusive and have little bearing on the effects of the spill.

Comment: The control areas for Study 6B are not described well in the Plan or in the baseline reference. Assessing oil impacts from change in age structure of beached carcasses necessitates a full understanding of trends and variation in the population and subpopulation age structure dynamics. (ESC)

Response: Ten years of pre-spill carcass collection efforts provide the control for this study. Beaches which were walked pre-spill for carcass recovery will be the focus of post-spill collection efforts. With data available from multiple years, we have a very good understanding of pre-spill sea otter age distributions at death in PWS, and of the variance among years.

Comment: The spring 1990 carcass count and age structure data in Study 6B will not have valid predictive value for estimating long-term impact. (ESC)

Response: The main purpose of collecting carcasses in the spring of 1990 is to evaluate age-class distribution of the dead otters and to compare this to pre-spill data. This study in itself was not intended to predict the long-term impact of oil exposure. Continued studies of recovered carcasses will provide insight on the long-term impacts to the population.

Comment: The carcass drift experiments will greatly overstate the direct spill-related mortality because distressed otters are very likely to haul out on land, thereby increasing the likelihood of their being found. No such behavior will occur with the drift buoys. The drift study is inadequately described and gives insufficient information regarding the locations, deployments, and extent of any follow-up efforts. (ESC)

Response: The drift study was not intended to estimate direct spill related mortality but rather to simulate drift characteristics of floating carcasses. We recognize that many factors would affect carcass recovery and estimates of direct mortality. The floats were deployed based on information provided in the boat surveys.

Comment: Statistical procedures are poorly described. It is not clear how the oil spill effects will be estimated and statistically tested. The level of the effect being tested and the effort needed to detect that effect are not provided. (ESC)

Response: See response for the following comment.

Comment: The sampling effort is not appropriate to meet the study's objectives. The probability of declaring an effect when there really is not one is not given. Nor is the probability of failing to find an effect when there really is one given. Thus, it may be impossible to ascertain whether a statistically significant effect was linked to the oil spill. Criteria for choosing impact and control sites were not given. (ESC)

Response: Marine Mammal Study 6 (A, B, & C) is a large study involving several approaches to the estimation of damage to the sea otter populations in PWS, with a total of 32 objectives listed.

The above comments are very general, and thus necessitate a general response. A biostatistician assisted the principal investigators in design of the studies, including determination of sampling design and sample sizes. A biostatistician will provide guidance in data analyses. Although any single approach to damage assessment may not in itself provide a conclusive result regarding links to oil-related damages, information gained by different approaches will be supportive in synthesizing the overall assessment of damages to the sea otter populations following the oil spill.

Comment: The sublethal effect investigation is research-oriented and not useful for assessing injury. The methods employed are not routine for wildlife or oil spill impact assessment. The mechanism by which the oil spill could cause chromosomal damage to otters is remote, given the toxicity of crude oil, its environmental fate, and the levels of polycyclic aromatics in otter prey stemming from the spill. (ESC)

Response: Methods in this study for evaluating chromosomal damage have been utilized in previous wildlife studies; references were included in the bibliography. Crude oil contains many toxic components which could provide mechanisms for chromosomal damage. It is erroneous to conclude that research-oriented studies do not have a role in the damage assessment process, particularly because no routine methods have been established for assessing effects of oil on mammalian populations.

Marine Mammal Study No. 7 - Otter Rehabilitation

Comment: It will be difficult to establish causal relationships for chemical residue data and pathologic observations in the investigation of tissue hydrocarbon levels or histologic changes in Marine Mammals 7. (ESC)

Response: Studies on sea otters from the rehabilitation centers that were known to be oiled and died in the spring and summer of 1989 will provide evidence on associations between exposure, pathologic changes, and hydrocarbon burdens. Histopathological examination of several different tissues from a large number of otters, and determination of hydrocarbon levels in these tissues, will provide insight on relationships involved.

Comment: Objectives A and B of this study are inadequately described and cannot be achieved. They ignore the fact that translocation of otters will likely play a larger role in otter survival than will oil exposure. (ESC)

Response: Objective A can be tested using control groups as described in the study plan. Our ability to test Objective B will depend on movement of a portion of the radio-instrumented sea otters into oiled areas. Translocation is a necessary component of the rehabilitation process. There is no basis for the statement that translocation effects will likely play a larger role in survival than oil exposure. The circumstances involved in translocation in this study are not similar to those in historical translocations, and effects thus cannot be assumed to be the same as in previous translocations. Furthermore, because of our ability to monitor the radio-instrumented sea otters, we will be able to distinguish between mortality and emigration.

Comment: Field methods of this study are inadequately described: the frequency of relocation of instrumented animals is not given; the health assessment criteria are not described; and it is not clear how females will be distinguished from males during counts of the study populations. (ESC)

Response: As stated in the study plan, it was intended to relocate the instrumented sea otters at least biweekly. However, weather conditions in the Sound can be severe, especially in winter, and movements of the otters can make it difficult to track all of them on a regular basis. Health of the surviving otters is not being directly assessed; rather, we are determining biweekly rates of survival, where feasible. In this study, there are no counts being made on study populations that require distinguishing males from females. Sex is known for each of the instrumented otters.

Comment: Analytical methods are not detailed enough. Sample sizes may be too small to be meaningful. A sample of 45 rehabilitated otters with diverse characteristics is too small to detect differences that can be extrapolated to the rehabilitated otter populations. (ESC)

Response: A sample size of 45 instrumented sea otters is sufficient to measure effects that can be extrapolated to the rehabilitated otter population. The 45 animals are generally representative of the otters at the rehabilitation centers.

Comment: Study objectives are compromised by the fact that otters were captured, maintained in captivity, stressed and translocated. Oil exposure is only one factor that has potentially impacted the otters. Several otters were judged to be unoiled by otter center workers when they were admitted for rehabilitation, so the findings will pertain primarily to the effects of captivity and translocation. (ESC)

Response: We recognize that the fate of the sea otters following release may be influenced by various factors including oiling, cleaning, and captivity. Records were kept on the degree of oiling at arrival and the clinical history of the otters while at the centers, and these will be considered in interpretation of the data. Hydrocarbon burdens in blood and fat (collected prior to release) will be available for instrumented sea otters and will provide a basis for judging the effects of oiling on the fate of the otter.

TERRESTRIAL MAMMALS

Comments on Terrestrial Mammals Studies - General

Comment: Although the study descriptions are improved over those provided in 1989, the 1990 studies are inadequately detailed to make a proper scientific evaluation. (ESC)

Response: The Trustees believe that sufficient detail was provided to allow scientific evaluation. Additional information is available from referenced publications.

Comment: The omission of results from related 1989 studies (Terrestrial Mammal 1, Terrestrial Mammal 3, Terrestrial Mammal 4, Terrestrial Mammal 6) makes it difficult to understand the justification for their continuation into 1990. Given the lack of mortality, substantial indications of injury would be necessary in order to justify these studies. (ESC)

Response: Because these studies are conducted for purposes of litigation, results of studies are confidential; they will be made public either in the course of the litigation or after final reports are prepared and authorized for release.

Comment: Terrestrial Mammals 1, 3, and 4 lack evidence of exposure of these species to oil. There are no documented mortalities of deer, river otters, or brown bears in the 1990 study descriptions, so there is no reason to continue these studies. It is extremely unlikely that these species or black bear (Terrestrial Mammals 2) or mink (Terrestrial Mammals 6) could have been significantly impacted by the spill. (ESC)

Response: All of these species use intertidal habitats that were heavily impacted by oil. Therefore, there is significant potential for contact with oil and resulting injury.

Comment: Relevant law requires that the anticipated costs of the assessment be less than the anticipated damage amount in order for the assessment costs to be reasonable. Many of the studies, notably those regarding Terrestrial Mammals, violate this requirement. (ESC)

Response: The NRDA regulations, which are optional, indicate that the anticipated cost of the assessment should be less than the anticipated amount of damages. See 43 C.F.R. § 11.14(ee). There is no requirement that each individual element of the assessment meet this test. Rather, individual elements need only lead to an increase in accuracy and precision in the assessment that outweighs their costs. See Id. The Trustees believe that the assessment meets these standards.

Comment: The Plan contains studies designed to do scientific research that will not lead to identification of injuries, and the costs of such research cannot be recovered under the NRDA regulations, but should be funded by alternate means. Examples include Terrestrial Mammal 6, the toxicity study of which is an inappropriate laboratory simulation of actual environmental conditions. (API, ESC)

Response: Terrestrial Mammal 6 is very clearly focused on determination of injury from ingestion of sublethal doses of oil. The use of a laboratory simulation is a reliable, scientifically accepted technique that will produce results that can be extrapolated to mink and other related species impacted by EVOS.

Comment: The need for any studies of terrestrial mammals should have been motivated by 1989 data wherein injury to mammal populations, sufficient to merit further study to define restoration needs, was documented. Since it is very unlikely any such injury to terrestrial mammal populations was documented, the justification for these studies is highly unquestionable. (API, ESC)

Response: Terrestrial mammal studies are expected to provide information on injury and to support restoration planning. Specific results of 1989 studies are confidential.

Comment: The natural variability of species is not adequately addressed. (API)

Response: Studies are designed to account for major sources of natural variation.

Comment: The studies concerning Sitka black-tailed deer and black and brown bear disregard the fact that these animal populations are in good health and abundant, evidenced by the fact that the State still permits hunting of these animals. Had there been a sizable mortality of terrestrial mammals or a significant exposure potential to petroleum hydrocarbons, these species would have been investigated under the joint NOAA, ADF&G, and Exxon subsistence program. (ESC)

Response: The presence of a huntable surplus does not mean that significant injury did not occur as a result of EVOS. The joint subsistence program investigated the possible impact of hydrocarbon contamination on the health of humans who consume various species. It did not consider impact on the animals themselves.

Comments on Terrestrial Mammal Studies - Specific

Terrestrial Mammal Study No. 3 - River Otter and Mink

Comment: The study's overall objective, that of determining if the EVOS will have measurable effects on river otter populations, cannot be achieved given the absence of valid pre-spill population data. (ESC)

Response: Comparison of total numbers and survivorship between oiled and unoiled areas over several years will allow an assessment of injury to populations. Other information being collected on direct effects, food habits, and habitat use will be a valuable aid in interpreting population data.

Comment: Some of the specific objectives associated with food habits and habitat use may be achievable. However, observations of differences in certain parameters cannot be related to potential impacts from the EVOS. (ESC)

Response: All objectives were formulated with the expectation that differences can be related to EVOS. The study was designed to account for significant natural variation that could influence results, and, therefore, it is expected to detect injury from oil contamination.

Comment: The "food habitats" and "habitat use" sections of this study will not show any negative impacts on the population of otters. They may show otters are adjusting to new habitats. (API)

Response: It is reasonable to examine closely both food habits and habitat use because both are expected to show injury given the heavy contamination of intertidal areas that are critical for otter survival. Oil contamination does not create "new habitat". Any adjustments detected will be the result of otters responding to habitat injury.

Comment: This study will provide data that may be useful for long-term goals of managing Prince William Sound but not directly related to oil spill impacts. It will provide much information about the habitat use and movement patterns of this species, but it will not measure any population impacts. (ESC)

Response: This study focuses directly on investigation of injury from EVOS. Comparison of oiled versus unoiled areas is a key study design feature.

Comment: The Plan does not make clear that sampling programs will produce information necessary to prove that a statistically significant portion of the expected biological variability is a function of hydrocarbon contamination as opposed to other natural factors. Terrestrial Mammal 1, Terrestrial Mammal 3 and Terrestrial Mammal 4 suffer from this defect, such as severe winters, predator/prey relationships, and disease, which clearly affect key life cycle events of various species. (ESC)

Response: The study plan provides sufficient detail to allow evaluation of the statistical validity of the design. Additional details can be found in referenced publications.

Comment: This study will not identify avenues of oil contamination. It does not distinguish between contamination via digestion and contamination via thermal absorption or grooming. This study should provide for the coordination and integration of data from river otter food habits and from studies of the species on which they prey. This study will not detect simultaneous reductions in the populations of river otters and their prey species. (NWF)

Response: Identification of specific avenues of contamination is not part of this study. It will rely on other NRDA projects for information about contamination of the river otter food chain. A full suite of coordinated environmental studies is being conducted in the oiled area.

Comment: There is insufficient evidence that river otters were exposed to oil. (API)

Response: River otters were exposed to oil. Intertidal habitat critical to this species' survival was heavily impacted by oil.

Comment: "Direct effects" and "population change" parameters can show biological effects which cannot be quantified. (API)

Response: The study design is expected to allow quantification of both direct effects and population change resulting from EVOS.

Comment: It is inappropriate to compare an impacted site to a reference site for density comparisons when, in all probability, neither site has any valid pre-spill data on population trends or variance. (ESC)

Response: The lack of historical data on populations does not invalidate comparison of density between oiled and unoiled areas.

These two areas will be monitored for several years and they are similar enough that differences can likely be attributed to injury from the EVOS.

Comment: This study is not cost effective and will only assess short-term impact. There will be a quick recovery from any short term impact on otter density. River otters mature rapidly and have relatively large litters. The "takes" planned in this study will probably result in more otter fatalities than have been observed since the EVOS. Very little of this study will relate to natural resource injury. (ESC)

Response: It is anticipated that this study will be cost effective. The ability to detect injury over time is a function of the duration of the study. The design will produce reliable results and is focused on assessment of injury. Recovery rates for the otter population are difficult to predict. Plans to collect otters were canceled.

Comment: Study locations are not described well. (ESC)

Response: Sufficient detail concerning study locations was provided to allow evaluation of the project; more detailed descriptions might have jeopardized the study.

Comment : The radio transmitter and radioisotope implant techniques are not described adequately. (ESC)

Response: Sufficient detail concerning transmitter and radioisotope implants were provided to allow evaluation of these techniques. Additional detail is available in referenced publications.

Comment: Statistical procedures are vaguely defined. It is not clear how the effects of the oil spill are to be estimated and tested statistically. The level of effect being tested and the effort (number of samples, replicate subsamples, etc.) needed to detect that effect were not given. The sampling effort does not appear to be appropriate to meet objectives. The probability of declaring an effect when there really is not one (Type 1 error) is not given. The probability of declaring an effect when there really is one (Type II error) is not given. It will be difficult to determine if a statistically significant effect was due to the oil spill or to natural variation. (ESC)

Response: Sufficient detail concerning statistical procedures was provided to allow evaluation of tests. Additional detail is available in referenced publications. The study is undergoing rigorous statistical analysis.

Terrestrial Mammal Study No. 4 - Brown Bear

Comment: Objectives A-C are concerned with possible physiological effects and mortalities of brown bear due to the EVOS, and cannot be achieved primarily because no direct exposure pathway to spilled oil is outlined. Also, there is insufficient information on how tissue and feces analyses are to be related with mortality. (ESC)

Response: Intertidal foraging is the likely exposure pathway. Other studies will provide details on contamination of forage species.

Comment: Objective D's estimation of the adult population density of the study area has nothing to do with natural resource damage assessment, particularly since no historical database exists. (ESC)

Response: Estimation of population impacts of the EVOS is an important part of damage assessment. Estimates over several years will provide trend information necessary to quantify injury.

Comment: Population estimates for only two years, 1990/1992, cannot be used to predict any trend or identify any impact from EVOS on brown bear populations on the Alaskan Peninsula. (ESC)

Response: Estimates will be obtained for several additional years if the study is continued. In addition, monitoring radio- collared bears will provide the opportunity to identify bear mortality and determine whether it is oil-related.

Comment: Two assumptions used in the model to estimate adult population levels are very weak: (1) the brown bear population is geographically and demographically isolated; and (2) all brown bear have equal capture probabilities that are constant over time. (ESC)

Response: Potential difficulties with these two assumptions are acknowledged in the study plan and details concerning how they will be addressed are presented.

Comment: The significance of hydrocarbons in fecal samples, particularly as it relates to ingestion, is not discussed in sufficient detail to determine its validity. No literature is cited as to how this technique has been used with previous spills. (ESC)

Response: The presence of hydrocarbons in fecal samples will be an indication of exposure through ingestion of contaminated food. Other NRDA studies will provide information on contamination of individual food items. We know of no studies, other than EVOS, where fecal analysis has been used.

Comment: No explanation is given why blood is to be analyzed for packed cell volume and percent hemoglobin. These measurements are not likely to establish any impact on the bear from spilled oil. (ESC)

Response: Analysis of samples has been delayed pending additional review of the range of blood parameters that can be the most useful indicators of injury.

Comment: This study will provide data that may be useful for long-term goals of managing PWS but not data that is directly related to oil spill impacts. (ESC)

Response: This study is designed to focus specifically on assessment of injury from the EVOS, but does not relate directly to PWS populations.

Comment: Study areas in the Katmai National Park, on Kodiak Island, and near Black Lake are not described as to exact location and study area size. (ESC)

Response: Sufficient detail on study areas is provided to allow evaluation of the work.

Comment: The spill area site in the Katmai National Park is not a good choice for determining injury to brown bear from the EVOS. The bear population age structure, particularly for old males, would be quite different in Katmai because the bears are protected, not hunted. This contrasts with the control areas where hunting is permitted. As a result, some population difference might be improperly assigned to oil spill effects. (ESC)

Response: Age structure difference between the study areas is recognized and is considered in the study design. We expect it will be possible in analysis of the data to isolate this variable and, therefore, avoid improperly assigning differences to impacts of EVOS.

Comment: The Plan does not make clear that sampling programs will produce information necessary to prove that a statistically significant portion of the expected biological variability is a function of hydrocarbon contamination as opposed to other natural factors. Terrestrial Mammals 1, 3 and 4 suffer from this defect, such as severe winters, predator/prey relationships and disease, clearly affect key like cycle events of various species. (ESC)

Response: Sufficient detail is presented to allow evaluation of the statistical design and sampling programs. Natural variation is considered in selection of study sites and appropriate statistical tests.

Comment: The Trustees should consider collection of tissue samples from denning females and their cubs, as well as tissue samples from fetuses of necropsied adult females. (NWF)

Response: Collection of tissue from denning animals will be considered. A full suite of appropriate samples is planned for collection from any animals found dead.

Comment: The stress caused by the capture of live bears, the implantation of radio transmitters, and the drawing of blood has not been adequately considered. (API)

Response: Stresses caused by capture of bears are well understood and will be considered in interpretation of results. No transmitters are being implanted by this study. It is highly unlikely that drawing of a small amount of blood will cause any significant stress.

BIRDS

Comments on Bird Studies - General

Comment: The bird studies ignore current scientific literature on the effect of oil on birds, which indicates that bird populations recover extremely rapidly after an oil spill. They also ignore evidence of recovery of bird populations in PWS and the Gulf of Alaska, which confirms a healthy density and diversity of resident and migratory species there. Failure to rely on the existing literature, which would have enabled the Trustees to narrow the field studies, is contrary to the NRDA regulations. (API, ESC)

Response: The bird studies were developed with full cognizance of information available in the current scientific literature. There is considerable information in that body of literature to indicate that bird populations do not always recover rapidly after an oil spill. This is especially true of long-lived species with low reproductive rates. Further, it is essential to measure the impact resulting from individual environmental calamities to account for unique circumstances which may have a bearing on impacts to birds. The EVOS was unique in its size as was the biological richness of the area where it occurred. Observation that there are still birds in the spill zone does not constitute scientifically objective information that ". . . confirms a healthy density and diversity of resident and migratory bird species there." Studies are essential before any such conclusion can be drawn.

Comment: The Plan contains studies, such as Birds 4 and 5, that are designed to do scientific research that will not lead to identification of injuries. The costs of such research cannot be recovered under the NRDA regulations, but should be funded by alternate means. (API, ESC)

Response: All bird studies were designed specifically to provide information that would be used in assessing injury. Although some objectives, in and of themselves, are not able to define injury, they provide information that, in conjunction with other data, do support injury determination.

Comment: A disproportionate number of bird studies were discontinued with little or no explanation. The reference to cost-effectiveness in the introductory section to the bird studies suggests that the Trustees made a value judgment as to the relative costs of studying damages to multiple species and the injuries to those species without explaining their conclusions. Impacts to certain species cannot be ignored simply because they are more costly to study than other species. The impacts on one species are integral to understanding the impacts on other parts of the ecosystem. (NWF)

Response: The practicality of conducting scientifically credible injury assessment studies was a critical factor in determining whether studies should be conducted. Some studies were discontinued because it was determined that continuation would not provide substantially more information on injuries than had already been gathered. In a number of cases, elements of discontinued studies were incorporated into continuing studies or into base agency programs.

Comment: Birds 2, 3, 4, and 5 are not well integrated, as there is no apparent attempt to correlate census or distribution data with factors other than the presence of EVOS oil. (ESC)

Response: Efforts are being made to correlate survey data with factors other than the presence of oil. Information on water temperature, weather, and other factors are being considered.

Comment: The bird studies involve invasive procedures, including the killing of birds to determine the potential destination of birds that did not wash up on shore after the spill. (API)

Response: Certain bird studies involved the killing of specimens to gather information needed to assess injury, such as histopathology, condition, and hydrocarbon uptake. In all cases, studies were thoroughly reviewed by leading experts and agency representatives to insure that their methods were required, that the take was kept to a minimum, and that the number of birds taken was insignificant to the overall population.

Comment: Studies that disrupt breeding grounds during the nesting season or require the handling of birds to take blood samples should not be undertaken, unless the studies are clearly necessary. (API)

Response: No bird studies were conducted that involved disruption of breeding grounds. Surveys and censuses were conducted utilizing standard methodologies. It is necessary to gather blood samples to measure differences in blood chemistry parameters between populations in different areas.

Comment: Most of the Bird studies do not adequately account for the fact that there was substantial variability in resource levels before the spill or the fact that there is no reliable baseline data. Thus, the statistical detection of differences due to oiling will not be possible. These facts also make it impossible to develop sufficient data to describe the subtleties of historical populations dynamics or to relate any potential response to extremely low hydrocarbon levels. (ESC)

Response: We recognize that there is a possibility of substantial variability in resource levels before the spill and have designed our program to consider this variability. For example, it is unlikely that variability between years would consistently be different between oiled and unoiled areas. The best way to address this variability for seabirds is to look at long term studies or monitoring efforts; these are available for murres at the Farallons, Semidi Islands, Pribilof Islands, and Bluff colonies in the Bering Sea. Some aspects of murre biology vary, but other aspects such as productivity vary very little. It appears that changes in numbers of murres may vary from one year to the next, but a long term change of any magnitude does not generally occur without some complicating factors of mortality such as oil spills or gill netting interferences.

Comment: The 1990 Plan still does not contain an adequate description of the studies for review purposes: survey techniques are not described in Birds 2, 3, 5, and 13 in sufficient detail to permit the reviewer to determine whether the stated objectives can be met; sampling approaches are defined only in general terms; and the descriptions of the application of statistical models to data obtained from the studies is brief and incomplete. (ESC)

Response: Efforts were made to provide sufficient information in the 1990 Plan to enable the public to understand how studies were to be conducted and how data would be analyzed.

Comment: Except for Birds 1, the studies will not render injury estimates. Birds 2, 3, 4, 5, and 13 fail to identify and consider variables, such as severe seasonal weather, food supply, disease, and commercial fishing activities, that could affect bird populations. Thus, any changes in population size cannot be linked to the spill or to other significant environmental conditions. (ESC)

Response: By utilizing appropriate comparisons (e.g., oiled vs. unoiled, pre-spill vs. post-spill) it is possible to account for these other variables. It is highly unlikely that these variables would consistently affect bird populations in oiled areas and not in unoiled areas. By looking at several species over a number of years at a large enough number of sites, these other causes can be evaluated. If any of these other causes are influential, then it should affect species and sites outside of the oil spill.

Comments on Bird Studies - Specific

Bird Study No. 1 - Beached Birds

Comment: The tracking of birds killed by researchers is an unnecessary study. It is inappropriate when considering the potential injury to the birds and the economic damages to be recovered. Other methods were available to test the accuracy of the count of the dead birds at the time of the spill. (API)

Response: Careful review by expert scientists concluded that, in order to calculate a more reliable estimate of the number of birds killed by the EVOS, it was necessary to kill and radio-track a small number of birds. Other methods were considered and determined to be inadequate to achieve a more reliable bird mortality estimate.

Comment: The killing of birds was not mentioned as part of the experiment, and this portion of the study was not subject to public comment. (API) Bird 1 would have been canceled by the Trustees if it had been made public prior to publication of the Plan in September of 1990. (APSC)

Response: Although detailed information on the collection of birds was not provided in the 1990 Plan, it was specifically noted that carcasses would be radio-tracked to determine recovery rates. The study was approved after thorough review. The number of birds killed was kept to an absolute minimum and the birds were taken from populations not affected by the EVOS.

Comment: The model to be used in Birds 1 is only vaguely referenced and cannot be evaluated without more detail, such as information regarding application of the model, the model's input parameters and its underlying assumptions, and the source and nature of the historical bird density data to be used in the trajectory modeling effort. Although two options for pursuing model sensitivity analysis are presented (but not well described), there is no mention of the criteria for choosing between them. (ESC)

Response: The findings of field studies conducted for Bird Study 1 affected the structure of the model to be used; therefore, it was not possible to describe the model in greater detail before field studies were conducted. General methodologies used may be found in the following references:

Ford, R.G., G. W. Page, and H.R. Carter. 1987. Estimating mortality of seabirds from oil spills. Pp. 848-751. In Proc. 1987 Oil Spill Conference, American Petroleum Institute, Washington, D.C.

Page, G.W. and H.R. Carter (eds.). 1990. Numbers of seabirds killed or debilitated in the 1986 Apex Houston oil spill in central California. Studies in Avian Biology. In press.

The two options discussed for pursuing model sensitivity analysis were presented in order for the reader to be able to evaluate the accuracy of the model results. It was not a matter of choosing between the two options.

<u>Comment</u>: Objectives B and D are not distinguishable as written. (ESC)

<u>Response</u>: Objective B addressed the portion of the study that would look at 10% of the birds recovered on beaches after the spill. Seabirds die for a variety of reasons and some of the birds collected could have died of natural causes and been oiled secondarily.

Objective D refers to assessing mortality of birds by adapting existing bird damage assessment models to estimate total seabird mortality.

<u>Comment</u>: Any mortality estimate rendered by Birds 1 will only be an order of magnitude approximation given the assumptions and uncertainties that modeling will require. (ESC)

<u>Response</u>: The estimate of the total number of birds killed by the EVOS that will result from the model will be significantly more precise than any of the current estimates. Current estimates do not consider the number of uncertainties such as sinking, scavenging, floating out to sea, and failure to recover that are analyzed in the model used in this study.

<u>Comment</u>: Radio-tagging of drifting carcasses may not yield useful information other than sinking rates because trajectories followed by floating birds can be controlled predominantly by weather patterns. (ESC)

<u>Response</u>: This comment is correct in stating that radio-tagging of drifting carcasses may not yield useful information other than sinking rates. The primary intent, however, was to determine sinking rates rather than deposition patterns. Information on decomposition and scavenging rates was also gathered.

Comment: There is insufficient information provided in the description of the carcass drift study for critical review. Lacking are: the source of carcasses for the drift study; the source of information describing the initial state of oiling and decomposition of the carcasses; the locations of carcass releases; the number of samples to be used; and the nature of the transmitters used. (The assumption that the transmitters will remain upright and exposed may be weak, depending on the sea state.) (ESC)

Response: The source of carcasses for the drift study was not mentioned because availability of birds, permits, and logistics of getting to various sources had not yet been fully determined. Carcasses were oiled using weathered Prudhoe Bay crude oil. Carcasses were moderately and heavily oiled. Great care was taken to ensure that carcasses were as fresh as possible. Location of carcass release was not discussed in advance of the release because winds, currents, and sea states had to be taken into careful consideration at the time of the release. Availability of aircraft and boats were also critical factors in deciding the locations of carcass release. Sample sizes were selected that would permit differentiation between effects of various species used, the degree of oiling of the carcass, and the release sites as sources of variation. It was not assumed that the transmitters used would remain upright. Identical transmitters were used in previous experiments with marbled murrelets and did, in fact, remain upright.

Comment: The use of decoys as a calibration tool has several weaknesses, e.g., that they do not match birds in profile and that decoys not found have drifted out of range. (ESC)

Response: Decoys were used in a previous experiment. They were weighted to simulate bird carcasses being used. They do, in fact, act as a reasonable control. Experimental results indicate that the decoys do float similarly to bird carcasses and they did not float out of range.

Comment: As described, the study does not take into account the sensitivity of eagle nests, seal and sea lion haulout areas, and seabird colonies. The 500-foot ASL flight altitude in flights "near the beach" could violate the 1,000-foot ceiling and the 1/4 to 3-mile buffer zones established by the Fish and Wildlife Service, the National Marine Fisheries Service, and the Alaska Department of Fish and Game. (ESC)

Response: Every effort was made to minimize these disturbances as a result of flights conducted for this study. The slight activity generated by this study was minimal when compared to that generated by spill cleanup activities.

Comment: The assumption that the "average lineal density of carcasses for a given beach type in the unsampled area was the same as that in the sampled area in a given sector" is unsubstantiated. (ESC)

Response: The Trustees recognize the validity of this comment. However, this assumption can be tested by using ESI data (Sensitivity of Coastal Environments & Wildlife to spilled oil, Atlas of Coastal Resources) and comparing this data with oil deposition data. It will be corrected if a relationship is shown between the two.

Comment: The intended use of a 10% sample of freezer-stored birds to reflect the oiled/non-oiled distribution of birds on unsearched beaches may not be appropriate. (ESC)

Response: A 10% sample would give some indication of oiling trends, however, there are plans to look at a larger sample size during the 1991 season.

Comment: The intended use of bird carcass notes and logbooks to indicate the level of effort is improper since it may not indicate the intensity of effort applied at other locations where birds were not found. (ESC)

Response: Logbooks and bird carcass notes may not indicate the level of intensity of effort applied at other locations where birds were not found or they could, in fact, indicate intensity of effort in locations where birds were and were not found. Until logbooks and other sources of information were reviewed it was not possible to know what they would reveal. The model is not dependent upon any one piece of information such as effort.

Comment: There are no necropsies planned for oiled birds, which implies that any bird with oil on it expired as a result of contact with oil. This ignores natural mortality and post-mortem oiling. (ESC)

Response: A number of oiled birds were necropsied during the spill. Estimates of mortality will consider natural mortality. Numbers of dead birds found during 1990 response activities, as well as those found during 1990 damage assessment studies and other activities, will provide useful information in estimating natural mortality.

Comment: The assumption that carcass disappearance rates increase as the birds enter the nearshore environment is questionable. (ESC)

Response: This was simply a description of an understanding, at the time, of the physical process of carcass sinking. This assumption is not critical in any sense to the model.

Comment: This study should take into account the effects of the intensive search effort. (ESC)

Response: This study makes every effort to include all pertinent information on recovery of bird carcasses during the spill, including the intensive search effort.

Bird Study No. 2 - Censuses

Comment: Comparison of the 1990 and 1971 aerial data will not produce a valid determination of injury. This study does not explain how effects of oil spill will be determined. (API, ESC)

Response: Although more recent pre-spill survey information would have been preferable, the 1971 survey data are still useful and provide important information about distribution of birds throughout the Sound. The survey was designed as an index to migratory bird populations and was not designed to provide a total population of the study area. Because this study provides only an index to migratory bird populations, it will not measure actual numbers of birds lost to the oil spill, but will document displacement of birds and loss of habitat use.

Comment: Use of aerial surveys to provide census and seasonal distribution information for comparison with historical data from 1971 is inappropriate. Without knowing data from the surrounding years and being able to compare survey techniques used, it is not likely that the 1971 data are representative of the earlier time period and therefore an appropriate set of baseline data. Population status could have been affected by environmental and other unaccounted-for changes in the intervening years, which cannot be segregated from the effects of the spill. (ESC)

Response: We agree that a direct comparison of post-spill aerial survey data with 1971 aerial survey data may present problems in identifying other intervening events or changes that may have affected bird distribution and population. The aerial survey data provide valuable information on these parameters in 1989 and 1990 and will be used accordingly. Survey dates and methodologies between 1971 and 1989/90 are similar.

Comment: It may be impossible to establish a causal relationship between observed changes and the spill. Objectives A.3 and B.3 cannot be met without long-term studies; they will be compromised on account of the natural variability in waterbird and waterfowl populations. (ESC)

Response: Information from this study will be considered in conjunction with other information to determine causality of any documented changes. Additionally, this study compares data between oiled and unoiled areas.

Comment: The study does not indicate whether the level of effort, observer experience, or other critical factors affecting the accuracy of the boat surveys will match those of earlier surveys or whether a similar protocol will be used for collecting these survey data. Further, there is no way to evaluate the reliability or the methodologies of the earlier surveys since they are contained in unpublished reports. (ESC)

Response: Similar protocols to previous studies are used in current surveys, and in all cases, through training and selection of observers, a high level of observer accuracy is assured.

Comment: There is no discussion of count replication or any other survey strategy for achieving a 95% confidence limit, and it appears that the sampling effort will not take into account natural variability, thereby potentially precluding comparisons with historical data. (ESC)

Response: The plans for this study provide information on the number and timing of counts and the statistical tests to be applied.

Comment: The sampling design is not sufficiently described for review purposes. (ESC)

Response: The sampling design is described in detail in the study plan.

Comment: The methodology used to identify the presence or absence of oil during the boat surveys is not disclosed and it is not clear that other variables that can influence bird distribution and densities are being recorded. (ESC)

Response: The presence or absence of oil is being determined by use of available data sets on oil on water (ADEC and NOAA data) and oil on shorelines.

Comment: The assumption in the aerial surveys that visibility bias affecting surveys in different years with different conditions and different observers is similar probably is not correct. (ESC)

Response: The assumption by the reviewer that aerial surveys were conducted during 1989 and 1990 under different conditions and using different observers is incorrect. The visibility bias is similar because the same observers, pilot/observers, and aircraft were utilized for both years. Conditions (weather) were also similar in that minimum weather conditions for conducting the surveys were strictly adhered to. The timing was also similar since each survey in 1990 was accomplished within a few days of the date that survey was done during the previous year.

Comment: As described, the study does not take into account the sensitivity of eagle nests, seal and sea lion haulout areas, and seabird colonies. The 150-foot ASL flight altitude in flights 200 meters offshore appears to be in conflict with the 1,000-foot ceiling and the 1/4 to 3-mile buffer zones established by the Fish and Wildlife Service, the National Marine Fisheries Service, and the Alaska Department of Fish and Game. (ESC)

Response: Every effort was made to minimize the impact of these flights to bald eagle nests, seabird colonies, and seal and sea lion haulouts. The frequency of these flights resulted in substantially less potential disturbance than the more frequent flights and other human activity associated with EVOS cleanup activities. Flight 150 ft above sea level is necessary for accurate species identification. The 200 meter offshore distance was necessary for survey width in order to duplicate Haddock's aerial survey done in 1971 and also to cover the same area being surveyed by the boat crews. Once the 400 meter survey width (200 meters off each side of the survey aircraft) was started, it was continued for continuity of the survey data throughout the study. During 1990, no surveys were done during the eagle and seabird nesting period, as surveys were accomplished during the spring (May) and fall (October). Seal and sea lion haulouts were given a wider berth when possible. Very little disturbance was observed on the seal and sea lion haulout areas during the aerial surveys as the aircraft were operated at a reduced power setting (i.e., noise abatement procedures) in order to reduce the airspeed for survey purposes.

Comment: The Plan appears to put more emphasis, unjustifiably, on the more variable spring and fall surveys. (ESC)

Response: Greater emphasis is not placed upon the spring and fall surveys than on the winter survey which is considered to include the most stable migratory bird population. If any emphasis is placed upon one survey over the other, it would be the winter and spring surveys because those cover the time period of the initial oil spill. The fall survey usually only covered PWS because inclement weather encountered on the Kenai Peninsula portion of the study area prevented complete survey of the Peninsula during both 1989 and 1990.

Comment: The statistical procedures for data comparisons are vaguely defined; it is not clear how spill effects will be estimated and tested. (ESC)

Response: As was previously stated, this survey is intended only as an population index to cover the entire shoreline of the study area. It was not a survey of selected sample areas that would then be extrapolated out into a total population of the survey area. All surveys were done using time proven, standardized aerial survey techniques used throughout the FWS for surveying migratory bird populations.

Comment: It is not clear from the Plan how studies at Naked Island reflect on injury elsewhere. While these studies may estimate changes in local density, they will not establish a causal relationship between such a change and the spill. (ESC)

Response: The availability of pre-spill information on certain species, such as pigeon guillemots, on Naked Island provided a valuable opportunity to compare pre-spill and post-spill information.

Comment: The ability to measure a change in marbled murrelets is debatable; the available historical data from the 1979-81 era may be less useful because of their age. (ESC)

Response: The boat surveys replicate counts made in previous years and will provide information on changes in marbled murrelets populations from previous years.

Comment: The proposed Kodiak Island transect surveys do not appear to have any baseline data for comparison. If this is the case, this work cannot be used to determine injury; it can only further research. (ESC)

Response: The Kodiak Island survey transects (winter) have 10 years of pre-spill data. There were no pre-spill summer surveys at Kodiak and these surveys have been discontinued.

Bird Study No. 3 - Seabird Colony Surveys

Comment: It is unclear, given the apparent similarities of Birds 2 and 3, why these two studies were not combined. (API)

Response: Bird Study 2 deals with distribution and abundance of many waterfowl and seabird species in all habitats throughout the year while Study 3 concentrated on seabird colony numbers and reproduction. They require very different methods and efforts.

Comment: Comparison of the 1990 and 1971 aerial data may not indicate injury. It is unclear how effects of oil spill will be determined in this study. (API, ESC)

Response: Bird Study #3 did not utilize information from any aerial surveys.

Comment: The use of the Semidi Islands as a control site is inappropriate because these islands are not representative of the habitat in the spill area. They are relatively far removed from many of the study sites and are affected by different oceanographic conditions and environmental influences. (ESC)

Response: Evidence suggests otherwise. If a control site such as the Pribilof Islands in the Bering Sea had been chosen, these comments might have had some validity. However, the Semidis are right on the edge of the spill, contain the closest and most comparable large murre colonies, are positioned on the continental shelf in a similar fashion as the Barrens, have exhibited similar sea water temperatures, and are in the same oceanographic regime as the Barren Islands, if not that of PWS. In addition, there have been feeding studies of diving alcids and the food they bring to their young which support this comparison. The Semidis are one of the few close sites in the Gulf of Alaska where we have a more continuous string of yearly data on both murres and their reproduction.

Comment: It is unclear whether the proposed census study properly accounts for the diurnal variability in nest attendance of the various species that occurs even during the stated study hours. (ESC)

Response: A number of studies have demonstrated that day-to-day variability is more of a concern when determining an adequate degree of precision than hourly or diurnal variation, provided that the hourly variation by censusing at certain hours is minimized. The stated study hours are the standards used at this time in Alaska.

Comment: The use of boat- and land-based surveys is problematic; the different levels of reliability of these surveys may make comparisons questionable. (ESC)

Response: Boat-based surveys are being compared to boat-based surveys and land-based are compared with land-based at particular sites, thereby coming up with consistent comparisons of relative indices. One type of survey may be preferable if choices are available since precision of estimates will be easier to refine, but standardized methods and enough replicate counts on different days will refine precision enough for either method to evaluate the large degree of change that is apparent at this time.

Comment: Much of the historical data is too dated to be valid. Its use will limit the Trustees' ability to measure population change for some species and will make difficult any link between change in population status and the spill. (ESC)

Response: If Bird Study 3 only concentrated its effort on one site where there were gaps in the historical baseline data, there would be more concern with this issue. Instead, the approach has been to look at many different sites and several different species, some of which have a much better historical baseline of data, with the idea that any effect caused by something other than the oil spill should show up at other sites and with other species in some consistent pattern. This certainly would be true for any large degree of change, if not small changes.

Comment: Statistical models are too vaguely defined. It is not clear how the effects of EVOS will be determined, particularly given the natural variation due to time and locations. The probabilities of Types I and II errors are not given. (ESC)

Response: This project has done no modeling. This study has relied on the advice of highly regarded professional statisticians who have looked at our data and treated them appropriately with programs such as SAS. Fieldwork has attempted to refine precision of estimates with as many standardized replicates as field conditions will allow.

Bird Study No. 4 - Bald Eagles

Comment: Bird surveys indicate that species density and diversity are returning to pre-spill norms; eagle surveys show more than 1,000 active nests in previously oiled areas with normal numbers of live chicks, and the subsistence study indicates that eagles' food supply and habitat are no longer in danger. This evidence should have been taken into account in the Plan. (ESC)

Response: Pre-spill norms for bald eagle density or of density, distribution, and diversity of prey are essentially unknown. FWS surveys found something less than 1300 bald eagle nests in the area of PWS that were surveyed. The survey area included portions of eastern PWS and areas not oiled in western PWS. Many of these nests were not active and many of the nests that were active in the early part of the breeding season were not successful. To say that there were 1,000 active nest in previously oiled areas does not consider all relevant data.

Comment: The eagle studies should be discontinued given the results of the 1990 surveys indicating the rapid recovery of this species and the health of its habitat. (ESC)

Response: Although 1990 surveys indicate eagle populations may be recovering from losses suffered in 1989, complete recovery may take several years. Long-term effects of losses of breeding and sub-adult eagles, the 1989 reproduction, and the progeny of these birds that were lost due to the spill will not be evident for at least one generation of eagles or 5-6 years (the time it would have taken for the lost progeny to be recruited into the population as breeding adults).

Comment: It is not clear that this study has addressed potential impact of radio tagging and the taking of blood from bald eagles. (API)

Response: Radio-tagging of bald eagles with transmitters similar to the ones used in this project has never been shown to have detrimental effects on study birds. Transmitters weighing up to 90g have been used in other studies, while those used in PWS weigh only 60g. To date no transmitter or harness-related mortalities have been documented. During this study a maximum of 13cc of blood was drawn from captured eagles. Studies by Dein (1986) and Cooper and Eley (1979) indicate up to 47cc may be taken without harmful effects to eagles.

Comment: Bird 4's use of eagles from the Copper River Basin in the survival and productivity research is inappropriate since eagle demographic data from that area (differences in habitat, food supply, and the timing of egg-laying), which is well outside the zone of the spill's impact, is not relevant to the determination of injury. (ESC)

Response: It is currently unknown where all eagles from the Copper River Basin winter. One objective of this study was to determine if birds from the Copper River were potentially impacted by the oil spill. Only one eagle from the Copper River was radioed in 1990.

This eagle is currently wintering in PWS. It is important to study areas adjacent to PWS for potential oil-related impacts since eagles range widely.

Comment: The population survey, radio-tracking, and productivity survey components of this study are research-oriented and should not be included in the Plan. (ESC)

Response: Without studying the population and productivity trends of bald eagles in PWS it is impossible to identify impacts of the spill. By comparing trends between oiled and unoiled areas within a similar geographic region, variation in environmental and prey base conditions are minimized. In addition, without radioing individuals, it would be unknown which areas have been impacted. For example, oiled material was found in one nest distant from oil impacted beaches. It is also important to identify how far eagles range to determine which areas may have been affected by oil or if eagles from oiled areas are moving to areas with cleaner shorelines. Radio-tagging also yields information on survival of eagles from oiled areas vs. eagles from unoiled areas within a similar geographic region. The location of radio-tagged eagles found dead is useful in calculating how many eagles may actually have been killed as result of oil spill. In addition, radio telemetry is useful in validating population surveys by helping to evaluate potential biases such as seasonal movements of eagles.

Comment: It is not clear whether Objectives A, B, and C can be met to the degree of accuracy and certainty stated in the Plan. Even if these objectives can be met, the poor understanding of the baseline may hamper injury determination efforts. (ESC)

Response: The survey of resident bald eagles as well as objectives B and C were met in 1990 by following the procedures outlined in the proposal. Wintering bald eagle surveys were determined to be unfeasible due to weather conditions. We believe comparisons of surveys conducted in 1982 to those from the current study are valid. Procedures established in 1982 were followed in 1989 and 1990. All population plots randomly selected in 1982 were flown in 1989 and 1990. In addition, the shorelines of all islands in PWS were surveyed in 1989 and 1990. By surveying all shorelines, populations can be analyzed on a micro scale (i.e. eagles/km of oiled vs. unoiled shoreline) as well as on a macro scale (east vs. west PWS in 1982, '89, '90). Continuation of these surveys will provide documentation of trends since 1989. Since 1982, with the exception of the oil spill, we see no reason for a decline in productivity or densities of bald eagles in PWS as data from other parts of coastal Alaska indicate bald eagle numbers have been increasing. Populations have undoubtedly been increasing in PWS since the bounty years, and prey species such as pink salmon have increased in abundance due to growing hatchery production.

Comment: The highly weathered and non-toxic state of EVOS oil in 1990 suggests that costs and capturing activities associated with Objective D are not warranted. Short-term reductions in productivity have little affect on eagle populations. (ESC)

Response: There has never been an oil spill of this magnitude in an ecosystem similar to that of PWS. The long term sublethal effects of North Slope crude oil are unknown. Currently, too little is known about the survival of all age classes of eagles to create an accurate population model. Therefore, the effects of short term reductions in productivity in this long-lived species are unknown.

Comment: The 1982 baseline data is too dated to be valid and may not reflect pre-spill conditions. There is no assurance in the Plan that the data to be obtained in this study will be collected in a fashion similar to that of 1982. Other environmental factors may have affected eagle populations since 1982, so the study may not be able to demonstrate that a change in eagle populations between the two sets of data is spill-related. (ESC)

Response: Population surveys conducted during this study have been conducted in the same manner as those in 1982 (Hodges et al. 1984) as described in the review plan. Surveys plots, aircraft, and experience levels of personnel were similar. There has been no cause for a major decline in eagle populations between 1982 and 1989 in PWS, and the population should be stable or expanding. We are also comparing areas of oiled and unoiled shoreline within similar geographic regions to examine relative changes in the numbers and densities of eagles attributable to the spill.

Comment: The locations of the oiled and control sampling areas for the population surveys are not described and there is no indication of criteria that will be used to distinguish these areas. (ESC)

Response: Sampling areas vary depending on what is being sampled. Some sampling areas for this study are based upon the location of nest sites, and the amount of oiling along shorelines in the immediate vicinity of the nest can be determined by reference to maps developed by ADEC. Sampling areas for free flying birds is also based upon where they are found. The oiling status of the trapping site is, of necessity, a more or less well quantified measure due to the mobility of the eagles. Eagles trapped in eastern PWS were considered to have been from unoiled areas. Eagles from areas such as Northwest Bay were considered to have come from oiled areas. Eagles from locations such as the southern shore of Green Island were identified as coming from unoiled shorelines as most shoreline in the area was untouched by oil. This conservative approach raises the likelihood that eagles exposed to oil were included in the pool of birds considered to be from unoiled areas, but this strengthens the significance of differences that may be observed.

Comment: Plot selection criteria are not described adequately; plot selection methodology and number of plots are needed for a proper review. (ESC)

Response: For population surveys in PWS, all island shoreline was surveyed along with 23 randomly selected mainland plots. All of Kachemak Bay and 14 random plots were counted on the Kenai Peninsula coast. Methods were those described in Hodges et al. (1984).

Comment: The inclusion of areas well outside the spill area, such as Malaspina Glacier, is questionable. Acquisition of such data is more in the nature of research than damage assessment. (ESC)

Response: As stated previously, it is unclear how large an area was impacted by the spill as eagles may range widely. Therefore, it is necessary to sample areas with historical data distant from the immediate spill area.

Comment: Comparison of eagle productivity in widely separated areas such as PWS and Southeast Alaska is invalid. (ESC)

Response: Habitat and environmental conditions in southeast Alaska are similar to PWS, and long-term research in southeast provides a useful body of information for comparison. In addition, effects of the spill in areas adjacent to PWS were unknown, and southeast Alaska provided a safe control for some aspects of this study.

Comment: The application of "home range" implies two assumptions that may not be correct: one is that the level of use of the shoreline is constant throughout the home range; the second is that eagles lack the ability to avoid oil. (ESC)

Response: We defined a biologically meaningful "core use area" around active nests as the average length of shoreline in front of each nest used by the resident radio tagged eagles during the nesting season. Telemetry indicated that eagles with oiled shoreline in their core use areas continued to utilize this same area. Relative use of oiled and clean areas within a core use area is not possible to determine. Assuming acquisition of food is the primary motivation for coming into contact with oiled beaches, eagles are not likely to differentiate between clean and oiled beaches or prey.

Comment: The comparison of survival between 15 adult eagles from oiled and 15 adult eagles from unoiled areas employs too small a sample to ensure that random samples across the age structure of the population are obtained. (ESC)

Response: Adult eagles are of indeterminate age and nothing is known about the age structure in adult bald eagle populations. With no knowledge of age structure in the population, it cannot be stated that the sample is too small. Individuals in a given age class have an equal probability of being captured, while younger year classes have a higher probability of being sampled given consistent annual mortality. Age structure is unlikely to be different in eagles trapped in east vs. west PWS.

Comment: The radio-tagging program does not account for the natural dispersal of immature eagles and could potentially increase the risk of mortality to fledglings, thereby creating a bias in the study. Also, there is no explanation of how the failure of radio tags will be taken into account. (ESC)

Response: It is undoubtedly true that the dispersal of juvenile eagles increases their risk of mortality compared to adults, but the risk is not associated with the natal area in normal situations. We are comparing survival of juveniles from oiled and unoiled areas that are subject to the same risks with the exception of the pollutants in the oiled area. Radio failures are equally likely for either group. Literature on the Kaplan-Meier procedure cited in the study plan (Pollack, 1989) discusses how missing transmitters are "taken into account".

Comment: The oiled and non-oiled sampling areas for the survival study are not described adequately to allow proper review. (ESC)

Response: Sampling areas are based on the occurrence of successful nests and where adults are found. Obviously, these cannot be determined until they are observed in the field. Of the 71 chicks radioed, 41 were from areas potentially impacted by oil (west PWS) and 30 were from known clean areas (east PWS). 37 adults were captured in west PWS while 29 were captured in east PWS. Specific oiling status is determined as described above. Survival estimates will be calculated on macro (east vs. west PWS) and micro (oil in vicinity vs. no oil in vicinity) levels.

Comment: Neither the number of blood samples nor the means of selection of the individual eagles to be tested was provided. (ESC)

Response: The number of blood samples taken was equal to the number of adult eagles trapped and from which a sample of blood was obtained. Fifteen individuals were selected from dispersed areas in west and east PWS. We trapped eagles in west PWS from areas with oiled shorelines. Subsequent radio telemetry of trapped and released eagles further defined potential exposure to oiling.

Comment: The post-mortem changes evident in dead eagles may invalidate the results of hydrocarbon analyses performed on recovered carcasses. (ESC)

Response: Post-mortem changes in eagles from oiled and unoiled areas are unlikely to be different. Determination of causes of mortality are being made by highly qualified professionals who are eminently qualified to determine whether the analyses performed provide reliable data.

Comment: The oiled and control sites for the toxic/sublethal effects portion of this study are not described sufficiently to permit review. (ESC)

Response: See response to similar comments above vis-a-vis the population surveys and survival study components of this study.

Comment: Statistical models are too vaguely defined. Study sites are neither disclosed nor described adequately, and the probabilities of Types I and II errors are not given. (ESC)

Response: Statistical models mentioned in the plan are routine tests presented in statistical texts. Study sites are discussed above. It is accepted statistical practice to set the Type I error at 5%, termed "significant", or at 1%, termed "highly significant". Type II error will be evaluated in consultation with statisticians.

Bird Study No. 11 - Sea Ducks

Comment: Better explanation is needed of the correlation between hydrocarbon intake and increased mortality and reproductive failure. There will be no real measurable data on effects without this. Objective A seems unattainable given the scope and design of the program. (API, ESC)

Response: Increased information on the correlation between hydrocarbon intake and increased mortality and reproductive failure is needed and will be gathered in 1991. Objective A is attainable and is well underway. Food items from collected ducks have all been identified and the information entered into database files awaiting statistical analyses.

Comment: The statement in the Plan that seaduck collection will be integrated with other data to demonstrate that seaducks feed on contaminated prey reveals a bias in the study. (ESC)

Response: Seaduck collection was integrated with sample sites of blue mussels in exposed and unexposed areas of PWS to test the hypothesis that seaducks are exposed to petroleum contamination through their prey base.

Comment: Given the number of ducks to be collected in this study in 1990 and the fact that waterfowl hunting is still permitted, seaduck populations must be healthy. Thus, there is a question about the cost-effectiveness and reasonableness of this study. (ESC)

Response: The presence of a huntable surplus of ducks does not mean that significant mortality did not occur and, therefore, that injury from EVOS did not occur.

Comment: The study and control sites within PWS are not defined, the methodology used in selecting the individual seaducks to be collected at each site is not described, and the number of samples to be collected at the control sites is not given. The relatively small sample sizes will not justify the planned statistical work. (ESC)

Response: The exposed study site is the oil spill area of western PWS. The PWS control site is a series of bays and inlets north of Cordova in the unoiled area of the eastern Sound. Ten individual seaducks of each species per site is considered the optimal sample size. It is adequate to obtain information needed but will not exert undue population pressure. Statistical interpretation of small sample sizes has made considerable progress in recent years.

Comment: The use of a control site in Southeast Alaska is inappropriate since that area is not representative of the spill zone. (ESC)

Response: Use of a control site in southeastern Alaska is appropriate because intertidal habitats, where these ducks forage, are similar to PWS. Intervening sites along the North Gulf Coast

(Icy Bay, Yakutat Bay) had naturally occurring oil seeps and were deleted from consideration.

Comment: The predictive models for estimating the effect of oil on morbidity, mortality, and reproductive potential are not described. It will be subject to a large degree of uncertainty on account of the ranges of reasonable variables used for input. The use of a model in this fashion represents use of a non-standard technique for injury determination that is not widely accepted. This violates the NRDA regulations. (ESC)

Response: The study has evolved away from the predictive model postulated at early stages of the investigation into actual documentation of morbidity, population decline, and reproductive failure.

Comment: Integration of data from other studies likely will not be possible due to the high degree of spatial variation present even on a small scale. (ESC)

Response: Integration of data from a study of petroleum hydrocarbon levels in blue mussels and other intertidal forage species is possible and is proceeding.

FISH/SHELLFISH

Comments on Fish/Shellfish Studies - General

Comment: Fish/Shellfish studies 2, 5, 7, 8, 10, 17, 23, 27, and 28 will provide data that may be useful for long-term goals of managing Prince William Sound, but are not directly related to oil spill impacts. (ESC)

Response: These studies have components that will demonstrate exposure of fish and shellfish to oil (observations of oiling), bioavailability (hydrocarbon and mixed function oxidase analysis), or injury to individual organisms (histopathology). Taken together they are structured to determine damage to fish stocks. Damage due to the oil spill may require management actions that would otherwise not have been necessary and ancillary benefits improving the management of stocks in general may result from these studies as there are ancillary benefits for many kinds of scientific studies; however that is not the primary reason for conducting these studies.

Comment: Despite more complete descriptions for the 1990 studies, there are still problems with the changes these studies seek to measure. (API) Details are inadequate to support a comprehensive review of study design, field methods, or interpretation of results. (ESC)

Response: It is impossible to respond to unidentified problems or inadequacies. Each study is followed by a reference section of literature in the public domain from which the study designs, methods, and likely avenues of interpretation were derived.

Comment: Results of the 1989-90 subsistence program conducted by NOAA, ADF&G, and Exxon provide evidence that fish from the spill-impacted area do not contain hydrocarbons above background levels. (ESC)

Response: This statement is not entirely consistent with the results obtained to date. The subsistence tests focussed on hydrocarbons in edible fish tissues; however, fish (unlike clams) have physiological pathways by which they process hydrocarbons into forms soon unidentifiable as having originated from the EVOS (the fish themselves are largely composed of hydrocarbons). This does not mean that the fish have not been harmed by exposure to oil in either a short or a long term fashion nor that this harm cannot be assayed by means other than hydrocarbon analysis.

Comment: Except for those shellfish collected from the few obviously oiled areas, there are no problems. Even those few present extremely low risk for consumption. (ESC)

Response: It is unclear whether the first statement applies also to the general health of the shellfish or only to the question of human consumption. Shellfish containing hydrocarbon levels that would pose a risk if consumed were identified in certain areas. The NRDA shellfish studies are designed to assess impacts of the EVOS on the mortality rates and general health of certain shellfish. It is well documented that the *Amoco Cadiz* oil spill had a severe impact on shellfish in Brittany, France, and similar impacts could be expected here.

Comment: It is not apparent how the results of the fish/shellfish studies will provide data useful for the restoration effort. The lack of significant injury as shown by the record fishing season and the population management focus of many of the studies will not guide a reasonable restoration strategy if restoration is warranted. (ESC)

Response: It is impossible to restore anything until it is understood what has been lost. The fish/shellfish damage assessment studies are designed to identify injuries to these resources and provide the basis for restoration actions. The record fishing season was largely a function of good hatchery management and does not necessarily reflect returns to any particular oil-impacted stock, particularly wild stocks. Complex population management of the fisheries was in place prior to the oil spill, and management changes needed for restoration as revealed by these studies will have a very solid historical basis on which to build.

Comment: No information is provided describing the reasons certain studies were discontinued. Without access to the data generated during 1989, it is impossible to determine whether or not these decisions were justified. (UM)

Response: Some studies were completed and some did not show sufficient likelihood of demonstrating injury to justify continued investigation.

Comment: Other than analysis of gut contents, almost none of these studies (the rockfish studies being a notable exception) address key predator/prey interactions, and many do not even assess reproductive status of the adults. (UM)

Response: Fish/Shellfish studies being conducted were designed to get the most information for determining injury with the available funding. Fish/Shellfish 4 addresses predator/prey relationships between juvenile salmon and harpacticoid copepods. Other studies address broader predator/prey relationships. Histopathology in some studies will touch upon reproductive status of the adults even though this is not the primary focus of the study. Observed recruitment will define ultimate reproductive effects in some studies.

Comment: Many of the studies have inappropriate reference lists. Some studies list almost no references, some have reasonable lists, and some list large numbers of reports, many only tangentially related to the particular study. (UM)

Response: Some of the areas being investigated received considerable attention before the oil spill and some were essentially new ground. Thus, there were many references appropriate for some studies and few for others. In accordance with accepted scientific publication practice, a reference section is only a list of all of the authors and their associated papers mentioned in the preceding text. Those must be listed if mentioned in the text whether the paper has a great deal of significance to the study or not.

Comment: There is convincing evidence that fishery resources are vital and productive: no fish kills were reported in 1989 and commercial herring catch rates and pink salmon harvest reached record levels in PWS in 1990. This evidence should be taken into account in the Plan. (ESC, API)

Response: Though dead adult rockfish were reported in 1989, many fish suffering oil-induced acute mortality, particularly small fish, would probably sink or be consumed by predators. Ultimate injury to the herring population will not be evident until the 1989 year class becomes susceptible to fishing or enters the spawning population in 1992. As noted above, the record pink salmon harvest was largely a hatchery phenomenon and was not reflected in wild stock returns in 1990.

Comment: Many fish and shellfish studies are too general for damage assessment purposes. (API)

Response: The Trustees disagree. The studies have been carefully peer reviewed and tailored to address injury assessment.

Comment: Studies are uncoordinated and perhaps repetitive. (API)

Response: The Trustees disagree. Every effort has been made to assure that the studies are complementary; the studies have undergone extensive peer review and synthesis processes.

Comment: The tagging of juvenile fish will cause stress that will result in physiological changes and increased mortality. The invasive techniques will create injury to the resources. (API)

Response: The tagging process has been exhaustively studied and reported in the fisheries literature for many years. Coded wire tagging possibly has the least effect on fish of any method employed. CWT associated mortalities are extremely small. This technique is so well understood and successful that many millions of salmon and steelhead are tagged by this method every year along the Pacific coast of North America. Nevertheless, the methods for all of the studies employing tagging include techniques for estimating tagging associated mortalities. Impact on the resource is negligible.

General - Sublethal and Chronic Effects

Comment: Expensive studies focusing on sublethal and chronic effects are problematic. Results found may not be the result of oil, and may be due to natural causes or the capture and handling of the fish. (API)

Response: Many of the individual assays may not demonstrate changes pathognomonic for *Exxon Valdez* oil. However, the combination of the results from these several types of assays may lead to the conclusion that the injuries observed were due to the EVOS. Changes due to capture and handling are distinguishable from oil-induced changes.

Comment: Many of the 1990 studies rely on non-specific or non-standard indicators to correlate evidence of hydrocarbon exposure to presume population impacts, which will not bear technically conclusive results. Examples of this include: biochemical measurements of bile fluorescent aromatic hydrocarbon concentrations and enzyme level changes in fish, which are highly variable in nature (Fish/Shellfish 18 and 24). (ESC)

Response: Assays of this nature employ appropriate and adequate controls in order to produce meaningful results. The Trustees believe that the results of the assays will be conclusive.

Comment: The Plan contains studies designed to do scientific research that will not lead to identification of injuries. The costs of such research should be funded by alternate means since they cannot be recovered under the NRDA regulations. Examples of this include: the use of mixed function oxidase levels in fish tissues to assess hydrocarbon exposure - this is an unproven technique that has yielded greatly varying results between different life cycles, seasonal factors, and food sources; and Fish/Shellfish 13's use of mussel tissue to assess hydrocarbon contamination - in particular, to determine hydrocarbon concentrations, pathways, and effects. (ESC)

<u>Response</u>: The Trustees disagree with the first statement, particularly in reference to the examples cited. MFO and hydrocarbon analyses are recognized scientific techniques for demonstrating hydrocarbon contamination. When combined with other analyses in the studies these produce reliable evidence of injury. It is well established in the toxicological literature that MFO's are produced as a response to hydrocarbon exposure. MFO's, though a defensive mechanism, often convert these hydrocarbons into more toxic substances than the original compound and create ultimate carcinogens. Thus, these hydrocarbons can have acute toxic effects and long term mutagenic effects. Assaying for MFO's and hydrocarbons is clearly appropriate for identification of injuries.

General - Oiling Levels

<u>Comment</u>: The Fish/shellfish studies contain a fundamental flaw: their designs are based on detecting differences between oiled and non-oiled areas that cannot necessarily be attributed to the oil spill. Many of the study designs have statistical problems in identifying the effect of oiling, physical location, and timing. Too little consideration has been given in these studies to distinguishing effects of the spill from natural factors that can influence population sizes, productivity, or physiology. (ESC, API)

<u>Response</u>: Statisticians have reviewed the studies and have determined that the methods will take into account variables due to natural variation and other factors.

<u>Comment</u>: It is unlikely that the sampling design of the Fish/Shellfish 1, 3, 8, 18, 22, and 28 will be able to relate observed biological responses to any particular hydrocarbon concentrations since the areas to be sampled represent a wide range of hydrocarbon exposures levels. (ESC)

<u>Response</u>: These studies are not intended to be carefully controlled laboratory experiments. They are not bioassays to estimate a given concentration of oil in water. There are other tests by which we are attempting to do that. The Fish/Shellfish studies were designed to determine the injury done to fish as a result of the EVOS.

<u>Comment</u>: Many studies are based on the development of data from

oiled and control sites. Inadequate information is provided to document that control sites are ecologically similar to test sites to establish baseline information. (ESC)

Response: The control sites were carefully selected in order to accurately determine the differences between oiled and unoiled sties. Their use is not intended to provide pre-spill baseline information.

Comment: The criteria used to select stream and sampling sites for the Fish/Shellfish studies do not include the evaluation of the level of oiling. Some quantitative method of assessing the degree of oiling should be included in the site selection criteria since these studies are designed to evaluate the effects of oil on egg-to-fry survival. (ESC, API)

Response: Quantitative assessment of oiling was not possible when most sample sites were selected. Criteria were usually based on visual observations followed by quantitative assessment of the levels of oiling. In some of the streams involved in the egg to fry survival studies, oil has penetrated deep into the substrate. In some cases, fry incubating in the gravel may be adversely affected by chronic exposure to low levels of oil leaching out of the gravel.

Comment: A large number of salmon spawning areas have been retained for additional study, yet evaluation of the level of hydrocarbon contamination is limited to the visual presence of oil and the hydrocarbon content of bivalves at the mouth of these streams and rivers. (UM)

Response: As noted above, great care is being taken to accurately quantify levels of hydrocarbon contamination. Whenever possible, several means of estimating the presence of oil are compared. Bivalves are good indicator organisms because, unlike fish, they do not possess an MFO-like system for ridding themselves of hydrocarbons. Thus the presence of hydrocarbons in bivalves provides an additional indicator on the level of oiling to which other organisms were exposed.

General - Variable Methodology

Comment: The level of detail and justification provided in the Fish/Shellfish studies is extremely variable. Frequently great detail is given on the methods employed without any discussion as to the significance of the measurements to be made. (UM)

Response: Specific questions about the methods or the significance of the measurements should be directed to a particular study.

Comment: The methodologies used in the various studies seem highly variable. Analysis of parent hydrocarbons in tissues of organisms capable of rapid hydrocarbon metabolism is of limited value. Most fish and many crustacean species at developmental stages from larvae through adults fall into this group. (UM)

Response: Hydrocarbon analysis of organisms that can quickly metabolize them is of limited utility unless samples are collected very soon after exposure or there is a potential for continued exposure. Where neither of these is the case, other methods for establishing injury from exposure to oil are employed. The variety of methods reflects these considerations, among others.

Comment: Several methods are available to assess metabolite body burdens and effects. In some studies these are mentioned but in others they are not, and there is no explanation given for this apparent inconsistency. (UM)

Response: See response to comment above.

Comment: Different methods are being used to assess a biochemical measure of hydrocarbon exposure (induction of cytochrome P4501a1). In some cases analyses will be done on formalin fixed samples, in others on subcellular fractions of fresh tissue. No information is given that would allow an evaluation of whether theses methods will produce comparable results. (UM)

Response: The appropriate controls should allow for comparable results. Because the method of sample preservation limits the kinds of assays performed, the particular method chosen for each study that is assaying cytochrome P450 is somewhat dependent upon the other types of assays that will also be performed on the same samples.

Comment: Testing procedures are inconsistent. Mixed, fixed, and nested effects models are planned for data from the same field sampling protocols. In most cases the appropriate testing model was not determined before taking samples. (ESC)

Response: While general comments like this are difficult to address, the Trustees do not believe that testing procedures are incorrect nor do they need to be consistent from one study to another if the goals for each study or analysis are different.

Comment: Error terms for testing are infrequently documented. Often the proposed error term is incorrect. (ESC)

Response: Without specific examples, this comment cannot be addressed adequately.

Comment: Procedures for estimating the total effect of oil over the area impacted are not described. Estimates are likely to be biased and highly variable. (ESC)

Response: To the extent that this is possible, the combined results of all NRDA projects, not just the Fish/Shellfish studies, will achieve this. Because a variety of life forms over an immense area were affected, only an approximation will be possible. Every effort has been made to provide consistency among the NRDA studies.

Comment: Clark and Bernards' procedures, as planned for the tagging studies, are inappropriate and will reject the hypothesis of no effect too often. This is true for Fish/Shellfish studies 1, 2, 4, 5, and 11. (ESC)

Response: Clark and Bernards' procedures are not planned for any of the studies indicated. Where these procedures are being used, we believe they are appropriately applied.

General - Natural Variability

Comment: The Plan does not make clear that sampling programs will produce information necessary to prove that a statistically significant portion of the expected biological variability is a function of hydrocarbon contamination as opposed to other natural factors. Fish/Shellfish 1, 3, 8, 13, and 17 suffer from this defect. (ESC)

Response: Appropriate controls and continued sampling in post-spill years will address this concern. However, the premise is not that the observed biological variability is a function of hydrocarbon contamination in each case; rather, if biological variability is a function of hydrocarbon contamination, our methods will allow us to distinguish this from variability caused by natural factors. The studies are observational rather than experimental.

Comment: Most of the Fish/Shellfish studies do not adequately account for the fact that there was substantial variability in resource levels before the spill or the fact that there is no reliable baseline data. Thus, the statistical detection of differences due to oiling will not be possible. This is particularly true of Fish/Shellfish 3, 8, 15, and 17. (ESC, API)

Response: For any study in which substantial random variability is expected, an increase in the number of sample sites and sizes improves the statistical power of the test. For those studies in which variability is expected to be large, statisticians have determined the number of sites and the number of samples necessary to demonstrate oil-related variability. Some of the observed pre-spill variability for which there is baseline data was harmonic area-wide. An absence of harmonic variation would point to EVOS effects. A return to harmonic variation would be expected as the area recovers.

Comment: It will be impossible to develop sufficient data to describe the subtleties of historical population dynamics or to relate any potential response to extremely low hydrocarbon levels, as these factors are not well understood by fisheries managers. This is true in Fish/Shellfish 3, 4, 5, 13, 17, and 27. (ESC, API)

Response: Some of the populations being examined lend themselves very well to the study of subtleties of historical dynamics. There will be some level of hydrocarbon exposure that will not produce observable effects. Examining fish with low levels of exposure as well as those fish with hydrocarbon levels that produce observable effects will help estimate the total injury to fish and shellfish as a result of the EVOS.

Comments on Fish/Shellfish Studies - Specific

Salmon Studies

Comment: The 1990 adult pink salmon catch consisted of fish present in PWS as sensitive juveniles in April 1989. The record catch in 1990 provides convincing information regarding the lack of injury to this population. The need for extensive study of potential oil impacts has been obviated. (ESC)

Response: The record catch was largely a hatchery phenomenon not necessarily paralleled by wild returns. Among other factors, hatcheries' net pens were shielded from the oil by booms or were outside the spill area and their fish were able to spend a month or longer in this protected saltwater environment before they were released. Wild fish did not have those options. PWS pink salmon are not a single population and, therefore, hatchery successes and failures are not the only criteria by which to determine the effect of the EVOS.

Fish/Shellfish Study No. 1 - Salmon Spawning

Comment: It is unclear whether studies are presuming organisms were exposed to oil in areas where oil was only visible on the water surface. DOI regulations require confirmation of exposure. It is not clear how exposure pathways will be verified. (API)

Response: Fish/Shellfish 1 collects mussels from the immediate vicinity of each stream in studies 1 and 2. These mussels will be analyzed for hydrocarbon uptake (bioaccumulation) to indicate oil impact. Adults will be collected from 22 streams (12 oiled, 10 not oiled) and analyzed for histopathological abnormalities as well as mixed-function oxidases (MFO's). Eggs and fry will be collected during study 2 and also examined for hydrocarbons, histopathological abnormalities, and MFO's.

Comment: Studies do not address issues such as error margins in egg counts and the impact of sampling frequency on fish migration. (API)

Response: All eggs and fry are individually enumerated not estimated; consequently, if an egg or fry is removed from the gravel, it is counted. The counting of adults during study 1 has very little or no impact on spawning. Egg and fry sampling takes place in mid-September to mid-October and again during mid-March to mid-April. This is after the fall spawning migration and before the fry emerge from the gravel to begin their spring migration.

Comment: The methodologies used for objective A, visual observation, aerial photography, and hydrocarbon analysis of tissue samples from intertidal mussels at stream mouths, are inappropriate for determining hydrocarbon concentrations, pathways, or their effects. (ESC)

Response: Objective A reads: "To determine the presence or absence of oil in the intertidal habitat used for salmon spawning." The collection of photos, visual observation data, and mussel hydrocarbon data will show presence or absence of oil.

An objective was added in the 1991 studies which reads: "Document the presence or absence of hydrocarbons from the EVOS in the tissues of adult salmon." This objective will be met by the collection of tissues from spawning adults in 12 oiled streams and 10 unoiled streams. These tissues will be analyzed for histopathological abnormalities and MFO's.

Comment: For objective B, documenting the physical extent of oil distribution on intertidal spawning areas is insufficient to determine hydrocarbon concentrations, exposure pathways, or their effects. (ESC)

Response: See response to comment above.

Comment: Regarding objective D, no selection criteria ensuring that streams selected will be representative of PWS streams are presented. (ESC)

Response: Four streams were weired in 1990. One on the east side of PWS and the other three in southwest PWS (2 unoiled, 1 oiled). Stream selection was made by biologists familiar with the area and based on subjective criteria.

Comment: In objective E, the correction factor for one stream does not include the variables which would allow that correction to be applied to 138 or 218 other streams. (ESC)

Response: Objective E estimates bias between aerial and ground surveys for 138 streams and estimates accuracy of the 2 methods for 4 weired streams. A correction factor can be estimated for the weired streams.

Comment: Objective F will likely be compromised through biased criteria used in determining in-stream residence time of young salmon. (ESC)

Response: Average stream life in this case is the number of days that adult pink or chum salmon spend in the stream from the time they enter the stream during their spawning migration until they die.

Comment: Objective J, the recalculation of historical escapement from 1961 to 1988, is of little relevance to impact assessment for a 1989 spill. The assumption that survey and environmental parameter estimates based on the conditions of the past 2 years can be applied as a correction to the past 30 years is invalid. (ESC)

Response: This comment apparently addresses objective G. Historically, escapement estimations in PWS have been more of an index program than an actual escapement estimate. Basically the same survey methodology using only 3 or 4 different observers has been used to build the historic database. Once a satisfactory methodology has been obtained for all 138 streams, estimates of historical escapements will be made. Knowledge of salmon total run (catch + escapement) is essential if a loss is detected during any of the life stages (studies 1, 2, 3, 4, and 28).

Comment: For objective H, no attempt is made to identify or measure other variables that may affect available spawning habitat. (ESC)

Response: The incorporation of instream flow models to obtain refined spawning area estimates for 138 streams would be too costly (both in terms of manpower and money). The stream area provides an accurate estimate of relative stream size.

Comment: Regarding objective I, a catalog of aerial photographs and detailed maps of spawner distribution is not necessary for use in designing sampling transects. (ESC)

Response: The catalog makes it more efficient to locate and plan the egg/fry sampling for study 2 and provides reproducible maps for stream surveyors to use in recording counts by stream zone. This data will be useful for detecting a change in spawner distribution (such as a decrease in intertidal spawners).

Comment: The relationship between hydrocarbon data from mussels taken from the intertidal area and salmon exposures in the stream is questionable. (ESC)

Response: Up to 75% of the PWS pink salmon spawn intertidally. The mussel data will indicate if the intertidal areas of the stream were impacted by oil.

Comment: The study plan does not identify the selection criteria or a plan for developing criteria to select the appropriate technique for evaluation of stream life. (ESC)

Response: The stream life estimates will be tested against what is observed at the weirs. Weirs provide known escapements based upon daily stream walks to provide numbers of live and dead fish.

Comment: The number of fish tagged weekly (80) to determine stream life is static and may be inappropriate for streams where the weekly escapement can vary by several thousand fish. (ESC)

Response: It is assumed that fish are randomly tagged (each fish present has an equal chance of being tagged). The number of fish tagged needs is based upon the need to have sufficient recoveries to provide a meaningful estimate. It was determined that 30-40 recoveries would provide such an estimate.

Comment: The visual observations used to define the levels of hydrocarbon contamination and to categorize stream zones is an inappropriate methodology. (ESC)

Response: Visual observations only provide the presence or absence of oil. Levels are determined by analysis of mussels (this study) and sediments (other studies).

Comment: The criteria used for separation of streams based on their exposure to oil is unclear. In one section the plan says it will be based on visual inspection, in another on levels of hydrocarbons in mussel tissue sampled near each stream. Both methods have weaknesses that will affect the basic categorization of streams. This categorization is the basis upon which the data will be evaluated. (ESC)

Response: Data from both methods as well as other sources will be used for the final oiling categorization of streams.

Comment: Statistical procedures are vaguely defined. It is unclear how the effects of EVOS are to be estimated and tested. The sampling effort may not be appropriate to meet objectives. (ESC)

Response: Study 1 provides stream oiling information, effects of oiling on adults that incubated in oiled substrate, and an estimate of adult escapement. These data will be used by the other salmon projects (Fish/Shellfish 2, 3, 4, & 28) to determine injury to the population. Type 1 and 2 power calculations will be made as the studies progress.

Comment: The probabilities of type 1 and type 2 errors, finding an effect when there is none and failing to find an effect when there is one, are not given. (ESC)

Response: Study 1 provides stream oiling information, effects of oiling on adults that incubated in oiled substrate, and an estimation of adult escapement. This information will be used by the other Fish/Shellfish projects dealing with pink and chum salmon.

Comment: Criteria for selecting treatment and control sites are not given. (ESC)

Response: This study is not designed as a traditional treatment-control experiment. The oiling data will go into the determination of "treatments" and "controls" for study 2.

Comment: The type of data resulting from this study has large variances among sites and times. It will be difficult to determine if a statistically significant effect is due to EVOS or natural variations. The study methods and analytical approach do not address or control for these potential problems. It is not clear that the sampling program will provide the information to prove that a significant portion of variability in escapement is from oil contamination. (ESC)

Response: This study is not intended to show statistically significant impacts due to oiling. It is a source of supporting data for studies 2, 3, 4, & 28. The combination of these studies will determine the impacts.

Comment: The number of streams used in this study (138) seems quite high considering that only 41 appear to be in the affected area. A reasonable evaluation of potential damage to spawning areas could have been done on a much smaller sample size with good statistical sampling design at a lower cost. (ESC)

Response: This study was designed to estimate escapement throughout PWS. Sound wide estimates are required in conjunction with coded-wire tag results (Fish/Shellfish 3) to obtain wild catch contribution for use in run modeling (Fish/Shellfish 28) to estimate potential numbers of fish impacted for the 41 streams.

Fish/Shellfish Study No. 2 - Egg/Fry

Comment: It is unclear whether studies are presuming organisms were exposed to oil in areas where oil was only visible on the water surface. DOI regulations require confirmation of exposure, and it is not clear how exposure pathways will be verified. (API)

Response: Samples of eggs and fry will be collected from each stream zone for each stream. These samples will be examined for histopathological aberrations as well as mixed-function oxidases (MFO's).

Comment: Studies do not address issues such as error margins in egg counts and the impact of sampling frequency on fish migration. (API)

Response: All eggs and fry are individually enumerated, not estimated; consequently, if an egg or fry is removed from the gravel, it is counted. The counting of adults during study 1 has very little to no impact on spawning. Egg and fry sampling takes place in mid-September to mid-October and again during mid-March to mid-April. This is after the fall spawning migration and before the fry emerge from the gravel and begin their spring migration.

<u>Comment</u>: For objective 1, no effort is made to identify the level of accuracy expected from density estimates, or to determine if the damage resulting from sampling is greater than that attributable to EVOS. (ESC)

<u>Response</u>: The level of sampling for density is a tradeoff between what is required to achieve a specified level of precision, what is practical with regards to time spent sampling, and loss of eggs and fry from the salmon population. The Trustees believe that this study provides a proper balance of these considerations.

<u>Comment</u>: For objective 2, no effort is made to identify the level of error in mortality estimates, or to identify factors other than oil that may lead to over-winter mortality of eggs. (ESC)

<u>Response</u>: This study is a "control-treatment" experiment. Error rates were estimated using data collected during the mid 1970's. This information was used to estimate the number of streams required for the experiment. Because of the "control-treatment" design, sources of mortality other than oil should be common to both groups; consequently, an increase or decrease in mortality can be linked to oiling.

<u>Comment</u>: Objective 3 reflects an assumed increase in over-winter mortality in oiled streams. The significance of this cannot be determined as no methods are given for estimating adult returns. (ESC)

<u>Response</u>: Adult returns will be estimated for studies 1, 3, and 28.

<u>Comment</u>: Regarding objective 4, the use of mixed function oxidase levels in eggs and alevins as a means of assessing hydrocarbon contamination is an unproven technique and clearly research. The MFO technique is greatly variable with different life stages, seasonal factors and food sources. The use of mussel tissue to assess hydrocarbon contamination is not appropriate for determining hydrocarbon concentrations, exposure pathways, or their effects on the salmon species being studies. (ESC)

<u>Response</u>: Peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with the MFO analysis as well as examination for histopathological abnormalities.

Comment: There are no controls for the comparison of alevin samples for tissue analysis. The method of collection does not preclude contamination, so no accurate control values can be expected. (ESC)

Response: Alevins collected for hydrocarbon analysis were collected using a rake and strainer pre-rinsed in dimethylchloride. The fry were stored in pre-rinsed glass jars. Alevins collected for MFO and histopathological analysis were not affected by the sampling methods.

Comment: Although a sample of mussels near the stream bed will be used to determine the amount of hydrocarbon impacting the stream, there is no attempt to test the assumption that hydrocarbon levels in those mussels are representative of fish exposures to hydrocarbons in the stream bed. This methodology is inappropriate to measure hydrocarbon contamination and undermines the basis upon which the data are being evaluated. (ESC)

Response: Levels of hydrocarbon in mussels near the stream bed are indicators of impact upon the spawning gravel and the eggs and fry in the gravel. Eggs and fry are collected for further analysis for MFO and histopathological abnormalities.

Comment: Visual assessment to determine degree of oiling is inappropriate to define levels of hydrocarbon contamination for impact assessment. (ESC)

Response: Visual assessment provides a starting point for categorization. This information is refined with mussel hydrocarbon data, fry hydrocarbon data, egg and fry MFO data, and histopathological data.

Comment: Statistical procedures are vaguely defined. It is unclear how the effects of EVOS are to be estimated and tested. This study does not identify the effect due to EVOS and the effort needed to detect that effect. The sampling may not be appropriate to meet objectives. (ESC)

Response: A nested analysis of variance will be used to estimate effects on egg and fry mortality as well as over-winter survival. Power of the study was estimated using similar data collected during the mid-1970's.

Comment: The methodology for injury determination is not clearly stated. (ESC)

Response: See response to comment above.

Comment: MFO analysis of eggs and fry is an experimental methodology and is inappropriate for injury assessment. (ESC)

Response: It is well established in the toxicological literature that MFO's are produced as a response to hydrocarbon exposure. MFO's often convert these hydrocarbons into more toxic substances than the original compound and create carcinogens. Thus, these hydrocarbons can have acute toxic effects and long-term mutagenic effects. Assaying for MFO's and hydrocarbons is clearly involved with identification of injuries. Peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with the MFO analysis as well as examination for histopathological abnormalities.

Comment: There is no evidence that sufficient parameters are being considered by which to identify major aspects of variability in egg to fry mortality. It is not clear that the study will obtain information that will enable an accurate assessment of oil effects versus other environmental factors. (ESC)

Response: Since the oil spill was not anticipated, few pre-spill samples existed. The study will sample both oiled and unoiled areas. As differences between these areas begin to disappear as the environment recovers, it will become more apparent that the initial differences were due to oiling rather than other "natural factors." In the absence of known parameters that identify variability, our statisticians have identified those parameters from the literature and from their experience that most likely indicate variability in egg and fry mortality versus other environmental factors.

Comment: Generalization of results from this study to all 900 anadromous streams in PWS is inappropriate as the streams used in this study are the better, more consistent salmon producing streams. (ESC)

Response: Not all of the streams selected for this study are the better, more consistent salmon producers. Selection criteria included "sufficiently large adult salmon returns to indicate a high probability of success in egg/fry digging." F/S-1 allows us to estimate the stream life for streams that might otherwise fall below the level of practical egg/fry sampling. Using streams ranging from the high end producers to the very low end will allow extrapolation of results to the remainder of the streams.

Fish/Shellfish Study No. 3 - Wire Tagging

Comment: It is unclear whether studies are presuming organisms were exposed to oil in areas where oil was only visible on the water surface. DOI regulations require confirmation of exposure. It is not clear how exposure pathways will be verified. (API)

Response: Fish Studies 1 through 4 provide a comprehensive approach to assessing the impact of oil exposure on pink salmon. Samples of pink salmon eggs, fry, and juveniles have been collected for confirmation of oil exposure using the best available methods. The presence of tagged fish in oiled areas will allow stock specific confirmation of oil exposure for fish from both oiled and unoiled areas. Extensive collections of mussel samples from the intertidal zones of spawning streams will provide confirmation of the presence of oil at specific sites.

Comment: The study does not address issues such as error margins in egg counts and the impact of sampling frequency on fish migration. (API)

Response: Egg counts are used by hatchery operators to properly load incubators with salmon eggs. Outmigrations of fry from the incubators are monitored with electronic fry counters. Fish/Shellfish Study 3 uses fry outmigration counts to determine release numbers and the proportion of tagged fish in the release.

Comment: It is unclear how objective 1 will be used to evaluate effects of the spill on hatchery-released salmon. The data will be of use to hatchery managers, but they will not be valid for injury assessment. The Plan's statement that "outmigrating smolt and returning adults from these hatcheries are exposed to oil at varying degrees" is a nebulous tie to oil effects. (ESC)

Response: Determining the catch and survival rates for wild salmon and salmon released from five hatcheries in PWS will allow investigators to estimate differential survival based on their exposure to contaminated waters. A history of exposure to oil can be confirmed with results from Fish Studies 2 and 4 and used to tie in the effects of oil to losses in production.

Comment: Using the tag results as indicated in objective 2 may obtain a rough estimate of the catch of wild stock pink salmon, but is unlikely to produce information on spill-related effects. (ESC)

Response: Adult returns to the pink salmon streams will be determined by operating weirs at each site rather than by using stream surveys. Knowing the catch and escapement, differential survival of salmon between oiled and unoiled areas can be investigated. Returning tagged fish that stray to streams other than their natal streams may provide evidence of lost populations and habitat.

Comment: Field methods are not detailed enough in Objective 3 to evaluate the validity of this study. (ESC)

Response: Detailed methodologies for coded-wire tag application to wild and hatchery fish is readily available in the literature. Weir operations also have well established methodologies and standard operating procedures.

Comment: The results for Objective 5 will provide little insight into the effects of the spill on any detected differential in survival rates. There is no measurement of exposure to oil, nor is there adequate baseline data for historical comparison. (ESC)

Response: Objective 5 calls for the identification of relevant injuries for which methods of restoring lost use, populations, and habitat must be developed. This objective summarizes the long term goal of all damage assessment studies to identify injured populations. Identifying these populations can be accomplished by satisfying objectives 1 through 4 of this study. These results, along with those of other salmon studies, will identify where and how restoration of injured populations can best proceed. There are other NRDA studies addressing the oil exposure of salmon. These studies rely on coded-wire tagged fish to verify the origin of captured fish. There is a great deal of historical data relevant to the salmon populations of PWS as well as information on the effects of exposure to crude oil on salmon.

Comment: The tagging methods have little application for evaluating effects of the oil spill. (ESC)

Response: The presence of marked fish will allow investigators to confirm stock specific exposure to oil as well as to estimate catch and survival rates for returning adults. Tagging allows identification of fish that stray from their natal streams, which is important to document true returns to streams.

Comment: The methods used to capture sensitive wild stock pink salmon fry are not specified and could have significant effects on the success of the program. (ESC)

Response: The method used to capture wild pink fry in the intertidal zone employed a modified fyke, a common gear type used to collect juvenile salmon.

Comment: The study proposes tagging coho from Valdez, Esther, and Fort Richardson (for release at Whittier and Cordova) hatcheries, and chinook from Esther Hatchery. These releases are not in oil-affected areas and it will be difficult to link results to oil. (ESC)

Response: These releases will provide a control for releases in oiled areas.

Comment: The evaluation of tag return data uses standard analytical methods, but has little application for determining the effects of the spill. (ESC)

Response: The data obtained from tag returns will allow the catch and escapement of hatchery and wild fish to be determined. This information is needed to evaluate the potential numbers of salmon lost to oil contamination. The results obtained from meeting the objectives of Fish Studies, 1, 2, 3, and 4 all apply to the effects of oil exposure on the same specific stocks of fish.

Comment: Inter-annual and inter-facility survival variation for hatchery stocks has been so large that observed differences will be difficult to interpret. It is unlikely that those differences in survival could be linked to the spill and used for damage assessment, even though the observed survival fits a pattern based on the possibility of effects. (ESC)

Response: The use of multiple tag codes at each hatchery and wild stream allows for information from individual release groups to be compared between hatcheries or within the same hatchery. Observed survival differences can therefore be examined more closely than simply between years or facilities. The use of multiple tag codes verifies the presence of fish in contaminated waters during their early marine life and will also help identify injuries and further link the exposure history to losses in production.

Fish/Shellfish Study No. 4 - Early Marine Salmon

Comment: It is unclear whether studies are presuming organisms were exposed to oil in areas where oil was only visible on the water surface. DOI regulations require confirmation of exposure, and it is not clear how exposure pathways will be verified. (API)

Response: It is not assumed that juvenile salmon captured in oiled areas were exposed to oil. Mixed-function oxidase and hydrocarbon analyses are being performed to determine if organisms were exposed to oil. Experiments will be conducted by the NMFS in 1991 to obtain more information about pathways of exposure and effects on growth.

Comment: The definition of technical terms is inadequate. (API)

Response: This comment does not provide enough information for a response.

Comment: This study does not address issues such as error margins in egg counts and the impact of sampling frequency on fish migration. (API)

Response: Egg counts from the hatcheries are used to estimate the numbers of fry released. This issue is addressed in Fish/Shellfish 3. The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. The effect of sampling frequency will be determined at that time.

Part I

Comment: For objective A, the study assumes all fry released together remain so and grow at a proportional rate. This may be biased if groups of fish from a release move to different habitats or grow at different rates. Nonrandom distribution of sizes along the migration corridor, which is likely, can cause bias. Sampling one segment in an oiled area, and one in a non-oiled area, could lead to incorrect conclusions on relative growth rates. (ESC)

Response: It is not assumed that fry released together remain so and grow at a proportional rate. Fry have been sampled at many sites in both oiled and unoiled areas to minimize any bias resulting from local effects. Analyses of stomach fullness will be used to assess differences in feeding rate in oiled and non-oiled areas.

Comment: Regarding objective B, the study is unlikely to give precise enough data to detect differences in migration speed and patterns caused by oil-related effects. (ESC)

Response: The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. Questions relating to migration speeds and patterns will be addressed at that time.

Comment: No information is given on the method for determining hydrocarbon content in tagged fry captured in 1989. (ESC)

Response: Individual tagged fry were placed in clean glass vials immediately after capture. They remained in these vials until shipment for hydrocarbon analysis. Mass spectrophotometry is used to estimate hydrocarbon content. The ratio of the metals vanadium and nickel is used to identify oil from the *Exxon Valdez*.

Comment: The methods used to determine growth, migration paths, and migration speeds are imprecise and based on assumptions regarding behavior and swimming speed that are likely to be invalid. The variability of these estimates will be too great to determine changes caused by EVOS. (ESC)

Response: More precise estimates of fry growth will be obtained from otolith microstructure analysis. The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. Questions relating to migration speeds and paths will be addressed at that time.

Comment: Differences in migration distance and patterns will be analyzed with ANOVA, but no information on how these parameters will be quantified is given. They are likely to be highly variable and of marginal use for evaluating spill-related effects. (ESC)

Response: The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. Questions relating to migration distance and patterns will be addressed at that time.

Comment: Migration rate estimates will be influenced by the sampling frequency. Insufficient information is provided to evaluate the appropriateness of this method. (ESC)

Response: The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. Questions relating to migration distance and patterns will be addressed at that time.

Comment: There is no indication of how differences from geographical effects will be separated from effects due to presence of oil, where the primary definition of oiled and unoiled is based on geography. As most of the oiled areas occur in one part of the Sound and the unoiled in another, factors other than history of oil exposure would affect the variables measures. (ESC)

Response: Fry have been sampled at many sites in both oiled and non-oiled areas to minimize any bias resulting from local effects.

However, it is recognized that geographic effects confound oil effects. A bioenergetics model, multiple regression techniques, and analyses of stomach fullness will be used to evaluate growth conditions in oiled and non-oiled areas. All available data on environmental conditions in oiled and non-oiled areas will be used in these analyses.

Comment: The study design introduces a stock-related bias that is not controlled or tested. There are potential stock-area interactions that are not controlled or tested. (ESC)

Response: Repeated measures analysis of variance will be used to determine if there are differences in fry growth among tag lots. Data from tag lots that are not significantly different will be pooled into groups. Comparisons of growth between oiled and non-oiled areas will be made within these groups. Refer to the previous comment/response for a discussion of area effects.

Comment: The methods for injury determination are weak: they consist of testing for growth differences, migration speed, migration distance, and migration patterns between oiled and unoiled areas. The criteria used to define oiled and unoiled are not given. The definitions of growth, migration speed, distance, and pattern are not given or are deficient. (ESC)

Response: Results from mixed-function oxidase and hydrocarbon analyses of fry will be used to determine the level of oil exposure of fry in different areas. This information will be compared with all available data on hydrocarbon contamination in the environment. Cumulative growth will be estimated by regression of final body weight on time for fish within tag lots or groups. Growth of individual fry over short time periods will also be estimated from otolith microstructure analysis. The applicability of a Maximum Likelihood Estimator of fish migrations will be determined. Questions relating to migration speed, distance, and patterns will be addressed at that time.

Part II

Comment: The detailed measurements and analyses to evaluate effects on abundance, distribution, habitat utilization, size, growth rate, feeding habits and migratory behavior are governed by the appropriateness of the field sampling program. This program may not have adequately included geographic effects or other natural variabilities. (ESC)

Response: The investigators considered geographic variation and other natural variabilities. Study sites were chosen to minimize geographic differences while maintaining the treatment difference of oiled versus unoiled sites. Environmental parameters were monitored at each site to determine the extent of physical differences.

Comment: The abundance and distribution of copepods is dependent on factors other than oil, which are not addressed sufficiently to determine species abundance or distribution in a statistically significant manner. (ESC)

Response: Sampling to evaluate the effects of sediment contamination on harpacticoid copepods in 1990 was designed to reduce geographic variability by comparing heavily oiled and lightly oiled beaches within the same contaminated embayment. Substrate composition and algal coverage, as well as sediment hydrocarbon contamination, were quantified at each transect to determine their effects on the observed numbers and species composition of copepods. Procedures for collection were consistent across all sampling locations.

Comment: The abundance and distribution of meiofauna is dependent on factors other than oil, which are not addressed sufficiently to determine species abundance or distribution in a statistically significant manner. (ESC)

Response: The meiofauna recolonization experiment is a field-manipulative study involving azoic sediments that have been quantitatively contaminated with crude oil. Control and treatment sediments were randomly placed along the same beaches. Any differences observed in recolonization among treatment levels can thus be directly attributed to oil contamination.

Comment: Insufficient information is given to evaluate the appropriateness of the sampling frequency, which will influence the estimates of migration rates. (ESC)

Response: Coded-wire tagged juveniles represent groups of fish released at specific locales and times. Recoveries of these fish yield information on average rate of movement and general direction of movement within and between habitat types.

Comment: The comments made above in Part I regarding stock and location effects that are not controlled by this study design also apply to Part II. (ESC)

Response: The investigators considered geographic variation and other natural variables. Study sites were chosen to minimize geographic differences while maintaining the treatment difference of oiled versus unoiled sites.

Comment: The study design does not indicate that variables that affect biota or biological endpoints are being considered when establishing a cause and effect attributable to oil. (ESC)

Response: The investigators considered natural variables. Environmental parameters are monitored at each site to determine the extent of physical differences. The study design selected oil and control sites in comparable habitat areas to minimize the effects of other variables.

Fish/Shellfish Study No. 5 - Dolly Varden Char and Cutthroat Trout

Comment: The Trustees will not be able to attribute differences in survival or growth to oil. The assumption that the differences in average growth rate are attributable to an external disturbance assumes that pre-spill growth and survival rates were similar in both control and treatment streams and any differences are entirely caused by spill-related effects. Natural variability or geographical differences are not considered. (ESC)

Response: It is important to point out that fish were sampled before any potential exposure to an oiled marine environment since the Dolly Varden and cutthroat trout were overwintering in freshwater when the oil spill occurred. Given this, the first sample from each stream (the emigration during 1989) provides the baseline data for stocks in control and oiled groups. These data indicate mean-length-at-age was similar among control and oiled groups which indicate that fish of the same size grow at the same rate regardless of their overwintering location. Since overwintering populations of Dolly Varden and cutthroat trout are composed of many genetic stocks and the ambient climates in the experimental areas of PWS are similar, differences in average growth rates were not expected. Therefore, large differences in average growth rates between control and oiled groups would be attributed to some external disturbance so long as initial size of fish is corrected for.

We do not have a direct measurement of pre-spill survival rates among the treatment groups but since the mean-length-at-age were similar between control and oiled groups this would indicate that survival rates were probably similar. If one of the treatment groups had higher survival rates a greater difference in the mean-length-at-age would be expected and in particular in the older age classes (age 4 and older) but this was not the case.

The experimental design, which includes replicate sites in both treatment groups, **does** take into consideration both natural variability and geographical differences. The study tests for differences in growth and survival between treatment groups only with tagged fish. The analysis tests to see if the differences in growth and survival are greater between control and oiled groups than differences within each treatment group.

Comment: There are no baseline data to show populations in all study areas had equal growth and survival rates prior to the spill. (ESC)

Response: See the preceding response.

Comment: Differences in survival and growth rates are likely due to natural differences. There is no indication of how results will be analyzed to show a link between the oil spill and survival or growth differences. Data are not being gathered to analyze for spill-related effects. (ESC)

Response: See the preceding response.

Fish/Shellfish Study No. 11 - Herring Injury

Comment: It is necessary to account for natural variables that would give the same results when estimating the proportions of dead herring eggs from oiled areas. (API)

Response: It is because of the natural variables that control sites are included with the same treatment (depth and replicate level) parameters as the oiled sites.

Comment: Estimates of biomass often have sampling errors. (API)

Response: Sampling errors can be measured using the sampling techniques employed in the study and an accuracy goal (± 25% of the true mean, 95% of the time) has been met for the 1989 and 1990 biomass estimates.

Comment: The herring season yielded over 8300 tons in a 20-minute season, a record catch rate. Since herring do not die after spawning, living to spawn in several successive years, most of the 1990 spawning population was present in PWS in April 1989 when potential exposure to oil was greatest. As the 1989 herring season was closed, the harvestable surplus was not taken, resulting in a larger fish population in 1990. This should have decreased fears of an impact on population, and resulted in reductions to the study program. (ESC)

Response: Much of the study is designed to measure the sublethal impacts (effects on egg production, larval survival, possible metabolic affects due to ingestion of oil, etc.), that proved to be significant in 1989. The sublethal impacts occurring from exposure of eggs, larvae, juveniles, and adults could affect populations for many years and affect egg survival of the 1990 production year. As a result, the study was continued to enable researchers to further define the potential impacts (complicated by sublethal impacts) and to further refine results analyzed from 1989 and 1990.

Comment: It is very unlikely that the determination of biomass to within ± 25% of the true value, a goal of objective 1, will provide the sensitivity to determine the impact of EVOS. (ESC)

Response: The biomass estimate may be utilized to examine the effects of EVOS on a population level, and if this were the only tool available to determine impacts, the above statement would be true; natural variability may mask some subtle impacts. However, this is not the only tool being employed to measure impact and, as stated in previously released results, sublethal impacts have been observed in early life stages of herring.

Comment: The oil level information from maps and analyses of mussel tissues does not represent hydrocarbon exposure of herring in PWS, and will not be useful in determining any impact from EVOS. (ESC)

Response: The Trustees disagree. Mussels are recognized in scientific literature as indicators of oil contamination. Additional analyses on herring will confirm effects of oil exposure of herring.

Comment: Mortality of eggs in the field is a function of density dependent survival and natural factors. The goal of objective 4 appears to be the development of egg loss information for better management of herring. (ESC)

Response: One of the goals in the study is to insure the accuracy of the spawn deposition biomass estimate. Since the egg loss factor is directly tied to biomass improvements in the egg loss factor and development of an associated error will result directly in improving the accuracy of the biomass estimate. The fact that it will improve herring management is incidental to the determination of injury and may aid in future restoration of the herring stock.

Comment: The evaluation of embryonic and larval tissue for MFO is an experimental technique which is variable depending upon season, life stage, food type, etc. Impact assessment should not be used to develop experimental techniques. In 1989 NOAA found that DNA/RNA ratios did not provide significant endpoints, and there was no need to repeat this effort in 1990. (ESC)

Response: Use of MFO analysis has been demonstrated in the literature as a viable technique to document hydrocarbon exposure. Use of this technique has been recommended by expert peer reviewers.

Comment: The field methods indicate that the unacceptable ± 25% biomass estimation could be compromised by logistical problems. The Plan indicates that this work augments the ability to manage the resource so that EVOS damage can be predicted. This does not fall within the purview of NRDA damage assessment. (ESC)

Response: The Trustees disagree with this comment. Management of a potentially injured resources can only be done wisely with improved resource knowledge. As management of the resource hinges on the injury that may have occurred, augmentations of management techniques to aid in determination of injury are not only essential, but fall within CERCLA guidelines, and are economical.

Comment: The biomass to be estimated in 1990 will not include the fish that are the product of 1989 egg production. The plan provides that there were no significant 1989 adult mortalities. Thus, biomass estimation is necessary for herring resource management but has little to do with EVOS impact determination. (ESC)

Response: While adult mortalities may not have been documented, there may have been significant sublethal injuries to adults including: reduced reproductive potential, lower egg survival, and genetic aberrations to adults' tissues, including reproductive tissues. Further injury may be minimized through management adjustments, which is why accuracy in the biomass estimate and forecasted biomass is essential.

Comment: An estimation of fecundity is included, but the literature provides no evidence of fecundity effects on adult fish from one acute exposure to hydrocarbons. (ESC)

Response: The Trustees believe that there is a substantial scientific basis for estimation of fecundity. Some Literature shows that not only are eggs resorbed in exposed adult females, but oocyte-loss can be measured and quantified. In addition, there is no evidence that adult herring in PWS received "one acute exposure;" for example, Knight Island was heavily oiled, and it is possible that in 1989, adult and juvenile herring in this area were repeatedly exposed to various levels of toxic hydrocarbons. Samples of adult tissues, including sac roe collected in 1989 and 1990, may reveal sublethal injury.

Comment: The measurement of growth will be unable to discriminate differences with regard to EVOS. Growth is simply a parameter necessary for better management of herring. (ESC)

Response: Exposure of herring larvae to oil in the laboratory impedes growth which is a quantifiable injury. Whether differences could be detected in the field can only be answered by processing samples RNA/DNA. The RNA/DNA analyses have been run and future analyses to determine growth are not necessary. Knowledge of larval growth, using RNA/DNA techniques is not necessary for better management; growth in adults is measured during standard AWL sampling in the spring which is not funded by NRDA monies.

Comment: Herring exhibit density dependent survival. There is no relationship between herring spawning biomass and later recruitment, so the death of eggs is meaningless in this study. (ESC)

Response: The Trustees disagree. In a year where density dependent factors do not interfere and a cohort from a hatch will become a large part of the biomass in four years, oil exposure has the potential to inflict significant injury to that cohort and resulting returning biomass. There is no proof that the 1989 cohort would not have contributed significantly to the future biomass whether or not the stock was impacted. Therefore, the study was necessary to discover the potential impacts and to aid in possible restoration planning. In addition, death of eggs, whether from a strong recruiting cohort or not, is significant to PWS food chains, because herring are a prime link in the ecological chain in the Sound every year.

Comment: The statistics appear to be aimed toward the development of models with which to manage herring, rather than to detect impact attributable to EVOS. (ESC)

Response: The Trustees disagree. Statistical models are designed to address population injuries. Any management benefits are serendipitous.

Comment: The methodology focuses on modeling the population based on the number of eggs laid. The size of the 1989 year class will be estimated and compared with what it might have been based on measurement of 1989 egg loss. This may be impossible, as egg numbers do not equate directly to fish numbers. Number of eggs spawned will explain only a portion of the variation in abundance among brood-years, due to density dependent survival. (ESC)

Response: Estimation of eggs laid is used to back-calculate the year's spawning adults, not to predict the return from the eggs laid. Since fecundity, density of spawn, and extent of spawn are all well known, numbers of adults can be back-calculated using an estimated egg loss component, with relative accuracy. It is from the spawn biomass estimate that the next year forecast is made employing age dependent natural and fishery mortality components in the model. In addition, other models, such as catch-age analysis, are currently being employed to compare various estimation models and to provide an index of accuracy.

Fish/Shellfish Study No. 13 - Clam Injury

Comment: It is unlikely that objectives A-D will be attained, as the study design greatly underestimates the natural variability in all the biological and chemical parameters that will be measured, although the available literature on the effects of oil on intertidal clam populations is considered. (ESC)

Response: Incremental growth data (both pre-and post-spill) will be available for comparison of the growth rate by site.

Comment: The field sampling strategy is flawed. Hydrocarbon analysis is done on sediments and clams collected from the lower intertidal zone along transects oriented perpendicular to the shore. As samples are composited into single samples, gradients of chemistry and biological response at different shore levels are obscured, and sample variance is increased. (ESC)

Response: Due to the need to take samples in triplicate, it was deemed prohibitive to take triplicate sediment samples at each tide height that was sampled.

Comment: Except for the largest site differences, the amount of sample replication at each site may be insufficient to detect statistical differences. Differences due to natural causes will be difficult to distinguish from those due to oiling. (ESC)

Response: Stepwise regression using level of oiling, tide height and incremental growth will help distinguish natural effects from oil effects.

Comment: Necropsy analysis is improperly applied to mean histopathological examination. Necropsy would be unlikely to yield useful information. (ESC)

Response: The term "necropsy" will be changed to "histopathology" in appropriate studies.

Comment: Methods used to count live and dead clams are invalid. As it is usually impossible to estimate accurately how long dead shells have been in sediments, the presence of dead shells cannot be used to estimate the number of clams killed by the oil spill or later cleanup effort. (ESC)

Response: The enumeration of dead shells is only one method for possible differences between oil impact levels.

Comment: As the parameters measured are variable over small temporal and spatial scales, it will be difficult to characterize the baseline condition. Quantification of injury from the spill or later cleanup efforts may be difficult. (ESC)

Response: Characterization of the baseline growth rate in clams is accomplished by measuring annuli which are retained.

Comment: As background histopathology is poorly understood, it will not be possible to link any observed effects with EVOS. Relationships have not been established between observed histopathology and oil-related effects on the survival potential of natural mollusk populations. The significance of observed effects is questionable. (ESC)

Response: Histopathology results must be linked with data on the level of oiling in sediments, growth rate prior to the spill and growth rate after the spill.

Fish/Shellfish Study No. 15 - Spot Shrimp Injury

Comment: Estimates of biomass often have sampling errors. (API)

Response: This study does not attempt to estimate biomass.

Comment: The shrimp study focuses on the changes in individual organisms, rather than in the population. For this type of organism, without a demonstrated effect on a population, no injury should have occurred. (API)

Response: The study in 1991 is focusing on potential differences in the 1991 year class, not individuals.

Comment: Objective D are the study will test the hypothesis that hydrocarbon levels are not related to site contamination levels. The methods do not give procedures for collecting water/sediment samples to define the level of contamination at a site. (ESC)

Response: The two oiling categories are based on the initial path of the oil spill. The study has not continued to document oiling in the environment because the project assumes only an impact to the 1989 year class, which was in the water column at the time of the oil spill. The 1989 year class settled to the bottom in mid 1989.

Comment: For objective E, the methods do not describe what is meant by injury to tissues, what tissues will be studied, or how injury will be determined. (ESC)

Response: If hydrocarbon testing indicates exposure, then whole shrimp samples will be submitted for histopathology.

Comment: There is no documentation that selected control sites are sufficiently similar to test sites for baseline production of shrimp, and other environmental factors that could affect the results of the study. Aside from CTD water column profiles, there is no indication that environmental data will be collected. (ESC)

Response: The major focus of this study for 1991 is to determine if a difference can be detected between the two oiling categories for the 1989 year class. CTD water profiles are collected during each sampling period. The bottom salinity, temperature, and dissolved oxygen will be compared between oiling levels.

Comment: The oiled test sites have varying degrees of exposure to floating and stranded oil. The criteria given for selecting impact and control sites, and how those sites chosen will be documented for specific levels of oiling or exposure, is insufficiently explained. (ESC)

Response: The path of the oil spill was initially documented by aerial surveys. For the purpose of this study, sites were chosen as either oiled or unoiled based on surface oiling. No attempt was made to document the degree of oiling.

Comment: The shrimp pots described are designed to catch adult shrimp of commercial market size and are inadequate for the objective of determining if the 1989 year class had a high mortality rate in areas of high oil impact. (ESC)

Response: The shrimp pots utilized in this study capture male, transitional, and female spot shrimp. Occasionally juvenile shrimp are captured, however they are not fully recruited to the sampling gear. To determine if the 1989 year class was impacted, the year classes are separated using modal analysis. For the purpose of this study there is a lag between the time of capture and full recruitment for the 1989 year class. Alternative methods to capture shrimp smaller than 20 millimeters have not been developed.

Comment: How samples for hydrocarbons and fecundity will be handled and preserved in the field to ensure sample quality and integrity are maintained until analysis in the laboratory is not revealed. Chain of custody and QA/QC procedures are not discussed. (ESC)

Response: Samples for fecundity are frozen on board the research vessel. Each fecundity sample has a unique sample label, which accompanies the sample. The label identifies the location where the shrimp was captured. Upon return to port, the samples are transferred to a freezer at the Alaska Department of Fish and Game facility in Cordova. All hydrocarbon samples are maintained under strict QA/QC guidelines as established by the management ream. This includes chain of custody.

Comment: Except for tissue hydrocarbon measurements, no information is given as to what criteria will be applied for attributing differences to oil and what level of effects will be tested. (ESC)

Response: In addition to tissue hydrocarbon measurements, histopathology may be conducted if hydrocarbons are present. Significant differences in fecundity, egg mortality, catch per unit effort, and year class strength will be compared between the levels of oil impact.

<u>Comment</u>: The probabilities of statistical Type I and Type II errors are not given. The sampling effort may not be appropriate to meet statistical analysis objectives. (ESC)

<u>Response</u>: The probabilities of 0.05 and 0.10 for Type I and Type II errors respectively are given in the "Methods" section of this study plan. Technical experts and statisticians have determined the sampling level that is appropriate and adequate to meet this study's objectives.

<u>Comment</u>: The number of individuals required per sample, as well as the interpretation of the results, will vary greatly depending upon what is sampled for tissue hydrocarbon analysis, which is not sufficiently described. (ESC)

<u>Response</u>: The objective of this comment is not clearly stated. The types of tissues being tested are muscle and egg. The types of hydrocarbons for which these tissues are being examined are listed in Appendix A. The number of specimens to be examined was determined, as noted above, by technical experts and statisticians.

<u>Comment</u>: There is insufficient information regarding the method for treating composited samples for hydrocarbon analyses in the analysis of results. (ESC)

<u>Response</u>: The tissues contributing to a composite sample are pooled prior to processing, thus the resulting values obtained refer to the entire composite sample rather than to any component of it.

<u>Comment</u>: Inadequate information is provided to determine what statistically significant differences will be detectable within the study design. (ESC)

<u>Response</u>: The differences the study is designed to detect, if they exist, are listed in the objectives of this study plan.

<u>Comment</u>: The objectives and methods do not indicate the study will lead to a quantification of the baseline condition, the level of injury, the variance of degree of injury in space, the length of time over which injury will persist, the likelihood and rate of recovery, or the link between EVOS and the injury. There is no indication that an exposure pathway will be documented. (ESC)

Response: Quantification of the baseline condition of the population was not an objective of this study. However, the study does attempt to assess the survival of the 1989 year class of spot shrimp that was in the water column as zoea larvae at the time of the oil spill and to view survival of this 1989 year class in the context of year class survival both pre- and post-spill. The study will also assess the survival of the 1989 year class in oiled and unoiled areas.

Fish/Shellfish Study No. 17 - Rockfish

Comment: This study is not consistent with the exposure requirements for conducting natural resource studies. (API)

Response: The Trustees disagree.

Comment: Ocean floor studies should be done only when there is data showing high concentrations of oil and a long residence time. If such data exists, it has not been made available. (API)

Response: Hydrocarbons were found in rockfish species that dwell on or near the bottom. Therefore these studies are appropriate. The aspects of the study involving sediments and sessile organisms were warranted to help determine route of contamination based on presence of hydrocarbons in bile from demersal rockfish.

Comment: The presence of hydrocarbons does not presumptively indicate injury. Evidence of the causality of the oil to injury must be shown. (API)

Response: Presence of hydrocarbons in organisms in treatment and not in control sites warranted efforts to determine presence or absence of injury. Further studies, specifically histopathological evaluation and MFO sampling, will help in establishing injury.

Comment: The study methods and data analysis sections do not describe how objective C, toxicological analyses of effects on growth and reproduction, will be conducted. (ESC)

Response: This portion of the study has been discontinued for 1991.

Comment: Objective D, the determination of the feasibility of using microstructure to evaluate depressed growth from oil contamination, implies an experimental technique of a research nature. (ESC)

Response: Use of otolith microstructure to show environmental stress is a proven technique. The feasibility aspect of this study is to ascertain its applicability to showing stress relative to the oil spill.

Comment: The reference to Rosenthal which cites seasonal variations in abundance in nearshore habitats contradicts the premise that demersal rockfish complexes have a high degree of fidelity to their habitat and are relatively sedentary. The study of reef habitats for histopathological and other long term effects may be invalidated by mixing of populations. (ESC)

Response: Rosenthal's study involved species counts using underwater transects. In that reference Rosenthal attributes changes in abundance and species composition species disappearing or becoming more secretive. This, in light of other studies, (especially Carlson and Barr, 1977), indicates that demersal species go into hiding during the winter months rather than leaving the area. Pelagic species will move into deeper waters.

Comment: Sampling locations are not identified, and the criteria for choosing sites does not indicate adequate scientific control or baseline determination. It is not clear whether the test sites are representative of the entire resource. The appropriateness of sampling sites as controls and test sites cannot be evaluated adequately, particularly regarding other important variables, such as other sources of petrocarbons. (ESC)

Response: Sample sites and selection techniques were identified in the methods section.

Comment: Sampling design is inadequately addressed and biased to improperly sample target fish species. (ESC)

Response: Demersal rockfish, specifically yelloweye rockfish, were being specifically targeted because during 1989 they were the species which were found dead immediately after the spill and also showed elevated hydrocarbon levels in the bile. The sampling design was not designed to get a random sample but directed to get a representative sample of the demersal fish at each site.

Comment: The level of effect from EVOS which will be tested for, and the probabilities of making Type I and Type II errors are not specified with respect to experimental design, sampling strategies and statistical significance. (ESC)

Response: The level of effect for our hydrocarbon analysis with a sample size of 40 fish in the treatment group will allow us to detect a difference of 20% with the probabilities of type I and type II errors of .05 and .2 respectively. The histopathological samples with a sample size of 60 fish will allow us to detect a difference of 15%.

Comment: The appropriateness of sample sizes specified cannot be evaluated. (ESC)

Response: See answer to previous comment.

Comment: How the different levels of variability (geographic, oiling, and reef communities) will be handled in the analysis is not explained. (ESC)

Response: The Trustees are not trying to account for different levels of oiling, but determining the presence or absence of hydrocarbons.

Comment: How samples for hydrocarbons and fecundity will be handled and preserved in the field to ensure sample quality and integrity are maintained until analysis in the laboratory is not revealed. Chain of custody and QA/QC procedures are not discussed. (ESC)

Response: Sample handling and chain-of-custody procedures were discussed in the methods section.

Comment: Bile, which is non-specific to hydrocarbon source and may be subject to interference by exogenous and endogenous compounds, cannot be analyzed to determine whether EVOS hydrocarbons are present in demersal rockfish. (ESC)

Response: The hydrocarbon analysis may be non-specific, however the presence of hydrocarbons in bile, in concert with other results, may lead to the conclusion of contamination by EVOS.

Comment: Tissue analysis to detect EVOS hydrocarbons is questionable due to the efficient, and possibly selective, metabolic functions in fish. (ESC)

Response: The primary indicator of exposure to hydrocarbons is bile. Other tissues will be analyzed only if results of bile analysis indicate further investigation is necessary.

Comment: Specific techniques for determination of hydrocarbons in sediments and tissues are inadequately described. How contamination will be defined and determined is not stated. (ESC)

Response: All samples for hydrocarbon analysis were sent to Auke Bay NMFS laboratory for analysis on site or through sub-contractors.

Comment: It is unclear how descriptions of otoliths are to be interpreted. It is not possible to determine how otolith-derived age composition and mean length-at-age data are to be used. (ESC)

Response: Otoliths and length data are collected as ancillary information to better describe the organisms being sampled.

Comment: The objectives and methods do not indicate that this study will result in a quantification of injury to resources. The objectives are split between documenting exposure and identifying aspects of injury. There is no indication that damage will be assessed beyond testing the statistical significance of its occurrence, or will be related to EVOS. (ESC)

Response: This study is designed to produce a qualitative assessment, rather than quantitative assessment.

Fish/Shellfish Study No. 27 - Sockeye

Comment: Studies appear to penalize potentially responsible parties for the increase in pink salmon population to the level which would occur without commercial fishing. That more fish is an injury defies common sense, and appears to be utilizing damage assessment in a manner inconsistent with Congress's intent. No evidence is cited which proves injury to spawning habitats, or elsewhere, resulted from the elevated population. (API)

Response: This is a sockeye directed project and the intent is to investigate the potential damage of sockeye overescapements to future sockeye production and to lake (freshwater) ecosystems where spawning and rearing occur. Given the sockeye salmon life-history (5-7 years), the evaluation of injury will be derived from studies being conducted in this and subsequent years.

Comment: This study does not account for the State's management of this ecosystem. Overescapement is the result of fishery management practices. Thus, this is not an EVOS impact assessment study. Measures could have been taken in anticipation of injury caused by the closure of commercial fisheries, such as the use of weirs, to minimize effects. These measures would have been less invasive than those found in other fish studies. Studies should evaluate the impacts, if any, of historic management practices. (API, ESC)

Response: Overescapement is the result of not being able to harvest adult sockeye in traditional fisheries because of the presence of EVOS oil on the fishing grounds.

Comment: Evidence may exist that shows that salmon population levels have been artificially deflated by commercial fishing. The increase in salmon population should not be assumed to be injury, as positive effects are seldom injurious. (API)

Response: A basic tenet in the management of pacific salmon (all species) is that escapements beyond a specific level results will decrease numbers of adults in future populations. It may be true that sockeye production in some systems has been limited by heavy fishing pressure. However, the evidence for the sockeye systems being studied here is that escapement levels consistent with established goals will produce the greatest yields.

Comment: The study methodology does not provide data useful for correlating oil exposure with any potential observed fishery effects. (ESC)

Response: Sockeye salmon overescapements were caused by the lack of fishing pressure on the stocks due to the presence of oil on the fishing grounds. With the inclusion of non-impacted study sites, potential fishery effects can be factored out.

Comment: The determination of number, age, and size of sockeye salmon juveniles is selected freshwater systems is of marginal use in determining EVOS injury as no oil reached this freshwater spawning habitat. (ESC)

Response: Oil did not directly reach this spawning habitat, but may have reached the spawning grounds through contamination of adult fish. However, the main objective of this study is to document injury as the result of overescapements. These freshwater ecosystems are very oligotrophic and large numbers of predatory sockeye juveniles can disrupt the entire food chain of these lakes. Once disrupted, the food chain is difficult to restore, e.g., lost species of zooplankton.

Comment: The field methods were developed to perform fisheries research unrelated to EVOS. (ESC)

Response: The field methods employed in the EVOS related fisheries projects were, in large part, developed in research projects totally unrelated to the EVOS. This project uses those methods proven to be scientifically accepted.

Comment: The determination of injury in this study has no relation to EVOS. (ESC)

Response: The Trustees disagree. The injury to the freshwater ecosystem as the result of sockeye salmon overescapements may be linked to the EVOS.

Fish/Shellfish Study No. 28 - Run Reconstruction

Comment: There should be a modeling effort comparable to the one proposed in this study to assess damage to other components of the ecosystem. (UM)

Response: Pacific salmon support immense commercial, sport, and subsistence fisheries, and, for this reason, their life histories and population dynamics have been exhaustively studied for the past century. It is only because of this historical information that the run reconstruction study is possible. The governments intend to determine injury to the rest of the ecosystem and to restore these other components.

Comment: The salmon population dynamics in PWS indicate that the status quo is not stable, but transitional. Since even obvious factors affecting salmon population dynamics are not fully understood by area fisheries managers, it will not be possible to provide the input to describe the subtleties of historical population dynamics. (ESC) The effects noted as oiling values for parameters consider only negative values. (ESC)

Response: This comment is not clear. However, using the run reconstruction model to estimate catch and escapement counts in the absence of the oil contamination, the effects of the spill will be determined by the difference between these estimates and the observed catch and escapement counts.

Comment: The comprehensive timing model of Schnute and Silbert (1983) may not represent the salmon dynamics of Prince William Sound. (ESC)

Response: The timing model of Schnute and Silbert was developed for a terminal fishery. The PWS study deals with several stocks, which will add another dimension to the model. Using the historical tagging data, the study will obtain estimates of district-to-district transition probabilities for each stock, allowing the addition of the Markovian exchange process to the timing model (Hilborn, 1989).

Comment: Testing the model parameters against a single year class will not be adequate to prove that the model works. (ESC)

Response: There exist thirty years of catch, fishing effort, and escapement data that can be used not only to fit the model, but also to evaluate its effectiveness. Moreover, simulation is also a commonly used technique in evaluating a model's effectiveness.

Comment: The model and the input data are not sufficiently described to determine if this modeling procedure is technically sound. It is necessary to know what EVOS effect the model is intended to detect and the Type I and Type II errors expected. (ESC)

Response: The references of Schnute and Silbert (1983) and Hilborn (1990) outline the timing model and procedures for obtaining maximum likelihood transition probabilities from tag recoveries. The study plan outlines how the two techniques will be combined for the PWS run reconstruction.

The model will provide estimates of the catch and escapement counts in the absence of the spill. Obtaining any probablistic confidence in these estimates (type I and type II errors of a hypothesis test, for example) will have to be done through simulation. Only until we have developed the model can we evaluate it.

Comment: The utility of models such as this is to provide a range of possible future conditions. Such models lack precision. Managers have had the data necessary to construct similar models for years, and have not done so due to their limited validity and application. (ESC)

Response: On the contrary, these models can be effective in environmental assessment and decision making. The models require an enormous data base source, a comprehensive understanding of the dynamics of the phenomenon to be modeled, and the latest in numerical software and computer hardware. This modeling effort will use publications of this past decade for its mathematical foundation and will utilize the thirty years of catch, fishing effort, escapement, and tag recovery data that is available.

Comment: The Plan states that these models will be useful for establishing harvest policies and for allocating fishing activities among areas and times. The investigators' approach appears to focus on the development of data for guiding fish allocation policy decisions and not on NRDA impact assessment. (ESC)

Response: The inspiration for the development of this model is for NRDA impact assessment. Once the model is built and the database developed, it can be used for future management decisions.

Fish/Shellfish Study No. 30 - Salmon Database Management

Comment: There is no timetable for accomplishing this study, and no explanation of the need for it in light of the salmon database management tasks being undertaken in Technical Services 3. (UM)

Response: Technical Services 3 provides a geographic information system. This project develops a biological database, and should terminate within one year after completion of field data collection and completion of laboratory analysis.

Comment: Although described as a study, the objective of this program is to develop the computing capacity and facilities to manage historic and spill-related data for the Trustee Council's efforts in the Fish/Shellfish area. The construction of a database system to maintain both historical and spill-related data does not fall within the purview of the NRDA regulations, nor does the structural facility to house that database system. (ESC)

Response: Development of the database is necessary for analysis of data collected in NRDA field projects. The hardware required by this project is limited to that necessary to accomplish the work.

COASTAL HABITAT

Comments on Coastal Habitat Studies

Phase I

Comment: The description of Phase I does not include enough information to ascertain whether the study has been designed to be statistically valid or how extrapolation from specific stratified random sample sites to all possible sites in a given category can be accomplished. (ESC)

Response: The objective of the 1990 plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study. Statisticians have been consulted during the plan development to ensure that appropriate statistical designs are followed to allow for extrapolation.

Comment: No criteria for understanding how potential study sites were ground-thruthed have been included in Phase I. (ESC)

Response: As stated on pages 11-12 of the 1990 plan, the potential study sites were visited by coastal habitat personnel examining the sites' physical and biological attributes to verify their appropriateness as a matched pair to respective oiled or control sites.

Phase II, Part A

Comment: The study design of Coastal Habitat 1 does not permit the Trustees to estimate chronic or sublethal effects, particularly in fish. (NWF)

Response: The coastal habitat study is designed to measure sublethal effects to the intertidal fauna and flora considering such factors as mussel reproduction, intertidal fish parasitism, respiration, and growth.

Comment: This is one of the most important studies of the whole plan, yet it has improved only marginally in detail from 1989. The description of the study plan indicates that analysis of the 1989 samples was not sufficiently complete to be used to modify the 1990 sampling plan. Considering the funds expended, this is reprehensible. (UM)

Response: Sufficient analysis of the 1989 field samples was completed before the 1990 field work began. The study was modified to reflect the results of this analysis, including the pairing of sites, the selection of new study sites, and the addition of site-specific biological experiments.

Comment: Hydrocarbon analyses of plant and algal materials is still lacking. It is impossible to tell if productivity of subtidal plants and algae is being assessed. (UM)

Response: Due to the large number of field samples, the process of hydrocarbon analysis is taking a long time to complete. This information is being analyzed together with field measurements to determine the direct and indirect effects of oil, and the effects of cleaning on plant survival and productivity.

Comment: Although in the study description it is stated that an "integrated ecosystem approach" will be stressed, only lip service is given to assessment of the functioning of the ecosystem and potential for trophic transfer of contaminants. From the information presented it is impossible to tell if this will be accomplished. (UM)

Response: The coastal habitat study is founded upon an ecosystem approach to determining injury. By examining biotic and abiotic links within coastal habitat zones, and by providing information to those responsible for other damage assessment studies, it is expected that a comprehensive, ecosystem-wide determination of injuries may be established. A synthesis process integrating appropriate resources has been initiated.

Comment: The bibliography supplied is very dated in most cases, and the relevancy of the references chosen is somewhat questionable. (UM)

Response: The 1990 study plans included bibliographies of only selected literature; moreover, the quantity of literature pertinent to cold northern climates is sparse. A complete listing of appropriate literature is being assembled and likely will be made public.

Comment: This study may be continued in an attempt to document recovery of areas where significant effects are observed. Clearly, this and other studies where significant effects of the EVOS are observed should be continued at least until some estimate of the recovery period can be made. (UM)

Response: Coastal habitat data collection is scheduled to be conducted over a three-year period that began in 1989. Several samplings per year are being collected to assess potential injuries and recolonization (recovery) rates of intertidal flora and fauna.

Comment: Some measure of both aerobic and anaerobic carbon cycling, such as respiration and sulfate reduction, should be made to assess potential effects of the EVOS on energy flow in these systems. (UM)

Response: These measures are beyond the scope of the coastal habitat study.

Comment: There is no way to determine whether the study's objectives will be met. Without adequate description, it is impossible to tell whether results can be extrapolated to other sites exposed to oil. (API)

Response: The objective of the 1990 plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study and the interrelationships between studies, and the scope of the overall damage assessment program. The Trustees believe there is sufficient information provided for that type of review.

Comment: Although the Coastal Habitat Study claims to be following an ecosystem approach, the level of detail provided makes it impossible to determine how well this will be accomplished, and to what extent community structure or function will be addressed. (UM)

Comment: The damage assessment section has been significantly expanded from the 1989 plan, but the information is still inadequate to determine how well injury will be assessed. (UM)

Comment: The Coastal Habitat study fails to recognize the findings of the Net Environmental Benefit Analysis, which indicates that oil-impacted areas are recovering. (ESC)

Response: The 1990 study has again been reviewed extensively by appropriate experts for design and cost-effectiveness and, where appropriate, has been revised accordingly. We have reviewed the findings of the Net Environmental Benefit Analysis and have incorporated any applicable findings into the study design.

Comment: Much of this year's work will be the "analysis of samples obtained in 1989." In 1989 "specific methods" were developed for each component of the study, but are listed by title only. Most of these are very procedural, ("locating quadrants, sample identification and chain of custody, sample storage and identification", etc.), somewhat generic, and necessary for any study. Usually, this information would appear in the QA/QC plan, which were not, other than the analytical chemistry and histology groups, submitted as part of either the 1989 or 1990 plans. Only a few titles in this list indicate what type of data they are generating. (UM)

Response: The work performed in 1990 involved the completion of a limited amount of sorting and analysis of 1989 samples, and the collection and initiation of sorting and analysis of 1990 field samples. A detailed study plan of data analysis, collection techniques, and QA/QC standards was not included because the plan is aimed at providing a summary of individual studies adequate for reviewers to understand the general scope of the studies, and the interrelationships between studies.

Comments: To be reviewed adequately, the "Specific Methods" developed for this study would have to be available to qualified experts. (UM)

Response: The specific methods in the coastal habitat study may produce results used in litigation. They therefore constitute confidential information unavailable during the study process. A less detailed review version is provided to allow reviewers to understand the scope of this study and its interrelationship with other studies.

Comment: The "Specific Methods" section should be expanded to include measures of both primary and secondary productivity in matched oiled and unoiled habitats in the supratidal, intertidal and subtidal zones. (UM)

Response: Due to the extent of the spill-affected area and the study's primary objectives of estimating the quantity, quality, and composition of critical trophic levels in moderate-heavily oiled sites relative to non-oiled sites, an estimate of community function cannot be directly determined. The study, however, does take an integrated ecosystem approach to assessing the interrelationships between and within the intertidal community.

Comment: The flora and fauna of the intertidal communities of Prince William Sound and the Gulf of Alaska are thriving. Thus, the justification for the Coastal Habitat study is questionable. (ESC)

Response: Our data do not support the conclusion that these communities are thriving. The data to date have been extensively reviewed by experts, resulting in the continuation of the coastal habitat project.

Comment: The Plan does not address QA/QC or chain-of-custody issues. (ESC)

Response: The QA/QC standards were established by the analytical chemistry portion of the damage assessment process and are appropriately included in that section of the plan. There is no need to duplicate these standards in the coastal habitat study plan.

Comment: The Coastal Habitat study does not describe how information gained from subtidal sites can be related to the stratified random sample sties since subtidal sites were chosen independently of the intertidal and supratidal sites. (ESC)

Response: The subtidal portion of the study is not directly linked to the stratified random sampling design of the intertidal and supratidal portions of the study. The subtidal study is now incorporated into the Subtidal study 2, to which it was linked last year.

Comment: It is unlikely that the Coastal Habitat study will yield an objective quantification of injury and recovery since lightly oiled shorelines were eliminated from study and moderately and heavily oiled shoreline were combined into one category for the stratified random sample study. (ESC)

Response: Detailed hydrocarbon analysis is being performed on samples from each location that will yield a range of precise levels of hydrocarbons. This range in levels will provide the means for extrapolating injury.

Comment: There is no indication in the Coastal Habitat study of the total number of sites samples or their distribution between control and oiled sites; among Prince William Sound, the Gulf of Alaska, or Kodiak Island; or among habitat or the five shoreline types. Nor are the five shoreline types identified. There is no mention of whether any of the sites were sampled more than once in 1990 or the number of sites that were sampled in both 1989 and 1990. It is not known from the write-up of this study whether the same criteria were used to select sites in both years. (API, ESC)

Response: Page 10 of the 1990 plan identifies that there were 102 sites to be studied in 1990. These are distributed equally between control and oiled sites with 42 sites in PWS, 27 in CI/KP and 33 in KAP representing the five following habitat types: (1) exposed rocky shores; (2) fine textured beaches; (3) coarse textured beaches; (4) sheltered rocky shores; and (5) sheltered estuarine shores. Seasonal and annual collection of data has been integrated into the study design integrating 1989 and 1990 sampling sites. A discussion of the site selection process is given on pages 10-12 of the plan.

Comment: Estimation of recovery rate in Phase II - Part A requires several sites visits. The study does not explain how seasonal changes will be integrated into the estimation of impact/recovery or what parameters will be used to predict recovery rate and potential for restoration. The habitat types examined in the stratified random sample are not provided. And the degree of oiling is not clearly defined. (ESC)

Response: Coastal habitat data collection is scheduled to be conducted over a three-year period that began in 1989. Several samplings per year are being collected to determine potential injuries and recolonization (recovery) rates of intertidal flora and fauna.

Comment: Methods are not given for random selection of sites in Phase II - Part A. Inclusion of nonrandom sites, chosen in 1990 for Coastal Habitat 1, may make the whole sampling design nonrandom. Thus, it may be difficult to extrapolate impacts to the entire spill-affected area. None of the statistical procedures for detecting differences are described. (ESC)

Response: The selection process is explained in the August 1989 and the 1990 State/Federal Natural Resource Damage Assessment and Restoration Plans. As explained in the 1990 plan, the additional 1990 sampling sites were deductively selected to provide additional spatial and habitat distribution thus providing a paired comparison that maintains the statistical validity of the design. Statisticians were consulted during the development of the 1989 and 1990 study plans to ensure that appropriate statistical designs were met.

Comment: The Coastal Habitat study contains no reference to the determination of appropriate restoration techniques or the assessment of the effectiveness of natural recovery. (ESC)

Response: Coastal habitat data collection is scheduled to be conducted over a three-year period that began in 1989. Several samplings per year are being collected to assess potential injuries and recolonization rates of intertidal flora and fauna. This information will be used to determine appropriate restoration techniques.

Comment: None of the methods used to determine hydrocarbon concentrations in sediment and soil are given in Phase II - Part A. Objective B of this study should be to "measure" rather than "estimate". (ESC)

Response: Hydrocarbon analysis of sediments and soil samples collected by the coastal habitat project will be analyzed in Technical Services study 1. The analysis will measure concentrations of petroleum hydrocarbons and their metabolites.

Phase II, Part B

Comment: The use of historical data in Coastal Habitat 1 may not be relevant because there is no information provided on the location of the ten historical sites from which mussel and sediment contamination data have been collected. If they are from low-energy, low gradient beaches at the head of embayments, they are not typical of most of the oiled sites in Prince William Sound. It is unclear from the Plan whether the methods for detection of petroleum hydrocarbons in the mussel tissues is the same for the historical and the post-spill samples. The presence of hydrocarbons in mussel tissues should not be considered an injury unless it can be shown that these oil residues are causing biological damage. (ESC)

Response: The historical sites and sites established just prior to the spill were placed at low energy sites where fine sediments are available. Although some of these sites received light oiling, they are not typical of the exposed areas that received moderate to heavy oiling. The information from these sites will provide a basis for evaluating the extent of oiling and impact in protected areas adjacent to high energy oiled areas. Analytical methods for the historical samples and post-spill samples are the same. The presence of hydrocarbons in mussel tissues are used as an indicator of availability to organisms of hydrocarbons in the water column.

Comment: Since no information is given as to the locations of the ten historical sites, it is not possible to know whether they are in areas that were affected by the oil spill. There is no explanation as to how the ten historical sites or the ten new sites were selected. (ESC)

Response: Most of the ten historical sites were outside the spill area with two or three exceptions. These are located in areas considered most likely to be oiled in the event of a spill. The ten additional sites were established during the early days of the spill in areas that were most likely to be oiled.

Comment: Increased efforts at modeling historical data and that obtained as part of the NRDA to predict both effects and recovery has only been given limited attention. (UM)

Response: Currently the historical hydrocarbon data are being examined in detail. Individual concentrations of aromatic hydrocarbons in sediments and mussels in spring, summer, and fall periods for the years 1977-1980 are being summarized. Results from NRDA samples will be compared to the historical data.

Comment: Part A of Phase II of the study contains only a general list of methods: there is no description of the number of transects per site or the number of tide levels sampled at each site; methods for sampling and analysis of biota and sediments are not given; there is no description of the tests of biological conditions and community function; and none of the methods for injury determination are included. Consequently, it is not possible to assess the technical soundness of this program. (ESC)

Response: One transect is sampled per site. Sampling on the transect is described in the study plan. Hydrocarbon analysis of sediments and mussels by GS/MS will occur under Technical Services 1. Direct injury will be documented if community changes are found on the photo transects.

Comment: There has been no consideration of shoreline treatment procedures in site selection for phase II - Part A and only one level (moderate to heavy) of oiling is being compared to control conditions, so the "response to varying degrees of oiling and subsequent clean-up procedures" cannot be measured. And it may not be possible to demonstrate any biological response unless all control sites in the stratified random sampling were randomly selected. (ESC)

Response: Sites were selected before any oil reached them and prior to shoreline treatment. Two sites subsequently received extensive cleanup and two received moderate to light cleanup. The sites included heavily, moderately, and lightly oiled sites. All sites were selected according to a stratified random procedure. They are all in protected bays, but the sediments vary somewhat.

Comment: There is insufficient information in Objective B of Phase II to determine whether field sampling or laboratory analysis methods used to collect the historical data are the same as those employed in selecting the 1989-90 data. No methods are outlined for determining whether differences measured over time can be attributed to the spill or to natural or anthropogenic changes. (ESC)

Response: The historical and new sites are treated the same for field sampling and laboratory analysis. Hydrocarbons in sediments over the baseline levels can be linked to Prudhoe Bay crude oil through the compounds analyzed under Technical Services 1.

AIR/WATER

Comments on Air/Water Studies - General

Comment: Other than a comment stating that extremely low concentrations of hydrocarbons in water and air observed during the 1989 sampling indicated that further sampling of these compartments was no longer needed, no rationale was given for why specific studies were excluded from the 1990 plan. Many of the species and life stages covered by the canceled studies are important resource species and/or sensitive components of the life cycle which could sustain damage in years subsequent to the spill. It would seem premature to abandon these studies so early in the damage assessment process. (UM)

Response: The portions of the Air/Water studies that were discontinued and not combined with another project were activities that the Trustees determined had little potential to contribute to the documentation of resource injury.

Comment: These studies are not cost-effective. (API)

Response: The Air/Water studies focus on a broad and complex ecosystem that provides the habitat for a large variety of organisms. Most of these organisms serve as prey items for higher trophic levels in the food chain. The overall documentation of the extent and persistence of EVOS hydrocarbons in the environment, and the pathways by which habitats became contaminated and the contamination entered the food chain, will continue to be understood poorly unless these studies are conducted. The Trustees have determined that the expense of conducting these studies is justified by their overall contribution to the documentation of injury.

Comment: These studies consist of basic research. They are not targeted to show specific injury and are not consistent with DOI damage assessment regulations. (API, ESC)

Response: An evaluation of injuries to the benthic resources and habitats addressed under the Air/Water studies is a critical component in assessing the overall injuries to natural resources caused by the EVOS, and is consistent with the DOI damage assessment regulations.

Comment: The only available techniques to measure the effects the studies are attempting to measure are unreliable. Sediment toxicity assays and their application are still being developed by the scientific community. Toxicity source identification methods for sediments are unavailable. (API)

Response: The GC-MS analysis performed on sediments under Technical Services 1 is a well developed scientific technique. It can identify enough hydrocarbon compounds in sediments so that major sources can usually be identified.

Comment: Major components of all three studies, particularly Study AW6, are research. Methods proposed for trace hydrocarbon analysis (AW2) and toxicity testing (AW6) are neither standard nor accepted for this purpose and any new methods will have to be developed as part of the studies. (ESC)

Response: The techniques used to document injury to the benthic resources and habitats addressed under the Air/Water studies are well established and documented in scientific literature.

Comment: The study plans are flawed in that they assume that the chemical analyses from sediment samples are related to the oil spill. The methods fail to take into account effects that have occurred over time from other sources. (API)

Response: The GC-MS analysis performed under Technical Services identified enough compounds so that EVOS oil should be distinguishable from hydrocarbons from other sources. Air/Water Study 6 examines long-term toxicity of weathered Prudhoe Bay crude oil and oxidation products of oil.

Comment: Site selection was not random. (API)

Response: As a random site selection approach to subtidal sediment sampling over the entire spill area is cost prohibitive, a paired sampling approach using oiled and unoiled areas is used. The Air/Water 6 study relies on the measurement of hydrocarbons in sediments under Air/Water 2 (samples were shared) to establish which sampling sites were oiled.

Comment: There are potential methodological problems with chemical analyses of sediment. (API)

Response: The GC-MS technique used to analyze sediments will provide a detailed breakdown of the hydrocarbon compounds present in sediment samples. This is a well established analytical technique accepted in the scientific community.

Comment: The method used most frequently to measure petroleum hydrocarbons in water and sediments (UV fluorescence) is specific for aromatic hydrocarbons and is not always conclusive in distinguishing between aromatics from the oil spill and aromatic hydrocarbons from other sources. (ESC)

Response: The UV fluorescence method is used primarily as a screening device to determine whether hydrocarbons are present in a sample and to guide selection of samples for more detailed analysis.

Comment: Air/Water 2, 3 and 6 are not well integrated internally or with each other or with Coastal Habitat 1. (ESC)

Response: The sampling locations of these studies and the logistical support (vessel charters) are well-coordinated. Air/Water studies 2 and 6 share sediments from the same samples. Due to the stratified random site selection approach used for the Coastal Habitat 1 study for 1990, it was not practical to coordinate Air/Water study sites with that project. The subtidal eel grass bed sampling portion of the Coastal Habitat study was coordinated with Air/Water 2 sampling sites however.

Comments on Air/Water Studies - Specific

Air/Water Study No. 2 - Subtidal Sediments

Comment: It is questionable whether the budget cuts made as a result of combining Air/Water Studies 2 and 4 are appropriate since there is no line item in the budget for sample analysis. (NWF)

Response: Air/Water 4 was combined with Air/Water 2 in 1990. Collections for these studies were combined on tightly coordinated cruises that maximized the efficiency of the field sample collections. Air/Water 6 samples were taken on the same cruises. Sample analysis was performed by the individual components of Air/Water 2 with a major portion of the costs for hydrocarbon analysis of sediment samples included in Technical Services 1.

Comment: Proposed analytical methods are inappropriate to distinguish various hydrocarbon sources from EVOS. (ESC)

Response: Technical Services Study 1 established the quality control procedures for hydrocarbon analysis for EVOS oil. The methods employed will allow the identification of North Slope crude oil in cases where the analysis is being performed directly on oil found in the sediments sampled by Air/Water 2.

__Comment__: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources for studies Air/Water 2 and 6. (ESC)

__Response__: The compounds analyzed under Technical Services No. 1 will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish North Slope crude oil from other sources.

__Comment__: Although the description of samples to be taken and the methodology to be employed are much more complete than that presented in the 1989 plan, the actual number of samples that will be eventually analyzed is not stated. (UM)

__Response__: Currently, 385 sediment samples are being or have been analyzed from those collected in 1990. Additional samples may be submitted for analysis once the results from these initial samples are available.

__Comment__: Statistical tests of hypotheses are vaguely defined, and it is not clear how abundance and biomass are to be tested. (ESC)

__Response__: A Kruskall-Wallis and a multiple comparison test for significance will be used to test for differences in total abundance and biomass between stations sampled each year and in multi-year data sets. The tests will be made on the abundance and biomass of selected predominant taxa at stations. Analysis of variance (ANOVA) has been added to the statistical analysis. ANOVA will be used to test differences in abundance and biomass between predominant taxa for stations at similar depths within oiled and unoiled bays.

__Comment__: It is unlikely that the statistical analysis of the benthic infauna will have much meaning considering the numbers of both oiled (6) and unoiled (6) sites to be sampled. Furthermore, because the geochemical techniques being employed will not discriminate the various sources of hydrocarbons (biogenic, pyrogenic, and other petrogenic) the statistical analysis will be unable to correlate any effects observed with EVOS oil or its weathering products. (ESC)

__Response__: Sample size is minimal. However, it is expected to be adequate to detect major faunal differences between sites. It will be possible to correlate effects with EVOS oil because chemical analysis of sediments at sample sites will allow identification of oil.

Comment: It is proposed that injury determination will be accomplished by correlating the results of the chemical analyses (HPLC) with the Microtox measurements (as a measure of toxicity) and with the deep benthos biological statistics for oiled and unoiled sites. It will be impossible to determine EVOS-imposed injury in this manner because: (1) it will not be possible to quantitatively discriminate an EVOS signature from other hydrocarbon sources, and (2) the Microtox tests are invalid tests of toxicity as explained above. (ESC)

Response: Preliminary tests with Microtox in 1990 indicated low sensitivity to *Exxon Valdez* oil in sediments and this technique was discontinued. The analysis for aromatic compounds and the C10-C34 alkanes in sediments under Technical Services 1 will allow the separation of North Slope crude oil from other sources of oil.

Comment: The site selection procedure, the number of sites selected, and the hydrocarbon chemistry methods to be used, preclude the use of deep benthos infaunal species diversity, species abundance, and total biomass from being used to assess EVOS-related injury to subtidal marine resources. Further, the site selection procedure precludes extrapolation of the site data to the entire region. (ESC)

Response: The site selection procedure is appropriate for assessment of total abundance and biomass using Kruskal-Wallis and multiple comparison tests. The results will be useful for investigating major faunal differences between oiled and unoiled sites. The study was not designed to enable extrapolation to the entire region. Subtidal benthic systems differ sufficiently so that area-wide extrapolation is not possible. However, common fauna between benthic sites are typically found, and differences in these predominant and ubiquitous faunal components may be extrapolated.

Comment: Objectives A-H. The small number of sites and the method of their selection are such that it is unlikely that the major objectives will be realized in a manner that will permit them to be extrapolated to the region as a whole. Therefore, it will not be possible to obtain one of the main goals in the study which is to "evaluate the extent of subtidal hydrocarbon contamination in PWS, along the lower Kenai Peninsula, and near Kodiak Island." (ESC)

Response: Sampling was conducted in a paired design (treatment/control pairs of sites). The number of pairs was limited by the number of adequate control sites. The main objective of Air/Water 2 is to determine the distribution, composition, persistence, and toxic effects of petroleum hydrocarbons in bathymetric space. Air/Water 2 is not designed to extrapolate sampling results "to the region as a whole." This requires a random stratification approach and a sampling effort that is cost prohibitive for the required subtidal sampling.

Comment: One study uses the Microtox test for toxicity. This method is not accepted as a sole indicator and should be used in conjunction with other methods to determine the toxicity of sediments and the effect of oil exposure. Microtox bacteria would not be expected to be a part of the sediment infauna, thus the relationship of the test to the environment is not clear. (API)

Comment: The Microtox assay, although very quick and relatively inexpensive to perform, is at best a very crude barometer of the relative toxicity of these sediments. Comparisons between toxicity estimated with Microtox and more routine acute toxicity yield highly variable correlation coefficients depending on species compared. Attempts to use the Microtox assay as a direct measure of sediment toxicity have indicated that toxicity results are highly dependant on the method used to obtain an aqueous sample from the sediment under consideration and suggest that further method development is needed. Even the study by Schiewe et al. (1984) cited in the plan points out many of the limitations of this assay in addressing sediment toxicity. (UM)

Comment: When compared experimentally, the Microtox assay was found to be less sensitive than either the *Daphnia magma* 48-hour lethality assay or the *Hexagenia limbata* 168-hour lethality assay in assessing the toxicity of a freshwater sediment contaminated with aromatic hydrocarbons and metals. (UM)

Comment: The Microtox bioassay, based on the response of a marine bacterium to methylene chloride extracts of sediments (used in Studies AW2 and AW6) is not an appropriate method for estimating the toxicity of in-place oiled sediments to marine organisms. Recent studies of sediments from Puget Sound show that results from Microtox bioassays of methylene chloride sediment extracts do not correlate with the toxicity of the sediment interstitial water or to concentrations of polycyclic aromatic hydrocarbons in the sediments. (ESC)

Comment: Microtox bioassay is considered a poor indicator of the toxicity of the lipophilic organic compounds, such as petroleum hydrocarbons. (ESC)

Comment: The microtox bioassay is an EPA water quality test and its application to sediment extracts is inappropriate. (ESC)

Comment: The Microtox measurements proposed will be unable to attribute dose response relationships to an EVOS component. (ESC)

Response: This responds to the preceding 7 comments. Preliminary tests with Microtox in 1990 indicated low sensitivity to *Exxon Valdez* oil in sediments and this technique was discontinued.

Comment: Bioaccumulation, toxicity, and growth should be assessed in a number of representative benthic organisms, as is suggested in the proposed update of the EPA ecological evaluation of dredged material. (UM)

Response: Sediment toxicity and its effect on test organisms will be addressed in 1991 in Subtidal #3.

Comment: The HPLC/fluorescence method chosen to estimate petroleum hydrocarbon concentrations has the advantage of allowing large numbers to be processed relatively quickly and inexpensively, but it is not very specific. Will it be used only as a screening tool to identify samples with elevated levels to be analyzed by more conventional methods with better accuracy? If not, erroneous conclusions on levels of hydrocarbon contamination could be made. (UM)

Response: Under Air/Water 2, the HPLC/fluorescence method will only be used as a screening tool.

Comment: There is no reason given for the fact that detailed sediment sampling is scheduled to take place three times while the biological samples will only be collected in June/July. It is questionable whether measurable differences in sediment concentrations over that short a time period exist that long after the spill. If they do, the frequency of biological sampling should be increased. (UM)

Response: The expense of collection and laboratory processing of the infaunal samples rendered the cost of seasonal assessments of the deep benthos prohibitive. Collection and analysis (in conjunction with HPLC/fluorescence) of sediment samples is much less expensive, and is providing for the opportunity for seasonal hydrocarbon sediments collections.

Comment: Using a 1 mm sieve on the benthic infaunal sampling will miss many of the numerically dominant species, including most invertebrate larvae and some very important meiobenthic prey species for salmon fry such as harpacticoid copepods. Many investigators of soft-bottom community structures require 0.5 mm mesh sizes or smaller. (UM)

Response: Both 1.0 and 0.5 mm sieves have been incorporated into the sampling. The benthic study was designed to assess macrofauna, and was not intended to examine meiofauna quantitatively. However, use of the 0.5 mm screen should allow quantitative examination of the larger meiofaunal taxa.

Comment: The total number of sites, the manner in which they were selected, and the numbers of samples to be collected may be inappropriate for a statistically based study. (ESC)

Response: Sampling was conducted in a paired design (treatment/control pairs of sites). It was not the goal of the study to extrapolate results over the entire spill-impacted area. This is cost prohibitive considering the extensive subtidal sampling that is required.

Comment: Since only 6 oiled and 6 non-oiled sites will be investigated for effects on the structure of subtidal benthic communities, it is extremely important that the control and oiled sites be well matched for sediment characteristics, depth, light and nutrient conditions if potential effects of the EVOS are to be assessed adequately. Potential effects on benthic community structure should be a key component of the NRDA. (UM)

Response: Although it is difficult to match completely all sites with all characteristics, sea grass beds at the heads of bays were chosen as the common denominator that is expected to have an important influence on the benthic environment of all sites. A sea grass system can be expected to flux a sizable and annually reliable amount of organic carbon to the subtidal environment. Similar benthic faunal components responding in a roughly similar manner would then be expected in the subtidal sites selected.

Comment: The field program is very inefficient and is therefore not cost effective. The total number of sites, the manner in which they were selected, and the number of samples to be collected may be inappropriate for a statistically based study. Non-random site selection can yield biased results. (ESC)

Response: The field program was greatly increased in efficiency in 1990 by combining the sampling needs of all Air/Water 2 (including previous Air/Water 4) and Air/Water 6 program components into the same cruises.

Comment: The biological sampling plan for the intertidal zone (along a 30 m transect parallel to the shoreline in the range +1m to -1m relative to mean lower low water) is inappropriate due to the pronounced stratification of biota in that zone. (ESC)

Response: It was appropriate to sample the intertidal zone as this zone is most likely to contain infauna in association with fine sediments.

Air/Water Study No. 3 - Geographic and Temporal Distribution of Hydrocarbons

Comment: Sediment traps will be deployed at only a very limited number of locations and can only assess the concentrations of petroleum hydrocarbons on particulate material settling out of the water column. (UM)

Response: The sediment trap study is designed to monitor suspended particulates and hydrocarbons settling out of the water column. With the exception of control sites, the traps are located at sites believed to be most likely to still have detectable, mobile hydrocarbons in the water column. Sediment traps will measure both adsorbed hydrocarbons and hydrocarbon "globules." Previous studies have shown both forms to be important components of hydrocarbon mobilization and subsequent deposition.

Comment: Although use of caged mussels is a well accepted approach, particularly in areas with more heavily oiled sediments, some analysis of the concentration and patterns of petroleum hydrocarbons in the dissolved or whole fraction of the water column would seem to be warranted. Measurements of this type will be of particular importance to calculate the flux of hydrocarbon material out of sediment reservoirs. (UM)

Response: By 1990, water column concentrations of petroleum-derived hydrocarbons were below detection limits using practically sized samples (i.e., up to about 5 liters) in PWS.

Comment: Objective 1. Sediment traps are not appropriate for determining particulate transport of hydrocarbons in shallow-water environments. (ESC)

Response: The sediment traps have been designed to account for a range of environmental conditions encountered in nearshore subtidal areas where they are deployed. While the traps are not designed to quantify flux rates, they are effective at capturing particulates to determine the presence or absence of hydrocarbons.

Comment: Objective 2. This objective does not relate ambient water quality or mussel hydrocarbon burdens to EVOS. (ESC)

Response: Methodology relating PAH concentrations in sediments and in mussels due to the EVOS with resource injury and lost services is not within the scope of Air/Water 3, although it is within the scope of the overall NRDA process and is based on the integrated results of the individual projects. Project investigators have coordinated studies to the extent considered necessary to facilitate an integrated assessment of resource damage. The linkage of this study to other NRDA studies consists primarily of demonstrating the transport and availability of spilled oil from the beach and surface waters to the water column and subtidal sediments where it is available to marine organisms.

Comment: The depth(s) of deployment of the sediments traps are not given. Justification for why three sampling periods were chosen instead of one deployment, possibly for a longer period, should be given. For some compounds four weeks is too short a time period. (UM)

Response: The depth of deployment was given as less than 20 meters below MLLW. In practice, the traps were deployed at approximately 10 meters. Sampling periods were chosen to correlate with naturally occurring erosional and depositional events. The length of deployment is intended to maximize deposition while minimizing naturally occurring degradation of any hydrocarbons present.

Comment: The field extraction method for the sediment trap samples is not described. Other than attempting to determine differences in hydrocarbon concentrations between samples and sites, no methods describe how any of the results from these efforts can be attributed to EVOS. (ESC)

Response: The field extraction method for sediment trap samples are described in the 1991 plan. Clear differentiation of sources of hydrocarbon burdens will be accomplished using details provided by the GC/MS analyses, and by comparison of these details with historical data on hydrocarbon burdens of various compartments within PWS.

Comment: Because body burdens of hydrocarbons in mussel tissue can change fairly rapidly, levels in caged mussels will only be indicative of ambient water column concentrations if the concentration of these components in the water column is somewhat constant during the exposure period. (UM)

Response: From the definition and magnitude of the bioconcentration factor of polynuclear aromatic hydrocarbons (PAH) for mussels, the rate of depuration is several orders of magnitude less than the rate of uptake. In particular, accumulated PAHs have an apparent half-life on the order of 2 weeks in mussels. A 4-week exposure period was chosen as a sufficient time period for accumulation of some PAH to occur. The study objectives do not include an attempt to calculate absolute seawater PAH concentrations on the basis of concentrations found in mussels.

Comment: Use of sediment traps to measure transport of petroleum hydrocarbons to offshore sediments will not produce information enabling the Trustees to relate hydrocarbon levels to population impacts on benthic organisms because sediment traps are not useful for predicting the rate of flux of suspended particles to the bottom and, if they are mounted near the bottom, they measure mainly sediment resuspension. (ESC)

Response: The sediment trap study is designed to determine the continuing mobilization of hydrocarbons. This study will be integrated with the results from other studies to address the question of continuing temporal and spatial exposure of benthic organisms to hydrocarbons. The sediment traps are designed to minimize capture of resuspended sediments.

Comment: The geographic distribution of study sites is not adequate: Only 5 of 20 sediment-trap sites are listed and referenced figures for caged mussel sites are not included in the document. The use of sediment traps for measuring flux to the subtidal region is not a valid or standard technique in shallow-water environments. Neither the sediment trap-design nor the periods of deployment are set forth. No field chain-of-custody is described nor are QA/QC procedures for field-extraction of the particulates. (ESC)

Response: The geographic distribution of study sites is adequate to monitor suspended particulates and hydrocarbons settling out of the water column. With the exception of control sites, the traps are located at sites believed to be most likely to have detectable, mobile hydrocarbons in the water column. The sediment traps are not designed to measure flux rates but rather the presence or absence of hydrocarbons. This study follows the standard chain-of-custody procedures for all NRDA studies. Standard QA/QC procedures have been established.

Comment: These injury pathway studies do not attempt to differentiate hydrocarbon burdens found from EVOS, pyrogenic, natural sources (seeps), or other (boating) sources. (ESC)

Response: Clear differentiation of sources of hydrocarbon burdens will be accomplished using details provided by the GC/MS analyses, and by comparison of these details with historical data on hydrocarbon burdens of various compartments within PWS.

Comment: No methodology is provided which will tie differences in hydrocarbon concentrations in the sediment traps and mussels to resource injury and lost services. The few sites that are proposed to overlap with Coastal Habitat Study No. 1 and Air/Water Study No. 2 will not "provide a comprehensive picture of damage." (ESC)

Response: This study will provide documentation of the pathway of hydrocarbon contamination that eventually reached a number of marine organisms. This study, in concert with other NRDA studies, will tie hydrocarbon contamination to resource injury.

Comment: The linkage between this study and the other injury-related studies is not apparent. (ESC)

Response: Close coordination between this study and other studies has been carried out throughout the NRDA process.

Comment: Only two control sites are listed for the caged-mussel studies and none are specified for the sediment trap deployments, making it impossible to evaluate whether the baseline determination will be adequate. (ESC)

Response: In addition to the control sites in PWS, mussels collected from an uncontaminated site on Admiralty Island in S.E. Alaska will provide a reference.

Air/Water Study No. 6 - Fate and Toxicity of Oil

Comment: Objectives A-C. The study is of limited value in estimating injury from weathered crude oil in sediments. Because of the study design, these objectives will not be accomplished in a scientifically defensible manner. (ESC)

Response: Because the information on the persistence and toxicity of oil and its oxidation products in the marine environment is very limited, this study was initiated in 1990 to provide this type of documentation. The information developed will support other studies by confirming or eliminating potential sources of injury to marine organisms.

Comment: Objectives D. This study cannot be performed in a technically sound fashion and is of no use for identifying restoration needs or quantifying injury to natural resources. (ESC)

Response: The establishment of an understanding of the fate of the EVOS oil over time and space, in concert with other NRDA studies, will help further the understanding of how the environment was affected by the EVOS. The cost of meeting this objective is minimal as existing information from other sources will be used to construct the fates model.

Comment: Air/Water 2, 3, and 6 are not well integrated internally or with each other or with Coastal Habitat 1. (ESC)

Response: Air/Water 2 and Air/Water 6 are closely coordinated with each other and the Coastal Habitat studies. Subsamples of the same sediments from the same suite of sites are subjected to chemical analysis and toxicity testing. See also response to this same comment in the general comments in this section.

Comment: It is not possible to ascertain from the Plan whether there is duplication of effort in the studies of petroleum hydrocarbon concentrations in Coastal Habitat 1 and Air/Water 6. (ESC)

Response: Although sediments are sampled under the Coastal Habitat study, they are subjected to more detailed testing for toxicity and the presence of oxidation derivatives of oil in Air/Water 6.

Comment: Air/Water 6 does not contain sufficient specificity regarding the construction of a "summary budget or 'mass balance' summarizing the fate of spilled oil." It fails to indicate when this calculation will be made and to explain how the calculation will be utilized in the assessment of damages. (NWF)

Response: Primary sources of information have been identified for the synthesis of a budget for the fate of oil, and contacts have been made to help ensure the compatibility of the data to be synthesized. The budget will represent a best synthesis effort with the information that is available. While not directly documenting damage, this information will support damage assessment by providing an overall picture of how the oil was distributed in the environment.

Comment: The data generated by Air/Water 6 will not be sufficient to construct an accurate mass balance of the spilled oil. It is extremely unlikely that a mass balance, even if constructed, would be sufficient for quantifying injury to natural resources. (ESC)

Response: The primary sources of information that have been identified for use in constructing the budget are detailed enough so that a representation of the general distribution of oil in the environment can be produced. While not directly documenting damage, this information will support damage assessment by providing an overall picture of how the oil was distributed in the environment and was available to organisms.

Comment: There is no statement in the study plan as to how the mass balance would be used in restoration or injury determination and quantification. Because of the imprecision of the fate estimates, the results of this mass balance will not be useful for injury determination. (ESC)

Response: Although the oil fates budget will not have a direct use in documenting injury to organisms, the background information on spatial and temporal distribution of oil in the environment it provides will aid in understanding how and when oil was available to various organisms and in extrapolating injury beyond immediate study areas.

Comment: The introduction to the study states that effects of petroleum hydrocarbons themselves are well enough documented in previous work to allow accurate predictions in the case of EVOS without additional study, but this is questionable. Although a substantial body of work does exist on the WSF and OWD of different petroleum products in laboratory conditions, these studies may not adequately assess the long-term, sublethal effects of petroleum hydrocarbons on all key components of the ecosystems. (UM)

Response: Not everything is known about the long-term sublethal effects of oil on all components of the ecosystem. However Air/Water 6 is designed to address two fundamental issues: 1) whether residual oil exerts acute toxicity on test organisms, and 2) whether polar breakdown products contribute to any of the observed toxicity.

Comment: There are no details regarding how the mass balance will be attempted. The Plan states that recognized experts will be consulted in its execution, but that progress will be heavily influenced by timely reporting of data from other groups, and the suitability of these data for constructing the mass balance. The timely reporting of data from different members of the damage assessment team, and the compatibility of the different data sets were one of the major concerns with the original 1989 damage assessment plan. (UM)

<u>Response</u>: Primary sources of information have been identified for the synthesis of the "oil fates" budget. Not all of these are within the damage assessment arena. Current plans are for this budget to be completed by the fall of 1991.

<u>Comment</u>: This study lacks baseline measurements, so it will not be possible to compare toxicity of polar fractions of organic extracts of oiled and unoiled sediments. Therefore, the increment in toxicity of sediments due to oil cannot be measured. (API, ESC).

<u>Response</u>: Where baseline data does not exist, a comparison of the toxicity of sediments from oiled and unoiled sites has been utilized. The measurement of oil in the sediments (from the same sample) from Air/Water 2 are being used to confirm whether oil is present at a sampling site.

<u>Comment</u>: The analytical methods will not allow definitive identification of EVOS oil as the material causing toxicity in sediments. Therefore, there will not be a clear link established between the injury (toxicity of intertidal and subtidal sediments) and the EVOS. (ESC)

<u>Response</u>: The sampling for the sediment toxicity survey included 7 sites designated as unoiled or very lightly oiled. For the polar fractionation/toxicity study, one unoiled site was included for comparison. The detailed chemical information from all the sites will provide further basis for determining the sources of any toxicity that may be found.

<u>Comment</u>: Twenty "heavily oiled" sites were chosen for this study, but no other information is given: Are these sites representative? If so, of which of the oiled habitats? What range of grain size or organic carbon content was chosen? (UM)

<u>Response</u>: Sites were selected under Air/Water 2 to represent a broad range of characteristics and geographic coverage. Unoiled reference sites are included to permit assessment of oil-related toxicity.

<u>Comment</u>: Use of the Microtox test to assess sediment toxicity is of value only as a screening tool. This is a source of concern in

this study especially because it will be used to assess whether or not the polar fraction is more or less toxic than the complete sediment. (UM5)

Response: Microtox is used only as a screening device. It is expected that Microtox will respond to epoxides and free radicals, if present, even though the microorganism does not generate those compounds itself.

Comment: Only the toxicity study (Objectives A-C) includes field methods that are a part of this study plan. Sampling is restricted to the intertidal/subtidal areas of 20 heavily oiled sites and, therefore, probably is most representative of the worst case situation. (ESC)

Response: Results should not and will not be extrapolated from either the 2 heavily oiled sites used for the fractionation and toxicity testing of polar constituents or the 20 oiled sites used for the field toxicity survey. However, objective inferences may be drawn from these results regarding the magnitude and extent of potential toxicity to marine organisms and the relation of the toxicity, if any, to polar constituents.

Comment: Samples for whole animal sediment toxicity tests are not the same as those used for extraction, fractionation, and testing with the Microtox bioassay. Therefore, the results of these two phases of the project cannot be compared and extrapolations cannot be made about the contribution of polar degradation products of petroleum to the toxicity of oiled sediments to marine animals. (ESC)

Response: Objective inferences may be drawn from these results regarding the magnitude and extent of potential, if any, toxicity to marine organisms and the relation of the toxicity to polar constituents.

Comment: There is no explanation given for using *Mytilus edulis* instead of *Mytilus trossulus*, the species that was used in the bioaccumulation studies and that presumably is indigenous to the area. (UM)

Response: The purpose of the bioassays is to verify whether residual oil might exert some acute toxicity to indigenous organisms. *Crassostrea gigas*, not *Mytilus*, was used in the Air/Water 6 bioassays because of the availability of spawning stock at the time. *M. Trossulus* is the correct name for Pacific mussels previously referred to as *M. edulis*.

Comment: Although the authors state that well-established protocols exist for this assay, it is unclear from the references listed what they are basing this information on. Varying results are obtained in sediment toxicity bioassays depending on whether whole sediment, diluted sediment, pore waters, or elutriate are used. (UM)

Response: The purpose of the bioassays is to verify whether residual oil might exert some acute toxicity to indigenous organisms. Standard bioassay species and protocols are used for this purpose.

Comment: In determining the toxicity of sediments, a test with benthic larvae, which would be most likely exposed to these sediments, should be employed. The *Ampelisca* sediment toxicity study is well documented, but toxicity to additional species should also be assessed. (UM)

Response: It is desirable to work only with organisms that are indigenous to the spill area. However, the availability of test organisms and the fact that the protocols for certain historically used species are well established ruled out the use of local organisms.

Comment: One primary aspect of the toxicity of hydrocarbon metabolites concerns their susceptibility to be metabolized to electrophilic epoxides, a reaction prokaryotic microorganisms such as those used in the Microtox assay cannot perform. Consequently, the appropriateness of using the Microtox assay to assess the toxicity of metabolites is questionable. It is questionable whether methylene chloride will extract sufficient quantities of polar metabolites to address adequately their contribution and toxicity in these sediments. (UM)

Response: Microtox is only used as a screening device. It was expected that Microtox would respond to such epoxides and free radicals, if present, even though the microorganism does not generate those compounds itself. Mixtures of ethyl acetate and methylene chloride were used in the final study to ensure more complete extraction of polar constituents.

Comment: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources for studies Air/Water 2 and 6. (ESC)

Response: The compounds analyzed under Technical Services 1 will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish Prudhoe Bay crude oil from other sources.

TECHNICAL SERVICES

Comments on Technical Services - General

Comment: Most technical services studies are not detailed enough to be evaluated. (API, ESC)

Response: The Trustees disagree. Detailed documentation on analytical procedures, including: 1) data documentation and reporting and 2) quality control measures and the acceptance criteria associated with these procedures, as implemented by each laboratory analyzing NRDA samples, have been developed. The QA/QC standards are contained in Appendix A.

Comment: Technical Services appears to be little modified from the 1989 plan. (UM)

Response: The nature of the support provided by the technical services projects has not varied from the originally established quality control measures and procedures for data control, sampling, and reporting.

Comment: Technical Services is very limited in scope, providing descriptions of the chemical and histopathological analysis of samples only. Similar sections are needed for the other measurements being made, as well as some mechanisms to insure coordination between methods and sampling between different parts of the plan. (UM)

Response: Technical Services currently encompasses chemical analysis and mapping. Histopathology has been discontinued as a separate support service although continuing analysis of histopathology samples will be conducted as part of specific NRDA studies. Descriptions of protocols and methods for sampling and other measurements being made by NRDA studies are contained within the specific studies, cited references, and appendices to this document. Technical Services is intended to provide support of a kind required by many NRDA studies and this can best be accomplished by a single support function.

Comment: Due to concerns regarding the invasive tests conducted, the benefits of the histopathology study are questionable. (API)

Response: Histopathology is no longer addressed by a separate Technical Service program. Histopathology continues to be considered within specific studies as needed. Every effort is being and continues to be made to ensure that the number of animals collected is kept to a minimum and that individual takes are essential to assess injury.

Comment: The proposed audits of field and laboratory procedures, as described, are inadequate: only chemistry audits are mentioned. Other areas should be audited as well, such as sample analysis, biological observations, database input, chain of custody, and mapping. (ESC)

Response: Sufficient detail for adequate review is provided in Appendices A & B, and Technical Services Studio 1, 2, and 3.

Comments on Technical Services - Specific

Technical Services No. 1

Comment: Technical Services 1 will make extensive use of UV fluorescence, which is not always conclusive in distinguishing between aromatic compounds from the EVOS and the petrogenic or biogenic aromatic hydrocarbons from other sources. (ESC)

Response: UV fluorescence is being used extensively only for the analysis of bile for petroleum hydrocarbon metabolites and for the determination of oiled versus unoiled sites in Coastal Habitat. This method is well documented as an indicator of exposure to petroleum hydrocarbons (Varanasi et al.)

Comment: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources in Air/Water Studies 2 and 6. (ESC)

Response: The compounds analyzed under this study will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish Prudhoe Bay oil from other sources.

Comment: Insufficient information is given in Technical Services 1 and Appendix A to allow evaluation of analytical methods, adequacy of the number of samples analyzed, or sample identification procedures. (ESC)

Response: Detailed documentation of analytical procedures, including data documentation, reporting, quality control measures, and the acceptance criteria associated with these procedures, as implemented by each laboratory, has been developed. The number of samples to be analyzed is determined on a project by project basis by the Project Leaders in consultation with biometricians using the Technical Services 1 procedures.

Comment: The statement in the Quality Assurance plan for chemical analyses in Technical Services 1 and Appendix A that "unacceptable performance in the intercalibration exercise will result in the discarding of associated data" is unclear. Intercalibration after samples have been analyzed may result in the discarding of valuable data and may bias results. Data should instead be reported with qualifications. (ESC)

Response: To date, no laboratory analyzing NRDA samples has performed unacceptably in the intercomparison exercises. If this occurs, the data associated with that laboratory for that time frame will be flagged in such a manner that they will not automatically be incorporated into data retrieval.

Comment: The list of calibration compounds in Technical Services 1 is insufficient to distinguish *Exxon Valdez* oil from hydrocarbons from other sources. It focuses on C12-C20 alkanes and ignores the C21-C31 alkanes that can indicate whether sediment hydrocarbons are predominantly biogenic rather than from the oil spill. (ESC)

Response: The list provided in the plan is a minimum. Analytical data are being collected on C10-C34 alkanes.

Comment: The analytical methods of Objective A cannot be judged since no details were provided, other than a minimum list of compounds, which are probably calibration standards. (ESC)

Response: Detailed documentation on analytical procedures including data documentation, reporting, quality control measures, and acceptance criteria associated with these procedures, as implemented by each laboratory, has been developed.

Comment: Details of the QA/QC plan for sample collection procedures were not provided in Objective B and cannot be fully evaluated. It is unclear how the sample labeling plan guarantees "unique" sample numbers across the entire 1990 program. (ESC)

Response: See Previous Response.

Comment: Data should not be excluded or discarded simply because unnecessarily tight performance standards are being applied in Objective C. It is not clear from this objective what "associated data" means. (ESC)

Response: Data that do not conform to the established standards are flagged in such a manner that they will not be automatically retrieved into a data sort. Associated data means those data developed by the indicated laboratory during that time.

Comment: The audits proposed in Objective D are incomplete. (ESC)

Response: The audits proposed meet federal standards. Refer to the Toxic Substances Control Act, part 792, Good Lab Practices Standards.

Comment: Construction of a material balance on the fate of spilled oil is a complex task that will be compounded by the use of data generated by possibly inadequate analytical techniques. (ESC)

Response: The methods that will be used to construct a material balance on the oil are well represented in the literature. For references see Boehm, McKay, or Payne.

Technical Services No. 3

Comment: Although the necessity and goals of the geographic information system (GIS) are clearly laid out, no information is given as to how this is to be accomplished or what specific products will be available. Considering that in the Coastal Habitat study much of the 1990 activities will involve completion of processing of samples taken in 1989, data completion and management is clearly a problem. (UM)

Response: Implementation of Technical Services 3 objectives will be accomplished with an interdisciplinary mapping and analysis team using state of the art mapping science methods and technology. Both hard copy and digital map products are being made available to ongoing study participants.

Comment: Insufficient information is given in Objective 1 regarding the specific types of maps and analytical products to determine whether this program will provide valuable products in monitoring geographic distributions of data pertinent to the assessment of injury from the EVOS. (ESC)

Response: Map types and analytical products are litigation sensitive; however, accepted mapping science methods will be used recognizing all data limitations.

Comment: The specific objective concerning the type of database(s) to be developed and organization of data is not provided. (ESC)

Response: Development of database(s) will include a geographic component that will provide for commonality of data types.

Comment: There is insufficient information given to allow the reader to determine the adequacy of quality control on the inputting of data to the mapping process. There is nothing that indicates how the data, once it is in the mapping database, compares to the original data. (ESC)

Response: Technical Services 3 adheres to accepted mapping methods using state-of-the-art technology that includes quality assurance steps that compare data input with source information and with subsequent iterations of database development.

Comment: No information is given regarding the statistical treatment to be used to average data values for input to the mapping process. Similar problems exist with respect to database quality control. (ESC)

Response: Real data will be inputted to the mapping process. Source data will be used to verify database input and output.

Comment: It cannot be determined from the Plan whether objective, "multi-thematic atlases of pre-spill data" exist on the same scale as post-spill data. Thus, it is not possible to assess whether this work will contribute to the objective quantification of injury to resources or whether it is cost-effective. (ESC)

Response: Objective "multi-thematic" atlases of pre-spill data exist and are central to the objectives of Technical Services 3.

ARCHAEOLOGICAL RESOURCES

Comments on Archaeological Resources

Comment: The studies evaluating and quantifying injuries to archaeological resources are beyond the scope of the Trustees' authority as these resources are man-made under the definitions found in CERCLA and the Clean Water Act. Under these federal statutes, costs cannot be recovered for restoration, replacement, or lost use of such resources. Archaeological resources are addressed in other federal statutes, such as the Archaeological Resources Protection Act, and study of damages to these resources should not be funded under the NRDA. (API, ESC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the CERCLA/Clean Water Act damage assessment process. While other statutes may address injuries to archaeological resources, they do not preclude damage assessment activities undertaken pursuant to the CERCLA/Clean Water Act.

Comment: This study is poorly discussed and supported. Objectives and field, analytical, and statistical methodologies are not adequately described to allow review and comment. (API, ESC)

Response: The objective of this study is clearly stated to be the assessment of injuries to archaeological resources as a result of the EVOS. The study design is to request proposals from the professional community to meet the objective of injury assessment most efficiently and then to award a contract to perform the study. Because archaeological investigations are by nature labor intensive and therefore costly, the approach adopted is to use sample sites and statistically project injury estimates. This statistical approach is similar to the random stratified approaches adopted in other damage assessment studies. Final approval of the methodology will occur when competing proposals to perform the study are evaluated.

Comment: This study does not take into account data gathered during beach cleanup. Much of the information to be generated by this study is already available to the Trustees because of the extensive beach surveys undertaken as part of Exxon's clean-up operations. Site survey and site selection efforts will duplicate Exxon's existing documentation. (API, ESC)

Response: The principal purpose of Exxon's beach survey work was to identify sites for cleanup. Archaeological investigations of the sites was limited. However, the data gathered by Exxon in 1989 and 1990 contributed to the development of a list of archaeological resource sites that were injured, from which selected study sites were chosen. This study will intensively examine injuries through subsurface testing of sites and sampling of deposits to determine the extent of oiling contamination. Information obtained from Exxon-generated reports will be made available to investigators.

Comment: There is no explanation as to why surveys will be made in non-oiled areas. Site injury is a function of many factors (shoreline type, stratigraphy, location, degree of oiling, cleanup techniques and artifacts present) and the unique nature of individual sites, the range of their distribution and the diversity of time span make it inappropriate to extrapolate from control sites to oiled areas. (ESC)

Response: Archaeological sites are individually unique. As a result, the cost of investigating archaeological sites is high and the funds available to determine injuries are limited. Therefore, archaeological sites will be defined by site types and injuries will be determined from a statistically derived sample. In order to describe the population of sites most accurately and to give a basis for statistical treatment, a sample of study sites located in the general spill area was selected rather than biasing the study by only looking at oiled sites.

Comment: The costs of the study appear excessive. (ESC)

Response: Archaeological investigations are labor intensive and involve complicated and expensive laboratory analyses. Tests necessary to identify the presence of oil are costly. Additionally, the geographic study area is extremely remote. This factor causes very high logistical costs both for access and safety reasons.

Comment: There is insufficient information provided in the Plan to determine whether the methods to be employed will meet the standards and guidelines for archaeology and historic preservation set forth in 48 Federal Register 44716-44740 (September 29, 1983). (ESC)

Response: Because the Trustees are required to comply with applicable federal regulations, the procedures and investigators used to perform the study will be required to meet the standards presented by the Secretary of the Interior.

Comment: There is insufficient information to evaluate how the significance of historical properties, typologies, site investigations, impacts resulting from interviews, soil column characteristics and analysis, radiocarbon dating of artifacts, vandalism, and erosion rates will be determined. (ESC)

Response: The significance of historic and prehistoric properties will be determined using processes outlined in existing federal regulations. The issue of site significance was addressed in the Memorandum of Agreement signed by Exxon, Federal agencies, the State Historic Preservation Officer, and Native Corporations. The validity of typologies, adequacy of site investigations, and effects of archaeological investigations will also be addressed following existing federal procedures and normal scientific archaeological standards. The degradation of spill-affected historic properties will be compared with properties that have not suffered oil spill-related injuries to arrive at rates of degradation.

Comment: There is no indication of methods for preventing bias from response workers and government employees who are interviewed from entering this study. Nor is there any information on how results will be used to quantify injury. (ESC)

Response: Information received from interviews will be evaluated for bias and verified. One of the goals of the study is to document injury to sites both quantitatively and qualitatively. Once the types of injury are estimated, those injuries can be projected statistically to the total body of archaeological data in the study area.

ECONOMICS

Comments on Economics Studies - General

Comment: Although some investigation of loss of private use values may be undertaken for reference, the NRDA process does not allow for recovery of such damages or for investigation for private interests. (API)

Response: The Federal Trustees do not intend to include loss of purely private use values in their damage claim.

Comment: The economic studies do not appear to be tied in any way to the Clean Water Act standards for measurement of damages based on cost of restoration. These studies attempt to estimate foregone use and non-use values without applying the results to the determination of whether restoration costs are grossly disproportionate to the value of the injured resource or the identification of the most cost-effective restoration alternative. The NRDA regulations do not permit the Trustees to recover for lost use values. (ESC)

Response: The Federal Trustees have not determined the extent to which the economic damage assessment will adhere to the NRDA regulations (43 C.F.R. Part 11). It is the Federal Trustees' intention, however, to base their claim on the cost of restoration, replacement and the acquisition of equivalent resources plus the interim lost use value of the injured natural resources as authorized in Ohio v. Department of the Interior.

Comment: It is not reasonable for the Trustees to expend large sums of money on studies of lost use before determining whether natural recovery will be chosen as the means of restoring the environment. (ESC)

Response: Lost use will continue to occur until natural and/or man-made recovery of the natural resources takes place. The Federal Trustees will continue to expend such funds as are necessary to accurately measure those lost uses for as long as it is prudent to do so. Length of recovery and restoration options are being studied in other components of this NRDA process and are communicated to the economic experts regularly.

Comment: Several of the economic studies are double-counting alleged damages: those relating to non-use losses of natives; changes in property values which include separately measured use value effects; and separately alleged losses in sport fishing and charter boat operations. There is no mention in the Plan of any methods for accounting for double-counting, which implies that the Plan will lead to an inflated damage award. (ESC)

Response: The steps that are necessary to eliminate all double-counting in the estimates of lost value will be taken. There will be no double-counting in the federal economic damage claim.

Comment: Since the State's economic studies are not included in the Plan, there is a great likelihood that the federal and state economic studies are not coordinated or overlap. This will inflate assessment costs, reduce study quality and will double-count losses. Failure to include the State's studies in the Plan makes comment on the federal economic studies meaningless. Studies not contained in the Plan are "not reimbursable or admissible in the NRDA under federal law." (ESC, NRDC)

Response: The Federal Trustees are not aware of the contents of the State of Alaska's economic studies plans. Furthermore, the State of Alaska has chosen not to include any information about their economic studies in this document. The Federal Trustees do not view comments on their own economic studies plans as meaningless in the absence of information about the State of Alaska's economic studies plans.

Comment: The economic studies lack sufficient description of study objectives and methodologies to permit a thorough evaluation. (ESC, API)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose.

Comment: Since the assumptions, tasks and objectives identified in the 1989 and 1990 Plans were the same and a budget of $2.8 million was allocated for the economic studies in 1989, the status of the 1989 economic studies and expenditures made should be made available for evaluation of the 1990 study plans. (ESC)

Response: Information about the status of the previous years' efforts is litigation sensitive. The Trustees cannot reveal detailed information about that subject.

Comment: Many of the economic studies are undertaking expensive efforts to obtain data that should be available without cost from government and business sources. These include the demand for cruise ship tours, subsistence use data, identification of research studies underway before the spill, and data on the quantity and quality of fish. (ESC)

Response: All data necessary for estimating economic damages is being obtained at the least possible cost.

Comment: The Plan does not indicate that available substitutes for services affected by the spill, such as those existing in the unaffected areas of Alaska, Prince William Sound and the Gulf of Alaska, will be considered. Without this evaluation, the economic analysis will not be valid. (ESC)

Response: Where appropriate, availability of substitute resources and services will be taken into consideration in all of the economic studies.

Comment: The Trustees, in responding to public comment on the 1989 Plan, recognized that the NRDA regulations require the use of a 10% discount rate, but the 1990 Plan does not indicate that this rate is being used or, if it is not, how a different discount rate can be used. (ESC, APSC)

Response: The Trustees recognize that the NRDA regulations by reference to an Office of Management and Budget directive, require a 10% discount rate. Nevertheless, the NRDA regulations are optional, and there is no consensus among economists which would specify a particular discount rate as the only correct one.

Comment: The Trustees cannot select those portions of the regulations, such as the contingent valuation methodology, that inflate their claims and ignore others, such as the willingness-to-pay methodology. Willingness-to-pay is the only acceptable methodology for estimating damages using the contingent valuation technique. (ESC)

Response: The Trustees have selected economic methodologies that will result in the most accurate valuation of natural resource injury. The Trustees have not selected only those methodologies that will inflate their claims.

Comment: Economics 4, 8 and 9 are measuring speculative or potential, rather than committed, uses. Expenditures for this purpose are contrary to 43 C.F.R. Section 11.83(b). (ESC)

Response: The Federal Trustees will not include purely speculative damages in their natural resource damage claim.

Comments on Economics Studies - Specific

Economics Study No. 1 - Commercial Fisheries

Comment: This study fails to explain how it will exclude from consideration damages which are the subject of private economic claims. Hence double-counting will occur. They are not compensable under the laws and regulations that govern natural resource damage assessment. (ESC)

Response: The Federal Trustees have taken all steps necessary to eliminate double-counting from their final economic damage estimates. The Federal Trustees do not intend to include private damages in their claim.

Comment: There is no description of the methods to be used to measure the economic loss to seafood consumers. (ESC)

Response: The purpose of this plan is to provide public notice of the types of economic studies contemplated by the Federal Trustees. It is not intended to provide detailed descriptions of the specific methods being used owing to the litigation sensitive nature of the study.

Comment: The losses this study purports to measure are known already to be negligible. Salmon supply increased significantly in 1989 and prices decreased for reasons not associated with the spill. The net result did not have a detectable influence on consumer surplus. (ESC)

Response: The Federal Trustees are not aware of any studies that show that the EVOS caused only negligible losses to consumers of seafood products.

Comment: Modelling of the effects of the spill on seafood quality and quantity changes on consumers is unnecessary because quantity was substantially higher at every market level and because the State of Alaska assured that no quality-deficient seafood reached the market. (ESC)

Response: Appropriate data sets on the landings and values of Alaskan seafood products will be analyzed for evidence of quantity and quality changes caused by the EVOS. Other data, as appropriate, will also be collected and analyzed. Since it may be several more years before the spill's long-term effects on fish populations is known, it is premature to draw firm conclusions about the potential damages to consumers of seafood products.

Comment: There appears to be no relationship between this study and the numerous fish injury assessment studies. (ESC)

Response: This study will make use of the results of the fish injury studies, as appropriate.

Comment: Much of the data necessary to estimate commercial fisheries losses is available from state and federal sources, so the efforts to collect such data in this study are unnecessarily costly and duplicative. (ESC)

Response: The Trustees will use all accurate available data sources. No unnecessarily costly or duplicative data will be collected by the Federal Trustees.

Economics Study No. 4 - Public Land Effects

Comment: Nothing in the Clean Water Act or the NRDA regulations permits the Trustees to recover for damages such as those being measured by Economics 4: the purported losses are those to the commercial value of public lands if those lands are sold to a third party by the government. They are not natural resource losses. (ESC)

Response: The Federal Trustees believe that public lands constitute public natural resources. Thus, any change the EVOS caused in the value of public lands is a natural resource injury.

Comment: Description of the methodology of this study is extremely vague and insufficiently detailed to permit a thorough evaluation. (ESC)

Response: The purpose of this Plan is to provide notice to the public of the types of studies being carried out or contemplated. This notice is not intended to provide information sufficient for a thorough evaluation of all aspects of the studies.

Comment: The study does not identify the public lands to be included in the assessment. Damages cannot be assessed for lands not directly impacted by oil. (ESC)

Response: The study will identify all public lands that the Trustees believe were impacted by the EVOS.

Comment: The study cannot meet its objective of determining the change in market value of public lands simply by estimating pre-and post-spill prices. It must take into account factors unrelated to the spill such as changes in interest rates, but there is no indication of the method by which this will be done. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages. It is not the purpose of this Plan to present detailed information about the methods and data being used to estimate damages for this (or any other) category of loss.

Comment: The study must also factor in the effects of spill-related increases in land values. Land values in the affected area are influenced by the dominant role of public lands, use restriction, severe weather, poor access and low population density. Also, there is nothing in this study indicating methods for determining whether lands affected by previous spills are comparable to lands in this area or for determining the comparability of EVOS to prior spills. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages. It is not the purpose of this Plan to present detailed information about the methods and data being used to estimate damages for this (or any other) category of loss.

Comment: This study will lead to the double-counting of some damages because damages for some uses of public lands will be covered by other studies, e.g., recreation and foregone use. (ESC)

Response: This study will not necessarily lead to double-counting of damages. The Federal Trustees will ensure that the final damage estimate does not contain any form of double-counting.

Comment: Reduced land values become actual losses only to the extent that sales actually occur during the period of depressed value, so the study must focus only on losses actually incurred, not hypothetical losses. (ESC)

Response: Property values in the region affected by the EVOS may have been damaged, regardless of whether the losses were actually realized through transactions which occurred during the period of depressed land prices.

Comment: The Plan incorrectly assumes that losses in sale prices of public land leased or sold in 1989 apply to all public land in the affected area. (ESC)

Response: The economic methodology contemplated for this study does not necessarily assume that all public land in the region has been adversely affected by the EVOS.

Comment: There is a great number of near substitutes for almost any parcel of land in Alaska, so compensable damages to land values should be very low, due in part to the fact that a large percentage of land in the state is publicly owned and is rarely subject to sale. Given these facts, it is likely that the study costs will be unreasonable. (ESC)

Response: There are many factors that contribute to the value of any given parcel of land. All relevant factors will be taken into consideration in the assessment of damages to public lands. The Federal Trustees will not incur unreasonable costs in the pursuit of the NRDA for this or any other category of loss.

Comment: Paired-sale data should not be used since it is not appropriate to compare pre-and post-spill selling prices. (ESC)

Response: Paired-sale data will be used in this assessment only when doing so is consistent with appropriate economic and legal theories.

Comment: There is no provision for the recovery of land value that stems from cleanup and restoration. (ESC)

Response: All damages to land values consistent with appropriate economic and legal theories will be estimated.

Comment: The status of the 1989 study and the corresponding expenditures should have been made available for review of the 1990 Plan since there was so little change in the study premises and objectives between the two years. (ESC)

Response: The purpose of this Plan is to provide the public with a general notice of the types of studies being carried out or contemplated for the NRDA. Hence, unless the type of study described in the Plans of earlier years has changed, there is no reason to revise the general description provided previously. Detailed information about the status of the studies and expenditures to date is litigation-sensitive and therefore has not been included in this public document. The Trustees believe that they have provided adequate information to achieve the intended purpose of this Plan.

Economics Study No. 5 - Recreation

Comment: This study fails to explain how it will exclude from consideration damages which are the subject of private economic claims. Hence double-counting will occur. (ESC) Nor does it explain how double-counting of recreational fishing and boat charters for sport fishing and sea kayaking and boat charters for kayak transportation will be avoided. Also, damages included in this study duplicate in part those included in Economics 4. (ESC)

Response: No duplication or double-counting will be permitted in the estimation of natural resource damages caused by the EVOS.

Comment: Economics 5 does not define "natural resource services" precisely, which may result in the underestimation of damages: recreational fishing is defined from the global perspective rather than by species of fish; no distinctions are made for the wide variety of camping activities in Prince William Sound. The categorization of recreationists is unrealistically simple and not useful. Visitors to the Sound normally engage in a multiplicity of activities that overlap rather than individual ones. Placing each recreationist into one category lowers the value of the experience of that recreationist in the wilderness of the Sound, which can underestimate damages. (NWF)

Response: The Federal Trustees have never suggested that they intend to categorize recreationists in such a way as to be "unrealistically simple" for purposes of the economic assessment. Recreation damages will be estimated using state-of-the-art methods consistent with sound economic theory.

Comment: The study's assumptions ignore the facts that the most popular sea kayak and charter boat destinations (College Fjords and Columbia Glacier areas) were unaffected by the spill and the fact that increased escapement due to closure of commercial salmon fisheries led to increased sport fishing catches. If considered, these facts would influence study design and scope. (ESC)

Response: The study design and scope have been influenced by all relevant information about factors such as salmon fishing, recreational use patterns, and areas impacted and non-impacted by the EVOS.

Comment: Without details concerning its application to this study, it is not possible to ascertain whether the use of contingent valuation will provide valid or reliable results. It is an unproven and controversial methodology. (ESC)

Response: The Federal Trustees believe that contingent valuation is an appropriate method for valuing natural resource injuries. Use of contingent valuation methodology was approved by the court in Ohio v. Department of the Interior.

Comment: It is not clear from this study whether losses to commercial providers of recreational services will be estimated. They should not be since compensation is available to the Trustees only for foregone public use of publicly owned natural resources. (ESC)

Response: The Trustees do not contemplate estimating purely private losses.

Comment: There is no description of the methodology to be used for determining the spill's effect on the demand for cruise ship tours to Prince William Sound. (ESC)

Response: This Plan is not intended to provide detailed descriptions of the various economic studies. The Federal Trustees believe that the study descriptions provided are sufficient to provide general notice of the types of studies contemplated.

Comment: There is not enough detail to assess how substitution will be accommodated. (ESC)

Response: The availability of substitutes will be considered in all studies that measure the value of goods for which substitute goods are available.

Comment: The Plan indicates that virtually no work on this study was carried out in 1989. It is important to obtain data relevant to the purposes of this study while it still can be recalled accurately by the source. (ESC)

Response: The Federal Trustees agree that much of the data is time-sensitive. The Trustees have made every effort to gather all data as expeditiously as possible.

Comment: There is no reference to which "existing model for recreational fishing in the KP area" will be considered, the criteria that will be used to determine its applicability, what will be done in the event that the model is determined to be inapplicable or the geographical area to be examined. (ESC)

Response: The Federal Trustees do not intend for this Plan to include all details of the damage assessment methods they will be using.

Comment: Much of the data to be acquired in this study, such as cruise line bookings and sport fishing catch rates, is available from federal, state and business sources. Duplicating this data is unnecessary and costly. (ESC)

Response: The Federal Trustees will use the most cost effective sources they can identify to obtain data necessary for the estimation of economic damages.

Economics Study No. 6 - Subsistence

Comment: Documentation of the study plan is inadequate and there is no explicit objective stated in the Plan. Methods are not provided. (ESC)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose.

Comment: This category of alleged losses is the subject of other claims, including those by native groups. This study may double-count these losses. (ESC)

Response: The Federal Trustees will take all necessary steps to eliminate double-counting from their economic damage estimates.

Comment: Alleged losses of non-use values by subsistence communities are included in Economics 7 and 9. There is no method described in this study for distinguishing subsistence populations from the relevant populations in Economics 7. Nor is there a method provided for quantifying archaeological-based non-use values referred to in Economics 9 or reducing the non-use values estimated in other studies accordingly. These deficiencies will produce double-counting. (ESC)

Response: The Federal Trustees will take all necessary steps to eliminate double-counting from their economic damage estimates.

Comment: To the extent that contingent valuation will be used in this study, it should be noted that this is an unproven and controversial technique and there are not sufficient details in the study description to determine whether its use will produce reliable or valid results. (ESC)

Response: The Trustees believe that contingent valuation is an appropriate method for valuing natural resource injuries. Use of contingent valuation methodology was approved by the court in Ohio v. Department of the Interior.

Comment: There is no indication that the study will take into account the actions undertaken by Exxon Shipping Corporation, such as delivery of food and materials and payment for cleanup employment, to offset losses sustained by subsistence groups and to explain why they ceased to rely on traditional sources. (ESC)

Response: The Federal Trustees will take into consideration all relevant factors appropriate for accurately measuring economic damages.

Comment: The description contained in the 1990 Plan indicates that virtually no work was done on this study in 1989. The Trustees should make available the expenditures and status of this study. (ESC)

Response: Detailed information about the status of the studies and expenditures to date is litigation-sensitive and therefore is not included in this public document.

Economics Study No. 7 - Contingent Valuation

Comment: To the extent the State is conducting a contingent valuation study, the rationale for the Federal government to conduct a similar one is not apparent. (NRDC)

Response: The state and federal governments are pursuing separate claims that are likely to be heard in separate courts. The federal government has no control over, or information about, the state economics studies. Therefore, the Federal Trustees are performing their own economic studies.

Comment: The Trustees are using contingent valuation techniques to determine the value of some resources which appear to be non-public. (API)

Response: The Trustees will not use contingent valuation, or any other economic methodology, to measure injury to any purely private resources.

Comment: Contingent valuation's reliability for non-use values, such as intrinsic value, is controversial. Such methods are not supported by the literature. Unless the Trustees exercise care in their design and implementation, the results of these studies may not be reasonable. They are not likely to provide valid or reliable estimates of damages in the circumstances of this case. (API, ESC,) The difficulty of separating the use and non-use components of a contingent valuation response dictate against use of contingent valuation in this study. (ESC)

Response: The Trustees are proceeding very carefully with their contingent valuation study which is being performed by recognized experts in the field and which will be peer reviewed by nationally renowned economists. There is no need to separate the use and non-use components of contingent valuation responses.

Comment: The public is poorly informed as to actual conditions in Prince William Sound. Before contingent valuation questions are asked, it is important to assure that the respondents are given accurate information. (API)

Response: Contingent valuation respondents will be provided the amount and type of information deemed most appropriate for accurately measuring the natural resource damages.

Comment: Economics 7 does not describe: the survey plan; the survey design; the methods by which survey results will be analyzed; the type of research to be conducted to determine the accuracy of survey instruments; the type of preliminary testing that will be done; the basis for conducting a nationwide survey; or the type of econometric analysis that will be used. (APSC, API)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: There is no explanation as to how Economics 7 will exclude the lost public land, recreation, subsistence, research, and archaeological values that Economics 4, 5, 6, 8, and 9 purport to measure. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: The description of Economics 7 implies that that study will duplicate some portion of the state's economic studies. (ESC)

Response: The state economics studies are proceeding separately from the federal studies.

Comment: There is no legal basis for recovery of damages based on "intrinsic values." (ESC)

Response: The Trustees are obligated to study and to recover for all lost value to natural resources caused by the oil spill. Intrinsic values are a well-recognized component of the total value of a good, and the court in Ohio v. Department of the Interior held that use value is not the sole component of natural resource value.

Comment: Bequest values will not be reduced because full restoration of the natural resources will occur within a relatively short period of time. There cannot be losses of existence or bequest values for temporary injuries to natural resources. And option value losses should be small because future use is not expectedly to be adversely affected by the spill. (ESC)

Response: Bequest, option, and existence values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive time period.

Comment: Non-use value losses have been confined in the relevant literature to permanent, irreversible injury to unique resources. The extension in this study of non-use loss concepts to temporary injury to resources for which there are vast numbers of substitutes is contrary to the basic principles underlying these concepts. (ESC)

Response: There may have been permanent and irreversible injury to natural resources affected by the EVOS. Even if complete recovery does occur, contingent valuation is an appropriate methodology to use to measure decreased value of injured natural resources from the time of injury to the time of recovery.

Comment: Natural resource economists generally no longer consider option value to be a separate source of value. Hence the Trustees should not include option values as a component of value. Nor should the present discounted value of future use be included within the category of use value losses. Otherwise, double-counting will occur. (ESC)

Response: The Federal Trustees believe that all aspects of intrinsic value of the injured natural resources are recoverable. The Trustees do not believe that including present discounted value of any future lost use values will result in double-counting.

Comment: Use of willingness-to-accept measures in this study would contradict the NRDA regulations which provide that the only acceptable contingent valuation methodology requires use of willingness-to-pay measures. (ESC)

Response: Both willingness to pay and willingness to accept will be considered in the contingent valuation study. The Federal Trustees will use the measure that most accurately values the loss.

Comment: There is not an adequate description of the statistical design or quality assurance provisions of this study or any indication of the method for defining the sample population or drawing a representative sample. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: The budget is inadequately explained. Of note is the $670,000 for supplies and equipment. (ESC)

Response: The economic study plans are not intended to provide detailed information about the budgets for various studies.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation sensitive and cannot be provided in this public document.

Economics Study No. 8 - Affected Research

Comment: Loss of information associated with the interruption of scientific studies does not constitute a natural resources injury compensable under relevant statutes or DOI regulations. (API)

Response: The Trustees believe that the relevant statutes and the DOI regulations entitle them to recover for losses to the various services provided by the natural resources. One such service is the provision of scientific information that may be learned through scientific studies.

Comment: This study is to account for the cost of resources expended on research programs affected by the spill, but these expenditures should be the subject of private claims by the research program sponsors, not the Trustees. They are not natural resource injuries for which recovery can be had under the relevant statues or the DoI regulations. And whatever losses in knowledge might have occurred will be offset by the knowledge gained as a result of spill-related research. (API, ESC)

Response: The loss of scientific information provided by public natural resources is a public loss that the Federal Natural Resources Trustees should value. The Trustees do not view the research expenditures necessitated by the EVOS as a public benefit.

Comment: There is no identification of the research activities that were delayed or canceled as a result of the spill. Thus, it is not possible to determine whether the study costs are reasonable. (ESC)

Response: The study of affected research programs will inventory the research activities that were damaged or destroyed by the EVOS. These study plans and their budgets were intended only to provide the public with general information about the studies, not to reveal detailed information about the plans themselves or about the corresponding budgets.

Comment: The Plan does not set forth the criteria that will be applied to assure that assessment is directed to committed uses of the resource. (ESC)

Response: The "committed use" requirement derives from the NRDA regulations which are optional. Thus, the Trustees need not limit their studies to committed uses of the injured natural resources. Nevertheless, the Trustees do not intend to measure losses associated with purely speculative uses.

Comment: The Plan fails to set forth how the "total project costs, extra sums expended amounts spent on each study" will be used to evaluate research losses. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation sensitive and cannot be provided in this public document.

Economics Study No. 9 - Archaeological Damage

Comment: There is no explanation for inclusion of the remains of past human activity within the definition of "natural resources." (ESC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as, the natural components of cultural sites is properly within the natural resources damage assessment process.

Comment: The Plan contains no methods for assuring that double-counting will be avoided. This study potentially will double count the following alleged loss of value of archaeological resources as tourist attractions, which is also being studied in Economics 5, and archaeological science value, which is also being assessed in Economics 8. As to the latter, "intrinsic values" held by native groups will be counted three times unless there is some available method for dividing this value into subcomponents for existence values of archaeological resources, existence values for cultural heritage and culturally-derived intrinsic values held by native groups as members of the general population. (ESC)

Response: The Trustees note these concerns and intend to perform their studies so as to avoid double-counting.

Comment: There is no description of the methods for measuring economic damages and no explanation for valuation of allegedly damaged sites. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: There is no identification of the unique archaeological sites that have value as tourist attractions. (ESC)

Response: All archaeological sites are unique and may have a use value as tourist attractions.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation-sensitive and cannot be provided in this public document.

RESTORATION PLANNING

Comments on Restoration Planning - General

Comment: The Restoration Planning Project does not provide enough information on objectives or on field, analytical and statistical methodologies to permit adequate review. (ESC)

Response: The objective of the 1990 plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study and the interrelationships between studies, as well as the scope of the overall damage assessment program.

Comment: In order for the public to effectively participate in the restoration process, the results of the feasibility studies are needed. (NRDC)

Response: The information in the 1990 plan was provided to give the public a general understanding of restoration activities to be conducted in 1990. Additional information on the results of the feasibility studies will be published in a Federal Register Notice.

Comment: Many of the components of the restoration program are actually research. The program develops and tests unproven methods, such as the murrelet dawn detection technique, that do not focus on restoring the ecosystem. (ESC)

Response: Identifying and developing technically feasible restoration procedures for natural resources and services affected by the spill is an objective of restoration planning. Restoration will focus broadly on the recovery of ecosystems as well as individual components.

Comment: There is no information in the Restoration Planning Project as to the extent to which results of the technical studies were considered, if at all, in creating its objectives. Without such coordination, the undertaking of restoration studies is premature. (ESC)

Response: The restoration process is a dynamic process that allows for the incorporation of new information as it becomes available. The objectives for restoration include incorporating the results of technical studies in the selection of any restoration measures.

Comment: The Plan inadequately deals with the role to be played by natural recovery in the restoration process. The literature regarding historical spills indicates that natural recovery is a viable restoration option and one to be preferred. And the extensive natural recovery that has already occurred makes natural recovery the most cost-effective and environmentally sound restoration option. (API; APSC; ESC)

Response: Natural recovery monitoring will help determine the nature and extent of any natural recovery that is occurring. If natural recovery appears to be adequate, and within a reasonable time-frame, no direct restoration projects will be implemented. Information on the adequacy of natural recovery is central to determining whether to implement restoration actions or to allow injured resources to recover on their own.

Comment: The Plan assesses damages regardless of the prospects for natural recovery. Many of the studies are designed to demonstrate only that there are differences between oiled and unoiled areas without any consideration of whether these differences result in lost use or whether it would be desirable to correct these differences with restoration measures. (ESC)

Response: Identifying injured resources is the first step in the restoration process. Additional steps include determining the need for restoration, identifying potential restoration alternatives, evaluating potential restoration alternatives, implementing restoration alternatives on a continuing basis and evaluating the effectiveness of restoration activities. Even if natural recovery is deemed adequate, the Trustees are authorized to recover the lost use value of the resource during the period of recovery.

Comment: There is no connection between the restoration alternatives set forth in the Plan and the economic work evaluating the need for restoration and determining whether any of these projects are supportable in light of natural recovery. (ESC)

Response: An integral component of the restoration planning process is to determine the nature and pace of natural recovery of injured resources, and identify where direct restoration measures may be appropriate. All proposed restoration alternatives will undergo economic and environmental analyses to determine whether these projects are justified in light of natural recovery.

Comment: Restoration studies are only necessary if technical studies show that a resource will be adversely affected for a long period of time. Restoration studies that are being conducted before the results of the assessment studies are available must assume that all resources are injured and will require restoration measures. This approach requires the unnecessary expenditure of monies for feasibility studies and literature searches concerning resources that are later determined not to require active restoration measures. While this approach may shorten implementation time once the damage assessment process is over, it unwisely expends resources with little, if any, hope of benefit. (ESC)

Response: The Trustees disagree that restoration studies are only necessary if a resource will be adversely affected for a long period of time. Restoration studies may concern any degree of injury to a natural resource in order to determine whether to enhance natural recovery. During the course of the NRDA studies, where the nature of the resource injury is reasonably clear, and where no alternatives would be foreclosed, it may be desirable to begin implementation of certain restoration activities prior to the conclusion of the NRDA studies and a final restoration plan.

Comment: The focus of the Plan should be redirected toward the identification of alternative restoration strategies. The Plan incorrectly assumes that all resources were injured and that additional research is needed. (ESC)

Response: The Trustees have determined that in some instances they can begin identification of restoration strategies, but they have not obtained a full picture of injuries to all resources and for this reason will continue to study certain resources. When appropriate, further study of particular species will be discontinued. The Plan does not assume that all resources were injured; rather the Trustees are obligated to uncover injuries to all natural resources.

Comment: The Plan fails to focus on restoration. The restoration section of the plan is too cursory and the assessment therefore will not be cost-effective or produce a usable result. Cost-effectiveness does not appear to be a criterion of the Plan and does not play a role in the identification and selection of feasible restoration measures. (API, APSC)

Response: Restoration is receiving increased emphasis as the results of the damage assessment studies are analyzed. Cost-effectiveness is one of several criteria used to determine the appropriateness of a restoration option.

Comment: Thus far the Trustees have attempted to identify restoration approaches that have been used in the past, and then have pursued feasibility studies for other methods which may be costly or less proven. (API)

Response: Restoration options that have worked in the past or have known potential are the first options that were evaluated. Feasibility studies focus on identifying methods that are not as well-established in the sub-arctic conditions of the oil spill area.

Comment: Implementation of restoration strategies should only be undertaken at this stage if their funding does not diminish that available for damage assessment and they are limited to funding urgently needed acquisition projects or initiating pilot restoration projects that have a firm foundation in restoration studies that have been completed and analyzed. (NWF, NRDC)

Response: The Trustees and EPA view the entire restoration process as dynamic and evolving. As information about injuries, resource recovery, restoration methods or costs becomes available, certain activities may be recommended and implemented prior to completion of all damage assessment studies.

Comment: Any restoration projects conducted before the assessment is complete should be funded separately. Although the plan refers to pilot restoration projects, many of the experts consulted have stated that only after several years of damage assessment have been completed can a decision be made regarding the restoration measures to be undertaken. (NRDC)

Response: Any restoration projects that may be implemented prior to the completion of the assessment process will not be funded with monies appropriated for damage assessment activities, but will be funded separately. Restoration projects that are urgently needed to protect or restore injured resources may be implemented if they do not disturb ongoing damage assessment studies.

Comment: The types of restoration projects considered in the Plan are limited. More attention should be paid to acquisition of equivalent assets such as reacquiring timber rights in Prince William Sound and buying back the Bristol Bay oil leases. (NWF, NRDC)

Response: Acquisition of equivalent resources is one restoration option being evaluated.

Comment: Although Ohio v. Department of the Interior indicated that restoration or replacement of resources is the object of damage assessment, it also recognized where costs were grossly disproportionate to loss, such restoration should not be undertaken. (API)

Response: The value of the resource being restored, and the cost of restoration options, will be evaluated before any recommendations to conduct restoration projects are made.

Comment: Few restoration projects are scheduled for action. Restoration projects now consist primarily of workshops, public meetings and comment, and additional feasibility studies. Most of the restoration research remains piecemeal. (API)

Response: As more information becomes available on the nature and extent of damaged resources, additional restoration options will be identified. Workshops, public meetings and comments were, and will continue to be, solicited to help identify possible restoration options.

Comment: Feasibility studies are supported in advance of more expensive restoration activities when restoration has been justified and the realistic means for restoration have been found. Feasibility studies should be realistically selected from methods that have been successfully used in the past. (API)

Response: Due to the dearth of restoration information related specifically to the spill area, feasibility studies may be conducted in the oil spill area using methods that previously have not been employed in the sub-arctic environment as well as well-established methods that have been identified through the damage assessment process.

Comment: The 1990 Plan improperly focuses on potential injuries to natural resources without analyzing the need for restoration or the means to restore damaged resources, replace those that cannot be restored or acquire equivalent resources if restoration is required. Thus, the Plan does not provide a reasonable basis for recovering damages under the Clean Water Act or the NRDA regulations. (ESC)

Response: Before appropriate restoration activities can be fully implemented, it is necessary to make a tentative conclusion regarding natural resources injury. Restoration under the DOI regulations is a four step process: (1) The injured resources are identified; (2) The extent of injury is quantified; (3) A restoration methodology plan is developed to the level of detail required to determine the cost of restoration; and (4) After litigation or settlement, a final restoration plan is developed. The Trustees are acting in a manner consistent with these regulations.

Comment: Section 311(f)(4) and (5) of the Clean Water Act clearly makes the cost of restoration, replacement or acquisition of equivalent resources the exclusive measure of damages. There is no authority for recovery of lost use values. Lost use values can be used only to determine whether proposed restoration techniques are grossly disproportionate to the value of the injured resource and/or to determine the cost-effectiveness of various alternatives for achieving restoration. The Plan ignores this concept. (ESC)

Response: While lost use values may be used for the purposes suggested above, Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989), makes it clear that lost use values may also serve as a measure of damages under section 311 of the CWA.

Comment: The Clean Water Act and the NRDA regulations refer only to "acquisition of equivalent resources." There is no authority for the Plan's expansion of this concept to include acquisition of equivalent goods and services. (ESC)

Response: While the use of NRDA regulations is optional, the regulations generally define "acquisition of the equivalent" as the substitution of an injured resource with a resource that provides the same or substantially similar services. 43 C.F.R. § 11.14(a).

Thus, any restoration option that includes the acquisition of equivalent resources therefore, properly may consider the services those resources provide, both to the ecosystem and to humans.

Comment: The Plan contemplates calculation of natural resource damages independent of the cost of reasonable restoration activities for the recovery of natural resources affected by the spill. This contradicts the fundamental purpose of the damage assessment, which is restoration. (ESC)

Response: The Trustees are directing the damage assessment and restoration planning processes with the objective of restoring injured resources. As indicated in Ohio v. Department of the Interior, the cost of restoration is not the sole measure of damages.

Comment: The Plan fails to include cost-effectiveness criteria in its evaluation of restoration alternatives. It refers on page 333 only to the identification of costs of implementation of restoration measures without referring to the benefits associated with those measures. And on page 336, the list of criteria for selecting restoration feasibility projects makes no reference to any requirement that restoration be more cost-effective than natural recovery. (ESC)

Response: The services provided by the resource, as well as the cost of implementing the restoration measure, will be evaluated before any restoration option is selected. The requirements for restoration include cost-effectiveness and the standard that the cost of the restoration measure not be grossly disproportionate to the value of the resources or services restored.

Comment: The Plan seems to assume that the environment must be restored to a pristine state. Support for this is not found in the Clean Water Act, the NRDA regulations or in Puerto Rico v. S.S. Zoe Colocotroni. Restoration measures should simply return or replace resource services to their baseline condition. (ESC)

Response: The intent of the restoration process is to return the injured resources to their baseline condition. This includes not only their biological condition but also their ability to provide the previous level of services.

Comment: The Trustees are responsible for selecting a cost-effective restoration program; the public's participation in this process is unproductive since the public does not have any independent knowledge about injuries or restoration needs. Public meetings held to develop lists of restoration ideas create expectations in the public that are not justifiable given the actual state of the environment. (ESC)

Response: The Trustees believe that public involvement is an important part of the restoration process. The commenter's desire to increase the influence of responsible parties while excluding the public is inconsistent with the goals of the restoration process.

Comment: The Trustees alone are responsible for choosing active restoration measures. The restoration project's emphasis on public involvement is contrary to the regulatory requirements since it is not cost-effective and distracts the Trustees from focusing on the technical information needed to identify whether specific restoration measures are needed. (ESC)

Response: While the decision to plan for implement restoration activities does rest with the Trustees, they have determined that public participation is important to the damage assessment and restoration planning process. To invoke the public in this process is not contrary to the assessment regulations and assists the Trustees in identifying information important to the restoration process.

Comments on Restoration Planning Activities - Specific

Restoration Technical Support Project No. 1

Comment: The Introduction's statement that "an additional more formal round of peer review is not possible" implies that the "comments received at the technical workshop and series of public meetings" were part of a review process. These meetings were part of an informational effort, not a review process. This statement also implies that the projects were conceived and initiated hastily. They should have been conceived during the winter and aired for comment by interested parties before they were undertaken. (ESC)

Response: Comments received during public technical workshops and meetings were considered during the process of proposing feasibility studies for the 1990 field season. In addition, experts were consulted during other non-public technical workshops.

Comment: The peer review process described appears to be flawed and may generate biased comments. Some of the peer reviewers may have a vested interest in the outcome since they are part of the NRDA process. No information about the reviewers is provided to ensure that such bias does not occur and that a thorough technical review will be made. (ESC)

Response: It is not necessary to list the names of individuals providing expertise in order to review the validity of the studies. Every effort has been made to ensure that a balanced, objective review occurs for each study.

Comment: The cost-effectiveness of this project's review of 1990 feasibility study results is questionable given that those projects are not justified. (ESC)

Response: The cost of this study is reasonable. The peer review process ensures that proposed feasibility studies are appropriate for implementation.

Restoration Technical Support Project No. 2

Comment: This project should have as its objective natural recovery. (API)

Response: The goal of this project is to create a database of information that will help identify areas where direct restoration is appropriate.

Comment: Acquisition-based restoration studies, such as Project No. 2, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: This project is designed to provide information necessary to determine appropriate restoration procedures that are not limited to acquisition.

Comment: This project is neither cost-effective nor focused. It obtains, translates and analyzes data for all the major resources instead of concentrating only on those resources that are in need of restoration efforts. This study's support of off-site habitat acquisition is premature since it has not been shown that impacted habitats cannot be restored. (ESC)

Response: It is appropriate to have a database that shows the status of all resources potentially impacted by the oil spill so that all reasonable restoration options can be analyzed. It is intended to provide a base from which candidate sites for restoration or acquisition can be identified.

Comment: No information is given for evaluation of the type, amount or usefulness of the information to be integrated, the procedure to be used or any quality assurance checks to be employed. And it is unclear whether natural recovery processes will be incorporated into the final result. (ESC)

Response: The information is being reviewed to ensure that it is in an appropriate format for use in the overall restoration planning process. The information provided may also prove advantageous for documenting natural recovery processes that may be occurring.

Restoration Technical Support Project No. 3

Comment: There is no basis for this type of study given that there has not been an identification of injuries requiring restoration. This approach to identifying and developing restoration plans is neither focused nor cost-effective. And there is no consideration given to the ability of the natural resources damaged to recover naturally. (ESC)

Response: This project established a process for developing and reviewing feasibility studies to be considered for implementation in 1991. No decisions have been made about which studies to actually carry out, pending further evaluation of damage assessment study results. The ability of natural resources to recover naturally is being taken into account; one of the feasibility studies considered would explore methods for monitoring of natural recovery rates.

Comment: There is not enough information given to evaluate the nature and content of the meetings or how future project plans will be more fully developed. (ESC)

Response: More information will be provided about feasibility study proposals prior to implementation in the field.

Comment: There is no way to determine whether and how cost-effectiveness criteria will be considered and whether the focus is solely on restoring oil-spill related injury. The artificial reef project is suspect because there are no confirmed fish kills, reefs were not impacted by oil, and water quality is good. (ESC)

Response: Cost-effectiveness criteria will be considered before implementation of any restoration project, and one of the purposes of conducting feasibility studies is to establish the costs associated with implementation. Construction of artificial habitats for fish and shellfish can enhance productivity and may be one means of restoring damaged population. No decisions have been made about the for, or appropriateness of, such measures in the oil-spill environment. It was cited here as an example of the type of restoration project for which a feasibility study might be need.

Feasibility Study No. 1

Comment: This feasibility study is unnecessary since there is evidence that this resource is recovering rapidly. Recruitment has proven to be effective for restoring oiled shoreline areas, so the benefits of natural recovery will far outweigh those of any of these restoration efforts. (ESC)

Response: Based on further surveys conducted prior to actual field work, the study was modified to determine the causes of variation in fucus recovery and document the extent of natural recruitment in areas disturbed by oil and cleanup efforts. Understanding the causes of natural variation in recruitment may suggest restoration measures to enhance the natural process.

Comment: The majority of this study appears to be research and should not be funded under the NRDA program. Objectives B, C, D and E should only be considered if Objective A reveals that there is a definite need. Otherwise, implementing all of these objectives at the same time is not cost-effective. (ESC)

Response: Objective A was the primary focus of the 1990 study. Objectives B, C, D, and E were modified based on the results of natural recovery monitoring.

Comment: Objective A may overlap with, or duplicate, work being performed in Air/Water 2 or Coastal Habitat 1.

Response: Objective A was similar to objectives in Coastal Habitat 1. However the studies looked at different aspects of the environment and close coordination prevented overlap and duplication.

Comment: Considering the potential for natural recovery, the advantages of transplanting *fucus* are not well discussed. The success of this project is questionable. (API)

Response: The project was modified and no transplanting occurred in 1990.

Comment: Objective C is confusing since *fucus* has spores rather than seeds. And the high energy environment of Prince William Sound will create a dispersal of planted spores greater than the 1 meter noted in the study. (API, ESC)

Response: The word seeding was used in a general sense to mean artificial establishment of *fucus* in barren areas. *Fucus* embryos are dispersed from the parent plant.

Comment: The dispersal test for oiled areas treated with differing cleanup methods is basic, general and unnecessary research. (API)

Response: The study was modified to eliminate this part of the project in 1990.

Comment: There is insufficient information given regarding field methodologies. Although three methods are referred to in the field tests, only two are specifically mentioned. The lack of detail on types of habitat, measured parameters and statistical methods will leave the findings of this study open to challenge. (ESC)

Response: The field methodologies and statistical methods were subject to evaluation to ensure they were valid.

Comment: There is insufficient information concerning the laboratory experiments to evaluate them. (ESC)

Response: The study was modified, and laboratory experiments were conducted as part of this study.

Comment: The statement in the introduction to this study regarding the reduction of *fucus* over large areas fails to consider the vertical distribution of *fucus*. Most *fucus* below the lower intertidal would have suffered little impact from oiling or cleanup. It therefore remains a diversified source of spores for recruitment. (ESC)

Response: The upper edge of the *fucus* zone is in a highly hostile environment where it is difficult for plants to become established. *Fucus* living below the intertidal zone were taken into account in the design and execution of the study.

Feasibility Study No. 2

Comment: The reestablishment of grazers and predators will not restore the ecosystem if primary producers on which the grazers feed are not present. (API)

Response: The study also examines the recolonization of primary producers.

Comment: As the larvae of rocky intertidal species are pelagic, it is likely that the community will recover naturally within a few years, without planting species. (API)

Response: The study examines the rate of natural recovery to determine if it is sufficient or can be enhanced by artificial means.

Comment: The term "enhancement plots" mentioned in the study description is unclear. (API)

Response: Enhancement plots are experimental sites that were established.

Comment: Predator exclusion studies may be basic scientific research beyond the scope of the DoI regulations. (API)

Response: Predators are a variable in the ecosystem that need to be experimentally controlled to identify the potential impacts of EVOS.

Comment: This feasibility study is unnecessary since this resource is recovering rapidly. And cleanup techniques were designed to minimize further injury, thereby leaving a good source of fauna available for recruitment. It is more in the nature of research than damage assessment. (ESC)

Response: The study was conducted to determine if it was reasonable to continue exploring restoration of an intertidal ecosystem heavily impacted by the EVOS. The Trustees disagree with the general assertions of the review that the resource is recovering rapidly and cleanup techniques minimized injuries.

Comment: There is insufficient information given to evaluate how the feasibility of enhancing colonization of key species and recovery rates will be determined and statistically verified. (ESC)

Response: The study was technically and statistically reviewed to ensure its design is valid.

Comment: There is no information on the source or selection of limpets as grazers and *Nucella* and *Leptasterius* as predators to be the key intertidal species as a baseline for measuring recovery. (ESC)

Response: *Nucella* and *Leptasterius* are important predators in the intertidal community and are likely to have an impact on the community structure. They both have limited dispersal capability and are likely to have been impacted by the oil spill. There is ample literature that identifies limpets as critical grazing components in the community structure.

Feasibility Study No. 3

Comment: This feasibility study is unnecessary since this resource is recovering rapidly. And cleanup techniques were designed to minimize further injury, thereby leaving plenty of growth available for recruitment. (ESC)

Response: Beach wild rye appears to be recovering at most locations. At some sites recovery is slow or non-existent. These sites are subject to erosion and will require intervention to mitigate otherwise deleterious effects. The actual number of sites and the type of intervention necessary will be determined after the 1991 spring shoreline assessment. Although cleanup techniques may have been designed to minimize injury, the actual conduct of the cleanup did result in injury to beach wild rye at some locations.

Comment: Restoration methods cannot be evaluated because there is no information given on the "well-established techniques for restoring rye grasses." (ESC)

Response: Only limited information was given on restoring rye grasses since the methods are simple, have been used successfully for years, and are commonly known.

Comment: There is not enough information available to judge the cost-effectiveness of this study. The objectives, even if necessary, should be phased so that B and C are only carried out if it is determined from Objective A that restoration will be necessary. (ESC)

Response: This study determined that there are sites that need restoration and that given the injury observed to date, a pilot project is not necessary before restoration is implemented. Sites to be restored will be determined after the 1991 spring shoreline assessment.

Comment: The information to be gained from this study is not worth a full-scale beach wildrye restoration project. It is not appropriate to identify and prevent erosion which may occur for reasons unrelated to the oil spill. (ESC)

Response: Beach wildrye sites will be restored where there is a danger of further injury if the sites are not restored. There has never been the intent of the Trustees to restore beach wildrye just to study restoration methods. The intent is to identify and prevent erosion for reasons related to the EVOS.

Comment: Too little information is provided to evaluate the criteria used to establish the site potential for wildrye restoration. The mere presence of oil during a site visit does not necessarily mean that there is injured beach wildrye in need of restoration. This grass can grow well even in the presence of oil. (ESC)

Response: The need for wildrye restoration is based primarily on the potential for natural recovery or the lack thereof and the likelihood of continuing erosion if restoration measures are not implemented. The Trustees are aware that beach wildrye can survive in the presence of oil.

Feasibility Study No. 4

Comment: Acquisition-based restoration studies, such as this one, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: Marbled murrelets and harlequin ducks were killed by oil from the spill. Such injury warrants small scale feasibility studies to help determine the need and practicality of possible restoration activities that may be necessary in the future.

Comment: This study is poorly defined. Identification of upland habitats used by murrelets and harlequin ducks is not instructive of habitats used by other species. This study should identify instead scarce habitat types or habitat types used by the greatest number of species (or the species most vulnerable to disturbance or disruption) or those habitats most threatened by human activities. (NWF)

Response: Injury to these species necessitates an understanding of their critical upland and marine habitat.

Comment: Objective E of this study is ambiguous and cannot be evaluated without a definition of the scope of the term "full-scale restoration project concerning upland habitats." If these habitats have not been injured, there is no need for restoration. (API, NWF)

Response: Objective E of restoration feasibility project #4 was not carried out in 1990.

Comment: The budget for Restoration Feasibility Study No. 4 is disproportionately small, especially when compared to that for Restoration Feasibility Study No. 5. (NWF)

Response: The goal of each restoration feasibility project is to accomplish its goals in a cost-effective manner. People and equipment were jointly shared by projects, thus enabling a very modest budget to accomplish the primary tasks.

Comment: Evaluating new research methods such as the dawn detection technique for marbled murrelets is inappropriate. This work is research. (ESC)

Response: The dawn detection technique for marbled murrelets has been used in other west coast areas with some success. Thus, testing its applicability in Alaska was within the scope of feasibility project guidelines. Because it is not known where marbled murrelets nest in PWS, this must be determined before other more specific restoration projects can be developed.

Comment: Insufficient information is provided to evaluate whether the monitoring of two species of birds can provide sufficient data to develop a feasibility study or full-scale restoration project. (ESC)

Response: The type of data provided in the project descriptions is limited due to the need to keep specific information confidential pending potential litigation.

Feasibility Study No. 5

Comment: Acquisition-based restoration studies, such as this one, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: This study will provide background information on the oil-spill area and adjacent lands and will also serve to identify potential sites for restoration projects.

Comment: The description of Restoration Feasibility Study No. 5 is too vague. It is not possible to ascertain whether it will review an appropriate number of potential equivalent assets. (NWF)

Response: The focus of the study is on the entire area influenced by the EVOS.

Comment: The study indicates that equivalent resources will be acquired. There is no connection between timber land or land proposed for development and lands affected by the spill. (API)

Response: This study is looking at the status of upland resources and the relationship of that land with resources impacted by the EVOS. No decision has been made to acquire upland resources.

Comment: The assessment of alternative cultural sites is not appropriate as they are not natural resources. (API)

Response: Acquisition of cultural sites is one option mentioned by the public as a possible restoration measure. A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the NRDA process.

Comment: Much of this study does not appear to be related to areas affected by the spill; rather, it appears to be data-gathering. Considering the large amount of information that has been gathered, additional mapping is neither warranted nor cost-effective, without knowing which, if any, natural resources should be considered for off-site habitat acquisition. (API, ESC)

Response: The Trustees disagree. The results of this study will help identify the upland resources that may assist in the recovery of injured resources if acquired.

Response to Public Comment on the 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill

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COMMENTS AND RESPONSES CONCERNING THE 1991 STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION PLAN FOR THE EVOS

The 1991 Plan was made available to the public for review and comment. Seven reviewers representing industry, environmental groups, and the general public submitted comments on the Plan. The reviewers included: Alyeska Pipeline Service Company (APSC), American Petroleum Institute (API), Exxon Shipping Company (ESC), National Wildlife Federation (NWF), and Natural Resources Defense Council (NRDC). Reviewers commented on the overall nature and content of the Plan and provided technical remarks concerning many of the individual studies. All comments will be considered by the Trustees during their evaluation of the 1991 data and the formulation of the 1992 Plan.

The comments and responses are organized into two categories--those dealing with the general nature of the plan and those concerning a specific category of studies or individual studies. This section provides a synthesis of the comments and their respective responses, while the following sections address the categories of studies. For the information of the reader, the reviewers have been identified with their comments.

General Comments on the Plan

Comment: The Trustees are continuing to study resources for which they have no conclusive evidence of injury, such as brown bear, or for which they have no documented significant injury, such as several species of coastal and offshore fish (see 56 Fed. Reg. at 14690 and 14692, Apr. 11, 1991). These studies should be discontinued. Also, the Trustees should release data so that the public can determine whether there are other studies which should be discontinued. (APSC)

Response: The process by which conclusive and significant injuries can be demonstrated is frequently slow because sublethal injuries often have substantial but not acute effects to populations and must be investigated over an extended period in order to be determined. Acute effects, when they occur in remote locations, are often difficult to document, and evidence of their occurrence must be extrapolated from the observations of sublethal effects. The Federal Register notice referenced was an interim report of the findings. The report does not predict that conclusive and significant injury will not be established. In fact, if the Trustee's believed that the likelihood of establishing significant injury were poor, such studies would be discontinued as some have been.

Comment: Several studies violate the regulatory requirement that their costs not exceed the amount of damage anticipated. The studies that fall into this category are Fish/Shellfish Study No. 11 and Terrestrial Mammals Studies Nos. 3 and 4. The Trustees' view that the overall cost of damage assessment must be cost-effective (rather than each project being cost effective) subverts the safeguards against irrational spending that appear in the DoI regulations. (ESC)

Response: The regulations require a determination that the assessment is likely to be obtained at reasonable cost. In each of these instances there exists substantial evidence of injury. The current studies are designed to determine the extent of that injury following which it will be possible to value it. In the judgement of the Trustees, the costs of the studies are reasonably related to the probable damage.

Comment: Contingent valuation is not an appropriate method for valuing natural resource injuries, as the Trustees suggest in their response to public comments on the 1990 Plan. It was not "approved" by the court in Ohio v. Department of the Interior: the court would not have endorsed a methodology that does not work, and contingent valuation has not been shown to be a reliable or valid measure of non-use damages. Thus, it should not be used to produce the non-use or the total value of injured resources. (ESC)

Response: In Ohio v. Department of the Interior the court upheld DOI's decision to include the contingent valuation method in the Natural Resource Damage Assessment Regulations. Contingent valuation has been recognized by leading experts in the field as a valid method for measuring non-use damages.

Comment: Although the Trustees have agreed to consider NEPA in future restoration projects, there is no reason for excepting NRDA studies from NEPA's purview. (NWF)

Response: Restoration projects that have already been implemented by the Trustees have met NEPA requirements. The application of NEPA to future projects will continue to be considered by the Trustees.

Comment: The Trustees' request for public comment on the 1991 Plan is ill-timed. Most of the studies have already commenced by the time public comments are received and therefore can have little impact on study designs and implementation. (NRDC) DOI's regulations require public involvement before implementation of the assessment plan. (APSC)

Response: While it is true that some studies are implemented in the spring, most were not begun until the summer season and could be modified where appropriate. Public comment can also be used to benefit the subsequent years' planning efforts as well. Likewise, analysis of samples and data is an ongoing process, and can be responsive to meaningful public comment at any time.

Comment: There is no suggestion in either CERCLA or the Clean Water Act that the Trustees may ignore the DOI regulations or vary from them, and they have not provided any justification for doing so. Their departure from the regulations is unlawful and will result in the scientific invalidity and the legal indefensibility of the final assessment. (APSC)

Response: Scientific validity arises from the scientific methods used and the scientific scrutiny applied to the results. The Trustees have employed the best available scientists to conduct the damage assessment studies. The Trustees therefore believe the assessment is legally defensible.

Comment: The rebuttable presumption does not apply in the event that the Trustees selectively use the DOI regulations. According to the preamble to the regulations, only the dollar figure representing damage assessment is entitled to the presumption, not the method used for reaching that figure. (APSC)

Response: The rebuttable presumption applies to damage assessments performed in accordance with the DOI regulations. While the Trustees have not made a final decision regarding the extent to which they will apply the DOI regulations, those aspects of the assessment conducted in accordance with the regulations are entitled to a rebuttable presumption.

Comment: The State's game management policies are not consistent with the Trustee's claims of effects on wildlife: the brown bear and waterfowl studies fail to acknowledge that continued sport hunting of these species is a tacit recognition of harvestable surplus. (ESC)

Response: The presence of a huntable surplus does not mean that injury did not occur. Populations may have been reduced due to EVOS related mortality, but perhaps not to a level requiring hunting season closures.

Comment: The study designs do not reflect the fact that natural variability can alter population trends. This is especially true of the Terrestrial Mammal Studies Nos. 3 and 4 and the harbor seal study (Marine Mammal Study No 5). (ESC)

Response: The studies were designed to account for significant natural variation that could influence results, and, therefore are expected to detect injury from oil contamination. The cause of much of this variability is identifiable through empirical field observations, laboratory testing of tissues, through the use of control site study areas or other scientific controls. It is unlikely that biological communities in oiled study areas and unoiled areas would respond differently to a natural perturbation that was not detected by biologists.

Comment: The Trustees are obscuring the fact that the environment is recovering rapidly by attempting to maximize their legal claims through the publication of the Summary of Injuries, which disregards scientific evidence of the ecological health of the area. (ESC)

Response: While the Summary of Injuries was filed in the Federal District Court for Alaska, it was prepared in response to a request from three U.S. House of Representatives Subcommittees of the Committee on Merchant Marine and Fisheries. The Subcommittees were considering the merits of the proposed settlement agreement among the Trustees and Exxon that was negotiated, but rejected, in early 1991. The Subcommittees specifically requested a summary that described the scope and severity of known injuries caused by the EVOS, which did not disregard any known evidence of recovery. If the reviewer wishes to provide scientific data supporting its statement regarding the ecological health of the area, the Trustees will consider this data in conducting the damage assessment.

Comment: The Trustees' response to commentators' suggestions that archaeological sites and other man-made artifacts are not appropriate subjects of study under either the Clean Water Act or CERCLA relies on a stilted interpretation of the term "natural resources." (API)

Response: The Trustees believe a study of injuries to archaeological resources is properly within the damage assessment process and disagree that their interpretation of the term "natural resources" is stilted.

Comment: The Trustees have focused their efforts on point-by-point rebuttal of public comments rather than ensuring that the process is redesigned to correct its procedural and substantive deficiencies. (ESC)

Response: Where appropriate, while implementing the studies the Trustees have incorporated recommendations made by the public. The Trustees do not seek to rebut comments made by reviewers, but rather seek to be responsive to concerns raised by the public.

Comment: The potentially responsible parties have been excluded from participating in the process, which is contrary to the Department of Interior regulations. This has produced an ill-focused project that will not link measured differences between spill and reference sites to specific restoration needs; a prolonged process that will delay implementation of restoration activities and limit their effectiveness; and a process in which monies are spent on ill-advised studies that have little chance of identifying cost-effective restoration activities. (ESC)

Response: Under the NRDA regulations, the degree of participation by potentially responsible parties in the damage assessment process is within the discretion of the Trustees. See 43 C.F.R. 11.32. In this damage assessment, the potentially responsible parties have been given a full opportunity to review and comment upon the damage assessment plan. If the commentator wishes to provide scientific data supporting its statements that the current damage assessment studies do meet the needs of identifying appropriate restoration activities, the Trustees will consider this data in conducting the assessment.

Comment: It cannot be discerned from the Scientific Peer Review Outline whether peer reviewers, including a Chief Scientist, have already been designated and, if so, whether they have been reviewing 1989-90 study plans and data. Nor is there any indication whether the Trustees have been following the advice of the peer reviewers. The budget for peer review does not indicate the purposes for the intended expenditures, and there is some question as to whether NOAA will be a contributor to this funding for the peer review process or will rely solely on reimbursement from the remaining federal trustees. (NWF, NRDC)

Response: Federal and state peer reviewers with expertise in all major resource areas were contracted in 1989 and have been fully involved in reviewing study plans and data. The study plans have been modified, where necessary, based on expert review. The chief scientist position was established in 1990. The Chief Scientist has been very active in providing expertise and direction for all NRDA and Restoration activities. Funding for all peer review activities has been shared among the Trustees.

Comment: It is not clear whether the Chief Scientist referred to in the Plan is NOAA's Chief Scientist or someone else. Nor does the Plan indicate what is the role of the State of Alaska vis-a-vis the Chief Scientist. (NRDC)

Response: The Chief Scientist serves all of the Trustees. The position is contracted through NOAA for the Federal Trustees, but funding is shared among the Trustees.

Comment: The damage assessment process undertaken by the Trustees fails to take into account the overall vitality of the ecosystem and fails to identify steps needed for restoration. This approach will give a biased view of the environment because the damages assessment studies are focused on chemical and biological differences at the microscopic level. (ESC)

Response: The 1991 damage assessment plan has been reviewed extensively by appropriate experts to ensure the study designs will measure injury and determine links to potential restoration activities. The NRDA studies have been devised to allow for an ecosystem approach to injury determination, not merely a superficial approach.

Comment: The Trustee Council's program of scientific inquiry is a chase for phantom injuries. Even after $70 million worth of scientific studies, no significant restoration needs have been identified; the Trustees' approach presumes injury and a need for active restoration. (ESC)

Response: As demonstrated by the summary of effects that was filed with the Federal District Court in Alaska and made available to the public on April 8, 1991, the injuries to natural resources caused by the oil spill are not phantom injuries. Once an ecosystem has suffered such an assault, it is time consuming to review the injuries and develop a comprehensive restoration program. To date, the resources needed to accomplish restoration planning and implementation have been supplied by public funds and not by the responsible parties. The Trustee Council has planned and executed restoration planning programs during 1990 and 1991 that provide information for comprehensive restoration planning.

Comment: The study designs fail to take into account the potential for natural recovery, which the DOI regulations clearly anticipate as a restoration option. The Trustees also fail to put the injuries in perspective: they have ignored the vast amounts of shoreline that were untouched by the spill, the vast wildlife populations that inhabit the spill area and the evident of recolonization of the areas previously oiled. Without taking these factors into account, the Trustees' restoration options will be meaningless. (ESC)

Response: The study designs do not fail to consider the potential for natural recovery. The Trustee Council has attempted to provide a perspective of the injury by providing the total mileage of oiled shoreline and the extent to which those shores were oiled, the number of mortalities of species and the estimated fraction of the population in that area. In addition, the commentator errs in equating magnitude of unaffected shoreline and large wildlife populations with a certainty that the ecosystem and individual species are unaffected. While some areas that were despoiled by the oil spill are now being recolonized by opportunistic species, full recovery is neither certain nor complete.

Comment: The 1991 Plan continues the deficiencies of the previous years' plans in that it: fails to focus on restoration and ignores the role of natural recovery in restoration; improperly calculates natural resources damages; conducts studies that will produce the double-counting of damages; and fails to follow the DOI regulations. (ESC)

Response: The 1991 Plan continues to follow a comprehensive approach to identifying injuries to natural resources and developing a comprehensive restoration program. Consideration of the role of natural recovery is an element of this approach. While the Trustees are not required to comply with the DOI regulations, they have followed a process that is very similar to the DOI provisions.

Comment: The 1991 Plan fails to include basic information about the restoration studies such as the nature, extent and location of the injured resources that are the subject of the restoration projects and the restoration alternatives that were considered. The restoration Work Plan also fails to justify the cost-effectiveness of the proposed projects. (ESC)

Response: Information concerning the restoration studies has been provided in two Federal Register notices. The first notice provided a description of the planned restoration work for 1991. 56 Fed. Reg. 8898 (March 1, 1991). The second announced the availability of work plans for these restoration activities. 56 Fed. Reg. 36150 (July 31, 1991). Cost effectiveness was one of the factors used to evaluate the selection of these activities.

Comment: Many of the studies make no effort to investigate and define restoration options and methodologies. This is a misuse of statutory and regulatory authority. (ESC)

Response: The studies mentioned are focused to assess the extent and type of injury as the first step in developing restoration measures. Restoration measures either have been or will be considered as injury is more defined.

Comment: Where studies have been combined or reorganized, there is too little information given as to the manner in which the new studies will meet the goals of the studies they replaced. (NWF)

Response: Most of the goals of the reorganized studies remain the same. The new combinations of elements is believed to be a more logical representation of the overall study objectives than previously. For example, the deep and shallow benthic studies were elements of previous studies (Air/Water 2 and 4, and Coastal Habitat) that were combined as one subtidal benthic study (Subtidal 2).

Comment: Study objectives are not uniformly presented in terms of a null hypothesis. The hypothesis proposed to be tested are most often stated in terms of whether a particular change/difference is due to EVOS rather than the classic null hypothesis, i.e. that the change/difference is due to chance. It may be advisable for the peer reviewers to consider whether these discrepancies affect study design or the legal import of the NRDA studies. (NWF)

Response: The point is well taken. Detailed study designs have been subject to scrutiny of statisticians and are believed appropriate. In cases where the null hypothesis may have been misstated in the study plan, this will be corrected for data analysis to conform to the accepted definition of the null hypothesis.

Comment: The scientific studies do not establish or document an obvious and continuing pathway for exposure to the oil. Continued exposure to hydrocarbons is unlikely, as shown by Dr. Neff's water quality report. The studies do not distinguish between EVOS and other natural and/or anthropogenic sources of hydrocarbons. (ESC)

Response: In the case of the subtidal studies, determining pathways of exposure are important elements of these studies. When exposure is no longer detected or an issue, these studies will be discontinued. The hydrocarbon chemistry data will be used to establish the source of the oil.

Comments on Marine Mammals Studies - General

Comment: Marine Mammals Studies No. 5 and 6F and 6G are unlikely to quantify injury from EVOS because it will be difficult to establish a clear and unequivocal cause and effect relationship between chemical residue data and histologic changes in those marine mammals.

Response: Determining that harmful pathological conditions resulted does not require that residue levels be elevated. Pathological changes may or may not be associated with elevated residues depending on what residues are tested, time and duration of exposure to oil, length of time after exposure that samples were taken, etc. Pathological conditions may have been caused by volatile substances that were gone by the time the seals were collected.

Comments on Marine Mammals Studies - Specific

Marine Mammal Study No. 2 - Killer Whales

Comment: It appears that the data being collected in Marine Mammal Study No. 2 will not be sufficient to address all of its objectives. (API)

Response: The data to be collected during the third year of this study will be sufficient to address all the objectives. Sighting effort is more than adequate to encounter all killer whale pods occurring in Prince William Sound (PWS) during the study period. Once each pod is observed, photographs are obtained of each individual within the pod. These photographs, and other data collected at the time of the encounter, allow assessment of the number of animals present and to identify individuals (Objective A), to note the various locations in PWS where animals occur (Objective B), to characterize the individuals within each pod (Objective C), to note the relative physical size of all pod members and the presence of new, young animals (Objective D), and the absence of any members known to be in that pod from previous years (Objective E).

Comment: The potential for the observations being made in the killer whale study to be intrusive is not adequately addressed in the Plan. (API)

Response: The observations made during the study are not intrusive but passive. Some disturbance may occur as the study vessels approach the pods for counting and to obtain photographs. All the activities in the study are conducted under a MMPA permit issued to the researchers. MMPA permits are reviewed by the Marine Mammal Commission, and the public prior to issuance by the National Marine Fisheries Service.

Comment: The cost is unwarranted given that killer whale population impacts attributable to EVOS are unlikely. (ESC)

Response: Similar studies conducted by non-government entities may cost twice as much, or more, because the government absorbs most of the salary, administrative, and data analysis costs associated with such studies. The assertion that killer whale impacts attributable to EVOS are unlikely is invalid. Killer whale impacts attributed to the EVOS probably occurred in the form of injury (loss of animals), but this must be confirmed by year three studies.

Comment: The normal distribution pattern of this species has not been established sufficiently to permit meaningful comparisons with post-spill data. There is no documentation linking deaths of killer whales to contact with oil; nor is there a known pathway for oil to be harmful to whales. Further, there is no way to attribute whale mortality to oil exposure when factors such as interactions with fishing fleets and natural mortality are ignored. Food source distribution should also be taken into account. (ESC)

Response: Killer whale pods are repeatedly seen in certain areas of PWS at specific times of the year over many years. A trend has been documented in the arrival times of certain resident pods at feeding areas in southwestern PWS and other locations. These areas and times were documented prior to the spill and are sufficiently established to make meaningful comparisons to post-spill distribution and movement patterns, at least for certain pods. At least five different killer whales pods were seen swimming through oil; no cetacean, including killer whales, has ever been documented to avoid oil in the water. There is no reason to assume that killer whales did not encounter and swim into oiled areas. Other mortality factors, such as those attributable to interactions to fishing vessels is not ignored. The timing and distribution of fishing vessels with various gear types has and will be reviewed to ascertain the possible level of mortality to killer whales by commercial fisheries. To date there are no fisheries that were likely contributors to killer whale mortality during the EVOS year. Natural mortality rates are too low to account for the high number whales missing from PWS pods. Food source distribution is too difficult to tract since the prey eaten by killer whales cannot reasonably be sampled.

Comment: It is not possible to evaluate the study plan without a clear definition in Objective B of the term "adjacent waters". Killer whales move in and out of PWS and "adjacent waters" so it is impossible to quantify what is "similar to that reported for prior years." (ESC)

Response: The term "and adjacent waters" should be deleted from the study plan. Conducting study activities outside PWS was deleted.

Comment: Since pod integrity and structure are not defined, the hypothesis of Objective C, i.e., that the parameters have remained constant, is not valid. Even if it could be tested, this hypothesis cannot be either accepted or rejected based on the information gained two years after the spill. (ESC)

Response: Pod integrity and structure are defined and accepted terms amongst killer whale biologist world-wide, and were discussed in-depth in previous study plans and the published literature. Killer whale pods are known to be matriarchal in structure with most individuals remaining in the same pod throughout their lives. Absence of whales from a pod for one year is adequate to assume mortality; absence for two years is stronger evidence of mortality. The hypothesis in Objective C is a valid test and data can reasonably be collected for its rejection or acceptance.

Comment: Without considering environmental factors other than the occurrence of the spill, it does not make sense to relate differences in whale natality and mortality to oil exposure since these parameters vary naturally. (ESC)

Response: Killer whale natality and mortality rates are low throughout their range. Mortality rates calculated for PWS, based on animals missing from pods since EVOS, are abnormally high. The marine environment in which killer whales exist is a relatively stable environment and variation in water temperature, salinity, and other properties is minimal. Since the EVOS there have been no extreme environmental perturbations (such as an El Niño event) in the eastern North Pacific Ocean or Gulf of Alaska that could reasonably account for the absence of seven killer whales during the EVOS and six whales the following year.

Comment: The Plan does not provide adequate detail regarding methodologies, sampling locations, survey design, and data compilation. Examples of this include: the description of sampling locations as those areas "known for whale concentrations"; a lack of reference to data other than photographs that will be used on the survey form; a lack of detail regarding the sampling methods and their statistical sufficiency; a lack of quantification of search effort to allow the evaluator to assess whether cross-year comparisons of abundance and distribution will be valid; and the potential bias inherent in the disturbance and harassment of whales caused by the field activities. (ESC)

Response: The objective of the 1991 Plan was to provide adequate information for reviewers to understand the scope and methods of the assessment. The Trustees believe the information provided is sufficient for this purpose.

Comment: Objectives A, B, and D appear to depend on a constant probability of whale sighting over the survey route when in reality this probability is highly variable. It is dependent on such factors as prey densities and bathymetry. This problem will be compounded by the addition of the sighting network. (ESC)

Response: The objectives do not depend on a constant probability of whale sighting. It is true that sightings are variable, but the locations of sightings are not. Past studies have shown that all killer whale pods occurring in PWS during the study period consistently pass through certain areas in southwestern PWS. These areas are part of the study survey route. Thus, any killer whale pod occurring in PWS during the study period will likely be sighted. Once sighted data are collected that will satisfy Objectives A,B, and D (as well as C and E).

Comment: The study description implies that the investigators will assume that an individual killer whale that is not found in Prince William Sound has died. The high mobility of this species makes this an indefensible conclusion. (ESC)

Response: As mentioned, individual killer whales remain in the same pod for life. There are no documented occurrences of killer whales leaving one pod and becoming members of another. If a pod is sighted, all the members of that pod will be present and accountable. The probability of sighting a particular pod is high since they regularly occur in PWS at certain times of the year. The species is not have a particularly large home range, when compared to other cetaceans and some pinniped species.

Comment: Reported injuries will not be valid because the baseline data are insufficient. In particular, pre-spill natality and mortality data are insufficient to allow "accurate, precise, complete or representative comparisons" required by the NRDA regulations. Nor does data sufficient exist to allow a meaningful definition of "normal" whale pattern distributions for comparison to post-spill data. (ESC)

Response: As mentioned above, the historical data base is adequate for comparative purposes to establish the presence or absence of individual whales within their respective pods. Pre-spill data are adequate to meet the objectives of the study plan. Intense killer whale studies began in PWS in 1984 that collected similar data to that proposed in the study plan and that were collected during the first two years of the oil-related research. The pre-spill data are sufficient in detail and quantity to make meaningful comparisons. The assertion that insufficient data exists for these comparisons is wrong.

Marine Mammals Study No. 5 - Harbor Seals

Comment: It is questionable whether the aerial surveys in Marine Mammals Study No. 5 are equivalent to previous aerial studies conducted in 1984, 1986, 1989 and 1990. Harbor seals can only be counted during molting and pupping periods. (API 12)

Response: Techniques, including survey route, aircraft type, air speed and altitude, and data collection and analysis, were the same for all surveys. The same observers were used throughout, specifically to eliminate the problem of observer variability. Historical data and multiple year surveys will allow valid statistical comparisons. Surveys were made during pupping and molting periods.

Comment: The term "normal year" (on page 16) with respect to aerial survey data concerning harbor seals is unclear in light of the fact that this species was declining in the five years prior to EVOS. Further, this reference cannot be reconciled with the Trustees' statement on page 17 that "a single year of post-spill data from 1990 is not sufficient to establish what is normal in a non-oil spill year." (NWF)

Response: "Normal year" refers to a non-oil-spill year. The statement regarding "a single year of data is not sufficient" is meant to point out the need for additional survey data in 1991. Because there are no historical data during the pupping period, we are required to use data collected in the years following the spill and to compare those data to data collected the year of the spill. Without 1991 data, we can only state that 1989 and 1990 were different. The 1991 data set will allow comparison of three years of data. From this comparison we will be able to conclude if the number of harbor seals counted the year of the oil spill was statistically different in regards to harbor seal abundance and distribution in subsequent years. Ideally an historical data set would have aided the statistical comparisons. However, since we do not have those data, we must either ignore pupping completely, or try to compare post-spill years to the spill year.

Comment: Populations of harbor seals have been declining over the last several decades. This study will not permit the Trustees to segregate the effects of the oil spill from the natural factors that have affected this species. (ESC)

Response: Design of the study will allow for detection of differences between oiled and unoiled areas that can be attributed to EVOS. Pre-spill data indicate that oiled and unoiled areas both demonstrated a decline of similar magnitude prior to the spill. Following the spill, the rate of decline was significantly higher at the oiled sites.

Comment: There is no clear cause-and-effect relationship between petroleum hydrocarbon exposure, tissue burdens and pathologic effects, so the cause of death in harbor seals will not be traceable. (ESC)

Response: The exposure pathway included seals lying and rolling in both fresh and weathered oil for, in some cases, the entire summer following the spill; seals swimming in and through oil on the water; seals breathing at the surface and inhaling fumes from the oil; and possibly seals eating contaminated prey. All of these are indicated in the study plan.

Comment: Objectives C and D are really just ongoing research efforts aimed at determining the cause of the decline in harbor seal populations in the northern Gulf of Alaska. The monies expended for this research are not compensable under the NRDA regulations. (ESC)

Response: The harbor seal project is not part of a long-term research or management project. Previous data were available, at 4-year intervals, but there was no plan to conduct annual surveys or do a study of this type prior to the spill. This study was designed directly in response to the spill, to take the best advantage of historical data.

Comment: The field methods will not be capable of separating changes in distribution from changes in abundance because of the lack of understanding of seal distribution dynamics. (ESC)

Response: Although the dynamics of harbor seal distribution are not well known in PWS, we do know that harbor seals demonstrate strong site fidelity. Radio-tagging studies from different parts of their range support this. Satellite-tagging studies ongoing in PWS will provide additional information directly relevant to PWS. Following the spill when seals were coated in black oil which served as a marker, there was little or no observed movement of oiled seals into unoiled areas or vice versa. Furthermore, a reduction in numbers at oiled sites was not accompanied by a concurrent increase at other sites.

Comment: QA/QC issues are not addressed in this study. (ESC)

Response: Standard, scientifically accepted procedures are followed.

Comment: There is no description of the locations where "impacted" and "control" seals were taken. Thus, the reader cannot assess the validity of the analytical methods of this study. If control animals were taken from Southeast Alaska, they are not a valid reference since they likely have different genetic characteristics and different habitat and food supplies that affect their well-being. (ESC)

Response: The selection of oiled and control seals was very straight forward. In 1989, "oiled" seals were physically oiled seals (blackened by oil) collected in areas that had oil on the haulouts. Seals collected in 1990 were taken in areas that had been oiled. Selection of seals from Southeast does provide a valid reference. They give an indication of levels of contaminants in an area far removed from the spill. Genetic differences are not considered in the study. We did not propose to collect substantial numbers of seals in unoiled areas. Instead we focused on documenting contaminant levels in seals within oiled areas. Simple comparisons were made between seals collected in heavily oiled areas of PWS to seals from more lightly oiled areas of PWS, seals collected one year later, and 2 seals from Southeast.

Comment: The analytical strategy incorrectly assumes that pathologic findings correlate to tissue residue data and that oiling levels two years ago in sample collection locations represent exposure of the collected seals to hydrocarbons in their home range. (ESC)

Response: Pathological conditions are not assumed to correlate with measurable residue data. Determining that harmful pathological conditions resulted does not require that residue levels be elevated. Pathological changes may or may not be associated with elevated residues depending on what residues are tested, time and duration of exposure to oil, length of time after exposure that samples were taken, etc. Pathological conditions may have been caused by volatile substances that were gone by the time the seals were collected.

Comment: It will not be possible to tell whether a statistically significant effect found between oiled and unoiled areas or pre-and post-spill comparisons is due to oil or other factors such as survey techniques, quality of observers, food supply or habitat differences. (ESC)

Response: Comparison of unoiled and oiled and pre- and post-spill data sets will be statistically straight-forward. Survey techniques were the same for all surveys. The same observers were used throughout, specifically to eliminate the problem of observer variability. Historical data and multiple year surveys will allow valid statistical comparisons. There are pre-spill data indicating that trends in abundance were the same in oiled and unoiled areas, despite any inherent differences in habitat or food.

Comment: There is no description of the types of tissues collected, methods for toxicological analyses, or techniques for fingerprinting of hydrocarbons. (ESC)

Response: Toxicological analysis of tissues has been done according to standard QA/QC procedures developed by an analytical chemistry working group of experts. The procedures were also reviewed and approved by an expert group of marine mammal veterinarians, the Marine Mammal Commission and its Committee of Scientific Advisors. Harbor seal samples were submitted through the NOAA/NMFS Oil Spill Damage Assessment Office to ensure that qualified laboratories and procedures were used.

Comment: Statistical procedures are too vaguely defined and sample sizes for the exposure/pathway work are inadequate. The level of effect being tested and the effort needed to detect that effect are not given. The sampling effort is not appropriate to the objective of the study: the probabilities of Type I and II errors are not given. (ESC)

Response: Sample sizes are considered appropriate and statistical methodology is clearly stated. It is also clear that the level of statistical significance is 0.05, an acceptable level in biological studies.

Comment: The 40% decline in abundance that was observed in the trend counts is insufficient for establishing any meaningful baseline, trend or natural variation because it was based on only two years worth of data. Since the cause of the decline in harbor seals is not known, it is unlikely that any impact of the spill on this species will be detected by this study. (ESC)

Response: Historical data in combination with data collected at the control sites will provide a basis for evaluating the ongoing population decline and any natural variation in the population. It is not necessary to know the cause of the ongoing decline in order to determine injury from EVOS.

Marine Mammal Study No. 6 - Sea Otters

Comment: MM6 is unwarranted in light of the fact that 1990 observations found large numbers of adults and pups in previously oiled areas feeding and behaving normally. Natural reproduction will overcome the losses suffered by this species as a result of the oil spill as there is a large population reservoir in the affected portions of Prince William Sound and the Gulf of Alaska. (ESC)

Response: Results from 1990 sea otter studies do not confirm that feeding and behavior of sea otters in oiled areas is normal. There is evidence of continuing injury to the population, and the injury does not appear to be limited to those sea otters that suffered acute exposure to the oil immediately following the spill. Oil persists in some areas of western PWS, and potential exposure of the sea otters continues. Study MM6 involves eight components which will be collectively interpreted to provide a comprehensive look at the status of sea otter populations in PWS.

Marine Mammal Study No. 6A - Boat Surveys

Comment: Study 6A's objective of estimating winter 1991 offshore densities in oiled and unoiled areas to enable the Trustees to estimate otter density values at the time of the spill does not address the need for confirmation of exposure to oil of otters that might have been present during the spill. (API)

Response: This study has the potential to determine if there are differential trends in the otter population between oiled and unoiled areas (i.e. a continuing decline in the oiled area with a stable trend in the unoiled area may support the hypothesis of continued oil-related injuries).

Comment: Eastern PWS is not a valid control area for Objective A because it supported higher densities of sea otters before the spill owing to its higher quality habitat. (ESC)

Response: The variations in habitat between eastern and western PWS are being considered, as appropriate, during data analysis and synthesis.

Comment: The assumption of Objective B that sea otter populations are stable in the absence of oil is wrong; there are many factors that could cause differences between years. (ESC)

Response: That changes in population cannot be automatically attributed to oil has been a consideration throughout the entire NRDA process: how to validate injury above and beyond the number of recovered carcasses. Although no single NRDA study will be adequate to determine additional injury to the sea otter population, in combination the studies should provide the needed information.

Comment: Any difference between pre- and post-spill otter populations found in carrying out Objective C could be the result of variation in distribution rather than abundance. (ESC)

Response: Since the study area encompasses PWS as a whole, we are able to detect if a decline within the oiled area is accompanied by an increase in the unoiled area (a change in distribution, perhaps due to avoidance). If the reviewer is suggesting that an overall decline within the study area could be due to emigration, that may also constitute an injury to the PWS population.

Comment: Objective D will create more of an index than a quantitative estimate of the post-spill population of otters in PWS because of the problems inherent in censusing otters. (ESC)

Response: As noted, the results of this study are actually a population index, rather than a population estimate. Sightability during surveys is also being considered. It is certainly quantitative not qualitative, and comparable over time. This study provides a random sample of both shoreline and offshore habitats, which produces an estimate with confidence levels for the sea otter population.

Comment: Sea otter populations are not constant in PWS from year to year, so using densities during the winter of 1991 to estimate densities during March of 1989 makes Objective E invalid. (ESC)

Response: Post-spill surveys may provide useful insight on what the population was like at the time of the spill and may help support the use of summer pre-spill data for comparative purposes.

Comment: Pre- and post-spill densities of otters are not comparable because of the variance among methods and transects in years 1984, 1985, 1990 and 1991. (ESC)

Response: This statement is in error. Considerable thought was given to the issue of comparability of surveys. The methods used in post-spill surveys are identical to those of Irons et al., 1988. Irons assisted in the design and implementation of this survey, and has also participated in the field effort. Paragraph 2 of the methods section clearly states the procedures followed to insure that the methodology is consistent from survey to survey. The statement that transect location is different every year is false. Post-spill surveys use the same shoreline transect design used in the pre-spill survey. This point is clearly stated in paragraph 5 of the methods section. The randomly selected sample is a subset of the pre-spill sample (which was itself, almost a complete count of all shoreline habitat within the Sound). While the actual sample size of transects may vary slightly, most of the same transects are surveyed with each replication. Regardless, since the set of transects was selected as a random sample, it is a simple matter to calculate a consistent population estimate or index with which to determine trends.

Comment: There is no documentation of an exposure pathway that will link any changes in distribution and abundance in 1991 to EVOS. (ESC)

Response: The determination of an exposure pathway is the purpose of other components of Marine Mammal study 6.

Comment: This study does not follow conventional scientific methods: there are no testable hypotheses or statistical assumptions given. Comparing third year post-spill surveys to pre-spill estimates will not produce an injury determination. (ESC)

Response: In an attempt to streamline the study plan for the current document, certain sections were deemed to be redundant, having already been presented in earlier study plans (significance levels, statistical assumptions, etc.). The focus of this study has remained essentially the same throughout.

The March 1991 survey documented a record low number of sea otters in the PWS area. This study is beginning to produce a picture of the population trend since the spill, a link in assessing damages.

Comment: The statement that "differences in sea otter densities will be tested using two sample t-tests and/or ANOVA, dependent upon post-stratification of oil condition" needs to be clarified. (ESC)

Response: Standard statistical conventions will be used.

Marine Mammal Study No. 6B - Intersection Model

Comment: Study 6B will provide little useful information since the lack of available information precludes testing the accuracy of the model or the underlying data. (API)

Response: The model is intended to synthesize available information and to provide an alternative estimate of exposure of sea otters to oil.

Comment: The model to be used for estimating sea otter mortality is not a widely accepted technique. It misuses the NOAA model of oil movement which was developed for response purposes and is not sufficiently sensitive for long-term modeling of oil trajectories. Because the mathematical model to be employed in this study relies on such uncertain data and invalid assumptions, it will not provide any useful information for damage assessment purposes. Its use is therefore contrary to the NRDA regulations. (ESC)

Response: The use of the NOAA model extends only for about 30 days following the spill, while it was still being used in response efforts. Trajectories are not projected beyond the model provided by NOAA. The NOAA model is used to estimate potential exposure. Mortality is estimated directly from data collected at the time of the spill.

Comment: The exposure region for each group of otters is too large. There is no basis for assuming that California otter movement patterns will be valid for estimating PWS otter movement regions; the food base distribution and colony sizes are different in Alaska and California. Also, using the whole otter region as an exposed area will result in an overstatement of numbers of otters potentially exposed. (ESC)

Response: The exposure region is a relative measure as compared to absolute. Under the definitions of the model, it cannot overestimate potential exposure.

Comment: The measure of exposure of a particular location to oil does not take into account the changing characteristics of oil from slick to mousse. (ESC)

Response: The model does account for exposure.

Comment: The assumption that all mortality in rehabilitation centers that occurred within thirty days of the spill is spill-related is unreasonable. All otters that died did so within 34 days; 28 of these deaths were of unoiled otters and clearly not spill-related. (ESC)

Response: There is no basis for the statement that the deaths of 28 "unoiled" sea otters were clearly not spill-related. Their deaths resulted from EVOS or associated activities.

Comment: The mortality model will lack precision because it does not account for the entire range of oiling levels. (ESC)

Response: The resolution of the model will reflect the resolution of the data. This is not an issue of precision.

Comment: The method of relating degree of oiling to exposure is not described sufficiently. There were significant changes in physical and chemical properties of oil in different geographical areas and over time. The degree-of-oiling categories are subjective and the cut-off points for classifying captured otters based on the quantity of oil on pelage are arbitrary. Without basing these classifications on pathological factors, mortality rates for this study will be mere guesses. (ESC)

Response: The mortality data associated with the model was collected beginning about 7 days into the weathering process. The categories are ordinal and reflect the relative extent of oiling and are therefore meaningful. Mortality estimates are derived directly from animals collected during the spill.

Comment: The statement that values defining high, moderate and low exposure will be defined for each study area needs clarification. There is no justification for this classification scheme and it appears from the study description that the data will be modified until they fit the preconceived model output. (ESC)

Response: Site selection was based on visual observations of sea otter oiling which provided a ranking of high and low levels of oiling.

Comment: The model for this study will produce only a coarse estimation of sea otter mortality and will not permit an estimation of confidence intervals. (ESC)

Response: The model is intended to provide an approximate estimate of mortality and will be used with other components of MM6 including data on actual carcass recovery and other studies to provide scientifically reliable information.

Comment: There has not been an adequate demonstration of exposure of otters to EVOS oil and the model does not account for the weathering of oil. Thus, the model will overestimate mortality. (ESC)

Response: The collection of hundreds of oiled sea otter carcasses unequivocally demonstrates exposure to oil. Not all sea otters exposed are represented in this sample. (See previous comment regarding changing properties of oil with respect to weathering.)

Marine Mammal Study 6C - Radiotelemetry

Comment: Two years of study are adequate to meet the stated objectives of Study 6C. The description of this study does not contain an adequate rationale for its continuation. (API)

Response: There has not been two full years of study on the sea otters being monitored in this study. To date, adults have been monitored for periods from about 1 to 1.5 years; weanlings have been monitored less than 1 year. Valuable information on movements, reproduction and survival can be gained by additional monitoring of the instrumented sea otters.

Comment: This study ignores the fact that translocation will play a larger role in otter survival than exposure to oil from EVOS. In addition, the objectives of this study will be compromised by the use of higher quality habitat of Eastern PWS as a control area. (ESC)

Response: Translocation was a necessary part of the rehabilitation process. There is no basis, however, for the statement that translocation will play a larger role in survival than oil exposure. Habitat in Eastern and Western PWS was judged to be sufficiently similar in quality to warrant using eastern PWS as a control.

Comment: Objectives A for the weanlings study and Objectives A through C for the adult females study cannot be achieved because there is no reliable baseline survival or age structure data available for PWS and because sample sizes will be far too small to assess survival at various age classes. (ESC)

Response: The hypotheses on survival can be tested using control (eastern PWS) and treatment (western PWS) groups. For the weanling sea otters, survival at different age intervals is being examined, which does not imply a comparison of different age classes. Sample sizes are adequate to test the stated hypotheses.

Comment: Objectives B of the weanlings study and Objective D of the adult females study cannot be tested by documenting movement in 1991 and comparing it to areas affected by oil in 1989 because this incorrectly assumes that differences in movements are attributable only to oil. (ESC)

Response: Objectives B and D involve documentation of movements of sea otters relative to areas affected by EVOS. Movements of sea otters in a control area are also being recorded. Testing for a relationship between movement of the otters and oiling of specific areas does not necessarily imply an assumption that differences in movements are attributable only to oil.

Comment: Comparisons to be made as part of Objectives A through C regarding rehabilitated otters' survival, movement and reproduction as between eastern and western PWS will not be valid owing to the differences in pre-spill habitat between those two areas. (ESC)

Response: Comparisons, with respect to rehabilitated sea otters' survival and reproduction, are being made between otters that underwent oiling, cleaning, treatment, and release and otters that did not undergo these processes. Because some rehabilitated otters have remained in eastern PWS after release differences in pre-spill habitat between eastern PWS and western PWS will not have significant bearing. However, habitat in eastern PWS and western PWS is sufficiently similar to justify using the east as a control area.

Comment: The Plan does not describe the field methods with sufficient specificity: there is no frequency of relocation of instrumented otters given; there is no method given for distinguishing between female and male otters during population counts; and there is no method for classifying oiled and unoiled areas. (ESC)

Response: Field methods were described in greater detail in Study Plans for previous years; less detail was supplied here in interests of brevity as radiotracking methods have not changed. Population counts in which male and female sea otters need to be distinguished are not a component of Study 6C. Generally, it is assumed that eastern PWS was unoiled and western PWS was oiled.

Comment: A sample size of 45 rehabilitated otters is too small to detect differences that could be extrapolated to the entire rehabilitated otter population. (ESC)

Response: A sample size of 45 instrumented sea otters, which represents approximately 25 percent of the total number released, is sufficient to measure effects that can be extrapolated to the rehabilitated sea otter population.

Comment: The assumption that sea otters captured in treated areas have been exposed to EVOS is not valid; nor is the assumption that otters from unoiled areas of PWS are healthy because of the habitat differences between eastern and western PWS. (ESC)

Response: Given the knowledge of sea otter movements, it is valid to assume that sea otters captured in and around oiled areas were exposed to oil, and sea otters captured in non-oiled areas were not exposed to oil. Further, the health status of sea otters in eastern PWS and western PWS would otherwise have been similar. Examination of blood and tissue samples will provide information regarding oil exposure.

Comment: The objectives of this study are compromised by the fact that otters were captured, maintained in captivity, stressed and translocated. Oil cannot be segregated from the other factors affecting rehabilitated otters. (ESC)

Response: It is recognized that various factors, including oiling, cleaning and captivity, may have influenced the fate of the sea otters following release. Records were kept on the degree of oiling at arrival and the clinical history of the sea otters while at the centers, and this will be taken into account when interpreting the data.

Comment: There is no documentation of current exposure pathway for all rehabilitated or untreated otters and no discussion of how this information will be utilized in either the selection or the implementation of rehabilitation. (ESC)

Response: Potential pathways of exposure to hydrocarbons are being considered; some testing (see study 6D) is ongoing, and results from other NRDA studies will be evaluated for information relevant to exposure pathways for sea otters.

Marine Mammal Study No. 6D - Prey Selection and Foraging

Comment: Given the limited purposes of Study 6D, a third year of this study is not necessary. (API)

Response: This is the first year that Study 6D has been implemented. It will provide specific information valuable in assessing EVOS induced injuries to sea otters.

Comment: This is not a study with testable hypotheses because description, estimations and collections are not scientific objectives and there are neither baseline nor comparative data by which to judge the results of this study. (ESC)

Response: This is a descriptive study. Sea otter prey species will be described as frequency of occurrence within each study area. Forage success can be tested among areas and over time to baseline data for 2 of the 3 study areas.

Comment: There are no methods for separating spill effects on foraging ecology from the effects of observer quality, natural variability in prey abundance and type, and differences in study areas. (ESC)

Response: All observers were trained in the field identification of sea otter prey species prior to data collection; observers will remain constant throughout the field study. The study design accounts for the natural, patchy distribution of sea otter prey species by sampling an area rather than a specific point. Effects of the spill will be measured in terms of the hydrocarbon assays of the sea otter prey for species occurring in all study areas.

Comment: There is no discussion of sample sizes or replication. (ESC)

Response: The study design stated a minimum sample of 500 identified sea otter prey items at each study area to describe the frequency of occurrence of specific prey. The study design is comparable to historic data available for 2 of the 3 study areas, which may serve as a replicate.

Comment: Site selections do not include control sites. No pre-spill data are available for Knight Island. Nor is there any control apparent over changes in prey populations among the study sites. (ESC)

Response: Toxicology of sea otter prey species will be tested along a gradient of shoreline oiling as described by the study areas, and this gradient will provide a basis for statistical testing of the data. Although pre-spill data are not available for the Knight Island area for forage success and frequency of occurrence of species in sea otter diet, this is not expected to be an impediment to interpretation of the results.

Comment: There is no strategy mentioned for listing prey by species, which is probably impossible if done with binoculars. (ESC)

Response: Sea otter prey species will be identified to the lowest taxon possible. All observers are trained in the identification of sea otter prey species prior to data collection. High resolution scopes will be used for all forage observations in the field. Under good viewing conditions, trained observers are capable of identifying prey by species.

Comment: There is insufficient description of toxicological analyses of prey item tissues and no mention of the compounds to be analyzed. (ESC)

Response: Toxicological analyses standardized for all damage assessment studies (see Technical Services Study Number 1) will be used for the prey items.

Comment: This study will not quantify injury to sea otter populations in PWS. Nor is there a justification for undertaking this study for restoration purposes. Therefore it is not a compensable study. (ESC)

Response: This study, in conjunction with other components of MM6 examining toxicology of sea otter tissues, reproduction and survival, will further the understanding of potential pathways of exposure to hydrocarbon contaminants persisting in the environment. Data acquired from study 6D will aid in the prediction of recovery of the sea otter populations in PWS and will be useful in planning appropriate restoration measures.

Marine Mammal Study No. 6E - Sea Otter Mortality

Comment: Study 6E does not appear to take into account the parameters unrelated to the spill that may be affecting otter mortality. The data collected in 1974 and 1975 may no longer be useful as baseline information. (API)

Response: Parameters unrelated to the oil spill may affect sea otter mortality and this should be reflected in variation among the ten years of baseline data to which post-spill data will be compared. All existing data is considered and applied as appropriate.

Comment: There are not adequate baseline data for making definitive comparisons of the number of deaths among prime age and female otters in the pre- and post-spill eras. In particular, there are no age structure data available for Knight and Naked Islands. Any differences found could be due to disease and/or meteorological conditions. (ESC)

Response: The ten years of baseline data provides a very good estimate of the number of deaths of prime age and female sea otters in an unoiled environment. There is little pre-spill information on age at death in the Knight and Naked Island areas, but these should be comparable to other areas in western PWS where baseline data are available. Information from other components of MM6, examining toxicology of tissue samples, and survival, reproduction and movements of sea otters in these areas, will be interpreted in coordination with results from Study 6E.

Comment: Objectives B and C fail to take into account the migration patterns and differences in natural mortality factors, search efforts, search dates, and wind and tide conditions. (ESC)

Response: Information on movements of sea otters will be forthcoming from Study 6C. Examination of recovered carcasses will provide insight into natural mortality factors. Physical factors such as wind and tide were recognized in the study plan as potential sources of variability. The 10 years of baseline data will provide an estimate of variation among years when oil was not a factor.

Comment: There is no information regarding the comparability of test and control sites. (ESC)

Response: The test and control sites were not described in detail in the study plan, but a reference was provided to earlier work in which the methods for baseline data collection were presented. Each of the sites should be comparable over time, and it is the across year comparisons that are central to the study.

Comment: Methods to be employed by the study do not distinguish between population distribution and population abundance effects. (ESC)

Response: Information gained in other components of MM6 (specifically, in MM6A and MM6C) will clarify differences in population distribution and abundance that may be pertinent to interpretation of this study.

Comment: The Plan is unclear as to the statistical procedures that will be used for this study: neither the level of effect to be tested nor the effort needed to detect an effect was given; sample sizes and replication are probably inadequate for valid statistical testing; and analyses assumes incorrectly that there was a stable pre-spill age distribution. (ESC)

Response: The sample sizes cannot be presented in the study plan as it is not possible to determine beforehand the number of carcasses that will be recovered. Chi-square contingency tables and t-tests were identified for the statistical analysis. A relatively stable pre-spill age distribution was observed and this information will be presented in the final report of the study.

Comment: Toxicological analyses of tissues to be performed in conjunction with this study are not sufficiently defined in light of the breadth of analyses described under Technical Services, and hydrocarbon analysis of decaying tissue will not provide results that can be interpreted. (ESC)

Response: The toxicological analyses that will be performed are standard analyses as described in Technical Services Study Number 1. It is recognized that some recovered carcasses are too decayed to allow comparisons of tissue sample analyses with analyses on fresh samples. However, results from analysis will be worthwhile in determining presence or absence and location of hydrocarbons.

Comment: Rates of carcass deposition are influenced by current patterns, wind fields, beach morphology and wave activity, but there is no indication that this study will take these factors into account. (ESC)

Response: Rates of carcass deposition may vary over years due to physical factors and with varying population densities--this was stated in the study plan. This will be considered when evaluating patterns of mortality over time.

Comment: There are differences in prime age between eastern and western PWS otters that create a natural bias in this study's data from control and oiled sites. This factor has not been considered in designing this study. (ESC)

Response: Comparisons between pre- and post-spill data are within eastern PWS or western PWS and so account for any relevant natural discrepancy.

Marine Mammal Study No. 6F - Bioindicators

Comment: Study 6F should not continue. There is too little known concerning baseline conditions and normal variability to reach any conclusions. (API)

Response: Extensive information on sea otter blood samples has been accumulated in previous years from California and PWS. Samples collected in southeast Alaska will complement the existing data. Furthermore, comprehensive information on normal variation and pathological changes in blood values in other mammalian species can be utilized as needed. It is not valid to state that too little is known concerning baseline conditions and normal variability to draw meaningful conclusions.

Comment: There is no explanation for the absence of funding for salaries in Marine Mammals Study # 6F. (NWF)

Response: Personnel to conduct Study 6F have been drawn from other parts of MM6; their salaries are identified in other components of the overall study.

Comment: Blood sample analyses taken for Objective A will depend on habitat, food availability and diet, thereby making otters from southeast Alaska an improper set of control animals. (ESC)

Response: Data analysis for Study 6F will be conducted with the participation of a highly qualified clinical pathologist with knowledge of the variation that may be expected from such factors. Blood samples collected from sea otters in southeast Alaska will be valuable for control purposes.

Comment: Objective B will create additional and unwarranted harassment of otters from rescue centers since blood analyses of otters indicate that conditions returned to normal in a short time. This objective also will invalidate the results of Study 6C. (ESC)

Response: Capture and collection of a blood sample are not expected to significantly affect the survival, movements, or reproductive capabilities of sea otters. Although the comment states that "conditions returned to normal," changes in kidney and liver function resulting from oil exposure may develop over time and be detected in blood values. Therefore current (and perhaps future) samples are potentially valuable as bioindicators of the effects of oil exposure.

Comment: Measurements of pre-weaning growth rates has no meaning since there are insufficient background data for comparison and interpretation and since growth rates are subject to a number of ecological variables that this study does not consider. (ESC)

Response: The component of Study 6F (Objective C) that was examining pre-weaning growth rates will not be conducted this year.

Comment: Objective D is research; it has no mechanism for relating oil exposure to EVOS. (ESC)

Response: Physical examinations are a standard routine in veterinary practice, and it is logical that all sea otters handled as part of this study should be examined. Any abnormalities that may be noted will be evaluated in terms of oil exposure.

Comment: Comparisons of study data to unpublished and undocumented pre-spill growth rate data will not provide valid scientific conclusions. (ESC)

Response: Comparison of data to unpublished work is an acceptable scientific approach, as unpublished does not connote unsubstantiated. Pre-spill data of significance to results will be presented as appropriate.

Comment: Comparison of otter baseline data to "mapped data on shorelines and offshore areas affected by oil" is not clearly described. There is no definition of the exposure index or any indication that an exposure pathway can or will be identified for use with the blood/urine samples collected in 1991. (ESC)

Response: The mapped data on shorelines and offshore areas affected by oil is being provided by Technical Services Study Number 3. We will work with them in conjunction with a biostatistician to determine valid methods for comparison of baseline data collected on the sea otters to oiling of an area. Results from the different components of MM6 will be interpreted in conjunction to evaluate extent of exposure and potential continuing injury to the sea otter population.

Marine Mammal Study No. 6G - Toxicity

Comment: The Trustees should be careful not to make Study 6G so broad a research project that it cannot be used specifically to rehabilitate otters in Prince William Sound. (API)

Response: Evaluating success of a rehabilitation effort will require an understanding of pathological changes induced by oil exposure. The scope of work under MM6G will provide information on rehabilitated and wild populations of sea otters in PWS.

Comment: It is unlikely that a pathway for exposure of sea otter to oil can be found in MM6F and MM6G since the waters of Prince William Sound and the Gulf of Alaska have returned to background levels of hydrocarbons and there is no evidence of substantive contamination of fish or other food on which otters might prey. (ESC)

Response: Hydrocarbon levels of waters in PWS and the GOA, and hydrocarbon levels of prey species will be evaluated in concurrent NRDA studies and results considered in interpretation of potential pathways of exposure for sea otters.

Comment: This study is duplicative of efforts being undertaken in MM6D and 6E and contains no testable hypotheses. (ESC)

Response: This study supports MM6D and MM6E and is complementary, not duplicative. Specific testable hypotheses are not stated as they will depend on numbers of carcasses and samples available in the different categories.

Comment: Objective A constitutes wasteful spending since there is already a publication containing information regarding the efficacy of medical treatment and rehabilitation of otters during the spill. (ESC)

Response: The current effort will further integrate the available data and provide additional detailed information on rehabilitation, acute and chronic injuries.

Comment: There is no exposure pathway that would justify evaluation of chronic effects of residual oil on otters. (ESC)

Response: Potential exposure pathways are being examined in this study. Chronic effects could come from an initial exposure or from longer term continued exposure to hydrocarbons persisting in the environment, or from a combination of both.

Comment: This study is pure research. It fails to indicate the type of model to be used to assess toxic effects and pathological processes. Descriptions of methods for examining recovered carcasses is too scant for meaningful comment. This study is unnecessary since necropsies and pathology studies have already been done. (ESC)

Response: This study is intended to develop a model to assess toxic effects and pathological processes resulting from exposure to oil. Important information not yet interpreted or summarized can be gathered from additional carcasses now being recovered as well as carcasses that were recovered in the summer of 1989 and 1990, and necropsied in the summer of 1990. Methods employed were not described in detail because they are standard veterinary pathology techniques of necropsy.

Comment: There is no discussion of methods or techniques of the histopathology, toxicology and hematology studies to be performed. (ESC)

Response: Histological and hematological methods and techniques utilized will be standard methods; pathologists doing the work are Board Certified. Toxicological techniques used are described in Technical Services Study Number 1.

Comment: There is no discussion of the manner in which date and duration of exposure and changing composition of oil will be determined. (ESC)

Response: These factors are recognized to be of potential importance and will be examined as part of the study where appropriate.

Comment: It is unreasonable to expect that the recovery of carcasses in 1991 will provide valuable clues to the factors surrounding the death of the animals thought to have died from exposure to EVOS two years ago. (ESC)

Response: There may be relationships between the death of animals in 1991 and their exposure to oil. This study may provide evidence of continuing damage from acute and chronic oil exposure, as well as information that relates to death of oiled sea otters in the rehabilitation centers.

Comment: To the extent that this study aims to further the understanding of pathology processes, it is basic research and not compensable under the NRDA regulations. (ESC)

Response: Pathological changes resulting from exposure to oil may continue to affect the health and recovery of sea otter populations in oiled areas. An understanding of these processes is a critical component of the overall sea otter study.

Comment: The following are not discussed in the study plan: statistical methods for testing a scientific hypothesis, methods for relating pathology to geographic locations of carcasses, and testing and validation of toxicity modeling effort. (ESC)

Response: Analysis of data and development of statistical tests will be done in coordination with a biostatistician. Geographic locations of carcasses will be combined with oiling data provided by other studies; pathologies in areas of different degrees of oiling will be compared. The toxicity modeling effort will be developed as a part of study MM6G.

Marine Mammal Study No. 6H - Database Management

Comment: The cost of this study is excessive given the limited amount of data generated by the sea otters studies; individual principal investigators should be able to manage their own data sets without creating a new database system. Further justification is needed for the employment of three full-time scientists devoted to this task. (ESC)

Response: A large amount of data already have been generated by the sea otter studies, and additional information is being collected and added to the data base. The scientists with direct involvement in the study are based in six different locations and coordination and distribution of data among them is required. The individuals assigned to this task full-time are one scientist and two biotechnicians, not three full-time scientists. All three individuals have been involved in supporting other aspects of Marine Mammal Study Number 6, and if their salaries were not identified under Study 6H they would be identified under Studies 6A-G as they are providing assistance to those studies.

Comment: The database management system (MM6H) is beyond the scope of NRDA and duplicates funding for MM6A, 6B, 6C, 6E, 6F, and 6G. (ESC)

Response: The database management system is required to coordinate data collected under the different substudies for MM6. If funding for the database support had not been identified in MM6H, an increased cost for personnel would have been incorporated into the other MM6 studies.

Comments on Terrestrial Mammals Studies - General

Comment: There is no justification for continuing the terrestrial mammals studies in 1991 because no continuing pathway for exposure to oil has been identified and no significant effects of oil from EVOS on these populations has been demonstrated. In fact, NOAA has observed that shoreline conditions are such that there is no potential threat to terrestrial mammals as a result of oiled biota in the intertidal zones. And there was no indication in the Summary of Injuries that these populations have been affected. (ESC)

Response: Only brown bear and river otter studies were continued in 1991. Both these species use intertidal habitats that are still contaminated by hydrocarbons. Therefore, a continuing pathway does exist. Brown bear are a relatively long-lived species with a low reproductive potential which will require long-term study in order to fully assess injury to populations. The Summary of Injuries clearly stated that there are indications of injury to river otter. In oiled habitat, home ranges are larger, movements are more erratic, and body weights are lower. These indications are adequate justification to continue the study.

Comment: The terrestrial mammals studies do not recognize that many natural variables such as severe winters, predator/prey relationships, and disease affect life cycle events. Thus, it is unlikely that these studies will be able to link a significant portion of the biological variability to contamination from oil. (ESC)

Response: The studies were designed to account for significant natural variation that could influence results, and, therefore are expected to detect injury from oil contamination. Variability in a biological system is expected, however, the cause of much of this variability is identifiable through empirical field observations, laboratory testing of biological tissues, and most importantly through the use of control site study areas. It is unlikely that biological communities in oiled study areas and unoiled areas would respond differently to a natural perturbation that was not detected by biologists.

Terrestrial Mammal Study No. 3 - River Otters

Comment: There does not appear to be sufficient background information on river otters blood analyses to make the comparisons undertaken by TM3 meaningful. Thus, it is questionable whether the study should be continued. (API)

Response: All pertinent literature and background information was thoroughly reviewed in preparation for blood analyses. This information was determined to be adequate to make reasonable comparisons of differences in blood parameters. In addition, this is only a part of the information expected from this project. Continuation is easily justified when the study as a whole is evaluated.

Comment: The river otter study is not cost-effective in light of the fact that few, if any, fatalities of river otters stemming from EVOS occurred, and it can only study short-term impacts on otter density since this species matures rapidly and has relatively large litters. (ESC)

Response: It is highly likely that significant fatalities occurred among river otter due to EVOS because of this specie's reliance upon intertidal habitat that was heavily oiled. Carcasses were likely not found because river otter tend to seek out concealed dens when ill. Long-term injury is possible because of continuing contamination of food items.

Comment: There is no valid pre-spill population data for river otters so this study cannot determine whether EVOS had any measurable impacts on this species. This cannot be overcome by comparing total numbers and survivorship between oiled and unoiled areas over the 1989 - 1991 period. (ESC)

Response: Comparison of total numbers and survivorship between oiled and unoiled areas over several years will allow an assessment of injury to populations. Other information being collected on direct effects, food habits, and habitat use will be a valuable aid in interpreting population data.

Comment: There are inadequate references for the statistical procedures to be used in the TM3, and criteria for selecting impact and control sites were not provided in the Plan. Thus, it will be difficult to determine whether a statistically significant effect was the result of EVOS or natural factors. (ESC)

Response: The study plan provides sufficient detail to allow evaluation of the statistical procedures. Additional information can be found in referenced publications. Sites for oiled and nonoiled study areas were selected on the basis of their similarities in habitat and in populations of otter.

Terrestrial Mammal Study No. 4 - Brown Bear

Comment: There is no data presented in the Plan to support the need for continued study of brown bear populations and the observational approach is not likely to meet the objectives of Terrestrial Mammals Study No. 4. (ESC)

Response: The purpose of the Plan is to provide information on project plans not to report results. The approach will adequately meet objectives because it involves both observation of radio-collared bears and necropsy of any mortalities to determine the cause of death.

Comment: The brown bear study ignores the obvious health of this population evidenced by the fact that the huntable surplus of this species has not been altered and the lack of documentation of brown bear mortality stemming from EVOS. Further, brown bears metabolize petroleum hydrocarbons quickly so it is doubtful that tissue analyses of dead bears will be traceable to EVOS oil. (ESC)

Response: The presence of a huntable surplus does not mean that injury did not occur, although we have thus far been unable to conclusively document injury. The ability of brown bears to metabolize petroleum hydrocarbons is not conclusively known. However, petroleum hydrocarbons have been found in dead brown bears, and EVOS is the most likely source of these contaminants.

Comment: There was insufficient detail given in the plan regarding the Katmai National Park and Black Lake study locations for TM4 to enable the reader to evaluate the study. Further, the use of the Katmai National Park spill area as a site for assessing injury to brown bear is inappropriate. The age structure of the brown bear population there, where the species is protected, is different from that of the bear in the control area where hunting is permitted. Thus, it will be difficult to isolate the age structure differences from effects of EVOS on bear populations. (ESC)

Response: Sufficient detail on study areas is provided to allow evaluation of the work. Age structure difference between the study areas is recognized and is considered in the study design. We expect it will be possible in analysis of the data to isolate this variable and, therefore, avoid improperly assigning differences to impacts of EVOS.

Comment: Population density estimates of brown bear for 1989 and 1990 will not be a sufficient database from which to predict any trend or identify impacts from EVOS on that population on the Alaska Peninsula. (ESC)

Response: The only population estimate available is from 1990. This will not be a sufficient data base for prediction of any trends or identification of impacts from EVOS. Population estimation was eliminated from the study for 1991 because obtaining additional estimates was not justified given the absence of conclusive evidence of injury.

Comments on Bird Studies - General

Comment: The bald eagle and peregrine falcon studies were discontinued because "all data pertinent to gathering injuries had been collected." If this is the case, the data obtained should have been reported to enable the reader to assess whether discontinuation of the studies was appropriate. (NWF)

Response: The Trustees exercise discretion regarding the manner and timing by which data and results are released, whether the study is ongoing or discontinued.

Comment: Several of the bird studies discuss studying oiled and unoiled areas, but it is not clear whether the oiled areas referred to are areas that were affected by the spill or are areas that currently contain oil. (API)

Response: Oiled areas are generally defined as those areas which were contaminated by the EVOS any time since the spill.

Comment: The bird studies are unnecessary owing to the information contained in the literature indicating that restoration work will not be needed for these species. The mortality they suffered is comparable to that occasioned by natural events and chronic pollution which do not cause long-term adverse effects. (ESC)

Response: The bird studies were developed with full cognizance of information available in the current scientific literature. There is considerable information in that body of literature to indicate that bird populations do not always recover rapidly after an oil spill. The EVOS was unique in its size as was the biological richness of the area where it occurred. Studies are essential before any such conclusion can be drawn regarding the health, density and population of resident and migratory species.

Comment: The Trustees' Plan ignores the record of natural recovery on the part of seabirds and the abundance of fish on which they feed. (ESC)

Response: Natural recovery and natural occurrence of bird and fish populations are being considered in the damage assessment.

Comment: There is no evidence of a continuing pathway for exposure of birds to oil. And NOAA found no evidence of oil causing sublethal effects through progression up the food chain. (ESC)

Response: The Trustees, including NOAA, are considering this point. The pertinent data and corresponding conclusions being made by the Trustees and their scientists are not being released at this time.

Comment: The bird studies fail to identify and consider variables such as severe weather conditions, food supply, disease and commercial fishing activity that can significantly affect bird populations. Thus, it will not be possible to determine whether an observed change is the result of EVOS or some other factor. (ESC)

Response: By utilizing appropriate comparisons (e.g., oiled vs. unoiled, pre-spill vs. post-spill) it is possible to account for these other variables. It is highly unlikely that these variables would consistently affect bird populations in oiled areas and not in unoiled areas. If any of these other causes are influential, appropriate weight will be given that factor in the relevant study.

Comment: The use of boat and land-based surveys will provide different levels of disturbance among the colonies and decrease the reliability of making comparisons among survey methods. (ESC)

Response: Boat-based surveys are being compared to boat-based surveys and land-based are compared with land-based at particular sites, thereby coming up with consistent comparisons of relative indices. Standardized methods and enough replicate counts on different days will refine precision enough for either method to evaluate the large degree of change that is apparent at this time.

Comment: The bird survey studies (B2, B3 and B4) lack valid pre-spill data and suitable control sites for an assessment of injury from EVOS. (ESC)

Response: In cases where baseline data did not exist, treatment (oiled) and control (unoiled) data sets were gathered to make comparisons. Control areas are selected and non-spill related variables are evaluated.

Comment: The description of survey techniques and analyses to be used in B2, B3, B4 and B11 are not detailed enough to allow the reader to evaluate whether the accuracy objectives will be met. Sampling approaches are defined only generally. The description of the application of statistical analyses to the data likewise is vague. (ESC)

Response: Efforts were made to provide sufficient information in the 1991 Plan to enable the public to understand how studies were to be conducted and how data would be analyzed.

Comments on Bird Studies - Specific

Bird Study No. 1 - Beached Birds

Comment: The funding of Bird Study 1's re-examination and cataloguing of carcasses for distribution to universities and museums is clearly non-compensable and has no bearing on ascertainment of restoration options. (API, ESC)

Response: The Trustees believe that they have a responsibility to make the best use of the resources destroyed as a result of the EVOS. The dead birds will need to be responsibly disposed of in some manner. Various alternatives were considered including incineration consistent with the regulations pertinent to the disposal of biological hazardous wastes. All the alternatives considered were expensive and had various limitations This alternative was considered to be a reasonable solution to the problem. The Trustees believe that this action will be compensable.

Comment: Re-examining bird carcasses to refine numbers and identification to species level will not serve any quantification of injury purpose. This will duplicate information already collected. There is no specification of the number of carcasses needing further identification; most birds are already identified by species. (ESC)

Response: Re-examining carcasses to refine numbers will serve to further quantify injuries. A re-examination of the carcasses will allow a determination of the portion of the total number beachcast birds that were killed by the spill based upon condition of oiling rather than on the basis of temporal differences in the species composition.

Comment: Multiple bird carcasses within a single bag will have contaminated each other and therefore will invalidate the classification of amount and distribution of oil on each individual bird, resulting in a bias of the data. (ESC)

Response: Efforts will be made to account for carcasses that were secondarily oiled while in contact with oiled birds in bags.

Comment: Objective C of B1 is clearly outside the scope of NRDA. (ESC)

Response: Reorganization of the storage system would be taking place as a result of the re-identification and is a secondary benefit to the study.

Comment: Objectives D and E are unclear and do not appear to have any relevance to NRDA. Also, there is no identification of the protocols to be used to select certain birds for further study, the types of data to be gathered, or the uses to which this additional data will be put. (ESC)

Response: Updating the log sheets with the best available information is referring to oiling information based upon actual examination of carcasses and identification to species where possible. Objective E is referring to data that could be collected by the distribution of carcasses to the scientific community. Data which could pertain to other studies might include specific numbers of birds killed by oil and the age class structures of certain species.

Comment: Repeated thawing and refreezing will accelerate decomposition and prevent accurate determination of the time of each bird death. This process also will disperse oil over the carcasses, preventing an accurate depiction of the proportion and distribution of oil on the plumage. This factors will produce unrealistic interpretations of oil spill effects on birds. (ESC)

Response: Carcasses will not be repeatedly frozen and thawed. Care will be taken to prevent further oil dispersion on carcasses.

Comment: There is no mention of the type of analyses that will "focus on the number of carcasses, species and degree of oiling" or the techniques to be used to assess and quantify injury. (ESC)

Response: The analyses that will be undertaken are primarily descriptive.

Comment: This study does not present testable hypotheses or methods for interpreting or rejecting results. (ESC)

Response: This study is merely an inventory of the contents of the vans. No testable hypotheses are pertinent to this study.

Comment: The cost of B1 appears to be excessive given its potential for rendering information to the NRDA and restoration processes. (ESC)

Response: The Trustees have considered the cost effectiveness of this proposal.

Bird Study No. 2 - Censuses

Comment: Bird Study No. 2 is not likely to produce anything definitive given the number and magnitude of variables associated with the distribution and abundance of highly mobile birds occupying such a large area as Prince William Sound. (API)

Response: Many variables have been taken into account in the design and data analysis of this study.

Comment: Natural variation of migratory birds, dissimilar observation techniques and extrapolation from local surveys to regional populations will counter the damage assessment objectives of this study. (ESC)

Response: These factors will be taken into account, when appropriate, during review of the data and analysis of the results.

Comment: Determination of distribution and estimation of abundance of waterbirds in PWS makes Objective A of B2 mere research. (ESC)

Response: Abundance and distribution inside and outside the oiled areas can be compared, making this a valid pursuit for NRDA. In addition, comparisons can be made to pre-spill abundance estimates.

Comment: The Trustees will not be able to establish a causal relationship between any observed change in the relative abundance of seabirds in Objective B because of the lack of baseline data and control areas. (ESC)

Response: There exist baseline data and areas of PWS outside the oiled area which can be used as controls.

Comment: Objective C will not be accomplished because B2 does not take into account the natural variability in waterbird populations. (ESC)

Response: Natural variability in waterbird populations is included as appropriate.

Comment: There is no indication that the level of effort, observer experience, seasonal timing or other factors affecting survey accuracy will match that of earlier surveys. Nor is there any confirmation that the same protocols will be used among surveys. Use of 25-foot boats likely will disturb birds and compromise the validity of any observations. Survey locations are not clearly enough described to assure the reader that representative data will be obtained. (ESC)

Response: The Plan states (Vol. 1, p. 66) that similar methods were used in the pre-spill studies. The principal investigators of this study went to great lengths to determine and duplicate methods used in previous studies and to otherwise assure that useful, comparable data will result.

Comment: The study does not mention replicate counts or survey strategies that would indicate achievement of a 95% confidence limit for survey data. (ESC)

Response: The 95% confidence limit referred to is for Objective A on P. 64 of Vol. 1 of the Plan.

Comment: Comparisons of the data obtained in this study to unpublished USFWS reports does not allow for adequate review because earlier methodologies cannot be evaluated against the proposed methodologies nor can the reliability of the prior studies be assessed. (ESC)

Response: Reports from previous studies are public information and can be obtained from the originating agency.

Comment: The Plan does not identify how this study will identify the presence or absence of oil during the boat surveys or a means of linking oil observed to EVOS. Nor does it appear that other variables that affect bird distributions and abundances will be recorded. (ESC)

Response: Information on the presence of oil exists in many databases. If corroboration is necessary, the presence of oil will be determined visually. All variables recorded during surveys are listed in the Methods section at page 65 of the 1991 Plan.

Comment: It appears from this study that the Trustee Council is combining oiling information from three separate data sets. This will produce an internally inconsistent database. (ESC)

Response: Consistent application of oiling information data sets is being addressed.

Comment: B2 does not describe adequately the statistical procedures for data comparisons. It is unclear how the effects of EVOS will be estimated and tested, especially with respect to Objective C. (ESC)

Response: Pages 67-70 outline specific statistical procedures and formulas to be used in analysis.

Comment: The use of baseline data from the 1970's is inappropriate since environmental and other changes have affected the bird populations in the intervening time and these cannot be segregated from the effects of the spill. (ESC)

Response: When data from the 1970's is used in conjunction with data collected during the 1980's, pre-spill trends can be discerned, and may be used in support of other documentation of damage to a given species.

Comment: Pre- and post-spill surveys used different transects. Thus, population estimates will not be comparable. Even if changes in bird densities among the years is found, the surveys will not be able to link the changes to the spill. (ESC)

Response: If two surveys are done for an area using the same observation techniques and both using valid methods for estimating populations, those estimates are both valid and can therefore be compared.

Bird Study No. 3 - Seabird Colony Surveys

Comment: Mass mortalities of murres, together with nesting and reproductive losses, are not rare events even in nature. The Trustees should consider that the reproductive failure of murres and the loss of that population's breeding adults is attributable to some factor other than EVOS. (ESC)

Response: This is being considered, but it is equally important to consider what effect such a widespread oil spill and the subsequent mortality might have on these colonies.

Comment: Bird Study No. 3 does not appear to take into account the natural variability of bird populations. Absolute numbers cannot be calculated using the assumptions relied upon in this study. (API)

Response: Natural variability is being taken into account, using baseline historical data which is available for certain sites.

Comment: The survey of seabird populations at sites far beyond the spill area in B3 has no relevance to establishing baseline populations. (ESC)

Response: No sites have been censused or monitored that are not in the spill area or adjacent to it.

Comment: Use of the Semidi Islands as a control site for B3 is inappropriate because of the unique oceanographic conditions which influence their food supply and because of their unique habitat. (ESC)

Response: The Trustees disagree. The Semidis are right on the edge of the spill, and contain comparable large murre colonies. In addition, there have been feeding studies of diving alcids and the food they bring to their young (U.S.F.W.S., Research Center, Alaska, Hatch pers. comm.) which support this comparison.

Comment: The objective of B3 cannot be attained because the study design does not account for such factors as climate, weather, food supply and natural variability, which affect bird populations. Therefore the Trustees will not be able to demonstrate a causal link between any measured change in numbers of birds and EVOS. (ESC)

Response: If any of these other causes are influential, then they should affect species and sites within and outside of the oil spill area.

Comment: Baseline data for nesting productivity is grossly inadequate and control and test sites are not comparable. Therefore the Trustees will not be able to make valid comparisons of reproductive parameters between oiled and unoiled colony sites. (ESC)

Response: There is good baseline data for certain sites. Control and test sites are considered comparable if done appropriately.

Comment: Diurnal variability in nest attendance can be greater than 100%. It is unclear whether this study takes this factor into account. (ESC)

Response: The stated study hours are the standards used at this time in Alaska.

Comment: This study will produce unrealistic comparisons because of the different levels of reliability of boat- and land-based surveys. (ESC)

Response: Standardized methods and enough replicate counts on different days will refine precision enough for either method to evaluate the large degree of change that is apparent at this time.

Comment: There is no justification in the study description of the secondary emphasis on kittiwakes, cormorants and parakeet auklets or the method for determining baseline reproductive success of murres. (ESC)

Response: It is anticipated that the data on the secondary species may be obtained in the course of this study most efficiently.

Comment: Although Middleton Island is mentioned in the introduction as a control site, the body of the study description does not explain how it will be used to gather or interpret results. (ESC)

Response: The type of census work done in the past on Middleton Island is being repeated in a comparable fashion and will be assessed in connection with overall study.

Comment: Much of the historical data concerning the proposed colony sites is outdated and too poorly documented to enable the Trustees to measure recent changes for some populations. Thus, it will not be possible to link changes in population status to the spill. (ESC)

Response: The approach has been to look at many different sites and several different species with the idea that any effect caused by something other than the oil spill should show up at other sites and with other species in some consistent pattern.

Comment: The statistical models for B3 are vaguely defined, so it is unclear how effects of EVOS will be measured, especially in light of the natural variations owing to time and location. (ESC)

Response: This study has relied on the advice of professional statisticians. Fieldwork was conducted to refine precision of estimates with as many standardized replicates as field conditions allowed. The probabilities of error types was examined and this information will be included in reports and discussions rather than in study plans.

Bird Study No. 4 - Bald Eagles

Comment: The estimate of acute mortality to bald eagles that Bird

Study No. 4 is designed to improve will be highly speculative. How the number of birds killed but never found can be determined is not well supported. It is questionable whether such a determination can be made at all. (API)

Response: This portion of the study is designed to provide a reasonable estimate of the numbers of eagles that died in addition to those found on the beaches of the spill area. It is inconceivable that workers found 100% of the eagles that died. Our task is to put reasonable bounds on the estimated mortality.

Comment: Objective A of Bird Study No. 4, an estimate of the numbers of resident bald eagles, will be difficult given the large area encompassed by Prince William Sound. (API)

Response: The technique has been applied to numerous areas significantly greater in extent than Prince William Sound. The technique has proven to be reliable and repeatable.

Comment: Bird Study No. 4 should explain how the investigators will assess whether birds sampled from oiled and unoiled areas have had access to both such areas given their mobility. (API)

Response: It is anticipated that the eagles in close proximity to oiled beaches will have higher probability of contamination than eagles resident on beaches 40-50 miles from contaminated shores. The comparison is being made between these groups of eagles. If eagles from the "control" group are exposed to oil and contaminated, it may reduce the observable differences between the groups and add to the extent of the area affected by EVOS.

Comment: Contrary to their statement concerning Data Analysis in Bird Study No. 4, the Trustees must assume that factors other than major physical changes in habitat will have occurred between 1982 and the time of the spill and that these factors could have caused changes in the eagle population. (API)

Response: Such changes have not been documented and there is no reason to expect they exist. There have been no catastrophic changes in the spill area since 1982, other that the spill itself. If any such factor becomes apparent it will be assessed.

Comment: Results of bird studies indicating that all known eagle territories were occupied in 1990 should be factored into future decision making and data analyses. (API)

Response: The Trustees will be considering the results of the 1990 studies conducted under NRDA.

Comment: The population survey, radio-tracking and productivity survey efforts of B outside the spill area will not serve any NRDA purpose. These aspects of this study are simply research. (ESC)

Response: It is difficult to collect comparative data if data are collected from only impacted areas. In addition, effects of oil on an individual eagle may not be evident only when the eagle is in the immediate area of the spill.

Comment: Collection of blood samples from eagles is unnecessary because samples from the same eagle population in 1989 showed normal blood characteristics. (ESC)

Response: Certain blood tests were significantly different between eagles captured along oiled beaches and those captured along clean beaches. It is reasonable to continue the blood work to determine if these differences are still detectable.

Comment: The historical data for B4 are outdated. And there is no indication whether the 1991 data will be gathered in a manner comparable to that of the 1982 data. (ESC)

Response: There is no reason to expect that the number of eagles would have fluctuated wildly from the estimate for 1982. The same methodology has been used for population surveys in 1982, 1989, 1990 and 1991.

Comment: Use of Copper River Basin eagles is inappropriate because of the different feeding ecology and nesting habitat in that area. (ESC)

Response: Occupancy and productivity data from the Copper River is remarkably similar to data from saltwater habitats in southeast Alaska and not significantly different from data collected on eagles in clean habitats throughout Alaska. Because of the potential for this population of eagles to be impacted by the spill and their proven similarity to other populations in the state, it is entirely reasonable to include these eagles in the study.

Comment: Objective A of B4 cannot be achieved because of the lack of comparable baseline or control data and because the natural variability of eagle populations in the region remains unknown. (ESC)

Response: See previous responses.

Comment: The sample sizes to be used are too small to allow the testing of Objective B's hypotheses concerning survival rates. (ESC)

Response: Unless the reviewer has unique knowledge, not available to the scientific community, about the variability of bald eagle survival rates there is no way this statement can be construed as valid.

Comment: The effects of the radio telemeter on eagle behavior and the inadequate sample size will render accomplishment of Objective C impossible. (ESC)

Response: Radio-tagging of hundreds of bald eagles with transmitters similar in design and attachment to the ones used in this project, has been documented to have no detrimental effects on the birds.

Comment: The costs and capturing activities for Objective D are not warranted because of the small amounts of highly weathered oil in 1991 and the absence of any exposure pathway. (ESC)

Response: Significant results obtained from the previously conducted sampling warrant follow up observations.

Comment: The locations, and criteria for choosing, oiled and unoiled sampling areas are not described adequately, especially in light of 1991 shoreline conditions. (ESC)

Response: Areas are selected by the presence of an eagle. Random locations without eagles are rejected. Areas that were heavily oiled, according to ADEC maps, will be given priority for the collection of additional samples. The point of the sampling is to find out if there are continuing impacts to bald eagles, not necessarily if abundant oil remains on the beaches.

Comment: Use of Malaspina Glacier, which is well outside the spill zone, as a control area is not appropriate. Collection of data from this area is simply research. (ESC)

Response: The population surveys begun in the 1970's encompassed the northern edge of the Gulf of Alaska from Cape Spencer to Cape Elizabeth. For comparability, the same area was surveyed for the assessment. It is an elementary scientific approach to use results from areas beyond the range of suspected impacts as controls.

Comment: The radio-tagging program does not account for natural dispersal of immature eagles and could increase the risk of mortality to fledglings, thereby creating study bias. The samples are too small to ensure that random samples across the age structure of the population will be obtained. There also is no description of how radio tag failure will be overcome. (ESC)

Response: Radio-tagging has not been shown to cause mortality in bald eagles. The comparison is being made between radio-tagged eagles from oiled areas and radio-tagged eagles from unoiled areas making the effect of the transmitter of little consequence as it would be the same for either group. There is no reason to expect that the age structure of adult eagles is significantly different between the eastern and western sides of PWS. The Kaplan-Meier procedure, cited in the study plan, discusses how missing transmitters are "taken into account".

Comment: The Trustees failed to indicate how individual eagles will be selected for blood sampling. Nonrandom selection may bias results. Post-mortem changes may invalidate the results of hydrocarbon analyses on eagle carcasses recovered. The carcass recovery study will only demonstrate where telemetered birds die. The oiled and unoiled areas in that portion of B4 that is to assess toxic and sublethal effects of EVOS on eagles are neither described adequately nor distinguished from one another. (ESC)

Response: Blood samples were taken from adult eagles. Individuals were selected from widely dispersed areas in both eastern and western PWS. Eagles in western PWS were trapped from areas with oiled beaches. Eagles were not trapped at random locations because neither eagles nor oil are distributed randomly and it serves no purpose to trap at sites without eagles. Post-mortem changes in eagles from oiled and unoiled areas are unlikely to be different. Determination of causes of mortality are being made by highly qualified individuals who are eminently qualified to determine if the analyses performed provide reliable data.

Comment: The statistical analyses to be performed in B4 are not described sufficiently; study sites are not disclosed; and the probabilities of Type I and Type II errors are not given. (ESC)

Response: Statistical models mentioned in the plan are routine tests presented in standard statistical texts. See for example, Zar, J.H. 1984. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, New Jersey. Study sites are discussed above.

Comment: B4 does not appear to take into account the fact that short-term reductions in productivity have little impact on eagle populations. (ESC)

Response: Productivity analyses are taking into account acute and chronic population effects, as relevant.

Comment: The Trustees' bald eagle study disregards the results of the Fish and Wildlife Service's study evidencing the 1990 breeding success of this species, the survival of its fledglings and its recolonization of spill-affected areas. (ESC)

Response: The analysis and synthesis of the bald eagle data will consider the results of all relevant available studies.

Bird Study No. 11 - Sea Ducks

Comment: It is questionable whether there remains any pathway for exposure of sea ducks to oil (since oil is no longer present at the water surface or in the water column below the surface). Thus, the objective of Bird Study No. 11 may not be met. Also, the mobility of these birds could complicate the comparison of populations in oiled and unoiled areas. (API)

Response: The purpose of this study is to assess whether there is continuing harm as indicated by earlier studies. All relevant factors will be considered in evaluating the data.

Comment: This study is unwarranted in light of the Trustees' continued permitting of waterfowl hunting in spill-affected areas and their intent to take more ducks in 1991 for this study. (ESC)

Response: The population of waterfowl and the effects of EVOS on the population are proper for consideration by the Trustees.

Comment: Use of a predictive analytical model is not a standard technique for determining injury and therefore is not in accordance with the DOI regulations. (ESC)

Response: Modelling is a standard scientific technique in studies of this type.

Comment: Development of a data base for food habits of six species of seaducks in PWS is not likely to produce any data useful to

either injury assessment or identification of restoration alternatives. (ESC)

Response: This study is necessary to assess the continuing and longterm effects of EVOS.

Comment: Samples, statistical assumptions and results of Objective F will not be valid because harlequin ducks fly between oiled and unoiled areas. (ESC)

Response: Comparison techniques allow for scientifically valid conclusions to be reached.

Comment: Given the scope and design of Objectives B-E, B11 will not be able to predict mortality and reproductive effects broadly by correlating hydrocarbon gut and tissue data and morbidity data. (ESC)

Response: In corporation of all relevant data will allow the investigator to draw necessary and supportable conclusions.

Comment: The study and control sites are not defined, and the methodology for selecting individual sea ducks to be collected at each site is not given. Sample sizes will likely be too small for the Trustees to draw valid scientific conclusions from their analysis of harlequin duck productivity and development. (ESC)

Response: The Trustees retain the best scientific investigators available in order to obtain reliable results.

Comment: The use of a control site in Southeast Alaska is inappropriate owing to the 500-mile separation between the site and the spill zone. (ESC)

Response: For comparison it is necessary to assess sites both within and without the spill area.

Comment: There is no description of the techniques to be used in collecting tissues, the analysis of petroleum residue to be performed, or the manner in which fat deposition is to be classified. Thus, the reader cannot assess whether the study results will be based on subjective interpretations that would invalidate conclusions. (ESC)

Response: All techniques and analyses are performed pursuant to scientifically valid methods.

Comment: Integration of data from other studies such as coastal habitat probably will not be possible because of the spatial variation between data sets. (ESC)

Response: The Trustees are mindful of the need to integrate studies where appropriate.

Comment: It is not clear how oiling differences will be segregated from natural variability in the interpretation of data. Any differences in histopathology results between western and southeastern PWS could be due to natural differences in the two bird populations. In addition, nesting habitat, wintering habitat and food base differences will affect tissue analysis. (ESC)

Response: The principle investigator and the Trustees will consider and weigh various factors in arriving at a supportable damage assessment.

Comments on Fish/Shellfish Studies - General

Comment: The Plan fails to include any reference to the results of the subsistence sampling program conducted by NOAA and ADF&G and Exxon which provides convincing evidence that fish from throughout the spill area do not contain hydrocarbons above normal background levels. (ESC)

Response: The subsistence tests focussed on hydrocarbons in edible fish tissues; however, fish (unlike clams) have physiological pathways by which they process hydrocarbons into forms soon unidentifiable as having originated from the EVOS (the fish themselves are largely composed of hydrocarbons). This does not mean that the fish have not been harmed by exposure to oil in either a short or a long term fashion nor that this harm cannot be assayed by means other than hydrocarbon analysis.

Comment: The use of mixed function oxidase levels in fish tissues as a means of assessing hydrocarbon contamination is research rather than a method for determining restoration needs. The use of MFO's and cytogenetics to demonstrate injury is unproven and can yield a good deal of variability among season, food sources and life stages. Nor do they have a restoration purpose. (ESC)

Response: It is well established in the toxicological literature that MFO's are produced in response to hydrocarbon exposure. MFO's, though a defensive mechanism, often convert hydrocarbons into more toxic substances than the original compounds and create ultimate carcinogens. Thus these hydrocarbons can have acute toxic and long term mutagenic effects. While MFO's do mediate compounds which cause injuries, they are not injuries in themselves. They do indicate hydrocarbon exposure and suggest the possibility of injury. Histopathology and other assays actually document the injuries if they occur. MFO production (and potential for harm) does vary by life stage, etc. which is why control samples at the same stage, etc. are taken.

Conversely, cytogenetics do not change with life stage, etc. unless an organism has been exposed to a mutagen such as petroleum. Changes in this case can much more justifiably be classified as injuries since a much greater proportion of these changes have a negative survival impact than a positive one on an organism.

Both MFO and cytogenetic analyses have restoration purposes in that they can monitor decline in the continuation of injury. If they do not decline, more active intervention may be necessary in order to accomplish restoration.

Comment: Biochemical measurements such as bile fluorescent aromatic hydrocarbon concentrations and enzyme level changes are nonspecific indicators of exposure; they are highly variable naturally; they cannot be linked directly or positively with EVOS;

and they have no use in correlating population level impacts. (ESC)

Response: The Trustees will compile a variety of oiling data bases to demonstrate that these nonspecific indicators of hydrocarbon exposure were a result of the EVOS. Both types of data are necessary, however, in order to show that these organisms were not only in the path of oil but also came into intimate contact requiring a metabolic response.

Comment: A review of salmon population dynamics in Prince William Sound reveals a high degree of variability between stocks. Since differences between wild and hatchery stocks are not clearly understood by the fisheries managers of the area, it is not plausible to expect that the studies described in the Plan (FS 2, FS 3, FS 4, FS 5, FS 11, FS 27) will be able to adequately describe the subtleties of historical population dynamics with sufficient precision to assess the incremental impact of extremely low hydrocarbon levels. (ESC)

Response: The Trustees have great confidence in the area fisheries managers and their understanding of the wild and hatchery stocks. We believe that the impact of the EVOS will be assessable and that our published plans demonstrate this to be the case. The Trustees would also like to note, however, that FS 27, the sockeye overescapement study, does not take place in Prince William Sound and that the study locations are identified in the published study plan.

Comment: Studies 2, 3, 5, 27 and 28 may provide information that will be useful to fisheries managers, but not information that will assess oil spill impacts. They therefore are not compensable. (ESC)

Response: These studies have components that will demonstrate exposure of fish and shellfish to oil (observations of oiling), bioavailability (hydrocarbon and mixed function oxidase analysis), or injury to individual organisms (histopathology) and populations (survival data). Taken together they are structured to determine damage to fish stocks. Damage due to the oil spill may require management actions that would otherwise not have been necessary and ancillary benefits improving the management of stocks in general may result from these studies as there are ancillary benefits for many kinds of scientific studies; however, that is not the reason for conducting these studies.

Comment: Fish/Shellfish studies 2, 5 and 13 are designed to detect differences between oiled and unoiled areas, but not to determine the reasons for those differences. It will be very difficult to demonstrate that fish have not migrated between oiled and unoiled areas and that selected control sites are ecologically similar to oiled sites. It will be difficult to determine whether statistically significant differences are due to EVOS rather than biological factors. (ESC)

Response: Fish/Shellfish study 2 examines eggs and pre-emergent fry which have no ability to migrate. Mark and recapture experiments have determined that Dolly Varden and cutthroat trout have not wandered significantly between oiled and unoiled areas (FS 5). Fish Shellfish study 13 examines clams which have the ability to migrate very insignificant distances relative to oiling. Pairing ecologically similar sites was a high priority in choosing sampling locations. The preponderance of oiling, exposure (MFO and hydrocarbon analyses), and injury (histopathology, growth and survival) data will establish the EVOS as the cause of the injuries, if there are any.

Comment: Recruitment to fish and shellfish populations is also highly variable from year-to-year, resulting in equally variable commercial catch statistics and escapement numbers. Most of the fishery studies do not adequately consider this high degree of variability or the lack of reliable baseline data. Detection of differences exclusively due to oiling will not be statistically possible. (ESC)

Response: Fish/Shellfish Study 4 relies on coded wire tag recovery to estimate fry to adult survival. This data is very good and is extensively used by fisheries managers along the entire Pacific coast of North America. Otherwise it does not appear that this comment is properly addressed to this study. The comment is certainly incorrectly applied to Fish/Shellfish Studies 5 (Dolly Varden/cutthroat trout) and 13 (Clams in PWS) because there are no commercial fisheries for these species in Prince William Sound.

Comment: Studies 2, 3, 4, 5, 11 and 27 do not take into account the natural variables which affect key life cycle events, and it is not clear that the sampling programs for these studies will aid in distinguishing the percentages of biological variability that are due to hydrocarbon contamination and those due to other, natural factors. (ESC)

Response: The Trustees believe that these factors have been taken into account and that EVOS-induced changes will be detectable, particularly given the thorough examination of each study's methods by peer reviewers.

Comment: Studies 1, 2, 3, 4, 5, 11, 27 and 28 employ sampling programs that cover a broad range of very low level hydrocarbon exposures within a given area. Given this variability, it is unlikely that the sampling designs will be able to relate observed biological responses to any particular hydrocarbon concentrations. (ESC)

Response: These studies are not intended to be carefully controlled laboratory experiments. They are not bioassays to estimate a given concentration of oil in water. There are other tests by which we are attempting to do that. The Fish/Shellfish studies were designed to determine the injury done to fish as a result of the EVOS. Fish/Shellfish Study 27, sockeye overescapement, is related to hydrocarbon exposure levels only in that a sufficient quantity was present to force the closure of fisheries thereby resulting in the overescapements.

Fish/Shellfish Study No. 1 - Salmon Spawning

Comment: Since mussels are filter feeders, the Trustees should conduct water column hydrocarbon analyses and correlate these to mussel tissue analytical results to determine the need for and scope of this year's F/S Study No. 1. (API)

Response: Mussel samples provide a qualitative indication that contamination could occur in living organisms in the intertidal zone at the selected sites. The samples also provide a rough quantitative estimate of the degree of contamination. Mussels are indicator species that are particularly appropriate, being filter feeders that continuously process the water column. They are repositories for contamination that would likely go undetected by anything but a continuous sampling program which is impractical. Sampling in 1991 is designed to measure injury, of course, but will also hopefully measure recovery now or in the future.

Comment: Any study of oil spill effects on pink salmon is not justified in light of the record catches of 1990. Despite the juveniles' high risk of exposure to oil in 1989, their strong returns as adults in 1990 show lack of injury for that year class. (ESC)

Response: The record catch was largely a hatchery phenomenon not necessarily parallelled by wild returns. Among other factors, hatcheries' net pens were shielded from the oil by booms or were outside the spill area and their fish were able to spend a month or longer in this protected saltwater environment before they were released. Wild fish did not have those options. PWS pink salmon are not a single population and, therefore, hatchery successes and failures are not the only criteria by which the EVOS effects are determined. Additionally, some damage to wild salmon populations may have been specific to stocks from streams where intertidal spawning sites were oil contaminated. Strong returns of stocks originating from unoiled areas could easily mask damage to stocks from unoiled areas. If total adult returns to the entire Prince William Sound (PWS) are the sole criteria used for damage assessment, no damages could be discerned. Furthermore, the greatest stock specific damages may have occurred in eggs laid in oiled intertidal spawning areas in 1989. Adult pink salmon returns from those eggs will not occur until the summer of 1991.

Comment: The criteria used to select streams for survey are subjective and unrelated to the spill. In addition, application of results to non-surveyed streams will be limited. (ESC)

Response: Survey stream selection is based on very clearly defined criteria. Selected streams represent the spatial and temporal distribution of pink salmon stocks in PWS and include a broad representation of stream types. The greatest sampling effort occurs in western PWS where oil impacts were greatest and oiled and unoiled streams share geographic proximity, run timing, and similar stream characteristics. Included in the treatment and control streams selected are those streams where wild stocks received coded wire tags (F/S Study 3).

Comment: Prior knowledge of the study design and streams could result in observer bias. (ESC)

Response: It is not clear how prior knowledge of the study design might bias aerial observers. These streams do not receive additional survey effort nor do aerial observers have access to the results of foot surveys and weir programs. It may be possible that foot survey observers may be more conscientious on designated study streams than on non-study streams. This could result in reduced observer variance but would not introduce bias into their observations. Foot survey observers are rotated through the study streams in order to negate any bias due to prior knowledge or differences in counting skills.

Comment: Recalculating escapement to 1961 bears no relevance to impact assessment for a 1989 spill. (ESC)

Response: Recalculating historical escapements is critical to reconstructing historical stock specific total returns. Stock specific total return statistics will be used to test for and quantify significant declines in returns of oiled stocks.

Comment: The methods described will provide an estimate of average wetted area under conditions that prevailed when the measurements were taken. The relationship between this variable and "area-available-for-spawning" is not known for the study streams. (ESC)

Response: The measurements described are for average wetted area under conditions at the time measurements were taken. If the measurements are repeated in subsequent years, they will be representative of those stream conditions and the mean of measurements from all years should provide a reasonable measure of wetted area. While wetted area does not directly translate to total available spawning area, it is a good relative index for comparisons of available spawning area between streams.

Comment: Methods of selecting sampling locations using aerial photographs are important for evaluating potential bias. (ESC)

Response: We do not use aerial photographs to select sampling locations. They are merely an aid to mapping streams.

Comment: The study does not discuss the potential for uncontrolled environmental variables and how these factors might affect statistical analyses and interpretation of results. It is not clear how the subjective choice of study streams will affect the application of assessment results to non-study streams. (ESC)

Response: All streams selected for this study must be included in the ADFG Aerial Survey program. Selected streams include all those in F/S Studies 2 and 3 in 1989, 1990 and 1991. The historic foot survey data base includes many, but not all of the selected streams. Among the streams selected there is approximately equal temporal representation of returns of pink salmon stocks. Selected streams also represent the entire range of stream types in PWS. The study includes all oiled streams in the aerial survey program. Oiled streams selected are paired with at least one, and usually more than one control stream that shares geographic proximity, similar stream characteristics, stock run timing and stock run size. Because the study streams are a representative subset of all streams in PWS, results from study streams can readily be applied to non-study streams.

Comment: Selection criteria for estimating fish life in the stream are not identified. To avoid an arbitrary selection, a standard technique for estimating fish life in the stream should be used. (ESC)

Response: Fish life, or stream life, employs three or more methods at each study stream. Results of each method will be compared using data from the weired systems where total escapement and total fish days are known. These comparisons are the basis for the stream life estimating procedures for unweired systems.

Comment: The criteria used for separation of streams based on their exposure to oil, i.e., visual inspection and levels of hydrocarbons in mussel tissue sampled near each stream, have weaknesses. Thus, basic categorization of streams for this study will be affected. (ESC)

Response: The Exxon Valdez Oil Spill was not a controlled laboratory experiment. Prior knowledge of the stocks, the streams and the area and visual observations were the only sources of information upon which stream categorizations could be made. However, the Trustees plan to compile a variety of sets of oiling data which should more clearly delineate the EVOS hydrocarbon exposure various stocks received and the injuries they incurred.

Comment: Log-linear models for contingency table analysis should not be used since the data will represent estimated (rather than absolute) counts, there is a lack of temporal independence between years, and there is a need to test effects based on streams treated alike and not multinominal sampling error. (ESC)

Response: We agree this approach may not provide strong evidence of oil impact by itself. This study is designed to provide stream oiling information, effects of oiling on adults which had incubated in oiled substrates as eggs and pre-emergent fry, and an estimate of adult escapement. These data will be used by the other salmon projects (Fish/Shellfish 2, 3, 4 & 28) to determine injury to the population.

Comment: Methods do not indicate that covariates for stream size and spawning area will be used to adjust for differences not randomized to strata. (ESC)

Response: This study is not intended to show statistically significant impacts due to oiling and therefore it is not important that covariates for stream size and spawning area be used. It is a source of supporting data for studies 2, 3, 4 & 28. The combination of these studies will determine the impacts.

Comment: Effects of oiling, location, and time are confounded. It will be hard to determine whether a certain effect was due to EVOS or natural variation due to time and location. (ESC)

Response: As noted above, oiled streams were paired with at least one other unoiled stream. This should reduce or remove confounding factors.

Comment: It is not clear that the sampling program will yield data showing that the change in escapement is a function of oil contamination rather than other factors. (ESC)

Response: The Trustees have not yet stated that this is the case; however, we believe that our methods will demonstrate this if it is the case.

Fish/Shellfish Study No. 2 - Egg/Fry

Comment: Overwinter mortality is the result of a calculation of the change in mean density estimates from eggs to alevins. Factors other than mortality may cause changes in density among tidal zones. (ESC)

Response: "Overwinter mortality" is not a statistic mentioned in the plan although overwinter survival is. Overwinter survival is the ratio of live fry densities in the spring fry dig to the density of eggs (dead and live) and fry (dead and live) present in the gravel in the fall. Factors other than overwintering mortality could change this ratio. When treatment and control streams are paired into groups by similarities of stream type, stream size, climatological regime, stock size and stock run timing, the effects of factors other than mortality will be minimized.

Comment: The use of MFO levels in eggs and alevins to assess hydrocarbon contamination is clearly research. The use of MFO to demonstrate injury is an unproven technique which shows a great deal of variability among life stages, seasonal factors and food sources, and other factors. (ESC)

Response: MFO's as indicators of hydrocarbon contamination are well documented for many vertebrate species including salmon and trout. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Differences in MFO activity by life stage, seasonal factors and food sources are not relevant when samples are taken simultaneously from oiled and unoiled fish or eggs at the same life history stage. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO analysis.

Comment: Criteria used to select streams are unrelated to the spill. Results will not be applicable to non-surveyed streams. (ESC)

Response: Criteria used to select study sites are not subjective. The distribution of spilled oil is the basis for selection. Oiled streams are from sites representing a range of contamination from heavy to light. Control streams are specifically paired with oiled sites with respect to geographic proximity, climatic regime, stream size, stream type and stock timing.

Comment: Hydrocarbon levels in mussels near the stream bed may not be directly related to exposure of the stream. These data should not be used to determine the amount of hydrocarbon impacting the stream. (ESC)

Response: Results of hydrocarbon testing of mussels will be used to document whether oil contamination of organisms in the intertidal stream mouth may have occurred, although, of course, no direct comparison may be made with that portion of the stream above the intertidal area. However, since 75% of PWS pink salmon spawn in the intertidal area, the use of mussels as indicator organisms is valid. Results from F/S Study 1 samples will be used in a matrix of hydrocarbon sample data collected as part of the Natural Resource Damage Assessment (NRDA) process. Data from other projects will be used to test the implicit assumption that contamination in mussels can be related to instream contamination in other organisms.

Comment: It is not clear that analysis of shoreline mussels can discriminate EVOS hydrocarbons from other natural background hydrocarbons. (ESC)

Response: Please see Technical Services Study Number 1. Where hydrocarbon analyses in this and other studies are unable to precisely identify contaminants as being derived from the EVOS, parallel oiling data bases, observations and analyses will be employed to make this determination.

Comment: Several variables should be used to trace egg injury to fry mortality in order to obtain sufficient data for an accurate assessment of oil effects. (ESC)

Response: Eliminating these variables is largely a measure of site selection and was considered at that time.

Fish/Shellfish Study No. 3 - Wire Tagging

Comment: The Plan states that FS3 is being "transitioned" to a restoration program, yet no injury has been identified. The Plan should specify what is being restored, and how the study will facilitate restoration. (ESC)

Response: Most of the NRDA studies, including this one, have restoration value in that continuing damage assessment also provides a measure of the recovery of the environment. Documenting recovery or continuing damage is important in that it allows us to actively intervene where necessary to restore the environment and to focus our limited resources. The means by which the portion of this study transitioning into the restoration program accomplishes this is described in that new study available through the Federal Register.

Comment: Field methods are not sufficiently detailed to evaluate the validity of success for this study. (ESC)

Response: The success of this study is intimately associated with that of FS 1, FS 2, FS 4, and FS 28. Review of all of these studies should provide sufficient detail to evaluate the likelihood of success.

Comment: It is not clear how estimates of the survival and harvest rate of wild and hatchery salmon will be used to evaluate effects of the spill. (ESC)

Response: Two tests for oiled effects are possible. Pre-spill survival rates (control) for hatchery stocks are well known. They can be compared to post-spill survival rates (treatment) for each facility. Because juveniles from each facility were subject to different levels of contamination due to geographical differences, survival rates for each facility also can be compared for differences within years. The same is true for wild juveniles. Identification of oiled effects could occur at the juvenile stage (F/S 4) or at the adult stage (F/S 3).

Comment: There is not enough data for historical comparison and no measurement of exposure to oil. Thus, any differences in survival rates related to the oil spill may not be detectable. (ESC)

Response: Pre-spill survival estimates are available for one stock in each category. Even if subtle damage effects may not be discernable, significant effects will be. It is not valid to assume that damage effects will necessarily be minor and undetectable. It is only necessary to determine that the observed injuries, if any, are due to the EVOS rather than to use the injuries as a means of estimating the quantity of oil to which fish were exposed.

Comment: The Plan does not even describe criteria the analysts will use to classify areas as oiled or unoiled. (ESC)

Response: The classification of systems as oiled and unoiled uses visual observations of oil which will be supported by water sample and sediment analyses, mussel tissue analyses and MFO analyses of fish tissues. The categorization of oiled and unoiled is important to the project but a detailed description of the categorization procedures is unnecessary for this operational plan.

Comment: The level of replication (pink salmon: 2 oiled and 3 controls; sockeye: 2 oiled and 1 control) can only be used for determining the more obvious effects. (ESC)

Response: In total, stocks of pink salmon from three oiled and three control streams were tagged. Survival estimates will be made at four life history stages for each of these stocks. Stocks were selected to minimize non-spill effects and tagging levels. Tag recovery rates will be adequate for very accurate estimates of stock-specific catch contribution rates. The catch contribution estimates will be combined with weir enumerations of escapement for total return estimates of sufficient precision to estimate significant oiling effects.

Comment: For species other than pink salmon, the tag rate is different among groups. The approach is apparently inconsistent. (ESC)

Response: Tag rates are held constant for each release group within a facility. This minimizes the effects of differential tag loss and tagging mortality when adjusting tag rates in hatchery brood stock returns. Tag rate adjustments are hatchery-specific. Therefore, it is not necessary to maintain constant tagging rates between facilities.

Comment: Analysis of CWT data uses a modification of Clark and Bernard (1987) that estimates sampling error. There is no discussion on how this step leads to a test of impact that incorporates spatial/temporal variance. (ESC)

Response: Stratification by tag lot, time and processor allows for more precise estimates of fishery contributions for each tagged wild stock stream and hatchery facility. These contribution estimates will provide survival estimates for the tagged groups as well as an estimate of wild stock contribution to the catch. This information, in conjunction with information from studies 1, 2, & 4, will be used by F/S 28.

Comment: Interpretation of the variance formula is incorrect. The formula ignores the covariance between catches of strata within a single release, not "covariance between release groups." The formula should be an estimate of the variance and not the variance as denoted. (ESC)

Response: The sentence preceding the variance algorithm indicates the variance estimate is an approximation.

Comment: Sampling error is likely to vary among locations, fisheries, stocks, and times. It is not likely that any observed differences in survival among stocks could be attributed to the spill effect. (ESC)

Response: All catch contribution estimates are stratified by time and area. Each temporally and spatially stratified contribution estimate has an associated variance. Heterogeneous spatial and temporal entry patterns for tagged stocks may result in different variances for the catch contribution estimates for different tag groups. However, the results for each group will be comparable. Based on previous analyses, variances associated with catch contribution estimates based on coded-wire tag results are not so large as to preclude discerning survival differences between oiled and unoiled stocks.

Fish/Shellfish Study No. 4 - Early Marine Salmon

Comment: It is not possible, without the data collected in prior years, to evaluate the need to continue F/S Study No. 4. Further, there is no explanation given for analyzing stomach contents or for failing to conduct comparisons of hydrocarbon analyses of prey items in oiled and unoiled areas. (API)

Response: This study needs to be continued in order to compare current data to that from previous years. The stomach analysis will provide information on food abundance in oiled and unoiled areas. Hydrocarbon analysis of food items did not appear to be as useful to this portion of FS 4 as MFO analysis of the fish themselves. MFO analysis provides an ultimate measure of exposure and bioavailability.

Comment: The study will compare growth and migration of salmon fry between oiled and unoiled areas. The relationship between areas of capture and areas where the apparent growth occurred is unknown. (ESC)

Response: The relationship between the area of capture and the area where growth occurred will be strengthened by examining otolith growth for the period immediately before capture of the fry.

Comment: The use of MFO to demonstrate injury is a yet unproven method. It shows much variability among life stages, seasonal factors, and food sources. Thus, it may not yield reliable results. (ESC)

Response: MFOs as indicators of hydrocarbon contamination are well documented for many vertebrate species including salmon and trout. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Differences in MFO activity by life stage, seasonal factors and food sources are not relevant when samples are taken simultaneously from oiled and unoiled fish at the same life history stage. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO analysis.

Comment: The study does not discuss potential effects of hatchery operations and procedures on the study analyses and interpretation of results. (ESC)

Response: Each tag lot belongs to a specific treatment group at a hatchery. The effects of different hatchery practices on growth will be considered by including "tag code" as a variable in the statistical analyses.

Comment: The use of an untested model developed for a shallow, arctic lagoon does not cure the statistical problems in the sampling design and is not likely to help injury assessment or restoration in Prince William Sound. (ESC)

Response: Unless the problems to which you are referring are noted, they cannot be addressed. However, spatial differences in fry growth may be due to spatial differences in environmental conditions. The relative effects of water temperature, prey density, and prey composition on fry growth can only be examined with a bioenergetics model that accounts for the complex interactions among these variables.

Comment: There is insufficient description of the criteria for classifying areas as oiled or unoiled. The distribution of sampling effort in time and space must be known to determine whether the study design can achieve its goals. (ESC)

Response: Six broad geographic sampling areas are described in the study plans for F/S Study #4 in oil years 1 and 2. The same areas will be sampled again in 1991. Results from Alaska Department of Environmental Conservation (ADEC) beach and aerial surveys were used to classify these areas as oiled and unoiled.

Comment: Reliance on a bioenergetics model to estimate growth will have a subjective influence on the relation of spill impacts to fish growth. It is not clear how model validation and sensitivity analyses will be used to interpret results. (ESC)

Response: Bioenergetics model validation and sensitivity analyses will be used to estimate model precision and the relative effects of model inputs. These analyses are unrelated to statistical tests of growth differences in oiled and unoiled areas. The bioenergetics model will be used to examine whether the observed growth differences may have resulted from different environmental conditions in oiled and unoiled areas.

Comment: Chi-square tests are restricted to analysis of count data, not the proportions or continuous random variables. (ESC)

Response: Prey composition in the diet in 1989 will be examined using Chi square tests on counts of prey items in the stomachs of fry taken from oiled and unoiled areas. The analysis will test for differences (p=.05) in the amount of prey taken in each of four prey categories between oiled and unoiled areas.

Comment: There is no indication how differences caused by geographic effects will be separated from oiled vs. unoiled effects, where the primary definition of "oiled" and "unoiled" is based on geography. (ESC)

Response: Fry have been sampled at many sites in both oiled and non-oiled areas to minimize any bias resulting from local effects. However, it is recognized that geographic effects confound oil effects. The bioenergetics model, multiple regression techniques, and analyses of stomach fullness will be used to evaluate growth conditions in oiled and non-oiled areas. All available data on environmental conditions in oiled and non-oiled areas will be used in these analyses. Data bases which document exposure (e.g. MFO, mussel and sediment analyses) will be used. The Trustees believe that differences between geographic and oiling effects will be distinguishable.

Fish/Shellfish Study No. 5 - Dolly Varden Char and Cutthroat Trout

Comment: Survival and growth rates of Dolly Varden char and cutthroat trout could be caused by other factors than the oil spill. No analysis is included to test for cause and effect due to oiling versus natural variability or geographical differences. (ESC)

Response: It is important to point out that fish were sampled before any potential exposure to an oiled marine environment since the Dolly Varden and cutthroat trout were overwintering in freshwater when the oil spill occurred. Given this, the first sample from each stream (the emigration during 1989) provides the baseline data for stocks in control and oiled groups. These data indicate mean-length-at-age was similar among control and oiled groups which indicate that fish of the same size grow at the same rate regardless of their overwintering location. Since overwintering populations of Dolly Varden and cutthroat trout are composed of many genetic stocks and the ambient climates in the experimental areas of PWS are similar, differences in average growth rates were not expected. Therefore, large differences in average growth rates between control and oiled groups would be attributed to some external disturbance so long as initial size of fish is corrected for. That this external disturbance is, in fact, the Exxon Valdez Oil Spill, will be documented in the same manner as other studies using a compilation of various oiling data bases, tissue and sediment analyses.

We do not have a direct measurement of pre-spill survival rates among the treatment groups but since the mean-length-at-age were similar between control and oiled groups this would indicate that survival rates were probably similar. If one of the treatment groups had higher survival rates, a greater difference in the mean-length-at-age would be expected and in particular in the older age classes (age 4 and older). This was not the case.

The experimental design, which includes replicate sites in both treatment groups, does take into consideration both natural variability and geographical differences. The study tests for differences in growth and survival between treatment groups only with tagged fish. The analysis tests to see if the differences in growth and survival are greater between control and oiled groups than differences with each treatment group.

Comment: It is unlikely that "all migrating fish can be examined for marks," in which case, the simple estimate of population size ($S=M_2/R_1$) will not be appropriate. (ESC)

Response: The Trustees believe every fish can be examined.

Comment: The three-sample Jolly-Seber model will provide an estimate of survival for only the period 1989-1990, assuming the three capture samples in 1989, 1990, and 1991. Thus, with only post-spill sampling, comparisons of survival before and after the spill will not be possible. (ESC)

Response: The study design uses replicates as described in a response above. Since we were able to census all of the fish at each site in the spring of 1991, we did not have to use the Jolly-Seber Model.

Comment: Comparison of 95% confidence intervals is an invalid means of testing differences between oiled and unoiled conditions since such a comparison should be based on the variance among streams treated alike. (ESC)

Response: Comparisons of 95% confidence intervals are valid since the streams are treated alike.

Comment: There are likely to be differences in survival and growth because of natural differences between the studied populations. Data should be gathered to analyze for spill-related effects. (ESC)

Response: The first answer under comments for this study apply here. However, please note that three oiled and two control sites were used in this study. The reason for the replication was to account for natural variability or geographic differences.

Fish/Shellfish Study No. 11 - Herring

Comment: The necessity for conducting F/S Study No. 11 (Injury to Herring) is questionable given the record number of herring netted over the last two years and the extensive work already done on this species in the prior years of damage assessment. (API)

Response: Impacts to herring recruitment from the 1989 oil spill would not be observable before 1992 at the earliest, when the majority of the 1989 year class begins returning as 3-year olds in the spawning biomass. Even then, not all of that year class will return as 3-year-olds; some will not return until 1993 or even later. Sublethal effects to adults exposed to the EVOS could also affect recruitment, although this again would not necessarily be reflected in catch records until 1992. Since herring are multi-year spawners, a missing age class would result in significant negative survival value to the spawning biomass perhaps for as long as seven years; not to mention damage to the food chain. Please see the answer to the following question for further elaboration on possible injury to recruitment.

Comment: The herring studies are not warranted in light of the apparent good health of the resource. The studies from prior years do not show any significant concerns. (ESC)

Response: Most of the herring harvested in the 1990 and 1991 fisheries were 1984, 1985 and 1986 year classes and, very likely, well out to sea at the time of the oil spill. Studies have shown herring to be most susceptible to the effects of hydrocarbons and other toxins in their early life history stages (i.e., egg and larval stages). Obviously, the Exxon Valdez oil spill would have had the greatest impact on the eggs laid down and the larvae that hatched in 1989, the year of the spill. Herring do not start to recruit to the fisheries until age 3, and there is evidence that they may not fully recruit to the fishery until age 4 or even 5. The effects at the population level will not begin showing up before 1992. Consequently, should the success of the fishery decide the health of the stocks, we would be unable to evaluate that success until at least then.

Comment: The ability to measure the biomass to within +/-25% in future years will not provide the resolution necessary to measure possible EVOS injury. (ESC)

Response: The biomass estimate may be utilized to examine the effects of EVOS on a population level, and if this were the only tool available to determine impacts, the above statement would be true; natural variability may mask some subtle impacts. However, this is not the only tool being employed to measure impact and, as stated in previously released results, sublethal impacts have been observed in early life stages of herring.

Comment: The study description does not provide sufficient detail to determine whether an accurate representation of AWLS (Age, Weight, Length, and Size) will be achieved. (ESC)

Response: AWLS sampling is more than adequate to provide a true representation of the AWLS for the population. The sampling program conducts a test fishery that evaluates both the major sightings of herring in Prince William Sound and herring caught in the fisheries. This sampling design gives a true representation of the herring in the population and those caught in the fisheries.

Comment: Hydrocarbon burden does not necessarily produce tissue injury. Any tissue damage may have resulted from other chemical or natural exposures during the course of annual migrations of these animals. (ESC)

Response: We agree that hydrocarbon burden does not necessarily produce tissue injury. However, demonstration of MFO activity suggests that these hydrocarbons may be converted into metabolites of acute toxicity to the fish and form ultimate carcinogens. Subsequent histopathology would tend to link hydrocarbon burden and MFO activity to observed injury, but a compilation of many sets of oiling data bases and laboratory analyses will provide the links which need to be established, if there are links.

Comment: There are no studies which demonstrate population level impacts from sublethal effects at exposures of this magnitude. MFO and cytogenetics analyses are experimental and results vary with diet, season, spawning activity, etc. Experimental measurements are not an acceptable measure of injury under NRDA regulations. (ESC)

Response: Cytogenetic abnormalities and MFO activity certainly have been linked with injuries to fish and other vertebrates including humans. Cytogenetic analysis results do not vary with diet, season, or spawning activity as claimed by Exxon, though MFO results do. Differences in MFO activity by life stage, seasonal factors and food sources are not as relevant when samples are taken simultaneously from oiled and unoiled fish or eggs at the same life history stage. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO and cytogenetic analysis. Sublethal effects such as these by their definition make an individual animal less fit and less likely to survive. Whether effects upon individuals will have an impact upon the population remains to be empirically determined when the 1989 year class enters the exploitable portion of this population in 1992.

Comment: Estimating egg loss due to wave action or predation is not related to EVOS damage assessment. (ESC)

Response: The estimate of egg loss will make the biomass estimates more reliable. Measuring egg loss is just one way to improve the precision of the biomass estimate. Biomass will be estimated from spawn deposition surveys. From the time the eggs are deposited on the shoreline and a survey conducted by divers, some eggs will be lost to wave action and/or predation. The egg loss study measures this loss from the time of egg deposition until completion of the survey.

Comment: The diver surveys for spawn estimation are based on an inadequate sample design. Kelp should be taken to a laboratory for adequate estimation of egg cover. The samples selected for diver calibration must be representative of the available plant type and egg cover to be acceptable in correcting the diver estimates. (ESC)

Response: Randomly selected samples of kelp have been taken to the laboratory for diver "calibration" and are representative of the available vegetative cover and egg cover. This process, used to estimate biomass, has proven to be more than adequate in assessing egg production and subsequently herring biomass. The process used in Prince William Sound is similar to that used by biologists in British Columbia and Southeast Alaska for years.

Comment: Measuring distance from MLLW perpendicular to the shoreline is necessary to calculate the size of the spawning beds. (ESC)

Response: The distance from MLLW perpendicular to the shoreline is measured during the spawn deposition survey and is used to calculate the size of the spawning beds. The measurements are accurate and the tide level is taken into account when the measurements made.

Comment: The 12-16 dives to assess survival are proposed to be included as a factor in the ANOVA indicated by model Eq. 15. In actuality, these constitute repeated measures on only a few replicate locations. The repeated measurements on successive dives are not independent and violate the assumption of independence in ANOVA. (ESC)

Response: The measurements are not repeated measures but a measure of egg survival over time. The measurements are independent and time is included as a covariate in the subsequent ANCOVA. In this analysis, the assumption of independence is not violated.

Comment: Egg loss will be measured in the field. Herring depend on density for survival and there are no means of identifying the degree to which this affects year-class production. (ESC)

Response: The statement concerning herring exhibiting density dependent survival and there being no apparent relationship between herring spawning biomass and subsequent recruitment are contradictory. It has to be one or the other. If herring exhibit density dependent survival then there should be a relationship between herring biomass and subsequent recruitment. Studies on other fish species show such a relationship when considering certain factors, i.e., water temperature, salinity, size of other fish species. We have observed no such relationship for herring in our study.

Comment: The egg survival studies are being conducted at three locations which limits the investigation. Thus, the scope of the study to resolve effects throughout the impacted region will be limited. (ESC)

<u>Response</u>: There are only five significant spawning areas in Prince William Sound, one of them a small one. We conducted the egg survival study in the four major areas.

<u>Comment</u>: The biomass which will be estimated in 1991 will not include the fish which are the product of 1989 egg production. There were no significant 1989 adult mortalities. Thus, this study seems more geared to herring resource management than EVOS impact. (ESC)

<u>Response</u>: The 1991 biomass estimate is a continuance of baseline information that will be employed in a model that will predict affects. The increase in accuracy over the last three years will go toward improving that model. Impact studies on eggs and larvae were continued in 1991 for the following reasons:

1. When the effects from oil have disappeared, we would expect to see a return to baseline levels of abnormalities and natural variation due only to environmental factors outside the spill effects.

2. If adults continue to metabolize oil, potentially affecting egg production and reproduction, we would expect to measure the impact with samples collected and tests conducted in 1991 and possibly 1992.

<u>Comment</u>: There is no description for the oil exposure study (e.g. Is fresh or weathered oil used?) and it may not be representative of field conditions. (ESC)

<u>Response</u>: The exposure study will provide data on effects of oil on larval abnormalities, MFO levels, cytogenetics, and histopathology in relation to known levels of oiling. If effects are similar to our findings in the field, damage can be inferred. In addition, larvae will be sampled that have been reared at field sites but without being exposed to oil to test for and separate site effects from oiling effects. Two oiling mechanisms are being employed; one is a flow through system with particular levels of WST maintained in the water supply (standard dose-response with petroleum); the second is a "dip" or one time exposure method in whole fraction, which imitates what may have happened in nature; both methods will include a variety of dosages, all sublethal. Therefore, we believe this will be comparable to field conditions.

<u>Comment</u>: The test of the effects on fecundity based on comparison among five areas of sampling bears no relationship on EVOS exposure. This test selects individuals of a specific length range near the mean size. This sampling will produce a fecundity-weight relationship that will not be representative. (ESC)

Response: The literature suggests that herring egg atresia (therefore affecting fecundity) occurs following exposure to petroleum. Our range of sampling sizes around the mean represents 80% of the returning stock which, we believe, is sufficiently representative.

Fish/Shellfish Study No. 13 - Clam Injury

Comment: While the stated objectives do consider the available scientific literature on effects of oil on intertidal clam populations, the study design greatly underestimates the natural variability in all the biological and chemical parameters that will be measured. (ESC)

Response: Incremental growth data (both pre- and post-spill) will be available for comparison of the growth rate by site and this should clearly delineate oil spill effects if there are any.

Comment: Sediment samples for hydrocarbon analysis and clam samples for growth from all three positions at a given tide level are composited into single samples, obscuring any gradients of chemical and biological response at different levels on the shore. (ESC)

Response: Due to the need to take samples in triplicate it was deemed cost-prohibitive to take triplicate sediment samples at each tide level sampled; nevertheless, we believe this will not hamper our efforts to document damage if it has occurred.

Comment: It will be difficult to distinguish differences due to natural causes from those due to the presence of oil in the sediments or the clam tissues. (ESC)

Response: The compilation and comparison of oiling data bases, sediment and tissue analyses should allow this distinction to be made in this case as in other studies.

Comment: The sample size for estimating clam growth is reduced from 150 to 3 study sites because of pseudoreplication. (ESC)

Response: The sample size for estimating clam growth is unchanged from last year for this study. The reviewer is confusing this study with Coastal Habitat Study 1. The two studies are and have been independently investigated.

Comment: The growth measurements are not adjusted for clam territories. The study does not describe how the most appropriate growth model will be chosen. (ESC)

Response: We assume that "territories" refer to clam densities or plots, both of which will be considered in our analyses. Schnute's

Generalized Growth Model, which incorporates the classic growth models such as von Bertlanffy and Gompertz, will be used to select the most appropriate model.

Comment: The parameters being measured are quite variable over small temporal and spatial scales. As a result, it will be hard to assess the baseline condition. (ESC)

Response: Characterization of the baseline growth rate in clams is accomplished by measuring annuli which are retained.

Comment: Relationships between observed histopathology and oil-related effects on survival potential of natural mollusk populations have not been accurately established. Thus, the significance of any observed effects is questionable. (ESC)

Response: Various toxic components of petroleum have produced histopathologically documented lesions in mollusks and whole petroleum has been shown to kill populations of natural and cultured mollusks. Demonstrating that oil-induced histopathology has a negative survival impact on populations of mollusks should not be difficult though quantification may be. As well as mortalities; however, changes in growth rates could also be considered injuries. Histopathology results will be compared with data on the level of tissue and sediment hydrocarbons, growth rates prior to the spill and growth rates after the spill as well as a variety of other oiling data bases.

Fish/Shellfish Study No. 28 - Run Reconstruction

Comment: F/S Study No. 28 is unwarranted in light of the record salmon catches and the failure of the Trustees to demonstrate an injury to this resource that would require fishery restoration strategies. (API)

Response: The Trustees disagree. This study integrates data from F/S Studies 1 to 10, which includes, in addition to pink salmon, all of the other species of salmon. Adults of these other species will not return for some years yet so we really cannot claim record returns. Record pink salmon returns are largely a hatchery phenomenon, though even hatchery returns may have been greater in the absence of a spill. Wild pink salmon did not have the protective devices which somewhat shielded hatchery fish from the EVOS. The Trustees are concerned with stock specific injuries which cannot be directly inferred from the magnitude of returns of mixed stocks to a large area.

Comment: Historical data will be analyzed to develop estimates of model parameters. Other historical studies (FS1-FS10) focus on the correction of historical values based upon the results of recent data collections. These data are being collected at a time when the wild stocks are in recovery from over fishing and in transition, therefore, they are not representative. (ESC)

Response: Corrections are based on understanding the relationships between historical assessments and the more complete and comprehensive assessments done under the Natural Resource Damage Assessment (NRDA) studies. Key measurements of stream life are consistent with historical values and valid to apply to historical data.

Comment: The wild fish which made up 100% of the annual catch ten years ago have been reduced to less than 15% of the annual catch in recent years. Under these circumstances, it is difficult to determine the status quo. (ESC)

Response: Current wild pink salmon runs and escapements are in the range of historical levels. NRDA studies focused on separating hatchery and wild stocks and therefore can assess the changes in wild stock runs due to EVOS damages.

Comment: The anticipated performance on the life history modeling and run construction approaches are not discussed. An evaluation of the anticipated power of the methods to assess effects needs to be discussed in light of Peterman and Bradford (1987) and Peterman (1989) who indicate extremely low statistical power using stock assessment techniques. (ESC)

Response: We are aware of the possibility of low statistical power using these methods. Presently, we are awaiting additional data which will enable us to assess the power of these and other methods as well.

Comment: The study description does not include a plan for a model verification or sensitivity analysis in interpreting the presence or absence of effects. Errors in parameter estimates and model simplifications need to be measured and contrasted with estimation of any perceived effects. (ESC)

Response: On the contrary, these models can be effective in environmental assessment and decision making. The models require an enormous data base source and a comprehensive understanding of the dynamics of the phenomenon to be modeled. This modeling effort will use publications of this past decade for its mathematical foundation. It also will use the thirty years of catch, fishing effort, escapement, and tag recovery data that is available.

Fish/Shellfish Study No. 30 - Salmon Database Management

Comment: The expenditure of funds for F/S Study No. 30 should be limited to better organizing those data from projects directly related to the determination of potential injuries to resources in

Prince William Sound. The State of Alaska is contributing funds to this study to cover other uses of the data. (API)

Response: The organization of data from projects directly related to the determination of potential injuries to resources in PWS is exactly what this study does. The objective is to develop a biological database necessary for the analysis of data collected in the field studies. It is scheduled to terminate within one year after completion of field data collection and completion of laboratory analysis.

Comments on Coastal Habitat Studies

Coastal Habitat Intertidal Study 1A

Comment: The coastal habitat program is grossly disproportionate to restoration costs. Studies of shoreline recovery and restoration indicate that there are no practical approaches to restoration that will enable these habitats to recover more quickly than they will naturally. Thus, further intensive study is not justified. (ESC)

Response: This study has been reviewed extensively by appropriate experts for design and cost-effectiveness and, where appropriate, has been revised accordingly. Further, it has been coordinated with other studies to ensure integration of collection methods and study results. Our data do not support the conclusion that there are no practical approaches to restoring intertidal habitats, and do indicate a need to continue the study. Thus, the budget reflects the most cost-effective means to determine the extent of injury to coastal habitats resulting from the EVOS and is not disproportionate to the costs of restoration.

Comment: The coastal habitat studies and the restoration feasibility study concerning theses resources appear to be independent of one another with neither providing the justification necessary for actual restoration. Nor do they provide the method of identifying and selecting restoration options. (ESC)

Response: The coastal habitat damage assessment and restoration studies are being conducted by the same principal investigator and thus are fully coordinated. The comprehensive study provides the data needed to identify and test restoration options.

Comment: The coastal habitat studies do not describe how EVOS hydrocarbons will be distinguished from other natural and/or anthropogenic hydrocarbon sources. (ESC)

Response: Hydrocarbon samples collected by the Coastal Habitat project will be analyzed in Technical Services study #1. The analysis will measure concentrations of petroleum hydrocarbons specific to the EVOS.

Comment: The list of methods does not include the number to tide levels sampled at each site, the methods for sampling and analysis of biota and sediments, or the tests of biological conditions and community function. Thus, it is not possible to assess whether all the types of biological and chemical analyses were performed on samples from all sites. (ESC)

Response: The objective of the 1991 Plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study. The Trustees believe there is sufficient information provided in the Plan for this type of review. The specific methods utilized during the study may produce results used in litigation and therefore constitute confidential information.

Comment: It is not clear whether the studies of hydrocarbon concentrations mentioned in both CH1 and CH2 are duplicative of one another or whether they will be used to address different components of injury determination. (ESC)

Response: A chemical analysis group was established to direct and monitor sample collection, coordination, and priorities. Sampling sites for all studies including CH1 and CH2 have been mapped for reference and coordination by field investigators to prevent duplication.

Comment: NOAA's remarks about the resiliency of the flora and fauna of intertidal communities belie the need to continue the Coastal Habitat study. NOAA's Net Environmental Benefit Analysis recognized that shoreline conditions do not pose any significant threat to wildlife, but studies continue in spite of this fact. (ESC)

Response: We have reviewed the findings of the Net Environmental Benefit Analysis and have incorporated any applicable findings into the study design. Our data to date do not support the conclusion that intertidal communities are free from contamination or that shoreline conditions pose no threat to wildlife.

Comment: The methods for random site selection are not adequately described. The criteria for selecting control sites may not have been rigorous enough to ensure that they will be comparable to oiled sites. (ESC)

Response: The site selection process is detailed in the August 1989 and 1990 State/Federal Natural Resource Damage Assessment and Restoration Plans. As explained in the 1990 plan, the additional 1990 control and experimental sampling sites were deductively selected to provide additional spatial and habitat distribution, thus providing a paired comparison that maintains the statistical validity of the design. Statisticians have been consulted during the development of the 1989, 1990 and 1991 study plans to ensure that appropriate statistical designs are met.

Comment: The Plan indicates that the Trustees did not place individual sites in oiling categories properly because they did not know oiling levels. (ESC)

Response: As stated on pages 11-12 of the 1990 plan, the potential study sites were visited by coastal habitat personnel verifying the sites physical, biological and oil classifications to ensure matched pairs with respect to oiled and control sites. Cumulative oiling data collected as part of the response actions were used to provide oiling data.

Comment: Shoreline treatment procedures were not considered in site selection, so "responses to varying degrees of oiling and subsequent clean-up procedures" really cannot be measured. (ESC)

Response: Shoreline treatment procedures have been incorporated to the extent possible into the restoration portion of the Coastal Habitat study. In addition, experimental techniques have been employed to further measure rates of recovery.

Comment: The Plan does not detail the total number of sites sampled, their distribution between control and oiled sites, their geographic location, or their shoreline type., Nor does it indicate whether individual sites were sampled more than once in 1990 or whether they were sampled in both 1989 and 1990. (ESC)

Response: Page 10 of the 1990 plan identifies that there were 102 sites to be studied in 1990. This number has been reduced to 57 sites for 1991. These sites are located throughout the spill area, with 26 sites in PWS, 18 in CIK and 13 in KAP. The sites are equally distributed between control and oiled sites and represent the five previously identified habitat types. As in 1990, all sites will be sampled twice.

Comment: There is no justification offered in Coastal Habitat Intertidal Study 1A for reducing the number of sampling stations from 97 in 1989-90 to 57 in 1991. Given the reduced field season in 1991, it is difficult to understand how this reduced sampling will permit the Trustees to detect injuries and extrapolate from them. (NWF)

Response: Coastal habitat data collection was scheduled to be conducted over a three-year period that began in 1989. Several samplings per year were collected to assess potential injuries and recolonization rates for intertidal flora and fauna. Sampling was reduced to allow for the timely processing of 1990 and 1991 samples, while still providing the necessary data to complete injury extrapolation.

Comment: It still is not possible to determine whether a statistically valid site selection strategy was developed to achieve Objective 1. (ESC)

Response: As with the 1989 and 1990 plans, the objective of the 1991 Plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study. Biometricians have been consulted during the development of the study to ensure that appropriate statistical designs are followed that will allow for the accomplishment of Objective 1.

Comment: There are no criteria given to enable the reader to understand how individual sites were "ground-truthed" so as to meet Objective 2. Nor are the criteria given for selection of sites for each of the three years of study. (ESC)

Response: Study sites were selected and ground-truthed during Phase I of the Coastal Habitat study, which is described on pages 11-12 of the 1990 Plan. The potential study sites were visited by coastal habitat personnel examining the sites' physical and biological attributes to verify their appropriateness as a matched pair to respective oiled and control sites. Phase I of the study concluded in 1990.

Comment: The methods for injury determination that will be used for Objectives A and B are not provided. (ESC)

Response: The specific methods used in the coastal habitat study may produce results used in litigation and therefore constitute confidential information unavailable during the study process. A less detailed version is provided in the Plan to allow reviewers to understand the scope of the study and inter-relationships with other studies.

Comment: None of the Trustees' Plans to date have considered shoreline treatment in site selection for the stratified random study. (ESC)

Response: The random study design is based upon oiling category and habitat type and not upon such factors as, for example, shoreline treatment or berm relocations. However, such factors may be integrated as part of the coastal habitat restoration work.

Comment: It will not be possible to extrapolate biological and chemical responses observed at two levels of oiling to all oiled areas of PWS in order to achieve Objective C. By eliminating very lightly and lightly oiled sites from the study in 1990 and 1991, the Trustees have skewed the study toward the worst-case scenario. Any differences in biological or chemical parameters found among sites should apply only to moderately and heavily oiled sites. (ESC)

Response: Detailed hydrocarbon analysis is being performed on samples from each location and will provide a range of precise levels of contamination. This range of data will provide the means for extrapolating injury to a wide range of hydrocarbon levels, thus meeting study objectives.

Comment: It is not clear how the Trustees plan to meet Objective F since there is no discussion of linkages to other studies. (ESC)

Response: Inherent in the injury determination is a synthesis process that will integrate injuries from many studies in an ecosystem approach. Such factors as critical nesting habitat, food availability and contamination, and others will be considered.

Comment: It will not be possible to extrapolate impacts to the entire spill area because all control sites may not have been randomly selected. (ESC)

Response: As explained on page 11 of the 1990 Plan, the additional 1990 sampling sites were deductively selected to provide additional spatial and habitat distribution. This process provides for a paired comparison that maintains the statistical validity of the design. Statisticians were consulted during the development of the study plans to ensure that appropriate statistical designs were achieved.

Comment: It is not clear from Objective E how natural seasonal changes will be factored into estimating impact/recovery or what parameters will be used to predict recovery rates and their potential for restoration. (ESC)

Response: Coastal habitat data collection is a three year study that began in 1989. Several samplings per year are being collected to determine potential injuries and recolonization (recovery) rates of intertidal flora and fauna. In 1990, restoration feasibility studies were initiated designed to compare the rates of faunal recovery in rocky intertidal communities, and to demonstrate the feasibility of restoring these communities by enhancing recolonization rates of key species. Parameters examined include the presence or absence of common intertidal species on impacted and reference sites, population dynamics of several species of invertebrates, larval settlement on oiled versus non-oiled surfaces, and differences in algal grazing by limpets between oiled and non-oiled sites.

Comment: Insufficient information is provided to determine whether analytical methods of this study are based on standard and widely accepted techniques. The study description does not address QA/QC of biological samples, field methods or taxonomy. (ESC).

Response: The design of the study has been reviewed extensively by appropriate experts to ensure that it is based on standard and widely accepted techniques. A detailed study plan of data analysis, collection techniques, and QA/QC standards is not necessary for reviewers to understand the general scope of the study, and its inter-relationship with other damage assessment studies.

Comment: The study description does not indicate how the Trustees plan to address varying oiling levels, treatment/cleanup effects and physical environmental factors that affect the results. (ESC)

Response: The objective of the 1991 plan was to provide summary information on individual studies adequate for reviewers to understand the scope of the study, inter-relationships among studies, and the scope of the overall damage assessment program. A description of factors that may affect results used in litigation constitute confidential information unavailable during the study process.

Comment: The Plan does not address the extrapolation from specific stratified random sample sites to the universe of sites in each category or the statistical methods used to determine injury. (ESC)

Response: As noted above, the objective of the 1991 plan was to provide summary information on individual studies adequate for reviewers to understand the scope of the study, inter-relationships among studies, and the scope of the overall damage assessment program. A description of factors that may affect results used in litigation constitute confidential information unavailable during the study process.

Coastal Habitat Intertidal Study 1B

Comment: Reduction of sampling in Study 1B is unwarranted given the extensive baseline data available and the opportunity for obtaining valuable data that this presents. It is not clear whether this study is related to Fish/Shellfish # 13 and, if so, how. (NWF)

Response: The peer reviewers concurred that this study could meet its stated objectives at a reduced level. Subsequent information justified a second sampling effort under Restoration Science projects to monitor natural recovery at these sites. Fish/Shellfish #13 - "Effects of Hydrocarbons on Bivalves" - is studying clams at selected sites in the lower intertidal. Data from mussels and sediments may be useful to interpretation of their results, but the sampling sites and habitats are different.

Comment: According to Appendix D, "'Sites were selected before any oil reached them and prior to shoreline treatment'". Thus, it will not be possible to establish the response of biological and chemical parameters to varying degrees of oiling and subsequent clean-up procedures. (ESC)

Response: The response of biological and chemical parameters will be measured over a multi-year time series that will be influenced by degree of initial oiling, subsequent re-oiling, clean-up activities, natural weathering processes, and biological depuration. It is the sum of these responses that will determined and of most interest to identifying long-term contamination and injury.

Comment: The laboratory methods for analyzing tissue and sediment are missing. (ESC)

Response: Laboratory methods follow accepted standard practices and were approved in the QA/QC procedures. It was felt that detailed methodology was not necessary to present here, as it is the same methodology that is applied to all studies that take sediment or tissue samples for hydrocarbon analysis, and use TS#1 approved laboratories for these analyses.

Comment: There is no information given to determine whether the methods used for collection of the 1977-1981 data are the same as those used in 1989-1990. (ESC)

Response: Data collection methods are the same.

Comment: The Trustees fail to address how differences measure over time can be attributed to EVOS rather than natural or anthropogenic changes. (ESC)

Response: The presence of detectable Prudhoe Bay crude oil in sediments and mussels in Prince William Sound would not reasonably be considered to result from natural or anthropogenic sources other than the EVOS.

Comment: It will not be possible to extrapolate from nonrandomly selected sites to the universe of sites. (ESC)

Response: Nor would the Trustees attempt to do so.

Comment: The ten historical sites used in the coastal habitat program to assess sediment and mussel contamination are atypical of most oiled sites in PWS, which are in areas of high energy. Therefore differences observed between oiled and control sites cannot be used to extrapolate effects to the entire spill area.

Response: Most of the historical sites are moderately sheltered. Data obtained will be comparable among this subset of sites, many of which were also oiled by EVOS.

Comment: Presence of petroleum hydrocarbons in mussel tissues alone cannot be considered EVOS-related injury. The tissue residues must be found to have caused biological injury before pathway exposure is sought. (ESC)

Response: Pathways of exposure are not being sought. The presence of hydrocarbons in mussels and/or sediments is evidence of exposure itself. Evidence of exposure is necessary to establish linkages to injury.

Comment: There is no information regarding whether any of the ten nonrandomly selected sites are in areas affected by the spill. No site selection criteria were provided for those sites selected after the spill.

Response: Although not presented in the study description, there is substantial evidence on the degree of oiling of each site. Some sites were not oiled and serve as control sites, others were oiled and are maintained as study sites. The sites selected after the spill were done so rapidly, as soon as the path of the oil slick was apparent. These new sites were initially sampled before oil impact.

Comment: It does not appear that the transect selection, mussel sample collection or the photo-documentation is random. (ESC)

Response: Transects were selected according to the appropriate tide level for sampling. Along each 30-m transect, mussel, sediment, and photo-documentation are taken at random locations.

Comment: The Plan does not address QA/QC of biological samples or field methods or the statistical methods for determining injury. (ESC)

Response: QA/QC procedures are established for all NRDA studies (see Technical Services #1). This study complies with these QA/QC procedures. Appropriate statistical tests will be used depending upon the type of data to be analyzed.

Comments on Subtidal Studies - General

Comment: Subtidal studies 5, 6, and 7 ignore the highly successful salmon and herring fisheries of 1990 and 1991 and the positive findings of the subsistence sampling program indicating that fish throughout the spill area do not contain above-normal levels of hydrocarbons. (ESC)

Response: Although an apparent immediate impact on some fisheries may not have been observed (*e.g.* herring and salmon), our laboratory has found evidence suggesting continuing exposure of pollock and other fish species to oil. Since reproductive impairment and some histological changes may require longer times to manifest themselves, investigation of these biological effects is warranted. It is also important to note that the subsistence program is not focussing on benthic fish and is limited to specific areas near fishing villages. There is greater evidence of oil exposure to bottom-feeding fishes than fishes that reside primarily in the water column.

Comment: Subtidal sediment studies 1, 2 and 3 will not achieve their objective of extrapolating results to the entire spill area because the number of sites remains too small and the sites chosen for study were selected based on their potential for detecting impact rather than on a random basis. (ESC)

Response: Extrapolation of the results to the entire spill area was not an objective of these studies. Proper stratification of Prince William Sound would have been necessary to accomplish that objective. The process of stratification would have been far too costly and time-consuming. We chose, instead, to compare paired (oiled vs. unoiled) sites in a statistical design where sites are fixed rather than random. This precluded the delays associated with stratification allowing us to begin sampling soon after the spill thereby providing a complete record of the temporal changes in the hydrocarbon contamination of subtidal sediments.

Comment: The methods for detecting PAH metabolites in tissues from Subtidal Studies 6 and 7 are too imprecise to establish a conclusive link to EVOS oil in subtidal sediments. (ESC)

Response: The HPLC/florescence method for detecting metabolites of PAH in bile is a screening method that can identify fish that have been exposed to aromatic compounds. Using GC/MS to analyze for individual metabolites of aromatic compounds present in bile, a link between the source of aromatic compounds and the compounds present in the organism can be made. The analytical method that screens for the fluorescent aromatic compounds (FAC) in bile has been validated. In addition, a series of marker compounds identified by GC/MS, the dibenzothiophenols, provide a link to the source of the oil.

Subtidal Study No. 2 - Injury to Benthic Communities

Comment: Inclusion in the 1991 mass balance calculations of data from sites sampled in 1989 and 1990 is not valid because the temporal changes that have occurred in the nearshore subtidal zone where waves and currents are most active. (ESC)

Response: A valid comment if the 1991 mass balance calculations are to be considered a discrete entity to be viewed in isolation. Data from Air/Water Study No. 2 would then be useful for documenting shifts in the bathymetric distribution of those hydrocarbons included in the earlier mass balance calculations.

Comment: The microbial hydrocarbon oxidation potential will not establish a causal relationship to spill oil except in heavily oiled samples because it reacts to total available hydrocarbons and does not distinguish spill oil from background hydrocarbons that are present. (ESC)

Response: Microbial populations at a given site could show high activities to hydrocarbons due to acclimation to hydrocarbon inputs from sources other than the EVOS. However, the use of control sites and information from other studies will be used to help interpret the results of this study. This study is not being done in a vacuum.

Comment: The number of 1991 PWS study sites is not adequate to calculate the amount of oil remaining from the spill that could be present in subtidal sediments for mass balance models or to map "'the geographic and bathymetric distribution of hydrocarbon contamination of sediments in PWS and northeastern GOA'". (ESC)

Response: The goal of Air/Water Study No. 2 was to document the bathymetric distribution of oil at selected sites at various distances from the spill site. Oiled sites were chosen so that a range of levels of contamination of intertidal sediments would be included in the study design. Reference sites were paired with oiled sites by sediment type, aspect and exposure to wave action whenever possible. The 1991 sites are a subset of the original set of sites sampled in 1989-90. The 1991 sites were selected chiefly to document shifts in the subtidal distribution of petroleum hydrocarbons and to measure the persistence of oil in subtidal sediments.

Comment: Sampling sites were not selected randomly, so the results cannot be extrapolated to the entire spill region. (ESC)

Response: Correct. See responses above.

Comment: The mathematical methods for estimating maximum potential for *in situ* biodegradation and for distinguishing effects due to oiling from other factors are not provided. (ESC)

Response: In situ biodegradation will not be measured in this study nor will it be estimated from the data. Potential rates of biodegradation will be measured. These rates give an indication of the ability of the microbial populations at a given site to utilize certain hydrocarbon fractions. If a population can immediately utilize a given fraction the implication is that the population is acclimated to use of that hydrocarbon.

Comment: This study does not identify injury, its cause or its significance. The study does not mention the link between the microbial assay results, chemical analyses of the extracted hydrocarbon fraction, EVOS oil present in that fraction, and changes noted in subtidal infaunal communities associated with eelgrass and Laminaria beds from Subtidal Study No. 2. (ESC)

Response: This comment relates more directly to Subtidal Study No. 1 than Subtidal Study No. 2. Subtidal Study No. 1 is not intended to identify injury. Instead, the intent of the study is to determine the amount of oil that contaminated subtidal sediments and its chemical fate. By following the persistence of petroleum hydrocarbons in time, Subtidal Study No. 1 continues to estimate exposure for affected subtidal communities and, in this sense, supports other studies designed to more directly assess injury. This study is linked to Subtidal Study No. 2, however, and provides for both hydrocarbon and microbiological analyses of sediments associated with infaunal collections from eelgrass and *Laminaria* habitats.

Comment: The faunal composition of subtidal soft-bottom benthic communities varies dramatically even at very small spatial scales and year-to-year recruitment of the species represented in this zone is very high. Accordingly, variances within this survey will be high and the possibility of detecting changes due to EVOS is very small. None of the descriptors of community composition identified in the study description acts in a precise manner when responding to pollution, so it will not be possible to link oil pollution and observed changes in the composition and abundance of macro-infauna. (ESC)

Response: We recognize the complexity of soft-bottom benthic communities and the dramatic variation of faunal composition spatially and temporally. We are also aware of the problems of great variance in grab data. We expect, based upon previous studies by our investigators and others, to successfully apply the univariate and multivariate techniques outlined to demonstrate pollution effects from EVOS.

Comment: Volume of freshwater input is more important in site selection than proximity of a site to sources of fresh water. And the paired sites, e.g., Bay of Isles and Drier Bay and Herring Bay and Lower Herring Bay, do not meet the design criteria because their physical characteristics are so different. This makes the stratified random sampling design for the sites meaningless. (ESC)

Response: We are well aware of the differences in hydrology and oceanography between the bays selected. In most cases, sea grass beds at the heads of bays were chosen as the common denominator that is expected to have an important influence on the benthic environment of all sites. A sea grass system can be expected to flux a sizable and annually reliable amount of organic carbon to the subtidal environment. Similar benthic faunal components responding in a roughly similar manner would then be expected in the sites selected.

Comment: Continuation of this study for five years indicates that it is research, and not NRDA, oriented. (ESC)

Response: Comparison of data over several years is expected to make a significant contribution to injury assessment.

Comment: The procedure for calculating "'approximate carbon values for all wet-weights'" of the various taxonomic groups is not given and Appendix C does not contain the "'methodologies, rationale, and problems with the use of diversity indices, K-dominance curves, and geometric abundance as measures of pollution-induced disturbance.'" (ESC)

Response: Details concerning calculating approximate carbon values are not included because they are not considered essential for evaluating the study. Appendix C was inadvertently omitted from the published plan. However, details on the analysis techniques can be found in the referenced publications.

Comment: The Trustees will not be able to attribute changes in benthic communities to the presence of EVOS oil with any reasonable degree of confidence because: (1) the number of sites relative to the degree of freedom is small; (2) the control sites were not selected according to the design criteria; and (3) there is no baseline benthic community data for the study sites. (ESC)

Response: The experimental design is a reasonable approach to determination of injury from EVOS. For the shallow benthic work, the stratified random sampling design does have the minimum number of sites considered necessary. Addition of more sites is logistically impossible. Control sites were selected randomly within each strata, according to design criteria. For the deep benthic portion of the study, sampling is conducted in a paired design (treatment/control pairs of sites). The number of pairs was limited by the number of adequate control sites. The deep benthic study is not designed to extrapolate sampling results to the entire region. This requires a random stratification approach and a sampling effort that is cost prohibitive. The lack of baseline benthic data does not mean injury cannot be determined. Comparison of oiled and unoiled areas over time is expected to provide useful information.

Comment: The methods of SS2 refer to the fact that taxonomic identifications of shallow and deep benthos will only be taken to the family level or higher. This will preclude the Trustees from understanding the impacts of the oil spill on individual species and biological diversity which occurs at that level. It is possible then that there could be significant reduction in species diversity, a typical scenario in environments stressed by oil spills, without detection by the Trustees. If species identification is undertaken, it should not be limited to those taxa that are particularly abundant. (NRDC)

Response: Identifications to the family level will not allow understanding of impacts of EVOS on individual species. However, it will be useful for describing injury at the community level, which is expected to be adequate. It has been shown that the overall diversity of a community is comprised of hierarchial components which include family, genus and species, and thus the concept can be applied to families.

Comment: The Trustees should carry out deep benthic biological sampling at depths between 40 and 100 meters as well as at those two levels. (NRDC)

Response: It would be useful to have a continuum of sampling stations between 40 and 100 meters. However, time and funding constraints did not permit additional sampling.

Subtidal Study No. 3 - Bio-Availability & Transport of Hydrocarbons

Comment: Use of sediment traps for Objective C duplicates the direct sampling of subtidal sediments of Subtidal Study No. 1. They are inappropriate for determining particulate transport of hydrocarbons in shallow water because of the few sites sampled, the highly variable circulation patterns. The Trustees should simply sample the subtidal sediments if their aim is to demonstrate the presence or absence of absorbed hydrocarbons. (ESC)

Response: Objective C is "Determine if sediments settling out of the water column in nearshore subtidal environments contain adsorbed hydrocarbons." The sediment trap study does not duplicate the direct sampling of subtidal sediments by SS1, but instead compliments that work. The sediment traps will help determine how long after the spill oil remains mobile in the environment. The sediment trap study is not intended to determine particulate transport for all of Prince William Sound, but instead to determine if hydrocarbons are continuing to expose or re-expose subtidal areas at selected sites.

Comment: The mussel cages to be deployed at ten sites will not yield a representative picture of bio-availability in the spill area; the temporal trends noted will be site-specific and not suitable to extrapolation. (ESC)

Response: Determination of "...a representative picture of bio-availability in the spill area;" is not among the stated objectives of this study. Accomplishment of such an objective would require a sampling effort that is on the order of 100 times more expensive, and is not deemed cost-effective by the principal investigators. The proposed sampling effort is adequate to demonstrate oil transport mechanisms within the seawater column at heavily impacted sites.

Comment: There are no procedures mentioned that would differentiate EVOS oil from other sources of adsorbed hydrocarbons in mussels and sediments. Methods of analyzing bottom core samples and relation that data to data obtained from sediment traps are not included in the Plan. (ESC)

Response: Such procedures are discussed within the context of Technical Services Study No. 1.

Comment: The trustees do not explain the significance for damage assessment purposes of suspended cage mussel uptake or suspended sediment sorption of hydrocarbons. (ESC)

Response: Oil has caused damage to sub-surface organisms, but the mechanism of oil transport to various sub-surface habitats and organisms is not immediately obvious as it is with the surface habitats and organisms. Sampling caged mussels and trapping sediments is an attempt to complement the direct water sampling for hydrocarbons and to determine the availability of hydrocarbons to sub-surface habitats and organisms. These measurements have the advantage of integrating low level hydrocarbons for long periods of time.

Subtidal Study No. 4 - Fate and Toxicity of Spilled Oil

Comment: The study of oxidation products in SS4 is research and not compensable. Nothing in the literature quantitatively relates oxidation products/metabolites to parent hydrocarbon compounds, and GC/MS analysis may be inappropriate because many of the oxidation products are thermally unstable. (ESC)

Response: The study of oxidation products focuses on the sources of the toxicity associated with EXXON VALDEZ oil. The study is designed to determine whether, and to what extent, oxidation products contribute to the measurable toxicity of oiled sediment samples. Oxidation products are not routinely included in chemical analyses performed in oilspill assessments, and their omission could conceivably lead to an underestimate of overall potential effects, based on measurements of hydrocarbons alone.

<u>Comment</u>: It does not appear that this study will be used in the quantification of injury to natural resources. The study objectives include documentation of exposure and identification of aspects of damage, but there is no indication that injury will be assessed beyond the testing of statistical significance of observed differences. (ESC)

<u>Response</u>: As noted in the previous response, Subtidal Study No. 4 focuses on the mechanisms of oilspill toxicity. Toxicity bioassays provide information on the potential toxicity of the oil still residing in the Prince William Sound subtidal environment and on the threshold concentrations of oil required to elicit toxicity responses in test organisms. Separation of polar oxidation products was included to determine whether, and to what extent, oxidation products of oil may contribute to the measurable toxicity of oiled sediment samples. Used in conjunction with analytical data on the spatial distribution and chemical composition of petroleum residues in the environment, this information will be useful in assessing the potential biological impact of the spill.

Subtidal Study No. 5 - Spot Shrimp

<u>Comment</u>: There is an inconsistency between Objective D and Appendix D regarding whether the Trustees will attempt to make a determination of the oiling at study sites. (ESC)

<u>Response</u>: This apparent inconsistency is due to an unintentionally poor phrasing of Objective D. Hydrocarbon analysis of eggs and tissues could produce results anywhere in a continuous range from no contamination to a maximally heavy, quantifiable level. Thus there is potentially an infinite range of possible contamination levels in the tissue. The levels of oiling in the study area sites are considered to be either oiled or unoiled. Thus the sites have only two potential levels of oiling which are qualitative, not quantitative. This study therefore attempts to compare the quantitative levels of hydrocarbons in the tissues with the qualitative levels of oiling at the sites.

<u>Comment</u>: There are no methods given for documenting injury to tissues and comparing differences between oiled and unoiled sites. (ESC)

<u>Response</u>: Injury to tissue will be documented by necropsy and histopathology. The "Methods" section of this study plan notes that Chi-Square analysis will be used to compare differences. See Appendix B for histopathology procedures.

Comment: The Trustees should not use southwest PWS and northwest PWS as their oiled and control sites because of the differences between these two areas. (ESC)

Response: Data have been collected which allow comparisons of environmental conditions at each site. These data indicate that these sites are similar with regard to salinity, temperature, and dissolved oxygen content. There is no evidence to suggest that growth rates are different between sites. The selection of study sites was constrained both by the path the oil was known to have travelled and the distribution of the study animals.

Comment: There is no weight given to the fact that there was a marked decline in spot shrimp stocks prior to the spill in statistical areas 201-00 and 201-02, which cover three of the four oiled test sites. There is no information indicating that the Trustees have selected control sites that are similar to test sites in terms of baseline production of shrimp. (ESC)

Response: Declines in the spot shrimp stocks in these areas were due to over fishing and addressed via closures in 1988. Given the stock conditions, efforts to locate study sites in these areas focused on their ability to provide spot shrimp to the study. With no commercial effort since 1988 and if there were no oil spill effect, expectations would be for improvement in the stock's condition.

Comment: The study description does not consider seasonal migration of shrimp from shallow to deep water. Larval mobility into and out of potentially injured areas will not be documented in this study. (ESC)

Response: Seasonal migration of shrimp from shallow to deep water is not an issue because the field portion of this study takes place at the same time each year. Furthermore, with fishing depths of 20 to 120 fathoms, vertical migration should be bracketed within the sampling zone. Little is known of larval mobility within PWS.

Comment: The oiled test sites, Chenega Island, Herring Bay, Elrington Passage and Green Island, were affected by oil in varying degrees. The Trustees have provided insufficient information regarding the selection of control and impact sites and how the oiling at these sites will be documented. Appendix D indicates that sites are classified as oiled or unoiled based only on observations of surface oil. This will produce a quantification of injury based upon a spectrum of exposure levels in both time and space. (ESC)

Response: The shrimp study does not attempt to relate injury to particular quantitative levels of oiling but simply to the qualitative presence of oil. Oiling at study areas was documented via ADEC overflights as well as by ADF&G personnel. The EVOS was not a controlled laboratory experiment. Visual observations and knowledge of the stocks were the only means of making early decisions as to where and how sampling should take place. Testing tissues for hydrocarbons will provide one means of documenting the presence of oil in these areas. But the Trustees do plan to compile all oiling data bases and make these available to the study principal investigators.

Comment: Use of the commercial shrimp pots will not aid in the determination of whether the 1989 year class suffered a high mortality rate in heavily oiled areas relative to other year classes because the pots are designed to catch adult shrimp of marketable size. In 1991, the 1989 year class will still be juveniles and a statistically significant proportion of them will not be captured by the gear. (ESC)

Response: The gear used in this study is known to be able to capture both juveniles and shrimp of a non-marketable size. At 2.5 years of age, some of the 1989 year class should recruit to the fishing gear this year and give an indication of the class presence or absence. The survey to be conducted in the Fall of 1992 will further substantiate this.

Comment: Use of sampling pot strings of 11 pots per station is not random. Subsequent analysis of catch data seems to assume that all pots are independent. This has questionable validity. (ESC)

Response: Pot spacing was adjusted in 1990 to remove any effective overlap. Efforts will be made to determine whether the current interval accomplishes this.

Comment: There is no information given as to how EVOS hydrocarbons will be distinguished from other hydrocarbons in analysis of shrimp tissue and egg samples. Without environmental exposure data, the Trustees cannot document a pathway and causal link between EVOS and differences in abundance, size, distribution and fecundity. (ESC)

Response: See Technical Services Study Number 1 for further information on the analysis of hydrocarbon tissue samples. The Trustees will use a compilation of oiling data bases, including but not limited to those gathered in this study, to demonstrate environmental exposure.

Comment: By focusing on the 1989 year class, the Trustees have precluded documentation of pre-spill baseline conditions for pot shrimp captured by gear and therefore will not be able to distinguish spill effects from natural differences between the test areas. (ESC)

Response: The multiple age classes of spot shrimp captured in 1989 and 1990 will indicate pre-spill conditions such as recruitment and age structure.

Comment: Owing to the pre-spill bias between oiled and control areas which will influence the test results, this study really focuses on resource management and not injury assessment. It therefore is not compensable. (ESC)

Response: A stock subject to a high level of exploitation may be even more vulnerable than one exploited at a lower level. This study collects data not only on relative abundance but fecundity, growth and recruitment as well. With the possibility of a pre-spill bias, the spot shrimp stocks in oiled areas are more, not less, deserving of post-spill monitoring and study. Injuries which force resource management changes are certainly compensable.

Subtidal Study No. 6 - Rockfish and Shallow Reef Habitats

Comment: The use of otolith microstructure to evaluate depressed growth stemming from oil contamination is an experimental technique. (ESC)

Response: The need to evaluate depressed growth was indicated. The use of otolith microstructure to show environmental stress is a proven technique and was selected as the best means to meet this objective.

Comment: Sampling of reefs in shallow water biases the outcome because of the accessibility of these waters to divers. (ESC)

Response: The same sampling techniques are used at all sampling locations. This allows us to compare differences between sites and does not bias results. While the sampling depths are accessible to project divers, the sampling locations are essentially unexploited by sports divers because of the distances between the sites and area ports.

Comment: The Trustees cannot determine the presence or absence of EVOS hydrocarbons in demersal rockfish by analyzing bile. This is non-specific to hydrocarbon source and may be subject to interference by other compounds. (ESC)

Response: The hydrocarbon analysis may be non-specific; however, the presence of hydrocarbons in bile, in concert with other results, may lead to the conclusion of contamination by the EVOS.

Comment: Identification of EVOS hydrocarbons by tissue analysis is questionable because of the efficient, and perhaps selective, metabolic functions in fish as well as the possible occurrence of non-Evos hydrocarbons. (ESC)

Response: Other assays and observations will be used in association with the bile hydrocarbon results to establish damage due to the EVOS if it has occurred.

Comment: It is unclear how otolith descriptions will be interpreted, specifically otolith-derived age composition and mean length-at-age data. (ESC)

Response: Examination of age structures (otoliths) and comparison with length data are standard techniques commonly used in many fisheries studies. This enables the researcher to better define the population being examined and to observe changes in growth rates.

Comment: It does not appear that this study will be used in the quantification of injury to natural resources. The study objectives include documentation of exposure and identification of aspects of damage, but there is no indication that injury will be assessed beyond the testing of statistical significance of observed differences. (ESC)

Response: Results are intended to be qualitative, not quantitative. Although the sampling sites will not be representative of all depths due to the nature of the sampling techniques, there will not be a bias between oiled and unoiled sites.

Subtidal Study No. 7 - Measurement of Hydrocarbons & Metabolites

Comment: The discussion of the reduction in scope of Subtidal Study No. 7 raises questions about the previous year's findings and whether the likelihood of the deleted portions of the study to document injury stems from the study design. (NWF)

Response: The narrowing of focus of the 1991 study is aimed at continuing only those aspects which are most likely to assist in documentation of injury or damage.

Comment: The fish bile metabolite analysis methods provided in Subtidal Study No. 7 are not source-specific. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: This study ignores the apparent good health of fish populations in PWS and focuses on biochemical indicators that will not draw links to EVOS or to actual resource injury. (ESC)

Response: The potential long-term effects of oil exposure of fish populations are not known, therefore we are assessing such biological effects as reproductive impairment, as well as biochemical indicators. The biochemical indicators will be used to link long-term effects to exposure.

Comment: The techniques described in Objective B cannot distinguish between metabolites stemming from EVOS and non-EVOS hydrocarbons in the large and diverse area of study. Analysis of enzyme induction is subject to these same problems. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: The lack of baseline data in the literature for pathological incidence, mortality and fecundity for the species in the study area casts doubt on the validity of any input data used in a simulation model. (ESC)

Response: There is some literature on flathead sole and we have information on many species from reference areas.

Comment: Some of the species to be sampled and analyzed are highly mobile and exhibit low fidelity to the collection site. It is not explained how their geographic range can be accounted for in assessing the significance of apparent exposure. (ESC)

Response: The study will assess both the exposure to oil and the resulting biological effects on individual fishes using a number of chemical, biochemical and biological methods. Models will be tested which are based on results of analyses of individual fish and which, thus, are not site-dependent.

Comment: The analytical methods described are not specific to the source of hydrocarbons that may be metabolized. AHH activity in liver and measurement of cytochrome P-450IA1 are not specific to hydrocarbons. Thus, a causal link to EVOS cannot be established. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: The Trustees have not accounted for the variability of concentrations of metabolites in bile with recent feeding behavior of fish. (ESC)

Response: The bile results are corrected for protein content which does reduce variability. The bile method is a screening technique which detects exposure of fish to oil, it does not attempt to precisely quantitate the level of exposure and thus variability in actual levels of FACs due to feeding behavior or other factors is not as important as the ability to detect and document exposure.

Comment: The time lag inherent in detection of metabolites in bile and enzymatic activity in liver will frustrate any attempt to correlate exposure and effect. (ESC)

Response: The time lag is very short (several hours to a few days) between exposure to oil and appearance of metabolites in bile or changes in enzyme levels or activity.

Comment: Analysis of stomach contents and sediments for hydrocarbons is of questionable value in documenting exposure in more mobile species. (ESC)

Response: Measurement of hydrocarbons in sediments documents the contamination of a particular site. Analysis of stomach contents is important because diet is a potentially important route of exposure of fish to hydrocarbons. These analyses, along with the measurement of bile FAC, liver AHH, reproductive function and histolopathological effects in individual fish help document exposure and resultant biological effects of petroleum hydrocarbons.

Comment: The use of pollock and yellowfin sole to assess reproductive impairment is questionable because there is no evidence that these species represent the total finfish population or are the dominant species in that resource. (ESC)

Response: Pollock is a commercially important species that had shown evidence of oil exposure in the previous years analyses. Yellowfin sole is a species that matures during the time of sampling and is thus appropriate for studies of reproductive impairment. In addition, yellowfin sole is a benthic fish. Benthic fishes have tended to show evidence of continuing oil exposure more than fish like Dolly Varden, which are not bottom-feeding.

Comments on Technical Services Studies

Technical Services Study No. 1 - Hydrocarbon Analysis

Comment: TS1 (and Appendix A) still does not provide sufficient detail to evaluate the analytical methods or the adequacy of the numbers of samples analyzed. (ESC)

Response: Appendix A includes general information on standard operating procedures for collecting and handling samples for hydrocarbon analysis. The study plan for the 1991 studies includes more specific information on procedures to be used in the collection of study-specific samples.

Comment: There is insufficient detail for the reader to determine whether the analytical models for measuring hydrocarbons are capable of distinguishing between low levels of EVOS hydrocarbons and other natural and/or man-made sources. (ESC)

Response: The list of hydrocarbon compounds for which analyses are being conducted was carefully chosen to ensure that distinction could be made between EVOS hydrocarbons and other natural and/or man-made sources.

Comment: The description of the program for measuring hydrocarbon metabolites in bile lacks standards and reference materials. (ESC)

Response: Laboratories measuring bile metabolites commonly use naphthalene and phenanthrene standards. In addition, bile from a bile pool reference material (control material) are being analyzed.

Comment: The quality assurance plan for chemical analyses in TS1 and Appendix A indicates that intercalibration of data will occur after samples have been analyzed by a laboratory. This could result in the discarding of relevant data and ultimately a bias in results. All data should be reported with necessary qualifications rather than discarded. The Plan should be revised to make clear whether data that do not meet the Trustees' standards will be discarded or archived. (ESC)

Response: Laboratories analyzing samples for the EVOS Natural Resource Damage Assessment (NRDA) are required to analyze an accuracy based material within +/-15% of the value of each analyte or measurement parameter. If a laboratory failed to meet this standard, they were not allowed to analyze EVOS samples. Intercalibration exercises are used to insure that participating laboratories are maintaining proficiency in the analyses of the samples. If a laboratory fails to analyze a set of intercalibration samples correctly, data from that laboratory produced during the time period covered by the intercalibration samples are flagged. They are not destroyed.

Comment: The analytical methods of Objective A of TS1 cannot be evaluated because of the lack of detail in the Plan. The Trustees should include the full list of compounds that will be collected for alkane analysis. (ESC)

Response: The alkanes from C_{10} through C_{34} are currently being reported by each of the laboratories analyzing samples for the EVOS NRDA.

Comment: The Plan should include the detailed procedures used by field personnel in collecting samples, identifying and shipping them, and maintaining the chain of custody.

Response: The Plan gives the general procedures that must be followed to meet the standards. Each project is responsible for providing specific guidance for field personnel. Training was provided for principal investigators and field personnel to ensure that samples were taken correctly. Specific guidance is given on chain of custody and shipping of samples.

Comment: The proposed audits of field and laboratory procedures are inadequately detailed, and there is no mention of auditing sample analysis, biological observations, database input, chain-of-custody procedures or mapping. (ESC)

Response: The audits proposed meet applicable Federal standards, i.e., refer to the Toxic Substances Control Act, part 792, Good Laboratory Practices Standards.

Comment: It is not clear how the proposed method of labelling samples will produce a unique set of sample numbers. (ESC)

Response: A sample identification is given to each sample as it is received from the field. Therefore, the sample identification is unique to that sample.

Comment: Analytical techniques and biased sampling programs will make the production of a material balance on the fate of spilled oil virtually impossible. (ESC)

Response: The analytical techniques being used are adequate to characterize the oil and its fate. The methods used in constructing a material balance on the oil are well represented in the literature, for example, see Boehm, McKay, or Payne.

Technical Services Study No. 3 - Mapping

Comment: Proposed mapping efforts lack appropriate detail regarding the types of maps and analytical products for the reader to determine whether this study will aid in monitoring geographic distributions of data pertinent to assessing injury from EVOS. Nor is there mention of the types of databases to be developed or the organization of those databases. (ESC)

Response: Map types and analytical products are varied as required to support the range of NRDA studies. The geographic information system (GIS) is one of several tools used by investigators to assess injury from EVOS. The types of databases to be developed in the GIS are relational using geographic and other components. The organization of the databases is determined by the state-of-the-art computer operating systems, application, software, and client needs.

Comment: There is not sufficient information in the Plan regarding the quality control on data input to the mapping process to determine whether it will be adequate. (ESC)

Response: Data processing standards and procedures are implemented to ensure adequate quality control on data input.

Comment: No information is given in statistical treatments used to average data values for input to the mapping process. (ESC)

Response: Real data will be input to the mapping process. The source data will be used to verify database input and output, and inputted as appropriate.

Comment: It is not possible to determine from the information provided: (1) whether the mapping work will contribute to the objective quantification of injury to resources; or (2) whether "multi-thematic atlases of pre-spill data" exist on the scale needed for comparison with post-spill data; or (3) whether the mapping effort will be cost-effective. (ESC)

Response: (1) Technical Services #3 (TS3) mapping group provides support to NRDA studies. TS3 has been well utilized by investigators in their assessment studies. (2) Multi-thematic atlases of pre-spill data exist and are central to the objectives of TS3. (3) TS3 supports several NRDA studies and has been determined to be cost effective on a study by study basis. Also TS3 provides consolidated services for cost effectiveness. TS3 is designed to provide support to the entire NRDA process. It provides consolidated services to facilitate the management and presentation of information and avoid duplication of effort.

Technical Services No. 3 - Geographic Information System

Comment: Proposed mapping efforts lack appropriate detail regarding the types of maps and analytical products for the reader to determine whether this study will aid in monitoring geographic distributions of data pertinent to assessing injury from EVOS. Nor is there mention of the types of databases to be developed or the organization of those databases. (ESC)

<u>Response</u>: Map types and analytical products are litigation sensitive; however, accepted mapping science methods will be used, recognizing all data limitations. Development of databases will include a geographic component that will provide for commonality of data types.

<u>Comment</u>: There is not sufficient information in the Plan regarding the quality control on data input to the mapping process to determine whether it will be adequate. (ESC)

<u>Response</u>: Technical Services 3 adheres to accepted mapping methods using state-of-the-art technology that includes quality assurance steps that compare data input with source information and with subsequent iterations of database development.

<u>Comment</u>: No information is given on statistical treatments used to average data values for input to the mapping process. (ESC)

<u>Response</u>: Real data will be inputted to the mapping process. Source data will be used to verify database input and output.

<u>Comment</u>: It is not possible to determine from the information provided: (1) whether the mapping work will contribute to the objective quantification of injury to resources; or (2) whether "multi-thematic atlases of pre-spill data" exist of the scale needed for comparison with post-spill data; or (3) whether the mapping effort will be cost-effective. (ESC)

<u>Response</u>: Sufficient detail is given to allow assessment of whether this work will contribute to quantification of injury. Objective "multi-thematic" atlases of pre-spill data exist and are central to the objectives of this project. The work will be conducted in an efficient cost-effective manner.

Comments on Cultural Resources

Comment: Because cultural resources are not a natural resource within the meaning of the NRDA regulations, this study should not be funded by the NRDA process. (ESC, APSC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the CERCLA/Clean Water Act damage assessment process. While other statutes may address injuries to archaeological resources, they do not preclude activities undertaken pursuant to the CERCLA/Clean Water Act.

Comment: The information given in this study plan does not explain its objectives or methodologies sufficiently. (ESC)

Response: The objective of this study is clearly stated to be the assessment of injuries to archaeological resources as a result of the EVOS. The study methodology adopted is to use sample sites and statistically project injury estimates.

Comment: The survey work proposed to be undertaken in this study has already been accomplished as part of Exxon's clean-up efforts. Thus the survey and site selection portions of the cultural resources program are duplicative of existing information. (ESC)

Response: The principle purpose of EXXON's beach survey work was to identify sites for cleanup. Archaeological investigations of the sites were limited. However, the data gathered by Exxon in its cleanup effort contributed to the development of a list of archaeological resource sites that were injured, from which selected study sites were chosen.

Comment: It is not clear why investigations of sites in unoiled areas will be made. Potential site injury is a function of shoreline type, stratigraphy, location, degree of oiling, impacts from cleanup techniques, and the artifacts present. Given the unique nature of each site, the range of distribution and the diversity of time span, it is inappropriate for the Trustees to extrapolate control sites to oiled areas. (ESC)

Response: Archaeological sites are individually unique. As a result, the cost of investigating archaeological sites is high and the funds available to assess injuries are limited. Therefore, archaeological sites will be defined by site types and injuries will be determined from a statistically derived sample. In order to describe the population of sites most accurately and to give a basis for statistical treatment, a sample of study sites located in the general spill area was selected rather than biasing the study by only looking at oiled sites.

Comment: The cost associated with this study seems excessive given the small number of documented disturbances to cultural and archeological resources. (ESC)

Response: Archaeological investigations are labor intensive and involve complicated and expensive laboratory analyses. Tests necessary to identify the presence of oil are costly. Additionally, the geographic area of study is extremely remote. This factor causes very high logistical costs both for access and safety reasons. The use of a government contract to perform the study allows for a reduction in costs and the successful achievement of the goals of the study.

Comment: The study description does not indicate whether the methods employed will meet the standards and guidelines for archeology and historic preservation. (ESC)

Response: This study conforms to all appropriate standards and guidelines.

Comment: The Plan fails to provide adequate information to evaluate how the significance of historical properties, topologies, site investigations, interview impacts, soil characteristics, radiocarbon dating and erosion rates will be determined. (ESC)

Response: The significance of historic and prehistoric properties will be determined using processes outlined in existing Federal regulations. The issue of site significance was addressed under the Memorandum of Agreement signed by EXXON, Federal agencies, the State Historic Preservation Officer, and Native corporations. The validity of topologies, adequacy of site investigations, and effects of archaeological investigations will also be addressed following existing federal procedures and normal scientific archaeological standards. For example, the degradation of spill-affected historic properties may be compared with properties that have not suffered oil spill related injuries to arrive at rates of degradation.

Comment: Interviews of response workers and government employees may result in biased information. No description is given of the manner in which results of these interviews will be used to quantify injury. (ESC)

Response: Information received from interviews will be evaluated for bias and verified. One of the aims of the study is to document injury to sites both quantitatively and qualitatively. Once the types of injury are estimated, those injuries can be projected statistically to the total body of archaeological data in the study area.

Comments on Economic Studies - General

Comment: The reliability of using contingent valuation to measure alleged non-use losses is questionable. (API)

Response: The Federal Trustees believe that the contingent valuation method can provide an accurate estimate of the existence (non-use) value losses that occurred in this incident.

Comment: The 1991 economic studies bear no relevance to CWA standards for assessing damages based on restoration costs. As such, they do not serve their purpose: determining cost of restoration vs. value of the injured resource, or identifying most cost-effective restoration alternative. (ESC)

Response: The Clean Water Act does not establish restoration costs as the sole measure of recoverable natural resource damages. In addition to funds necessary to restore injured natural resources, the Trustees are entitled to recover interim lost use value. The economic studies are designed to measure that value.

Comment: The 1991 Plan still does not include state studies, contrary to the agreement between federal and state trustees announced on January 14, 1991. This is an indicator of lack of coordination and questionable quality of study methods. (ESC)

Response: The fact that the State and federal studies were not conducted jointly in no way suggest that the study methods were inadequate.

Comment: Insufficient description of study objectives and methodologies points to Trustee Council's lack of intention to elicit meaningful review and comments on those studies. (ESC)

Response: The descriptions of the economic studies are intended to provide the public with general information about studies that are planned or ongoing. The Trustees believe that the quantity of information provided is sufficient to serve that purpose.

Comment: Most of the 1991 studies assess alleged damages that are noncompensable under the laws and regulations governing natural resource damage assessment. (ESC)

Response: The Trustees disagree. The studies are designed to value natural resource damages that are recoverable under controlling law.

Comment: The 1991 studies include several cases of double counting of damages: non-use losses of natives in three separate studies; changes in property values which include separately measured use value effects; separate estimates of losses in sport fishing and charterboat operations; inclusion of duplicate non-use values.

(ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: The 1991 studies are defective due to the use of contingent valuation as methodology, the lack of integration with studies of injury determination and state studies, and the inclusion of unnecessary data collection. (ESC)

Response: The contingent valuation method is not defective; all economic damage studies are fully integrated with the injury studies, no unnecessary data will be collected for the natural resource damage assessment.

Comments on Economic Studies - Specific

Economics Study No. 1 - Commercial Fisheries

Comment: Economic Study No. 1 is really geared toward determining whether consumers perceive problems with seafood as a result of the spill, but how this will be determined is unclear and the multitude of factors that influence the seafood market and the existence of alternate seafood resources will make such a determination very complex. (API)

Response: The purpose of this plan is to provide public notice of the types of economic studies contemplated by the Federal Trustees. It is not intended to provide detailed descriptions of the specific methods being used owing to the litigation sensitive nature of the study.

Comment: If any losses were incurred by fishermen, processors, wholesalers, retailers, and consumers, such losses are private not public. (ESC)

Response: The Trustees agree that losses experienced by fishermen, processors, wholesalers and retailers are private. However, general losses to consumers through supply and price changes may be considered a public loss for which the Trustees may recover.

Comment: Any such losses are negligible. Salmon supply increased in 1989 and prices dropped due to factors unrelated to the spill. In fact, ADF&G has cited surplus salmon inventories in Tokyo, increased Japanese hatchery production of chum salmon, and increased international sales as reasons for commercial fishery losses. (ESC)

Response: The Trustees do not expect to claim any losses that were not caused by the oil spill.

Comment: From 1988 to 1989, salmon quantity increased in Alaska by 37% and worldwide by 23%. Specifically, Alaska's major markets are in fresh/frozen red salmon and canned pink salmon. Worldwide production of fresh/frozen red salmon increased 39% from 1988 to 1989 and that of canned pink salmon increased 100%. Thus, salmon production was not affected by the spill. (ESC)

Response: See above response.

Comment: Claims for any losses incurred by consumers would constitute double-counting of private claims already made by individuals, businesses, and classes. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There appears to be no relationship between ECON1 and the other fish injury assessment studies contained in the Plan. Some data regarding any commercial fisheries losses are available from state and federal sources, e.g., Savikko, Herman, and Tim Page, "1989 Preliminary Alaska Commercial Fisheries Harvests and Values". Therefore, more data collection is not necessary. (ESC)

Response: This damage study will use information provided through the injury studies where applicable. Furthermore, it will make use of any accurate data and information available through other sources, where appropriate.

Economics Study No. 4 - Public Land Value

Comment: Any reduction in land value is not compensable as a natural resource damage. Recourse for alleged damage should be through private claims. Public lands affected by oil are not identified. (ESC)

Response: The Trustees do not intend to present claims for property value decreases experienced by private landowners.

Comment: Spill effects are hard to assess by comparing pre-spill and post-spill prices. Other factors, such as interest rates, use restrictions, low population density, access problems, and severe weather influence land values. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages.

Comment: ECON4 will lead to double counting of damages because damages for some uses of public lands are covered by other studies. For example, the value of land directly reflects the services provided by the land, such as recreation, and ECON5 covers estimated recreational use damages. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure the estimates of natural resource damages do not include double-counting.

Comment: Hypothetical values are not compensable. For depressed values to be compensable, actual transactions must take place. Most of the allegedly affected area consists of state and federal lands and is rarely subject to sale. In addition, there is a vast supply of near substitutes for almost any parcel of land in Alaska. Thus, any compensable damages to land values will be very low. (ESC)

Response: Property values in the region affected by the EVOS may have been damaged regardless of whether the losses were actually realized through transactions. The concept of substitutes will be taken into account as appropriate in this study.

Comment: No accounting is provided for recovery in land value as a result of cleanup and restoration. (ESC)

Response: All damages to land values consistent with appropriate economic and legal theories will be estimated.

Economics Study No. 5 - Recreation

Comment: The Trustees should avoid underestimation of damages that could result from placing recreation users in a single category. Many kayakers also fish and camp and use charter boat services. The models do not clearly reflect this phenomenon. (NWF)

Response: The Federal Trustees will try to avoid underestimation of damages wherever possible. The fact that recreationists engage in multiple activities on a single trip will be taken into consideration in the estimation of damages.

Comment: The study aims to assess any damages to recreational users who had to choose substitutes or derived less enjoyment. The study ignores the fact that popular recreational resources such as the College Fjords and Columbia Glacier areas were unaffected by the spill. In addition, closure of commercial salmon fisheries resulted in increased escapement which most likely led to increased sport fishing. (ESC)

Response: All relevant facts will be taken into consideration for the estimation of recreation damages, including availability of substitute recreation sites and changes in sport fishing catch rates.

Comment: Contingent valuation is an unproven methodology for assessing losses incurred by sea kayakers. (ESC)

Response: The Federal Trustees believe that contingent valuation can be an appropriate method for estimating damages to sea kayakers under certain circumstances.

Comment: Any damages to commercial services, such as equipment rental businesses, charter boat services, tour boats and guides, should not be estimated. Compensation is available to public trustees only for foregone use of publicly owned natural resources. (ESC)

Response: The Trustees may recover for consumer surplus losses experienced by individuals that were prevented from enjoying natural resources because of the spill, even though their access would ordinarily be through commercial services.

Comment: Any recreational losses could be double counted, for example, recreational fishing and boat charters for sport fishing; sea kayaking and boat charters for kayak transportation. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: Much of the data sought in this study is available from other sources, i.e., cruise ship bookings, cruise line capacities, visitor rates, hotel occupancy rates, sport fishing catch rates, rail passengers. Thus, additional collection effort is not required. (ESC)

Response: The Federal Trustees will use the most cost effective sources they can identify to obtain data necessary for accurate estimation of economic damages.

Economics Study No. 6 - Subsistence

Comment: Economic Study No. 6 addresses losses incurred by private individuals and is therefore beyond the scope of the Trustees' authority to study damages. There must be a public use of the resource identified and a means for discounting private uses to avoid double-counting. (API)

Response: The subsistence study will measure a loss associated with the use of natural resources. The Trustees do not intend to double count losses.

Comment: Double counting of losses is likely, including claims by native groups. Any losses of non-use values by subsistence communities are also counted in ECON7 and ECON9. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There is still no discussion of the goods or amenities to be analyzed by either market or non-market methods. Contingent valuation should not be used as a method in this situation. (ESC)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose. Further, they believe that the contingent valuation method can be appropriate for estimating damages to subsistence households.

Comment: Mitigation efforts or income effects that offset losses are not considered. The oil spill resulted in increased employment opportunities provided by the cleanup. (ESC)

Response: The Federal Trustees will take into account all relevant factors appropriate for accurately measuring economic damages.

Economics Study No. 7 - Total Value of Natural Resources

Comment: It is not possible to tell from the description of Economic Study No. 7 whether it could permit double-counting from valuation estimates derived from other studies such as recreation uses. (API)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: This study aims to estimate the total value of natural resources affected by the spill by summing up the intrinsic and use values. The term "intrinsic value" covers existence value, option value, and bequest value. Intrinsic value should represent only inherent worth of natural objects, independent of any values held or imposed by man. No legal basis exists for damages based on intrinsic value as defined by the Trustees. (ESC)

Response: The Ohio decision and the DOI natural resource damage assessment regulations both authorize recovery for all components of the intrinsic value of natural resources.

Comment: Crude oil is naturally degradable. After bulk oil removal, natural resources will be fully restored within a short period. Thus, there cannot be losses of existence or bequest values for temporary injuries to natural resources. (ESC)

Response: Existence, bequest and option values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive period of time.

Comment: Option values represent the expected discounted value of future use. Future use is not expected to be adversely affected by the spill. Therefore, option value losses must be confined to temporary effects. (ESC)

Response: Existence, bequest and option values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive period of time.

Comment: Non-use value losses are permanent irreversible damage to unique resources. These cannot be applied to resources temporarily injured and for which there exist substitutes. (ESC)

Response: There may have been permanent and irreversible injury to natural resources affected by the EVOS.

Comment: Contingent valuation is an untested method of assessing damages. There has been no evidence presented that contingent valuation can be used to assess lost non-use values or the total values of injured resources, and there was no explanation given for changing the scope of this study to include the measurement of use values. (ESC)

Response: The Federal Trustees believe that the peer-reviewed literature and the opinions of known experts in the field are sufficient to establish the validity of the contingent valuation method for purpose of estimating certain natural resource damages in this case.

Comment: Use of willingness-to-pay measures should be applied in contingent valuation, rather than use of willingness-to-accept measures. (ESC)

Response: The Federal Trustees do not intend to discuss litigation sensitive information in this plan.

Comment: Estimating total value will result in double-counting. There is no description of the methods to compare estimates from other studies and to determine which is the most accurate assessment. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resources damages are not double-counted.

Comment: This study will use contingent valuation to estimate the total value of natural resource losses stemming from EVOS without distinguishing between use value and non-use value. Use value could be estimated through other means such as travel cost and hedonic pricing methods. (ESC)

Response: Direct use values can be estimated via a number of market and non-market based economic methodologies. Contingent valuation is an accurate method for estimating both direct use and indirect use (existence values) that may have been lost in this incident.

Comment: Using contingent valuation to estimate non-use value amounts to attempting to determine intrinsic value. Thus, if contingent valuation were used to determine use value and non-use value, then accuracy of study would be doubtful. (ESC)

Response: The Federal Trustees believe that the contingent valuation method is an accurate way to estimate both use and non-use (existence, option, etc.) values that may have occurred as a result of the EVOS.

Comment: Any damages are a fraction of the total value of natural resources. It is not clear how damages will be assessed from attempts to estimate total value. (ESC)

Response: The total value of the injury to natural resources as a result of the EVOS will be estimated.

Comment: Revision of ECON7 to estimate total value would result in double-counting the value estimated in ECON5 and other studies. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Economics Study No. 8 - Affected Research Programs

Comment: Losses to research programs are not appropriate subjects for damage assessment; they should be asserted by the private parties who were conducting them. Whether any of the programs would have culminated in useful information is speculative. (API)

Response: The Trustees may recover for losses to the public associated with decreased ability to gather scientific knowledge.

Comment: Researchers and research institutions are the proper parties to assert claims for any such losses. Losses of any reduction in knowledge available to mankind are hypothetical and noncompensable. (ESC)

Response: The Trustees believe that these losses are not hypothetical.

Comment: No credit is given to spill-related research which generated large increases in knowledge. (ESC)

Response: Trustees are not required to give "credit" for spill-related research knowledge gained as a result of combating the effects and measuring the damages of an oil spill.

Economics Study No. 9 - Archaeological Resources

Comment: Archaeological damages should not be included in the definition of natural resources. (ESC)

Response: The Trustees believe a valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly included in the natural resources damage assessment.

Comment: Losses will be double counted. For example, alleged loss of value of archaeological resources as tourist attractions is also counted in ECON5 and archeological science values are also included in ECON8. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There should be a method to divide "intrinsic" values held by native groups into subparts, e.g., existence values for archeological resources and existence values for cultural heritage, in order to avoid double or triple counting. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Economics Study No. 10 - Petroleum Products Price Impacts

Comment: Petroleum price increases are not caused by the injury to natural resources. There are many variables which affect the price of oil. (ESC)

Response: The Federal Trustees will take into consideration all relevant factors appropriate for accurately measuring economic damages.

Comment: Any economic effects on private individuals are secondary and indirect. Therefore, the proper claimants should be the consumers and/or distributors. (ESC)

<u>Response</u>: The Trustees may legally recover the losses experienced by consumers of petroleum products if price increases were caused by the oil spill.

<u>Comment</u>: The study that purports to measure the possible impact of EVOS on the price of petroleum products on the West Coast fails to describe a resource that has been injured. Thus the study is beyond the authority of the Trustees, especially given the Department of the Interior's position with respect to the scope of compensable value taken in its proposed revisions to the damage assessment regulations. (API)

<u>Response</u>: The Trustees are entitled to recover for losses to services that would have been provided by natural resources but for the oil spill. Transportation is one of those services that is provided by Prince William Sound. Closure of the Sound to tanker traffic for a period after the spill may have caused the gasoline price increase that occurred on the West Coast shortly after the spill. If the spill did cause the increase in prices, the Trustees may recover the associated consumer surplus losses.

<u>Comment</u>: Economic Study No. 10 cites no "natural resource" as its subject of study. Consequently, there is no legal authority for conducting this study. (API, APSC)

<u>Response</u>: See above response.

Comments on Restoration Planning

Comment: Because the principal means of restoring Prince William Sound is likely to be through natural recovery and some selected measures designed to foster this process, the Trustees' focus on finding statistical differences in resources that they may not be able to rehabilitate is inconsistent with the restoration intent of the damage assessment process. (API)

Response: A thorough examination of injury to natural resources from the spill is necessary to determine whether the rate of natural recovery to pre-spill condition, if indeed natural recovery will occur, is acceptable. If it is determined that natural recovery will not be acceptable, other restoration alternatives will be considered. In any case, complete examination and understanding of the effects of the spill on natural resources will enable more informed decision-making for restoration. Statistical analysis is an essential component to scientific investigation and will continue to be a part of all scientific studies conducted by the Trustees.

Comment: The Trustees have not focused on the need for restoration and cost-effective means for achieving it. The acquisition of land should be a choice of last resort. (API)

Response: The Trustees have proposed that only projects that are directly linked to injured natural resources and are necessary to restore these resources are implemented in 1991. Cost-effectiveness is one of several criteria the Trustees are employing in evaluating potential restoration alternatives. If other restoration measures will restore the injured natural resources and services they provided to their pre-spill conditions more effectively and less expensively than through acquisitions, the Trustees may choose those other measures as the alternative, provided that other evaluation criteria do not contradict this decision.

Comment: The Draft Restoration Work Plan lacks information necessary for the public to understand and evaluate the proposed restoration activities. This includes sound technical and scientific information concerning the nature and extent of injuries to the natural resources; an estimate of the amount of the resources that have been impacted or the service level reduction; a description of alternative restoration measures, including natural recovery; and the cost-effectiveness and time associated with each restoration project. This information is crucial to determining whether the proposed restoration measures are reasonable and necessary, regardless of whether the Trustees follow the DOI regulations. The Plan's lack of information concerning the nature and extent of injuries uncovered as a result of the trustees' studies impedes the public's ability to comment or suggest restoration alternatives. (ESC, NWF, API, ESC)

Response: The Trustees believe there is sufficient information to proceed with a limited and modest restoration program in 1991. The majority of the 1991 science studies address information necessary to assess restoration alternatives and to develop restoration projects. Cost-effectiveness is a consideration in determining projects to be implemented in 1991. Detailed restoration study work plans are available to the public.

Comment: Information regarding the extent of the results obtained to date from the studies that were the subject of the 1990 technical support project #3, the status of further study proposals and time frames for future activities is very sketchy. (NWF)

Response: A summary of the effects of the oil spill on natural resources was filed with the Federal District Court in Alaska and made available to the public on April 8, 1991. Until there is a judicially approved settlement or the litigation process concludes, the Trustees have determined that litigation sensitive material will not be released if it might compromise the Trustees' ability to pursue their natural resources damage claims.

Comment: The Draft Work Plan does not assess the cost-effectiveness of a range of restoration options, only the option proposed for implementation. It also fails to take into account a cost-benefit analysis of the proposed restoration measures. The Trustees should not simply consider the cost-effectiveness of restoration alternatives, but they should choose the most cost-effective alternative. (API, ESC)

Response: Cost-effectiveness is a consideration in determining projects to be implemented in 1991 and is one of several factors the Trustees are employing in evaluating potential restoration alternatives. It would be inappropriate to select restoration alternatives based only on cost-effectiveness without regard to ecological and other factors.

Comment: One of the goals of the Draft Work Plan is to "identify life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced." This appears to go beyond the identification of cost-effective restoration measures that would return injured resources to conditions that would have existed but for the spill. (API, ESC)

Response: Life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced are critical components which need to be understood in the development of any restoration plan. Without this information it is impossible to determine if an activity will be effective in restoring a resource. Focusing only on the mechanism of injury may not be as effective or successful for restoration as dealing with other limiting factors. As stated above, cost-effectiveness is one of several criteria the Trustees are employing in evaluating potential restoration alternatives.

Comment: The Trustees' 1990 restoration feasibility studies and those proposed for 1991 appear to be simply basic scientific research projects rather than necessary restoration work. It is premature and inappropriate to undertake these studies prior to documenting injuries. The Trustees should limit their restoration planning activities to those necessary to restore injured resources to conditions that would exist but for the spill. (API, ESC)

Response: Although the quantification of injury to some resources is still being conducted, the Trustees believe there is sufficient information to proceed with a limited and modest restoration program in 1991. Waiting for a complete documentation of all injuries before proceeding with feasibility studies would unnecessarily delay the start of restoration.

Comment: The proposed Protection of Strategic Fish and Wildlife Habitats and Recreation Sites project aims to protect resources not impacted by the spill since it appears to cover non-spill territory. The Plan does not explain why such acquisitions represent the best means of restoring affected resources. This may not be cost-effective compared to other options. This method of protecting these resources may enhance the recovery of injured resources, but land acquisition should be employed as a restoration measure only if it is the sole viable alternative. The Trustees should consider other restoration alternatives in lieu of this project, including natural recovery, the enforcement of Alaska Statute 41.17.010 - 41.17.950 to prevent harvesting of timber in those areas where protection is required, and more direct restoration measures. (API, ESC)

Response: There is an ecological link between the marine and intertidal habitats injured by the oil spill and adjacent uplands. For injured species that use the uplands as well as marine habitats, protecting the upland habitats may facilitate their recovery. Restoring injured resources within the oil spill area is the preferred alternative of the Trustees. If that is not feasible or sufficient, resources in other areas will be considered for replacement restoration.

Comment: There is no justification in the Draft Work Plan for choosing as the preferred restoration alternatives those activities that are proposed. (API)

Response: The Trustees are proposing to conduct restoration activities in 1991 that are linked to injured resources and have a demonstrated ability to restore or improve the habitat for the selected species.

Comment: The areas of injured rye grass communities should be identified and there should be a discussion of the results expected from natural recovery vis-a-vis transplanting and fertilization. (API, ESC)

Response: This project was dropped from the 1991 program after the spring shoreline assessments failed to identify sites requiring rye grass restoration.

Comment: The Public Information and Education project should be limited to the distribution of information apprising the public of ways to avoid disturbing injured resources. (API, ESC)

Response: Though a variety of media may be used in this project, the main focus is on reducing human impacts to injured resources. Materials will be directed toward specific "user" groups.

Comment: The Salmonid Stock and Habitat Restoration project, and in particular its construction of fish ladders and spawning channels to overcome hydrological barriers, goes beyond restoring the injured resource to its pre-spill condition. It appears to modify pre-existing ecosystem conditions rather than to redress a demonstrable spill induced injury. These measures also are out of character with the wilderness quality of the area for which they are proposed. Given no demonstrated injury to the salmon resource, it is debatable whether this restoration project is even necessary. (API, ESC)

Response: The Summary of Effects of Exxon Valdez Oil Spill in Natural Resources, filed with the U.S. District Court, District of Alaska on April 8, 1991, describes the injury to salmonid stock. The activities proposed in this project work toward restoring species injured by the oil spill. In some cases this will involve enhancing fish populations in streams not injured by the oil spill as a replacement for injured populations. Neither fish habitat enhancement projects, nor other restoration activities will be conducted where they conflict with existing land management direction.

Comment: In order for the public to be able to assess the propriety and cost-effectiveness of the restoration activities, the Final Plan should include: a description of the natural resource sought to be restored; its baseline; the injury it has suffered, including the pathway and the amount of the resource impacted; the locations of the injured resources; an estimate of the foregone benefit or service level reduction caused by the injury and the valuation thereof; an explanation of the manner in which the proposed project will act to restore the injured resource and the amount of time needed to achieve complete restoration; a listing of alternative restoration measures and estimate of time for each to achieve its purpose; and a cost-effectiveness analysis of the restoration alternatives. (ESC)

Response: A final restoration plan will be developed when funds are received from the responsible parties. The final plan may contain the information identified.

Comment: The Trustees should not simply consider the cost-effectiveness of restoration alternatives, but they should choose the most cost-effective alternative. (ESC)

Response: Cost effectiveness is one of many factors the Trustees will use in evaluating restoration alternatives. It is not anticipated that restoration options analysis will use only one of these factors.

Comment: There is no budget outlined in the Plan for restoration implementation projects or any other indication of how these projects will be funded. (NRDC)

Response: Until responsible parties supply resources for restoration projects, funds will be provided by the sponsoring agencies. A projected budget for the implementation projects was published in the March 1, 1991 Federal Register (56 FR 8898) identifying restoration projects.

Comment: The Clean Water Act permits recovery for only those damages stemming from the costs actually incurred in restoration or replacement of damaged natural resources. The Trustees cannot recover lost use and non-use values. (APSC)

Response: In Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989), the court indicated that lost use values may serve as a measure of damages under Section 311 of the Clean Water Act.

Comment: The 1991 plan disregards the restoration implementation project designed to protect strategic fish and wildlife habitats and recreation sites. Acquisition and protection of critical habitats demands immediate action so that restoration options are not foreclosed. (NWF)

Response: The 1991 plan includes an acquisition program as identified in the March 1, 1991 Federal Register (56 FR 8898).

Comment: Objective D's reference to "support of the overall natural resource damage assessment process" is unclear. (NWF)

Response: The ultimate objective of the natural resource damage assessment process is to restore the resources injured by the oil spill. Identifying the costs associated with implementing restoration actions is one aspect of that overall process.

Comment: The descriptions of the results of field studies to date are too cursory to be of use in evaluating the feasibility of individual restoration techniques. (NWF)

Response: The information on the field studies has been provided to give the public an understanding of the kinds of restoration projects the Trustees may pursue. The release of further information regarding the studies may compromise the Trustees' ability to recover damages for injuries to natural resources. (See Response No. 3)

Comment: The 1991 Plan states that "restoration approaches" will be "further evaluated' and that "further implementation activities may be recommended." These remarks are puzzling since no Restoration implementation activities had been undertaken at the time of the Plan's publication. (NWF)

Response: Four restoration implementation projects were identified in the March 1, 1991 Federal Register (56 FR 8898). Portions of the implementation projects, except the beach wild rye grass rehabilitation project, are being implemented this year.

Comment: It is unclear from the 1991 Plan's reference to the August 1990 Progress Report what the Trustees are doing to assess the feasibility of the other restoration options suggested in the matrices of that report. (NWF)

Response: The Trustees are continuing to evaluate all reasonable restoration options, including those identified in the August 1991 Progress Report.

Comment: It is not clear why monitoring should not be implemented prior to resolution of the damage claims. (NWF)

Response: The Trustees are implementing several monitoring studies in 1991, including concentrations of hydrocarbons in mussels and sediments, harbor seals, killer whales, sea otters, harlequin ducks, black oystercatcher, pink salmon and coastal (intertidal) habitats.

Comment: The budgetary information included in the 1991 Plan is puzzling. It is not clear what "restoration science studies" are referred to or how they could cost $4 million since some of them are only being considered in 1991. And the Trustees' statement on page 280 that implementation projects are being considered in 1991 contradicts the fact that no funds are allocated for implementation projects. (NWF)

Response: The restoration planning work group estimated the restoration science studies would cost $3.875 million in 1991. Since that time the cost figures have been revised based on completed study plans. The availability of those study plans was published in the Federal Register on July 31, 1991. The Trustees have made some funds available to conduct direct restoration projects in 1991.

Comment: The scope of the restoration feasibility studies conducted thus far is too narrow. For example, Objective D of F/S 13 is to identify potential alternative methods and strategies for restoration, lost use, populations, or habitat where injury is identified. Yet restoration or acquisition of equivalent resources is required for all injured resources, so this study should not be singled out. (NWF)

Response: The ultimate goal of all damage assessment studies is restoration of injured resources. Not all NRDA studies have reached the stage where development of restoration options is possible. As information concerning injury becomes available the restoration plan will include an evaluation of restoration options for all injured resources to determine the best way to restore them to their baseline level.

Comment: The Trustees should not prioritize restoration needs based on an assumption that restoration funds will not meet those needs because the potentially responsible parties are responsible for the entire liability. Restoration needs must be determined on the basis of damage assessment and economic studies. (NWF)

Response: Until the responsible parties provide funds to restore the injured resources, the Trustees will prioritize restoration needs based on resource injury, information needs, and the availability of funds.

COMMENTS AND RESPONSES CONCERNING THE DRAFT 1991 RESTORATION WORK PLAN

The Trustees received 20 comments on the March 1, 1991 Federal Register notice requesting comments on the draft 1991 Restoration Work Plan. Comments were received from industry, environmental, native and archaeological groups and individuals. This section provides a synthesis of the comments and their respective responses. Comments and responses are organized into two categories, general comments on the 1991 Restoration Work Plan and comments on specific restoration projects.

General Comments on the Work Plan

Comment: No NRDA studies are available to the public so that alternative activities or measures could be suggested.

Response: A summary of the 1991 NRDA studies is provided in the 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill published April 1991. Additionally, a summary of the effects of the oil spill on natural resources was lodged with the Federal District Court and made available to the public on April 8, 1991.

Comment: Due to lack of data, we cannot understand what has happened or make informed and pertinent comments. Without information on technical and science studies it is impossible to determine if proposed activities are necessary, reasonable, or cost effective.

Response: A summary of the effects of the oil spill on natural resources was lodged with the Federal District Court and made available to the public on April 8, 1991. Detailed study plans and work plans for 1991 science studies and implementation projects were made available to the public on July 31, 1991 (56 Fed. Reg 36150).

Comment: Due to the lack of data available to the public it is, in many cases, impossible to advise the Trustees regarding the optimum restoration approaches. This is a violation of the legal requirements to provide opportunity for public participation in the restoration planning process pursuant to the Administrative Procedures Act, the National Environmental Policy Act, and the Clean Water Act.

Response: The Trustees recognize that due to remaining litigation concerns, the release of natural resource injury data has been restrained. However, as noted in the previous response, a significant amount of information regarding injury has been released to the public. The Trustees recognized the need for meaningful public participation in the restoration planning process in the Memorandum of Agreement between the State and Federal government and intend to comply with all applicable laws.

Comment: Requests for comments must be made early enough so that comments can meaningfully affect the design and conduct of studies. The delay in release of the Draft 1991 Restoration Plan cripples public efforts to comment on the Work Plan and the Trustees' efforts to carry out critical restoration duties.

Response: The Draft 1991 Restoration Work Plan was released to the public with sufficient time to provide meaningful comment on the overall scope of the program. To the extent possible, the Trustees have incorporated public comments into development of the work plan. The Trustees continue to strive toward providing sufficient time for public review so that substantive comments may be incorporated into the design and conduct of the proposed projects and studies.

Comment: Technical workshops discussed in Federal Register notice must be open to scientists and public representatives.

Response: The technical workshops discussed in the Federal Register notice reviewed information from the damage assessment process that is litigation sensitive and therefore the workshops could not be open to the public. However, these workshops were attended by several "outside" experts, competent in the disciplines being discussed. This peer review assured scientific review of any proposed projects.

Comment: Release more data in light of pending settlement.

Response: Additional information on the nature and extent of the effects of the oil spill on natural resources has been made available. Until all litigation concerns are resolved, the Trustees must proceed under the assumption that litigation sensitive material should not be released.

Comment: The draft plan lacks documentation of extent of injuries or cost effectiveness of proposed alternative restoration measures.

Response: Though the full extent of the injuries to natural resources is still being assessed under the Natural Resources Damage Assessment, there is sufficient information to proceed with certain restoration measures in 1991. The detailed study and work plans provide additional information on the costs of the proposed projects.

Comment: Cost of a project can only be chargeable to the potentially responsible party under the NRDA framework if the project constitutes necessary restoration work.

Response: The Trustees have approved only those projects that are directly linked to injured resources and are necessary to restoring the resources.

Comment: The DOI regulations require complete description of the nature and extent of injury, estimate of the amount of resource which has been impacted or service level reduction, valuation of the loss attributable to the injury, description of alternative restoration measures, including natural recovery, and costs and time associated with each restoration alternative.

Response: The DOI regulations are discretionary and the Trustees believe it is inappropriate to disclose fully the value or extent of injury at this time. Alternative restoration measures were evaluated before selecting any restoration activity.

Comment: The DOI regulations require selection of the cost-effective restoration alternative.

Response: Though the Trustees are not required to follow the DOI regulations, cost-effectiveness was a consideration in determining projects to be implemented in 1991.

Comment: DOI regulations provide the standards under which proposed restoration activities must be evaluated. Regulations require that the work plan be judged by its ability to identify the necessity for, and reasonable costs of, restoration of injured resources. The final plan must follow procedures in 43 CFR 11.81 and 11.82. To comply with the DOI regulations and to allow for meaningful review, the final plan must provide specific information.

Response: As stated above for the implementation projects, the Trustees are not required to follow the NRDA regulations. However, the Trustees believe that the selection process for the implementation projects is broadly consistent with the NRDA regulations.

Comment: The restoration studies have been or are being undertaken before there has been any determination or quantification of injury to the resource in question. It is premature to conduct restoration feasibility studies before the injury is first quantified and understood.

Response: Though the formal quantification of injury to some resources is still being conducted, the studies proposed under the restoration program in 1991 have been reviewed to ensure linkage to the effects of the oil spill. Feasibility studies serve to determine the effectiveness of a restoration method that may be applied later.

Comment: What is the relationship between the restoration process described in this notice and the organizational structure and process to be employed under the Memorandum of Agreement governing the use of the settlement money? How will the settlement affect EPA's role in the restoration planning process?

<u>Response</u>: The organizational structure that will implement any settlement has not been developed. Until an organizational structure is agreed to by the Trustees it is premature to speculate on the relationship.

<u>Comment</u>: The prospect that the settlement may provide money to finance restoration activities should not short-circuit or distort the essential program of scientific studies of the on-going damage to the Prince William Sound caused by the oil spill.

<u>Response</u>: Though restoration is the ultimate goal of the NRDA process, the identification and quantification of injury will proceed to a logical conclusion. Continuing to monitor injuries may be an appropriate component of a restoration program.

<u>Comment</u>: More money is required for needed restoration. The proposed settlement may sound like it provides a lot of money for Prince William Sound, as much as $1.1 billion, and the terms specifying uses for the money appear to limit the spending to needed restoration projects. However, after closer review a very different picture emerges.

<u>Response</u>: The 1991 Restoration Work Plan has been developed separately from any proposed settlement and work on it will continue. Trustee agencies funded the restoration activities proposed in the work plan.

<u>Comment</u>: We generally support the criteria for evaluating restoration alternatives. However, we urge that those criteria be amended to provide that when acquisitions are an alternative they be subjected to an additional criterion such as, "the degree to which the acquisition addresses conservation of lands that are important for a multiple set of habitat and use and nonuse values, where those habitats or values face a clearly identifiable near or long term risk."

<u>Response</u>: Not all of the criteria for identifying habitats appropriate and suitable for acquisition have been developed. If areas meet the initial evaluation factors for restoration, additional criteria will be applied to identify and prioritize suitable sites. The suggested criterion will be evaluated for inclusion into the selection process.

<u>Comment</u>: We believe that the restoration planning process should not just consider the cost effectiveness of the restoration alternative but require selection, as do the DOI regulations, of the cost-effective alternative. Furthermore, the reasonableness of the cost of a restoration project must be evaluated through a cost-

benefit analysis.

Response: Cost-effectiveness is one of seven factors the Trustees will employ in evaluating potential restoration alternatives. A cost benefit analysis has been conducted on restoration implementation projects proposed for 1991 that involve market resources.

Comment: The Draft Plan states that a "key goal of the restoration planning activities is to identify life history requirements, limiting factors, and environmental processes that are especially sensitive or that may be enhanced." These goals seem to go beyond identifying cost-effective restoration measures which will return the injured resources to their baseline.

Response: Life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced are critical components which need to be understood in the development of a restoration plan. Without this information it is difficult to determine if an activity may be effective in restoring injured resources.

Comment: We are concerned about use of the sixth criterion for evaluating restoration projects, i.e. the "reasonableness of cost of the restoration project in light of the value or ecological significance of the resource." Comparing restoration costs with benefits is difficult, and not authorized under the recent Ohio decision, which required restoration costs to be recovered unless they were "grossly disproportionate" to the value of the resource lost.

Response: The wording of the sixth criterion is not inconsistent with the Ohio decision. The Trustees intent is to provide some reasonable measure of the cost of restoration options relative to resource values that would help determine if a restoration option is grossly disproportionate to the value of the resource lost.

Comment: The restoration planning process proposed in the Draft Work Plan fails to require selection of the cost-effective restoration alternative and limit restoration projects to measures required to restore the injured resources to the conditions which would exist absent a spill.

Response: Section II.A.1. of the March 1, 1991 Federal Register notice identifies cost effectiveness as one of the factors the Trustees intend to use in evaluating potential restoration alternatives. The intent of the restoration plan, and any alternative restoration options chosen, is to return the injured resources to their baseline condition.

Comment: Though a project may be desirable from the viewpoint of environmental conservation or protection, the cost of a project can only be chargeable to the potentially responsible party under the NRDA framework if the project constitutes necessary restoration work.

Response: The Trustees will only implement projects considered to be restoration work necessary to return the injured resources toward their baseline condition.

Comment: Alaska Trustees want to dismantle the science program. According to recent press reports, the Alaska trustees are seeking to end the damage assessment and restoration studies so that more funds will be available to pay for restoration implementation. The science program must guide restoration planning. It is impossible to restore the ecosystem unless there is knowledge about the nature and extent of injuries.

Response: The Trustees intend to continue the damage assessment studies until they are satisfied the extent and nature of injury is fully documented and understood. Their overall objective is to restore the injured resources and toward that end will continue to emphasize attaining the information necessary to achieve restoration as the damage assessment portion of the process winds down.

Comment: Additional projects that would benefit the Chugach Region should be looked at for funding out of the restoration process include a shellfish mariculture test program in Tatitlek, Chenega Bay and Eyak; the English Bay sockeye salmon enhancement project; the Port Graham pink salmon hatchery and a small fish hatchery located in the Seward Lagoon.

Response: These projects, in addition to other projects proposed by Trustee Agencies or members of the public, will be evaluated as part of a continuing restoration program, provided that injuries are documented.

Comment: I would like to propose that the restoration program fund an $80,000 investigation of third and fourth year recovery of beach and intertidal ecosystems at Green Island RNA.

Response: See response above.

Comment: Remove introduced predators (foxes, rats, etc.) from islands where they have severely reduced or destroyed seabird colonies would be a good form of mitigation.

Response: This proposal will be evaluated as part of a continued restoration program. See response above.

Comment: I suggest that you consider measures that would restrict visitation around certain seabird colonies where reproductive rates have not returned to normal by 1990.

Response: The Public Information and Education project identified in section III B of the Federal Register notice works toward encouraging voluntary compliance with this proposal. The Trustees will evaluate the need for additional management measures to restrict human interference as part of a continuing restoration program.

Comment: I suggest that the work plan describe measures to restore murre populations. I am particularly interested in your decision to fund feasibility studies for restoration on murrelets and harlequins, but not on murres. Your work plan should clearly identify the process you used to fund certain feasibility studies, but not others.

Response: Alternative restoration measures for murres have not been fully identified or evaluated. Restoration measures identified for 1991 are those where sufficient information is available to determine whether restoration projects or science studies are appropriate. In 1991 murres will continue to be studied as part of the damage assessment program.

Comment: We urge the Trustees to devote their energies to developing restoration and acquisition programs to address the significant injuries to sea and river otters, harbor seals, sea lions, murres, intertidal and subtidal habitats.

Response: These species are the subject of continued damage assessment studies or restoration science studies. The end point for these studies is the identification of restoration options. The sea lion damage assessment study for 1991 is funded only for the completion of data analysis and final report preparation.

Comment: The Bird Treatment and Learning Center has recently established a trust fund and is eligible and well qualified to receive funds to accomplish, as appropriate, objectives of the Exxon Oil Spill settlement.

Response: Contracting with organizations or individuals outside of Trustee Agencies may be an appropriate method of achieving restoration objectives and will be considered as part of an ongoing restoration program.

Comment: There were projects started by many villages during the year 1989 and because of the spill were not able to either continue these projects or apply for continued funding. I would like to see those projects completed and funding made available to apply for and finish incomplete projects such as community halls, youth shelters, etc.

Response: Restoration funds can only be used to restore injured natural resources or their services.

Comment: We have several product lines that should be considered in the Valdez cleanup project. All of our chemical products are nonflammable, biodegradable, nonfuming, noncorrosive, noncaustic, and contain no hazardous products.

Response: These chemicals appear to be more appropriate for the response activities than for restoration. Though the Trustees do not foresee the need for further cleanup as part of the restoration process, should there be need for these types of chemicals, they would be evaluated by the appropriate response personnel.

Comment: I believe that it is important and would be very useful to restoration goals to initiate a much more comprehensive and explicitly integrated long-term monitoring program on the condition (health) of the interacting marine, intertidal, and shoreline resources of Prince William Sound and southcoastal Alaska.

Response: A comprehensive long-term monitoring program may be developed as part of a final restoration plan.

Comment: I strongly encourage immediate implementation of as broad a range of monitoring studies as possible. As soon as possible, all pertinent data must be shared throughout the scientific community.

Response: Monitoring activities are proposed as part of the 1991 science program. A comprehensive monitoring program also may be developed as part of a final restoration plan. Data will only be released if they do not jeopardize the Trustees' ability to pursue damage claims in a judicial forum.

Comment: We urge the Trustees to limit consideration of natural recovery as one of the routine factors used to determine restoration options. Any use of natural recovery in analyzing restoration alternatives should place a heavy emphasis on the burden of proving, through strong scientific evidence, that natural recovery would occur subsequent to the spill. Uncertainties about future recovery of the ecosystem should be resolved in favor of active restoration programs.

Response: Natural recovery will be analyzed in the same context as any other restoration option and the rate of natural recovery will be considered in making decisions regarding restoration alternatives and priorities.

Comment: It would be beneficial to see continued subsistence foods testing and monitoring, restoration of natural resources like fish, clams, mussels, sea urchins, herring roe, and/or enhancement of these and other natural resources.

Response: Food testing of subsistence resources is continuing during 1991 as part of the Oil Spill Health Task Force program. In addition, monitoring studies have been initiated for other resources used for subsistence purposes to determine their recovery. As restoration options for these resources are identified they will be evaluated as part of a continuing restoration program.

Comment: At the present time, there is no emphasis being placed on the dependence of communities on damaged subsistence resources. When determining priorities for project sites to be funded, consideration should be given to he proximity of such projects to communities where there are subsistence uses.

Response: Resource uses, such as for subsistence harvest, will be a consideration in determining which restoration projects will be included in a final restoration plan.

Comment: There is a need for continuing testing of subsistence foods and an information program to disseminate the information. Data on the toxicity of subsistence foods as well as the long term health risks associated with consumption of contaminated foods is necessary.

Response: The Oil Spill Health Task Force program is conducting studies on the toxicity of subsistence foods and disseminating the information.

Comment: The draft 1991 Restoration Plan indicates that no restoration feasibility studies on cultural resources were conducted during 1990. Nor does the draft plan identify cultural resources as part of the restoration study plans contemplated for 1991. It is important that future restoration plans include appropriate restoration planning activities for cultural resources.

Response: Impacts to cultural resources are being studied under the current damage assessment process. As information on the extent and nature of injury to cultural resources becomes available, restoration options will be evaluated.

Comment: Restoration planning activities that should be considered to restore cultural resources damaged by the oil spill include studies focusing on the feasibility of techniques for removing oil from contaminated organic materials to permit radiocarbon dating, stabilization of sites damaged from erosion or pedestrian traffic, enhanced public education or law enforcement and continued inventory of areas for cultural sites.

Response: The Trustees will consider these suggested activities once the nature and extent of damages to cultural resources is known.

Comment: Removal and relocation of some cultural artifacts with appropriate documentation may be necessary on some sites. These activities must be coordinated closely with the Alaska State Historic Preservation Officer, Alaska Native Corporations and the appropriate land managers.

Response: The Alaska State Historic Preservation Officer and land managers will be involved in any activities that may affect cultural resources. Whenever appropriate, Alaska Native Corporations and appropriate land managers will also be consulted.

Comment: We remain concerned about the lack of assessment and restoration of cultural/archeological resources and compliance with Federal Historic Preservation Laws. We urge the funding of planning and projects to include these natural resources.

Response: A major archeological resource study is being conducted this year under the damage assessment process. Restoration options for cultural and archeological resources will be evaluated and carried out as funds become available.

Comment: The Restoration Plan sometimes includes and sometimes erroneously excludes the value of services provided by natural resources. Section IIA.1.a. should be rewritten as "the nature and extent of natural resources and services injured, lost or destroyed. "Services" should be incorporated into the objective and identification of areas to be protected in Restoration Project No. 4.

Response: The Trustees agree that the services provided by a natural resource are a component of their value.

Comment: We support the approach in the plan that restoration activities should benefit "multiple rather than single species or resources", but suggest that this be reworded as "multiple species, resources, and services, rather than single species, resources or services."

Response: The Trustees intend to take an ecosystem approach to restoring the oil spill area and select projects that benefit multiple resources and their services whenever possible.

Comment: Overall the plan seems to be very heavily directed toward office activities. The bulk of the 1991 plan is the Planning Process (II A), Restoration Feasibility Studies (II B), Technical Support Projects (II C), and Restoration Planning Activities (III A) which are all similar in the exclusive inclusion of state and federal personnel and their assessment and analysis of information that has not been made public.

Response: The majority of the 1990 and 1991 Restoration Feasibility Studies, Technical Support Studies and Restoration Implementation Activities are field projects.

Comment: In section III A there is a reference to "applying knowledge or toxicological effects derived from the oil spill literature." Is that the published literature, unpublished literature or both?

Response: Both the published literature and unpublished literature will be reviewed in determining restoration options.

Comment: The restoration work plan does not identify where restoration would occur. You should not be swayed into placing all resources in Prince William Sound. Although the area was hard hit, much if not most of the wildlife damage occurred beyond Prince William Sound. You should recognize that most of the seabirds were killed along the Kenai Peninsula and Kodiak Island. I suggest that restoration efforts for seabirds be focused on areas outside Prince William Sound.

Response: The entire oil spill area is being evaluated in determining restoration options.

Comment: Major parts of the proposed restoration projects appear to be directed toward habitats not affected by the spill.

Response: The Trustees disagree. The 1991 restoration program was developed with a direct link between injured resources and proposed restoration activities.

Comment: It appears that the Trustees failed to analyze what measure of restoration is necessary; instead they are tailoring the restoration program to the small amount of funds projected to become available in the short term from the settlement. Instead of attempting to decide the extent of restoration and acquisition that is possible with the funds recovered through settlement, the Trustees are under an obligation to determine the costs of restoration, replacement, and acquisition necessary to return the ecosystem to full productivity and diversity, plus the lost value of the resources. Then, the next step is to ensure that funds are sought to fulfill these obligations.

Response: It is not possible, based on present information, to develop a comprehensive restoration program. In addition, until funds are provided by the responsible parties the Trustees are carrying out the restoration program with agency funds. The normal budgeting appropriation process determines the amount of funds available in any year. The restoration planning process will continue to identify a suite of restoration options, and associated costs, necessary to restore the ecosystem to pre-spill condition.

Comments Relating to Specific Restoration Projects

Restoration Project No. 4 - Protection of Strategic Fish and Wildlife Habitats and Recreation Sites

Comment: Restoration project number 4 should focus on fish and wildlife habitats and recreation areas, rather than fish and wildlife habitats and recreation sites.

Response: Recreation sites will probably vary in size and will be determined on a case-by-case basis.

Comment: The Restoration Planning Working Group should initiate a project to determine if landowners of land specifically or generally identified by the public are interested in receiving financial benefits in return for conservation of their lands.

Response: As part of the planning toward restoration, areas identified by the public may be evaluated to determine their potential for possible acquisition. The willingness of the landowner to participate in an acquisition program will play a critical role in the process.

Comment: The geographic scope of the acquisitions project should not be limited to the oil spill area. A better criterion would be "to acquire or conserve lands that are important for a multiple set of habitat, use or nonuse value services where those habitats or values face a clearly identifiable near or long term risk."

Response: Restoring resources injured within the oil spill is the first priority of the restoration program. Areas outside the spill zone that are important for injured resources and services will also be considered.

Comment: Acquisition of land for federal management should only be developed if, in the judgment of the agency acting as trustee, it constitutes the only viable method of obtaining the lost services.

Response: The cost effectiveness criterion identified in II. 1. a. in the Federal Register will be applied to this project as well as all others. If other restoration measures restore the lost services or resources more effectively and less expensively than acquisitions they will generally be used.

Comment: No information is given to explain the need to protect habitats or recreation sites outside the area impacted by the oil spill in order to address injuries related to the oil spill.

Response: Effort will be made to protect habitats and recreation sites within the oil spill area before replacement or equivalent sites are considered.

Comment: There is serious concern as to whether this activity can be justified as cost effective compared to natural recovery or other more direct restoration measures.

Response: Cost effectiveness is a criterion that will be applied to this project.

Comment: The project appears to be focused primarily on protecting resources (e.g., uplands) that were not impacted by the oil spill. This is evidenced by the fact that the project's scope appears not to be limited to the oil spill area. Acquisition of land for federal management should only be considered if it is the sole viable restoration alternative.

Response: There is a clear and important ecological link between the marine and intertidal habitats injured by the oil spill and adjacent uplands. For injured species that use the uplands as well as marine habitats, protecting the upland habitats may facilitate their recovery. Restoring injured resources within the oil spill area is the preferred alternative of the Trustees.

Comment: Studies 4 & 5 from 1990 should be expanded to expedite the identification of critical habitats as targets for acquisition and land use management changes. These studies should be expanded to include all species that were damaged by the spill, with priority given to those species identified as being most severely impaired.

Response: As more information from the damage assessment studies becomes available, it will be used to expand, as needed, any ongoing studies or identify new restoration activities.

Comment: Proposed changes in land use status should include changes in designations of existing federal and state lands.

Response: The Trustees are establishing a process to evaluate existing federal and state land management plans and status and identify possible changes to facilitate restoration of injured resources.

Comment: Where important lands have already been identified for acquisition, such acquisition should begin this summer. Any funds available from the settlement should be devoted to these uses on a priority basis. Federal and state funds should be used for such acquisition subject to later reimbursement if funds from a settlement are not immediately available.

Response: The Trustees have been utilizing appropriated funds to carry out the damage assessment and restoration programs and insufficient funds were appropriated to acquire upland resources in 1991. In addition, the Trustees must first focus on identification and evaluation of acquisition options.

Comment: Acquisition should not be limited to a "willing seller" basis. Eminent domain, where consistent with applicable federal and state law, should be used to acquire critical resources in private lands where the existing owner is not willing to sell.

Response: The Trustees do not anticipate a need to use eminent domain to extinguish private property rights under the restoration program.

Comment: We are concerned with the "no action" option where it is most appropriate to allow "natural" recovery to proceed. If direct restoration or replacement is not feasible or appropriate, then acquisition becomes the preferred option.

Response: All options, including natural recovery, will be evaluated on a case-by-case basis.

Comment: I encourage you to consider purchase of critical wildlife property from the private sector and place it [in] protective status in the public domain. Examples are: Purchase Gull Island in Kachemak Bay; purchase inholdings and timber rights in Kachemak Bay State park; purchase or cause to be set aside the intertidal and supratidal lands at the base of the Homer Spit, including portions of Mud Bay.

Response: These examples, as well as others identified by the public or agencies, will be evaluated as part of any acquisitions program.

Comment: Purchase inholdings in Kachemak Bay State Park.

Response: See comment above.

Comment: Purchase old growth forest habitat in PWS and the GOA oil spill area. These areas are important nesting habitat for the Marbled Murrelets.

Response: See comment above.

Comment: Purchase privately owned seabird colonies. Thirty Three seabird colonies are recommended (listed) for purchase.

Response: See comment above.

Comment: Villages that have expressed an interest in the purchase of equivalent resources would need to be approached individually and dealt with on a case-by-case basis.

Response: The Trustees agree and intend to discuss potential acquisitions individually with private landowners should the decision be made to seek acquisition of private lands.

Comment: Implementation project 4, acquisition of habitat, warrants the highest priority and immediate action.

Response: The priority for implementation projects is determined on a case-by-case basis. At this time the Trustees have not determined priorities for these or other science studies.

Restoration Project No. 1 - Beach Wildrye

Comment: The specific locations of the injured rye grass communities should be identified in the Final Plan, and a comparison of the results expected from natural recovery and transplanting/fertilizing should be provided.

Response: After further investigation and assessment, it was determined that implementation of this project was not necessary for restoration of injured rye grass in the spill area.

Comment: Use of fertilizer to promote beach grass restoration should be done with caution, so that excess nutrients are not a problem on a localized water quality basis. Consideration should be given to the use of organic fertilizers, where nutrients are less soluble, thus less likely to run off into receiving waters, and more likely to be retained for long-term benefit to the plants being restored.

Response: Though implementation of this project was determined not to be necessary at this time, this comment will be taken into consideration in the design of any future projects that involve fertilizers.

Restoration Project No. 3 - Salmonid Stocks and Habitat Restoration

Comment: I would urge you to include a longer cycling salmon, such as the chum salmon, into the studies and restoration plans.

Response: Chum salmon are included in the fish habitat improvement project.

Comment: Section III B (3.) describes projects that are incompatible with the existing management schemes of the Kenai Fjord National Park and the Kachemak Bay State Wilderness Park. Am I correct in assuming that these areas will then be precluded from these recovery remedies?

Response: Fish habitat enhancement projects and other restoration activities will be reviewed to ensure compliance with laws and management plans before they are implemented. In some cases, changes in the management plans may be recommended.

Comment: Section III B (3.) has a funding level that is grossly insufficient to effect recovery for the valuable subsistence, commercial and recreational fisheries that were damaged by the oil spill. The loss of resource is different from the loss of income derived from the resource.

Response: The funding identified in the Federal Register notice is an estimate of the funds necessary to carry out a program in 1991 only and does not reflect fish restoration projects that may take place in the future.

Comment: It appears that this project contemplates activities which go beyond restoration of an injured resource to its baseline levels. Additionally, these measures are not consistent with the wilderness character of the area.

Response: The activities proposed in this project will work toward restoring species injured by the oil spill. In some cases this may involve enhancing fish populations in streams not injured by the oil spill as a replacement for injured populations. Activities will be carried out consistent with land management plans and policies, including wilderness.

Restoration Project No. 2 - Public Information and Education for Recovery and Protection of Alaska's Marine and Coastal Resources

Comment: The project should be limited to distributing information on how to avoid disturbing the injured resources.

Response: The primary purpose of the project is to reduce human impacts on injured resources. The Trustees believe that through public education people can better understand the effects of their actions on injured wildlife.

Comment: This project could be expanded to include cultural/archeological resources. The Needs and Objectives should be amended to read "The Exxon Valdez oil spill caused direct and indirect injury to the marine birds, mammals and archeological sites of southcentral Alaska. The purpose of this project is to make users of the area aware of the changes to the ecosystem resulting from the oil spill and to lessen the potential for additional harmful human disturbances". The Methods section should then be expanded to include cultural/archeological resources.

Response: Although the extent of injury to cultural/archeological resources is still being determined by the NRDA process, the Trustees are interested in fully informing the public about ways to reduce impacts to injured resources. Consideration will be given to including the suggestion in the project.