ALASKA LEGISLATURE SPECIAL COMMITTEE/SUBJECT FILE 8672
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182

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, [illegible] 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 spi[illegible]

Otters [illegible]itation Centers

A. To [illegible]ypothesis that surviva[illegible] otters that un[illegible]ng, cleaning, treatmen[illegible]lease is not di[illegible]m that of sea otters tha[illegible]t affected by the [illegible]

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 [illegible] include crab, clam, and mussel (Calkins 1978; Garshelis 198[illegible] 1987). Damages to the nearshore benthic community [illegible] from the EVOS may influence the recovery of affected s[illegible]lations. Probable mechanisms of influence include (1) [illegible] availability and (2) consumption of prey contaminate[illegible]rbons.

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 south-western 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.

Pre-Oil Spill Surveys. 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

<u>Population estimates and variances</u> (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 $= [(R_1 - R_2)_{oiled} - (R_1 - R_2)_{non\text{-}oiled}]\ X_{oiled}$
in oiled compared
to non-oiled area

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

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* $z(x^*)$

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

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

$$v\hat{a}r(\hat{\tau}_1 - \hat{\tau}_2) = X^2 \left[\left(\frac{1}{(n_1 + n_2)} - \frac{1}{N}\right) \frac{(s^2_{1counts} + R^2_1\, s^2_{1area} - 2R_1\, s_{1counts,area})}{\left(\frac{x + x'}{n_1 + n_2}\right)^2} + \left(\frac{1}{n_1 + n_2} - \frac{1}{N}\right) \frac{s^2_{2counts} + R^2_2 s^2_{2area} - 2R_1 s_{2counts,area}}{\left(\frac{x + x^*}{n_1 + n_3}\right)^2} - \frac{2\left(\frac{n_1}{(n_1 + n_2)(n_1 + n_3)} - \frac{1}{N}\right) s_{(y_{1i} - R_1 x_i)(y_{2i} - R_2 x_i)}}{\frac{(x + x')}{(n_1 + n_2)} * \frac{(x + x^*)}{(n_1 + n_3)}} \right]$$

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 ea les are at the lowest availability of the year and eagles are presum y 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.

Toxic and Sublethal Effects of Oiling (Objective D). 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.

BIBLIOGRAPHY

Helle, J.H., R.S. Williamson, and J.E. Baily. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish and Wildlife Service, Fisheries No. 483. Washington D.C.

McCurdy, M.L. 1984. Eshamy District pink salmon streamlife study, 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries. Prince William Sound Data Report No. 94-18. Cordova

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.