EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	Restoration of the Coghill Lake Sockeye Salmon Stock.
Project ID number:	94259
Project type:	Restoration Manipulation and Enhancement
Name of project leader(s):	Mark Willette, ADFG Kate Wedemeyer, USFS
Lead agency:	Alaska Department of Fish and Game
Cooperating agencies:	U.S. Department of Agriculture, Forest Service
Cost of project/FY 94:	$324,100
Cost of project/FY 95:	$324,100
Cost of Project/FY 96 and beyond:	$324,100
Project Start-up/Completion Dates:	March 1, 1994 - September 30, 1994
Geographic area of project:	Coghill Lake, Prince William Sound
Name of project manager:	Joe Sullivan

B. INTRODUCTION

The goal of this project is to restore the natural productivity of Coghill Lake and the resident sockeye salmon (*Oncorhynchus nerka*) population through use of established lake fertilization techniques (LeBrassseur et al. 1978; Stockner and Hyatt 1984; Koenings and Burkett 1987; Kyle et al. 1991). Coghill Lake is located 130 km northwest of Cordova at an elevation of 18 m. The outlet of the lake empties into the eastern side of Port Wells, Prince William Sound. Coghill Lake has a surface area of 12.7 km^2, a mean depth of 46.3 m, and a total volume of 587 x 10^6 m^3 (Pellisier and Somerville 1984). This project will be conducted cooperatively by the Alaska Department of Fish and Game (ADFG) and the U.S. Forest Service (USFS).

The Coghill Lake sockeye salmon stock has historically supported an important commercial fishery in western Prince William Sound (PWS), but in recent years returns have declined considerably. In 1982, 1.2 million sockeye salmon returned to Coghill Lake, but by 1991 only 9,800 fish escaped into the lake. Results from damage assessment studies on juvenile salmon suggest that the Exxon Valdez oil spill (EVOS) may have contributed to the stock decline, because the juveniles migrated through oil-contaminated habitats in western PWS in 1989.

This project should be continued in 1994, because the Coghill Lake stock is presently at dangerously low levels. Action must be taken to restore the stock before any further decline occurs. Sockeye salmon rear in lakes for one to three years before emigrating to sea. The production of sockeye salmon populations is closely linked to the productivity of rearing lakes (Koenings and Burkett 1987). Limnological studies indicate that fry food resources in Coghill Lake cannot support large numbers of fish. Continued fertilization is needed to increase lake productivity and boost zooplankton abundance until natural nutrient input from salmon carcasses is restored (Edmundson et al. 1991).

C. PROJECT DESCRIPTION

This project will restore the natural productivity of Coghill Lake through use of lake fertilization techniques. Nutrient loading from adult salmon carcasses is expected to maintain lake productivity after the fertilization program is completed and the run is restored. Restoration of the Coghill sockeye stock will provide natural resource services to replace those once provided by other injured stocks in the EVOS area. The USFS will apply fertilizer to the lake each summer for five years. ADFG will conduct limnological and fisheries studies needed to monitor and refine the fertilization program. These studies will focus on the effects of fertilization on primary and secondary production and the growth and survival of juvenile sockeye salmon in the lake. The results of the monitoring program will be used to estimate changes in lake carrying capacity and smolt-to-adult survival rates.

1. **Resources and/or Associated Services**

This project will restore the natural productivity of Coghill Lake and the resident sockeye salmon population. Restoration of the Coghill Lake sockeye salmon stock will replace resources and services injured by the EVOS.

2. **Relation to Other Damage Assessment/Restoration Work**

This project is related to restoration Project 94137 (Stock Identification of Chum, Sockeye, Chinook, and Coho Salmon in Prince William Sound). Catches from the commercial and cost recovery fisheries will be scanned for coded-wire tagged fish. Tagged sockeye salmon released from Coghill Lake in 1989 and 1991 will likely be recovered in 1994. The recovered heads will be shipped to the CWT laboratory in Juneau for decoding and data posting. CWT recovery data will be used to estmate the smol-to-adult survival of Coghill Lake sockeye salmon.

3. **Objectives**

This project will achieve the following objectives. More than one year of study will be required to achieve objectives 3 through 5.

1. Apply fertilizer to Coghill Lake and elevate the productivity of the lake ecosystem.

2. Monitor the residence time of nutrient-enriched water in Coghill Lake.

3. Determine the effect of fertilization on primary and secondary production.

4. Determine the effect of fertilization on the food consumption, growth, and condition of sockeye salmon fry.

5. Determine the effect of fertilization on the overwinter survival, age, size, and condition of smolts emigrating from the lake.

4. **Methods**

Objective 1:

Lake fertilization is recommended for one sockeye life cycle (5 years) to elevate the productivity of the lake and the resident sockeye salmon population. The recent five-year average loading of phosphorus into Coghill Lake is 312 mg m^2 yr^2 (Edmundson et al. 1992). The critical loading rate (Vollenweider 1976) needed for full phytoplankton productivity is 650 mg m^2 yr^2 (Edmundson et al. 1992). Therefore, an additional 273 mg m^2 yr^2 of phosphorus is needed to achieve full phytoplankton productivity. In addition, 2,273 mg m^2 yr^2 of nitrogen is needed to maintain an 18:1 atomic ratio of nitrogen to phosphorus. A pharmaceutical-grade liquid fertilizer will be applied to the lake by releasing it from a low-flying aircraft. Application will consist of six to nine passes of five-minute duration one day each week. Approximately 3,000 kg of fertilizer will be applied each day. The area for application of fertilizer will be increased from 3.9 km^2 in 1993 to 5.5 km^2 in 1994 to encompass the majority of the sockeye salmon rearing area of the lake. The amount of fertilizer applied will be increased in 1994 to compensate for the expanded application zone and increase the base loading of phosphorus. Sixty-five thousand kilograms of liquid fertilizer (20-5-0) containing 20% nitrogen and 5% phosphorus will be applied from June 1 to August 15. Seventy-two hundred kilograms of nitrogen fertilizer (32-0-0) comprising equal portions of ammonium, nitrate-nitrite, and organic nitrogen will be applied from July 15 to August 30. People reserving the cabin at Coghill will be notified of the fertilization schedule. Notices will also be posted in the cabin. Fertilizer will be applied no closer than a mile and a half from the cabin and lagoon where most recreational activity takes place. The pilot will not drop fertilizer in a portion of the application area if anyone is within that area.

Objective 2:

The residence time of nutrient-enriched water in Coghill Lake will be monitored to determine the most effective spatial and temporal distribution of fertilization effort. Discharge will be measured in the Coghill River twice during low, medium, and high flow periods. Water depth and current speed will be measured at 10 m intervals along a transect drawn perpendicular to the stream length. The cross-sectional area of each segment and the current speed will be used to estimate the discharge within each segment. The discharge estimates for all the segments along the transect will be summed to estimate the total stream discharge. Water level in the lake will be measured at the same time that discharge is estimated. Regression analysis will be used to develop an empirical model relating lake level to stream discharge. An electronic pressure recorder will be installed in the lake to continuously monitor changes in lake level. The empirical model will be used to construct a time series of lake flushing rate throughout the fertilization period.

Objective 3:

The effect of lake fertilization on primary and secondary production will be assessed by comparing limnological data collected pre- and post-fertilization. Five years of limnological data collected monthly at Coghill Lake is available for the comparison. Analysis of variance and multiple comparisons will be used to test for pre- and post-fertilization differences ($P = .05$) in several limnological variables (filterable reactive phosphorus, ammonia, nitrate-nitrite, chlorophyll a, copepod biomass, and cladoceran biomass). The independent variables in the model will include sampling period (July-August; Sept.-October), year, and treatment (pre- and post-fertilization).

Limnological sampling will be conducted as in past years to insure valid pre- and post-fertilization comparisons. Sampling will be conducted twice each month from June through October at two stations that have been sampled in past years. The samples collected within each month will be used as replicates in the pre- and post-fertilization comparison. Temperature and dissolved oxygen concentrations will be measured from the surface to a depth of 40 m using a YSI model-57 meter. Measurements of light penetration (footcandles) will be measured at 1 m increments from the surface to a depth equivalent to 1% of the subsurface light using a Protomatic submarine photometer. The euphotic zone depth (Schindler 1978) will be calculated as the y-intercept derived by regressing depth against the logarithm of the percent subsurface light. Secchi disk transparency will be determined as the averaged reading (depth) taken by lowering a standard 20 cm disk until it disappears, and then raising the disk until it reappears. Water samples will be collected from the 1 m stratum, chemocline, and monimolimnion using a non-metallic, opaque Van Dorn sampler. Eight liters of water will be collected from each depth, stored (<24 hr) in pre-cleaned polyethylene carboys, transported to Cordova for processing, and then shipped to the Limnology Laboratory in Soldotna for analysis.

Water samples will be analyzed for the following parameters as detailed by Koenings et al. (1987). Conductivity (μmhos/cm) will be measured with a YSI model-32 conductance meter. Alkalinity levels (mg/L) will be determined by acid titration (0.02 N H_2SO_4) to pH 4.5, using a Corning model-399A specific ion meter. Calcium and magnesium (mg/L) will be determined from separate EDTA (0.01 N) titrations after Golterman (1969), turbidity (NTU) will be measured with a HF model-DRT100 turbidimeter, and color (Pt units) will be determined with a spectrophotometer. Total iron (μg/L) will be analyzed by reduction of ferric iron with hydroxylamine during hydrochloric acid digestion after Strickland and Parsons (1972).

All nutrient samples will be analyzed by methods detailed by Koenings et al. (1987). In general, filterable reactive phosphorus (FRP) will be analyzed by the molybdate-blue/ascorbic-acid method of Murphy and Riley (1962), as modified by Eisenreich et al. (1975). Total phosphorus will be determined using the FRP procedure, after persulfate digestion. Nitrate and nitrite ($NO_3 + NO_2$) will be determined as nitrite, following Stainton et al. (1977) after cadmium reduction of nitrate. Total Kjeldahl nitrogen (TKN) will be determined as total ammonia following sulfuric acid block digestion (Crowther et al. 1980). Total nitrogen will be calculated as the sum of TKN and $NO_3 + NO_2$. Reactive silicon will be determined using the method of ascorbic acid reduction to molybdenum-blue (Stainton et al. 1977). Estimation of the yearly phosphorus loading in Coghill Lake will be calculated after Vollenweider (1976).

Algal standing crop will be estimated by chlorophyll a analysis, after the fluorometric procedure of Strickland and Parsons (1972). The low-strength acid addition recommended by Riemann (1978) will be used to estimate phaeophytin.

Water samples (1-2 L) will be filtered through 4.25-cm GF/F filters to which 1-2 mls of a saturated $MgCO_3$ solution is added just prior to the completion of filtration. The filters will be stored frozen in individual plexislides for later analysis. Samples of unfiltered lake water will be preserved with Lugol's acetate solution for later identification of phytoplankton species.

Replicate vertical zooplankton tows will be taken from 40 m depth at four stations using a 0.2 m diameter, 153-μ mesh, conical net. The net will be pulled at a constant 1 m s^1, and all organisms will be preserved in a 10% neutralized formalin solution. Cladocerans and copepods will be identified using keys developed by Brooks (1957), Pennak (1978), Wilson (1959), and Yeatman (1959). Copepodite stages will be identified and enumerated. Enumeration will consist of counting animals in triplicate 1 ml subsamples taken with a Hansen-Stempel pipette in a 1 ml Sedgewick-Rafter cell. Cladoceran body length will be measured to the nearest 0.01 mm for at least 10 individuals along a transect in each 1 ml subsample (Koenings et al. 1987). Cladoceran weight will be estimated from an empirical regression between body length and dry weight. Body weights of copepodites will be estimated using the average dry weight for each stage. Zooplankton biomass will be estimated for each species by the product of average body weight and abundance (Koenings et al. 1987).

Objective 4:

The effect of the fertilization program on food consumption and growth will be assessed by testing for changes in these variables over time as the fertilization proceeds. This analysis will be preceded by a survey of the lake to determine the habitats occupied by the fish in July, August, September, and October. Visual surveys, beach seine and tow net catches, and hydroacoustic surveys will be used to assess habitat utilization. A 120-Khz dual-beam echo sounder will be used to determine the vertical distribution of fry in the lake during the day and at night. Data will be collected along 10 randomly selected transects oriented perpendicular to the longitudinal axis of the lake. The data will be analyzed using echo integration or echo counting techniques depending on fish density (Kyle 1990). Electronic water temperature recorders will be moored in habitats commonly occupied by sockeye salmon fry.

Food consumption rate will be estimated from studies of diel feeding periodicity and stomach contents analysis. The diel feeding periodicity study will estimate the food consumption rate of fish throughout the day at a single site. The stomach contents analysis will estimate the variability of stomach contents weight and prey composition among 10 sites and test for differences in these variables between months.

The diel feeding periodicity study will estimate food consumption utilizing gastric evacuation rates obtained from laboratory studies and stomach contents weight data obtained in the field. Brett and Higgs (1970) estimated the gastric evacuation rate of juvenile sockeye salmon (30-40 g) between 3 and 23° C. Gastric evacuation rate is described by a negative exponential function, i.e.

$$V_t = V_o e^{-bt} \quad (1)$$

where V_t is the stomach weight (g) at time t, V_o is the stomach weight (g) at time 0, and b is the instantaneous gastric evacuation rate (Fange and Grove 1979). Samples of ten sockeye salmon fry will be collected at three hour intervals throughout a 24 hour period using a tow net. The lengths and weights of the fish will be measured fresh. Fry stomachs will be removed and preserved in 10% buffered formaldehyde. Prey items in the stomach will be identified later in the laboratory to the lowest possible taxonomic level. Prey length will be measured to the nearest .01 mm. Prey body weight will be estimated from an empirical regression between zooplankter body-length and dry weight (Koenings et al. 1987). Stomach contents weight will be estimated by the product of abundance and mean body weight for each taxonomic group. Food consumption rate (I) during each three hour period will be estimated by:

$$I = V_o - V_o e^{-bt} \quad (2)$$

where V_o is the mean stomach contents weight at the beginning of the three hour interval, and b is the temperature-specific gastric evacuation rate (Brett and Higgs 1970). The vertical distribution of the fish and water temperature profiles will be used to estimate the temperature of the habitat occupied during each time period. The food consumption estimates during each of the three hour periods will be summed to estimate the daily ration. This study will be conducted in July, August, September, and October. If the pattern of diel migration and feeding does not change significantly over time, the study will be discontinued. Food consumption rate will then be estimated from stomach samples collected in the morning.

Stomach contents analysis will be used to test for differences in total stomach contents weight and prey composition between months. Stomach samples (n=10) will be collected from at least ten sites throughout the lake in July, August, September, and October. The samples will be collected between 6 and 9 a.m. on the same day that the food consumption study is conducted. The lengths and weights of the fish will be measured fresh. Fry stomachs will be removed and preserved in 10% buffered formaldehyde. The remainder of the fish will be preserved in 100% ethanol for later analysis of otolith microstructure. Laboratory analysis of the samples will be performed as described above. Analysis of variance will be performed to test for differences (P=.05) in stomach contents weight and prey composition between months. Separate analyses will be conducted on total stomach contents weight as a proportion of fish body weight and on prey biomass in each taxonomic group as a proportion of total stomach contents weight. The distribution of each dependent variable will be examined to determine an appropriate transformation. As more data is obtained over the five year study, the analysis will be restructured to also test for differences between years.

Growth rate will be estimated for monthly time periods using measured fish body weights and estimated age from time of outmigration into the lake. Otolith microstructure analysis will be used to estimate fish age from otolith increment counts. Otolith increments are formed daily in juvenile sockeye salmon (Marshall and Parker 1982, Wilson and Larkin 1980). Thin sections of the otoliths will be prepared using methods developed by Volk et. al. (1984). A computer image analysis system will be used to examine the otoliths. The number of otolith increments produced since outmigration will be visually counted, and the outmigration check will be visually identified. Otolith increment counts will be used to track the growth of the dominant cohort of fish in the lake. The mean growth rate of the cohort during the previous month will be estimated from the following equation:

$$G = \frac{\overline{\ln(W_2)} - \overline{\ln(W_1)}}{t_2 - t_1} \qquad (3)$$

where $\overline{\ln(W_2)}$ is the mean of natural logarithmn (ln) of body weight in the current sample, and $\ln(W_1)$ is the mean of ln body weight in the previous sample. Samples of Coghill stock sockeye fry outmigrating from incubators at the Main Bay hatchery will be used to estimate W_1 for the first time period. The variance (s^2_p) about the mean growth rate will be estimated by:

$$s^2_p = \frac{s^2_2 + s^2_1}{(t_2 - t_1)^2} \qquad (4)$$

where s^2_2 is the variance of $\overline{\ln(W_2)}$, and s^2_1 is the variance of $\overline{\ln(W_1)}$ (Zar 1984). Analysis of variance and pairwise comparisons will be used to test for differences ($P=.05$) in mean growth between months. As more data is obtained over the five year study, the analysis will be restructured to also test for differences between years.

The effect of the fertilization program on fry growth will be evaluated by testing for changes in temperature-specific growth between years. The vertical distribution of the fish, water temperature profiles, and continuous temperature measurements (obtained from electronic recorders) will be used to estimate the mean temperature of the habitat occupied by the fish during each month. Monthly mean growth will be regressed against monthly mean water temperature. Analysis of covariance will be used to test for differences ($P=.05$) in the intercept and slope of the regression between years.

The effect of the fertilization program on the condition of sockeye salmon fry will be evaluated by testing for changes in condition between months and years. The relationship between body weight (W) and length (L) is described by

$$W = a L^b \tag{5}$$

where a is the condition factor and b is the slope of the linear-transformed model (Ricker 1975). Regression analysis will be used to estimate the relationship between ln body weight and ln length. Analysis of covariance will test for differences ($P = .05$) in the intercept and slope of the regression between years. The condition factor (a) of individual fish will be estimated by

$$a = \frac{W}{L^b} . \tag{6}$$

Analysis of variance and multiple comparisons will be used to test for differences in condition factor between months within years.

Objective 5:

The effect of the fertilization program on the overwinter survival of sockeye fry will be evaluated by estimating fall population size and testing for pre- and post-fertilization differences in fall fry condition and size-at-age. Fall fry and spring smolt population size will be used to estimate overwinter survival. The poor overwinter survival of sockeye salmon fry in Coghill Lake appears to be due to insufficient energy reserves needed for metabolism during winter (Edmundson et al. 1992). Fulton's condition factor will be used to estimate the chemical composition and caloric content of sockeye fry immediately before winter (Harris et al. 1986). A hydroacoustic survey will be conducted in October to estimate the population size of sockeye salmon fry in the lake. A stratified-random design will be used each year to select 10 transects oriented perpendicular to the longitudinal axis of the lake. A 120-Khz dual-beam echo sounder will be used to collect data along the transects. The data will be analyzed using echo integration or echo counting techniques depending on fish density (Kyle 1990). The acoustic survey will be conducted during the darkest period of night when juvenile sockeye salmon are distributed in the upper to middle part of the water column (Narver 1970; McDonald 1973; Eggers 1978; Simpson et al. 1981; Nunnallee 1983; Burczynski and Johnson 1986; Levy 1987). A 7.5-m long mid-water trawl with a 2 x 2 m opening will be used in conjunction with the hydroacoustic surveys to determine species composition, size, and age of fish targets. Fish will be preserved in 10% buffered formaldehyde for at least six weeks, measured to the nearest millimeter, and weighed to the nearest 0.1 g. A scale smear will be taken from each fish, affixed to a glass slide, and aged using a microfiche projector. Changes in the species composition of tow-net catches will also be evaluated to determine if the fertilization program is affecting the composition of the fish community in the lake. Analysis of variance will be used to test for pre- and post-fertilization differences in the proportion of total catch for each species in tow-net samples. Analysis of variance and multiple comparisons will be used to test for pre- and post-fertilization differences in fall fry condition factor, and length and weight at age, respectively. The distributions of these dependent variables will be examined to determine an appropriate transformation. The independent variable in these analyses will be treatment (pre- and post-fertilization).

The effect of the fertilization program on outmigrant smolts will be evaluated by testing for pre- and post-fertilization differences in smolt age composition, condition, and size at age. Sockeye salmon smolts emigrating from Coghill Lake will be enumerated using incline-plane traps (Kyle 1983). The traps will be operated continuously from early May to early June. The catch efficiencies of the traps will be determined by mark and recapture analysis. At least 300 individuals will be marked and released at the lake outlet for each mark-recapture experiment. Overwinter survival will be estimated by dividing the number of outmigrating smolts by the fry population size estimated the previous fall. A sample of 40 smolts will be collected each day to estimate age composition. The fish will be anaesthetized with MS-222. Several scales will be taken from each fish, affixed to a glass slide, and aged in the laboratory using a microfiche projector. Each fish will be measured to the nearest millimeter and weighed to the nearest .01 g. Analysis of variance will be used to test for pre- and post-fertilization differences ($P = .05$) in the proportion of total smolt abundance in each age group. Sampling period, year, and treatment will be independent variables in the model. The distributions of the dependent variables will be examined to determine an appropriate transformation. Analysis of covariance will be used to test for pre- and post-fertilization differences ($P = .05$) in smolt condition. The independent variables in the model will be sampling period, year, and treatment with ln length as a covariate. Overwinter survival will be estimated by the ratio of fall fry and spring smolt population estimates. Techniques described by Seber (1982) will be used to estimate the variance of the survival estimate.

5. Location

This project will be conducted at Coghill Lake which is located in northwestern Prince William Sound.

6. Technical Support

No technical support will be required to complete this project.

7. Contracts

Contracts will be needed for aerial application of the fertilizer, hydroacoustic data processing, and water sample processing. Contractual services for air charter will also be used to provide logistical support for field sampling operations. Contracts will be awarded through competitive bid when necessary.

D. SCHEDULES

Table 1: The schedule of events for this project will extend beyond September 30, 1994. No additional funds will be required to complete the activities described in this study plan.

Date	Activity
May - June	Enumerate outmigrant smolts and collect samples to estimate smolt age and size composition
June - Oct.	Apply fertilizer each week, conduct limnological sampling twice each month, and collect fish samples for growth and stomach contents analysis.
July - Dec.	Conduct laboratory analyses of limnological, otolith, and stomach samples
October	Estimate fall fry population size using hydroacoustic techniques
Dec. - Feb.	Analyze data and prepare annual report
April 1, 1995	Submit annual report for peer review

E. EXISTING AGENCY PROGRAM

The ADF&G operates a weir on Coghill River to enumerate salmon returning to Coghill Lake. Age, weight and length (AWL) data is collected along with the recovery of coded-wire tagged fish. Along with AWL data from commercial catches, data from the weir is used to forecast adult salmon returns to the lake system. The salmon run forecast for Coghill Lake is an important element in the ADF&G management program for the Coghill sockeye stock. The annual operating cost of the weir project is $18.5K.
ADF&G also will conduct a test fishery project to determine the exploitation rate on Coghill Lake sockeye salmon in the Eshamy District and Esther Subdistrict. Data from the test fishery will be used to refine the present fishery management strategy for Coghill Lake sockeye salmon.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The USFS has conducted an environmental assessment to evaluate the various alternatives for rehabilitating Coghill lake and the resident sockeye salmon population (USFS 1993). The assessment has concluded that the lake fertilization program is the most appropriate method for rehabilitation of the Coghill Lake ecosystem and resident sockeye salmon stock.

G. PERFORMANCE MONITORING

An annual report detailing project results will be prepared and submitted for peer review on April 1, 1995. At the end of the five year study, all results and conclusions will be published in a referred scientific journal.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is integrated with the restoration project 94137 (Stock Identification of Chum, Sockeye, Chinook, and Coho Salmon in Prince William Sound). Catches from the commercial and cost recovery fisheries will be scanned for coded-wire tagged fish. Tagged sockeye salmon released from Coghill Lake in 1989 and 1991 will likely be recovered in 1994. The recovered heads will be shipped to the CWT laboratory in Juneau for decoding and data posting. CWT data will be used to estimate smolt-to-adult survival of Coghill Lake sockeye salmon. The limnological and juvenile sockeye salmon production data obtained at Coghill Lake will be interpreted by the ADF&G Limnology Laboratory relative to similar data collected from many other lakes in Alaska.

I. PUBLIC PROCESS

An Environmental Assessment was conducted by the USFS in which various alternatives for the rehabilition of Coghill Lake and the resident sockeye population were present for public review. The project was also publicly reviewed by the Prince William Sound/Copper River Regional Planning Team (RPT).

J. PERSONNEL QUALIFICATIONS

Mark Willette
Alaska Department of Fish and Game
Commercial Fisheries Management and Development
P.O. Box 669
Cordova, Alaska 99574

Experience:

March 1991 - present: Area Resource Development Biologist with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Cordova, Alaska. Supervised by Dr. Stephen Fried. Conduct various fisheries enhancement and evaluation projects in Prince William Sound (PWS) including limnological investigations of sockeye salmon producing lakes, and quality control of coded-wire tagging at private hatcheries. Conduct fisheries oceanographic studies in PWS in cooperation with private hatcheries and University of Alaska investigators. Principal Investigator on Natural Resource Damage Assessment studies on juvenile salmon in PWS. Chairman of PWS Regional Planning Team.

March 1986 - February 1991: Fisheries Instructor/ Assistant Research Professor, University of Alaska Fairbanks, School of Fisheries & Ocean Sciences, Supervised by Dr. Don Kramer. Conduct research on the effects of oceanographic conditions on the growth and survival of juvenile salmon in PWS, fish bioenergetics in an arctic lagoon ecosystem, age and growth of juvenile fish in the Chukchi and Bering Seas, ocean temperature variability in the North Pacific Ocean and effects on pink salmon production, salmon feeding on the high seas. Design and implement a program of education, research, and public service to promote fisheries development in northwest Alaska. Teach college level course in oceanography. Teach a marine safety and vocational training courses in fisheries.

Education:

1985 Master of Science, Fisheries Oceanography, University of Alaska Fairbanks.

1983 Bachelor of Science, Fisheries Science, University of Alaska Fairbanks.

Kate Wedemeyer
U.S. Forest Service, Glacier Ranger District
P.O. Box 129
Girdwood, Alaska 99587

Experience:

1988 - present: District Fisheries Biologist, U.S. Forest Service, Glacier Ranger District, Girdwood, Alaska. Development of fishery enhancement projects through planning,environmental documentation, permitting, and construction. Fishery enhancement projects have been conducted in western Prince William Sound.

1987-1988: Fishery Biologist, U.S. Fish and Wildlife Service, Fisheries Resources, Fairbanks, Alaska. Performed field work and report writing for U.S. Canada Yukon River Salmon Treaty projects on the Chandalar River in interior Alaska.

1976, 1979-80, 1983: Fisheries Technician, Alaska Department of Fish and Game, F.R.E.D. Division, Sport Fish Division, and Commercial Fisheries Divisions.

Education:

1988, Master of Science, Natural Resource Management, University of Alaska, Fairbanks, Alaska.

1987, Master of Science, Fisheries Science, University of Alaska, Fairbanks, Alaska.

1985, Bachelor of Science, Biology, University of Alaska, Fairbanks, Alaska.

1972, Bachelor of Science, Psychology, minor zoology, Iowa State University.

K. BUDGET

Table 2. Budget summary for the Restoration of the Coghill Lake Sockeye Salmon Stock for FY94, FY95, and FY96 and beyond.

Line Item	FY94	FY95	FY96 and beyond
Personnel	126.5	126.5	126.5
Travel	2.0	2.0	2.0
Contractual	154.0	154.0	154.0
Supplies	11.8	11.8	11.8
Equipment	0.0	0.0	0.0
Total	294.3	294.3	294.3
Indirect Costs	29.8	29.8	29.8
Grand Total	324.1	324.1	324.1

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EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: This project will restore the natural productivity of Coghill Lake through the use of established fertilization techniques. Limnological and fisheries investigations will be conducted to monitor and refine the fertilization program. The investigations will focus on the effects of fertilization on primary and secondary production, and the growth and survival of juvenile sockeye salmon in the lake.

Budget Category:	1993 Project No. 93024 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$95.5	$59.1	$67.4	$126.5	$125.1	
Travel	$12.2	$2.0	$0.0	$2.0	$7.4	
Contractual	$55.6	$4.5	$149.5	$154.0	$148.6	
Commodities	$10.2	$1.8	$10.0	$11.8	$10.8	
Equipment	$20.2	$0.0	$0.0	$0.0	$1.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$193.7	$67.4	$226.9	$294.3	$292.9	
General Administration	$11.7	$9.2	$20.6	$29.8	$29.2	
Project Total	$205.4	$76.6	$247.5	$324.1	$322.1	
Full-time Equivalents (FTE)	1.4	1.1	1.5	2.6	2.2	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
See Individual 3A Forms for Personnel Details				
Personnel Total	0.0	$0.0	0.0	$0.0

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Agency: AK Dept. of Fish & Game

FORM 2A
PROJECT
DETAIL

EXXON VALDEZ [illegible]STEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Coghill Lake Sockeye Salmon Restoration - This project will restore the natural productivity of Coghill Lake through the use of established fertilization techniques. Limnological and fisheries investigations will be conducted to monitor and refine the fertilizations program. The investigations will focus on the effects of fertilization on primary and secondary production, and the growth and survival of juvenile sockeye salmon in the lake.

Budget Category:	1993 Project No. 93024 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$85.3	$59.1	$55.8	$114.9	$114.9	
Travel	$6.8	$2.0	$0.0	$2.0	$2.0	
Contractual	$48.6	$4.5	$38.1	$42.6	$42.6	
Commodities	$9.5	$1.8	$8.3	$10.1	$10.1	
Equipment	$20.2	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$170.4	$67.4	$102.2	$169.6	$169.6	
General Administration	$9.7	$9.2	$11.0	$20.2	$20.2	
Project Total	$180.1	$76.6	$113.2	$189.8	$189.8	
Full-time Equivalents (FTE)	1.2	1.1	1.2	2.3	2.3	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt 1 Fishery Biologist I	2.5	$11.0	3.0	$13.2
1 Fishery Biologist I	2.0	$8.5	0.0	$0.0
1 Fish & Wildlife technician III	2.5	$8.8	3.0	$10.5
1 Fish & Wildlife technician III	2.0	$7.0	0.0	$0.0
2 Fish & Wildlife technician II	0.0	$0.0	7.0	$25.4
1 Limnologist	1.0	$6.1	0.0	$0.0
1 Biometrician II	2.5	$14.3	0.0	$0.0
1 Program Manager	0.5	$3.4	1.0	$6.7
Personnel Total	13.0	$59.1	14.0	$55.8

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994

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Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project: Limnology/Fisheries Investigation
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:		Reprt/Intrm	Remaining
Reprt	4 RT Anchorage/Cordova @ $350/trip + 1 day per diem @ $150/day	$2.0	$0.0
	Travel Total	$2.0	$0.0

Contractual:			
Reprt	Air charter Cordova/Coghill Lake (approximately 38 hours @ $400/hour)	$2.0	$13.0
	Hydroacoustic data processing to estimate fry abundance through a cooperative agreement with the Prince William Sound Science Center	$2.5	$15.0
	Water sample processing (84 samples @ $120/sample)	$0.0	$10.1
	Contractual Total	$4.5	$38.1

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1994

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Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project: Limnology/Fisheries Investigation
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-PROJECT
DETAIL

Commodities:	Reprt/Intrm	Remaining
Reprt Field sampling supplies (weir material, nets, containers)	$1.0	$7.9
Office supplies (paper, pens, toner cartridges, etc.)	$0.8	$0.4
Commodities Total	$1.8	$8.3

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project: Limnology/Fisheries Investigation
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Coghill Lake Sockeye Salmon Restoration - This project will purchase and apply fertilizer to Coghill Lake to increase the productivity of the lake.

Budget Category:	1993 Project No. 93024 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$10.2	$0.0	$11.6	$11.6	$10.2	
Travel	$5.4	$0.0	$0.0	$0.0	$5.4	
Contractual	$7.0	$0.0	$111.4	$111.4	$106.0	
Commodities	$0.7	$0.0	$1.7	$1.7	$0.7	
Equipment	$0.0	$0.0	$0.0	$0.0	$1.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$23.3	$0.0	$124.7	$124.7	$123.3	
General Administration	$2.0	$0.0	$9.5	$9.5	$9.0	
Project Total	$25.3	$0.0	$134.3	$134.3	$132.3	
Full-time Equivalents (FTE)	0.2	0.0	0.4	0.4	0.3	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Staff Biologist GS 11/3	0.0	$0.0	1.3	$4.5
Fisheries Biologist GS 9/1	0.0	$0.0	1.3	$3.5
Fisheries Technician GS 5/1	0.0	$0.0	1.3	$2.3
Program Manager	0.0	$0.0	0.3	$1.4
Personnel Total	0.0	$0.0	4.2	$11.6

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994

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Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project: Coghill Lake Fertilization
Agency: Dept. of Agricu[illegible] Forest Service

FORM 3A
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EXXON VALDEZ [hole-punch] STEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:	Reprt/Intrm	Remaining
Travel Total	$0.0	$0.0

Contractual:		
Fertilizer (based on Fish & Game projections of fertilizer needed)	$0.0	$106.0
Aircraft charter to transport and apply fertilizer to Coghill Lake (bid price)	$0.0	$5.4
Contractual Total	$0.0	$111.4

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1994

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Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project:
Agency: Dept. of Agriculture, Forest Service

FORM 3B
SUB-
PROJECT
DETAIL

Commodities:	Reprt/Intrm	Remaining
Field supplies	$0.0	$0.7
Sampling gear	$0.0	$1.0
Commodities Total	$0.0	$1.7

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94259
Project Title: Coghill Lake Sockeye Salmon Restoration
Sub-Project:
Agency: Dept. of Agricu[illegible] Forest Service

FORM 3B
SUB-
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EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title:	Shoreline Assessment and Oil Removal
Project ID number:	94266
Project type:	Research and Monitoring; General Restoration
Name of project leader(s):	Gail Irvine, NBS Mark Brodersen, ADEC
Lead agency:	ADEC
Cooperating agencies:	DOI-NBS, NOAA
Cost of project/FY 94:	$402.3K
Cost of project/FY 95:	$56.5K
Project start-up: Project Completion:	April 1, 1994 April 15, 1995 (Multi-year project)
Geographic area of project:	Kenai Peninsula, Alaska Peninsula, Prince William Sound,
Name of project leader:	Gail Irvine, NBS Dan Mann, NBS Mark Brodersen, ADEC
Name of lead agency project manager:	Ron Bruyere

accurate Environmental Sensitivity Index to be created by linking the persistence of oil to site classifications.

C. PROJECT DESCRIPTION

1. Injured Resources to be Addressed

This proposal addresses injury to the lost services of scientific, recreational, and park wilderness values in the national park areas affected by the Exxon Valdez Oil Spill. Additionally, sediments and designated wilderness have been identified as injured resources by the EVOS Trustees.

The specific areas that are being targeted for study are the sheltered, armored beaches that are at risk for retaining oil. Continuation of the study this summer will allow us to assess the current status of the sites and compare changes in both chemical and physical aspects of the oil. The 1992 study established study sites, developed sampling methodology, and obtained initial data for later determination of rates of physical and chemical change of oil. Sheltered beaches are being targeted in this study since past shoreline experience indicates that they are highly likely to retain oil after contact. The geomorphological component will allow correlation between the degradation rates and the shoreline classification. This will help identify areas that may still be retaining high levels of oil contamination in the extensive coastline affected by the EVOS, and will create a criterion for future oil spill contingency plans.

As stated above, investigation of chemical and physical degradation rates of oil will allow for appropriate decisions to be made regarding restoration activities (e.g. oil removal).

2. Relation to Other Damage Assessment/Restoration Work

1989-1991 Monitoring Programs

Between 1989 and 1991 several monitoring programs were initiated to define and monitor the fate and persistence of shoreline oil and the effects of winter storms. These programs were all short-lived and inconclusive.

The NPS established transects on nine oiled beaches in 1989 along the Katmai coast. These sites proved unsuitable for study the following year because they were either on beaches that were cleaned, or high energy beaches that were naturally cleaned by wave action. Reexamining these transects did, however, lead to the discovery that sheltered areas near the original study sites were still contaminated.

Exxon studied five representative test sites along the Katmai coast in 1989. These sites provided a cross-section of the most heavily oiled beaches with varying types of wave exposure and shoreline morphology. Periodic visits throughout the year

B. INTRODUCTION

The Exxon Valdez oil spill (EVOS) directly affected the scientific and recreational values and wilderness characteristics of shorelines of three national park areas, namely Kenai Fjords National Park, Katmai National Park and Preserve and Aniakchak National Preserve and Monument. Injury to Kenai Fjords and Katmai National Parks is addressed in this part of the project description.

These injured values and characteristics continue to be injured by the persistence of oil that degrades the "naturalness" of the coasts. These values and characteristics are clearly stated in both ANILCA (1980) and the Wilderness Act (1964). The National Park Service (NPS) initiated a research and monitoring study in 1992 to determine the relative physical and chemical degradation rates of *Exxon Valdez* oil stranded on beaches in Kenai Fjords National Park and Katmai National Park and Preserve. The study included an assessment of the geomorphological characteristics of each site so that trends in degradation of oil could be correlated with geomorphology.

The NPS (now NBS) study focuses on the natural degradation rate of surficial and buried oil mousse, a type of oil more resistant to degradation and more prevalent throughout the Gulf of Alaska than in Prince William Sound. A parallel study conducted in Prince William Sound by NOAA has shown that the geomorphology of PWS differs from the NPS study areas. Oil degradation rates could differ based on variance in geomorphology or variance in the type of oil stranded.

Chemical degradation rates are monitored by comparing gas chromatography/mass spectroscopy (GC/MS) analysis of oil samples taken from the study sites each year since the spill. We are attempting to obtain and analyze some 1989 oil samples from the same or nearby sites for historical comparison. Physical degradation rates are assessed quantitatively by changes in physical coverage of the oil.

The slow rate of degradation expected for stranded oil trapped in sheltered areas necessitates comparison of multi-year data. The data obtained in 1992 allowed for establishment of "baseline" conditions of the physical and chemical nature of stranded oil in armored beaches of the Gulf of Alaska. Further study is necessary in order to establish rates of degradation, both chemical and physical. In 1992, sampling showed that pockets of stranded oil still contained toxic components that could be released into the environment by heavy storms or other similar disturbances.

Documentation of physical and chemical degradation rates, coupled with an assessment of the magnitude of continuing injury, will allow for appropriate decisions to be made regarding restoration actions (e.g. oil removal). This study also provides new research results on the physical and chemical changes in stranded oil mousse through time. The geomorphological component of this project will allow a more by consultants to Exxon, and detailed surveys of surface and subsurface oil coverage were conducted. The data collected during this study are proprietary and subject to litigation and have not been made available to the public in spite of the new data-sharing agreement between Exxon and the State and Federal Trustees.

The 1989-1991 Kodiak interagency group, which included ADNR, ADEC, ADF&G, NOAA, and the NPS, collected similar shoreline data at four sites. These sites were eventually abandoned for various reasons but at least one oil sample was collected at each of the four sites. The ADEC maintains these unanalyzed samples; these data are accessible through the NOAA Scientific Support Coordinator in Anchorage.

The ADEC study showed that physical and chemical weathering gradually removed surficial oil from boulder faces during the three-year study but persistent mousse impact, which underlies boulders and cobbles at a number of sites, was expected to remain for some time.

The state study did not include GC/MS analyses of oil mousse samples to isolate chemical degradation rates from physical processes. However, oil samples were collected, frozen, and archived by ADEC.

It is hoped that existing data generated by historical studies can be used to create a multi-year degradation study. However, we have had difficulty obtaining the historical samples.

3. Objectives

The overall purpose of this project is to determine the status of shoreline recovery. The more specific objectives are:

1. To continue monitoring the chemical and physical degradation of oil at permanently marked sites along the Kenai Fjords and Katmai National Park coastlines to establish rates of degradation.

2. To evaluate existing conceptual models of shoreline geomorphology and oil persistence using data from this project to refine our understanding of shoreline sensitivity. This analysis may also allow identification of other sites of persistent oil contamination that may warrant restoration.

4. Methods

The 1992 NPS study focused on sites where oil mousse had been consistently observed since 1989 according to the comprehensive surveys done by Exxon, ADEC, NPS, USGS and NOAA. These surveys showed that oil mousse remained in a relatively unchanged physical condition in interstitial spaces on boulder beaches and locally-protected substrates. The choice of such sites allows for long-term monitoring of oil degradation rates under the most conservative conditions. Approximately 15 sites were assessed for inclusion in this study, with six of the most heavily oiled established as study sites. The following sites were selected for the NPS study.

	Katmai
Cape Douglas	K0909CD003A
Kiukpalik Island	K0914SK101A
Ninagiak Island	K0919HB050B
Kaflia Bay	K0923CG001A
Kashvik Bay	K0935KA002A
	Kenai Fjords
McArthur Pass	MR-1

At each of these study sites, a vertical transect was established and the head permanently marked. A horizontal transect was set along the highest concentration of oil and sampled. The area of surficial coverage on the transect line was quantified from photographs of a 0.30m x 0.50m quadrat with 0.05m grid squares placed over the numerous scattered oil patches. Emphasis was placed on the ability to replicate the protocol at exactly the same quadrat locations so that the same areas could be resurveyed and monitored for decreased oil persistence (physical degradation). Two oil samples were taken along the transect at each site to enable definition of chemical degradation of the oil. Historical samples of oil from the same locations are being sought in order to develop a longer time line for the chemical degradation process. Since the oil reaching these sites in 1989 was in the form of mousse, this study offers an opportunity to look at the longer-term degradation of this form of oil, which could differ substantially from the degradation of oil in Prince William Sound.

The 1994 methods will duplicate those of 1992 in order to ensure comparability of the data.

5. Location

The study will take place along the Kenai Fjords National Park and Katmai National Park and Preserve coastlines, at sites previously established in 1992 (see listing in Methods section). The spread of these sites, bordering the Gulf of Alaska, suggests that the results may be generalizable to this region. However, the results will relate to the identified geomorphologies of the sites.

No communities exist near these sites.

6. Technical Support

Hydrocarbon analysis (GC/MS) will be needed for the oil samples collected. Monies for hydrocarbon analysis inadvertently were not requested in January; previously this project had been part of the Oiled Mussel Project and hydrocarbon analyses for all sub-projects were included in the NOAA/NMFS section. Hydrocarbon analyses need to be run on 16 samples (12 samples from sites and 4 historical samples). These costs ($9K) are being requested as FY95 interim/report budget needs. We expect these samples to be analyzed by NOAA's Auke Bay Lab for consistency of comparison, and we have been told that samples taken this summer cannot be analyzed until 1995.

7. Contracts

In order to visit the remote sites included in this study, the services of a research vessel will be contracted. This contract is necessary because the NPS does not have appropriate vessels to accommodate this requirement. The NPS plans to use an extension of a boat contract that was competitively bid in 1992.

D. 1994 SCHEDULE

April	Coordination and planning with cooperating agencies; Confirmation of boat contract with Kittiwake II, Inc.
May/June	Procure supplies. Track down historical samples held by other agencies.
July/August	Field crew (4 members) reassessing study sites for approximately 10 days. Crew will be housed on the R/V Waters and access the sites by skiff.
August/September	Process and analyze data; record updating and data entry.
September/October	Report writing in cooperation with other agencies.
October/November	Draft Interim Report to Trustee Council.
June 1995	Draft Final Report (date dependent on completion of hydrocarbon analysis by Auke Bay Lab).

Personnel involved will include: Gail Irvine, Project Manager; Dan Mann, Geomorphologist; Joel Cusick, Biological Technician; 1 Surveyor.

E. EXISTING AGENCY PROGRAM

There are no other agency activities planned for the field this year that relate to this proposal or resource. The most closely related work, the Oiled Mussel Project, Gulf of Alaska, will be in the report-writing phase.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The ADEC will serve as the lead for NEPA compliance. An environmental assessment (EA) has been written to ensure compliance with NEPA.

G. PERFORMANCE MONITORING

This project will be supervised by Dr. Gail Irvine of the National Biological Survey (previously with the National Park Service). Dr. Irvine, a marine ecologist, will supervise the general scope of the project and will participate in the field work in order to ensure continuity with previous and future work. She will also function to integrate results of this study with those of the Oiled Mussel project being conducted in the Gulf of Alaska.

The geomorphologist is expected to be Dr. Dan Mann of the University of Alaska, Fairbanks. Dr. Mann has extensive experience in the dynamics of geomorphology of coastal areas of Alaska, as well as experience following the EVOS as a coastal geomorphologist assessing oil location and persistence. Mr. Joel Cusick will provide technical support for the project, and was previously involved in 1992. Additional surveying support will be provided by another technician.

There are no changes expected in NBS or NPS personnel during this fiscal year. If there are any personnel changes in the geomorphology position, an interagency agreement with the U.S. Geological Survey or the Minerals Management Service should enable another qualified geologist/geomorphologist to be brought into the project.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

There are no other similar projects that will be operating this year in the Gulf of Alaska, but results will be shared with other cooperators of this project, and chemical results will become part of the hydrocarbon database managed by the Auke Bay Lab. Discussion concerning exchange of results has been going on with a NOAA HAZMAT project in Prince William Sound, and sheen samples may be collected in conjunction with this project for a coordinated analysis with that project. Results of this project are expected to be compared with results of the Gulf of Alaska Oiled Mussel project (both being conducted by NBS, and supervised by Dr. Irvine).

I. PUBLIC PROCESS

The Shoreline Assessment and Oil Removal Project was reviewed by the Public Advisory Group. Public review also has occurred as part of the 1994 Work Plan public review process.

J. PERSONNEL QUALIFICATIONS

Dr. Irvine received her doctoral degree in Biology from the University of California at Santa Barbara in 1983, with an emphasis in Aquatic and Population Biology. She has a M.S. degree from the University of Washington in Zoology, and a B.A. (with honors) from the University of California, Santa Barbara. After receiving her Ph.D., Gail worked with the Minerals Management Service in Alaska, doing broad-scale analysis of effects of oil and gas activities on marine and coastal ecosystems, projecting likely effects of oil spills on pelagic, benthic and coastal biological communities. She was a technical reviewer on a multi-year oil spill project conducted by the Smithsonian Tropical Research Institute in Panama. Since joining the National Park Service in 1990, she has been involved in conducting research on intertidal ecology and has been supervising the Oiled Mussel, Gulf of Alaska and the 1992 predecessor to this proposal. Her position at the NPS has recently been transferred to the new National Biological Survey.

Dr. Dan Mann received his doctoral degree from the University of Washington, College of Forest Resources in 1983, with a dissertation examining the quaternary history of the Litaya Glacial Refugium, Alaska. He has additional research experience in the areas of Arctic soil genesis and geomorphology, glacial geology, fire history, landscape analysis, and sea level and tetonic history of coastal areas in Alaska. Following the Exxon Valdez oil spill, he worked as a coastal geomorphologist for Woodward-Clyde assessing oil pollution and cleanup methods. In the scope of that work he conducted winter monitoring of standed oil, and wrote summary reports on the oceanography, climatology and geology of southern Alaska.

Mr. Joel Cusick has a B.S. degree from Michigan Technological University. He has been working as a Biological Technician for the National Park Service since 1989. In 1989, he set up permanent transects along the Katmai National Park coastline to study oil persistence. He has been actively involved in the Oiled Mussel, Gulf of Alaska project and the 1992 Oil Persistence Project (the predecessor of this proposal).

K. BUDGET ($K)

See attached budget.

B. INTRODUCTION

Shoreline assessment activities in Prince William Sound in 1993 indicated that remaining subsurface oil was degrading with time, but that surface oil, mainly in the form of asphalt, had stabilized and that little reduction had occurred since 1991. Most of the remaining surface oil is around the community of Chenega. Residents of the area continue to express uncertainty about the health of subsistence resources, and that uncertainty has led to changes in traditional subsistence patterns. In addition, recreational users have expressed continuing concern about the visual impact of surface oil on the quality of the recreational experience. Also, recreational users have placed a high priority on removing rebar, flagging, signs, back-stakes, and other shoreline debris left on shorelines by cleanup and damage assessment crews. The primary purpose of this project is to manually break up the asphalt on the surface into small pieces that experience has shown will quickly degrade with the help of microbes and photo-oxidation. Removal of shoreline debris left by cleanup and damage assessment crews will be undertaken as possible.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

Residual surface oil has important social and economic consequences for subsistence and recreation. It may affect the safety of subsistence resources, residents' perception of the quality of subsistence resources, and subsistence use of resources on beaches with remaining surface oil. In addition, recognizable surface oil reduces the quality of recreation use of oiled beaches. These areas will improve over a long time period, but recovery will probably take many years. This does not appear to be acceptable to the people of Chenega Bay, who hunt and fish and beachcomb in the area adjacent to their village on a day-to-day basis. They have expressed continuing interest in accelerating the improvement through treatment of some kind.

The first purpose for the proposed action is to accomplish light-duty manual treatment of surface oiling at critical sites in order to accelerate natural degradation of the oil and help restore natural and human use of the resources at those sites.

This project will assess shorelines with surface oiling as determined by the 1993 shoreline assessment. If the shorelines are still oiled, the surface oil (mainly in the form of asphalt) will be manually broken up to accelerate natural degradation through microbial action and photo oxidation.

2. Relation to Other Damage Assessment/Restoration Work:

The project will be coordinated under the same ADEC manager as Project 94090, mussel bed restoration and monitoring, which will result in both administrative and logistic savings.

3. Objectives:

1. The overall purpose of the project is to accelerate natural degradation of surface oil (mostly asphalt) that still remains on some beaches as a result of the *Exxon Valdez* oil spill.
2. A secondary objective is removal of rebar, flagging, signs, back-stakes and other shoreline debris left by cleanup and damage assessment crews.

4. Methods:

The main treatment method will consist of manually breaking up asphalt and other heavily weathered materials to accelerate natural degradation. The asphalt in its present form is very stable. A small crew using tools such as pick-axes and shovels will be used to break up the asphalt. Once these materials are broken down into small pieces, sunlight and microbes quickly break the asphalt down further by oxidizing and metabolizing it. Occasionally, other simple and non-intrusive techniques will be used such as cleaning with absorbent materials in the few locations where sheening or other liquids are present. Experience from the clean-up and shoreline assessments in previous years shows that this treatment will enhance natural degradation and is unlikely to cause sheening or recontamination. The treatment will be accomplished by four to six-person crews recruited from Prince William Sound communities such as Chenega Bay under the supervision of a project manager or f[illegible] supervisor from the Alaska Department of Environmental Conservation.

The Alaska Department of Environmental Conservation, in conjunction with the other Trustee Agencies, the local community, and in consultation with the U.S. Coast Guard, will review the 1993 shoreline survey information and produce a list of potential subdivisions to be treated in 1994. An assessment of each site will be carried out to determine what changes, if any, have occurred during the winter. Field information will be recorded on forms standardized during previous surveys to facilitate comparison and compatibility with the existing databases. Sites that are found to still be in need of treatment will than be scheduled for treatment. Following treatment, sites will be monitored as logistics allow. An assessment of each treated site will be carried out at the end of the summer to determine the effectiveness of treatment.

Assessment surveys and treatment will be conducted daily during both low tide windows unless adverse weather conditions develop. Any restoration activities done in oiled mussel beds will be conducted in conjunction with Project #94090 to ensure appropriate treatment methods are used and to monitor the effectiveness of treatment.

The survey team will be housed in Chenega or berthed on a vessel as appropriate and use skiffs to access the shoreline. Float planes will provide logistics support. Previous *Exxon Valdez* assessment surveys have used these logistics as the most cost-effective and time-efficient support structure. Agency representatives will be chosen for their environmen[illegible] and habitat experience. Each person will have extensive *Exxon Valdez* spill experience[illegible]

5. Location:

This project will assess and treat *Exxon Valdez* impacted shorelines in Prince William Sound. The actual sites will be determined following review of the 1993 data. Probable areas are Knight Island segment 132, Latouche Island Segments 20B and 20C, Evans Island Segments 37, 38 and 39, Elrington Island Segment 20, and Bettles Island Segment EV53 in Prince William Sound. These areas are in proximity to Chenega Village.

6. Technical Support:

The project will require some data processing support to update existing files detailing the conditions of the specific beach segments that are cleaned. Production of some maps for the report will be necessary.

7. Contracts:

Local communities for labor
Helicopter for logistics and transportation of observers and scientists
Vessel for transportation and housing

D. SCHEDULES

May 1994	Coordination and planning with participating agencies
May 1994	Negotiate contracts with communities for crews
May 1994	Procure supplies Obtain Haz-Mat training
June - August 1994	Staff and crews in field 1. Treat beaches and mussel beds 2. Remove shoreline debris left from cleanup
September 1994	Record updating and data entry
October - April 1994	Report to Trustees

E. EXISTING AGENCY PROGRAM

None

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

An Environmental Analysis jointly written for shoreline treatment and mussel bed treatment is nearing completion. As in prior years, permits and notifications will be required by several permitting agencies. All permits will be obtained prior to commencement of field work. A letter notifying the following agencies must be sent prior to any field work:

1. Regional Response Team - Captain Bodrine - USCG
2. Department of Interior - Deborah Williams
3. ADEC - Water Quality - Doug Redburn
4. ADNR - Ron Swanson
5. All Native landowners whose lands are adjacent to the treatment sites.

Additionally, the EPA and USFS will be notified through the Regional Response Team.

G. PERFORMANCE MONITORING

A list of segments which will need to be assessed during the project will be prepared and distributed prior to shoreline cleanup. A report detailing restoration actions and their initial effectiveness at each shoreline segment will be produced following completion of the field work.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The logistics for restoration of shoreline assessment and oil removal from beaches will be shared and closely coordinated with the field needs and activities under Mussel Bed Restoration and Monitoring (#94090). ADEC will supervise the process of the actual cleanup of oil that occurs, while dialogue with both villagers and NOAA will aid in site selection and before and after sampling for petroleum hydrocarbon monitoring.

I. PUBLIC PROCESS

The public process for this project has been integrated with the Trustee Council process for the 1994 Work Plan.

J. PERSONNEL QUALIFICATIONS

RONALD J. BRUYERE

EDUCATION:

Graduate Studies, Department of Education, State University College of New York at Potsdam, Potsdam, NY 1982, 3.8 GPA

B.S., Mathematics, Physics, State University College of New York at Potsdam, Potsdam, NY 1975, 3.3 GPA

WORK EXPERIENCE:

2/94- Present Alaska Department of Environmental Conservation (ADEC), Anchorage, Alaska
Project Manager

Act as principal technical support between the Restoration Chief of ADEC and manage the projects that are part of the 1994 *Exxon Valdez* Oil Spill Work Plan.

May 1990 - 2/94: CACI, INC. - COMMERCIAL, Anchorage, Alaska
Project Manager

Responsible for hiring, training, tasking and directing a support staff of 11 people for a large restoration support contract with Departments of Justice and Agriculture. Coordinated all legal research that Department of Justice required within the facility. The facility housed the Restoration Planning Work Group and the complex support of the *Exxon Valdez* Restoration Team and Trustee Council in Anchorage, Alaska. The building located on two floors housed meeting and office space for seven Federal and State Agencies, and a public repository for oil spill research. Interfaced daily with agency representatives, scientific experts and attorneys. Delegated task assignments, monitored personnel, and closely coordinated project movement with the main office in Washington, D.C. [illegible]s ultimately responsible for all aspects of quality control at the site.

DATA PROCESSING EXPERIENCE:

IBM 9370 Series Model 2, Vax 8050, 8250, and 8550, IBM microcomputers, Optical Character Recognition (OCR) equipment and imaging. VM/CMS, CS/MVS, VMS, Word Perfect - 4.2, 5.0, 5.1, 6.0, Paradox, DBase III Plus, IV, BASIS, DM, Revelation, Nutshell Plus, Peachtree, Lotus, Excel, Bluefish, AMICUS, LEXIS/NEXIS, DW4, Inmagic, Procomm.

K. BUDGET

See attached.

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Shoreline Assessment & Oil Removal - Beaches in western Prince William Sound with remaining surface oil will be rehabilitated. Rehabilitation of beaches to be carried out in 1994 will be based on assessment findings in 1993 and confirmed in 1994.

Budget Category:	1993 Project No. 93038 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$170.1	$22.3	$95.8	$118.1	$40.8	FFY 95 costs are closeout costs for this project. FFY 93 activities did not include any oil removal.
Travel	$6.0	$3.2	$13.9	$17.1	$3.4	
Contractual	$252.1	$7.8	$205.8	$213.6	$5.2	
Commodities	$16.5	$0.2	$11.8	$12.0	$0.6	
Equipment	$5.0	$0.0	$8.9	$8.9	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$449.7	$33.5	$336.2	$369.7	$50.0	
General Administration	$40.0	$3.9	$28.8	$32.7	$6.5	
Project Total	$489.7	$37.3	$365.0	$402.3	$56.5	
Full-time Equivalents (FTE)	2.7	0.3	1.7	2.0	1.6	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
See Individual 3A Forms for Personnel Details				
Personnel Total	0.0	$0.0	0.0	$0.0

NEPA Cost: $5.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994

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Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Lead Agency: AK Dept. of Environmental Conservation

FORM 2A PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Shoreline Assessment & Oil Removal - Beaches in western Prince William Sound with remaining surface oil will be rehabilitated. Rehabilitation of beaches to be carried out in 1994 will be based on assessment findings in 1993 and confirmed in 1994.

Budget Category:	1993 Project No. 93038 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95
Personnel	$150.1	$22.3	$68.9	$91.2	$20.3
Travel	$6.0	$3.2	$10.0	$13.2	$3.4
Contractual	$252.1	$7.8	$180.8	$188.6	$4.9
Commodities	$16.5	$0.2	$7.8	$8.0	$0.2
Equipment	$5.0	$0.0	$8.9	$8.9	$0.0
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0
Subtotal	$429.7	$33.5	$276.4	$309.9	$28.8
General Administration	$37.0	$3.9	$23.0	$26.9	$3.4
Project Total	$466.7	$37.3	$299.4	$336.7	$32.2
Full-time Equivalents (FTE)	2.5	0.3	1.1	1.5	0.3

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt Project Manager	2.5	$15.8	6.0	$40.6
Restoration Specialist	1.5	$6.5	6.0	$22.6
Overtime (25% of RS time)	0.0	$0.0	1.5	$5.7
Personnel Total	4.0	$22.3	13.5	$68.9

Comment

NEPA Cost: $5.0

*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994

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Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: AK Dept. of Env[illegible]nental Conservation

FORM 3A SUB-PRO[illegible]CT D[illegible]

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:	Reprt/Intrm	Remaining
Reprt Anchorage-Juneau ($450 air fare + 4 days per diem @ $150/day -- 2 trips)	$3.2	$5.2
Anchorage to Prince William Sound ($300 air fare + 2 days per diem @ 150/day -- 8 trips)	$0.0	$4.8
Travel Total	$3.2	$10.0

Contractual:		
Vessel contract	$0.0	$40.0
Airplane contract	$0.0	$10.0
Contract(s) with communities for labor	$0.0	$104.0
Equipment rental (boats, motors, testing equipment, cleaning equipment, etc.)	$0.0	$2.0
Reprt Telecommunications, fax, postage, and courier	$2.0	$3.0
Dispose of oily waste	$0.0	$7.0
Reprt Freight and cartage (move equipment, ship supplies)	$0.3	$0.6
Reprt Xerox, printing	$1.5	$3.0
Storage unit rental	$0.0	$1.8
Film processing	$0.0	$0.4
Training (hazardous materials)	$0.0	$3.0
Reprt Office space	$4.0	$0.0
Risk Management (mandatory insurance)	$0.0	$6.0
Contractual Total	$7.8	$180.8

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: AK Dept. of Environmental Conservation

FORM 3B SUB-PROJECT DETAIL

Commodities:	Reprt/Intrm	Remaining
Consumable office supplies	$0.2	$1.5
Computer supplies including upgrades	$0.0	$1.8
Consumable OSHA required field equipment (gloves, rain suits, hats, boots, cleaning supplies, survival equipment)	$0.0	$2.0
Small tools (shovels, picks, pry bars, buckets)	$0.0	$2.5
Commodities Total	$0.2	$7.8

Equipment:	Reprt/Intrm	Remaining
Laser printer	$0.0	$1.9
Computer - 486 with 400 meg hard drive and monitor	$0.0	$4.0
Safety equipment (mustang suits)	$0.0	$3.0
Equipment Total	$0.0	$8.9

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: AK Dept. of Env[illegible]ental Conservation

FORM 3B SUB-PR[illegible]CT DE[illegible]L

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Shoreline Assessment & Oil Removal - Seven sites will be assessed for the continued presence of hydrocarbons on the Alaska Peninsula. These sites have not been visited since 1992.

Budget Category:	1993 Project No. 93038 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$10.0	$0.0	$26.9	$26.9	$12.2	
Travel	$0.0	$0.0	$3.9	$3.9	$0.0	
Contractual	$0.0	$0.0	$25.0	$25.0	$0.0	
Commodities	$0.0	$0.0	$4.0	$4.0	$0.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$10.0	$0.0	$59.8	$59.8	$12.2	
General Administration	$1.5	$0.0	$5.8	$5.8	$1.8	
Project Total	$11.5	$0.0	$65.6	$65.6	$14.0	
Full-time Equivalents (FTE)	0.1	0.0	0.5	0.5	0.1	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Physical Scientist GS 11	0.0	$0.0	3.0	$11.2
Biological Technician GS 7	0.0	$0.0	1.5	$3.3
Project Manager	0.0	$0.0	2.0	$12.4
Personnel Total	0.0	$0.0	6.5	$26.9

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project: Gulf of Alaska
Agency: Dept. of Interior, National Biological Survey

FORM 3A
SUB-PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:	Reprt/Intrm	Remaining
Anchorage to Gulf of Alaska (3 trips - air fare $500/trip + $200 per diem)	$0.0	$2.1
1 staff to interagency meetings and symposia	$0.0	$1.8
Travel Total	$0.0	$3.9

Contractual:	Reprt/Intrm	Remaining
Vessel charter (12 days x $1645/day)	$0.0	$19.7
Film processing, reproductions	$0.0	$0.3
Helicopter charter (2 days x $2,500/day)	$0.0	$5.0
Contractual Total	$0.0	$25.0

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project: Gulf of Alaska
Agency: Dept. of Interior[illegible]onal Biological Survey

FORM 3B
SUB-
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Commodities:	Reprt/Intrm	Remaining
Safety, survival gear (radio, ELT batteries, survival suit)	$0.0	$0.8
Field gear (boots, rain gear)	$0.0	$0.3
Sampling jars	$0.0	$0.6
Sampling tools and supplies	$0.0	$0.3
Sample shipments	$0.0	$0.2
Film	$0.0	$0.1
Publication costs	$0.0	$0.7
Computer software upgrades	$0.0	$1.0
Commodities Total	$0.0	$4.0

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project: Gulf of Alaska
Agency: Dept. of Interior, National Biological Survey

FORM 3B
SUB-
PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Shoreline Assessment & Oil Removal - Oiling conditions on beaches in the spill area will be assessed by the agencies and the upland owner. Sites to be assessed will be based on the 1993 assessment and any additional information presented by interested parties. Rehabilitation of beaches to be carried out in 1994 will be based on assessment findings in 1993 and 1994.

Budget Category:	1993 Project No. 93038 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$10.0	$0.0	$0.0	$0.0	$8.3	The funds for 1995 are for hydrocarbon analyses of samples taken by National Biological Survey in 1994.
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$0.0	$0.0	$0.0	$0.3	
Commodities	$0.0	$0.0	$0.0	$0.0	$0.4	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$10.0	$0.0	$0.0	$0.0	$9.0	
General Administration	$1.5	$0.0	$0.0	$0.0	$1.3	
Project Total	$11.5	$0.0	$0.0	$0.0	$10.3	
Full-time Equivalents (FTE)	0.1	0.0	0.0	0.0	1.2	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Personnel Total	0.0	$0.0	0.0	$0.0

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: National Oceani Atmospheric Admin.

FORM 3A
SUB-PROJECT
D

Travel:	Reprt/Intrm	Remaining
Reprt		
Intrm		
Travel Total	$0.0	$0.0

Contractual:		
Reprt		
Intrm		
Contractual Total	$0.0	$0.0

07/14/93

Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: National Oceanic & Atmospheric Admin.

FORM 3B
SUB-PROJECT
DETAIL

Commodities:	Reprt/Intrm	Remaining
Reprt		
Intrm		
Commodities Total	$0.0	$0.0

Equipment:	Reprt/Intrm	Remaining
Reprt		
Intrm		
Equipment Total	$0.0	$0.0

07/14/93

1994

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Project Number: 94266
Project Title: Shoreline Assessment & Oil Removal
Sub-Project:
Agency: National Oceani[illegible] Atmospheric Admin.

FORM 3B
SUB-
PROJECT
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EXXON VALDEZ OIL SPILL DETAILED PROJECT DESCRIPTION

Project Title:	Chenega Chinook Release Program
Project Number:	94272
Project Type:	General Restoration
Project Leader:	Jeff Olsen, PWSAC Operations Manager
Lead Agency:	Ak. Depart. of Fish and Game (ADF&G)
Cooperating Agency:	None
Other Cooperating Parties:	Prince William Sound Aqua. Corp. (PWSAC)
Cost of Project, FY94:	$57,400
Cost of Project, FY95:	$36,000
Project Startup Date:	February 1, 1994
Project Completion Date:	June 30, 1994
Geographic Area:	Crab Bay near the Chenega village on Evans Island in PWS
Project Leader:	Jeff Olsen, PWSAC Operations Manager
Project Manager:	Joe Sullivan, ADF&G Resource Prog. Mgr.

INTRODUCTION

In 1992, the Alaska Department of Fish and Game (ADF&G), in cooperation with the residents of the village of Chenega Bay, proposed to the Exxon Valdez Oil Spill (EVOS) Trustee Council that local salmon runs be established at Crab Bay (Evans Island, PWS), near the Chenega village to restore damaged subsistence resources resulting from the Exxon Valdez oil spill in 1989. The ADF&G approached the Prince William Sound Aquaculture Corporation (PWSAC), which operates four salmon hatcheries in Prince William Sound, requesting use of a portion of the chinook salmon released from the Wally Noerenberg Hatchery for retoration purposes at Crab Bay. The PWSAC Board of Directors agreed to assist the ADF&G and the residents of Chenega with the proposed restoration project provided funding was made available and all permitting needs were met.

The proposal called for EVOS Trustees funding the release of hatchery fish at Chenega beginning in Spring, 1993. Due to timing requirements for planning, permitting and initiating such a release program, the proposed release could not be executed in 1993 and was delayed until 1994.

PROJECT DESCRIPTION

1. Resources and/or Associated Services:

This project will provide for the replacement of subsistence resources damaged by the EVOS. The residents of the Chenega village and local commercial and sports fisherman will be the principle beneficiaries of this project because of their proximity to the proposed release site.

2. Relation to Other Damage Assessment/Restoration Work:

This project will complement on-going efforts by the EVOS Trustee Council to restore and replace lost services.

3. Objectives:

The objectives of this project are:

A. Rear and release 50,000 Wally Noerenberg Hatchery chinook salmon smolt in Crab Bay near the Chenega village on Evans Island beginning in Spring, 1994.

B. Develop a return of 2,000 adult chinook beginning in 1998. At an average of 20 pounds per returning chinook, Chenega residents can expect to harvest 40,000 pounds of salmon annually. This projection is based on current fish culture criteria including marine survivals and growth.

4. Methods:

Annually, 820,000 chinook salmon eggs are taken at PWSAC's Wally Noerenberg hatchery (WNH) on Esther Island. Brood stock are harvested from among adult chinook salmon returning to the hatchery. Following incubation, hatch and outmigration from incubator trays, chinook fry are reared in raceways at WNH for one year. Prior to release, chinook smolts are transferred to saltwater net pens at the hatchery or to remote release sites for a short period of saltwater rearing.

Beginning the spring of 1994, 50,000 chinook smolt will be taken from WNH and transported via barge and fry/smolt transport tanker to Crab Bay. This operation will annually occur during May. The smolt will be released into a 350 m^3 (40 ft X 40 ft X 5 ft) net pen anchored in Crab Bay. Smolts will be reared for approximately two to three weeks at the site for imprinting and additional growth prior to release. Technical support for the incubation, hatching and feeding of the smolts will be provided by PWSAC. Residents of Chenega village will be trained as to the feeding schedule and feeding routine during the rearing period at Crab Bay.

The smolt will be released at the net pen location by removing net attachments from the floating platform and allowing fish to swim freely into the marine environment. The net pen will be annually transported from the Armin F. Koernig Hatchery (AFK) near the Chenega village on Evans Island and anchored at the release site. After the smolt are released, the net pen will be disassembled for transportation, or towed back to AFK hatchery.

5. **Location:**

The location for the release is in Crab Bay, located near the Chenega village on Evans Island in PWS.

6. **Technical support:**

Technical support for the project will be provided by PWSAC. Feeding at the release site will be accomplished by the residents of Chenega.

7. **Contracts:**

A contract between ADF&G and PWSAC will be required for the annual production and delivery of 50,000 WNH chinook salmon smolt to Crab Bay.

SCHEDULE

The project activities are as follows:

Activity	Begin	Complete
Eggtake	7/92	8/92
Incubation	8/92	3/93
Outmigration	3/93	4/93
Rearing	4/93	5/94
Acquire needed permits	9/93	3/94
Fabricate net pen	3/94	5/94
Install net pen	5/94	5/94
Feed and imprint smolt	5/94	6/94
Release smolts	6/94	6/94
Dismantle/Remove net pen	6/94	6/94

PWSAC hatchery staff from WNH, AFK and Cordova will provide the needed technical expertise to accomplish the above activities. The residents of Chenega village will be trained by PWSAC fish culturists to feed the chinook smolts during the final rearing and imprinting phase at Crab Bay.

EXISTING AGENCY PROGRAM

None

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

An Environmental Assessment (EA) is required for this project to comply with the National Environmental Policy Act (NEPA). Other permits including forms for completion and fees are required. Status of permitting and environmental compliance for this project is as follows:

Env. Compliance/Permit	Agency	Status
Environmental Assessment	NOAA	Complete
Hatchery Permit Alteration Req.	ADF&G	Complete

Env. Compliance/Permit	Agency	Status
Fish Transport Permit	ADF&G	Complete
Ak. CZMP Questionare	ADGC	Complete
Tidelands Use Permit	ADNR	Comp 4/94
Permit for anchors	Army COE	Complete
Letter of non-objection	ADNR	Complete
Insurance certification	ADNR	Comp 4/94
Bond	ADNR	Comp 4/94
Annual fee	ADNR	Complete
Document handling fee	ADNR	Complete

PERFORMANCE MONITORING

The number of adult chinook returning annually to Crab Bay will indicate the degree of success for the project

COORDINATION OF INTEGRATED RESEARCH EFFORT

Not Applicable

PUBLIC PROCESS

Alaska state law requires that PWSAC, as the regional aquaculture corporation in PWS, be comprised of representative of all interested user groups and possess a board of directors "which includes no less than one representative of each user group that belongs to the association". The concept of a regional association is intended to allow active public participation in the salmon rehabilitation program. The PWSAC board of directors is comprised of: commercial / sport / subsistence / personal use fisherman, native representatives from villages in PWS and the Copper River region, representatives of the fish processing industry and representatives of the communities in PWS.

To the extent that PWSAC is directed by a board of all interested users of the salmon resources in PWS, PWSAC will assist with this project and advocate for future funding.

PERSONNEL QUALIFICATIONS

Jeffrey B. Olsen

Work Experience

1989-Date: Operations manager for PWSAC. Oversee operations of five salmon hatcheries producing five species of Pacific salmon. Work with the PWSAC and regional planning groups to develop fish production goals. Responsible for achievement of hatchery production objectives.

1988-1989: WNH manager, PWSAC. Oversee operations of PWSAC's largest salmon hatchery. Responsible for production of four species of Pacific salmon.

1986-1988: WNH assistant manager, PWSAC.

1982-1986: AFK hatchery fish culturist and assistant manager, PWSAC.

Education

1977-1981: Univ. of Washington., B.S. Degree in Fisheries Science

BUDGET (attached)

EXXON VALDEZ TRUSTEE COUNCIL

1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

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Project Description: Chenega Chinook Release Program - This project will provide an alternative subsistence fishery for the village of Chenega through the stocking of Chinook salmon. This is necessary because of the loss of traditional subsistence food sources due to the Exxon Valdez oil spill.

Budget Category:	1993 Project No. 93016 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$0.0	$0.0	$3.4	$3.4	$3.4	FFY 93 costs were for NEPA compliance.
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$10.0	$0.0	$50.0	$50.0	$30.0	
Commodities	$0.0	$0.0	$0.0	$0.0	$0.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$10.0	$0.0	$53.4	$53.4	$33.4	
General Administration	$0.7	$0.0	$4.0	$4.0	$2.6	
Project Total	$10.7	$0.0	$57.4	$57.4	$36.0	
Full-time Equivalents (FTE)	0.0	0.0	0.0	0.0	0.0	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Program Manager	0.0	$0.0	0.5	$3.4
Personnel Total	0.0	$0.0	0.5	$3.4

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994

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Project Number: 94272
Project Title: Chenega Chinook Release Program
Agency: AK Dept. of Fish & Game

FORM 2A PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Commodities:	Reprt/Intrm	Remaining
Reprt		
Intrm		
Commodities Total	$0.0	$0.0

Equipment:	Reprt/Intrm	Remaining
Reprt		
Intrm		
Equipment Total	$0.0	$0.0

07/14/93

1994

Page 3 of 3

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Project Number: 94272
Project Title: Chenega Chinook Release Program
Agency: AK Dept. of Fish & Game

FORM 2B PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:	Reprt/Intrm	Remaining
Travel Total	$0.0	$0.0

Contractual:		
Contract for obtaining the necessary permits, constructing net pens, and obtaining, raising and releasing salmon near Chenega.	$0.0	$50.0
Contractual Total	$0.0	$50.0

07/14/93

Project Number: 94272
Project Title: Chenega Chinook Release Program
Agency: AK Dept. of Fish & Game

FORM 2B PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: SUBSISTENCE FOOD SAFETY TESTING

Project ID number: 94279

Project type: Subsistence

Name of project leader(s): Rita A. Miraglia

Lead agency: Alaska Department of Fish and Game

Cooperating agencies: National Oceanographic & Atmospheric Administration

Cost of project/FY 94: $268,300

Cost of project/FY 95: $198,900

Cost of Project/FY 96 and beyond: $90,000

Project Start-up/Completion Dates: 2/1/94 through 9/30/94

Geographic area of project: Prince William Sound, the lower Kenai Peninsula, Kodiak Island, and the Alaska Peninsula.

Name of project leader: Rita A. Miraglia

Name of lead agency project manager: Dr. Joseph R. Sullivan

B. INTRODUCTION

Subsistence uses of fish and other wildlife constitute a vital natural resource service that was injured by the *Exxon Valdez* oil spill. Data collected by the Alaska Department of Fish and Game's Division of Subsistence demonstrated this injury. Annual per capita subsistence harvests declined dramatically (from 12 percent to 77 percent decline compared to pre-spill averages) in ten of the communities in the path of the spill during the first year of the event. In subsequent years, levels of subsistence harvests, ranges of uses, harvest effort, and the sharing of resources have gradually increased in all of the spill area communities. Generally, subsistence uses rebounded first in communities of the Kodiak area and the lower Kenai Peninsula, but lagged a year or more in the Prince William Sound villages.

Reasons for increases in subsistence uses after the first post-spill year are varied and difficult to pinpoint. Some households had renewed confidence in traditional foods after receiving information and health advice from the Oil Spill Health Task Force. Others returned to using subsistence foods despite their misgivings because of economic and cultural reasons. Still others have traveled to unoiled areas, sometimes outside their traditional use areas, to harvest subsistence resources.

Concern over the long term health effects of using resources from the spill area contribute to the reduced harvest levels. These concerns include: 1) a loss of confidence on the part of subsistence hunters and fishermen in their own abilities to determine if their traditional foods are safe to eat; 2) a scarcity of some available resources (most notably, the failure of pink salmon and herring runs in 1993 and the observed scarcity of harbor seals in Prince William Sound); and 3) observed abnormalities in resource species. Even in 1993, more than four years after the *Exxon Valdez* oil spill, some subsistence users of the spill area were still raising questions and still looking for answers, as they had since the first post-spill year.

Although subsistence harvests and use had bounced back to pre-spill levels for most people and communities, a view persisted in the Prince William Sound communities, and to a lesser extent in the lower Kenai Peninsula and Kodiak Island communities, that the natural environment had changed in ways that still posed a potential threat to their health and their way of life. We propose to undertake a subsistence restoration project involving the following communities; Chenega Bay, Tatitlek, Nanwalek, Port Graham, Larsen Bay, Karluk, Old Harbor, Akhiok, Port Lions, Ouzinkie, Kodiak City, Chignik Lake, Chignik, Chignik Lagoon, Perryville and Ivanof Bay.

The incidence of subsistence food safety concerns related to the *Exxon Valdez* oil spill were evaluated in other communities in the first year of this project (Restoration Project Number 93017). As a result, Cordova, Valdez, Seldovia, Kenai, and Seward were dropped from the project because of the relative lack of such concerns. While some residents of these communities will continue to receive issues of the Subsistence Restoration Project Newsletter, we do not anticipate conducting any subsistence resource sample collection or testing, nor public meetings in these communities in 1994.

Residents of the Alaska Peninsula communities expressed less concern than residents of the Chugach and Koniag communities in the winter months of 1992-1993. However, in the spring of 1993, tar balls and dead murres washed up on the beach between Three-star Point and the Kametolook River, near Perryville. This event renewed concern over the possible effect of the oil spill on subsistence resources in the communities of the Alaska Peninsula, for this reason it may be necessary to do some subsistence resource sample collection and testing from this area.

The goal of the project is to restore the subsistence uses of fish and wildlife damaged by the *Exxon Valdez* oil spill. This is the second year of a proposed three year project; the 1994 plan builds on the results of the work done in 1993. Community meetings will be held in order to identify and map the specific areas and resources of continued concern to subsistence users. Samples of those subsistence species cited in community meetings as being of continued concern will be collected from harvest areas identified during the mapping. Community representatives will assist in site selection, as well as the collection of samples. This year is intended to be the final year of hydrocarbon testing, so the emphasis will be on testing resources and sites not previously tested, as well as some of the more heavily contaminated sites. The samples will be analyzed for the presence of hydrocarbon contamination, at the National Oceanic and Atmospheric Administration/National Marine Fisheries laboratory in Seattle. Community representatives from Kodiak Island will be transported to the lab and given a tour of the facilities. The results of the tests, along with findings from other damage assessment and restoration studies, will be interpreted by the Oil Spill Health Task Force, and reported to the communities in an informational newsletter and community visits.

This information will assist the Trustee Council in making decisions concerning restoration, enhancement or replacement of lost subsistence resources and uses.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

Subsistence uses of natural resources.

2. Relation to Other Damage Assessment/Restoration Work:

This project pulls together information from damage assessment and restoration projects regarding the oil spill injury to and recovery of various subsistence resources (including salmon, herring, harbor seals, ducks, and shellfish). This information is then put into context with the subsistence food safety advice, and presented to subsistence users in Oil Spill Health Task Force meetings, community meetings, household visits, and informational newsletters.

Information gathered as part of a study of oil spill impacts on the communities in the spill area, undertaken jointly by the Division of Subsistence and the U.S. Minerals Management Service, is also used to evaluate the effectiveness of this project and determine where more attention is needed.

3. Objectives:
The goal of the project is to restore the subsistence uses of fish and wildlife damaged by the *Exxon Valdez* oil spill.

4. Methods:
Community meetings will be held in Chenega Bay, Tatitlek, Nanwalek, and Port Graham, as well as a meeting for representatives from the Kodiak Island communities, to identify the specific harvest areas and resources of continued concern to subsistence users. Additionally, the Division of Subsistence will use the results of a joint study currently being conducted in cooperation with the U.S. Minerals Management Service in 15 communities impacted by the *Exxon Valdez* oil spill to determine the communities where concern continues to exist, as well as the nature of that concern. In 1993, those communities where no concern was indicated in either the community meetings or the joint Division of Subsistence/Minerals Management Service study were dropped from the study. This will also be the case in 1994.

Samples of subsistence foods will be collected from representative harvest areas identified during the mapping as either being persistently oiled, or of especial importance to subsistence users. Depending upon the comments at the community meetings, it is likely we will be sampling finfish and shellfish from the harvest areas of the communities, and may also take samples of seals and ducks harvested for subsistence use by local hunters. Four samples would be taken from each fish and shellfish site during each sampling trip. It is necessary to test the fish and shellfish at different times of the year, because uptake and accumulation of hydrocarbons is influenced by temperature, as well as by the reproductive cycle. There will be two sampling trips, one in the summer and the other in the fall. The selection of species will take into account concerns expressed in the community meetings. Community representatives will assist in site selection, as well as the collection of samples.

All samples will be analyzed for the presence of hydrocarbon contamination or metabolites. The results of the tests, along with findings from other damage assessment and restoration studies, will be interpreted by the Oil Spill Health Task Force, and reported to the communities in a series of informational newsletters and community visits.

As in 1993, site selection will be done by the Subsistence Division in consultation with the communities. The collection of samples will be contracted out to the Pacific Rim Villages Coalition under a government to government agreement. The Pacific Rim Villages Coalition was formed by the village corporations of Chenega Bay, Tatitlek, Port Graham and Nanwalek with Chugach Alaska Corporation, and is endorsed by the village councils of Prince William Sound and the lower Kenai Peninsula. The Pacific Rim Villages Coalition will be required to (1) hire a biologist to train local assistants and to supervise the collection of samples, (2) schedule two collection trips to each study community, in coordination with the Division of

Subsistence and the study communities, (3) collect samples of finfish and shellfish at predetermined sites near the study communities, handling the samples according to a protocol established by the Division of Subsistence and the National Marine Fisheries Laboratory, which is attached (Appendix A), (4) pack the samples, and send them to the National Marine Fisheries Laboratory, again following the protocol, (5) provide the Division of Subsistence with a report after each sampling trip detailing sample collection, handling and delivery, including copies of all relevant field notes, and an inventory of samples. Collection of any seal and duck samples will be carried out by local subsistence hunters in cooperation with Alaska Department of Fish and Game personnel. Testing of all samples will be done by the National Marine Fisheries Laboratory, to provide consistency with earlier studies undertaken by the Division of Subsistence and Exxon. Community representatives for the Kodiak Island communities, which were excluded by bad weather from the 1993 visit to the lab in Seattle, will be transported to the lab and given a tour of the facilities, with an explanation of the procedures used in the testing. Interpretation of the test results should be undertaken by the Oil Spill Health Task Force.

The communication of test results and the evaluation of the effectiveness of the program should be done by the Subsistence Division as the group with the expertise and community contacts. Communication of the test results and to residents of the impacted communities will require the production of a series of informational newsletters. It is important that the findings of damage assessment and restoration studies be integrated into this communication effort. As shown by the response to the failure of the pink salmon and herring runs in Prince William Sound in 1993, as well as the appearance of lesions attributed to viral hemorrhagic septicemia in the herring, such events have an impact on the confidence of subsistence users in the safety of the resources. The newsletter also serves to put such events into context for subsistence users, following an evaluation of the information by the Oil Spill Health Task Force. It will also be important to continue community visits. These can involve formal visits to households as well as more formal community or regional meetings. The purpose will be to further the dialogue that has begun to develop between researchers and the communities regarding study findings.

5. Location:
The project will be carried out in communities along Prince William Sound, the lower Kenai Peninsula, Kodiak Island and, if necessary, the Alaska Peninsula.

6. Technical Support:
Hydrocarbon assay and bile metabolite fluorescence tests will be conducted by the National Oceanic and Atmospheric Administration/National Marine Fisheries Laboratory in Seattle under the direction of Dr. Usha Varanasi.

Interpretation of the test results will be undertaken by the Oil Spill Health Task Force in cooperation with the appropriate state and federal agencies and the impacted communities.

7. **Contracts:**
The collection of fish and shellfish samples for testing will be done by the Pacific Rim Villages Coalition under a government to government agreement. The Division of Subsistence does not have personnel available to devote to this time consuming task as it has done in the past. Also, by contracting the work out to the Pacific Rim Villages Coalition, which is a joint undertaking by a number of village corporations in the area impacted by the *Exxon Valdez* oil spill, and endorsed by the village councils of Prince William Sound and the lower Kenai Peninsula, we can maximize community involvement and local hire on this project. This helps to increase the confidence of the target group in the reliability of the test results.

D. SCHEDULES

Note: there will be ongoing communication with subject communities throughout the duration of the project, with visits to communities as needed. Additional newsletters will be issued as events warrant it.

February-March 1994: Community meetings to report results of 1993 test results and to map areas and species of concern.

May-June 1994: Collect subsistence food samples for testing (anticipate 2 month turn around for test results).

August 1994: Informational newsletter issued.

August-September 1994: Collect subsistence food samples for testing.

September 1994: Tour of NOAA/NMFS lab for Kodiak community representatives.

November 1994: Informational newsletter issued.

April 1995: Final report to Trustee Council.

E. EXISTING AGENCY PROGRAM

The Division of Subsistence has been conducting annual household harvest surveys in many of the communities included in this project since 1989. As part of the interviews, we collect information on the relative degrees of confidence in the safety of subsistence resources, and fear of contamination. This is both a result of specific questions on this topic, and of answers to open ended questions regarding changes in the subsistence harvest. The surveys are continuing in the spring of 1994.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project is categorically excluded under NEPA guidelines.

A scientific collection permit will be obtained from the Alaska Department of Fish and Game to allow for the collection of fish and shellfish samples. We will not need a permit for the seal samples, as they will be taken from seals killed by subsistence hunters for food.

G. PERFORMANCE MONITORING

The progress of the project will be monitored by the Oil Spill Health Task Force, in consultation with the National Marine Fisheries Laboratory. In the past, the member groups in the Oil Spill Health Task Force have included the Indian Health Service, the North Pacific Rim (Chugachmuit), the Kodiak Area Native Association, the Alaska Department of Fish and Game, the United States Coast Guard, and the National Oceanic and Atmospheric Administration.

As noted above, the Division of Subsistence is conducting household interviews in many of the communities in the spill area in the spring of 1994, as part of these surveys we collect information on concerns regarding subsistence food safety arising from the oil spill. In those communities where we are not conducting surveys, progress will be monitored through community meetings, conversations with community leaders and informal visits to the community by researchers.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project pulls together information from damage assessment and restoration projects regarding the oil spill injury to and recovery of various subsistence resources (including salmon, herring, harbor seals, ducks, and shellfish). This information is then put into context with the subsistence food safety advice, and presented to subsistence users in Oil Spill Health Task Force meetings, community meetings, household visits, and informational newsletters.

I. PUBLIC PROCESS

This project involves an extensive public outreach effort, including bringing community representatives to meetings of the Oil Spill Health Task Force, community meetings to decide on the species and sites to be tested, contracting out the collection of samples, with local participation in the actual sample collection, a tour of the laboratory where tests are done for community representatives, and follow-up community meetings, household visits and informational newsletters to disseminate the test results and to answer questions about subsistence food safety and the *Exxon Valdez* oil spill.

J. PERSONNEL QUALIFICATIONS

James Fall

Dr. Fall is the regional program manager for the Division of Subsistence, Alaska Department of Fish and Game, for southcentral and southwest Alaska. He has held this position since 1981. Since 1989, he has supervised the division's oil spill response and research program. Also, he has served as the department's representative on the Oil Spill Health Task Force. Dr. Fall has written several articles and reports on the effects of the *Exxon Valdez* oil spill on subsistence activities and harvests, based upon division research.

Rita Miraglia

Ms Miraglia has served as the oil spill coordinator for the Division of Subsistence since 1990. As such, she has organized and participated in the subsistence resource collection and testing programs of 1990 and 1991, and has served as the project leader on the subsistence restoration project since 1993. She has also been the lead communicator of study findings to communities through organizing community meetings and writing newsletters. She has also assisted the Oil Spill Health Task Force's activities.

Craig Mishler

Dr. Mishler has been a Subsistence Resource Specialist with the Division of Subsistence since 1989, with primary responsibility for Kodiak Island. He organized and conducted the division's subsistence resource collection and testing program in the Kodiak Island area in 1990 and has participated in Oil Spill Health Task Force informational meetings there in 1989 and 1992.

Jody Seitz

Ms Seitz has worked as a Subsistence Resource Specialist with the Division of Subsistence since 1989, with responsibility for Prince William Sound communities sine 1991. She has participated extensively in Division of Subsistence research projects in these communities, including the collection of information about subsistence harvests after the spill.

Ron Stanek

Mr. Stanek has worked as a Subsistence Resource Specialist with the Division of Subsistence since 1980, with responsibility for Cook Inlet communities. He has participated extensively in Division of Subsistence research projects in these communities, including the collection of information about subsistence harvests after the spill.

K. BUDGET

(see attached)

APPENDIX A

SUBSISTENCE FOODS SAMPLING PROGRAM
Protocols for the Collection and Handling of Samples
Alaska Department of Fish and Game
Division of Subsistence
January 8, 1993

Chain of Custody

Chain of custody and collection forms (attached) will be used. The beach and water conditions (degree of oiling) will be clearly noted on the collection forms as well as the results of sight and smell tests conducted in the field. These waterproof forms will be placed in the zip lock bag with each individual tissue sample. Be sure that the species identification and sample location are displayed through the ziplock bag.

Field note books will be rite-in the-rain. Any deviation from protocol and the study plan can be documented in the field notes. The location of the sampling site will be determined with the aid of USGS grid maps or NOAA charts. The site locations should be plotted on the map.

Whenever samples are split, a separate chain of custody record will be prepared for each portion and marked to indicate with whom the samples are being split.

Evidence tape must be affixed to the shipping container before the samples leave the custody of the sampling personnel. The seal must be signed and dated before the container is shipped. The original chain of custody record accompanies the shipment; a copy is retained by the sample shipper. If samples are sent by common carrier, copies of all bills of lading or air bills must be retained as part of the permanent documentation.

Entries into the field logbooks or field data sheets are signed or initialed and dated by the person making the entry at the time of entry. Each days entries are closed out with a horizontal line, date and initial. Errors in field logbooks or other records are corrected by drawing a single line through the error, entering the correct information, and signing and dating the correction. Never erase an entry or any part of an entry. Do not remove the pages from the logbook.

Preparation

Aluminum foil will be cooked at 350 degrees Fahrenheit for one hour before it can be used to wrap tissue samples. All other sampling equipment will be washed using detergent and rinsed before and after each sample collection. This includes clam shovels, knives, containers, and gloves. Instruments used for exterior dissection must be cleansed before they can be used for internal dissection.

Collection Blank

At least one field blank and replicate sample should be taken for each collection site. A field blank is a sample container (foil and zip lock bag or bile container) opened in the field, closed and stored as if it contained a sample. Chain of custody forms will accompany blanks, and blanks will be sent to the laboratory.

Collection

The method of collection must not contaminate the samples. Do not collect any subsurface samples through surface slicks. Organisms to be analyzed for petroleum hydrocarbons should be freshly killed. Decomposed organisms should not be collected.

Fish will always be handled with latex gloves. Each fish will be brought on board the boat in a manner so as not to contaminate it with any petroleum products such as fuel, plastics, or fuel-soaked material. The fish will then be dissected in an appropriately clean container or on aluminum foil.

At least three fish of the same species must be sampled from each fin fish sampling site. Approximately 0.6 to 1.0 kilograms of edible tissue will be excised from each fish. This will provide sufficient tissue to perform chemical analysis. The dissected tissue will then be double-wrapped in aluminum foil and placed in a zip lock bag.

The bile of all fin fish will be collected by drawing it from the gall bladder with a sterile disposable syringe and injecting it into a collection vial. The vial will then be placed in a zip lock bag. The gall bladder may puncture and the bile get lost while the fish is being eviscerated. This should be clearly noted on the chain of custody form belonging to the fish from which the bile was lost.

Invertebrates will be collected with clean shovels. Samples should be taken at the same location and tidal elevation on both the June and September sampling trips. The samples will then be double wrapped in aluminum foil, in groups of ten to twelve individuals (this is referred to as a composite sample), and placed in a ziplock bag. At least three composite samples must be collected from each shellfish sampling site.

Identify the species of finfish and shellfish as clearly as possible. It is necessary to be very accurate so the species dependent differences in bile metabolites can be ascertained by the laboratory. If you are unsure of the species, write detailed descriptions of the animal in the field note book, including the color, size, shape, etc.

Each sampling site should be carefully defined and described in field notes and sketch maps so that the site can be resampled when desired. At least one member of the sampling team must be present at both the June and September sampling events to ensure consistency.

After they are wrapped and labelled, the samples will be placed in insulated coolers containing ice packs. Keep all samples from the same station together by placing them in a separate large plastic bag.

Sample Preservation
Samples must be kept cool. They should be frozen as soon after collection as possible, and the freezing process should be rapid. Once frozen, the samples must be kept frozen until extracted or prepared for analysis. Therefore, care must be taken that the samples remain frozen throughout the shipping process.

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Subsistence Food Safety Testing - This project is to restore the use of subsistence resources in PWS by testing subsistence resources for oil contamination and reporting those findings to the villages.

Budget Category:	1993 Project No. 93017 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$143.7	$71.8	$118.5	$190.3	$130.3	
Travel	$30.0	$10.0	$15.0	$25.0	$22.0	
Contractual	$85.5	$6.8	$86.3	$93.1	$12.3	
Commodities	$18.1	$11.0	$24.7	$35.7	$13.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$1.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$277.3	$99.6	$244.5	$344.1	$178.6	
General Administration	$29.8	$11.2	$23.8	$35.1	$20.3	
Project Total	$307.1	$110.8	$268.3	$379.2	$198.9	
Full-time Equivalents (FTE)	2.3	1.3	2.3	3.7	2.5	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
See Individual 3A Forms for Personnel Details				
Personnel Total	0.0	$0.0	0.0	$0.0

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

1994 Page 1 of 7

Printed: 3/16/94 11:41 AM

Project Number: 94279
Project Title: Subsistence Food Safety Testing
Lead Agency: AK Dept. of Fish & Game

FORM 2A
PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Subsistence Food Safety Testing - This project is to restore the use of subsistence resources in PWS by testing subsistence resources for oil contamination and reporting those findings to the villages.

Budget Category:	1993 Project No. 93017 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$78.5	$36.8	$58.5	$95.3	$101.3	FFY 95 costs may vary depending upon
Travel	$30.0	$10.0	$15.0	$25.0	$25.0	FFY 94 results.
Contractual	$85.5	$3.8	$86.3	$90.1	$130.1	
Commodities	$0.8	$0.5	$1.5	$2.0	$2.5	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$194.8	$51.1	$161.3	$212.4	$258.9	
General Administration	$17.8	$5.8	$14.8	$20.6	$24.3	
Project Total	$212.6	$56.9	$176.1	$233.0	$283.2	
Full-time Equivalents (FTE)	1.1	0.6	1.0	1.6	1.7	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt Subsistence Resource Specialist II	4.0	$17.7	8.0	$36.9
Subsistence Resource Specialist II	1.0	$5.7	0.0	$0.0
Subsistence Resource Specialist II	1.0	$4.6	2.0	$9.4
Subsistence Resource Specialist II	1.0	$5.4	0.0	$0.0
Research Analyst	0.0	$0.0	1.0	$5.5
Program Manager	0.5	$3.4	1.0	$6.7
Personnel Total	7.5	$36.8	12.0	$58.5

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

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Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Sample Collection/Field Work
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

EXXON VALDEZ [illegible]TEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:		Repr/Intrm	Remaining
Reprt 4 RT Anchorage-Kodiak = $760	Remaining 6 RT Anchorage-Kodiak = $1,140	$10.0	$15.0
4 RT Kodiak-Akhiok = $600	6 RT Kodiak-Akhiok = $900		
4 RT Kodiak-Karluk = $440	6 RT Kodiak-Karluk = $660		
4 RT Kodiak-Larsen Bay = $320	6 RT Kodiak-Larsen Bay = $480		
4 RT Kodiak-Old Harbor = $400	6 RT Kodiak-Old Harbor = $600		
4 RT Kodiak-Ouzinkie = $240	4 RT Kodiak-Ouzinkie = $360		
4 RT Kodiak-Port Lions = $400	4 RT Kodiak-Port Lions = $600		
2 RT Anchorage-Homer = $200	3 RT Anchorage-Homer = $300		
2 RT Homer-Port Graham & Nanwalek = $200	3 RT Homer-Port Graham & Nanwalek = $300		
2 RT Anchorage-Chenega Bay = $1,800	3 RT Anchorage-Chenega Bay = $2,700		
2 RT Anchorage-Tatitlek = $1,100	3 RT Anchorage-Tatitlek = $1,650		
2 RT Anchorage-Valdez = $320	3 RT Anchorage-Valdez = $480		
2 RT Anchorage-Cordova = $408	3 RT Anchorage-Cordova = $612		
Per diem = $2,835	Per diem = $4,200		
	Travel Total	$10.0	$15.0

Contractual:		
Reprt Two newsletters to communicate project results to the communities	$3.8	$4.0
Contract to collect subsistence resource samples from 8 native villages, two times a year. Samples to be collected are from mussels, butterclams, littleneck clams, rockfish, chitons, softshell clams, snails and sea urchins. In addition, five harbor seals (bile & blubber) and 20 ducks (skin & internal organs) will be taken depending on results from the FFY 94 sampling. These samples will be analyzed at the National Marine Fisheries Lab.	$0.0	$80.8
Copying and long distance phone charges	$0.0	$1.5
Contractual Total	$3.8	$86.3

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Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Sample Collection/Field Work
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-PROJECT
DETAIL

Commodities:	Reprt/Intrm	Remaining
Reprt Supplies (paper, maps, etc.)	$0.5	$0.5
Computer network charges	$0.0	$1.0
Commodities Total	$0.5	$1.5

Equipment:		
Equipment Total	$0.0	$0.0

07/14/93

Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Sample Collection/Field Work
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Subsistence Food Safety Testing - Hydrocarbon Analysis

Budget Category:	1993 Project No. 93017 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$65.2	$35.0	$60.0	$95.0	$115.0	
Travel	$0.0	$0.0	$0.0	$0.0	$2.0	
Contractual	$0.0	$3.0	$0.0	$3.0	$0.0	
Commodities	$17.3	$10.5	$23.2	$33.7	$3.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$1.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$82.5	$48.5	$83.2	$131.7	$121.0	
General Administration	$12.0	$5.5	$9.0	$14.5	$17.3	
Project Total	$94.5	$54.0	$92.2	$146.2	$138.3	
Full-time Equivalents (FTE)	1.2	0.7	1.3	2.0	2.4	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt Supervisory Chemist GS-13	1.5	$10.0	2.0	$13.2
Chemist GS-11	2.0	$10.0	3.5	$16.5
Biological Technician GS-7	2.4	$7.5	3.5	$10.5
Biological Technician GS-7	2.4	$7.5	3.5	$10.5
Phys. Science Technician GS-6	0.0	$0.0	3.5	$9.3
Personnel Total	8.3	$35.0	16.0	$60.0

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

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Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Hydrocarbon Analysis
Agency: National Oceanic & Atmospheric Admin.

FORM 3A SUB-PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

	Reprt/Intrm	Remaining
Travel:		
Travel Total	$0.0	$0.0
Contractual:		
Reprt Maintenance contract for analytical equipment	$3.0	$0.0
Contractual Total	$3.0	$0.0

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Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Hydrocarbon Analysis
Agency: National Oceanic & Atmospheric Admin.

FORM 3B
SUB-
PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Commodities:	Reprt/Intrm	Remaining
Reprt Chemistry lab supplies (glassware, gloves, stoppers, tubing, paper towels, scalpels and blades, eye guards, first aid supplies, protective clothing, instrument repair parts, filter paper, etc.)	$3.0	$7.0
Analytical grade solvents/chemicals	$7.5	$16.2
Commodities Total	$10.5	$23.2

Equipment:		
Equipment Total	$0.0	$0.0

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Project Number: 94279
Project Title: Subsistence Food Safety Testing
Sub-Project: Hydrocarbon Analysis
Agency: National Oceanic & Atmospheric Admin.

FORM 3B SUB-PROJECT DETAIL

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94285

RESTORATION SCIENCE STUDY PLAN

Project Title: Subtidal Monitoring: Recovery of sediments in the northwestern Gulf of Alaska

Project ID#: 94285

Project Type: Research/Monitoring

Project Leaders: Charles E. O'Clair, National Marine Fisheries
Stanley D. Rice, National Marine Fisheries Service

Lead Agency: National Marine Fisheries Service

Project Cost: FY94: $311.0K FY95: $129.3K

Start Date: March, 1994 Finish Date: September, 1995

Geographic Area of Project: Gulf of Alaska

Project Leader: Charles E. O'Clair

Project Manager: Bruce Wright

A. INTRODUCTION

Subtidal sediments were found to be contaminated by petroleum hydrocarbons at five locations in the Gulf of Alaska (GOA) in 1989. Although hydrocarbon contamination was usually confined to shallow sediments (0-3 m) in GOA, sediment contamination reached a depth of 20 m at least one location (Chugach Bay). Recovery rates of subtidal marine sediments contaminated by petroleum hydrocarbons at the latitude of GOA are poorly known. Recovery to background levels of hydrocarbons in subtidal sediments at the contaminated sites in GOA may be nearing completion. The purpose of this project will be to determine the amount of oil, if any, that remains in the subtidal sediments at the locations formerly contaminated by petroleum hydrocarbons in GOA and to compare the concentration of petroleum hydrocarbons remaining in sediments at those locations with that at comparable locations in Prince William Sound.

This study will provide the first assessment since 1990 of the contamination of subtidal sediments by *EXXON VALDEZ* oil (EVO) outside Prince William Sound. Because hydrocarbon contamination in GOA in 1989 was restricted to shallow depths (<20 m) and because hydrocarbon contamination below 20 m in Prince William Sound was attributable largely to petrogenic background rather than EVO we will restrict our attention to the depth range 0-20 m.

The present project will be linked closely with Project Number 94090, Mussel Bed Restoration and Monitoring where the sampling locations of the two studies overlap. The study will provide information on environmental hydrocarbon concentrations of use to the study on Subsistence Food Safety Testing (Project 94279) and to other studies where information on hydrocarbon exposure is required.

B. PROJECT DESCRIPTION

1. RESOURCES AND/OR ASSOCIATED SERVICES

The resource that will be monitored is subtidal sediments in the bathymetric depth range of 0 to 20 m on the Kenai and Alaska Peninsulas. Organisms associated with subtidal sediments include demersal fish and benthic invertebrates which may serve as food for certain diving birds and mammals. Some of these organisms are exploited for subsistence use. Investigators attempting to restore or monitor recovery of populations of these organisms following the *EXXON VALDEZ* oil spill must know the concentrations of petroleum hydrocarbons present in subtidal sediments to determine whether the organisms are currently exposed to elevated concentrations of petroleum hydrocarbons or are likely to carry a burden of petroleum hydrocarbons in their tissues above background.

2. RELATION TO OTHER DAMAGE ASSESSMENT/RESTORATION WORK

This study is designed to follow up on the results of NRDA study Air/Water #2. Sediment resources found to be damaged by the *EXXON VALDEZ* oil spill will be monitored for recovery. Part of this study will examine recovery of sediment resources shown to be damaged by NRDA Subtidal Study #1. This study is linked to Restoration Project #93047 which monitored recovery of sediment resources in Prince William Sound. The methodology used in all of these studies is virtually the same although the scope has changed from study to study. Restoration studies of biological systems may have need for the results of the present study for information on hydrocarbon exposure.

3. OBJECTIVES

1. Determine the composition and concentration of petroleum hydrocarbons from the *EXXON VALDEZ* oil spill in intertidal and subtidal sediments (0-20 m) in the Gulf of Alaska by GC/MS.

2. Compare concentrations of hydrocarbons in subtidal sediments outside Prince William Sound with concentrations at comparable depths inside the Sound.

3. Compare concentrations of hydrocarbons in subtidal sediments outside Prince William Sound in 1994 with concentrations found at the same stations in 1989 and 1990 and assess the extent of recovery of those sediments.

4. Complete hydrocarbon analysis of sediments collected in Prince William Sound in July 1993.

4. METHODS

The methods will be similar to those employed for sediment sampling under the Natural Resource Damage Assessment Air/Water Study Number 2 and Subtidal Study Number 1 and Restoration Project Number 93047. They are summarized briefly below. Sediment samples will be collected at one intertidal station and three subtidal stations. Intertidal collections will be made at a single tidal height in the range of +1 to -1 m relative to mean lower low water (MLLW) depending on the distribution of fine sediments. Three samples, each a composite of 8 subsamples, collected randomly along a 30 m transect laid parallel to the shoreline will be taken at each intertidal site. These samples will be collected at low tide or by divers.

Subtidal sediment collections will be made at 3, 6 and 20 m below MLLW. Collections will be made by divers on transects laid along the appropriate isobath and sampled in the same way as described above for the intertidal transects.

All samples will be taken from the surface (top 0-2 cm) of the sediment column. Samples will be collected using a chrome-plated brass core tube (3.6 cm inside diameter) and chrome plated spatula. Each subsample will be transferred to a sample jar using the spatula. The core tube and the spatula will be washed, dried and rinsed with methylene chloride between samples. Sample jars will be cleaned to EPA specifications for hydrocarbon sampling. The jars will be fitted with teflon lined caps also cleaned to EPA specifications. Samples will be placed in coolers with ice immediately after collection and will be frozen within an hour. Appropriate blanks will be collected at each site. Chain of custody procedures will be followed after collection of all samples.

5. LOCATION

This project will be undertaken at 7 sites in the Gulf of Alaska (2 reference sites and 5 contaminated sites) and two sites in Prince William Sound (1 reference site and 1 contaminated site). The sites will be Black Bay, Tonsina Bay, Windy Bay, Chugach Bay, Hallo Bay, Katmai Bay, Wide Bay, Northwest Bay and Olsen Bay (Figures 1 and 2). Except for Wide Bay which was sampled only in 1989 all sites were sampled at least once in 1989 and in 1990 under the NRDA program .

6. TECHNICAL SUPPORT

The project will require technical support in hydrocarbon chemistry (UV spectrophotometry and gas chromatography/mass spectrometry). The chemistry will be performed at the Auke Bay Laboratory. The cost of the hydrocarbon chemistry is included in the project budget.

7. CONTRACTS

A contract will be required to charter a vessel to collect the sediment samples for hydrocarbon analysis. The vessel must be capable of accommodating four scientists, be equipped to conduct diving operations and must have freezer space adequate for storing the sediment samples. The contract will be awarded by competitive bid. The vessel charter is necessary because there are no appropriate NOAA vessels available to support the study during the specified sampling period.

D. SCHEDULES

Sediment sampling will be conducted from 11 to 17 July 1994. Chemical analyses will be completed by November 1994. Data compilation and analysis will be completed by March 1995. A progress report will be submitted in November 1994 and a final report will be completed by April 1995. A vessel charter will be required to support the field sampling (see Contracts above).

Management Plan

Name	Responsibility
Stanley Rice	Overall management
Charles O'Clair	Management of data analysis and report writing.
Jeffrey Short	Management of chemical analyses.

E. EXISTING AGENCY PROGRAM

The agency will contribute the management salaries of Rice, O'Clair and Short (~$34K). The project will pay the salaries required for field work, analytical chemistry and data analysis. During the time period October 1, 1993 to September 30, 1994 the agency will complete hydrocarbon analysis, data compilation and analysis and report writing for the field study conducted in Prince William Sound in July 1993.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project will fall under the categorical exclusion within NEPA. The project will involve routine environmental sampling for which no requirement to undertake National Environmental Policy Act review is necessary.

G. PERFORMANCE MONITORING

Performance monitoring by the Program Manager, OOSDAR will take the form of review of the project status and final reports. The project status report will present the results of the field sampling and will give the progress on the chemical analyses and data compilation, analysis and interpretation. It will be submitted in November 1994. The final report will detail the distribution of petroleum hydrocarbons at previously contaminated sites in the Gulf of Alaska and will compare the concentrations with those at comparable depths at selected sites in Prince William Sound. That report will be submitted by April 1995. Both reports will be submitted to the Program Manager, OOSDAR through the Habitat Program Manager, ABL following in-house review.

The Project Leader and Chief Chemist will report directly to the Habitat Program Manager. Quality control measures in the field will be overseen by the Project Leader according to Standard Operating Procedures established for sediment sampling under NRDA. Quality assurance procedures for the hydrocarbon chemistry will be overseen by the Chief Chemist following analytical quality assurance standards established by NOAA under NRDA.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be closely coordinated with two ongoing restoration projects: Project Number 94090, Mussel Bed Restoration and Monitoring and Project Number 94290, Hydrocarbon Data Analysis and Interpretation.

Sampling by the present project will be closely coordinated with Project Number 94090 in Prince William Sound where the same sampling platform may be used. In the Gulf of Alaska this project will sample sediments near mussel beds studied by the mussel bed project in 1993.

Subtidal sediments collected under NRDA projects Air/Water Study Number 2 and Subtidal Study Number 1 and Restoration Project Number 93047 constitute a large proportion of the total number of sediment samples in the hydrocarbon database necessitating frequent interaction and close coordination between the project leaders of those studies and the leader of the database project (currently Project Number 94290, Hydrocarbon Data Analysis and Interpretation). This coordination will continue between the present project and Project Number 94290 and will involve strict adherence to chain-of-custody procedures by the present as well as close communication between the two projects on the disposition of the samples.

I. PUBLIC PROCESS

To date the general public has not been involved in the development or implementation of this project. However, the sampling methodology, sample site selection and levels of analyses used in those NRDA and restoration studies of subtidal sediments that have lead up to the present project have benefitted from public review as a result of the detailed study plan review process. The methods, some of the sites and the levels of analyses are the same for this study as for the previous studies. The Public Advisory Group will be contacted about whether additional sites on Kodiak and Afognak Islands should be included in the study.

J. PERSONNEL QUALIFICATIONS

See attached sheets.

K. BUDGET

See attached detailed budget developed for the *Draft 1994 Work Plan*.

Personal Qualifications

CHARLES E. O'CLAIR S.S. No.: 012-32-1851

Personal: Born May 29, 1941; Ayer, Massachusetts

Education: University of Massachusetts, B.S., Zoology, 1963
University of Washington, Ph.D., Fisheries, 1977

Experience: 1977 - present: Fishery Biologist (Research), National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. Research experience includes seven years of field and laboratory work on the effects of oil pollution and, later, the effects of logging on benthic invertebrates, eleven years of research on the ecology and behavior of Dungeness, king, and Tanner crabs in relation to the management of these species, four years of research on the impact of the *EXXON VALDEZ* oil spill on subtidal sediments in Prince William Sound and the Gulf of Alaska and one year on the recovery of subtidal sediments in Prince William Sound.

Selected Publications:

O'Clair, C. E. 1981. Disturbance and diversity in a boreal marine community: the role of intertidal scouring by sea ice. In The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. 2. D. W. Hood and J. A. Calder, Eds. University of Washington Press, Seattle. pp. 1105-1130.

O'Clair, C. E. and S. D. Rice. 1985. Depression of feeding and growth rates of the seastar Evasterias troschelii during long-term exposure to the water-soluble fraction of crude oil. Mar. Biol. 84:331-340.

O'Clair, C. E. and S. T. Zimmerman. 1987. Biogeography and ecology of intertidal and shallow subtidal communities. In: The Gulf of Alaska: Physical Environment and Biological Resources. D. W. Hood and S. T. Zimmerman, Eds. National Technical Information Service, Springfield, Virginia. pp. 305-344.

O'Clair, C.E., J.W. Short and S.D. Rice. 1993. Contamination of subtidal sediments by oil from the *EXXON VALDEZ* in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Symposium, February 2-5, 1993, Anchorage, AK. Program and Abstracts pp. 55-56.

O'Clair, C.E., J.W. Short and S.D. Rice. In prep. Petroleum hydrocarbon-induced injury to subtidal marine sediment resources. Available Auke Bay Lab., 11305 Glacier Highway, Juneau, AK 99801.

Personal Qualifications

Stanley D. Rice
Principal Investigator, ABL Habitat Program Manager

Received BA (1966) and MA (1968) in Biology from Chico State University, and PH. D. (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader, and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory EXXON VALDEZ damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chem labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

Figure 1. Study locations, Olsen Bay (1) and Northwest Bay (2), in Prince William Sound.

Figure 2. Study sites in the northwestern Gulf of Alaska. Numbered locations are: 1, Black Bay; 2, Tonsina Bay; 3, Windy Bay; 4, Chugach Bay; 5, Hallo Bay; 6, Katmai Bay; 7, Wide Bay.

EXXON VALD.. TRUSTEE COUNCIL

1994 Federal Fiscal Year Project Budget

October 1, 1993 - September 30, 1994

Project Description: Recovering Monitoring of Hydrocarbon-Contaminated Subtidal Marine Sediment Resources

Budget Category:	1993 Project No. 93047 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$99.7	$102.6	$73.2	$175.8	$102.0	
Travel	$12.6	$2.0	$9.6	$11.6	$2.0	
Contractual	$160.0	$0.0	$60.0	$60.0	$0.0	
Commodities	$18.0	$13.0	$20.0	$33.0	$10.0	
Equipment	$9.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$299.3	$117.6	$162.8	$280.4	$114.0	
General Administration	$26.2	$15.4	$15.2	$30.6	$15.3	
Project Total	$325.5	$133.0	$178.0	$311.0	$129.3	
Full-time Equivalents (FTE)	1.9	2.0	1.4	3.4	2.1	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt Program Manager GS-12	0.9	$4.4	0.6	$3.1
Project Leader GS-12	1.8	$12.4	1.2	$8.9
Chemist GS-11	7.0	$37.0	5.0	$26.4
Fishery Biologist GS-9	7.0	$28.9	5.0	$20.6
Zoologist GS-7	7.0	$19.9	5.0	$14.2
Personnel Total	23.7	$102.6	16.8	$73.2

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94285

Project Title: Subtidal Sediment Recovery Monitoring

Sub-Project: Sediment [illegible]rocarbons

Agency: National Ocea[illegible] & Atmospheric Admin.

FORM 3A SUB-[illegible]OJECT DETAIL

Travel:	Reprt/Intrm	Remaining
Reprt Juneau to Anchorage (2 trips - air fare $450 + $550 per diem)	$2.0	$0.0
Juneau to NE Gulf of Alaska and Prince William Sound (12 trips - air fare $450/trip + $800 per diem)	$0.0	$9.6
Travel Total	$2.0	$9.6

Contractual:		
Vessel charter to collect intertidal and subtidal sediment samples (25 days @ $2,400/day)	$0.0	$60.0
Contractual Total	$0.0	$60.0

Commodities:	Reprt/Intrm	Remaining
Chemical lab supplies	$7.0	$5.0
Laboratory solvents	$6.0	$4.0
Dive gear replacements	$0.0	$3.0
Field gear and sampling supplies	$0.0	$4.0
Office, mapping, computer software and upgrades (pencils, pens, paper, Excel, AutoCad, memory upgrade)	$0.0	$4.0
Commodities Total	$13.0	$20.0
Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94285
Project Title: Subtidal Sediment Recovery Monitoring
Sub-Project: Sediment …rocarbons
Agency: National Oce… & Atmospheric Admin.

FORM 3B
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DETAIL

94290

RESTORATION SCIENCE STUDY PLAN

Project Title: HYDROCARBON DATA ANALYSIS, INTERPRETATION AND DATABASE MAINTENANCE FOR RESTORATION AND NRDA ENVIRONMENTAL SAMPLES ASSOCIATED WITH THE *EXXON VALDEZ* OIL SPILL

Project ID#: ~~93053~~ 94290

Project Type: Technical Support

Project Leaders: Sid Korn, National Marine Fisheries Service
Jeff Short, National Marine Fisheries Service
Jeep Rice, National Marine Fisheries Service

Lead Agency: National Marine Fisheries

Project Cost: 105.5 K

Start Date: October 1, 1994 Finish Date: September 30, 1995

Geographic Area of Project: Entire Oilspill Area

Project Manager: Bruce Wright

A. INTRODUCTION

The Auke Bay Laboratory (ABL) has provided data archival and interpretive services for environmental samples that have been collected and analyzed for hydrocarbons in support of the Exxon Valdez NRDA and restoration efforts. The samples derive from all projects, investigators, and agencies (including both State of Alaska and Federal agencies) that have collected samples for hydrocarbon analysis. The general purpose of this project is to make a large and complex hydrocarbon database available to principal investigators, resource managers, and the public by providing user friendly services. The hydrocarbon database contains sample collection and chemical analyses information from thousands of samples from 1989 to the present. Briefly the database contains:

1) Sample collection information for >40000 samples including major sample types of sediment, tissue, water, and oil.
2) Hydrocarbon analysis information for >9000 samples, each sample analyzed has results for 73 analytes plus quality assurance data.
3) Bile and HPLC analysis for >2000 samples.
4) Data in support of NRDA and restoration projects over the period 1989-1992.

This project will provide the following:

a) Continued use and access of NRDA hydrocarbon data
b) Expansion of the hydrocarbon database with restoration data resulting in a consistent database allowing comparison of NRDA and restoration results
c) Interpretation of hydrocarbon results for PI's managers, and the public.
d) Continued quality control of sample storage, and hydrocarbon analyses.

Interpretive services include hydrocarbon data interpretation to identify probable sources of hydrocarbons found, evaluation of new hydrocarbon data for evidence of systematic bias, hydrocarbon data editing according to consistent criteria and hydrocarbon data mapping to facilitate identification of temporal and geographic trends of these data . The results of these efforts provide numerical correlates that are directly related to oil, and that may be used by PI's of other Restoration projects, by other governmental agencies, and by the general public, to assess associations of observed biological effects with concentrations of Exxon Valdez oil. These archival and interpretive services have been provided by staff at ABL for hydrocarbon samples generated for the Exxon Valdez NRDA effort, who have developed automated computer methods to insure that the various criteria are consistently applied to these data, and which result in computer-generated maps of the final results. The purpose of the presently proposed project is to integrate these additional data with the Exxon Valdez NRDA hydrocarbon database, and to continue to provide interpretive services, thereby insuring that hydrocarbon data resulting from Restoration efforts are directly and unequivocally comparable with the existing data.

B. PROJECT DESCRIPTION

1. RESOURCES AND/OR SERVICES

Data associated with hydrocarbon samples will be added to the existing Exxon Valdez database. Principle investigators from all projects collecting hydrocarbon samples will be assisted by this project through archival, interpretation, and mapping of their data. Data archival will include maintenance of a Rbase database with sample collection information and hydrocarbon results. This database allows inventory of hydrocarbon sample collection, and retrieval of collection and hydrocarbon results for PI and management use. Data interpretation will include examination of the data for evidence of systematic bias, which will provide the basis for an evaluation of data quality, and a probability based determination of sources of hydrocarbons found in samples. Finally, maps of specific hydrocarbon samples will be provided on request by principal investigators, government agencies, or the general public.

2. OBJECTIVES

The objective of this project is to apply and extend hydrocarbon interpretation methods and data archival developed in NRDA assessments to new samples analyzed for the Restoration effort, to insure the comparability of analytical and interpretive results with those of the NRDA effort, and provide access and continuing interpretive service to principal investigators using complex hydrocarbon data.

3. METHODS

Procedures developed during the NRDA effort will be followed in this project. Incoming samples are inventoried and collection information is entered into a database located at Auke Bay, AK and described by Manen et al, (1993). Hydrocarbon results returned from analytical laboratories are also added to the database. Hydrocarbon data will be evaluated using methods described in the final reports of Exxon Valdez NRDA project Subtidal #8 (in prep.). These methods were developed specifically for Exxon Valdez NRDA hydrocarbon data.

4. ALTERNATIVES

There are alternative database designs which were rejected because they are not completely compatible with NRDA data. Location of NRDA and restoration data in the same database was judged important for compatibility and comparison reasons. Two alternatives for evaluating hydrocarbon data quality and for interpreting and mapping hydrocarbon data were considered: (1) leaving these tasks to the PI's who collected samples for analysis, and (2) contracting these tasks to a private-sector consultant. Alternative (1) was rejected because many PI's do not have direct access to the expertise required (ABL staff include most of the agency chemists that participated in collection, analysis, and interpretation on Exxon Valdez NRDA hydrocarbon samples), because different PI's would almost certainly adopt different methods for data analysis and interpretation which would invalidate data comparison among projects, and because of anticipated inefficiencies that would result due to many PI's duplicating and re-inventing methods that are already standard procedures available at ABL. Alternative (2) was rejected because of anticipated inefficiencies that would result due to contractors' efforts to re-invent or acquire methods that are already developed and available at ABL, and because of the difficulty of stipulating contractual requirements that would guarantee strict comparability with existing Exxon Valdez NRDA data.

5. LOCATION

The project will be undertaken at the Auke Bay Laboratory in Juneau Alaska.

Benefits: Hydrocarbon sample data archival in the Exxon Valdez database will insure that these data are available to PI's, government agencies, and the interested public on a timely basis. The database will allow direct comparisons of restoration and NRDA data, and provide an inventory of hydrocarbon sample, collection, storage, analysis, and results. The continued use of the methods for hydrocarbon data evaluation and interpretation developed for the Exxon Valdez NRDA samples will insure direct comparability of future with previous samples, which will substantially increase the probability that temporal trends in these data will be detected when actually present. Principal investigators will be able to get assistance with chemical interpretation and mapping of hydrocarbon results from their project or other projects that relate to their project when needed. Since many PI's are not chemists, this type of assistance is usually required for proper interpretation of hydrocarbon results.

6. TECHNICAL SUPPORT

This project will provide it's own technical support including chemical, mapping and database needs.

7. CONTRACTS

No contracts are anticipated.

8. MITIGATION MEASURES

No mitigation measures will be part of this study.

D. SCHEDULES AND PLANNING

This project is an ongoing service task and therefore has few set milestone dates. All of the methods, including computer software written specifically for these tasks, have already been developed, tested, and applied. The requested funds are entirely for continuation of these services for additional data that will be produced by Restoration projects. A final examination of hydrocarbon data will be performed for all hydrocarbon data received as of September 15, 1993, and will be summarized in a report that will be completed by September 30, 1993. Interpretations and maps of hydrocarbon data will be provided on request. A publication describing the chemical interpretive methods will be completed in June 1993. A description of the database and CD rom disk containing the data is scheduled for release in April 1993. Sample data entry and interpretation depend on the timeframe of sample receipt, and analysis.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This is not a field study nor does it have any significant effect on the environment. Consequently, an Environmental Impact Statement or Environmental Assessment need not be provided.

All federal, state, and local laws are followed in the management of chemical analysis.

G. PERFORMANCE MONITORING

The portion of this project examination of hydrocarbon data for systematic bias is, in itself, a performance monitoring function. The performance of the methods developed for examination and interpretation of these hydrocarbon data have already been verified. Database integrity is assured by signed reviews of data entered by principle investigators. We will continue to follow all quality assurance procedures outlined in NRDA efforts.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project attempts to provide a common cross-over point for ALL projects involved with the EXXON VALDEZ oil spill by providing universal access to hydrocarbon data from all studies, and analyses and interpretations in a common format.

I. PUBLIC PROCESS

All principle investigators are encouraged to use interpretive services from this project. Since this is a very technical projects we do not expect public participation but would welcome suggestions from chemist, PI's and other interested parties.

J. PERSONNEL QUALIFICATIONS

GS-11 Fishery Research Biologist - Sid Korn

Education:
BA 1966, Nasson College
Graduate Studies 1967, Institute of Marine Biology, University of Miami
Graduate Studies, 1967-68, Humboldt State University
Numerous additional coursework including, fish physiology, Dbase programming, project management, supervision.
Relevant Experience:
1989-1990 Assisted Jim Price in development of the NRDA database and the management of incoming samples and database management.
1990-present Is the database manager of NRDA and restoration hydrocarbon data after the departure of Jim Price. Responsibilities include: supervision of data entry of sample and analytical data; processing and dissemination of data for principle investigators use; database management and design; setup and maintenance of GIS mapping system.

GS-13 Chemist - Jeffrey W. Short

Education:
BS, 1972, University of California, Riverside (Biochemistry & Philosophy)
MS, 1982, University of California, Santa Cruz (Physical Chemistry)

Relevant Experience:
1989 - Present: Established and manage the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the Exxon Valdez NRDA effort (about 20% of these samples were analyzed at ABL).
1989 - 1992: Principal Investigator, Exxon Valdez project Air/Water #3; Determination of petroleum hydrocarbons in seawater by direct chemical analysis and through the use of caged mussels deployed along the path of the oil spill.
1991 - 1992: Principal Investigator, Exxon Valdez project Subtidal #8; Development of computer-based statistical methods for global examination of sediment and mussel hydrocarbon data produced for the Exxon Valdez NRDA effort for systematic bias, and for identification of probable sources of hydrocarbons. In addition, this project produced both hard-copy and computer display maps of all the sediment and mussel hydrocarbon data.

GS-14 Physiologist - Stanley D. Rice

Principal Investigator, ABL Habitat Program Manager

Education:
Received BA (1966) and MA (1968) in Biology from Chico State University, and PH. D. (1971) in Comparative Physiology from Kent State University.

Relevant Experience:
1971-present: Employed at Auke Bay Fisheries Laboratory as a research physiologist, task leader, and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory Exxon Valdez damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chem labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

K. BUDGET

LITERATURE CITED

Carol-Ann Manen, and James R. Price, 1994 (In Prep) Natural Resource Damage Assessment; . Database Design and Structure. NOAA Technical Memorandum NOS/ORCA

EXXON VALDE[illegible]USTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Hydrocarbon Data Analysis and Interpretation and Sample Archiving

Budget Category:	1993 Project No. 93053 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$82.9	$61.0	$43.5	$104.5	$115.0	
Travel	$6.2	$2.0	$2.0	$4.0	$2.0	
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	
Commodities	$4.0	$1.5	$2.0	$3.5	$3.0	
Equipment	$0.0	$1.0	$1.5	$2.5	$1.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$93.1	$65.5	$49.0	$114.5	$121.0	
General Administration	$12.4	$9.2	$6.5	$15.7	$17.3	
Project Total	$105.5	$74.7	$55.5	$130.2	$138.3	
Full time Equivalents (FTE)	1.4	0.9	0.6	1.4	1.5	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt Program Manager GS-12	0.9	$4.4	0.6	$3.1
Project Leader GS-11	7.0	$43.8	5.0	$31.3
Chemist GS-13	1.8	$12.8	1.2	$9.1
Personnel Total	9.7	$61.0	6.8	$43.5

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94290
Project Title: Hydrocarbon Data Analysis & Interpretation
Agency: National Oceanic & Atmospheric Admin.

FORM 2A PROJECT DETAIL

Travel:	Reprt/Intrm	Remaining
Reprt Juneau to Anchorage (4 trips - air fare $450/trip + $550 per diem)	$2.0	$2.0
Travel Total	$2.0	$2.0

Contractual:		
Contractual Total	$0.0	$0.0

Commodities:	Reprt/Intrm	Remaining
Reprt Computer software upgrades	$1.5	$0.5
Office supplies, mapping	$0.0	$1.0
Freezer maintenance	$0.0	$0.5
Commodities Total	$1.5	$2.0

Equipment:	Reprt/Intrm	Remaining
Reprt Computer monitor	$1.0	$0.0
Freezer for archiving samples	$0.0	$1.5
Equipment Total	$1.0	$1.5

07/14/93

Project Number: 94290
Project Title: Hydrocarbon Data Analysis & Interpretation
Agency: National Oceanic & Atmospheric Admin.

FORM 2B
PROJECT
DETAIL

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94320A

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	SEA Program: Salmon Growth & Mortality
Project ID number:	94320A
Project type:	Research/Monitoring
Name of project leader(s):	Mark Willette
Lead agency:	Alaska Department of Fish and Game
Cooperating agencies:	University of Alaska Prince William Sound Science Center Prince William Sound Aquaculture Corporation
Cost of project/FY 94:	$282,164
Cost of project/FY 95:	$326,510
Cost of Project/FY 96 and beyond:	$322,510
Project Start-up/Completion Dates:	March 1, 1994 - September 30, 1994
Geographic area of project:	Prince William Sound
Name of project manager:	Joe Sullivan

B. INTRODUCTION

This project is a component of the Sound Ecosystem Assessment (SEA) program. SEA is a multi-disciplinary effort to acquire an ecosystem-level understanding of the marine and freshwater processes that interact to constrain levels of fish, and marine bird and mammal production in Prince William Sound (PWS). Pink salmon runs to PWS failed in 1992 and 1993. These salmon run failures have drastically affected the economy of the PWS region which is largely based on the salmon resources. It is essential that we develop an understanding of the processes that are causing these events. This information is needed to develop a strategy to restore salmon runs in PWS, if possible.

At the present time, it is not clear to what extent oil-spill impacts or environmental conditions may have caused the run failures in PWS. Restoration project 94191 (Injury to Salmon Eggs and Pre-emergent Fry in PWS) will determine if genetic damages to pink salmon may have reduced survival. The proposed project will contribute to a multi-disciplinary effort to determine if changes in the PWS ecosystem caused the run failures. Recruitment to adult salmon populations is strongly affected by mortality during the early marine period, because mortality at this time is typically very high (Parker 1968; Ricker 1976; Hartt 1980; Bax 1983). During this period, slow-growing individuals sustain a higher mortality, because they are vulnerable to predators for a longer time than fast-growing individuals (Parker 1971; Healey 1982; West and Larkin 1987). Low returns of hatchery-produced salmon in 1992 and 1993 indicates that the run failures were likely caused by processes occurring during the early marine period. Damage assessment studies on juvenile pink salmon in PWS have demonstrated that growth during the juvenile lifestage is related to survival to adult (Willette 1993). Growth rates of juvenile salmon were estimated in 1991 and 1992 after the fish were released from hatcheries. Juvenile growth and ocean temperatures were low in PWS during the early marine period in 1991. However, in 1992 juvenile growth and ocean temperatures were near average; although, zooplankton abundance was very low. The relationship between juvenile growth and mortality changed dramatically for pink salmon released in 1992 suggesting a change in predation rate.

C. PROJECT DESCRIPTION

This project will track the migration of juvenile salmon through PWS, estimate juvenile salmon growth, and contribute to studies of carrying capacity of the Sound. The project will complement other components of SEA by providing essential data needed to improve our understanding of the mechanisms regulating ecosystem function.

During the past decade, five salmon hatcheries have been established within PWS. These facilities, operated by private non-profit corporations, will release approximately 500 million juvenile salmon in 1994. Approximately one million of these fish will be marked with a coded-wire tag (CWT). Recovery of these CWT fish will play a major role in tracking the migration and growth of juvenile salmon.

1. **Resources and/or Associated Services:**

This project will focus on juvenile pink salmon (Oncorhynchus gorbuscha) in PWS. However, the information obtained from the study will also contribute to our understanding of the mechanisms affecting population dynamics of other juvenile fishes (forage fish) that serve as food for apex predators (marine birds and mammals). Project 94163 (Forage Fish) will examine competition for food among juvenile salmon, Pacific herring (Clupea harengus pallasi), capelin (Mallotus villosus), Pacific sandlance (Ammodytes hexapterus), and others. The Salmon Growth and Mortality component of SEA will provide data on diet composition of juvenile salmon, and collect samples of other juvenile fishes (sandlance, capelin, etc.) for later stomach analysis as part of Project 94163. The data from both of these projects will be used to evaluate the carrying capacity of PWS for juvenile fishes.

2. **Relation to Other Damage Assessment/Restoration Work:**

This project is a component of the Sound Ecosystem Assessment (SEA) program. During its first year, SEA will focus on the interactions of pink salmon and herring with other components of the PWS ecosystem. Several other projects complement SEA by providing SEA researchers with the data or tools needed to examine ecosystem function. These projects include Oil-related Egg and Alevin Mortality (94191), Pink Salmon Coded-wire Tag Recovery (94184), Pink Salmon Otolith Marking (94187), Pink Salmon Genetics (94189), Forage Fish Influence on Recovery of Injured Species (94163), Herring Spawn Deposition and Reproductive Impairment (94166), and Herring Genetic Stock Identification (94165). This project is also related to damage assessment project FS#4 Early Marine Salmon Injury Assessment in PWS.

3. **Objectives:**

This project will achieve the following six objectives in 1994.

1. Estimate the growth rate and condition of juvenile CWT salmon in PWS in 1994, and test for differences in growth rate among years (1989-1994).

2. Describe the migration of juvenile salmon through PWS, estimate migration rate, and provide inseason data to other SEA researchers.

3. Estimate diet composition of juvenile pink salmon in PWS in 1994, test for differences in diet composition among years (1989-1992, 1994), and collect juvenile fish stomach samples for project 94163 (Forage Fish).

4. Determine if the growth rate of juvenile salmon was likely limited by low food abundance in 1994.

5. Test for differences in the relationship between juvenile salmon growth and fry-to-adult survival among years (release years 1989-1993).

6. Develop techniques to estimate the mortality of juvenile salmon in PWS and the Gulf of Alaska.

4. Methods:

Objective 1:

Juvenile pink salmon will be collected using beach and purse seines deployed from a 6 m long aluminum skiff. Sampling will begin the first week of May and extend to the end of June. A 40 m long beach seine and 70 m long purse seine will be used to capture the fish. An approximately 25 m long vessel will provide logistical support to the field crew enabling them to track the juvenile salmon migration and obtain samples of fry from a large area. Juvenile salmon will be located from visual surveys of nearshore nursery habitats. The Nearshore Fish component of SEA will provide data on juvenile salmon distribution to the Salmon Growth and Mortality project. A portable tube CWT detector will be used to isolate CWT juvenile salmon from untagged fish in the catch. Approximately one fish in a thousand will be coded-wire tagged on average. As a result, a large number of juvenile salmon must be captured to obtain an adequate sample of CWT salmon. All CWT salmon will be retained for later analysis of growth. The total number of fish in the catch will be estimated volumetrically. Live fish will be placed in a volumetric beaker with a known volume of water. Displacement volume of the fish will be calculated by subtraction. The number of beakers of live fish in the total catch will be recorded. Total number of fish in the catch will be estimated from number of beakers and number of fish per displacement volume. Water temperature at 1 m depth will be measured at all sample sites using a thermistor.

A stratified-random sampling design will be employed to estimate the growth rate of juvenile pink salmon in PWS (Cochran 1977). Strata will be established based upon recovery date (May, June), hatchery, and treatment group. Previous studies of juvenile pink salmon growth in PWS have shown that growth sometimes differs among these groups (Willette 1993). An analysis of gain in precision will be used to identify strata that can be combined. Three treatment groups receiving different feeding regimes at the hatcheries will be employed: (1) an early-fed group composed of individuals released during high zooplankton abundance after 1-2 weeks of feeding in net pens, (2) a direct-release group released during high zooplankton abundance after only 2-5 days of feeding, and (3) a late-fed group released during declining zooplankton abundance and increasing temperatures after 1-2 weeks of feeding. Approximately 12 treatment groups will be released from all four pink salmon hatcheries in PWS in 1994. Therefore, it will likely not be possible to meet each of the sampling objectives for each of the treatment groups. The following criteria (listed in order of priority) will be employed in making sampling decisions in the field:

1) Recover a minimum of 100 tagged fish from each treatment group.
2) Recover fish from each treatment group in at least three different areas during a single sampling period.
3) Recover fish from each treatment group during at least three different sampling periods.

Coded-wire tags will be extracted and interrogated as they are recovered in the field. This will enable specific treatment groups to be targeted. More than one tag code is typically applied to each treatment group. Methods developed by the ADF&G CWT Laboratory for extracting and interrogating CWTs will be employed. Damage to the fishes' head will be kept to a minimum when dissecting CWTs. The remains of the head and the body will be placed in a pre-weighed vial and frozen. The vials will be weighed later on shore when accuracies of .01 g can be obtained. An exponential model will be used to estimate growth rates (G_i) of individual CWT juvenile salmon, i.e.

$$G_i = \frac{\ln(W_c) - \ln(W_r)}{t_c - t_r} \qquad (1)$$

where W_c is the weight of the fish at capture, W_r is the mean weight at release of the fish in a specific tag-code group, t_c is the date at capture, and t_r is the mean date at release. Analysis of variance (split-plot design) will be used to test for differences in growth rate among years. Recovery site will be used as the sample unit in the analysis. A nested model will be used with hatchery and treatment group nested within months (May, June) and years.

Condition of CWT juvenile salmon will be examined to evaluate feeding and growth conditions. The relationship between body weight (W) and length (L) will be described by

$$W = a L^b \qquad (2)$$

where a is the condition factor and b is the slope of the linear-transformed model (Ricker 1975). Analysis of covariance will test for differences in the intercept and slope of the linear-transformed model between years. Samples from all hatcheries, treatment groups, and months (May, June) will be pooled in the analysis. The slope of the regression (b) will be used as a measure of the condition of juvenile CWT pink salmon in different years.

Objective 2:

Immediately after the juvenile salmon are released from the Wally H. Noerenberg (WHN) Hatchery, the sampling crew will begin surveys of nearshore habitats adjacent to the hatchery. The sampling crew will start surveying at a distance from the hatchery and move toward it until juvenile salmon are encountered. It is expected that this approach will enable detection of the leading edge of the juvenile salmon migration as the fish move away from the hatchery. CWT juvenile salmon will be recovered from selected schools to determine the origin and time of release of the fish. The migration rate of juvenile salmon will be estimated during the initial phase of the migration from recovery of CWT fish. Later in the season after the fish have dispersed, it will likely not be possible to track the leading edge of the salmon migration or estimate migration rate. Information on juvenile salmon distribution will be radioed to other SEA program researchers focused on salmon predation. After the field season, the migration of juveniles through PWS will be described. The numbers of CWT juvenile salmon recovered at various sites will be summed for each hatchery. Maps will be prepared indicating the number of CWT juvenile salmon recovered from each hatchery at various sites in the Sound.

Objective 3:

Stomach contents analysis will be used to estimate diet composition of juvenile salmon, examine diet overlap among juvenile fishes, and determine if the growth rate of juvenile salmon was likely limited by low food abundance. A stratified-random sampling design will be employed to estimate diet composition of juvenile salmon. Strata will be established based upon date (May, June), area (Figure 1), and habitat type (shallow bay, moderate slope, steep slope adjacent to current). Site will be used as the sample unit in the analysis. Samples of untagged juvenile pink salmon (n = 15) will be collected between 1500 and 2100 hours from approximately 12 randomly selected sites within each strata. Samples will be preserved in 10% buffered formaldehyde solution. Whenever possible, samples of other juvenile fishes (forage fish) will be collected along with samples of juvenile salmon. These samples will be provided to project 94163 (Forage Fish) for stomach contents analysis. This approach will allow for a paired comparison of diet overlap among various species of juvenile fishes in PWS (see Project 94163 DPD).

Stomach contents analysis will be conducted later in the laboratory. Fish showing signs of regurgitation will not be included in the sample. Prey items in the gut will be identified to the lowest possible taxonomic level and enumerated. Prey biomass in each category will be estimated by the product of prey abundance and average prey wet weight (Coyle et al. 1990). Total stomach weight including contents and lining will be measured to an accuracy of 0.1 mg. A sample of individuals from a range of sizes (n = 100) will be used to estimate a regression equation relating fish total length to stomach lining weight. Total stomach contents weight will be estimated by subtracting estimated stomach lining weight from total stomach weight. Diet composition will be expressed as a proportion of total stomach contents weight. Stomach fullness will be expressed as a proportion of fish body weight.

An analysis of variance will be conducted to test for differences between years in total stomach contents weight and biomass in each prey category after the data are rank transformed (Conover and Iman 1981). Independent variables in the model will include date (May, June), area, and habitat type. Site will be used as the sample unit in the analysis of variance.

Objective 4:

A simple bioenergetics model will be applied to evaluate whether the growth of juvenile pink salmon was likely limited by low prey density in 1994 (Willette 1993). The model will estimate the time required for a 1 g pink salmon to obtain a maximum daily ration composed of either large or small copepods at specific temperatures and prey densities (Brett and Groves 1979). The time required to obtain a ration composed of mixed prey will be estimated from diet composition data and model estimates of feeding times required for large and small copepods, respectively. It will be assumed that approximately twenty hours is available for feeding in PWS during May and June. Feeding times in excess of twenty hours will indicate that the fish may not have acquired the daily ration. Holling (1966) developed a model to estimate the feeding rate of invertebrates in relation to prey density, i.e.,

$$I_f = \frac{\gamma p U}{1 + \gamma p U h} \tag{3}$$

where I_f is the feeding rate (g sec^{-1}), γ is the cross-sectional area of the reactive field (cm^2), p is the prey density (g cm^{-3}), U is the swimming speed (cm sec^{-1}), and h is the prey handling time (sec g^{-1}). This model was successfully used by Ware (1975, 1978) to estimate the feeding rate of fish. To account for prey that are attacked but not captured, equation (3) will be multiplied by the prey capture success rate. A prey capture success rate of 85% is typical for juvenile fishes (Ware 1972). The distance from which a fish will approach prey is called the reactive distance (Ware 1972). This distance is a function of fish size (Ware 1978) and prey size (Ware 1972). Data provided by Ware (1972) was used to estimate a regression equation relating reactive distance to fish length and prey length, i.e., $d_r = 0.29\, L_f^{1.1} + 3.3\, L_p$ ($r = .98$, $P = .005$), where d_r is the reactive distance (cm), L_f is total fish length (cm) and L_p is prey length (mm) (Willette 1993). Given d_r, the cross-sectional area of the reactive field (γ) is πd_r^2. Bailey et al. (1975) estimated that pink salmon swim at 11 to 20 cm sec^{-1} when feeding in currents. In the present study, an average swimming speed of 15 cm sec^{-1} will be assumed, because juvenile pink salmon are often observed feeding while swimming in currents. For a 1 g pink salmon, this is approximately the critical swimming speed, i.e. 3.0 body lengths per second. Parsons and LeBrasseur (1973) estimated the feeding rates of juvenile pink salmon in tanks at different prey densities. Their data have not be used to estimate feeding rates directly, because the prey densities used in their experiment were an order of magnitude greater than those measured in PWS. Their data were used to estimate handling times for fish feeding on Pseudocalanus spp. and Neocalanus plumchrus assuming an experimental duration of two hours. The inverse feeding rate (I^{-1}) will be used to estimate the time required for a fish to obtain the maximum daily ration.

The maximum daily ration will be estimated by a simple mass balance equation, i.e.

$$I_c = \frac{G + R}{A} \tag{4}$$

where I_c = food consumption (cal day^{-1}), G = growth rate (cal day^{-1}), R = total metabolism (cal day^{-1}), and A = assimilation coefficient. The temperature-specific growth rate (G) at maximum ration will be estimated from a regression equation relating temperature to the growth of juvenile CWT pink salmon in PWS (Willette 1993). The upper 95% confidence interval on predicted growth from the regression will be used as an estimate of growth at maximum ration. Data from laboratory studies will not be used to estimate growth at maximum ration, because estimated temperature-specific growth in PWS is approximately two times greater than in the laboratory (Kepshire 1976, Mortensen and Savikko 1991). An assimilation coefficient (A) of 0.86 will be used (Ware 1975). Total metabolism (R) is composed of feeding metabolism, standard metabolism, active metabolism, and migration metabolism (Brett and Groves 1979). Brett and Glass (1973) estimated the active metabolism (including standard metabolism) of sockeye salmon at the critical swimming speed. The critical swimming speed is the maximum speed that can be sustained without incurring an oxygen debt. The critical swimming speed is typically 2.5 to 3.0 body lengths per second. Juvenile pink salmon appear to swim at this speed while feeding along steep rocky shorelines (Bailey et al. 1975). Data provided by Brett and Glass (1973) will be used to estimate temperature-specific active metabolic rates for a 1 g pink salmon. Feeding metabolism is a function of the rate of food consumption, i.e. R_f = sI, where s is the weighted mean of the specific dynamic action factors associated with protein, lipid, and carbohydrate catabolism (i.e. ~0.16, Ware 1975). Feeding metabolism will be added to active metabolism after an initial estimate of food consumption. Migration metabolism will not be included in total metabolism, because active metabolism has been estimated while the fish were swimming at the critical speed.

Objective 5:

The relationship between juvenile growth rates and fry-to-adult survival will be evaluated from recoveries of CWT juveniles and adults. Restoration project 94194 (Pink Salmon Coded-wire Tag Recovery) will provide data on survival rates of CWT pink salmon released in 1993. Analysis of covariance will test for differences in the intercept and slope of the regression model between years. Mean growth and survival rates for fish from various treatment groups (early fed, direct release, late fed) will be used in the analysis. The independent variable will be release year with mean growth rate of juvenile pink salmon in each treatment group as a covariate. Only treatment groups with at least ten recoveries of juvenile CWT pink salmon will be included in the analysis.

Objective 6:

A feasibility study will be conducted to develop a techniques to estimate the mortality of pink salmon in PWS and the Gulf of Alaska. This critical element of the SEA program is intended to determine if year-class success is established in PWS. It is expected that a full-scale project will be initiated during the 1995 field season when otolith mass-marked pink salmon will be released from PWS hatcheries. The project will employ a technique developed by Parker (1968). In 1995, pit tags will be applied to large juvenile pink salmon (total length > 100 mm) captured near the southwest entrances to PWS. At about 100-125 mm in length, juvenile pink salmon migrate from bays and passages into the coastal zone adjacent to the Gulf of Alaska (Royce et al. 1968). If possible, pink salmon of primarily hatchery origin will be tagged, because in this case recovery of tagged adults will be greatly simplified. If wild fish are tagged, the tag recovery program will need to scan wild fish in hundreds of streams in PWS - greatly increasing the cost of the program. The feasibility study conducted in 1994 will determine if large juvenile pink salmon of primarily hatchery origin can be captured near the southwest entrances to PWS in large numbers. In early July, a purse seine vessel will use an approximately 250 m x 20 m (11/16 " stretch mesh) purse seine to capture juvenile salmon. The vessel and gear will be provided by the Salmon Predation component of the SEA program. The number of CWT fish in the catch will be estimated by passing the fish through a portable tube CWT detector. The total number of fish in the catch will be estimated volumetrically (see objective 1). The proportion of hatchery-origin fish in the catch will be estimated assuming a tag-to-untagged ratio of 1 in 600 (See Project 94184 DPD).

5. Location:

This project will be conducted in PWS which has experienced failures in both wild and hatchery salmon runs in 1992 and 1993. The economy in the PWS region is based upon these salmon resources. The economic health of the communities (Whittier, Valdez, Cordova) in this region is dependent on the salmon resource. During the first year of study, the project will focus sampling effort in western PWS which is known to be a major migratory pathway for juvenile salmon exiting the Sound.

6. Technical Support:

Hydroacoustic assessments of juvenile salmon distribution and abundance will be provided by the Nearshore Fish component of SEA. Data archiving services will be required for this project to insure that all information is adequately documented and archived. This service will be provided by the modeling and data management component of SEA.

7. Contracts:

An approximately 25 m vessel will be contracted to provide logistical support for the field crew. Vessel support is needed to provide the mobility needed to track juvenile salmon migrations. The vessel contract will be awarded through competitive bid.

D. SCHEDULES

The field season for this project will be from April to July of each year. Laboratory and data analysis will be conducted during the remainder of the year (Table 1).

Table 1: Schedule of project activities related to 1994 field season.

Time Period	Activity
Track Migration & Growth	
May 1 - June 30	Track migration and growth
July 6 - July 10	Sample juveniles exiting PWS
Laboratory & Data Analyses	
7/1/94 - 12/31/94	Conduct stomach contents analysis.
1/1/95 - 3/31/95	Analyze data and prepare annual report.

E. EXISTING AGENCY PROGRAM

The Prince William Sound Aquaculture Corporation (PWSAC) will provide logistical support to this project. Bunk space, shower facilities, and water will be provided to project vessels and crews at PWSAC hatcheries as needed. PWSAC will also apply coded-wire tags to nearly 1,000,000 juvenile pink salmon that will be released into PWS during April, 1994. These fish will provide an essential tool for researchers examining growth, migration, and predation on juvenile salmon in PWS. The ADFG is responsible for managing the pink salmon resource in the PWS area. The department enumerates pink salmon catch and escapement and forecasts returns from a pre-emergent fry index program. These activities provide essential data needed to estimate the survival of pink salmon returning to PWS each year.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project will qualify for an exclusion from the requirements of the National Environmental Policy Act. The project will not cause a significant environmental impact.

G. PERFORMANCE MONITORING

An annual report detailing the results from the previous year's investigations will be submitted by April 1 of each year.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be highly integrated with several other components of the SEA Program as well as other projects in the FY94 workplan. Within the Physical Oceanography component of SEA, conductivity, temperature, depth (CTD) profilers will be deployed from vessels working under Salmon Growth and Mortality. Within the Zooplankton component of SEA, zooplankton samples will be collected using nets deployed from vessels working under Salmon Growth and Mortality. Salmon Growth and Mortality will also provide fish stomach samples for the project 94163 (Forage Fish). The Pink Salmon Coded-wire Tag Recovery Project will provide data on survival rates of pink salmon released from PWS hatcheries. This data is essential to quantify the relationship between juvenile salmon growth and fry-to-adult survival. The Otolith Mass Marking Project (94187) will develop a new mass marking tool for pink salmon in PWS. Mass marking of juvenile salmon will greatly improve the feasibility of studies designed to examine interactions between wild and hatchery salmon during the early marine period. All data collected as part of Salmon Growth and Mortality will be provided to the Information and Modeling component of SEA. The data will be essential for development and implementation of ecosystem models.

I. PUBLIC PROCESS

This project was developed through three months of ecosystem research planning by the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG). The PWSFERPG conducted public meetings each week in the fall of 1993. Scientist from the University of Alaska, University of Maryland, Prince

William Sound Science Center, Prince William Sound Aquaculture Corporation, Alaska Department of Fish and Game, and U.S. Forest Service participated in the planning process. The resulting ecosystem research plan was reviewed by scientist from the United States and Canada at a public workshop held in Cordova, Alaska in early December 1993. The methods and results of Salmon Growth and Mortality will continue to be reviewed by various scientists within the Program Management component of SEA. A workshop will be held in the fall of 1994 to review the first year's results from Salmon Predation and other components of SEA. Results reviewed at the workshop will be preliminary, because all samples from the 1994 season will not be processed before December 31, 1994.

J. PERSONNEL QUALIFICATIONS

Mark Willette
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574
(907)424-3214

EMPLOYMENT:

March 1991 - present: Area Biologist with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Cordova, Alaska. Supervised by Dr. Stephen Fried. Conduct various fisheries enhancement and evaluation projects in PWS including juvenile salmon growth studies, lake stocking, limnological investigations of sockeye salmon producing lakes, and quality control of coded-wire tagging at private hatcheries. Conduct fisheries oceanographic studies in PWS in cooperation with private hatcheries and University of Alaska investigators. Chairman of PWS Regional Planning Team. Principal Investigator: Natural Resource Damage Assessment Study FS4A: Injury Assessment for Juvenile Salmon in Prince William Sound; Restoration Project R105: Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for Wild Salmon in Prince William Sound; Restoration Project 93024: Restoration of the Coghill Lake Sockeye Salmon Stock.

March 1986 - February 1991: Fisheries Instructor/ Assistant Reseach Professor, University of Alaska Fairbanks, School of Fisheries & Ocean Sciences, Supervised by Dr. Don Kramer. Conduct research on the effects of oceanographic conditions on the growth and survival of juvenile salmon in PWS, fish bioenergetics in an arctic lagoon ecosystem, age and growth of juvenile fish in the Chukchi and Bering Seas, ocean temperature variability in the North Pacific Ocean and effects on pink salmon production, salmon feeding on the high seas. Design and implement a program of education, research, and public service to promote fisheries development in northwest Alaska. Teach college level course in oceanography. Teach a marine safety and vocational training courses in fisheries.

EDUCATION:

1985 Master of Science, Fisheries Oceanography, University of Alaska Fairbanks.

1983 Bachelor of Science, Fisheries Science, University of Alaska Fairbanks.

Stan R. Carlson
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
34828 Kalifornsky Beach Rd, Suite B
Soldotna, Alaska 99669
(907)262-9368

EMPLOYMENT:

January 1993 - present: Biometrician for the Alaska Department of Fish and Game, Limnology Section, Commercial Fisheries Management and Develop Division, Soldotna, Alaska. Supervised by Dr. Dana Schmidt. Conduct statistical data analyses to evaluate factors that affect dynamics of the biota in lake ecosystems. Design limnological experiments and determine methods to estimate zooplankton and salmon abundance. Develop and approve methods to estimate hatchery contributions to the fishery. Develop, review, and conduct statistical analyses for projects related to the impact of oil on commercial fishery species. Provide biometrical consulting to area and regional biologists and statewide limnologists.

November 1991 - January 1993: Mathematical Statistician for the National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. Supervised by Mr. Steven Ignell. Conduct statistical studies on community attributes of pelagic fauna in the north Pacific Ocean. Provide biometrical consulting, technical editing, and collaborative input on projects such as salmon bycatch and climate change studies.

January 1989 - May 1991: Statistics Teacher, Experimental Statistics Department, New Mexico State University, Las Cruces. Supervised by Dr. Michael Ames. Instruct laboratory courses in statistics for undergraduate science majors.

May - August 1990: Research Specialist (statistician), Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University. Dr. Ellis Huddleston, Supervisor. Provide statistical modeling, analysis, and design of experiments related to agricultural field studies and pest management programs.

May - December 1988: Field Biologist, Biology Department, New Mexico State University. Supervised by Mr. Roger Skaggs. Conduct field population surveys and habitat analyses of night birds in Lincoln National Forest, New Mexico. Collect field data, supervise field personnel, and maintain data records. Develop operational strategies and conduct follow-up statistical estimation procedures.

August 1985 - June 1988: Graduate Assistant, Biology Department, New Mexico State University. Supervised by Dr. Ralph Raitt and Dr. Walt Whitford. Teach undergraduate biology and zoology laboratory courses. Collect data and maintain field ecology experiments for ecological research programs. Develop and conduct original field research on desert insect ecology.

June 1983 - May 1985: Research Specialist, Gordon Environmental Studies Laboratory, University of Montana, Missoula. Supervised by Dr. Philip Tourangeau. Manage data, conduct quality assurance/control procedures, and perform statistical analyses for environmental science projects. Aid in the design and implementation of field research, primarily in the area of pollution biomonitoring.

EDUCATION:

1991 Master of Science, Experimental Statistics, New Mexico State University.

1988 Master of Science, Biology (ecology), New Mexico State University.

1983 Bachelor of Arts, Environmental Biology, University of Montana.

K. BUDGET

Table 2: Budget summary for the Salmon Growth and Mortality component of the SEA program in FY94, FY95, and FY96 and beyond. Budgets for FY95 and beyond may change as information from the first year of study is applied to refine the methodology.

Line Item	FY94	FY95	FY96 and beyond
Personnel	124.1	161.8	161.8
Travel	0.5	0.9	0.9
Contractual	114.3	114.3	114.3
Supplies	12.6	13.2	13.2
Equipment	4.0	4.0	0.0
Total	255.5	294.2	290.2
Indirect Costs	26.6	32.3	32.3
Grand Total	282.2	326.5	322.5

References:

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Kepshire, B.M. 1976. Bioenergetics and survival of chum (Oncorhynchus keta) and pink (O. gorbuscha) salmon in heated seawater. Ph.D. Dissertation, Oregon State University.

Mortensen, D.G. and H. Savikko. 1991. The effects of water temperature on the growth rate of juvenile pink salmon (Oncorhynchus gorbuscha). NMFS, Auke

Bay Laboratory, Alaska, (in prep.)

Parker, R.R. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. J. Fish. Res. Bd. Can. 25:757-794.

Parker, R.R. 1971. Size selective predation among juvenile salmonid fishes in a British Columbia inlet. J. Fish. Res. Bd. Can. 28:1503-1510.

Parsons, T.R. and R.J. LeBrasseur. 1973. The availability of food to different trophic levels in the marine food chain. In: Marine Food Chains. J.H. Steele (ed.), Oliver and Boyd, Edinburgh.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fish. Res. Board Can. no. 191, 382p.

Ricker, W.E. 1976. Review of the growth rate of and mortality of Pacific salmon in salt water, and non-catch mortality caused by fishing. J. Fish. Res. Bd. Can. 33:1483-1524.

Royce, W.F., L.S. Smith, and A.C. Hartt. 1968. Model oceanic migrations of Pacific salmon and comments of guidance mechanisms. U.S. Fish and Wild. Serv., Fish. Bull. 66: 441-462.

Ware, D.M. 1972. Predation by rainbow trout (Salmo gairdneri): the influence of hunger, prey density, and prey size. J. Fish. Res. Board Can. 29: 1193-1201.

Ware, D.M. 1975. Growth, metabolism, and optimal swimming speed of a pelagic fish. J. Fish. Res. Board Can. 32: 33-41.

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Project Title: **ASSESSMENT OF JUVENILE SALMON GROWTH AND MORTALITY IN PRINCE WILLIAM SOUND**

Agency: Alaska Department of Fish and Game

Project Description: This project is a component of the Sound Ecosystem Assessment (SEA) program. SEA is a multi-disciplinary effort to acquire an ecosystem-level understanding of the marine and freshwater processes that interact to constrain levels of fish and marine bird and mannal production in Prince William Sound (PWS). This project will achieve the following objectives: (1) estimate the growth rate of juvenile salmon in PWS and test for differences in growth among years (1989-1994), (2) describe the migration of juvenile salmon through PWS, estimate migration rate, and provide inseason data to other SEA researchers (3) estimate the diet composition of juvenile pink salmon in PWS in 1994, test for differences in diet composition among years (1989-1992, 1994), and collect juvenile fish stomach samples for project 94163 (Forage Fish), (4) determine if the growth rate of juvenile pink salmon was likely limited by low food abundance in 1994, (5) test for differences in the relationship between juvenile salmon growth and fry-to-adult survival among years (1989-1993), and (6) develop techniques to estimate the mortality of juvenile pink salmon in PWS and the Gulf of Alaska. Field sampling will be conducted from early May to early July. An approximately 25 m vessel will be chartered to provide logistical support needed to track the juvenile salmon migration in PWS. Recoveries on coded-wire tagged juvenile salmon from PWS hatcheries will provide an essential tool for tracking migrations and estimating growth.

Budget Category	Proposed 01-Feb-94 31-Sept-94	FY 95	Sum FY 96 & Beyond
Personnel	$124,143.0	$161,843.0	####
Travel	$445.0	$890.0	####
Contractual	$114,350.0	$114,300.0	####
Commodities	$12,600.0	$13,200.0	####
Equipment	$4,000.0	$4,000.0	$0.0
Capital Outlay	$0.0	$0.0	$0.0
Sub-total	$255,538.0	$294,233.0	####
General Administration	$26,626.0	$32,277.0	####
Project Total	$282,164.0	$326,510.0	####
Full-time Equivalents (FTE)	1.9	2.5	2.5

Project Title: ASSESSMENT OF JUVENILE SALMON GROWTH AND MORTALITY IN PRINCE WILLIAM SOUND

	Cost
Travel:	
One round trip between Juneau and Cordova to have biometrician review data collection procedures in the field.	$350.0
Per Diem for biometrician	$95.0
Total	$445.0
Contractual:	
Air charter flights to transport staff from Cordova to the vessel.	$1,850.0
Charter for approximately 60' vessel to provide logistical support to track juvenile salmon migration	$112,500.0
Total	$114,350.0
Commodities:	
Office supplies	$1,600.0
Laboratory supplies	$4,900.0
Field sampling supplies (food, fuel, etc.)	$4,500.0
Utilities	$1,600.0
Total	$12,600.0
Equipment:	
One small mesh purse seine to capture juvenile salmon in the nearshore areas.	$4,000.0
Total	$4,000.0

Budget Year Proposed Personnel:

Position	Months Budgeted	Cost	Comment
Fishery Biologist IV	1.0	$5,168.0	Project Manager
Fishery Biologist III	3.0	$17,118.0	Project Leader
Fishery Biologist I	5.5	$35,237.0	Arrange vessel charter and supervise field sampling
Fishery Technician II	2.5	$16,885.0	Conduct field sampling
Fishery Technician II	2.5	$16,885.0	Conduct field sampling
Fishery Technician II	2.5	$12,280.0	Process CWT's on vessel
Fishery Technician II	1.0	$3,070.0	Data entry
Fishery Technician III	1.0	$3,500.0	Set-up and maintain database
Fishery Technician III	2.0	$7,000.0	Conduct stomach content analysis on juvenile salmon
Fishery Technician III	2.0	$7,000.0	Conduct stomach content analysis on juvenile salmon
Total		$124,143.00	

94320B

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	Coded Wire Tag Recoveries From Pink Salmon in Prince William Sound
Project ID number:	320B (94184)
Project type:	General Restoration and Research/Monitoring
Name of project leaders:	Samuel Sharr, Alaska Dept. Fish and Game
Lead agency:	Alaska Department of Fish and Game
Other Cooperating Parties:	Prince William Sound Aquaculture Corp. Valdez Fisheries Development Assoc.
Cost of project/FY 94:	$244.4
Cost of project/FY 95:	$244.4
Cost of Project/FY 96 and beyond:	$244.4
Project Start-up/Completion Dates:	October 1, 1993 through January 1996
Geographic area of project:	Prince William Sound

Project leader:

Sam Sharr (ADF&G) By Brian Bue — 3/4/94 Date

Agency project manager:

Joe Sullivan (ADF&G) — Date

B. INTRODUCTION

Wild stock production of pink salmon in Prince William Sound (PWS) ranged from less than one million to more than 21.0 million fish in the last three decades. Pink salmon play a major role in the PWS ecosystem. Migrating pink salmon fry are an important Spring food source for various fish, birds and terrestrial mammals. Marine mammals, birds, and fish also prey on the ocean life stages of pink salmon and returning adult salmon comprise a large portion of the summer diet of terrestrial mammals and birds such as bears, river otters, wolverines, bald eagles, gulls, and kittiwakes. Returning adult salmon which die in streams also provide a pathway for the transfer of nutrients accumulated from high seas marine areas to near shore and terrestrial ecosystems. As the principal species harvested in the PWS salmon purse seine fishery, pink salmon play a major role in the commercial fishing and fish processing industries which are the backbone of the economy in Cordova and other PWS communities. Ex-vessel values for this fishery ranged from 10 to almost 40 million through the 1980's.

PWS pink salmon returns originating from brood years subsequent to the March 24, 1989, *Exxon Valdez Oil Spill* (EVOS) have been aberrant or weak. Returns of wild and hatchery pink salmon in 1991 were only slightly below the mid-point of the pre-season foreeast but arrived late, had very compressed run timing, and the fish were small and of poor commercial quality. Returns of pink salmon in 1992 and 1993 were far fewer than expected. The 1992 return of wild pink salmon was the fourth smallest even year return in the last 30 years and the hatchery return was less than one third of expected. The 1993 return of wild pink salmon was the third smallest in the last 30 years and the hatchery return was less than one fifth of expected.

There is a growing body of evidence which indicates that the EVOS was partially responsible for weak pink salmon returns to PWS. Much of the spawning for wild pink salmon (up to 75% in some years) occurs in intertidal areas. Intertidal spawning areas are susceptible to marine contaminants and there is strong evidence the EVOS adversely affected spawning success and early marine survival in PWS. Pink salmon embryos incubating in the intertidal portions of oiled streams in western PWS have shown significantly higher mortalities than in nearby unoiled streams since 1989 (Sharr et. al. 1992). Despite apparent reductions in the amount of observable oil in intertidal salmon spawning areas since 1990, the differences in mortality between oiled and unoiled streams persisted in 1991, 1992 and 1993 and were also observed in spawning areas upstream of oil influence (Sharr et. al. 1993a and 1993 in prep.). These findings may be indicative of heritable genetic damage which has resulted in reproductive impairment among first and second generation fish originating from populations whose fry incubated in oiled streams in 1989 and 1990.

In addition to damage incurred during the embryo stages of development, pink salmon fry and juveniles rearing in the western portions of PWS in 1989 also exhibited reduced growth and survival (Willette 1993). Because almost all wild and hatchery fry exit PWS through straits and passages that were most heavily oiled, it is likely that at least portions of almost all pink salmon populations in PWS were damaged as rearing fry and juveniles in 1989. There are presently no data to substantiate any heritable damage to populations which traveled through and fed in oiled marine waters as fry in 1989. Nevertheless, such a possibility is at least plausible given the findings of Sharr et. al. (in prep.) relative to populations which incubated in oiled streams.

Although hatchery pink salmon production in PWS began in the 1970's, returns from maximum permitted levels of fry production did not occur until the late 1980's and early 1990's and coincided with the EVOS era. Wild salmon populations injured by the EVOS are heavily exploited in mixed stock commercial, sport, and subsistence fisheries which are dominated by these huge returns from more productive hatchery populations. Wild pink salmon populations originate from hundreds of streams in PWS. Migratory timing and abundance of wild returns in marine fishing areas varies among populations. To sustain production from wild populations managers must insure that adequate numbers of wild fish from all portions of the wild return escape fisheries and enter streams to spawn. To achieve this goal, mixed stock fisheries must be managed to achieve exploitation rates appropriate for less productive wild populations. Managers must therefore be able to distinguish wild from hatchery fish and estimate their relative spatial and temporal abundance in fishing areas.

Results of this study will provide accurate, real-time and post-season estimates of hatchery and wild contributions to commercial harvests by date and fishing district, hatchery cost recovery harvests, hatchery brood stocks and wild stock escapements. Catch contribution estimates for wild and hatchery fish and real-time escapement estimates from an Alaska Department of Fish and Game (ADF&G) aerial survey program will be used inseason by fisheries managers to reduce effort on damaged stocks and target effort on healthy hatchery returns. Post season analyses of current year as well as historic tag recovery data will be coupled with escapement data for wild populations to make estimates of total wild returns. These data are important as a tool for assessing the effectiveness of various management strategies. Post season analyses of tagging data will identify time and area distribution trends for wild and hatchery fish in fisheries. This information is important for fisheries managers who must anticipate the effects of fishing strategies in future years if injured populations are to be protected. Similar analyses of coded wire tag data funded by the NRDA and Restoration processes have been used to justify time and area fishery closures and effectively reduce exploitation on oiled populations in portions of southwestern PWS in 1990, 1991, 1992, and 1993.

The results of the coded wire tag recovery project are also critical to the success of an integrated package of Sound Ecosystem Assessment (SEA) studies (94320). The SEA proposal has roots in a broader SEA plan developed by the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG), a bioregional coalition of PWS scientists, resource managers, resource users, aquaculture associations, and communities, formed to "develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon...in PWS". Projects under the SEA proposal which address the relationship of pink salmon survival to fry outmigration timing, size, growth rate, and abundance; zooplankton population abundance, composition, and distribution and; predator population abundance, composition, and distribution all depend upon release group specific survival estimates provided by this project.

In the absence of improved stock specific management capabilities afforded by this project, salmon stocks in western PWS which have been injured and depleted by the oil impacts will potentially be over-exploited in the commercial, sport and subsistence fisheries. Population levels of stocks may be reduced below those needed for rapid recovery and in some instances may result in virtual elimination of impacted stocks. In the absence of survival estimates for specific hatchery release groups, provided by this project, other projects under the SEA umbrella which are designed to understand the role of natural and anthropogenic effects in controlling the abundance of pink salmon populations will fail.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

This restoration and monitoring project is designed to facilitate the recovery of wild pink salmon populations in PWS. The project is intended to provide fisheries managers with data pertaining to the stock composition of the catch. These data will be used for improving stock specific management capabilities in PWS fisheries thereby reducing the exploitation rate on salmon stocks in western PWS which have already been stressed and depleted by the oil impacts. Improved management will insure that damaged wild pink salmon populations are not reduced below those needed for rapid recovery. The monitoring portion of this project will track the recovery of damaged populations. Monitoring will also insure that fisheries alterations designed to direct fishing effort to areas of less oil impact do not inadvertently result in over exploitation of otherwise healthy wild populations which were not damaged by oil.

2. Relation to Other Damage Assessment/Restoration Work:

The foundations for this project were firmly established in joint feasibility studies which were conducted by ADF&G and non-profit aquaculture associations in PWS beginning in 1986 and extending through 1988. Results of these studies have been summarized by Peltz and Miller (1990), Peltz and Geiger (1990), and Geiger and Sharr (1990). During the damage assessment process large scale tagging and recovery projects were instituted and perfected by Natural Resources Damage Assessment (NRDA) Fish/Shellfish (F/S) Study #3. Damage assessment funds were expended for tagging hatchery releases of pink salmon in 1989 and 1990 and wild populations of pink salmon in 1990 and 1991 (NRDA F/S Study #3). Tag recovery efforts for wild and hatchery pink salmon were funded by damage assessment funds in 1989, 1990, and 1991 (F/S Study #3) and by restoration funds in 1992 and 1993 (Restoration Studies 60A and 93184). Results of damage assessment and restoration coded wire tag studies have been reported by Sharr et. al. (1993b, 1993c and 1993d). Following the loss of funds for further tagging of hatchery stocks of pink salmon in 1990, the private non-profit aquaculture associations in Prince William Sound have continued to tag pink salmon releases at their own expense. Tags applied to pink fry from the four pink salmon hatcheries in Prince William Sound in 1993 must be recovered. Prince William Sound Aquaculture Corporation (PWSAC), Valdez Fisheries Development Association (VFDA), and the ADF&G have pooled their resources to come up with approximately half of the funds required to field a full fledged pink salmon tag recovery effort in 1994. The additional funds to complete tag recovery efforts and data analyses are to be provided by the EVOS Trustee Council.

The pink salmon coded wire tag recovery project has complimented several other projects since 1989. Improved escapement estimates for PWS pink salmon from NRDA F/S Study 1 and restoration Study 60B were used in conjunction with catch contribution estimates from the Coded Wire Tag Recovery projects to adjust fishery exploitation rates and achieve wild stock escapements. Growth and survival estimates from NRDA F/S Study #4 could not have been obtained without F/S Study #3 which provided coded wire tagged fish of known origin and release timing for growth studies as well as estimates of survival to adulthood from coded wire tag recoveries in fisheries.

3. Objectives:

Funds which match those contributed by ADF&G, PWSAC, and VFDA will contribute to the completion of the following objectives for the 1994 salmon season in PWS:

a. make inseason estimates of the temporal and spatial contributions of tagged hatchery stocks of pink salmon to PWS commercial and hatchery harvests based on the number of tags detected in adipose clipped fish which are recovered during catch sampling;
b. provide timely inseason estimates of hatchery and wild stock contributions to harvests by time and area to fisheries managers so they can closely regulate exploitation of injured wild stocks;
c. use data from fully decoded tags recovered from commercial catches, cost recovery harvests, and hatchery brood stock to verify or adjust inseason contribution estimates;
d. estimate marine survival rates for each uniquely coded hatchery release group and;
e. write a final report which summarizes temporal and spatial distributions of hatchery and wild contributions to commercial and cost recovery harvests in PWS, survival estimates by stock, and fisheries management actions taken to reduce the exploitation on wild stocks based on in season catch stock composition estimates.

4. Methods:

Personnel policy, purchasing practices, field camp operations, safety procedures, and project administration will be in compliance the ADF&G Division of Commercial Fisheries Manual of Standard Operating Procedures (SOP). Data collection procedures are similar to those used in NRDA F/S Study #3. These procedures have been thoroughly reviewed by the NRDA peer review process and approved by the Management Team.

Tag Recovery

Commercial and Cost-Recovery Harvests

Recoveries will be stratified by district, week, and processor. This stratification was chosen as a result of the findings of Peltz and Geiger (1990) who detected significant differences between the proportions of some tag codes among such strata. The differences indicate that processors tend to receive catches from only certain parts of a district and is believed to be the result of traditional tendering patterns.

Recoveries of pink salmon tags from commercial and cost-recovery harvests will be made as fish are pumped from tenders onto conveyor belts at land-based processors located in Cordova, Valdez, Seward, Anchorage, Whittier and aboard a floating processor after each opening. Fish will be sampled by technicians standing beside the belt. Each sampled fish will be subjected to a visual and tactile examination for a missing adipose fin. It will never be possible for an observer to census all fish from a tender during the unloading process. However, on occasion, holding tanks in processing plants contain fish from only one tender and all fish in the tank are processed on the same processing line. In those instances it will be possible for an observers standing on the processing to get an independent census of an entire tender load which was previously sub sampled by technicians on the unloading conveyor. A Chi-square test of independence will be used to assess the randomness of samples taken during tender unloading procedures by comparing the rate of adipose clip occurrence in the subsample from the conveyor during the tender unloading process to the rate of clips observed during the complete census on the processing line.

Data recorded for each tender will include harvest type (i.e., commercial or cost-recovery catch), fishing district(s) from which the catch was taken, catch date, processor, and the number of fish examined. Catch data will be obtained later from fish tickets.

Heads of adipose-fin clipped fish will be excised, identified with a uniquely numbered cinch tag, and bagged. These heads will then be individually passed through a tag detector machine which produces an audible signal in the event that the head contains a coded wire tag. This procedure yields numbers of undecoded tags in the sample. Heads will then be frozen for subsequent shipment to the ADF&G Coded Wire Tag Laboratory in Juneau (Tag Lab).

Brood Stock Harvests

Tag shedding from release to return and differential mortality between tagged and untagged fish lead to discrepancies between marking rates at release and recovery. Hatchery brood stocks will be scanned for tags in order to estimate adjustment factors which can be used to account for the loss of tags from the population. Three assumptions inherent in the use of the brood stock for this purpose are a) it consists solely of fish reared at the hatchery, b) the propensity for a fish to lose a tag is similar for all fish marked at the same hatchery, and c) for a specific tag code, the marking rate in the commercial fishery is the same as that in the brood stock. In the current study, it is believed that the first of these assumptions had been violated at all facilities except the W.H. Noerenberg hatchery (Sharr et. al. 1993). Consequently, only the adjustment factor calculated from the brood stock from the W.H. Noerenberg hatchery is considered an appropriate quantity with which to adjust for tag loss and differential mortality. With respect to the second assumption, tagging practices vary little within a facility, and it is believed that the rate of tag loss and tag-induced mortality are similar for all fish tagged within a hatchery. The third assumption relates to the possibility of tag-induced straying of hatchery fish away from the brood. Some histological evidence to this end was referenced in Sharr et al. (1993 a), and some more direct preliminary evidence is discussed by Sharr et al. (1993c).

The adjustment factor may be defined as that quantity which, when multiplied by the marking rate in returning fish, yields the marking rate at release. The factor is 1.0 when there is no tag loss or differential mortality. The adjustment factor for hatchery h, a_h, will be estimated as the ratio of sampled fish in the brood stock to the expanded number of fish based on tags found in the sample :

$$\hat{a}_h = \frac{s_h}{\sum_i^T \frac{x_i}{p_i}} , \qquad (1)$$

where

T = number of tag codes released from hatchery h,

p_i = tagging rate at release for the ith tag code (defined as number of tagged fish released with the ith tag code divided by the total number of fish in release group i),

x_i = number of tags of the ith code found in s_h and,

s_h = number of brood stock fish examined in hatchery h.

The adjustment factor will then be used to adjust contribution estimates (Equation 3) if it can be shown that it was significantly greater than 1.0 at the 90% level. An appropriate test of the hypothesis :- $Ho : a_h \leq 1.0$ is given in Sharr *et al* (1993 b).

Brood stock samples will be taken during hatchery egg-take operations. Technicians, stationed at each of the four Prince William Sound pink salmon hatcheries, will examine approximately 95% of the fish through visual and tactile means for missing adipose fins. The number of fish sampled will be recorded and when adipose-clipped fish are found, the heads will be excised and shipped on a weekly basis along with sample data to the Tag Lab.

Tag Extraction, Tag Decoding, and Data Archiving

During the fishing season all sampling data and heads from fish adipose-clipped fish will be sent daily to the ADF&G Tag Lab. Data received at the Tag Lab will be logged and tag recovery sampling forms edited a second time for accuracy and completeness. Samples which affect critical fisheries decisions will be processed first. Tag lab staff will locate and remove tags from heads, decode extracted tags, and enter tag code and sample data into a statewide database accessible to biologists in Cordova. Completed tag recovery data for prioritized samples will be transmitted electronically to Cordova project personnel within 36 hours of the receipt of unprocessed data at the Tag Lab. In the following 12 hours Cordova project personnel will integrate tag recovery and catch data from the ADF&G fish ticket reporting system to estimate hatchery and wild catch contributions. Contribution estimates are used by fisheries managers to implement the inseason management actions required.

Following the fishing season, processing of all lower priority tag recovery samples will be completed by the Tag Lab. All tags recovered throughout the season will be examined a second time to insure that they have been properly decoded. All codes will be validated with a master Pacific States Marine Fisheries Commission (PSMFC) list of codes potentially present in Pacific coast fisheries. Fully edited tag code and sampling data from all samples collected during the season will be forwarded to the Cordova office for final summarization and analyses. A complete historic database of coded-wire tag information from Prince William Sound tagging and tag recovery programs will be maintained by the ADF&G Tag Lab, the PSMFC and, the Cordova ADF&G. The ADF&G historic fish ticket catch database is maintained at the ADF&G Juneau headquarters office and in the Cordova area office. All coded wire tagging and recovery data and all fisheries harvest data are freely available from any of these sources.

Estimation of Contributions and Survival Rates

Post-season Hatchery Contributions and Survival Rates

The contribution of release group t to the sampled common property, cost-recovery, brood stock and special harvests, and escapement, C_t , will be estimated as:

$$\hat{C}_t = \sum_{i=1}^{L} x_{it} \left(\frac{N_i \; \hat{a}_h}{s_i \; p_t} \right) , \qquad (2)$$

where

- x_{it} = number of group t tags recovered in ith stratum,
- N_i = total number of fish in ith stratum,
- s_i = number of fish sampled from ith stratum,
- p_t = proportion of group t tagged,
- a_h = adjustment factor associated with hatchery h, and
- L = number of recovery strata associated with common property, cost-recovery, brood stock, special harvests and escapement in which tag code t was found.

The contribution of release group t to unsampled strata, Cu_t, will be estimated from contribution rates associated with strata which were sampled from the same district-week openings as the unsampled strata:

$$\hat{Cu}_t = \sum_{i=1}^{U}\left[N_i * \left(\frac{\sum_{j=1}^{S}\hat{C}_{tj}}{\sum_{j=1}^{S}N_j}\right)\right], \qquad (3)$$

where

- U = number of unsampled strata,
- N_i = number of fish in ith unsampled stratum
- S = number of strata sampled in the period in which the unsampled stratum resides,
- C_{tj} = contribution of release coded with tag t to the sampled stratum j,

and

- N_j = number of fish in jth sampled stratum.

When a district-week opening is not sampled at all (an infrequent occurrence), the catch from that opening will be treated as unsampled catch of the subsequent opening in the same district.

An estimate of the contribution of tag group t to the total Prince William Sound return for 1994 will be obtained through summation of contribution estimates for sampled and unsampled strata. An estimate of the total hatchery contribution to the Prince William Sound return will be calculated through summation of contributions over all release groups. A variance approximation for $\hat{C}_t$, derived by Clark and Bernard (1987) and simplified by Geiger (1988) will be:

$$\hat{V}(\hat{C}_t) = \sum_{i=1}^{L} x_{it}\left[\frac{N_i\ \hat{a}}{s_i\ p_t}\right]\left[\frac{N_i\ \hat{a}}{s_i\ p_t} - 1\right]. \qquad (4)$$

Assuming that covariances between contributions of different release groups to a stratum can be ignored, summation of variance components over all tag codes will provide an estimate of the variance of the total hatchery contribution. Inspection of the formula given by Clark and Bernard (1987) for the aforementioned covariances shows them to be negligible for large N and s, and to be consistently negative, so that when ignored, conservative estimates of variance are obtained. Variances associated with unsampled strata are believed to be small (Sharr et al., 1993).

The survival rate of the release group coded with tag t (S_t), will be estimated as:

$$\hat{S}_t = \frac{\hat{C}_t + \hat{Cu}_t}{R_t} , \qquad (5)$$

where

C_t = contribution of release coded with tag t to sampled strata,

Cu_t = contribution of release group coded with tag t to unsampled strata,

R_t = total number of fish in release group coded with tag t released from hatchery.

Assuming the total release of fish associated with a tag code is known with negligible error, and that the cumulative variance contributions associated with the unsampled strata are small, a suitable variance estimate for $\hat{S}_t$ is given by:

$$\hat{V}(\hat{S}_t) = \frac{\sum_{i=1}^{L} x_{it} \left[\frac{N_i \hat{a}}{s_i p_t}\right]\left[\frac{N_i \hat{a}}{s_i p_t} - 1\right]}{R_t^2} . \qquad (6)$$

In-season Hatchery Contributions

Inseason fisheries decisions which must be made on very short notice require rapid, real time analysis of coded wire tag data. Two in-season estimates of hatchery contributions of pink salmon will be generated for each opening. The first and more timely estimate will be made using the method suggested by Sharr et al (1993 a). This method depends upon the number of tags (undecoded) detected in heads of adipose-clipped fish by a scanner sensitive to the magnetic field created by the tag. Estimation using undecoded tags required that assumptions be made about expansion ($1/p_t$) and adjustment (a) factors (see Equation 3). For fishery openings in the western and northern portions of Prince William Sound, late run hatchery returns from PWSAC facilities are assumed to be the only hatchery contributors. For openings in the Southwestern district, an expansion factor which is a weighted average of all expansion factors associated with tags released at the A.F. Koernig, W.H. Noerenberg and Cannery Creek hatcheries in 1992, will be used. The weighting scheme depends upon historical contributions of hatcheries to the district in question. The adjustment factor will be taken as a weighted average of the historical adjustment factor estimates for the same three hatcheries. A similar weighting scheme for expansion and adjustment factors will be used for the Coghill and Northern districts based on historical data from Cannery Creek and W. Noerenberg hatcheries. Calculations of in-season contributions will follow those used to generate post-season results (Equation 3).

A more thorough but less timely inseason contribution estimation method will use data from extracted and fully decoded tags. Use of historical adjustment factor estimates will still be required because current year brood stock data are not available until the end of the season, but knowledge of tag identities will allow hatchery-specific historical factors to be used.

Alternatives

Estimation of stock specific contributions to large commercial fisheries requires some sort of natural or man-induced mark which is characteristic of the stock or groups of stocks to be distinguished. Any mark to be used for estimates of stock specific catch contributions for inseason fisheries management must: (1) be naturally present in all or a fixed portion of the population or easy to apply permanently to a fixed portion of the population in the early life stages before stock mixing occurs, (2) be easy to distinguish in adult returns, (3) be present or can be applied to a large enough portion of the population such that significant numbers can be recovered among adult returns for accurate and precise estimates of catch contributions, (4) not affect survival or behavior of fish and, (5) application and recovery of the mark must be cost effective.

Until recently, coded wire tag technology has been the only man-induced mark available which meet most of the above criteria. Although this technology has given us the opportunity to distinguish hatchery and wild fish in commercial harvests with reasonable accuracy and precision, it is not without problems. The cost effectiveness of coded wire tag technology decreases as the size of populations marked increases and the size of the fish marked decreases. The pink salmon tagging program in PWS is the largest of its kind in the world and is pushing the limit of the technology for both application and recovery. Furthermore, application in very small fish such as pink salmon may affect survival, may not be permanent (tag loss), and tagging may affect behavior. Some cost effective methods do exist and are used to adjust for tag loss from differential mortality and tag shedding. However, the effect of tag-induced straying, though thought to be small, is difficult and costly to account for.

Based on the drawbacks of coded wire tag technology with respect to PWS pink salmon, an alternative mark or method for distinguishing stocks from one another would certainly be desirable. The most likely alternative to coded wire tags are thermal or chemical otolith marks. Otolith marking methods meet all of the five criteria described above. Thermal marks have been thoroughly tested in all salmon species. They are permanent, they are easily applied to every individual in a hatchery population and they are less expensive to apply and recover relative to coded wire tags. Because they can be applied to every individual in the population, contribution estimates based on thermal marks will be more accurate and precise than those based on coded wire tags. Differential mortality of tagged fish will no longer be a problem. Because the mark is non intrusive, permanent tag loss through shedding and straying of tagged fish will also be eliminated. A large scale otolith marking program for PWS hatchery pink salmon releases has been proposed fir 1994 (Study 94187). Recoveries of otolith marks from these releases can begin in 1996.

Chemical marking of otoliths has been less tested in salmon but is widely used in other species. Chemical marking requires that young fish be fed or immersed in a chemical agent which leaves a recognizable band on otoliths or skeletal structures. Tetracycline is one widely used chemical which deposits a distinctive skeletal or otolith growth band which is florescent under ultraviolet light. Because it is retained in the tissues, Food and Drug Administration permits for its use in fish destined for human consumption fish were initially difficult to obtain but permitting is now done on a routine basis for many species. The method has promise for marking wild fish where heated water is not available for thermal marks. A small feasibility study has been proposed as part of the thermal marking proposal (94187) to test its use in this regard.

To date no natural markers have been discovered in PWS pink salmon which allow researchers to distinguish hatchery stocks from all wild stocks. Genetic marks are a possibility but hatchery parent stocks in PWS originated from wild stocks in the area and are shared by more than one facility, and hence are probably not distinguishable.

5. Location:

By aiding restoration through improved fisheries management, this project will benefit wild pink salmon populations in PWS, other segments of the marine and terrestrial portions of the PWS ecosystem which are dependent upon pink salmon. Restoration through improved management will also benefit the salmon fishing fleets including those in Cordova, Valdez, Tatitlek, New Chenega, Whittier, and Seward, fish processing plants in Cordova, Valdez, Whittier, Seward, Anchorage, Kenai, and Kodiak. The project will employ local residents for data collection activities in fish processing plants located in Cordova, Valdez, Whittier, Seward, Anchorage, Kenai, and Kodiak, and at hatcheries in PWS. The project will also employ residents of Juneau for tag extraction and decoding activities performed by the ADF&G Statewide Tag Laboratory. Permanent ADF&G Biologists stationed in Cordova and biometrics staff stationed in Anchorage will complete data analyses and reports. Goods and services required by the project will obtained from vendors in the local communities where data are collected.

6. Technical Support:

Tag recovery data forms and heads from tagged fish will be shipped to the Cordova office for logging, sorting, editing, and final shipment to the centralized ADF&G Coded Wire Tag Laboratory in Juneau, Ak. Tag Laboratory personnel will use specialized equipment to detect, extract and decode tags. The Tag Laboratory uses a Honeywell minicomputer with an ULTIMATE operating system and PIC database software to construct, manipulate, and store the PWS data in a statewide coded wire tag database. A copy of the statewide is database is also incorporated into a Pacific Coast database maintained by the (PSMFC) in Gladstone, Oregon. Summarized data from the Juneau tag laboratory and summaries of ADF&G fisheries sales receipts (fish tickets) are stored and analyzed on a micro-computers in the ADF&G Cordova and on a mainframe in the ADF&G headquarters office in Juneau. All inseason and post season data analyses and reporting are completed on micro-computers using RBASE database management, LOTUS spreadsheet, and WORDPERFECT word processing software.

7. Contracts:

Matching funds from PWSAC and VFDA will be conveyed to ADF&G through cooperative agreements.

D. SCHEDULES

Date(s)	Activity
June 20-Sept 10, 1994	Tag recoveries in commercial fisheries, cost recovery harvests, and brood stocks. Inseason catch stock composition estimates by time and area for management of commercial and cost recovery fisheries.
Nov 15, 1994	Draft Report
Dec 30, 1994	Final Report

The Project Leader (PL) for the project is a permanent full time Fisheries Biologist III (FB III), PWS Salmon Research Project Leader with the Alaska Department of Fish and Game. The PL will be responsible for writing project operational plans, administering project budgets, quality control of data collection, supervising data analyses and, co-authoring final reports. A permanent seasonal Fisheries Biologist II (FB II) will act as the Assistant Project Leader (APL), hire project personnel, supervise day to day project operations, maintain data quality, assist in data analyses, and coauthor final reports. The APL will be assisted by a two non-permanent Fisheries Biologist I's (FB I). One of these FB I's assistants will be in charge of supervising day to day sampling activities in Cordova and will assist the PL in supervising sampling at other ports, on floating processors, and at hatcheries. The other FB I will supervise sampling crews in Valdez. A non-permanent Fish and Wildlife Technician III (FWT III) will assist the Cordova FB I and act as a crew leader. Fish and Wildlife Technician II's (FWT II) will be placed in ports where only one sampler is expected to work under minimum supervision. The remainder of crews in each port will be pairs of non-permanent FWT II's and Fish and Wildlife Tech I's (FWT I). Each day, two persons on each crew will scan pink salmon at each processing plant. Under the supervision of the and FB I, a FWT III in Cordova will conduct daily data logging, editing and archiving activities. An FB I will supervise similar activities in Valdez.

A Biometrician I from the ADF&G Commercial Fisheries and Development Division Region II office in Anchorage will provide biometrics support for the project. The Biometrician I will assist in experimental design, inseason and post season data analyses, and report writing.

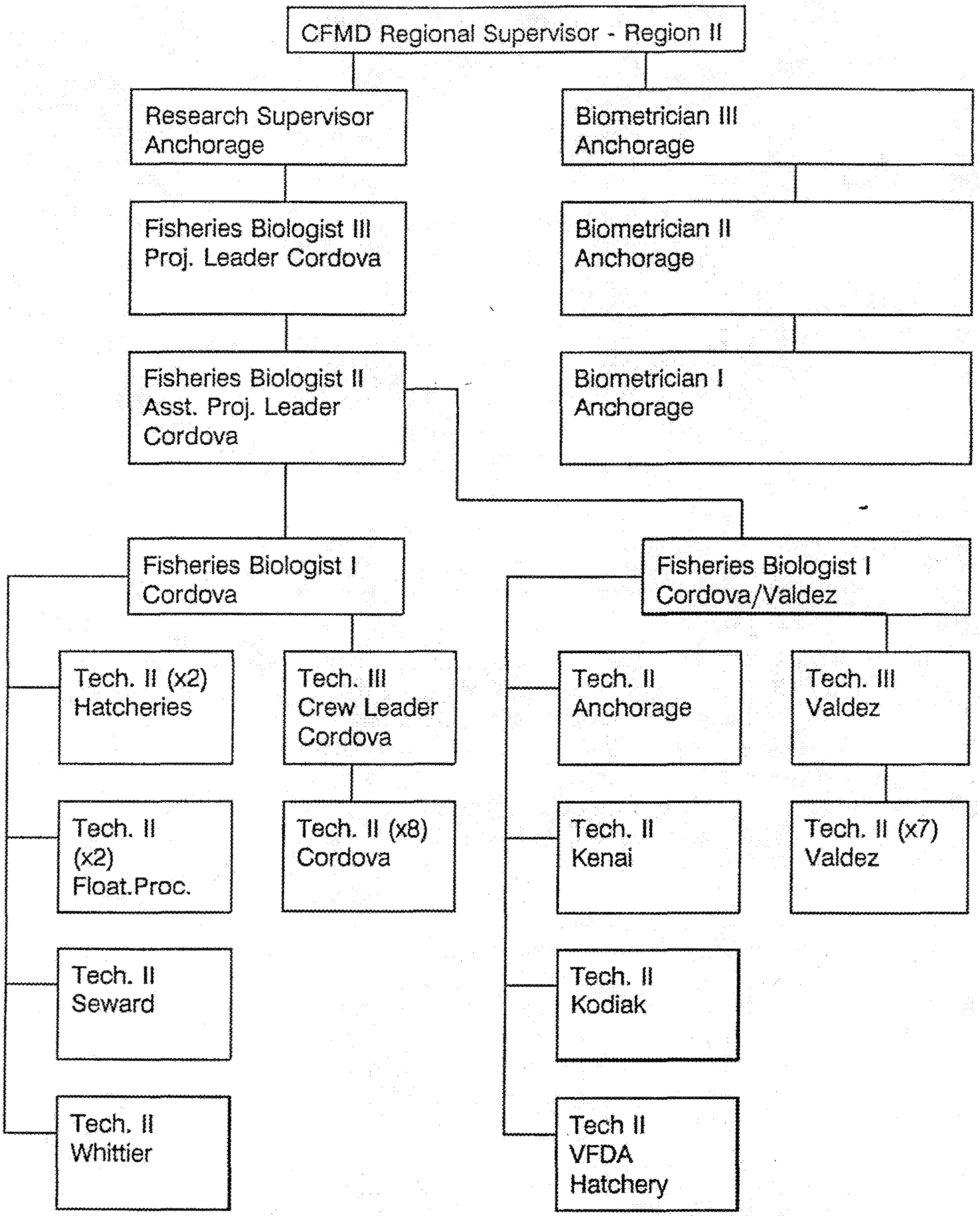

Figure 1. Organizational chart of project personnel and related ADF&G CFMD Region II supervisory and biometrics staff.

The PL, APL or, a project FB I will maintain daily phone contact with project technicians stationed in ports other than Cordova or Valdez and at several remote hatchery locations. Copies of data forms from these sites will be faxed to Cordova daily and heads from sampled fish will be shipped once or twice weekly to Cordova via scheduled commercial flights or via chartered aircraft depending upon which is available. The PL, APL, or project Fisheries Biologist I's will make routine supervisory visits to each sampling port via chartered or commercial aircraft at least twice monthly for sampling quality control inspections, data collections, and industry contacts. The Biometrician I will travel to Cordova several times during the season to assist with inseason data analyses and occasionally post season to assist with final data analyses and report writing.

E. EXISTING AGENCY PROGRAM

The Alaska Department of Fish and Game permanent staff of biologists and biometricians write operational plans and provide overall all supervision for this project. The Alaska Department of Fish and Game, Prince William Sound Aquaculture Corporation, and Valdez Fisheries Development Association also provide matching funding for project operations. These funding contributions for the period October 1, 1993 through September 30, 1994 are as follows:

ADF&G	-	$81.6
PWSAC	-	$100.0
VFDA	-	$26.2

In addition, data and personnel from ongoing ADF&G fisheries catch and escapement monitoring and management programs will be used in conjunction with results of this study to make fisheries catch contribution estimates and formulate stock specific management strategies.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

All sampling activities for this project occur within fish processing plants of fish hatcheries. The ADF&G will coordinate with PWSAC and VFDA with respect to locating samplers within their respective fish hatcheries.

G. PERFORMANCE MONITORING

The PL is the permanent full time Fisheries Biologist III PWS Salmon Research project Leader for the ADF&G, Region II, Commercial Fisheries Management and Development Division (CFMD). The PL is supervised by the ADF&G, CFMD, Region II, Regional Research Supervisor. The APL is an eleven month permanent season ADF&G employee supervised by the PL. The APL has supervisory authority of all project Fisheries Biologist I's and Fish and wildlife Technicians. A Biometrician assigned to assist the PL and APL is supervised by an ADF&G, Commercial Fisheries Management and Development Division, Region II, Biometrician II. The PL and the project Biometrician coordinate through the regional Biometrician II, the Regional Biometrician III, and the Regional Research Supervisor. The PL and APL have equal knowledge of all aspects of this project and can exchange roles in the event of a personnel change. In addition, one of the Project Fisheries Biologist I's has sufficient knowledge and experience with the project that she could be promoted to the APL position and trained in data analysis and report writing tasks very quickly. Biometrics responsibilities are interchangeable between the Biometrician I and the Biometrician II. Technician III crew leaders with the project can be replaced in the short term by the Fisheries Biologist I's. Several Technician II's have been with the project for more than one season and qualify as easily trained replacements.

The PL is a permanent ADF&G employee and can work on project tasks at any time. The APL is seasonal but dedicated 11 months to project tasks. Fisheries Biologist I's who assist the APL will assume their duties in early June approximately two weeks prior to the onset of recovery activities for pink salmon. Fish and Wildlife Technicians employed for sampling will be hired in mid-June and assume their duties when commercial or cost recovery fisheries commence. Crews sampling in Anchorage, Whittier, and Valdez will be hired locally and will provide their own room and board. Project biologists will visit each port and minimum of once every two weeks to answer questions, and provide quality control supervision.

Sampling materials, data forms, and sampling equipment will be purchased or shipped to Cordova from the ADF&G Statewide Coded Wire Tag Laboratory no latter than June 1, 1993. Sampling protocol, data forms, data recording procedures and conventions, data editing procedures, and data transmission procedures are all in accordance with statewide standards established by the ADF&G Statewide Coded Wire Tag Laboratory. Data standards adopted by the ADF&G Statewide Coded Wire Tag laboratory are in accordance with those used by the PSMFC. Incomplete censusing of tender loads of fish during the unloading process will be tested for randomness when the opportunity for and independent total census arises. All data are edited immediately upon completion of sampling and are edited twice more by Statewide tag laboratory personnel.

The project has real time in-season as well as longer term post-season products. Real time estimates of wild and hatchery catch contributions will be used to make inseason fisheries management decisions. Data for inseason estimates will be from important segments of the fishery which have the biggest impact on wild pink salmon populations. Samples from these strata will be given top priority. Data sheets will be edited and logged and heads from these samples will be scanned immediately for estimates of the number of undecoded tags. Preliminary estimates of wild stock catch contributions will be made from this undecoded tag data and these estimates will be available to fisheries managers within a few hours of the time that sampling for a fishery opening is completed. Data sheets and heads and copies of the data log will be shipped to Juneau for tag extraction on the day they are collected. Tag laboratory personnel cross check all samples received with the accompanying copy of the data log and work around the clock to insure that data editing, entry, tag extraction, tag decoding, and data transmission back to Cordova are completed within 36 hours of the time of sample receipt. Project biologists and biometricians in Cordova complete data analyses of decoded tag data and use this data to verify and update preliminary catch contribution estimates based on undecoded tag data.

Following the fishing season processing of all lower priority tag recovery samples will be completed by the coded wire tag lab. In addition, all data collected through the season are edited again for quality control, and all tags recovered throughout the season will be examined a second time to insure that they have been properly decoded. All codes will be validated with a master Pacific States Marine Fisheries Commission (PSMFC) list of codes potentially present in Pacific cast fisheries. Fully edited tag code and sampling data from all samples collected during the season will be forwarded to the Cordova office for final summarization and analyses. A complete historic database of coded-wire tag information from Prince William Sound tagging and tag recovery programs will be maintained by the ADF&G statewide coded wire tag laboratory, the PSMFC and, the Cordova ADF&G. The ADF&G historic fish ticket catch database is maintained by the ADF&G at the Juneau headquarters office and in the Cordova area office. All coded wire tagging and recovery data and all fisheries harvest data are freely available from any of these sources.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The monitoring, research and restoration objectives of this project are integral to the success of broader ecosystem research and restoration effort described in part by the Sound Ecosystem Assessment (SEA) plan. It is an integral part of a package of proposed projects including the SEA (94320), the Salmon Otolith Marking (94187), and the Pink Salmon Egg and Alevin Mortality (94191) projects. This project monitors the total returns and survival rates of wild stocks identified as damaged by the Pink Salmon Egg and Alevin Mortality Study (94191) and provides information critical to their restoration. This project provides survival estimates for individual release groups from the Experimental Release component of the SEA proposal. These estimates are critical to several components of SEA including those investigating:

1) pink salmon survival in relation sea surface temperature and other oceanographic features of PWS during the fry and juvenile life stages.

2) pink salmon survival in relation to abundance, size, growth rate, and distribution of pink salmon fry and juveniles and, zooplankton population distribution, abundance, and species composition, and

3) pink salmon survival in relation to abundance, size, growth rate, and distribution of pink salmon fry and juveniles and the abundance distribution, size, and species composition of predator populations.

This project is also directly linked to the proposed Otolith Marking project (94187). Otolith marking is a logical extension of marking technology which will ultimately replace many of the functions of coded wire tags and provide more accurate and precise estimates of hatchery and wild contributions to salmon catches and escapements in PWS at less expense. However, until otolith marks can be applied, coded wire tagging and recovery projects will continue to provide those estimates.

This project will integrate tender fleet tracking, processor plant logistics, and crew scheduling with existing ADF&G salmon port sampling projects. Local aquaculture associations which apply tags as part of study 94320 provide all tagging, fry release, sales harvest, and broodstock data necessary for data analysis. Aquaculture associations also provide room, board, and logistics support for broodstock samplers at their hatcheries. Air charter and boat transportation required to get samplers to remote locations in PWS will be shared with other projects having similar needs.

I. PUBLIC PROCESS

The general public has been involved in the development and evolution of the coded wire tag program in Prince William Sound since its inception in 1986 as a cooperative effort between ADF&G and the PWS area private non-profit (PNP) aquaculture associations. These PNP's, operated by a broad constituency of commercial, sport, personal use, and subsistence fishers and community representatives, review coded wire tag project plans and results annually before approving subsequent funding. Operational plans and results of the coded wire tag program are also reviewed periodically by the PWS Regional planning team as well as interested fishing industry groups. As part of the Trustee Council NRDA and Restoration process the code-wire tag recovery project has also been subject to extensive peer review and annual public review and comment. Results of the coded-wire tag project have been presented at the March 1993 Oil Spill Symposium sponsored by the Trustee Council, the 1993 Pink and Chum Workshop, and at the annual Spring meeting of the PWSAC board of directors in 1993.

J. PERSONNEL QUALIFICATIONS

Fisheries Biologist III Project Leader - Samuel Sharr

Mr. Sharr received a Bachelor of Science degree in biology from the University of Washington in 1968. He has been a research biologist for ADF&G since 1979 and has worked on PWS salmon and herring since 1981. He assumed his present position as the ADF&G, Division of Commercial Fisheries, Biologist III, PWS Area Fin Fish Research Project Leader in 1986. In this capacity, Mr. Sharr oversees all the salmon and herring research conducted by the Division of Commercial Fisheries in PWS. His involvement with the PWS salmon escapement aerial survey program dates from the early 1980's. Mr.Sharr has supervised a total re-edit of the historic aerial and ground survey data and designed a new RBASE data base for inseason escapement analyses. Mr. Sharr wrote the original operational plans for NRDA F/S Studies 1,2 and, 3, in 1989 and 1990, and 1991, restoration studies 60A, 60B, and 60C in 1992, and 93137, 93184, and 93191 in 1993 and has been the Principal Investigator for all of those projects. Mr. Sharr is also a member of the scientific committee of the Prince William Sound Fisheries Ecosystem Planning Group and a co-author of the Sound Ecosystem Assessment research plan and science proposal.

Fisheries Biologist II Assistant Project Leader - Carol Peckham

Ms. Peckham has a Bachelor of Science in Wildlife Biology from the University of Alaska and complete all course work requirements for a Masters degree in statistics. She has been employed by ADF&G since 1984. As a college intern for the ADF&G Stock Biology Group Ms. Peckham gained valuable experience in a wide variety of biological sampling and stock identification techniques in Cook Inlet and Prince William Sound. Ms. Peckham is been involved in coded-wire tag recovery activities in PWS since their inception and since 1987 she has been the Fisheries Biologist in charge of coded-wire tag recovery operations for PWS salmon. Her experience includes supervision of sampling activities spread throughout south central Alaska. She has co-authored several reports in the ADF&G Technical Data Report series, interim and final reports for the 1991 NRDA F/S Study #3, the 1992 Restoration Study 60C, and 1993 Restoration studies 93137 and 93184.

Biometrician I - David Evans

David Evans has a Bachelor of Science in soil science from the University of Nottingham (U.K.), a Master of Science and a Doctor of Philosophy degree in soil science from the University of Guelph (Ontario, Canada), and a Master of Science in statistics from Oregon State University. David has worked with the Alaska Department of Fish and Game since October, 1991. His primary responsibility has been analysis of coded-wire-tag data from Prince William Sound. He has designed the statistical procedures and computer spread sheets used for inseason analysis of tag recovery data, has overseen most of the post season data analyses and has co-authored interim and final reports for the 1991 NRDA F/S Study #3, the 1992 Restoration Study 60C, and 1993 Restoration studies 93137 and 93184.

K. BUDGET (attached)

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Sharr, S., T.M. Willette, C.J. Peckham, D. G. Sharp, J.L. Smith, D.G. Evans, and B.G. Bue. 1993b. Coded Wire Tag Studies On Prince William Sound Pink Salmon. State/Federal Natural Resources Damage Assessment Final Report. Alaska Department of Fish and Game, Cordova, AK.

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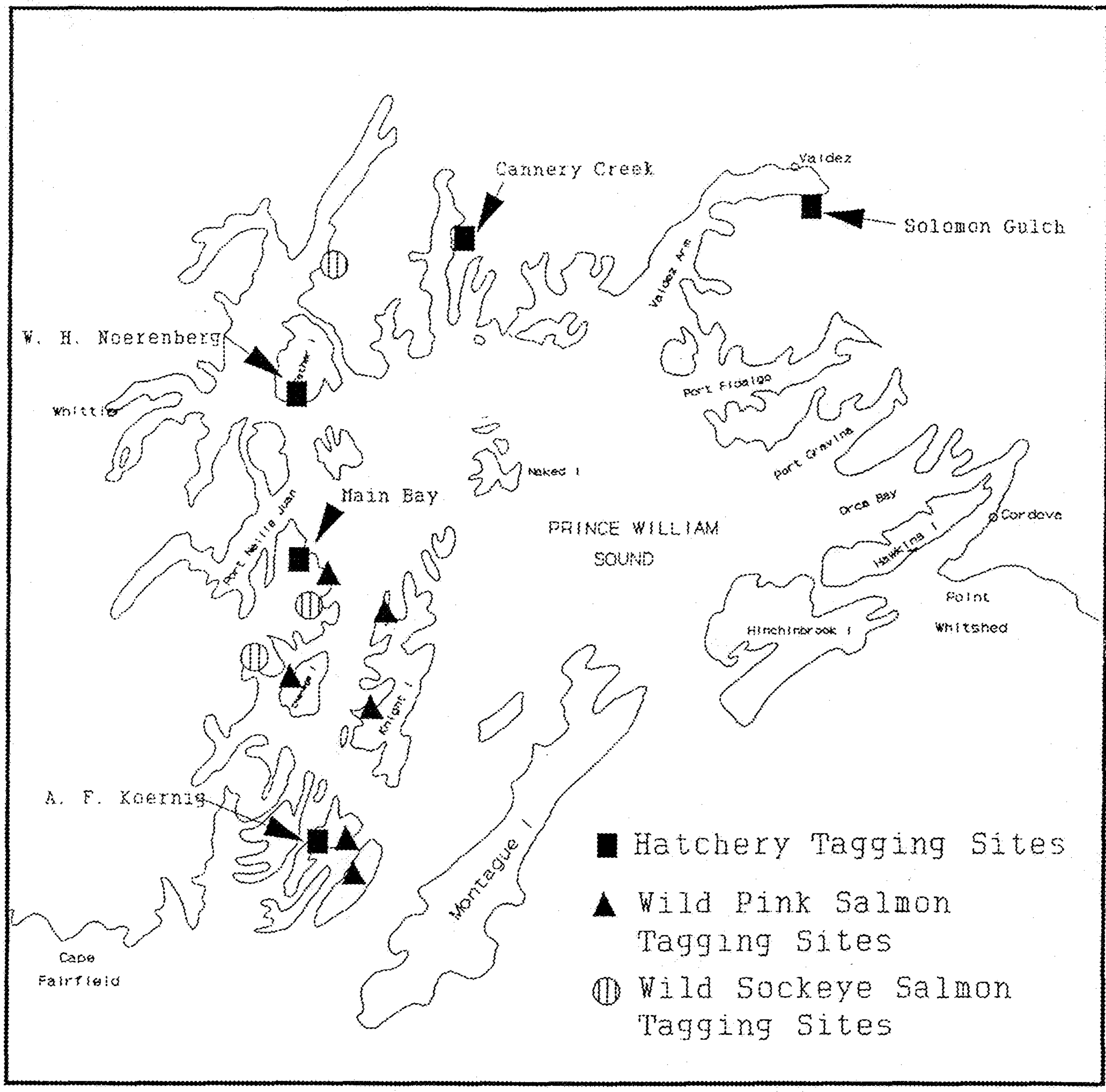
Sharr, S., C.J. Peckham, D. G. Sharp, D.G. Evans, and B.G. Bue. 1993d. Coded Wire Tag Recoveries From Pink Salmon in Prince William Sound Salmon Fisheries. State/Federal Natural Resource Restoration Draft Report. Alaska Department of Fish and Game, Cordova, AK.



Attachment 1. Map showing the location of tagging sites for Hatchery and wild stocks of salmon which will contribute to adult returns in 1992.

EXXON VALDE[illegible]STEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Coded Wire Tag Recoveries from Pinks in PWS - This project involves the recovery of coded wire tags that were placed in pink salmon in previous study years. Data from tag recoveries are used for in-season fisheries management decisions which allow optimal escapement of impacted wild stocks and harvest of excess hatchery and wild fish in high market quality condition.

Budget Category:	1993 Project No. 93067 Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$155.0	$37.9	$125.2	$163.1	$172.5	
Travel	$9.6	$0.8	$11.8	$12.6	$12.6	
Contractual	$20.4	$3.2	$23.4	$26.6	$21.6	
Commodities	$10.3	$0.0	$14.7	$14.7	$10.3	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$195.3	$41.9	$175.1	$217.0	$217.0	
General Administration	$24.7	$5.9	$21.5	$27.4	$27.4	
Project Total	$220.0	$47.8	$196.6	$244.4	$244.4	
Full-time Equivalents (FTE)	3.6	0.7	3.0	3.7	3.1	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Reprt 14 Fish & Wildlife Technician II/III	0.0	$0.0	19.8	$58.3
2 Fishery Biologist II/I	3.5	$17.1	3.0	$11.3
2 Analyst Programmers	0.4	$1.9	0.0	$0.0
1 Publication Specialist	0.2	$0.9	0.0	$0.0
1 Biometrician I	1.0	$5.0	4.0	$20.3
1 Analyst Programmer (tag lab)	0.0	$0.0	3.0	$14.3
3 Fisheries Technicians II/III (tag lab)	3.0	$9.6	5.0	$14.3
1 Program Manager	0.5	$3.4	1.0	$6.7
Personnel Total	8.6	$37.9	35.8	$125.2

NEPA Cost: $0.0
*Oct 1, 1993 - Jan 31, 1994
**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94320 - B
Project Title: Coded Wire Tag Recoveries from Pinks in PWS
Agency: AK Dept. of Fish & Game

FORM 2A PROJECT DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Travel:	Reprt/Intrm	Remaining
Reprt 2 RT between Anchorage & Cordova @ $400 Per diem included	$0.8	$0.0
Supervisory trips to Whittier (7 trips @ $500/trip), Kodiak (7 trips @ $600/trip), Anchorage (7 trips @ $350/trip) plus 11 days per diem @ $150/day	$0.0	$11.8
Travel Total	$0.8	$11.8

Contractual:		
Reprt Transportation - Air charter to hatcheries for recovery of coded wire tags and transportation of salmon heads to lab	$2.0	$0.0
Two DOT Fleet Vehicles (2 months each)	$1.2	$0.0
Air charter to hatcheries, Valdez (18 trips @ $600/trip + 9 days per diem @ $150/day)	$0.0	$12.2
Temporary office rental at Valdez and Whittier for project only	$0.0	$3.0
DOT fleet vehicles (2 vehicles @ $400 each/month x 4 months)	$0.0	$3.2
Supply, head and data shipments to and from the Tag Lab		$4.0
Computer mainteneance		$1.0
Contractual Total	$3.2	$23.4

Project Number: 94320-B
Project Title: Coded Wire Tag Recoveries from Pinks in PWS
Agency: AK Dept. of Fis[illegible] Game

FORM 2B
PROJECT
D[illegible]L

Commodities:	Reprt/Intrm	Remaining
Field supplies (rain gear, gloves, knives, sampling kits, jars, ice chests, containers for thousands of pink salmon heads)	$0.0	$10.3
Tag Lab supplies		$4.4
Commodities Total	$0.0	$14.7

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - B
Project Title: Coded Wire Tag Recoveries from Pinks in PWS
Agency: AK Dept. of Fish & Game

FORM 2B
PROJECT
DETAIL

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94320C

***EXXON VALDEZ* TRUSTEE COUNCIL**
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Feasibility of Otolith Marking Wild Pink Salmon in Prince William Sound

Project ID number: 94320C

Project type: Research/Monitoring

Name of project leader(s): Sam Sharr

Lead agency: Alaska Department of Fish and Game

Cooperating agencies:

Cost of project/FY 94: $53.9K

Cost of project/FY 95:

Cost of Project/FY 96 and beyond:

Project Start-up/Completion Dates: April 1, 1994 - September 30, 1994

Geographic area of project: Prince William Sound

Project leader(s):

Sam Sharr by [signature] — 4/7/94
Sam Sharr — **Date**

Regional Research Supervisor:

[signature] — 4/7/94
Steve Fried — **Date**

Agency Project Manager:

[signature] — 4/7/94
Joe Sullivan — **Date**

B. INTRODUCTION

Each year approximately one half billion wild pink salmon fry emerge from the streams of Prince William Sound (PWS) and migrate seaward. Adult returns of wild pink salmon to PWS averaged approximately 10 million fish annually over the last two decades. The huge fry outmigrations and subsequent adult returns of pink salmon play major roles in the Prince William Sound (PWS) ecosystem. Both juveniles and adults are important sources of food for many fish, birds, and mammals. Adults returning from the high seas also convey needed nutrients and minerals from the marine ecosystem to estuaries, freshwater streams, and terrestrial ecosystems. Wild pink salmon also play a major role in the economy of PWS because of their contribution to commercial, sport, and subsistence fisheries in the area.

Up to 75% of pink salmon spawning in PWS occurs in intertidal areas. In the spring of 1989 oil from the *T/V Exxon Valdez* oil spill (EVOS) was deposited in layers of varying thickness in intertidal portions of many western PWS streams utilized by spawning salmon. Pink salmon eggs and fry rearing in these intertidal areas appear to have been adversely affected by the oil. Sharr *et al.* (1993a and 1993b) observed salmon embryo mortalities which were 67%, 51%, 96%, and 80% higher in oiled streams than in comparable and nearby unoiled streams in 1989, 1990, 1991, and 1992. Weibmer (1992) also observed a high incidence of deformities and elevated levels of cytochrome P-450 among fry in oiled streams in 1989. Willette and Carpenter (1993) reported reduced growth and survival of pink salmon fry and juveniles which reared in oiled marine waters of PWS in 1989. Mortality differences between oiled and unoiled streams in 1989 and 1990 were confined to intertidal spawning areas and may be attributed to direct lethal effects of oil. Large differences observed across all tide zones in 1991 and 1992 may be the consequence of damage to germ cells of the adults which originated from the 1989 and 1990 brood years when egg and larval exposures to intertidal oil were greatest. A consequence of this genetic damage may be persistent functional sterility and reduced returns per spawner for populations from oiled streams.

PWS pink salmon returns originating from brood years subsequent to the March 24, 1989, *Exxon Valdez Oil Spill* (EVOS) have been aberrant or weak. Returns of wild and hatchery pink salmon in 1991 were only slightly below the mid-point of the pre-season forecast but arrived late and had very compressed run timing. The fish were also small and in advanced stages of sexual maturity long before reaching their natal streams. As a result of this small size and advanced maturity, the fish were of little commercial value. Returns of pink salmon in 1992 and 1993 were far fewer than expected. The 1992 return of wild pink salmon was the fourth smallest even year return in the last 30 years and the hatchery return was less than one third of expected. The 1993 return of wild pink salmon was the third smallest in the last 30 years and the hatchery return was less than one fifth of expected.

Although hatchery pink salmon production in PWS began in the 1970's, returns from maximum permitted levels of fry production did not occur until the late 1980's and early 1990's and coincided with the EVOS era. Wild salmon populations injured by the EVOS are heavily exploited in mixed stock commercial, sport, and subsistence fisheries which are dominated by the huge returns from more productive hatchery populations. Wild pink salmon populations originate from hundreds of streams in PWS. Migratory timing and abundance of wild returns in marine fishing areas varies among populations. To sustain production from wild populations managers must insure that adequate numbers of wild fish from all portions of the wild return escape fisheries and enter streams to spawn. To achieve this goal mixed stock fisheries must be managed to achieve exploitation rates appropriate for less productive wild populations. To this end, managers must be able to distinguish wild from hatchery fish and estimate their relative spatial and temporal abundance in fishing areas.

In addition to their dominance in the catch, hatchery stocks may also complicate management of PWS fisheries by straying into streams and spawning with wild fish. Hatchery fish may be poorly adapted to spawning and rearing in wild conditions. If they enter wild streams, they may fail to spawn. If they do spawn with other stray hatchery fish or with wild fish their progeny may be less fit than fish originating from 100 percent wild parentage. Sharp *et al.* (*in prep.)* found evidence that significant numbers of fish originating from hatcheries strayed into PWS streams and spawned in 1991 and 1992. Extensive straying by tagged wild stocks was also documented both years. The magnitude and range of straying by both hatchery and wild pink salmon stocks in PWS may significantly influence the success or failure of restoration efforts directed at wild stocks. The definition of what constitutes a wild population and the scale of restoration efforts may change if significant straying also occurs among wild populations. If straying of hatchery fish is significant and does lower the fitness of wild populations, restoration efforts which concentrate on insuring that spawning escapement goals are met may fail if no attention is given to the origins of the escapement.

Coded wire tags have been the tool of choice for applying unique marks to populations of pink salmon in PWS. The methodology has been used extensively to estimate hatchery and wild stock contributions to commercial harvests and has also been used in preliminary straying research. Despite its usefulness, there are drawbacks to coded wire tag technology. In PWS marked populations are huge consequently the number of tags applied must also be huge if accurate and precise catch contribution estimates are to be made for returning adults. Tagging and recovery are both very labor intensive and the number of tags applied and recovered are sometimes inadequate for the levels of accuracy and precision desires. Coded wire tags are also intrusive, tags can be shed, and tagging may affect the subsequent survival. Tag loss through shedding and differential mortality of tagged individuals affects subsequent estimates of adult returns based on tag recoveries and must be accounted for. There is also recent evidence that the propensity for straying among tagged fish may be related to tag placement.

Because of the cost and problems associated with coded wire technology, other alternatives of marking larger portions of populations with relatively inexpensive non-intrusive methods must be investigated. By marking most or all of the fish in a population sample sizes at the time of tag recovery can be much smaller without affecting the accuracy and precision of contribution estimates. Non-intrusive marks which cannot be shed and which do not affect survival or behavior will eliminate important sources of error in adult population estimates based on tag recoveries.

C. PROJECT DESCRIPTION

This study is designed to test the feasibility of chemically marking fish otoliths or skeletal parts by short term immersion in a dilute solution of tetracycline during the embryo or emergent fry life stages. Tetracycline has been used very successfully to apply chemical marks in many other fish species. Tetracycline is now regularly permitted by the United States Food and Drug Administration (FDA) for use as an antibiotic and otolith marking agent on fish destined for human consumption. Marks from tetracycline are permanent, relatively easy to apply, easily recognizable, and at low dosages do not appear to be alter fish survival. While the most widely reported means of applying tetracycline is by feeding, several investigators have reported successful marking of fish species by immersion in dilute solutions of the chemical. Spot and pinfish, coregonids, and striped bass, have all been successfully marked using immersion methods (Hettler 1984, Dabrowski and Tsukamoto 1986, and Secor *et al.* 1991) successfully marked. There are less documented instances of pink and chum salmon having been successfully marked by immersion as well (R.C. Johnson, National marine Fisheries Service, retired, personal communication and J. Short, National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska, personal communication). While probably not cost effective for large hatchery releases reared in massive flow through incubator systems, tetracycline immersion is an attractive alternative for marking much smaller wild populations of pink salmon as the migrate out of their natal streams as fry. Marking the total fry population in a stream provides an accurate and precise tool for estimating total adult returns and survival. As a non-intrusive method which does not appear to alter fish behavior, chemical otolith marking also provides a powerful tool for investigating straying among wild populations.

1. Resources and/or Associated Services:

This is project is designed to test the feasibility of a potentially powerful research and monitoring tool for wild populations of salmon in PWS. Wild populations of salmon in PWS are vital to the health of the marine, freshwater, and terrestrial portions of the PWS ecosystem and to the PWS fishing industry which is the cornerstone of the area economy.

2. Relation to Other Damage Assessment/Restoration Work:

The foundations for this study were firmly established by previous NRDA studies (F/S #1,#3) which demonstrated the technical feasibility of capturing and enumerating the entire fry outmigration from wild streams, applying coded-wire tags to wild pink salmon fry, and recovering tagged individuals in subsequent adult returns. Recoveries of tagged fish from the commercial catch and from numerous streams have demonstrated that estimates of stock abundance, timing, survival, and straying can be obtained using mark recapture techniques. This study seeks to test the feasibility of a more cost effective and reliable marking tool as a means of improving existing methodology.

3. Objectives:

a. Test and refine remote field camp methods and equipment to be used for immersing wild pink salmon fry in tetracycline solutions for up to 18 hours at varying temperatures,

b. determine the minimum immersion time and temperature of pink salmon fry in tetracycline solution to insure that otoliths from 100% of the individuals immersed have a unique fluorescent tetracycline mark which is distinguishable from otoliths selected randomly from a pool of individuals which are not immersed,

c. determine the maximum number of fry which can feasibly be marked daily at a remote field camp, and

d. compare short term growth and survival among pink fry which are treated with tetracycline following capture versus those which are not.

4. Methods:

Marking feasibility studies will be conducted adjacent to the Prince William Sound Aquaculture Corporation Cannery Creek Hatchery in Unakwik Inlet, PWS using equipment identical to that proposed for future field camp use. Fry for the study will be donated by the hatchery.

Testing Marking Procedures

A buffered solution of tetracycline hydrochloride (Tetra-bac) diluted to 400 parts per million in fresh water will be used to mark all treatment groups in this experiment. Although lessor dosages have been successfully used for some warm water species, Short (National Marine Fisheries Service, Auke Bay Laboratory personal communication) used this dose with success in chum salmon. Emergent hatchery pink salmon fry immersed in this dose for 24 hours during a small test conducted by the Cordova ADF&G staff in the March of 1994 had no short term mortalities and exhibited no signs during exposure. Short (personal communication) also reported that results improved to a point with increasing temperature and length of immersion. This study will test 12 unique combinations (t_{ij}) of immersion time (i) and temperature (j). Immersion times of three, six, 12 and 18 hours (i = *1,2, 3,* and 4) will be tested at 2°, 5°, and 8° C (j = *1,2,* and 3). There will be five replicates (r = *1,2,3,4, and 5*) for each t_{ij}.

Sharr *et al.* observed as many as 50,000 fry migrating daily from moderate sized pink salmon streams during tagging and enumeration studies conducted in PWS in 1990 and 1991 as part of NRDA F/S Study #3 . Larger streams having peak daily fry outmigrations of 100,000 fish per day may be considered for enumeration and tagging studies if otolith marking proves to be feasible. Projections of costs and logistics constraints indicate that heating water and loading densities for immersion baths will be the factors which define the upper limit of chemical otolith marking at a remote field camp. Present projections for fry handling and personnel time as well as fuel and camp supply needs indicate that a typical two person crew at a remote fry enumeration camp can heat approximately 540 liters of tetracycline solution daily for marking fry. Under these constraints, loading densities of approximately 2,500 fry per treatment bag (approximately 180 fry per liter) must be possible if 100,000 fry are to be marked daily. Local aquaculture associations use loading densities as high as 320 fry per liter of aerated water for fry transport operations. It is likely that loading densities that high will result in significant mortalities among fry in a heated tetracycline immersion bath but it is assumed that the required densities of 180 fry per liter can be maintained. This experiment will also test that assumption.

Three 750 liter water baths, one for each temperature treatment, will be prepared in large insulated fish totes. Water will be heated and maintained at temperature by thermostatically controlled electric immersion heaters supplied by a gasoline powered generator. Fry emerging from hatchery incubators will initially be divided into 60 groups (12 treatments x 5 replicates) of 600 individuals each. Each 600 fish group will be placed in a clear polyethylene bag containing four liters of hatchery (stream) water at ambient stream temperature. Compressed air will supplied to each bag via air stones to insure that fry receive adequate oxygen. A pre-mixed 135 ml. buffered tetracycline solution prepared by dissolving 2.25g of Tetra-bac and 2.0g dibasic sodium phosphate in 135ml of warm (~30°C) fresh water will be cooled to stream temperature and added to the each of 60 treatment bags. Fifteen additional bags will be left untreated and used for controls (c_{ij}) to test the effects of tetracycline on survival at different temperatures and exposure times. Treatment bags and control bags will then be transferred in equal numbers to each of the three heated water baths. The water temperature in treatments bags will be monitored and when all bags in a tote have reached the desired immersion temperature timing for duration of immersion will begin. At the endpoints of each time treatment (j = 1, 2, 3, and 4), five treatment bags will be removed from each of the three totes, transferred to a saltwater enclosure in front of the hatchery and allowed to cool to ambient seawater temperature. Fry from each bag will then be transferred to separate saltwater rearing cylinders constructed of fine meshed plastic screen (vexar). In addition at the start of the treatment day fifteen groups of 600 fry each will be transferred directly from the hatchery into saltwater rearing cylinders. These fry will act as controls (c_0) for testing the marking effectiveness of each of the 12 treatments. All treatment and control groups will be held and fed in saltwater rearing pens for four weeks to insure that the treatment band is deposited on the otolith and that otolith growth occurs beyond the marking band. At the end of four weeks fry from each rearing cylinder which represent one replicate of a treatment group will be transferred to a light proof black plastic bottle containing 90 % ethyl alcohol and shipped to the Alaska Department of Fish and Game Otolith Processing Laboratory in Juneau (Otolith Lab) for otolith removal and processing.

Determining the Minimum Required Treatment

If otolith marked wild populations are to be considered as being representative of other unmarked wild populations then one important criteria for marking success should be that application of the mark does not significantly affect survival. The number of mortalities in each 600 fish treatment and control group will be enumerated for the treatment and rearing periods and totaled. A one way analysis of variance will be used to test for total mortality differences between each treatment group and their corresponding control. Any treatment which has total mortalities significantly greater than those observed in the corresponding control group will be eliminated from further consideration as a potential marking treatment.

All otolith extractions and processing will be completed by the Otolith Lab. Initially a random sample of 30 otoliths from the first replicate of the maximum treatment group t_{341} will be mounted and processed to determine if the maximum treatment resulted in a tetracycline mark. If some or all of the 30 otoliths examined bear no mark it will be assumed that lesser treatments are equally or more ineffective, that tetracycline marking procedures tested are not effective, and that the experiment should be terminated with no further expenditure of funds for otolith processing. If all 30 otoliths from t_{341} bear marks then a systematic search will be initiated to find the minimum treatment required to insure that a recognizable mark is produced in 100 percent of the individuals treated.

The systematic search for the minimum required treatment from among those having no effect on survival will proceed according to the following steps:

(1) 30 otoliths from each replicate of t_{11} will be processed and examined by a trained observer.

(2) If all 30 are in each replicate are marked, 30 more otoliths from the first replicate t_{111} will be extracted, mounted on slides then randomly mixed with 30 similarly prepared otoliths from the control group of fish c_0. The trained observer will examine this pool of 60 otoliths and attempt to correctly identify the treated individuals.

(3) If the observer correctly identifies all of the treated individuals from a pool of t_{111} and c_0, the procedure in step (2) will be repeated three more times for similar t_{111}, t_{112}, t_{113}, t_{114}, t_{115} and control pools.

(4) If at any point in these tests the observer fails to detect a mark on an otolith which has been treated, the procedure will terminate for $i=1$ and begin anew at step (1) for $i=2$ through 4.

(5) If the observer fails to classify any time treatments of temperature $j=1$ with 100 percent accuracy the steps (1) through (4) will be repeated for treatments t_{12} through t_{34}.

(6) At the first instance of the observer correctly identifying all marked individuals in all replicates for a treatment t_{ij} it will be determined that this is the minimum treatment suitable for marking.

Subsequent to identifying the minimum suitable treatment, 30 otoliths from each of the first replicates of each remaining untested treatment group which had no significant mortalities may be examined to determine if more readily identifiable marks available and if accidentally elevated temperature in the field may adversely affect marking. If a more readily identifiable mark is identified, steps one through three list above will be repeated for that treatment. If 100 percent classification accuracy is achieved by the observer for all replicates of the treatment, this new treatment will be designated as the minimum treatment of choice and the former selected treatment will become the alternate treatment of choice. The decision as to which to use in future field studies will based upon which had the lowest mortality rate during treatment and subsequent rearing.

Testing Effects of Tetracycline

If results of this study indicate that tetracycline is a suitable marking agent for use on wild pink salmon an FDA permit for use in future years when marked fish are to be released. As part of the permit the FDA stipulates that investigators must contribute to furthering the knowledge about the biological effect of tetracycline. Typically they require that a set of controls be maintained for each treatment application of the chemical and that results of treatments and controls be compared. Because fry are not being released, these comparisons are not required for this feasibility study. However, they can be done at no additional cost and by doing them, we may facilitate obtaining future permits when fish are to be released.

Mortalities from each of the treatment controls (c_{ij}) which were held in fresh water but subject to time and temperature treatments will be enumerated and totaled for the treatment and rearing phases of the experiment. A one way analysis of variance will be used to test for significant differences between mortalities observed among controls and those observed in the corresponding treatment groups immersed in tetracycline (t_{ijr}).

5. Location:

All feasibility tests will be conducted in PWS at the PWSAC Cannery Creek Hatchery. Otoliths will be extracted and processed at the Otolith Lab in Juneau. Data analyses and reporting will be completed by ADF&G staff in Cordova and Anchorage.

6. Technical Support:

The ADF&G Commercial Fisheries Management and development Division will provide biometrics support for review of project methods and data analyses. The ADF&G Otolith Lab will supply processing expertise.

7. Contracts:

No contracts are needed. ADF&G will administer and supervise the project.

D. SCHEDULES

Dates	Activity
April 5 - May 5, 1994	Apparatus set up at Cannery Creek Hatchery, marking immersion treatments, and rearing of treatments and controls.
May 5 - May 15	Dismantle and remove equipment at Cannery Creek and ship otolith samples to Otolith Lab
May 15 - Sept 15	Process otoliths at Otolith Lab
Nov. 15, 1994	Draft Summary Report
Dec. 15, 1994	Final Report

E. EXISTING AGENCY PROGRAM

The ADF&G permanent staff of biologists and biometricians write operational plans and provide overall supervision for this project. PWSAC will supply up to 50,000 fry for and space to the experiment as well as room and board for project personnel at Cannery Creek Hatchery. the ADF&G Otolith Lab will process all otoliths from the experiment.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

None of the fish reared in this experiment will be released. The Alaska Department of Environmental Conservation has determined that amounts of tetracycline being deposited in PWS from the experiment are well below allowable standards and require no permits. Net pens and fish rearing activities at Cannery Creek Hatchery fall within existing ADF&G and PWSAC permits.

G. PERFORMANCE MONITORING

The Assistant Project Leader is a seasonal permanent Fisheries Biologist I with the ADF&G. The Project Leader is a full time Fisheries Biologist III PWS Salmon Research Project Leader for the ADF&G, Region II, Division of Commercial Fisheries Management and Development (CFMD). The Project Leader is supervised by the ADF&G, CFMD Region II Regional Research Supervisor.

An ADF&G Biometrician II from the CFMD office in Anchorage will review the experimental design for the project. The Assistant Project Leader will purchase all equipment needed and set up the marking and rearing apparatus. The Assistant Project Leader will conduct all treatments with the assistance of the Project Leader and a Fish and Wildlife Technician II and oversee a Fish and Wildlife Technician II will monitor the rearing of the fish. The ADF&G Otolith Lab will process all otolith samples. The assistant project leader will write draft and final reports for the project.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The Project Leader, Assistant Project Leader, and the Biometrician positions are shared with EVOS pink salmon research projects 94191 and 94184. Fry donated by PWSAC are part of those included in the experimental release portion of the SEA project (94320). Cannery Creek Hatchery is on the regular sampling route for the field monitoring portion of project 94191 and the research vessel conducting that sampling will transport all marking and rearing apparatus for this project to the hatchery site during a scheduled sampling trip.

Without the availability of a non-intrusive mass marking methodology it is unlikely that reliable estimates of total return, survival, and straying rates for wild populations will be possible. Therefore, the monitoring, research and restoration objectives of this project are related to several other projects including the suite of SEA projects (94320), the Pink Salmon Genetics project (94189), and the Pink Salmon Egg and Alevin Mortality (94191) projects. Total return, survival and straying data which may become possible to obtain as a result of methods developed by this project will be critical to several components of SEA and related pink salmon projects by including those investigating:

1) wild salmon survival in relation sea surface temperature and other oceanographic features of PWS during the fry and juvenile life stages.

2) salmon survival in relation to abundance, size, growth rate, and distribution of pink salmon fry and juveniles and, zooplankton population distribution, abundance, and species composition,

3) salmon survival in relation to abundance, size, growth rate, and distribution of salmon fry and juveniles and the abundance distribution, size, and species composition of predator populations and,

4) pink salmon population structure in PWS.

I. PUBLIC PROCESS

The general public has been involved in the development and evolution of mass marking programs such as the Prince William Sound coded wire tagging programs since their inception in the early 1980's as a cooperative effort between ADF&G and the PWS area private non-profit (PNP) aquaculture associations. These PNP's, operated by a broad constituency of commercial, sport, personal use, and subsistence fishers and community representatives, review coded wire tag project plans and results annually before approving subsequent funding. Operational plans and results of mass marking projects are also reviewed periodically by the PWS Regional planning team as well as interested fishing industry groups. As part of the Trustee Council NRDA and Restoration process the code-wire tag mass marking and recovery project has also been subject to extensive peer review and annual public review and comment. Results of coded-wire tag projects have been presented at the March 1993 Oil Spill Symposium sponsored by the Trustee Council, the 1993 Pink and Chum Workshop, the annual Spring meeting of the PWSAC board of directors in 1993 and, the Alaska Board of Fisheries in 1994. The PWSAC board and the PWS Regional Planning Team have endorsed the concept of otolith marking of hatchery and wild fish and thermal otolith marking of hatchery fish is considered to be the methodology of choice for the future.

J. PERSONNEL QUALIFICATIONS

Fisheries Biologist III Project Leader - Samuel Sharr

Mr. Sharr received a Bachelor of Science degree in biology from the University of Washington in 1968. He has been a research biologist for ADF&G since 1979 and has worked on PWS salmon and herring since 1981. He assumed his present position as the ADF&G, Division of Commercial Fisheries, Biologist III, PWS Area Fin Fish Research Project Leader in 1986. In this capacity, Mr. Sharr oversees all the salmon and herring research conducted by the Division of Commercial Fisheries in PWS. His involvement with the PWS salmon escapement aerial survey program dates from the early 1980's. Mr.Sharr has supervised a total re-edit of the historic aerial and ground survey data and designed a new RBASE data base for inseason escapement analyses. Mr. Sharr wrote the original operational plans for NRDA F/S Studies 1,2 and, 3, in 1989 and 1990, and 1991, restoration studies 60A, 60B, and 60C in 1992, and 93137, 93184, and 93191 in 1993 and has been the Principal Investigator for all of those projects. Mr. Sharr is also a member of the scientific committee of the Prince William Sound Fisheries Ecosystem Planning Group and a co-author of the Sound Ecosystem Assessment research plan and science proposal.

K. BUDGET

(see attached)

LITERATURE CITED

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EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	Genetic Structure of Prince William Sound Pink Salmon
Project ID number:	94320-D
Project type:	Research/Monitoring
Name of project leaders:	James E. Seeb Lisa W. Seeb Christopher Habicht
Lead agency:	Alaska Department of Fish and Game (ADFG)
Cooperating agencies:	None
Cost of project/FY 94:	171.2K
Cost of project/FY 95:	203.7K
Cost of Project/FY 96 and beyond:	None
Project Start-up/Completion Dates:	3/94 to 9/96
Geographic area of project:	Prince William Sound

Project leaders:

James E. Seeb 3/8/94
Date

Lisa W. Seeb 3/8/94
Date

Christopher Habicht 3/8/94
Date

Agency project manager:

Joe Sullivan 3/15/94
Date

B. INTRODUCTION

Historically, wild stocks produced approximately five-hundred-million pink salmon (*Oncorhynchus gorbuscha*) fry which emerged from streams throughout Prince William Sound (PWS) each year to migrate seaward. Adult returns of wild pink salmon averaged from 10 to 15 million fish annually. Unlike returns of adult hatchery fish, these returning wild-stock adults play a critical role in the total Prince William Sound ecosystem; they convey essential nutrients and minerals from the marine ecosystem to estuaries, freshwater streams, and terrestrial ecosystems. Both juveniles and adults are important sources of food for many fish, birds, and mammals. Wild pink salmon also play a major role in the economy of PWS because of their contribution to commercial, sport, and subsistence fisheries in the area.

Wild-stock pink salmon suffered both direct lethal and sublethal injuries as a result of the *Exxon Valdez* oil spill (EVOS). Pink salmon embryos and alevins suffered increased mortality, diminished growth, and a high incidence of somatic cellular abnormalities as a result of spawning ground contamination and rearing in oiled areas. Elevated mortality of embryos in the oiled streams has continued through 1993, three generations after the oiling, suggesting that genetic damage have occurred (see discussions in Sharr et al. 1993). Also, in 1989 the commercial harvest of pink salmon had to be shifted away from the hatchery and wild stocks in the oiled areas to target only the wild stocks in eastern Prince William Sound. This resulted in over-harvest and depletion of these stocks evidenced by general run failures of eastern-sound stocks in 1991.

Prince William Sound is also the center of one of the State of Alaska's largest aquacultural industries. Alaska Department of Fish and Game has been grappling with management of the wild stocks in face of intractable hatchery/wild-stock interactions for nearly a decade. The EVOS-related damages to wild stocks, coupled with full-scale hatchery egg takes, has exacerbated wild-stock management concerns. The commercial fishing industry and the two aquaculture associations are facing serious financial challenges due to the alterations in management imposed resulting from declines in abundance of wild pink salmon.

This project is designed to delineate the genetic structure of populations of wild pink salmon inhabiting Prince William Sound. While "stock" is used by biologists as a convenient term designating fish that spawn at a certain time at a certain place, these stocks may not be genetically distinct from each other. "Population" describes genetically distinct groups of fish which are the building blocks of species, and it is essential to manage and restore the EVOS resources on a population basis.

Gene flow is restricted between populations (thus carbon flow is restricted--see related proposals in Trustee Council project 94320), and the resulting between-population diversity is responsible for many aspects of the fitness of the species.

In the case of commercially harvested species like pink salmon, fitness is defined to include the peak productivity and long-term sustainablity. Between-population diversity provides optimal production for species inhabiting diverse ecosystems such as PWS; highly diverse population mixes also provide a biological buffer to environmental change (droughts, floods, major earthquakes, and other routine events that occur in Alaskan ecosystems).

Understanding genetic structure of the wild stocks inhabiting PWS is critical to their management and conservation. For example, managing on too fine a scale may adversely affect the fishing industry and waste management resources, while managing on too large a scale may result in lost of genetic adaptations and diversity in the wild pink salmon populations within Prince William Sound. Knowledge gained through this project is needed to correctly interpret and apply the findings obtained from the proposed ecosystem analyses on a population basis, more properly define the population-level nature of the damage documented in previous study of EVOS damaged pink salmon, and otherwise guide the decision-making process in the management-oriented restoration of the EVOS-damaged pink salmon populations.

C. PROJECT DESCRIPTION

Our goal is to provide the basis for key management decisions by defining the genetic structure of representative populations from throughout PWS, measuring both within and between population diversity. An understanding of the population genetics of affected pink salmon populations will be used to guide restoration management decisions including those regulating commercial harvest. The same knowledge of population structure will be used for genetic monitoring and risk assessment which will be required in order to evaluate any supplemental restoration programs. This monitoring and risk assessment is analogous to the process currently being conducted to evaluate supplemental restoration of damaged populations on the Columbia River by the Northwest Power Planning Council (Waples 1991).

Both allozyme analysis and DNA analysis (e.g., Allendorf and Phelps 1981, Carr and Marshall 1991) will be used to discriminate populations and describe population structure. Genetic studies using allozyme analysis have proven especially useful for the conservation/management of populations of pink salmon (e.g., Shaklee et al. 1991, White and Shaklee 1991); we will also include a pilot analysis of the utility of mtDNA analysis, as such an approach has shown potential usefulness in other studies of salmonids (e.g., see Cronin et al. 1993).

1. Resources and/or Associated Services:

In this study we will investigate pink salmon in Prince William Sound, Alaska.

2. Relation to Other Damage Assessment/Restoration Work:

Previous assessments of egg and fry survival in oiled and unoiled streams demonstrated detrimental effects of EVOS on pink salmon (Natural Resources Damage Assessment Fish/Shellfish Study # 2 *Injury to Salmon Eggs and Preemergent Fry* and EVOS Trustee Council studies R60C and 93003 *Oil Related Egg and Alevin Mortalities*). The heritable, genetic nature of the damage was revealed in matings performed as a part of study 93003. In response to those findings, coded-wire tag recoveries from pink salmon in PWS (e.g., Natural Resources Damage Assessment Fish/Shellfish Study # 3 and studies R60A and 93067) were used to reduce the fishing effort on wild pink salmon "populations" through fisheries management. Yet the actual genetic structure of pink salmon populations in Prince William Sound remains unknown.

Therefore, this project, 94320-D, was designed to provide a genetic basis for the hatchery/wild-stock components of study 94320 *Prince William Sound Ecosystem Investigation* and to provide the information essential for population-specific management through such projects as 94184 *Coded-Wire-Tag Recoveries from Pink Salmon in Prince William Sound Fisheries* and others that may be proposed as a consequence of 94320.

3. Objectives:

The project objective is to define the genetic structure of pink salmon stocks in the EVOS-affected area of Prince William Sound. We will test for both temporal and geographical structuring by examining genetic differences between even and odd year stocks, early and late season spawners, upstream and intertidal spawners, and stream of spawning. This genetic structure information will be used in order to:

1. correctly interpret and apply the findings obtained from the proposed ecosystem analyses (94320 A-P) on a population basis.

2. provide genetic information needed for risk assessment and genetic monitoring of supplementation programs (e.g., proposed as a result of projects R105 or project 94320 A-P) to guide population-specific restoration and enhancement.

3. better direct harvest management decisions made for restoration purposes on a population-specific rather than species-specific basis.

4. Methods:

Field Sampling

Tissues for baseline genetic data will be collected from up to 100 individuals from each of 30 spawning aggregations each year (see Appendix A for instructions for samplers). Sampling will incorporate a broad geographical distribution of locations within the Sound (Table 1) including two hatcheries (Cannery Creek and Armin F. Koernig) and 28 spawning aggregates from wild-stock streams. Pink salmon have a two-year life cycle. Even and odd-year pink salmon are genetically distinct (Beacham 1988), so both must be sampled. Sampling will be designed to include both early and late stocks and inter-tidal and upstream-spawning stocks. Because abundance of pink salmon varies annually, selection of spawning aggregations will be determined by field personnel who will be instructed to sample streams that maximize the ability to investigate temporal (between years and within years) and spatial (between streams and within streams) comparisons. Tissue samples from heart, liver, muscle, and aqueous humor from each individual will be immediately frozen on liquid nitrogen and returned to Anchorage for storage at -80° C.

Sampling will be done in coordination with other restoration programs in order to reduce costs and facilitate cross-referencing of biological data. For example, some suitable samples from odd-year populations are already available from tissue collections made as a part other studies such as R60C. Samples for even-year populations were to be collected as a part of study 94185; however, as that project was not funded by the Trustees for 1994, field sample collections will be integrated between 94191 and this project in 1994.

Laboratory Analysis

Genetic data will be collected using the techniques of allozyme electrophoresis on all samples (Utter et al. 1987, Seeb et al. 1987). An extensive allozyme screening will be undertaken to maximize the potential number of available gene markers. Tissue-buffer combinations will be based on existing pink salmon staining schedules (Table 2) A pre-oilspill data base of allozyme frequencies exists for Prince William Sound pink salmon which facilitates analyses of potential changes of population structure and gene flow (Seeb and Wishard 1977). Data will be merged into the state and federal inter-agency databases.

Allozyme techniques will follow those of Harris and Hopkinson (1976), May et al. (1979), and Aebersold et al. (1987); nomenclature will follow the American Fisheries Society standard (Shaklee et al. 1990). Gels will be scored using an online scoring program developed by ADF&G Genetics Laboratory. This Windows based application (Microsoft Windows 3.1) provides extensive documentation of results and error checking capability and facilitates rapid collation, analysis, and reporting of genetic data in order to ensure rapid turnaround, complete documentation, and immediate availability of summary statistics. A photographic record of each gel will be made.

Another Windows based application (Microsoft Windows 3.1) developed by ADF&G Genetics Laboratory, will be used to calculate allele frequency estimates, to test for conformation of genotype frequencies to Hardy-Weinberg expected frequencies using likelihood ratios, and calculate Nei's (1978) genetic distance and Cavalli-Sforza and Edwards (1967) genetic distance. This application will also be used to perform hierarchical analyses using G-Statistics (modified from Weir 1992) to determine if significant population substructuring exists among Prince William Sound pink salmon based on the following parameters: even versus odd year, upstream versus intertidal spawning location, early versus late run, and geographic location of spawning.

We will estimate genetic relationships by deriving a neighbor-joining tree (Saitou and Nei 1987) with Cavalli-Sforza and Edwards (1967) genetic distance and a UPGMA tree (Sneath and Sokal 1973) with Nei's (1978) genetic distance. RESTSITE (Nei and Miller 1990) and BIOSYS-1 (Swofford and Selander 1981) will be used to calculate the neighbor-joining and UPGMA trees, respectively. The stability of these trees will be tested using Lanyon's jackknife (1985).

A pilot study using DNA techniques will be conducted on a subset of samples. DNA will be extracted from liver and heart tissue (Chapman and Brown 1990, Bermingham et al. 1991) using proteinase-K and RNase-A digestion, phenol/chloroform extractions and ethanol precipitation (Sambrook et al. 1989) from a subsample of the individuals used in the allozyme analysis. After extraction, the DNA will be amplified using the polymerase chain reaction (PCR) (Saiki et al. 1988, Kocher et al. 1989, Chapman and Brown 1990, Carr and Marshall 1991). Primer selection for PCR will include the universal cytochrome-b primers (Kocher et al. 1989) and include those from the ND5/6 and ND3/4 regions of mtDNA (Cronin et al. 1993). These regions have proven useful in other populations identification studies within the genus *Oncorhynchus* (Cronin et al. 1993), and we have detected restriction fragment length polymorphisms in a preliminary examination of pink salmon in our laboratory (Tables 3 and 4). Amplified DNA will be cut with up to 27 restriction enzymes and separated on agarose gels (Table 5). Fragments will be visualized under UV light, and a photographic record will be made of each gel.

Since genes which are encoded by the mitochondrial genome are inherited as a single unit (i.e., analogous to linked loci), the restriction sites detected for each enzyme, for all regions examined, will be pooled as composite haplotypes. The frequencies and distributions of these composite haplotypes will then be used to examine the structure of salmon populations.

Nucleotide (*d*) and haplotype (*h*) diversity measures (Nei, 1987) will also be calculated for all populations using the restriction enzyme analysis package (*REAP*) of McElroy et al. (1990). These measures estimate the number of nucleotide substitutions per site between DNA sequences (i.e., sequence divergence) and the amount of DNA polymorphism within populations, respectively. These values will then be used to calculate an overall genetic distance (Nei, 1978) between populations, which in turn, will be used to generate a branching diagram using the Fitch and Margoliash (1967) least-squares algorithm in the *PHYLIP* (Felsenstein, 1993) package. This dendrogram will depict relationships among the populations.

5. Location:

The field portion of this project will be conducted in Prince William Sound (based out of Cordova), and the laboratory work and data analyses will be completed in Anchorage. The project outcome will influence the long-term viabilities of wild populations in Prince William Sound which will in turn affect the economies of the fishing communities therein.

6. Technical Support:

Administrative support is provided by the Administrative, Habitat, and Commercial Fisheries Management and Development (CFMD) Divisions staff of the Alaska Department of Fish and Game. The project leaders are fully funded with general funds from the State of Alaska. This study is integrated with other studies conducted by the CFMD Division. Consequently, all other technical, logistical, biometrical, and other support have been consolidated into the normal operations of these Divisions for efficiency in completing the objectives of these studies.

7. Contracts:

Becaue of the current state hiring freeze, Alaska Department of Fish and Game Genetics Laboratory is evaluating personnel requirements for this and other commitments such as the genetic stock identification of Cook Inlet sockeye salmon (EVOS study 94255). If personnel are available to perform the laboratory portion of the allozyme analysis, this portion of the project will be done in house. If not, a contract to do the laboratory portion of the allozyme analysis will be awarded to a qualified bidder following the state bidding process.

D. SCHEDULES

Lab analyses (odd-year samples)	Mar. 1994 - Feb. 1995
Data analyses (odd-year samples)	Dec. 1994 - May 1995

Additional field collections	July - Aug. 1994
Draft status report for FY 1994	Mar. 1995
Final status report for FY 1994	June 1995
Lab analyses (even year samples)	Mar. 1995 - Feb. 1996
Data analyses (even year samples)	Sept. 1995 - May 1996
Draft status report for FY 1995	May 1996
Final report	Sept. 1996

E. EXISTING AGENCY PROGRAM

ADF&G spends approximately $30.0K annually on PWS field studies and $500.0K annually on other non-oilspill-related genetics studies.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The studies proposed provide for data collection and field sampling programs. No environmental effect of these programs occurs beyond that of traditional fisheries management data collection activities. These activities are within existing collecting permits or Federal special use permits issued to the Department of Fish and Game for scientific data collection. No other permits or other coordination activities are involved. This project received a categorical exclusion under the National Environmental Policies Act.

G. PERFORMANCE MONITORING

The performance monitoring of this project is through the checks and balances of the State of Alaska Accounting System within the Commercial Fisheries Management and Development, Habitat and Restoration, and Administration Divisions of the Department of Fish and Game and the Department of Administration. Contractual compliance, personnel hiring, EEO compliance, and other administrative provisions are within the State of Alaska hiring and administrative chains of command and covered in standard operating procedures and administrative regulations. Filling new position follows state hiring guidelines when permanent vacancies occur. Project time frames for reports and analysis are maintained through proper planning and integration of these activities within the existing administrative structure of the Commercial Fisheries Management and Development Division.

The scientific and technical aspects of the study are subject to internal review within the Commercial Fisheries Management and Development Division. Publications are submitted through an internal peer review process with the major findings submitted to peer review journals. Reports, work plans, and study design are subject to the peer review process established by the EVOS Board of Trustees and Chief Scientist office.

This study provides the basis for the management programs being developed under other oilspill restoration projects. Interim annual status reports will be generated with publications being provided in peer review journals and scientific symposia, as significant findings are obtained. The final report will be issued upon completion of the final year of field data collection.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

In order to conserve funds, some field sample collections were opportunistically conducted by personnel working on pink salmon egg/fry survival projects in 1991 and 1992. Additional sample collections in 1994 will be integrated between 94191 and this project in order to most efficiently utilize resources.

Collections will represent populations of concern identified in part by pink salmon coded wire tag study 94184.

I. PUBLIC PROCESS

This project was originally conceived through the peer review process. In 1991, reviewers of other EVOS pink-salmon-related projects recommended that the population structure analysis be an essential component of restoration monitoring.

This project also has had strong support from the Prince William Sound Aquaculture Corporation and the Cordova fishing community since it was first drafted in 1991.

J. PERSONNEL QUALIFICATIONS

James E. Seeb, Principal Geneticist
Commercial Fisheries Management and Development
Alaska Department of Fish and Game
Anchorage, Alaska 99518 (907) 267-2385

EDUCATION: B.S., Biology, 1974, University of Puget Sound
M.S., Fisheries, 1982, University of Washington
Ph.D., Fisheries, 1987, University of Washington

PROFESSIONAL EXPERIENCE:

1990- Principal Geneticist, CFMD Division, ADF&G
1991- Affiliate Associate Professor, University of Alaska Fairbanks
1988-1990 Assistant Professor, Southern Illinois University
1987-1988 Research Assistant Professor, University of Idaho
1982-1986 Graduate Research Assistant, University of Washington
1980-1982 Fish Biologist, Pacific Fisheries Research, Olympia,WA
1978-1980 Fish Biologist, Washington Department of Fisheries

SELECTED PUBLICATIONS:

Seeb, J.E., L.W. Seeb, and F.M. Utter. 1986. Use of genetic marks to assess stock dynamics and management programs for chum salmon. Trans. Amer. Fish. Soc. 115:448-454.

Seeb, J.E., and L.W. Seeb. 1986. Gene mapping of isozyme loci in chum salmon (*Oncorhynchus keta*). J. Hered. 77:399-402.

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Utter, F. M., J. E. Seeb, and L. W. Seeb. 1993. Complementary uses of ecological and biochemical genetic data in identifying and conserving salmon populations. Fisheries Research. Fish. Res. 18:59-76.

Lisa. W. Seeb (L. Wishard), Statewide Geneticist
Division of Commercial Fisheries Management and Development
Alaska Dept. of Fish and Game
Anchorage, Alaska 99518 (907) 267-2249

EDUCATION:

A.B. Zoology, 1973, University of California, Berkeley
M.A. Zoology, 1977, University of Montana
Ph.D. Fisheries, 1986, University of Washington

PROFESSIONAL EXPERIENCE:

1991-	Statewide Geneticist, ADF&G, Anchorage
1991-	Affiliate Associate Professor, University of Alaska Fairbanks
1988-1990	Assistant Professor, Southern Illinois University
1984-1988	Research Assist. Prof., University of Idaho
1978-1981	Fish Geneticist, Pacific Fish. Research, Olympia WA
1977-1979	Geneticist, National Marine Fisheries Service, Seattle

SELECTED PUBLICATIONS:

Wishard, L. N., J. E. Seeb, F. M. Utter, and D. Stefan. 1984. A genetic investigation of suspected redband trout populations. Copeia 1984(1):120-132.

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Christopher Habicht, Fisheries Biologist II
Commercial Fisheries Management and Development
Alaska Department of Fish and Game
Anchorage, Alaska 99518 (907) 267-2385

EDUCATION:

B.S., 1986, Fisheries Science, Cornell University, Ithaca NY
M.S., 1994, Zoology, Southern Illinois University, Carbondale IL

PROFESSIONAL EXPERIENCE:

1992- Fisheries Biologist, C.F.M.D. Division, ADF&G
Supervising laboratory analysis of genetic markers for EVOS Trustee Council study 93012 (Genetic Stock Identification of Kenai River Sockeye Salmon). Conducting laboratory evaluations of genetically altered salmonids. Analyzing straying data from pink salmon and chinook salmon tag recoveries.

1989-1992 Graduate Assistant, Southern Illinois University
Conducted allozyme species identification, developed *in vivo* ova storage techniques, and optimized triploid induction and gynogenesis protocols for moronids.

1986-1989 Research Associate, Ohio State University
Provided field and laboratory support for aquatic ecology studies on bioenergetics of essocids.

PUBLICATIONS AND PRESENTATIONS:

Habicht, C. 1993. Electrophoretic Identification of *Morone* species, and *In Vivo* ova storage, induced gynogenesis, and induced triploidy in white bass (M. chrysops). Masters Thesis, Southern Illinois University, Carbondale IL.

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Seeb, J. E., C. Habicht, G. D. Miller. 1994. Gene conservation of triploids in the management of salmonids. To be presented at North American Fish and Wildlife Conference, Anchorage, AK.

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K . BUDGET

(See attached)

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Table 1. Pink salmon producing tributaries in Prince William Sound targetted for genetics sampling. Tributaries are uniformly distributed around the Sound, and 28 spawning aggregations will be sampled each year according to annual abundance of spawning adults.

Tributary	Anadromous Stream Cat. No.[1]
Hartney Cr.	221 - 10 - 10020
Koppen Cr.	221 - 20 - 10350
Beartrap R.	221 - 30 - 10480
Olsen Cr.	221 - 30 - 10516
Whalen Cr.	221 - 40 - 10800
Indian Cr.	221 - 50 - 11170
Siwash Cr	221 - 60 - 11430
Long Cr.	222 - 10 - 12140
Wells R.	222 - 20 - 12430
Jonah Cr.	222 - 20 - 12580
Blackbear Cr.	222 - 30 - 12760
Coghill R.	223 - 30 - 13220
Mills Cr.	223 - 10 - 14210
Swanson Cr.	223 - 10 - 14320
Paulson Cr.	224 - 10 - 14550
W. Finger Cr.	224 - 40 - 14850
McClure Cr.	224 - 40 - 14980
Jackson Cr.	226 - 20 - 16130
Bainbridge Cr.	226 - 20 - 16300
Hayden Cr.	226 - 40 - 16770
Herring Cr.	226 - 10 - 16982
Quadra Cr.	227 - 10 - 17110
Wilby Cr.	227 - 20 - 17440
Rocky Cr.	227 - 20 - 17590
Constantine R.	228 - 60 - 18150
Cook Cr.	228 - 40 - 18280
Hardy Cr.	228 - 20 - 18340
Canoe Cr.	228 - 30 - 18490

[1]Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes. Habitat Division, ADF&G, Juneau, AK.

Table 2. Enzymes or proteins to be analysed for genetic variation. Enzyme nomenclature follows Shaklee et al. (1990), and locus abbreviations are given. Information provided by Washington Department of Fisheries, stewards of the Washington/British Columbia/Alaska interagency database for pink salmon population genetics.

Enzyme or Protein	Enzyme Number	Locus	Tissue
Aspartate aminotransferase	2.6.1.1	*sAAT-1,2*	Heart
		sAAT-3	Eye
		sAAT-4	Liver
		mAAT-1	Heart
		mAAT-2	Liver
		mAAT-3	Liver
Acid phosphatase	3.1.3.2	*ACP-1*	Liver
Adenosine deaminase	3.5.4.4	*ADA-1*	Heart
		ADA-2	Heart
Aconitate hydratase	4.2.1.3	*mAH-1,2*	Heart
		mAH-3	Heart
		mAH-4	Heart
		sAH	Liver
Adenylate kinase	2.7.4.3	*AK*	Muscle
Alanine aminotransferase	2.6.1.2	*ALAT*	Muscle
Creatine kinase	2.7.3.2	*CK-A1*	Muscle
		CK-A2	Muscle
		CK-B	Eye
		CK-C1	Eye
		CK-C2	Eye
Esterase-D	3.1.1.-	*ESTD*	Heart

Enzyme or Protein	Enzyme Number	Locus	Tissue
Fructose-biphosphate aldolase	4.1.2.13	*FBALD-3*	Eye
		FBALD-4	Eye
Fumarate hydratase	4.2.1.2	*FH*	Muscle
β-N-Acetylgalactosaminidase	3.2.53	*βGALA*	Liver
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	*GAPDH-1*	Muscle
		GAPDH-2	Heart
		GAPDH-3	Heart
		GAPDH-4	Eye
		GAPDH-5	Eye
Guanine deaminase	3.5.4.3	*GDA-1*	Liver
		GDA-2	Liver
N-Acetyl-β-glucosaminidase	3.2.1.53	*βGLUA*	Liver
Glycerol-3-phosphate dehydrogenase	1.1.1.8	*G3PDH-1,2*	Muscle
		G3PDH-3	Heart
		G3PDH-4	Heart
Glucose-6-phosphate isomerase	5.3.19	*GPI-B1,2*	Muscle
		GPI-A	Muscle
Glutathione reductase	1.6.4.2	*GR*	Eye
Hydroxyacylglutathione hydrolase	3.1.2.6	*HAGH*	Liver
L-Iditol dehydrogenase	1.1.1.14	*IDDH-1*	Liver
		IDDH-2	Liver
Isocitrate dehydrogenase (NADP+)	1.1.1.42	*mIDHP-1*	Heart

Table 2. Continued

Enzyme or Protein	Enzyme Number	Locus	Tissue
		mIDHP-2	Heart
		sIDHP-1	Liver
		sIDHP-2	Liver
L-Lactate dehydrogenase	1.1.1.27	*LDH-A1*	Muscle
		LDH-A2	Muscle
		LDH-B1	Eye
		LDH-B2	Liver
		LDH-C	Eye
αMannosidase	3.2.1.24	*αMAN*	Liver
Malate dehydrogenase	1.1.1.37	*sMDH-A1,2*	Liver
		sMDH-B1,2	Heart
		mMDH-1	Muscle
		mMDH-2	Muscle
Malic enzyme (NADP+)	1.1.1.40	*sMEP-1*	Muscle
		mMEP-1	Muscle
		mMEP-2	Muscle
Mannose-6-phosphate isomerase	5.3.1.8	*MPI*	Heart
Dipeptidase	3.4.-.-	*PEPA*	Eye
Tripeptide aminopeptidase	3.4.-.-	*PEPB-1*	Heart
Peptidase-C	3.4.-.-	*PEPC*	Eye
Proline dipeptiase	3.4.13.9	*PEPD*	Heart
Peptidase-LT	3.4.-.-	*PEPLT*	Muscle

Table 2. Continued

Enzyme or Protein	Enzyme Number	Locus	Tissue
Phosphogluconate dehydrogenase	1.1.1.44	*PGDH*	Liver
Phosphoglucomutase	5.4.2.2	*PGM-1*	Heart
		PGM-2	Heart
Phosphoglycerate kinase	2.7.2.3	*PGK-1*	Muscle, Liver
		PGK-2	Muscle, Liver
Purine-nucleoside phosphorylase	2.4.2.1	*PNP-1*	Eye
Superoxide dismutase	1.15.1.1	*sSOD-1*	Heart
		mSOD	Heart
Triose-phosphate isomerase	5.3.1.1	*TPI-1,2*	Eye
		TPI-3	Eye

Table 3. Distribution of mtDNA haplotypes among six populations of pink salmon (*Oncorhynchus gorbuscha*) from Prince William Sound. Frequencies of the haplotypes are in brackets[a].

			Composite Haplotype[b]						
Population	Year	N	P1	P2	P3	P4	P5	P6	P7
Chenega Creek	1992	20	13 (0.65)	3 (0.15)	3 (0.15)	-	1 (0.05)	-	-
Duck River	1992	20	15 (0.75)	1 (0.05)	3 (0.15)	1 (0.05)	-	-	-
Fish Creek	1992	20	15 (0.75)	4 (0.20)	-	-	-	1 (0.05)	-
Duck River	1991	20	8 (0.40)	11 (0.55)	-	-	-	-	1 (0.05)
Humpback Creek	1991	20	14 (0.70)	4 (0.20)	-	-	-	-	2 (0.10)
Swanson Creek	1991	20	9 (0.45)	11 (0.55)	-	-	-	-	-

[a] Data may not be used without written consent from authors.

[b] Haplotypes were determined from polymorphic enzymes (*BstU I, Hinf I, Apa I*, and *EcoR V*, respectively) and are as follows: P1 = AAAA, P2 = BAAA, P3 = ABAA, P4 = BBAA, P5 = ACAA, P6 = BAAB, P7 = BABA.

Table 4. Approximate fragment sizes and number of sites for the 16 restriction enzymes used on six populations of pink salmon from Prince William Sound[a].

Enzyme	Haplotype	Fragment sizes (kb)	# of Sites
Apa I	A	1300, 1100	1
	B	1300, 650, 450	2
Bam H I	A	2400	0
Bcl I	A	1750, 650	1
BstE II	A	2000, 400	1
BstU I	A	1650, 750	1
	B	1150, 750, 500	2
Dpn II	A	1300, 400[b], 300	3
EcoR I	A	2025, 375	1
EcoR V	A	2400	0
	B	1500, 900	1
Hae III	A	675[b], 550, 500	3
Hind III	A	2250, 150	1
Hinf I	A	725, 450, 325[b], 200[b], 175	6
	B	1050, 450, 325, 200[b], 175	5
	C	450, 400, 325[c], 200[b], 175	7
Kpn I	A	2400	0
Pst I	A	2400	0
Rsa I	A	1605, 265[c]	3
Stu I	A	900, 825, 675	2
Xba I	A	2400	0

[a] Data may not be used without written consent from authors.
[b] Two comigrating fragments of the same length.
[c] Three comigrating fragments of the same length.

Table 5. Restriction enzymes that will used in to screen for mtDNA restriction fragment length polymorphisms in pink salmon populations inhabiting Prince William Sound.

	Restriction Enzyme	Recognition Site
1	Apa I	GGGCC'C
2	BamH I	G'GATCC
3	Bcl I	T'GATCA
4	Bgl I	GGCNNNN'NGGC
5	Bgl II	A'GATCT
6	BstE II	G'GTNACC
7	BstU I	CG'CG
8	Dpn II	'GATC
9	EcoR I	G'AATTC
10	EcoR V	GAT'ATC
11	Hae III	GG'CC
12	Hha I	GCG'C
13	Hind III	A'AGCTT
14	Hinf I	G'ANTC
15	Kpn I	GGTAC'C
16	Mse I	T'TAA
17	Msp I	C'CGG
18	Nci I	CC'SGG
19	Pst I	CTGCA'G
20	Sac I	GAGCT'C
21	Sac II	CCGC'GG
22	Sau96 I	G'GNCC
23	Sca I	AGT'ACT
24	Stu I	AGG'CCT
25	Taq I	T'CGA
26	Xba I	T'CTAGA
27	Xho I	C'TCGAG

APPENDIX A

7 March 1994

Collection of Finfish Genetic Samples
ADF&G Genetics Laboratory, Anchorage

I. General information

We use tissue samples from muscle, liver, heart, and eye from individual fish to determine the genetic characteristics of a particular run or stock of fish. The most important thing to remember in collecting samples is that tissues need to be as fresh and as cold as possible at all times.

II. Sample size

A sample size of 50-100 adult fish is preferred for the baseline electrophoretic study. Samples of juveniles are statistically less desirable and sample sizes will need to be larger than for adults; generally a sample size of 150-200 juveniles is necessary.

III. Tissue sampling

A. General set up

We use four tissues (muscle, liver, eye, and heart) for protein electrophoresis and liver for DNA analysis. Working fast is necessary, so it is best to try to get set up in as comfortable a place as possible. You might use a portable table, piece of plywood, or anything to give you a surface at a good height. Before sampling (night before?), label tubes using lab markers or adhesive labels (provided in sampling kit). Place the prepared tubes in the racks provided. Four separate tubes, corresponding to the four tissues, should be labeled for each individual. The following code should be used:

Species code * see instructions for each project

Location code * see instructions for each project

Individual # # i.e. 01, 02, 03....100

Tissue M,L,E,H (muscle, liver, eye, heart)

B. Use of liquid nitrogen

We will be using a liquid nitrogen container to immediately freeze the tissues. Inside the liquid nitrogen container are 6 cylindrical canisters. We have shipped special test tubes called "cryotubes" in which to place the samples. These cryotubes have plastic seals and screw on caps to withstand liquid nitrogen storage. Five to six tubes are stored in a cane.

The working time of the liquid nitrogen container under normal conditions is 81 days (35VHC) or 50 days (18HC). To prolong the liquid nitrogen, samples can be pre-frozen (if a freezer or dry ice is available) and added in a group to minimize the number of times the container is opened. The liquid nitrogen level can be checked periodically with a flashlight or actually measured with a stick (2.3 liters/inch in 35VHC; 1.25 liters/inch in 18HC).

"Large" 35 VHC container:
30 canes will fit in each of the six canisters. 5 cryovials will fit on a cane comfortably or 6 in a pinch. Total capacity is 900 - 1080 tubes.

"Small" 18HC container:
17 canes will fit in each of the six canisters. 5 to 6 cryovials will fit on a cane. The total capacity is 510 - 612 tubes.

Safety with liquid nitrogen:

1. Wear gloves, protective eyewear, and protective footwear when placing samples in container. Liquid nitrogen boils at -196°, and it will spit and boil when samples are added.

2. Do not tip the tank over as it does not seal.

3. Keep lid on liquid nitrogen container at all times when you are not placing samples in it.

4. Use a small cooler with ice, snow, or blue ice to hold canes until an adequate number are collected to be put in liquid nitrogen container. Depending on the conditions and the speed of sampling, place samples in liquid nitrogen within about one hour of sampling.

5. Use liquid nitrogen only in well ventilated areas (usually not a problem in the field). Avoid directly breathing the vapor.

6. Hazardous Materials Forms need to be filled out when shipping a filled liquid nitrogen container by air cargo.

B. Actual sampling

Please take samples from freshly killed fish. We find it easiest to set up four canes simultaneously and organize the samples in canes by tissue. Thus, muscle tissue from fish 1-5 would all be in one cane.

Fill the tubes approximately 3/4 full or to the 1.8 ml mark, leaving air space at the top. Overfilling the tubes can cause them to burst when frozen. Please minimize the amount of blood, dirt, skin, and fat in the sample.

1. Muscle

Muscle samples should be "white" muscle, not muscle from along the lateral line. Use a piece of muscle dorsal to the lateral line. If you have trouble getting the tissue into the tubes, cut it into smaller pieces.

2. Liver

The liver is (generally) located on the fish's left side, just behind the pectoral fin. An L-shaped incision slicing down ventrally behind the pectoral fin then caudally along the belly works well. Please do not include the gall bladder (the small green/yellow sac of fluid attached to the liver).

3. Heart

Once you have taken the liver, it is easy to get the heart by just opening the belly incision towards the head.

4. Eye

There are two ways to take the eyes. If the eyes are small enough (juveniles), they can be placed intact into a cryotube. This is the easiest method. If they are too large, you must pipette out the liquid and black retinal fluid. Using a sharp scalpel, cut a small slit in the surface of the eye, then insert a pipette into the slit and suck out the fluid and black retinal material. Squirt this into the cryotube.

We appreciate your help with the sampling. If you have any questions, please give us a call.

Laboratory (Lori Wagoner)	267-2454
Chris Habicht	267-2169
Jim Seeb	267-2385

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Pink Salmon Stock Genetics in Prince William Sound - This project will use proven genetic techniques to determine separate genetic stocks of pink salmon in Prince William Sound. This information will be used to manage commercial harvest to protect wild pink salmon populations while maintaining a viable commercial fishery for hatchery released pink salmon.

Budget Category:	1993 Project No. . . . . Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$0.0	$0.0	$36.2	$36.2	$55.0	
Travel	$0.0	$0.0	$3.0	$3.0	$5.5	
Contractual	$0.0	$0.0	$112.2	$112.2	$118.2	
Commodities	$0.0	$0.0	$6.5	$6.5	$8.5	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$157.9	$157.9	$187.2	
General Administration	$0.0	$0.0	$13.3	$13.3	$16.5	
Project Total	$0.0	$0.0	$171.2	$171.2	$203.7	
Full-time Equivalents (FTE)	0.0	0.0	0.7	0.7	0.6	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Fishery Biologist II	0.0	$0.0	2.0	$8.6
Biometrician I	0.0	$0.0	3.0	$14.7
Fish & Wildlife Technician II	0.0	$0.0	2.0	$6.2
Program Manager	0.0	$0.0	1.0	$6.7
Personnel Total	0.0	$0.0	8.0	$36.2

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94320-D
Project Title: Pink Salmon Stock Genetics in PWS
Agency: AK Dept. of Fish & Game

FORM 2A
PROJECT
DETAIL

Travel:	Reprt/Intrm	Remaining
2 RT Anchorage/Cordova (air fare $350 + 1 day per diem @ $150/day)	$0.0	$1.0
4 RT Anchorage/Cordova for staff/biometrics meetings (air fare $350 + 1 day per diem @ $150/day)	$0.0	$2.0
Travel Total	$0.0	$3.0

Contractual:		
Air freight, postage	$0.0	$1.0
Long distance telephone charges	$0.0	$1.2
Contract for genetics work to separate discrete genetic stocks of pink salmon in Prince William Sound	$0.0	$110.0
Contractual Total	$0.0	$112.2

Project Number: 94320-D
Project Title: Pink Salmon Stock Genetics in PWS
Agency: AK Dept. of Fish & Game

FORM 2B
PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Commodities:	Reprt/Intrm	Remaining
Computer software upgrades	$0.0	$1.5
Field supplies (cryotubes, knives, tweezers, jars, label tape, markers, preservatives, gasoline, etc.)	$0.0	$5.0
Commodities Total	$0.0	$6.5

Equipment:		
Equipment Total	$0.0	$0.0

07/14/93

1994

Printed: 3/8/94 11:46 AM

Project Number: 94320-D
Project Title: Pink Salmon Stock Genetics in PWS
Agency: AK Dept. of Fish & Game

FORM 2B
PROJECT
DETAIL

94320E

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	SEA Program: Salmon Predation
Project ID number:	94320E
Project type:	Research/Monitoring
Name of project leader(s):	Mark Willette
Lead agency:	Alaska Department of Fish and Game
Cooperating agencies:	University of Alaska Prince William Sound Science Center Prince William Sound Aquaculture Corporation U.S. Fish and Wildlife Service
Cost of project/FY 94:	$998,300
Cost of project/FY 95:	$1,040,586
Cost of Project/FY 96 and beyond:	$1,040,586
Project Start-up/Completion Dates:	March 1, 1994 - September 30, 1994
Geographic area of project:	Prince William Sound
Name of project manager:	Joe Sullivan

B. INTRODUCTION

This project is a component of the Sound Ecosystem Assessment (SEA) program. SEA is a multi-disciplinary effort to acquire an ecosystem-level understanding of the marine and freshwater processes that interact to constrain levels of fish, and marine bird and mammal production in Prince William Sound (PWS).

The purposes of this project are to (1) determine to what extent variations in predation affect the survival of juvenile pink salmon (and other age-0 fish), and (2) identify and describe the mechanisms that cause variations in predation. Pink salmon runs to PWS failed in 1992 and 1993. These salmon run failures have drastically affected the economy of the PWS region which is largely based on the salmon resources. It is essential that we develop an understanding of the processes that are causing these events. This information is needed to develop a strategy to restore salmon runs in PWS, if possible.

At the present time, it is not clear to what extent oil-spill impacts or environmental conditions may have contributed to the run failures in PWS. Restoration project 94191 (Injury to Salmon Eggs and Pre-emergent Fry in PWS) will determine if genetic damages to pink salmon may have contributed to the run failures observed in PWS during the past two years. The proposed project will determine to what extent changes in the PWS ecosystem may have contributed to the run failures. In 1992, pink salmon returns were low in Kodiak, Lower Cook Inlet, and PWS, but pink salmon returns in 1993 were low only in PWS. Low returns of hatchery-produced salmon in both years indicates that the failures were likely caused by processes occurring during the juvenile lifestage. Damage assessment studies on juvenile pink salmon in PWS have demonstrated that growth during the juvenile lifestage is related to survival to adult (Willette 1993). Growth rates of juvenile salmon were estimated in 1991 and 1992 after the fish were released from hatcheries. Juvenile growth and ocean temperatures were low in PWS during the early marine period in 1991. However, in 1992 juvenile growth and ocean temperatures were near average; although, zooplankton abundance was very low. The growth of juvenile fishes is believed to be related to survival, because slow-growing individuals are vulnerable to predators for a longer time (Parker 1971; Healey 1982; West and Larkin 1987). The growth and mortality rates of juvenile salmon released into PWS in 1992 suggests that a change in predation rate may have contributed to the observed run failures.

C. PROJECT DESCRIPTION

This is a multi-year project designed to test two hypotheses regarding mechanisms that may regulate predation on juvenile salmon and other age-0 fish in PWS. Regulation of prey population size by a predator requires that prey mortality rate increase with prey population size (i.e density-dependent mortality; Holling 1959).

Intense predation immediately after ocean entry may have contributed to poor survival of relatively large release groups of hatchery-reared coho salmon (Bayer 1986, Olla and Davis 1989, Pearcy 1992). Learned behavior or response to environmental cues may cause predators to aggregate in areas where prey are consistently abundant (Ware 1971, Godin 1978). Alternatively, predation on a prey population may increase when the preferred prey of potential predators is not available (Werner and Hall 1974, Ringler 1979, Winfield et al. 1983). In the northern Gulf of Alaska, predators such as juvenile walleye pollock (Armstrong and Winslow 1968) that prefer macrozooplankton (Clausen 1983, Dwyer et al. 1987, Bailey 1989) may switch to age-0 fish when macrozooplankton abundance is low. Macrozooplankton abundance was very low in PWS in 1992 indicating that predators may have switched to juvenile salmon. The following hypotheses will be tested by the project:

Hypotheses:

1. The predation rate (mortality rate) on juvenile salmon is greater when juvenile salmon abundance is high.

2. The predation rate on juvenile salmon is greater when macrozooplankton abundance is low.

During the first year of this project, basic information will be obtained regarding the identity, distribution, and behavior of salmon predators. Data obtained during the first year will be used to refine field sampling techniques and sampling designs. Field and experimental studies will be conducted in future years to (1) monitor intra- and inter-annual changes in predation rate, and (2) test the density-dependent and prey-switching hypotheses.

1. Resources and/or Associated Services:

This project will focus on the fish and marine birds that prey on juvenile pink salmon (*Oncorhynchus gorbuscha*) in PWS. Important fish predator species may include walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*) Pacific herring (*Clupea harengus pallasi*) and coho salmon (*Oncorhynchus kisutch*). Logistical support will be provided to staff from the U.S. Fish and Wildlife Service who will identify marine bird predators and develop preliminary estimates of predation rate. The economic survival of the communities in the PWS region is dependent on restoration of the salmon resource. Attempts to restore the salmon resource cannot proceed without understanding the cause of these run failures.

The information obtained from the study will also contribute to our understanding of the mechanisms affecting population dynamics of other juvenile fishes (forage fish) that serve as food for apex predators (marine birds and mammals). Analyses of fish stomach contents will provide information regarding predation on Pacific herring, capelin (*Mallotus villosus*), Pacific sandlance (*Ammodytes hexapterus*), and others. Samples of forage fish (sandlance, capelin, etc.) will be collected for later stomach contents analysis within project 94163 (Forage Fish). This data will be used to evaluate the carrying capacity of PWS for juvenile fishes.

2. Relation to Other Damage Assessment/Restoration Work:

This project is a component of the Sound Ecosystem Assessment (SEA) program. SEA is a multi-disciplinary program designed to develop an understanding of the mechanisms regulating ecosystem function in PWS. During its first year, SEA will focus on the interactions of pink salmon and herring with other components of the PWS ecosystem. Several other projects complement SEA by providing SEA researchers with the data or tools needed to examine ecosystem function. These projects include Oil-related Egg and Alevin Mortality (94191), Pink Salmon Coded-wire Tag Recovery (94184), Pink Salmon Otolith Marking (94187), Pink Salmon Genetics (94189), Forage Fish Influence on Recovery of Injured Species (94163), Herring Spawn Deposition and Reproductive Impairment (94166), and Herring Genetic Stock Identification (94165). This project is also related to damage assessment project FS#4 Early Marine Salmon Injury Assessment in PWS.

3. Objectives:

This project will achieve the following three objectives during the first year of study.

1. Identify the principal predators on juvenile salmon.

2. Determine the distribution, abundance, species and size composition of fish predators along the juvenile salmon migratory pathway.

3. Recommend methods for improving field sampling techniques, sampling designs, and hypothesis testing capabilities.

4. Methods:

Objective 1:

Identification of the principal fish predators on juvenile salmon will require estimation of the juvenile salmon consumption rate for each potential predator species along the juvenile salmon migratory pathway. Fish biomass, food consumption rate (daily ration), and diet composition must be estimated for each potential predator species to estimate juvenile salmon consumption rate. The Nearshore Fish component of the

SEA program will estimate fish biomass using hydroacoustic techniques. The Salmon Predation component of SEA will estimate predator species and size composition, food consumption rate, and diet composition.

A stratified random sampling design will be employed to estimate the juvenile salmon consumption rate during six ten-day sampling periods (Table 1). Techniques developed by Mehl and Westgard (1983) will be used, i.e.

$$C_{ijk} = DR_i \times B_{ijk} \times P_{ijk} \quad (1)$$

where C_{ijk} is the consumption (grams) of juvenile salmon by a predator belonging to size group j during time period i in strata k, DR_i is the daily ration (%body weight per day) during the ten-day sampling period, B_{ijk} is the biomass (grams) of the predator species within the stratum, and P_{ijk} is the proportion by weight of juvenile salmon in predator stomachs within the stratum. Total juvenile salmon consumption rate will be estimated by summing among all important predator species. Variances will be estimated and confidence intervals placed about the juvenile salmon consumption rate estimate for each predator species, as well as the total consumption estimate.

The daily ration of salmon predators will be estimated from diel feeding periodicity studies conducted once during each ten-day sampling period. Three random samples (3 net sets) of 30 individuals each will be collected in a single area at midnight (0000 hrs), 0400 hrs, 0800 hrs, 1200 hrs, 1600 hrs, 2000 hrs, and midnight. Samples will be processed as described above. The daily ration (DR_i, % body weight per day) will be estimated for each ten-day sampling period (i) by

$$DR_i = \frac{Rt}{1-e^{-Rt}} \sum_{j=1}^{m} S_j(1-e^{-Rt}) \quad (2)$$

where t is the duration of each time interval (j) over which stomach samples are collected, S_j is the mean stomach contents weight as a percent of fish body weight within time period j, m is the total number of j time intervals in a 24-h day, and R is instantaneous temperature-specific gastric evacuation rate (Elliot & Persson 1978). Water temperature will be measured at the depth where fish were captured. Temperature-specific gastric evacuation rates have been estimated for walleye pollock (Dwyer et al. 1986, Smith et al. 1989) and Atlantic cod (Ursin et al. 1985).

Field studies will be initiated on April 1 and continue until July 22 (Table 1). Approximately 180 million juvenile salmon will be released from the Wally H. Noerenberg (WHN) Hatchery beginning in late April through late May. The high abundance of juvenile salmon near the hatchery will increase the likelihood of encountering salmon in predator stomachs. Estimates of juvenile salmon consumption rate will be made for six ten-day sampling periods (Table 1) in two study areas in northwest and southwest PWS (Figure 1). The first four surveys will be conducted in northwest PWS prior to June 15 when juvenile salmon released from the WHN Hatchery will likely be abundant in the area (Willette 1993). The last two surveys will be conducted in southwest PWS prior to July 22 when juvenile salmon from all hatcheries in PWS will likely be abundant in the area.

Prior to the salmon fry release at the WHN Hatchery (April 12-15), a detailed predator distribution survey will be conducted in the Northwest Study Area adjacent to the hatchery (see Nearshore Fish component). A mid-water trawl vessel will collect hydroacoustic data in offshore areas. Two seine boats working in conjunction with two small hydroacoustic survey boats (Nearshore Fish component) will survey predator distribution in nearshore habitats. Net samples will be collected from selected schools of fish to determine the variability in species and size composition within and among schools. Preliminary analyses of the hydroacoustic and net data will be conducted to select sample sizes and develop a stratified sampling design to minimize variance estimates of abundance, species and size-class composition (Cochran 1977).

After the first fry are released from the WHN Hatchery (late April), six predation rate surveys (ten days each) will be conducted to estimate the juvenile salmon consumption rate. The stratified random sampling program will be designed to minimize the variance estimate of predator biomass (Bazigos 1976) and the proportion of predator stomach contents weight comprised of juvenile salmon. As a result, strata will be established based upon the abundance of predators and juvenile salmon in the study area (Smith and Gavaris 1993). Juvenile salmon abundance will be estimated from hydroacoustic data, visual observations, and data on juvenile salmon migration patterns from earlier studies (Willette 1993). It is expected that these criteria will result in strata established by time of day (day; night), depth, habitat type (nearshore; offshore), and geographic location (i.e., areas). During the first year of study, the number of strata and sample sizes within strata will be liberal. Hydroacoustics will be used to estimate predator biomass within each strata and locate schools of fish for net sampling (see Nearshore Fish component). The Schools will be randomly sampled within each strata.

Three vessels will be employed to sample salmon predators during predation rate surveys. An approximately 25 m trawl vessel will sample fish in offshore areas using a 40 m x 28 m mid-water wing trawl equipped with a net sounder. The cod end of the the trawl will be lined with approximately 2.0 cm stretch-mesh web to retain small specimens. Data from the net sounder will be used to insure that the number of fish caught in each set does not greatly exceed required sample sizes. A smaller mid-water trawl net 5 m x 3 m (cod-end 1.0 cm stretch mesh) will be used to sample small fish in deep water areas. Two purse seine vessels will sample salmon predators in nearshore areas. Each vessel will fish a small-mesh purse seine approximately 250 m x 30 m with 2.0 cm stretch mesh web. The small-mesh seines will also be used to capture small fish that may compete with juvenile salmon for food, as well as, larger juvenile salmon later in the season. Approximately 150 m variable-mesh gill nets (1.5

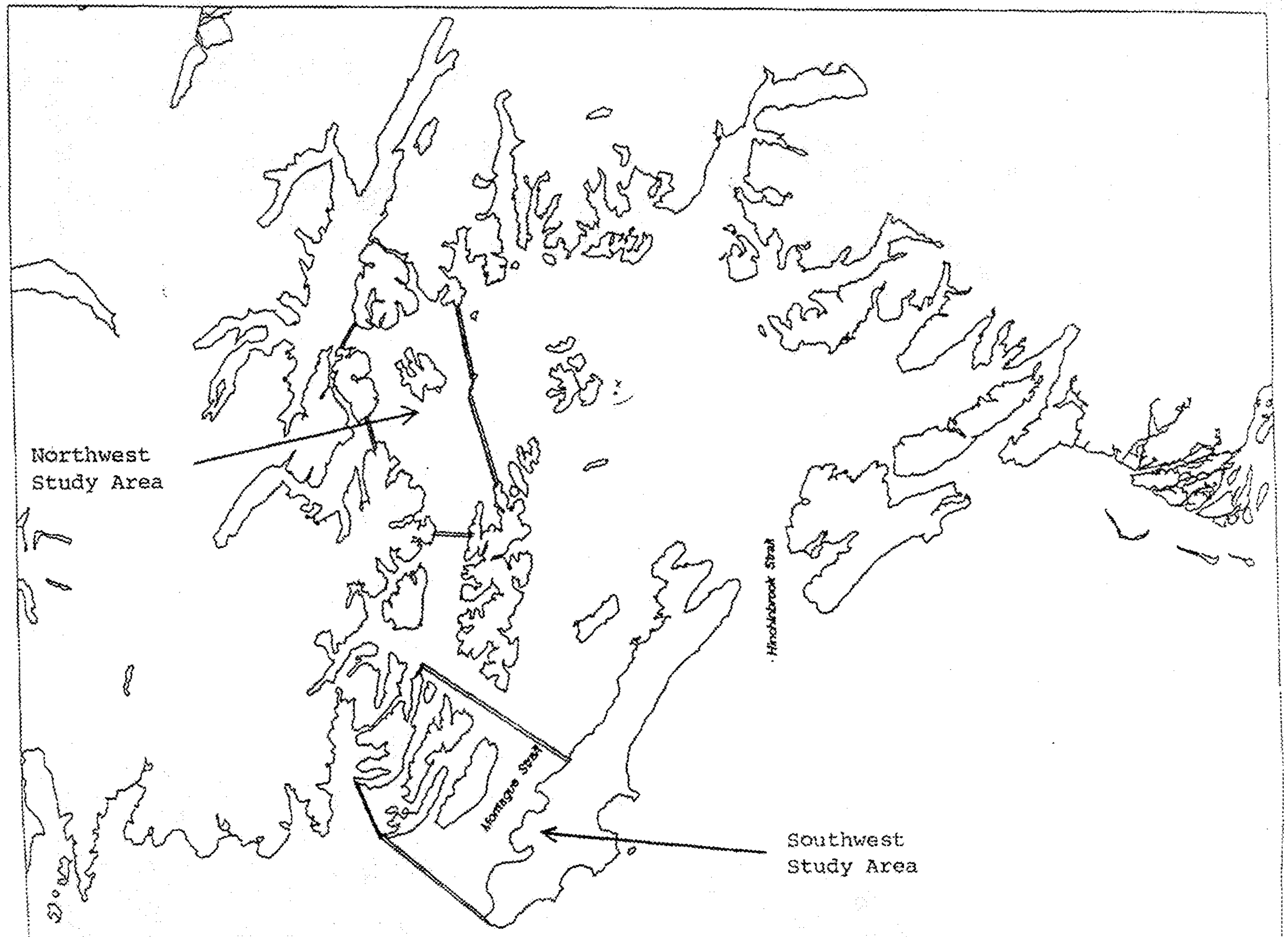

Figure 1: Northwest and southwest study areas in Prince William Sound.

cm to 10 cm stretch mesh) will be deployed in shallow nearshore habitats that cannot be effectively sampled with purse seines. These samples will be used primarily to identify potential predators and generally not for stomach contents analysis.

Processing of fish samples from each net set will occur in two stages following procedures outlined by Livingston (1989) and Dwyer et al. (1987). On board the sampling vessel, length will be measured for a randomly selected subsample (n≈60) from each species in the catch. If a large number of fish are caught, species composition will be estimated from a random sample of 300 individuals. Fish body weight will be estimated from length-weight regression equations developed for each species from a sample of 300 individuals randomly selected from a range of sizes. Stomach contents analysis will be conducted on a randomly selected subsample (n=15) of fish from each species. In cases where distinct size classes occur within species, stomach contents analysis will be conducted for a subsample (n=15) from each size class. Size related shifts in diet toward piscivory have been noted in several species of gadoid fishes, including Pacific cod (*Gadus macrocephalus*) (Livingston 1989), walleye pollock (*Theragra chalgogramma*) (Dwyer et al. 1987), Atlantic cod (*Gadus morhua*) (Daan 1973), Pacific whiting (*Merluccius productus*) (Livingston 1983), and silver hake (*Merluccius bilinearis*) (Langton 1982). Stomach contents analysis will be conducted on board the sampling vessels for large fish and later in the laboratory for small fish. Fish showing evidence of regurgitation will not be included in the sample. Sex and sexual maturity will be recorded for fish processed for stomach analysis. For large fish, total stomach contents wet weight will be measured to the nearest gram. Invertebrate prey in the gut will generally be identified to the family level. Fish in the gut will be identified to the lowest possible taxonomic level, measured to the nearest millimeter, and weighed to the nearest 0.1 grams. Stomachs of small fish will be removed, placed in cloth bags, and labelled regarding location of capture, length, sex, and sexual maturity. Stomachs will be preserved in 10% formalin and later transferred to 50% isopropyl alcohol. Later in the laboratory, total stomach contents wet weight will be measured to the nearest milligram. Prey items in the gut will be identified to the lowest possible taxonomic level. Fish in the gut will be measured to the nearest millimeter and weighed to the nearest milligram. Juvenile salmon will be distinguished from other juvenile fishes in the gut by body or otolith morphology. Diet composition will be expressed as a proportion of total stomach contents weight. Stomach fullness will be expressed as a proportion of fish body weight. A preservative adjustment equation will be determined from a random sample of approximately 60 stomachs weighed (to the nearest .01 g) before and after 40 days of preservation.

The age composition of potential fish predator populations will be estimated from otolith analysis and length-frequency data. Length modes are clearly separated for ages 1-3 among juvenile walleye pollock from the northwest Gulf of Alaska (Smith et al. 1984). Otoliths will be collected from a random sample of 300 individuals from each species over a range of sizes. Fish age will be estimated from otoliths read by clearing with 50% glycerin solution or by the break-and-burn method. A normal curve separation technique will be employed to assign length categories to age groups (MacDonald and Pitcher 1979). Age assignments will be validated from a sample (n=60) of otoliths that were not used to build the model.

Objective 2:

Four broad-scale predator surveys will be conducted to determine the spatial distribution, abundance, and species and size-class composition of fish predators along the juvenile salmon migratory pathway (Table 1). The Nearshore Fish component of SEA will employ hydroacoustic techniques to map the abundance of fish predators from the WHN Hatchery to the Gulf of Alaska (Figure 1). The surveys will be conducted by an approximately 25m mid-water trawl vessel. The Salmon Predation component of SEA will sample selected fish targets with a 40 m x 28 m mid-water trawl net (described above). A spatial statistics method, such as Kriging (Clark 1979), will be used to develop contour maps of predator density. Fish samples will be processed to estimate species and size composition of hydroacoustic targets using the methods described in objective (1).

Objective 3:

Analysis of variance and multiple comparison tests and an analysis of gain in precision will be conducted to identify strata that can be combined in future years (Smith and Gavaris 1993, Cochran 1977). Post-stratification techniques based on predator and juvenile salmon abundance estimates will be applied to the 1994 data to help develop an improved stratification scheme that approaches optimal allocation (Jolly and Hampton 1990). The relative contribution of each component (daily ration (DR), predator biomass (B), and proportion of salmon in the diet (P)) to the estimated variance of the salmon consumption rate will be computed to identify where gains in precision can be made by increasing sample sizes.

Feeding characteristics of each predator species identified under objective (1) will be determined by examining graphically the individual components (DR, B, and P) of juvenile salmon consumption rate. Multivariate analysis of variance procedures will also be employed (e.g., Johnson and Wichern 1988). Multiple regression analysis will be used to provide a preliminary assessment of the two project hypotheses. Juvenile salmon predation rate will be used as the dependent variable in the model with juvenile salmon abundance and macrozooplankton abundance (from the Zooplankton component) as independent variables.

5. Location:

This project will be conducted in PWS which has experienced failures in both wild and hatchery salmon runs in 1992 and 1993. The economy in the PWS region is based upon these salmon resources. The economic health of the communities (Whittier, Valdez, Cordova) in this region is dependent on the salmon resource. During the first year of study, the project will focus sampling effort in western PWS which is known to be a major migratory pathway for juvenile salmon exiting the Sound.

6. Technical Support:

Hydroacoustic estimates of predator abundance, biomass, and size composition will be provided by the Nearshore Fish component of SEA. Data archiving services will be required for this project to insure that all information is adequately documented and archived. This service will be provided by the modeling and data management component of SEA.

7. Contracts:

Three vessels will be contracted to provide logistical support for predator surveys in western PWS. The vessels will also provide logistical support for the Physical Oceanography, Nearshore Fish, Zooplankton, and Primary Production components of the SEA program. A mid-water trawl vessel will collect samples of salmon predators in offshore areas of the Sound. This vessel must have adequate dry laboratory space for hydroacoustic gear and wet laboratory space for stomach contents analysis. Two purse seine vessels will be contracted to collect samples of predators in nearshore areas. The vessel contracts will be awarded through competitive bid.

D. SCHEDULES

The field season for this project will be from April to July of each year. Laboratory and data analysis will be conducted during the remainder of the year (Table 1).

Table 1: Schedule of project activities related to 1994 field season.

Time Period	Activity
<u>Predation Rate Surveys</u>	
April 16 - April 26	Northwest PWS Survey
May 1 - May 10	Northwest PWS Survey
May 15 - May 25	Northwest PWS Survey
June 1 - June 10	Northwest PWS Survey
June 16 - June 27	Southwest PWS Survey
July 11 - July 22	Southwest PWS Survey
<u>Predator Distribution Surveys</u>	
April 1 - April 7	Western PWS Survey
April 12 - April 15	Northwest PWS Survey
May 11 - May 14	Western PWS Survey
June 11 - June 15	Western PWS Survey
July 6 - July 10	Western PWS Survey
<u>Laboratory & Data Analyses</u>	
6/1/94 - 12/31/94	Conduct stomach contents analysis and read otoliths.
1/1/95 - 3/31/95	Analyze data and prepare annual report.

E. EXISTING AGENCY PROGRAM

The Prince William Sound Aquaculture Corporation (PWSAC) will provide logistical support to this project. Bunk space, shower facilities, and water will be provided to project vessels and crews at PWSAC hatcheries as needed. PWSAC will also apply coded-wire tags to nearly 1,000,000 juvenile pink salmon that will be released into PWS during April, 1994. These fish will provide an essential tool for researchers examining growth, migration, and predation on juvenile salmon in PWS. The ADFG is responsible for managing the pink salmon resource in the PWS area. The department enumerates pink salmon catch and escapement and forecasts returns from a pre-emergent fry index program. These activities provide essential data needed to estimate the survival of pink salmon returning to PWS each year.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project will qualify for an exclusion from the requirements of the National Environmental Policy Act. The project will not cause a significant environmental impact.

G. PERFORMANCE MONITORING

An annual report detailing the results from the previous year's investigations will be submitted by April 1 of each year.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be highly integrated with several other components of the SEA Program as well as other projects in the FY94 workplan. Within the SEA Program, Physical Oceanography, Nearshore Fish, Zooplankton, and Phytoplankton components of SEA will share research platforms with the Salmon Predation Project. Within the Physical Oceanography component of SEA, conductivity, temperature, depth (CTD) profilers and Acoustic Doppler Current Profilers (ADCP) will be deployed from the mid-water trawl vessel that will be chartered as a part of Salmon Predation. Within the Nearshore Fish component of SEA, hydroacoustic gear will be deployed from the mid-water trawl vessel and a dry lab will be provided on the vessel for a hydroacoustic technician. Within the Zooplankton and Phytoplankton components, zooplankton and water samples will be collected using nets and water bottles from the mid-water trawl vessel. Each of the two seine vessels chartered by Salmon Predation will provide logistical support (bunks, meals, etc.) for an associated small hydroacoustic boat. The hydroacoustic technician will be responsible for CTD deployment. Fishery biologists on each seine vessel will collect zooplankton samples for the Zooplankton component. Salmon Predation will provide a research platform for one marine bird observer in cooperation with the USFWS component of the Forage Fish Project (94163). An additional marine bird observer will be accomodated on each of the seine vessels if possible. Salmon Predation will also collect age-weight-length data from forage fish and provide stomach samples for the Forage Fish Project. The Pink Salmon Coded-wire Tag Recovery Project will provide data on survival rates of pink salmon released from PWS hatcheries. This data is essential to quantify the effect of predation on juvenile salmon survival rates. The Otolith Mass Marking Project (94187) will develop a new mass marking tool for pink salmon in PWS. Mass marking of juvenile salmon will greatly improve the feasibility of studies designed to examine interactions between wild and hatchery salmon during the early marine period and later during spawning. All data collected as part of Salmon Predation will be provided to the Information and Modeling component of SEA. The data will be essential for development and implementation of ecosystem models.

I. PUBLIC PROCESS

This project was developed through three months of ecosystem research planning by the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG). The PWSFERPG conducted public meetings each week in the fall of 1993. Scientist from the University of Alaska, University of Maryland, Prince William Sound Science Center, Prince William Sound Aquaculture Corporation, Alaska Department of Fish and Game, and U.S. Forest Service participated in the planning process. The resulting ecosystem research plan was reviewed by scientist from the United States and Canada at a public workshop held in Cordova, Alaska in early December 1993. The methods and results of Salmon Predation will continue to be reviewed by various scientists within the Program Management component of SEA. A workshop will be held in the fall of 1994 to review the first year's results from Salmon Predation and other components of SEA. Results reviewed at the workshop will be preliminary, because all samples from the 1994 season will not be processed before December 31, 1994.

J. PERSONNEL QUALIFICATIONS

Mark Willette
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574
(907)424-3214

EMPLOYMENT:

March 1991 - present: Area Biologist with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Cordova, Alaska. Supervised by Dr. Stephen Fried. Conduct various fisheries enhancement and evaluation projects in PWS including juvenile salmon growth studies, lake stocking, limnological investigations of sockeye salmon producing lakes, and quality control of coded-wire tagging at private hatcheries. Conduct fisheries oceanographic studies in PWS in cooperation with private hatcheries and University of Alaska investigators. Chairman of PWS Regional Planning Team. Principal Investigator: Natural Resource Damage Assessment Study FS4A: Injury Assessment for Juvenile Salmon in Prince William Sound; Restoration Project R105: Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for Wild Salmon in Prince William Sound; Restoration Project 93024: Restoration of the Coghill Lake Sockeye Salmon Stock.

March 1986 - February 1991: Fisheries Instructor/ Assistant Reseach Professor, University of Alaska Fairbanks, School of Fisheries & Ocean Sciences, Supervised by Dr. Don Kramer. Conduct research on the effects of oceanographic conditions on the growth and survival of juvenile salmon in PWS, fish bioenergetics in an arctic lagoon ecosystem, age and growth of juvenile fish in the Chukchi and Bering Seas, ocean temperature variability in the North Pacific Ocean and effects on pink salmon production, salmon feeding on the high seas. Design and implement a program of education, research, and public service to promote fisheries development in northwest Alaska. Teach college level course in oceanography. Teach a marine safety and vocational training courses in fisheries.

EDUCATION:

1985 Master of Science, Fisheries Oceanography, University of Alaska Fairbanks.

1983 Bachelor of Science, Fisheries Science, University of Alaska Fairbanks.

Stan R. Carlson
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
34828 Kalifornsky Beach Rd, Suite B
Soldotna, Alaska 99669
(907)262-9368

EMPLOYMENT:

January 1993- present: Biometrician for the Alaska Department of Fish and Game, Limnology Section, Commercial Fisheries Management and Develop Division, Soldotna, Alaska. Supervised by Dr. Dana Schmidt. Conduct statistical data analyses to evaluate factors that affect dynamics of the biota in lake ecosystems. Design limnological experiments and determine methods to estimate zooplankton and salmon abundance. Develop and approve methods to estimate hatchery contributions to the fishery. Develop, review, and conduct statistical analyses for projects related to the impact of oil on commercial fishery species. Provide biometrical consulting to area and regional biologists and statewide limnologists.

November 1991 - January 1993: Mathematical Statistician for the National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. Supervised by Mr. Steven Ignell. Conduct statistical studies on community attributes of pelagic fauna in the north Pacific Ocean. Provide biometrical consulting, technical editing, and collaborative input on projects such as salmon bycatch and climate change studies.

January 1989 - May 1991: Statistics Teacher, Experimental Statistics Department, New Mexico State University, Las Cruces. Supervised by Dr. Michael Ames. Instruct laboratory courses in statistics for undergraduate science majors.

May - August 1990: Research Specialist (statistician), Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University. Dr. Ellis Huddleston, Supervisor. Provide statistical modeling, analysis, and design of experiments related to agricultural field studies and pest management programs.

May - December 1988: Field Biologist, Biology Department, New Mexico State University. Supervised by Mr. Roger Skaggs. Conduct field population surveys and habitat analyses of night birds in Lincoln National Forest, New Mexico. Collect field data, supervise field personnel, and maintain data records. Develop operational strategies and conduct follow-up statistical estimation procedures.

August 1985 - June 1988: Graduate Assistant, Biology Department, New Mexico State University. Supervised by Dr. Ralph Raitt and Dr. Walt Whitford. Teach undergraduate biology and zoology laboratory courses. Collect data and maintain field ecology experiments for ecological research programs. Develop and conduct original field research on desert insect ecology.

June 1983 - May 1985: Research Specialist, Gordon Environmental Studies Laboratory, University of Montana, Missoula. Supervised by Dr. Philip Tourangeau. Manage data, conduct quality assurance/control procedures, and perform statistical analyses for environmental science projects. Aid in the design and implementation of field research, primarily in the area of pollution biomonitoring.

EDUCATION:

1991 Master of Science, Experimental Statistics, New Mexico State University.

1988 Master of Science, Biology (ecology), New Mexico State University.

1983 Bachelor of Arts, Environmental Biology, University of Montana.

K. BUDGET

Table 2: Budget summary for the Salmon Predation component of the SEA program in FY94, FY95, and FY96 and beyond. Budgets for FY95 and beyond may change as information from the first year of study is applied to refine the methodology.

Line Item	FY94	FY95	FY96 and beyond
Personnel	229.5	339.3	339.3
Travel	1.7	3.3	3.3
Contractual	617.7	619.5	619.5
Supplies	10.2	20.2	20.2
Equipment	97.6	0.0	0.0
Total	956.5	982.3	982.3
Indirect Costs	41.8	58.3	58.3
Grand Total	998.3	1,040.6	1,040.6

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Project Title: ASSESSMENT OF JUVENILE SALMON PREDATION IN PRINCE WILLIAM SOUND

Agency: Alaska Department of Fish and Game

Project Description: This project is a component of the Sound Ecosystem Assessment (SEA) program.SEA is a multi-disciplinary effort to acquire an ecosystem-level understanding of the marine and freshwater processes that interact to constrain levels of fish and marine birdand mammal production in Prince William Sound (PWS). This project will test tow hypotheses regarding mechanisms that may regulate predation on juvenile salmon and otheage-0 fish in PWS. During the first year of study, the project will (1) identify the principal predators on juvenile salmon and other age-0 fishes, (2) determine the distribution abundance, species and size composition of fish predators along the juvenile salmon migratory pathway,and (3) recommend methods for improving field sampling techniques, sampling designs, and hypothesis testing capabilities. A mid-water trawl vessel and two purse seine vessels will be chartered to provide logistical support the project. These vessels will also provide logistical support for the Physical Oceanography, Nearshore Fish, Zooplankton, and Primary Production components of the SEA program. This project will also collect samples of juvenile fish for restoration project 94163 (Forage Fish).

Budget Category	Proposed 01-Feb-94 31-Sept-94	FY 95	Sum FY 96 & Beyond
Personnel	$229,292.0	$339,285.0	$339,285.0
Travel	$1,650.0	$3,300.0	$3,300.0
Contractual	$617,750.0	$619,501.0	$619,501.0
Commodities	$10,200.0	$20,200.0	$20,200.0
Equipment	$97,600.0	$0.0	$0.0
Capital Outlay	$0.0	$0.0	$0.0
Sub-total	$956,492.0	$982,286.0	$982,286.0
General Administration	$41,766.0	$58,300.0	$58,300.0
Project Total	$998,258.0	$1,040,586.0	$1,040,586.0
Full-time Equivalents (FTE)	3.7	5.8	5.8

Budget Year Proposed Personnel:

Position	Months Budgeted	Cost	Comment
Fishery Biologist IV	0.7	$4,522.0	Project Manager
Fishery Biologist III	2.5	$14,265.0	Project Leader
Fishery Biologist II	6.0	$28,200.0	Arrange vessel charter and conduct trawl survey
Fishery Biologist I	3.5	$33,040.0	Conduct trawl survey and conduct stomach analysis
Fishery Technician II	3.5	$23,025.0	Conduct trawl survey and conduct stomach analysis
Fishery Technician II	3.5	$23,025.0	Conduct trawl survey and conduct stomach analysis
Fishery Technician II	3.5	$23,025.0	Conduct trawl survey and conduct stomach analysis
Fishery Technician II	3.5	$23,025.0	Conduct trawl survey and conduct stomach analysis
Fishery Technician III	2.0	$7,000.0	Set-up and maintain database
Fishery Technician III	2.0	$7,000.0	Conduct stomach contents analysis on predators
Fishery Technician III	2.0	$7,000.0	Conduct stomach contents analysis on predators
Fishery Technician III	2.0	$7,000.0	Conduct stomach contents analysis on predators
Fishery Technician III	2.5	$8,750.0	Conduct stomach contents analysis on predators
Fishery Technician II	2.0	$6,140.0	Data entry
Biometrician II	2.5	$14,275.0	Design sampling program and analyze data
Total		$229,292.00	

Project Title: **ASSESSMENT OF JUVENILE SALMON PREDATION IN PRINCE WILLIAM SOUND**

		Cost
Travel:		
Two round trips between Soldotna and Cordova to have biometrician review data collection procedures in the field.		$700.0
Per Diem for biometrician		$950.0
	Total	$1,650.0
Contractual:		
Air charter flights to transport staff from Cordova to the vessels.		$4,000.0
Charter of a 70' trawl vessel to conduct mid-water trawl sampling of juvenile salmon predators		$358,750.0
Charter of 42'+ purse seine vessel to conduct nearshore sampling of juvenile salmon predators		$127,500.0
		$127,500.0
	Total	$617,750.0
Commodities:		
Office supplies		$1,600.0
Laboratory supplies		$4,000.0
Field supplies (groceries, food, fuel, etc.)		$3,000.0
Utilities		$1,600.0
	Total	$10,200.0
Equipment:		
One 486 IBM compatatible computer for data entry and analysis.		$6,000.0
Dissecting microscopes for stomach contents analysis (2)		$5,600.0
Small-mesh purse seines (2)		$56,000.0
Mid-water trawl net (1)		$30,000.0
	Total	$97,600.0

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EXXON VALDEZ OIL SPILL PROJECT DESCRIPTION - ECOSYSTEM STUDY

Title: Trophic interactions of harbor seals in Prince William Sound.

Project Identification Number:

Lead Agency: ADF&G

Cooperators: University of Alàska, NOAA/NMFS

Cost of Project, FY94: $24,000 **Cost of Project, FY95:** $24,000

Project Startup Date: 5/94 **Duration:** 2 years

Geographic Area: Prince William Sound

Introduction: Harbor seals in Prince William Sound and the northern Gulf of Alaska are declining for unknown reasons (>60% decline since 1984). In PWS the decline was exacerbated by the Exxon Valdez oil spill. There has been no indication of recovery following the spill. Because of the significant and unexplained decline, harbor seals are currently being considered for listing as depleted under the Marine Mammal Protection Act.

Harbor seals are apex predators of forage fishes and to a lesser extent octopus and shrimps. Seals in PWS probably consume 5 to 10 million pounds of prey annually. Harbor seals are preyed upon by killer whales and harvested by subsistence hunters in PWS. They bear their young on terrestrial haulouts or glacial ice where they are subject to disturbance by boats and aircraft.

To date, the cause of the ongoing decline in PWS and the northern Gulf is unknown. The following questions have been posed about possible causes of the decline:

1) Is the cause anthropogenic?
2) Is it due to reduced productivity or to disease?
3) Is it related to availability of prey?

Other EVOS restoration studies (94064, 94244) are addressing questions 1 and 2. Monitoring surveys provide information about pup production and trend of the population. Satellite tagging studies are providing information about site fidelity and location and depth of feeding. A subsistence monitoring study is quantifying mortality due to harvest. Based on these studies, pup production appears to be normal and adults on haulouts appear to be healthy. However, surveys during pupping indicate a continued decline while those during molting suggest numbers have stabilized since 1989. Tagged seals show marked fidelity to haulouts sites and feed near these sites. There appears to be little seasonal movement. Subsistence hunters harvest about 300 harbor seals annually. Killer whale predation, harvest by subsistence hunters, and incidental take by fishermen may be contributing to the decline, but are probably not the primary cause.

The possible effects of prey availability have not been addressed by studies to date. However, changes in the availability of prey have been postulated as possible causes for recent declines of harbor seals, Steller sea lions, and sea birds in the Gulf of Alaska and the Bering Sea.

PROJECT DESCRIPTION

1. **Resources and/or Associate Services:** The resources/services which may benefit from this study include harbor seals, subsistence users, tourists and others who view or photograph harbor seals, and fisheries whose management may be affected by the status of harbor seals. Information from this study will be incorporated into ecosystem models to help better understand the trophic interactions between marine mammals and forage fishes such as herring.

Ongoing studies are providing information to document trend in harbor seal abundance, to identify important haulout and feeding habitat, to evaluate site fidelity, to learn about feeding behavior, and to quantify the subsistence harvest. While such data are important for interpreting trophic impact of harbor seals, none of these ongoing studies directly address the trophic interactions of harbor seals and the possible effects of prey availability on their status and trends.

Because harbor seals are being considered for listing as depleted under the Marine Mammal Protection Act, they have a high political profile. It is essential to obtain data that will improve understanding of the decline and to do anything possible to reverse the declining trend through protection of habitat or food resources. Under federal law, subsistence is the priority use of marine mammals. If data are not adequate to determine that subsistence takes and fisheries removals are sustainable, more restrictive regulations for PWS fisheries could result.

2. **Objectives:** This study is designed to investigate the trophic ecology of harbor seals and to assess the role of prey availability in the ongoing decline. It will integrate information about harbor seal trophodynamics with other studies of key ecosystem components.

> Hypothesis: The decline in harbor seal numbers in PWS in the last decade has occurred primarily because of changes in the availability of their prey, particularly forage fishes.

The objectives are:

1) Integrate information from ongoing satellite tagging studies about areas where harbor seals feed and depths at which they feed with information about the distribution and abundance of key

species of forage fishes. (Tagging information from 94064 and forage fish information to come from separate study.)

2) Use fatty acid signatures to elucidate the trophic ecology of harbor seals. Marine mammal diets are high in particular fatty acids which may be specific to particular prey species. Differences in fatty acid composition in seals can lead to identification of prey types, establishing species composition of diets, and tracing trophic relationships among species. Lipid analysis would be conducted on harbor seal blubber, serum, and if available milk, in conjunction with lipid analysis of prey (forage fishes, octopus, shrimps). This will enable a determination of which prey are utilized by seals and of their relative contribution to the diet/energy budget.

3) Provide samples to a proposed stable isotope study and integrate results of stable isotope analysis of seal tissue with analyses of other components of the pelagic ecosystem. This will help describe carbon flow and establish key trophic links in PWS. Results will be integrated with results of lipid analysis to trace trophic relationships of harbor seals, to evaluate the nature of trophic pathways, and to examine trophic differences between juveniles and adults.

3. **Methods:** Information from Study 94064 (Habitat use, behavior, and monitoring of harbor seals) will be integrated with detailed information about the distribution, abundance and depth of forage fishes (including herring, salmon and others) in PWS. Information on harbor seal numbers, biomass, and per capita food consumption will be compiled and made available for input into trophic models of PWS.

In conjunction with satellite tagging conducted under project 94064, samples of harbor seal serum and blubber will be collected. These tissues will be analyzed for fatty acid composition using high-performance liquid chromatography (HPLC). Forage fishes which are potential prey species of harbor seals, as well as some zooplankton preyed upon by fishes, will also be analyzed for fatty acid composition using HPLC. Samples will be provided by investigators of forage fish and zooplankton studies. Fatty acid signatures of prey species will be compared to fatty acid composition of seal blubber and serum in order to estimate the type and relative proportions of different prey consumed by the seals. An estimated 20-30 samples will be collected from seals during two periods, May and September, as part of project 94064. It will be possible to compare early summer diets with fall diets, as well as to compare the diets of juveniles and adults. Samples are also available from harbor seals collected in PWS following the EVOS. These samples will be analyzed as part of this project.

If a stable isotope study is being conducted in PWS as part of an overall ecosystem study, samples of harbor seal tissue will be provided for analysis. It is estimated that 20-30 samples will be obtained. Harbor seal investigators will work with investigators from other disciplines to interpret the results of stable isotope analyses. Preliminary work with stable isotope analysis in harbor seals and sea lions has provided useful information about trophic differences between juveniles and adults and about the trophic status of different species in different geographic areas.

4. **Location:** The study will be conducted in Prince William Sound. Samples will be collected from all seals that are satellite-tagged and from fishes and plankton that are collected in PWS as part of other studies.

5. **Technical Support:** Computer and statistical support will be provided by project personnel from Wildlife Conservation.

6. **Contracts:** Fatty acid composition will most likely be analyzed at the University of Alaska Fairbanks. We will work cooperatively with Dr. Michael Castellini, a marine mammals physiologist at UAF, and one of his graduate students. The analyses will be done under a Reimbursable Services Agreement between ADF&G and the Institute of Marine Sciences at UAF. The RSA will be processed by the Division of Wildlife Conservation.

SCHEDULES

This project will be conducted during 1994 and 1995. Seals will be sampled during April/May and again in September concurrent with satellite tagging activities conducted under project 94064. Laboratory analyses will be conducted following the field season.

EXISTING AGENCY PROGRAM

The Division of Wildlife Conservation is conducting an ongoing restoration study entitled "Habitat Use, Behavior, and Monitoring of Harbor Seals in Prince William Sound, Alaska." This study will be active during 1994. The proposed study of the trophic interactions of harbor seals in PWS is designed to supplement project 94064 by providing information on diet composition of harbor seals and integrating information about seal movements with information about distribution and abundance of forage fishes. There will be no additional cost for field work or sampling. All seal samples will be obtained during field work conducted as part of study 94064.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

NOAA has determined that the harbor seal study (94064) qualified for categorical exclusion (CE) and does not require an environmental assessment. As required by the Marine Mammal Protection Act, ADF&G has been authorized under Permit No. 770 to instrument and take samples from harbor seals during the period

1992-1995. The procedures required for this study are allowed under terms of that permit. All MMPA permit applications are reviewed by federal agencies and the U.S. Marine Mammal Commission and are available for review by state agencies and the public through a Notice of Receipt published in the Federal Register.

PERFORMANCE MONITORING

The PWS harbor seal trophics project will be coordinated by principal investigator Kathryn J. Frost, who is a Marine Mammals biologist with the ADF&G Division of Wildlife Conservation. Other key personnel from ADF&G will be Lloyd Lowry, Marine Mammals Coordinator; Rob DeLong, Analyst Programmer; and Jay Ver Hoef, Biometrician II. This project will be fully coordinated and integrated with project 94064. Fatty acid analyses will be done in cooperation with Dr. Mike Castellini at UAF. The investigators will coordinate with other PWS investigators who are studying forage fishes and zooplankton.

BUDGET ($K)

(May 1, 1994 to September 30 1994)

Personnel	6.5
Travel	1.0
Contractual (RSA)	15.0
Commodities	1.5
Equipment	0.0
Capital Outlay	0.0
General Administration	2.0
Total	26.0

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SFOS 94-124

PROPOSAL

TO: *Exxon Valdez* Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 402
Anchorage, Alaska 99501

FROM: Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: SEA Plankton Dynamics: Phytoplankton and Nutrients

PRINCIPAL INVESTIGATORS:

C. Peter McRoy	David L. Eslinger
Professor	Assistant Professor
SS# 333-32-8153	SS# 518-86-5260

NEW/CONTINUING: New

DURATION: 18 Months

PROPOSED START DATE: 1 March 94

AMOUNT REQUESTED: FY94: $143.0K
FY95: $181.3K

15 Mar 94 — C. Peter McRoy /Date
Principal Investigator
(907)474-7783

15 Mar '94 — David L. Eslinger /Date
Co-Principal Investigator
(907)474-7797

3-15-94 — Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

3/16/94 — A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

15 Mar 94 — Donald M. Schell /Date
Director
Institue of Marine Science

3/18/94 — Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

March 1994

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project Title:	SEA Plankton Dynamics: Phytoplankton and Nutrients
Project ID Number:	94320G
Project Type:	Research and Monitoring
Name of Project Leader(s):	Drs. C. Peter McRoy and David L. Eslinger
Lead Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	NOAA, ADF&G, PWSAC, PWSSC, and other SEA projects.
Cost of project:	FY94 $143.0K FY95 $181.3K
Start Date:	1 March 1994
Completion Date:	30 September 1995
Geographic Area:	Prince William Sound

Name of project leader: ______________________________
C. Peter McRoy

Project Manager(s): ______________________________
To Be Determined; ADF&G

B. INTRODUCTION

The proposed Sound Ecosystem Assessment program (SEA) targets the prediction of recruitment success of pink salmon and herring from the perspective of ecosystem process controls. Specifically, the SEA hypothesis states that the physical oceanographic forcing on the circulation of Prince William Sound alternates between years of strong through-flow, river-like conditions, and relatively stagnant, lake-like conditions. The consequence of these alternate states is a high biomass of large zooplankton in lake years that are the primary nourishment for target fish and their predators (this has been termed the "middle-out" food web control). In alternate river years, the large zooplankton are sparse and predation on the target species predominates (the "top-down" control). Ecological theory provides yet another possibility, that of "bottom-up" control, where the production of upper trophic level species is modulated by variations in nutrient-driven phytoplankton production.

The structure and composition of the zooplankton community could be determined by the total amount of phytoplankton primary production and/or by the species composition of the phytoplankton community. For example, a phytoplankton population dominated by large diatoms may support an abundance of large oceanic copepods, whereas a phytoplankton population dominated by smaller flagellates may result in a reduced number of larger copepods, or in a shift to a zooplankton community dominated by smaller neritic copepod species. In this component, we will provide the nutrient and phytoplankton data that are essential to evaluate the influence of phytoplankton dynamics on the food web.

A central tenet of the SEA hypothesis is that there is variable advection of Gulf of Alaska waters into Prince William Sound. This advection affects not only zooplankton populations, but also the Prince William Sound phytoplankton populations. Strong advection may confound the effects of *in situ* Prince William Sound primary production with Gulf of Alaska production. We propose to use satellite-derived sea-surface temperatures to monitor the movement of Gulf of Alaska surface waters into Prince William Sound and, after September 1994, to use satellite-measured surface chlorophyll concentrations to determine the effect of advection on the observed chlorophyll field.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

All components of the marine ecosystem study will benefit from this project. Primary production is the basis of the food web and, in a general way, all subsequent energy transfers are ultimately based on the phytoplankton growth in the Sound or the biomass imported in the oceanic water mass. Many species in PWS have suffered declines in recent years. In particular, the pink salmon and herring populations in the Sound have been damaged and are not recovering. Also harbor seals, predators of these and other fishes, are continuing to experience a population decline (Pitcher, 1990). While many ideas have been proffered about the causes of mortality and/or low production, food cannot be ruled out, and hence phytoplankton production is directly or indirectly implicated. Surprisingly, at least to us, there has been almost no work on phytoplankton in Prince William Sound since the earliest impact studies in the 70's, and it was not until 1993 that a complete cycle of phytoplankton was measured (via the CFOS buoy). Throughout the oil spill recovery period there has been no measurement of ambient nutrient conditions or phytoplankton biomass and production, so what is often considered a major deterministic variable of food webs in other marine systems has been ignored in damage and restoration studies.

2. Relation to Other Damage Assessment/Restoration Work:

This project is one part of the multi-component SEA and Related Studies program in Prince William Sound, which has been designed to provide a comprehensive ecosystem-based understanding of population trends in the upper trophic levels, specifically in pink salmon, herring, marine bird, and marine mammals. Within SEA, the Phytoplankton and Nutrient project will work most closely with the Physical Oceanography/Meteorology, Zooplankton, and Ecosystem Data Base and Modeling projects. The phytoplankton and nutrient work proposed here will provide data for the examination of the temporal and spatial variability in the chemical and primary production fields, and for the testing of the hypothesis of "bottom-up" control of the Prince William Sound ecosystem.

3. Objectives:

This study is designed to investigate the pattern, amount, and type of phytoplankton growth and the major inorganic nutrient fields associated with the growth processes. Our hypothesis is that variations in the phytoplankton are transferred to the zooplankton and that such variations are a function of oceanographic conditions that control the supply of inorganic nutrients.

The specific objectives are:

1) To measure the timing, and biomass of the phytoplankton cycle;
2) To measure the primary production of the phytoplankton;
3) To determine the spatial and temporal patterns in phytoplankton distribution using satellite imagery;
4) To determine the species composition of the phytoplankton community;
5) To measure the distribution and quantity of the major dissolved nutrients including nitrate+nitrite, ammonium, phosphate and silicate;
6) To contribute phytoplankton and nutrient data to the SEA ecosystem model.

4. Methods:

Field work will be done in conjunction with other projects that require a vessel. We estimate the need for 2 people on each cruise to accomplish the work program. In 1994, if sufficient vessel time is not available, we will conduct a portion of the work in conjunction with the zooplankton project from a shore base at the PWSAC Esther Island hatchery. Timing of the field work should be arranged to cover the spring phytoplankton increase period. Based on the limited historical data and the excellent record obtained in 1993 by the CFOS buoy the sampling period should begin in mid-March and extend to mid-June. Discrete sample times can be integrated with the assistance of the continuous chlorophyll record obtained from the CFOS buoy sensor array and satellite data.

a) Phytoplankton Biomass, Spatial and Temporal Patterns:

Phytoplankton biomass will be determined using the standard chlorophyll technique (Parsons *et al.*, 1984) as determined by a Turner Designs Fluorometer. Data will be collected at specific locations that allow mapping the areal pattern and at selected depths that describe the water column profile. At each location (station) water samples will be collected with a Niskin Sample Bottle and an aliquot (usually 1 liter) will be filtered to collect the contained plankton. The chlorophyll in the sample will be extracted with the appropriate solvent and the fluorescence of the solution measured quantitatively with the fluorometer. Chlorophyll units will be converted to carbon units using carbon to chlorophyll ratios determined from the field samples.

b) Phytoplankton Primary Production:

The biomass pattern provides a picture of what is present, but it does not provide information on the phytoplankton dynamics. For example, a phytoplankton population with a relatively low chlorophyll value may be growing rapidly, but not exhibiting an increase in chlorophyll concentration due to strong grazing by the zooplankton community. To determine the actual primary production rate, we will use a labeled inorganic carbon tracer to measure direct uptake of carbon by phytoplankton photosynthesis. As with chlorophyll, the measurements will be on samples from discrete depths that represent the phytoplankton community distribution in the water column. We will use the standard techniques for deck incubations (Strickland and Parsons, 1972) with more recent modifications to avoid contamination (Fitzwater *et al.*, 1982; Chavez and Barber, 1987). Field sampling will be based at PWSAC salmon hatcheries or, when available, conducted aboard ship with incubations performed using natural or artificial light, depending on the location and capabilities of the site. Since these are time-dependent measurements, they will be done once per day.

c) Phytoplankton Community Composition:

While biomass and rate measurements provide information on the availability of food, they do not give insight on the potential quality of phytoplankton as food. This requires a more detailed examination of the composition of the community. The composition of the phytoplankton community may be as important as the total primary production in determining zooplankton species and abundance. We will take 25 ml aliquots and preserve them in Lugol's solution for later species identification using inverted microscopy (Sournia, 1978). Beginning in 1995, we will monitor the distribution of the phytoplankton and other particulates using a WET Labs dual path absorption and attenuation meter. This instrument can easily be configured to provide continuous attenuation and chlorophyll absorption measurements from an underway vessel. We will analyze the resulting distribution of phytoplankton and other particulates to monitor spatial and temporal changes in chlorophyll concentration and particle size distribution (Spinrad, 1986).

d) Satellite Image Analysis:

Satellite images are a powerful integrative tool. Once we obtain some field samples for ground truth data, images can be valuable sampling mechanisms to examine the pelagic ecosystem on a broad geographic scale and over the entire year. We will use NOAA Advanced Very High Resolution Radiometer (AVHRR) imagery from the University of Alaska Fairbanks High-Resolution Picture Transmission (HRPT) ground station. This station has been operational since 10 August, 1993. The AVHRR data will be processed to produce sea-surface temperature images of the and regions. We will use these images to monitor the inflow of water to Prince William Sound and to determine the spatial extent of water masses identified by the field program. This information will be made available to all SEA investigators. We will acquire ocean color imagery of Prince William Sound from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) after the launch of the SeaStar satellite in September, 1994. We will examine images of chlorophyll distribution from the SeaWiFS data using both Terascan and Seapak (McClain *et al.*, 1992) image processing software. We will analyze the chlorophyll and sea-surface temperature images to determine the spatial and temporal variability in the surface water masses and phytoplankton in the Sound throughout the year. The satellite data will allow us to put the field data into the correct spatial and temporal context. D. Eslinger will be responsible for providing the processed AVHRR (and SeaWiFS imagery to NASA approved SeaWiFS investigators) as part of the Ecosystem Data Base and Modeling project.

e) Nutrient Fields:

Phytoplankton require the major inorganic nutrients -- nitrogen, phosphorus and silica -- for growth. Nutrients are supplied by the general oceanographic circulation and land run-off. Since phytoplankton also require light, the problem is understanding how the nutrients are supplied to the illuminated zone of the sea. Here we will gather quantitative data on the distribution of nutrients throughout the phytoplankton growth season. We expect that the depletion of nutrients will be the major factor that defines the period of high phytoplankton growth. In the field, water samples will be collected with Niskin Bottles at standard depths over the upper 100 m (deeper if deemed necessary). A small aliquot (250 ml) is to be filtered and frozen for later chemical analysis. Chemical determination of the quantity of dissolved nitrogen (as nitrate, nitrite and ammonium), phosphate and silicate will be measured using prescribed methods with an Alpkem Auto-Analyzer (available) in our laboratory in Fairbanks.

f) Data Sharing:

All data from this project will be available electronically to the modeling project. We also expect to interact extensively with the modeling effort and the development of a coupled physical and primary production sub-model.

5. Location:

Prince William Sound and UAF.

6. Technical Support:

Nutrient analysis and phytoplankton species identification will be performed at the Institute of Marine Science Marine Ecosystem Laboratory at UAF using existing facilities. Field observations of chlorophyll will initially be performed using a Turner Designs flow-through fluorometer. In FY 95, funds will be requested (this proposal) for a WET Labs dual beam attenuation and absorption meter to obtain high precision measurements of particle and chlorophyll concentrations. Satellite image analysis will be performed at the IMS Remote Sensing Laboratory at UAF utilizing both Terascan and Seapak analysis packages.

7. Contracts:

None.

8. References:

Chavez, F.P. and R.T. Barber. 1987. An estimate of new production in the equatorial Pacific. Deep-Sea Research, 34: 1229-1243.

Fitzwater, S.E., G.A. Knauer, and J.H. Martin. 1982. Metal contamination and its effect on primary production measurements. Limnology and Oceanography, 27: 544-551.

McClain, C.R., G. Fu, Darzi, M., and J.K. Firestone. 1992. PC-SEAPAK User's Guide, ver. 4.0. NASA Technical Memorandum 104557, 332 pp.

Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. A Manual of Cemical and Biological Methods of Seawater Analysis, Pergammon Press, New York.

Pitcher, K.W. 1990. Major decline in the number of harbor seals, *Phoca vitulina richardsi*, on Tugidak Island, Gulf of Alaska. Mar. Mam. Sci. 6:121-134.

Sournia, A. 1978. "Phytoplankton manual", UNESCO, Paris, 337pp.

Spinrad, R.W. 1986. A calibration diagram of specific beam attenuation. Journal of Geophysical Research, 91: 7761-7764.

Strickland, J.D.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. Bulletin 167, Fisheries Research Board of Canada, Ottawa, 310 pp.

D. SCHEDULES:

This project will be conducted in 1994 and 1995. The field season will concentrate on the period March--June. All laboratory analysis of samples will occur following the field season. Satellite observations will begin in 1994 and continue throughout the duration of the project.

E. EXISTING AGENCY PROGRAM:

There is presently no agency program to determine the distribution and spatial and temporal variability of phytoplankton production and nutrient concentrations in Prince William Sound, Alaska.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS:

Use of radioisotopes for the determination of primary productivity is covered under the license of the University of Alaska, and will be performed in accordance with all Federal and State and University requirements.

G. PERFORMANCE MONITORING:

This contract will be supervised by Drs. C. Peter McRoy and David L. Eslinger, Institute of Marine Science, University of Alaska Fairbanks.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT:

The SEA phytoplankton and nutrient project will interact with other SEA projects by contributing information on the timing and intensity of the spring phytoplankton bloom, the character and composition of the bloom, and the spatial extent and variability of the bloom and nutrient concentrations. We will interact with the physical and meteorological components to determine the effects of advective and mixing processes on nutrient and phytoplankton distributions. We will collaborate with the zooplankton project to determine the importance of *in situ* Prince William Sound primary production in determining the zooplankton dynamics and how this interacts with the river/lake hypothesis. We will work closely with the data and modeling project to provide appropriate parameter measurements and field "truth" data with which to check the model, and will help in the development of a nutrient, phytoplankton, zooplankton component for the model.

I. PUBLIC PROCESS:

R. T. Cooney: *An Integrated EVOS-Sponsored Ecosystem Approach to Marine Fish, Bird and Mammal Issues in Prince William Sound: Sound Ecosystem Assessment (SEA) and Related Studies* (Project 94320 Summary).

J. PERSONNEL QUALIFICATIONS:

Dr. C. Peter McRoy received a masters degree from the University of Washington in 1966 and a doctoral degree from the University of Alaska in 1970. Since that time he has been a faculty member of the University of Alaska. He has been a full professor since 1979, and has been an invited visiting professor at San Francisco State University, the University of Tokyo, and the University of Hawaii. He is a member of eleven professional societies and has received the Diamond Award from the Botanical Society of the America. Dr. McRoy teaches at the graduate level in the Marine Science and Limnology program of the School of Fisheries and Marine Sciences at UAF. He has worked on large, inter-disciplinary, multi-university, international projects such as the Processes and Resources of the Bering Sea Shelf (PROBES) program and, recently, the Inner Shelf Transfer and Recycling (ISHTAR) program. Dr. McRoy has published over 55 manuscripts in the referred literature and is author of 8 book chapters.

Dr. David Eslinger received his Ph.D. from Florida State University in 1990. He has since been a National Research Council Research Associate at the NASA/Goddard Space Flight Center from 1990 to 1992. He has been an Assistant Professor at the University of Alaska, Institute of Marine Science since 1992. Dr. Eslinger teaches Biological Oceanography and Satellite Oceanography at the graduate level in the Graduate Program in Marine Science and Limnology of the School of Fisheries and Marine Sciences at UAF. Dr. Eslinger is a member of five professional societies and was awarded a NASA Graduate Student Researcher Award. He has cruise experience on five cruises in the North Atlantic. He has presented nine papers at national and international meetings, has two published manuscripts and three others in preparation or in press. Currently, Dr. Eslinger is examining coupled biological and physical models of the Bering Sea Shelf, the relation of ocean color to groundfish biomass, and the occurrence and biological effects of mesoscale eddies in Alaskan waters. He is also the SeaWiFS Coordinator for the HRPT satellite downlink station located at the University of Alaska Fairbanks.

EXXON VALDEZ TRUSTEE COUNCIL

Project Description: Sound Ecosystem Assessment (SEA): Plankton Dynamics - Phytoplankton and nutrients

Budget Category[1]	Proposed 1-Mar-94 30-Sept-94	Proposed 1-Oct-94 30-Sept-95	FY 94	FY 95	FY 96	FY 97	Sum FY 98 & Beyond
Personnel[2,3]	119.8	141.8	119.8	141.8			
Travel	5.6	5.6	5.6	5.6			
Contractual	6.3	3.8	6.3	3.8			
Commodities	11.3	11.3	11.3	11.3			
Equipment	0.0	18.8	0.0	18.8			
Capital Outlay	0.0	0.0	0.0	0.0			
Sub-total	142.9	181.2	142.9	181.2			
General Administration	0.0	0.0	0.0	0.0			
Project Total	143.0	181.3	143.0	181.3			
Full-Time Equivalents (FTE)	3.4	2.8	3.4	2.8			

Budget Year Proposed Personnel:	Months Budgeted	Cost	Comment
McRoy, C. P.	2	$24,816	Project leader, principal scientist
Eslinger, D.	3	22,510	Asst. project leader
Bergeron, B.	5	23,513	Field work/laboratory
Research Assistant	7	13,316	Ph.D. Studen
Research Assistant	7	11,628	M. S. Student

[1]Indirect costs at a rate of 20% of Total Project Costs (TPC) have been included in each budget category.
[2]Tuition for the graduate student is listed in the personnel category.
[3]Includes leave accrual and benefits for all eligible personnel.

SFOS 94-081

PROPOSAL

9450

TO: *Exxon Valdez* Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 402
Anchorage, AK 99501

FROM: Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: Sound Ecosystem Assessment (SEA): The role of zooplankton in the Prince William Sound Ecosystem

PRINCIPAL INVESTIGATORS: Robert T. Cooney
Associate Professor
SS# 516-44-6552

NEW/CONTINUING: New

DURATION: 18 Months

PROPOSED START DATE: 1 March 1994

AMOUNT REQUESTED: $695,600

28 Feb 94
Robert T. Cooney /Date
Principal Investigator
(907)474-7407

2-28-94
Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

2/28/94
A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

Feb 94
Donald M. Schell /Date
Director
Institute of Marine Science

3/2/94
Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

February 1994

EXXON VALDEZ TRUSTEE COUNCIL
FY94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project Title:	SEA: The Role of Zooplankton in the Prince William Sound Ecosystem
Project ID Number:	94320 H
Project Type:	Research and Monitoring
Project Leader:	R. Ted Cooney; Univ. Alaska Fairbanks
Lead Agency:	Alaska Department of Fish and Game
Cooperating Agency:	
Other Cooperating Parties:	Prince William Sound Science Center Prince William Sound Aquaculture Corporation University of Alaska Fairbanks
Cost of Project:	FY94 $308.1 FY95 $387.5
Start Date:	1 March 1994
Completion Date:	Multi-year; to be determined
Geographic Area:	Prince William Sound
Project Leader:	______________________ R. Ted Cooney; UAF
Project Manager(s):	______________________ To Be Determined; ADF&G

B. INTRODUCTION

Surface zooplankton populations in Prince William Sound are dominated by calanoid copepods (Damkaer, 1977). During April and May of each year, the biomass of large calanoids in the upper 20-m is characterized by two prominent genera, *Neocalanus* and *Calanus*. *Neocalanus* spp. occur as the progeny of deep overwintering populations hypothesized as seeded into the Sound by surface and deep circulation each year (Cooney, 1986; Cooney and Coyle, 1988). *Calanus marshallae* also overwinters in the region, but migrates to the surface as adults in the spring to feed and then reproduce. Both genera represent some of the largest calanoid copepods in the Subarctic Pacific. Their morphologies and life histories have been extensively studied (Fulton, 1973; Miller, et al., 1984; Miller and Clemons, 1988; Miller, 1988; Peterson, 1988).

The results of previous studies in the region indicate a major role for large calanoids in food webs supporting pink salmon (and probably herring) in Prince William Sound (Cooney et al., 1981; Urquhart, 1979; Barnard, 1981). More recent calculations associated with the development of a carbon budget for the region (SEA Plan; December 1993) also suggest that macrozooplankton may be much more important than previously suspected as a forage resource for other fishes, marine mammals and birds. If this is so, interannual and longer-period trends in spring-time stocks of macrozooplankton should drive detectable variability in production trends at higher trophic levels in the region.

Since 1981, salmon hatchery measurements of March-June upper-layer zooplankton settled volumes have exhibited a consistent increase in early to mid-April, a maximum in early May, and significant reductions by late May and early June. Although this "bloom" of large calanoids is predictable in time, its magnitude and duration are quite variable. Over the 13 years of the AFK Hatchery record, an annual food day index has varied by about two orders of magnitude.

During this same period, the annual survival of wild pink salmon brood years (return/spawner) has been highly correlated with the early-season calanoid bloom experienced by fry in most years (10 of 13). This statistical coincidence supports a paradigm about oceanographic factors influencing the production of pink salmon - namely that growth during the fry stage modifies losses to predators (Bax, 1983; Hartt, 1980; Healy, 1982; Holtby et al., 1990; Walters et al., 1978). The faster the growth, the less time fry spend in the smallest, most vulnerable sizes, and the higher their survival and the subsequent adult production.

Recent observations by Willette (unpublished) on relationships between early marine growth rates for hatchery released pink salmon fry in Prince William Sound demonstrate that growth rates are closely tuned to upper-layer temperatures, but not to zooplankton biomass. This surprising finding, coupled with the SEA carbon budget for the pelagic ecosystem of Prince William Sound, led to the conjecture (by SEA) that springtime macrozooplankton biomass in the region modulates consumer relationships. In years of high zooplankton abundance, most consumers can adopt planktivory as the major feeding strategy. In contrast, when upper layer macrozooplankton is weak, consumers have to shift to piscivory. The result is that good zooplankton years provide an ecological refuge for 0-class fishes (salmon, herring, other species) from predators. Conversely, when upper-layer macrozooplankton stocks are low, consumers are forced to derive more of their energy from small fishes.

Where the species composition of springtime macrozooplankton stocks has been investigated in the Sound (Tuttle, unpublished M.S. thesis draft), interannual differences in standing stock appear to be associated with year-to-year fluctuations in the *Neocalanus/Calanus* guild rather than changes in other, smaller calanoids. Analyses of interannual differences in springtime zooplankton biomass (settled volume) as a function of oceanographic variables (Cooney and Salmon, unpublished) identified a strong statistical correlation with wind-driven oceanic convergence computed for the continental shelf south of Hinchinbrook Entrance. For the 13 year hatchery plankton watch data set, 70 percent of the interannual variability is accounted for by fluctuations in the upwelling index computed for 60N 146 W. In years of reduced springtime convergence, *Neocalanus* and *Calanus* tend toward higher biomass. The opposite is generally observed under stronger wind-driven convergence - reduced upper-layer stocks of *Neocalanus* and *Calanus*.

The SEA Plan formalized these observations as the lake/river and prey switching hypotheses. Under strong wind-forcing and onshore oceanic flow in April and May, flushing of the Sound's upper-layers becomes well developed - "riverlike" - and surface populations of *Neocalanus/Calanus* are transported out of the region. The result is a shift to piscivory by all consumers with the smallest fishes in the assemblage targeted for the highest losses. Under reduced onshore flow, springtime upper-layer flushing is reduced and the resulting "lakelike" nature of the region retains surface populations of the larger calanoids more efficiently. Under these conditions, energy derived by planktivory drives the system, and smaller fishes (0-class and others) enjoy "sheltering" and reduced losses to predation. This physical mechanism for prey switching has fundamental implications for all consumers in the pelagic ecosystem of the region.

C. PROJECT DESCRIPTION

1. Resources and/or Associate Services:

Pink salmon and herring populations, and some marine bird and mammal species are listed by the EVOS Trustee Council as injured resources whose recovery status is uncertain. The work proposed in this detailed project plan, in collaboration with other SEA and related studies projects, will provide the Trustees and their agents with information about the mechanisms forcing ecosystem dynamics that can be used to more accurately evaluate damage and design appropriate restorative measures. Unless the mechanics of the Prince William Sound ecosystem are clearly understood, actions taken to restore pink salmon, herring, and marine bird and mammal populations may be ineffectual, or even damaging to other populations in the region.

2. **Relation to Other Damage Assessment/Restoration Work:**

This project is one part of the multi-component SEA and Related Studies program in Prince William Sound designed as an ecosystem approach to understanding pink salmon, herring, and marine bird and mammal population trends. Within SEA, the Zooplankton project will work closely with the Physical Oceanography/Meteorology, Nearshore Fishes, Salmon Growth and Survival, Salmon Predators, Hatchery Experimental and Manipulation, and Ecosystem Data Base and Modeling projects. The zooplankton work proposed here will provide data for eventual tests of the Lake/River and Prey/Predator hypotheses.

3. **Objectives:**

1) Use continuing PWSAC salmon hatchery plankton watch collections to describe the timing, duration, magnitude and species composition of springtime upper-layer (20 m) zooplankton stocks in northern and western Prince William Sound.

2) Use shipboard collections of zooplankton to describe how ontogenetic and diel shifts in the vertical distributions of macroplankters influence trophic coupling between higher-level consumers.

3) Provide direct measures of the species composition and indices of abundance of macrozooplankton in layers and swarms detected and censused acoustically and with optical plankton counters by other SEA investigators.

4) Work cooperatively with SEA biological oceanographers to determine how the timing, magnitude and duration of the springtime phytoplankton bloom influences the timing, distribution, and developmental rates of surface macrozooplankton populations.

5) Work cooperatively with SEA physical oceanographers, fisheries scientists, modelers and marine bird and mammal biologists to affect formal tests of the lake/river and prey-switching hypotheses proposed by SEA.

6) Provide taxonomic assistance (when requested) to ADF&G laboratory technicians processing zooplankton collections at the Limnology Laboratory in Soldatna and establish a voucher collection of major species and life-history stages.

This project is designed specifically to provide collaborative information on the trophic ecology of consumer populations in Prince William Sound, namely the investigation of a zooplankton-modulated prey-switching mechanism hypothesized as setting levels of carrying capacity for juvenile fishes each year. In so doing, the work will be guided by the following conjectures:

Hypothesis 1: The species composition and standing stock of springtime upper-layer macrozooplankton is derived from overwintering populations resulting from local production and seeding (previous summer) from the adjacent Gulf of Alaska. These stocks are reduced by rates of wind and buoyancy-driven flushing in the April and May.

Hypothesis 2: Levels of upper-layer springtime macrozooplankton stocks in Prince William Sound shift consumptive processes between piscivory and planktivory each year strongly influencing the survival of 0-class fishes (including pink salmon and herring).

4. Methods:

Direct Sampling with Nets

Macrozooplankton studies in 1994 and 1995 will be conducted aboard a variety of vessels and from PWSAC hatcheries in Prince William Sound from March through July, and then from the research vessel *Alpha Helix* in November or December (Figure 1). Several standard nets (ring, bongo, Tucker, MOCNESS) will be employed to obtain quantitative indices of species composition and abundance. In general, the mesh size of these nets will be 0.333-mm. This mesh size provides samples of most of the life-history stages of ecologically important macrozooplankters in the region but is large enough to avoid serious clogging by phytoplankton.

Zooplankton will be sampled twice weekly at 3 PWSAC salmon hatcheries from March through June (Figure 2). Vertical tows from 20 m to the surface constitutes the standardized methodology in place for the plankton watch since 1981. More than one tow may be composited (average 3) at times when upper-layer plankton is weak to assure that enough material is collected for accurate settled volume measurements. Following this procedure, samples will be preserved in 10 percent formalin for later processing at the University of Alaska Fairbanks. These samples and records of the volume sampled (m3), and sampling times and locations will be forwarded from each of the participating hatcheries at the end of the seasonal plankton watch.

Zooplankton will also be sampled during seine and trawling operations for salmon fry and their predators throughout the April-July field season to characterize zooplankton forage populations. Most samples will be taken with vertical (1/2-m nets) or horizontal tows (metered 60-cm bongo nets) in the upper-layers of the water column. These samples will be used to track the life history stages and general abundance of the dominant macrozooplankters along the migratory route of the juvenile pink salmon. In FY94, the northwest corner of the Sound near the PWSAC Esther Island hatchery will be studied most intensively. In FY95, both the northwest and southwest regions will be intensively investigated. The general migration of pink salmon fry is thought to occur from north to south along the western boundry of the region. Fry are often found feeding in large schools near the southern passages of the sound in late June and July, presumably staging for their ocean feeding migration. More detailed information on the horizontal and vertical extent of upper-layer macrozooplankton populations will be obtained by acoustic and optical-counting methods(see below).

Samples used to describe vertical profiles of abundance (diel and seasonal) will be obtained from closing vertical tows (0.5 and 0.75 Puget Sound nets) and with a MOCNESS (multiple opening-closing net environmental sensing system) sampler activated through a conducting cable. During the spring and summer, a deep index profile will be obtained weekly at a UAF historical hydrographic station in the deepest part of the region (Lone Island - 28) using vertically towed closing nets (to 750 m). The MOCNESS system (R/V *Alpha Helix*) will be used in the late fall or early winter (much less predictable weather) to census overwintering populations prior to their reproductive activities. Station 28 will be sampled with the MOCNESS (same depth strata as closing vertical tows), but other portions of the deep central basin will also be visited. The purpose of the fall/winter cruise is to begin monitoring levels of interannual variability in the overwintering population size.

In cases where specific statistical hypotheses are being tested, sufficient replication will be undertaken to measure laboratory subsampling error, field sampling error, and levels of variability associated with location, time of day, depth and year. ANOVA and other parametric and nonparametric techniques will be employed as the statistical tools.

In the laboratory, whole samples will be sorted for large or otherwise obvious plankters. The more numerous taxa will be identified and enumerated in subsamples. Between 150 and 200 organisms will be examined in subsamples to assure that the biologically important organisms are accounted for. Particular attention will be given to *Neocalanus* and *Calanus*. Here, the late copepodite stages (3-adult) will be identified and counted separately.

Acoustic and Optical Sampling

Nets will be used to identify zooplankters associated with swarms and layers that are also being censused by optical plankton counting and high-frequency acoustics. In special cases, the sizes (lengths) of copepods and other taxa will be measured for comparison with size information obtained by continuous optical methods. A high-frequency (420 kHz) quantitative acoustic system will be used aboard the trawler (and other vessels as needed) to measure acoustically determined biomass (ADB) adjacent to and along the migratory pathways of pink salmon leaving their natal areas (hatcheries and wild) for open ocean feeding areas. General levels of volume scattering and conversions to ADB will provide measures of upper-level (0-50 m) macrozooplankton populations seasonally and by day and night. This information will be compared with net samples take at the same times and places to identify the major sound-scatterers (see Nearshore Fishes for details on acoustic sampling).

An optical plankton counter (OPC) is available on loan from Alaska Department of Fish and Game. This instrument will be operated simultaneously with the MOCNESS (for comparative purposes) and more routinely with the acoustic and net sampling programs. The optical counter is capable of providing numbers and sizes of zooplankters encountered along its tow path. An "aqua-shuttle" and special winch will be used to deploy and fish the OPC along sampling transects (see details of optical plankton counting in the Information Services and Modeling project).

Acoustic and optically-measured plankton information will be used to evaluate meso and small-scale zooplankton distributions associated with diel, seasonal and physical phenomena (fronts, clines, shears). This information will be made available to the modeling component in near "real time" (10 days at most) for nowcasting and predictive purposes.

All zooplankton data sets (nets, acoustic, optical) will be made available to all the other components of SEA as part of the comprehensive data base for the program. The zooplankton project leader and other personnel will interact with other investigators in the field and laboratory as needed to test hypotheses concerning lake/river-driven prey switching and other mechanisms. Several zooplankton people will be in the field during the sampling season to assure that the appropriate samples are acquired each year.

5. Location:

Prince William Sound

6. Technical support:

For FY94, a small portion of the samples taken to support the seine and trawling operations, and all hatchery plankton watch and vertical profile samples will be processed at the University of Alaska. The remainder of the FY94 zooplankton samples will be processed by the ADF&G Limnology Laboratory in Soldatna in FY95 (new project phased into SEA in FY95). In general, the University of Alaska (this proposal) will process all hatchery watch, vertical profile and MOCNESS samples each year. The remaining samples (up to 2000 annually) will be processed by ADF&G.

7. Contracts:

None

8. Literature Cited

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D. SCHEDULES

Dates (FY94 and FY95)	Activity
December - February	Stage for field season
15 March - 15 July	Field season
1 August - 30 November	Data analysis, integration
15 September	Preliminary report
15 - 20 October	PWS System Planning Workshop
1 December - 1 January	Final Report preparation
15 January	Final Report and deliverables

E. EXISTING AGENCY PROGRAM

There are no present agency or other programs (outside the PWSAC annual plankton watch) collecting zooplankton in Prince William Sound. SEA and related studies will request the addition of the zooplankton sample processing project (ADF&G limnology laboratory; $100.0K) for FY95.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The zooplankton project does not foresee special needs in terms of compliance, permits or coordination status as part of the SEA and related studies project for Prince William Sound.

G. PERFORMANCE MONITORING

This project will be supervised by Dr. R. Ted Cooney, Assoc. Professor of Marine Science, University of Alaska Fairbanks. He will work cooperatively with other SEA and related studies projects to obtain information on the distribution, abundance, biomass and species composition of zooplankton in Prince William Sound. These projects include physical oceanography/meteorology, nearshore fishes, phytoplankton productivity, salmon growth and survival, salmon predators, and modeling.

In the field, Dr. Cooney will be joined by Mr. Ken Coyle (Research Associate; UAF) and Mr. Chris Stark (Marine Technician; UAF) to collect zooplankton and coordinate the interactions between other SEA and related studies projects. Mr. Coyle is an accomplished zooplankton taxonomist and field investigator with expertise in acoustic and net sampling (including the MOCNESS). Mr. Stark is also a competent taxonomist and field assistant, having experience with the forage resources for juvenile pink salmon. These three individuals will supervise other UAF field and laboratory personnel (field aid and graduate students) needed to acquire and process the samples for this project. Standard oceanographic field and laboratory methods will be employed.

Collection of acoustic data will be the responsibility of the SEA Nearshore Fishes study (Dr. Gary Thomas; Prince William Sound Science Center), and optical plankton counting will be part of the data base/modeling program (Dr. Vince Patrick; University of

Maryland). These individuals and their associates will work with the zooplankton project leader to produce syntheses of the zooplankton data (nets, acoustic and optical) for preliminary and final reports.

Formal tests of SEA hypotheses using information from the zooplankton project will be affected cooperatively using the SEA and related studies data base. Conclusions about the role of macrozooplankton in the ecology of Prince William Sound will be based on data synthesis and integration activities of all investigators. It is anticipated that most publications for the reviewed scientific literature will be joint efforts.

H. Coordination of Integrated Research Effort.

The SEA zooplankton project will interact with other SEA and related studies projects by contributing information to several of the hypothesis-driven components including the Lake/River Program, the Prey/Predator Program, the Herring Overwintering Program, the Wild/Hatchery Interaction Program, and the Modeling Program (Table 1).

For the Lake/River Program, the zooplankton project will provide measures of the standing stock of macrozooplankton overwintering and reproducing in the deep water, and subsequent levels of abundance of progeny in the upper layers in the spring. Working cooperatively with the physical oceanography project (seasonal transports), the time and duration of seeding the region with zooplankton from the bordering Gulf of Alaska will be determined, as well as estimates of how upper-layer stocks are flushed from the Sound in the spring. Estimates of zooplankton production supported by local primary productivity will be obtained by cooperation with the phytoplankton and nutrients project as a means to judge the importance of the alleged seeding process.

For the Prey/Predator Program, the zooplankton project will provide information about the prey for juvenile salmon and their predators, critical for understanding how prey-switching may be influencing fry survival during early marine residence. This will necessitate working with the prey/predator and fry growth and survival projects (simultaneous fish and plankton sampling), with the nearshore fish project (acoustic census of predators and macrozooplankton and prey), hatchery projects (plankton watch sampling) and the modeling project (optical plankton counting, data synthesis and integration). Zooplankton field personnel will ride the trawler (and/or seiners) to undertake and supervise the plankton sampling.

Zooplankton samples will be taken in support of the herring overwintering program. This information will be coordinated between net towing (this project) and acoustic and optical counting. Formal interaction will be with the nearshore fish project during the fall and winter months. Zooplankton will furnish nets and assist with sample design. The project leader will also interact with the modeling component and other projects to test hypotheses about herring overwintering.

The Wild and Hatchery Stock Interaction Program will rely on estimates of the carrying capacity of Prince William Sound for juvenile salmon and other planktivores. The zooplankton project will provide estimates of local plankton forage populations for this purpose. The project will work cooperatively with hatchery releases and manipulations (numbers and timing of fry releases relative to fry food), with the forage fish study to determine numbers of planktivores (fishes), with the prey/predator program to determine predator stocks and their food requirements, and with the nearshore fishes project to interpret multi-time (daily, seasonally and interannually) and space scale estimates of forage (zooplankton) and consumer populations. Tests of hypotheses about competition for food (wild and hatchery stocks) will be addressed with the modeling component and project data synthesis activities.

The zooplankton component will contribute information to the overall SEA and related studies data base and modeling program for tests of all hypotheses requiring an understanding of upper-layer plankton species composition, production, standing stock and diel, seasonal and interannual variability.

I. Public Process

The SEA program was developed in the public arena by fishermen and other resource users, and by scientists from the agencies, and the academic and non-profit sectors in Prince William Sound and elsewhere in Alaska. The SEA Plan and the concepts it presented was rigorously peer reviewed and discussed in a public workshop held in Cordova in December, 1993. A summary version of the SEA implementation plan (including zooplankton) was presented to, reviewed and endorsed by the Public Advisory Group of the EVOS Trustee Council in January, 1994. The plan was conceptually accepted (with revision) by the Trustees at a January 31 public meeting in Anchorage.

SEA and related studies plans to conduct an annual workshop each year to review progress and plan future field programs. This workshop will be open to the invited public, members of which will be asked for their comments and suggestions about the research.

J. Personnel Qualifications

Dr. Cooney received his doctoral degree in Biological Oceanography in 1971 from the University of Washington. Since that time he has been a faculty member at the University of Alaska Fairbanks, first in Fisheries Biology and later in Marine Science. He received tenure in 1976 and is standing for promotion to full professor this year. In his academic capacity, Dr. Cooney teaches at the graduate level in the Marine Sciences and Limnology Program, although his primary responsibility is research. In this pursuit, Dr. Cooney is known for contributions to the literature in the areas of zooplankton ecology and fisheries oceanography. He has worked with the pink salmon ecosystem of Prince William Sound since 1976, most recently as the principal investigator of the Cooperative Fisheries and Oceanographic Studies (CFOS) program. Together with scientists from Alaska Department of Fish and Game and the Prince William Sound Aquaculture Corporation, CFOS has investigated oceanographic factors influencing the production of pink and chum salmon in Prince William Sound. The results of that work have been instrumental in structuring the SEA Plan and the implementation program that has followed. Dr. Cooney has published 6 book chapters, and 30 manuscripts. He is a member of Sigma Xi (Scientific Research Society), the American Geophysical Union, the

American Association for the Advancement of Science, the Oceanographic Society and the American Fisheries Society.

Mr. Ken Coyle received his M.S. degree in Oceanography in 1974 from the University of Alaska Fairbanks. Since that time he has served in a technical capacity (zooplankton, marine acoustics) and most recently as a Research Associate. He is presently in a doctoral program under the supervision of Dr. R. Ted Cooney. Mr. Coyle is an acknowledged expert on marine Amphipoda. His most recent research activities have involved collaborated efforts with Dr. George Hunt (UC-Irvine). These activities have included macrozooplankton and forage fish studies associated with marine bird colonies in the Pribilof and Aleutian Islands. Mr. Coyle has 23 manuscripts in the scientific literature. He is a founding member of the Crustacean Society.

Mr. Chris Stark is a graduate student (Fisheries Biology) and marine technician in the Institute of Marine Science. He has zooplankton taxonomic expertise and field experience with juvenile salmon forage resources as part of Alyeska funded hatchery studies in Port Valdez.

K. Budget

EXXON VALDEZ TRUSTEE COUNCIL

Project Description: Sound Ecosystem Assessment (SEA): The role of zooplankton in the Prince William Sound Ecosystem

Budget Category[1]	Proposed 1-Mar-94 30-Sept-94	Proposed 1-Oct-94 30-Sept	FY 94	FY 95	FY 96	FY 97	Sum FY 98 & Beyond
Personnel[2]	218.3	262.1	218.3	262.1			
Travel	18.8	20.6	18.8	20.6			
Contractual	22.5	85.0	22.5	85.0			
Commodities	9.3	7.3	9.3	7.3			
Equipment	39.4	12.5	39.4	12.5			
Capital Outlay	0.0	0.0	0.0	0.0			
Sub-total	39.4	387.5	39.4	387.5			
General Administration	0.0	0.0	0.0	0.0			
Project Total	308.1	387.5	308.1	387.5			
Full-Time Equivalents (FTE)	6.1	8.0	6.1	8.0			

Amounts are shown in thousands of dollars

Budget Year Proposed Personnel:	Months Budgeted	Cost[3]	Comment
T. C. Cooney, Assoc. Professor	5	$64,444	Project leader, principal scientist
K. Coyle, Research Associate	5	34,121	Asst. project leader, field supervisor
C. Stark, Marine Technician	7	37,210	Field work/laboratory taxonomy
E. Stockmar, Lab Technician	6	25,619	Laboratory taxonomist
TBN, Field Tchnician	6	25,619	Field work/boat surveys
TBN Graduate Students, M.S. (2)	14	31,238	Field work/boat surveys

[1] Indirect costs at a rate of 20% of Total Project Costs (TPC) have been included in each budget category.
[2] Tuition for the graduate student is listed in the personnel category.
[3] Includes leave accrual and benefits for all eligible personnel.

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Travel:	15 round trips, Fairbanks to Cordova/Seward for field work, science planning	$15,000
	1 National meeting in FY95	1,500
Contractual:	Gear and sample shipping	3,000
	Communications and clerical	8,000
	MOCNESS maintenance fee	6,000
	*CTD/Termperature logger calibrations	6,000
	R/V *Alpha Helix* - 5 days FY95	50,000
Commodities:	Bottles and preservative/lab supplies	4,300
	Foul weather gear	2,000
	Computer software (spreadsheet/database)	1,000
	Telephone answering machine	100
Equipment:	Nets/flow meters	25,000
	Field notebook computer/printer	2,500
	Officer laser printer	1,000
	Temperature logger (2)	3,000

Table 1. FY94 SEA and Related Project Integration

Detailed Projects	NHP	LRP	PPP	HOP	WHSI	MP
	Program Elements*					
PHYSICAL PROCESSES						
Meteorology, Oceanography	X	X	X	X	X	X
Ocean State		X	X	X	X	X
PLANKTON DYNAMICS						
Phytoplankton, Nutrients		X			X	X
Zooplankton		X	X	X	X	X
FISH						
Juvenile Salmon Growth		X	X		X	X
Juvenile Salmon Predators			X		X	X
Nearshore Fish Distributions				X		X
Hatchery Experimental			X		X	X
Hatchery Manipulation		X	X		X	X
94184 CWT Recovery					X	X
94187 Otolith Marking			X		X	X
94189 Pink Salmon Genetics					X	X
94166 Herring Spawning	X					X
94163 Forage Fish Injury			X			X
MARINE BIRDS, MAMMALS						
94102 Murrelet Prey, Foraging						X
94173 Pigeon Guillimot Monitoring						X
Harbor Seal Condition			X			X
Avian Predation	X					X
ECOSYSTEM INTEGRATION						
Stable Isotopes			X			X
Data Base, Models	X	X	X	X	X	X

* NHP Natal Habitat Program
LRP Lake River Program
PPP Prey Predator Program
HOP Herring Overwintering Program
WHSIP Wild/Hatchery Stock Interaction Program
MP Modeling Program

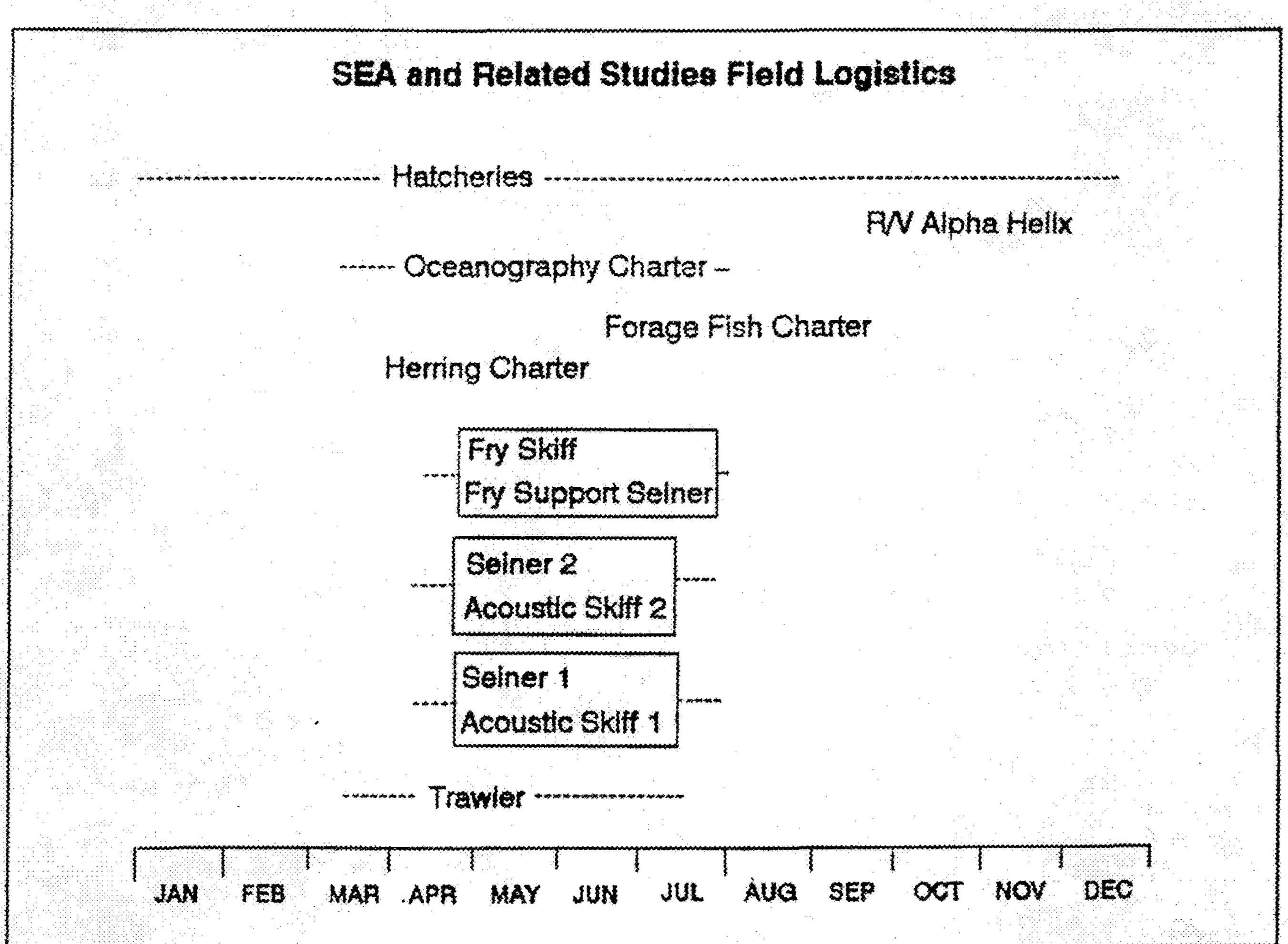

Figure 1. SEA field logistics for FY94 field season.

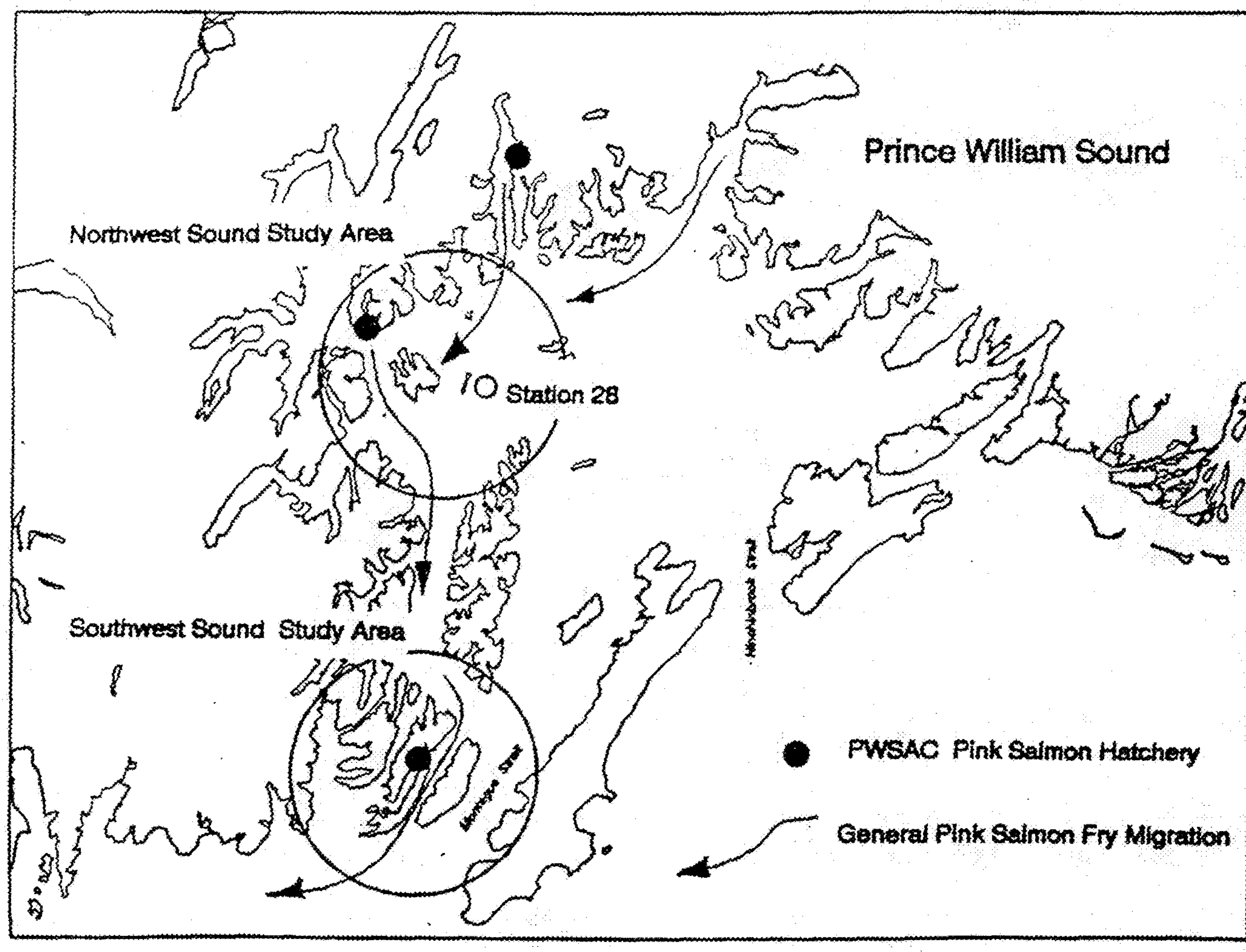

Figure 2. Study areas, hatchery locations, and pink salmon fry migratory routes.

943201

SFOS 94-118

PROPOSAL

TO: *Exxon Valdez* Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 402
Anchorage, AK 99501

FROM: Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: SEA: Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers

PRINCIPAL INVESTIGATORS:

Donald M. Schell	Thomas Kline
Professor	Post Doctoral Associate
SS# 034-30-1600	SS# 227-64-8284

DURATION: 19 Months

PROPOSED START DATE: 1 March 1994

AMOUNT REQUESTED: (FY94): $58,400 (FY95): $100,000

Donald Schell 2 March 94
Donald M. Schell /Date
Principal Investigator
Director, Institute of Marine Science
(907)474-7978

2 March 94
Thomas Kline /Date
Co-Principal Investigator
(907)474-5675

3-2-94
Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

3/4/94
A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

Ted DeLaca 3/7/94
Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

March 1994

EXXON VALDEZ TRUSTEE COUNCIL
FY94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project Title:	SEA: Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers
Project ID Number:	94320 I
Project Type:	Research and Monitoring
Name of Project Leader(s):	Drs. Donald M. Schell and Thomas C. Kline
Lead Agency:	Alaska Department of Fish and Game
Cost of Project:	(FY94): $58,400 (FY95): $100,000
Project Start-up Date:	1 March 1994
Project Completion Date:	1 October 1995
Geographic Area:	Prince William Sound, Fairbanks
Project Leader:	Donald Schell TK Donald M. Schell; UAF
Project Manager:	To Be Determined; ADF&G

B. Introduction.

Stable isotope ratios of carbon can serve as effective tracers of energy supply in the study area due to conservative transfer of carbon isotope ratios between the lower tropic levels (phytoplankton to zooplankton to forage fishes, etc.) of Prince William Sound and adjacent Gulf of Alaska waters up to the top consumers. The seals, whales and birds acquire these isotope ratios in response to the importance of the food sources and record temporal signals in keratinous tissues (claws, hair, feather) and reflect the major sources of their food in the bulk body tissues (muscle and fat). Isotope ratio analysis of these tissues can provide insight into both habitat usage and assist in quantifying amounts derived from various areas. Nitrogen isotope ratios, in turn, provide excellent definition of relative trophic level. The heavy isotope of nitrogen is enriched by about 0.3% with each trophic level and thus can accurately indicate the relative trophic status of species within an ecosystem.

B.1.1. The Problem: Pinniped Population Declines.

The impetus for this work arises from the rapid decline of pinniped populations, specifically steller sea lions and harbor seals, in the Gulf of Alaska, Prince William Sound (PWS) and the Bering Sea. In spite of apparent strong correlations between the rapid rise of fisheries in the Bering Sea and Gulf of Alaska and commercial pressure on herring and pollock stocks, no definitive links or cause-and-effect relationships have been established. If populations of marine mammals continue to decline, severe restrictions may be placed on fisheries deemed likely to be impacting food resources to these marine mammals. Stable isotope ration studies, which link both energetics and feeding by specific top consumers, as well as providing a means to validate conceptual food web models, are a powerful tool in deciphering both temporal and spatial variation in ecosystem energy flow.

B.1.2. The Problem: Declining Production of Salmon and Herring in PWS.

The availability of macrozooplankton forage for salmon, herring, and their predators varies in space and time because of changes in physical processes in PWS. In the SEA context, the latter is known as the Lake/River processes (SEA hypothesis number 2). When macrozooplankton are not available, macrozooplankton consumers are forced to switch prey, thus Predator/Prey Relationships (SEA hypothesis number 3) shift in space and time. These shifts represent fundamental changes in the way the PWS ecosystem produces commercial species, i.e. herring and salmon. A better understanding, particularly a quantitative understanding, is a prerequisite to determining protocols for restoration and recovery of these species.

B.2. The Stable Isotope Approach.

The use of natural abundance ratios of stable isotopes in biological systems has expanded rapidly in recent years and has proved extremely valuable in tracing carbon and nitrogen in both terrestrial and aquatic ecosystems. Most ecosystem studies depend upon two approaches: One is to construct budgets or mass balances of a key element such as carbon and attempt to determine which actions or processes in the natural history of the species of interest dominate these budgets. The second approach is to measure key rates or feeding processes and to relate the findings to the overall goal of assessing energy intake from the habitat. Although the two approaches should ideally coalesce into a coherent and complementary picture, this goal is difficult to attain. There are mismatches between time and space scales of the two approaches and such processes as feeding and isotopes can contribute both source (tracer) information and process information, they are ideally suited for identification and measurement of the movements of carbon and nitrogen in the ecosystem. Since they occur naturally, there are no concerns regarding perturbing the system or the need for experimental manipulations that might alter behavior or ambient conditions.

It can be postulated that natural stable isotope abundance of PWS biota will shift because of changes in trophic level, food web structure, and primary producer in the context of the SEA hypotheses, thus providing an independent tool to verify, quantify and model ecosystem processes. The tracer nature of the approach will enable the integration of ecosystem components. It will enable us to monitor both "top down" (predatory) and "bottom up" shifts (food supply) in herring and salmon production.

This project is an interdisciplinary effort focused on the food web dynamics supporting top trophic levels in Prince William Sound. The study would provide a integrating function to projects focusing on several levels in the food chains and will employ the stable isotope ratios of carbon and nitrogen to trace trophic transfers of carbon and nitrogen between levels. One focus will concern building the data base regarding harbor seals whereas the remaining work will seek to build a comprehensive base of isotopic data for the Prince William Sound region. In cases where regional gradients in isotope ratios exist, it may also be possible to identify critical habitats used by marine biota.

B.3. Objectives.

Natural stable isotope abundances reflect (1) trophic level and (2) source of assimilated matter and are thus a proxy for the change in diet specified in the Lake/River->Predator/Prey Relationships hypotheses. Stable isotope ratios will thus be used as a biomonitor of salmon and herring production and shifts in predation as tests of the SEA hypotheses. An example of how stable isotopes might shift is provided in section C.4.

C. Project Description

C.1. Resources and/or Associated Services.

Species: Harbor seals and their forage species, herring, pink salmon and related species and their forage species.

Benefits: Determination of flow of material to (via forage) and away (via predators) from production of herring, salmon and related species.

Beneficiaries: Resource managers and restoration activities: ADF&G, etc.

C.2. Relation to Other Work.

The shifts in predator-relationships occurring as a result variations in the physical environment represent fundamental changes in the way the PWS ecosystem produces commercially important species. Because a quantitative understanding understanding of these phenomena is a prerequisite to determining protocols for restoration and recovery of these species, these results will have direct application to all future rehabilitation and restoration efforts..

C.3. Objectives.

C.3.1 Time Specific Objectives.

FY94
Spring '94: Establish sampling protocols on harbor seal tissues using archived samples and samples collected from specimens obtained in 1993. These preliminary samples of vibrissae, claws, and tissues will be run to determine optimum sampling intervals on tissues with temporal signals and to begin building a data base for inter- and intra-specific variations. Integrate and plan with agencies regarding sampling of pink salmon, herring, zooplankton, and other fishes and initiate sampling

Summer '94: Field collection of harbor seal samples by ADF&G personnel. Sampling of fishes and zooplankton (primarily by ADF&G personnel), initiate isotopic analysis after conferring with other components in order to select most effective samples

FY95

Fall - Winter '94: Undertake laboratory program to determine isotope ratios in harbor seal tissues, fishes, zooplankton, and potential prey species. Compare findings with isotope data from forage fishes and other potential prey species. Participate in overwintering study by collecting samples for stable isotope analysis. By comparing conceptual food webs with isotope data, design future sampling to fill data gaps and to continue investigation of any discovered trends.

Spring - Summer '95 Undertake a field sampling program similar to 1994 with changes as determined by our 1994 results.

C.3.2. Measurable Objectives.

FY94: Collect/acquire samples
Analyze ~500 1994 samples
FY95: Analyze ~1500 1994 samples
Collect /acquire samples
FY96: Analyze ~1500 1995 samples
Collect /acquire samples

C.3.3. Hypotheses.

Hypothesis 1. Carbon and nitrogen stable isotope ratios of biota from Prince William Sound can be used to identify major food sources to top trophic levels and to assign trophic positions to specific consumers of given age classes and habitat.

Hypothesis 2. Isotope ratios in consumers provide a means to validate conceptual food web structures, identify trophic variability by individuals within species, and to validate quantified energy flows in ecosystem models.

C.3.4. Goals.

The proposed study would build upon our existing data base and add new data to construct and test conceptual food webs supporting harbor seals (and other species for which samples are, or become available) in Prince William Sound and their prey organisms. The goal is to determine the trophic positions and to define the natural history parameters accessible from isotope ratio data in light of the observed declines in their populations. These include changes in trophic level over the lives of seals, habitat dependencies, seasonal energetics and trophic dynamics relative to other community organisms. As part of this goal, we will integrate our analytical work with the field and laboratory studies of other investigators looking at food web structure, productivity of lower trophic levels, and provide validation data for assessment of conceptual and quantitative models.

Specific objectives of this project are:

1. To determine the $^{15}N/^{14}N$ and $^{13}C/^{12}C$ of species collected from the Prince William Sound ecosystem with a focus on those components important to man or important in the food webs supporting these species. Herring and salmon collected from PWS will be matched with regional isotope abundances in prey species (zooplankton, forage fishes) to allocate food sources and to assess trophic transfer efficiencies in specific areas of the sound.

2. Determine migratory patterns and habitat dependencies of harbor seals by comparing isotope ratios in seal tissues such as vibrissae and claws. If additional body tissues (muscle and blubber) become available from concurrent studies by ADF&G researchers, these samples will also be analyzed to determine energy supplies on a semiquantitative basis.

3. Determine isotope ratios on prey species favored by marine mammals in different regions of Prince William Sound. These data will allow estimation of seasonal importance of various prey species and the trophic levels of various seal species in the ecosystem. Past data has shown that there are considerable differences between individual animals of a given age and also changes in trophic level over the lifespan.

4. Synthesize the data obtained in context with conceptual food webs to validate feeding models and expand the natural history information.

5. Contribute stable isotope results to formal tests of the Lake/River-driven prey switching hypothesis developed by SEA to explain pink salmon and herring production trends.

C.4. Methods.

C.4.1. Lower Trophic Levels: Fishes and Zooplankton.

C.4.1.1. Sampling Strategy.

The sampling strategy is:

1. Collect synoptic samples from the greater PWS using the available fleet (ADF&G et al.) sampling effort. These same individual samples will receive multiple analyses (e.g. stomach content analysis) in addition to the the stable isotope analysis described.

2. Post-season analysis will reveal where macrozooplankton were and were not available to consumers (this will be discussed among collaborators at the fall workshop)

3. Conduct a posteriori tests of trophic level and food web shifts on samples from appropriate sites using the natural stable isotope methodology

Sampling design:

Biotic Groupings:
1. Pink salmon
2. Herring
3. Macrozooplankton
4. Other fishes that are predators and competitors of 1 & 2 and other forage species (e.g. sand lance)

Regions:
1. Western PWS
2. Northwestern PWS
3. Southwestern PWS

Timing:
1. Early season, spring bloom (April-May)
2. Late summer (July-August)
3. Late Fall-early winter (October-November) Alpha Helix Cruise

Because zooplankton availability at the various sites are not known ahead of time, a broad-scale sampling effort with sufficient sample sizes at each sampling site-time for post-season selection is required. This is important because one objective is to observe shifts in feeding among the target species, their prey and their predators in relation to zooplankton abundance. Thus a minimal sampling design would consist of stratifying the sampling over space and time corresponding to the sampling interval dictated by natural events. A minimal of 50 samples per biotic grouping is required for statistical validation to test for variation with respect to size (Kline et al. 1993) and to determine modalities occurring at a sampling site/time (Kline et al. 1989). Monthly sampling intervals has been identified in SEA. Sampling will occur in the following regions: W. PWS, NW PWS, and SW PWS. Three sampling periods times three sampling areas yield 9 time-space strata. The total minimal sample of 50 thus adds up to 450 for the '94 season. A sample of 100 per stratum is preferred thus 900 samples per biotic grouping will be the target. The biotic groupings to be sampled are: (1) pink salmon (juveniles and adults), (2) herring, (3) macrozooplankton (these will be sub-stratified by depth and taxonomic classification (e.g. euphausids), (4) predatory and competitory fish of target species (true cod, tom cod, black cod, sand lance, sculpins). During the early season, herring are not available and late, slamon are not available. at these times additonal samples will be taken of other biotic groupings to maintain an even sampling effort throughout the year. The four main biotic groupings times 900 samples each, will yield 3600 samples.

C.4.1.2. Sample Analysis Strategy.

Of the 3600 fish and plankton samples collected, only ~1000 will be analyzed following the a posteriori protocol. The selection of samples to be analyzed will be based on questions generated by events occurring during the season. Analysis will follow standard protocols at the stable isotope facility at UAF.

C.4.2. Marine mammals, birds and cetaceans.

C.4.2.1. Field collections.

We plan to coordinate all sampling with Alaska Department of Fish and Game personnel collecting and studying harbor seals during the summer of 1994. Vibrissae and small clippings of claws will be taken from anesthetized seals during tagging and physiology measurements by agency personnel. Any dead animals found will be sampled for body tissues as wells as keratinous tissues. Preliminary determination of the reproducibility of isotopic data from one whisker or claw to another will also be undertaken on samples from dead animals. Samples of sea lions, cetaceans or birds from Prince William Sound will also be opportunistically sampled in collaboration with agency investigators in the field. We will undertake sampling of species or tissues from archived samples where collections are inappropriate or need to be expanded. Vessels of opportunity and under charter to project scientists will be employed for sampling (see below).

C.4.3. Analytical procedures.

The methodology involved in the isotopic analyses and the interpretation of the data are documented in several publications resulting from prior work (See Schell and Saupe, 1993). The UAF Stable Isotope Facility has three isotope ratio mass spectrometers including a new automated system which will facilitate faster sample processing and allow more replication in small samples.

Sampling protocols in the field for zooplankton and fishes are well established and will be used in any future sampling. Claws collected from phocid seals will be sampled at close intervals along their lengths using dental drills under low power microscopes. Samples from anesthetized seals will be collected by clipping small portions from along claws using small wire clippers. Vibrissae from seals will be clipped in the field and sampled in the laboratory at closed intervals along their lengths. These samples will provide a temporal record of feeding by the seal over the last few years of life. The isotopic data will then be compared with values obtained from prey species in the same habitats. Where samples of prey species are missing of few, we will try to select proxy samples from the same area (zooplankton, benthos) which will enable a similar comparison. After the isotopic values are in hand, we will synthesize the data with past unpublished data and with other literature isotope ratio values to establish a trophic model.

C.4.4. Basis for the Stable Isotope Application.

The natural abundance of stable isotopes, e.g. $^{15}N/^{14}N$ and $^{13}C/^{12}C$, is a very powerful tool for ecological analysis because of the conservative nature of isotopic signatures in food webs (Wada and Hatori 1991). The most extensively measured process that enriches ^{15}N is the trophic level enrichment phenomenon (e.g., the transfer of material and energy from plants to animals or animals to animals). It is now well-established that consumers are enriched in ^{15}N by 0.34 $\pm$ 0.10 % compared to their diet irrespective of taxon or ecosystem (Minagawa and Wada, 1984). Even though the consistency of the enrichment is not understood, the universality of it allows one to determine the number of trophic steps in a food chain from a given producer to consume (Fry, 1988; Wada et al., 1991).Thus change in $^{15}N/^{14}N$ ratio in biota over time will reflect change in trophic level (TL). Shifts in herring and salmon diets that normally consist of macrozooplankton (largely reflecting allochthonous production having been advected into PWS) to autochthonous production (e.g. PWS benthos) will be evidenced by stable isotope ratios because (1) a greater proportion of benthic production (enriched in ^{13}C) will be needed to make up the deficit (see below) and (2) restructuring of the food web will cause concomitant shifts in $^{15}N/^{14}N$ (reflecting TL shift) with $^{13}C/^{12}C$ (reflecting alternative prey). The shift in $^{15}N/^{14}N$ will be especially notable in predators because of the large TL shift (see Table 1 below). The numerical nature of stable isotope data lend themselves to modeling, e.g. modeling effects of marine-derived nitrogen using ^{15}N (Kline, 1991). The data can thus be used in collaboration with modeling efforts in SEA.

Table 1. Normal and shifted TL (trophic level) depending on availability of macrozooplankton prey from Appendix 1 and predicted shift in ^{15}N based in established 0.34 % per trophic interaction enrichment in ^{15}N (Minagawa and Wada, 1984). ^{15}N analytical precision is at the 0.02 % level.

Box model component	normal TL	shifted TL	Predicted % ^{15}N increase
1. Macrozoop	2.09	2.09	0
2. YOY Herring+	3.02	3.00	0
3. YOY Salmon	3.19	3.42	0.08
4. 1+ Fishes	3.09	3.95	0.30
5. Predators	3.16	4.80	0.56

The concomitant shift in ^{15}N and ^{13}C can be analyzed using a two or three end member mixing model (Kline 1991, Kline et al. 1993). These results can also be directly applied to modeling components in SEA.

The stable isotope approach is unique in its ability to integrate time and spatial scales to mesoscale levels. No other technique currently available can generate such results. The natural tracer aspects of the approach emulatesw artificial tracer experiments without the burden of needing to generate signals or experimental artifacts.

C.5. Location.

The sampling will be carried out throughout PWS as part of the cruise plan. All analytical work will be carried out using the stable isotope facility at UAF.

C.6. Technical Support.

None external to UAF.

C.7. Contracts.

All analyses will be preformed in-house to enable higher quality cǒntrol, controlled turn-around time, and lower costs.

D. Schedule.

The time line for this work will begin in spring 1994 with the retrieval and analysis of archived samples from Prince William Sound collected by the Alaska Department of Fish and Game. These samples will provide a background upon which to design future and summer 1994 isotope ratios sampling in order to contrast food web structure prior to and following the EVOS.

D.1. Projected activities upon commencement of funding.

Spring 1994 - Design sampling program in coordination with other principal investigators. Obtain archived samples of biota from Prince William Sound through coordination with K. Frost and L. Lowery of ADF&G. Other samples will be requested from the US Fish and Wildlife Service and NOAA-NMFS.

Summer-fall 1994 - Conduct field sampling from charter ships and other vessels operating in PWS. Subsampling and preparation for isotopic analysis will be continued as time permits.

Fall - winter 1994-95 - The collected samples will be analyzed for $^{15}N/^{14}N$ and $^{13}C/^{12}C$ and a conceptual trophic and food web model assembled for the Prince William Sound ecosystem with the focus on commercially important species and on protected species such as harbor seals, birds, etc.

Spring - summer 1995 - The data obtained will be used in the preliminary models to identify data gaps and to direct summer 1995 sampling operations. Summer sampling will be undertaken in closed cooperation with other projects to optimize sampling and to help validate/test other models of ecosystem interactions by species of interest. Manuscripts describing the results will be prepared for the open scientific literature.

Field-work: Field-work will coincide with other project components. For example, fishes sampled for stomach content analysis can also be be analyzed for stable isotopes. A P.I. will make visits to the vessels to instruct personnel on correct procedures and for in-season quality assurance.

Sampling events: Sampling will occur according to the cruise schedule.

Sample stable isotope analysis will be carried out at UAF. Samples will need to be transported from field sites and on-shore support facilities (ie. hatcheries) to Fairbanks as frozen cargo (All sample preservation for isotope analysis will be by freezing).

Data compilation and analysis will commence upon receipt of samples.

D.2. Deliverables.

The deliverables for this work will include such reports as are required by the EVOS scientific coordinating committee and papers published in the open scientific literature. We will also present our findings at annual scientific meetings, at national meetings for peer review, and public forums.

Opportunities for public involvement will come through presentations/seminars

Construction: None

Draft and final report submissions: Annual

Project Personnel (responsibilities).

Schell will conduct the marine mammal stable isotope component
Kline will conduct the plankton and fish stable isotope component
The personnel will be responsible for analysis and publication of their respective components. They will collaborate by exchanging data that support each others components and to generate a synthesis paper.

Logistic Needs.

Field: Vessels and Gears of all types, on-shore facilities for storage of samples for transshipment to UAF. Pick up PI at port on road system, i.e. Valdez, Whitier or Seward, cruise participation.

E. Existing Agency Program.

None

F. Environmental Compliance/Permit/Coordination Status.

ADF&G Scientific Collection Permit: Kline will have own permit for this as well as other projects

NEPA: None

G. Performance Monitoring: Quality Assurance/Quality Control Procedures/Measures.

Sample processing and mass spectrometry results are incorporated into a rigorous in-house quality control and assurance program. Field samples are collected and kept in vials labeled at the collection site and stored in plastic bags with external labels for corroboration. All but the smallest samples are archived for later resampling in cased of spurious results or loss in processing.

Laboratory standards for carbon and nitrogen isotope ratios consist of organic matter primary standards obtained from the National Bureau of Standards and secondary working standards of tank gases and a powdered bowhead whale baleen standard. The latter standards have been calibrated in our laboratory and at the University of Texas and the Marine Biological Laboratory, Woods Hole, Massachusetts. Samples of baleen standard are routinely carried through the entire analytical procedure at regular intervals and whenever new reagents or any change in procedure occurs.

To insure adequate sampling, a minimal of 50 samples will be collected of each lower trophic level target species per sampling time-area stratum. Replicate analyses during mass spetrmetry for stable isotopes is the standard procedure at the UAF stable isotope facility

H. Coordination of Integrated Research Effort.

Field:
Sampling vials and bags will be provided to people on vessels engaged in sampling. These vials will have alphanumeric identifiers that will be used to track samples through sample prepartion, mass spectrometry and data analysis stages. These identifiers will be used to correlate isotopic data with other data. It will be encumbent on the collaborating agencies to provide the investigators with the following data for each sample:

Sample ID
Sampling Date
Station Number
Location Code (lat-long if applicable)
PWS region
Station name (e.g. name of bay)
Depth where sample was taken
Set or haul number
Species name
Age of sample (if a fish)
Fork length (if a fish)
Wet weight (if a fish)

A PI will partcipate on an early cruise and one later in the summer of 1994 to instruct ADF&G on sample handling procedures and to bring back samples to UAF for initial stable isotope analyses. As analyses proceed, results pertaining to each sample, e.g. stomach content analysis, lipid content or caloric value, will be merged to enable interdiscipinary comparison, this aspect should be conducted at a workshop occurring in 1995 for 1994 samples.

Platform Sharing.

Fish and plankton sampling will be conducted within the auspices of other biota sampling programs. Pertinent data of each sample (ie. data on each individual fish will be shared among components; thus sample id will be consistent among components).

Workshops.

Workshops will be conducted to facilitate collaboration and to direct analysis efforts. Results of analyses will be exchanged at workshops and by telecommunications. For example, stable isotope analysis emphasis can be placed on samples acquired coincident with phenomena that we wish to investigate in detail. As over-sampling will be conducted, sample selection will come through consultation based on observations made on-site during the sampling and remote sensing. The workshop will facilitate this coordination and will provide a starting date for intensive sample analysis.

I. Public Process.

R. T. Cooney: *An Integrated EVOS-Sponsored Ecosystem Approach to Marine Fish, Bird and Mammal Issues in Prince William Sound: Sound Ecosystem Assessment (SEA) and Related Studies* (Project 94320 Summary)

J. Personnel qualifications.

Don Schell has been involved with stable and radioisotope tracers in arctic and subarctic ecosystems for over 25 years. Work has involved quantifying energy and nutrient flows in food webs in such varied habitats as coastal Southeast Alaska, the north Aleutian Shelf, Kotzebue Sound and the coastal Beaufort Sea. As a principal investigator on several NOAA-OCSEAP programs, he is used to working on multi-investigator projects and shifting the focus of the study to aid other investigators as problems arise. Projects requiring stable isotope data have included the determination of food web structures in estuaries on the North Slope of Alaska, in the nearshore zone and lagoons on the Alaska Peninsula and in the energetics of feeding bowhead whales. The work on whale feeding has now been expanded to include species in the Southern Ocean with a focus on right whales and pygmy right whales. This work is continuing. When completing projects, the data has always been synthesized to yield final products that are of direct use to agency personnel and other users.

Over the past decade, the results produced by Dr. Schell's research has supported his request for the funding of two new mass spectrometers -- a VG Series II and a new Europa automated sample preparation unit coupled to a 20/20 mass spectrometer system. These machines and our older VG SIRA 9 now comprise the UAF Stable Isotope Facility. This analytical capability will assure that sample throughput will be timely and that samples from other investigators can also be accommodated.

Tom Kline has been involved in stable isotope research since 1985. His use of stable isotopes has been in fish ecology with emphasis on salmonid fishes in western, south central and southeast Alaska. His innovative use of the techniques has allowed him to quantify the effect of salmon carcass nutrient input to juvenile sockeye salmon production. This research has been the first to provide direct evidence for the importance of salmon carcasses for juvenile salmon production. He has generated stable isotope models that enable the quantification of different sources of production important in salmon ecosystems. Dr. Kline is also leading an investigation to relate feeding strategies to growth forms in North Slope salmonids. His on-going efforts include collaborations with ADF&G, the North Slope Borough, and BPX. The results of these projects have been presented in numerous scientific papers (written and oral, see biographical sketch) as well as in public forums (speaking to local groups and classes).

K. Budget

Project Description: Sound Ecosystem Assessment (SEA): Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers

Budget Category[1]	Proposed 1-Mar-94 30-Sept-94	Proposed 1--Oct-94 30-Sept	FY 94	FY 95	FY 96	FY 97	Sum FY 98 & Beyond
Personnel[2]	34.5	63.1	34.5	63.1			
Travel	.7	3.8	.7	3.8			
Contractual	15.1	25.0	15.1	25.0			
Commodities	6.8	8.1	6.8	8.1			
Equipment	1.3	0.0	1.3	0.0			
Capital Outlay	0.0	0.0	0.0	0.0			
Sub-total	58.4	100.0	58.4	100.0			
General Administration	0.0	0.0	0.0	0.0			
Project Total	58.4	100.0	58.4	100.0			
Full-Time Equivalents (FTE)	0.8	0.8	0.8	0.8			
				Amounts are shown in thousands of			

Budget Year Proposed Personnel:	Budgeted Months	Cost[3]	Comment
Donald M. Schell, Professor	0.6	6,990	Project leader, principal scientist
Thomas C. Kline, Post Doctoral Associate	3.0	12,623	Asst. project leader, field supervisor
N. Haubenstock, Technician	1.4	5,990	Mass spectrometry
M. Hobert, Technician	.5	2,029	Laboratory

[1]Indirect costs at a rate of 20% of Total Project Costs (TPC) have been included in each budget category.
[2]Includes leave accrual and benefits for all eligible personnel.

L. Literature Cited.

Fry, B. 1988. Food web structure on Georges Bank from stable C, N, and S isotopic compositions. Limnol. Oceanogr. 33:1182-1190.

Kline, Thomas Clayton, Jr. 1991. The significance of marine-derived biogenic nitrogen in anadromous Pacific salmon freshwater food webs. Ph.D. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska, 114pp.

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M. Biographical Sketches. See Attached.

N. Appendix 1. A prediction of isotopic shifts due to the Predator/Prey switching hypothesis in relation to conceptual model of PWS salmon and herring production (SEA Fig. 21)

SEA Fig. 21 illustrates flow of C from primary production to various functional components of salmon and herring production in PWS. This model when converted to canonical trophic levels illustrates how stable isotope abundance can be used to monitor ecological shifts (Tables 1 and 2). In calculating trophic level shifts it was assumed that the fractional component of C from alternative sources had an equal fractional component of N from the same sources, i.e. there is direct coupling of C and N during trophic transfers. Because stable isotope measurements are empirical, no such assumptions are necessary for project execution.

Table 1. Trophic levels of box model (SEA Fig. 21) components based on carbon flow. Trophic levels (TL) shown in bold are assumed, others are calculated. TL are calculated when macrozooplankton are replete (A) and when macrozooplankton levels are 10% of replete (B).

A. Normal: Replete in Macrozooplankton, carbon flow as in SEA Fig. 21

Organism (box-component)	Source (TL)	flux $gCm^{-2}yr^{-1}$	fraction	effectiveTL of diet
1. Macrozoop	Phytoplank (**1**)	120	.91	(.91)1
	Microzoop(**2**)	12	.09	(.09)2
	total	132	2.09	
2.YOY Herring+	Macrozoop(2.09)	.2	.2	(.2)2.09
	Microzoop(**2**)	.8	.8	(.8)2
	total	1.0	3.02	
3. YOY Salmon	Macrozoop(2.09)	.05	.81	(.81)2.09
	YOY Herring+(3.02)	.006	.1	(.1)3.02
	Epibenthos(**2**)	.006	.1	(.1)2
	total	.062		3.19
4. 1+ Fishes	Macrozoop(2.09)	20.2	1.0	(.996)2.09
	YOY Herring+(3.02)	.08	.004	(.004)3.02
	OY Salmon(3.19)	.01	.0004	(.0004)3.19
	total	20.29	3.09	
5. Predators	Macrozoop(2.09)	5.05	.68	(.68)2.09
	YOY Herring+(3.02)	.02	.003	(.003)3.02
	YOY Salmon(3.19)	.004	.0005	(.0005)3.19
	1+ Fishes(3.09)	2.03	.27	(.27)2.03
	Adult Salmon(**3.5**)	.36	.05	(.05)3.5
	total	7.464		3.16

B. Alternative: Depauperate in Macrozooplankton (10% of normal macrozooplankton amount in diets, remaining diet demand made up by other components in same proportion as when macrozooplankton are replete).

Organism	Source (TL)	flux	fraction	effective TL
1. Macrozoop	Phytoplank (**1**)	120	.91	(.91)1
	Microzoop(**2**)	12	.09	(.09)2
	total	132	2.09	
2.YOY Herring+				
	Macrozoop(2.09)	.02	.02	(.02)2.09
	demand	1.0		
	remainder	.98		
	Microzoopl(**2**)	.98	.98	(.98)2
				3.0
3. YOY Salmon	Macrozoop(2.09)	.005	.08	(.08)2.09
	demand	.062		
	remainder	.057		
	YOY Herring+(3.0)	.028	.45	(.45)3.0
	Epibenthos(**2**)	.028	.45	(.45)2
				3.42
4. 1+ Fishes	Macrozoop(2.09)	2.02	.10	(.1)2.09
	demand	20.29		
	remainder	18.27		
	YOY Herring+(3.0)	16.32	.80	(.8)3.0
	YOY Salmon(3.42)	2.04	.10	(.1)3.42
				3.95
5. Predators	Macrozoop(2.09)	.505	.068	(.068)2.09
	demand	7.464		
	remainder	6.959		
	YOY Herring+(3.0)	.058	.008	(.008)3.0
	YOY Salmon(3.42)	.012	.016	(.016)3.42
	1+ Fishes(3.95)	5.85	.784	(.784)3.95
	Adult Salmon(**3.5**)	1.04	.139	(.139)3.5
				4.80

Table 2. Normal and shifted TL (trophic level) depending on availability of macrozooplankton prey from Table 1 and predicted shift in ^{15}N based in established 3.4 per mil per trophic interaction enrichment in ^{15}N (Minagawa and Wada, 1984).

Box model component	normal TL	shifted TL	Predicted per mil ^{15}N increase
1. Macrozoop	2.09	2.09	0
2. YOY Herring+	3.02	3.00	0
3. YOY Salmon	3.19	3.42	0.8
4. 1+ Fishes	3.09	3.95	3.0
5. Predators	3.16	4.80	5.6

Biographical Sketch
THOMAS CLAYTON KLINE, JR.

January, 1994
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks, Alaska 99775-7220
(907) 474-5675 (office)

Education

1991	Ph.D. in Oceanography, University of Alaska, Fairbanks
1983	M.S. in Fisheries, University of Washington, Seattle
1979	B.S. in Fisheries, University of Washington, Seattle
1976	B.S. in Oceanography, University of Washington, Seattle
1972-74	Coursework at Sophia University, Tokyo

Research Interests

- Biogeochemical Ecology • Natural abundance of stable isotopes
- Aquatic ecology with emphasis in ecosystem productivity as it affects megafauna
- Nutrient cycling • Underwater science and technology

Professional Societies

American Academy of Underwater Sciences
American Fisheries Society
American Society of Limnology and Oceanography
Sigma Xi
The Explorers Club

Selected Related Research Publications

1994 Kline, T.C. Jr., J.J. Goering, and R. Piorkowski. The effect of salmon carcasses on freshwater systems. *In* A. Milner and M. Oswood (eds.), Alaskan Freshwaters. Springer-Verlag. IN PRESS.

1993 Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, P.L. Parker, and R.S. Scalan. Recycling of elements transported upstream by runs of Pacific salmon: II. $\delta^{15}N$ and $\delta^{13}C$ evidence in the Kvichak River watershed, southwestern Alaska. Can. J. Fish. Aquat. Sci. 50: IN PRESS.

1991 Kline, Thomas Clayton, Jr. The significance of marine-derived biogenic nitrogen in anadromous Pacific salmon freshwater food webs. Ph.D. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska, 114pp.

1990 Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, and P.L. Parker. Recycling of elements transported upstream by runs of Pacific salmon: I.

$\delta^{15}N$ and $\delta^{13}C$ evidence in Sashin Creek, southeastern Alaska. Can. J. Fish. Aquat. Sci. 47:136-144.

1988 Mathisen, O.A., P.L. Parker, J.J. Goering, T.C. Kline, P.H. Poe, and R.S. Scalan. Recycling of marine elements transported into freshwater by anadromous salmon. Verh. Int. Ver. Limnol. 23:2249-2258.

Selected Other Research Publications

In preparation: Kline, T.C. Jr., L. Moulton, L. M. Philo, J. C. George. Isotopic evidence of ecological separation of dwarf and normal forms of two sympatric coregonine fishes in an Alaskan Arctic Lake.

In revision: Kelley, J.J., T.A. Gosink, and T.C. Kline. The variability and causes of the partial pressure of carbon dioxide in the Barents Sea region.

1993 Kline, T. C. Stable isotope ecology of Alaskan sockeye salmon lakes. *In*: Heine, J. N., and N. L. Crane (eds.), Diving for Science...1993, Proceedings of the American Academy of Underwater Sciences Thirteenth Annual Scientific Diving Symposium. p.89-94.

1993 Kline, T. C., J. J. Goering, V. Alexander, and J.J. Kelley. The importance of marine-derived nitrogen in subarctic sockeye salmon lakes. Proceedings of the Eigth International Symposium on Sea Ice and the Okhotsk Sea. 1-4 February 1993 Mobetsu, Hokaido, Japan.

1992 Kelley, J.J., T.A. Gosink, T C. Kline, and M. Aota. Carbon dioxide and other trace gases in Arctic seas. Proceedings of the Seventh International Symposium on Sea Ice and the Okhotsk Sea. 2-5 February 1992 Mobetsu, Hokaido, Japan.

Advisors

Postdoctoral: John J. Kelley

Doctoral: John J. Goering

Masters: Kenneth K. Chew

Collaborators not in citations

None

DONALD M. SCHELL
Biographical Sketch

SS# 034-30-1600

Institute of Marine Science, and Water Research Center, Institute of Northern Engineering,
University of Alaska Fairbanks, Fairbanks, Alaska, 99775
Phone: (907) 474-7115 or 474-7775; e.mail FFDMS1@ACAD3.ALASKA.edu
Fax: (907) 474-6087

EDUCATION

B.S. Chemistry (University of Massachusetts, No. Dartmouth) 1962
M.S. Chemistry (University of Alaska) 1964;
Ph.D. Chemical Oceanography (University of Alaska) 1971. **John J. Goering, Advisor**

PROFESSIONAL EXPERIENCE

1994 - Present; Director, Institute of Marine Science, Univ. of Alaska Fairbanks
1987 - Present; Professor of Marine Science, Univ. of Alaska Fairbanks
1983-1987; Associate Professor of Marine Science and Water Resources, Univ. of Alaska Fairbanks;
1981-83; Assistant Professor of Marine Science and Water Resources, Univ. of Alaska;
1978-81; Visiting Assistant Professor, Univ. of Alaska;
1976-78; Research Fellow, Univ. of Alaska;
1973-75; Postdoctoral Fellow, Univ. of Hawaii; **(Dr. John Caperon, Advisor)**

RESEARCH INTERESTS

Natural abundance stable and radioisotope tracers in ecosystems; Arctic oceanography with emphasis on nutrient dynamics and primary production and trophic energetics; Nitrogen fixation in arctic tundra; Land-sea interactions with respect to energy and nutrient budgets; Marine mammal migrations and energetics; Carbon accumulation and cycling in arctic tundra.

PUBLICATIONS RELEVANT TO PROPOSAL

Michener, R. H. and D. M. Schell. (in press) The use of stable isotopes in tracing marine aquatic food webs. In: R. Michener and K. Ljatha (eds.). *Stable Isotopes in Ecology* Blackwell Scientific Publications.

Gu, Binhe, D. M. Schell, and V. Alexander. (in press) Stable carbon and nitrogen isotope analysis of a plankton food web in a subarctic lake. Can. J. of Fisheries and Aquatic Sciences.

Oswood,M. W., J. G. Irons III, and D. M. Schell. (in press) Dynamics of dissolved and particulate carbon in a tundra stream in arctic Alaska. In J. Reynolds and J. Tenhunen (eds.), *Landscape function: Implications for Ecosystem Response to Disturbance*, Ecological Studies, Springer- Verlag.

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Schell D. M. 1993. Bomb radiocarbon in arctic Alaskan aquatic and terrestrial biota. In: *Radioactivity and environmental security in the oceans: new research and policy priorities in the Arctic and North Atlantic* (V. Adushkin and G. Krasilov, eds.) Woods Hole Oceanographic Inst. Woods Hole MA. Pp 135 - 144.

Saupe, S. M., D. M. Schell and W. Griffiths. 1989. Carbon isotope ratio gradients in western arctic zooplankton. Mar. Biol. 103:427-432.

Dunton, K. H., S.M. Saupe, A. N. Golikov, D. M. Schell, and S.V. Schonberg. 1989. Trophic relationships and isotopic gradients among western Arctic Ocèan fauna. Marine Ecol. Prog. Ser. 56:89-97.

Schell, D.M., S.M. Saupe, and N. Haubenstock. 1989. Natural isotope abundances in bowhead whale (*Balaena mysticetus*) baleen: markers of aging and habitat usage. In: P. Rundel, J. Ehleringer and K. Nagy (eds.) *Stable Isotopes in Ecological Research*. Springer-Verlag p. 260-269.

Schell, D. M. 1983 $\delta^{13}C$ and ^{14}C abundances in Alaskan aquatic organisms: delayed consumer production from peat in arctic foodwebs. Science 219:1068-1071

Recent Collaborators

Linda Deegan
Brian Fry
Mark Oswood
Catherine Kemper
William Griffith
Walt Oechel
Lee Cooper
Bruce Peterson
Binhe Gu
Peter Best
Robert Michener
James Reynolds
John Tenhunen
Curtis Olsen

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RESEARCH PROPOSAL

TO: Mr. James Ayers, Executive Director
EVOS Trustees Council, Restoration Office
645 G Street, Anchorage Alaska 99501
(907) 276-8012, -7176 facsimile

FROM: Institute of Marine Science (IMS)
School of Fisheries and Ocean Sciences (SFOS)
University of Alaska Fairbanks (UAF)
Fairbanks, Alaska 99775-1080

and

Prince William Sound Science Center (Science Center)
P.O. Box 705, Cordova, Alaska 99574
(907) 424-5800, -5820 facsimile

TITLE: Sound Ecosystem Assessment (SEA)
Information Systems and Model Development (SEA-DATA)

PRINCIPAL INVESTIGATORS:

Dr. Donald Schell
Director, Institute of Marine Science
School of Fisheries & Ocean Sciences, University of Alaska Fairbanks (IMS/SFOS/UAF)

Dr. Vincent Patrick
Prince William Sound Science Center &
Institute for Systems Research, University of Maryland, College Park

NEW/CONTINUING: New

PROPOSED STARTING DATE: March 1, 1994

PROPOSED DURATION: Two years

AMOUNT REQUESTED: FY94 SEA-DATA - Total $ 653.10 K for PWSSC & UAF;
$32.4K for NBS
FY95 SEA-DATA - Total $ 635.69 K

Donald Schell 4/13/94 Date
Director, IMS/SFOS-UAF
(907) 474-7531

Vincent Patrick (signed for) Date
Principal Investigator
(907) 424-5800

A.V. Tyler 4/18/94 Date
Associate Dean, SFOS
(907) 474-6732

Ted DeLaca 4/20/94 Date
Director, Office of Arctic Research

Joan Osterkamp 4-13-94 Date
Executive Officer, SFOS
(907) 474-7824

G.L. Thomas Date
President, PWS Science Center
(907) 424-5800

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Sound Ecosystem Assessment (SEA) - An Ecosystem Study for Prince William Sound - - Information Systems and Model Development (SEA-DATA)

Project ID number: 94320

Project type: Research/Monitoring

Name of project leader(s): Dr. Vincent Patrick

Lead agency: Prince William Sound Science Center (PWSSC)

Cooperating agencies: U.S. Forest Service (USFS)
Prince William Sound Aquaculture Corporation (PWSAC)
University of Alaska Fairbanks (UAF)
National Biological Survey (NBS)
Alaska Department of Fish & Game (DF&G)
National Oceanic and Atmospheric Administration (NOAA)

Cost of project/FY 94: $653.10 K for PWSSC & UAF portions; $32.4K for NBS
Cost of project/FY 95: $635.69 K
Cost of Project/FY 96 and beyond: $635.69 + inflation

Project Start-up/Completion Dates: FY94: March 1,1994 - September 30, 1994
FY95: October 1, 1994 - September 30, 1995

Geographic area of project: Prince William Sound and North Gulf of Alaska

Name of project leader: Dr. Vincent Patrick

Name of lead agency project manager: Dr. Jerome Montague, Alaska Dept. of Fish & Game

B. INTRODUCTION

Subsystems and their quantitative representation

The Sound Ecosystem Assessment (SEA) Project Plan (November, 1993) provides a detailed formulation of an ecosystem study with the ultimate goal of a quantitative representation with predictive capabilities. From the outset the approach assumes that a single entity (e.g., species, subspecies, or population) can be properly understood only as a component of a system. On the other hand, not every component of the ecosystem is equally tightly coupled to every other component. Much of the SEA Plan is devoted to the identification of the coupling or relationships between system components. In so doing, the Plan identifies the relevant subsystem of the larger ecosystem. This identification is the first step toward a quantitative description as well as a major conceptual simplification of the scope of the problem.

The SEA Project addresses two subsystems: (1) the subsystem associated with pink salmon during the life stages of egg through the time of migration out of Prince William Sound and (2) the subsystem associated with Pacific herring during the life stages of egg through the third year juvenile. For each species and each life stage the SEA Plan describes the processes whereby the components of the subsystem either are coupled to, act upon, or are affected by other components. That is, it identifies the predators, the competitors, the prey, and the physical and chemical environmental variables that effect these populations.

Just how broad a subsystem must be dealt with is determined by how far up, down, and across a food web there is significant coupling to the target species over the time intervals of interest. For some of the early life stages the subsystem is quite simple. For example, throughout all of the pink salmon egg and alevin life stages predators, prey, and competitors can be neglected; the subsystem is essentially that of the microclimate and stream hydrology acting upon egg and alevin distributions.

The later life stages involve substantially more complex subsystems that extend down to include primary production. These subsystems may have effects that extend to apex predators. In turn, apex predators may have effects that extend to primary production. The major hypotheses of SEA are conjectures regarding the quantitative structure of the coupling or regulating processes within the subsystem. These are the river-lake, prey switching, fry growth, and herring overwintering hypotheses.

Primary objectives of SEA are quantitative representations of the two subsystems for pink salmon and Pacific herring. The term quantitative representation is used here as a generic identifier covering a broad range of complexity and sophistication. On the one hand, it refers to quantitative descriptions of the past states of some system component based upon measurements alone. On the other, it refers to a four dimensional numerical model of the wind-driven ocean state with a space-time evolution model for multiple, coupled trophic levels. Quantitative representations with predictive capabilities are the goal.

The first issue is what can be measured and when. Fishery data is, in effect, measurements at only a few times throughout a year (e.g., catch and hatchery release). The SEA field survey attempts to measure the state of the system throughout the time of residency of pink salmon and Pacific herring in Prince William Sound. In addition, the survey makes measurements to determine the rate of change of the state of the system and the processes responsible for those changes.

The SEA field survey, together with other data sources, will provide information such as the following regarding the state of the system:

from the SEA field survey (buoys, surface vessels, aircraft):
- ocean current vectors, temperature, salinity, sea state, fronts;
- plankton densities, distribution, species and cohort composition;
- fish densities, distribution, size and species composition, diet;
- bird and mammal counts, distribution, predation.

from the satellite downlink site:
- sea surface temperature (Advanced Very High Resolution Radiometer - AVHRR))
- ocean color and derived values (Sea viewing Wide Field of view Sensor - SeaWiFS)
- meteorological data

There is a similar list, though much less complete, for the case of historical data.

A primary objective for FY94 is the integration of all of the data from all of the SEA projects and all of the remote sources into a quantitative representation of the state of the system. The mechanism for this integration is the interface to the data. The interface provides an ecosystem view of the data that is consistent and independent of data source, project, or measurement system. In particular, as seen through the interface data on fish, plankton, ocean state, surface winds, and apex predators will share a common space and time reference. In this form these data and time series of these data can be explored and analyzed with available software for scientific data visualization. Since the data consists of multiple variables defined on the three dimensional pelagic system, the three dimensional display capabilities of scientific data visualization systems provide the means to evaluate and explore marine systems in ways analogous to the use of geographical information systems for surfaces.

The second objective for FY94 is the approach and a project plan for the development and application of deterministic models. A deterministic model predicts how quantities will change over a time interval and over some spatial region. Ocean current models are of this type, as are the "physical-biological" models that address jointly the ocean transport of plankton, phytoplankton production, and zooplankton grazing. In addition, the diffusion-advection-reaction models for fish are of this type. In their classical forms, such models require the knowledge of initial values throughout the spatial region and the future knowledge of boundary values.

These models are applied in ways that are suited to the data and to the prediction objectives. The methods of data assimilation address the problem of insufficient data from observations for initial conditions by incorporating observations over extended time periods. Stochastic methods are used when the boundary conditions or parameters cannot be adequately specified over the time interval of interest. In FY94 the focus will be on the short term predictions and issues associated with sparseness of data and initial conditions. The development of methods for longer term forecasts will begin in FY95.

Models with some level predictive capability are implied by the notions of response, restoration, and recovery. Specifically, the idea of response suggests some capability for forward and backward projections of events, risk analysis, what-if simulations, and possibly the ability to adjust projections in response to updated current information. Similarly, restoration and recovery suggest capabilities for using active and passive strategies for moving a system from one state to another. These capabilities are the goals of this project.

C. PROJECT DESCRIPTION

For FY94 there are five SEADATA projects:

(1) Field data communications
(2) Data management
(3) Descriptive model
(4) Numerical models
(5) Sampling technologies

The objectives of each SEADATA project are described. The time for completion of objectives is given as weeks or months After the StartUp (ASU) of the program.

SD94#1. Field data communications.

This subproject will implement on a demonstration scale near real-time data communications from the SEA field survey platforms to the SEA data ingestion site. The goal is to complete during FY94 transmit capability for at least one of the moored sites, transmit and receive capability for at least one of the SEA survey vessels, and a transmit capability suitable for use with a vessel of opportunity.

During the first month after startup all of the data sources in SEA will be reviewed regarding real-time communications with the principal investigator. The review will examine technical difficulty and significance to the FY94 objectives. The data sources to be included int the FY94 real-time communications effort will be selected by the SEA Science Committee. An approach and hardware design using off-the-shelf components will be finalized and procurement will be based upon requests for quotations.

2.5 mos After StartUp (ASU): communications for first buoy and survey vessel operational.

SD94#2. Data management

All data related tasks are collected into the Data management project which, in turn, has seven subprojects.

SD94#2.1. Coordination.

The objective of this subproject is the coordination of the Data management project with the needs and interests of the SEA participants and the Trustee Council. The goals are (1) to identify and consult individuals with data expertise and responsibilities and (2) to establish a vehicle for sustained coordination and consultation by forming an ad hoc advisory group on data issues. This initial consultation and review will be the basis for the selection of an approach that is consistent and compatible with activities elsewhere.

5 wks ASU: approach finalized.

SD94#2.2. SEA data services.

This subproject is configured to incrementally build the FY94 resources for SEA data.

SD94#2.2.1 Flat file database.

To start quickly and to focus early efforts elsewhere, the startup database will be a UNIX file server and the native file system along with one or more of the widely used self-describing data formats (CDF, HDF, NEONS). A server suitable for growth will be used.

3 wks ASU: specification and request for quotes.

6 wks ASU: delivery.

SD94#2.2.2. Data ingestion

For each project and for each sensor or sampling effort, the procedures will be developed with the principal investigator for moving data from the field to the SEA archive. There is a broad array of issues: data formats and conversion, real-time versus physical media, media type, raw versus reduced data, and processing of real-time data.

6 wks ASU: ingestion plan, hardware specifications and request for quotations (RFQ).

10 wks ASU: ingestion system and procedures operational.

SD94#2.2.3. Mass storage

10 wks ASU: Finalize requirements and configuration for SEA mass storage.

13 wks ASU: delivery

SD94#2.2.4. Quality control and availability.

Establish procedures with principal investigators whereby data migrates (1) to new certification following checking and referencing and (2) from high availability storage (high speed hard disks) to lower availability storage (on-line optical disks and off-line archive media). The terminology adopted by the Earth Observation System (EOS) will be used to describe the level of processing:

Level 0. Unprocessed instrument data at full resolution.
Level 1.
- 1A. time referenced; georeference and calibration information, applied if reversible.
- 1B. nonreversible georeference and calibration processing applied.

Level 2. Derived ecosystem variables with time and location as Level 1.
Level 3. Level 1 or Level 2 mapped to uniform space-time grid.
Level 4. Model output, analysis results, assimilated data sets.

Ongoing project.

SD94#2.2.5. Relational database.

The objective is to implement a relational search capability sufficient to support the SEA project during FY94. The specific implementation will depend upon needs specific to SEA as well as upon requirements for compatibility and coordination with other data systems. The preliminary approach is to retain unchanged the initial data storage using scientific data format files while using the relational data base for metadata and pointers to the files.

15 wks ASU: selection and order

SD94#2.2.6. Security plan.

The requirement is to implement a system and procedures that (1) meet the requirements set forth in license agreements for data that are used in SEA and that (2) protect SEA from malicious system entry and destruction.

18 wks ASU: complete FY94 plan and implement

SD94#2.3. Site access

The site access subproject establishes (1) the wide area connections needed for communications to sites with Internet access and (2) the local area network for SEA within Cordova.

First priority is for wide area connectivity for this will connect SEA operations in Cordova to all sites with Internet access. In particular, this will meet the requirements of SEA for connectivity to the University of Alaska and to essentially all universities worldwide, to an increasing number of government agencies, to private companies involved in R&D, to gateways to OMNET and BITNET, and to national and international data centers. Because of this priority, wide area connectivity has been included in a request for time critical startup funds. A memorandum discussing the technical background and the cost basis for the request was provided to the Chief Scientist. This memorandum is included as Appendix 1. It describes the significance of this connectivity to the efficiency and cost effectiveness of SEA.

The Internet connection has significance to the community beyond the functioning of the SEA project. In particular, the implementation plan was prepared several months ago and was submitted to NSF for cost sharing support under the program **Connections to the NSFNET**. The proposal is still active. Additional information has been requested regarding services to the Cordova Branch of Prince William Sound Community College. The final determination is contingent upon funding for the balance of the project, specifically, the funds requested for this subproject. The discussion in Appendix 1 reflects information available on February 17, 1994. Since that date, more information has become available and that is reflected in the cost estimates of this document. A final design approach will be determined after all technical and cost information is complete and, in particular, after a review of the best approaches to minimizing the degrading effects of satellite latency.

The FY94 objectives for a local area network are also discussed in Appendix 1. The objective is to establish a limited scale local area network that connects the majority of the SEA investigators in Cordova and that connects several of the principal Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG) organizations. The connectivity to the user organizations will provide those groups with access to the progress, findings, and near real-time data of SEA. A portion of the NSF support is used to fund the local area connection of the Community College.

6 wks ASU: dedicated 256kbs telecommunications link to Internet.

12 wks ASU: limited scale local area networking of investigators and PWSFERPG.

SD94#2.4. Remote sensing data

For FY94 the effort will focus on Advanced Very High Resolution Radiometry (AVHRR) for sea surface temperature (SST) and the soon-to-be launched Sea viewing Wide Field of View Sensor (SeaWiFS) for ocean color data. The objectives are the near real-time acquisition, archiving, screening, and reduction, referencing, clipping, and mounting of AVHRR SST (and later SeaWiFS ocean color) for the SEA area of investigation and to begin this effort as soon as possible. There are three subprojects that will be ongoing.

SD94#2.4.1. Downlink and archive.

The dish and downlink site of the Geophysical Institute of UAF (GI-UAF) will be used to collect and tape all AVHRR passes with SEA coverage. After the SeaWiFS launch the availability of only a single dish will mean occasional downlink schedule conflicts and the consequent loss of one pass for one sensor.

SD94#2.4.2. SEA data product.

Data will be screened (e.g., for cloud cover) and selected for a composite data image. Images are corrected and georeferenced and the SEA region clipped.

SD94#2.4.3. Distribution.

SEA image is mounted on the SEA data site and is transmitted to the SEA field survey.

This subproject will be conducted by Dr. David Eslinger in collaboration with the Geophysical Institute.

SD94#2.5. Remote data sources

These are data sources for current data other than SEA data and satellite data. The primary objective for FY94 is acquiring meteorological data in a format that can be readily integrated into the SEA data and with sufficient timeliness to contribute to the adaptive sampling effort. It is anticipated that there will be significant limitations due to the currently available resolution for meteorological information on Prince William Sound and that results for FY94 will be an assessment and plan for improvements.

SD94#2.6. Historical data

This long term objectives of this subproject are:

(1) assemble a digital index of historical data relevant to SEA,
(2) establish an off-line (tape) and low-availability on-line (CD-ROM) data base for historical data available in digital form,
(3) select high priority data resources and complete necessary data processing to integrate these data in the SEA data base.

For FY94, the objective is to complete these objectives for AVHRR and Coastal Zone Color Scanner (CZCS). Cumulatively, much of work has been completed previously by SEA collaborators. During FY94 these investigators will collaborate to fill any gaps in the records, complete remaining data processing, and integrate these records into the SEA. The libraries will be mounted in a distributed data base with redundancy as required by nonexistent or low speed data communications. This project will combine the prior work of the following investigators:

(1) David Eslinger, (IMS-UAF): CZCS data for Alaska;
(2) Kevin Engle, (GI-UAF): AVHRR
(3) David Douglas, Gary Drew, (NBS Anchorage): AVHRR

The effort will be carried out during the last quarter of FY94 with completion during September, 1994. It will be carried out by the above investigators under contract.

SD94#2.7. SEA data tools

The fundamental objective is accessibility and utility of the SEA data, models, and forecasts for the SEA investigators and for those using the results of the investigations. Functionally, these tools must identify the contents (browse tools) and explain access and use. They should work in conjunction with higher level research tools and increase the productivity of those tools. In particular, these tools provide a large part of the integration of the SEA data and results into a unified representation of the ecological subsystems.

The objective for FY94 is a demonstration scale implementation of such tools that is sufficient for the efficient functioning of both the investigation and the distribution of results to users. This subproject will begin after a relational database is added (15 wks ASU) and will continue over an eight week period during which time capabilities are incrementally added.

The approach will be to adapt interface and query approaches used in

(1) the Environmental Center for Mesoscale Ocean Prediction (ECMOP) interface for oceanographic data, developed at the Center for Air and Sea Technology, Stennis, Mississippi
(2) the Planetary Data Systems Small Body Nodes interface, developed at the University of Maryland, College Park, Maryland.

These will be extended to address the three dimensional pelagic system by adapting approaches used in the

(3) Science Planning and Operations Facility (SPOF) for International Solar Terrestrial Program, developed for NASA by the Advanced Visualization Lab, University of Maryland.

The SPOF tools provide a query and display interface for scheduling multiple satellites according to their positions relative to the locations of predicted events in the magnetosphere. The approaches will be adapted to the display, scheduling, and reporting of the SEA survey vessels, buoys, and ships of opportunity relative to predicted, observed, and historical oceanographic events.

SD94#3. Descriptive model and interface

This subproject addresses

(1) the description of the state of the system given measured data and an incomplete abstract definition or model of the system, and
(2) an interface to the data in terms of the system variables.

The measured data for this subproject is Level 2 data, that is, biological and physical variables derived from Level 1 instrument and sampling data. (Level refers to the data classification system used in the National Atmoshperic Space Administration's Earth Observation System (NASA EOS). Level 1 refers to data that has been processed to include instrument calibration and time and space referencing.) The derived variables include

from the SEA field survey (moored, ship, and aerial survey):
- ocean current vectors, temperature, salinity, sea state, front locations;
- plankton densities, distribution, species and cohort composition;
- fish densities, distribution, size and species composition, diet;
- bird and mammal counts, distribution, predation.

from satellites:
- sea surface temperature, phytoplankton densities, sea state, sea surface

height;
- meteorological variables.

The derivations of these variables depend upon a model for the instrument or sampling method. There may be some dependence upon the system model, but in general the derivations do not depend upon the way variables may be coupled.

The overall objective is to implement an interface to the derived variables in terms of their description (or partial description) of the time varying state of the system. That interface is to provide tools for display, query, and the computation of further variables that are functions of the state of the system. In particular, the tools provide Level 3 processing of the data. Specifically, display, query, and computation with multiple Level 2 variables having differing space-time sampling necessitates interpolation and regridding using a common grid.

The objectives for FY94 are:

(1) visualization of the time varying state in the form of sequences of three dimensional renderings of each of the SEA Level 2 variables;
(2) support for adaptive field sampling.

SD94#3.1. Visualization

The Level 2 variables include time-varying scalar fields (temperature, salinity), vector fields (ocean currents), densities with respect to volume (biomass per unit volume), and spatially varying continuous (size) and discrete (cohort, sex) spectra. The spatial domain of definition for each of these as system variables is the three-dimensional region of Prince William Sound and the North Gulf of Alaska. For each of the variables there are well developed methods in scientific visualization for the display of the values of the variable in a three-dimensional region defined by the ocean surface and the bathymetry of the bottom. Scientific visualization software from several sources provides extensive libraries of these methods. In addition to the libraries, the software also provides an integrated application development environment. The first task is to select the hardware and software and to implement the visualization tools for each type of system variable.

However, unlike the system variable, the Level 2 derived variable is nearly always defined only on a proper subset of the space-time domain of the system variable. For example, temperatures derived from satellite measurements, towed thermistors, moored thermistors, and acoustic tomography are defined only on the ocean surface, a curve, a point, and a vertical plane, respectively. Fish density from trawls, acoustics, and LIDAR is defined on points, vertical planes, and, for range-gated lasers, a volumetric region. In addition, the domain for the derived variable may need to be viewed as time varying rather than a "snap shot." For example, the data on a vertical plane from an acoustic survey may have been acquired over many hours. The further objective of this effort is the visualization of each Level 2 variable on the appropriate spatial domain for a given time interval.

13 wks ASU: basic visualization capability, applied to bathymetry and several variables.

18 wks ASU: visualization of all Level 2 variables.

SD94#3.2. Support for adaptive sampling

The objective is to develop the resources to meet the specific information requirements of adaptive field sampling strategies. For FY94 the objectives will be to provide

(1) near real-time support;
(2) transmission of reduced data to the field and decision aid tools for field use;
(3) short term forecasts.

In general, the decisions regarding sampling strategies will be based upon information about the recent past and the present of several variables. They will also require some level of prediction, even if it is no more than an estimate of the time during which the present state is expected to persist. The purpose here is to establish, during FY94, support procedures for these requirements based upon an effective interface to available real-time data in conjunction with partial, albeit incomplete, modelling resources.

The first issue is the common one of interpolation and regridding. It is the problem of processing the data for several variables (Level 2) such that all data is defined on a common, possibly regular, set of sampling points in space-time (Level 3). In addition to the problem of interpolating any one variable, there is the further issue of consistency between the interpolated values of several variables that are coupled in some way. Without recourse to dynamical models, the approach must remain a statistical one that depends upon the statistics of past and present data.

However, the approach here will be to reduce the impact of this problem by exploiting three of the central features of the SEA survey design:

(1) the use of sensors with high sampling rates along extended, connected subsets (acoustics, echo and doppler), satellite and airborne sensors, and depth shuttling towed sensors have high sampling rates along a vertical plane, ocean surface, and undulating curve within a vertical plane);
(2) simultaneously deployed multiple sensors with coincidence measurement domains (common vertical plane for acoustics and towed sensors, satellite and low altitude images of common regions at near time coincidence);
(3) simultaneous measurements from sensors with transversal measurement domains (the vertical plane is transverse to the surface plane).

Interpolation and regridding issues are of much less consequence within any one of the domains with high sampling density. Interpolation across the continuous, undulating path is less problematic than interpolation across isolated vertical drop measurements. With interpolation and regridding within a domain the variables are jointly given and provide a partial description of the state of the system. The transversal domains provide two such partial descriptions. In this situation, the problem is not that of differing sparse sample points for each variable. Instead, there are two sparse sets of two-dimensional planes (vertical slices and the ocean surface at distinct times) on which partial descriptions of the state of the system are given. The interface provides the means to view and manipulate this description of the state. Specifically, interpolation between planes, whether subjective or formal, can now be viewed as interpolation of the partial description and not of uncoupled variables.

This, in effect, defines a Level 3 data specification on the measurement domains. With compression, and with possibly lossy compression within the domains, this data is a first choice to use for transmission to the field.

This same Level 3 data is the basis for computations of system related quantities that are defined by models that depend only upon the system variables and not upon space and time explicitly. Such quantities are the instantaneous Lagrangian drift of plankton (using ocean current fields), the feeding rates of predators upon specific prey and prey mortalities (from foraging models using predator and prey size and space distributions, light level, temperature), dispersion rates (from distribution models using any or all of foraging rates, energetics related rates, or temperature or light intensity preferences). As before, these model based features can be computed on the sparse domains and can be visualized and manipulated along with the Level 3 variables.

The models used to compute such features are some of the parts of a numerical model. The computed features add a degree of projection into the future. Because the model is incompletely defined, it cannot accurately predict the evolution of the state in time. However, with some caution and attention to the sizes of the computed rates it should be possible to identify those processes likely to dominate and those of lesser consequence for the short term. This type of insight and the ability to visually track such indicators in near real-time is the goal for the Descriptive model and interface subproject for FY94. In addition to supporting adaptive strategies, this capability will be used to develop near realtime on-line visual reports for the SEA participants.

SD94#4. Numerical models

The work of this subproject is the development of numerical models. The objective is the capability to predict the time evolution of populations of pink salmon and Pacific herring in Prince William Sound during their early life stages. The ecosystem approach is, in effect, the recognition that this objective necessarily implies the capability to predict the time evolution of the ecological subsystems of Prince William Sound associated with these two species.

The approach is shaped by basic aspects of the problem. A first such aspect is the sparseness of data. It is argued that there are processes acting at fine spatial and fast temporal scales that cannot be measured synoptically. As a result it is not possible to adequately characterize the present state of the system. If the present state cannot be adequately known then it is problematic how to construct a statistical model or, given any model, how to initialize it.

A complementary aspect is the incomplete information on the processes that determine the system dynamics. A completely specified present state can be projected forward in only very limited ways.

The development of a dynamic model is relevant to both aspects. For the issue of sparse data, the combination of available data and an accurate model of the system should provide more information than the data alone. It should be possible to use the additional information of the model as a means to effectively interpolate and extrapolate. For example, a better representation of the present state should be possible. That, in turn, should result in a better initial condition and, thereby, a more accurate forecast.

A mathematical framework

A mathematical and numerical formulation of the modelling problem and the ecological context of that formulation are described in the SEA Science Plan (Sound Ecosystem Assessment, *Initial Science Plan and Monitoring Program*, Report Number 1, Draft, November 24, 1993). The marine populations are represented in general by functions of time, physical space, and a set of optional variables. The functions define densities with respect to volume and a measure for the optional variables. That is, they define time varying number of individuals per unit volume and per unit measure of the optional variables. The optional variables are those over which the population is non-uniformly distributed, and may be either continuous or discrete. Common examples are size and age. The physical and chemical environment is represented by a vector of environmental variables, each variable a function of time and space. These environmental variables are the usual ocean state variables (current velocity components, temperature, salinity, pressure, density) along with variables such as light level, dissolved oxygen, and turbidity.

The subsystem is then identified according to those variables and populations that can be modelled as solely "forcing" relative to the target population, those that are coupled to the target population, those for which the target population is forcing, and those that are none of these three.

(1) A variable or population is referred to as "forcing" if its value affects the target population but is not itself affected by changes in the target population.
(2) A first population is coupled to a second if a change in the first causes a change in the second and conversely.

The modelling problem is simplified to the extent it is possible to identify a prioi the populations not coupled to the target population and only forced by it, for these can be neglected. The problem is further simplified by approximating coupling by forcing wherever possible. For SEA, the environmental variables are modelled as forcing only. One rule of thumb that is cited is that of limiting a model to "plus/minus 1" trophic levels and to use forcing for all else.

The time evolution of the population densities and the environmental variables are determined using two types of processes

(1) coupling processes: feeding and dispersion;
(2) within-population processes, e.g., growth, swimming, reproduction, advective transport, egg desiccation.

Two coupling processes, (1) feeding and (2) dispersion, are used to determine the coupling between two populations. That is, these two processes are the mechanisms whereby the distribution of a first population relative to spatial position and to optional variables (e.g., size, age, sex) changes in response to a second population distribution. The actual change may also depend on processes within-population such as growth, swimming speed, and regeneration.

FY94 objectives

There are four objectives for FY94.

(1) subsystem identification;
(2) implementation plan for an ocean circulation model;
(3) implementation plan for a physical-biological model;
(4) identification and representation of observations regarding feeding, dispersion, mortality, and growth for near-shore and pelagic nekton.

SD94#4.1. Subsystem identification.

The SEA Science Plan reviews the life stages for pink salmon and Pacific herring during the period of residency in Prince William Sound. These life stages are short intervals of weeks to months and have relatively sharp transitions. The earliest of the stages are subsystems that are simple in terms of coupled component and complexity of forcing factors. Later stages are increasingly complex. The objective here is to formulate an appropriate subsystem approximation for each stage. The survey findings on coincident distributions, feeding, dispersion, and ocean state will be used to identify the populations that constitute the subsystems for pink salmon and Pacific herring at each life stage. The objective is the identification of the components; this identification then determines the interaction processes between those components that require description and modelling.

It will be likely that one such subsystem approximation will not suffice for all needs. A first goal in SEA is a model sufficient to account for natural variability. The prudent approach is simplicity and first order effects. A further goal is a model suitable for assessing the consequences of a major perturbation to the system. In this case the first order approximation may not adequately reflect the consequences. Yet another goal is to predict the consequences of long term sustained perturbation. One approximation may not be appropriate for all time scales. Because of these multiple requirements, the objective is to also identify the more complex subsystems that may be needed for use with major one-time perturbations (risk analysis, response) and with long term sustained perturbations (restoration, enhancement).

The following illustrate the system identification tasks.

(1) For wild pink salmon, the egg and alevin stages are to a good approximation uncoupled. There is no feeding and negligible predation. This subsystem is affected solely by processes associated with the stream hydrology. The modelling objective is to relate stream processes and "stream type" to survival and to timing of outmigration

of fry, and to develop methods whereby stream processes throughout the watershed could be predicted from a combination of in situ sensors, remote sensing, and past climatological data. The significance of this effort is that such a model will provide the initial conditions for the next lifestage, that of fry in the nearshore region. There is no measurement alternative. This model development will begin in FY95 and the initial condition from hatchery stocks will be used in FY94.

(2) The herring egg stage is subject to the "forcing" processes of the intertidal ocean, and the larva stage undergoes forced advective dispersion. There is no feeding until several weeks into the larva stage. There is substantial predation, especially during the egg incubation. The question is whether there is significant feedback: whether the predator populations or distributions are affected by the egg or larva density (i.e., by their extent and the number). Examples of such effects are changes in numbers of predators due to switching to or from alternative prey, or changes from one year to the next in the number of predators due to effects upon reproductive or rearing success.

(3) The river-lake hypothesis describes a process whereby ocean circulation has a forcing relationship upon a principal prey of the subject species. It does not say anything about the rest of the system. Identifying the likely extent of the system with regard to coupling and forcing from phytoplankton through fry and juvenile herring to their predators must be done as the first step toward using the ocean circulation effects in a dynamic model.

(4) Pacific herring at metamorphosis become a new component of an existing pelagic system. Both the "before" and the "after" subsystems are the question here. They are likely to extend from primary production through adult herring. In contrast, the overwintering subsystem for age one through age three herring is simpler and may, for first approximation, be simply forced by ocean temperatures.

SD94#4.2. Ocean circulation model.

Every biological process relevant to SEA is a function of the ocean state variables. The approximation that the environment is only forcing means that the ocean state can be addressed without regard for the biology. It is not possible, on the other hand, to predict anything about the time evolution of the biology without a prediction of the ocean state. The slow rate of change for the ocean is not a way around this requirement, for there is then the problem of adequately describing at sufficiently high resolution the state of the ocean. The contemporary method for obtaining good representations of the ocean state is through data assimilation, the combined use of measurements and dynamical models.

The objective for FY94 is to review contemporary capabilities for modelling and to select the one or more approaches needed to model the ocean dynamics of Prince William Sound and its interactions with the Gulf of Alaska. This review will include a survey of current activities and recent results and communications with academic, government, and private research centers. An implementation plan will be developed for a continuously running four dimensional circulation model for Prince William Sound and the adjacent regions of the Gulf of Alaska. The plan will include the assimilation of data from SEA and from other observation programs.

The schedule for FY94 is

Aug 15, 1994: implementation plan completed
Sept 15, 1994: first steps of implementation plan completed.

The project will collaborate with Dr. Mark Johnson, UAF/IMS, for technical leadership. Dr. Johnson is active in the field of ocean circulation models with extensive experience in Alaskan waters.

The project has the advantage of an extended network of resources by virtue of the multi-institutional collaborations in SEA. The primary resource is UAF/IMS. A second is the Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami. There are collaborative relationships with investigators at RSMAS who are involved with the U. S. Coast Guard project for ocean modelling to support an oil spill response system. A third resource is the Prince William Sound Oil Spill Recovery Institute. The Institute maintains a clearinghouse for spill related technological information at the Prince William Sound Science Center. This clearinghouse contains comprehensive and current information on the ocean modelling activities of industry and government.

SD94#4.3. Physical-biological model.

The dispersion of nutrients and phytoplankton is determined by ocean eddy diffusion and advection. The distribution of zooplankton is similarly determined except for some independent vertical mobility. The recent advances in ocean circulation models and their numerical solution have led to efforts to model and simulate the time evolution of planktonic populations in a subsystem. These time evolution models are often called physical-biological models. (Much of the work prior to these focused on equilibrium distributions of these populations.) Satellite ocean color scanners have provided synoptic scale data on phytoplankton distribution. These data have been used in model validation and in data assimilation trials. The less complex forms of the models address only plankton dispersion. More complex models combine dispersion with regeneration and feeding.

They are hybrid models combining ocean circulation models with biological models for foraging, natural mortality, regeneration. These models can address the mixed layer temperature and depth, nutrient consumption and redistribution, phytoplankton production and sinking, zooplankton grazing and diel migration, and advective transport. They can be extended to include planktivore grazing with the addition of models for the foraging and dispersion of the planktivores.

These are the models needed for the river-lake hypothesis.

The objectives for FY94 are

(1) Review contemporary modelling approaches and their applicability to the subsystem associated with the zooplankton prey of pink salmon fry and juvenile herring;
(2) Formulate a model and a plan for its numerical solution as an extension of the ocean circulation model;
(3) Assess the feasibility and utility of a lower level implementation of the model that can

be used with ocean state data from the SEA field observations and with available satellite data for ocean temperature and color.

(4) If the finding in (3) is favorable, implement a data driven model of the time evolution of the plankton populations, up to but excluding plantivore grazing.

The schedule is:

July 1, 1994: review and model implementation plan complete.
Aug 1, 1994: simulations from a data-driven implementation of the model.

Dr. David Eslinger, UAF/IMS, will be contracted to conduct this effort. He has developed physical-biological models, applied them to historical data sets for the Bering Sea and the Atlantic Bight, and has evaluated their performance using CZCS ocean color data. He is a co-principal investigator for the SEA project for in situ measurements of the phytoplankton populations and nutrient concentrations. He is also the technical lead for the SEADATA subproject to acquire and process remote sensing data, including forthcoming SeaWiFS ocean color data.

SD94#4.4. Nekton processes.

According to the foregoing model the observed distribution of phytoplankton reflects the past transport and the mortality and regeneration along the way. In contrast, the observed distribution of nekton can be modelled as a response to the present distribution relative to alternative distributions. There is no consensus regarding responses and possible mechanisms. A simple formulation consists of a "preference" measure for an environmental variable such as temperature, light level, or temperature gradient (thermal front). In these cases the environmental variable is forcing the dispersion just as for phytoplankton. More complex formulations involve weighted measures of rates for one or more processes. Examples here are rate of feeding, rate of net energy flux, rate of predator attack, gut fullness, and combinations of these.

There can be feedback. For example, there is no feedback in the hypothetical example of planktivore response to feeding rate and zooplankton response to light level. There is feedback in the case of a predator and its prey both responding to some combined measure of rates of feeding and rates of predator attack. In such cases, diel migrations would be expected if changes in light level have an effect upon feeding rate or upon rates of predator attack.

The objectives for FY94 are:

(1) identification of the "plus/minus 1" subsystem (i.e., the predators, competitors, and the prey) for each postlarva life stage of pink salmon and herring as determined from the SEA surveys.

(2) from the SEA data, the identification of the time varying distributions with respect to space and size of each population in the two subsystems.

(3) preliminary, trial models for dispersion for each of the populations in the "plus/minus 1" subsystem.

(4) numerical solutions for the trial models and the simulation of the time evolution of the

space and size distributions of the subsystem, with diel and within season variations.

(5) trial models for foraging and growth and the simulation of the time evolution of pink salmon and herring feeding, growth, and predation mortality.

These objectives depend upon the data and visualization capabilities developed in SD94#3.1 and upon the SEA measurement approaches. The populations that are members of the "plus/minus 1" trophic levels are identified by direct sampling in conjunction with the simultaneous sensor measurements throughout the water column of the "plus/minus 1" trophic levels. Prior information and SEA data are used to formulate trial dispersion models. Methods for numerical solutions are adapted or developed, and resulting simulations are visualized and compared to the SEA data. Trial models for growth and foraging are used to simulate fry and juvenile herring growth and predation mortality for various initial conditions, changes to environmental variables, and for changes in predator and prey abundances. These trials are compared with the SEA survey results from coded wire tag studies for salmon fry growth.

Schedule:

August 1, 1994: trial models for dispersion.

September 1, 1994: preliminary numerical methods and simulations.

The project will draw upon the collective knowledge of SEA regarding the distribution and behavior of specific populations, the interpretation of observed overlapping distributions, and results from field studies of diet and foraging. Dr. Doran M. Mason, University of Wisconsin Limnology Laboratory, will collaborate with Dr. Vince Patrick in the development of distribution-feeding-growth models. Dr. Ricardo Nochetto will also collaborate as an expert in numerical methods for the classes of equations used in this project.

SD94#5. Sampling technologies

The issue addressed in this subproject is the efficiency and cost effectiveness of the SEA monitoring effort with respect to the resolution and scale of sampling. In both the geosciences and in ecology the identification of the state of a system and the dynamics of that system is fundamentally limited by the density and the scope of measurements in space and time that can be realized for a given level of effort. There have been major advances in sampling and measurement technologies that push back these limitations, and the rate at which such advances are made is increasing as more effort and attention is directed at these problems. With regard to such advances, this subproject has two ongoing objectives:

(1) to serve as the vehicle whereby available technological advances relevant to SEA can, on a selective and prioritized schedule, be introduced in a manner that does not impair the ability of existing projects to fulfill their immediate monitoring responsibilities.;

(2) to provide the means whereby newly available advances or emerging technologies can be reviewed and evaluated.

For FY94, the objectives are the topics of the following five subprojects:

5.1. The addition of a towed platform, fitted with optical plankton counter, Conductivity, Temperature, Depth (CTD), fluorometer, and flowmeter, providing a programmable, depth varying, undulatory trajectory, and suitable for unattended deployment on ships-of-opportunity;

5.2. The addition of the optical plankton counter (OPC) to the SEA monitoring program;

5.3. The integration of the sensors, data-loggers, and near real-time communications for the sensor packages to be deployed on the U.S. Coast Guard buoys;

5.4. A review and evaluation of the applicability of acoustic tomography in SEA;

5.5. An exploratory program for the use of acoustic, multi-spectral, and thermal sensors, both shipboard and airborne, in bird and mammal surveys.

SD94#5.1. Depth shuttling platform.

The objective is to specify and procure a commercially available towed platform capable of carrying physical, chemical, and biological sensors along a preprogrammed trajectory of periodically varying depths. Towed acoustic systems such as doppler current profilers and echo sounders provide repetitive sampling of the water column along the path of the towed system. In contrast, physical and chemical measurements are often made only along isolated vertical drops. This restricts measurements to the beginning and end of trawls and plankton tows and necessitates stopping mid-transect with acoustic systems. Depth shuttling platforms permit the continuous deployment of physical and chemical sensors and the repetitive excursion of the water column from the surface to depths up to 150 meters. This deployment scheme is of particular significance to SEA: the towed depth shuttling approach combined with towed acoustics is the only means currently available for making simultaneous measurements throughout the water column of the ocean state, turbidity, light level, phytoplankton density, zooplankton size spectra and biomass density, and fish size spectra and biomass density. Such simultaneous measurements of spatial distribution, size structure, and environmental variables are central to the identification and subsequent measurement of interactions between and within trophic levels and processes controlling foraging, mortality, growth and distribution.

The objective for FY94 is to complete the specification and procurement of a depth shuttling vehicle. An initial product review has been completed. Thus far, the "Aquashuttle" from Chelsea Instruments, Ltd. is unique both in price and performance. Because of the lateness of the start of SEA relative to the beginning of sampling in the northern hemisphere, there remains only one uncommitted unit available for 1994 delivery. It is an immediate concern whether SEA will be able to obtain a shuttle for FY94. Assuming a unit can be purchased, there is a long delivery time of 15 weeks. During that time, vessel preparations will be completed along with any custom fabrication for the fitting of sensors to the shuttle. At the end of FY94 work will start for configuring the shuttle for use on ships-of-opportunity during intervals of less frequent SEA field work.

As soon as possible ASU: specification and procurement.

16 wks ASU:	delivery;
18 wks ASU:	completion of mechanical trials and supervised deployment; begin routine use;
Sept. 15, 1994:	complete configuration for use on ships-of-opportunity.

(Revised delivery time as of 3/10/94: 9 wks after purchase order)

SD94#5.2. Optical Plankton Counter.

The objective is to extend the density and scale of zooplankton measurements through the use of the FOCAL optical plankton counter. An optical plankton counter is being loaned to SEA by the Soldotna office of ADF&G. In towed applications, the OPC uses optical counting and sizing technologies along with a flowmeter, depth sensor, clock, and Global Positioning System (GPS) to determine the local density and size structure of the zooplankton community and the depth, time, and position of each measurement. It does not distinguish between species, and the determination of species composition requires direct sampling.

E. Jin of University of Toronto will carry out the integration of the FOCAL OPC and the Aquashuttle and the use of these two in SEA. He has been using the FOCAL OPC on the Great Lakes for more than four years. Since 1984 he has been the field and laboratory manager of the plankton ecology program led by Gary L. Sprules. He has done extensive work in the areas of calibration and ground truth procedures, flow rate adjustments, and data analysis, and on these issues he has conferred directly with Dr. Alex Herman, Bedford Institute, the inventer and developer of the OPC.

The objectives and schedule for FY94 are:

10 wks ASU: complete calibration of the OPC and field operations trials.
17 wks ASU: the adaptation of the OPC to the Aquashuttle.
18 wks ASU: the development of procedures for field survey and for routine deployment with the Aquashuttle.

SD94#5.3. U.S.C.G buoys: sensor packs.

The objective is to implement a prototype design for a sensor package with near real-time communications with one buoy, and to later proceed with further implementation of two or three additional buoys.

4 wks ASU: coordinate with SEA projects the sensors to be deployed in the initial package.
5 wks ASU: complete package design.
6 wks ASU: integrate with communications approach (see 1. Field data communications).
9 wks ASU: delivery and deployment.

SD94#5.4. Acoustic tomography: review and evaluation.

Tomography, in general, attempts to determine the pointwise properties of a medium from a knowledge of the cumulative effects of that property along paths through the medium. In practice, the knowledge is usually limited to a finite set of paths. In oceanography, acoustic tomography is used to determine the speed of sound pointwise throughout the water column between two moored transducers from a knowledge of the total time for sound to travel from one transducer to a second along the possible "multipaths" for sound between the two transducers. From the relationship between sound speed and temperature and pressure, the temperature through the water column can be estimated. This measurement provides simultaneously and instantaneously what could be determined with a thermistor on an Aquashuttle after many tens of hours.

The addition of a third transducer station increases the information by a factor of three because one then has the temperature through the water column along each side of a triangle defined by the three stations. With "moving ship tomography" the temperature can be determined for each water column defined by the line between the current ship position and a fixed transducer, but each one sequentially and not simultaneously. Acoustic tomography is an extremely cost effective means for synoptic scale, high resolution, real-time measurements of the structure of the water column.

The usual methods for acoustic tomography rely on a sound channel and the consequent multipaths. Prince William Sound is in most places too shallow for this approach. The objective here is to assess whether the efficiencies and cost effectiveness of acoustic tomography can be realized in SEA through alternative schemes of the generation of multiple paths.

This review will be conducted by Prof. Carlos Berenstein, Institute for Systems Research, University of Maryland.

July 1, 1994: preliminary findings
August 30, 1994: final evaluation with recommendations regarding trials in FY95

SD94#5.5. Sensor trials in conjunction with bird and mammal counts.

This subproject is to use conventional, direct observational assessments of the abundance and distribution of birds and mammals along with experimental recordings of acoustic signals and the recording of video, panchromatic, multispectral, and thermal images. The objective is to use the observational records of skilled observers along with the video and panchromatic images as ground truth. The acoustic records and the multispectral and thermal images are to be evaluated for their potential use in more autonomous survey schemes wherein species identification, abundance, and distribution can be extracted from some combination of the recorded signals.

The objectives for FY94 are:

(1) develop and execute a survey plan using conventional observation methods.
(2) to complete an initial review of information on acoustic, optical, and thermal signatures of the bird and mammal species of interest and the degree to which these signatures

can be distinguished from background clutter.

(3) if promising approaches can be identified through loaned or leased equipment

(a) supplement the observations with a video record and, as appropriate, a high resolution panchromatic film record such that a trained human observer could reproduce the counts of the original observers over the recorded field of view.

(b) begin the creation of sequences of recorded observation sessions that contain the reports of the expert observers, the video and film ground truth record, and the recordings from special sensors.

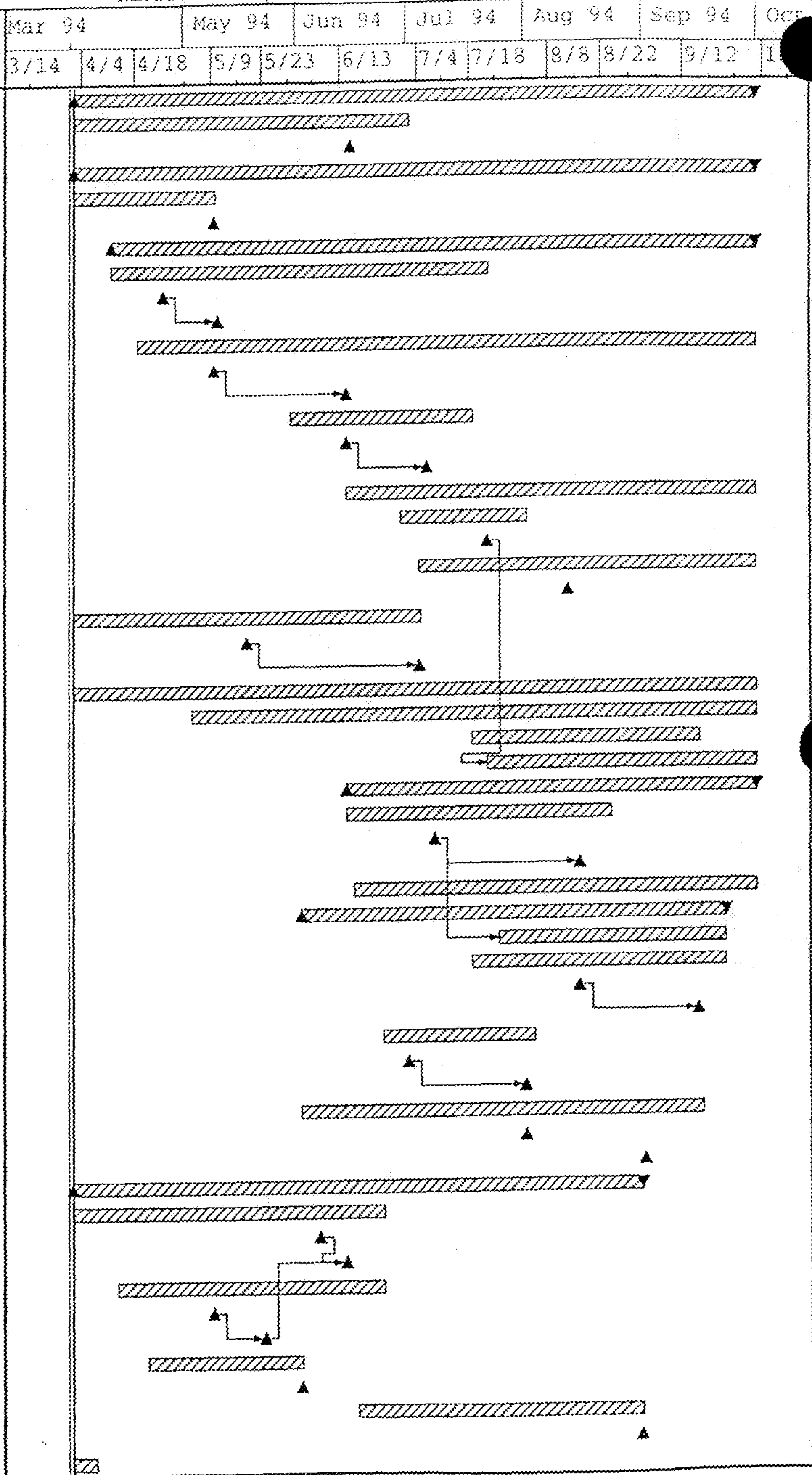
(c) prepare a collection of special sensor records and a companion collection of referenced ground truth recordings, and develop a plan for FY95 for joint programs with acoustic and image signal processing labs to develop algorithms for automatic generation of bird and mammal counts.

SEADATA - GANTT CHART

Report Span: 03/15/94 To 10/15/94

Project Start: 04/01/94 Run Date: 04/01/94

Activity Name	Dur	Act Type	Pref Start	Pref Finish
proposal	131.000	S	04/01/94	09/30/94
field data common.	66.000	N	04/01/94	07/01/94
first buoy	0.000	N	06/15/94	06/15/94
data management	131.000	S	04/01/94	09/30/94
coordination	27.000	N	04/01/94	05/09/94
approach finalized	0.000	N	05/09/94	05/09/94
data services	125.000	S	04/11/94	09/30/94
flat file database	75.000	N	04/11/94	07/22/94
spec & RFP	0.000	N	04/25/94	04/25/94
delivery	0.000	N	05/10/94	05/10/94
data ingestion	120.000	N	04/18/94	09/30/94
ingestion plan	8.000	N	05/09/94	05/05/94
ingestion system	0.000	N	06/14/94	06/14/94
mass storage	36.000	N	05/30/94	07/18/94
requirements	0.000	N	06/14/94	06/14/94
delivered	0.000	N	07/06/94	07/06/94
quality control	75.000	N	06/14/94	09/30/94
relational database	24.000	N	06/29/94	08/01/94
selected & ordered	0.000	N	07/22/94	07/22/94
security plan	65.000	N	07/04/94	09/30/94
implemented	0.000	N	08/12/94	08/12/94
site access	67.000	N	04/01/94	07/04/94
internet: connected	0.000	N	05/18/94	05/18/94
local area network: stage 1	0.000	N	07/04/94	07/04/94
remote sensing data	131.000	N	04/01/94	09/30/94
remote sources	109.000	N	05/03/94	09/30/94
historical	44.000	N	07/18/94	09/15/94
data tools	51.000	N	07/22/94	09/30/94
descriptive mdl	79.000	S	06/14/94	09/30/94
visualization	53.000	N	06/14/94	08/23/94
see basics	0.000	N	07/08/94	07/08/94
see all	0.000	N	08/15/94	08/15/94
adaptive sampling	77.000	N	06/16/94	09/30/94
numerical mdls	81.000	S	06/02/94	09/22/94
subsystem identification	44.000	N	07/25/94	09/21/94
ocean circ. mdls.	49.000	N	07/18/94	09/22/94
implement. plan complete	0.000	N	08/15/94	08/15/94
stage one complete	0.000	N	09/15/94	09/15/94
phys-biol mdls.	29.000	N	06/24/94	08/03/94
implement. plan complete	0.000	N	07/01/94	07/01/94
simulations from data	0.000	N	08/01/94	08/01/94
nekton mdls.	77.000	N	06/02/94	09/16/94
dispersion trial mdls.	0.000	N	08/01/94	08/01/94
numeric. meth. & sim.	0.000	N	09/01/94	09/01/94
sampling technol.	109.000	S	04/01/94	08/31/94
depth shuttling	61.000	N	04/01/94	06/24/94
delivered	0.000	N	06/07/94	06/07/94
trials complete	0.000	N	06/14/94	06/14/94
opt	53.000	N	04/13/94	06/24/94
calibrated	0.000	N	05/09/94	05/09/94
integrated with shuttle	0.000	N	05/23/94	05/23/94
ocean buoy	31.000	N	04/25/94	06/07/94
delivery and deploy	0.000	N	06/02/94	06/02/94
acous. tomography	54.000	N	06/17/94	08/31/94
recommendations	0.000	N	08/31/94	08/31/94
sensor trials	5.000	N	04/01/94	04/07/94



E. EXISTING AGENCY PROGRAMS

Not applicable

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The activities to be performed in SEADATA are in no known ways similar to, or precursors for, activities with known or suspected environmental impact. SEADATA should qualify for a categorical exclusion from the requirements of the National Environmental Policy Act.

G. PERFORMANCE MONITORING

SEADATA has two roles within SEA:
(1) the generation of ecosystem information from project data and
(2) the implementation of the functionality to generate that information.

The review and oversight of the first role is at the level of the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG) and its Scientific Committee. In the first role, SEADATA supports, facilitates, and coordinates all of the SEA projects. Consequently the review is of the collective functioning of SEA. The second role is more technology specific. The review here is at the level of the Prince William Sound Science Center and the subgroup of the Scientific Committee participating in modelling and data systems resource development.

The SEADATA milestones are in many cases tangible enhancements to SEA for investigators, users, and sponsors. Wherever possible, the project has been organized to deliver resources and results in increments with immediate utility to SEA. This provides both the project manager and the project reviewers readily visible milestones with operational significance.

The project leader is Dr. Vincent Patrick. In the event of his inability to fulfill these duties the responsibility for the overall project will be assumed by Dr. Gary. L. Thomas. The responsibility for each subproject will be assumed by the technical lead for that subproject as indicated in the Section C.

The project plan was developed with the aid of project management software, and these management aids will be used in managing and tracking the project. Software that is X11 compatible will be used so that project accomplishments, schedules, slippage, changes, and summary charts can be reviewed at any time by any participant using the Internet.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

SEADATA is an integrated effort in terms of its goals and objectives and in terms of its methods. The goals and objectives described in this project plan are the result of seven months of close collaboration with the members of the region served by the study, with the on-site resource managers, with scientists based in the community, with scientists from the University of Alaska, and with administrators responsible for the oversight of the restoration resources. The goals and objectives here were developed in the same crucible as the goals and objectives of the field study projects of SEA. Quite early in this process the goals for SEADATA were set: (1) to develop numerical models with predictive capabilities, and (2) to pursue an approach that would as quickly as possible add guidance and direction to field sampling strategies. SEADATA was planned alongside and along with ADF&G and UAF plans for SEA projects and for SEA related projects.

SEADATA is coordinated with terrestrial data and modelling efforts conducted by the Oil Spill Recovery Institute and the Hazardous Substance Spill Technology Review Council.

By design SEADATA applies cross-disciplinary methods and technology to fulfill its functional mission in SEA. The SEADATA plan provides for the coordinated application of expertise and technology from six institutions in North America. The methods and technologies, the collaborators, and the plan itself are shaped by six years experience with interdisciplinary collaborations and technology transfers supporting marine and Great Lakes studies.

In drawing from a broad interdisciplinary basis the plan incorporates tools and resources that are commonplace in one discipline but that are new in another. The plan incorporates a "show me" attitude and by design incrementally introduces new capabilities. These new capabilities will be available to all networked SEA investigators, users, and administrators.

Much effort has been expended in acquiring cost sharing opportunities for SEA. In July a proposal was submitted to NSF for assistance with wide area network costs. This effort depends upon the integration of the SEA wide area communications with that of the Cordova Branch of the Community College. That effort will go forward following the startup of SEADATA. In another effort SEADATA is administering the introduction of optical plankton counter (OPC) technology in the SEA field study. For FY94 the OPC will be on loan from ADF&G Soldotna.

I. PUBLIC PROCESS

The SEADATA project plan was formulated during the last half of 1993 as one component of the PWSFERPG process. The project plan is the result of that process. During the fall of 1993 SEADATA approaches and technologies were presented in the public meeting forum of PWSFERPG. The approaches and technologies were illustrated through the use of scientific visualizations of data from the Great Lakes and from the Chesapeake Bay. Following that introduction the approaches and technologies were integrated into the SEA planning process.

During January, 1994, the methods and technologies of SEADATA were presented to the Cordova Aquatic Marketing Association (CAMA). Scientific visualizations of six fisheries ecosystems were presented: Chesapeake Bay blue crab; Chesapeake Bay anchovy; Lake Ontario alewife and zooplankton; Coghill Lake salmon; and Prince William Sound overwintering Pacific herring. These visualizations were used to describe the objectives of

SEA and the role of SEADATA in delivering an integrated, near real-time view of the Prince William Sound ecosystem. A video- taped demonstration of the ECMOP graphical interface was shown. In that video, the developer, James Corbin of the Center for Air and Sea Technology, Stennis, MS, described the use of the interface and demonstrated its use with time series animations of Gulf of Mexico sea surface data. As described in Section C, an FY94 goal of SEADATA is the implementation of a pelagic version of ECMOP for Prince William Sound.

During FY94 CAMA and Prince William Sound Aquaculture Corporation (PWSAC) will be the first of the community sites to be connected to the SEA local area network. The plan is to provide both CAMA and PWSAC with X-terminal displays. With these they can display and query all of the SEADATA products, including 3-dimensional visualizations and animations of the river-lake processes, near-shore fish distributions and dispersion, ocean currents at the surface and at depth at Hinchinbrook Entrance, and the distribution of juvenile salmon and their predators. These will be available to any of the SEA community with Internet access. For example, the SEADATA products will be accessible by SEA users from a graphics display terminal at UA- Anchorage and UA-Fairbanks.

J. PERSONNEL QUALIFICATIONS

This project will be conducted by an expert staff from academic, management and industry sectors. These experts will be recruited by the Prince William Sound Science Center through broad area and directed advertisement. The Science Center is an equal opportunity employer.

Project Leader: Vincent Patrick, Ph.D.

Education:
1967 B.A. Physics Thiel College, Greenville, Pennsylvania
1982 M.A. Mathematics University of Maryland, College Park.
1987 Ph.D. Mathematics University of Maryland, College Park.

Professional Experience:
ACADEMIC
Research Associate, Institute for Systems Research, University of Maryland 1993-present
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1992-1993
New UNIX installation; visualization; Chesapeake Bay blue crab survey.
Research Associate, Advanced Visualization Lab, University of Maryland 1991-1992
Start-up and first year operations of the U. of Maryland Advanced Visualization Lab.
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1990-1991
Computer systems administrator (acting); new UNIX system and LAN.
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland,1988-1991
Underwater acoustics; introduce visualization.
NON-PROFIT
Affiliate Scientist, Prince William Sound Science Center, Cordova, Alaska, 1993-present

INDUSTRY
Senior Engineer, AIMS, Inc., Rockville, Maryland 1991-1992
GOVERNMENT
Physicist, Center for Night Vision & Electo-Optics, U.S. Army ECOM, Ft. Belvoir, VA
1982-1986 Advanced Modelling Team 1968-1982 Image Intensifier Technology Team

Selected Publications:
D. M. Mason and E. V. Patrick. 1993. A model for the space-time dependence of feeding for pelagic fish populations. Trans. Am. Fisheries Soc. 122(5):884-901.

B. J. Rothschild and E. V. Patrick. 1993. Generation of a phytoplankton maximum in a grazing-extended logistic model, Fisheries Oceanography 2(3/4):223-230.

S. B. Brandt, D. M. Mason and E. V. Patrick. 1992. Spatially explicit models of fish growth rate. Fisheries 17(2):23-35. (includes journal cover)

C. A. Berenstein and E. V. Patrick. 1992. Exact deconvolution for multiple convolution operators-an overview, plus performance characterizations for imaging sensors. Proceedings of the IEEE, Special Issue on Multidimensional Signal Processing 78:723-734.

S.B. Brandt, D.M. Mason, E.V. Patrick, R.L. Argyle, L. Wells, P. Unger and D.J.Stewart. 1990. Acoustic measures of the abundance and size of pelagic planktivores in lake michigan. Canadian Journal of Fisheries and Aquatic Sciences 48:894-908.

Patents:
Eight patents in the fields of image intensifiers and ultrahigh vacuum processing

Memberships:
American Mathematical Society
Society for Industrial and Applied Mathematics

1. Project Staff: Ravi Kulkarni

Education:
1980, M.S. Electrical Engineering, University of Maryland

Professional Experience:
President, Grafikon, Ltd., a small consulting firm specializing in advanced scientific visualization, scientific data management, and discipline-specific graphical user interfaces.

Current activities:
NASA grant to develop a distributed database consisting of heterogenous data centers, the Small Bodies Node (SBN) of the Planetary Data System (PDS/JPL), and the Advanced Visualization Laboratory (AVL) of the University of Maryland.

Ravi Kulkarni has contributed frequently to the definition and implementation of data standards at NASA. In joint work with NASA he has evaluated scientific data formats (including HDF, CDF, and NetCDF) for suitability for NASA missions (e.g. ISTP). He designed the current generation Common Data Format (CDF) software for NASA/NSSDC. He has participated in numerous workshops and conferences on data management and visualization, including the NASA Office of Standards (NOST) data formats workshop, and as a panel member at Visual- ization 93. He is a co-developer of the International Halley Watch (IHW) archive for SBN, and he developed the IHW graphical user interface that combined rapid search with a "quick look" graphical view of the data.

With the AVL he is integrating advanced visualization tools (AVS, IBM Data Explorer) into NASA's mission planning and data archives at the National Space Science Data Center (NSSDC) and with Science Planning and Operations Facility (SPOF) of the International Solar Terrestrial Program (ISTP). He is especially interested in the comparison and assimilation of model/simulation based data with observational data from remote/insitu satellites. He is a member of the American Geophysical Union.

2. Project staff: Edward H. Jin

Education:
1983, Bachelor of Science (Honors) Zoology, University of Toronto.
Area of concentration: Limnology, environmental ecology. Undergraduate Thesis: "Effects of prey composition on the feeding of Chaoborus flavicans larvae." Supervisor: Dr. W. Gary Sprules.

Professional and Teaching Experience:
Research Assistant(Freshwater Ecology), Dept. Zoology, University of Toronto, 1984-present.
Guest Lecturer and field instructor in Limnology. Lectured on zooplankton ecology in a senior limnology course as well as providing demonstrations and instructions on field techniques.
1986,87,90 - Teaching Assistant, University of Toronto. Directed and lectured in an introductory ecology laboratory.

Selected Publications and Presentations:
Jin, E.H., D.M. Mason, W.G. Sprules and A.P. Goyke. 1993. A comparison of zooplankton community structure between Lakes Michigan and Ontario: Implications of planktivory. Can. J. Fish Aquat. Sci.(submitted)

Sprules, W.G., S.B. Brandt, D.J. Stewart, M. Munawar, E.H. Jin, and J. Love. 1991. Biomass size spectrum of the Lake Michigan pelagic food web. Can. J. Fish Aquat. Sci. 48(1):105- 115.

Jin, E.H. and W.G. Sprules. 1990. Distribution and abundance of Bythotrephes ceder-stroemii (Cladocera: Cercopagidae) in the St. Lawrence Great Lakes. Verh. Internat. Verein. Limnol. 24:383-385.

Sprules, W.G. and E.H. Jin. 1990. Composition and size structure of zooplankton communities in the St. Lawrence Great Lakes. Verh. Internat. Verein. Limnol. 24:378-382.

Sprules, W.G., H.P. Riessen and E.H. Jin. 1990. Dynamics of the Bythotrephes invasion of the St. Lawrence Great Lakes. J. Great Lakes Res. 16(3):346-351.

Sprules, W.G., M. Munawar and E.H. Jin. 1988. Plankton community structure and size spectra in the Georgian Bay and North Channel ecosystems. Hydrobiologia 163:135-140.

Jin, E.H. and W.G. Sprules. 1988. Effects of prey composition on the feeding of Chaoborus flavicans larvae. Verh. Internat. Verein. Limnol. 23:2165-2169.

Zimmerman, A.P., I. Creed, E.H. Jin, S. Smith, L. Warren, and L. Wong. 1986. Limnological survey of Grenadier Pond and Catfish Pond in High Park, Toronto. Report to the Ministry of the Environment, Ontario, Canada.

Jin, E.H., W.G. Sprules and J.D. Stockwell. 1994. Zooplankton assessment in the Great Lakes - Calibration of an optical plankton counter. Ocean Sciences Meeting, San Diego, USA.

Memberships:
Society of International Limnologists
American Society of Limnology and Oceanography
International Association of Great Lakes Research
Partner, LIMNOTECH (an aquatic equipment company)

3. Project staff: Doran M. Mason, Ph.D.
Center for Limnology University of Wisconsin, Madison,Wisconsin

Education:
1983, B.S. Michigan State University, East Lansing (Fisheries and Wildlife)
M.S. State University of New York, College of Environmental Science
1994, Ph.D. University of Maryland, College Park - Marine Estuarine Environmental Studies

Professional Experience:
Chesapeake Biological Laboratory, University of Maryland, Solomons, Maryland, Graduate Research Assistant, January 1989 - February 1994
Chesapeake Biological Laboratory, University of Maryland, Solomons, Maryland, Faculty Research Assistant, March 1987 - January 1989
State University of New York College of Environmental Science and Forestry Syracuse, New York, Graduate Research Assistant, June 1984 - March 1987

Publications:
Mason, D.M., and S.B. Brandt. Submitted. Spatially-explicit models of fish growth rate: the role of spatial scale, foraging efficiency, and predator behavior. Environmental Biology of Fishes.

Mason, D.M., A. Goyke, and S.B. Brandt. Submitted. A spatially-explicit bioenergetics measure of environmental quality for salmonines: a comparison between Lakes Michigan and Ontario. Canadian Journal of Fisheries and Aquatic Sciences.

Goyke, A., S.B. Brandt, and D.M. Mason,. Submitted. Distribution, abundance, and size structure of pelagic planktivores in Lakes Michigan and Ontario. Canadian Journal of Fisheries and Aquatic Sciences.

Brandt, S.B., and D.M. Mason. In Press. Landscape approaches for assessing spatial patterns in fish foraging and growth. Proceedings of the Gutworkshop 1992.

Mason, D.M., and P.V. Patrick. 1993. A model for the space-time dependence of feeding for pelagic fish populations. Transactions of the American Fisheries Society 122(5):884-901.

Garcia-Moliner, G., D.M. Mason, C.H. Greene, A. Lobo, B. Li, J. Wu, and G. Bradshaw. 1993. Description and analysis of spatial patterns. In: S.A. Levin, J. Steele, and T. Powell (eds.), Patch dynamics in terrestrial, marine and freshwater ecosystems. Biomathematics Series, Springer-Verlag, New York.

Brandt, S.B., D.M. Mason, and E.V. Patrick. 1992. Spatially-explicit models of fish growth rate. Fisheries 17(2): 23-35.

Brandt, S.B., D.M. Mason, E.V. Patrick, R.L. Argyle, L. Wells, P.A. Unger, and D.J. Stewart. 1991. Acoustic measures of abundance and size of pelagic planktivores in Lake Michigan. Canadian Journal of Fisheries and Aquatic Science 48(5): 894-908.

Brandt, S.B., D.M. Mason, D.B. MacNeill, T. Coates, and J.E. Gannon. 1987. Predation by alewives on larvae of yellow perch in Lake Ontario. Transactions of the American Fisheries Society 116(4): 641-645.

Memberships:
American Fisheries Society
Computer Section of the American Fisheries Society
Ecological Society of America
International Association of Great Lakes Research

4. Project staff: Carlos A. Berenstein, Ph.D.

Education:
1970, Ph.D., New York University

Professional Experience:
B.Pierce Asst. Professor, Harvard University, 1970-73
Asst Professor, University of Maryland, 1973-75
Assoc. Professor, Brandeis University, 1975-76
Assoc. Professor, University of Maryland, 1976-80
Professor, University of Maryland, 1980-present
Director, Center for Applied Mathematics, GMU, 1990-91
Visiting Professor, Paris, Orsay, Pisa, Bordeaux
Editor: Publications Matematiques, Multidimensional Systems & Signal Processing
Managing Editor: J. Fourier Analysis Applications

In the area of tomography specifically:

Taught a two semester course at the Univ. of Maryland, 1992,
Invited to several special meetings AMS, Oberwolfach, SIAM,
Member of the organizing Committee of a special session on wavelets in bioengineering, IEEE annual meeting in Nov 1994.
Boeing Lecture at Wichita St. U. on tomography/electrical impedance tomography.

Selected Publications:
Author/Editor: 9 books
About 120 papers

Inversion formulas for the k-dimensional Radon transform in real hyperbolic spaces,, with E. Casadio"Tarabusi, Duke Math. J. 62 (1991), 613-632.

Computerized tomographic imaging for space plasma physics,, with M. Coplan et al., J. Applied Physics 68 (1990), 5883-5889.

Range of the k-dimensional Radon transform in real hyperbolic spaces,, with E. Casadio "Tarabusi, to appear in Forum Math.

On the Radon and Riesz transforms in real hyperbolic spaces,, with E. Casadio"Tarabusi, Contemp. Math. 140 (1992), 1-21, E. L. Grinberg (ed.), Amer. Math. Soc., Providence.

Computer Assisted Tomography Applied to Plasma Electron Distribution Functions,, with Li et al., SRC TR-92-38.

Local inversion of the Radon transform in even dimensions using wavelets,, with D. Walnut, to appear in the proc. of the Vienna conference "75 Years of Radon Transform".

The inverse conductivity problem and the hyperbolic X-ray transform,, with E. Casadio "Tarabusi, to appear in the proc. of the Vienna conference "75 Years of Radon Transform'.

5. Project staff: James M. Kirsch

Education:
1991, B.S., Electrical Engineering, State University of New York at Binghamton, T.J. Watson School -- Concentrations: Signal Processing, Computer Architecture and Programming, Acoustics, Communications, MIDI
Design Projects: Electro-acoustical notch Filter TMS320-based DSP Microcomputer
New York State Licensed Intern Engineer

Professional Experience:
Faculty Research Assistant, 12/91 - present, Chesapeake Biological Laboratory, University of Maryland, Solomons, Maryland

Create software to process bioacoustical, geographical and physical data. Generate algorithms for calibration, interpolation and visualization. Operate sonar and plan scientific cruises.Investigate and implement new hardware/software technologies. Train biologists and technicians in computer and sonar use.

Software Systems Engineer 9/90 - 12/91 General Electric Westover, NY
Generate testdatabases, software, and documentation for aircraft flight control computers. Assist senior engineers in the development of autopilot actuator systems.

Sound Engineer 8/87-7/91 Music Department SUNY Binghamton

Selected Publications and Presentations:

Brandt, S.B., and J. Kirsch. 1993. Spatially-explicit models of striped bass growth in the mid-Chesapeake Bay. Transactions of the American Fisheries Society. In press.

Kirsch, J. 1992. Multifrequency Acoustic Visualization And Information Retrieval (MAVAIR) System. Annual meeting of the Acoustical Society of America, New Orleans, LA.

Memberships:

Acoustical Society of America, 1991-Present

K. BUDGET

Budget for SEA-DATA Program

Line Item	FY94	FY95
Personnel	184.3	175.7
Travel	27.9	23.4
Contractual	6.3	86.8
Commodities	2.1	10.9
Equipment	260.0*	198.6
Total	480.6	495.4
Indirect costs**	53.0	71.2
PWSSC portion	533.6	566.6
UAF portion***	119.5	tbd
Total PWSSC & UAF	653.1	tbd
NBS portion****	32.4	tbd
Grand Total	685.5	635.69

* Indirect costs = 24% of total direct costs less equipment; $62,400 in indirect costs on equipment is waived contingent on ownership of equipment remaining with the Prince William Sound Science Center.

** Total overhead or General administration costs are 10% ($53,000/$533,600 = 10%).

*** See attached "Form 3A-B" budget sheets for details of the Science Center and UAF FY 94 budgets.

**** Appropriated directly to NBS by Trustee Council; see attachment to "Form 3A-B" for budget details.

*(5-page document titled
"The requirements and plans for Internet connectivity in the SEA program")*

The requirements and plans for Internet connectivity in the SEA program

February 16, 1994

SUMMARY

Contemporary capabilities for the communication of data and multimedia information play fundamental roles in the SEA program. One of these capabilities is the Internet, something that in recent months has been referred to as the "national information superhighway". The Internet is now over twenty years old and is a familiar tool throughout the science and engineering communities. The name Internet collectively refers to the physical network, to the communications capabilities of that network, and to the vast array of data and information resources mounted on that network. This collection of capabilities is particularly essential to "large" science and technology projects—that is, to projects involving a large number of investigators, large spatial scales, long time intervals, or large data sets. The SEA program is in this sense a large program. Specifically, in the SEA program the objectives, the collaborations, the interdisciplinary structure and its coordination, the cost efficiencies of shared and distributed data and computer resources, and the distribution of end products all very much depend upon the Internet.

This note describes

- those areas of SEA that depend upon Internet access,
- the existing Internet access,
- the implementation plan for upgraded access,
- costs for the upgrade,
- the status of a proposal to NSF for partial support of an upgrade that includes the Cordova Branch of the Prince William Sound Community College.

The requirements and plans for Internet connectivity in the SEA program

Areas of SEA dependent upon access to the Internet

SEA has the following communications requirements:

- The SEA program involves a large number of investigators from a variety of home institutions working in collaboration and with large data sets. Each investigator requires access to SEA data and SEA results, both current and historical, regardless of physical location of either the investigator or the data.
- SEA data sources include the SEA field survey projects, a variety of satellites, and meteorological data centers. SEA data products include ecosystem descriptions based upon the reduction and integration of the data, model based refinements of these ecosystem descriptions, and short term forecasts. During the sampling season these data products are required in near real-time for use in model assisted adaptive sampling strategies. Similar data products are basic deliverables of SEA and are to be communicated in a variety of formats to the regional community and to receiving sites designated by the Trustee Council Executive Director and the Chief Scientist.
- The effective administration and coordination of SEA depends upon similar communication capabilities. In particular, collaborators within SEA must be able to communicate in a conference mode wherein SEA data and results can be interactively communicated along with voice and video.

There are a variety of approaches to meeting these requirements. These approaches utilize the Internet in ways that are now routine. The issues discussed here are not the specifics of the approaches but rather

- the speed (or bandwidth) of the Internet connection needed to meet these requirements
- the timing for the implementation of that connection.

- **speed**

A typical data set in SEA for a single sensor will range in size from 100 kilobytes (100KB) to 10 megabytes (10MB). For example, a single AVHRR sea surface temperature image, in its most reduced form and clipped to cover only the geographic region of interest, is, after compression, from .5MB to 1MB and larger. A processed data set from a one hour acoustic transect for a single transducer is of a similar size, with 10MB not uncommon in cases of high fish abundance. Time series data sets from single sensors are smaller, but a moored sensor pack can consist of multiple thermistors and a number of other sensors each generating time series.

These sizes must then be viewed in terms of the numbers of sensors. At the minimum we are planning for one usable (sufficiently cloud free composite) AVHRR image and one usable SeaWIFS image every other day. The SEA field survey will involve three vessels, each with at least one acoustic sensor generating from 14 to 20 hours of data each day. One vessel will deploy along with the acoustic sensors an undulating towed vehicle carrying a CTD, fluorimeter, and an optical plankton counter. One vessel will also deploy an acoustic Doppler profiler. There is also the continuous time series data from at least one CFOS buoy, several custom sensor packages deployed at U. S. Coast Guard buoys, drifters, and a bottom tethered Doppler profiler.

Table 1 The time to transfer a 10 megabyte file assuming 100% efficiency. The speeds of 256, 384, 512, and 1536 correspond to the multiples 4, 6, 8, and 24 respectively of 64Kbs, but for data the actual transfer rates are these multiples of 56Kbs; these latter rates are used for the time interval calculations.

speed in kilobits per second	theoretical time for 10 megabyte file transfer
1.2	18.5 hrs
19.2	1.2 hrs
24	56 min
56	24 min
256	6 min
384	4 min
512	3 min
1536	1 min

A conservative estimate is that for each day a highly processed and compressed data set containing synoptic information on multiple trophic levels and the physical environment is at least 10MB.

Internet connectivity is available at a wide range of speeds. At the very low end is the 1200 bits per second available with low cost modems. At the higher end is T1 service at 1.5 megabits per second (1.5Mbs). A source of confusion is the fact that telecommunication line speeds are typically given in bits per second, whereas computer data is typically expressed in bytes, with 8 bits per byte. Consequently T1 service at 1.5Mbs is roughly only 0.2 megabytes per second (MBs). Table 1 shows the theoretical time required to transfer 10MB for a variety of connection speeds. These times are never realized. A practical guide is to expect two to three times the time interval shown.

Based upon the foregoing and Table 1 a minimum speed is 256Kbs. This speed is also sufficient for Internet video or audio conferencing. It is also adequate for the use of currently available "chalkboard" conferencing software, such as ShowMe and X/Telescreen, wherein participants view the same display on each monitor connected to the conference. Any participant can modify the display and each participant then sees his display correspondingly modified. These factors are discussed later in conjunction with factors affecting the implementation plan.

- **timing**

The factors affecting the timing for initiating the effort to bring the required upgraded connection on-line are

- the cost advantages of fully exploiting all available information resources in the design, the adaptation, and the execution of the field survey,
- the communication of near real-time satellite imagery from UAF and the accessibility of SEA data for analysis,
- lead time.

• cost advantages

As discussed below, high speed communications costs are on the order of a few thousand dollars per month whereas field survey costs are a few hundred thousand dollars per month. The relative costs of the communications are small compared to the role they play in providing near real-time data that can be used to more optimally direct the field survey efforts.

• data

SEA is collaborating with the Geophysical Institute at UAF for AVHRR and SeaWIFS data. Through that collaboration SEA has cost effective access to a downlink site and to rapid, on-site data reduction. The Internet connection provides the means by which reduced data can be made immediately available in Cordova and to SEA investigators. Although SeaWIFS will not be launched until the late summer, AVHRR images will be available at the commencement of SEA. Until the high speed communications are available the data will have to be mailed or transferred using a high speed modem and direct dial long distance. The latter approach will involve at least a half hour of attended data transfer for each image. The situation regarding getting data out of Cordova will be similarly limited. The lack of a high speed line all but eliminates the involvement of collaborators that are not physically located in Cordova. It similarly precludes the use of available off-site high speed computing resources, such as the Supercomputing facility in Fairbanks

• lead time

The time to implement the communications is three to five weeks.

Existing access to the Internet

The Internet can now be reached from Cordova by

- modem and local direct dial to a bank of 1200bps dedicated lines connecting the Cordova Branch of the Prince William Sound Community College and the University of Alaska Computing Network (UACN).
- modem and long distance direct dial to 9600bps modems at UAF.

Neither the Prince William Sound Science Center nor the Cordova Branch of the Community College can be reached from the Internet.

Plan for implementation

Access to the Internet at speeds of 56kbs and greater requires

- a leased Digital Data Service (DDS) line from Cordova to a site providing access to the Internet, a so called Internet "point of presence",
- the interface hardware at both ends of the DDS line,
- "membership" fees for the organization providing the regional network infrastructure.

During July and August of 1993 a detailed implementation plan for a 256kbs connection was developed. This plan was the basis for a proposal to NSF for partial support under their Connection to the NSFNET program. That proposal is still active and its status is discussed below.

The regional provider serving Alaska is NorthWestNet. The University of Alaska is establishing and "aggregator" agreement with NorthWestNet whereby the University provides Internet access to

Alaska users through the University network. The University network extends from Fairbanks to the other campuses at a variety of bandwidths and from Fairbanks to Seattle at T1 (1.5Mbs) speed. The Fairbanks to Anchorage connection provides data transmission at 256kbs.

The implementation plan is to connect to the UA Computing Network in Anchorage, the site closest to Cordova providing 256kbs speed to both Fairbanks and to Seattle.

Costs

Table 2 shows the costs for two years. It separates the one-time first year charges from the reoccurring charges. The tariffs are quoted on a monthly basis, however the table shows the annual costs. The full two year costs are shown, for that is the period for any NSF contribution. The table also shows the first year costs for a shortened first year. The line charges shown are those that were in effect on October, 1993. The IXC charges have been confirmed, but the local channel charges have not. In addition, the membership rates shown are the full membership rate that would be imposed by NorthWestNet. A more accurate membership charge for SEA under the University aggregator agreement has been requested from the University but is not available at this time.

NSF support

In July 1993 a proposal was submitted by the Prince William Sound Science Center to NSF for partial support for access to the Internet under the NSF program "Connections to NSFNET". This proposal received a preliminary review and is being held. To proceed further with the proposal NSF has requested that we provide by early March

- evidence that the balance of the required funds for the two year period of the grant have been secured,
- a more complete description of the participation of the Cordova Branch of the Community College, to include,
  - the significance of the connection for the enhancement of instructional programs, including those programs unique to a remote site,
  - the manner in which the connection enhances faculty research and collaborations,
  - provisions for network support,
  - provisions for user support and instruction to ensure full utilization of the Internet resources by the College community,
  - and a commitment to assume the costs of maintaining the connection following the two years of NSF support.

We are completing work with Dean Fenili to submit a modified proposal addressing the requests from NSF. The NSF Program Officer handling this request is David A. Staudt, NSFNET Division, 703-306-1949. A successful proposal is expected to result in approximately $30,000 over the two year support period. Of this total $20,000 applies to items in Table 2 and $10,000 applies to items not shown that are specific to connections at the College.

Table 2 Two year cost summary. The totals do not reflect any possible contribution from NSF. *The information on membership charges is approximate and updated costs will be provided as soon as they become available.

LOC.	ITEM	COSTS non-recurring	year 1	year 2
	LEASED LINE			
	installation charge	$95		
Anchr-Cos	IXC Anchorage-Cordova 256Kbps $2400/mo.		$28,888	$28,888
Cordv	Local Channel: $534/mo	$476	$6,408	$6,408
Anchr	Local Channel: $800/mo (est)	$932	$9,600	$9,600
	Leased line SUBTOTAL	$1503	$44,896	$44,896
	HARDWARE			
	NorthWestNet Connection Service	$15,000		
Cordv	router and CSU/DSU			
Anchr	router and CSU/DSU			
	Hardware SUBTOTAL	$15,000		
	REGIONAL CARRIER			
	membership		$18,000*	$18,000*
	TOTAL	$16,503	$44,896	$44,896
	TOTAL excluding membership		$61,399	$44,896
	TOTAL including membership		$79,399	$62,896
	TOTAL incl membership, yr1@7mos		$60,677	$62,896

EXXON VALDE[illegible]STEE COUNCIL
1994 Federal Fisca[illegible]ear Project Budget
October 1, 1993 - September 30, 1994

Project Description:

Sound Ecosystem Assessment - An Ecosystem Study for Prince William Sound - Information Systems and Model Development (SEA-DATA); for FY94, there are five SEA-DATA projects: (1) Field data communications; (2) Data management; (3) Descriptive model; (4) Numerical models; (5) Sampling technologies.

Budget Category:	1994 Project No. Authorized FFY 94	'94 Report/ '95 Interim* FFY 94	Remaining Cost** FFY 95	Total FFY 95	FFY 96
Personnel	$ 184.3	$ 50.0	$125.7	$175.7	
Travel	$ 27.9	10.0	13.4	23.4	
Contractual	6.3	30.0	56.8	86.8	
Commodities	2.1	5.0	5.9	10.9	
Equipment	$ 260.0*	0	198.6	198.6	
Capital Outlay					
Subtotal	$ 480.6	95.0	400.4	495.4	
General Administration	53.0	22.8	48.4	71.2	
Project Total	$ 533.6**	$117.8	$448.8	$566.6*****	
Full-time Equivalents (FTE)					

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Project Manager $6771 /mo. for 3.0 mos.: $20.3K				
Technical Admin Assist $4008 /mo. for 4.0 mos.: $16.0K				
Communications Eng $4333 /mo. for 1.9 mos.: $8.4K				
Marine System Specialist $4550 /mo. for 1.5 mos.: $6.7K				
Data Systems Specialist $4333 /mo. for 3.0 mos.: $13.0K				
Computer Systems Admin $4333 /mo. for 6.0 mos.: $26.0K				
Telecom Eng $6717 /mo. for 0.2 mos.: $1.2K				
Sci Data Systems Eng $10400 /mo. for 1.0 mos.: $10.4K				
Interface Programmer $5417 /mo. for 1.0 mos.: $5.4K				
Interface Designer $7392 /mo. for 0.2 mos.: $1.7K				
Personnel budget continues at right in Comment section				
Personnel Total				

Comment

* $62,400 of indirect costs are waived on equipment based upon ownership residing with PWSSC

** SEADATA 1994 Project Budget
PWSSC portion, $533,600
UAF portions, $119,500***
NBS portion, $32,400****
SEADATA Total, $653,100

*** see attached page for detailed UAF SEADATA budget

**** appropriated directly to NBS by Trustee Council

***** Total costs for SEADATA in 95 with UAF and NBS portions are estimated at $635,690.

(Personnel cont. from left col.)

Applied Math_1 $6771 /mo. for 1.5 mos.: $10.2K
Sci Data Analyst $4333 /mo. for 3.0 mos.: $13.0K
Fish Ecologist_1 $5417 /mo. for 1.9 mos.: $10.5K
Applied Math_2 $6771 /mo. for 2.0 mos.: $13.5K
Numerical Analyst $7583 /mo. for 1.0 mos.: $7.6K
Fish Oceanographer_1 $7367 /mo. for 0.4 mos.: $2.7K
OPC Specialist $5200 /mo. for 2.0 mos.: $10.6K
Tomography Specialist $11917 /mo. for 0.4 mos.: $4.8K
Ecologist $4550 /mo. for [illegible] mos.: $[illegible]K

NEPA Cost:

*Oct 1, 1994 - Jan 31, 1995
**Feb 1, 1995 - Sep 30, 1995

07/14/93

1994

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Project Number: 94320
Project Title: Sound Ecosystem Assessment
Sub-Project: Information Systems and Model Development (SEA-DATA)
Agency: Prince William Sound Science Center
%University of Alaska Fairbanks

FORM 3A
SUB-PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL

1994 Federal Fiscal Year Project Budget

October 1, 1993 - September 30, 1994

	Reprt/Intrm	Remaining
Travel: 2 RT Cordova to Fairbanks $456 air fare ea., $140 per diem, $30/da car rental, 6 days: $10.2 3 RT Cordova to Anchorage $224 air fare ea., $170 per diem, $30/da car rental, 5 days: 2 RT Cordova to Washington DC $1100 air fare ea., 1 RT Cordova to Miami $1300 air fare ea., $97 per diem, $30/da car rental, 8 days: 1 RT Cordova to Norfolk VA $600 air fare ea., $102 per diem, $30/da car rental, 2 days: 1 RT Cordova to Stennis MS $1100 air fare ea., $82 per diem, $30/da car rental, 3 days: 1 RT Logan UT to Cordova $900 air fare ea., $103 per diem, 42 days: $5.2 1 RT Chicago to Cordova $900 air fare ea., $2.5 2 RT Cordova to Fairbanks $456 air fare ea., $140 per diem, $30/da car rental, 4 days: 1 RT Boulder to Cordova $900 air fare ea., $0.9 1 RT Washington DC to Cordova $1100 air fare ea., $103 per diem, 6 days: $1.7 1 RT Madison WI to Cordova $700 air fare ea., $103 per diem, 18 days: $2.6 1 RT Miami to Cordova $1200 air fare ea., $103 per diem, 5 days: $1.7 2 RT Toronto to Cordova $1200 air fare ea., $103 per diem, 7 days: $3.1 TOTAL travel: $27.9K		
Travel Total	$27.9K	
Contractual: Telephone, E-mail and facsimile $4.75K Mail, freight and shipping $1.00K Office equipment maintenance and repair $0.55K		
Contractual Total	$6.3K	

07/14/93

1994

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Project Number: 94320
Project Title: Sound Ecosystem Assessment
Sub-Project: Information Systems and Model Development (SEA-DATA)
Agency: Prince William Sound Science Center
%University of Alaska Fairbanks

FORM 3B
SUB-PROJECT
DETAIL

Commodities:	Reprt/Intrm	Remaining
Paper and office supplies $2.1 K		
Commodities Total	$2.1K	

Equipment:

Hardware and electronics for demonstration system for near-real time buoy and ship data telemetry

TOTAL		$30.0K

Data storage, management, and retrieval hardware:

workstation (server)	$20.0K	
X-terminal	$5.0K	
optical drive	$3.8K	
hard drive	$5.0K	
fast CDROM	$2.0K	
DAT tape drive	$2.0K	
media	$3.0K	
software	$10.0K	
UPS	$0.5K	
ann. maintenance	$2.0K	
TOTAL		$59.3K

Leased data line @256kbs, with hardware, network fees:

install	$1.7K	
hardware	$10.0K	
maintenance	$1.8K	
IXC	$20.2K	
local channel Cordova	$3.4K	
local channel Anchorage	$6.5K	
NWNET membership	$3.0K	
TOTAL		$46.7K

Community LAN hardware:

X11 for PCs, 5 pack	$2.0K	
hub	$2.0K	
cable, connectors	$0.5K	
UPS	$0.3K	
ethernet cards	$0.7K	
link (e.g., mcrwave)	$5.0K	
X-terminal	$4.0K	
pc router	$1.1K	
TOTAL		$15.8K

Descriptive model & visualization development hardware:

	workstation (server)	$20.0K	
	terminal	$5.0K	
	hard drive	$5.0K	
	media	$2.0K	
software	AVS	$12.0K	
	IDL	$5.0K	
	productivity items	$5.0K	
	project mgmnt	$1.5K	
	network conference	$3.0K	
hardcopy output	laser printer	$2.0K	
	UPS	$0.5K	
	TOTAL		$61.8K

Towed vehicle providing depth shuttling:

aquashuttle	$46.6K	
TOTAL		$46.6K

	Reprt/Intrm	Remaining
Equipment Total	$260.0K	

07/14/93

Project Number: 94320
Project Title: Sound Ecosystem Assessment
Sub-Project: Information Systems and Model Development (SEA-DATA)
Agency: Prince William Sound Science Center
%University of Alaska Fairbanks

FORM 3B
SUB-
PROJECT
DETAIL

BUDGET - SEADATA
ESLINGER
1 March - 30 September 1994

	Mos.		
SALARIES AND BENEFITS			
Eslinger, D.	2.00	$10,816	
Technician	4.50	$14,523	
Benefits		$8,901	
TOTAL SALARIES AND BENEFITS			$34,240
TRAVEL			$0
SERVICES			
Shipping (UPS)		$807	
Terrascan license		$6,000	
TOTAL SERVICES			$6,807
SUPPLIES			
Data charges		$5,833	
Tapes		$1,000	
TOTAL SUPPLIES			$6,833
EQUIPMENT			
Hard disks (5GB)		$5,000	
TOTAL EQUIPMENT			$5,000
TOTAL DIRECT COSTS			$52,880
INDIRECT COSTS (20% Total Project Costs)			$13,220
TOTAL FUNDING REQUIRED			$66,100

BUDGET - SEADATA
JOHNSON
1 April - 30 September 1994

SALARIES AND BENEFITS			
	Mos.		
Johnson, M.	1	$5,740	
Technician	3	$9,490	
M.S. Student	6	$7,279	
Benefits		$5,337	
TOTAL SALARIES AND BENEFITS			$27,846
SERVICES			
Clerical/Secretarial Support (Academic Services @$35/hr)		$3,990	
TOTAL SERVICES			$3,990
TRAVEL			$0
SUPPLIES			$0
EQUIPMENT			
UNIX Workstation		$6,000	
Printer		$2,400	
TOTAL EQUIPMENT			$8,400
TUITION			$2,500
TOTAL DIRECT COSTS			$42,736
INDIRECT COSTS (20% TOTAL PROJECT COSTS)			$10,684
TOTAL FUNDING REQUIRED			$53,420

NBS PORTION OF SEADATA
1 March - 30 September 1994

*NBS, Gary Drew

Scientist(s)	2.5 Mos.	$18,800	
Data, software		$10,000	
TOTAL COSTS NBS			$28,800

*Archived and distributed data for SEA: archived AVHRR and other data for use in the SEADATA descriptive model and data interface. NOTE: These funds are to be passed directly to National Biological Survey, U.S. Department of the Interior by the Trustee Council.