RECOMM.

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	SEA Program: Salmon Growth & Mortality
Project ID number:	94320-A
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:	$282.8 K (estimate; see detailed budget)
Cost of project/FY 95:	$326.5 K
Cost of Project/FY 96 and beyond:	$322.5 K
Project Start-up/Completion Dates:	March 1, 1994 - September 30, 1994
Geographic area of project:	Prince William Sound
Name of project manager:	Dr. Joseph R. 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.,

$$I_f = \frac{\gamma\, p\, U}{1 + \gamma\, p\, U\, h} \qquad (3)$$

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.

$$I_c = \frac{G + R}{A} \qquad (4)$$

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
<u>Track Migration & Growth</u>	
May 1 - June 30	Track migration and growth
July 6 - July 10	Sample juveniles exiting PWS
<u>Laboratory & Data Analyses</u>	
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
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Commercial Fisheries Management and Development Division
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(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
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(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	124.2	161.8	161.8
Travel	0.5	0.9	0.9
Contractual	114.3	114.3	114.3
Supplies	13.2	13.2	13.2
Equipment	4.0	4.0	0.0
Total	256.2	294.2	290.2
Indirect Costs	26.6	32.3	32.3
Grand Total	282.8	326.5	322.5

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

Project Description: Assessment of Juvenile Salmon Growth and Mortality in PWS- This projects objectives are to: 1) estimate the growth rate of juvenile salmon in PWS, 2) describe the migration of juvenile salmon though PWS, 3) estimate the diet composition of juvenile salmon in PWS, 4) determine the growth rate of juvenile salmon was limited by low food abundance in 1994, 5) test for differences in the relationship between juvenile salmon growth and fry-to-adult survival , and 6) develop techniques to estimate the mortality of juvenile salmon in PWS and the GOA.

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	$124.1	$124.1	$161.8	
Travel	$0.0	$0.0	$0.5	$0.5	$0.9	
Contractual	$0.0	$0.0	$95.0	$95.0	$114.3	
Commodities	$0.0	$0.0	$13.2	$13.2	$13.2	
Equipment	$0.0	$0.0	$4.0	$4.0	$4.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$236.8	$236.8	$294.2	
General Administration	$0.0	$0.0	$26.6	$26.6	$32.3	
Project Total	$0.0	$0.0	$263.4	$263.4	$326.5	
Full-time Equivalents (FTE)	0.0	0.0	1.9	1.9	0.8	
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
1 Program Manager			0.8	$5.4
1 Fishery Biologist III			3.0	$16.9
1 Fishery Biologist I			5.5	$35.2
4 Fish and Wildlife Technician II			8.5	$49.1
3 Fish and Wildlife Technician III			5.0	$17.5
Personnel Total	0.0	$0.0	22.8	$124.1

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: 94320 - A
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Growth
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

Travel:	Reprt/Intrm	Remaining
One round trip between Juneau and Cordova to have biometrician review data collection procedures in the field.		$0.4
Per diem for biometrician		$0.1
Travel Total	$0.0	$0.5

Contractual:	Reprt/Intrm	Remaining
Air charter flights to transport staff from Cordova to the vessel		$2.0
Charter for approximately 60' vessel to provide logistical support to track juvenile salmon migration		$93.0
Contractual Total	$0.0	$95.0

Project Number: 94320 - A
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Growth
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

Commodities:	**Reprt/Intrm**	**Remaining**
Office supplies		$1.8
Laboratory supplies		$4.9
Field sampling supplies (food, fuel, etc.)		$4.7
Utilities		$1.8
Commodities Total	$0.0	$13.2

Equipment:		
One small mesh purse seine to capture juvenile salmon in the nearshore areas.		$4.0
Equipment Total	$0.0	$4.0

Project Number: 94320 - A
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Growth
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

B

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:	94320B (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 (estimate; see detailed budget)
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 forecast 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 maxlmum 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 *i*th tag code (defined as number of tagged fish released with the *i*th tag code divided by the total number of fish in release group *i*),
x_i = number of tags of the *i*th 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 *i*th stratum,
N_i = total number of fish in *i*th stratum,
s_i = number of fish sampled from *i*th 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:

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

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:

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

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:

$$\hat{S}_t = \frac{\hat{C}_t + \hat{Cu}_t}{R_t} , \tag{5}$$

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:

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

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.

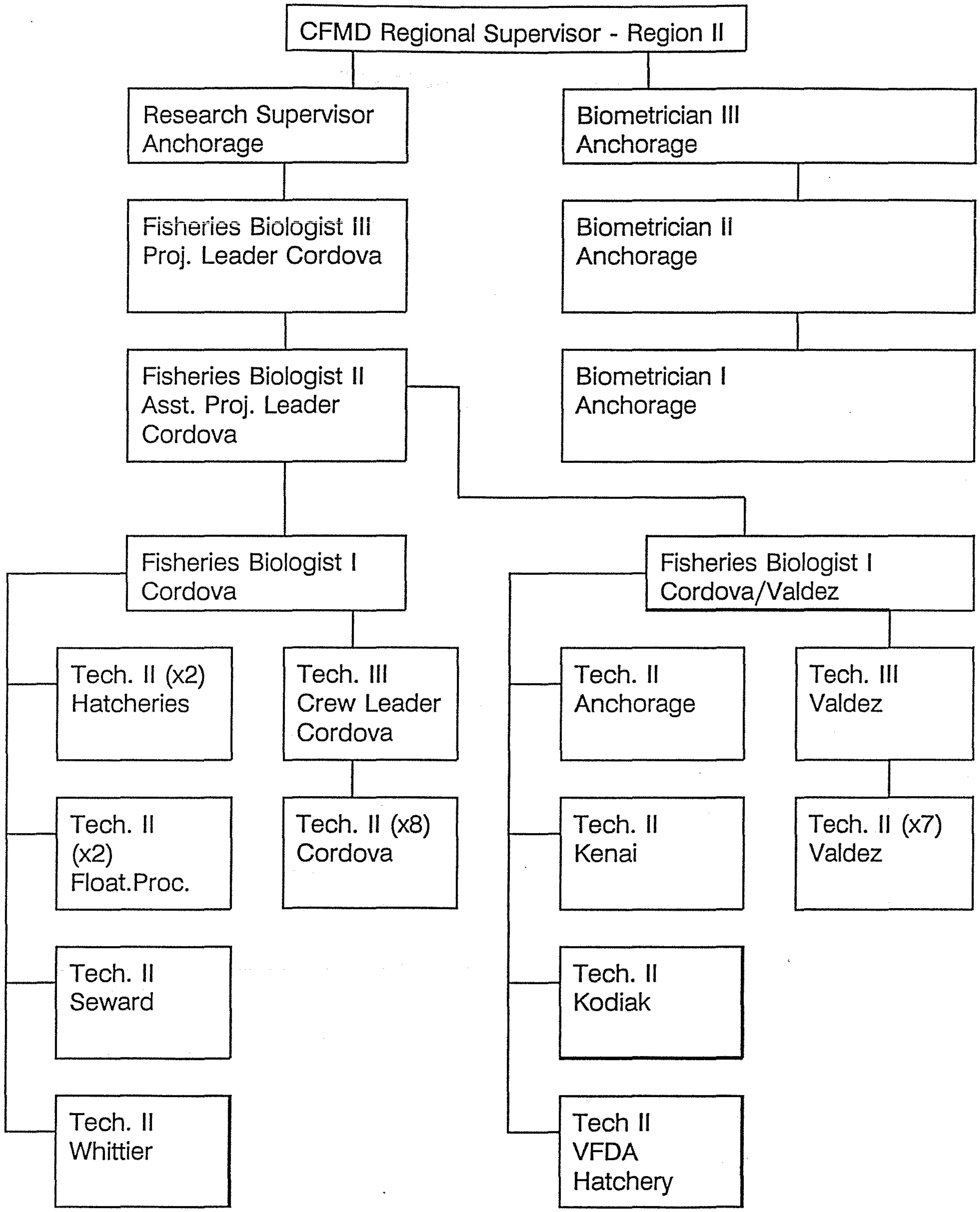

Figure 1. Organizational chart of project personnel and related ADF&G CFMD Region II supervisory and biometrics staff.

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)

LITERATURE CITED

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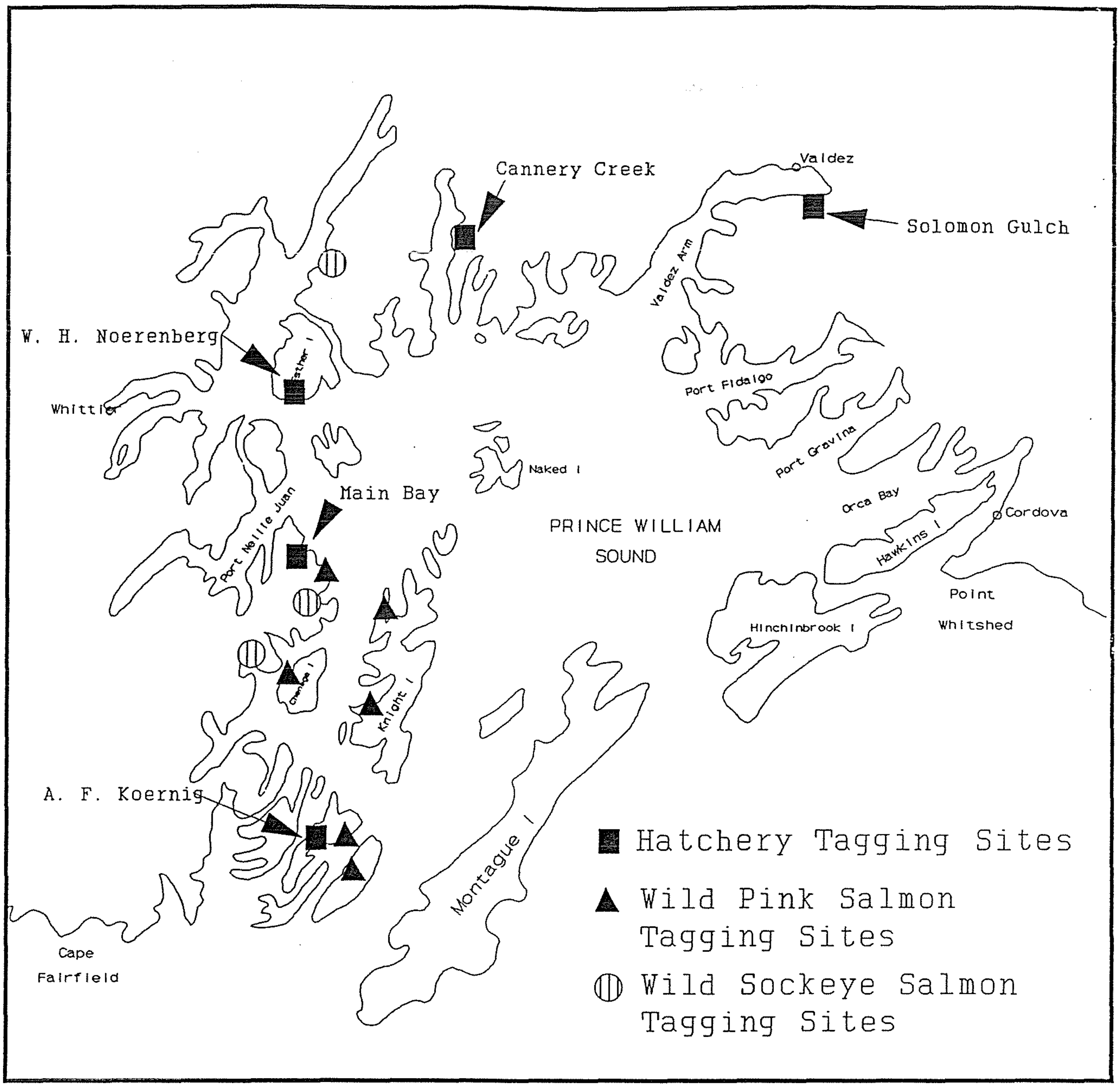

Attachment 1. Map showing the location of tagging sites for Hatchery and wild stocks of salmon which will contribute to adult returns in 1992.

EXXON VALDEZ TRUSTEE 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. . . . . Authorized FFY 93	'93 Report/ '94 Interim* FFY 94	Remaining Cost** FFY 94	Total FFY 94	FFY 95	Comment
Personnel	$0.0	$37.9	$125.2	$163.1	$172.5	
Travel	$0.0	$0.8	$11.8	$12.6	$12.6	
Contractual	$0.0	$3.2	$23.4	$26.6	$21.6	
Commodities	$0.0	$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	$0.0	$41.9	$175.1	$217.0	$217.0	
General Administration	$0.0	$5.9	$21.5	$27.4	$27.4	
Project Total	$0.0	$47.8	$196.6	$244.4	$244.4	
Full-time Equivalents (FTE)	0.0	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
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: Prince William Sound System Investigation
Sub-Project: Coded Wire Tag Recoveries From Pinks in PWS
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

Travel:	Reprt/Intrm	Remaining
Rept 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:		
Rept 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 maintenance		$1.0
Contractual Total	$3.2	$23.4

Project Number: 94320 - B
Project Title: Prince William Sound System Investigation
Sub-Project: Coded Wire Tag Recoveries From Pinks in PWS
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

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: Prince William Sound System Investigation
Sub-Project: Coded Wire Tag Recoveries From Pinks in PWS
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

C

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

Sharr, S., B. Bue, S.D. Moffitt, and A. Craig (1993a). Injury to salmon eggs and pre-emergent fry in Prince William Sound. Federal/State Natural Resources Damage Assessment Fish/Shellfish Study Number 2 Final Report, Alaska Department of Fish and Game, Cordova.

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Hettler, W.F. 1984. marking otoliths by immersion of marine fish larvae in tetracycline. Transactions of the American Fisheries Society 113:370-373.

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

Project Description: Otolith Tetracycline Mass Marking of Pink Salmon in PWS- This project tests the feasibility of chemically marking the otoliths of pink salmon by immersing newly emerged fry in a highly dilute solution of tetracycline. If feasible, this technology will be used to apply a unique mass mark to wild populations of pink salmon for estimates of survival and straying rates which are integral to the SEA research effort.

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	$23.1	$23.1	$19.7	
Travel	$0.0	$0.0	$0.6	$0.6	$0.6	
Contractual	$0.0	$0.0	$3.5	$3.5	$3.5	
Commodities	$0.0	$0.0	$10.4	$10.4	$10.4	
Equipment	$0.0	$0.0	$12.6	$12.6	$12.6	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$50.2	$50.2	$46.8	
General Administration	$0.0	$0.0	$3.7	$3.7	$3.2	
Project Total	$0.0	$0.0	$53.9	$53.9	$50.0	
Full-time Equivalents (FTE)	0.0	0.0	0.5	0.5	1.3	
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Fishery Biologist I	0.0	$0.0	1.0	$4.5
Fish and Wildlife Technician II	0.0	$0.0	0.2	$1.2
Fish and Wildlife Technician II (Tag lab)	0.0	$0.0	4.5	$14.0
Program Manager	0.0	$0.0	0.5	$3.4
Personnel Total	0.0	$0.0	6.2	$23.1

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: 94320 - C
Project Title: Prince William Sound System Investigation
Sub-Project: Otolith Marking - Inseason Stock Separation
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
One round trip Cordova/Juneau @ $400/trip		$0.4
Per diem 2 days @ $100/day		$0.2
Travel Total	$0.0	$0.6

Contractual:		
Air charter to hatcheries (5 trips @ $400/trip)		$2.0
Vessel Charter		$1.5
Contractual Total	$0.0	$3.5

07/14/93

1994

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Project Number: 94320 - C
Project Title: Prince William Sound System Investigation
Sub-Project: Otolith Marking - Inseason Stock Separation
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

Commodities:	Reprt/Intrm	Remaining
Hatchery supplies - Totes, hoses, bags, buckets, pipe fittings, chemicals	$0.0	$5.0
Lab supplies	$0.0	$5.0
fuel	$0.0	$0.4
Commodities Total	$0.0	$10.4

Equipment:		
Microscope attachments and alterations		$12.6
Equipment Total	$0.0	$12.6

07/14/93

1994

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Project Number: 94320 - C
Project Title: Prince William Sound System Investigation
Sub-Project: Otolith Marking - Inseason Stock Separation
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

D

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

Project title:	Genetic Structure of Prince William Sound Pink Salmon
Project ID number:	94320-D (94189)
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 (estimate; see detailed budget)
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 (signed) — Date 3/8/94

Lisa W. Seeb (signed) — Date 3/8/94

Christopher Habicht (signed) — Date 3/8/94

Agency project manager:

Joe Sullivan (signed) — Date 3/15/94

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

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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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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.

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

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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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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 <u>fresh</u> and as <u>cold</u> 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

1994

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Project Number: 94320 - D
Project Title: Prince William Sound System Investigation
Sub-Project: Pink Salmon Stock Genetics in PWS
Agency: AK Dept. of Fish & Game

FORM 3A
SUB-
PROJECT
DETAIL

Travel:	Reprt/Intrm	Remaining
Two RT Anchorage/Cordova (air fare $350 + 3 days per diem @ $100/day)		$1.0
Four RT Anchorage/Cordova for staff/biometricians meetings (air fare $350 + 6 days per diem @ $100/day)		$2.0
Travel Total	$0.0	$3.0

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

Project Number: 94320 - D
Project Title: Prince William Sound System Investigation
Sub-Project: Pink Salmon Stock Genetics in PWS
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

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - D
Project Title: Prince William Sound System Investigation
Sub-Project: Pink Salmon Stock Genetics in PWS
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

E

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

Project title:	SEA Program: Salmon Predation
Project ID number:	94320-E
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:	$996.9 K (estimate; see detailed budget)
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:	Dr. Joseph R. 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.

$$C_{ijk} = DR_i \times B_{ijk} \times P_{ijk} \tag{1}$$

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

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

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 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 ($n \approx 60$) 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 ($n \approx 60$) 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
Predation Rate Surveys	
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
Predator Distribution Surveys	
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
Laboratory & Data Analyses	
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	231.2	339.3	339.3
Travel	1.7	3.3	3.3
Contractual	597.6	619.5	619.5
Supplies	10.2	20.2	20.2
Equipment	95.6	0.0	0.0
Total	937.7	982.3	982.3
Indirect Costs	60.6	58.3	58.3
Grand Total	996.9	1,040.6	1,040.6

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

Project Description: Assessment of Juvenile Salmon Predation in Prince William Sound - This project tests 2 hypotheses mechanisms that regulate predation on juvenile salmon and other age-0 fish in PWS. The objectives are : 1) identify principal predators on juvenile salmon, 2) determine distribution, abundance, species and size composition of fish predators along the juvenile salmon migratory pathways, and 3) recommend methods for improving field sampling techniques, sampling designs, and hypothesis testing capabilities.

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	$228.9	$228.9	$339.3	
Travel	$0.0	$0.0	$1.7	$1.7	$3.3	
Contractual	$0.0	$0.0	$510.1	$510.1	$619.5	
Commodities	$0.0	$0.0	$10.2	$10.2	$20.2	
Equipment	$0.0	$0.0	$95.6	$95.6	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$846.5	$846.5	$982.3	
General Administration	$0.0	$0.0	$60.6	$60.6	$75.8	
Project Total	$0.0	$0.0	$907.1	$907.1	$1,058.1	
Full-time Equivalents (FTE)	0.0	0.0	3.5	3.5	5.8	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description		Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
1	Fishery Biologist IV			1.0	$6.5
1	Fishery Biologist III			2.5	$14.3
1	Fishery Biologist II			5.5	$25.9
1	Fishery Biologist I			3.5	$33.0
5	Fish & Wildlife Technician III			10.5	$36.8
5	Fish & Wildlife Technician II			16.0	$98.1
1	Biometrician II			2.5	$14.3
	Personnel Total	0.0	$0.0	41.5	$228.9

The budget for the FB I and F&WT include sea duty and overtime hours aboard a ship

NEPA Cost: $0.0

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

Project Number: 94320 - E
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Predators
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
Two round trips between Soldotna and Cordova to have biometrician review data collection procedures in the field.		$0.7
Per diem for biometrician		$1.0
Travel Total	$0.0	$1.7

Contractual:	Reprt/Intrm	Remaining
Air charter flights to transport staff from Cordova to the vessels		$4.0
Charter for a 70' trawl vessel to conduct mid-water trawl sampling of juvenile salmon predators.		$300.7
Charter of a 42'+ purse seine vessel to conduct nearshore sampling of juvenile salmon predators		$96.6
Charter of a 42'+ purse seine vessel to conduct nearshore sampling of juvenile salmon predators		$108.8
Contractual Total	$0.0	$510.1

Project Number: 94320 - E
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Predators
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

Commodities:	Reprt/Intrm	Remaining
Office supplies		$1.6
Laboratory supplies		$4.0
Field sampling supplies (food, fuel, etc.)		$3.0
Utilities		$1.6
Commodities Total	$0.0	$10.2

Equipment:		
One 486 IBM compatible computer (w/ 80Mb hard disk and 8Mb Ram) for data entry and analysis		$6.0
Two dissecting microscopes for stomach contents analysis		$5.6
Two small mesh purse seines		$54.0
One mid-water trawl net		$30.0
Equipment Total	$0.0	$95.6

07/14/93

1994

Printed: 4/7/94 7:00 PM

Project Number: 94320 - E
Project Title: Prince William Sound System Investigation
Sub-Project: Salmon Predators
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

F

EXXON VALDEZ OIL SPILL PROJECT DESCRIPTION - ECOSYSTEM STUDY

Title: Trophic interactions of harbor seals in Prince William Sound.

Project Identification Number: 94320-F

Lead Agency: ADF&G

Cooperators: University of Alaska, 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

[* estimate; see detailed budget]

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

Project Description: Trophic Interactions of Harbor Seals - This project will investigate trophic ecology of harbor seals in PWS and assess the role of prey availability in the ongoing declines. The objectives of this project are to: 1) integrate information from ongoing tagging studies with information about distribution of key species of forage fishes, 2) determine fatty acid composition of blubber and blood samples taken from seals during tagging, 3) assess diet and harbor seal position in the food chain using lipid and stable isotope analysis.

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	$6.5	$6.5		Anticipated budget for FY95 is unknown at this time
Travel	$0.0	$0.0	$1.0	$1.0		
Contractual	$0.0	$0.0	$15.0	$15.0		
Commodities	$0.0	$0.0	$1.5	$1.5		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$24.0	$24.0	$0.0	
General Administration	$0.0	$0.0	$2.0	$2.0	$0.0	
Project Total	$0.0	$0.0	$26.0	$26.0	$0.0	
Full-time Equivalents (FTE)	0.0	0.0	0.1	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
Wildlife Biologist III			1.0	$6.5
Personnel Total	0.0	$0.0	1.0	$6.5

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

07/14/93

Project Number: 94320 - F
Project Title: Prince William Sound System Investigation
Sub-Project: Harbor Seals
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
Two RT Fairbanks/Whittier to assist with field work @$350/trip		$0.7
Per diem and lodging at combination of commercial, state, and field facilities.		$0.3
Travel Total	$0.0	$1.0

Contractual:	Reprt/Intrm	Remaining
RSA with the University of Alaska - Fairbanks for lipid analysis of seal blood and blubber and also prey species		$15.0
Contractual Total	$0.0	$15.0

Project Number: 94320 - F
Project Title: Prince William Sound System Investigation
Sub-Project: Harbor Seals
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

Commodities:	Reprt/Intrm	Remaining
Laboratory and sampling supplies to biopsy seals and collect blood and other tissues for stable isotope analysis		$1.1
Office supplies (paper, pens, etc.)		$0.4
Commodities Total	$0.0	$1.5

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - F
Project Title: Prince William Sound System Investigation
Sub-Project: Harbor Seals
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

G

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients

Project ID Number: 94320-G

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
[* estimate; see detailed budget]

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.

9456

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

Project Description: 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 GOA surface waters into PWS and, after September 1994, to use satellite-measured surface chlorophyll concentrations to determine the effect of advection on the observed chlorophyll field.

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	$0.0	$0.0	$113.5	
Travel	$0.0	$0.0	$0.0	$0.0	$4.5	
Contractual	$0.0	$0.0	$136.3	$136.3	$3.0	
Commodities	$0.0	$0.0	$0.0	$0.0	$9.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$15.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$136.3	$136.3	$145.0	
General Administration	$0.0	$0.0	$5.2	$5.2	$36.2	
Project Total	$0.0	$0.0	$141.5	$141.5	$181.2	
Full-time Equivalents (FTE)	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
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: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
RSA with UAF to conduct a phytoplankton project		$136.3
Contractual Total	$0.0	$136.3

Project Number: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-PROJECT
DETAIL

Project Description: 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 GOA surface waters into PWS and, after September 1994, to use satellite-measured surface chlorophyll concentrations to determine the effect of advection on the observed chlorophyll field.

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	$90.5	$90.5	$113.5	
Travel	$0.0	$0.0	$4.5	$4.5	$4.5	
Contractual	$0.0	$0.0	$5.0	$5.0	$3.0	
Commodities	$0.0	$0.0	$9.0	$9.0	$9.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$15.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$109.0	$109.0	$145.0	
General Administration	$0.0	$0.0	$27.3	$27.3	$36.2	
Project Total	$0.0	$0.0	$136.3	$136.3	$181.2	
Full-time Equivalents (FTE)	0.0	0.0	1.8	1.8		
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
P. McRoy			2.0	$24.8
D. Eslinger			3.0	$22.6
B. Bergeron			5.0	$23.5
PhD. Student			5.5	$10.5
M.S. Student			5.5	$9.1
Personnel Total	0.0	$0.0	21.0	$90.5

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

Project Number: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: University of Alaska - Fairbanks

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

Travel:	Reprt/Intrm	Remaining
Eight RT Fairbanks/PWS @$365/trip		$2.9
Per diem (8 people X 5 days X $40/person/day)		$1.6
Travel Total	$0.0	$4.5

Contractual:		
Equipment fabrication (2 photosynthetron @ $2.0 K)		$4.0
Publications/Page charges		$1.0
Contractual Total	$0.0	$5.0

Project Number: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	Reprt/Intrm	Remaining
Isotopes		$1.0
Chemicals		$1.0
Auto-analyzer supplies		$2.0
Glassware		$1.5
Sample Containers		$2.0
Field supplies		$1.0
Office supplies		$0.5
Commodities Total	$0.0	$9.0

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - G
Project Title: Prince William Sound System Investigation
Sub-Project: Phytoplankton/Nutrients
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

H

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

[* estimate; see detailed budget]

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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Urquhart, D. L. 1979. The feeding, movement and growth of pink salmon (*Oncorhynchus gorbuscha*) fry released from a hatchery in Prince William Sound. M.S. Thesis, University of Alaska Fairbanks, 111 p.

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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.

(FY94)

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	Program Elements*					
	NHP	LRP	PPP	HOP	WHSI	MP
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

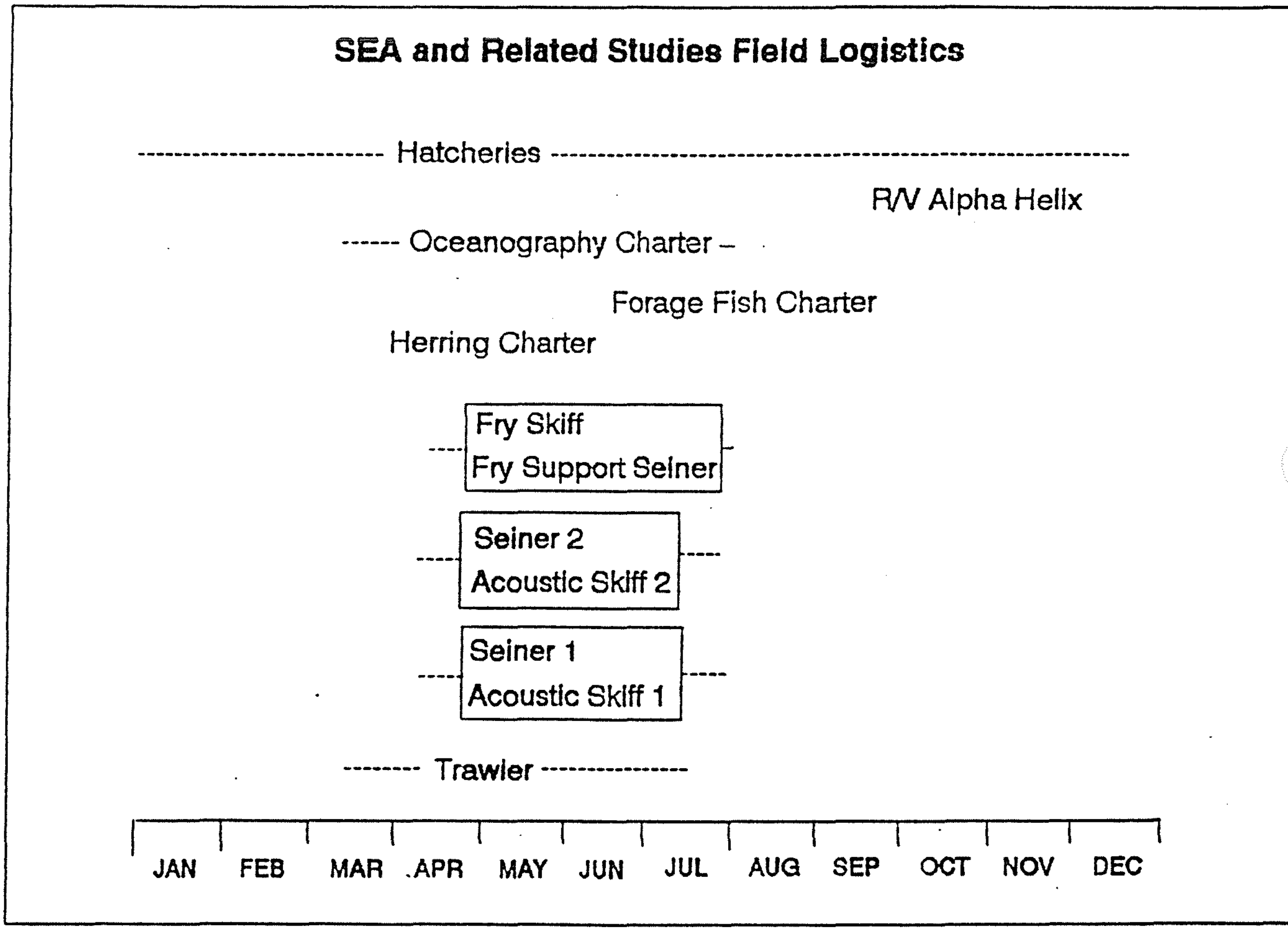

Figure 1. SEA field logistics for FY94 field season.

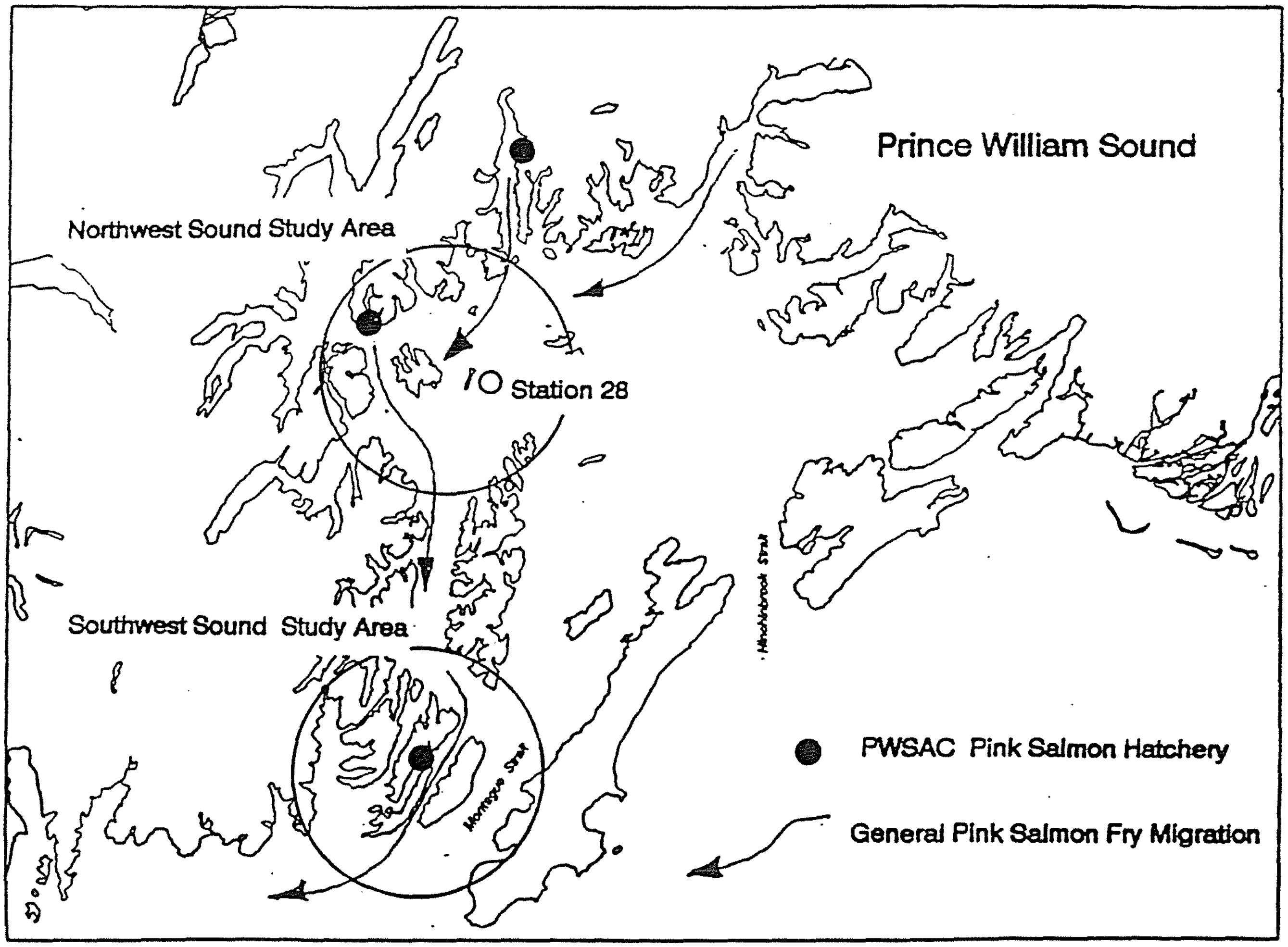

Figure 2. Study areas, hatchery locations, and pink salmon fry migratory routes.

SFOS 94-081

9456

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: 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

Robert T. Cooney 28 Feb 94

Robert T. Cooney /Date
Principal Investigator
(907)474-7407

Joan Osterkamp 2-28-94

Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

A. V. Tyler 2/28/94

A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

Donald M. Schell 28 Feb 94

Donald M. Schell /Date
Director
Institute of Marine Science

Ted DeLaca 3/2/94

Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

February 1994

EXXON VALDEZ TRUSTEE COUNCIL

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

Project Description: 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.

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	$0.0	$0.0	$209.7	
Travel	$0.0	$0.0	$0.0	$0.0	$16.5	
Contractual	$0.0	$0.0	$289.1	$289.1	$68.0	
Commodities	$0.0	$0.0	$0.0	$0.0	$12.3	
Equipment	$0.0	$0.0	$0.0	$0.0	$3.5	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$289.1	$289.1	$310.0	
General Administration	$0.0	$0.0	$11.0	$11.0	$77.5	
Project Total	$0.0	$0.0	$300.1	$300.1	$387.5	
Full-time Equivalents (FTE)	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
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

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Project Number: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
RSA with UAF to conduct the zooplankton study		$289.1
Contractual Total	$0.0	$289.1

Project Number: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
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: 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.

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	$159.4	$159.4	$209.7	
Travel	$0.0	$0.0	$15.0	$15.0	$16.5	
Contractual	$0.0	$0.0	$18.0	$18.0	$68.0	
Commodities	$0.0	$0.0	$14.3	$14.3	$12.3	
Equipment	$0.0	$0.0	$24.6	$24.6	$3.5	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$231.3	$231.3	$310.0	
General Administration	$0.0	$0.0	$57.8	$57.8	$77.5	
Project Total	$0.0	$0.0	$289.1	$289.1	$387.5	
Full-time Equivalents (FTE)	0.0	0.0	3.1	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
	R.T. Cooney			5.0	$51.5
	K. Coyle			5.0	$27.3
	C. Stark			5.5	$23.4
	E. Stockmar			5.5	$18.8
1	Field Aid			5.5	$18.8
2	M.S. Students			11.0	$19.6
	Personnel Total	0.0	$0.0	37.5	$159.4

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: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
Agency: University of Alaska - Fairbanks

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

Travel:	Reprt/Intrm	Remaining
15 RT Fairbanks-PWS @ $500/trip		$7.5
10 RT Anchorage-Cordova @ $350/trip		$3.5
Per diem (15 trips X 7 days @$40/day)		$3.9
Car rental (5 trips @ $25/day)		$0.1
Travel Total	$0.0	$15.0

Contractual:		
Shipping		
Zooplankton samples - surface Cordova-Fairbanks		$0.5
Equipment/supplies - air freight Seward/Fairbanks-Cordova		$2.0
Supplies and equipment from vendors		$0.5
Communications		
Photocopy		$0.5
Phone/Fax		$1.5
Typing/Clerical (Recharge center @ $35/hour)		$6.0
MOCNESS Maintenance Fee - pre-cruise calibration and staging		$6.0
CTC/Seabird pre-cruise calibration of system on hand		$1.0
Contractual Total	$0.0	$18.0

Project Number: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	Reprt/Intrm	Remaining
Bottles (1000 - 8 oz. plastic @ $1/bottle, 270 - 16 oz. glass @ $3.67/bottle, 215 - 32 oz glass @ $4.67/bottle)		$3.0
Preservative (Formaldehyde, 24 liters @ $12.50 /liter)		$0.3
Foul weather gear (7 full deck weatherproof suits @ $250/suit, assorted gloves and boots ($250))		$2.0
Other field/lab supplies		
Dissecting kits (10 @ $20/kit)		$0.2
Glassware		$0.5
Plankton splitter		$0.3
Software - new and upgrades		$1.0
Telephone answering machine		$0.1
Calvnets/frames (2 @ $200/net)		$0.4
Flowmeters (15 @ $250/flowmeter)		$3.8
1/2 - meter ring nets (6 @ $200/net)		$1.2
Miscellaneous replacement nets/cups		$1.5
Commodities Total	$0.0	$14.3

Equipment:		
MOCNESS nets/cups (2 sets @ $6750/set)		$13.1
1/2 - meter Closing net (2 @ $500/net)		$1.0
6 - centimeter bongo systems (2 @ $1000/system)		$2.0
1 - meter opening/closing net (2 @ $1000/net)		$2.0
Field 486 Notebook computer/printer		$2.5
Office laser printer		$1.0
Temperature logger		$3.0
Equipment Total	$0.0	$24.6

Project Number: 94320 - H
Project Title: Prince William Sound System Investigation
Sub-Project: Zooplankton in Ecosystem
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

I

SFOS 94-118

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

[*estimate; see detailed budget]

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 control, 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

EXXON VALDEZ TRUSTEE COUNCIL

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:	Months Budgeted	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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Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, P.L. Parker, and R.S. Scalan. 1993. Recycling of elements transported upstream by runs of Pacific salmon: II. ^{15}N and d^{13}C evidence in the Kvichak River watershed, southwestern Alaska. Can. J. Fish. Aquat. Sci. 50:IN PRESS.

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Wada, E. and A Hattori. 1991. *Nitrogen in the Sea: Forms, Abundances, and Rate Processes.* CRC Press, Boca Raton, 208pp.

Wada, E., H. Mizutani, and M. Minagawa. 1991. The use of stable isotopes for food web analysis. Crit. Rev. Food Sci. Nutr. 30:361-371.

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
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Fairbanks, Alaska 99775-7220
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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

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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.

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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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Recent Collaborators

Linda Deegan
Brian Fry
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Walt Oechel
Lee Cooper
Bruce Peterson
Binhe Gu
Peter Best
Robert Michener
James Reynolds
John Tenhunen
Curtis Olsen

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
Professor
SS# 034-30-1600

Thomas Kline
Post Doctoral Associate
SS# 227-64-8284

DURATION: 19 Months

PROPOSED START DATE: 1 March 1994

AMOUNT REQUESTED: (FY94): $58,400 (FY95): $100,000

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

3/7/94

Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

March 1994

Project Description: This project is an interdisciplinary effort focused on the food web dynamics supporting top trophic levels in Prince William Sound. The study would provide an 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 database regarding harbor seals whereas the remaining work will seek to build a comprehensive base of isotopic data for the Prince William Sound area. In cases where regional gradients in isotope ratios exist, it may be possible to identify critical habitats used by marine biota.

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	$0.0	$0.0	$50.5	
Travel	$0.0	$0.0	$0.0	$0.0	$3.0	
Contractual	$0.0	$0.0	$58.4	$58.4	$20.4	
Commodities	$0.0	$0.0	$0.0	$0.0	$6.1	
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	$58.4	$58.4	$80.0	
General Administration	$0.0	$0.0	$2.1	$2.1	$20.0	
Project Total	$0.0	$0.0	$60.5	$60.5	$100.0	
Full-time Equivalents (FTE)	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
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

Printed: 4/7/94 4:08 PM

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

	Reprt/Intrm	Remaining
Travel:		
Travel Total	$0.0	$0.0
Contractual:		
Contract with UAF to conduct food web dependency study		$58.4
Contractual Total	$0.0	$58.4

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
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: This project is an interdisciplinary effort focused on the food web dynamics supporting top trophic levels in Prince William Sound. The study would provide an integrating function to project 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 database regarding harbor seals whereas the remaining work will seek to build a comprehensive base of isotopic data for the Prince William Sound area. In cases where regional gradients in isotope ratios exist, it may be possible to identify critical habitats used by marine biota.

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	$27.6	$27.6	$50.5	
Travel	$0.0	$0.0	$0.6	$0.6	$3.0	
Contractual	$0.0	$0.0	$12.6	$12.6	$20.4	
Commodities	$0.0	$0.0	$4.9	$4.9	$6.1	
Equipment	$0.0	$0.0	$1.0	$1.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$46.7	$46.7	$80.0	
General Administration	$0.0	$0.0	$11.7	$11.7	$20.0	
Project Total	$0.0	$0.0	$58.4	$58.4	$100.0	
Full-time Equivalents (FTE)	0.0	0.0	0.5	0.5		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
T. Kline			3.0	$12.6
D. Schell			0.6	$7.0
N. Haubenstock			1.4	$6.0
M. Hoberg			0.5	$2.0
Personnel Total	0.0	$0.0	5.5	$27.6

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

07/14/93

1994

Printed: 4/7/94 4:08 PM

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
Agency: University of Alaska - Fairbanks

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

Travel:	Reprt/Intrm	Remaining
One RT Fairbanks-Seward, Valdez or Whittier		$0.4
Per diem (5 days@ $40/day)		$0.2
Travel Total	$0.0	$0.6

Contractual:		
Mass spectrometry @ $15/sample		$8.5
Shipping, communication, etc.		$1.6
Air charters		$1.0
Report preparation, photocopy, etc.		$1.0
Computer/Equipment Maintenance		$0.5
Contractual Total	$0.0	$12.6

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	**Reprt/Intrm**	**Remaining**
Scintillation vials		$0.6
Whirlpacks, plastic bags, scalpels		$0.3
Lab/office		$0.5
Computer peripherals		$1.1
Software upgrades		$0.4
Glassware and chemicals		$0.8
Liquid nitrogen, standards, gases		$1.2
Commodities Total	$0.0	$4.9

Equipment:		
Freezer		$1.0
Equipment Total	$0.0	$1.0

Project Number: 94320 - I
Project Title: Prince William Sound System Investigation
Sub-Project: Trophic/Stable Isotopes
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

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 - J

Project type: Research/Monitoring

Name of project leader(s): Dr. Vincent Patrick

Lead agency: Prince William Sound Science Center

Cooperating agencies: U.S. Forest Service
Prince William Sound Aquaculture Corporation
University of Alaska Fairbanks
National Biological Survey
Alaska Department of Fish & Game
National Oceanic and Atmospheric Administration

Cost of project/FY 94: $ 689.9 [estimate; see detailed budget]
Cost of project/FY 95:
Cost of Project/FY 96 and beyond:

Project Start-up/Completion Dates: FY94: March 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

B. INTRODUCTION

Subsystems and their quantitative representation

The Sound Ecosystem Assessment (SEA) Project Plan (December, 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. One 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 (AVHRR)
- ocean color and derived values (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 ad- just 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 spec. 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 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 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 AVHRR for sea surface temperature (SST) and the soon to be launched SeaWiFS sensor 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 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 CZCS. Cumulatively much of work has been completed previously by SEA collaborators. During FY94 these investigators will collaborate in filling any gaps in the records, completing remaining data processing, and integrating 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 be 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 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 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. 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 dessication.

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 upon within-population processes 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 contract with Dr. Mark Johnson, UAF/IMS, for technical leadership. Dr. Johnson is active in the field of ocean circulation models with extensive experience with 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:
Jul 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:

Aug 1, 1994: trial models for dispersion.
Sept 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. It is anticipated that Dr. Doran M. Mason, University of Wisconsin Limnology Laboratory, will be contracted and that he and Dr. Vince Patrick will collaborate in the development of distribution-feeding-growth models. It is anticipated that Dr. Ricardo Nochetto will be available for contracted expertise 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, 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 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 a Aquashuttle after many tens of hours.

The addition of a third transducer station increases the information by a factor of three for 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 contract to 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.

D. SCHEDULE

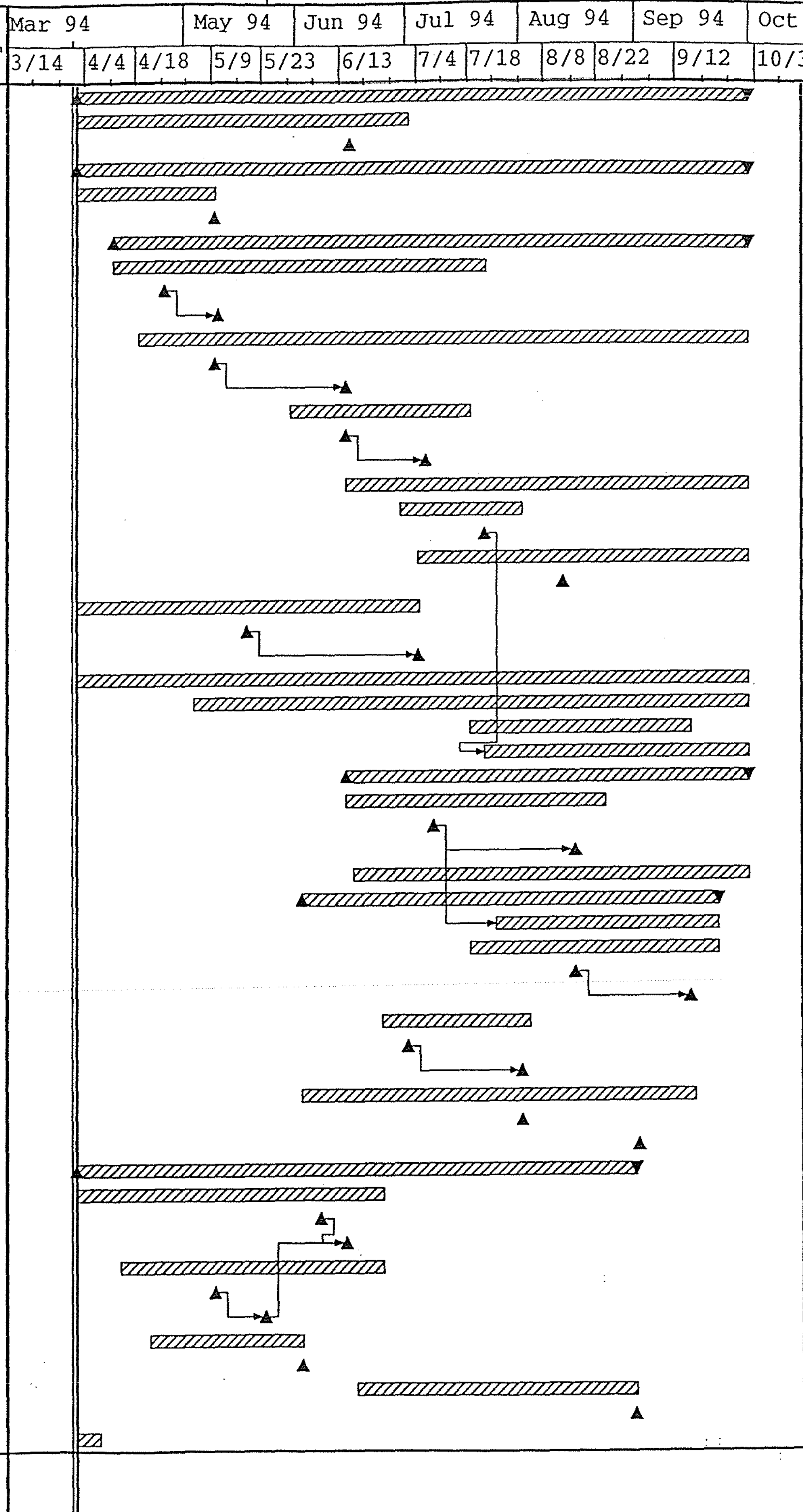
Gantt chart attached.

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	131.00D	S	04/01/94	09/30/94
field data commun.	66.00D	N	04/01/94	07/01/94
first buoy	0.00D	K	06/15/94	06/15/94
data management	131.00D	S	04/01/94	09/30/94
coordination	27.00D	N	04/01/94	05/09/94
approach fnlized	0.00D	K	05/09/94	05/09/94
data services	125.00D	S	04/11/94	09/30/94
flat file database	75.00D	N	04/11/94	07/22/94
spec & RFQ	0.00D	K	04/25/94	04/25/94
delivery	0.00D	K	05/10/94	05/10/94
data ingestion	120.00D	N	04/18/94	09/30/94
ingestion plan	0.00D	K	05/09/94	05/09/94
ingestion system	0.00D	K	06/14/94	06/14/94
mass storage	36.00D	N	05/30/94	07/18/94
requirements	0.00D	K	06/14/94	06/14/94
delivered	0.00D	K	07/06/94	07/06/94
quality control	79.00D	N	06/14/94	09/30/94
relational database	24.00D	N	06/29/94	08/01/94
selected & ordered	0.00D	K	07/22/94	07/22/94
security plan	65.00D	N	07/04/94	09/30/94
implemented	0.00D	K	08/12/94	08/12/94
site access	67.00D	N	04/01/94	07/04/94
Internet: connected	0.00D	K	05/18/94	05/18/94
local area network: stage 1	0.00D	K	07/04/94	07/04/94
remote sensing data	131.00D	N	04/01/94	09/30/94
remote sources	109.00D	N	05/03/94	09/30/94
historical	44.00D	N	07/18/94	09/15/94
data tools	51.00D	N	07/22/94	09/30/94
descriptive mdl	79.00D	S	06/14/94	09/30/94
visualization	51.00D	N	06/14/94	08/23/94
see basics	0.00D	K	07/08/94	07/08/94
see all	0.00D	K	08/15/94	08/15/94
adaptive sampling	77.00D	N	06/16/94	09/30/94
numerical mdls	81.00D	S	06/02/94	09/22/94
subsystem identification	44.00D	N	07/25/94	09/22/94
ocean circ. mdls.	49.00D	N	07/18/94	09/22/94
implement. plan complete	0.00D	K	08/15/94	08/15/94
stage one complete	0.00D	K	09/15/94	09/15/94
phys-biol mdls.	29.00D	N	06/24/94	08/03/94
implement. plan complete	0.00D	K	07/01/94	07/01/94
simulations from data	0.00D	K	08/01/94	08/01/94
nekton mdls.	77.00D	N	06/02/94	09/16/94
dispersion trial mdls.	0.00D	K	08/01/94	08/01/94
numeric. meth. & sim.	0.00D	K	09/01/94	09/01/94
sampling technol.	109.00D	S	04/01/94	08/31/94
depth shuttling	61.00D	N	04/01/94	06/24/94
delivered	0.00D	K	06/07/94	06/07/94
trials complete	0.00D	K	06/14/94	06/14/94
opc	53.00D	N	04/13/94	06/24/94
calibrated	0.00D	K	05/09/94	05/09/94
integrated with shuttle	0.00D	K	05/23/94	05/23/94
uscg buoy	31.00D	N	04/21/94	06/02/94
delivery and deploy	0.00D	K	06/02/94	06/02/94
acous. tomography	54.00D	N	06/17/94	08/31/94
recommendations	0.00D	K	08/31/94	08/31/94
sensor trials	5.00D	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 Scientific Committee and PWSFERPG. 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 re- sources 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 subprojects 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 of SEADATA was set: to develop numerical models with predictive capabilities, and 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

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)

<u>3. Project staff:</u> 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	168.90	175.66
Travel	22.50	23.40
Contractual	83.50*	86.84
Supplies	10.50	10.92
Equipment	267.00	198.64
Total	552.40	495.45
Indirect costs	68.50	71.24
Subcontract: UAF**	40.00	40.00
Subcontract: NBS**	29.00	29.00
Grand Total	689.90	635.69

* This does not include subcontracts to primary collaborators from UAF and NBS; see below.

** The amount planned for primary collaborators from UAF and NBS for SEA-DATA. The exact amount depends upon the level of communications that are available, design decisions regarding optimal locations for specific data (both of which impact access to and duplication of data and software) and the actual startup date.

APPENDIX 1

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

- o those areas of SEA that depend upon Internet access,
- o the existing Internet access,
- o the implementation plan for upgraded access,
- o costs for the upgrade,
- o 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 video 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

- o the cost advantages of fully exploiting all available information resources in the design, the adaptation, and the execution of the field survey,
- o the communication of near real-time satellite imagery from UAF and the accessibility of SEA data for analysis,
- o 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 greater than 384kbs.

The implementation plan is to connect to the UA Computing Network in Anchorage, the site closest to Cordova providing greater than 256kbs speed to both Fairbanks and to Seattle. In addition to providing the required speed for data transmission, this connection will enable sites in Cordova to take advantage of the video conferencing capabilities being implemented by UACN.

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

TOTAL P.06

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year 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, and 5) sampling technologies.

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	$18.8	$18.8	$0.0	
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$0.0	$701.5	$701.5	$0.0	
Commodities	$0.0	$0.0	$10.0	$10.0	$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	$0.0	$0.0	$730.3	$730.3	$0.0	
General Administration	$0.0	$0.0	$26.2	$26.2	$0.0	
Project Total	$0.0	$0.0	$756.5	$756.5	$0.0	
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
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

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1994

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
Contractual Total	$0.0	$0.0

07/14/93

1994

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
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

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

Equipment:		
Equipment Total	$0.0	$0.0

07/14/93

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
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: 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, and 5) sampling technologies.

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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$0.0	$701.5	$701.5		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$701.5	$701.5	$0.0	
General Administration	$0.0	$0.0	$23.4	$23.4		
Project Total	$0.0	$0.0	$724.9	$724.9	$0.0	
Full-time Equivalents (FTE)	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
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

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: AK Dept. of Fish & Game

FORM 3A-1
SUB-PROJECT
DETAIL

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

Contractual:		
Contract with the UAF		$118.8
Contract Prince William Sound Science Center		$582.8
Contractual Total	$0.0	$701.5

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: AK Dept. of Fish & Game

FORM 3B-1
SUB-PROJECT
DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: AK Dept. of Fish & Game

FORM 3B-1
SUB-PROJECT
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year 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, and 5) sampling technologies.

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	$64.0	$64.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$0.0	$10.8	$10.8		
Commodities	$0.0	$0.0	$6.8	$6.8		
Equipment	$0.0	$0.0	$13.4	$13.4		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$95.0	$95.0	$0.0	
General Administration	$0.0	$0.0	$23.8	$23.8		
Project Total	$0.0	$0.0	$118.8	$118.8	$0.0	
Full-time Equivalents (FTE)	0.0	0.0	1.3	1.3		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
M. Johnson			1.0	$7.8
D. Eslinger			2.0	$14.7
Technician			4.5	$19.5
Technician			3.0	$12.8
M.S. Student			5.5	$9.2
Personnel Total	0.0	$0.0	16.0	$64.0

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

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: University of Alaska - Fairbanks

FORM 4A
SUB-PROJECT
CONTRACTUAL
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:		
Clerical/Secretarial support (Academic Services @ $35/hr)		$4.0
Shipping (UPS)		$0.8
Terrascan licencse		$6.0
Contractual Total	$0.0	$10.8

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	Reprt/Intrm	Remaining
Data charges		$5.8
Tapes		$1.0
Commodities Total	$0.0	$6.8

Equipment:	Reprt/Intrm	Remaining
Unix Workstation		$6.0
Printer		$2.4
Hard disks (5 GB)		$5.0
Equipment Total	$0.0	$13.4

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
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DETAIL

EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year 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, and 5) sampling technologies.

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	$173.3	$173.3		
Travel	$0.0	$0.0	$27.9	$27.9		
Contractual	$0.0	$0.0	$6.3	$6.3		
Commodities	$0.0	$0.0	$2.1	$2.1		
Equipment	$0.0	$0.0	$256.6	$256.6		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$466.2	$466.2	$0.0	
General Administration	$0.0	$0.0	$116.6	$116.6		
Project Total	$0.0	$0.0	$582.8	$582.8	$0.0	
Full-time Equivalents (FTE)	0.0	0.0	2.7	2.7		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
1 Project Manager			5.5	$37.2
1 Technical administrative assistant			4.0	$16.0
3 Communication/Sci. Data System Engineer			4.3	$27.1
2 Marine/Data Systems Specialist			7.0	$30.6
1 Systems Administrator			5.5	$23.8
1 Numerical analyst			1.0	$7.6
2 OPC/ Tomography Specialist			2.4	$15.2
3 Fish Ecologist I/Ecologist/Fish Oceanographer			2.9	$15.8
Personnel Total	0.0	$0.0	32.6	$173.3

NEPA Cost: $0.0

*Oct 1, 1993 - Jan 31, 1994

**Feb 1, 1994 - Sep 30, 1994

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Prince William Sound Science Center

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

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

Travel:	Reprt/Intrm	Remaining
2 round trip Cordova/Fairbanks @ $456/trip + 6 days per diem @ $140/day, 6 days car rental @ $30/day		$1.9
3 round trip Cordova/Anchorage @ $224/trip + 5 days per diem @ $170/day, 5 days car rental @ $30/day		$1.7
2 round trip Cordova/Washington D.C. @ $1100/trip		$2.2
1 round trip Cordova/Anchorage @ $1200/trip + 8 days per diem @ $97/day, 8 days car rental @ $30/day		$2.1
1 round trip Cordova/Norfolk VA @ $600/trip + 2 days per diem @ $102/day, 2 days car rental @ $30/day		$0.9
1 round trip Cordova/Stennis MS @ $1100/trip + 3 days per diem @ $82/day, 3 days car rental @ $30/day		$1.4
1 round trip Logan UT/Cordova @ $900/trip + 42 days per diem @ $103/day		$5.2
3 round trip Chicago/Cordova @ $900/trip		$0.9
2 round trip Cordova/Fairbanks @ $456/trip + 4 days per diem @ $140/day, 4 days car rental @ $30/day		$1.6
1 round trip Boulder/Cordova @ $900/trip		$0.9
1 round trip Washington D.C./Cordova @ $1100/trip + 6 days per diem @ $103/day		$1.7
1 round trip Madison WI/Cordova @ $700/trip + 18 days per diem @ $103/day		$2.6
1 round trip Miami/Cordova @ $1200/trip + 5 days per diem @ $103/day		$1.7
2 round trip Toronto/Cordova @ $1200/trip + 7 days per diem @ $103/day		$3.1
Travel Total	$0.0	$27.9

Contractual:		
Long distance telephone charges, E-mail, and facsimile		$4.7
Mail, freight, and shipping		$1.0
Office equipment maintenance and repair		$0.6
Contractual Total	$0.0	$6.3

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Prince William Sound Science Center

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:				Reprt/Intrm	Remaining
Paper and office supplies					$2.1
		Commodities Total		$0.0	$2.1

Equipment:					
Hardware & electronics for demonstration system		Community LAN hardware:			
for near-real time buoy & ship data telemetry	30.0	5 - X11 for PC's ($2.0), hub ($2.0), cable ($0.	4.5		$34.5
Data storage, management, & retrieval hardware		UPS ($0.3), ethernet cards ($0.7), link ($5.0)	6.0		$6.0
Workstation- ($20.0K), x-terminal ($5.0K)	25.0	x-terminal ($4.0), pc router ($1.1)	5.1		$30.1
Optical drive ($3.8), Hard drive ($5.0)	8.8				$8.8
Fast CDROM ($2.0), DAT tape drive ($2.0)	4.0	Descriptive model & visualization development:			$4.0
Media ($3.0), software ($10.0), UPS ($0.5)	13.5	Workstation ($20.0), terminal ($5.0)	25.0		$38.5
annual maintenance($2.0)	2.0	hard drive ($5.0), media ($2.0), AVS software ($1	19.0		$21.0
		IDL software ($5.0), productivity items ($5.0)	10.0		$10.0
Leased data line @ 256 kbs, w/hardware, network fee		project mgmnt ($5.0), network conference ($3.0)	8.0		$8.0
Install ($1.7), hardware ($10.0), maintenance	13.5	laser printer ($2.0), UPS ($0.5)	2.5		$16.0
IXC ($20.2), LAN-Cordova ($3.4)	23.6				$23.6
LAN-Anchorage ($6.5), NWNET mbrship ($3.0	9.5	Towed vehicle providing depth shuttling			$9.5
		aquashuttle	46.6		$46.6
		Equipment Total		$0.0	$256.6

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Prince William Sound Science Center

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

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

Project Description:

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	$18.8	$18.8		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$0.0	$0.0	$0.0		
Commodities	$0.0	$0.0	$10.0	$10.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$28.8	$28.8	$0.0	
General Administration	$0.0	$0.0	$2.8	$2.8	$0.0	
Project Total	$0.0	$0.0	$31.6	$31.6	$0.0	
Full-time Equivalents (FTE)	0.0	0.0	0.2	0.2		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
2 Scientists			2.5	$18.8
Personnel Total	0.0	$0.0	2.5	$18.8

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

07/14/93

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Dept. of Interior, National Biological Survey

FORM 3A-2 SUB-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:		
Contractual Total	$0.0	$0.0

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Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Dept. of Interior, National Biological Survey

FORM 3B-2
SUB-PROJECT
DETAIL

Commodities:	**Reprt/Intrm**	**Remaining**
Software		$10.0
Commodities Total	$0.0	$10.0

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - J
Project Title: Prince William Sound System Investigation
Sub-Project: Information and Modeling
Agency: Dept. of Interior, National Biological Survey

FORM 3B-2
SUB-PROJECT
DETAIL

K

EXXON VALDEZ OIL SPILL DETAILED PROJECT DESCRIPTION

Project Title:	PWSAC - PWS System Investigation - Experimental Fry Release
Project Number:	94320 -K
Project Type:	Research/Monitoring
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) University of Alaska Fairbanks (UAF) PWS Science Center (PWSSC)
Cost of Project, FY94:	$45,000 (estimate; see detailed budget)
Project Startup Date:	March 1, 1994
Project Completion Date:	June 30, 1994
Geographic Area:	Prince William Sound
Project Leader:	__________________ Jeff Olsen, PWSAC Operations Manager
Project Manager:	__________________ Joe Sullivan, ADF&G Resource Prog. Mgr.

INTRODUCTION

Pink salmon hatcheries operated by the Prince William Sound Aquaculture Corporation annually release approximately 400 million pink salmon fry from three hatcheries located in the northern, northwestern, and southwestern corners of Prince William Sound. The fact that release timing, release location, size at release and number released per day can be controlled makes the hatchery pink salmon attractive as an experimental tool. The Sound Ecosystem Assessment (SEA) program advocates that experimental releases of hatchery juveniles will provide a powerful test of the influence of ocean-entry timing and of fry size at ocean entry on losses to predators. This notion is further supported by Dr. George Rose who wrote "experimental management can be done at Prince William Sound hatcheries in collaboration with the SEA research proposal".

SEA focuses on processes and mechanisms that regulate losses of fry and juveniles to predators after emergence from nearshore natal habitats. Previous studies in Alaska and elsewhere suggest that fry size is an important determinant of survival during early marine residence. Faster growing juveniles are thought to enjoy better marine survivals than slower growing fish. Preliminary evidence from

Prince William Sound indicates that fry growth rate is often a good predictor of adult survival.

Current release strategies for PWSAC hatchery pink salmon include the following three groups:

"Early Fed Fry": These fry are held in saltwater rearing pens and fed for 10-20 days prior to release at the peak of the nearshore macro-zooplankton bloom. This group typically comprises 80%-90% of the total release. The average size at release is generally between 0.25 grams and 0.35 grams

"Direct Release": These fry are held in saltwater rearing pens for no more than 3 days and released because their outmigration timing corresponds with the macro-zooplankton bloom. This group typically comprises 5%-10% of the release. The average size at release is generally 0.23 grams.

"Late Fed Fry": These fry outmigrate after the macro-zooplankton bloom and are held in saltwater rearing pens until late May/early June. This group typically comprises 5%-10% of the release. The average size at release is generally between 0.30 grams and 0.35 grams.

A portion of all fry from each group are coded wire tagged making comparisons of the various strategies possible. In general the "early fed fry" have outperformed the other two groups in terms of fry to adult survival. Preliminary results from fry recapture studies using tagged hatchery pink salmon suggest that fry entering the ocean at the time of the macro-zooplankton bloom show a size advantage by mid June to early July apparently because of their longer exposure to natural food sources. This size advantage is modified by temperature and is correlated to better overall marine survival. To further assess the influence of size at ocean entry and time of ocean entry on survival of PWS pink salmon, a fourth rearing strategy is proposed for hatchery pink salmon. Approximately 16 million pink salmon fry at two hatcheries will be reared to 1.5 grams for a late spring release in 1994.

Finally, the project described here is an integral component of the ecosystem based research called the Prince William Sound Sysytem Investigation. This amalgamation of research projects includes the SEA progam studies. The ADF&G is the lead agency on the Prince William Sound System Investigation and several of the other Trustee agencies are acting in a cooperating capacity.

PROJECT DESCRIPTION

1. Resources and/or Associated Services:

This project is a critical component in research and restoration of PWS pink salmon because it will allow control of key variables that are thought to effect early marine growth rate and mortality. In addition, pink salmon are thought to play an important role in the survival of other fishes, birds and mammals. This project will help identify those other species and the importance of pink salmon to each.

2. Relation to Other Damage Assessment/Restoration Work:

This project is part of the SEA program research planned for 1994. Further, "experimental release" of PWS hatchery pink salmon have been identified as a necessary component of any ecosystem based research in PWS. The pink salmon release strategy defined in this proposal will complement the three strategies currently used by PWSAC which are described in a separate project description. Together, the experimental release and experimental manipulation projects complement the planned juvenile salmon growth and predator projects. All are critical components of the SEA project necessary to support or refute the program hypotheses regarding the PWS ecosystem.

3. Objectives:

The goal of this project is, through collaboration with the SEA program, to assist "to develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon...in PWS". Specific objectives are:

A. Rear 8 million early emerging fry each at the Wally Noerenberg hatchery (WNH) on Esther Island and Armin F. Koernig hatchery (AFK) on Evans Island to 1.5 gram live weight for release in mid-June.

B. Determine the marine survivals of fry in experimental releases from coded wire-tagged individuals recovered in the brood stocks and common property fishery the following year.

C. Compare the marine survivals of late released larger fry with other releases (see "experimental manipulation" project description) at these same hatcheries.

4. Methods:

AFK and WNH hatchery pink salmon fry begin exiting the incubators volitionally at an average weight of 0.23 grams in mid March and are carried, via gravity flow, through plastic plumbing and a bank of electronic fry counters. Following enumeration, the pink fry are conveyed via flex hose to 12m X 12m X 3m (450m3) saltwater rearing pens. Approximately 8 million fry will be loaded in two rearing pens of 4 million each at the two hatchery locations. Pen loading should be complete by late March.

During pen loading, 1/2mm Coded Wire Tags (CWT) will be applied to approximately 1 out of every 200 fry in the experimental groups. Each pen of fry will contain a unique code. The CWT fry are integral to tracking migration patterns of pink fry, and estimating fry growth and mortality.

All fry will be fed a standard commercial diet of soft semi-moist fish food during the 75-85 days prior to release. Releases will occur simultaneously at the two facilities on or about June 15 when the fry are expected to have attained an average live weight of 1.5 grams. Routine reports on the rearing status of the fry as well as final release information will be communicated to SEA biologists on board trawl and purse seine vessels to assure nearshore and open water sampling is targeted on released fry.

5. Location:

This project will take place in PWS at the Armin F Koernig hatchery on Evans Island, and the Wally Noerenberg hatchery on Esther Island.

6. Technical support:

The PWSAC salmon program receives technical support from permitting agencies, University of Alaska Fairbanks, University of Alaska Juneau, and PWS Science Center. The ADF&G pathology lab, genetics lab, and coded wire tag lab are among specific expertise areas overseeing the hatchery salmon program. ADEC provides technical support on terrestial and tidelands concerns. The Cordova ADF&G staff are in constant communication with PWSAC staff to monitor marine conditions and provide technical guidance in hatchery practices.

7. Contracts:

PWSAC contracts barge services for transporting bulk supplies and personnel to each hatchery.

SCHEDULE

The project activities are as follows:

Feb 1994-Apr 1994:	Oversee development of incubating pink salmon eggs and perform routine eggcare and incubation environment monitoring.
Mar 1994-Jun 1994:	Enumerate, CWT, rear and release pink salmon fry.
Apr 1994-Jun 1994:	Coordinate/communicate rearing and release of hatchery pink salmon fry with SEA research team.

Operations at each hatchery are coordinated by a hatchery manager. Each hatchery manager is responsible for meeting the incubation, rearing and release goals at his/her facility. During the fry release cycle, the hatchery managers will be responsible for communicating release plans and detailed information to the SEA biologist coordinating the pink salmon fry studies. The operations manager is responsible for overseeing the operations at all hatcheries and coordinating involvement in the PWS ecosystem study. The hatchery managers report to the operations manager.

EXISTING AGENCY PROGRAM

PWSAC operates four salmon hatcheries in PWS and one on the Copper River system. Five species of salmon are produced between the five facilities. The total annual operating budget including administrative services and capital and major maintenance replacement for these facilities is approximately $8.0 million.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

Permiting is a significant aspect of the PWSAC salmon program. Hatcheries must receive extensive permitting prior to construction which address water use and quality, land use, wild stocks and other concerns. Each salmon project must receive ADF&G review and permitting with scrutiny for genetic and disease histories, wild stock interactions, fishery management implications and common property benefit. Hatchery sites also require permitting from Department of Army Corp, DNR Lands Division, Forest Service special use or EA permitting if necessary, and ADF&G fish transport permits.

PERFORMANCE MONITORING

Monthly hatchery reports prepared by each PWSAC hatchery manager are forwarded to the operations manager and president. These reports detail on-going results of each production cycle relative to established goals for PWSAC hatchery pink salmon. The parameters measured include total eggs taken, number of eggs surviving to the eyed stage of development, number of fry surviving to emergence, number of fry surviving to release, number of fry released by treatment group, number of fry tagged by treatment group. A summary of pink salmon fry releases by hatchery, day released and tag code will be prepared for inclusion in the SEA program progress reports. All pink salmon incubation and release data will be summarized in an annual report required of all hatchery operators by the ADF&G.

The PWSAC operations manager and production manager travel to all hatcheries for quarterly production reviews to support hatchery staff through review of quality standards and production goals. Production schedules such as planned hatchery releases and procedures are defined in advance of each production cycle. The PWSAC management team and SEA researchers will plan and coordinate the pink salmon fry release schedule to assure the goals of the SEA program are met (as described under Coordination of Integrated Research Effort below).

In addition to monthly reports and annual reports, all CWT data is summarized on D-Base database software provided by the ADF&G. ADF&G quality control standards will be followed throughout tag application and reporting.

A report will be provided to the EVOS Trustees describing the results of the 1994 hatchery pink salmon fry release program.

COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is part of the SEA ecosystem research studies which will be undertaken in FY94 (project 94320). In particular, those studies looking at salmon growth, salmon predators and prey, primary and secondary production, avian predation and nearshore fish aggregations are collaborating with the hatchery operator to describe pink salmon fry rearing and release plans and establish the protocol for in-season communication and coordination of results in the field.

The funding described for this project is necessary for the production and release of 1.5 gram coded wire tagged hatchery pink salmon. Because the approved SEA proposal is the first integrated ecosystem study of its kind in PWS, SEA researchers, in consultation with the hatchery operator, recommend the hatchery release strategies employed in 1994 emulate those used in the past by PWSAC with the exception of this proposed release group.

PUBLIC PROCESS

Alaska state law requires that PWSAC, as the regional aquaculture corporation in PWS, be comprised of representatives 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 fishermen, native representatives from villages in PWS and the Copper River region, representatives of the fish processing industry and representatives of the communities in PWS.

At their September 1993 meeting, the board of directors endorsed PWSAC's participation in the ecosystem planning effort that had just begun and supported PWSAC's involvement in the PWSFERPG. The board gave high priority to research objectives that addressed the current decline in the PWS pink salmon runs and emphasized the need to include hatchery pink salmon fry releases as part of the larger ecosystem study being developed by PWSFERPG.

PWSAC, other members of the PWSFERPG, and the public participated in a workshop in December, 1993 at which the SEA ecosystem plan was endorsed as innovative, reasonable and scientifically testable by a group of independent scientists and agents of the EVOS Trustee council. The SEA plan identifies the hatchery releases of pink salmon fry as important to develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon.

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. Work with the ADF&G and other state and federal agencies to assure the PWSAC enhancement program is in compliance with regulation and required permits. Work with hatchery staff, fish culture industry, ADF&G, and scientific community to develop research goals for enhancement program. Oversee the budgets of five hatcheries totaling over $4.0 million.

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

1986-1988: WNH hatchery 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

Project Description: PWS System Investigation- Experimental Release - This project is part of the SEA ecosystem study. Approximately 16,000,000 pink salmon fry will be reared at two hatcheries to 1.5 grams for a late spring release in 1994. This project will measure the influence of size at ocean-entry and time of ocean entry on growth and mortality.

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	$0.0	$0.0	$3.4	
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$0.0	$45.0	$45.0	$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	$0.0	$0.0	$45.0	$45.0	$33.4	
General Administration	$0.0	$0.0	$1.6	$1.6	$2.6	
Project Total	$0.0	$0.0	$46.6	$46.6	$36.0	
Full-time Equivalents (FTE)	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
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

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Project Number: 94320 - K
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Fry Release
Agency: AK Dept. of Fish & Game

FORM 3A
SUB-PROJECT
DETAIL

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

Contractual:	Reprt/Intrm	Remaining
Contract with PWSAC to raise and release 16,000,000 1.5 gram pink salmon fry into PWS @ $2,813/million.		$45.0
Contractual Total	$0.0	$45.0

Project Number: 94320 - K
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Fry Release
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - K
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Fry Release
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

L

EXXON VALDEZ OIL SPILL DETAILED PROJECT DESCRIPTION

Project Title:	PWSAC - PWS System Investigation - Experimental Manipulation
Project Number:	94320 – L
Project Type:	Research/Monitoring
Project Leader:	John McMullen, PWSAC President
Lead Agency:	Ak. Depart. of Fish and Game (ADF&G)
Cooperating Agency:	None
Other Cooperating Parties:	Prince William Sound Aqua. Corp. (PWSAC) University of Alaska Fairbanks (UAF) PWS Science Center (PWSSC)
Cost of Project, FY94:	$1,750,000
Project Startup Date:	February 1, 1994
Project Completion Date:	June 30, 1994
Geographic Area:	Prince William Sound

Project Leader: ____________________________
John McMullen, PWSAC President

Project Manager: ____________________________
Joe Sullivan, ADF&G Resource Prog. Mgr.

INTRODUCTION

During the 1980's commercial catches of pink salmon in Prince William Sound (PWS) reached record highs as a result of record wild stock returns and increasing production of hatchery pink salmon. However, in 1991, an aberrant return of adult pink salmon, spawned in the parent year of 1989 (the year of the Exxon Valdez oil spill), came in late and Dark and millions went unsold. In 1992, the wild and hatchery pink salmon return was approximately one-third of the projected size; in 1993, pinks came back at about one-fifth of their expected strength.

These failed pink salmon returns to Prince William Sound, coupled with deflated fish prices, resulted in financial disaster for commercial fisherman and for the Prince William Sound Aquaculture Corporation (PWSAC). In an effort to understand the ecosystem of the Sound and determine the causes of the pink salmon run failures, the fisherman, PWSAC and ADF&G joined in a bioregional
PWSAC - PWS System Investigation - Experimental Manipulation
coalition - Prince William Sound Fisheries Ecosystem Research Planning Group

(PWSFERPG) - encouraged and funded by the Exxon Valdez Oil Spill (EVOS) Trustee council. PWSFERPG also consists of local scientists, communities, resource managers and other resource users of the Sound.

The task undertaken by the PWSFERPG was to develop a research plan for the Sound, using an ecosystem approach to study damaged pink salmon and herring and the principal species interacting with them. These pelagic fishes support a host of birds and mammals, some of which have also been described as injured species. The result was the Sound Ecosystem Assessment (SEA) program. The draft SEA plan was reviewed by independent scientists and agents of the EVOS Trustee council at a workshop in December 1993, and was endorsed as innovative, reasonable, and scientifically testable.

Key to rehabilitating the pink salmon of PWS is understanding the complex species interactions that occur during the critical early marine life stages. As is addressed in the SEA proposal, releases of hatchery produced pink salmon fry "will provide a powerful test of the influence of ocean-entry timing and fry size at ocean entry on losses to predators". By using hatchery pink salmon, important variables such as release timing, release location, number of fry released, fry age, and fry size can be controlled. In addition, a portion of all hatchery pink salmon fry released are marked, making assessments of early marine growth, life stage mortality and migration patterns possible at a reasonable cost.

This plan advocates the integral role of the hatchery program in the research and restoration of PWS pink salmon populations as well as those injured fishes, birds and mammals whose survival is linked to the overall health of the pink salmon. PWSAC, as the regional aquaculture corporation in PWS, recognizes its vital role and supports the notion expressed by Dr. George Rose that "experimental management can be done at PWS using hatcheries in collaboration with the SEA research proposal". PWSAC has been and will continue to be heavily involved in the ecosystem research envisioned by the EVOS Trustee Council as necessary for restoration of PWS.

Finally, the project described here is an integral component of the integrated ecosystem based research called the Prince William Sound System Investigation. This amalgamation of research projects includes the SEA program studies. The ADF&G is the lead agency on the Prince William Sound System Investigation and several of the other Trustee agencies are acting in a cooperating capacity.

PROJECT DESCRIPTION

1. Resources and/or Associated Services:

This project is a critical component in research and restoration of PWS pink salmon because it will allow control of key variables that are thought to effect early marine growth rate and mortality. In addition, pink salmon are thought to play an important role in the survival of other fishes, birds and mammals. This project will help identify those other species and the importance of pink salmon to each.

2. Relation to Other Damage Assessment/Restoration Work:

This project is integral to the SEA program research planned for 1994. Further, this project has been identified as a necessary component of any ecosystem based research in PWS. Included in this project is the continuation of a spring time macro-zooplankton sampling program at each salmon hatchery. This program will compliment the SEA program research by continuing a 12 year long database that is crucial to understanding pink salmon population dynamics.

3. Objectives:

The goal of this project is, through collaboration with the SEA program, to assist "to develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon...in PWS". Specific objectives are:

A. Provide SEA researchers, in 1994, with the tools needed to determine the effect of ocean-entry timing, ocean entry location, and fry size on losses to predators.

B. Provide, in 1994, through the hatchery release of pink salmon fry, support necessary to conduct Prince William Sound ecosystem investigations that will provide further information that will aid in understanding hatchery and wild stock interactions.

C. Provide SEA researchers with the tools needed to determine the migratory path of pink salmon fry in PWS.

D. Monitor macrozooplankton abundance, ocean temperature, and meteorological conditions at three hatcheries in PWS.

E. Coded wire tag and release 1,000,000 hatchery pink salmon fry.

4. Methods:

Approximately 411 million pink salmon eggs will be taken at three hatchery locations in PWS in the fall of 1993. Eggtake estimates by facility are as follows: 1) 126 million eggs for the Armin F. Koernig (AFK) hatchery on Evans Island in southwest PWS, 2) 180 million eggs for the Wally Noerenberg Hatchery (WNH) on Esther Island in northwest PWS, 3) 105 million eggs for the Cannery Creek Hatchery (CCH) in Unakwik Inlet in northern PWS. Eggs are taken from brood stock returning to each facility.

All pink salmon eggs will be incubated at their respective hatcheries in aluminum egg boxes with a loading density of approximately 305,000 eggs per box. Eggs will be monitored throughout the fall and winter to assure a clean incubation environment is maintained. This involves continual monitoring of water quality parameters such as dissolved oxygen, pH, total water hardness, and ammonia as well as adjustment to water flow. Removal of dead eggs is important to prevent fungal growth within the incubators and is done prior to hatch with forceps or by hand. Periodic "venting" of incubators is required to purge air bubbles that build up below the perforated plate and prevent adequate water flow to the eggs. Newly hatched pink salmon fry (Alevins) exist in the incubators, feeding off their yolk sac, until early to mid March.

By mid March, 0.23 gram pink salmon fry begin exiting the incubators volitionally and are carried, via gravity flow, through plastic plumbing and a bank of electronic fry counters. Following enumeration, the pink fry are conveyed via flex hose to 12m X 12m X 3m (450m3) saltwater rearing pens. Fry loading density per saltwater pen varies by location, ranging from 7,000,000 fry to 12,500,000 fry per pen. The higher densities are possible in deeper bays such as at WNH hatchery.

During outmigration, 1/2mm Coded Wire Tags (CWT) will be applied to approximately 1 out of every 600 fry. Each pen of fry will contain a unique code. The CWT fry are integral to tracking migration patterns of pink fry, and estimating fry growth and mortality.

All fry will be fed a standard commercial diet of soft semi-moist fish food for 10 - 20 days prior to release. Releases will begin in mid to late April when the calanoid copepods, a key prey item of the pink salmon fry, become available in the upper 20 meters of the water column. All releases will be done in concert with the ship board sampling carried out by the SEA research team. Fry release data from the hatcheries will be communicated to biologists on board trawl and purse seine vessels to assure nearshore and open water sampling is targeted on released fry.

Approximately 371,000,000 hatchery pink fry will be released in 1994. Releases will occur during and after the zooplankton bloom (from about April 15 to June 1) to assess the influence of timing of ocean entry on predation of pink salmon (see Coordination of Integrated Research Effort below). Fry will be released in groups of 7,000,000 to 36,000,000 to assess the impact of number of fry released on predation and fry growth. Generally, fry release size will be between 0.25 and 0.35 grams. The wide geographic separation of each hatchery will test the influence of location of ocean entry to growth, mortality and migration pattern.

Twice weekly, near shore plankton abundance will be monitored from mid March through late June. Samples are taken in two pre-selected locations near each hatchery site using a 1/2m sample net hauled vertically from 20 meters. Up to three replicates are made per sample location. Samples are transferred to 250ml graduated cylinders and allowed to settle 24 hours. The relative density of zooplankton and phytoplankton as well as their percent composition is determined. The samples are then preserved in 10% buffered formalin for later species identification by SEA researchers.

A sub-project of the SEA program for 1994 will address the influence of fry size at ocean entry on predation by looking at the growth and mortality of large fry (1.5 gram) released late in the season. A separate project description has been prepared for this program.

5. Location:

This project will take place in PWS at the Armin F Koernig hatchery on Evans Island, the Wally Noerenberg hatchery on Esther Island and the Cannery Creek hatchery in Unakwik Inlet.

6. Technical support:

The PWSAC salmon program receives technical support from permitting agencies, University of Alaska Fairbanks, University of Alaska Juneau, and PWS Science Center. The ADF&G pathology lab, genetics lab, and coded wire tag lab are among specific expertise areas overseeing the hatchery salmon program. ADEC provides technical support on terrestial and tidelands concerns. The Cordova ADF&G staff are in constant communication with PWSAC staff to monitor marine conditions and provide technical guidance in hatchery practices.

7. Contracts:

PWSAC contracts barge services for transporting bulk supplies and personnel to each hatchery.

SCHEDULE

The project activities are as follows:

Feb 1994-Apr 1994:	Oversee development of incubating pink salmon eggs and perform routine eggcare and incubation environment monitoring.
Feb 1994-Oct 1994:	Coordinate hatchery operations and provide logistics support such as freight and transportation.
Feb 1994-Jun 1994:	Enumerate, CWT, rear and release pink salmon fry. Assess marine plankton abundance.
Apr 1994-Jun 1994:	Coordinate/communicate releases of hatchery pink salmon fry with SEA research team.

Operations at each hatchery are coordinated by a hatchery manager. Each hatchery manager is responsible for meeting the incubation, rearing and release goals at his/her facility. During the fry release cycle, the hatchery managers will be responsible for communicating release plans and detailed information to the SEA biologist coordinating the pink salmon fry studies. The operations manager is responsible for overseeing the operations at all hatcheries and coordinating involvement in the PWS ecosystem study. The hatchery managers report to the operations manager.

EXISTING AGENCY PROGRAM

PWSAC operates four salmon hatcheries in PWS and one on the Copper River system. Five species of salmon are produced between the five facilities. The total annual operating budget including administrative services and capital and major maintenance replacement for these facilities is approximately $8.0 million.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

Permiting is a significant aspect of the PWSAC salmon program. Hatcheries must recieve extensive permitting prior to construction which address water use and quality, land use, wild stocks and other concerns. Each salmon project must recieve ADF&G review and permitting with scrutiny for genetic and disease histories, wild stock interactions, fishery management implications and common property benefit. Hatchery sites also require permitting from Department of Army Corp, DNR Lands Division, Forest Service special use or EA permitting if necessary, and ADF&G fish transport permits.

PERFORMANCE MONITORING

Monthly hatchery reports prepared by each PWSAC hatchery manager are forwarded to the operations manager and president. These reports detail on-going results of each production cycle relative to established goals for PWSAC hatchery pink salmon. The parameters measured include total eggs taken, number of eggs surviving to the eyed stage of development, number of fry surviving to emergence, number of fry surviving to release, number of fry released by treatment group, number of fry tagged by treatment group. A summary of pink salmon fry releases by hatchery, day released and tag code will be prepared for inclusion in the SEA program progress reports. All pink salmon incubation and release data will be summarized in an annual report required of all hatchery operators by the ADF&G.

The PWSAC operations manager and production manager travel to all hatcheries for quarterly production reviews, supporting hatchery staff through review of quality standards and production goals. In general, production schedules and procedures are defined in advance of each production cycle. The PWSAC management team and SEA researchers will plan and coordinate the pink salmon fry release schedule to assure the goals of the SEA program are met (as described under Coordination of Integrated Research Effort below).

In addition to monthly reports and annual reports, all CWT data is summarized on D-Base database software provided by the ADF&G. ADF&G quality control standards will be followed throughout tag application and reporting.

All plankton and meteorological data is summarized on a computer spreadsheet provided by UAF. Following the sampling season each hatchery's data is forwarded to UAF where it is added to a larger PWS data base. This data is used by the Cooperative Fisheries and Oceanographic Studies program led by UAF. The data will also be used by SEA researchers studying primary and secondary productivity.

The PWSAC program must also comply with a host of agency regulations which direct production limits and outline specific objectives for hatchery enhancement. Annual review of accomplishments by ADF&G personnel and the Regional Planning Team (RPT), and recommendations for program revisions are processes to guide salmon programs and maintain performance within permitting requirements. (The RPT is composed of ADF&G staff appointed by the Commissioner and representatives from the regional salmon association. The RPT develops specific salmon rehabilitation and enhancement objectives which receive public review and approval by the ADF&G Commissioner).

A report will be provided to the EVOS Trustees describing the results of the 1994 hatchery pink salmon fry release program.

COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is complementary to the SEA ecosystem research studies which will be undertaken in FY94 (project 94320). The timing of the shipboard sampling program is set by the anticipated schedule for release of various groups of hatchery produced pink salmon fry. In particular, those studies looking at salmon growth, salmon predators and prey, primary and secondary production, avian predation and nearshore fish aggregations are collaborating with the hatchery operator to describe pink salmon fry rearing and release plans and establish the protocol for in-season communication and coordination of results in the field.

The funding described for this project is necessary for the production and release of marked groups of hatchery pink salmon in 1994. Because the approved SEA proposal is the first integrated ecosystem study of its kind in PWS, SEA researchers, in consultation with the hatchery operator, recommend the hatchery release strategies employed in 1994 emulate those used in the past by PWSAC. Those three strategies include:

"Early Fed Fry": These fry are held in saltwater rearing pens and fed for 10-20 days prior to release at the peak of the nearshore macro-zooplankton bloom (end of April/early May). This group typically comprises 80%-90% of the total release.

"Direct Release": These fry are held in saltwater rearing pens for no more than 3 days and released because their outmigration timing corresponds with the macro-zooplankton bloom. This group typically comprises 5%-10% of the release.

"Late Fed Fry": These fry outmigrate after the macro-zooplankton bloom and are held in saltwater rearing pens until late May/early June. This group typically comprises 5%-10% of the release.

To assure the goals of SEA are met, potential deviations from the 1994 planned fry release schedule will be communicated between the PWSAC management team and SEA research team prior to and during the field season. As an example, conversations between the PWSAC operations manager, SEA chief scientist and SEA salmon growth/predator study leader suggest that the mild winter weather in PWS could accelerate the macrozooplankton bloom by as much as one week. Because most of the hatchery pink salmon fry are relased into the "bloom", the SEA ship-board sampling schedule has been developed with an "earlier than normal" fry release in mind.

Finally, the hatchery facilities will provide support to the SEA research team during the extended field season. This will include shower and laundry, water for vessels, bunking as needed, some equipment storage, communication assistance, and additional lab space if needed.

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.

At their September 1993 meeting, the board of directors endorsed PWSAC's participation in the ecosystem planning effort that had just begun and supported PWSAC's involvement in the PWSFERPG. The board gave high priority to research objectives that addressed the current decline in the PWS pink salmon runs and emphasized the need to include hatchery pink salmon fry releases as part of the larger ecosystem study being developed by PWSFERPG.

PWSAC, other members of the PWSFERPG, and the public participated in a workshop in December 1993 at which the SEA ecosystem plan was endorsed as innovative, reasonable and scientifically testable by a group of independent scientists and agents of the EVOS Trustee council. The SEA plan identifies the hatchery releases of pink salmon fry as important to develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon.

PERSONNEL QUALIFICATIONS

John C. McMullen

Work Experience

1991-Date: President of PWSAC. Administers a program which features the operations of five salmon hatcheries, and active capital projects program, both of which are supported by a finance department and an administrative support group. Works on legislative and Alaska Board of Fisheries affairs which deal with the future of salmon enhancement programs in Alaska. Deals with the Alaska Department of Fish and Game, and Commerce on issues of hatchery transfer grants and loans, enhancement taxes, and hatchery management plans, and the development of fisheries genetics and fish stocking policies. Serves as a member of the Regional Planning Team (RPT) and the Salmon Harvest Task Force. Works closely with the PWSAC board of directors and executive committee.

1989-1991: Special projects manager for PWSAC. Worked as a liason to the oil industry and State and Federal agencies following the EVOS. Served as a member of the Regional Citizens Advisory Committee (RCAC). Also served as a member of the RPT and the PWSAC Production Planning Committee (PPC).

1986-1987: Fishery advisor (unpaid) to Alaska gubernatorial candidate, Steve Cowper. Responded to questions from advocacy groups and drafted policy statements.

1985-1986: Retired from the ADF&G.

1979-1985: Chief of Operations for the ADF&G Salmon Enhancement Program. Responsible for the development and achievement of the program's fish production objectives and development and management of the Operating and CIP budgets.

Education

1958-1961: Northern Michigan Univ., B.S. Degree in Biology.

1962-1964: Michigan State Univ., Graduate School Fisheries

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 hatchery manager, PWSAC. Oversee operations of PWSAC's largest salmon hatchery. Responsible for production of four species of Pacific salmon.

1986-1988: WNH hatchery 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

Project Description: PWS System Investigation- Experimental Manipulation - This project aids in the restoration of PWS pink salmon through collaboration with the SEA ecosystem study. 390,000,000 pink salmon fry will be released from three hatcheries at various times and at various sizes to assess the influence of these variables on growth, mortality and migration patterns. This subproject budget identifies the line item allocations for the contract with PWSAC.

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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$0.0	$1,750.0	$1,750.0		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$1,750.0	$1,750.0	$0.0	
General Administration	$0.0	$0.0		$0.0		
Project Total	$0.0	$0.0	$1,750.0	$1,750.0	$0.0	
Full-time Equivalents (FTE)	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
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

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Project Number: 94320 - L
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Manipulation
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
Contract with PWSAC to raise and release 355,000,000 juvenile pink salmon @ $4930/million fish released.		$1,750.0
Contractual Total	$0.0	$1,750.0

Project Number: 94320 - L
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Manipulation
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

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

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

Project Number: 94320 - L
Project Title: Prince William Sound System Investigation
Sub-Project: Experimental Manipulation
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

M

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Sound Ecosystem Assessment (SEA), An Ecosystem Research Plan for Prince William Sound -- Observational Physical Oceanography in Prince William Sound and the Gulf of Alaska (SEA OCEAN)

Project ID number: 94320 - M

Project type: Research/Monitoring

Name of project leader(s): Dr. David K. Salmon, Oceanographer, PWS Science Center and Institute of Marine Science, University of Alaska Fairbanks

Lead agency: PWS Science Center

Cooperating agencies: University of Alaska, ADF&G, DOI/USFWS

Cost of project/FY 94: $657.81K (estimate; see detailed budget)
Cost of project/FY 95: $506.30K
Cost of Project/FY 96 and beyond: $475.00K + equipment + 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. David K. Salmon

Name of lead agency project manager: Dr. Jerome Montague

B. INTRODUCTION

The overall goal of this study is to improve our understanding of ecosystem level processes in Prince William Sound (PWS) and how they are influenced by natural and anthropogenic perturbations. Recent run failures of wild and hatchery pink salmon, as well Pacific herring stocks, were not predicted, and were probably *unpredictable* given our present understanding of the ecosystem. Further, given our present understanding of the marine ecosystem, it is not possible to discern whether these run failures were due to natural or anthropogenic processes. These run failures underscore the need to gain a more comprehensive understanding of the PWS ecosystem. Within this context SEA has chosen to focus initially on specific components of the PWS ecosystem. In particular, the initial SEA study will focus on what has been termed the "fisheries ecosystem"; this includes those elements of the PWS ecosystem that are important in limiting the production of fish stocks. The fisheries ecosystem as defined is taken to include the predators, competitors and prey associated with specified target species throughout their life history, as well as environmental processes that act to constrain the production of the target species, their predators, competitors and prey.

The initial phase of SEA will focus on pink salmon and Pacific herring stocks as target species, because of their major ecological roles in the Sound, as well as their economic importance to the communities of the Sound. The approach to be used by SEA is an ecosystem level approach in that it seeks to identify critical processes that affect survival of the target species, as well as their predators, competitors and prey along the migratory routes that the target species utilize within the Sound. This approach is now possible because of important groundwork laid by investigators from state and federal agencies and from other research centers. These prior studies have established an extensive knowledge of many aspects of the life stages of the target species; the SEA approach builds upon this foundation. SEA seeks to combine this prior knowledge with new information and new technologies to complete a quantitative understanding of the ecosystem components associated with the early life stages and to develop numerical models that simulate those subsystems. We believe that this level of understanding is both necessary and sufficient to distinguish between natural and anthropogenic effects. The objective of the SEA project is to use mechanistic, coupled models, in conjunction with data assimilation, to provide nowcasts and short term forecasts of the success or decline of year classes and stocks of the target species. In addition, the results of SEA are envisioned to be useful tools for decisions concerning management, enhancement and restoration of these stocks.

SEA will encompass an ecosystem level perspective to identify and analyze both physical and biological processes within the Sound that act to limit the production of the target species. This ecosystem level approach is powerful in that it is highly applicable to other target species including fish, seabirds and marine mammals. The approach can also be carried into other geographic regions. Future studies of other target species can easily be modeled using the migratory pathway approach put forth in SEA. Future studies within PWS will integrate well with the initial studies in terms of identifying how components of the PWS ecosystem are linked to one another. In this way, results of future studies will prove to be useful for management, enhancement and restoration of critical elements of the PWS ecosystem.

Single species population dynamics models have proven to be inadequate for making preseason predictions of animal abundance for both conservation and economic purposes (Cullen 1989). Without adequate predictive capabilities the practices of restoration, enhancement, and the impacts of other anthropogenic activities have been and will remain controversial. The growth conditions and the carrying capacity of the coastal marine ecosystem in this region vary interannually, and are influenced by the physical, chemical and biological processes in the Gulf of Alaska (Thomas and Mathisen 1993). The SEA plan assumes that coupling knowledge of the fluctuating carrying capacity and growth conditions of the system to animal population dynamics is an important step towards improving predictive capabilities, and ultimately developing a better understanding of the ecosystem.

There is general agreement that top-down and bottom-up forces act on populations and communities simultaneously (Hunter and Price, 1992). In an approach similar to that used in the GLOBEC Northwest Atlantic Study (1991b), SEA seeks to examine the ecology of important species by studying environmental and trophic interactions along their migratory pathways. The SEA program will utilize the conceptual experimental design of GLOBEC (1991a), which involves the nesting of fine scale measurement programs within large scale ecosystem monitoring efforts. Underlying both the large scale and fine scale measurement programs are the scientific questions that need to be answered to improve our understanding of the ecosystem and to improve predictive capabilities for animal abundance.

The disturbing trends in the major fisheries of PWS following the *Exxon Valdez* oil spill (EVOS) have focused public attention on the need to understand how this large and productive coastal environment functions to support marine resources of immense commercial, sport and subsistence value. The fisheries resources of the Sound are components of a broader marine and freshwater ecosystem that fosters their survival. This plan outlines the rationale, scientific methodologies, and research priorities needed to describe the ecological roles of selected fishes and their inter-relationships with the components of the ecosystem (physical, chemical and biological) that limit their annual production and harvest.

In using an ecosystem approach, SEA has identified the following goals as the means to focus planning and subsequent studies. Achieving these goals will ultimately address scientific and public concerns about the health of this valuable Alaskan coastal environment:

(1) Acquire an ecosystem-level understanding of marine and freshwater processes that interact to maintain levels of fish production in PWS;

(2) Use this new information to more accurately forecast fisheries production and predict fisheries responses to different levels of ecosystem disturbance, both natural and anthropogenic;

(3) Establish a comprehensive scientific data base describing the status of the PWS ecosystem and the fisheries along with a data and information program serving the needs of the region for improved information for management (primarily fisheries), enhancement and mandated restoration activities.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

SEA Observational Physical Oceanography in Prince William Sound and the Gulf of Alaska

The Sound Ecosystem Assessment program (SEA) evaluates changes occurring in the Prince William Sound (PWS) ecosystem in the context of groups of interacting species. The knowledge gained by implementing SEA is vital to determining the feasibility of, and the approach to, restoring many resources and services injured by EVOS. Resources addressed by SEA include pink salmon, herring, and the principal species interacting with these fishes. These pelagic organisms support a host of birds and mammals, some which have also been described as injured species. Services addressed include subsistence, commercial fishing, recreation and tourism, and passive use. While SEA is primarily a monitoring and research activity, this program will also provide support for other EVOS Trustee Council programs (i.e., informing land and fisheries management to promote a healthy ecosystem, increasing public information about the state of the ecosystem). The SEA program was created by the PWS Fisheries Ecosystem Research Planning Group, comprised of the scientists, communities, managers and resource users of the Sound. Plans for SEA were developed with the encouragement and support of the EVOS Trustee Council to provide an understanding of important ecological influences on injured resources and services. The draft SEA plan (with related technical information) was reviewed by independent scientists and agents of the EVOS Trustee Council at an workshop in December 1993, and was endorsed as innovative, reasonable, and scientifically testable. Future expansion of SEA will involve coupling pelagic and nearshore benthic ecology and linking aquatic and terrestrial ecology through dominant ecosystem pathways.

2. Relation to Other Damage Assessment/Restoration Work:

Background: Physical Oceanography and Meteorology of Prince William Sound and the Gulf of Alaska

The climate in PWS is maritime and is influenced by a nearly continuous procession of low pressure systems. Adiabatic uplift of the moisture-laden air masses delivers precipitation as rain and snow to the coastal region each year (Royer, 1979). Mean annual precipitation totals approximately 200 cm with pronounced seasonal variability among weather stations (Royer 1978). Minimum precipitation occurs in June and July (10 cm month^{-1}) with a maximum in September and October [25 cm month^{-1} (Royer 1978)]. The annual discharge cycle for coastal rivers reflects the release of stored winter precipitation which peaks in May and June.

The annual cycles of temperature and salinity in PWS waters are forced by freshwater input, seasonal shifts in large-scale weather patterns, and by interaction with the surface and deep water of the bordering open ocean. Active exchange of water with the open Gulf of Alaska (GOA) occurs through Hinchinbrook Entrance (HE) and Montague Strait (MS) (Schmidt, 1977). Wind intensities are greatest from October to April (Wilson and Overland, 1986). Cyclonic winds associated with the passage of storm systems over the Gulf drive an onshore Ekman transport that results in strong coastal convergence, downwelling outside PWS, and the transport of surface water (upper 150 m) northward through HE As winter progresses, the surface-mixed layer cools to 2-4 °C and surface salinities increase to nearly 32 ppt. The upper layers of the Sound are generally coldest and most saline in March.

Following a transition in weather patterns in late April and May, the period of strong onshore Ekman transport is replaced by occasional offshore transport and weak upwelling outside of the Sound due to a relaxation of wind-forcing. These periodic flow reversals occur intermittently from late May to September. Under these conditions, deeper, more saline oceanic waters intrude onto the shelf south of PWS. When the density of this intrusion exceeds the density at the depth of sills (180 m) in sea valleys outside the Sound (HE and MS), a period of deep water renewal is initiated. The duration and magnitude of this annual event is governed by the nature of the period of relaxed onshore wind forcing. During the summer and early fall, surface waters of the region are freshening in response to local rains and the melting winter snow pack.

Upper-layer (100 m) circulation patterns in PWS are also driven by freshwater input, local winds, and interactions with the Alaska Coastal Current (ACC) flowing westward around the margin of the Gulf (Royer, 1981). Upstream of the Sound the ACC is augmented by freshwater inputs from glaciers (Royer et al., 1990) and rivers that ring the Gulf. A portion of the ACC enters the Sound through HE, traverses the region from east to west and then exits through MS (Niebauer et al. 1993). The magnitude and direction of this ACC inflow depends on multiple variables such as seawater density gradients, atmospheric pressure differences within and outside of the Sound, regional winds, and seasonal changes in the internal Rossby radius of deformation (Royer et al., 1990). Seasonal variability in the ACC has been addressed by Johnson et al. (1988) and modeled by Luick (1988). A cyclonic circulation cell has been observed in the Sound about 30 km north of HE (Muench and Schmidt, 1975), and is likely related to interactions between the bathymetry, the regional wind field and ACC inflow. Under summer and early fall conditions of reduced onshore transport and increased freshwater input, substantial surface outflow can occur through HE.

The large scale wind driven upper layer circulation in the GOA consists of a cyclonic gyre, with broad slow currents in the southern and eastern Gulf, and an intense western boundary current (Alaskan Stream) on the northern margin. The circulation is also characterized by the occurrence of mesoscale (100 - 300 km diameter) anticyclonic eddies, some of which propagate westward along the northern margin of the Gulf (Musgrave et al., 1992), while others such as the Sitka eddy (Tabata, 1982) are essentially standing features. These features appear to be important in the transport of properties onto and off of the continental shelf, and may also affect the timing and migration patterns of salmon stocks returning to the coastal region to spawn (Hamilton and Mysak, 1986).

The GOA is characterized by large interannual variations in the atmosphere and ocean. This variability exerts considerable control over changing environmental conditions within the Sound on time scales of years. Variations in the frequency and intensity of storm systems that enter the Gulf (or form there) translate to variable amounts of precipitation in the coastal mountains which in turn produces changes in coastal runoff and the intensity of the flow into the Sound from the ACC. Periods of increased storminess bring higher air temperatures to the subarctic North Pacific while periods of decreased storminess result in lower air temperatures (*cf.* Salmon 1992). Changes in the timing and intensity of spring runoff occur partly due to prevailing air temperatures in the region in late winter and early spring.

The most prominent cyclic time scales of interannual variation that occur in the atmosphere over the GOA are those at periods of about 3 and 5 years. These variations appear to be atmospherically and oceanically linked to large scale changes occurring in the tropical Pacific in relation to El Niño, La Niña, and the Southern Oscillation (ENSO). Thus there is a tendency for changes in North Pacific storm frequency and intensity to occur on these time scales. The atmospheric variations over the GOA and central North Pacific also translate into changes occurring within the oceanic environment of the Gulf in terms of chemical properties and ocean currents (Tabata, 1991a, 1991b; Salmon, 1992). In particular, ocean circulation in the subarctic tends to be stronger during El Niño warm events and weaker during the La Niña phase of the cycle, largely in response to variable wind forcing. Currently, it is not known whether the 3 and 5 year time scales are the most important determinants of interannual variability in PWS.

Decadal scale variability in the physical environment of the North Pacific occurs in conjunction with phenomena that are both cyclic and quasi-periodic. Low frequency variations related to the 18.6 year nodal tide cycle occur in time series of both atmospheric and oceanic parameters in the eastern North Pacific (Royer, 1989; 1993). This 18.6 year variability shows up clearly in Gulf of Alaska air and ocean temperatures and a time series of Pacific halibut, *Hippoglossus stenolepis*, recruitment (Parker et al., 1993). Decadal scale variability in the North Pacific also occurs in relation to quasi-periodic ENSO phenomena. For example, from 1976 through 1988 the environment of the North Pacific was characterized by large and persistent anomalies of air and sea surface temperatures as well as upper level and surface winds that can be partially linked to variations occurring in the tropical Pacific in relation to ENSO. (Trenberth 1990; Salmon 1992). North Pacific ecosystems have responded to these persistent anomalies through increases in biomass of phytoplankton in the central North Pacific (Venrick et al., 1987), and increases in abundance of zooplankton, pelagic fishes, and squid in the subarctic North Pacific (Brodeur and Ware, 1992). Within PWS however, the effects of decadal scale climatic forcing on the ecosystem have not been demonstrated and are poorly understood.

The SEA Approach: Connecting the Physics to the Ecology in PWS

Major hypotheses in the SEA program include the idea that the physical environment of PWS and the GOA is the major determinant of natural variability in the ecosystem. In particular, changes in the large scale advective regime in PWS are thought to constrain growth and survival of juvenile pink salmon both through differential availability of important food resources (calanoid copepods) and through a prey switching mechanism by which presence or absence of these resources causes potential pink salmon predators to feed more heavily on either pink salmon or copepods. The elucidation of the physical oceanographic structure of PWS, and its space/time variability is critical to understanding how the ecology of the region changes in response to natural perturbations such as ENSO phenomena and large scale long term temperature fluctuations associated with the 18.6 year nodal tide. This project will characterize and monitor major physical processes (atmospheric and oceanic) that constrain the ecology of pink salmon, their predators, and their prey in PWS. Information concerning the origin, modifications, and fate of water masses that constitute both the surface and deep waters of PWS and determine their biology will be obtained in PWS/GOA. Large scale physical oceanographic measurements will consist of temperature, salinity, and ocean currents (derived density and baroclinic ocean currents) obtained from conductivity/temperature/depth and acoustic doppler recording instruments. Meteorological measurements will include air temperature, precipitation, wind speed and direction and derived products that relate atmospheric forcing to oceanic structure, properties and circulation. Fine scale oceanographic measurements will include determination of horizontal and vertical physical structures (e.g. thermocline, pycnocline, fronts, eddies, tidal rips, shear zones). This study will be closely coordinated with all components of SEA, in particular both chemical (silicate, phosphate, nitrate, oxygen) and biological data (phytoplankton, zooplankton, ichthyoplankton) will be used as physical oceanographic tracer fields in the determination of how physical processes in PWS act to control the fluctuations of ecological populations.

3. Objectives:

Objectives of SEA Observational Physical Oceanography

The objectives of the physical oceanography program within SEA are as follows:

(1) Determine the space/time variability of atmospheric and oceanic processes and structures within PWS and the GOA. Atmospheric processes of interest will include winds, precipitation and temperature, while the focus in the ocean will be on currents, fronts, eddies, tidal rips, thermocline, halocline, and changes in properties (both physical and chemical) of both the surface and deep waters.

(2) Determine the relationships and interactions between atmospheric forcing (winds, storms, long term temperature changes) and wind and buoyancy driven ocean currents in PWS/GOA.

(3) Determine how the relationships described in 2) act to retain or disperse major food resources for ecologically important species within PWS.

(4) Ascertain the large and fine scale oceanographic structure and the major climatic cycles (ENSO, nodal tide) and events (e.g storms) that affect PWS/GOA within the context of the space/time distributions and changes in abundance of important populations in these regions.

4. Methods:

Large Scale Physical Oceanography in Conjunction with the River/Lake Hypothesis

The large scale measurements made in the SEA physical oceanography program are crucial to testing the validity of the river-lake hypothesis. Baseline information concerning the water masses that constitute the externally advected surface and deep waters of Prince William Sound will be obtained from transects in the Gulf of Alaska (local freshwater input to PWS will be estimated from stream measurements and a hydrologic model). These oceanographic sections will cut across the Alaska Coastal Current (ACC) and the deep shelf waters in the northern Gulf of Alaska. Baseline physical information will consist of temperature, salinity, density and dissolved oxygen profiles obtained from conductivity/temperature/depth (CTD) measurements (augmented by an oxygen sensor), ocean current velocities obtained from acoustic doppler current profiler (ADCP) measurements and (geopotential) dynamic heights calculated from CTD data. ADCP backscatter will also be used in SEA investigations to augment biological (i.e. net capture) measurements of zooplankton distribution and abundance. Chemical signatures (nitrate, silicate, and phosphate, possibly tritium or other tracers) of ACC and shelf derived waters will be obtained from Niskin bottle samples mounted with the CTD on a rosette. Conservative nutrient based tracers (NO and PO, cf. Broecker 1974) will be computed from the nutrient distributions because of their utility in ascertaining distinctions between water masses (cf. Salmon and McRoy, 1994). These tracers will be particularly useful for discerning deep water characteristics. In addition, the biota found in ACC waters are distinct from those found on the deep shelf (i.e. neritic versus oceanic) and will be used as tracers to further discern differences between water masses that enter the Sound via Hinchinbrook Entrance (HE).

Transects across HE, southwestern PWS, Montague Strait (MS), and regions of the central Sound will be made to determine the advective regime within PWS. Sampling will encompass the entire water column in shallow regions or down to about 600 m in the deeper areas of the Sound. This will allow for the determination of both surface water flushing patterns (and rates) and deep water renewal processes in the Sound, as well as the abundance of associated deep and near surface zooplankton assemblages. Sampling will include CTD, ADCP, and chemical measurements (Zooplankton sampling techniques are described in the zooplankton sampling program). Ocean current sampling will be conducted over the course of several tidal cycles in order to determine the relative contribution of tidal currents to the net flow regime. In the southwestern Sound, physical and zooplankton sampling will be conducted for all passages that drain out of PWS. ADCP and CTD transects will be run across Elrington and LaTouche Passages as well as across Port Bainbridge to include (presumably) outflow from Bainbridge and Prince of Wales Passages. Further north, transects will be run across Knight Island Passage and MS to determine the relative contributions from these areas. Physical and zooplankton sampling in the southwestern Sound will be conducted in close coordination with predator and juvenile salmon sampling.

Four vessels will be equipped with CTD instruments. Three of these vessels will intensively sample in western PWS, one being based in the southwestern region in close proximity to MS. One CTD in western PWS will be towed from a large mid water trawler on a fish that is also mounted with a fluorometer, optical plankton counter and a dissolved oxygen sensor.

One CTD will be mounted on a rosette for use in chemical oceanographic sampling. This instrument will be used both in the MS and HE/GOA regions, and will be deployed aboard a seining vessel, and occasionally on vessels of opportunity. The two other CTDs will be used for fine scale surveys in conjunction with salmon predation and growth studies in both the northwestern and southwestern Sound. The fine scale sampling is described below in a separate section. Initially one ADCP will be deployed aboard a vessel that will alternately sample in western PWS, concentrating on the region of outflow to the GOA (which includes MS). This vessel will also work frequently in HE and the adjacent GOA to characterize flow in the ACC, determine how much of this flow is deflected into PWS, and determine the shelf water contribution into PWS. ADCP backscatter will be used in conjunction with net sampling to determine densities of zooplankton in these regions. Chemical and biological sampling will provide data to assist in determining the advective regime and its source waters in the Sound in both time and space. Station spacing along transect lines within central PWS and the Gulf of Alaska will be approximately 5 km. Station spacing within HE and MS will be about 2 km. Later in the field season 2 ADCPs will be utilized, one aboard a vessel in western PWS and one in the HE/GOA region. This instrument (HE/GOA) will be used alternately aboard a vessel and in a self contained moored deployment within HE. The moored deployment is also anticipated to be used over the winter months to determine the flow field in response to intense atmospheric forcing, and the presence/absence of biological scattering layers . The principal and most intense sampling periods for CTD, ADCP and chemical measurements will occur from April through July, although measurements will also be made in the fall and winter months in order to determine how the regional oceanography and meteorology fits into the larger scale variability (i.e. interannual variability). The months of April and May will be sampled most intensively in HE, the GOA, MS and the central Sound, since the correlations observed between zooplankton abundance and atmospheric forcing are strongest during these months (Cooney and Salmon, unpublished data).

Meteorological data (sea level pressure, air temperature, humidity, wind speed and direction) will be obtained onboard of the sampling platforms, and will also be obtained in a nearly continuous fashion from meteorological buoys moored within PWS. These meteorological buoys will also be equipped with oceanographic sensors (fluorometer, thermistor chain) to augment the data obtained from the mobile sampling platforms. Satellite tracked drifting buoys will also be deployed in the Sound periodically in order to track surface ocean circulation patterns and their evolution throughout the year.

In terms of temporal sampling frequencies, routine sampling transects will be run on time scales of hours to weeks depending on the problem being pursued, for example physical measurements during daytime and nighttime transitions in feeding behavior will be conducted on time scales of hours, while changes in large scale advection will be determined on scales of days to weeks. There will also be an opportunistic, event driven component to the sampling regime that will maximize the flexibility and therefore optimize the conditions under which certain types of sampling occur. An example of event driven sampling in field investigations is in determining the advective regime and associated plankton assemblages before, during, and after the passage of major low pressure systems through the PWS/GOA region. Another example would be for intense sampling to occur during periods when large schools of predators are observed in PWS.

Vessels of opportunity will also be employed in obtaining large scale physical and biological oceanographic data in the SEA program. A tanker vessel makes a transit from Valdez, AK to Honolulu, HI once every three months. During the course of transit the vessel meridionally transects both PWS and the GOA. The data taken from the vessel have thus far included standard weather data and expendable bathythermograph (XBT) data. Expendable CTDs (XCTDs) could easily and productively be used in place of XBTs. The advantage of using XCTDs is that their data allow for discerning changes in the surface and deep salinity fields, as well as computation of the baroclinic geostrophic component of the oceanic circulation, both in PWS and the GOA, whereas XBTs only provide ocean temperature data. This convenient and (relatively) inexpensive source of gathering data will provide valuable information in terms of ocean state, particularly in relation to atmospheric forcing. Both the state ferries and the SERVS vessels can be instrumented to provide quasi-synoptic oceanographic and atmospheric data within PWS. It is envisioned that the SERVS vessels would be used for physical, chemical and biological data using CTD, ADCP, OPC, fluorimetry and possibly some nets for zooplankton and ichthyoplankton. Both the SERVS vessels and the state ferries would be used for XBT and XCTD work. The SERVS vessels will also be equipped with ADCP, as well as optical and sonar gear for biological data collection.

In addition to directly measured oceanographic and atmospheric variables, SEA physical oceanography will use prepared data products. In particular these will include satellite imagery when available (e.g. AVHRR, CZCS, and possibly SAR) large scale atmospheric pressure and downwelling index data for the North Pacific (available from Fleet Numerical Oceanographic Center, Monterey, CA). These data have been utilized in initial analyses of relationships between zooplankton and atmospheric/oceanic forcing (Salmon and Cooney, unpublished data). Large scale North Pacific sea surface temperature fields (available from Scripps Institution of Oceanography, La Jolla, CA) have been obtained on a periodic basis for updates and computations of anomalies over large regions of the North Pacific that have been identified in empirical orthogonal function analyses (cf. Weare et al., 1976; Kawamura, 1984; Namias et al., 1988; Wallace et al, 1990; Salmon, 1992). Aerial photography will also be employed to determine the large scale distribution of mesoscale features in the Sound, particularly tidal rips and shear zones (these are expected to be regions of large aggregations of biomass of both plankton and nekton).

Fine Scale Physical Oceanography

Western PWS Salmon Outmigration/Predation/Growth Study

Measurements of mesoscale and fine scale oceanographic features are essential for the thorough characterization of environmental conditions that constrain the growth and survival of the species being studied (pink salmon, their predators and their prey) in the western Sound during the 1994 SEA program. Closely spaced CTD measurements will be made in conjunction with ADCP sampling to elucidate the fine scale physical structure (e.g. thermocline, pycnocline, fronts, eddies, shear zones) within the western regions of the Sound, particularly in relation to the distributions of phytoplankton, zooplankton, juvenile salmon and salmon predators such as juvenile pollock and cod. These measurements will address physical conditions that characterize diel vertical migrations of these species. Two Seabird Seacat CTDs will be used in the characterization of fine scale structures. These instruments are highly portable and self contained and will be transferred back and forth between the larger seiners for offshore and nearshore work and the small skiffs for inshore measurements. The ADCP will principally be used for characterizing the large scale velocity field in western PWS, but will occasionally be deployed aboard the seiner or a small skiff for nearshore work, particularly in relation to characterization of velocity fields related to small scale frontal structures and nearshore tidal rips.

Integration of Large and Small Scale Physical Oceanography

The migratory pathway that the salmon utilize during their outmigration from the Sound will be characterized in terms of its physical (and biological) oceanographic structure. The problem of whether these animals utilize specific physical conditions and oceanographic structures during their outmigration will be addressed. This will be accomplished through the integration of large and small scale horizontal and vertical measurements made in western PWS. Aerial surveys and possibly satellite images will be used to facilitate oceanographic sampling of physical features (such as fronts and tidal rips) that are visible from the air (with either a visible or thermal signature).The sampling frequency will be highest during the months of April through June, with less frequent sampling in July and August. Horizontal spatial sampling scales will range from meters to kilometers and vertical scales will range from meters to hundreds of meters.

Large and small scale physical, chemical and biological data will also be assimilated into numerical models of the deep and surface circulation in the GOA and PWS. The modeling efforts are described under a separate project (Information Systems and Modeling).

Fall and Winter Oceanographic Measurement Programs

Winter surveys of both large and small scale physical properties and structures within the PWS/GOA region will be conducted in order to fit observed environmental conditions within the context of the very substantial interannual variability that governs the meteorology and oceanography of the North Pacific. In particular the physical transitions from El Niño to La Niña conditions will be documented in order to assess and predict changes in the structure and distribution of animal and phytoplankton assemblages in response to these environmental regime shifts. The nature and phasing of large scale long term temperature changes in PWS in relation to the (18.6 year) nodal tide will also be addressed. CTD, ADCP and chemical data will be used to characterize the overwintering environment for herring (and possibly other forage fishes such as pollock, tom and true cod, capelin, sandlance, and smoothtongue smelt). ADCP backscatter data will also be used to augment (net) measurements of zooplankton distribution and abundance. These measurements will dovetail with and provide temporal continuity for the ongoing NOAA forage fish study to be conducted during spring and summer months. Larval drift studies (herring in the ichthyoplankton stage) will be conducted using ship (and possibly satellite) tracked drifters. Physical and chemical properties of the water in which the plankton are adrift will be measured using CTD and standard chemical measurements.

Data Management

The SEA physical oceanography program will generate large amounts of data due to the length of the field season and the nature of the instrumentation used for observational sampling. *The management of the data is budgeted under a separate program* (Information Systems and Modeling) that will integrate the data collected in all SEA programs. It is critical to the success of the physical oceanography program (and all other components of SEA) that the data management be funded at an appropriate level. The approach taken here is non traditional in that data management is usually budgeted for within each component of a research program. It is anticipated that this new approach will allow for a fast turn around time on preparing the data for analysis by the field investigators and will also result in numerous data sets to be online in an easily usable and accessible format that will facilitate an integrated and interdisciplinary analysis of the data.

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5. Location:

Field research will be conducted in Prince William Sound and the North Gulf of Alaska. Data analysis will be completed at the PWS Science Center in Cordova and at the Institute for Marine Sciences/University of Alaska Fairbanks.

6. Technical Support:

Technical support for the physical oceanography program will consist of several subcontracts. These include: 1) System commissioning and startup support for two Acoustic Doppler Current Profiler systems, 2) Mooring conceptualization, building, and deployment in Hinchinbrook Entrance for a 150 kHz ADCP system. 3) Vessel charters (40 days) for work in Hinchinbrook Entrance and the Gulf of Alaska, and Montague Strait. 4) Integration, interpretation and technical scientific support.

7. Contracts:

Vessel charters will be contracted for 40 days of work in Hinchinbrook Entrance, the Gulf of Alaska and Montague Strait. The vessel contracts will be awarded through competitive bid. Contracts will also be necessary for system commissioning and start-up support for two Acoustic Doppler Current Profiler systems. These will be a sole source contract because there is only one manufacturer of these systems. Another contract will be let for mooring conceptualization, building and deployment in Hinchinbrook Entrance for a 150 kHz ADCP system. Additional contracts may be necessary for the integration, interpretation and technical scientific support. Competitive bidding will be used in all situations except in cases where only one manufacturer or technical support service is available.

D. SCHEDULES

Field Work will be initiated on April 1, 1994 and will be concluded on August 1, 1994. (See attached vessel schedule and schedules for salmon predation/growth/survival studies for detailed dates of anticipated field surveys.)

The Principal Investigator (David Salmon) will be in the field April 1- August 1, with intermittent days in port every 10 days to 3 weeks. After August 1 the PI will be based in Cordova for data analysis, draft and final report writing and journal publication preparation.

The Associate Scientist (Mark Johnson) will be in the field for about 1.5 months over the course of the field season, after which he will be based in Fairbanks and will work on analysis of observational data and development and implementation of numerical models for SEA.

The Technicians will be in the field between April 1 and August 1, with intermittent days in port. One technician will spend significant amounts of time in Cordova engaged in the editing and analysis of physical oceanographic data. After August 1, both technicians will assist the PI and Associate Scientist in the analysis of data, the preparation of draft and final reports, and the preparation of journal publications.

The Graduate Student will spend part of the spring and summer in the field assisting with data collection, and will be responsible for analyzing data that will pertain to a specific subproblem within the SEA program.
It is anticipated that data compilation and analysis will be begun within several days of the completion of the first field survey. This will be an ongoing assimilative process throughout the spring and summer. Near real time data will be edited by a full time staff of computer system and data managers under the direction of Dr. E. Vincent Patrick of the PWS Science Center and the University of Maryland. Dr. Patrick's staff will work in close coordination with Dr. Salmon and his field staff to have high quality data available for analysis, integration with other data sets compiled during the 1994 SEA field season and the production of draft reports beginning early in and continuing throughout the field season. This powerful approach to data management will also allow maximum flexibility to adjust the field sampling program to optimize the collection of field data to obtain sound scientific results.

Physical Oceanography/Zooplankton/Chemical Sampling Vessel Schedule for 1994

(Physical, chemical and zooplankton sampling will also be conducted aboard 3 other vessels in western PWS in association with salmon and predator growth/survival/predation studies)

April 17-20	Hinchinbrook/Montague Strait
April 26-29	Hinchinbrook/GOA/central Sound
May 9-12	Hinchinbrook/Montague Strait
May 22-25	Hinchinbrook/Montague Strait
June 1-4	Hinchinbrook/Montague Strait
June 12-15	Hinchinbrook/GOA/central Sound
June 23-26	Hinchinbrook/Montague Strait
July 8-11	Hinchinbrook/GOA/central Sound
July 19-22	Hinchinbrook/GOA/central Sound
July 29-Aug. 1	Hinchinbrook/GOA/central Sound

E. EXISTING AGENCY PROGRAM

No federal or state agency program currently exists that could be described as an ecosystem framework for studying resources in Prince William Sound and the EVOS region. For the physical oceanography component of the 1994 SEA field program, the PWS Science Center will contribute resources in the form of deep sea reversing thermometers and Nansen water sampling bottles. This equipment will be provided at no charge and will be used for the calibration of CTD measurements of ocean temperature and salinity.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

The only permits that could be necessary for the 1994 SEA program are those that would be required for mooring equipment near the tanker lane in Hinchinbrook entrance. The United States Coast Guard has been contacted and we have received their assurance that a joint and cooperative effort will be undertaken to ensure that the gear is deployed in a manner that will not interfere with any shipping operations in the region (Lt. Commander James Beckham, USCG, personal communication, 1994). The physical oceanographic program of SEA 1994 should qualify for a categorical exclusion in terms of NEPA compliance.

G. PERFORMANCE MONITORING

The chain of command is as follows:

Project Leader: Dr. David K. Salmon, Oceanographer PWS Science Center and University of Alaska (backup project leaders, Dr. Mark Johnson, Dr. Thomas Royer, University of Alaska)

Associate Scientist: Dr. Mark Johnson, Oceanographer, University of Alaska (backup associate scientists Dr. Thomas Royer, Dr. H. J. Niebauer, University of Alaska)

Technician
Technician
Graduate Student
(backup personnel for technicians will be drawn from a pool anticipated to be generated from the nationally circulated job advertisements for these positions, backup personnel for a graduate student would be selected from a nationally advertised pool as well)

The project leader will be responsible for project management and will delegate responsibility within the project as he sees fit. The project leader will in turn be responsible to his supervisor at PWS Science Center (Dr. G. L. Thomas).

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The SEA physical oceanography program will be closely coordinated with other components of the SEA field and modeling studies. All of the physical oceanographic field surveys will be conducted in conjunction with a combination of chemical oceanographic and phytoplankton sampling, zooplankton assessment and capture, and nekton (both juvenile and adult fish) assessment and capture. Also marine mammal and bird observers will be onboard some of the sampling vessels in coordination with projects 94102 (murrelet prey), 94159 (marine bird surveys) and 94173 (pigeon guillemot). The SEA program will be integrated with project 94163 (forage fish study) whenever possible and appropriate. Also the SEA program will be coordinated with ADF&G projects that relate to pink salmon and herring but were underway before the initiation of SEA planning efforts. These include projects 94166 (herring spawn deposition survey), 94184, 94185 (coded wire tagging studies), 94187 (otolith marking), and 94191 (oil related egg and alevin mortalities). In addition the field results from the physical oceanography program will be integrated into both numerical and analytical models of the PWS ecosystem that include oceanographic parameters and animal (and phytoplankton) distributions.

I. PUBLIC PROCESS

Sound Ecosystem Assessment (SEA) is an ongoing project with a mission to develop and advocate the best model for ecosystem research in Prince William Sound and the EVOS affected region. The concept of the SEA program has been in the region for several years, however only since August of 1993 has the plan been under intense development and come to fruition as a working document for guiding ecosystem level research in PWS and the EVOS region. The SEA Science Group consists of Scientists and Managers from the University of Alaska, Alaska Department of Fish and Game, PWS Science Center, U. S. Forest Service and PWS Aquaculture Corporation. There has been a tremendous amount of public input into the formulation of this project. Input has been received from Prince William Sound Communities Organized to Restore the Sound (PWSCORS), Cordova District Fisherman United, Cordova Aquatic Marketing Association and numerous Prince William Sound fisherman. A workshop sponsored by the EVOS Trustee Council and NOAA was held in Cordova Alaska during December of 1993 to peer review the SEA document and to further plans for coordinated and integrated ecosystem research in Prince William Sound and the greater EVOS affected region.

J. PERSONNEL QUALIFICATIONS

Project Leader: David K. Salmon Ph.D.
Oceanographer, Prince William Sound Science Center
Affiliate Assistant Professor, Institute of Marine Science, University of Alaska
Research and Development Coordinator PWS Oil Spill Recovery Institute.

Education:
Ph.D. 1992, Physical Oceanography, University of Alaska Fairbanks, Advisor T. C. Royer
B.A. 1985 Mathematics, Chemistry minor, Humboldt State University

Professional Experience:
1993-present Scientist at PWS Science Center
1993-present Affiliate Faculty Univ. of Alaska
1992-93 Postdoctoral Fellow Institute of Marine Science., University. of Alaska
1987-92 Research Assistant, Institute of Marine Science, University. of Alaska.
1985-87 Research Assistant, Dept. of Mathematical Sciences, University. of Alaska.

Field Experience in Prince William Sound and the Gulf of Alaska:
Participated in the collection of physical, chemical and biological data in PWS and the Gulf of Alaska during research cruises in these regions 1987-1991.
Collected physical, chemical and biological data during research cruises in PWS following Exxon Valdez oil spill 1989-90.

Selected Publications and Presentations:

Salmon, D. K. and C. P. McRoy 1994., Nutrient based tracers in the western Arctic: A new lower halocline water defined, in: *The Role of the Polar Oceans in Shaping the Global Climate*, American Geophysical Union.

Salmon, D. K. 1993. Long and short term climate driven processes that affect fisheries production in Prince William Sound and the Gulf of Alaska, EVOS Trustee Council/NOAA workshop on Ecosystem Research, Cordova AK December 1993, and Invited Public Lecture, Cordova AK, December 1993.

Oceanic Interdecadal Climate Variability, 1993. (co-authored with 10 others), International Oceanographic Commission of UNESCO, Technical Series Report #40.

Salmon, D. K. 1993. Aspects of the Meteorology of the Gulf of Alaska, Institute of Marine Science Technical Report, prepared for Arco Marine.

Salmon, D. K. and L. B. Tuttle, 1992. Variability in the physical environment of the North Pacific from the 1940s through the 1990s, abstract, Proc. American Fisheries Society.

Salmon, D. K. 1991. Changes in blocking activity over the North Pacific Ocean and its possible relationship to sea surface temperature, EOS, transactions of the American Geophysical Union.

Professional Memberships:
American Geophysical Union
The Oceanography Society.

K. BUDGET

Budget for SEA Physical Oceanography and Marine Meteorology Program

Table 1: Budget summary for the Physical Oceanography and Marine Meteorology program components of the SEA program in FY94 and FY95. The budget for FY95 may change as information from the first year of the study is applied to refine the methodology. Chemical oceanographic, phytoplankton and zooplankton sampling appear as separately budgeted components of SEA.

Line Item	FY94	FY95
Personnel	126.3	198.25
Travel	5.0	12.00
Contractual	105.0	125.00
Supplies	20.0	45.00
Equipment	340.0	50.00
Total	596.3	430.25
Indirect costs	61.51	76.05
Grand Total	657.81	506.30

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

Project Description: Sound Ecosystem Assessment- An Ecosystem Study of Prince William Sound Physical Oceanography (SEA-OCEAN) - a descriptive physical oceanography of Prince William Sound and the Northern Gulf of Alaska.

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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$0.0	$749.9	$749.9		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$749.9	$749.9	$0.0	
General Administration	$0.0	$0.0	$23.2	$23.2		
Project Total	$0.0	$0.0	$773.1	$773.1	$0.0	
Full-time Equivalents (FTE)	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
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

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1994

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Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
RSA with UAF and PWSSC to conduct a physical oceanography study in PWS		$749.9
Contractual Total	$0.0	$749.9

Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
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: Sound Ecosystem Assessment- An Ecosystem Study of Prince William Sound Physical Oceanography (SEA-OCEAN) - a descriptive physical oceanography of Prince William Sound and the Northern Gulf of Alaska.

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	$25.5	$25.5	$0.0	
Travel	$0.0	$0.0	$3.6	$3.6	$0.0	
Contractual	$0.0	$0.0	$70.4	$70.4	$0.0	
Commodities	$0.0	$0.0	$0.7	$0.7	$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	$0.0	$0.0	$100.2	$100.2	$0.0	
General Administration	$0.0	$0.0	$25.1	$25.1	$0.0	
Project Total	$0.0	$0.0	$125.3	$125.3	$0.0	
Full-time Equivalents (FTE)	0.0	0.0	0.7	0.7		
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Johnson, M.			1.0	$7.8
Technician			2.0	$8.5
M.S. Student			5.5	$9.2
Personnel Total	0.0	$0.0	8.5	$25.5

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

07/14/93

Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: University of Alaska - Fairbanks

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

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

Travel:	Reprt/Intrm	Remaining
2 round trips Cordova/Western Prince William Sound @ $500/trip		$1.0
Per diem - 6 days @ $125/day		$0.8
4 round trips Fairbanks/Cordova @ $465/trip		$1.8
Travel Total	$0.0	$3.6

Contractual:		
Vessel Charter (25days @ $1,400/day)		$35.0
Lease - ADCP and cable (2.9 months @ $8,600/month)		$24.9
Installation of thermosalinograph		$10.0
Long distance telephone charges		$0.5
Contractual Total	$0.0	$70.4

Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	Reprt/Intrm	Remaining
Paper and office supplies		$0.7
Commodities Total	$0.0	$0.7

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: University of Alaska - Fairbanks

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

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

Project Description: Sound Ecosystem Assessment- An Ecosystem Study of Prince William Sound Physical Oceanography (SEA-OCEAN) - a descriptive physical oceanography of Prince William Sound and the Northern Gulf of Alaska.

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	$112.3	$112.3	$198.3	
Travel	$0.0	$0.0	$3.8	$3.8	$12.0	
Contractual	$0.0	$0.0	$12.9	$12.9	$125.0	
Commodities	$0.0	$0.0	$11.0	$11.0	$15.0	
Equipment	$0.0	$0.0	$359.7	$359.7	$80.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$499.7	$499.7	$430.3	
General Administration	$0.0	$0.0	$124.9	$124.9	$84.1	
Project Total	$0.0	$0.0	$624.6	$624.6	$514.4	
Full-time Equivalents (FTE)	0.0	0.0	1.7	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
1 Physical Oceanographer			5.5	$32.8
1 Marine Engineer			3.6	$35.5
1 Technician			5.5	$22.0
1 Technician			5.5	$22.0
Personnel Total	0.0	$0.0	20.1	$112.3

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

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Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: Prince William Sound Science Center

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

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

Travel:	Reprt/Intrm	Remaining
1 round trip Cordova/Fairbanks @ $456/trip		$0.5
2 days per diem @ $140/day		$0.3
6 air charter trips Cordova/Western Prince William Sound @ $500/trip		$3.0
Travel Total	$0.0	$3.8

Contractual:		
Communications for real time data transmission and for communication between field personnel and Cordova		$5.0
Shipping (1%) and insurance (1%) for equipment		$6.4
Long distance telephone charges and facsimile		$1.0
Copying		$0.5
Contractual Total	$0.0	$12.9

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Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
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FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

EXXON VALDEZ TRUSTEE COUNCIL

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

Commodities:	Reprt/Intrm	Remaining
4 Mustang suits @ $250/each		$1.0
Floppy disks and accessories		$1.0
Statistics software		$3.0
Analytical Software		$2.5
Communications Software		$1.0
Marine hardware accessories		$1.0
Wet lab supplies		$1.0
Paper & Office supplies		$0.5
Commodities Total	$0.0	$11.0

Equipment:				Reprt/Intrm	Remaining
150 kHz direct reading broad band Acoustic		1 Chelea Instr. CTD-F, CTD & Flourimeter	20.0		$20.0
Doppler Current Profiler	64.2	1 Sea Bird underwater unit for 911 plus CTD	24.0		$88.2
1 ENDECO towing body	19.0	1 SBE 11 plus deck unit	5.0		$24.0
1 Towing cable	8.0	1 Modem and PCB interface	1.5		$9.5
1 ENDECO paravane system	7.0	1 SBE 32 Carousel	14.5		$21.5
1 EL - 1000 transducer adapter	4.0	1 Adapter for 5 liter Niskin bottle	0.4		$4.4
1 gyro interface	4.5	12 PVC Niskin Bottles - 1.7 liter @ $600/bottle	7.2		$11.7
1 Continental shelf broad band ADCP 150 kHz	53.0	2 Sea Cat CTD's & enhancements @ $9.4/each	18.8		$71.8
1 Direct reading capability	9.0	2 Deep Sea winches @ $18K/each	36.0		$45.0
1 Self contained end cap	1.0	3- 486 Computers for shipboard data acquisition	8.0		$9.0
1 Additional 30 MB recording capacity	3.0	1 Flourometer	15.0		$18.0
1 additional battery pack	7.5	1 Aandera current meter	10.0		$17.5
1 system Commissioning and ADCP training	4.0				$4.0
1 Acoustic release & buoy floats, lines for ADCP	15.1				$15.1
		Equipment Total		$0.0	$359.7

Project Number: 94320 - M
Project Title: Prince William Sound System Investigation
Sub-Project: Met/Phys. Oceanography
Agency: Prince William Sound Science Center

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

N

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project Title: Sound Ecosystem Assessment (SEA), An ecosystem research plan for Prince William Sound -- Nearshore Fish (SEA-FISH)

Project ID number: 94320 -N

Project type: Research/Monitoring

Name of project leader(s): Dr. G.L. Thomas

Lead organization: PWS Science Center

Cooperating agencies: University of Alaska Fairbanks
Alaska Department of Fish and Game
PWS Aquaculture Corporation
Copper River Delta Institute, USFS
U.S. Fish and Wildlife Service
National Biological Service
PWS Oil Spill Recovery Institute, NOAA

Cost of Project/FY 94: $ 571,400 (estimate; see detailed budget)
Cost of Project/FY 95: $ 624,400
Cost of Project/FY 96 and beyond: $ 358,800 + equipment + inflation

Project start-up/completion dates: March 1, 1994 to Sept. 30, 1995 (for FY94)

Geographic Area of project: Prince William Sound & North Gulf of Alaska

Name of Project Leader: Dr. G.L. Thomas, PWS Science Center

Name of Project manager: Dr. Jerome Montague, Alaska Dept. of Fish & Game

B. INTRODUCTION

1. The Problem

Paleoclimatic, botanical and zoological records reveal that the earth has historically experienced both gradual and abrupt changes as a consequence of natural processes (Huntley 1992). Today, many changes are thought to be the consequence of human intervention into the natural processes. As we work to gain control over our unsustainable uses of natural resources, we must recognize that shifts in the physical and geochemical environment can confound our efforts to evaluate, manage, enhance and restore nature.

By accepting that ecology is dynamic and undergoing continuous change, to determine and mitigate for anthropogenic impacts, it is important that we know the direction and magnitude of natural change that is occurring (Holling 1978). The concept of restoring an ecosystem to the numbers or biomass state that existed prior to a major anthropogenic event is ecologically unsound (Raven 1993). To address sustainability without implementing massive preservation practices, we must develop a better understanding of how the trophic structure responds to natural processes.

All animals in the sea are affected by the physics and chemistry of the water (Russel-Hunter 1976). The Sound Ecosystem Assessment Dynamics program, SEA, focuses on how the trophic structure that supports pink salmon and Pacific herring in Prince William Sound responds to climate forcing (SEA 1993). It is recognized that this trophic structure supports many other fish, bird and mammal populations of interest to the EVOS Trustee Council. The SEA program studies on the interactions between key organisms and their physical and biological environments are the first steps to improving our understanding of the PWS ecosystem.

2. The approach

SEA will be implemented by three interdisciplinary efforts: (1) large and fine scale, field studies on physical oceanography and plankton/nekton ecology, (2) applications and development of new technologies, and (3) mathematical modeling. The application of acoustic and optical technologies in the large and fine scale field studies, and the mathematical modeling are included in three proposals submitted by the PWS Science Center (SEAOCEAN, SEAFISH, SEADATA). SEAOCEAN and SEAFISH support several agency and university projects that address plankton, fish, bird and mammal problems. SEADATA supports: (1) the reduction and integration of quasicontinuous acoustic and optical data with discrete samples, (2) the modeling of physical and biological mechanisms, (3) analytical evaluations of new technologies, and (4) data simulation into the SEA model, which will provide other Principal Investigators working on complementary SEA projects large scale synoptic data on the physical and biological environment.

3. Justification

In 1993, the unexpected run failures of wild and hatchery pink salmon and Pacific herring (Funk 1993; SEA 1993) underscored the need to gain a more comprehensive understanding of how the fish populations are influenced by natural and anthropogenic perturbations in Prince William Sound (PWS). Responding to the outcry by commercial fishers and the communities of Prince William Sound, the Trustee Council funded the development a plan, Sound Ecosystem Assessment (SEA), to focus on the PWS fisheries ecosystem (SEA 1993).

The fisheries ecosystem that the SEA plan proposes to study is the nearshore and pelagic habitats along the migratory routes of juvenile pink salmon and herring in PWS (SEA 1993). New knowledge of the interacting predator, competitor and prey resources and the physical processes that limit production are expected to explain much of the variability in the recruitment of pink salmon and Pacific herring (Pearcy 1992).

The anthropogenic factor that is of paramount interest is the impact of the EXXON VALDEZ oil spill (Wolfe et al. 1993). Oiled animals cannot move or feed normally, and crude oil can alter physiology and genetics of individual organisms. Because the oil exposure and ingestion can affect prey, competitors and predators of pink salmon and herring, knowledge of the trophic structure is essential to determine impact. The number of possible prey, competitor and predator species, critical habitats and conditions suggest there are many mechanisms that operate simultaneously which contribute to oil spill impact (Holling 1978).

Confounding the cumulative impact of oil on PWS pink salmon and herring are other anthropogenic events (commercial fishing mortality and fish hatchery supplementation) and large natural fluctuations in marine productivity (Thomas and Mathisen 1993). Commercial fisheries have operated in PWS for over a century and hatcheries have been in operation for the last two decades. Because oil effects operate simultaneously with the other anthropogenic and natural effects, the impacts may not have to be immediate or continuous, but can appear abruptly, and sometimes long after the event (Holling 1978). Also, if the trophic structure or habitat was changed substantially by an event, shifts in the ecosystem productivity could result in something different from the original conditions (Westman 1985).

Holling states that it is unreasonable to measure all organisms within the ecosystem and suggested, "The parts of an ecological system are connected to each other in a selective way that has implication for what should be measured." (1978) Not everything in the ecosystem is strongly connected so unless there is good intuition that a causal mechanism between populations exists, linkages may never be found by statistical approaches or, those approaches may result in erroneous linkages (Green 1979). The SEA program has focused on hypothetical mechanisms that affect the pink salmon and Pacific herring, and their prey, competitors' and predators' growth and survival along their migratory route in the Sound.

4. The SEA model

Present single species population dynamic models are inadequate to predict animal abundance for management or conservation purposes (Cullen 1988). Models without trophic structure have limited use in the assessment of environmental impacts (Holling 1978). Since major changes and substitutions of species can take place within a trophic structure that maintains the same function or role, while changing the productivity of the system, measurement of ecosystem structure is important (Simon 1962; Holling 1978). The development of the SEA model will provide a more robust approach to evaluating the resiliency and reversibility (Westman 1985) of ecosystem impacts because it incorporates ocean and trophic state conditions in a mechanistic structure. Therefore, the causation for changes in abundance can be evaluated.

The SEA model was built upon a foundation of past research and monitoring conducted by researchers from universities and agencies. Like GLOBEC (1991a), this understanding and the assimilation of new data from acoustical and optical measurement technologies will be used to develop a first generation, PWS ecosystem model. Since the pink salmon and Pacific herring are dominant PWS fish populations, when combined with their co-occurring species, they are expected to represent most of the pelagic productivity of the Sound's ecosystem (SEA 1993). Once developed, the SEA model will be used for nowcasting[1] and short term forecasting of pink salmon and Pacific herring recruitment.

5. The SEA hypotheses

To understand anthropogenic or natural effects on the production of pink salmon and herring, SEA developed several hypotheses. The primary hypotheses of the SEA program concerns flushing of prey from the Sound (the river-lake hypothesis) and the switching by predators to larval fish when the macrozooplanktors are not abundant (the prey switching hypothesis). These are coupled hypotheses because when the flushing of PWS is high, the macro-zooplankton prey is low, which causes larval and juvenile fish predation to be high. Since flushing is positively correlated with storms, and stormy years are cold years, the physical growth conditions (temperature and currents) are also poor when there is limited prey.

Many researchers have proposed that multiannual, climate-driven cycles of three, five, seven, 14, 19.6 years have a dominant influence on marine productivity and fish recruitment (Trenberth 1990; Royer 1989, 1993; Brodure and Ware 1992; Salmon 1992; Thomas and Mathisen 1993). Shifts in predator populations as a response to climatic events have also been shown to have pronounced impacts on key marine fish populations (D.M. Ware, personal communication). Given the likelihood that natural, climate-driven cycles have a dominant influence on marine fish recruitment, the testing of the river-lake and prey-switching hypotheses as climate-driven mechanisms are prerequisites for impact assessment of oil, fishing and hatcheries.

6. The SEA field measurement program

Synoptic sampling of both the biological and physical characteristics of the water column and samplers that operate on quasi-continuous, spatial and temporal scales are essential if SEA is to link small scale process measurements to population and ecosystem parameters (Thomas 1992, GLOBEC 1991b). In response to this, the three core SEA projects, SEAOCEAN, SEAFISH and SEADATA incorporate the necessary acoustical, optical, measurement and computer intensive analytical and communication tools. Recognizing the rapid evolution of technologies, a small component of each SEA project will be the research

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[1] Nowcasting is the process of monitoring measurable variables (temperature, predator density, prey density) to predict in real time an unmeasurable variable such as fish survival.

and development of new hardware and software.

The SEA field program will utilize the conceptual experimental design of GLOBEC (1991c), which involves the nesting of fine scale measurement programs within large scale ecosystem monitoring efforts. Ocean state and prey monitoring will require large scale surveys in the: (1) eastern Sound, (2) western Sound, and (3) coastal buoyancy current, and fine scale studies in the: (4) Hinchinbrook Entrance, and (5) Montague Straits (Figure 1). Monitoring will require large scale and fine scale surveys in the western Sound, which is the primary migration route of pink salmon and Pacific herring.

7. Nearshore Fish - SEA-FISH

Although there are some long term databases on the commercially harvested fish populations, little is known about the plankton/nekton assemblage that resides in the Sound. Studies by Cooney (1986, 1987, 1993) have shown that the large oceanic calanoids and sometimes neritic harpacticoid copepods are the critical food sources for larval and juvenile fishes, but the euphausids which often form dense midwater layers throughout the Sound are an unknown quantity. Also, work by the Alaska Department of Fish and Game has shown that pink salmon and Pacific herring are dominant populations in the Sound, but sandlance, smelt and gadoid populations potentially represent even larger biomasses. Thus, at least along the migratory routes, SEAFISH needs to identify the dominant plankton and nekton, as well as assess their abundance, distribution and size to be able to address the SEA hypotheses.

SEAFISH will use underwater acoustics and optics, and aerial optics to map distributions and assess biomass of the fish and plankton assemblage in the Sound. Acoustic and optical targets will be subsampled with a variety of nets and optics to collect biological information. Underwater acoustic sampling will be conducted on both large and fine scales. Aerial optics will be used exclusively for large scale sampling.

Large scale sampling will define potential prey and predator fields along the pink salmon migratory route and in the juvenile Pacific herring rearing areas. This information will be collected simultaneously with the physical and biological oceanography to evaluate specific climate-driven hypotheses. The fine scale sampling will define the distribution and biomass of predators and prey, while tracking the migrating pink salmon. In most cases, acoustic information will be used to direct the net fishing efforts for biological information.

8. Expansion of SEA

SEA researchers have already developed cooperative sampling designs with Alaska Department of Fish and Game on sockeye salmon and harbor seals, the U.S. Fish and Wildlife Service on marble murrelets, pigeon guillemots, and kittiwakes, and the Copper River Delta Institute/U.S. Forest Service on gulls, sea ducks and shorebirds. Cooperative sampling with researchers on killer and humpback whales is pending and we are seeking an agreement with NOAA on forage groundfish assessments. Ultimately, we see listing the marine and terrestrial subsystems in the PWS comprehensive ecosystem model.

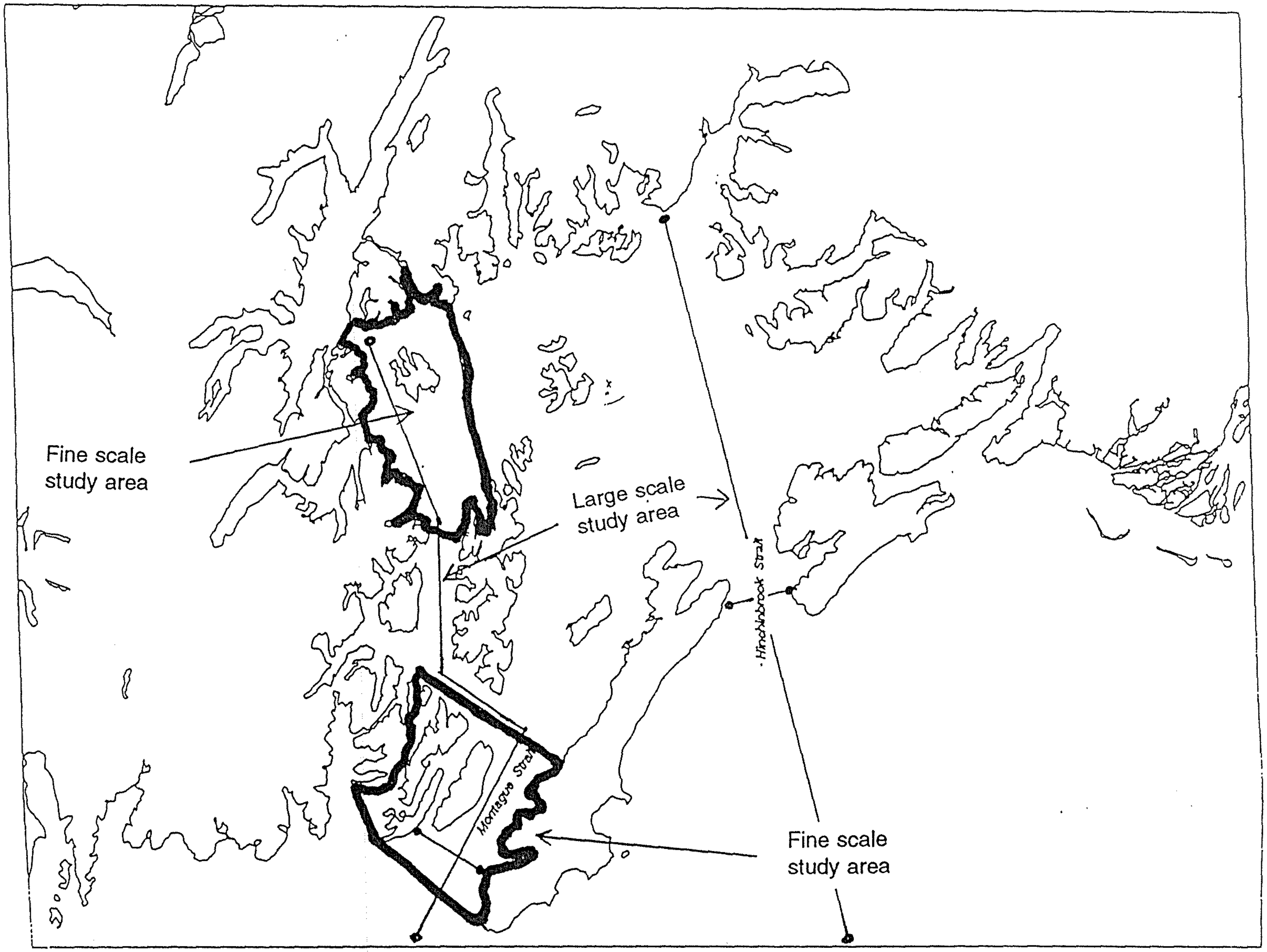

Figure 1: Large scale and fine scale study areas in Prince William Sound.

9. SEA Goals

The central scientific goals of SEA are: (1) to increase understanding of processes that determine the abundance of key animal populations in the Sound, initially pink salmon and Pacific herring have been chosen, (2) to develop and apply new methods and technologies for evaluating life history parameters of key marine populations important to evaluating the key species, and (3) to acquire the ability to predict how the abundance of key animal populations change.

Achieving these goals will ultimately address scientific and public concerns about the health of this valuable Alaskan coastal environment. Benefits will be first evidenced by having scientists and fishermen work together in the field, which will build public trust in scientific methods. This trust has waned in the aftermath of the spill. Second, ongoing, local, public education and outreach programs will be enhanced by having a comprehensive, locally available, scientific data base on the status of PWS resources. In addition, the availability of new information and technologies to acquire better information will allow improved harvest management strategies to be developed. Ultimately, better forecasts of fish production and improved predictions of fisheries responses to natural and anthropogenic perturbations will allow a policy of sustainability to be established. Sustainability is the insurance that local communities of the Sound need to protect their standard of living.

10. The next decade

Understanding the effects of climate change on the trophic structure that supports pink salmon and Pacific herring populations in the Sound will require multidisciplinary and multiorganizational effort. We can't ignore the processes any longer because the economies and life styles of the people in the Sound depend on assessment of these relationships. The SEA program will bring new ideas, instruments, and insights to scientists working to improve our recognition of ecosystem processes.

C. PROJECT DESCRIPTION

Knowledge of the effects of toxic chemicals on individual organisms is extremely useful to characterize the qualitative nature of impact that occurs with the introduction of a toxicant into the environment. However, to determine the quantitative impacts, an understanding of ecosystem-level interactions is essential. Westman (1985) presented four approaches that are used to study ecosystem level impact. They are listed here by the strength of the scientific method and logistic difficulty: (1) in situ, experimental manipulations of the natural ecosystem, (2) in situ, synecological studies of natural ecosystems along disturbance gradients, (3) in vivo, microcosm studies, and (4) in vitro, data assimilation into computer models of natural ecosystems, which can be subjected to disturbance by simulations.

The SEA program is offered a unique opportunity to take an ecosystem approach because of the operations of the PWS hatcheries, which release over 700 million salmon fry annually. Pilot field studies of predator response to hatchery releases were conducted using underwater acoustics at the Sawmill Bay, Esther and Cannery Creek facilities in 1992 and

1993. Therefore, the initial implementation of the SEA program will use hatchery releases as the experimental manipulation of the trophic structure supporting pink salmon. Synecological studies of the ecosystem along natural gradients and data assimilation into computer models are the approach that will be taken with both pink salmon and Pacific herring.

SEA's conceptual framework is similar to GLOBEC (1991c). The PWS pink salmon and herring populations fluctuate in abundance as the cumulative result of three processes: birth, mortality and transport. A simplified description of the population growth rate is:

$$dN/dt = \text{Birth rate} - \text{Death} - \text{Immigration} + \text{Emigration}$$

where,

- *Birth* is influenced by the numbers and condition of the parents and the environment at spawning,

- *Death* is influenced by the condition of the eggs or fish and the environment, which is primarily a function of growth and predator densities,

- growth = Consumption - (Respiration + Waste Losses), which are functions of food quantity and quality, competition, and condition of the fish and environment.

- *Immigration* is the transport (advection) or straying of fish (diffusion) into the population, which is primarily a function of the physical environment and the behavior of the fish,

- *Emigration* is the transport or straying of fish out of the population, which is primarily a function of the physical environment and the behavior of the fish.

The importance of general ocean state and the condition of the fish (population state) is emphasized since physical and physiology/behavior conditions affect each variable and their subvariables in time and space. The importance of trophic state is emphasized fewer times above, but can be dominant processes in the *dN/dt*. To understand the local rate of change in any pelagic population one must reliably quantify these processes. This is what SEA plans to accomplish and why large and fine scale nested surveys and new technologies are essential.

1. Resources and Associated Services:

The history of communities within Prince William Sound is closely linked, culturally, and economically, with the use of marine resources (Thomas et al. 1991). In particular, pink salmon and herring have historically supported the largest commercial fisheries in the region. These species are critically important to subsistence and recreational users of fishery resources in the Sound. They also provide a food source for many species of fish, birds, and mammals.

According to the EVOS Draft '94 Work Plan, pink salmon and herring currently show no sign of recovery nearly five years after the oil spill. Commercial, subsistence and sport users in

Cordova, Valdez, Whittier, Tatitlek, Chenega, Anchorage and other communities inside and outside Alaska depend on these resources and associated services. The depressed condition of these resources continues to effect the social and economic health of the resource users and communities in the Sound, and in the eyes of the public diminishes the value of these resources to levels below those that existed before the spill.

The Nearshore Fish project (SEAFISH) is an integral part of the SEA program. It will provide ecosystem level information, specifically on prey and predator abundance that influences the survival of pink salmon and Pacific herring populations in Prince William Sound. The SEAFISH information will assist the EVOS Trustee Council in planning future restoration efforts for these resources and associated services.

2. Relation to Other Damage Assessment/Restoration Work

Although designed around the dynamics of pink salmon and Pacific herring, the ecosystem approach of Nearshore Fish will result in information about the restoration of other injured resources throughout the oil spill area. SEAFISH will provide a better understanding of processes regulating the size of the pink salmon and herring spawning populations available to apex predators such as birds, marine and terrestrial mammals, and humans.

Initial collaborations in 1994 and further planning for work to be implemented beginning in 1995 will focus on expanding SEAFISH to address the roles of sea birds, marine mammals, and ecotoxicological factors in the marine system. Work has already begun to build connections with ongoing projects in these areas. The sampling design, technology and modeling efforts used in this study of Prince William Sound should also be transferable to other parts of the spill area, especially for sea birds and mammals.

3. Objectives

SEAFISH will provide large and fine scale trophic structure information to the SEA model where it will be integrated with ocean state and pink salmon or Pacific herring information. New information emerging from SEAFISH will contribute to a comprehensive data base for the fisheries of Prince William Sound. This information will serve the needs of the region for more informed management, enhancement, and mandated restoration activities. As a project within the multidisciplinary, integrated SEA program, SEAFISH will achieve the following objectives:

(1) Describe the macrozooplankton prey resource distribution and biomass in real time for allocation of net sampling. Combined with the catch and oceanographic data, this will be used to evaluate the river-lake hypotheses and availability of food for juvenile pink salmon and Pacific herring.

(2) Describe the fish predator distribution and biomass in real time for allocation of net sampling. Combined with the catch, macrozooplankton and oceanographic data, this will be used to evaluate the prey switching hypothesis.

(3) In collaboration with other EVOS researchers, integrate the SEAFISH research project with research on sea birds, mammals, other fishes, terrestrial ecology and ecotoxicology.

(4) Determine the relative recruitment of juvenile Pacific herring into the nearshore rearing areas and adult spawning population of PWS.

4. Methods

SEAFISH is a multidisciplinary study that will rely on: (1) cooperative, model development to assist in sampling design, data analysis and interpretation, (2) shared vessel and facilities for data collection and logistical support, (3) data sharing with the agency and university principal investigators, and (3) remote sensing with acoustical and optical technologies (Table 1). SEAFISH will rely heavily on the existing knowledge and skills of commercial fishers to prestratify surveys to areas preferred by the fishes, and for the capture fishes that are observed acoustically. Salmon hatcheries in the region will provide support for SEAFISH field crews and the hatchery releases of pink salmon will be treated as experimental manipulation of the nearshore Sound ecosystem.

The following methods will be used to address the specific objectives.

Objective 1 - macrozooplankton

The large scale distribution and information on density of the macrozooplankton will be measured using a high frequency scientific echosounder (HFSE), a 150 kHz acoustic doppler current profiler (ADCP) and an optical plankton counter (OPC). Initially, the program will use a 420 kHz dual beam or digital HFSE for macrozooplankton assessment, with 720 kHz as potential alternate. The BioSonics ESP software will be used to integrate the acoustic backscatter. IDL and AVS code will be developed on a workstation for visualization. The HFSE system will be deployed from the trawler and work the large scale western Sound transects.

Although developed for its current measuring capability, the ADCP backscatter has been used extensively to assess macrozooplankton distribution and density. The oceanographic project will deploy a towed ADCP system on the oceanography charter that transects the coastal buoyancy current, eastern Sound, western Sound, Hinchinbrook Entrance and Montague Straights (Salmon personal communication). This sampling will be paired with OPC, aquashuttle measurements to evaluate the use of this information for macrozooplankton assessment. On the western Sound transects, the 420 kHz HRSE measurements will be paired with the 150 kHz ADCP backscatter.

By arrangement, the ADF&G is providing the charter vessels and the OPC (Dana Schmidt). The information and modeling project specify the calibration and field engineering of the OPC system that will be mounted on an Aquashuttle towed vehicle (Patrick personal communication). The aquashuttle yo-yo's through the water column as it is towed by a vessel. By mounting the OPC on the shuttle, vertical distribution information on the size of macrozooplankton is obtained.

By arrangement, the University of Alaska Fairbanks researchers will provide the Bongo, RMT and vertical plankton nets and personnel to sample macrozooplankton. ADF&G and UAF will share responsibility to process zooplankton samples. The quasicontinuous, acoustical and optical information on the density of plankton will be used to direct net sampling and be shared among the individual researchers in the program.

Measurements of mesoscale and fine scale oceanographic features and trophic structure are essential for the thorough characterization of environmental conditions that constrain the growth and survival of pink salmon and Pacific herring in the Sound. In 1994, this effort will be concentrated in the western Sound; starting the sampling in April at the Esther hatchery, and ending the sampling in July at Montague Straits. The southward movement of the fine scale sampling is based upon a simulation of the spatial and temporal outmigration of pink salmon juveniles.

Simultaneous sampling with multibeam acoustics of plankton and nekton will be made to elucidate the fine scale physical and biological structure (e.g., thermocline, pycnocline, fronts, eddies, shear zones, plankton and fish aggregations). Water temperature, salinity, and turbidity will be measured simultaneous with the acoustic measurements. All data streams will be geotime coded using a global positioning system (GPS). The acoustics, water quality, navigational, and time data will be integrated through a graphical user interface, and data will be digitized and stored in the field on magnetic medium. Postsurvey processing of acoustic data will be conducted at the Science Center (Patrick personal communication).

As in the large scale sampling, subsampling and processing of plankton and fish catch data will be the responsibility of the University of Alaska Fairbanks (Cooney personal communication) and ADF&G (Willette personal communication), respectively.

Objective 2 - nekton

Large scale measurements of fish distributions will be made using BioSonics and Simrad 120 kHz dual or split beam HFSE, which may be supplemented with 38 kHz measurements. Initially, the program will use a 120 kHz dual beam, digital or split beam HFSE for fish assessment, with 38 kHz as potential alternate. The BioSonics ESP or Simrad ES software will be used to determine target strengths and integrate the acoustic backscatter. IDL and AVS code will be developed on a workstation for visualization. HFSE systems will be deployed from the trawler on the western Sound transects, and on two acoustic survey boats in the fine scale western Sound study areas.

By arrangement, the ADF&G is providing the charter vessels, nets and is responsible for processing catch information. The charters will be required to be equipped with search light sonars (typically Westmar manufacture). Operation of these sonars along acoustic transect lines allows for increased area swept along the transect line sampled by the scientific echosounder. Although this is a qualitative process, it is the only way to evaluate the contagiousness of fish schools in the study areas. In 1995, we plan to deploy a Simrad SD

570 electronic sector scanning sonar with the intent to develop a quantitative procedure to combine sector scanning and echosounding for fish stock assessment.

In 1994, a compact, airborne, spectral imager (CASI) or blue green laser (LIDAR) will be used systematically to map the distribution of fish schools along the western corridor of the Sound. This will be done in conjunction with the acoustic surveys to evaluate the capability of the aerial surveys to map large scale distributions of fish.

For the fine scale studies that track outmigrating pink salmon fry as they are released from the hatcheries, ADF&G is also providing two purse seiners, nets adequate to catch the smaller predators (100-200mm), and the crew to sample the net catches for biological information. In 1994, this effort will be concentrated in the western Sound; sampling will start in April at the Esther hatchery and end in July at Montague Straits. The southward movement of the fine scale sampling is based upon a simulation of the spatial and temporal outmigration of pink salmon juveniles.

Simultaneous sampling of plankton and nekton will be made with multibeam acoustics and nets to elucidate the fine scale physical and biological structure (e.g., thermocline, pycnocline, fronts, eddies, shear zones, plankton and fish aggregations). An ADCP will occasionally be deployed aboard the seiner or a small skiff for nearshore work particularly to characterize velocity fields of small scale frontal structures and nearshore tidal rips (Salmon personal communication). Water temperature, salinity, and turbidity will be measured simultaneous with the acoustic measurements. All data streams will be geotime coded using a global positioning system (GPS). The acoustics, water quality, navigational, and time data will be integrated using a graphical user interface, and data will be digitized and stored in the field on magnetic medium. Postsurvey processing of acoustic data will be conducted at the Science Center (Patrick personal communication).

Diel, tidal, weather, and seasonal patterns will be used to stratify sampling into comparable time windows. In the fine scale sample areas, a two-boat survey design (Thomas et al. 1978) will be used to assess zooplankton and fish. The first boat is used to conduct acoustic transects, while the second follows and samples fish targets observed by the first boat. Data will be recorded at both speeds, and the actual speed of transecting will be analytically determined for different nekton distributions.

A combination of side and downlooking sonar will be used to track juvenile pink salmon as they migrate southward along the shoreline of PWS. Visual observation and mini purse seining will be used to subsample the pink salmon for growth, feeding and tag recovery information. Subsampling will be the responsibility of ADF&G (Willette personal communication).

Although developed for its current and zooplankton measuring capability, the 150 kHz ADCP backscatter can be used to assess fish densities and distribution (David Salmon, personal communication). This will be evaluated on the oceanography charter that transects the coastal buoyancy current, eastern Sound, western Sound, Hinchinbrook Entrance and Montague Straits (Salmon personal communication). This sampling will be paired with the 120 kHz multibeam system on the western Sound trawler to evaluate the use of this information for fish assessment.

Objective 3 - birds, mammals, other fish

SEAFISH will collaborate with other EVOS researchers and integrate with research on sea birds, mammals, and other fishes. The large scale distribution and information on density of the macrozooplankton and fishes, and oceanographic data (current velocities and temperature), will provide valuable information to bird and mammal researchers. Bird and mammal observers will use visual, photographic, and video measurement techniques on the western Sound vessel and aerial transects. The USFWS will provide 2 observers and a 27 ft. Boston Whaler to serve as one of the acoustic survey vessels (David Irons personal communication).

Compact, airborne, spectrographic, imager (CASI), video and/or photographic techniques will be deployed to survey for events that create the formation of large patches of plankton, fish, bird and mammal concentrations. This surveying effort will be linked with the large scale distribution of mesoscale features in the Sound, particularly tidal rips and shear zones. It will be designed to test the tidal shuffle hypotheses, where large plankton/nekton/apex predator populations aggregate in cyclic fashion at specific locations due to tidal current velocities and shoreline or bottom morphology.

The aerial surveys and possibly satellite images (Eslinger personal communication) will be used to facilitate event driven sampling of physical and biological features (such as fronts, tidal rips and associated animals) that are visible from the air (with either a visible or thermal signature). These surveys will be conducted with small float planes along the western Sound migratory routes equipped with optical sensor systems. Data will be GPS linked, collected and processed by Science Center personnel (Scheel, personal communication). Qualitative records of events will be made available to all SEA investigators during or immediately after the flights.

By arrangement, USFWS, ADF&G, NOAA, UAF and the Science Center will develop a proposal to expand the SEA-FISH program to complement the forage fish project. There are also specific projects which routinely conduct surveys and overflights of the region, such as the Coghill Lake Sockeye salmon enhancement project, the marine mammal census by the National Marine Fisheries Service (NMFS) and independent scientists, and bird and mammal population surveys being conducted by the USFWS. We will pursue cooperation with other entities by subcontract where ever opportunities for sharing field logistics are cost efficient.

Objective 4 - Pacific herring nursery areas

The information on Pacific herring recruitment suggest that events in the juvenile nursery area of the Sound could influence recruitment into the adult population. Nearshore surveys to determine overwinter stock density and co-occurring species will use the two-boat survey method described under objective 2 - nekton assessment. Because of the unknown distribution of Pacific herring juveniles, only reconnaissance surveys are planned in 1994.

Integration of Large and Small Scale Measurements

The migratory pathway that the salmon utilize during their outmigration from the Sound will be characterized in terms of its physical and biological structure. Whether these animals respond to general or specific physical and biological conditions during their outmigration will be addressed. This will be accomplished through the integration of large and small scale horizontal and vertical measurements made in western PWS.

SEAFISH will generate large amounts of data due to the length of the field season and the nature of the measurement instrumentation. The management of the data is budgeted under a separate program (SEADATA - Information Systems and Modeling) that will integrate the data collected in all SEA programs (Patrick personal communication). Under this task, the large and small scale physical, chemical and biological data will be assimilated into numerical models. This task is critical to the success of the SEA as well as SEAFISH.

The approach taken here is non traditional in that all data management is usually budgeted for within each component of a research program. In SEA, large scale data are collected for all researchers as a service to integrate their fine scale programs with the surrounding ecosystem. Having the large scale data analyzed in this fashion should minimize the time necessary for the reporting of more complex information. The integration of data sets may also allow for several fine scale data sets to be online and accessible. The integrated interdisciplinary, interorganizational nature of SEA and the scale of sampling require that an information management and modeling effort be conducted to maintain communication between parties and the scientific community.

The acoustical, physical, spatial and temporal data will be collected simultaneously and integrated utilizing a navigational track plotter and graphic user interface. Most equipment are operated and data are logged by software from a 486, personal computer. Most data will be stored on optical or magnetic disks, displayed in real time on a color printer, and some data will be processed in real time. Preprocessing of the data will be with BioSonics and Simrad software, which provides echograms, electronic maps of track lines, in-situ target strength, echo integration and counting capabilities. After the data are appropriately scaled, they will be transferred to the Science Center's geographic information system and stored in the appropriate format for post processing (ARCINFO, IDL, AVS). The Center's GIS mapping, visualization and analytical software will be run on Sun workstations.

Post processing of echo-counting, echo-integration, target strength determination, patch size determination, and biomass estimation will be done in accordance to standard techniques (Traynor and Erenberg 1988, Thorne 1981, etc.). Acoustic, physical, ground truth, and seasonal measurements will be used to develop discriminate functions for patch identification (Rose 1991). GIS will be used to map and overlay nekton patches and physical conditions to develop specific hypotheses about their relationship.

Initial simulation modeling of pink salmon and herring populations in Prince William Sound will include assessments of ocean state, plankton dynamics, predators and prey abundance and size. The short term objective of the modeling will be to nowcasting and to make short term forecasts. Sensitivity and risk analysis approaches will be used to prioritize tasks, such as choice of sampling protocols to resolve biological and physical questions.

Regional database

A data base and archival/retrieval system will be developed so that the results of SEA are accessible to the agencies responsible for restoration in Prince William Sound. This system will be a tool for improving resource harvest strategies, forecasting, management, enhancement and education in the spill-impacted area.

A necessary component of this database will be interaction with or creation of a database of pertinent historical information (pre and post spill) already available on the ecosystem, with particular attention to EVOS-related research. Geographic visualizations and analyses, data listings, reports, and other services will be available as part of the SEA data base and management system. Predictive and "what if" scenario modeling tools, computer, communication, and library facilities will be available to assist in conducting SEA programs and to aid in restoration design and implementation, and resource management.

Integration with other studies

Since the selection of dominant species as key populations (Pacific herring and pink salmon) in Prince William Sound is a way to best represent the pelagic-nearshore ecosystem, it allows for successful integration with many of the ongoing apex predator studies in the region, regardless of oil-spill relationship. Nearly all pelagic-nearshore, apex predator populations are subject to the same ocean state conditions and dependent upon the dominant species, and/or the prey and predator populations that are monitored on the large scale. Thus, whether bird or mammal, the integration of apex predator studies with SEA is the efficient and most meaningful approach to improving ecological studies in the region.

There are no sharp boundaries between the pelagic-nearshore, intertidal ecosystems and the marine and terrestrial ecosystems. They are linked by the transfer of carbon and nutrients via the migrations of animal populations that feed on marine production. There are exciting areas of future cooperation and an expanded ecosystem studies program that can lead to a link of the SEA program with terrestrial resource ecosystem evaluations (TREE), or SEA TREE.

Table 1: Acoustic and target sampling vessel, equipment and personnel for SEA Program in 1994

Vessel	Activity	Equipment	Personnel
Trawler	Ocean State Plankton Dynamics Juv. Salmon Predators	CTD, Doppler Nets, Water Bottles Acoustics (2 frequencies for plankton/nekton), Mid-water Trawl CTD winch & boom	1 Phys. Oceanographer 1 Biol. Oceanographer 1 Acoustic Technician 1 Fish Biologist 1 Marine Bird/Mammal Observer
Seiner #1	Ocean State Plankton Dynamics Juv. Salmon Predators	CTD Ring net Acoustics, Seines/Gillnets	1 Oceanographer Tech. 2 Fish biologists
Acoustic #1	Fish Birds Mammals	Acoustics	1 Boat driver 1 Bird/Mammal Obs. 1 Acoustician
Seiner #2	Ocean State Plankton Dynamics Juv. Salmon Predators	CTD Ring net Acoustics, Seines/Gillnets	1 Oceanographer Tech. 2 Fish biologists
Acoustic #2	Fish Birds Mammals	Acoustics	1 Boat driver 1 Bird/Mammal Obs. 1 Acoustician
Phys. Ocn. Vessel	Currents Plankton Dynamics	CTD, Water Bottles Nets	1 Phys. Oceanographer 2 Biol. Oceanographers

5. Location

This project will be conducted within the EVOS impacted area in Prince William Sound and the waters immediately adjacent to this region. Prince William Sound is an ideal location for such a long term ecosystem study. The Sound is a semi enclosed basin, of tractable size, and suitable for sampling with small vessels. Because of fundamental similarities in the structure of northern pelagic ecosystems and the unexplained declines in seabirds and marine mammals in the north Pacific, an ecosystem study for Prince William Sound could serve as a model for understanding the ecosystem dynamics in other areas.

Siting of the SEA program in Cordova is both efficient and practical since the logistics of travel and freight are enhanced by daily jet service. Of critical importance is the easy access to the Sound on a year around basis from the protected Orca Inlet, Cordova. These logistics explain some of the reasons all of the following entities chosen to locate in Cordova: a major fishing fleet, the Alaska Department of Fish and Game, the U.S. Forest Service, the Copper River Delta Institute, the Prince William Sound Science Center, the Prince William Sound Aquaculture Corporation, the Hazardous Substance Spill Technology Review Council, and the Prince William Sound Oil Spill Recovery Institute. Cordova also serves PWS with an educational outreach program that ties the people and communities together.

6. Technical Support

The SEA science community is interdisciplinary and unique to the Trustee process in that it involves collaboration between nonprofit research organizations (the University of Alaska Fairbanks, PWS Science Center, PWS Aquaculture) and government agencies.

The Science Center has put together a multidipisciplinary team of scientists from several universities who are well versed in acoustical and optical technologies, physical and biological oceanography, quantitative aquatic ecology, population dynamics and mathematical modeling. Through their combined experience in aquatic research, the Center's science network brings expertise from throughout North America. This integration of technology and science is critical to effectively study and understand the structure and dynamics of the Sound ecosystem. Establishment of a coherent approach for SEA issues, especially to quantify the physical environment and its relation to the distribution of organisms in the Sound, will require the best measurement and analytical technologies.

Technical support for the acoustics will be supervised by Dr. G.L. Thomas. Robert DeCino, staff biologist, has conducted acoustic surveys at the PWSAC hatcheries, overwintering Pacific herring and Coghill Lake sockeye salmon. Jay Kirsch, electrical engineer, has been with the Chesapeake Bay Biological Station and writes IDL and AVS code for processing acoustic data on workstations. Dr. Vince Patrick, mathematician/physicist, is affiliated with the Advanced Visualization Laboratory at the University of Maryland and is an expert in modeling, data visualization and assimilation.

7. Contracts

The Advanced Visualization Laboratory at the University of Maryland, will be contracted for hardware and technical support for data processing and analysis. Dr. Richard E. Thorne, BioSonics Inc., will be contracted for hardware and software applications and backup field support for digital and dual beam acoustics. Consulting firms will bid for supplying technical support for the aerial remote sensing efforts. Acoustic survey vessels will be leased on a competitive bid basis.

8. Future planning

In addition to the SEA concepts, the PWS bioregional planning effort received overwhelmingly support from outside reviewers at the December 1993 workshop held in Cordova. It was recognized that the implementation of SEA as a large scale, long term ecosystem research program will require continual planning by local organizations and communities. This bioregional effort is proposed as the planning project, SEAPLAN.

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D. SCHEDULE

SEA hypothesizes that recruitment success of pink salmon and herring populations is related to losses due to physical processes and to predation during early life stages that occur within the Sound (SEA 1993). These hypotheses provide a means to focus the field efforts on those parts of the ecosystem that support these critical life stages. Thus, the juvenile Pacific herring and pink salmon rearing environments define the primary areas of study (Figure 1). The migration route and timing of pink salmon juveniles out of the Sound and release of fry from the hatcheries is well known. For Pacific herring, this is not the case so some basic work will be needed to determine the juveniles movement into nearshore rearing areas.

1. Biological timing

Previous studies of the Sound indicate that the important early portions of the marine production cycle are tightly compressed in time around the months of April and May (Cooney 1986). During this period, massive, upper layer, stocks of large zooplankton arise from the deeper water to graze on a short-lived diatom bloom. Herring spawning and both the wild and hatchery-reared pink salmon outmigration occurs at this time as well. SEA hypothesizes that the success or failure of a pink salmon depends on ecosystem level conditions at this time. Again, this picture is not as clear for Pacific herring whom migrate to the nearshore areas and rear for several years before recruiting into the adult population.

The principal sampling period will occur from April through July (Tables 2 and 3), although measurements will also be made in the nearshore areas of PWS in the fall and winter months to answer questions relevant to the overwintering Pacific herring growth and survival and ambient salmon predator densities (tba). The months of April and May will be sampled most intensively since the correlations observed between zooplankton abundance and atmospheric forcing are strongest during these months (SEA 1993).

2. Adaptive or event driven sampling

Routine sampling along transects will be run on time scales of hours to weeks depending on the problem being pursued. For example physical measurements during daytime and nighttime transitions in feeding behavior will be conducted on time scales of hours, while changes in large scale advection will be determined on scales of days to weeks. There will also be an opportunistic, event driven component to the sampling regime that will maximize the flexibility and therefore optimize the conditions under which certain types of sampling occur. Examples of event driven sampling are determining the advective regime and associated plankton and fish assemblages before, during, and after the passage of: (1) the juvenile pink salmon outmigration, (2) major low pressure systems through the PWS/North Gulf of Alaska region, or (3) when unexpected large aggregations of macrozooplankton or schools of fish are observed in an area.

3. Future timing

SEA is a long-term ecosystem project to be implemented in three phases: (1) an initial 1-2 year phase of preliminary modeling, planning, and field surveys that involve model development, technological research and field reconnaissance; (2) an intensive 4-5 year phase of field research that is supplemented with microcosm and laboratory studies focussed on production and trophic interactions, and model testing and improvement; and (3) an extended phase of routine monitoring and model validation, and perhaps involving adaptive management manipulations of stocking and harvest practices. Initial studies should commence in 1994-95 with this proposal.

A generalized annual schedule is: (1) January to March - staging for the field season, (2) March to April 1994 - surveys of Pacific Herring spawning, (3) April to July 1994 - surveys of juvenile pink salmon outmigration, (4) August to September - juvenile Pacific herring and forage fish nearshore surveys, (5) September to February - data analysis, (6) October to March - Pacific herring overwintering surveys, (7) November - macrozooplankton overwintering survey, (9) December - annual reporting, (10) January - SEA Workshops for outside review and presentations, Cordova.

4. Terms of performance.

This is to be a fixed price grant with quarterly progress reports and the fourth quarter report being the annual report. Each report will be accompanied by an invoice for expenses (Table 4). Figure 2 presents the 1994-95 and 1996+ tentative time schedules.

Table 2: Schedule for Physical Oceanographic Vessel in 1994.

Date	Activity
April 17-20	Hinchinbrook/Montague Strait
April 26-27	Hinchinbrook/GOA/Central PWS
May 9-12	Hinchinbrook/Montague Strait
May 22-25	Hinchinbrook/Montague Strait
June 1-4	Hinchinbrook/Montague Strait
June 12-15	Hinchinbrook/GOA/Central PWS
June 23-26	Hinchinbrook/Montague Strait
July 8-11	Hinchinbrook/GOA/Central PWS
July 19-22	Hinchinbrook/GOA/Central PWS
July 29-Aug. 1	Hinchinbrook/GOA/Central PWS

Table 3: Schedule for Predation Rate and Predator Distribution Surveys

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
August - March	Nearshore Surveys

Table 4: Schedule of payments and deliverables, 1994-95

Deliverable	Date Due	Amount
Progress report #1	3/31/94	$ 391,400*
Progress report #2	6/30/94	$ 100,000
Progress report #3	9/30/94	$ 50,000
Progress report #4	12/31/94	$ 50,000
Progress report #5	3/31/95**	$ 400,000*
Progress report #6	6/30/95	$ 100,000
Progress report #7	9/30/95	$ 50,000
Progress report #8	12/31/95	$ 50,000

* includes startup costs for equipment
** 1995 costs are preliminary estimates

Figure 2: Time Schedule for SEA FISH, 1994 and 1995 and beyond

Year 1 - 1994

```
month
(across)                    2  3  4  5  6  7  8  9

1. hire staff               s-------c
2. purchase equipment       s-------c
3. assemble and field
   test equipment              s----------------c
5. reconnaissance              s---c
6. monitoring                    s-----------------------*
7. data reduction                  s--------------------*
8. data analysis                       s-------------*
9. reporting and invoices     #1          #2          #3
```

* dependent upon continuation of SEA

1995 and beyond

```
month
(across)                    10 11 12 1  2  3  4  5  6  7  8  9

1. monitoring               s------------------------------------------c
2. reporting                       #4       #5         #6       #7
3. workshops                           *
```

E. EXISTING AGENCY PROGRAMS

1. Related Studies in the EVOS 1994 Draft Work Plan.

Besides the projects incorporated in SEA, others will benefit from interaction with ongoing EVOS Trustee sponsored projects, most notably those listed here. We expect that many of these projects could be profitably informed by the results of the SEA program as well. Some support is requested in this proposal to conduct research complementary to several of these studies in collaboration with the investigators on those projects (work proposed here is complementary to, rather than overlapping with, work proposed in the projects listed below).

94064	Harbor seal habitat use and monitoring
94070	Restoration of high intertidal fucus
94083	Monitoring of oiled and treated shorelines
94086	Herring Bay experimental and monitoring studies
94102	Marbled murrelet prey and foraging habitat in PWS
94147	Comprehensive monitoring program
94159	Marine bird and sea otter boat surveys
94163	Forage fish influence on injured species.
94165	Herring genetic stock identification, PWS
94166	Herring spawn deposition, reproduction
94184	Coded wire tag recoveries of pink salmon
94185	Coded wire tagging of wild pink salmon
94187	Otolith marking of pink salmon
94189	Pink salmon stock genetics
94191	Pink salmon egg mortality
94192	Evaluation of hatchery straying
94244	Harbor seal and sea otter co-op subsistence harvest assistance

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

SEAFISH will not cause a significant environmental impact and, therefore, should qualify for a categorical exclusion from the requirments of the National Environmental Policy Act.

G. PERFORMANCE MONITORING

An internal quality assurance and control program will be instituted through the modeling and data management project. Independent review of performance will be conducted continuously by the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG) board and at specific times via annual reports and workshops. Such review, begun in the December 1993 workshop, will work with the planning project to guide further development of the ecosystem research program, and ensure that the studies are integrated.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The SEA-NFISH project will be closely coordinated with SEA-OCEAN (Oceanography) and SEA-DATA (Information and modeling) for large scale data acquisition and analysis. NFISH will be integrated with pink salmon growth and survival and encompass overwintering herring survival studies. Other apex predator studies, marbled murrellets, pigeon gullimots, and harbor seals will be cooperatively sampling in the field. Where possible, NFISH will supply support for counting marine mammals and birds on plane and air transects where fish assessments are being conducted.

I. PUBLIC PROCESS

The SEA plan was developed by the people in PWS for PWS. The initial formation of a planning group was between the Alaska Department of Fish and Game, Cordova District Fishermen United, PWS Aquaculture Corporation, PWS Science Center, the PWS Oil Spill Recovery Institute and concerned fishermen. When news of the long-term ecosystem planning effort spread, the group expanded by the addition of representatives from the City of Cordova, the Eyak Corporation, the PWS Conservation Alliance, Cordova Aquatic Marketing Association, the University of Alaska Fairbanks and numerous concerned citizens. This effort later was joined by the PWS Communities Organized to Restore the Sound (PWSCORS) which includes Chenega Bay, Tatitlek, Valdez, Whittier, and Cordova. The expanded group was named the PWS Fisheries Ecosystem Research Planning Group (PWSFERPG).

The SEA plan incorporates what the people in PWS feel is important to know to protect their future quality of life in the Sound. The magnitude of the oil spill settlement and lack of tangible evidence of progress toward understanding the ecosystem has brought the regional public together to work as planners for their ecosystem. This process has been awkward for the traditional decision making structure to accommodate, but the rewards in bringing the people of the region into the decision making process are long term and offer the best way to implement ecosystem conservation practices.

J. PERSONNEL QUALIFICATIONS

G.L. Thomas, Ph.D., President and Director, Prince William Sound Science Center; Director, Prince William Sound Oil Spill Recovery Institute, P.O. Box 705, Cordova, AK 99574, (907) 424-5800, FAX 424-5820, Home 424-3117. **Education:** Ph.D. (Fish/1978/Univ. of Washington), MS (Zoo/1973/San Diego), B.A. (Bio-Chem/1970/CalWest). **Professional Experience:** 1990-present: PWS Science Center; 1973-89: student/research staff/faculty, University of Washington; 1971-73: research staff, Scripps Institute of Oceanography. **Publications:** 33 journal and peer reviewed papers, 11 proceedings papers, 56 technical reports and editor of two dedicated journal issues. **Selected publications:** Thomas, G.L. and Ole Mathisen, 1993, *Biological interactions between enhanced and wild salmon in Alaska.* 18(1-2):1-19. Fisheries Research. Thomas, G.L. 1992. *Successes and Failures of Fisheries Acoustics - An International, National and Regional Perspective.* 14:95-105. Fisheries Research. Thomas, G.L., Backus, E.H., Christensen, H.H.. and Weigand, J. 1991.

Prince William Sound/Copper River/North Gulf of Alaska Ecosystem. James Dobbin Associates, Alexandria, Virginia, 15 pp. Thomas, G.L. and Jackson, Darrell R., 1987. *Acoustic measurement of fish schools using array phase information.* Canadian Journal of Fisheries Aquaculture Science 44(9):1544-1550. **Research Projects:** >50 projects as principal investigator, >$5 million. **Teaching:** >20 graduate students, 4 Ph.D.'s. **Societies:** American Fisheries Society (life), AAAS, AFIRB, PFB. **Professional Panels:** NURC, NAML-WAML. **Affiliation:** Faculty, University of Alaska Fairbanks (IMS).

Vincent Patrick, Ph.D., Research Associate, Institute for Systems Research and the Advanced Visualization Laboratory, University of Maryland, College Park, Maryland 20742. **Education:** Ph.D., 1987, Mathematics, University of Maryland; M.S., 1982, Mathematics, University of Maryland; B.A., 1967, Physics, Thiel College. **Professional Experience:** 1993-present, Res. Assoc., Institute for Systems Research, UMD; 1992-93, Res. Sci., Chesapeake Biological Lab, UMD; Computer systems administration, visualization, mathematical modelling, Chesapeake Bay blue crab winter survey (with B.J. Rothschild, J.S. Ault). 1991-92, Res. Assoc., Astronomy, UMD; Start up of the Advanced Visualization Lab. 1988-91, Res. Sci., Chesapeake Biological Lab, UMD; Underwater acoustics (Lake Michigan, Chesapeake Bay), development of visualization resources for marine applications, mathematical modelling (with S.B. Brandt, D.M. Mason). 1968-82, Night Vision & Electro-Optics Lab, U.S. Army; image intensifier development. **Selected Publications:** D.M. Mason, E.V. Patrick, A model for the space-time dependence of feeding for pelagic fish populations, *Trans. Am. Fisheries Soc.*, 1993 in press. B.J. Rothschild and E.V. Patrick, Generation of a phytoplankton maximum in a grazing-extended logistic model, *Fisheries Oceanography*, 1993 in press. S.B. Brandt, D.M. Mason, E.V. Patrick, Spatially explicit models of fish growth rate, *Fisheries,* 17(2):23-35, 1992.

Robert D. DeCino, Aquatic Ecologist, Prince William Sound Science Center, P.O. Box 705, Cordova, Alaska 99574. **Education:** Masters of Science 1992, Utah State University, Aquatic Ecology, Logan Utah; Bachelor of Science 1986, Colorado State University, Fort Collins Colorado. **Professional Experience:** 1993 - present PWS Science Center; 1990-1992 student Utah State University; 1986-1989 Computer Systems Engineer, IBM Corporation, Anchorage, Alaska; 1982-1986 student Colorado State University.

Jay Kirsch, Electrical Engineer, Prince William Sound Science Center, P.O. Box 705, Cordova, Alaska 99574. **Education:** Bachelors of Science in Electrical Engineering, 1991, SUNY, T.J. Watson School of Engineering, Binghampton. **Professional Experience:** 1994-present PWS Science Center, 91-94 Chesapeake Biological Laboratory, created software to process bioacoustical, geographical and physical data, 90-91, General Electric, Software systems engineer, 87-91, Music Dept., SUNY, Sound engineer. **Selected Publications:** Brandt, S.B., and Kirsch, J., Spatially-explicit models of striped bass growth in the mid-Chesapeake Bay, *Transactions of the American Fisheries Society,* In press 1994.

K. BUDGET

Budget for SEA Nearshore Fish Program

Table 5: Budget summary for the salmon predation component of the SEA program in FY94, FY95 and FY96 and beyond, less equipment. Budgets for FY95 are subject to revision as the SEA and SEA-FISH program develops.

Line Item	FY94	FY95	FY96 and beyond
Personnel	188.4	198.7	207.6
Travel	11.8	13.7	14.9
Contractual	40.6	43.5	45.8
Supplies	18.4	20.4	21.7
Equipment	269.8	282.5	tba*
Direct costs	529.0	558.8	290.0
Indirect costs	62.4	65.6	68.8
Total Costs	**59.1.4**	**624.4**	**358.8***

*equipment costs are to be determined

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

Project Description: Sound Ecosystem Assessment - Nearshore Fish (SEA-FISH) - will use underwater acoustics and optics, and aerial optics to map distributions and assess biomass of the fish and plankton assemblage in Prince William Sound. SEA-FISH will provide large and fine scale trophic structure information to the SEA model where it will be integrated with ocean stated and pink salmon or Pacific herring information.

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	$0.0	$0.0	$189.7	
Travel	$0.0	$0.0	$0.0	$0.0	$56.7	
Contractual	$0.0	$0.0	$645.8	$645.8	$13.0	
Commodities	$0.0	$0.0	$0.0	$0.0	$14.7	
Equipment	$0.0	$0.0	$0.0	$0.0	$313.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$645.8	$645.8	$587.1	
General Administration	$0.0	$0.0	$21.1	$21.1	$65.8	
Project Total	$0.0	$0.0	$666.9	$666.9	$652.9	
Full-time Equivalents (FTE)	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
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: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
RSA with UAF to conduct the nearshore fish study		$645.8
Contractual Total	$0.0	$645.8

Project Number: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
Agency: AK Dept. of Fish & Game

FORM 3B SUB-PROJECT DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

07/14/93

1994

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Project Number: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
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: Sound Ecosystem Assessment- Nearshore Fish (SEA-FISH) - will use underwater acoustics and optics, and aerial optics to map distributions and assess biomass of the fish and plankton assemblage in Prince William Sound. SEA-FISH will provide large and fine scale trophic structure information to the SEA model where it will be integrated with ocean stated and pink salmon or Pacific herring information.

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	$167.8	$167.8	$189.7	
Travel	$0.0	$0.0	$51.5	$51.5	$56.7	
Contractual	$0.0	$0.0	$11.7	$11.7	$13.0	
Commodities	$0.0	$0.0	$14.7	$14.7	$14.7	
Equipment	$0.0	$0.0	$270.9	$270.9	$313.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$0.0	$516.6	$516.6	$587.1	
General Administration	$0.0	$0.0	$129.2	$129.2	$65.8	
Project Total	$0.0	$0.0	$645.8	$645.8	$652.9	
Full-time Equivalents (FTE)	0.0	0.0	2.8	2.8		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Principal Investigator			5.0	$42.4
Project Leader			5.5	$25.2
Electrical Engineer			5.5	$23.8
Ecologist/Modeler			5.5	$25.2
Senior Acoustician			3.7	$18.9
Ecologist			3.2	$13.5
Technician			5.5	$18.8
Personnel Total	0.0	$0.0	33.9	$167.8

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: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
Agency: Prince William Sound Science Center

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

Travel:	Reprt/Intrm	Remaining
3 round trips Cordova/Juneau @ $352/trip + 19 days per diem @ $128/day		$3.5
6 round trips Cordova/Anchorage @ $224/trip + 42 days per diem @ $170/day		$8.4
2 round trips Cordova/Fairbanks @ $456/trip + 11 days per diem @ $140/day		$2.5
PWS air charters (85 hours @ 230/hour)		$19.5
1 round trip Cordova/San Francisco @ $1,132/trip +10 days per diem @ $134/day		$2.4
3 round trips Cordova/Seattle @ $778/trip		$2.3
3 round trips Seattle/Halifax @ $1,683/trip + 27days per diem @ $153/day		$9.1
Misc. travel expenses		$1.2
Eighty-eight days of car rental @ $30/day		$2.6
Travel Total	$0.0	$51.5

Contractual:		
		$1.2
Long distance telephone charges		$1.3
Facsimile		$2.4
Copying		$2.6
Office Equipment maintenance and repair		$1.3
Electronic Mail and communication costs		$2.9
Contractual Total	$0.0	$11.7

Project Number: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
Agency: Prince William Sound Science Center

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Commodities:				Reprt/Intrm	Remaining
Analytical software					$1.0
Statistical software					$1.2
Communications software					$0.9
4 UPS (power supplies) @ $250/each					$1.0
4 Mustang suits @ $250/suit					$1.0
4 survival suits @ $750/suit					$3.0
4 sets raingear @ $150/each					$0.6
Electronics/Mechanical tools					$1.0
Marine hardware					$1.1
Office supplies					$0.9
Video tapes, disks, film					$1.0
Calibration and maintenance					$2.0
			Commodities Total	$0.0	$14.7
Equipment:					
4 Biosonics DT 38,120/420, 200/420, 720/1000 kHz		Tektronix color printer	13.9		$13.9
portable, digital, dual and split beam, scientific		Seagate barracuda disk drive (2 gigab	2.2		$2.2
sounder systems @ $25,915/sounder	103.7	Sun 1.7 gigabyte CDROM, 8mm,& .25"			$103.7
4 Pentiem color ntbk computer w/2PCMCIA slots @ $4,799	19.2	tape drive, w/ optical disk drive			$19.2
4 HP560 Color inkjet printers @ $902/each	3.6	storage systems	4.8		$8.4
4 Optical data storage systems @4,989/sys	20.0	Infocus screen projection system	4.8		$24.8
2 - 8' Biofin towed body @ $4970/ea	9.9	Nikon 35mm camera w/wide angle and			$9.9
2 - 4' Biofin towed Body @ $2735/ea.	5.5	telescopic lens	2.3		$7.8
6 Standard targets (38-1000kHz) @ $600/ea.	3.6	Sony, 8mm, 3 chip video camera	6.9		$10.5
4 - 50' tow cables @ $3,300/ea	13.2	Frame grabber	3.4		$16.6
Acoustic survey boat, 27'-32', dry hull, large cabin, twin OB's	37.5				$37.5
Polaroid color pallet	6.5				$6.5
Sun Sparc 2 work stations	9.9				$9.9
			Equipment Total	$0.0	$270.9

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Project Number: 94320 - N
Project Title: Prince William Sound System Investigation
Sub-Project: Nearshore Fish
Agency: Prince William Sound Science Center

FORM 4B
SUB-PROJECT
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P

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Sound Ecosystem Assessment (SEA), An Ecosystem Research Plan for Prince William Sound -- Planning and Communication (SEA PLAN)

Project ID number: 94320-P

Project type: Research/Monitoring

Name of project leader(s): Dr. David Scheel, Ecology, Prince William Sound Science Center

Lead agency: Prince William Sound Science Center

Cooperating agencies: University of Alaska Fairbanks (UAF), Alaska Department of Fish & Game (ADF&G), Department of Interior/U.S. Fish & Wildlife Service (DOI/USFWS)

Cost of project/FY 94: $49.6
Cost of project/FY 95: $110.4 K
Cost of Project/FY 96 and beyond: $110.4 K + 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. David Scheel

Name of lead agency project manager: Dr. Jerome Montague, Alaska Dept. of Fish & Game

Draft - not authorized by UAF

R³ 4/6/94

B. INTRODUCTION

The chief goal of SEA is to improve our understanding of ecosystem level processes in Prince William Sound (PWS), with particular regard to how natural and anthropogenic perturbations influence ecosystem processes. Recent run failures of wild and hatchery pink salmon, as well Pacific herring stocks, have focused our attention on the roles of these fish in the marine ecosystem. However, our present understanding of the marine ecosystem does not allow us to discern whether these run failures were due to natural or anthropogenic processes, underscoring the need to gain a more comprehensive understanding of the PWS ecosystem. In this context, the Sound Ecosystem Assessment (SEA) research plan is initially focused on components of the PWS ecosystem called the "fisheries ecosystem;" this includes those elements of the PWS ecosystem important in limiting the production of fish stocks. The first phase of SEA will focus on pink salmon and Pacific herring stocks as target species, because of their major ecological roles in the Sound, as well as their economic importance to the communities of the Sound. The fisheries ecosystem is defined to include the predators, competitors and prey associated with specified target species throughout their life history, as well as environmental processes that act to constrain the production of the target fish species.

It is recognized that this trophic structure supports many non-commercial fish as well as bird and mammal populations of interest to the EVOS Trustee Council. The ecosystem perspective used in SEA will identify and analyze processes within the Sound that act to limit the production of the target fish species. The SEA program studies on the interactions between key organisms and their physical and biological environments are the first steps to improving our understanding of the PWS ecosystem. This ecosystem approach is highly applicable to other target species including other fish, seabirds and marine mammals.

The central scientific goals of SEA are: (1) to increase understanding of processes that determine the abundance of key animal populations in the Sound, initially pink salmon and Pacific herring have been chosen, (2) to develop and apply new methods and technologies for evaluating life history parameters of key populations (initially marine species) important to evaluating the key animal populations, and (3) to acquire the ability to predict how the abundances of key animal populations change.

Scientific reviews of SEA at the December 1993 Ecosystem Workshop in Cordova were favorable: the reviewers called the plan innovative, reasonable, and scientifically testable. The reviewers also identified areas where additional attention was merited to augement SEA or strengthen an ecosystem approach to EVOS research. In particular, reviewers suggested that further attention to apex predator populations (sea birds and marine mammals), the intertidal and benthic systems, and to toxicology was warranted.

As SEA provides an increased understanding of how physical and biological factors interact within the ecosystem to limit the production of fish stocks, the next step is to ask how variation in fish production interacts with other variables in the system to alter population dynamics at higher trophic levels (e.g for animals such as sea birds and marine mammals). Beyond this, aspects of nutrient cycling between the continental shelf marine system and intertidal or benthic systems make a natural next step.

SEA researchers have already developed cooperative sampling designs with Alaska Department of Fish and Game on sockeye salmon and harbor seals, the U.S. Fish and Wildlife Service on marble murrelets, pigeon guillemots, and kittiwakes, and the Copper River Delta Institute/U.S. Forest Service on gulls, sea ducks and shorebirds. Cooperative sampling with researchers on killer and humpback whales is pending and we are seeking an agreement with NOAA on forage groundfish assessments. Ultimately, we see listing the marine and terrestrial subsystems in the PWS comprehensive ecosystem model. However, further planning within the SEA program is needed to continue to develop and evaluate preliminary models of important ecosystem processes. These models will be of the same type that led to the development of key testable hypotheses in the SEA program as designed for 1994. They are expected to lead to the development of additional testable hypotheses by expanding on existing SEA models and incorporating results from initial SEA field research.

Achieving the goals SEA has laid out will ultimately address scientific and public concerns about the health of this valuable Alaskan coastal environment. Benefits will be first evidenced by having scientists and fishermen work together in the field, which will build public trust in scientific methods. Second, ongoing, local, public education and outreach programs will be enhanced by having a comprehensive, locally available, scientific data base on the status of PWS resources. In addition, the availability of new information and the technologies to acquire better information will allow improved harvest management strategies to be developed. Ultimately, better forecasts of animal abundance and improved predictions of population responses to natural and anthropogenic perturbations will allow a policy of sustainability to be established. Sustainability is the insurance that local communities of the Sound need to protect their standard of living. This involvement of community interests and expertise does not happen without careful preparation, however. Some coordination of communication is needed between PWSFERPG constituent organizations, the public, SEA scientists, agencies, and the Trustee process.

C. PROJECT DESCRIPTION

1. Resources and/or Associated Services:

The Sound Ecosystem Assessment (SEA) program evaluates changes occurring in the Prince William Sound (PWS) ecosystem in the context of groups of interacting species. Implementation of the SEA program will result in vital knowledge for determining the feasibility of, and the approach to, restoration of many resources and services injured by the Exxon Valdez Oil Spill (EVOS). Resources addressed by SEA include pink salmon, herring, and the principal species interacting with these fishes. These pelagic organisms support a host of birds and mammals, some of which are listed as injured species of the EVOS. Services addressed include subsistence, commercial fishing, recreation and tourism, and passive use. While SEA is primarily a monitoring and research activity, this program will also support other EVOS Trustee Council programs (i.e., providing better information to land and fisheries management personnel that will promote a healthy ecosystem, and increasing public awareness of the state of the ecosystem).

As an integrated part of the SEA program, all resources and services benefiting from SEA stand to gain from careful planning, communication and community involvement. Future expansion of the SEA program will involve development and evaluation of hypotheses regarding the role of apex predators (sea birds and marine mammals) in ecosystem processes, coupling pelagic and nearshore benthic ecology, and linking aquatic and terrestrial ecology through dominant ecosystem pathways. Hypotheses must be evaluated not only for their scientific merit, but with consideration of their role in furthering an integrated, Trustee-sponsored ecosystem research program.

2. Relation to Other Damage Assessment/Restoration Work:

Initial collaborations in 1994 and further planning for work to be implemented beginning in 1995 will focus on expanding SEA to address the roles of sea birds, marine mammals, and ecotoxicological factors in the marine system. Work has already begun to build connections with ongoing projects in these areas (see above). The sampling design, technology and modeling efforts used in this study of Prince William Sound should also be transferable to other parts of the spill area, especially for sea birds and mammals.

3. Objectives:

(1) Continued Scientific Planning: Develop conceptual models of key ecosystem processes to link SEA research and results to an improved understanding of the greater ecosystem, including (a) apex predators, (b) benthic and intertidal communities, and (c) toxicological pathways and effects. This work will provide a framework to aid SEA integration with other EVOS research on sea birds, mammals, and other fishes, as well as direction for further SEA projects. Since the selection of dominant species as key populations (Pacific herring and pink salmon) in Prince William Sound is a way to best represent the pelagic-nearshore ecosystem, it allows for successful integration with many of the ongoing apex predator studies in the region, regardless of oil-spill relationship. Nearly all pelagic-nearshore, apex predator populations are subject to the same ocean state conditions and dependent upon the dominant species, and/or the prey and predator populations that are monitored on the large scale. Thus, whether bird or mammal, the integration of apex predator studies with SEA is an efficient and meaningful approach to improving ecological studies in the region.

There are no sharp boundaries between the pelagic-nearshore, intertidal ecosystems and the marine and terrestrial ecosystems. They are linked by the transfer of carbon and nutrients via the migrations of animal populations that feed on marine production. There are exciting areas of future cooperation and an expanded ecosystem studies program can lead to a link of the SEA program with terrestrial resource ecosystem evaluations.

(2) Communication and community involvement: Solicit the continued input of regional communities in the design and implementation of SEA, through maintaining open communications with regional organizations (e.g. fishermans' unions, PWSCORS) and through the periodic preparation and distribution of reports describing the progress and status of SEA programs. Although each SEA project will be responsible for reporting its own progress, SEA PLAN will be responsible for the compilation and distribution of such information to the community.

4. Methods:

Two methods will be used: First, conceptual and numerical modeling, combined with strategic plan development will be used to develop, refine and evaluate scientifically testable hypotheses. Carbon-budget, food-web, and population models will be employed, as well as other appropriate frameworks. This work will be coordinated by the Scientific Planner, but will receive the review and input of the SEA Scientific Committee.

Second, meetings, memos, maps, and reports will be used as needed to distribute information both among SEA scientists and to the regional community. Travel to Anchorage, Juneau and Fairbanks will allow SEA, EVOS and University programs to remain appraised about each other's planned research, thereby minimizing overlap between different EVOS-sponsored projects as they are developed. While all projects will have responsibilities for reporting their progress, the Communication Coordinator will ensure that all involved parties are apprised of developments in all areas, and will coordinate communication between PWSFERPG constituent organizations, the public, SEA scientists, agencies, and the Trustees.

5. Location:

This project will be conducted for Prince William Sound, the North Gulf of Alaska, and may involve other areas of the EVOS-impacted region if appropriate. Planning will involve organizations located throughout Alaska.

6. Technical Support:

The Planning and Communication portion of SEA will require the use of modeling and GIS computer services, as well as the continued involvement of the SEA Project Leaders and scientists. Computer services, including GIS, will be provided through the Prince William Sound Science Center. Involvement of Project Leaders will be accommodated by coordination with the SEA DATA program under Dr. Vince Patrick. Communication with local communities and expertise will be achieved as in the past, through interaction with regional organizations such as fisherman's unions and the PWS Communities Organized to Restore the Sound.

7. Contracts:

None

D. SCHEDULES

Since August of 1993 the SEA project has been under intense development and now has come to fruition as a working program of ecosystem research in PWS and the EVOS region. There has been a tremendous amount of public input into the formulation of this project. SEA PLAN provides for the continuation of project development and public input during the period 1 Mar-30 Sep 1994 of FFY94.

PWSFERPG meetings have always been open to the public. Meetings in the past have occurred twice monthly or more frequently. At a minimum, open meetings will be held monthly during the field season (1 Apr 94 to 1 Aug 94) and twice monthly there after. The Communications Coordinator will be available for public contact, by telephone or drop-in office visits at least 4 hours per week from 1 Apr 94 to 30 Sep 94. These opportunities for public involvement are the minimum that will be provided. Many individual project leaders have active involvement of local resources and expertise in their programs. PWSFERPG has an 'open-office' policy and welcomes public input at any time.

E. EXISTING AGENCY PROGRAM

Agency contributors to this project will include all agencies involved in SEA research. Further planning and/or communications will be needed for: cooperative research and sampling designs with Alaska Department of Fish and Game on pink salmon, sockeye salmon and harbor seals, with the U.S. Fish and Wildlife Service on marble murrelets, pigeon guillemots, and kittiwakes, and with the Copper River Delta Institute/U.S. Forest Service on pink salmon, gulls, sea ducks and shorebirds. Cooperative sampling with researchers on killer and humpback whales is pending and we are seeking an agreement with NOAA on forage groundfish assessments.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

SEA PLAN will not cause a significant environmental impact and, therefore, should qualify for a categorical exclusion from the requirements of the National Environmental Policy Act.

G. PERFORMANCE MONITORING

An internal quality assurance and control program will be instituted through the modeling and data management project (SEA DATA). Independent review of performance will be conducted continuously by the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG) board and at specific times via annual reports and workshops. Such review, begun in the December 1993 workshop, will work with the planning project to guide further development of the ecosystem research program, and ensure that the studies are integrated.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

The purpose of SEA PLAN is to establish clear communications between SEA projects and related FFY94 work plans; and to update plans to keep SEA an integrated part of the total EVOS-related research effort. Scientific planning for SEA PLAN will utilize initial SEA results collated by SEA DATA. Planning will involve the active participation of SEA lead scientists and open communication with the public and the Trustee-process to ensure that planned developments and project direction are well-integrated with other EVOS-related research.

I. PUBLIC PROCESS

Sound Ecosystem Assessment (SEA) is an ongoing project with a mission to develop and advocate the best model for ecosystem research in Prince William Sound and the EVOS affected region. The concept of the SEA program has been in the region for several years. Since August of 1993 the plan has been under intense development and come to fruition as a working document to guide ecosystem research in PWS and the EVOS region. The SEA Science Committee includes scientists and resource managers from the University of Alaska, Alaska Department of Fish and Game, PWS Science Center, U. S. Forest Service and PWS Aquaculture Corporation. There has been a tremendous amount of public input into the formulation of this project. Input has been received from Prince William Sound Communities Organized to Restore the Sound (PWSCORS), Cordova District Fisherman United, Cordova Aquatic Marketing Association and numerous Prince William Sound fisherman. A workshop sponsored by the EVOS Trustee Council and NOAA was held in Cordova Alaska during December of 1993 to peer review the SEA document and to further plans for coordinated and integrated ecosystem research in Prince William Sound and the greater EVOS affected region. The purpose of SEA PLAN is to continue to encourage substantial involvement of the public, and to develop streamlined communication pathways between SEA programs and the public in the EVOS-impacted region.

J. PERSONNEL QUALIFICATIONS

Scientific Planner:
David Scheel, Associate Scientist, Prince William Sound Science Center. Education: Ph.D. (Ecology, 1992, University of Minnesota), MS (Ecology, 1986, Univ. of MN), BS (Biology, 1980, Renesselaer Polytechnic Institute). Professional experience: 1993-present, Associate scientist, PWSSC; 1992-93, Postdoctoral associate, University of Houston; 1986-1992, Research scientist, Serengeti Wildlife Research Institute, Serengeti, Tanzania; 1984-1992, student/post-doc/consultant, Univ. of Minnesota. Selected publications: Scheel, D. & Packer, C. 1991. Group hunting behavior of lions: a search for cooperation. *Anim. Behav.* 41(4):697-709. Scheel, D. 1993. Profitability, encounter rates and the prey choice of African lions. *Behav. Ecol.* 4(1):90-97. Cameron, G.N. & Scheel, D. *In press.* Assessing effects of global climate change on mammals using GIS: A case study of lagomorphs and insectivores in Texas. *Geocarto International.* Research projects: Serengeti predator behavior and community dynamics, social behavior and resource use of primates in Gombe, impacts of global warming on mammal distributions and habitat use in Texas, frequency- and density-dependence in models of community evolution.

Communication Coordinator:
To be identified.

K. BUDGET

Budget for SEA Planning and Communication

Table 1: Budgets for FY95 are subject to revision as the SEA program develops.

Line Item	FY94	FY95	FY96 and beyond
Personnel	16,474	40,000	40,000
Travel	10,339	20,000	20,000
Contractual	2,400	0	0
Supplies	1,775	20,000	20,000
Equipment	0	0	0
General Administration	7,437	19,200	19,200
Direct costs	38,425	99,200	99,200
Indirect costs	11,175	11,175	11,175
Total Costs	**49,600**	**110,375**	**110,375**

EXXON VALDEZ TRUSTEE COUNCIL

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

Project Description: Sound Ecosystem Assessment - Information and Management (SEA-Plan)- This project is to provide continued integration of the SEAPLAN with new projects (birds, mammals and fish), educational outreach between SEA projects and the communities in the spill affected area, and coordination between existing SEA projects.

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	$0.0	$0.0	$0.0	
Travel	$0.0	$0.0	$0.0	$0.0	$0.0	
Contractual	$0.0	$100.0	$50.0	$150.0	$0.0	
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	$0.0	$100.0	$50.0	$150.0	$0.0	
General Administration	$0.0	$0.0	$1.8	$1.8	$0.0	
Project Total	$0.0	$100.0	$51.8	$151.8	$0.0	
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
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

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Fish & Game

FORM 3A SUB-PROJECT DETAIL

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

Contractual:		
Contractual Total	$0.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Fish & Game

FORM 3B
SUB-
PROJECT
DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
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

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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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$75.0	$50.0	$125.0		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$75.0	$50.0	$125.0	$0.0	
General Administration	$0.0	$0.0	$1.8	$1.8		
Project Total	$0.0	$75.0	$51.8	$126.8	$0.0	
Full-time Equivalents (FTE)	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
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

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Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Fish & Game

FORM 3A- 1 SUB-PROJECT DETAIL

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

Contractual:	Reprt/Intrm	Remaining
Contract to PWSSC to help with the development of the ecosystem study plan	$50.0	$38.8
Contract to The Nature Conservancy to help with the development of the ecosystem study plan	$25.0	$0.0
RSA with UAF for administation of non-ADF&G portion of 94320-P. UAF will subcontract with PWSSC for completion of the project and charge $11.2 pass through charges.		$11.2
Contractual Total	$75.0	$50.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Fish & Game

FORM 3B-1
SUB-PROJECT
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Commodities:	Reprt/Intrm	Remaining
Commodities Total	$0.0	$0.0

Equipment:		
Equipment Total	$0.0	$0.0

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Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Fish & Game

FORM 3B-1
SUB-PROJECT
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EXXON VALDEZ TRUSTEE COUNCIL
1994 Federal Fiscal Year Project Budget
October 1, 1993 - September 30, 1994

Project Description: Sound Ecosystem Assessment - Information and Management (SEA-Plan)- This project is to provide continued integration of the SEAPLAN with new projects (birds, mammals and fish), educational outreach between SEA projects and the communities in the spill affected area, and coordination between existing SEA projects.

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	$38.6	$16.5	$55.1	$40.0	
Travel	$0.0	$10.5	$10.3	$20.8	$20.0	
Contractual	$0.0	$0.5	$2.4	$2.9	$0.0	
Commodities	$0.0	$0.4	$1.8	$2.2	$20.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$50.0	$31.0	$81.0	$80.0	FFY 95 general administration budget reflects the Science Center portion excluding the projected general administration for the UAF
General Administration	$0.0	$0.0	$7.8	$7.8	$19.2	
Project Total	$0.0	$50.0	$38.8	$88.8	$99.2	
Full-time Equivalents (FTE)	0.0	0.6	0.3	0.9		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
1 Planner			2.0	$9.2
1 Administrative Coordinator			2.0	$7.3
Intrm 3 Oceanographer/Modeler/Ecologist	7.0	$30.6		
Intrm ? Peer reviewers		$8.0		
Personnel Total	7.0	$38.6	4.0	$16.5

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

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Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: PWS Science Center

FORM 4A
SUB-PROJECT
CONTRACTUAL
DETAIL

Travel:	Reprt/Intrm	Remaining
Two round trips Cordova/Juneau @ $350/trip + 12 days per diem @ $128/day		$2.2
Three round trips Cordova/Anchorage @ $672/trip + 28 days per diem @ $170/day		$5.4
Two round trips Cordova/PWS @ $456/trip + 7 days per diem @ $140/day		$1.9
Twenty-six days of car rental for the various trips @$30/day		$0.8
Intrm G. Thomas (Anchorage, Juneau, Fairbanks)	$2.0	
Intrm T. Cooney (Fairbanks, Cordova, Anchorage, Juneau)	$3.0	
Intrm V. Patrick (Maryland/Cordova RT)	$2.0	
Intrm D. Eslinger (Fairbanks/Cordova)	$1.0	
Intrm Peer reviewer travel	$2.5	
Travel Total	$10.5	$10.3

Contractual:		
Long distance telephone charges	$0.5	$0.5
Facsimile		$0.5
Copying		$0.5
Mail		$0.5
Maintenance		$0.4
Contractual Total	$0.5	$2.4

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: PWS Science Center

FORM 4B
SUB-PROJECT
CONTRACTUAL
DETAIL

Commodities:	Reprt/Intrm	Remaining
Office supplies (Paper, pens, tape, etc.)	$0.4	$1.8
Commodities Total	$0.4	$1.8

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

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: PWS Science Center

FORM 4B
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October 1, 1993 - September 30, 1994

Project Description: Sound Ecosystem Assessment - Information and Management (SEA-Plan)- This project is to provide continued integration of the SEAPLAN with new projects (birds, mammals and fish), educational outreach between SEA projects and the communities in the spill affected area, and coordination between existing SEA projects.

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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$18.0	$0.0	$18.0		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$18.0	$0.0	$18.0	$0.0	
General Administration	$0.0	$0.0	$0.0	$0.0	$0.0	
Project Total	$0.0	$18.0	$0.0	$18.0	$0.0	
Full-time Equivalents (FTE)	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
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

Printed: 4/7/94 6:57 PM

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Natural Resources

FORM 3A-2 SUB-PROJECT DETAIL

	Reprt/Intrm	Remaining
Travel:		
Travel Total	$0.0	$0.0
Contractual:		
Peer Reviewers for workshop to help develop the study plan for this project.	$18.0	$0.0
Contractual Total	$18.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Natural Resources

FORM 3B-2
SUB-PROJECT
DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: AK Dept. of Natural Resources

FORM 3B-2
SUB-PROJECT
DETAIL

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

Project Description: Sound Ecosystem Assessment - Information and Management (SEA-Plan)- This project is to provide continued integration of the SEAPLAN with new projects (birds, mammals and fish), educational outreach between SEA projects and the communities in the spill affected area, and coordination between existing SEA projects.

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	$0.0	$0.0		
Travel	$0.0	$0.0	$0.0	$0.0		
Contractual	$0.0	$7.0	$0.0	$7.0		
Commodities	$0.0	$0.0	$0.0	$0.0		
Equipment	$0.0	$0.0	$0.0	$0.0		
Capital Outlay	$0.0	$0.0	$0.0	$0.0		
Subtotal	$0.0	$7.0	$0.0	$7.0	$0.0	
General Administration	$0.0	$0.0	$0.0	$0.0	$0.0	
Project Total	$0.0	$7.0	$0.0	$7.0	$0.0	
Full-time Equivalents (FTE)	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
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

Printed: 4/7/94 6:57 PM

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: National Oceanic & Atmospheric Admin.

FORM 3A-3 SUB-PROJECT DETAIL

	Reprt/Intrm	Remaining
Travel:		
Travel Total	$0.0	$0.0
Contractual:		
Workshop to help develop the study plan for this project.	$7.0	$0.0
Contractual Total	$7.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: National Oceanic & Atmospheric Admin.

FORM 3B-3 SUB-PROJECT DETAIL

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

Equipment:		
Equipment Total	$0.0	$0.0

Project Number: 94320 - P
Project Title: Prince William Sound System Investigation
Sub-Project: Program Management
Agency: National Oceanic & Atmospheric Admin.

FORM 3B-3
SUB-
PROJECT
DETAIL

Q

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Sound Ecosystem Assessment (SEA), An Ecosystem Research Plan for Prince William Sound

Subproject title: Avian Predation on Herring Spawn

Project ID number: 94320– Q

Project type: Research/Monitoring

Name of project leader(s): Dr. Mary Anne Bishop, Research Wildlife Biologist, Copper River Delta Institute, Pacific Northwest Research Station, US Forest Service

Lead agency: USDA, U.S. Forest Service, Pacific Northwest Research Station

Cooperating agencies: Alaska Dept. of Fish and Game, Prince William Sound Science Center, Univ. Alaska, US Fish & Wildlife Service

Cost of project/FY 94 (7 months): $85.0K (estimate; see detailed budget)

Cost of project/FY 95: $173.0K

Cost of Project/FY 96 to FY99: $427.1K

Project Start-up/Completion Dates: March 1, 1994/December 31, 1998

Geographic area : Herring Spawning Grounds Throughout Prince William Sound

Project Leader: Mary Anne Bishop — 2/23/94
Mary Anne Bishop — Date

Project Manager: /S/ — 2/23/94
Fred Everest — Date

B. INTRODUCTION

Pacific herring (Clupea pallasi) has been identified as a resource injured by the Exxon Valdez oil spill. Studies conducted from 1989-1992 have documented a significant decline of spawner biomass. In 1993, the total observed spawning population was less than one third of pre-season prediction (J. Wilcock, ADF&G, pers. comm.).

The SEA Plan hypothesizes that the recruitment success of herring populations in Prince William Sound (PWS) is related to losses due to physical processes (high energy coastal storms and temperature extremes) and to predation during early life stages (embryo to larval) that occur within the Sound. Understanding egg loss will allow for a better estimate of survival to the larval stage.

It is also important to understand egg loss from a fisheries management standpoint. Currently ADF&G estimates the adult spawner biomass from total egg deposition, average fish size and sex ratio, and average fecundity at size measured. Egg deposition surveys take place 5-10 days after spawning. Losses to predation and physical processes between deposition and surveys are needed to accurately calculate spawning biomass. Until now, only potential sources of predation have been identified in PWS.

Pacific herring return to PWS every April and deposit their eggs on rocks and vegetative substrate in the intertidal and shallow subtidal zones. Depending on seawater temperature, egg density and egg distribution, herring eggs hatch into drifting larva at approximately 20-25 days. Throughout incubation, egg loss or the removal of eggs from their original incubation environment (Palsson 1984) can be significant. During a 2-year study in 1990 and 1991 in PWS, rates of egg loss as high as 91.2% have been measured, with an overall estimated egg loss rate of 50.4% throughout the incubation period and a daily rate of 2.1% (Biggs and Baker, in prep.). During 1994, ADF&G will study egg loss again to facilitate construction of an egg loss model required by the SEA Plan and fisheries management stock assessment models.

Herring egg loss is regulated by two processes: predation and physical translocation through wave action and currents (Palsson 1984; Haegele and Schweigert 1991). Egg loss due to storm-induced wave action was investigated in two studies in British Columbia. Losses ranged from 28% (Hay and Miller 1982) to 40% (Hart and Tester 1934) with lower losses on adjacent spawning areas. This year ADF&G will begin to test meteorological condition as a factor in egg loss in PWS and work toward building a sound-wide embryo survival model.

Predators of herring spawn include invertebrates, marine mammals, fish, and birds. Epibenthic invertebrates (crabs, snails, and starfish) and birds have been identified as the greatest sources of egg loss on spawning areas in Washington and British Columbia. Predator exclusion experiments conducted by Palsson (1984) determined that large predators, primarily diving ducks and gulls, accounted for 20-50% of the daily egg loss rate on 3 of 6 plots. Smaller predators (snails and amphipods) were major contributors to egg losses in exclosures. Palsson, concluded, however, that since birds compete for herring eggs with these invertebrates, the contribution of bird predation to egg loss is greater.

Using exclosures, Outram (1958) estimated egg loss to avian predators on the west coast of Vancouver Island at 30-55% with an average of 39% of spawn deposition consumed by birds. Highest losses occurred the first 3 days of incubation when egg densities were highest, with some 66% of total spawn loss occurring then. Glaucous-winged gulls (Larus glaucescens) and herring gulls (Larus argentatus) were found to be responsible for most of the predation. Haegele and Schweigert (1991) estimated egg loss in southern British Columbia at 58%. Egg loss was greater in shallow water and at sites where diving ducks congregated. Overall, 7.1% of the eggs were lost to predation, including an estimated 3.0% to birds.

Prince William Sound has a large resident population of potential herring spawn avian predators including surf scoters (Melanitta perspicillata) and glaucous-winged gulls. Surf scoters are abundant in the region and the most numerous sea duck. Migrant surf scoters are numerous in April and May. Glaucous-winged gulls are also an abundant resident. Although they are present in numbers throughout the year, an influx does occur in spring, mainly between mid-april and mid-May (Isleib and Kessel 1973). The primary nesting colony for glaucous-winged gulls in PWS, estimated at approximately 10,000 pairs, is at Egg Island on the east end of Prince William Sound (Patten 1980). Egg laying usually begins around the second week in May.

Historically, large numbers of glaucous-winged gulls have been observed in areas with herring spawn. On 10 May 1989, approximately 30,000 gulls were observed in Rocky and Zaikof Bay on northern Montague Island. On 6 May 1992, an estimated 50,000 gulls were observed in areas with herring spawn on the northwestern shore of Montague Island (P. Martin, USFWS, pers. comm.).

Prince William Sound is also an important migratory stopover for shorebirds that prey on herring spawn. In 1989, northern Montague Island was discovered to be the most important spring staging area for two species of shorebirds: surfbirds (Aphriza virgata) and black turnstones (Arenaria melanocephala). Total numbers using the area are not known, however, in May 1992 a single day count of almost 56,000 surfbirds and 25,000 black turnstones was recorded (P. Martin, USFWS, pers. comm.). These numbers suggest that a high proportion of the world's population of these two species use northern Montague Island in spring (Norton et al. 1990; Martin in review).

Spatially and/or temporally then, herring spawn deposition in PWS coincides with breeding for a large resident population of glaucous-winged gulls, and with spring stopover areas for seaducks and shorebirds. To date, however, we have no information on numbers and distribution, and how predictable or variable the use of herring spawn is by resident and migrant birds. Nor has the importance of herring spawn in providing a high-energy food resource for egg laying and migration been determined. From a fisheries management standpoint information on avian predation is important because if the avian predator population remains relatively constant or increases, then the lower herring stock levels that PWS is currently experiencing could experience higher rates of predation.

What follows is a description of a multi-year project that will investigate avian predation on herring spawn. As part of the SEA plan, it is designed to complement ongoing long-term studies on herring spawn deposition and survival. The cost of this project is reasonable when one considers the economic aspects of the commercial fisheries alone and not including the important contribution that herring makes to the ecosystem in PWS during all life stages. The exvessel value of the herring fisheries in 1992 was $12.0 million with an average annual value of $8.3 million. This compares to an exvessel of $2.0 million in 1993.

C. PROJECT DESCRIPTION

This project will assess and document the impact of avian predation on herring spawn in Prince William Sound. Results will eventually be integrated into a model relating sound-wide embryo survival to predation, habitat type, egg density, and meteorological conditions.

1. Resources and/or Associated Services:

The resources to be studied by this project are the avian predators on Pacific herring spawn (seabirds, seaducks, and shorebirds). Herring is a major commercial and minor subsistence resource in PWS. Ecologically, herring are an important forage base for a large number of fish and mammal predator species, as well as birds.

2. Relation to Other Damage Assessment/Restoration Work:

This project will provide critical information for EVOS Project No. 94166, Herring spawn deposition and reproductive impairment. This project is being conducted by the Alaska Department of Fish and Game (spawn deposition) and NOAA (reproductive impairment). The goal of Project No. 94166 is to improve herring fisheries management in Prince William Sound by determining accurate and precise estimates of herring abundance. A better understanding of the loss of herring spawn to avian predators will improve estimates of egg loss used in current stock assessment models. These models are used by fishery managers to set herring harvest quotas. As part of the SEA Plan, this project will also provide further information on the regulating effect that bird predation has on recruitment into the herring population.

3. Objectives:

a. Examine the phenology, relative abundance, and species composition of birds foraging in herring spawn areas in the rocky intertidal and subtidal habitats.

b. Examine spatial and temporal distribution (including length of stay for shorebirds only) in relation to habitat type and abundance of pacific herring spawn.

c. Assess the relative importance of prey, in particular herring spawn, for birds using nearshore habitats. Calculate the extent of losses of herring eggs to these birds using a combined analysis of bird and herring spawn distributions.

4. Methods:

The impact of avian predation on herring spawn will be documented by observing the distribution and relative abundance of birds foraging in herring spawn areas and by analyzing their diets. Herring spawn deposition density and subsequent egg loss will be documented by a concurrent ADF&G study. The extent and distribution of herring spawn will be documented from daily aerial flights conducted as a regular part of ADF&G commercial fisheries management.

The first year of this study will focus on identification of avian predators and their relative abundance, and the importance of spawn in their diets. Beginning the second year, this project will be scaled up to include more complete coverage of spawn areas, and to determine the relative numbers, movements, and length of stay for surfbirds and black turnstones staging on northern Montague Island.

a. Study area

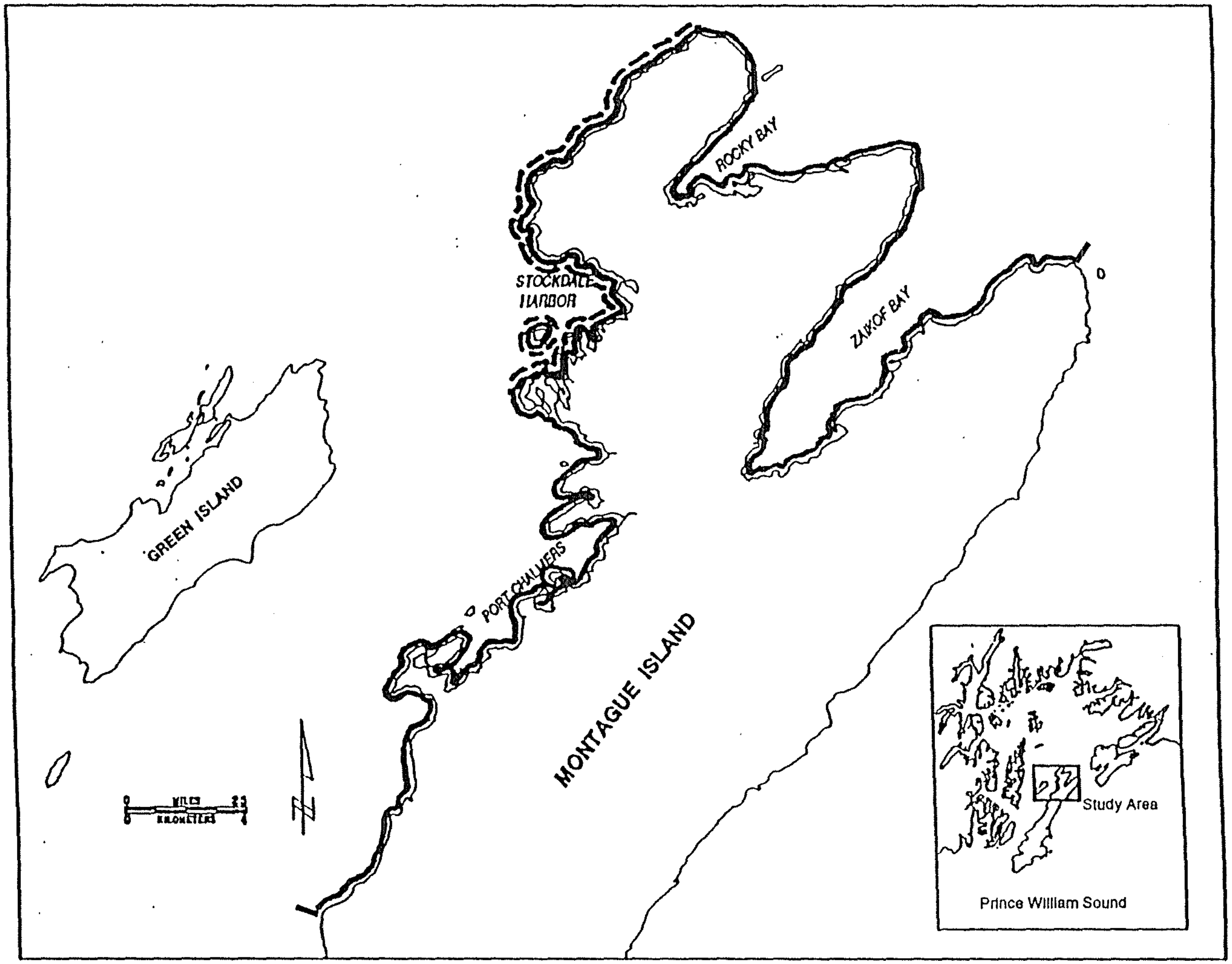
For the first year of this study, the study area consists of all locations in PWS with herring spawn that are sampled at ADF&G spawn deposition surveys. An intensive study will be conducted at northern Montague Island from Port Chalmers to Zaikof Bay (Figure 1). High densities of herring spawn have occurred in this area nine of the last ten years (E. Brown, ADF&G, pers. comm.). Northern Montague Island also hosts the highest numbers of migrant surfbirds and black turnstones from late April through May. More than 80,000 of these shorebirds were observed at one time in association with the herring spawn (P. Martin, USFWS, pers. comm.).

b. Data collection

The phenology, relative abundance and species composition of birds using herring spawn will be documented using boat and aerial shoreline surveys. Three types of boat transects will be conducted: 200m wide shoreline transects, intertidal zone surveys, and 100m x 300m shoreline transects.

Boat surveys. Beginning 8 April (approximately one week prior to estimated initial herring spawn deposition) and through 20 May, boat surveys will be conducted for seabirds, seaducks, and shorebirds from Stockdale Harbor to Montague Point (Figure 1). The starting point will be randomly switched each day between either end of the survey area. On days when weather prohibits travel outside of Stockdale Harbor, the survey will be restricted to the shoreline within the harbor.

Data collected for all boat surveys will include: number and species (or genus), shoreline type, and habitat (land, water or air). For seabirds and seaducks, the area within 200m of shore will be surveyed. The shoreline will be divided into transects based on natural landmarks and/or shoreline type. Transects will be surveyed using methodology adapted from the US Fish and Wildlife Service's marine birds and mammal surveys (USFWS 1991). Shorelines will be surveyed on alternate days (weather permitting) at a distance of 100m from shore and at a cruising speed of



Aerial Surveys ———— Boat Surveys - - - - -

Figure 1. Map of Northern Montague Island intensive study area showing aerial (solid line) and boat survey areas (dashed line). Avian Predation on Herring Roe Project, Spring 1994.

approximately 5 knots. While the boat is moving along the transect, all birds are counted within the space that extends 100m on each side, 50 m ahead, and 100m above the boat. One observer will be assigned to survey from the boat to shore, and the other from the boat seaward 100m. Data will be recorded on tape recorders and transcribed upon return.

Black turnstones and surfbirds are cryptic shorebirds and difficult to observe from a distance. Therefore, as soon as migrant shorebirds are detected in the intensive study area (projected date 20 April), shorebird surveys of the intertidal zone will be conducted from a boat moving 20m parallel to the shore. Shorebird transects will be conducted immediately following the completion of the 200m wide transect for each shoreline segment.

A sampling effort for numbers and species composition of potential avian predators will be conducted in other spawn areas of the Sound in conjunction with ADF&G spawn deposition and egg loss surveys. Depending on initiation of spawning, between approximately 1 April and 15 May, ADF&G will conduct an estimated 50-100 transects for egg densities within 5-10 days of initial spawn deposition. An additional 20 transects (10 at northern Montague Island, five at northern PWS) will be sampled every 3-4 days until hatching to determine egg loss. At northern Montague Island, egg-loss transects will include exclosures to prevent bird predation. At each of three depths along the transect line, three exclosure frames will be secured to the bottom including a coarse-meshed net exclosure, a fine meshed net exclosure and a control exclosure frame without netting.

One observer from this study will accompany the ADF&G crew throughout the Sound on their spawn deposition and egg loss surveys. As the ADF&G dive boat approaches the shoreline starting point for their underwater surveys, the observer (located in the boat) will survey a 100m wide x 300m long transect perpendicular to the shoreline. While most locations will be sampled only once, transects surveys at ADF&G egg loss sites will be conducted every 3-4 days in order to document changes in avian abundance and species composition as they relate to egg loss.

<u>Aerial Surveys</u>. Aerial surveys for seaducks and seabirds will be conducted before herring spawn deposition, beginning approximately 1 April until egg hatch around 20 May. Aerial surveys will cover nearshore areas at northern Montague Island from Port Chalmers to Zaikof Bay (Figure 1, pg. 6). Whenever possible, aerial surveys will be conducted on the same day as boat surveys on northern Montague. Surveys will be flown in a Cessna 185 float plane at a height of approximately 95m and at an airspeed of 90 knots. Surveys will be flown during low tide, approximately 200m from the shoreline. For protected bays where seaducks and gulls tend to use waters farther from the shoreline (e.g. Stockdale Harbor, Rocky and Zaikof Bays), multiple flight lines will be flown for complete coverage.

Two observers, one seated on each side of the plane will tape record locations and numbers of all birds seen. Birds will be identified as gulls, scoters, oldsquaws, and other. Any identifiable flocks of shorebirds will also be noted, although no attempt will be made to survey for surfbirds and turnstones due to their cryptic coloration, and their tendency to not flush at airplanes (B. Gill, USFWS Anchorage, pers. comm.).

Foraging Ecology. Foraging ecology will be determined from scan and focal animal samples, as well as an analysis of diets. KOWA Spotting scopes will be used for behavioral observations. Field observations will be recorded directly into a hand-held computer and the data uploaded daily to laptop computer, and backed up on disks.

Scan samples (Altman 1974) across flocks will provide information on distribution and activity of birds in high density spawn areas. At northern Montague Island two habitat types with high densities of spawn will be sampled: exposed, low gradient shoreline and protected, low gradient shoreline. For each habitat type, one designated plot that includes both intertidal and subtidal zones will be scanned for birds every 30 minutes over a 12 hour period (2 tidal cycles) every 4th day. Activity classes include feeding, sleeping/resting, preening, agonistic interaction, and unknown. Feeding subclasses will be by substrate. Locomotion classes include swimming, flying, stationary, walking, diving, and unknown. Habitat location will be ascribed by substrate and meters above or below the tideline.

To document activity budgets of avian predators, a series of focal-animal samples (Altman 1974) will be gathered at both ADF&G egg density transect sites and the northern Montague Island study site. Individual gulls, surfbirds, and black turnstones will be randomly selected. Each sample period (data point) will be for 15 minutes or until the bird becomes unobservable. Behaviors will be continuously recorded onto a hand-held computer. Depending on the species, behaviors recorded will include: search, peck, handle, and rest. Whenever possible, prey species will be recorded.

Bird diets for the intensive study area will be documented by collecting (shotgun or rifle) a target of 30 individuals of the following species: glaucous-winged gull, mew gull (Larus canus), surfbird, black turnstone, oldsquaw (Clangula hyemalis), and surf scoter. An additional 30 glaucous-winged gulls will be collected around the 100x300m transects associated with the ADF&G egg density transects. Collection of each individual will be random, however birds must have been observed foraging for at least 5 minutes. Sampling effort will be proportional to the spatial distribution of each species across the intensive study area. Collection schedule for each species will be: 5 during the first 5 days of spawn, 20 during the next 10 days, and 5 during the last 5 days.

For each specimen, date, time, tidal stage, shoreline type, and habitat will be recorded. Each bird will be weighed and the wing cord measured. Esophagus and proventriculus will be removed and immersed in a preservative in a polyethylene jar. A sample of the pectoral muscle will be collected and placed in an anti-oxidant chemical in a glass jar. Sex will be ascertained during dissection. Examples of prey items (herring eggs, mussels, barnacles, limpets) will be collected for reference and for lipid analysis.

c. Data analysis

Using data from aerial and boat surveys, phenology of spawn use by avian predators will be graphically represented by plotting relative abundances by both calendar date and location. A regression analysis will be performed to determine the relationship between bird abundance, habitat type, incubation stage of spawn, and estimated biomass of herring spawn (biomass provided from ADF&G aerial survey data). Wave height and wind speed will be used as covariates.

Density, species richness and species diversity will be determined from the perpendicular 100 x 300m transect data collected in association with the ADF&G egg density transects. Results will be related to geographic location, average spawn density and extent, and egg losses as determined from the ADF&G egg density transects. For all boat surveys, significant differences between shoreline type and bird numbers will be tested using analysis of variance.

Scan samples will be used to determine the proportion of each species foraging in relation to tidal height, intertidal habitat, and egg density (where available from ADF&G). A simple regression will be fitted to illustrate trends for each species. Paired t-tests will be used to compare activities between the 2 shoreline types.

Focal animal behavioral data will be averaged for each tidal cycle and location. We will use a multivariate approach to ascertain the effects of weather and habitat (eg., principle component analysis or multiple regression). Simple linear regression analysis will be used to detect the effects of tidal height and density of spawn (data obtained from ADF&G transects).

Analysis of esophageal and proventricular contents will be conducted at the University of Alaska - Fairbanks. Two measures will be used to describe the importance of prey types in the diet: frequency of occurrence and relative weight of prey items. Weight will be expressed as percent of wet weight aggregated over all taxa and all samples. Differences in frequency of use of foods among habitats will be summarized as contingency tables and tested with G-statistics (Sokal and Rohlf 1981). A subsample of herring eggs from every 10th gut, and 4 replicate samples from every 20th gut will be dried, counted and weighed. Total number of eggs consumed per bird will be estimated from these samples.

Analysis of lipid content of tissue samples and prey items will also be conducted by the University of Alaska - Fairbanks. Lipid content in samples will be determined using high performance liquid chromatography. Lipid signatures of tissues and prey items will be compared to determine relative importance of prey items in the diet.

d. Alternatives

Live capture and forced regurgitation was considered as an alternative to collecting the entire bird. This was deemed impractical due to capture difficulty and time constraints. Carbon and nitrogen stable isotope analysis was considered as an alternative to lipid signature analysis. Isotope analysis is more appropriate, however, when trying to determine the trophic level of prey items.

5. Location:

Field research will be conducted within the confines of PWS. Exact locations will depend upon the distribution of spawning herring. For the first year, northern Montague Island will serve as an intensive study site. Laboratory analyses will be conducted at University of Alaska-Fairbanks. Data analysis will be conducted at the Copper River Delta Institute, U.S. Forest Service in Cordova, Alaska. Data will be integrated with data management and modeling efforts for the SEA Plan as coordinated by the Prince William Sound Science Center in Cordova.

6. Technical Support:

Laboratory processing of esophageal and proventricular contents and lipid analysis will be completed at the University of Alaska-Fairbanks with projects funds. Herring egg densities and egg loss samples from ADF&G diver surveys will be processed by ADF&G. Aerial surveys on extent of herring spawn will be conducted by ADF&G. Results from both of these efforts will be made available to this study for further analysis. Data will be archived by project staff in accordance with standardized procedures set up for handling the SEA Plan database.

7. Contracts:

Aerial surveys will be a sole-source contract with Fishing and Flying in Cordova Alaska. Currently this is the only flying service in Cordova with a small (4-passenger) float plane that is approved for use by the US Forest Service. Biometric support is not currently available within the Copper River Delta Institute to support data analysis. This work will be therefore be subcontracted. Analysis of gut samples collected for diet analysis, including lipid analysis will be contracted through the University of Alaska-Fairbanks. The complexity of procedures and the specialized equipment needed to conduct analyses necessitate an outside contract.

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D. SCHEDULES

1. Milestones

FY 1994

March 1-April 4	Logistical planning and safety training
April 4-May 20	Field data collection
May 21-August 21	Data entry, data analysis, and diet analysis
August 22-October 31	Draft 1994 report writing and internal review

FY 1995

November 1	Draft report submitted for peer review
January 1	Peer review comments returned to USFS
February 15	Final report submitted for peer review

2. Project Personnel

Project Manager, Fred Everest (Pacific Northwest Research Station, Juneau Forestry Sciences Laboratory): Ensures that project deadlines are met by the project leader.

Project Leader, Mary Anne Bishop: Oversees the project and coordinates with other members of the SEA Plan, and the ADF&G herring spawn deposition study. Is responsible for project design, contract management, data analysis and completion of final products and data integration into SEA plan ecosystem models. Will conduct aerial surveys. Will also act as office liaison for field supervisor.

Assistant Project Leader and Field Supervisor, S. Patrick Green- During the field season wil be responsible for planning, data and specimen collection and logistics in the field. Responsible for purchasing equipment and organizing safety training for crew. Post season duties include data compilation, and analysis.

Bio Tech 1: Will assist in field preparation. Will accompany ADF&G spawn survey deposition study crew. Will conduct perpendicular shoreline surveys and focal bird samples. Will collect 30 glaucous-winged gulls for diet analysis.

Bio Tech 2 & 3: Will assist with data and specimen collection in the field and equipment maintenance.

3. Logistics

a. Field camps

A field camp located between Stockdale Harbor and Montague Point will be required for collecting data in the intensive study area If herring spawn distribution warrants a change to Rocky Bay, the Forest Service administrative cabin in Rocky Bay will be used as the field camp.

b. Vessel Support

Cordova Ranger District's vessel (Chugach National Forest) will provide transportation and supplies to and from the field camp on Montague Island. At the field camp, a 17' Boston whaler with 90 hp motor is needed to conduct shoreline surveys, and collect all other data. ADF&G has agreed to provide the 17' boat. One outboard motor-equipped inflatable raft will be used as a back up.

c. Small plane

A small float plane (Cessna 185) will be required to conduct aerial shoreline surveys on northern Montague Island.

E. EXISTING AGENCY PROGRAM

No federal or state agency program currently exists that could be described as an ecosystem framework for studying resources in Prince William Sound and the EVOS region. For the first seven months (FY94) of the bird avian predation component of the SEA field program, the Copper River Delta Institute will contribute resources in the form of personnel costs for the Project Leader (3.5 months) and Assistant Project Leader (1 month) as well as some field equipment (one inflatable skiff with motor and camping supplies). Ongoing spring shorebird migration studies on the Copper River Delta will provide additional information on the phenology and habitat use of surfbirds and black turnstones.

Other agency contributions to this project include equipment loans from the Cordova Ranger District, Chugach National Forest: one weatherport, one wall tent, and access to their administrative cabin at Rocky Bay. The US Forest Service will also make available for a minimal daily charge their 27' Boston Whaler to transport personnel and equipment to the study site at Montague Island. The ADF&G Habitat and Restoration division will provide a 17' boston whaler throughout the April-May field season at Montague Island. Costs for whaler modification required by this project will be covered under this budget.

F. ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This study primarily involves observations and infrequent collection of birds. A scientific collecting permit has been applied for with the US Fish and Wildlife Service to collect the gulls, waterfowl, and shorebirds. A decision should be rendered by the end of March. This study qualifies for a categorical exemption from the requirements of the National Environmental Policy Act.

G. PERFORMANCE MONITORING

1. Backup Strategy

In the event that the Project Leader, Mary Anne Bishop leaves before the project's completion, Robert Gill, Research Biologist at National Biological Survey in Anchorage will take on the analysis and writing responsibilities.

2. Quality Assurance and Control Plan.

Quality control will be accomplished by thoroughly training biological technicians for the shoreline surveys, the basic sampling method. Additionally, the assistant project leader will have been previously trained by USFWS in their shoreline survey techniques. All personnel will have previous experience in identifying shorebirds, seabirds, and seaducks. Training will emphasize flock size and distance estimation. Flock size estimation training will rely on computer programs especially designed for bird number estimation, slides of flocks with known numbers of birds, and practice before field work begins.

Field personnel will use aerial photographs and maps to record the locations. All data taken on hand-held tape recorders during shoreline surveys will be transcribed by the observer as soon as possible into the computer and checked by the field supervisor. Data taken on hand-held computers during scan and focal animal foraging samples will also be field-checked by the field supervisor.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

All aspects of field work for this project are coordinated with the Alaska Department of Fish and Game Herring Spawn Deposition study, (EVOS Project 94166). The herring spawn deposition study will provide a berth aboard their charter vessel and daily transportation to their sampling sites for one biological technician. The 100x300m perpendicular shoreline transects and some focal-animal sampling will be conducted in conjunction with ADF&G egg density transects. In addition, ADF&G will provide herring egg densities and egg loss results from ADF&G diver surveys and information on the timing and extent of spawn documented from ADF&G aerial spawn surveys.

All data from this project will be archived by the project staff in accordance with standardized procedures set up for handling the SEA Plan database. The field results from the avian predation study will be integrated into the SEA plan's numerical and analytical models of the PWS ecosystem that include predation parameters and animal distributions.

In that this study is scheduled to continue for 5 years, we will continue to coordinate with the Herring Spawn Deposition study as much as possible. Next year, we will also coordinate with the SEA Plan's Herring Larval Study scheduled to begin in FY95.

I. PUBLIC PROCESS

Sound Ecosystem Assessment (SEA) is an ongoing project with a mission to develop and advocate the best model for ecosystem research in Prince William Sound and the EVOS affected region. The concept of the SEA program has been in the region for several year, however only since August of 1993 has the plan been under intense development and come to fruition as a working document for guiding ecosystem level research in PWS and the EVOS region. The SEA Science Group consists of Scientists and Managers from the University of Alaska, Alaska Department of Fish and Game, PWS Science Center, PWS Aquaculture Corporation and the US Forest Service. There has been a tremendous amount of public input into the formulation of this project. Input has been received from Prince William Sound Communities Organized to Restore the Sound (PWSCORS), Cordova District Fisherman United, Cordova Aquatic Marketing Association and numerous Prince William Sound fisherman. A workshop sponsored by the EVOS Trustee Council and NOAA was held in Cordova Alaska during December of 1993 to peer review the SEA document and to further plan for coordinated and integrated ecosystem research in Prince William Sound and the greater EVOS affected region.

J. PERSONNEL QUALIFICATIONS

1. Project Leader - Mary Anne Bishop

Dr. Mary Anne Bishop received a B.B.A. from University of Wisconsin in 1974, a M.S. in Wildlife and Fisheries Sciences from Texas A & M University in 1984, and her Ph.D. in Wildlife Ecology from the University of Florida in 1988. Dr. Bishop has studied the ecology of cranes since 1980, including behavior and movements of subadult whooping cranes (Grus americana), breeding biology of Florida sandhill cranes (Grus canadensis pratensis), and wintering ecology of black-necked cranes (Grus nigricollis) in China. Since 1989, Dr. Bishop has worked for the Pacific Northwest Research Station of the U.S. Forest Service including since April 1990 as the research avian ecologist with the Copper River Delta Institute in Cordova Alaska. Bishop also served as the Institute's Acting Manager from May 1992 through April 1993. She is the Principal Investigator for a study on the migration ecology of shorebirds on the Copper River Delta. Additionally, she is the co-principal investigator of a study on spring and fall staging behavior of trumpeter swans (Cygnus buccinator)on the eastern Copper River Delta. In February 1994, Dr. Bishop along with Chris Iverson of the Tongass National Forest won the U.S. Forest Service's Taking Wing National Award for Research. This award was for their cooperative study on the spring migration ecology of western sandpipers on the Pacific coast. Dr. Bishop has presented numerous papers at national and regional meetings.

Relevant reports and publications:

Iverson, G.I., S. Wornock, N. Wornock, M.A. Bishop, R.W. Butler. in prep. Migration time and linkages between shorebird stopover areas.

Bishop, M.A. and S.P. Green. 1992. Shorebird migration on the Copper River Delta. Final rept. to U.S. Fish and Wild. Serv. Interagency Agreemt. No. 91-0085. Cordova, Alaska. 30pp.

Bishop, M.A. and P.S. Green. 1992. Shorebird migration on the Copper River Delta: report on the 1991 spring and fall migration. FY-91 year-end rep. U.S. Fish Wildl. Serv. Interagency Agreemt. No. 91-0085. Cordova, Alaska. 20pp.

Bishop, M.A., K.M. Portier, and M.W. Collopy. 1991. Sampling methods for aerial censuses of nesting Florida sandhill cranes in central Florida. Pages 235-239 in J. Harris, ed. Proc. 1987 Int. Crane Workshop.Int. Crane Fdtn., Baraboo, WI.

2. Assistant Project Leader & Field Supervisor - S. Patrick Green

S. Patrick Green received his B. Sc. in Wildlife Resources from West Virginia University in 1990. Since 1990 he has worked for the U.S. Forest Service first as a technician and then as a field supervisor at the Copper River Delta Institute in Cordova Alaska. For the past 3 years, he has been involved with the Copper River Delta Spring shorebird ecology study both in the field and as a data analyst. Patrick also participated in a study on Trumpeter Swans foraging ecology as a Field technician and a Field camp supervisor. In addition he has worked on Eastern deciduous forest passerines, on field contaminants and their effect on passerines, and worked for the National Audubon Society studying Roseate Spoonbill breeding and foraging ecology.

3. Project Manager - Fred Everest

Fred Everest is the Program Manager for the Aquatic/Land Interaction program of the Pacific Northwest Research Station, U.S. Forest Service. The Copper River Delta Institute and its research program is a major component of the Aquatic/Land Interaction program.

K. BUDGET

The budget for this subproject of the SEA Plan is attached. FY94 costs are for a 7-month (March-September 1994) fiscal year. FY95 increase reflect a scaling-up of the project for including an additional field crew.

Project Title:	AVIAN PREDATION ON HERRING SPAWN

Budget Category	Proposed 01-Mar-94 30-Sep-94		FY 95	FY 96	FY 97	FY 98	Sum FY 99 & Beyond
Personnel	$27.6		$77.4	$77.4	$77.4	$77.4	$30.0
Travel	$0.0		$1.6	$1.6	$1.6	$1.6	
Contractual	$24.5		$28.1	$28.1	$28.1	$28.1	
Commodities	$9.4		$13.5	$10.5	$10.5	$9.5	
Equipment	$15.0		$35.2	$2.6	$2.6	$0.5	
Capital Outlay	$0.0		$0.0	$0.0	$0.0	$0.0	
Sub-total	$76.5		$155.7	$120.2	$120.2	$117.1	$30.0
General Administration	$8.5		$17.3	$13.4	$13.4	$13.0	
Project Total	$85.0		** $173.0	$133.5	$133.5	$130.1	$30.0
Full-time Equivalents (FTE)	1.1		1.7	1.7	1.7	1.8	0.6

Budget Year Proposed Personnel:

Position	Months Budgeted	Cost	Comment
Research Wildlife Biologist	3	$15.0	Project Leader, 2.3 months of cost in-kind
Wildlife Technician	4	$10.8	Assistant Project Leader & Field Supervisor, 1 month of cost in-kind
Wildlife Technician	2	$5.4	Conduct boat surveys and behavioral observation
Wildlife Technician	2	$5.4	Conduct boat surveys and behavioral observation
Wildlife Technician	2	$5.4	Conduct boat surveys and behavioral observation
Total		$42.0	

** FY 1995 Project Total includes a second field crew, additional commodites and equipment for second crew, and a 17' Boston Whaler (in addition to the whaler on loan from ADF&G). Project expansion allows for full coverage of northern Montague Island which is critical to understanding the ecology of avian species foraging on herring roe in the study area.

Travel:	none	
Contractual:	Air charter ($14,400) - for aerial surveys Anaylsis of stomach contents ($3600,240 stomaches at $15/stomach) Analysis of lipid content ($2,500, 30 samples at $80 a sample)	
Commodities:	Supplies for field camp ($3,300)	$3,289.85
	Scientific supplies ($1000)	$1,010.00
	Field sampling supplies ($3,500)	$3,515.00
	Boat supplies and maintenance ($1600)	
Equipment:	Optics ($5000) - includes binoculars and spotting scopes Computer and software ($8000) - includes a computer for data analysis and software programs and interface for field dataloggers Communications($1100)	

FY 1995 Project Total includes a second field crew, additional commodites and equipment for second crew, and a 17' Boston Whaler (in addition to the whaler on loan from ADF&G). Project expansion allows for full coverage of north Montague Island which is critical to understanding the ecology of avian species foraging on herring roe in the study area.

United States Department of Agriculture

Forest Service

Pacific Northwest Research Station/ Alaska Region

Copper River Delta Institute
P.O. Box 1460
Cordova, AK 99574
(907) 424-7212
FAX (907) 424-7214

Caring for the Land and Serving People

Bob B. Spies, Chief Scientist
Exxon Valdez Restoration Trustee Council
645 G Street
Anchorage, AK 99501

Date: 23 February 1994

Dear Dr. Spies:

Attached please find the Avian Predation on Herring Spawn detailed project description. I would like to suggest that Stan Senner and Jake Schweigert be the two reviewers for this project. Below are their addresses.

Stan Senner
Migratory Bird Conservation Program
National Audubon Society
4150 Darley Avenue, Suite 5
Boulder, CO 80303
phone (303)499-7855; fax (303) 499-0286

Jake F. Schweigert
Dept. Fisheries & Oceans
Pacific Biological Station
Hammond Bay Road
Nanaimo, B.C. V9R 5K6 CANADA
phone (604) 756-7203; fax (604) 756-7138

I look forward to receiving the peer review comments. Thank you very much.

Best wishes,

Mary Anne Bishop

Mary Anne Bishop, Ph.D.
Project Leader - Avian Predation on Herring Spawn

Enc..
cc: Jim Ayers, Executive Dtr.
EVOS Restoration Trustee Council

R. Ted Cooney, Science Chair
SEA Plan

EXXON VALDEZ TRUSTEE COUNCIL
FY 94 DETAILED PROJECT DESCRIPTION

A. COVER PAGE

Project title: Sound Ecosystem Assessment (SEA), An Ecosystem Research Plan for Prince William Sound

Subproject title: Avian Predation on Herring Spawn

Project ID number: 94320

Project type: Research/Monitoring

Name of project leader(s): Dr. Mary Anne Bishop, Research Wildlife Biologist, Copper River Delta Institute, Pacific Northwest Research Station, US Forest Service

Lead agency: USDA, U.S. Forest Service, Pacific Northwest Research Station

Cooperating agencies: Alaska Dept. of Fish and Game, Prince William Sound Science Center, Univ. Alaska, US Fish & Wildlife Service

Cost of project/FY 94 (7 months): $85.0K

Cost of project/FY 95: $173.0K

Cost of Project/FY 96 to FY99: $427.1K

Project Start-up/Completion Dates: March 1, 1994/December 31, 1998

Geographic area : Herring Spawning Grounds Throughout Prince William Sound

Project Leader: Mary Anne Bishop 2/23/94
Mary Anne Bishop — Date

Project Manager: Fred H. Everest 2/23/94
Fred Everest — Date

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

Project Description: Avian Predation on Herring Spawn - This project will assess the effects of avian predation on Pacific herring reproduction in Prince William Sound. The data will be integrated in a model of Pacific herring survival and recruitment. Additionally, this project will assess the importance of herring roe to avian species breeding in the Prince William Sound area and using the herring spawn locations as migratory stopover areas.

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	$31.2	$31.2	$77.3	
Travel	$0.0	$0.0	$0.0	$0.0	$1.6	
Contractual	$0.0	$0.0	$20.5	$20.5	$28.1	
Commodities	$0.0	$0.0	$10.4	$10.4	$13.5	
Equipment	$0.0	$0.0	$16.7	$16.7	$35.2	
Capital Outlay	$0.0	$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$78.8	$78.8	$155.7	
General Administration	$0.0	$0.0	$6.1	$6.1	$17.3	
Project Total	$0.0	$0.0	$84.9	$84.9	$173.0	
Full-time Equivalents (FTE)	0.0	0.0	0.9	0.9	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
1 Research Wildlife Biologist			1.4	$6.9
1 Wildlife Technician			3.0	$8.1
1 Wildlife Technician			2.0	$5.4
1 Wildlife Technician			2.0	$5.4
1 Wildlife Technician			2.0	$5.4
Personnel Total	0.0	$0.0	10.4	$31.2

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

07/14/93

Project Number: 94320 - Q
Project Title: Prince William Sound System Investigation
Sub-Project: Avian Predation
Agency: Dept. of Agriculture, Forest Service

FORM 3A SUB-PROJECT DETAIL

	Reprt/Intrm	Remaining
Travel:		
Travel Total	$0.0	$0.0
Contractual:		
Air charter for aerial surveys (approx. 25 - 2.5 hour flights @ $.23/hr)		$14.4
Analysis of stomach contents (240 stomachs @ $.015/stomach)		$3.6
Analysis of lipid content (30 samples @ $.08/sample)		$2.5
Contractual Total	$0.0	$20.5

Project Number: 94320 - Q
Project Title: Prince William Sound System Investigation
Sub-Project: Avian Predation
Agency: Dept. of Agriculture, Forest Service

FORM 3B SUB-PROJECT DETAIL

Commodities:	Reprt/Intrm	Remaining
Camp supplies (40days of food for 4 ($2.4), first aid kits ($.33), bear box ($.4), 4 propane bottles and propane ($.14), lumber ($.2), 2 dry bags ($.09), miscellaneous ($.19))		$3.8
Scientific supplies (Pelican cases($.22), specimen jars ($.4), chemicals ($.2), personal protection equipment ($.07), dissection kit ($.12), pencils and paper ($.02))		$1.0
Field sampling supplies (270 gallons of gas ($.675), oil ($.04), six gas barrels ($.234), mustang and immersion suits ($2.61))		$3.7
Boat supplies (safety supplies ($.075), survival kit ($.25), tools ($.22), two dry bags ($.07), stainless steel prop ($.3), general boat maintenance and parts ($1.0)		$1.9
Commodities Total	$0.0	$10.4

Equipment:		
Optics (four Leica binoculars @ $.878 ($3.512), Kowa spotting scope and eye pieces ($1.09), two tripods ($.3), three microcassette recorders ($.23))		$5.3
Communications (two 6-watt handheld VHF radios ($.78)		$0.8
Boat (refiberglass hull on a 17' Boston whaler ($1.5), install semi-enclosed cockpit on17' Boston whaler ($1.7)		$3.3
Computer and software (486/66 Mhz desktop computer ($4.5), event recording program compiling software and data logger interface ($2.25), and tide prediction software ($.11))		$7.3
Equipment Total	$0.0	$16.7

Project Number: 94320 - Q
Project Title: Prince William Sound System Investigation
Sub-Project: Avian Predation
Agency: Dept. of Agriculture, Forest Service

FORM 3B SUB-PROJECT DETAIL