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Coastal Habitat Intertidal Monitoring and Experimental Design Verification

Project Number: 95086-A

Name of project leader(s): Drs. Michael S. Stekoll and Raymond C. Highsmith
University of Alaska Fairbanks

Lead agency: Alaska Department of Fish and Game, Habitat and Restoration

Cooperating agencies: University of Alaska

Cost of project/FY 95: $ 829,400

Cost of project/FY 96 Report Budget: $ 236,284

Project Start-up/Completion Dates: Oct 1, 1994/Sep 30, 1999

Geographic area of Project: Prince William Sound (FY 95 and FY 97)
Cook Inlet-Kenai Peninsula (FY 96 and FY 98)
Kodiak-Alaska Peninsula (FY 96 and FY 98)

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INTRODUCTION

The Coastal Habitat Injury Assessment Study (CHIA) was designed to measure ecosystem effects of the EVOS and cleanup on the nearshore community. The study encompassed Prince William Sound (PWS), Cook Inlet-Kenai Peninsula (CIK) and Kodiak-Alaska Peninsula (KAP). The study design allowed inductive statistical inferences of damage to the entire universe of oiled habitats through random selection of sites within habitat categories. Results of these studies can be applied to the damage assessment in higher trophic levels.

At the conclusion of the 1991 field season, several species of algae and invertebrates still showed significant damage to their populations. For most of these populations the recovery status is unknown. This study proposes to revisit the original CHIA sites and assess the recovery rate of damaged species. Percent cover, abundance, biomass, and density of key species will be quantified in all habitats. Recovery will have occurred when community composition, population abundance of component species, and ecosystem functions and services in each injured intertidal habitat have returned to levels that are found on matched, unoiled reference sites

The second component in this proposal is to validate the after, control-impact pairs (ACIP) design employed by the CHIA study. Matched sets of non-oiled sites will be selected using procedures established for the CHIA project. These sites will be monitored and the data evaluated using the same procedures used by the CHIA study.

NEED FOR THE PROJECT

Coastal Habitat Monitoring

This proposed project addresses the explicit need articulated in the "Invitation to Submit Restoration Projects for Fiscal Year 1995" to monitor the injured intertidal resources. Intertidal communities were subjected to the most severe impacts of the spill and subsequent cleanup operations. The intertidal zone is not only a very productive and diverse ecosystem, but it serves as an interface between marine and terrestrial organisms. Algae form a major part of the ecosystem structure, providing protective habitat and forage for many fish and invertebrate species In turn, birds and otters prey on these fish and invertebrates. Understanding the effects of the EVOS on the intertidal is critical in learning the extent of injury and the recovery rate of the effected areas.

Intensive sampling and research during three summers (1989-1991) show that the EVOS and subsequent cleanup had serious and long lasting effects on intertidal algae. Results generally showed lower percent cover and biomass of algal species (especially the perennial *Fucus*) on oiled sites compared to reference sites and there was a corresponding increase in the amount of bare rock at the oiled sites. In addition, *Fucus* plants in oiled sites were not as reproductive as those in reference sites and had higher levels of epiphyte infestation. Other algae had varying responses to the oiling, with significant differences detected for some species through 1991. However, each tidal elevation zone, each habitat, and each area had different patterns.

Analyses of intertidal invertebrate abundance and biomass revealed differences between oiled and control sites for several major taxa. These were the grazers *Tectura persona*, *Littorina sitkana*, and *L. scutulata*, the barnacles *Chthamalus dalli Balanus glandula* and *Semibalanus balanoides* and the mussel *Mytilus*; amphipods, and oligochaetes. Differences varied between regions and habitat types. Recovery of sheltered and exposed rocky invertebrate communities was proceeding in some areas based on comparisons of significant differences between oiled and unoiled sites. Coarse textured and estuarine invertebrate communities had not fully recovered as of the last observation in 1991.

The intertidal fish populations, which are important forage species for the river otter and some avian species, were altered in oiled sites in 1990, followed by some recovery in 1991 within PWS sites. Density and biomass of intertidal fishes were less at reference sites in all three habitat types; exposed rocky, sheltered rocky, and coarse textured, during 1990. In 1991 some recovery occurred in sheltered and exposed rocky habitats but not at coarse textured sites. In sheltered and exposed rocky habitats, oiled and reference sites density and biomass increased between 1990 and 1991, but the increases were much greater at oiled sites than at reference sites.

Because the intertidal ecosystems still showed damage in 1991, the recovery status of the intertidal is not known. This project will monitor the status of the intertidal at previously visited sites. All sites will be revisited twice over a four year period to determine if population structures of damaged species have returned to pre-spill levels and have stabilized.

Experimental Design Verification

The experimental design used in the Coastal Habitat Injury Assessment program has potential flaws, in that there may be intrinsic differences between the oiled and reference sites, even without oiling and/or cleanup. This problem has been recognized in the "Invitation to Submit Restoration Proposals". Accordingly, we have devised a scheme to verify the experimental design by monitoring matched, non-oiled sites.

The optimal design for environmental impact monitoring includes sampling both before and after a disturbance event, at pairs of impacted and reference sites (Green, 1979; Stewart-Oaten et al, 1986). This process is a BACIP (Before-After, Control-Impact Pairs) design. Very few of the current studies of the effects of the EVOS have been able to use this design due to the of the lack of pre-spill data. Instead, we have relied on sampling at pairs of oiled and reference sites after the spill to infer injury to biological resources in coastal habitats. This process is the ACIP (After Control-Impact Pairs) Design. Correct interpretation of the results produced from this design are based on the assumption that oiled and reference sites would not have differed if there an oil spill had not occurred.

There are resources within both the subtidal and intertidal habitats that have shown consistent differences among oiled and control sites using the ACIP design. For example, percent cover by *Fucus* in the mid intertidal in Prince William Sound has been consistently higher at reference than at oiled sites, and *Musculus* density on eelgrass in Prince William Sound has been consistently higher at oiled sites. Without pre-spill data, it is difficult to establish whether these differences represent long term impacts of the spill, or whether they represent inherent differences among sites. It may be that the predominant wind and current conditions within Prince William Sound that were responsible for bringing oil to specific beaches were also responsible for bringing higher concentrations of *Musculus* larvae to those same beaches.

There are essentially two ways to address this issue. First, long term monitoring of resources could be conducted to determine if the resources at oiled and reference sites "converge" after some period. This approach suffers from that fact that convergence may take very long to occur, or may never occur if some alternate stable state has been achieved after the spill. In the shorter term, agencies are faced with making decisions regarding possible restoration of supposedly injured resources. A second approach is to conduct an independent test of our ability to match oiled and control sites, and to demonstrate that the site selection process produced no biases that may have resulted in inherent differences among oiled and control pairs.

Verifying the process by which matched pairs are selected also has much larger implications with respect to monitoring programs that may be used to evaluate impacts of future oil spills as well as other disturbances. The uncertain time and location of oil spill beach impact makes it extremely difficult to obtain the appropriate "pre-spill" data at both impacted and reference sites. Costly "baseline" monitoring programs often result in data that are largely unusable for evaluating injuries. Evaluation of injuries from spills usually relies on sampling conducted only after the spill. The establishment of *a priori* criteria for the selection of oiled and control sites, and the *a priori* verification that this selection process does not produce biases in oiled-control comparisons, would be very useful in supporting inferences made from future post-spill surveys. In addition, establishment and verification of *a priori* site selection criteria, could prove much more useful, and much more cost effective than baseline monitoring studies.

PROJECT DESIGN

1. **Objectives**

General Objectives

a. To determine whether intertidal habitats still show damage, by conducting a comprehensive monitoring program of intertidal communities in the areas impacted by the EVOS, using the matched paired sites monitored during the CHIA study.

b. To determine if previously used site selection criteria may have resulted in biases that could lead to inherent differences among oiled and control sites that were unrelated to oiling.

c. To establish criteria for the unbiased selection of oiled and control site pairs to be used in assessing injury from future oil spills or other disturbances.

Specific Objectives

a. To monitor the original PWS CHIA study sites in sheltered rocky, exposed rocky, coarse textured, and estuarine habitats. Collect data on algal percent cover, densities of damaged invertebrate species, and densities of intertidal fish. Specific questions that will be addressed include:

i. Have algal, invertebrate, and fish species that showed damage in PWS in 1991 recovered? If not, to what degree has recovery occurred?

ii. What habitat variables seem to affect PWS populations of algae, invertebrates, and intertidal fish?

iii. Was the increase in density and biomass of intertidal fish at PWS oiled sheltered and exposed rocky habitats due to recovery or interannual variability?

b. To select new sites within the sheltered rocky and coarse textured habitats in PWS for testing the ACIP stratified random sampling design. Sites will be selected with the same protocol used to select the final CHIA sites.

c. To monitor the new sites from the sheltered rocky and coarse textured habitats with the same methods used in the original sites.

2. Methods

<u>CHIA Site Monitoring</u>

The original matched pairs in the PWS region on sheltered rocky, exposed rocky, coarse textured, and estuarine habitats will be sampled, for a total of 28 sites. The sampling efforts for this monitoring study will focus on non-destructive measurements of intertidal algae percent covers and abundances of grazers, primary space competitors, and invertebrates and fish predators. In addition, on coarse textured and estuarine sites, some infaunal sampling will occur as those organisms showed clear statistical differences through 1991. Quadrats are located along each of six vertical transects at the first, second, and third meters of vertical drop (MVDs) from the mean high water (MHW) line. For some measurements, additional transects will be laid out, i.e. for line transects as described below.

a. Methods for Algal Sampling

Percent cover of benthic algae will be determined on all undisturbed quadrats using the point-contact method developed by the CHIA studies. In addition, we will perform estimations of percent cover of understory ("turf") algae and characterize the substrate at each quadrat. Specific measurements will be made on randomly selected *Fucus* plants in each MVD at each site. Measurements on *Fucus* will include plant density, size frequency distribution, degree and type of epiphytism, and reproductivity.

b. Methods for Invertebrate Sampling

Direct counts will be made of epifaunal organisms within original undisturbed quadrats. Within a semi-circle placed directly to the side of the quadrat, size measurements will be made for the nearest limpets.Double sampling will be used to calibrate the enumeration method for counting larger epifauna in quadrats to the method of removing all organisms from within the quadrat and counting organisms in the laboratory.

At coarse textured and estuarine habitats, in addition to counting epifauna, infauna will be collected and preserved. Sorting will be limited to those taxa which are dominant and/or showed impact during the CHIA study (i.e. oligochaeta, amphipoda, and polychaeta). Counts and wet weight will be determined for each taxon.

Larger invertebrates such as sea stars, whelks, and anemones, which are important predator members of the intertidal community but are mobile and unevenly distributed, will be surveyed using 2-m wide strip transects from MHW to the water line. Additional surveys will be done by divers during high tides in order to get a better count of cryptic organisms that tend to seek refuge when emerged during low tides.

Coverage and extent of mussel beds or zones on oiled and reference sites will be estimated using a line intercept method. A series of transects perpendicular to the water mark will be traversed from MHW to the water line. The length of the intersection with mussel beds or dense mussel zones, as well as measurements of the size of each mussel zone or bed will be made. Subsamples from within each mussel zone or bed will be collected for size-frequency analyses.

c. Intertidal Fish Methods

Fish sampling methods will be similar to those employed during the CHIA studies. A one meter wide strip transect beginning at 1 MVD and orientated perpendicular to the MHW line will be sampled for intertidal fish. Percent cover by algae and substrate types will be measured using a point contact method. Fish species collected within the strip transect will be preserved, measured, and weighed. Abundance and biomass of fish per unit area will be computed from fish captured within each MVD. Resource selection techniques will be used to determine what habitats are preferred by intertidal fish.

In coordination with the line intercept invertebrate collections, percent cover of mussels, algal morphotypes, and substrate types will be estimated using a point contact method in a 1-m by 1-m quadrat frame. These data will aid in characterizing each site by substrate, algae, and invertebrates, and allow determinations of habitat preference by intertidal fish.

Experimental Design Verification

One way of assessing our ability to select matched pairs of oiled and reference sites would be to use existing reference sites, select a new set of reference sites that matched the old reference sites (using criteria that are the same as those used in previous oiled-reference comparisons), sampling at the old and new matched reference sites, and determining if there are significant differences among these. This process ignores possible biases related to oiling. It may be, for example, that wind and currents that bring oil to a site make the universe of potential oiled sites different from the universe of potential reference sites.

A second approach is to rely on an oil spill simulation model to define a potential universe of "simulated oiled" sites, select a set of "simulated oiled" sites from this universe, select matched reference sites, sample at "simulated oiled" and matched reference sites, and test for significant differences among sites. This approach also has potential drawbacks. Existing simulation models are very coarse grained and outputs from these models would likely result in large sections of coastline being simulated as oiled. This is in contrast to actual oiling observations which indicated that very often, heavily oiled and unoiled beaches were in close proximity to one another. Because of the coarse grained nature of the simulation models, "simulated oiled" and reference sites may be separated by large distances. As a result, using "simulated" oiled and reference comparisons could result in a very conservative test of our ability to select matched pairs.

As a result of the imperfect nature of both designs, we propose to use a combination of approaches. First we will use an oil spill simulation model (Galt et al, 1991) to predict what portions of the Sound will be oiled in a simulated spill. We will overlay the shoreline types onto the simulated oiling map using existing GIS (Geographic Information System) databases, and select "simulated oiled" sites. Matched reference sites will be selected using the same criteria used to select reference sites after the spill. In addition, a second set of reference sites will be matched to those reference sties so that we can make reference-reference comparisons. The distance between these reference pairs will be no closer than the minimum distance between oiled and reference sites in the original injury assessment studies.

These studies will be conducted only within Prince William Sound and only within two selected habitat types (sheltered rocky and coarse textured beaches). Sites from both habitats will be selected in 1995, but only the sheltered rocky habitat will be sampled in that year. Coarse textured beaches will be sampled two years later in 1997. A total of 5 "triplets" of sites (a simulated oiled site, its matched control, and a second control matched to the first) will be sampled in both sheltered rocky habitat and coarse textured beaches. The community attributes that will be measured and the sampling methods will be similar to that described for the monitoring program.

3. **Schedule**

Oct-Dec 94	GIS selection of additional sites for experimental design verification
Jan-Apr 95	Obtain helicopter charter/boat charters and visit sites selected by GIS
May-Jun 95	Sample on CHIA sites in PWS
Jun-Jul 95	Sample on additional sheltered rocky sites in PWS
Jul-Sep 95	Sample analyses in laboratory
Sep-Dec 95	Data analysis/report writing
Apr 96	Submit annual report for FY 95

The site selection for the verification for the intertidal reference sites will be conducted during early May 1995. We plan to select reference sites for both the sheltered rocky and coarse textured sites at this time. The sampling of these reference sites will be conducted for the sheltered rocky habitats in late June 1995 and for the coarse textured habitats in June 1997. The results of the site selection for the sheltered rocky habitats will have to be available to the team doing the intertidal monitoring by early June 1995.

May-Jun 96	Sample on CHIA sites in CIK and KAP
Jun-Sep 96	Sample analyses in laboratory
Sep-Dec 96	Data analysis/report writing
Apr 97	Submit annual report for FY 96
May-Jun 97	Resample CHIA sites in PWS
Jun-Jul 97	Sample on additional coarse textured sites in PWS
Jul- Sep 97	Sample analyses in laboratory
Sep-Dec 97	Data analysis/report writing
Apr 98	Submit annual report for FY 97
May-Jun 98	Resample CHIA sites in CIK and KAP
Jul-Sep 98	Sample analyses in laboratory
Sep-Dec 98	Data analysis
Jan -Jun 99	Report writing
July 99	Submit final report for project

4. **Technical support**

Principal investigators from the University of Alaska School of Fisheries and Ocean Sciences, will cooperate to provide expertise on different aspects of the intertidal study: algal, invertebrate and fish taxonomy and ecology. All mobilization and demobilization efforts associated with the charter vessel will be accomplished through the Seward Marine Center in Seward, Alaska. A project manager will oversee project logistics and personnel.

All sample and data analysis will take place at the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, the Juneau Center for Fisheries and Ocean Sciences and at Coastal Resources Associates, using available computers and established data management services. A contract will be issued for the use of research vessels able to support the field work in Prince William Sound. A similar contract will be established for air taxi support between Anchorage and Prince William Sound.

A contract will be issued to Coastal Resources Associates (CRA) of Vista, California and to Western EcoSystems Technology, Inc. (WEST) for the experimental design verification aspect and to assist with the monitoring program. CRA and WEST have been involved with the CHIA study since 1989, and have played an integral part in the experimental design and data analysis procedures. In order to maintain consistency with the data collection, experiment modifications, analyses and report writing, it will be necessary to continue the existing contracts established with CRA and WEST.

The GIS databases developed by the Department of Natural Resources will be an integral part of this program. We will require their assistance in integrating the NOAA oil spill model into the GIS database and in developing the GIS model to select the reference sites.

5. **Location**

a. Location FY 95 and FY 97

This study will take place in the intertidal zone on Prince William Sound sheltered rocky, exposed rocky, coarse textured, and estuarine sites.

b. Location FY 96 and FY 98

This study will take place in the intertidal zone on Cook Inlet-Kenai Peninsula sheltered rocky, coarse textured and estuarine sites and on Kodiak-Alaska Peninsula sheltered rocky and coarse textured sites.

PROJECT IMPLEMENTATION

The original CHIA project was implemented by the Alaska Department of Fish and Game (Phase I) and the U.S. Forest Service with a contract to the University of Alaska (Phase II). At this time the project should be implemented by the University of Alaska through the Habitat and Restoration Division of the Alaska Department of Fish and Game. The University has the historical records of the sites and all of the raw and processed data from 1989 to 1991. The University is in the best position to assure the consistency of the data to allow for comparisons to the previously collected data. The Alaska Department of Fish and Game is also currently involved in the monitoring and restoration of the nearshore through existing contracts with the University for work in the subtidal (S. Jewett) and at Herring Bay (R. Highsmtih and M. Stekoll).

In addition, both CRA and WEST were key players in the original site selection and ACIP experimental design. Verification of the experimental design will be difficult to perform without input from these two entities and the University of Alaska.

COORDINATION OF INTEGRATED RESEARCH EFFORT

This multi-disciplinary study will be conducted by a team of scientists with first hand experience in the monitoring of the effects of oil in Prince William Sound. This team of the investigators has been working together over the past 5 years in evaluating the effects of the EXXON VALDEZ oil spill on intertidal and subtidal communities. Principal investigators from the University of Alaska Fairbanks and University of Alaska Southeast will be coordinating efforts to study interactions between key algae, invertebrate and fish. Coastal Resources Associates, Inc. will be consulted for the selection process for the additional sites needed for verification of the matched pair design. Western EcoSystems Technology, Inc., will be consulted for the site selection procedures, for sampling protocols that will enable comparisons from the destructive sampling efforts used in 1989-1991 to the non-destructive sampling efforts to be used for this study, and for statistical analyses of all data.

PUBLIC PROCESS

Several presentations on results from previous field seasons to the CHIA sites have been made during EVOS Oil Spill Symposiums in Anchorage to which the public was invited. Each proposal and report is available to the public for comment and we anticipate that this process for public participation will continue.

This current proposal is a direct result of the public workshop concerning "Research Priorities for Restoration" held in Anchorage during April 13-15, 1994.

PERSONNEL QUALIFICATIONS

A list of the investigators, their responsibilities in the proposed study, and a brief description of their qualifications follows.

1. Dr. Raymond Highsmith, Professor, Director West Coast National Undersea Research Center, UAF/SFOS, Fairbanks - coordinator, co-principal investigator.

   Dr. Highsmith has been the coordinator and a principal investigator of two EXXON

VALDEZ Oil Spill projects; the Coastal Habitat Injury Assessment project and the Herring Bay Experimental and Monitoring studies. His specialties include ongoing research of recruitment and population biology in the intertidal zone and is familiar with the effects of the oil spill on intertidal invertebrates throughout the EVOS impacted area.

2. Dr. Michael Stekoll, Professor, UAF/JCSFOS and UAS, Juneau - co-principal investigator.

   Dr. Stekoll has been a co-principal investigator on three *Exxon Valdez* Oil Spill projects: the Coastal Habitat Injury Assessment project, the Herring Bay Experimental and Monitoring Studies, and the Shallow Subtidal Assessment project. He has co-authored annual and final reports for these projects and has produced refereed publications on various aspects of these projects. His specialties include, marine pollution biology, the biology and ecology of seaweeds in Alaska, especially *Macrocystis* and *Fucus*, and the mariculture of kelps and red seaweeds.

3. Dr. Lawrence Deysher, Sr. Scientist Coastal Resource Associates, Inc.- intertidal assessment and GIS mapping.

   Dr. Deysher is a marine ecologist who has been with CRA since it's conception. He directed field studies of intertidal algae as part of the EVOS damage assessment studies and participated in the original site selection of the CHIA monitoring sites. He has co-authored the annual reports on the intertidal algal monitoring studies and a paper on the use of the DNR GIS in selecting the intertidal monitoring sites for the CHIA studies. He is currently working on the experimental algal studies in Herring Bay as well as directing studies of kelp resources in California using a Geographic Information Systems.

4. Dr. Thomas A. Dean, Coastal Resources Associates Inc. - ACIP design

   Dr. Dean has over 15 years of project management experience in the field of environmental impact assessment. He has been responsible for studies of the effects of the EVOS on subtidal plant and epibenthic invertebrate communities, and for a 10 year study of the effects of the San Onofre Nuclear Generating Station on marine plant life. Dr. Dean is president of Coastal Resources Associates, Inc. (CRA). The firm specializes in marine environmental impact assessment and marine toxicology. CRA was founded in January 1988 and has a staff of eight full time employees.

5. Dr. Lyman McDonald, WEST Inc. - sampling design and statistical analysis.

   Dr. McDonald is a biometrician/statistician with 25 years of comprehensive experience in the application of statistical methods to design, conduct, and analyze environmental and laboratory studies. He is a co-founder of WEST Inc. and a past member of the faculty in the Departments of Statistics and Zoology at the University of Wyoming. Dr.

McDonald has served as the lead biometrician for studies of the effects of the EVOS on intertidal and subtidal communities. He was largely responsible for the design of the current sampling program being utilized in the EVOS Coastal Habitat studies. He is responsible for writing a NOAA guidance document for quantifying injury due to oil spills in Type B Natural Resource Damage assessments. Dr. McDonald presently is a scientific advisor to the EPA EMAP program.

6. Wallace Erickson, Biometrician, WEST Inc - statistical analysis.

   Mr. Erickson has served as one of the principle biometricians in the CHIA study. His duties included design, protocol, and quality control/assurance and report writing. In addition, he played an integral role during the sampling efforts of the 1990 and 1991 CHIA field seasons.

BUDGET

	FY 95 Experimental	Report Preparation
Personnel/Benefits	$342,100	$ 152,700
Travel	19,500	9,900
Contractual Service	272,000	29,100
Commodities	8,800	2,700
Equipment	39,000	0
Capital Outlay	0	0
Grad STudent Support	9,600	2,400
Overhead @ 20%	138,200	39,400
Total	**$ 829,200**	**$ 236,300**

REFERENCES

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Stewart-Oaten, Allen, W. Murdoch, and K. Parker. 1986. Environmental impact assessment: "Pseudoreplication" in time? Ecology 67:929-940.

Population and Community Dynamics of Eelgrass and Associated Fauna

Project Number:	95086-B
Name of project leader(s):	Drs. Michael S. Stekoll and Steve Jewett University of Alaska Fairbanks Dr. Thomas A. Dean Coastal Resources Associates
Lead agency:	Alaska Department of Fish and Game, Habitat and Restoration
Cooperating agencies:	University of Alaska
Cost of project/FY 95:	$64.8K
Cost of project/FY 96 Report Budget:	$35.0K
Project Start-up/Completion Dates:	March 1994/September 1997
Geographic area of Project:	Herring Bay. Prince William Sound
Contact Person:	Dr. Joe Sullivan Alaska Department of Fish and Game Habitat and Restoration 333 Raspberry Road Anchorage, AK 99518-1599 (907) 267-2213

Introduction

Resources within eelgrass beds have clearly been injured by the *Exxon Valdez* oil spill. A reduction in eelgrass density, a reduction in the densities of associated sea stars (*Dermasterias)* and crabs (*Telmessus*), an increase in the density of mussels that live attached to eelgrass (*Musculus*), and an increase in juvenile cod were observed within oiled eelgrass beds. *Musculus* are at times very dense and may inhibit the growth and survival of eelgrass. The sea stars, crabs, and cod feed on the *Musculus*.

We suspect that recovery of eelgrass may be inhibited by their inability to quickly recolonize bare patches after injury, and that the recovery may be slowed by an increase in *Musculus* at oiled sites. Furthermore, *Musculus* densities may be higher at oiled sites because of a lack of predators (sea stars and crabs) at those sites.

This project examines factors that may inhibit the recovery of subtidal populations of eelgrass and invertebrates within the eelgrass community. This task would lead to the determination of the necessity for, and appropriate design of, restoration activities. This is a continuation of community dynamics studies within the coastal habitat.

NEED FOR THE PROJECT

This project would allow us to understand whether eelgrass resources should be restored, and if so, what methods may be appropriate for restoration.

PROJECT DESIGN

Objectives

1. Determine the recovery rates of damaged eelgrass populations, both by vegetative growth of rhizomes, and by seedlings.

2. Determine the importance of *Musculus* on the growth of eelgrass.

3. Determine factors that may be responsible for determining the distribution of *Musculus*.

4. Examine recruitment rates of sea stars and crabs and estimate their potential for recovery.

Methods

Experimental manipulations of eelgrass within Herring Bay will be conducted to determine the growth and recolonization rate of eelgrass. Experiments will evaluate the expansion rate of eelgrass into cleared patches along the edge of the bed, and to isolated patches of eelgrass transplanted just outside the bed. The growth rate of rhizomes will be documented. The growth of transplanted eelgrass rhizomes and shoots will be examined both in the presence and absence of *Musculus*.

Factors affecting the distribution of *Musculus* will be examined. The distribution of *Musculus* both within and among eelgrass beds in Herring Bay will be examined. Correlations between distribution of *Musculus* and physical factors will be examined in order to provide testable hypotheses regarding factors affecting *Musculus*. *Musculus* transplant experiments will be conducted to examine if the distribution of *Musculus* is limited by factors influencing recruitment or survival.

Manipulative experiments will be conducted to examine the relative impact of grazing by crabs, sea stars, and cod on *Musculus*.

We will also conduct sampling to determine the size distribution of sea stars and crabs within the eelgrass habitat, and to estimate the potential for recovery via recruitment.

Schedule

Experiments will be conducted during four cruises in 1995. A progress report will be submitted in September of 1995 that summarizes field observations. A final report will be submitted in March 1996.

Technical Support

No technical support will be required.

Location

This project will be conducted within Herring Bay, Prince William Sound.

PROJECT IMPLEMENTATION

Principal investigators for this project have been conducting injury assessment studies in the shallow subtidal within Prince William Sound since 1989, and are submitting several proposals for continued monitoring and assessment of subtidal resources. The investigators involvement in other related projects makes them uniquely qualified to conduct cost effective studies on the interactions within the eelgrass community.

COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is to be conducted in concert with subtidal monitoring studies and with studies of population dynamics of intertidal populations within Herring Bay. The research platform used for this work will be shared with the team studying intertidal community dynamics within Herring Bay, and it is expected that information as well as logistical resources will be shared by these groups. For example, it is anticipated that an integrated subtidal and intertidal research effort will allow intertidal crews to examine the potential impacts of fish and crabs on populations within the lower intertidal during periods when these habitats are submerged.

PUBLIC PROCESS

Investigators in this project have taken part of public participation workshops sponsored by the

Trustee Council to examine research needs. Future workshops will be supported. All documents produced will be made available for public review.

PERSONNEL QUALIFICATIONS

Dr. Michael Stekoll - Dr. Stekoll is Professor at the University of Alaska, School of Fisheries and Ocean Sciences and the University of Alaska Southeast, Juneau. He has served as co-principal investigator on three *Exxon Valdez* Oil Spill projects: The Coastal Habitat Injury Assessment Project, the Herring Bay Experimental and Monitoring Studies, and the Shallow Subtidal Assessment Project. He has co-authored annual and final reports for these projects and has produced refereed publications on various aspects of these projects. His specialties are the biology and ecology of seaweeds in Alaska.

Mr. Stephen Jewett - Mr. Jewett is a Senior Research Associate with the University of Alaska Fairbanks, with over 25 years of research experience in the Alaskan coastal ecosystems. Mr. Jewett is author of over 15 publications, including several recent papers dealing with the effects of the *Exxon Valdez* oil spill on subtidal invertebrates. Mr. Jewett has been co-principal investigator of *Exxon Valdez* oil spill injury assessment and restoration studies for subtidal invertebrates and plants in Prince William Sound since 1989.

Dr. Thomas A. Dean - Dr. Dean is President of Coastal Resources Associates, Inc. He has authored over 20 publications in scientific journals on nearshore ecosystems, as well as numerous unpublished reports. Dr. Dean has published several papers dealing with impacts of the *Exxon Valdez* oil spill on subtidal invertebrates and plants. Dr. Dean has been co-principal investigator of *Exxon Valdez* oil spill injury assessment and restoration studies for subtidal invertebrates and plants in Prince William Sound since 1989.

BUDGET

The following is a preliminary budget for the proposed study.

Personnel	$ 15,000
Travel	2,000
Supplies	5,000
Equipment	4,000
Contractual Services	28,000
General Administrative	10,800
TOTAL	$64,800

Project: 95086C

Herring Bay Monitoring and Restoration Studies

Project leader(s): Drs. Raymond C. Highsmith and Michael S. Stekoll

Lead agency: Alaska Department of Fish and Game

Cooperating agencies: University of Alaska

Cost of project/FY 95: $ 549.1K

Cost of project/FY 96 report preparation: $ 163.0K

Project Start-up/Completion Dates: Oct 1994/ Sep 1999

Geographic area of project: Herring Bay, Knight Island, Prince William Sound

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INTRODUCTION

Following the *Exxon Valdez* oil spill (EVOS) and subsequent clean-up activities, research was conducted under the Coastal Habitat Injury Assessment (CHIA) program within the shallow subtidal and intertidal zones in the oil-affected habitats in Prince William Sound (PWS), and in the intertidal zones in Cook Inlet - Kenai Peninsula (CIK), and Kodiak - Alaska Peninsula (KAP). In addition, the Herring Bay Experimental and Monitoring Studies were conducted within Herring Bay, Knight Island, in Prince William Sound. All of these projects found damage to both the shallow subtidal and intertidal invertebrate and algal communities. Significant differences were detected between oiled and reference sites for grazing invertebrates such as *Tectura persona*, *Lottia pelta*, *Littorina sitkana*, and *L. scutulata* and for the primary space competitors *Fucus*, *Mytilus*, and several species of barnacles. Most of the invertebrates showing damage are prey for either other invertebrates or for foraging birds or marine mammals. Further research will allow better interpretations of key relationships in the damaged nearshore ecosystem.

Several ongoing monitoring and experimental studies have continued in Herring Bay since 1990 and are continuing through the 1994 field season. In addition to these studies, several new experiments are proposed to identify important community interactions between and among invertebrates and algae for determining factors that limit or control recovery. More specifically, the proposed studies are designed to answer one or more of the following ecosystem process questions:

1. Do dominant competitors and resident predators limit recovery of the damaged intertidal community? Included within this question are whether the presence of certain grazers limits the recovery of algal species.

2. Are predators limited by reduced populations of prey species? Included in this question are the affects of reduced algal cover as a food source to grazers.

3. Is the recovery of the community structure limited by recruitment processes?

4. Do physical processes limit recovery of damaged intertidal species, including the effects of damaged species that act as structure and protection for other species?

A combination of new and continued experiments in Herring Bay is proposed to elucidate the ecosystem processes that control community structure and recovery.

NEED FOR THE PROJECT

Five years after the EVOS, several intertidal species are still showing damage, including *Fucus*, the important structural component of the intertidal ecosystem. Continued monitoring of several key invertebrate and algal species in Herring Bay will allow estimates of the degree and rates of recovery of damaged species. This project will aid in defining the rates and potentials for recovery of damaged intertidal resources by ascertaining the major limitations to settlement, recruitment, and growth of *Fucus* and of invertebrates such as barnacles, mussels, and limpets.

A restoration aspect of the experimental study is focusing on the restoration of the damaged *Fucus* populations in the upper intertidal. This experiment is testing the feasibility of using a biodegradable substrate seeded with *Fucus* embryos to recolonize the high intertidal habitat by reducing heat and desiccation stress.

PROJECT DESIGN

1. Objectives

The objectives of this study are to identify the key relationships between damaged intertidal invertebrates and algae, to monitor the rates and degree of recovery of damaged intertidal resources, and to measure the natural rates and the feasibility of *Fucus* restoration in the upper intertidal.

These objectives will be accomplished by focusing each experiment to answer one or more of the following questions:

1) are some species limited by predation and/or competition?

2) what limits food availability for grazers (i.e. limpets, littorines) and predators (i.e. *Nucella)*?

3) is recovery limited by recruitment and, if so, what are the limiting factors?

4) how do physical factors, such as reduced protective cover or water circulation, limit species recovery?

We have keyed each experiment listed below to these question numbers.

2. Methods

Monitoring (Ongoing)

a. Population dynamics (1).

Population dynamics of *Fucus*, sessile invertebrates, and grazers will continue to be quantified in established quadrats at six pairs of oiled and reference sheltered rocky and coarse textured sites. Organisms will be counted within six quadrats that have been permanently established within each of the first three meters of vertical drop (MVD) below mean high water. The quadrats will be visited twice during the summer. The number of *Fucus* plants in various size classes will be determined. Reproductive status and condition of the plants will also be recorded. Limpets, *Nucella spp*., and *Littorina sitkana* will be counted, and subsamples of each will be measured.

b. *Fucus* egg settlement (3)

Fucus egg settlement on oiled and control sites will continue to be monitored because of its importance to *Fucus* recovery. Grooved plates designed to catch *Fucus* eggs will be placed at three tidal levels (0.5, 1.0, and 2.0 MVDs) along four transects at each of four pairs of sites. The number of eggs settled on plates after 24 hours will be recorded. The experiment will be repeated three consecutive days at each site.

Experimental (Ongoing)

a. Fucus/limpets/other algae interactions (1,3,4)

Evidence indicates that ephemeral algae colonized better in areas devoid of *Fucus*, while in areas where the *Fucus* beds remained relatively intact, ephemeral algae were less abundant. *Fucus* may release allelochemicals which assist in both interplant competition for space and resources and grazer deterrence. To investigate this we will continue to monitor cleared plots with various sized buffer zones that were established in 1993. Each replicate consists of four plots at 2 MVD, one for each buffer zone treatment plus an unmanipulated control. Circular buffer zones of 50 cm, 1 m, and 2 m radii were cleared around monitored plots. The sampling area consists of a cleared 25 cm radius circle. Percent cover, understory cover, and primary space occupancy will be measured. In addition, the effects of reduced *Fucus* cover on limpet densities will be determined. Limpet densities will be followed over time and comparisons made between plots of differing size and between treatment plots and controls.

b. *Nucella*/mussel interactions (1,2)

The size-frequency distributions of mussels will continue to be studied within the mussel band on three matched pairs of sites. Two major predators on mussels are the whelks *Nucella lima* and *N. lamellosa*. Both of these species will be censused on each site in an attempt to relate *Nucella* densities to the size-frequency distribution and densities of mussels on each site. *Nucella* exclusion and inclusion cages will be maintained over randomly selected plots within the mussel zone on each of the sites to estimate their rates of predation on mussels and their influence on the size-frequency distributions of mussel populations.

c. Barnacle species interactions (1,3)

Data collected during the Coastal Habitat Intertidal Assessment project showed significantly higher densities of *Chthamalus dalli* on oiled sites compared to control sites within the first three MVDs. In undisturbed systems, *Chthamalus* species tend to be restricted to the highest zones in the intertidal, as they are excluded by the superior space competitors, *Balanus glandula* and *Semibalanus balanoides*, in the lower intertidal. *Chthamalus dalli* appears to be the barnacle species that initially benefited from the free space created by the oil spill and clean-up activities. We will continue to monitor recruitment and post-settlement survival ratios of *C. dalli* compared to *S. balanoides* and *B. glandula*. The three sites used in this study are all on oiled vertical rock faces.

d. Effects of herbivores on *Fucus* recruitment, growth, and survival (1,3)

The effects of herbivores on *Fucus* recruitment, survival, and growth will be investigated. Heterogeneous polycarbonate plates manipulated by three treatments of full cage, open cage, and no cage will be set out at three tidal levels (1, 2, and 3 MVDs). The number of germlings and size of the five largest germlings on each plate will be recorded. The experimental design will be repeated at six sites.

e. Mussel recruitment/filamentous algae interactions (3,4)

Mussel larvae tend to settle temporarily on filamentous algae in the mid and low-intertidal zones. On sites used for *Nucella*/mussel interaction studies, filamentous algal percent cover will be determined within each MVD. Filamentous algae samples will also be collected at each MVD three times per field season to determine the number of young mussels that have settled onto the algae. The data will be related to the size-frequency distribution data collected in the *Nucella*/mussel interaction study.

f. Substrate use by *Fucus* (3,4)

Substrates used by large and small *Fucus* will be examined in relation to substrate availability. The proportion of plants from three different size classes (<2 cm, 2-10 cm, and >10 cm) using cracks, barnacles, rock surface, and other substrates will be compared to relative availability of the different substrates.

g. Effects of physical environment on *Fucus* recruitment (3,4)

The effects of physical environment on *Fucus* recruitment will continue to be studied. *Fucus* recruitment will be monitored on tiles with various sized grooves placed under a variety of conditions including in and out of *Fucus* canopy, at different tidal levels, and at oiled and control sites..

h. Effects of water movement on mussel and *Fucus* growth rates (4)

a. To test whether mussel growth rates on oiled sites within Herring Bay are different from those on control sites, tagged and measured mussels have been caged in the intertidal and periodic measurements will be made to determine growth rates. Any differences detected may be due to differences in relative water motion on oiled versus control sites. To test this idea, calcium sulphate dissolution rates will be determined on all sites where mussel growth rates are being measured.

b. Study of water movement effects on *Fucus* growth with and without *Fucus* canopy will continue. Two similar plants will be marked at 18 sites varying in exposure to waves. All plants able to touch one of the marked plants will be removed, and the canopy around the other marked plant will be left intact. Average water velocity will be measured at each site by deploying calcium sulfate dissolution sticks.

Experimental (New)

a. *Fucus*/barnacle/mussel interactions (1)

This study is designed to elucidate the positive or negative interactions among *Fucus*, mussel, and barnacle populations. Treatments will include replicated reciprocal removal of *Fucus* and barnacles in a mixed Fucus/barnacle zone; reciprocal removal of *Fucus* and mussels in a mixed Fucus/mussel zone; reciprocal removal of each species in a mixed Fucus/mussel/barnacle zone; and control treatments where no removal occurs. Recruitment and existing densities of each species will be monitored over time.

b. Oystercatcher/limpet/mussel interactions (1)

Because of the importance of integrating study of the intertidal system with that of external interacting systems, the effects of oystercatcher predation on intertidal community structure will be investigated. Oystercatchers will be excluded from foraging areas of the intertidal using cage domes. Plots within and outside of exclosures will be monitored for changes in intertidal community structure.

c. Effects of epiphytes on *Fucus* reproduction (1)

The effects of epiphytes on *Fucus* reproduction will be examined. Using existing population dynamics data, comparisons between percent cover of different types of epiphytes and both the number of reproductive plants and the mean number of receptacles per reproductive plant will be made.

d. *Fucus* as habitat for invertebrates (2,4)

The importance of *Fucus* as a structural habitat for intertidal invertebrates will be investigated. Similar plants located at 3 MVDs will be randomly chosen to be clipped and bagged while submerged under high tide or while exposed during low tide. Invertebrates trapped by the bags will be enumerated by taxa.

e. Effects of mobile predators (1,2)

Seastars are unevenly distributed in Herring Bay on coarse textured and sheltered rocky shorelines. We will census the numbers of these mobile predators on the five matched pairs of population dynamics sites and on the mussel study sites. These predator densities will be related to potential prey densities on the same sites.

Nucella are intense predators in the mussel zone and their densities will be determined in the mussel zone on selected sites as described under *Nucella*/Mussel Interactions. Many *Nucella* have been removed from the intertidal as prey for birds. Avian exclusion/*Nucella* inclusion cages will be placed in the intertidal on selected sites next to *Nucella* inclusion cages that allow access to bird predators. Comparisons between these two treatments will be made for determinations of avian predation pressure on *Nucella* populations around Herring Bay.

f. Effects of ice scouring (4)

Several areas within Herring Bay, especially on the eastern side of the bay, where most of the control sites are located, have shown severe destruction between a September field visit and a visit the following May. The loss of *Fucus*, mussels, and barnacles occurs in wide bands along the shoreline. The evidence (crushed mussel shells and barnacle tests and *Fucus* holdfasts ripped out) indicate that this destruction may have resulted from ice scouring over the winter. The extent of ice scouring within the intertidal will be addressed by placing painted and/or pencil rebar covered cement blocks in the intertidal in locations where ice scouring is suspected to have decimated populations in the past and in areas where no ice scouring has been observed. The condition of the paint and rebar will be assessed the following spring (1996).

g. Effects of desiccation on *Fucus* egg release (4)

Observations suggest that desiccation/temperature might have a negative impact on *Fucus* egg release. These effects will be tested by comparing the number of eggs released by plants under direct sunlight compared to artificially shaded plants. Twenty *Fucus* plants will be placed on a hard surface in the sun with ten randomly chosen to receive shading and watering. Desiccation rates and temperature will be recorded near each plant. After one, two, and three days of exposure, randomly chosen receptacles from each plant will be rehydrated for 24 hours and the number of released eggs will be assessed.

h. Structural importance of *Fucus* (4)

Observations suggest that the physical structure that *Fucus* provides to the intertidal environment might be more important than other resource attributes. To test this idea, artificial *Fucus* plants will be mounted above polycarbonate plates with heterogeneities. Differences in recruitment, growth, and survival of intertidal invertebrates on the plates and the plants with artificial *Fucus* canopy, no canopy, and *Fucus* canopy will be assessed.

Restoration (Ongoing)

a. High intertidal *Fucus* restoration (3,4)

Restoration of severely damaged intertidal algal populations has been started on a small scale basis at a heavily oiled rocky intertidal site in Herring Bay, Prince William Sound. A series of high intertidal plots were started in 1992 to test various techniques for increasing *Fucus* recruitment. These techniques included the attachment of erosion control fabrics to the rock substrate to produce a more favorable microclimate for small *Fucus* plants. Surveys made in May 1994 showed that there were dense populations of small *Fucus* plants on the coconut fiber fabric deployed in 1993, especially in the lower portions and where we had transplanted fertile plants. We will continue to monitor these plants to quantify their reproduction and their contribution to new recruitment on the substrate around the fabric strips. We will also test other methods for seeding the fabric with embryos to get higher densities of plants.

We have identified other areas of Prince William Sound where *Fucus* may not be recovering by using the Oil Spill Geographical Information System (GIS) databases assembled by the Alaska Department of Natural Resources (DNR). We have conservatively estimated that there are 12 miles of coastline throughout Prince William Sound that fit the physical criteria of the unrecovered beaches we have seen in Herring Bay. The results of surveys of some of these sites in May 1994 showed that the upper limit of *Fucus* at the oiled sites is approximately a half meter lower than populations at control sites. We will continue to survey a random selection of beach segments identified by the DNR GIS as being in the potentially unrecovered category. Surveys will quantify *Fucus* density in the 1 and 2 MVD tidal levels, as well as the upper limits of the *Fucus* on the transects.

4. Technical Support

Principal investigators from the University of Alaska School of Fisheries and Ocean Sciences, will cooperate to provide expertise on different aspects of the intertidal study: invertebrate and algal taxonomy and ecology. All mobilization/demobilization efforts associated with the charter vessel will be accomplished through the Seward Marine Center in Seward, Alaska. A project manager will oversee all logistical and personnel aspects of the project.

All sample and data analysis will take place at the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and the Juneau Center for Fisheries and Ocean Sciences, using available computers and established data management services.

A contract will be issued for the use of a research vessel able to support the field work in Herring Bay. This vessel must be able to meet all University safety requirements and be of sufficient size and configuration to meet the needs of the science specified above. Bid specifications will be drawn up and request for proposals will be sent out to prospective bidders. A similar contract will be established for air taxi support between Anchorage and Herring Bay. A contract will also be issued to Coastal Resources Associates (CRA) of Vista, California. CRA has been involved with the Herring Bay study from its inception in 1990. In order to maintain consistency with the data collection, experiment modifications, analyses and report writing, it will be necessary to continue the existing contract established with CRA.

We will need updates of the GIS model from the Alaska Department of Natural Resources to include various parameters for shoreline aspect and possibly oiling classification.

5. Location

The proposed restoration, monitoring, and experimental studies will be conducted in the Herring Bay, Knight Island area. Intertidal studies were initiated in Herring Bay in May 1990 and are continuing through the 1994 field season. Herring Bay was heavily oiled in 1989, and was a central area for clean-up efforts. The bay was chosen for experimental studies because of its oiling history and close proximity to non-oiled sites used as controls.

PROJECT IMPLEMENTATION

The Alaska Department of Fish and Game has implemented the Herring Bay Experimental and Monitoring Study for the last two years. Due to the successful coordination of the University of Alaska with this agency, a continuation of this partnership should continue for future funding.

COORDINATION OF INTEGRATED RESEARCH EFFORT

Principal investigators from the University of Alaska Fairbanks and University of Alaska, Southeast will be coordinating efforts to study interactions between key invertebrate and algal species. In addition, Dr. Stekoll will be cooperating with Dr. Deysher from Coastal Resources Associates for field sampling for the Restoration of High Intertidal *Fucus* study. Dr. Brad Andres of the U.S. Fish and Wildlife Service will be cooperating with the oystercatcher experiments.

The studies at Herring Bay are closely integrated with the Shallow Subtidal Studies (S. Jewett) and the Coastal Habitat Monitoring Studies (M. Stekoll and R. Highsmith). In addition this study will provide valuable information for use by studies of higher trophic level organisms such as those on shore birds, ducks and otters, that utilize the intertidal and shallow subtidal ecosystems.

PUBLIC PROCESS

Several presentations on results from previous field seasons in Herring Bay have been given during EVOS Oil Spill Symposiums in Anchorage to which the public was invited. Each proposal and report is available to the public for comment and we anticipate that this process for public participation will continue.

This proposal is based on information generated by the public workshop concerning "Research Priorities for Restoration" held in Anchorage during April 13-15, 1994.

PERSONNEL QUALIFICATIONS

1. Dr. Raymond Highsmith, Professor, Director West Coast National Undersea Research Center, UAF/SFOS, Fairbanks. - co principal investigator and coordinator.

   Dr. Highsmith has been the coordinator and a principal investigator of two *Exxon Valdez* Oil Spill projects; the Coastal Habitat Injury Assessment project and the Herring Bay Experimental and Monitoring studies. His specialties include ongoing research of recruitment and population biology in the intertidal zone and is familiar with the effects of the oil spill on intertidal invertebrates throughout the EVOS impacted area.

2. Dr. Michael Stekoll, Professor, UAF/JCSFOS and UAS, Juneau - co-principal investigator.

   Dr. Stekoll has been a principal investigator on three *Exxon Valdez* Oil Spill projects: the Coastal Habitat Injury Assessment project, the Herring Bay Experimental and Monitoring Studies, and the Shallow Subtidal Assessment project. He has co-authored annual and final reports for these projects and has produced refereed publications on various aspects of these projects. His specialties include, marine pollution biology, the biology and ecology of seaweeds in Alaska, especially *Macrocystis* and *Fucus*, and the mariculture of kelps and red seaweeds.

3. Dr. Lawrence Deysher, Sr. Scientist Coastal Resource Associates, Inc.- *Fucus* restoration and ecology

   Dr. Deysher is a marine ecologist who has been with CRA since it's conception. He directed field studies of intertidal algae as part of the EVOS damage assessment studies and participated in the original site selection of the CHIA monitoring sites. He has co-authored the annual reports on the intertidal algal monitoring studies and a paper on the use of the DNR GIS in selecting the intertidal monitoring sites for the CHIA studies. He is currently working on the experimental algal studies in Herring Bay as well as directing studies of kelp resources in California using a Geographic Information Systems.

4. Dr. Peter van Tamelen, Research Associate, UAF/JCFSOS,Juneau - algal studies.

   Dr. van Tamelen has been working in Herring Bay on intertidal algal studies since 1990. He has extensive experience in marine intertidal ecology, including studies on plant-herbivore interactions, succession, algal recruitment, and effects of physical factors on biological communities.

5. Susan Saupe, Chief Scientist, UAF/SFOS, Fairbanks.

   Susan Saupe has worked on intertidal invertebrate damage assessment studies since 1990 for both the CHIA and Herring Bay studies. She has supervised the design of experiments during field studies and oversaw the data analysis and integration for the CHIA reports and manuscripts.

BUDGET ($K)

	1995 Experimental	1995 Report
Personnel/Benefits	$ 257,400	$ 109,500
Travel	24,400	4,100
Contractural Services	148,700	17,800
Commodiites	11,700	2,000
Equipment	5,800	0
	9,600	2,400
Capital Outlay	0	0
Overhead @ 20%	91,500	27,200
Total	**$ 549,100**	**$ 163,000**

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Sea Urchin Population Dynamics: Changes in Population Density and Availability as Prey of Sea Otters

Project Number: 95087

Co-Principal Investigators: Stephen C. Jewett
University of Alaska Fairbanks

Thomas A. Dean, Ph.D.
Coastal Resources Associates, Inc.

Lead Agency: Alaska Department of Fish & Game

Cost of Project: $65,364

Project Start-up: March 1995

Project Duration: Two years

Geographic Area: Prince William Sound

Contact Person: Dr. Joseph Sullivan, ADF&G

B. Introduction:

This project will examine changes in the distribution and abundance of sea urchins in Prince William Sound, and will examine the availability of sea urchins as food for injured sea otters resources.

Sea urchins, a favored food of otters, consume large amounts of algae (especially kelps) and can have profound effects on the structure of nearshore ecosystems. Prior to the spill there were few urchins in Prince William Sound, presumably because of predation by otters. It was predicted that a decrease in otter populations as a result of the Exxon Valdez oil spill, may lead to increases in urchin densities and subsequent decreases in kelps. Observations in 1990, 1991 and 1993 suggest that in fact, urchin populations are increasing within the Sound. We noted higher than usual urchin densities in 1993 under cobbles in the lower intertidal, and occasional large patches of small urchins in eelgrass beds. This project will address several questions with regard to sea urchin populations:

1. Are the numbers of urchin population densities increasing in the Sound?
2. If so, is this increase related to the a lack of predation by otters?
3. Is the increasing urchin population a potential food source for recovering otter populations?

Monitoring of epibenthic invertebrates within the Sound has been carried out previously (Subtidal Studies, University of Alaska), but there have been no previous efforts to examine sea urchin populations specifically.

C. Need for the Project:

One hypothesis for a lack of recovery of sea otters is that food availability is limiting. Sea urchins provide an important potential food source for otters. An increase in urchin populations may provide food for otters that may offset otherwise impoverished food supplies.

In addition, increases in sea urchin densities may lead to drastic changes within the benthic community. Sea urchins can have profound effects on nearshore communities, including a reduction in kelps which provide substrate for herring spawn. We need to monitor these potential changes.

D. Project Design

1. **Objective:** Document changes in the population density of sea urchins and their availability as food for otters.

2. **Methods:** Measure the density of sea urchins at sites previously monitored in the shallow subtidal investigations in 1990, 1991 and 1993 to determine if there has been a significant increase in urchin density. Determine the population density, size structure, recruitment, and growth of urchins at sites with and without otters. Examine the distribution of urchins to define appropriate urchin habitat. Then select sites (at random) from the universe of sites within each category that has appropriate urchin habitat. At each site, determine the size frequency and density of urchins. Examine growth of urchins at representative sites by marking urchins with a calcine dye, releasing them, and collecting urchins at a later time and examining growth rings.

3. **Schedule:** The field work for this project will begin in June 1995 and be completed in September 1995. Laboratory analysis of urchin growth will be completed February 1996. Data analysis and draft report preparation will be completed in May 1996. Deliverables will consist of a FY 95 progress report to be submitted in September 1995, and a final report to be completed by May 1996.

4. **Technical Support:** Outside technical support will be required for the analysis of growth ring data.

5. **Location:** The project will be undertaken in Prince William Sound.

E. Project Implementation

The principal investigators have been conducting damage assessment/monitoring studies in the shallow subtidal regions of Prince William Sound since 1989. Since these studies have mainly been implemented through Alaska Department of Fish & Game (ADF&G), and since this project will overlap with the ongoing work in the subtidal eelgrass habitat, it is appropriate for this project to also be implemented through ADF&G.

F. Coordination of Integrated Research Effort

This project will integrate with several other nearshore ecosystem project descriptions (i.e., Processes Structuring Recovery of Injured Nearshore Vertebrate Predators submitted through National Biological Survey), as well as the subtidal eelgrass habitat investigation. It is anticipated that the majority of the urchin sampling will occur within and adjacent to established subtidal eelgrass study sites in western PWS in July 1995. It is also anticipated that sea otter investigators will make key observations of sea otter distribution and feeding that will be critical in evaluating the interactions between otters and urchins.

G. Public Process

Investigators in this project have taken part of public participation workshops sponsored by the Trustee Council to examine research needs. Future workshops will be supported. All documents produced will be made available for public review.

H. Personnel Qualifications

Stephen C. Jewett, Co-Principal Investigator, has been a Research Associate at the School of Fisheries and Ocean Science (SFOS), University of Alaska Fairbanks since 1975. During this time he has been involved in numerous benthic investigations throughout Alaska that emphasize assessment and/or monitoring. He has authored more than 30 publications in scientific journals and books. He has been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989-94). Mr. Jewett also serves as the Scientific Diving Officer for UAF, coordinating all scientific diving operations.

Thomas A. Dean, Ph.D., Co-Principal Investigator, is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista, CA. He has over 20 years of experience in the study of nearshore ecosystems, and has authored over 20 publications, including several papers dealing with sea urchin and kelp interactions. He has extensive experience in long-term monitoring studies with marine plants and invertebrates. He has had a major role in both the shallow subtidal and intertidal EVOS investigations since 1989.

I. Budget

1.	**Personnel**	$10,140
2.	**Travel**	2,030
3.	**Contractual Services**	39,000
4.	**Commodities**	3,300
5.	**Equipment**	0
6.	**Capital Outlay**	0
7.	**General Administration**	10,894
		$65,364

Salmon Instream Habitat and Stock Restoration Pink Creek and Horse Marine Barrier Bypass Development

Project Number: 95088

Name of Project leader or Principle Investigator: Steven G. Honnold

Lead Agency: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division

Cost of Project: FY95: $46,000
FY96-FY00: $158,000

Project Startup/Completion Dates: Start Date: 10/94
Completion Date: 9/99

Project Duration: 6 years

Geographic Area: Kodiak Island and Afognak Island

Contact Person: Steven G. Honnold
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(907) 486-1873

INTRODUCTION: This project is result of a Trustee Council funded three-year survey of the Kodiak Island oil-impact area which identified feasible, cost effective instream habitat restoration and development techniques for salmon. In 1993 (FY94) one project on Afognak Island (Little Waterfall Creek) was identified as feasible and was funded by the Trustees. The selection of this project was based on preliminary cost to benefit data. Two additional projects have been identified on Kodiak and Afognak Islands as cost-effective upon further cost to benefit analysis. These projects are designed to replace injured salmon spawning habitat by providing access to existing habitat. The projects are: **1) Horse Marine Creek Barrier Bypass - Kodiak Island; 2) Pink Creek Barrier Bypass - Afognak Island.**

Horse Marine Creek Barrier Bypass:

The project at Horse Marine Creek on southern Kodiak Island will provide access to spawning habitat capable of supporting 15,307 pink, 3,124 coho and 8,594 sockeye salmon. With consistent escapements to this habitat,annually, approximately 28,214, 22,914 and 90,237 pink, coho, and sockeye salmon would be produced. The average escapement of pink salmon at Horse Marine Creek has been 3,864. Coho and sockeye escapements do not reach optimum levels at low flow periods. The project will benefit areas effected by the oil spill by replacement production.

Pink Creek Barrier Bypass

The project at Pink Creek on Afognak Island will provide consistent access to spawning habitat capable of supporting 4,512 pink and 516 coho salmon. Consistent annual escapements into this habitat could produce 8,317 and 3,782 pink and coho salmon, respectively. Pink Creek drains into Afognak Bay which was oiled in 1989.

NEED FOR THE PROJECT

These projects will help restoration by enhancing salmon populations and improving the commercial, sport, and subsistence fishing opportunities on Afognak and southern Kodiak Islands. Thus, lost fishing opportunities, as result of the oil spill, will replaced or mitigated for.

PROJECT DESIGN

Goal:

The goal of this project is to increase pink, coho and sockeye salmon spawning capability, and overall salmon returns, by enhancing fish passage above barriers in Horse Marine and Pink Creeks.

Objectives:

The objectives of this project are:

1. Final evaluation of pre-project production parameters (egg-to-fry survival, salmon escapement and spawning distribution)
2. Determine final barrier bypass design for Horse Marine Creek..
3. Obtain the necessary permits for construction .
4. Construct two barrier bypasses in the oil spill impacted area.
5. Evaluate the success of the barrier bypasses by estimating spawning numbers utilizing enhanced habitat as well as the relative abundance of juveniles produced each year.
6. Conduct necessary project maintenance each year.
7. Provide documentation of project progress and results.

Methods:

Horse Marine Creek:

A barrier bypass will be designed and constructed to facilitate salmon passage over a 3.0 m falls. Low water diversion structures will be installed and a salmon diversion weir constructed to lead salmon into entrance tanks.

Pink Creek:

This project will require a channel be cut with diversion of stream flow to allow salmon passage over 1.9 m falls.

Schedule:

Each project will require pre-construction planning, permitting and surveys, construction, and a period of five years for performance monitoring. This evaluation period is necessary for projects producing sockeye and/or coho salmon which return as adults at age 5 or 6. The Horse Marine Creek project will likely require construction to be contracted, thus, initial planning is scheduled for FY95 with construction in FY96. The Pink Creek project will be completed in FY95. The following table describes the anticipated schedule of tasks for years 1 and 2 for each project.

		Project	
Task	Period	Pink Creek	Horse Marine Creek
Pre-project surveys, planning	10/94-9/95	X	X
Final engineer surveys	7/95		X
Permitting, planning, administration, award contract	1/95 - 4/95	X	X
Project construction	5/95 - 6/95	X	
	5/96 - 6/96		X
Spawner abundance estimates	8/95 - 11/95	X	
	8/96 - 11/96		X
Progress reports	as required	X	X
Egg-to-fry survivor estimates	3/96	X	
	3/97		X

Technical Support:

General administrative support is provided by the Administrative, Habitat and Restoration Division, and Commercial Management and Development Divisions (CFMD) of the Alaska

Department of Fish and Game (ADF&G). The project leader of this project is primarily funded by general funds and program receipts (Kodiak Regional Aquaculture Association - KRAA - cooperative funding) from the State of Alaska. Engineering support is provided by CFMD of the ADF&G, funded by general funds from the State of Alaska. This study is directly associated with ongoing rehabilitation and enhancement projects funded by program receipts provided by KRAA.

Location:

The project will be located at Pink Creek on Afognak Island and Horse Marine Creek on southern Kodiak Island. Pink Creek drains into Afognak River which drains into Afognak Bay on eastern Afognak Island. Horse Marine Creek drains into Olga Bay. The benefits of this project will be realized by increasing pink, coho and sockeye salmon returns to these systems, providing salmon for harvest. The residents of the city of Kodiak, and the village on northern Afognak Island as well as southern Kodiak Island will benefit economically from this project through direct commercial fishery receipts and all associated business enhancement. In addition, sport fishers, guides, and lodge owners as well as subsistence fishers, will benefit directly and provide direct economic return to the associated communities.

PROJECT IMPLEMENTATION

The Alaska Department of Fish and Game (ADF&G) will implement the project. The steeppass construction at Horse Marine Creek will likely require implementation through a competitive contract process. The ADF&G is currently managing approximately eight barrier bypass projects on Kodiak and Afognak Islands, therefore, is the appropriate agency to implement this project.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The ADF&G, CFMD Division, Development and Research Sections operate sockeye, coho king and pink salmon development projects at Frazer, Pauls/Laura, Portage and Little Waterfall Creeks, located on Kodiak and Afognak Islands. The Department conducts all maintenance, monitoring and evaluation activities associated with this fisheries development program with funding provide by KRAA through program receipts. This includes lake enrichment, smolt sampling, limnological sampling, and weir operation. In addition, the Finfish Management Section of CFMD Division conducts fisheries management operations in the area.

Also, KRAA operates a sockeye stocking programs via Pillar Creek Hatchery at Hidden Lake. In addition, KRAA operates Kitoi Bay Hatchery on northern Afognak Island, producing pink, coho, chum and sockeye salmon for commercial harvest. All evaluation associated with Pillar Creek and Kitoi Bay hatcheries is conducted by ADF&G with funds provided by KRAA program receipts. Lastly, the Alaska Department of Natural Resources, Kodiak State Parks operates several coho escapement weirs on Shuyak Island, located just north of Afognak Island. The ADF&G provides equipment and logistical support, as well as conducting aerial salmon escapement surveys in the area.

This project will be coordinated with all of the above mentioned programs.

PUBLIC PROCESS

The public will continue to be involved in the development of this project through the Trustee Council Advisory Group process. In addition, discussion of this project as well as the original "Instream Habitat Restoration Techniques" study that led to this project have been discussed in general membership meetings of the Kodiak Regional Aquaculture Association.

PERSONNEL QUALIFICATIONS

Steven G. Honnold
Commercial Fisheries Management and Development Division
211 Mission Road
Kodiak, Alaska 99615
(907)486-1873

March, 1989 to present. Fisheries Biologist - Assistant Area Biologist, Fisheries Enhancement Rehabilitation and Development Division, Alaska Department of Fish and Game, Kodiak, Alaska.

Responsible for planning, implementation, data analysis, and report writing for all Kodiak FRED/OSIAR (H&R) Division damage assessment studies and restoration programs, as result of EVOS. Studies included early marine life history damage assessment (this study was is the late planning phase when canceled), juvenile sockeye damage assessment via hydroacoustic surveys and limnological assessment at Red and Akalura Lakes, Red Lake restoration planning and NEPA reporting, Instream habitat and stock restoration feasibility - barrier bypass technique evaluation. In addition, responsible for all Afognak Island rehabilitation, enhancement or development projects conducted by FRED Division (Development Section of CFMD Division). Projects include Perenosa Rehab./Enhance., Malina Lakes Rehab., Afognak Rehabilitation, and Hidden Lake Development. Duties associated with these projects include: barrier bypass construction, maintenance and evaluation, sockeye stocking and subsequent smolt and fingerling monitoring and evaluation, lake limnology studies, and all associated planning, personnel supervision, data quality control and analysis, preparing budgets, report writing, and presentation of results at professional and public forums. Lastly, assist the Area FRED Biologist with all other Kodiak programs, including Spiridon Lake sockeye salmon development, Alaska Peninsula coho and sockeye salmon development feasibility studies, Kitoi Hatchery evaluation, and Kodiak lake limnology.

FY95 BUDGET($K)

	FY95 - Project	FY95 - Reporting and Restoration Meetings	Total
Personnel	$31.5	$5.2	$36.7
Travel	$ .6	$ .6	$ 1.2
Contractual	$ 3.2	$1.0	$ 4.2
Commodities	$ 6.6	$ .2	$ 6.8
Equipment	$ 0	$ 0	$ 0
Capital Outlay	$ 0	$ 0	$ 0
General Admin.	$ 3.8	$ 0	$ 3.8
TOTAL	$45.7	$7.0	$52.7

INFORMATION MANAGEMENT SYSTEM

Project Number: 95089

Name of Project Leader: Molly McCammon

Name of Principle Investigators: Carrie Holba and Carol Fries

Lead Agency, University or Organization (if known): ADF&G and ADNR

Cost of Project (for FY 95/future years, including reports, if known): $540.1K

Project Start-up/Completion Dates (month/year): October 1994/To Be Determined

Project Duration (number of years): Multi-year

Geographic Area (locations where field work will be conducted): Spill Area

Contact Person (name, address, phone):

Molly McCammon
645 G Street
Anchorage, Alaska 99501-3451
(907) 278-8012, (907) 276-7178 fax
800-478-7745 in Alaska, 800-283-7745 outside Alaska

B. Introduction — What You Propose as a Project

This project proposes to further develop an information management system that began with establishment of the Oil Spill Public Information Center (OSPIC) in September 1990 as a public repository for information and materials generated as a result of cleanup, damage assessment and restoration efforts following the Exxon Valdez oil spill. When fully developed, this system will contain distinct, but interrelated components, designed to make information relevant to the Exxon Valdez oil spill readily available for use by managers, scientists, and the public. This information will support restoration planning, management and policy making, scientific research and coordination, and public information. A central access point will be the OSPIC, with the potential for the establishment of additional access points as needs or interests are identified. In addition, this project plans and implements an appropriate update and distribution program for EVOS information in digital format for both the general public and cooperating agencies, managers and scientists.

C. Need for the Project — Why the Project will Help Restoration

An Information Management System supports the Mission of the Trustee Council in its efforts to restore the injured environment. Through the management, synthesis and dissemination of information and materials collected as a result of the Exxon Valdez oil spill, meaningful public participation in the restoration process as mandated by the settlement agreement between the state and federal governments and Exxon is facilitated.

The OSPIC responds to inquiries from local, state, national, and international users, including but not limited to students (from preschool to graduate school), educators, scientists, government agency personnel, state and federal legislators, environmentalists, the business community, the media, the legal profession, and other libraries and information providers.

In addition, the OSPIC staff provides priority information service to the Trustee Council, the Executive Director, the Director of Operations, the Public Information Officer, and the staff of the Exxon Valdez Restoration Office (EVRO). Through the reference services provided to restoration project personnel, the OSPIC serves all restoration activities.

Although the OSPIC does an excellent job at distributing what information is available, at present, it is still unclear what information has been collected, what additional information exists or would be useful, how to acquire it, who maintains it, or how to access it. This project provides an opportunity for the Trustee Council to efficiently synthesize and disseminate this collective pool of information, thereby providing a lasting legacy of oil spill funded work.

D. Project Design — Objectives, Methods, Schedule and Location

1. **Objectives** The objectives of the Information Management System are:

   a. Compile, manage, synthesize, and disseminate currently available information about the Exxon Valdez oil spill and the Trustee Council (including damage assessment and restoration final reports) in a manner which can easily and effectively be utilized and understood.

   b. Provide public access to local, state, national, and international users of this information through the Oil Spill Public Information Center.

   c. Maintain the Trustee Council Administrative Record, a growing collection of over 2,000 documents produced for and by the Trustee Council, to provide public access and document the decision making process of the Trustees.

   d. Develop two distinct but interrelated products as described below, for initial use and distribution as part of an overall strategy to provide up to date information on the status of restoration and recovery as well as historical knowledge of the Exxon Valdez oil spill.

EVOS Information Summary. An interactive multimedia computer program will be developed to allow the user to explore Exxon Valdez oil spill information. This information will be organized to present a variety of topics in a logical, hierarchical structure. Information would be presented graphically with links to more detailed in depth textual information. Emphasis will be given to general information about the oil spill, including but not limited to, the natural history of the spill area, oil spill history, including response, oil spill sponsored research, and the status of ongoing restoration efforts. The end point for most users would be a citation for further reference or actual study results, their physical location and availability in the form of an electronic bibliography.

This type of program will employ an easy to use mouse driven graphical user interface and would be ideal for educational settings such as schools, nature centers, visitor centers and home or library use for the general public. The product development approach will provide a great deal of flexibility and provide for expansion as new information becomes available, thus providing a current status report on restoration and recovery to date.

Geographical Database Application. A wide variety of complex geographic datasets have been compiled and used by the many organizations involved with the response, damage assessment, and restoration stages of the Exxon Valdez oil spill. The electronic information is sophisticated in its structure and detailed in its history, making it difficult to access by non-technical staff. Conventional access has been through the thousands of maps and other reports disseminated by the technical services group and the OSPIC library. A systematic compilation of the data resources, combined with a "point and click" software interface, will permit a broader application of the geographic information which serves as a common base to a wide range of ecosystem management strategies. The existing strengths of institutional ties among the data producers will continue to serve as the backbone to this project, which is coordinated through the present repository site at the Alaska Department of Natural Resources, Land Records Information Section (LRIS).

Of great importance to the success of an up to date information system is support for database maintenance and annual updates. It should be noted that the goal of this project involves the dissemination of publishable information (analyzed data) only. It should not be confused with the dissemination and distribution of raw or unverified scientific data.

2. Methods

Integration:

The Director of Operations will oversee the integration of Trustee Council-funded research in order to ensure cost-effectiveness, and maximize the ability to synthesize information and data collected from these efforts.

Reference Service:

All OSPIC staff members respond to information requests made by visitors in the library, or by telephone, fax, mail, or electronic mail from around the world. During the past four years, the OSPIC staff have received over 6,500 visitors including visitors from 25 countries, responded to 8,500 on site and off site requests for information, processed 1,300 interlibrary loans of materials to and from other libraries, performed 1,200 online database searches, and distributed over 16,000 documents. The OSPIC also serves Exxon Valdez Restoration Office personnel, including the Executive Director, the Director of Operations, the Restoration Work Force, the Public Information Officer, and other agency personnel.

Cataloging:

Materials acquired by the OSPIC staff are analyzed and described for entry into the OSPIC collection according to standard library practice. Materials are then made ready for the shelves with appropriate physical processing. The OSPIC collection is cataloged in the online database of the Western Library Network (WLN), a growing consortium of about 540 libraries in the western part of the United States, Canada, Australia, Korea, and Japan. Librarians from any member library can search the WLN database to locate OSPIC materials.

Computer Network and Technology:

To conduct research and catalog new items for the collection, the OSPIC staff uses a Novelle-based local area computer network linked by modem to WLN, DIALOG, and other databases. WLN's LaserCat, a CD-ROM product, functions as the OSPIC public access catalog. In addition, the OSPIC staff uses the Internet, a global network of over 10,000 computer networks in 85 countries linking 20 million users, to communicate with library users, seek out reference sources, and disseminate information. The OSPIC staff also provides Internet training to personnel in the Exxon Valdez Restoration Office.

Publication of Final Reports:

Working in conjunction with the Director of Operations, the OSPIC staff coordinates the collection, publication and distribution of the Natural Resource Damage Assessment Final Reports and the Restoration Project Final Reports to the National Technical Information Service (NTIS), other libraries, local commercial copy centers and the general public. The OSPIC Technical Services Librarian began the coordination of the cooperative cataloging of interim reports with a cataloger at the Alaska State Library and will continue with the final reports.

Trustee Council Support:

The OSPIC is a repository for documents produced for and by the Trustee Council, including meeting transcripts, agendas, budgets, work plans, correspondence, and public comments. The Trustee Council Administrative Record is maintained as a certified Administrative Record to track the decision making process of the Trustees and to address issues of accountability. The OSPIC staff distributes Trustee Council publications, such as annual reports, work plans, and information packets. An electronic mailing list is maintained online whereby interested persons may receive email notification of Trustee Council activities and publications via the Internet. The feasibility of additional applications of the Internet is currently being explored.

Development of new products:

Seven fundamental steps will be applied in a coordinated manner to the development of both the EVOS Information Summary and the Geographical Database Application:

a. Establish an interagency/multidisciplinary group to assist in the establishment of product objectives, identification of user needs, and testing of product design.

b. Develop product design and prototype programs.

c. Solicit input from chief scientist, executive director, restoration staff, principal investigators, and OSPIC to ensure accuracy and completeness of information, utility of design, and program integrity.

d. Fully implement product design with continued meetings with the interagency/multidisciplinary group and cooperators to keep project focused and ensure accuracy.

e. Provide for demonstration and review of beta versions of final products to oil spill managers, scientists, and the public.

f. Develop documentation for both products, provide for review and publication.

g. Establish a mechanism to facilitate information exchange and provide for the periodic update and dissemination of both products.

3. **Schedule**

a. OSPIC

Quarterly and annual reports documenting library usage, acquisitions, expenditures, and user information needs will be submitted by the designated deadline. The quarterly distribution of the OSPIC News will begin in September 1994.

b. New product development

Establish an interagency/multidisciplinary group. November 1994

Develop program design and prototype program. January 1994

Solicit technical and scientific input from OSPIC, Restoration Staff ,and Principal Investigators in areas of expertise. February - July 1995

Identify and develop information to be included in program templates. Refine product design and programming March - July 1995

Work with contractors, PIs, an interagency/multidisciplinary group, OSPIC, and restoration staff to QA/QC final product August 1995

Release of initial version of productsOctober 1995

Peer ReviewNovember 1995

With cooperation of an interagency/multidisciplinary group, OSPIC, Executive Director, Chief Scientist, and restoration staff, identify information gaps and areas to be targeted for annual updateNovember 1995

Final release of productsDecember 1995

4. **Technical Support**

The analyst programmer located in the Restoration Office provides maintenance of the LAN computer network and assistance in establishing a full-text online service for the public.

New product development will require support for digital scanning of slides and photographs. In addition, computer programming support and peer review will be needed in the initial product development and as a final review process to ensure that program development is technically correct and accurate oil spill information is presented.

5. Location

The project will be coordinated by the Director of Operations in the Anchorage EVOS Restoration Office, located at 645 G Street, Anchorage, Alaska, 99501-3451, which is also the site of the Oil Spill Public Information Center. Users in the spill area, and state, national and international users are served by mail, telephone, fax, and electronic mail.

E. Project Implementation — Who Should Implement the Project

The Exxon Valdez Restoration Office in Anchorage serves as the primary respository of information on the Exxon Valdez oil spill, related events and issues, and the actions of the EVOS Trustee Council in working towards restoration of the spill affected area. The OSPIC has been an integral part of the restoration proces since it was established in 1990. A major restructuring by Executive Director Jim Ayers in early 1994 has maximized library efficiency and reduced operating costs. The OSPIC Director reports directly to the Exxon Valdez Oil Spill Trustee Council's Director of Operations.

Since the OSPIC collection is narrowly focused on a single, albeit complex event, the staff can provide more in-depth reference service than other libraries where Exxon Valdez oil spill related materials are only a small fraction of the entire collection. The OSPIC staff receives frequent referrals from local public, academic, and special libraries, as well as numerous school districts throughout the nation. In addition, they have developed extensive contacts with state and federal agencies, private sector organizations, universities, and all types of libraries. These contacts enhance the ability of the OSPIC staff to serve the information needs of anyone participating in the restoration process.

In order to maximize the utility of information generated through the restoration process to resource managers, researchers, and the public, it is essential that the new products described in the Objectives section be developed. The Department of Natural Resources Oil Spill Project Office will provide the central focus for their development. DNR, Land Records Information Section (LRIS) is the current repository of Oil Spill GIS data and as such will have an important role in data maintenance, interface implementation, and as the facilitator in coordinating the update and dissemination of GIS information compiled as part of this project. OSPIC will provide a central location for access and distribution of all products.

The product development will be implemented in three phases:

Phase One: focuses on the development and dissemination of the two programs described above.
Phase Two: to be proposed for funding in FY96, will focus on the integration of the two previously developed products, and cross platform compatibility. Both products will initially be designed with the objectives of Phase Two in mind.
Phase Three: will focus on the establishment of an on-line connection for access to the two original programs.

F. Coordination of Integrated Research Effort

A further development of the Trustee Council's current Information Management System will go a long ways toward furthering the coordinated integration of the Trustees' research efforts. This project provides a unique opportunity for all Principal Investigators to effectively disseminate the information gathered through their work, to the general public, restoration staff, and the scientific community. The products generated as a result of this project have the potential to tie all EVOS related research and historical information together into a meaningful picture for the lay person, scientist, and manager alike. As new information products are developed, meetings will be held with other information managers, GIS managers, and representatives of various scientific disciplines to ensure that the initial design maintains data integrity, achieves a common goal and addresses the identified needs of principal investigators and managers in order to ensure coordination with the integrated ecosystem based approach to restoration.

G. Public Process

Providing readily accessible, user friendly information to the public facilitates the public process in restoration efforts. The OSPIC serves as a two way link between the public and the restoration process, providing information to and receiving input from the public. The publication of a quarterly newsletter, the OSPIC News, will inform library users of new materials and services and solicit their questions and comments.

In addition, an interagency/multidiscplinary group will be established to provide the product development team with a broad based understanding of cooperator and user needs and expectations and to assist in product testing. This interagency/multidisciplinary group will have representatives from state and federal agencies, with additional input from educators, the public, and students.

H. Personnel Qualifications

Carrie Holba, Director/Public Services Librarian, has a Master's Degree in Library and Information Science and joined the OSPIC staff in February 1991. Ms. Holba is responsible for management of the OSPIC, reference service and the acquisition of new materials. She attended the 1991 International Oil Spill Conference, and is a co-author of a paper, "The Oil Spill Public Information Center: Its Role in the Flow of Information on the Exxon Valdez Oil Spill," which appeared in the Proceedings of the 1993 International Oil Spill Conference.

Carol Fries has worked on the Exxon Valdez oil spill since May of 1991. She initially worked with NOAA, Scientific Support Coordinator's office during response, in support of the USCG Federal On Scene Coordinator. Her work there involved database design used to track documents and information pertaining to the Exxon Valdez oil spill. She has coordinated restoration programs for DNR and actively provided technical support to the Habitat Work Group for the past two years. As a result of this experience she has a broad based comprehensive understanding of the Exxon Valdez Oil Spill.

Dorothy Mortenson has twelve years of cartographic and geographic information system experience. She is a senior member of the GIS staff at Alaska Department of Natural Resources, and is responsible for all aspects of GIS services for the Exxon Valdez oil spill mapping and analysis. Ms. Mortenson cooperates with and exchanges information with various state, federal, and private agencies, performs needs analyses, and designs and implements methodologies for maps, reports, spatial modeling, and other data analysis and syntheses. In addition, Ms. Mortenson is responsible for developing and maintaining the means by which the public may easily access final map products and baseline data.

I. Budget

1.	Personnel	$290.9
2.	Travel	3.3
3.	Contractual Services	165.0
4.	Commodities	24.6
5.	Equipment	.2
6.	Capital Outlay	0.0
7.	General administration	55.1
	Total	$540.1

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Closeout: Mussel Bed Restoration and Monitoring; (Analysis and Report Writing for FY 94 Field Work)

Project Number: 95090 (closeout)

Name of Project Leader or Principal Investigator: Malin Babcock, NOAA; Ron Bruyere, DEC

Lead Agency, University or Organization (if known): NOAA

Cost of Project: $154,400
DEC: $38,500
NOAA: $115,900

Project Start-up/Completion Dates (month/year): February 1994. Draft Report due April 15, 1995.

Project Duration (number of years): Field work, FY 94; report writing, FY 95

Geographic Area (locations where field work will be conducted): Western Prince William Sound. (The analysis and report writing will occur in Juneau and Anchorage.)

Contact Person (name, address, phone):

NOAA: Malin Babcock
National Marine Fisheries Service
11305 Glacier Highway
Juneau, Alaska 99802
(907) 789-6018

DEC: Ron Bruyere
Alaska Department of Environmental Conservation
Exxon Valdez Oil Spill Restoration Office
645 "G" Street, Suite 401
Anchorage, Alaska 99501
(907) 278-8012

B. Introduction — What You Propose as a Project

On January 31, 1994, the Trustee Council authorized $518,000 for Project 94090, Mussel Bed Restoration and Monitoring. This authorization was intended to include project costs through FY 94 which ends September 30, 1994. During spring and summer 1994, NOAA and DEC personnel visited and sampled approximately 40 mussel beds, and selected approximately 16 of these beds for cleaning. This project requests $115,900 to complete the analysis and report-writing for the 1994 field work.

C. Need for the Project — Why the Project Will Help Restoration.

The summer field work will identify and, where appropriate, remove residual oil from under contaminated mussel beds. Oil trapped in the sediments beneath the byssal thread mats of mussels beds in protected areas has degraded slowly and has retained toxic components since the spill. The protected beds are one of the few sources of unweathered oil remaining from the oil spill. This oil is a likely route of continued oil exposure and contamination to higher trophic levels such as harlequin ducks. The continued exposure is thought to prolong the oil spill injuries to harlequin ducks and other species that feed on mussels. Pre- and post-cleaning samples of mussels and sediments will be collected to monitor for levels of oil. Also as a part of this task, routine samples of mussels and sediments and selected, untreated sites will be collected to evaluate changes in hydrocarbons under natural conditions.

During the 1994 field season, approximately 70 mussel beds will be visited to continue monitoring, and to select mussel beds where restoration is needed and feasible. There will be continued monitoring of treated and untreated beds to document the differential rates of recovery.

Resources and Services Addressed: The presence of substantial levels of petroleum hydrocarbons persisting under dense mussel beds in PWS and the Gulf of Alaska provides a continuing, potential source for oil to enter the food chain, impacting higher consumers, especially harlequin ducks, oystercatchers, juvenile otters, and humans. There is a possible link between the presence of oiled mussels and the disruption of reproduction in harlequin ducks and increased mortality in oystercatcher chicks.

D. Project Design — Objectives, Methods, Schedule and Location

1. **Objectives.** The objective of this request is to provide funds to finish laboratory analysis of the sediment and mussel samples collected during 1994, and finish the report writing for the project. Specifically, the following tasks need to be addressed:
   - The sediment and mussel samples need laboratory analysis to determine the extent, toxicity, and constituent components of the residual oil.
   - Update DEC and NOAA files and mapping archives concerning the location and extent of residual oil; archive the data so it is accessible for future research and monitoring, scientists working on projects, and to the public.
   - Write up the final report documenting methodology, and results.
   - Print, publish, and distribute the final report.

2. **Methods.** The laboratory analysis is being conducted by NOAA's Auke Bay Laboratory in Juneau. Sediments and mussels are collected for hydrocarbon analyses from identified oiled mussel beds. Sampling methods and protocols have been developed and established which allow inter-year comparisons to detect changes in concentrations. Sediments are screened by ultraviolet fluorescence (UVF) to estimate total petroleum hydrocarbons. Mussels and selected sediments will then be analyzed by gas chromatography/mass spectroscopy (GC/MS) to measure individual aromatic and alkane analytes. These procedures have been developed by previously funded *Exxon Valdez* Restoration Projects.

3. **Schedule.** Final writing for mussel bed monitoring requires return of NOAA's laboratory analysis. A draft report is expected April 15, 1995.

4. **Technical Support**. All technical support is provided by lead and cooperating agencies. Mapping information will be shared and used by DNR.

5. **Location.** The field work occurred in western Prince William Sound. The laboratory work will occur at NOAA's Auke Bay Laboratory in Juneau. The remainder of the report writing will occur in Juneau and Anchorage.

E. Project Implementation — Who Should Implement the Project. This is not applicable in that the project is already occurring.

F. Coordination of Integrated Research Effort. Not applicable.

G. Public Process. Not applicable. However, the project results will be made accessible for future mussel bed research and monitoring, scientists working on other projects, and to the public.

H. Personnel Qualifications. Not applicable in that the project is currently underway.

I. Budget (Figures in thousand dollars)

	NOAA	DEC
Personnel	$93.4	$27.7
Travel	$4.0	$3.6
Contractual Services	$0.0	$1.5
Commodities	$4.5	$0.7
Equipment	$0.0	$0.0
Capital Outlay	$0.0	$0.0
Subtotal:	$101.9	$33.5
General administration	$14.0	$5.0
Total:	$115.9	$38.5

Mussel Bed Restoration and Monitoring in Prince William Sound and Gulf of Alaska

Project Number: 95090

Project Leaders: Stanley D. Rice, National Marine Fisheries Service
Malin M. Babcock, National Marine Fisheries Service
Ron Bruyere, AK Department of Environmental Conservation
Patricia M. Rounds, National Marine Fisheries Service
Gail Irvine, National Biological Survey

Lead Agencies: National Marine Fisheries Service
National Biological Survey
Alaska Department of Environmental Conservation

Project Cost: FY95: $ 261.8K
FY95/in FY96: $ 166.8K
Total Fy96: $ 270.0K

Start Date: February, 1992

Finish Date: Unknown

Geographic Area of Project: Oil spill impacted areas of Prince William Sound, Kenai and Alaska Peninsulas

Contact Person: Bruce Wright
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, AK 99821
907-789-6600

B. INTRODUCTION

The persistence of *Exxon Valdez* crude oil underlying some dense mussel (*Mytilus trossulus*) beds in Prince William Sound (PWS) and the Kenai and Alaska Peninsulas began to cause concern in the spring of 1991 and was confirmed in annual surveys by NOAA's Auke Bay Laboratory (ABL) and the National Park Service (NPS).

In 1992, ABL documented 25 mussel beds in PWS with underlying sediment concentrations in excess of 10,000 $\mu g/g$ total petroleum hydrocarbons (TPH). The lack of clear indication of reduction in petroleum hydrocarbon (HC) levels between 1992 and 1993 in mussels and underlying sediments led the Trustee Council to fund NOAA and ADEC to restore selected mussel beds in 1994. Approximately 15 mussels beds were restored. This proposal is for evaluation of the restoration process and monitoring of control (natural recovery) sites in PWS and for sampling and monitoring of oiled mussels beds along the Kenai Peninsula.

Field surveys along the Kenai and Alaska Peninsulas and Kodiak Archipelago were conducted in 1992 and 1993 to establish the geographic extent and intensity of oiling of contaminated mussel beds by the Department of Interior's National Park Service (NPS). There was no sampling in 1994. The National Biological Survey (successor to this work under NPS) portion of this study will be to resample oiled mussel beds in the Gulf of Alaska.

In addition, ABL will handle the logistics of sampling mussels for pristane analyses. Levels of pristane will be used to index copepod production which will be used to help forecast salmon returns in future years. This is an objective of the Prince William Sound Ecosystem Study, but the collection logistics have been integrated into this study.

C. NEED FOR THE PROJECT

The presence of substantial levels of petroleum hydrocarbons persisting under dense mussel beds in PWS and the Gulf of Alaska provides a continuing, potential source for HCs. Restoration (cleaning) of selected mussels beds (approximately 15 mussels beds were restored in PWS in 1994) should reduce potential exposure to HCs in subsistence users and higher predators such as harlequin ducks, oyster catchers and juvenile otters. Sampling mussels and underlying replacement sediments, and comparing changes in size and density of mussels is necessary to evaluate the success of this restoration method. Periodic sampling for hydrocarbons in oiled mussel beds along the Kenai Peninsula is proposed to document their recovery progress. This information is needed for decisions relevant to cleaning mussel beds in the future in both Prince William Sound and the Kenai Peninsula. Additional potential oiled mussels beds brought to the attention of the Trustee Council by the public and other projects will also be examined.

Logistics for collecting mussels for pristane analyses is complex as periodic sampling over the spring and early summer needs to occur to measure changes over this period. Mussels from approximately 32 sites in PWS are being collected. Logistics for collecting mussels for purpose have been combined with this project to reduce overall field costs.

D. PROJECT DESIGN

1. Objectives

a. To evaluate the physical and biological stability of the 1994 restored oiled mussels beds by measuring petroleum hydrocarbon concentrations in mussels and underlying replacement sediments, measuring the size of the beds and calculating density of mussels (NOAA, ADEC).

b. To monitor natural recovery in levels of petroleum hydrocarbons in mussels and underlying sediments in oiled mussel beds in PWS not restored (NOAA, ADEC).

c. To monitor recovery in levels of petroleum hydrocarbons in mussels and underlying sediments in oiled mussel beds along the Kenai and Alaska Peninsulas (NPS).

d. Provide logistic and staff support for comprehensive sampling of mussels for indexing pristane levels in PWS. This project is closely coordinated among several resource groups (NOAA).

2. Methods

Sampling of mussels, underlying sediments, and replacement sediments will follow the methods used in previous years and consists primarily of triplicate pooled samples of mussels and underlying sediments for petroleum hydrocarbon analyses. Beds cleaned in 1994 as well as control (natural recovery) beds will be sampled in PWS. Similar experimental design is used for documented oiled mussels beds along the Kenai and Alaska Peninsulas.

To assess physical and biological stability of a restored bed, other measurements will be taken to compare with precleaned bed condition, i.e. bed size and density of mussels. Photos will also be taken for comparison purposes.

Sediment samples will be analyzed by ultraviolet fluorescence. Selected sediments and mussels then will be analyzed by gas chromatography/mass spectroscopy (GC/MS) for quantitative measurements of HC analytes. All mussels collected for pristane concentrations will be analyzed by GC/MS.

Freezing, chain-of-custody procedures and record keeping will follow Natural Resource Damage Assessment protocol. Data will be analyzed using standard statistical methods, mapped using ABL's computerized data mapping system, and entered into the *Exxon Valdez* Restoration Hydrocarbon Database.

3. Schedule

1 - 4.94 Logistics planning; evaluation of 1994 data for sites to actually sample; initiation and implementation of contracting for aircraft charter; and

	other preliminary planning for 1995 field season.
4.94	First PWS 1995 field trip during low tide series for sampling mussels at some established sites for pristane analyses.
5.95	Second PWS 1995 field trip during low tide series for sampling mussels at some established sites for pristane analyses. Site visits to 1994-restored mussel beds and to sample and evaluate restoration process. Sampling of mussels and underlying sediments will be done at several control (natural recovery) sites.
6.95	Third PWS 1995 field trip during low tide series for sampling mussels at some established sites for pristane analyses. Site visits to 1994-restored mussel beds and to sample and evaluate restoration process. Sampling of mussels and underlying sediments will be done at several control (natural recovery) sites. During low tide series, site visits and sampling of mussels and underlying sediments will be conducted in the Gulf of Alaska.
6-10.95	Ongoing chemical and data analyses.
10.95-4.96	Ongoing chemical and data analyses.
4.96	Annual Report

4. Technical Support

With the exception of transportation contracts, NOAA's Auke Bay Laboratory, the National Biological Survey and AK Department of Environmental Conservation will provide all technical support.

5. Location

Prince William Sound, Kenai and Alaska Peninsulas.

E. PROJECT IMPLEMENTATION

Management of this study is proposed to be led by NOAA's ABL with one objective the responsibility of the NBS. ADEC will participate in the evaluation of restored mussel beds and sampling for natural recovery in unrestored oiled mussel beds.

All three agencies have accomplished previous research and restoration work related to this project, 1991-1994 (1994 Study #94090) and have site experience, access to site and HC data, and NOAA's ABL is the only laboratory currently conducting HC analytical analyses for Trustee environment samples.

G. COORDINATION OF INTEGRATED RESEARCH EFFORT

Logistics and staff time will be shared and closely coordinated with field expertise needs and other activities under other projects particularly the proposed work on population structure of blue mussels in PWS. Data from this project will continue to be shared with subtidal sediment studies and injured species studies (i.e. harlequin duck, etc.). Logistic costs may be reduced for the Kenai and Alaska Peninsula portion by combining resources with the proposed Shoreline Assessment project.

All chemical data from environmental samples will become part of the *Exxon Valdez* oil spill database managed by ABL for the Trustees; as such, data can be shared with interested parties.

H. PUBLIC PROCESS

The Public Process for this project has been integrated with the Trustee Council process for the 1995 Work Plan. Interim status reports will be completed according to a schedule set by the Trustee Council.

I. PERSONNEL QUALIFICATIONS

STANLEY D. RICE

Education: Chico State Univ. B.A. 1966, M.A. 1968, Biological Sc.
Kent State Univ. Ph.D. 1971, Comparative Physiology

Experience: 1971-present. Researcher, Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska. Over 65 publications, most with oil toxicity and oil impacts to fish and invertebrates. Field, lab, and analytical expertise with hydrocarbons and effects. Studies have included field toxicity tests in Port Valdez, acute and long term toxicity tests, physiological impacts - including growth and reproduction. In 1986, became program manager for Habitat Investigations. Duties include management of all habitat related research at ABL, from parasite studies, logging impacts, oil toxicity exposures, to chem lab analyses. Program averaged about 24 man years of effort up to 1989. Management of budgets, staff, proposals, and research were part of my duties, plus continuation as a researcher on specific projects.

After the *Exxon Valdez* oil spill, I became responsible for management and coordination of all Damage Assessment studies from ABL, including multispecies trawling assessments and salmon impact studies by other ABL program units. I managed about 50 man years of effort in 1989 (Habitat programs plus *Exxon Valdez* Damage Assessment activities), and about 35-45 in 1990 and 1991. I was responsible for opening a NMFS office in Cordova for the summer of 1989, and spent the majority of summer 1989 in Cordova and PWS. I was a primary source of input to the management team during the first 6 months of the spill. In addition to management activities, I have continued to participate as a researcher in some studies.

Relevant Publications: Over 50 on oil exposures, including several major reviews on oil effects to fish and invertebrates. This includes the first major review of oil literature relevant to Alaska, in 1974, which was prepared as source material for the environmental impact statement for the marine aspects of the Trans-Alaska Pipeline.

MALIN M. BABCOCK

Education: Oregon State University, 1963. B. S., Zoology
University of Alaska Fairbanks, 1968. M. S., Zoology (Fisheries)

Experience: 1969-present. Researcher and Task Leader, Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska. Field, lab, and analytical expertise, and data analyses and interpretation particularly with effects of petroleum hydrocarbons on aquatic fish and shellfish. Studies have included Prince William Sound chemical baseline, short term and long term water-soluble fraction of crude oil and sediment toxicity tests assessing physiological and biochemical impacts - including growth and reproduction. I became Task Leader for the Coastal Habitat task within Habitat Investigations, ABL, in 1988 and directly supervise several staff scientists in varied research projects. I have strong participation in overall Habitat Investigations research planning, budget management and staffing.

After the *Exxon Valdez* oil spill, I was co-principal investigator for the EVOS Coastal Habitat Study "Pre-spill and post-spill hydrocarbon concentrations in mussels and sediments in Prince William Sound", becoming Principal Investigator of this project in 1991 and 1992; was also Principal Investigator for the NRDA study "Injury to Oysters" in 1989. In 1991, I participated in the interagency planning for investigating an evolving problem - that of the effects of contaminated mussel beds on higher consumer organisms, and led the preliminary field effort for identifying these beds and sampling parameters to establish the extent and intensity of petroleum hydrocarbons contamination.

I have been Project Leader for NOAA for the PWS portion of Mussel Bed Restoration and Monitoring - coordinating and leading a staff to investigate extent and intensity of oiling; distribution of HCs within a mussel bed; effects of minimally intrusive manipulative techniques to reduce HCs by increasing exposure of oiled sediments; effects of chronic oiling on mussels (byssal thread production, condition and reproductive indices, glycogen stores, feeding rates, growth, and histopathological abnormalities).

Additionally, staff under my direct supervision are involved in many aspects of EVOS Restoration program for several studies, training all NRDA study personnel in sampling for hydrocarbons, the NRDA/Restoration database, sample custody and tracking, etc.

Relevant Publications: Over 25 publication/reports - most of which involve effects of exposure to petroleum hydrocarbons on various Alaskan species of fish and shellfish. Over 20 public presentations of scientific studies.

PATRICIA M. ROUNDS

Education: University of Alaska Fairbanks; B.S. Biological Science 1966
Graduate work at U of A Fairbanks, U of A Southeast, University of British Columbia

Experience: 1986 - present. Researcher, Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska. As co-principal investigator of NRDA study Subtidal 3, I and was responsible for field logistics and sample collection and assisted in data analysis and report preparation. I also assisted other NRDA projects in field collections. In 1992 and 1993, I participated in study design, field work, and proposal preparation for this project, formerly restoration Project R103 and 93036). Other areas of research have been habitat requirements of juvenile red king crab and sockeye salmon stock separation using parasites.

Relevant publications: Co-author of final reports for NRDA study Subtidal 3. Several public presentations of oil-related scientific research.

GAIL V. IRVINE

Education: University of California at Santa Barbara, 1969. B.A.(honors), Zoology
University of Washington, Seattle, 1973. M.S., Zoology
University of California at Santa Barbara, 1983. Ph.D. Biological Sciences (Aquatic and Population Biology)

Experience: 1994 - Current. Position transferred to the new National Biological Survey, Department of Interior.

1990 - present. Coastal Resources Specialist, National Park Service. Research in marine community ecology; developing and directing a coastal monitoring and research program for the National Park Service. Thus far, the research has been concentrated in two national parks oiled by the *Exxon Valdez* spill, Kenai Fjords and Katmai National Parks. Supervised the oiled mussel bed, Gulf of Alaska project for the Trustee Council.

1984 - 1990. Marine Biologist, Minerals Management Service. Environmental analysis, including potential effects of oil and gas development on marine plants, invertebrates, and fishes (pelagic, nearshore and benthic communities). Research on coelenterate ecology in the

Chukchi Sea.

My education and experience have been concentrated in the fields of community and population biology, with most research in marine systems. I have spent extensive amounts of time doing research at marine labs in Puget Sound (the Friday Harbor Marine Labs) and Panama (through the Smithsonian Tropical Research Institute). Since coming to Alaska, I have gained additional experience in the Gulf of Alaska (Kenai Fjords and Katmai National Parks), Cook Inlet (Lake Clark National Park), and the Beaufort and Chukchi Seas.

I. BUDGET

A. Project

	NMFS	NBS	DEC
Personnel	$ 98.9K	$ 26.5K	$ 6.5K
Travel	24.0K	4.0K	3.0K
Contracts	25.0K	26.0K	0.0K
Commodities	16.5K	4.0K	0.0K
Equipment 0.0K	4.0K	0.0K	
Capital Outlay	0.0K	0.0K	0.0K
Sub-total	164.4K	64.5K	9.5K
General Administration	16.6K	5.8K	1.0K
TOTAL	$181.0K	$ 70.3K	$ 10.5K

B. Comprehensive Reporting

	NMFS	NBS	DEC
Personnel	$ 98.9K	$ 29.0K	$ 3.5K
Travel	4.0K	4.0K	1.0K
Contracts	0.0K	0.0K	0.0K
Commodities	4.5K	2.0K	0.0K
Equipment	0.0K	0.0K	0.0K
Capital Outlay	0.0K	0.0K	0.0K
Sub-total	107.4K	35.0K	4.5K
General Administration	14.8K	4.4K	0.7K
TOTAL	$122.2K	$ 39.4K	$ 5.2K

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Recovery Monitoring of Prince William Sound Killer Whales

Project Number: 95092

Project Leader: Marilyn E. Dahlheim, Ph.D.

Lead Agency: NOAA, Alaska Fisheries Science Center
National Marine Mammal Laboratory
Seattle, Washington 98115

Cost of Project: FY95: $103.7K
FY96: $27.2K
FY97: $105.0K
FY98: $29.0K

Project Dates: Start-up: 5/95; Completion: ?

Project Duration: 20 years. Monitoring every other year beginning in 1995. Ten samples are required to achieve statistically reliable information. If recovery of AB pod to 36 members occurs prior to complete sampling period, project can be terminated. Comprehensive reporting would occur every other year (alternating with the year that monitoring is conducted) and would begin in 1996.

Geographic Area: Prince William Sound, Alaska

Contact Person: Dr. Marilyn E. Dahlheim
Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way NE
Seattle, Washington 98115
Telephone: 206/526-4020
Fax: 206/526-6615

B. Introduction

Photographs of individual killer whales occurring in Prince William Sound (PWS) were collected from May to September 1989-91 to assess the impact of the EVOS on killer whale abundance and distribution (NRDA studies) and from July to September 1993 to determine the recovery status of AB pod.

Photographic analysis of resident pods revealed 14 animals missing from AB pod over the three-year period (1989-1991). Despite considerable searching effort in PWS (1989-1993), in Southeast Alaska (1989-94), and from the Kenai Peninsula to the Bering Sea (1992 and 1993), the missing whales have not been observed. Given the stability of resident pods, we assume that the missing whales are dead. The mortality rates for AB pod ranged from 3.1% in 1988 to 19.4% in 1989, 20.7% in 1990, and 4.3% in 1991. Zero mortality occurred in 1992 and in 1993. The adult annual mortality rate of killer whales is usually less than 2%. Annual pod mortality rates on the order of 20% are unprecedented for North Pacific killer whales.

The cause(s) of the disappearance of 14 whales from AB pod is unknown; however, we assume that the whales are dead from natural causes, a result of interactions with fisheries, from the EVOS, or a combination of these causes.

No new calves were born into AB pod in 1989 or 1990. There was one calf born into AB pod in 1991, two born in 1992 and one born in 1993. AB pod size in 1988 was 36; in late 1993 the pod had 26 members. The pod appears to be growing again. Recovery of AB pod to pre-spill levels (36 whales) could take 10 to 15 years given the current age and sex structure of the population. Killer whales will have fully recovered when the injured pod grows to at least 36 animals (1988 level).

We propose to continue monitoring AB pod to document natural recovery of this resident killer whale pod. This project will build on the research and monitoring data collected for the years 1989-1991 and 1993.

C. Need for Project

The proposed project on Prince William Sound killer whales will monitor the natural recovery of AB pod. Recovery to a pre-spill level of 36 animals is the restoration objective defined in the "Invitation to Submit Restoration Projects for FY 1995", dated 16 May 1994.

D. Project Design

1. Objectives:

1. Count the number and individually identify killer whales within AB pod.

2. Determine killer whale pod structure and integrity within AB pod.

3. Determine killer whale reproductive rates and trends in abundance for AB pod within Prince William Sound.

2. Methods:

Weather permitting, an average of 8 to 10 hours per day (six days per week) will be spent conducting boat surveys searching for or photographing whales. If whales are not located in known areas, a general search pattern will be implemented. This search method will consist of running for 30 minutes while scanning for killer whales and then stopping for ten minutes to scan with binoculars and listen for killer whale calls using a hydrophone. This will be repeated until killer whales are either sighted or until the end of the day. When reports of killer whales are received from sport and commercial fishing vessels, tug boats, and State ferries, researchers will break trackline and move to the area where whales are reported.

When encountered, killer whales will be photographed and survey forms completed. The vessel approximates the whale's course and speed. An approach within 30-60 meters of the whales left side is required. The whale's dorsal fin and saddle patch are then photographed with 35 mm camera systems equipped with motor drives and 300 mm lens set at 1/1000th sec shutter speed, or the highest speed possible. Black and white Fuji 1600 film will be used. Exposed film is labeled with date, roll number, photographer's initials, location, species code, and ASA setting.

Multiple encounters are needed throughout the season with AB pod because the pod may temporarily fragment while foraging. Because AB pod members frequently travel with other resident pods (associated with other pods 80% of the time, photographs of all killer whales encountered in Prince William Sound will be collected.

All exposed film will be analyzed for individual identification. Sub-standard photographs (not showing enough detail or improper angle/side) are not used. Photographs are then grouped by individual. Photographs collected will be compared to NMML's photographic database for the years 1989 to 1991 and 1993. Once all photographs are examined, it is then possible to determine 1) if all members of the pod were present, 2) if pod structure and integrity are similar to previous years, and (3) if new whales (calves) were born into the pod. Any missing animals are noted.
Daily effort logs will be maintained. These logs permit a quantification of the amount of time searching for whales versus photographing whales and depicts the daily vessel trackline. Researchers will be required to conduct line transect surveys while searching for whales. This will allow standardization of effort across years -- a requirement for understanding distribution patterns of killer whales. All cetaceans observed during survey work will be listed.

Killer whale calves of the year are identified by size, their mothers identified, and average pod birth rates calculated. Mortality is assumed based on the absence of an identified animal from its pod for more than one year. Due to the proposed sampling strategy (every other year beginning in 1995) it will not be possible to determine mortality the year immediately following the field season. A period of two years will lapse prior to establishing the fate of a missing whale.

3. Schedule:

Field Season: July to September 1995 (every other year)
Data Analysis: October to December 1995
Draft report of 1995 research: January 1996
Final report of 1995 research: March 1996
Comprehensive report: November 1996

A comprehensive report would be completed every other year beginning in 1996. Data collected for all years beginning in 1989 would be updated pending the results of each field season. As more data are collected, a detailed analyses and subsequent interpretation of existing data can occur. This will lead to a better understanding of the biology and life history of Prince William Sound killer whales.

4. Technical support: Technical support will be provided by the research/administrative staff of the Alaska Fisheries Science Center, National Marine Mammal Laboratory, Seattle, Washington.

5. Location: Field work conducted under this project will be restricted to Prince William Sound. Laboratory work (data analysis/archiving/reporting) will take place at the National Marine Mammal Laboratory, Seattle, Washington.

E. **Project Implementation.** Scientific personnel from the National Marine Mammal Laboratory would implement this project. Scientific/administration staff at the National Marine Mammal Laboratory are thoroughly familiar with all aspects of the proposed research. Previous photographic data associated with killer whale EVOS studies is archived at NMML. Photographic data collected in 1995 would be archived at NMML in a similar manner. NMML has the facilities to properly archive and organize the data to ensure its protection over the years. The accessibility of data is greater if stored at a government facility. By centralizing the data at a government facility, staff at NMML have been able to encourage additional studies of existing information. As an example, studies were conducted on 1) hearing capabilities of killer whales; 2) the effects of noise on killer whales; 3) killer whale aging studies; 4) killer whale foraging and 5) two separate projects are being considered by graduate students. All these studies have been supported by NMML using data collected on killer whales collected during EVOS studies. Research continuity is critical to the overall success of this project; NMML has been involved since the initiation of this project. Since 1989, a critical network has also been established. NMML researchers work closely with other EVOS Principal Investigator thereby ensuring the integration of marine mammal data throughout Prince William Sound. In addition, the National Marine Fisheries Service has a legal research mandate to conduct studies on cetaceans and a mandate to manage populations under the Marine Mammal Protection Act.

F. Coordination of Integrated Research Effort. All EVOS project leaders conducting field research in Prince William Sound will be contacted by the Principal Investigator of the killer whale study. A brief killer whale project description will be provided to each Project Leader. We will encourage other research teams to provide sighting information (on a not-to-interfere basis with their ongoing work). We will also routinely contact other Project Leaders to obtain information on current fisheries information. This fisheries information may be relative to the recovery rates of killer whales. If the monitoring project on killer whales is merged with the killer whale predation project on harbor seals being proposed by NMML, coordination on a much larger scale occurs.

G. Public Process. Since 1989, NMML has encouraged local community involvement. Of particular interest is our continued collaboration with native groups. In 1993, a successful NMML killer whale project was completed with the assistance of the Chenega Corporation. We are willing to visit local communities to present lectures and seminars and motivate local communities to get involved with our work. We encourage public participation at all levels of this scientific research (workshops, meetings, document reviews, etc.). The Principal Investigator of this Project has attended all scheduled meetings/workshops and has presented detailed summaries of all information collected pertaining to the whale studies. Lectures have been given to the general public at symposia, conferences, and in the published literature. Numerous reports of our research on killer whales are available through the Oil Spill Public Information Office. The Principal Investigator has and will continue to talk with representatives of the public, which have and will include those from tourism, industry, fisheries, and conservation groups.

H. Personal Qualifications. Dr. Marilyn E. Dahlheim is recognized worldwide for her expertise on killer whales. Dr. Dahlheim has been the Principal Investigator of the EVOS research on killer whales since 1989. Her involvement with Prince William Sound killer whales began in 1985 (killer whale/blackcod fisheries interactions), however, she has been conducting killer whale research throughout Alaskan waters since 1978. She has recently completed population assessment studies on killer whales throughout Alaska using photo-identification techniques. This work on killer whales occurred in the open waters of the southeastern Bering Sea, eastern Aleutian Islands, and the northwestern Gulf of Alaska; and the offshore and inshore waters of southeastern Alaska. In addition to her work on killer whales, Dr. Dahlheim has made significant contributions to the biology of gray whales, Alaskan humpback whales, and Alaskan harbor porpoise. Dr. Dahlheim has published extensively on cetacean biology; of which 20 manuscripts have been published on killer whales.

The monitoring project will require a team consisting of 2-3 researchers. Research personnel will vary depending upon the decision to merge the monitoring and the killer whale/harbor seal predation project. All selected personnel will have extensive experience (10 years+) in the conduct of cetacean research/photo-identification work.

I. Budget

A. Monitoring Project $103.7k (FY95)

Personnel	$18.0K
Travel	6.0K
Contractual Services	50.0K
Commodities	23.5K
Equipment	0.0
Capital Outlay	0.0
General Administration	6.2K
TOTAL	103.7K

B. Comprehensive Reporting - $27.2K (FY96)

Personnel	$21.0K
Travel	3.0K
General Administration	3.2K
Total	$27.2

Restoration of Pink Salmon Resources and Services

Project Number: 95093

Project Leader: Jeff Olsen, PWSAC Operations Manager

Lead Agency: AK. Dept. of Fish and Game (ADF&G)

Cost of Project, FY95: $2.219.1; **FY96** $2,241.2

Start/Completion: January, 1995 - September, 1995

Project Duration: 0.75 yr.

Geographic Area: Prince William Sound

Contact Person: Jeff Olsen, Operations Manager
PWSAC, P.O. Box 1110, Cordova, AK 99574
(907) 424-7511

B. Introduction

Prince William Sound Aquaculture Corporation, the regional salmon enhancement program for PWS and the Copper River, operates five salmon hatcheries in the region. Wild stocks have been affected and hatchery pink salmon production has declined precipitously since the **EVOS**. Pink salmon, which are defined as a "resource" by the Trustee Council, were injured by the **EVOS** and are not recovering (**EVOS** Trustee Council). As a result of these injured resources, individuals and communities of PWS have suffered lost or reduced services.

The purpose of this project is to provide partial funding to PWSAC to continue pink salmon enhancement as well as enhancement of other salmon species to restore and replace the "injured resource and benefit the same user group(s) that was (were) injured". (**EVOS** TC, 1994). Under **EVOS** Trustee Council general restoration strategies, "commercial fishing will have recovered when the population levels and distribution of injured or replacement fish used by the commercial fishing industry match conditions that would have existed had the spill not occurred". PWSAC's project is the only available method to do that.

Further, this restoration activity will (**EVOS** TC Draft Guiding Principles):

- "occur within the spill area";
- "support services necessary for the people who live in the area";
- include "meaningful public participation process";
- reflect "a reasonable balance between costs and benefits";
- provide a "cost-sharing opportunity";
- "have a sufficient relationship to an injured resource"; and,
- "state a clear, measurable and achievable endpoint".

C. Need for Project

Restoration funds must be used "...for the purposes of restoring, replacing, enhancing or acquiring the equivalent of natural resources injured as a result of the oil spill or the reduced or lost services provided by such resources". This project is needed to restore and replace injured resources by increasing the rate and degree of recovery of pink salmon, replacing injured pink salmon with other species, and to restore/replace injured or lost services by continuing to produce hatchery salmon which have "sufficient relationship to the injured resource...and will benefit the same user group(s) that was (were) injured.

D. Project Design Objectives, Methods, Schedule and Location

1. Objectives

A. To restore resources and services to pre-spill conditions.

B. To produce and release a total of 428 million pink salmon fry, 99 million chum fry, 2.1 million coho smolts, 820 thousand chinook smolts, 5.5 million sockeye smolts and 26 million sockeye fry.

C. To achieve a projected return of 21 million adult pink salmon, 2.2 million chum, 265 thousand coho, 16 thousand chinook and 1.1 million sockeye salmon resulting in revenues for common property users, processors, communities in PWS, and the enhancement program.

2. Methods

Salmon eggs will be taken from returning broodstock at hatchery locations in the fall of 1994. Incubation will occur during the winter months along with smolt rearing.

By mid March, salmon fry begin exiting the incubators and are carried through plastic plumbing and a bank of electronic fry counters. Fry are also coded wire tagged at this time. Following enumeration and tagging, fry are conveyed to saltwater rearing pens for rearing and release into the plankton bloom. Sockeye, coho and chinook smolts are also tagged prior to release. Fry and smolts are released at hatchery and remote sites.

Adult salmon begin returning in June at which time salmon are harvested by the hatchery for broodstock and sales revenue; the majority of the fish are harvested by commercial fishermen, with subsistence and sport fishers taking fewer nmbers..

3. Schedule

Activity	Begin	Complete
Smolt rearing	**4/94**	5/95
Incubation	9/94	2/95
Fry outmigration	3/95	4/95
Rearing/release	4/95	6/95
Brood and sales harvest	7/95	9/95
Eggtake	8/95	9/95

4. 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.

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.

E. Project Implementation

PWSAC will implement the project in conjunction with ADF&G as the lead agency.

F. Coordination of Integrated Research Effort

Continuation of hatchery pink salmon production and releases will contribute to restoring damaged pink salmon resources and common property fishery services to pre-spill conditions. This is not a research project although released fry may contribute to a better understanding of the ecology of PWS through the SEA research program.

G. Public Process

PWSAC is a regional association which by law (AS 16.05.380.) must include on their boards representatives of sport fishermen, municipalities, and Native organizations, in addition to commercial fishermen and processors. Similarly, it is PWSAC's mission to optimally produce salmon for the benefit of all user groups.

H. 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.

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

I. Budget FY95

100	Personnel	$1,043.0
200	Travel	$44.4
300	Contractual Services	$288.5
	Administration	$110.9
400	Commodities	$554.8
500	Equipment/capital	$177.5
	TOTAL	$2,219.1

Recovery of Intertidal Clams in Prince William Sound

Project Number: 95094

Principal Investigator: Stephen C. Jewett
University of Alaska Fairbanks

Lead Agency: Alaska Department of Fish & Game

Cost of Project: $229,181

Project Start-up: March 1995

Project Duration: Five years

Geographic Area: Prince William Sound

Contact Person: Dr. Joe Sullivan, ADF&G

B. Introduction

Prior to the EVOS, intertidal bivalves were an important subsistence food at numerous locations in Prince William Sound (PWS). However, subsequent to the EVOS and cleanup efforts on oil-contaminated beaches in the Sound recruitment success on hard-shelled clams (littleneck clams (LNC) *Protothaca staminea* and butter clams (BC) *Saxidomus gigantea*) was diminished. Additionally, the abundance of older clams on oil-impacted beaches was reduced (C. Trowbridge, ADF&G, Pers. Commun., 1993; Houghton *et al.*, 1993), thereby limiting the subsistance usage of this resource. In addition to the impact on subsistence harvesting of LNC and BC, sea otters, *Enhydra lutris*, within PWS will also be affected by the reduction in this food resource. Based on previous investigations, sporadic recruitment and slow growth of hard-shell clams in the Sound will result in protracted recovery.

C. Need for the Project

This project will contribute to an understanding of the rate of recovery of hard-shell clam populations on oil-impacted beaches in PWS.

D. Project Design

1. Objectives: Monitor recruitment success and density of clams from paired oiled and control beaches over a 5-year period.

2. Methods: Recruitment will be determined by *in situ* sampling intertidally. We will estimate and compare recruitment and abundance in oiled and control sites using established core and quadrate sizes. Sediment samples will be taken for grain size determination. The sites will be selected from a suite of sites previously sampled by ADF&G Division of Subsistance, NOAA Hazardous Materials Response and Assessment Division and/or identified by Native community residents. Laboratory analysis will entail size and abundance determinations, as well as sediment analysis.

3. **Schedule:** Sampling will occur during the low tide series over a 10-day period in the summer of each year. Laboratory analysis for the first year will be completed by February 1996. Data analysis and draft report preparation for the first year will be completed in May 1996. Deliverables for the first year will consist of a FY 95 progress report to be submitted in September 1995, and a final report to be completed by May 1996. Scheduling for the subsequent year will follow the above general schedule.

4. **Technical Support:** No technical support is required for the first year.

5. **Location:** Prince William Sound

E. Project Implementation

This project will be implement through ADF&G.

F. Coordination of Integrated Research Effort

This project will integrate with several other nearshore ecosystem projects (i.e., Processes Structuring Recovery of Injured Nearshore Vertebrate Predators submitted through National Biological Survey), and the subtidal eelgrass habitat investigation. It is also anticipated that sea otter investigators will make key observations of sea otter distribution and feeding that will be critical in evaluating the interactions between otters and hard-shell clams.

G. Public Process

The investigator in this project has taken part of public participation workshops sponsored by the Trustee Council to examine research needs. Future workshops will be supported. All documents produced will be made available for public review.

H. Personnel Qualifications

Stephen C. Jewett, Principal Investigator, has been a Research Associate at the School of Fisheries and Ocean Science (SFOS), University of Alaska Fairbanks since 1975. During this time he has been involved in numerous benthic and intertidal investigations throughout Alaska that emphasize assessment and/or monitoring. He has authored more than 30 publications in scientific journals and books. He has been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989-94).

I. Budget

1.	**Personnel**	141,504.0
2.	**Travel**	4,980.0
3.	**Contractual Services**	43,000.0
4.	**Commodities**	1,500.0
5.	**Equipment**	0.0
6.	**Capital Outlay**	0.0
7.	**General Administration**	38,197.0
		$229,181.0

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Quantification of Stream Habitat for Harlequin Ducks and Anadromous Fish Species from Remotely Sensed Data

Project Number: 95095

Project Leader: Richard Podolsky, PhD.
Avian Systems, Inc.
1275 15th St. #15G
Fort Lee, NJ 07024-1929
Tel: (201) 224-2025; FAX: (201) 224-2566

Lead Agency: NOAA

Cost of Project, FY95: $88.0K

Project Start-up/Completion Dates:

Project Duration: 4 years

Geographic Area: Spill Area

Introduction:

Harlequin ducks (Histrionicus histrionicus), feed in the shallowest water of all the seaducks in Alaska. Consequently, they were heavily impacted by the Exxon Valdez oil spill. Furthermore, because of the persistence of oil in certain estuaries, harlequins appear to be suffering from continued, chronic exposure to oil. Nearly total nesting failure of harlequins apparently has ocurred in the spill area. Identification and protection of nesting habitat through land acquisition, therefore, is critical to the recovery of this species.

Project Description:

Harlequins congregate at the mouths of fast streams where they nest. The goal of this study is to analyze aerial photographs and satellite imagery in order to identify and map all potential nesting streams in the spill area. With the aid of a geographic information system the distribution of historical or current harlequin nests will be incorporated.

The goal will be to prioritize sites in terms of their potential to support harlequins and make this information available to those charged with land acquisitions. Any land acquisitions made as a result of this study will also benefit the species of anadromous fish that co-occur in these streams.

Actions:

* Analyze satellite or aerial photos identifying all major and minor streams. This can be accomplished with GIS software such as GAIA, that allows the coregistration and overlay of hydrography vectors to the raster imagery.
* Catalogue all major and minor streams and rank them according to their value as potential harlequin nesting habitat.
* Build a GIS that includes the following data layers: imagery, historical harlequin nest sites, current harlequin nest sites, stream stretch ranking in terms of water motion, vegetation cover etc., vectorized hydrography, and proximity to shallow estuaries for feeding.
* Recommend specific sites to be acquired to maximize the number of harlequins and their reproductive output.

Restoration of Murres by way of Social Attraction and Predator Removal

Project Number: 95096

Project Leader: Dr. Richard Podolsky
Dr. Stephen Kress
National Audubon Society
1275 15th St. #15G
Fort Lee, NJ 07024-1929
Tel: (201) 224-2025; FAX: (201) 224-2566

Lead Agency: USFWS

Cost of Project, FY95: $167.0K (yearly)

Project Start-up/Completion Dates:

Project Duration: 4 years

Geographic Area: Spill Area

Introduction:

Common Murres (Uria aalge inornata) were the most heavily affected bird species as a result of the Exxon Valdez Spill. Restoration of selected populations and enhancement of habitat by way of auditory and visual attraction of pre-breeders in combination with removal of predatory mammals such as Arctic Fox, could be an important technique for reducing the recovery time of murre population.

Project Description:

Pre-breeding seabirds are known to wander widely in the years before breeding. During this prospecting phase it has been shown that behavioral attraction (sound playback and presentation of decoys or models) is an effective means of luring seabirds to new or extirpated habitat especially when done in conjunction with predator removal. The result could be a reduction in the recovery time, especially for Murres. Work by National Audubon with murres and other seabirds in the Gulf of Maine has shown that they are lured to habitat where predators have been eradicated.

Murres accounted for 61% of the dead birds recovered after the spill (22,000 of 36,000). But because many oiled birds were lost at sea or along the shores, the number of recovered murres represents perhaps only 5-10% of the total number of murres killed by the spill. It is therefore likely that in excess of one hundred thousand murres were killed as a result of the spill. This translates into a major mortality event that will affect the reproductive performance and population stability of murres in Alaska for years to come. It is known already that this mortality event has caused complete reproductive failure in some large colonies in each year since the spill, and this loss represents the cumulative lost production of some 300,000 young. Reasons for this "echo" of lost production into subsequent years is complex, but may have to do with the fact that many surviving adults have had to find new mates, a process that can be followed by several years of failed reproduction.

Actions:

* Conduct appropriate attraction trials at extirpated habitat WITHIN the spill area.
* Conduct appropriate attraction trials at predator infested colonies WITHIN and/or OUTSIDE the spill area (such as Walrus Island in the Aleutian Islands).

Restoration of Murres by way of Transplantation of Chicks: A Feasibility Study

Project Number: 95097

Project Leader: Dr. Richard Podolsky
Dr. Stephen Kress
National Audubon Society
1275 15th St. #15G
Fort Lee, NJ 07024-1929
Tel: (201) 224-2025; FAX: (201) 224-2566

Lead Agency: USFWS

Cost of Project, FY95: $176.0K

Project Start-up/Completion Dates:

Project Duration: 4 years

Geographic Area: Spill Area

Introduction:

Common Murres (Uria aalge inornata) were the most heavily affected bird species as a result of the Exxon Valdez Spill. Restoration of selected populations by way of transplantation and hand-rearing of chicks could be an important technique to reduce the recovery time of the murre population.

Project Description:

Translocation and hand-rearing of alcids has been successful in reestablishing Atlantic Puffins to former breeding sites in the Gulf of Maine. Similar methodologies might be adaptable to Common Murres and result in the re-establishment or enhancement of colonies impacted by the spill. Thus, the goal of this project is to conduct the background research necessary to ascertain whether this approach is adaptable and feasible with Common Murres and whether any significant restoration potential might be realized through this methodology.

Murres accounted for 61% of the dead birds recovered after the spill (22,000 of 36,000). But because many oiled birds were lost at sea or along the shores, the number of recovered murres represents perhaps only 5-10% of the total number of murres killed by the spill. It is therefore likely that in excess of one hundred thousand murres were killed as a result of the spill. This translates into a major mortality event that will affect the reproductive performance and population stability of murres in Alaska for years to come. It is known already that this mortality event has caused complete reproductive failure in some large colonies in each year since the spill, and this loss represents the cumulative lost production of some 300,000 young.

Reasons for this "echo" of lost production into subsequent years is complex, but may have to do with the fact that many surviving adults have had to find new mates, a process that can be followed by several years of failed reproduction.

Action:

* Conduct appropriate experiments in such places as the Barren Islands to ascertain the feasibility for translocations of Common Murre chicks from large colonies outside the spill area.

* Conduct the appropriate trials to establish a methodology for human-rearingof murre chicks.

Identification of seabird feeding areas from Remotely Sensed Data (AVHRR and/or Landsat MSS) and its impact on restoration efforts (with special focus on murres and murrelets)

Project Number: 95098

Project Leader: Dr. Richard Podolsky
Dr. Stephen Kress
National Audubon Society
1275 15th St. #15G
Fort Lee, NJ 07024-1929
Tel: (201) 224-2025; FAX: (201) 224-2566

Lead Agency: USFWS

Cost of Project, FY95: $74.0K

Project Start-up/Completion Dates:

Project Duration: 4 years

Geographic Area: Spill Area

Introduction:

Restoration efforts for seabirds should be focused on areas with the greatest likelihood of maximizing reproductive output and minimizing risk from human activities.

Project Description:

The two factors that are most important to the distribution and abundance of seabirds are: 1) the proximity to rich feeding areas, and 2) disturbance-free (especially predator-free) island habitat. Assessing the quality of seabird habitat entails measuring at least these two variables. These data can then be used to identify seabird "hot-spots", and 1) focus the restoration efforts in these areas and 2) identify hot-spots to be avoided by any shipping activities that pose the risk of spilling hazardous materials.

When abundant island habitat exists in close proximity to rich feeding grounds than seabird colonies typically attain impressive concentrations. These concentrations are at significant risk, however, when they co-occur with certain types of human activities, most notably the shipping of hazardous substances.

Action:

* Collect and summarize existing information on the distribution and abundance of seabirds within foraging distance (@200 km) of the islands and shores impacted by the Exxon Valdez Spill.

* Measure the productivity of the ocean within foraging distance (@200 km) of the islands and shores impacted by the Exxon Valdez Spill by analyzing ocean fronts, algae blooms, chlorophyll concentrations and related phenomenon from AVHRR (Advanced Very High Resolution Radiometer) and/or Landsat MSS (Multispectral Scanner) data.

* Examine the degree to which seabird distribution correlates with ocean productivity. Prioritize coasts and islands as a function of the overall quality of their seabird habitat and make logical recommendations to all appropriate agencies.

Marbled Murrelet Vocalizations in Conjunction with Artificial Nests: A Possible Means of Attraction to Restored or Acquired Habitat

Project Number: 95099

Project Leader: Richard Podolsky, PhD.
Avian Systems, Inc.
1275 15th St. #15G
Fort Lee, NJ 07024-1929
Tel: (201) 224-2025; FAX: (201) 224-2566

Lead Agency: USFWS

Cost of Project, FY95: $77.0K

Project Start-up/Completion Dates:

Project Duration: 4 years

Geographic Area: Spill Area

Introduction:

Marbled Murrelets (Brachyramphus marmoratus) were among the most heavily affected bird species as a result of the Exxon Valdez Spill. Restoration of selected populations by way of auditory and visual attraction of pre-breeders in conjunction with artificial nests could be an important technique to reduce the recovery time of the murrelet population.

Project Description:

Playback of vocalizations has been shown to be an effective method of attracting many seabirds including: alcids, terns, albatrosses, storm-petrels and gadfly petrels. Both storm-petrels and gadfly petrels have been successfully lured to artificial nests augmented with playback of vocalizations. Because this method has not been attempted with murrelets, the goal of this project is to ascertain whether murrelets are attracted to playbacks or other relevant sounds and whether there is any significant management potential to be realized through combining these stimuli with the presentation of artificial nests.

Actions:

* Conduct appropriate experiments on Knight and Naked Islands in order to ascertain whether murrelets are attracted to playback of vocalizations or other relevant sounds.

* Conduct appropriate experiments on Knight and Naked Islands in order to ascertain whether the number of murrelets observed, during dawn watches or through other population assessment methods, can be increased by broadcasting various sounds.
* Ascertain whether murrelets are attracted to, or will use, artificial nests with or without vocalization playback.

Relevant Past Work:

Podolsky, R. and S.W. Kress. 1992. Attraction of the endangered Dark-rumped Petrel to recorded vocalizations in the Galapagos Islands. The Condor 94: 448-453.

Podolsky, R.H. and S.W. Kress. 1989. Factors affecting colony formation in Leach's storm-petrel to uncolonized islands in Maine. The Auk 106: 332-336.

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL

FY 95 BRIEF PROJECT DESCRIPTION

<u>Project Number</u> **95100**

1. Project Title:	Administration, Public Information & Science Management
2. Project Leader:	James R. Ayers, Executive Director
3. Lead Agency:	n/a
4. Cost of Project:	$3,500.0 (estimated)
5. Start-up/Completion:	October 1, 1994 - September 30, 1995
6. Project Duration:	1 year
7. Geographic Area:	Spill area
8. Contact Person:	Molly McCammon Director of Operations *Exxon Valdez* Oil Spill Trustee Council 645 G Street Anchorage, Alaska 99501 (907) 278-8012

B. Introduction — What You Propose as a Project

The Administration, Public Information & Science Management project provides for overall management, administration and implementation of the Trustee Council's restoration program. This project makes extensive use of existing Trustee Council agency structures to keep administrative costs to a minimum.

The proposed FY 95 budget of $3,500.0 (estimated) for Administration, Public Information & Science Management represents a substantial reduction in costs relative to the FY 94 budget of $4,2000.0. The FY 95 project represents the final step in reorganization of the administration of the Trustee Council executive staff and operations. Specific components of the Administration, Public Information & Science Management project include:

- Office of the Executive Director — The budget for the Executive Director includes salaries, benefits, travel, office space, supplies, printing costs, contractual services, utilities, and other such items as may be necessary for efficient operation of the Juneau office of the Executive Director and the Director of Administration. In addition to budget and audit responsibilities, the Director of Administration is assuming the duties once performed by the six-member Finance Committee: developing fiscal procedures, adherence to the procedures, and ensuring overall fiscal standards and reporting for accountability, and efficiency.

- Chief Scientist: Science Review Board and Peer Review — The Trustee Council and the Trustee Council-supported principal investigators need access to the best possible scientific knowledge and understanding concerning injured resources and services. This information has been provided continuously by the Chief Scientist and expert peer reviewers since the injury assessment process started in 1989. It is essential that this expertise be retained on an upon-request basis to provide the unbiased scientific review and continuity essential to perform the best possible scientific work. This component will also include the Science Review Board, when adopted by the Trustee Council. A competitive Request for Proposals is underway for the Chief Scientist and science review technical capability.

- Operations — The budget for Operations includes salaries, benefits and travel for staff that perform the key planning, coordination, communications and project management functions of the Trustee Council. This budget also includes funds for public meetings throughout the spill area, teleconferences, Trustee Council meetings, newsletters, brochures and other publications, as well as the operating costs for offices in the Simpson Building in Anchorage.

- Public Advisory Group — The Public Advisory Group (PAG) consists of 17 members, plus two ad-hoc members from the State Legislature, representing 12 principal interest groups and five members from the public-at-large. The role of the PAG is to assist in gathering public input and to provide advice to the Trustee Council on such items as the annual work plans, budgets, and the Restoration Plan. The budget reflects the administrative support expenses for the PAG, including staff support, which is now being provided through the state in order to provide more user-friendly travel reimbursement.

- Restoration Work Force — The FY 95 budget for the Restoration Work Force reflects support for the six Trustees with a budget of 150.0 per Trustee Council agency. This provides the funding necessary for liaison staffing and good, quick information transfer and participation in daily activities. Some agencies may request funds for additional support. Liaisons oversee work plan development and generally represent the Trustee Council members in matters related to implementation of the restoration program. (Agencies also receive funding for project management in association with individual projects.) Costs involved are salaries, benefits, travel, per diem, equipment and commodities.

C. Need for the Project — Why the Project will Help Restoration

The project will provide the essential management and administration necessary to efficiently implement the restoration program developed by the Trustee Council.

D. Project Design — Objectives, Methods, Schedule and Location

1. Objectives:

The fundamental objective of the Administration, Public Information & Science Management project is implementation and management of the Trustee Council's direction to pursue a comprehensive, balanced approach to restoration built upon three basic elements:

- Research and Monitoring
- General Restoration
- Habitat Protection

Specific objectives for FY 95 include:

- implementation of a Final Restoration Plan, pending completion of the NEPA Environmental Impact Statement process;
- implementation of the approved FY 95 Work Plan;
- continued oversight and management of the Trustee Council science program that includes the peer review and project evaluation process under the direction of the Chief Scientist as well as development of a Science Review Board;
- sponsorship of an Annual Forum that brings together scientists, agency staff, Trustee Council staff and members of the general public to review the status of injured resources and services and help devise and refine appropriate restoration strategies through an adaptive management process;
- further refinement of draft monitoring strategies for injured resources;
- further habitat evaluation, appraisals and negotiation with potentially willing sellers as part of both the Large Parcel and Small Parcel Habitat Protection Programs;
- continued work on the proposed physical improvements to the Institute of Marine Science facilities in Seward to provide necessary facilities for enhancement and research necessary for restoration;
- regular meetings and interaction with the Public Advisory Group (PAG) as one means of gathering public input into the Trustee Council process;
- production of an Annual Report;
- publication of a newsletter six times/year regarding activities of the Trustee Council;
- development of the FY 96 Work Plan, including opportunity for substantial public involvement and review of the work plan;
- oversight and management of the Trustee Council's FY 92-95 Work Plan projects and expenditures, including the production of quarterly reports that track the status of Trustee Council authorized projects;
- completion of a financial audit; and
- development of an inventory tracking system.

2. Methods:

All Trustee Council operations are governed by the state and federal laws and regulations that apply to the respective agencies that comprise the Trustee Council.

3. Schedule:

The Trustee Council operates on the federal fiscal year (Sept 30 - Oct 1).

4. Technical Support:

Trustee Council operations require limited technical support with computer support services provided by in-house staff.

5. Location:

The Trustee Council maintains the Executive Director's Office in Juneau (709 west 9th Street, Juneau, Alaska, 99801) and a Restoration Office in Anchorage (645 G Street, Anchorage, 99501).

E. Project Implementation — Who Should Implement the Project

The Trustee Council, established under the terms of a court approved civil settlement, is comprised of the Commissioner of the Department of Environmental Conservation, the Commissioner of the Department of Fish and Game; the Attorney General of the State of Alaska; the Secretary of the Department of the Interior; the Secretary of the Department of Agriculture; and the Director of the National Oceanic and Atmospheric Administration. In order to manage the Settlement as directed by the Trustee Council, an Executive Director has been hired who oversees a small core staff while making use of existing Trustee Council's agency structures to keep administrative costs to a minimum.

F. Coordination of Integrated Research Effort

As part of an adaptive management process, the Trustee Council, through the Executive Director and Chief Scientist, will develop and maintain an integrated research effort. This integration will ensure that projects are reviewed, implemented, and evaluated as a comprehensive approach to restoring and maintaining the spill area ecosystem. This will enable scientists and managers to synthesize research and monitoring information and take appropriate adaptive management actions. This effort will include coordination with other existing public and private entities to ensure effective restoration. In addition, the Trustee Council will sponsor an Annual Forum that will bring together scientists, agency staff, Trustee Council staff and members of the general public to review the status of injured resources and services and help devise and refine appropriate restoration strategies. This is one mechanism by which research sponsored by the Trustee Council will be coordinated and integrated. Additionally, during FY 95, a Science Review Board will be established and used as a mechanism to provide overall coordination and integration of the Trustee Council science program.

G. Public Process

All meetings of the Trustee Council are public, with recordings and transcripts made of each meeting. The Trustee Council is committed to ensuring meaningful public participation at all levels of Trustee activities - in the formulation of project proposals, the development of major policies, and the actual implementation of restoration actions. The Public Advisory Group is a principal mechanism by which the Trustee Council obtains public input. The PAG consists of 17 members representing a diverse cross-section of interests that meets at least quarterly and assists in the formulation of the annual work plan as well as providing advice on major policy issues. The Trustee Council has also sponsored a series of public workshops to obtain input into the development of a scientific research and monitoring program. In addition to PAG members, participation in these workshops has included representatives of spill area communities and other interested public. An active communications and public outreach program actively solicits public involvement and provides regular communications about Trustee Council activities through newsletters, information briefs, media releases, and an annual report.

H. Personnel Qualifications

All personnel working for the Trustee Council are public employees and their qualifications are a matter of public record.

I. Budget

100	Personal Services	967.6
200	Travel	290.5
300	Contractual	1,081.5
400	Commodities	60.0
500	Equipment	50.0
600	Capital Outlay	0.0
700	General Administration	150.4
800	Restoration Work Force	900.0
	TOTAL	3,500.0

Closeout: Murrelet Prey and Foraging Habitat in Prince William Sound

Project Number: 95102

Project Leader: Kathy Kuletz

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $55.0K

Project Start-up/Completion Dates: 10/1/94 - 03/31/95

Project Duration: N/A

Geographic Area: N/A

Contact Person: Catherine Berg
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3598

B. Introduction

This project is the closeout of 94102 - Murrelet Prey and Foraging Habitat in Prince William Sound. The purpose of the project was to identify prey species, locate foraging areas, determine foraging patterns from known nesting areas, and characterize important feeding habitat for marbled murrelets.

C. Need for the Project

Not applicable.

D. Project Design

1. Objectives:

The purpose is to analyze 1994 project data and prepare a final report. The report will be prepared for the peer-review process and presentation to the Trustee Council.

2. Methods

Not applicable.

3. Schedule

October - December: Data analysis
December - January: Report writing
February 15: Draft report
March 31: Final report

4. Technical Support:

Not applicable.

6. Location:

Report preparation will occur at the Fish and Wildlife Service Regional Office in Anchorage, Alaska.

E. Project Implementation

The USFWS is the most appropriate entity to analyze the data and write the report.

F. Coordination of Integrated Research Effort

Not applicable.

G. Public Process

This project was reviewed by the public as part of the FY94 Work Plan.

H. Personnel Qualifications

Not applicable.

I. Budget ($K)

Personnel	$55.0
Travel	0.0
Contractual	0.0
Commodities	0.0
Equipment	0.0
Capital Outlay	0.0
Subtotal	$55.0
General Admin.	7.3
Total	$62.3

J. Literature Cited

Not applicable.

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Kenai River Ecosystem Restoration Pilot Enclosure Study

Project Number: 95105

Name of project leader(s): Dana Schmidt and Ken Tarbox

Lead agency: ADF&G

Cooperating agencies: USFWS and NBS

Cost of project/FY 95: $326.0K

Project Start-up/Completion Dates: October 1, 1994 / September 30, 1995

Geographic area of project: Skilak Lake

Contact Person: Dana Schmidt

B. INTRODUCTION

This study stems form the results of the 1989 EXXON Valdez oil spill (EVOS). During the summer of 1989, the presence of oil in the waters of Cook Inlet resulted in an overabundance of sockeye salmon escaping into the Kenai River system (Schmidt and Tarbox, 1993) The injury assessment of the Kenai River ecosystem has focused on changes to production of sockeye salmon caused by large escapements. This study is an extension of ongoing investigations of injury assessment of the Kenai River ecosystem with emphasis on productivity of sockeye salmon. This study will initiate a pilot restoration project using enclosures in Skilak Lake to provide an experimental design to determine possible restoration strategies. The enclosure studies will allow experimental manipulation of fish density and nutrients on a limited scale to determine the costs and benefits of larger scale programs, such as changing fry recruitment through escapement changes, or nutrient additions to simulate fish carcass decomposition. This program emphasizes a cooperative State/Federal involvement to insure goals are designed to meet restorative objectives of both the Alaska Department of Fish and Game and the concerns of the Kenai National Wildlife Refuge. The presence of the Fish and Wildlife Service personnel at Skilak Lake throughout the summer in the course of normal refuge operations provides the opportunity for cost effective management of the enclosures. In addition, the expertise in sockeye salmon studies of the now National Biological Survey research laboratory (formerly US Fish and Wildlife Service) in Anchorage, provides additional local expertise and facilities.

Background

Commercial fishing for sockeye salmon in 1989 was curtailed in upper CI, the outer Chignik districts, and the Kodiak areas due to presence of oil in the fishing areas from the EVOS. As a result, the number of sockeye salmon entering four important sockeye producing systems

(Kenai/Skilak, Chignik/Black, Red, and Frazer lakes) and two less important lake systems (Akalura and Afognak or Litnik lakes) greatly exceeded levels that are thought to be most productive. Sockeye salmon spawn in lake associated river systems. Adult salmon serve an extremely important role in the ecosystem, providing food for marine mammals, terrestrial mammals, and birds. Additionally, carcass decomposition serves to charge fresh water lake systems with important nutrients. Juvenile salmon, that rear in lakes for one or two years, serve as a food source for a variety of birds, fish and mammals. Sockeye salmon are also an important subsistence, sport, and commercial species. The ex-vessel value of the commercial catch of sockeye from these lake systems has averaged about $42 million per year since 1979, with the 1988 catch worth $115 million. Sockeye salmon returns to the Kenai River system support one of the largest recreational fisheries in the State.

Overly large spawning escapements may result in poor returns by producing more rearing juvenile sockeye than can be supported by the nursery lake (Kyle et al. 1988). In general, when rearing fish abundance greatly exceeds the lake's carrying capacity, prey resources are altered by changes in species and size composition (Mills and Schiavone 1982; Koenings and Burkett 1987; Kyle et al. 1988) with concomitant effects on all trophic levels (Carpenter et al. 1985). Because of such changes, juvenile sockeye growth is reduced, mortality increases, larger percentages holdover for another year of rearing; and the poor quality and small size of smolts decreases marine mortality. Where escapements are two to three times normal levels, the resulting high juvenile densities crop the prey resources to the extent that more than one year is required to return to normal productivity. Rearing juveniles from subsequent brood-years suffer from both the poor quality of forage and from the increased competition for food by holdover juveniles (Townsend 1989; Koenings and Kyle 1991). This is the brood-year interaction underlying cyclic variation in the year class strength of anadromous fish. Recent findings from the Kenai River drainage (Schmidt and Tarbox, 1993) suggest major economic injury to commercial, subsistence, and sport fisheries may result because of overescapement associated with fisheries closures caused by the 1989 oil spill. Smolt numbers emigrating from the Kenai River in the spring of 1992 and 1993 were less than one-fiftieth the numbers estimated in 1989. This suggests a likely possibility of future returns below existing escapement goals.

Recent studies on the Kenai River system indicate Skilak Lake fall fry are significantly smaller than nearby Tustumena Lake, a system that had normal escapements during the past decade (Schmidt and Tarbox 1993). Data collected in 1993 (Schmidt and Tarbox : In Prep.) suggest this trend has continued; Tustumena Lake fall fry were significantly larger than Skilak Lake. The estimated abundance of fall fry compared with total smolt estimates for Tustumena and Skilak lakes imply that the overwintering period resulted in major mortality of rearing fry in Skilak. We have also discovered an inverse relationship of egg-bearing *Diaptomid* copepods with fry abundance in Skilak Lake suggesting selective depletion of this food resource. Nutrient data (Schmidt and Tarbox, 1993) does not suggest nutrient depletion as the major cause of the decline of sockeye salmon in Skilak Lake. However, the low values of reactive phosphorous in the lake (less than 5 μgl^{-1}) suggest nutrients may be limiting, and may have some potential for accelerating the recovery of the system. Nutrient additions have been used in many Alaskan and Canadian sockeye salmon systems to improve productivity of oligotrophic systems by simulating the natural nutrient supplementation achieved through salmon carcasses (Kyle et al 1993). However, glacial lakes have had limited investigations, and there is limited understanding of the ecosystem dynamics of nutrient cycling in glacial lakes.

C. NEED FOR THE PROJECT

Restoration activites potentially possible for the Kenai River include adjustment of escapement levels, enhanced egg to fry survival through hatchery fry production, barren system stocking, smolt stocking and nutrient enrichment. All of these activities have potential to cause harm if improperly applied. The proposed project will provide experimental evidence as to the efficacy of some of these activities. Without such a program, we may face continued uncertainty as to what action to take in the future to restore the Kenai River sockeye salmon runs.

Injury assessment investigations to date have provided inferences as to the causal mechanism of the decline of sockeye salmon production from the Kenai River ecosystem. Although correlative studies and comparisons of results from neighboring Tustumena Lake provide valuable insights, major uncertainty remains because of the lack of true controls and replicates inherent in the study design used to date. Without bold experimental manipulations of the affected lakes through major changes of escapement or by whole lake nutrient enrichment programs, the development of a restoration plan with any reasonable expectation of success is unlikely. The use of enclosures, with the treatments outlined in this proposal are much more likely to provide insights as to what should be the future restorative actions without the biological, economic, and political risks associated with large-scale restorative activities within the Kenai River lake ecosystems. By understanding the mechanism which caused the collapse in sockeye salmon smolt production in the Kenai River system, valuable information will be available for fisheries management of the future. The resources affected have had annual economic value in excess of $100 million dollars in direct commercial value and have had major economic benefit to the sport fishing industry, and importance to subsistence and personal use fishers on the Kenai Peninsula. The forecasted decline has shown no sign of recovery. The investment in knowledge on glacial lake ecology will also provide benefits to other sockeye salmon investigations, such as the glacially influenced Coghill Lake in Prince William Sound.

D. PROJECT DESIGN

This study will be located within Skilak Lake on the Kenai Peninsula. Specific locations of the enclosures will be chosen to minimize conflict with public users and through the permitting and cooperative effort of the Kenai National Wildlife Refuge Staff. The proposed study will be conducted for a minimum of two growing seasons (years).

1. Objectives:

The following objectives have been developed for this study:

1. Test hypothesis of altered vertical migration by comparing vertical movement of fish and zooplankton within enclosures (a through d below) and with samples collected external to enclosures (pelagic lake samples).
2. Determine top down trophic level response by comparison of zooplankton and phytoplankton community compositions and biomass with enclosure treatments (a through d below) and with samples collected external to enclosures (pelagic lake samples).
3. Determine bottom up trophic level response by comparison of nutrient flux and phytoplankton, zooplankton, and fish composition and biomass responses to nutrient additions (enclosures c and d) with controls and other non-nutrient treatments.
4. Integrate the results of the enclosure studies to the time series of data collected from Skilak, Tustumena, and Kenai lakes in formulating optimal restoration strategies for these systems.

Enclosure types in replicate:

a. Fish removed from enclosure (no treatments or fish added)
b. Fish added to approximate densities observed in the western basin of Skilak Lake.
c. Nutrients added to simulate optimal phosphorous and nitrogen nutrient loading (fish excluded) using nutrient loading models developed for Alaskan and Canadian sockeye salmon lakes.
d. Nutrient additions to simulate optimal phosphorous and nitrogen loading and fish added to approximate densities observed in the western basin of Skilak lake (treatment b & c combined).

2. Methods:

These studies will be conducted concurrently with ongoing investigations of the biotic communities of Skilak, Kenai, and Tustumena lakes (proposed 1994 sockeye salmon overescapement work plan). These studies have provided insight into the apparent collapse of the Kenai River sockeye salmon fishery over the past several years. Since over 70% of the sockeye salmon production in the Kenai River system has been produced from fry rearing in Skilak Lake, this system is chosen for further experimental studies.

Enclosures will be deployed in a protected area in Skilak Lake, with the location developed jointly with the U.S. Fish & Wildlife Service. Eight enclosures of approximate 8 m diameter and a depth of approximately 25 m will be deployed using four replicate treatments following the design (2 X 2 factorial) of Mazumder et al. (1988). In addition, samples will be collected external to the enclosures for comparative control on the effect of enclosures and comparisons will be made with the other ongoing limnological studies of Kenai, Skilak, and Tustumena lakes. Fish added to the enclosures will be collected from the pelagic zone of Skilak Lake in late June/early July and will be less than 35 mm FL.

The enclosures will be sampled biweekly and the data analyzed similar to the methods used for the open water studies (Koenings et al. 1987; Tarbox and Schmidt 1993) with modifications from Mazumder et al. (1988). These will include seasonal nutrient trends, water temperature, turbidity, phytoplankton community analysis, chlorophyll *a*, zooplankton community composition and biomass, fish AWL (age, weight, lipid content, length) and other water chemistry parameters. These data will be analyzed to measure bottom up and top down lake ecosystem control mechanisms and will be used to better interpret inter-annual variations in lake limnological parameters. This analysis will provide insight as to the most effective strategies to initiate in the lake for restoring lost or reduced productivity of sockeye salmon to this freshwater ecosystem.

3. Schedule:

Although desired to be implemented in the spring of 1994, logistical planning may make this impossible. Enclosure design and construction will require customized modifications to insure the enclosures can be deployed in the conditions anticipated in Skilak Lake. Enclosures will be obtained through State of Alaska procurement procedures which may result in delays of implementation until the spring of 1995. The enclosures will be deployed as soon as we receive them from the manufacturer. Data obtained through monitoring of the Kenai River system lakes will be used to fine tune study design if deployment is delayed to the spring of 1995.

Laboratory analysis of field samples continues 12 months a year and will be in progress throughout the study period. These analysis include samples of zooplankton, water chemistry, juvenile fish scales and otoliths, weight/length of juvenile fish, lipid and N15 from juvenile fish.

Field data collection efforts begin in mid April for field deployment in May. Data are collected throughout the summer and terminated when the lakes form an ice cover at approximately December 1st. The weight and lipid content of fish in the enclosures will be determined by lethal sampling in September. Sampling of vertical distribution of fish, zooplankton, and related water quality and physical data are collected at preset intervals throughout the summer. Reporting activities and data summarization continues throughout the year with the primary effort occurring in September through December with interim reports completed by May 15th of each year of the study. Final report for this study will be completed by June 1, after the completion of the final year of field work. Tentative completion date for this study will be June 1, 1996.

Task	Dates
Initiate Field studies	May 1995
Complete Field studies	December 1996
Draft Report for FY 94	March 1996
Final Report	June 1997

4. Technical Support:

Administrative support is provided by the Administrative Division, Habitat Division, and Commercial Fisheries Management and Development Division staff of the Alaska Department of Fish and Game. The project leader and his assistants are not funded by this project and are supported with general funds from the State of Alaska. Most laboratory analyses are conducted by the limnology laboratory in Soldotna. Carl Burger (National Biological Survey) will assist with data analysis and report publication preparation. Asit Mazumder of the Universite de Montreal will be contracted as a consultant in the design and analyses of this study with assistance from graduate or post-doctoral students under his direction. Dr. Mazumder has over a decade of experience in these types of investigations on northern lakes. This study is integrated with ongoing studies by the Commercial Fisheries Management and Development Division on the Kenai Peninsula.

5. Location:

The investigations will occur on Skilak lake on the Kenai Peninsula. Specific locations will be devloped through a coordinated effort with NBS and the US Fish and Wildlife service staff in Soldotna. The locations will be chosen that meet technical objectives without intruding upon normal use patterns of the Kenai National Wildlife Refuge.

E. PROJECT IMPLEMENTATION

The project is integrated with the ongoing studies of the limnology of Skilak Lake. As logistics, special use permits, sources of fish for the enclosures, and the integration of the lake studies with the experiments require the work to be integrated with these studies. The deployment of this type of equipment and its design require a great deal of scrutinty in sight selection and enclosure engineering. There are only several experts in North American who have had adequate experience with these types of studies to provide the necessary technical guidance to insure a high probability of success. For the results to be comparable, laboratory and chemistry analyses should be done with the same facilities used in the Skilak Lake limnology studies. The dangerous conditions on Skilak Lake require some on sight experience to avoid danger to participating personnel. Experienced divers in low visibility will also be required to install the enclosures. These reasons suggest that this investigation be awarded to the same contractor or agency completing the Skilak Lake limnology studies.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This study requires on-site data collection of biological specimens both within and external to the enclosures; however no environmental effect will occur beyond that of traditional fisheries management data collection, that is within existing collecting permits or Federal special use permits issued to the Department of Fish and Game for scientific data collection activities. A special use permit will be requested through our cooperative agency, the U.S. Fish and Wildlife Service, prior to deployment of the enclosures. These studies will be closely integrated with the lake limnological studies and fry rearing investigations conducted by the same authors.

G. PUBLIC PROCESS

The proppposed study are consistent with the draft sockeye salmon restoration objectives and strategies. The experimental approach proposed ties in with the ecosystem approach to investigating which factors limit the productivity of the Kenai Lake systems. Public presentations of previous findings and the proposed investigations have been provided to a variety of public groups, including the Cook Inlet Regional Planning Team, Upper Cook Inlet Drift Netters Association, and the Alaska Sportfishing Association.

H. PERSONNEL QUALIFICATIONS

Principal Investigators

Dr. Dana Schmidt, Principal Limnologist, Soldotna, AK.

Dr. Schmidt will be the primary author of Kodiak studies and limnological investigations on the Kenai Peninsula. Dr. Schmidt has been the Regional Research Biologist for the Commercial Fisheries Division of the Alaska Department of Fish and Game in Kodiak for over 6 years and supervised all Kodiak Island and the Aleutian Island/Alaska Peninsula sockeye salmon research. In addition he was co-principal investigator of damage assessment studies on Kodiak Island with Dr. Koenings. He is the primary author of the 1991 and 1992 status reports on the over-escapement studies on the Kenai Peninsula

Mr. Carl Burger, Fisheries Research Biologist, U.S. National Biological Survey, Anchorage, AK. Mr. Burger completed his M.S. in Fisheries Science at Oregon State University. He has over 13 publications in peer reviewed journals on the habitat requirements, genetics, behavior, and adaptations of salmonid fishes and other natural history subjects. Mr. Burger has conducted a four year research program to identify factors that limit spawning and rearing by early and late-run chinook and coho salmon in the Kenai River. He has worked on Karluk Lake sockeye salmon where he investigated several factors believed to have caused declines in sockeye salmon production. He is currently researching the early life history of hatchery and wild sockeye salmon at Tustumena Lake and the distribution of lake shore spawners. His experience with the Kenai peninsula sockeye salmon and glacial lake ecosystems and their logistic problems will bring an additional asset to insure successful completion of this investigation.

Technical Consultant

Dr. Asit Mazumder, Assistant Professor, Universite de Montreal, Montreal, Canada
Dr. Mazumder will provide technical assistance in the design and analysis of data from the proposed investigation. He is currently an assistant professor at the U de Montreal in limnology and has completed a Ph.D. dissertation on the effects of predation and fertilization on community structure and dynamics in enclosures at the Univesity of Waterloo, Ontario. He has published numerous reports on the trophic level responses of predation and nutrient additions to northern lakes with particular focus on enclosure studies. His background and experience with this type of study design will prove invaluable in completing these investigations.

I. BUDGET

Detailed budget submittals are provided in the attached table.

Budget Category	NBS	ADF&G	Total FFY94
Personnel	$ 28 K	$72K	$100 K
Travel	$ 3 K	$6.2K	$9.2 K
Contractual	0	$204.7 K	$204.7 K
Commodities	$ 9 K	$25 K	$ 34 K
Equipment	$ 3 K	$15 K.	$ 18 K
Capital Outlay	0	0	0
Sub-total	$43 K	$318.2 K	$361.2 K
General Administration			
Project Total			
Full-time Equivalents (FTE)	1.1	1.3	2.4

Budget Year Proposed Personnel:

	Position	Months Budgeted	Cost
2	ADF&G FB I	16	$72
2	NBS Bio. Techs. GS-5	12	$23 K
1	NBS Project Leader GS-12	1	$ 5 K
	Total	29	$ 100 K

ADF&G

Travel: Includes in-state trips for meetings, project supervision, and conventions. Per diem is included

6 RT between Soldotna and Anchorage	$3 K
4 RT between Soldotna and Juneau	$3.2 K

Contractual:		
	Outboard motor and radio repair, freight, chemical analyses, software licensing,	$5 K
	Diving contracts for enclosure installation	$10 K
	Asit Mazumder, Universite de Montreal	$29.7 K
	Sampling equipment fabrication and calibration	$160 K
Commodities:	Scientific ($5 K), office and photo supplies ($2.0 K); special foul weather gear, ($1 K)	$8 K
	Groceries, safety supplies ($10.0 K); outboard fuel and oil ($2.0 K); repair and maintenance ($5 K).	
		$17 K
Equipment:	Boat and motors	$10 K
	Fry tow nets	$5 K
		NBS
Travel:	Includes in-state trips for meetings, project supervision, and conventions. Per diem is included	
	6 RT between Soldotna and Anchorage	$3 K
Contractual:	None	
Commodities:	Sampling supplies, rain gear, and tents	$4 K
	Groceries and safety supplies ($10.0 K)	
		$5 K
Equipment:	GSA Vehicle Use	$ 3 K

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Subtidal Monitoring: Eelgrass Communities

Project Number: 95106

Principal Investigator: Stephen C. Jewett

Lead Agency: Alaska Department of Fish & Game

Cost of Project: $399,934

Project Start-up: March 1995

Project Duration: One year

Geographic Area: Western Prince William Sound

Contact Person: Dr. Joseph Sullivan, ADF&G

B. Introduction:

The shallow subtidal habitats of Prince William Sound, from the intertidal zone to depths of approximately 20 m, typically has dense macrophyte or sea grass assemblages, and is critical habitat for many commercially and ecologically important animals. Subtidal eelgrass beds contain numerous polychaete worms, small snails and clams, amphipods, isopods, sea urchins, and sea stars, many of which serve as food for coastal-feeding otters, birds, and fishes.

The subtidal eelgrass community was one of the several habitats examined relative to Exxon Valdez Oil Spill (EVOS) effects and subsequent recovery. Investigations comparing oiled-control sites in this habitat were conducted in 1990, 1991 and 1993 and are summarized below (no sampling occurred in 1992).

- **1990:** Almost all components of the eelgrass habitat were affected by the EVOS by the summer of 1990. The health of the benthic community outside the eelgrass bed, at **6-20 m** depths, was generally less robust at oiled sites than at control sites. The oiled sites had significantly less total invertebrate abundance; several dominant invertebrate taxa had less abundance and/or biomass. These included families of clams that are important food for sea otters. Another group less prevalent at oiled sites were the oil-sensitive benthic amphipods. Measured parameters less prevalent at the oiled sites in the eelgrass bed (≤ **3 m**) included eelgrass turions and flowers, benthic amphipods, and helmet crabs (*Telmessus cheiragonus*). However, the benthic community in the bed had greater total invertebrate abundance and biomass at the oiled sites, primarily attributable to small epifauna attached to the eelgrass blades.

- **1991:**The 1991 data revealed partial recovery. Outside the eelgrass bed **(6-20 m)** oiled sites were more similar to control sites than in 1990. The greatest indication of recovery was with benthic amphipods which revealed no differences between oiled and control treatment groups. Within the bed (≤ **3 m**), no differences were now evident in density of eelgrass turions or flowers, benthic amphipods, and helmet crabs. However, several of the dominant taxa had lower abundance or biomass at oiled bed sites, indicative that recovery was lagging within the eelgrass bed.

- **1993:** The 1993 data, four years after EVOS, revealed that the oiled sites had not yet recovered. Furthermore, the data tended to resemble 1990, especially in the bed (≤ **3 m**) where densities of eelgrass flowers and oil-sensitive benthic amphipods were greater at control sites. Total abundance and biomass was greater at oiled sites, mainly because of small epifauna attached to the eelgrass blades. In the deep region (**6-20 m**) infaunal bivalve abundance was less at oiled sites.

After the 1991 sampling it was apparent that recovery was underway, however, the 1993 data reveals a reversal, suggesting that some segments of the community are once again in a toxic phase (e.g., amphipods) and other segments reflect enhancement (e.g., epifauna on eelgrass).

We know from other studies (e.g., McConnaughey, 1978; Calkins, 1978; Shaw and Hameedi, 1988; Faro *et al.*, 1993) and from our work that several of the species impacted are important links to higher trophic levels. For example, benthic amphipods are important prey to a variety of sea birds and fishes. The crab *Telmessus* feeds on eelgrass, *Musculus* mussels, and other epiphytes on eelgrass. In turn, *Telmessus* serves as prey for a variety of vertebrates, including sea otters, river otters, and birds. In addition, *Musculus* is a primary component of the diet of juvenile cod that are abundant in the eelgrass habitat. As noted earlier, some of the infaunal bivalves are important food for sea otters.

C. Need for the Project:

Since no sampling occurred in 1994, and since community recovery had not occurred through the 1993 sampling, it is advisable to reexamine these eelgrass sites again in 1995 to monitor recovery.

D. Project Design

1. Objective: The objective is to monitor the natural recovery of the shallow (< 20 m) subtidal eelgrass community in Prince William Sound that was impacted by the EVOS by spatially comparing richness, diversity, abundance and biomass of dominant taxa between paired (oiled:control) sites.

2. Methods: Our approach for 1995 is to monitor the various successional stages of the eelgrass community toward stabilization by comparing components of oiled and unoiled sites in a stratified sampling design. We will again sample the sites that were sampled in 1990, 1991 and 1993. Sampling will be conducted at four oiled and control eelgrass sites. Methods will be the same as was previously used in this project. Within this habitat we will determine estimates of abundance/biomass of eelgrass, infauna, small epifauna attached to eelgrass, amphipods, large epifauna (i.e., crabs and sea stars), and juvenile Pacific cod. These estimates will be used to indicate the effects of the EVOS on this community by comparing abundance (and other parameters) at oiled vs. control sites.

3. **Schedule:** July 1995 - Field activities are planned for two weeks during this time to correspond with previous samplings; December 1995 - completion of laboratory processing of samples; February 1996 - completion of draft final report.

4. **Technical Support:** A research vessel is needed for two weeks of diver sampling. In addition, two skiffs will be needed to assist in the field operations. Inflatable boats (14 ft) with 30 hp outboards has functioned best in past field efforts. These should be provided by ADF&G or the vessel subcontractor.

5. **Location:** A total of 4 oiled sites and 4 control sites have been selected from those we previously studied in western Prince William Sound. Sampling will occur at the following oil/control paired sites: Bay of Isles (O)/Drier Bay (C); Herring Bay (O)/Lower Herring Bay (C); and Sleepy Bay (O)/Moose Lips Bay (C); Clammy Bay (O)/ Puffin Bay (C).

E. Project Implementation

This project has been implemented by ADF&G for the past three years.

F. Coordination of Integrated Research Effort

This project is closely linked to the monitoring of oil in subtidal (< 20 m) sediments (conducted by NOAA). Several study sites are in common between the two projects.

G. Public Process

Since this study got underway in 1990, it has had intense internal and public review through workshops, EVOS Symposium, meetings, Final Report reviews, and peer reviews of manuscripts for publication in a special publication through the Transactions of the American Fisheries Society.

H. Personnel Qualifications

Stephen C. Jewett, Principal Investigator and Research Associate at the School of Fisheries and Ocean Science (SFOS), University of Alaska Fairbanks will be responsible for the organization and the management of this project, including interpretation and synthesis of data and writing of reports. Mr. Jewett has been a Research Associate at UAF since 1975. During this time he has been involved in numerous benthic investigations throughout Alaska that emphasize assessment and/or monitoring. He has been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989-94). Mr. Jewett also serves as the

Scientific Diving Officer for UAF, coordinating all scientific diving operations.

Thomas A. Dean, Ph.D., is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista, CA. He has had a major role in both the shallow subtidal and intertidal EVOS investigations conducted through UAF since 1989. His has extensive experience in long-term monitoring studies with marine plants and invertebrates. Dr. Dean will mainly be responsible coordinating the plant investigations on this study, as well as assisting in the carrying out of the project objectives.

I. Budget

1.	**Personnel**	$191,175
2.	**Travel**	7,803
3.	**Contractual Services**	127,300
4.	**Commodities**	7,000
5.	**Equipment**	0
6.	**Capital Outlay**	0
7.	**General Administration**	66,656
		$399,934

Subtidal Site Verification

Project Number: 95107

Co-Principal Investigators:
Stephen C. Jewett
University of Alaska Fairbanks

Thomas A. Dean, Ph.D.
Coastal Resources Associates, Inc.

Lead Agency: Alaska Department of Fish & Game

Cost of Project: $84,016

Project Start-up: March 1995

Project Duration: One Year

Geographic Area: Prince William Sound

Contact Person: Dr. Joseph Sullivan, ADF&G

B. Introduction:

The optimal design for environmental impact monitoring includes sampling both before and after a disturbance event, at pairs of impacted and control sites (Green 1979, Stewart-Oaten *et al.* 1986). This is referred to as the BACIP (Before-After, Control -Impact Pairs) design. Very few of the current studies of the effects of the EVOS have been able to use this design because of the lack of pre-spill data. Instead, we have relied on sampling at pairs of oiled and control sites after the spill to infer injury to biological resources in coastal habitats. This is the ACIP (After Control-Impact Pairs) design. Correct interpretation of the results produced from this design are based on the assumption that oiled and control sites would not have differed if there were not an oil spill.

There are resources within the subtidal habitats that have shown consistent differences among oiled and control sites using the ACIP design. For example, *Musculus* density on eelgrass in Prince William Sound has been consistently higher at oiled sites. Without pre-spill data, it is difficult to establish whether these differences represent long-term impacts of the spill, or whether they represent inherent differences among sites that resulted from bias in the site selection process. For example, it may be that predominant wind and current conditions within the Sound that were responsible for bringing oil to specific beaches, are also responsible for bringing higher concentrations of *Musculus* larvae to those same beaches.

There are essentially two ways to help address this issue. First, long-term monitoring of resources could be conducted and evaluated to determine if the resources at oiled and control sites "converge" after some period of time. This approach suffers from the fact that convergence may take very long to occur, or may never occur if some alternate stable state has been achieved after the spill. In the shorter term, agencies are faced with making decisions regarding possible restoration of supposedly injured resources. A second approach is to conduct an independent test of our ability to match oiled and control sites, and to demonstrate that the site selection process produced no biases that may have resulted in inherent differences among oiled and control pairs.

The verification of the process by which matched pairs are selected also has much larger implications with respect to monitoring programs that may be used to evaluate impacts of future oil spills as well as other disturbances. Because of the uncertain time and location of impact of oil spills, it is extremely difficult to obtain the appropriate "pre-spill" data at both impacted and control sites. Costly "baseline" monitoring programs often result in data that is largely unusable for evaluating injuries, and evaluation of injuries from spills almost always relies on sampling conducted only after the spill. The establishment of *a priori* criteria for the selection of oiled and control sites, and the *a priori* verification that this selection process does not produce biases in oiled-control comparisons, would be very useful in supporting inferences made from post-spill surveys in future spills. In addition, establishment and verification of *a priori* site selection criteria, could prove much more useful, and much more cost effective, than baseline monitoring studies. Establishing *a priori* criteria for selection of matched pairs could prove to be a useful monitoring tool in Prince William Sound as well as elsewhere.

C. Need for the Project:

A study is needed to test of our ability to match oiled and control sites, and to demonstrate that the site selection process produced no biases that may have resulted in inherent differences among oiled and control pairs.

D. Project Design

1. Objectives: A. Determine if previously used site selection criteria may have resulted in biases that could lead to inherent differences among oiled and control sites that were unrelated to oiling.

B. Establish criteria for the unbiased selection of oiled and control site pairs to be used in assessing injury from future oil spills or other disturbances.

2. Methods: We will test our ability to select appropriate matched pairs of sites by sampling at "simulated oiled" sites and their matched controls. An oil spill simulation model will be used to define a potential universe of "simulated oiled" sites. (Work on oil spill simulation will be the same as used in intertidal studies, and will be funded under that project). We will select a set of "simulated oiled" sites from this universe and select matched control sites using procedures used in earlier injury assessment studies. We will then sample at both simulated oiled and control sites and test for significant differences among sites. Variates measured and sampling methods will be similar to that described for the monitoring program. These studies will be conducted only within one depth strata, within eelgrass beds (< 3 m). A total of four pairs of sites will be visited.

3. **Schedule:** The field work for this project will begin in June 1995 and conclude in July 1995. Data analysis and draft report preparation will be completed in May 1996. Deliverables will consist of a FY 95 progress report to be submitted in September 1995, and a final report to be completed by May 1996.

4. **Technical Support:** Technical support includes a small float plane and small (< 32 ') vessel for site selection verifications in June. The bulk of the site selection verifications will occur during subtidal eelgrass habitat sampling in July.

5. **Location:** The project will be undertaken in Prince WilliamSound.

E. Project Implementation

The principal investigators have been conducting damage assessment/monitoring studies in the shallow subtidal regions of Prince William Sound since 1989. Since these studies have mainly been implemented through Alaska Department of Fish & Game (ADF&G), and since this project will overlap with the ongoing work in the subtidal eelgrass habitat, it is appropriate for this project to also be implemented through ADF&G.

F. Coordination of Integrated Research Effort

This project will integrate with the subtidal eelgrass habitat investigation, as well a similar project for Coastal Habitat Intertidal Site Verification.

G. Public Process

Investigators in this project have taken part of public participation workshops sponsored by the Trustee Council to examine research needs. Future workshops will be supported. All documents produced will be made available for public review.

H. Personnel Qualifications

Stephen C. Jewett, Co-Principal Investigator, has been a Research Associate at the School of Fisheries and Ocean Science (SFOS), University of Alaska Fairbanks since 1975. During this time he has been involved in numerous benthic investigations throughout Alaska that emphasize assessment and/or monitoring. He has authored more than 30 publications in scientific journals and books. He has been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989-94). Mr. Jewett also serves as the Scientific Diving Officer for UAF, coordinating all scientific diving operations.

Thomas A. Dean, Ph.D., Co-Principal Investigator, is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista, CA. He has over 20 years of experience in the study of nearshore ecosystems, and has authored over 20 publications, including several papers dealing with sea urchin and kelp interactions. He has extensive experience in long-term monitoring studies with marine plants and invertebrates. He has had a major role in both the shallow subtidal and intertidal EVOS investigations since 1989.

I. Budget

1.	**Personnel**	$3,902
2.	**Travel**	912
3.	**Contractual Services**	65,200
4.	**Commodities**	0
5.	**Equipment**	0
6.	**Capital Outlay**	0
7.	**General Administration**	14,002
		$84,016

Sustainable Rockfish Yield

Project Number:	95111
Name of Project Leader:	William R. Bechtol
Lead Agency:	Alaska Department of Fish and Game
Cost of Project/FY95:	$204.4K
Cost of Project/FY96:	$318.0K
Cost of Project/FY97:	$274.8K
Project Start-up/Completion Dates:	January 1, 1995 - September 30, 1995
Project Duration:	3 years
Geographic Area of Project:	Prince William Sound, Outer Kenai Peninsula
Contact Person:	William R. Bechtol, ADF&G, 3298 Douglas St., Homer, AK 99603, ph: 907/25-8191

B. Introduction

Rockfish include species in the genera *Sebastes* and *Sebastolobus*. Commercial rockfish harvests increased four-fold due to closures of the commercial salmon and shellfish fisheries following the EVOS. Recreational rockfish harvests have also increased, particularly in response to an increasing number charter operators. Rockfish harvest rates have remained high. In addition, rockfish mortalities attributable to oil ingestion were observed immediately after the EVOS. Subsequent histopathological sampling indicated continuing population injury. Because rockfish exhibit extreme longevity, slow growth, and late maturity, depressed populations recover very slowly. Due to concerns over the sustainability and yield from the rockfish resources, regulations have been implemented in recent years to reduce commercial and sport fishing harvest. Even with the curtailment of human use, the impacts and rebuilding of a severely depleted rockfish population may continue through several human generations.

Little information is available on rockfish abundance and composition in the EVOS-impacted area. Lacking data on population abundance, composition, and production, an estimate of maximum sustainable yield is unknown. The Alaska Department of Fish and Game (ADF&G) has attempted to increase the assessment of rockfish resources in recent years. However, both surveys and follow-up analyses have suffered from a lack of available funding. This project would compile and analyze existing data and conduct surveys to estimate relative rockfish population size and composition. The goal is to develop a management plan that assures recovery of damaged stocks and long-term sustainable yield.

C. Need for the Project

Relative to many other marine species, rockfish exhibit extreme longevity (>50 yrs), slow growth, and late maturity (7-20 yrs). Many rockfish species also have localized distributions. These characteristics reflect the relatively low annual productivity of rockfish, making these species highly susceptible to overfishing. Once depressed, populations recover very slowly.

Rockfish populations suffered direct mortalities and sublethal effects from the oil spill. Indirect spill impacts included an increase in effort directed at groundfish resources in general and rockfish in particular as traditional fishing opportunities such as salmon and shellfish declined or were curtailed to prevent product contamination by petroleum products. Rockfish are an integral, resident component of the spill area ecosystem. The loss of rockfish resources through direct and indirect effects following the spill may severely alter energy transfer within the spill area. While ADF&G has authority to curtail commercial and recreational fishing, that authority is dependent upon a meaningful and defensible biological justification.

Rockfish are difficult to study because of their unique habitat and physiological characteristics. Despite the importance of rockfish to the ecosystem and the potential for long-term damage from overfishing, there have been few studies to directly assess rockfish resources in the spill area. Because commercial rockfish fisheries typically generate a relatively low economic value, rockfish have a low institutional priority. Although limited rockfish sampling has provided some biological data, this low priority has left much data unprocessed.

This project is severely needed to compile and analyze data previously collected, to conduct fishery independent surveys to better assess the role that rockfish fill in the ecosystem, and to develop a management plan which modifies human use patterns to allow damaged stocks to recover and assure for the long-term yield of the rockfish resource.

D. Project Design

1. **Objectives** The goal of this project is to develop a plan that modifies human use to provide for restoration of rockfish resources in the area impacted by the EVOS. Initial objectives of this study are to:

a. *Describe biological characteristics of the rockfish resources.* Through port sampling and fisheries-independent test fishing: describe stock composition, mortality, growth, relative abundance, and relative recruitment.

b. *Clarify rockfish stock definition.* Tagging studies will further identify stock movements and potential recruitment.

2. **Methods**

a. Species, sex, size, and age data will be collected from commercial landings at ports and processors where rockfish are delivered from the EVOS impacted area. Observers placed aboard a sample of commercial vessels will quantify the magnitude and composition of discards. Test fishing will produce fisheries-independent stock composition data.

b. Relative, species-specific productivity will be estimated using: i) age composition of lightly exploited stocks; and ii) empirical relationships based on related biological characteristics.

c. Biological data from current and historical landings (ADF&G fish ticket system) will be analyzed over time and area to describe temporal and spatial patterns in human use.

3. **Schedule**

Sample collection - February 1995-September 1995 - 3 field technicians and the PI.

Otolith reading - January 1995-September 1995 - 1 lab technician

Data analysis - March 1995-July 1995 - 1 biometrician and PI

Report writing - August 1995-September 1995 - PI; an interim progress report will be available October 1, 1995.

4. **Technical Support** Determination of stock composition relies upon rockfish otolith ageing by the ADF&G ageing laboratory. ADF&G biometrics staff will provide input into sampling strategies and direct stock structure modeling.

5. **Location** The project will be conducted in Prince William Sound and the outer Kenai Peninsula. The public utilizing rockfish resources for commercial, recreational, or subsistence purposes, particularly Southcentral Alaska communities, will benefit from this project.

E. Project Implementation

ADF&G is ideally suited to implement this project. Having historically monitored the sport and commercial harvests in Prince William Sound and the outer Kenai Peninsula, ADF&G staff are uniquely familiar with the rockfish fishing fleet characteristics and areas fished, currently process all rockfish harvest data and conduct limited annual surveys in the study area.

F. Coordination of Integrated Research Effort

An understanding of stock composition and rockfish productivity will contribute significantly to the Sound Ecosystem Assessment (SEA) Plan.

G. Public Process

The public and, in particular, the commercial, recreational, and subsistence users of the rockfish resource have been and will continue to be actively involved in the development of strategies for the long-term yield from rockfish in the study area.

H. Personnel Qualifications

Bechtol, William R.

EDUCATION:	University of Alaska, Fisheries	1990	M.S.
	University of Washington, Wildlife	1979	B.S.

EMPLOYMENT: Fisheries Biologist II, ADF&G, Homer, 1992-present; Fisheries Biologist I, ADF&G, Homer, 1986-92; Fisheries Technician III, ADF&G, Homer, 1980-86; Commercial longline and pot shrimp fishing in Prince William Sound, 1979-81; Fisheries Technician, Fisheries Research Institute, Seattle, 1979; Field Technician, New Mexico Division of Forestry, 1978.

EXPERIENCE:
ADF&G, Commercial Fisheries, Central Region Groundfish, 1989-present: Primary responsibilities include research and management of commercial groundfish fisheries in Cook Inlet, Prince William Sound, and state waters of the Central Gulf of Alaska; design and implementation of port, trawl survey, and onboard observer sampling programs; herring egg deposition surveys in Prince William Sound using SCUBA; SCUBA surveys of log transfer facilities; development of fisheries regulations and management plans; (1983-1984) principally involved in design and implementation of jig, line transect, and mark-recapture surveys, including use of SCUBA, to assess pelagic and demersal rockfish resources along the outer Kenai Peninsula.

Overseas Fisheries Cooperative Foundation, Tokyo, Japan, 1988: mariculture strategies in Japan, with particular emphasis on *Laminaria spp.* grown on Hokkaido, Japan.

ADF&G, Fisheries Rehabilitation Enhancement and Development (FRED) Div., 1980-1989: Primary responsibilities included design and implementation of limnological surveys, particularly concerning juvenile sockeye rearing in barrier lake systems of lower Cook Inlet and the outer Kenai Peninsula; mark-recapture surveys to assess survival from different juvenile salmon rearing strategies; and aerial surveys to assess salmon escapements.

Fisheries Research Institute, 1979: Field technician in studies of side-scanning and upward-scanning hydroacoustic estimation of sockeye salmon escapement to the Kvichak River, Alaska.

SELECTED PUBLICATIONS:

Bechtol, W.R. 1994. Review of the 1993 groundfish fisheries in Prince William Sound: Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report No. 2A94-08, Anchorage.

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Bechtol, W.R. 1992. Review of the 1991 Central Region groundfish fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A92-13, Anchorage.

Yuen, H.J., W.A. Bucher, and **W.R. Bechtol**. 1991. Abundance, age, sex, and size statistics for sockeye and pink salmon in lower Cook Inlet, 1990. Alaska Department of Fish and Game, Technical Fisheries Report No. 91-13, Juneau.

Yuen, H.J., W.A. Bucher, and **W.R. Bechtol**. 1991. Abundance, age, sex, and size statistics for Pacific herring in lower Cook Inlet, 1990. Alaska Department of Fish and Game, Technical Fisheries Report No. 91-10, Juneau.

Bechtol, W.R. 1990. 1989 Central Region groundfish annual management report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2H90-14, Anchorage.

Bechtol, W.R. 1990. Foraging strategies of juvenile sockeye salmon (*Oncorhynchus nerka*) at high rearing densities in Leisure Lake, Alaska. M.S. thesis, University of Alaska, Fairbanks.

Bechtol, W.R., and N.C. Dudiak. 1988. The development of the Leisure Lake sockeye salmon: Smolt and adult production summary, 1977 to 1984. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement, and Development Division Report No. 83, Homer.

Bechtol, W.R., and R. Morrison. *Under review*. Development and management of the sablefish fishery in Prince William Sound, Alaska. Proceedings of the International Sablefish Symposium.

Bechtol, W.R. *In preparation*. Age, weight, and length of Pacific cod (*Gadus macrocephalus*) sampled from Lower Cook Inlet, Alaska. Alaska Department of Fish and Game, Homer.

I. FY95 Budget($K)

Line Item	FY95	FY96	FY97
Personnel	129.1	167.8	167.8
Travel	2.7	3.5	3.5
Contractual	34.4	65.9	65.9
Supplies	3.5	18.5	4.5
Equipment	25.0	47.2	20.0
Total	194.7	302.9	261.7
Indirect Costs	9.7	15.1	13.9
Grand Total	204.4	318.0	274.8

Rockfish Restoration Objective

Project Number:	95112
Name of Project Leader:	William R. Bechtol
Lead Agency:	Alaska Department of Fish and Game
Cost of Project/FY95:	$69,000
Cost of Project/FY96:	
Cost of Project/FY97:	
Project Start-up/Completion Dates:	October 1, 1994 - September 30, 1995
Project Duration:	
Geographic Area of Project:	Prince William Sound, Outer Kenai Peninsula
Contact Person:	William R. Bechtol, ADF&G, 3298 Douglas St., Homer, AK 99603, ph: 907/235-8191

B. Introduction

Rockfish include species in the genera *Sebastes* and *Sebastolobus*. Commercial rockfish harvests increased four-fold following the EVOS due to closures of the commercial salmon and shellfish fisheries. In addition, recreational rockfish harvests also increased. Both commercial and recreational rockfish harvests remain high. In addition, rockfish mortalities attributable to oil ingestion were observed immediately after the EVOS. Subsequent histopathological sampling indicated continuing population injury.

Because rockfish exhibit extreme longevity, slow growth, and late maturity, depressed populations recover very slowly. Due to concerns over the sustainability and yield from impacted rockfish resources and evidence of local depletions, regulations have been implemented since the EVOS to reduce commercial and sport fishing harvests. At the Department's request the Alaska Board of Fisheries adopted a management plan for North Gulf of Alaska commercial rockfish fisheries. This plan establishes seasonal and trip limits as well as bycatch provisions. In addition, bag and possession limits in area sport fisheries have been reduced. Even with these measures, the impacts and rebuilding of depleted rockfish populations are likely to continue through several human generations.

Information is available on rockfish relative abundance and species composition in the EVOS-impacted area. The Alaska Department of Fish and Game (ADF&G) has attempted to increase the assessment of the rockfish resource in recent years. However, surveys, follow-up analyses, and a synthesis with existing EVOS data have suffered from a lack of funding. This project would synthesize existing data on rockfish. The goal is to develop a recovery objective and make recommendations on whether monitoring or restoration activities (such as marine reserves/refuges) are needed to meet the defined objective.

C. Need for the Project

The *Exxon Valdez* Oil Spill Trustee Council has acknowledged that rockfish is an injured resource and has an obligation to determine if the resource has recovered or is recovering. A recovery objective needs to be defined and a framework created under which the trustees can decide on subsequent monitoring or restoration activities. Rockfish populations suffered direct mortalities and sublethal effects from the oil spill. Indirect spill impacts included an increase in effort directed at groundfish resources in general and rockfish in particular as traditional fishing opportunities such as salmon, herring, and shellfish declined. Rockfish are an integral, resident component of the spill area ecosystem. The loss of rockfish resources through direct and indirect effects following the spill may alter energy transfer within the spill area. While ADF&G has authority to curtail commercial and recreational fishing, that authority is dependent upon a meaningful and defensible biological justification.

Relative to many other marine species, rockfish exhibit extreme longevity (>50 yrs), slow growth, and late maturity (7-20 yrs). Many rockfish species also have localized distributions. These characteristics reflect the relatively low annual productivity of rockfish, making these species highly susceptible to overfishing. Once depressed, populations recover very slowly.

Rockfish are difficult to study because of their unique habitat and physiological characteristics. Despite the importance of rockfish to the ecosystem and the potential for long-term damage from overfishing, there have been few studies to directly assess rockfish resources in the spill area. Because commercial rockfish fisheries typically generate a relatively low economic value, rockfish have a low institutional priority. Although limited rockfish sampling has provided some biological data, this low priority has left much data unprocessed.

D. Project Design

1. **Objectives** The goal of this project is to develop a recovery objective following the synthesis of existing rockfish data. Initial objectives of this study are to:

a. *Describe biological characteristics of the rockfish resource.* Using port sampling, fishery performance, and EVOS study data describe stock composition, relative mortality, growth, relative abundance, and relative recruitment.

b. *Describe the stock status of the rockfish resource.* Using survey and fishery performance data describe stock distribution, habitat preference, and potential level of disturbance for rockfish in the EVOS affected area.

c. *Review and recommend recovery monitoring and restoration activities.* Possibilities include habitat based assessment and marine reserves/refuges.

2. Methods

a. Species, sex, size, and age data collected from commercial and sport landings at ports and processors where rockfish have been delivered from the EVOS impacted area will be analyzed.

b. Relative species-specific productivity will be estimated using: i) age composition of lightly exploited stocks; and ii) empirical relationships based on related biological characteristics.

c. Biological data from current and historical landings (ADF&G fish ticket system) will be analyzed over time and area to describe temporal and spatial patterns in human use.

d. An expert in rockfish biology will be contracted to review existing data and help define the level of damage, its possible causes, and restoration options

3. Schedule

Review literature and coalesce data - October 1994-February 1995

Otolith reading - October 1994-December 1994- 1 lab technician

Data analysis - March 1995-July 1995 - 1 biometrician and PI

Report writing - July 995-September 1995 - PI; an interim progress report will be available October 1, 1995.

4. Technical Support Rockfish otoliths will be aged by the ADF&G otolith laboratory in Juneau. ADF&G biometrics staff in Anchorage will direct stock structure modeling. An expert on rockfish biology will be contracted to help direct the synthesis of existing commercial, sport, and EVOS data and develop conclusions on stock status, restoration objectives, and monitoring and restoration options

5. Location The project will be conducted in Prince William Sound and the outer Kenai Peninsula. The public utilizing rockfish resources for commercial, recreational, or subsistence purposes, particularly Southcentral Alaska communities, will benefit from this project.

E. Project Implementation

ADF&G is ideally suited to implement this project. Having historically monitored the sport and commercial harvests in Prince William Sound and the outer Kenai Peninsula ADF&G staff are uniquely familiar with the rockfish fishing fleet characteristics, areas historically fished, currently process all rockfish harvest data and conduct limited annual surveys in the study area. Additional expertise will be contracted to help direct the synthesis of existing commercial, sport, and EVOS data and develop conclusions on stock status, restoration objectives, and monitoring and restoration options.

F. Coordination of Integrated Research Effort

An understanding of rockfish stock composition, distribution, and productivity will contribute significantly to the Sound Ecosystem Assessment (SEA) Plan. Data collected on rockfish distribution, habitat, or food habits from such SEA studies as *Salmon Predators* will be used. A thorough review of other marine studies funded by the EVOS will lead to a very efficient use of all rockfish data.

G. Public Process

The public and, in particular, the commercial, recreational, and subsistence users of the rockfish resource have been and will continue to be actively involved in the development of strategies for the long-term recovery and yield from rockfish in the study area.

H. Personnel Qualifications

<u>Bechtol, William R.</u>

EDUCATION:	University of Alaska, Fisheries	1990	M.S.
	University of Washington, Wildlife	1979	B.S.

EMPLOYMENT: Fisheries Biologist II, ADF&G, Homer, 1992-present; Fisheries Biologist I, ADF&G, Homer, 1986-92; Fisheries Technician III, ADF&G, Homer, 1980-86; Commercial longline and pot shrimp fishing in Prince William Sound, 1979-81; Fisheries Technician, Fisheries Research Institute, Seattle, 1979; Field Technician, New Mexico Division of Forestry, 1978.

EXPERIENCE:
ADF&G, Commercial Fisheries, Central Region Groundfish, 1989-present: Primary responsibilities include research and management of commercial groundfish fisheries in Cook Inlet, Prince William Sound, and state waters of the Central Gulf of Alaska; design and

implementation of port, trawl survey, and onboard observer sampling programs; herring egg deposition surveys in Prince William Sound using SCUBA; SCUBA surveys of log transfer facilities; development of fisheries regulations and management plans; (1983-1984) principally involved in design and implementation of jig, line transect, and mark-recapture surveys, including use of SCUBA, to assess pelagic and demersal rockfish resources along the outer Kenai Peninsula.

Overseas Fisheries Cooperative Foundation, Tokyo, Japan, 1988: mariculture strategies in Japan, with particular emphasis on *Laminaria spp.* grown on Hokkaido, Japan.

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Yuen, H.J., W.A. Bucher, and **W.R. Bechtol**. 1991. Abundance, age, sex, and size statistics for Pacific herring in lower Cook Inlet, 1990. Alaska Department of Fish and Game, Technical Fisheries Report No. 91-10, Juneau.

Bechtol, W.R. 1990. 1989 Central Region groundfish annual management report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2H90-14, Anchorage.

Bechtol, W.R. 1990. Foraging strategies of juvenile sockeye salmon (*Oncorhynchus nerka*) at high rearing densities in Leisure Lake, Alaska. M.S. thesis, University of Alaska, Fairbanks.

Bechtol, W.R., and N.C. Dudiak. 1988. The development of the Leisure Lake sockeye salmon: Smolt and adult production summary, 1977 to 1984. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement, and Development Division Report No. 83, Homer.

Bechtol, W.R., and R. Morrison. *Under review*. Development and management of the sablefish fishery in Prince William Sound, Alaska. Proceedings of the International Sablefish Symposium.

Bechtol, W.R. *In preparation*. Age, weight, and length of Pacific cod (*Gadus macrocephalus*) sampled from Lower Cook Inlet, Alaska. Alaska Department of Fish and Game, Homer.

I. Budget

Line Item	FY95	FY96	FY97
Personnel	40.0		
Travel	3.0		
Contractual	15.0		
Supplies	3.0		
Equipment	1.0		
Total	62.0		
Indirect Costs	7.0		
Grand Total	69.0		

Habitat Protection and Acquisition Support

Project Number: 95126

Principal Investigator: Habitat Work Group

Lead Agency: Alaska Department of Natural Resources

Cooperating Agencies: Alaska Department of Fish and Game; U.S. Department of Interior, Fish and Wildlife Service; U.S. Department of Agriculture, Forest Service

Project Cost: 1403.3

Project Term: October 1, 1994 to September 30, 1995

Geographic Area of Project: Prince William Sound, Kenai Peninsula, Alaska Peninsula, and Kodiak Archipelago

B. INTRODUCTION

This project is designed to support habitat protection activities of the Trustee Council and is a continuation of the Comprehensive Habitat Protection Process. These activities include evaluations by the Habitat Work Group, appraisals, title searches, hazardous materials surveys and other efforts necessary for the Trustee Council to achieve habitat protection objectives. In 1993 the Restoration Team, Habitat Protection Work Group conducted a survey and assessment of selected large parcels of private land (>1000 acres) within the oil spill zone. The lands were mapped, scored and ranked to determine the restoration value of these areas to injured resources and services and the benefits that could be achieved through habitat protection. Successful negotiations were conducted with owners of lands within Kachemak Bay State Park and on northern Afognak Island resulting in the purchase of the park inholdings and in the establishment of the Afognak Island State Park.

During 1994, technical support continues to be provided to the Executive Director, negotiators and appraisers engaged in negotiations with landowners. Parcel boundaries were refined by HWG in order to capture the key habitats within the smallest possible land area. Packages of ranked parcels, selected either by the negotiators or by HWG, as logical negotiation units, were evaluated and ranked. The results were provided to the negotiators and to the Executive Director. Secondary evaluations were conducted on acquisition proposals wherein *less than fee simple* interests were negotiated. Additional large parcels were identified for site surveys, evaluation and ranking which will take place during the summer field season. Presentation materials including numerous maps were produced and used by the Executive Director and negotiators in presentations to the Trustee

Council and the public.

In 1994, a method was developed for nominating, processing, evaluating and ranking parcels of private land less than 1000 acres, i.e., *The Small Parcel Process*. Responses to the solicitation for nominations of small parcels are currently being processed and evaluated.

C. NEED

The objective of habitat protection is to identify and protect essential wildlife and fisheries habitats and associated services and to prevent further environmental damage to resources injured by the *Exxon Valdez* oil spill. Nineteen resources and services injured by the spill are linked to protection of upland and nearshore habitats (See Section D). Protection of lands containing these habitats prevents additional injury to resources and services and natural support systems while recovery is taking place. Active negotiations with landowners for packages of ranked parcels are currently taking place and anticipated to continue into the Fall. Evaluations, starting with field surveys, of large and small parcels submitted this Spring will also continue into the Fall. This project provides support for HWG to provide technical support to the negotiators and the Executive Director and to conduct these additional evaluations.

D. PROJECT DESIGN

1. Objectives:

Habitat protection and acquisition is designed to protect lands linked to resources and services that were injured by the Exxon Valdez oil spill. Protection of these lands prevents additional injury to living resources and habitats, services and natural support systems while recovery is taking place. Habitat protection addresses cases where existing regulations affecting private land use are inadequate to protect essential habitats of recovering resources and services.

In situations where natural recovery is slow to occur or where direct restoration is neither technically feasible or cost effective, other measures need to be considered to mitigate injury. These may include replacement of injured resources and services with those that are equivalent {Replacement or acquisition of the equivalent means compensation for an injured, lost or destroyed resource by substituting another resource that provides the same or substantially similar services as the injured resource (56 Federal Register 8899 [March 1, 1991]).

The affected injured resources and associated services are listed below. Habitat protection objectives and benefits for each of these resources and services would differ depending on the particular parcel and the options acquired, however, general objectives and benefits are outlined below.

Pink salmon, sockeye salmon, cutthroat trout, Dolly varden, herring: ensure maintenance of adequate water quality, riparian habitat and intertidal habitat for spawning and rearing.

Bald eagle: ensure maintenance of adequate nesting habitat and reduce disturbance in feeding and roosting areas.

Black oystercatcher: reduce disturbance to feeding and nesting sites.

Common murre: reduce disturbance in nearshore feeding areas and near nesting colonies.

Harbor seal and sea otters: reduce disturbance at haul-out sites, pupping sites, and in nearshore feeding areas.

Harlequin duck: ensure maintenance of adequate riparian habitat for nesting and brood rearing, and reduce disturbance to nearshore feeding, molting, and brood-rearing habitats.

Intertidal/subtidal biota: maintain water quality along shoreline and reduce disturbance in nearshore areas.

Marbled murrelet: ensure maintenance of adequate nesting habitat and reduce disturbance to nearshore feeding and broodrearing habitats.

River otter: ensure maintenance of adequate riparian and shoreline habitats for feeding and denning.

Recreation: Maintain or enhance public access for recreational opportunities, reduce disturbances that would create visual impacts.

Wilderness: Maintain wilderness qualities, reduce impacts to wilderness qualities.

Cultural resources: Maintain or reduce disturbance to cultural resource sites.

Subsistence: Ensure subsistence opportunities in known harvest areas.

2. Methods:

The *Habitat Protection and Acquisition Process* is the method for acquiring lands or partial interests in lands that contain habitats linked to resources and/or services injured by the oil spill. Protection tools that will be considered for use by the Trustee Council include: fee acquisition, conservation easements, acquisition of partial interests, cooperative management agreements, and others. Following purchase, acquired parcels will be managed by the appropriate resource agency in a manner that is consistent with the restoration of the affected resources and/or services. The Trustee Council will decide which agency will manage the land or may create a new management authority.

Existing data and data obtained by HPWG in 1993 and 1994 will be analyzed to fill data gaps to the maximum extent possible. This will include some additional programming, data base management, and GIS work to sort data and to map resource information where appropriate.

Primary and secondary evaluations, will be conducted by the HWG using evaluation formats developed by the group. Site reconnaissance visits and post-acquisition management surveys will be determined on a site specific basis. Travel will be via air and boat charters.

Comparative Benefit Analysis will be carried out on all parcels or packages of parcels that have completed evaluations and appraisals. This technique, developed in 1994, utilizes appraisal values, parcel or package score and acreage to facilitate the acquisition of those lands that result in the greatest benefit at the lowest cost.

Funds from this project will be used to acquire full title or partial interests in lands, subject to approval by the Trustee Council, that contain habitats/sites linked to resources and services that were injured by the Exxon Valdez oil spill. Acquisition of lands or interests in lands will be accomplished according to accepted realty principles and practices. All acquisitions will require title evidence, appraisals of fair market value, litigation reports, hazardous substances surveys, legal review of title, and negotiations. Some acquisitions may require land surveys and additional ecological surveys.

3. Schedule

Support for negotiations and appraisals, for both large and small parcels, is dependent upon the progress of negotiations with landowners and the needs of the negotiators. Negotiations are currently taking place with large parcel landowners. Evaluation and ranking of small parcels will occur during this summer and fall. It is anticipated that negotiations for small parcels will commence in January, 1995. Field surveys of recently nominated large parcels will occur this summer.

4. Technical Support:

The Habitat Work Group will provide technical support to agencies during their negotiations for large and small parcels. Alaska Department of Natural Resources and the appropriate federal agencies will provide support for title searches, appraisals, and hazardous substances surveys. Maps will be produced by HWG staff and by ADNR/LRIS.

5. Location:

The analysis will cover all selected lands within the oil spill zone. Lands are located within Prince William Sound, Kenai Peninsula, Kodiak/Afognak Archipelago and on the Alaska Peninsula.

E. PROJECT IMPLEMENTATION

The proposed project is a continuation of 94110 and 94126, habitat protection projects that were started in 1992 by the Restoration Planning Work Group and outlined in concept in Volume I of the *Restoration Framework*. Implementation of this project would be by the Habitat Work Group. This group includes four members representing ADNR, USFS, ADF&G and USFWS. The HWG includes three individuals who have been working on the spill since early 1989 and who participated in the genesis and development of habitat protection as a restoration strategy. All four members are authors of the *Comprehensive Habitat Protection Process* report and participated in the development of the *Small Parcel Process*.

The multicriteria evaluation methods used in *Imminent Threat Process*, the *Large Parcel Element* and the *Small Parcel Element* of the *Comprehensive Habitat Protection Process* utilize explicit subjective values and judgments made by a group of biologists/resource

managers. This *collective best professional judgment* can vary as a function of the subjective weights applied by different individuals. Consequently, in order to maintain a consistent collective bias in these continuing evaluations, the same team should continue the effort.

It is appropriate that ADNR continue their technical support for mapping and GIS because of their demonstrated expertise, familiarity with the project and project participants and the in-house collection of relevant digital databases.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

All habitat protection efforts including this project are dependent upon the results of on-going research and monitoring projects. For example, the Large Parcel Element used information from the anadromous fish stream catalog, colonial seabird catalog, bald eagle nesting maps, and data from Trustee Council funded studies on black oystercatchers, marbled murrelets and pigeon guillemots.

G. PUBLIC PROCESS

The public has reviewed and commented favorably on all habitat protection efforts and has been highly supportive of habitat protection as a major restoration strategy into the future. All reports published as part of the Comprehensive Habitat Protection Process have been reviewed by the public. Input from natural resource and services specialists in the public sector was collected in a workshop conducted by The Nature Conservancy.

H. PERSONNEL QUALIFICATIONS

Resumes of all HWG members are available on request.

I. BUDGET

Personnel	331.0
Travel	46.7
Contractual	910.1
Commodities	16.7
Equipment	3.0
Subtotal	1307.5
General Administration	95.8
Total	$1403.3

Prince William Sound Salmon Stock Identification and Monitoring Studies

Project Identification Number: 95137

Lead Agency: ADF&G **Cooperating Agencies:**

Cost of Project, FY94: $273K **Cost of Project, FY95:** $273K

Project Startup Date: 10/93 **Duration:** years

Geographic Area: Prince William Sound

B: Introduction

Recent annual production of wild salmon in Prince William Sound (PWS) has included from 800 to 900 thousand chum salmon (*Oncorhynchus keta*) and 300 to 500 thousand sockeye salmon (*Oncorhynchus nerka*). As with pink salmon, up to 75% of wild chum salmon spawn in intertidal areas. Oil from the *Exxon Valdez Oil Spill* (EVOS) was deposited in intertidal spawning areas for pink and chum salmon salmon. Injuries from this contamination are well documented for pink salmon in PWS including direct lethal effects on embryos in the gravel and chronic reproductive impairment in subsequent generations exposed to oil (Sharr et. al. 1992). In addition, emergent fry and smolt of all salmon species from throughout PWS migrated through and reared in areas contaminated by oil. Willette and Carpenter (1993) demonstrated reduced growth and survival for pink salmon which reared in oiled portions of the Sound in 1989.

Chum salmon and sockeye salmon have life history similarities to pink salmon which may have also made them suseptible to injury from the EVOS. Chum salmon have both embryonic and early marine life history similarities and occur in many of the same streams as pink salmon. Sockeye salmon do not share intertidal natal habitat with pink salmon but they do spend portions of their early marine life historiy in areas of the Sound which were oiled. Given that both chum and pink salmon coexist with pink salmon during portions of the life history when EVOS related injuries occured in the latter, it seems likely that sockeye and chum salmon were similarly injured.

Salmon stocks impacted by the EVOS are heavily exploited in commercial, sport, and subsistence fisheries. Many of these populations have been depressed in recent years and some, such as the Coghill Lake sockeye salmon populaion are the subject of extensive EVOS Trustee Council restoration efforts. These restoration efforts are presently targeted at improving the productivity of the lake nursery area for juvenile sockeye salmon and cannot succed without simultaneous efforts to improve management of the commercial fishery. The damaged populations exist in fisheries dominated by hatchery populations. The management of this mixed stock fishery has historically been based on maintaining good temporal and spatial distribution of spawning escapement for groups of wild populations (stocks) originating from eight major fishing districts and its success has relied upon the manager's ability to control stock specific exploitation rates. Restoration premised on such a management strategy will require accurate in season catch stock composition estimates if lower harvest rates are to be achieved for damaged wild stocks.

The foundations for this project were firmly established in feasibility studies which were conducted beginning in 1986 and extending through 1988. 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 sockeye, coho and chinook salmon in 1989 and 1990 and releases of chum salmon in 1990. Tag recovery efforts for wild and hatchery salmon were funded by damage assessment funds in 1989, 1990, and 1991 and by restoration funds in 1993.

C. Need For Project

Although the extent of EVOS realted injury to populations of sockeye and chum salmon in PWS is unknown, populations of wild pink salmon in PWS were injured by the EVOS continue to experience poor reproductive success. Because they have life history similarities and overlap geographically with pink salmon it is likely that populations of of chum and sockeye salmon were similarly injured. Populations of wild chum salmon in the northern portions of PWS are in serious decline as is the population of sockeye salmon in Coghill Lake in northern PWS. These populations must be protected from other sources of injury or mortality which could further jeopardize their ability to reproduce in adequate numbers for long term sustained yield.

Adult returns from injured wild populations mingle with other wild and hatchery populations in PWS waters and all are heavily exploited by commercial fisheries. Successful restoration of injured populations will require that they be exploited at a lower rate in these fisheries until their reproductive rates return to historic average levels. Minimizing the exploitation of injured wild populations will insure that sufficient numbers adults from enter streams to spawn for sustained yield. This project provides fisheries managers with real time estimates of the numbers of wild and hatchery fish in commercial harvests. These estimates enable managers to identify areas where exploitation of wild populations can be minimized while permitting the timely harvest of economically important hatchery returns.

D. Project Design

This project is designed to provide estimates of hatchery and wild fish contributions to commercial and cost recovery fisheries in Prince William Sound. These estimates will allow fisheries managers to monitor the size and health of wild salmon populations and lessen interceptions of wild fish in mixed stock fisheries. The project will be administered and supervised by the Alaska Department of Fish and Game.

1. Objectives:

(1) make inseason estimates of the temporal and spatial contributions of tagged hatchery stocks of sockeye, chum, chinook and coho salmon to PWS commercial and hatchery harvests based on the number of tags detected in adipose clipped fish which are recovered during catch sampling;

(2) 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;

(3) use data from fully decoded tags recovered from commercial catches, cost recovery harvests, and hatchery brood stock to verify or adjust inseason contribution estimates and;

(4) estimate marine survival rates for each uniquely coded hatchery release group where possible.

2. Methods:

Tag recoveries will be made from a stratified random sample. Fisheries will be stratified by district, discrete time segments and processor. For each stratum, 25% of the sockeye, chum, chinook and coho salmon commercial harvest and cost recovery harvest will be scanned for fish with a missing adipose fin. Catch sampling will be conducted in processing plants located in Cordova, Valdez, Anchorage and Whittier. Broodstock sampling will also occur at 3 PWS hatcheries. A minimum of 50% of the daily broodstock requirements at each hatchery will be scanned for fish with missing adipose fins.

In the catch, cost recovery and broodstock samples, the total number of fish scanned and the total number of fish with missing adipose fins will be recorded. The heads of fish with missing adipose fins will be removed, labelled and shipped to the Tag Lab in Juneau for tag removal and decoding. Tag recovery, scanning, and catch data will be merged in a computer data base and returned to Cordova for analysis.

3. **Schedule:**

Date(s)	Activity
May 15 - Sept 30, 1995	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.
November 30, 1995	Draft summary report
January 15, 1996	Final Report

4. **Technical Support:**

ADF&G will supply biometrics support to ensure that project methods and data analyses will provide inseason stock contribution estimates at levels of accuracy and precision required for management of wild stocks in PWS.

5. **Location:**

Sampling of salmon catches from commercial and cost recovery fisheries will occur in shore based processing plants in Cordova, Valdez, Whittier, and Anchorage. There will also be sampling in Seward, Kenai, and aboard floating processors if significant numbers of Prince William Sound salmon are processed at those locations. Extraction and decoding of tags will be accomplished by the ADF&G coded wire tag lab in Juneau. All data analyses will be completed in Cordova with assistance from Anchorage based Alaska Department of Fish and Game biometrics staff.

E. Project Implementation

This project is applied research which has direct and immediate applications to ADF&G's statutory obligation to manage fisheries. Feasibility studies for the massive coded wire tagging and recovery operations required to manage PWS pink salmon were conducted by ADF&G and the local, private aquaculture associations for two years prior to the EVOS. Concurrently, these agencies developed the methods described for the other species in this this project, they have the infra-structure (e.g. the ADF&G coded wire tag laboratory) in place for large scale tagging and tag recovery operations, and they are the logical choice for conducting this project.

The project is proposed as a cooperative effort to be funded by the Trustee Council, ADF&G, and PWS aquaculture associations. Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) spend approximately $50K annually to apply tags to sockeye and chm salmon. ADF&G provides tagging equipment and technical expertise for tagging quality control. The Trustee Council will provide the funds for tag recovery in the commercial and cost recovery fisheries and in the hatchery brood stocks.

Overall project design, supervision, coordination, data analyses, and reporting will be the responsibility of Principal Investigator Sam Sharr, the ADF&G Fisheries Biologist III Salmon Research Project Leader in Prince William Sound. Carol Peckham, an ADF&G Salmon Research Biologist II in Cordova will act as the Project Leader, will supervise all the day to day project activities, complete inseason analyses for the ADF&G Fisheries Biologist III Area Management Biologist and, take the lead on all post season analyses and reporting. The Principal Investigator and the Project Leader will recieve approval of project design and quality control procedures, review of all data analyses, and editorial support for project reports from an ADF&G Biometrician I (David Evans) based in the ADF&G Anchorage Regional Office. The ADF&G Principal Investigator together with the local and regional ADF&G management staff are responsible for integration of information from this project into their inseason fisheries management decisions.

F. Coordination of Integrated Research Effort

The monitoring, research and restoration objectives of this project are integral to the success of ecosystem research and restoration efforts described in the Sound Ecosystem Assessment (SEA) plan. It is an integral part of a package of proposed projects including the SEA (95320), the Salmon Otolith Marking (95320c), and the Pink Salmon Egg and Alevin Mortality (95191) projects. This project monitors the total returns and survival rates of wild salmon populations which are known to be in decline and that may have experienced oil related injury similar to that demonstrated for pink salmon. Information from this project will be critical to the maintenance and restoration of populations which are exploited directly and indirectly in mixed stock salmon fisheries. This project provides survival estimates for individual release groups from PWS hatcheries. These estimates are critical to several components of SEA including those investigating:

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

2) the dependence of salmon survival on abundance, size, growth rate, and distribution of fry and juveniles and, zooplankton population distribution, abundance, and species composition, and

3) the dependence of salmon survival on abundance, size, growth rate, and distribution of 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 . 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 provide all tagging, fry release, sales harvest, and brood stock data necessary for data analysis. Aquaculture associations also provide room, board, and logistics support for brood stock 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.

G. 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 annual peer and 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.

H. 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 research conducted by the Division of Commercial Fisheries Management and Development in PWS. He designed and was the project leader for pink salmon coded-wire studies conducted by ADF&G prior to the EVOS. He 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; 93137, 93184, and 93191 in 1993 and 94137, 94191, 94320 and 94320c in 1994. He has been the Principal Investigator for all of those projects and co-authored all final reports. 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.

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.

BUDGET ($K)

	TRUSTEES	TOTAL
Personnel	205.3	205.3
Travel	8.5	8.5
Contractual	20.4	20.4
Commodities	7.0	7.0
Equipment	0.0	0.0
Capital Outlay	0.0	0.0
Sub-total	241.2	241.2
General Administration	32.2	32.2
Project Total	273.4	273.4

NEPA Compliance	0.0

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Proposed Spawning Channel Port Dick Creek, Lower Cook Inlet.

Project Number: 95139-B

Name of Project Leader or Principal Investigator: Nick Dudiak, Mark Dickson, Homer.

Lead Agency, Alaska Department of Fish and Game.

Cost of Project : FY95, $127.5K, FY96 and beyond $48.1K

Project Start-up/Completion Dates: 7/1/94 - 9/1/98.

Project Duration: 5 years.

Geographic Area: West Arm Port Dick, Southern Kenai Peninsula, Lower Cook Inlet.

Contact Person: Nick Dudiak, Mark Dickson
Alaska Dept. of Fish and Game
3298 Douglas St. Homer, AK 99603
(907) 235-8191

B: Introduction - To construct a pink and chum salmon spawning channel at Port Dick Creek to accelerate and restore the salmon stocks and services lost to the local commercial salmon seine fleet. This project is a proposed continuation of two prior years pre-construction investigations.

C. Need for the Project - To accelerate the recovery of the currently depressed wild pink and chum salmon stocks of Port Dick Creek by increasing the area available to salmon spawners.

D. Project Design -

Objectives: The major goal of this project involves the final engineering analysis during the fall of 1994 and actual construction of the spawning channel during the summer of 1995.

The following objectives and completion dates are proposed as follows:

1. Continue ground water level measurements, dataanalysis, final engineering design and bid preparation during the winter of 1994/95.
2. Construct the spawning channel during the spring/summer of 1995.
3. Conduct stream side egg-takes with native salmon stocks and replant the eggs into the new spawning channel at the eyed stage in 1995.
4. Monitor subsequent egg/fry survival through on site evaluations beginning in the spring of 1996 through 1998.
5. Monitor adult spawner density and species composition beginning in the summer of 1995.

4. **Methods:**

Continued ground water level measurements will be conducted using subsurface standpipes and a battery operated stream stage recorder. Results from these measurements will be used to finalize the size, depth and actual configuration of the spawning channel. The final spawning channel design will be prepared by a qualified engineer. The design will be advertised through the official state construction bid process.

The actual construction project will be awarded to the lowest qualified bidder. Construction of the spawning channel will be conducted with appropriate heavy equipment such as D9 Caterpillar tractors. Only on-site gravel materials will be used. Mobilization and demobilization of heavy equipment and logistical support materials will be conducted using a 110 ft. landing craft vessel.

Standard fish culture methods will be used to conduct on-site Port Dick Creek chum salmon egg-takes. Instream incubation systems will be used for incubation to the eyed egg stage. Eyed egg planting devices will be used to seed the spawning channel during the first few years to increase the probability of success. Several sample plots or enclosures will be identified for subsequent evaluation.

Sample plots or enclosures will be evaluated to determine overwinter survival from the eyed egg to emergent fry stage. These will be monitored during the spring pre-emergent and emergent phase.

Periodic stream surveys will be conducted during the spawning runs to determine adult spawner density and species composition. Stream life studies will also be conducted concurrent with this adult portion of the evaluation project.

Objectives:

1. Continue ground water level measurements, data analysis and report writing during the winter of 1994/1995.
2. Construct the spawning channel during the of summer of 1995.
3. Complete initial egg take and water hardened egg plant during the fall of 1995 through 1997.
4. Monitor fry survivals beginning in the spring of 1996 through 1997.
5. Monitor and control adult spawner density and species composition beginning in the summer of 1998 and 1999.

Technical Support: Technical support will come from Department of Natural Resources, Division of Water; Engineers from the Department of Fish and Game and Dryden Instrumentation, environmental engineers.

Location: The project site is located in the West Arm of Port Dick, Southern Kenai Peninsula, Lower Cook Inlet.

E. **Project Implementation:** The Alaska Department of Fish and Game will implement the project. A bid will be awarded through a competitive bid process for the actual channel construction. The Alaska Department of Fish and Game has the enhancement, restoration and fish cultural expertise to implement the instream restoration portion of the project.

F. **Coordination of Integrated Research Effort:** This instream habitat restoration project is the only EVOS related project on the Kenai Peninsula and Lower Cook Inlet currently being considered for further funding. There is no efforts to coordinate with other projects at this time.

G. **Public Process:**The proposed Port Dick Chum Salmon Spawning Channel was a topic at the Exxon Valdez Oil Spill Trustee Council meetings on January 31, 1994, with the general public invited. Future public involvement will include, but not be limited to meetings with the Cook Inlet Seiners Association (CISA) and the Cook Inlet Aquaculture Association (CIAA). All documents created by and for the proposed spawning channel will be available to the general public.

H. **Personnel Qualifications**: Project leader: Nick C. Dudiak; Lower Cook Inlet Fisheries Resource Development Biologist.

Mr. Dudiak has been a fisheries biologist with the Alaska Department of Fish and Game for the last 17 years. He has been responsible for the commercial and sport fisheries rehabilitation and enhancement work in the Lower Cook Inlet area during those 17 years. In this capacity, he has been responsible for multi-disciplinary work involving the rehabilitation of depleted salmon stocks as well as enhancement activities that have created new and developing commercial and sport fisheries. Mr. Dudiak has written several documents for ADF&G on the restoration and enhancement of sport and commercial fisheries.

Mark Dickson, Fish and Wildlife Technician IV.
Mr. Dickson has been employed as a fish culturist and fish and game technician with the Alaska Department of Fish and Game for the past 17 seasons. He has considerable experience in fish cultural practices in the field and in the hatchery managing projects that restores and enhances sport and commercial fisheries in the Lower Cook Inlet area.

I. **Budget($K)**

1.	**Personnel:**	24.4
2.	**Travel:**	1.0
3.	**Contractual Services:**	92.7
4.	**Commodities:**	7.4
5.	**Equipment:**	2.0
6.	**Capital Outlay:**	0.0
7.	**General administration:**	1.0

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Salmon Instream Habitat and Stock Restoration--Pink Creek and Horse Marine Barrier Bypass Development

Principle Investigator: Steven G. Honnold

Lead Agency: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division

Cost of Project: FY95: $ 46,000
FY96-FY00: $158,000

Project#: 95139C

Project Startup/Completion Dates: Start Date: 10/94
Completion Date: 9/99

Project Duration: 6 years

Geographic Area: Kodiak Island and Afognak Island

Contact Person: Steven G. Honnold
211 Mission Rd.
Kodiak, AK 99615
(907) 486-1873

INTRODUCTION: This project is result of a Trustee Council funded three-year survey of the Kodiak Island oil-impact area which identified feasible, cost effective instream habitat restoration and development techniques for salmon. In 1993 (FY94) one project on Afognak Island (Little Waterfall Creek) was identified as feasible and was funded by the Trustees. The selection of this project was based on preliminary cost to benefit data. Two additional projects have been identified on Kodiak and Afognak Islands as cost-effective upon further cost to benefit analysis. These projects are designed to replace injured salmon spawning habitat by providing access to existing habitat. The projects are: **1) Horse Marine Creek Barrier Bypass - Kodiak Island; 2) Pink Creek Barrier Bypass - Afognak Island.**

Horse Marine Creek Barrier Bypass:

The project at Horse Marine Creek on southern Kodiak Island will provide access to spawning habitat capable of supporting 15,307 pink, 3,124 coho and 8,594 sockeye salmon. With consistent escapements to this habitat,annually, approximately 28,214, 22,914 and 90,237 pink, coho, and sockeye salmon would be produced. The average escapement of pink salmon at Horse Marine Creek has been 3,864. Coho and sockeye escapements do not reach optimum levels at low flow periods. The project will benefit areas effected by the oil spill by replacement production.

Pink Creek Barrier Bypass

The project at Pink Creek on Afognak Island will provide consistent access to spawning habitat capable of supporting 4,512 pink and 516 coho salmon. Consistent annual escapements into this habitat could produce 8,317 and 3,782 pink and coho salmon, respectively. Pink Creek drains into Afognak Bay which was oiled in 1989.

NEED FOR THE PROJECT

These projects will help restoration by enhancing salmon populations and improving the commercial, sport, and subsistence fishing opportunities on Afognak and southern Kodiak Islands. Thus, lost fishing opportunities, as result of the oil spill, will replaced or mitigated for.

PROJECT DESIGN

Goal:

The goal of this project is to increase pink, coho and sockeye salmon spawning capability, and overall salmon returns, by enhancing fish passage above barriers in Horse Marine and Pink Creeks.

Objectives:

The objectives of this project are:

1. Final evaluation of pre-project production parameters (egg-to-fry survival, salmon escapement and spawning distribution)
2. Determine final barrier bypass design for Horse Marine Creek..
3. Obtain the necessary permits for construction .
4. Construct two barrier bypasses in the oil spill impacted area.
5. Evaluate the success of the barrier bypasses by estimating spawning numbers utilizing enhanced habitat as well as the relative abundance of juveniles produced each year.
6. Conduct necessary project maintenance each year.
7. Provide documentation of project progress and results.

Methods:

Horse Marine Creek:

A barrier bypass will be designed and constructed to facilitate salmon passage over a 3.0 m falls. Low water diversion structures will be installed and a salmon diversion weir constructed to lead salmon into entrance tanks.

Pink Creek:

This project will require a channel be cut with diversion of stream flow to allow salmon passage over 1.9 m falls.

Schedule:

Each project will require pre-construction planning, permitting and surveys, construction, and a period of five years for performance monitoring. This evaluation period is necessary for projects producing sockeye and/or coho salmon which return as adults at age 5 or 6. The Horse Marine Creek project will likely require construction to be contracted, thus, initial planning is scheduled for FY95 with construction in FY96. The Pink Creek project will be completed in FY95. The following table describes the anticipated schedule of tasks for years 1 and 2 for each project.

		Project	
Task	Period	Pink Creek	Horse Marine Creek
Pre-project surveys, planning	10/94-9/95	X	X
Final engineer surveys	7/95		X
Permitting, planning, administration, award contract	1/95 - 4/95	X	X
Project construction	5/95 - 6/95	X	
	5/96 - 6/96		X
Spawner abundance estimates	8/95 - 11/95	X	
	8/96 - 11/96		X
Progress reports	as required	X	X
Egg-to-fry survivor estimates	3/96	X	
	3/97		X

Technical Support:

General administrative support is provided by the Administrative, Habitat and Restoration Division, and Commercial Management and Development Divisions (CFMD) of the Alaska Department of Fish and Game (ADF&G). The project leader of this project is primarily funded by general funds and program receipts (Kodiak Regional Aquaculture Association - KRAA - cooperative funding) from the State of Alaska. Engineering support is provided by CFMD of the ADF&G, funded by general funds from the State of Alaska. This study is directly associated with ongoing rehabilitation and enhancement projects funded by program receipts provided by KRAA.

Location:

KEYBOARD() The project will be located at Pink Creek on Afognak Island and Horse Marine Creek on southern Kodiak Island. Pink Creek drains into Afognak River which drains into Afognak Bay on eastern Afognak Island. Horse Marine Creek drains into Olga Bay. The benefits of this project will be realized by increasing pink, coho and sockeye salmon returns to these systems, providing salmon for harvest. The residents of the city of Kodiak, and the village on northern Afognak Island as well as southern Kodiak Island will benefit economically from this project through direct commercial fishery receipts and all associated business enhancement. In addition, sport fishers, guides, and lodge owners as well as subsistence fishers, will benefit directly and provide direct economic return to the associated communities.

PROJECT IMPLEMENTATION

The Alaska Department of Fish and Game (ADF&G) will implement the project. The steeppass construction at Horse Marine Creek will likely require implementation through a competitive contract process. The ADF&G is currently managing approximately eight barrier bypass projects on Kodiak and Afognak Islands, therefore, is the appropriate agency to implement this project.

COORDINATION OF INTEGRATED RESEARCH EFFORT

KEYBOARD() The ADF&G, CFMD Division, Development and Research Sections operate sockeye, coho king and pink salmon development projects at Frazer, Pauls/Laura, Portage and Little Waterfall Creeks, located on Kodiak and Afognak Islands. The Department conducts all maintenance, monitoring and evaluation activities associated with this fisheries development program with funding provide by KRAA through program receipts. This includes lake enrichment, smolt sampling, limnological sampling, and weir operation. In addition, the Finfish Management Section of CFMD Division conducts fisheries management operations in the area.

Also, KRAA operates a sockeye stocking programs via Pillar Creek Hatchery at Hidden Lake. In addition, KRAA operates Kitoi Bay Hatchery on northern Afognak Island, producing pink, coho, chum and sockeye salmon for commercial harvest. All evaluation associated with Pillar

Creek and Kitoi Bay hatcheries is conducted by ADF&G with funds provided by KRAA program receipts. Lastly, the Alaska Department of Natural Resources, Kodiak State Parks operates several coho escapement weirs on Shuyak Island, located just north of Afognak Island. The ADF&G provides equipment and logistical support, as well as conducting aerial salmon escapement surveys in the area.

This project will be coordinated with all of the above mentioned programs.

PUBLIC PROCESS

The public will continue to be involved in the development of this project through the Trustee Council Advisory Group process. In addition, discussion of this project as well as the original "Instream Habitat Restoration Techniques" study that led to this project have been discussed in general membership meetings of the Kodiak Regional Aquaculture Association.

PERSONNEL QUALIFICATIONS

KEYBOARD() Steven G. Honnold
Commercial Fisheries Management and Development Division
211 Mission Road
Kodiak, Alaska 99615
(907)486-1873

March, 1989 to present. Fisheries Biologist - Assistant Area Biologist, Fisheries Enhancement Rehabilitation and Development Division, Alaska Department of Fish and Game, Kodiak, Alaska.

Responsible for planning, implementation, data analysis, and report writing for all Kodiak FRED/OSIAR (H&R) Division damage assessment studies and restoration programs, as result of EVOS. Studies included early marine life history damage assessment (this study was is the late planning phase when canceled), juvenile sockeye damage assessment via hydroacoustic surveys and limnological assessment at Red and Akalura Lakes, Red Lake restoration planning and NEPA reporting, Instream habitat and stock restoration feasibility - barrier bypass technique evaluation. In addition, responsible for all Afognak Island rehabilitation, enhancement or development projects conducted by FRED Division (Development Section of CFMD Division). Projects include Perenosa Rehab./Enhance., Malina Lakes Rehab., Afognak Rehabilitation, and Hidden Lake Development. Duties associated with these projects include: barrier bypass construction, maintenance and evaluation, sockeye stocking and subsequent smolt and fingerling monitoring and evaluation, lake limnology studies, and all associated planning, personnel supervision, data quality control and analysis, preparing budgets, report writing, and presentation of results at professional and public forums. Lastly, assist the Area FRED Biologist with all other Kodiak programs, including Spiridon Lake sockeye salmon development, Alaska Peninsula coho and sockeye salmon development feasibility studies, Kitoi Hatchery evaluation, and Kodiak lake limnology.

BUDGET

	FY95 - Project	FY95 - Reporting and Restoration Meetings	Total
Personnel	31.5	5.2	36.7
Travel	0.6	0.6	1.2
Contractual	3.2	1.0	4.2
Commodities	6.6	0.2	6.8
Equipment	0.0	0.0	0.0
Capital Outlay	0.0	0.0	0.0
General Admin.	3.8	0.0	3.8
TOTAL	45.7	7.0	52.7

Surveys to Determine Additional Oil Spill Effects and Recovery of Marine Bird and Sea Otter Populations in Prince William Sound

Project Number: 95159

Project Leaders: Beverly A. Agler

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $415.3K (includes $41K in FY96 for report writing)

Project Start-up/Completion Dates: 1/95-12/95

Project Duration: Every other year

Geographic Area: Prince William Sound

Contact Person:

Beverly A. Agler
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
907/786-3681

B. Introduction

The waters and shorelines of Prince William Sound (PWS) support abundant marine bird and sea otter (*Enhydra lutris*) populations throughout the year (Isleib and Kessel 1973, Hogan and Murk 1982, Irons et al. 1988a). Potential injuries to marine birds from exposure to the *T/V Exxon Valdez* oil spill included, but were not limited to, death, changes in behavior, and decreased productivity. Post-spill studies, identical to the one proposed here, suggested that the population abundance of several marine bird species (Klosiewski and Laing ms) and sea otters (Burn ms) declined as a result of the oil spill. Using surveys by small boats, this project will collect additional information to monitor the distribution and abundance of marine birds and sea otters in PWS. These post-spill data will be compared to data collected previously in 1989-91 (Klosiewski and Laing ms), 1993 (Agler et al. ms), and 1994 (Agler et al. unpubl. data) to ascertain trends in marine bird and sea otter distribution and abundance in PWS. This project will benefit restoration of PWS by determining additional species that show a latent oil spill effect and whether populations that declined due to the spill are recovering and by identifying what species are still of concern.

C. Need for the Project

Almost 30,000 bird (Piatt et al. 1990) and 900 sea otter (DeGange and Lensink 1990) carcasses were recovered following the spill. Based on modeling studies using carcass search effort, and population data, an estimated 300,000 - 645,000 marine birds were killed in PWS and the northern Gulf of Alaska by the oil spill (Ecological Consulting, Inc. 1991). Garrott et al. (1993) estimated that 2,800 sea otters were also killed. These estimates are probably low because they only include direct mortality occurring in the first five months after the spill.

The U.S. Fish and Wildlife Service conducted boat surveys of marine bird and sea otter populations in PWS in 1972-73 (Dwyer et al. 1976), 1984-85 (Irons et al. 1988b), and several years following the spill (1989, 1990, 1991, 1993, and 1994; Klosiewski and Laing ms, Agler et al. ms, Agler et al., unpubl. data). Klosiewski and Laing (ms) documented overall declines in 15 species or species groups between 1972-73 (Dwyer et al. 1976) and the years after the spill. When comparing population estimates with 1984 data, Klosiewski and Laing (ms) documented decline of 6 species or groups within shoreline habitats in the oiled zone relative to the unoiled zone.

Burns (ms), using data from the boat surveys, documented declines in sea otter abundance in shoreline habitats of PWS following the spill. He also detected a continuing pattern of significantly lower sea otter densities in oiled coastal areas, suggesting that mortality in or displacement of sea otters from these areas occurred. Agler et al. (ms) examined whether species shown to decline (Klosiewski and Laing ms) had recovered. Most species or groups showed no trends in population abundance since the *Exxon Valdez* oil spill, although results were inconclusive due to the few years of data available. In 1993, two new species showed a latent oil spill effect (Agler et al., ms). Klosiewski and Laing (ms) used Monte Carlo simulations to examine the power of determining trends from these data. These simulations showed that the number of surveys conducted has a large influence on whether a trend can be detected.

This project has several benefits. Restoration of marine bird and sea otter populations requires population estimates to determine whether recovery is occurring or if declines are continuing. Agler et al. (ms) also found additional populations declining that were not previously shown to be injured. This project will benefit marine birds and sea otters by revealing species that show continuing injury due to the *T/V Exxon Valdez* oil spill. Survey data from this project have been used for these purposes by investigators of other studies on pigeon guillemots (G. Sanger, pers. comm.), marbled murrelets (K. Kuletz, pers. comm.), black oystercatchers (B. Andres, pers. comm.), and sea otters (Burn, ms).

D. Project Design

1. **Objectives:** The purpose of this study is to obtain population estimates of marine birds and sea otters in PWS to monitor the recovery of species whose populations may have declined due to the T/V *Exxon Valdez* oil spill and to determine whether additional species may still be declining as a result of the oil spill. The specific objectives of this project include:

    a. To determine distribution and estimate population abundance, with 95%

confidence limits, of marine bird and sea otter populations in Prince William Sound during March and July 1995;

b. To determine whether the marine bird species whose populations declined more in oiled areas than in non-oiled areas of PWS have recovered;

c. To determine whether additional species begin to show oil spill effects;

d. To examine the relative abundance of common species groups over time;

e. To support restoration studies on harlequin duck, black oystercatcher, pigeon guillemot, marbled murrelet, and sea otter by providing data on population changes, distribution, and habitat use of PWS populations.

f. To examine the temporal variation in populations of marine birds in small index areas (i.e., Chenega, Tatitlek).

2. **Methods:**

a. Study Area

Prince William Sound is a large embayment of the northern Gulf of Alaska. The rugged coastline is dominated by the Chugach Mountains, which drop precipitously to the shoreline in an intricate pattern of fjords and bays. Including the mainland and more than 150 islands, PWS contains over 5000 km of shoreline. The depth of PWS varies from <1 fathom (2 m) on Middle Ground Shoal to >475 fathoms (870 m) east of Lone Island. The study area includes all water within PWS, as well as land within 100 m of the shoreline. The waters on the Gulf of Alaska side of Montague, Hinchinbrook and Hawkins Islands, as well as Orca Inlet, are excluded.

b. Sampling Methods

Survey methodology will remain identical to that of post-spill surveys conducted in 1989, 1990, 1991, (Klosiewski and Laing ms), 1993 (Agler et al. ms), and 1994 (Agler et al., unpubl. data). We will conduct 2 surveys during 1995. We will use three 25-foot fiberglass boats, which are currently under U.S. Fish and Wildlife Service jurisdiction, to survey transects over a 3-week period during March and July 1995.

We plan to redesign the sampling design of the survey to increase precision of our estimates. We will continue to use a stratified random sampling design containing 3 strata, shoreline, coastal-pelagic, and pelagic. Instead of dividing the Sound into 5-minute latitude-longitude blocks as in the past, we will divide the area into 1-minute latitude by 2-minute longitude blocks to determine the starting points for our transects. We have use a similar design in surveys of Lower Cook Inlet and Southeast Alaska. At the latitude of the study area, the blocks of the grid will be approximately 1 nautical mile (nm) square. In the same amount of time, we will be able to sample many more of these short transects, which will allow us to cover more area and should provide greater precision of our population estimates.

Temporal studies will be conducted annually in a limited area near both Chenega and Tatitlek by local people. Surveys would be conducted every month, January-December, as close to the first of the month as weather permits.

c. Data Analysis

As in previous surveys (Klosiewski and Laing ms, Agler et al. ms), we will use a ratio estimator (Cochran 1977) to estimate population abundance. Population estimates for each species will be combined with other post-oil spill population estimates to determine population trends. Regression analyses will be used to determine the recovery of injured species and population changes of other species.

3. Schedule:

Jan - Feb 95:	Hire personnel, make logistical arrangements for winter survey
Mar 95:	Conduct winter survey in PWS
Apr 95:	Return to Anchorage, enter data, and store equipment
May 95:	Hire personnel, make logistical arrangements for summer survey
July 95:	Conduct summer survey in PWS
Aug - Sept 95:	Analyze data from 1995 surveys

4. Technical Support:

All technical aspects, such as GIS, will be conducted by project personnel; therefore, outside technical support is not needed.

5. Location:

This study will be conducted in PWS. The study area includes all water within PWS, as well as land within 100 m of the shoreline.

6. Literature Cited

Agler, B. A., P. E. Seiser, S. J. Kendall, and D. B. Irons. ms. Marine bird and sea otter populations of Prince William Sound, Alaska: population trends following the *T/V Exxon Valdez* Oil Spill. Restoration Project No. 93045. Unpubl. Rep., U. S. Fish and Wildl. Serv., Anchorage, Alas. 60 pp.

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___, ___, & ___. 1988b. Prince William Sound waterbird distributions in relation to habitat type. Unpubl. Rep., U.S. Fish Wildl. Serv., Anchorage, Alas. 26 pp.

Isleib, P. and B. Kessel. 1973. Birds of the North Gulf Coast - Prince William Sound Region, Alaska. Biol. Pap. Univ. Alaska 14. 149 pp.

Klosiewski, S. P., and K. K. Laing. ms. Marine bird populations of Prince William Sound, Alaska, before and after the *Exxon Valdez* oil spill. NRDA Bird Study Number 2. Unpubl. Rep., U.S. Fish and Wildl. Serv., Anchorage, Alas. 85 pp.

Piatt, J. F., C. J. Lensink, W. Butler, M. Kendziorek, and D. R. Nysewander. 1990. Immediate impact of the 'Exxon Valdez' oil spill on marine birds. Auk 107:387-397.

E. Project Implementation

The Division of Migratory Bird Management (MBM) of U.S. Fish and Wildlife Service has conducted several surveys to estimate the population abundance and distribution of marine birds and sea otters in PWS. Surveys were conducted prior to the *Exxon Valdez* oil spill during 1972-73 (Dwyer et al. 1976) and 1984-85 (Irons et al. 1988a,b), and for several years after the oil spill (1989-91, 1993, and 1994; Klosiewski and Laing ms, Agler et al. ms, Agler et al., unpubl. data). MBM also has conducted several other studies within PWS. MBM has monitored reproduction of black-legged kittiwakes for over 10 years and has been conducting research in PWS on marbled murrelets, pigeon guillemots, and black oystercatchers for several years. During 1994, MBM staff will also participate in a coordinated effort with NOAA to study forage fish within PWS.

F. Coordination of Integrated Research Effort

This project will provide valuable information on the distribution and habitat use of marine birds and sea otters in PWS. This project is being coordinated with other DOI-FWS and NBS seabird monitoring studies in PWS and elsewhere (ie.- Lower Cook Inlet, Southeast Alaska). Survey data from this project will be available for use by investigators of other studies on marbled murrelets, black oystercatchers, pigeon guillemots, black-legged kittiwakes, forage fish, and sea otters.

G. Public Process

The final reports of the previous surveys (1989-91 Klosiewski and Laing ms, 1993 Agler et al. ms) are available upon request to the general public. The final report of the 1995 survey will also be available. The private business sector will be given the opportunity to bid on the 1995 vessel contracts, and the temporal study will be contracted out to local people.

H. Personnel Qualifications

1. Principal Investigator - Beverly A. Agler

Beverly Agler received her M.S. degree in Wildlife Management from University of Maine, Orono in 1992 and her B.A. degree in Human Ecology from College of the Atlantic in 1981. Ms. Agler has worked for the U.S. Fish and Wildlife Service since May, 1993 as Project Leader of the PWS, Lower Cook Inlet, and Southeast Alaska population surveys of marine birds and sea otters. Prior to her arrival in

Alaska, she participated in a joint National Science Foundation, National Oceanographic and Aeronautics Administration, University of Washington, and College of the Atlantic study of Antarctic seabirds and marine mammals. For over 10 years, she was the Project Director of the North Atlantic Fin Whale Catalogue, based at College of the Atlantic in Bar Harbor, Maine. She coordinated a collaborative study of fin whales in the western North Atlantic, including coordinating photographic identification of individuals, and genetic differentiation of individuals using skin biopsies. In addition to her work at College of the Atlantic, Ms. Agler was the Head Naturalist for Maine Whalewatch in Northeast Harbor, Maine. In this position, she led day-long offshore trips to study marine mammals and seabirds.

Selected Publications:

Agler, B. A., P. E. Seiser, S. J. Kendall, and D. B. Irons. ms. Marine bird and sea otter populations of Prince William Sound, Alaska: population trends following the *T/V Exxon Valdez* oil spill. Restoration Project No. 93045. Unpubl. Rep., U. S. Fish and Wildl. Serv., Anchorage, Alas. 50 pp. + appendices.

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_____, K. A. Robertson, D. DenDanto, S. K. Katona, J. M. Allen, S. E. Frohock, I. E. Seipt, and R. S. Bowman. 1992. The use of photographic identification for studying individual fin whales (*Balaenoptera physalus*) in the Gulf of Maine. Rep. int. Whal. Commn 42:711-22.

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_____. In review. The effects of photographic matching errors population estimates of fin whales using capture-recapture data. Submitted to Rep. int. Whal. Commn.

_____, K. A. Robertson, and D. DenDanto. In review. The value of scars for the photo-identification of individual fin whales. Submitted to Can. J. Zool.

I. Budget

Personnel	202.2
Travel	14.0
Contractual	116.0
Commodities	34.5
Equipment	27.0
Capital	0.0
Subtotal	393.5
General Administration	38.5
Total	432.0

Abundance and Distribution of Forage Fish and Their Influence on Recovery on Injured Species

Project Number: 95163

Project Leader: Bruce Wright (NOAA)

Principal Investigators: David Irons (USFWS)
Mark Willette (ADF&G)

Lead Agency: NOAA

Cooperating Agencies: ADF&G & USFWS

Cost of Project, FY95: $1,203.7K **Cost of Project, FY96:** $1,000K

Project Startup Date: April 1994 **Completion Date:** May 2000

Geographic Area: Prince William Sound & adjacent Gulf of Alaska waters

Contact Person: Bruce Wright, NOAA
Oil Spill Office
11305 Glacier Highway
Auke Bay, AK 99821
(907)-789-6600

B. Introduction: A better understanding is needed of how prey availability affects distribution, abundance, growth and reproductive success of apex predators. Efforts to restore predatory species affected by the oil spill, particularly harbor seals, pigeon guillemots, marbled murrelets, common murres, black-legged kittiwakes, and salmon, could be delayed or completely unsuccessful without understanding distribution, abundance, and availability of important forage fish including herring, pollock, sandlance, capelin, and invertebrate species including macrozooplankton and squid.

C. Need for the Project: This is the core project of the ecosystem project, Food Limitation on Recovery of Injured Resources: An Ecosystem Approach to the Restoration of Marine Birds and Mammals, a multi-disciplinary project designed to understand the Prince William Sound food web and the associated effects on the injured species.

This project will concentrate on determining distribution, abundance, and availability of important prey species (e.g., herring, pollock, sandlance, capelin, macrozooplankton, squid) to predatory species affected by the oil spill (i.e. harbor seals, pigeon guillemots, marbled murrelets, common murres, black-legged kittiwakes, and pink salmon). Diet overlap and prey selection among forage fish species will also be examined. This information, trophic position and niche overlap among species, will be used to establish the basic structure of future ecosystem models. The models of changing oceanographic regimes and prey species productivity and distribution would be necessary for understanding recovery of predatory species, and useful in guiding recovery activities.

D. Project Design: The forage fish project will evaluate existing field methods used in determining distribution, abundance, availability and class composition of forage fish. Provisions will be included to model affects of changing oceanographic regimes on forage fish species' distribution, abundance, and productivity.

The 1995 sampling program will be an expansion of the 1994 pilot project (94163) to determine distribution, densities and species composition of forage fish species. This project will also provide information on sex, age, growth, food habits, recruitment, and mortality of forage fish species. Field surveys will determine where apex predators forage and the distribution, abundance, and availability of forage fish of both nearshore and offshore waters within Prince William Sound and adjacent Gulf of Alaska waters. Ecosystem models to estimate biomass and productivity of forage fish species will be evaluated, and begun to be developed..

The overall project objective is to:

Determine temporal and spatial distribution, abundance, and availability of important prey species (e.g., herring, pollock, sandlance, capelin, macrozooplankton, squid) in Prince William Sound and adjacent Gulf of Alaska waters. It will attempt to determine how important biotic and abiotic factors affect both short- and long-term distribution and abundance of prey species in the oil spill area. It will also determine how predator distribution, abundance, and foraging strategy coincide with forage fish distribution and abundance.

The 1995 project design:

1. Objectives:

A. Evaluate existing field methods used in determining distribution, abundance and availability of forage fish.
B. Determine temporal and spatial distribution and abundance of prey species using hydroacoustic surveys and net sampling.
C. Investigate the relationships between forage fish abundance and distribution with oceanographic parameters.
D. Initiate development of ecosystem models to understand factors influencing distribution, abundance, and composition of forage fish.

E. Investigate relationships of forage fish abundance to marine birds and mammal abundance and productivity, in conjunction with complementary studies directed towards these species.
F. Determine forage fish prey using stomach content analysis for fish collected from nearshore and offshore sites, and estimate degree of diet overlap among species.

2. Methods: Ground-truth existing field methods used in determining distribution, abundance and availability of important prey species. Conduct both coarse and fine scale hydroacoustic surveys and determine forage fish composition and sizes by net sampling. Coarse scale surveys will consist of line transects spaced throughout PWS. Fine scale surveys will occur at two to four locations known to be sea bird or marine mammal feeding areas. Both coarse and fine scale surveys will be conducted at least monthly from April through August. Four permanent hydroacoustics stations will be established to observe temporal patterns in prey abundances within and between years.
During hydroacoustic surveys, simultaneous bird and mammal surveys will take place from the same vessel(s). Data from this study will be combined with data from other seabird studies to compare relative fish abundance to foraging behavior and reproductive success of marbled murrelets, pigeon guillemots, and black-legged kittiwakes.

Forage fish will be sampled in nearshore and offshore areas using nets. Each species will be identified and length and weight measured on a minimum of 150 individuals randomly selected in each sample. Fifteen fish from each species will be preserved from each sample for later analysis of stomach contents. Additional samples will be collected for later lipid and stable isotope analysis.

3. Schedule: The forage fish surveys will be conducted under contract. The contractor work will conduct hydroacoustic and net sampling surveys at monthly intervals from spring to late summer. Annual reports, will include progress on refining the forage fish models. A project status report will be submitted by the contractor in December, 1995 which will discuss existing field methods used in determining distribution, abundance, and availability of important prey species, and the process and justifications for selected survey techniques. The report will present and discuss the results of the field surveys including locations of forage fish and, when possible, the biomass of these species, and forage fish prey as determined from stomach content analysis. The contractor, in collaboration with NOAA, ADF&G and USFWS, will report on the correlation of forage fish distribution and abundance with marine birds (marbled murrelet, pigeon guillemot, black-legged kittiwake) and mammal abundance and productivity. The report will also describe and evaluate ecological models to estimate productivity of important prey species, and a sampling program to fulfill requirements of ecological models. Annual reports will include progress on refining the productivity models.

Table 1: Schedule of project activities for 1995 field season.

<u>Field Studies</u>
April - August: contractor field sampling

<u>Laboratory & Data Analyses</u>
June 1 - December 31, 1995: conduct stomach contents analysis
January 1, 1996 - March 31, 1996: analyze data and prepare annual report due within four months after cruise; submit draft annual project report

4. Technical Support: This project will generate data which will be useful to the monitoring projects and studies currently underway in Prince William Sound. In order to insure access to these data, the information collected from this project will be incorporated into a data base managed by the Trustee Council.

5. Location: This project will concentrate its initial activities within Prince William Sound. However, some sampling design feasibility work may be performed in Gulf of Alaska waters adjacent to Prince William Sound.

E. Project Implementation: This project will be contracted and coordinated by NOAA with cooperative components conducted by ADF&G and USFWS.

F. Coordination of Integrated Research Effort: This project will be highly integrated with several components of the SEA Program and several of the marine bird and marine mammals projects. The Physical Oceanography, Nearshore Fish, Zooplankton, and Phytoplankton components of SEA will collect data relevant to forage fish distribution and production. Within the SEA Physical Oceanography component, conductivity-temperature-depth (CTD) profilers and Acoustic Doppler Current Profilers (ADCP) will be deployed from a mid-water trawl vessel. Within the SEA Nearshore Fish component, hydroacoustic data will be obtained in offshore habitats from a mid-water trawl vessel and in nearshore habitats from small hydroacoustic survey boats. Within the SEA Zooplankton and Phytoplankton components, zooplankton and water samples will be collected using nets and water bottles. The Salmon Growth and Salmon Predation components of SEA will collect forage fish samples for later stomach contents analysis in offshore and nearshore habitats using mid-water trawls, and beach and purse seines. Age-weight-length data will be collected from the forage fish to accompany hydroacoustic data. All data collected as part of SEA will be provided to the Information and Modeling component for use in development and implementation of ecosystem models.

The forage fish study and the marbled murrelet, pigeon guillemot, and kittiwake studies will provide complementary and integral information to determine if food is limiting the recovery of sea bird species. Data on seabird foraging and reproductive parameters will be compared to the forage fish assessment data to investigation the relationship of food availability or limitation to seabird productivity.

G. Public Process: The public process for this project will be integrated with the Trustee Council process for the 1995 Work Plan. Local knowledge will be sought regarding forage fish abundances and the locations of high-use feeding areas of marine birds and mammals.

H. Personnel Qualifications:

Bruce Wright
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P.O. Box 210029
Auke Bay, AK 99821

Bruce Wright is the Program Manager, National Oceanic and Atmospheric Administration, National Marine Fisheries, Office of Oil Spill Damage Assessment and Restoration in Juneau, Alaska since November, 1991. Prior to that he has been on the Faculty, University of Alaska Southeast; Arctic Tern Researcher, U.S. Forest Service, Juneau Ranger District; and Fisheries Biologist and Habitat Biologist, Alaska Department of Fish and Game, Divisions of Commercial Fisheries and Habitat.

His education includes a Type A Teaching Certificate, University of Alaska Southeast (1981), Master of Science, Ecology, San Diego State University (1977), Bachelor of Science, Biology, San Diego State University (1976).

Dr. David Irons
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, AK 99503

David Irons received his Ph.D. from the U. of CA, Irvine in 1992. His dissertation was on foraging ecology and breeding biology of the black-legged kittiwake. The field work for this study was conducted in Prince William Sound. Irons received his M.S. from, Oregon State University in 1982 where he studied foraging behavior of glaucous-winged gulls in relation to the presence of sea otters. Irons conducted marine bird and sea otter surveys in PWS in 1984 and 1985. He has been studying kittiwakes in PWS for 11 years and has completed the EVOS kittiwake damage assessment study in PWS. Irons also has conducted seabird reproductive studies in Cook Inlet, PWS and on Little Diomede Island, and a cost of reproduction study on kittiwakes. Irons has authored and co-authored several reports and publications on seabirds and has made several presentations at scientific conferences on seabirds. Irons is currently project leader of a PWS kittiwake study and oversees five other seabird studies.

Mark Willette
Alaska Department of Fish and Game

Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574

EMPLOYMENT:

March 1991 - present: Area Biologist with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Cordova, Alaska. 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.

March 1986 - February 1991: Fisheries Instructor/ Assistant Research Professor, University of Alaska Fairbanks, School of Fisheries & Ocean Sciences. Conduct research on the effects of oceanographic conditions on the growth and survival of juvenile salmon in PWS.

Willetes education includes a Master of Science, Fisheries Oceanography, University of Alaska Fairbanks (1985) and a
Bachelor of Science, Fisheries Science, University of Alaska Fairbanks (1983).

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project will fall under the categorical exclusion within NEPA. The major component of this project is routine environmental sampling for which no requirement to undertake an additional National Environmental Policy Act review is necessary. NOAA will serve as the lead for NEPA compliance.

BUDGET ($K)

	NOAA	USFWS	ADF&G	TOTAL
Personnel	$ 30.0	$ 117.0	$ 45.5	$ 192.5
Travel	10.0	12.0	1.2	23.2
Contractual	700.0	0.0	183.6	883.6
Commodities	1.0	5.0	2.8	8.8
Equipment	6.0	4.0	3.5	13.5
Capital Outlay	0.0	15.0	0.0	15.0
Sub-total	$747.0	$ 153.0	$ 233.1	$1133.1
General Administration	33.3	17.6	19.7	70.6
Project Total	$780.3	$ 170.6	$252.8	$1203.7

NEPA Compliance: 0.0

Prince William Sound Herring Genetic Stock Identification

Project Number:	95165
Project Leaders:	James E. Seeb and Lisa W. Seeb
Lead Agency:	Alaska Department of Fish and Game
Cost of Project, FY95:	$ 94.0K
Cost of Project, FY96:	$ 97.0K
Project Start-up Date:	10/94
Project Completion Date:	7/97
Duration:	2 1/2 years
Geographic Area:	Prince William Sound
Contact Person:	James E. Seeb, 333 Raspberry Road, Anchorage, AK 99518 (907) 267-2385

B. INTRODUCTION

Herring are a major resource in Prince William Sound from both a commercial and ecological perspective. The timing of the *Exxon Valdez* oil spill (EVOS) overlapped the annual spring migration of herring spawners to nearshore staging areas. Over 40% of the herring spawning staging and egg deposition areas and over 90% of the documented summer rearing and feeding areas were lightly to heavily oiled prior to the spawning events. As a result, herring encountered oil during each of their four life stages in 1989 and, to a lesser extent, in 1990. Adult herring traversed oil sheens and mousse while traveling northward and eastward. Eggs were deposited on oiled shorelines and were "dipped" in sheen through tidal action while incubating. Larvae hatched that contained lipophilic petroleum hydrocarbons in their yolk sacs and encountered sheen near the surface while in their most sensitive state. Post-larval or juvenile herring swam through and remained near lightly to heavily oiled shorelines, regularly encountering sheen, mousse and dissolved oil particulates and components through the summer while feeding in shallow nearshore bays and passes.

In 1993, the total observed spawning population was less than one-third of preseason predictions and the average sizes of herring in each age class were some of the smallest on record. Only limited commercial herring fishing occurred. Preliminary pathology results implicated viral hemorrhagic septicemia (VHS) as a potential source of mortality and stress. In 1994, as in 1993, the spawning population was below preseason predictions. Aerial surveys indicated the population was less than minimum threshold harvest levels and no commercial fishing was allowed. The ex-vessel value of the herring fisheries in 1992 was $12.0 million. In 1993, the ex-vessel value dropped to $2.0 million and no commercial harvest occurred in 1994. This project will enable resource managers to better understand herring population dynamics to improve the recovery process. In addition, it will aid local resource users to make appropriate pre-season plans based on accurate and precise herring projections.

Incorporating genetically derived stock structure is crucial to the success of any fisheries or restoration program. Consistent exploitation of mixed stocks has to lead to the demise of the least productive stocks. Unfortunately, defining the stock structure of herring has been particularly difficult. There is evidence that herring home, but straying may also be substantial. Morphological and meristic differentiation of herring from discrete geographic regions has been used as evidence for the existence of genetically distinct stocks, but much of this variation may be environmentally mediated and has not been confirmed with genetic data.

Previous surveys of herring using the genetic techniques of allozyme electrophoresis have generally revealed differentiation only over broad geographic regions. Two distinct races of Pacific herring (Asian/Bering Sea - eastern North Pacific) have been defined, with further subdivision between Gulf of Alaska and more southerly North Pacific stocks. However, more recently, genetic divergence among local spawning populations of Pacific herring in the vicinity of northern Japan using allozyme markers has been described.

An explosion of new genetic techniques has occurred in recent years as a result of recent advances in molecular biology. The utility of these newer techniques to detect fine genetic structure in Pacific herring has not been properly assessed. We propose to use a combination of current allozyme techniques combined with mitochondrial and nuclear DNA techniques to more accurately define the stock structure of herring from the EVOS-affected area. The data can also be used to estimate the stock composition of non-spawning aggregations contributing to the fisheries in Prince William Sound. These data on stock structure will be essential in improving the stock assessment model in Prince William Sound and therefore the development of a restoration plan for the damaged herring stock.

C. NEED FOR THE PROJECT

Pacific herring *Clupea pallasi* are a major resource in Prince William Sound (PWS) from both commercial and ecological perspectives. Five commercial herring fisheries in PWS have an average annual combined ex-vessel value of $8.3 million. Pacific herring provide important forage for many species including some species severely injured by the *Exxon Valdez* oil spill. Predator species include humpbacked whales, seals, sea lions, gulls, sea ducks, shorebirds, halibut, salmon, rockfish, and other fish. In addition, several thousand pounds of herring and herring spawn-on-kelp are harvested annually for subsistence purposes and form an important part of the local native culture of Chenega and Tatitlek.

The goal of this project is to improve the accuracy of current stock assessment methods and models thus improving resource management. Incorporating genetically derived stock structure is crucial to the success of any fisheries or restoration program. Improved accuracy of stock distribution information will allow fishery managers to make fine adjustments of fishing quotas to harvest the maximum available surpluses with the lowest possible risk of overharvest, damage to the resource, or economic loss to the fishing industry. This information is also needed to help interpret oil spill damage results. Because commercial and subsistence herring harvests represent substantial contributions to local economies, intensive management is expected to benefit all communities in PWS. Restoration efforts can be directed and evaluated through improved fishery management and continued resource monitoring.

D. PROJECT DESIGN

1. Objectives:

We propose to initiate a study to test for genetic heterogeneity among spawning aggregations of Pacific herring within Prince William Sound. The objectives of the study are to:

a. Screen population samples using an array of molecular techniques for DNA-level genetic analysis. Techniques under consideration include DNA sequencing of mitochondrial and nuclear regions, microsatellite analysis (analysis of regions with variable number of tandem repeats (VNTR)), RAPD analysis (random amplified polymorphic DNA markers), and restriction analysis of mitochondrial and nuclear regions.

b. Screen population samples using alloyzme electrophoresis.

c. Evaluate the null hypothesis a single panmictic population of herring Prince William Sound using the results from a and b above.

A comprehensive survey of the entire EVOS-affected areas may be designed in future years pending the results of Objective c.

2. Methods:

Field collections of spawning Pacific herring will be made from four representative sites within Prince William Sound. The collection sites will be chosen to maximize the potential genetic differentiation among the aggregations. A sample of 100 individuals will be collected from each aggregation. Tissue extracts from muscle, liver, eye, and heart will be collected. Extracts from individual fish will be preserved in both alcohol and in liquid nitrogen.

A request for proposal will be issued for the molecular analyses to be conducted at the contractor's facilities. Allozyme electrophoretic analysis will be conducted by ADF&G following standard protein electrophoretic techniques.

The specific molecular techniques to be investigated will be chosen based on: 1) a review of the current literature and recently available research results, and 2) responses and qualifications of competitive bidders.

3. Schedule:

Activity	Inclusive Dates	
Advertise and award contract for DNA analyses	October 1994	January 1995
Collection of baseline samples	April 1995	
Laboratory analyses	May 1995	December 1995
Draft status report FY95	March 1996	
Second-year sample collection	April 1996	December 1996
Second-year lab analyses	May 1996	December 1996
Final status report FY95	August 1996	
Draft final report	March 1997	
Final report	August 1997	

4. Technical Support:

Administrative support is provided by the Administrative, Habitat, and Commercial Fisheries Management and Development Divisions (CFMD) staff of the Alaska Department of Fish and Game. The project leaders are fully funded with general funds from the State of Alaska. Project assistants are fully or partially funded by this project. Laboratory support is provided by the ADF&G Genetics Program which includes facilities for tissue archival, allozyme analysis, PCR-based and other DNA analyses, and data analyses. These studies are integrated with ongoing studies by the CFMD for efficiency in completing the objectives.

5. Location:

Field research will be conducted within the confines of PWS and exact locations will depend upon the distribution of spawning herring. Laboratory studies and data analysis will be conducted at the ADF&G area office in Cordova and regional office in Anchorage.

E. PROJECT IMPLEMENTATION

The statewide genetics laboratory within the Division of Commercial Fisheries Management and Development is located in Anchorage and is well equipped for allozyme and DNA studies. Current staff include geneticists, a genetics biometrician, and laboratory technicians. Collection of specimens and biological data will coordinated by ADF&G's ongoing herring research program in Prince William Sound and with the EVOS project Disease Impacts on Prince William Sound Herring Populations.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT:

The genetic analyses and biometric analyses will be coordinated among all Trustee Council projects related to genetics including 94320D, 94191, and 94255.

Sharing of project results will be used to evaluate and revise current strategies for management of commercial herring fisheries if warranted. Project results will also be used to improve our understanding of results from previous oil spill damage assessment studies.

G. PUBLIC PROCESS

Scientific and technical aspects of the study are subject to internal review within the CFMD reporting system. Publications are submitted through an internal peer review process with the major findings submitted to peer reviewed 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. Annual status reports will be generated with publications being provided in peer review journals and scientific symposia as significant findings are obtained. A final report will be issued upon completion of the final year of field data collection.

H. PERSONNEL QUALIFICATIONS

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

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

PROFESSIONAL EXPERIENCE:

1990-	Principal Geneticist, CFMD Division, ADF&G
1991-	Affiliate Associate Professor, U. 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.

Seeb, J.E., L.W. Seeb, D.W. Oates, and F.M. Utter. 1987. Genetic variation and postglacial dispersal of populations of northern pike (*Esox lucius*) in North America. Can. J. Fish. Aquat. Sci. 44:556-561.

Utter, F.M., and J.E. Seeb. 1990. Genetic marking of fishes: overview focusing on protein variation. Am. Fish. Soc. Sym. 7:426-438.

Seeb, J.E., G.H. Kruse, L.W. Seeb, and R.J. Weck. 1990. Genetic structure of red king crab populations in Alaska facilitates enforcement of fishing regulations. Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant, Fairbanks, AK. pp 491-502.

Seeb, J.E., and G.D. Miller. 1990. The integration of allozyme analyses and genomic manipulations for fish culture and management. *In*: D.H. Whitmore, Editor. Electrophoretic and Isoelectric Focusing Techniques in Fisheries Management. CRC Press, Boca Raton, pp 266-279.

Gharrett, A. J. B. Riddell, J. Seeb, and J. Helle. 1993. Status of the Genetic Resources of Pacific Rim Salmon. In: J. Cloud, Editor. Genetic Conservation of Salmonid Fishes. Plenum Press, New York. pp. 286-292.

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

Lisa. W. Seeb (L. Wishard), Statewide Geneticist
Division of Commercial Fisheries Management and Development
Alaska Dept. of Fish and Game
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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, U. 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

Seeb, L. W. and D. R. Gunderson. 1988. Genetic variation and population structure of Pacific ocean perch (*Sebastes alutus*). Can. J. Fish. Aquat. Sci. 45:78-88.

Seeb, L. W., J. E. Seeb, R. L. Allen and W. K. Hershberger. 1990. Evaluation of adult returns of genetically marked chum salmon, with suggested future applications. American Fisheries Society Symposium 7:418-425

Seeb, L. W., J. E. Seeb and A. J. Gharrett. 1990. Genetic marking of fish populations. pp 223-239 *in* D. H. Whitmore, ed. Electrophoretic and isoelectric focusing techniques in fisheries management. CRC Press, Boca Raton, FL.

Seeb, L. W., J. E. Seeb and J. J. Polovina. 1990. Genetic variation in highly exploited spiny lobster *Panulirus marginatus* populations from the Hawaiian Archipelago. Fishery Bulletin 88:713-718.

Seeb, L. W. and A. W. Kendall. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

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

Susan E. Merkouris, Fisheries Biologist II
Commercial Fisheries Management and Development
Alaska Department of Fish and Game
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EDUCATION:

A.A., 1974, Liberal Arts (Honors), Golden Valley Lutheran College, Mpls., MN
B.S., 1980, Biology and Chemistry, *magna cum laude*, University of Alaska, Anchorage AK

PROFESSIONAL EXPERIENCE:

1991- Shellfish and Marine Fishes Project Geneticist, CFMD, ADF&G

1989-1991 Lower Yukon Asst. Mgmt. Fisheries Biologist, C.F., ADF&G

1985-1989 Norton Sound Asst. Mgmt. Fisheries Biologist, C.F., ADF&G

1981-1985 Fisheries Biologist, C.F., ADF&G

1979-1981 Fisheries Technician, C.F., ADF&G

1976-1980 Clinical Laboratory Technician, Microbiologist, Norton Sound Regional Hospital, Nome, AK

SELECTED PUBLICATIONS AND PRESENTATIONS:

1993 Merkouris, S.E., L.W. Seeb. (in prep). A genetic investigation of hybridization between *Chionoecetes bairdi* and *C. opilio*. Presented at Genetics of Subarctic Fish and Shellfish International Symposium, Juneau, AK.

1990 Bergstrom, D. J. *et al.* 1991. Annual Management Report Yukon Area. Alaska Department of Fish and Game, Regional Information Report Series.

1988 Lean, C.F. *et al.* 1989. Annual Management Report Norton Sound - Port Clarence - Kotzebue. Alaska Department of Fish and Game, Regional Report Series.

I. BUDGET ($K)

Personnel	19.0
Travel	3.0
Contractual Services	60.0
Commodities	5.0
Equipment	0.0
Capital Outlay	0.0
Sub-total	87.0
General Administration	7.0
Project Total	94.0
NEPA Compliance	0.0

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Herring Natal Habitats

Project Number: 95166

Name of project leader(s): Component A. John Wilcock, Area Research Biologist, CFMDD, ADF&G, Cordova, Alaska

Component B. Terry Quinn,PhD and Lou Haldorson, PhD, SFO-IMS, University of Alaska, Juneau

Lead agency: ADF&G and UAJ joint project

Cost of project/FY 95:	A.	$413.3 K,
	B.	$80.0 K,
Total Cost,		**$493.3 K**

Cost of Project/FY 96 and beyond: $493 K in FY96, $350 K in FY97, and $210 K by FY98

Project Start-up/Completion Dates: October 1994. Component A. annually for at least 6 years until major recruiting event;
Components B. & C. for 2 additional years.

Geographic area of project: Prince William Sound

Contact Person: John Wilcock, ADFG, CFMDD, Box 669, Cordova AK 99574, 424-3213, FAX 424-3235

Dr. Terry Quinn, Juneau Center SFOS, UAF, 11120 Glacier Hwy., Jueanu AK 99801-8677, 465-5389, FAX 465-6320 or
Dr. Lewis Haldorson, same address as above, 465-6446, FAX 465-6320

INTRODUCTION

This project provides a direct measure of Pacific herring *Clupea pallasi* abundance that is vital to monitoring recovery of the injured PWS herring population. It also provides information about survival of herring eggs and information necessary for interpretation of previous oil spill damage assessment results and improvement of our understanding of long term damage. In addition, abundance estimates from this project are used to set commercial harvest strategies, thereby contributing to the recovery process for PWS herring populations.
Studies of oil spill injuries to herring were initiated in 1989 and continued through 1992 with contributions from both state general funds and the Trustee Council. Oil spill injuries were documented, primarily to embryo and juvenile life stages. PWS herring attained historic high population levels in the four years following the spill, and EVOS herring studies were not conducted in 1993. In 1993 the herring population unexpectedly crashed and population declines continued into1994. Herring are currently listed as not recovering. Spawn depostition

surveys, estimates of eggs lost due to predation and wave action, and laboratory studies of reproductive impairment were conducted in 1994 under Tructee Council funding. Spawn deposition surveys are currently considered the best available method for estimating population abundance. Surveys should continue for one recruitment cycle (4 years) or until the efficacy of an alternative abundance estimation method is proven.

NEED FOR THE PROJECT

Pacific herring are a major resource in Prince William Sound (PWS) from both commercial and ecological perspectives. Five commercial herring fisheries in PWS have an average annual combined ex-vessel value of $8.3 million. Pacific herring provide important forage for many species including some species severly injured by the Exxon Valdez oil spill. Predator species include humpbacked whales, seals, sea lions, gulls, sea ducks, shorebirds, halibut, salmon, rockfish, and other fish. In addition, several thousand pounds of herring and herring spawn on kelp are harvested annually for subsistence purposes and form an important part of the local native culture.

In 1993, the total observed spawning population of PWS herring was less than one third of preseason predictions and and the average sizes of herring in each age class were some of the smallest on record. Only limited commercial herring fishing occurred. Preliminary pathology results implicated viral hemorrhagic septicemia (VHS) as a potential source of mortality and stress. In 1994, as in 1993, the spawning population was again below preseason predictions. Aerial surveys indicated the population was less than minimum threshhold harvest levels and no commercial fishing was allowed. The ex-vessel value of the herring fisheries in 1992 was $12.0. In 1993, the exvessel value dropped to $2.0 million and no commercial harvest occurred in 1994. This project will enable resource managers to better understand herring population dynamics to improve the recovery process. In addition, it will aid local resource users to make appropriate pre-season plans based on accurate and precise herring return projections.

In response to the low apparent return, a comprehensive pathology study was initiated in 1994 to determine whether VHS plays a role in the apparent decline in the herring spawning population and to try to determine the magnitude of the effect. It is not clear whether the Exxon Valdez oil spill may be implicated, although numerous studies have indicated that previous exposure to toxins can reduce immunity to disease. Continuation and completion of the pathology study is being proposed for FY95. Population abundance information from spawn deposition surveys is prerequisite for meaningful interpretation of pathology results.

The cost of this project is reasonable considering the economic value of the commercial fisheries as well as the important contribution that herring of all life stages make to the PWS ecosystem.

PROJECT DESIGN

This project will be conducted in several parts. ADF&G will perform the field component constituting the continuation of herring spawn deposition surveys and egg loss studies in PWS. New elements for this component will include: (1) digitizing of historic spawn distribution information into geographical information system (GIS) format and development of descriptive measurements appropriate for analysis of spawning habitat use, (2) estimation of the incidence of cytogenetic abnormalities occuring in hatching herring, (3) modeling of embryo survival and recruitment in relation to biological and environmental variables. Prince William Sound Science Center will be contracted to perform the spawn map digitizing. Dr. JoEllen Hose with Occidental University will perform the cytogenetic abnormality examinations and data analyses. Dr. Terry Quinn with the Unversity of Alaska, Juneau, will oversee the modeling.

During spawn deposition surveys, SCUBA divers will estimate the abundance and distribution of herring eggs. This information will be incorporated with aerial observations of spawn distribution and basic biological information collected as part of ongoing ADF&G studies (age composition, sex ratios, average size, and fecundity) to estimate adult spawning biomass. Estimates of spawning biomass are used to forecast spawning returns the following year and form the basis of herring fishery management in PWS. New and existing data will be used to develop a classification system for spawning habitat types. Habitat use and spawner/egg density and distribution data collected during this project are needed to develop herring embryo survival models outlined in the Natal Habitat Program (NHP) of Sound Ecosystem Assessment (SEA).

The egg loss study will provide estimates of herring embryos physically removed from spawning areas by predation and wave action. Estimation of egg loss is useful (1) to improve accuracy of biomass estimates by accounting for eggs lost between the time of spawning and the time of spawn surveys and (2) as an important element in the estimation total embryo survival. Total embryo survival to the larval life stage is necessary as an initial population abundance input for life history models described in SEA. Improved understanding of larval production dynamics is also an important adjunct to improving our understanding of processes affecting herring recruitment.

Factors directly affecting survival of embryos to larvae include losses due to wave action and predation, dessication at low tide, cytogenetic abnormalities (which result in nonviable hatched larvae), pathogens, and pollution (which may elevate cytogenetic abnormality levels). These sources of direct mortality may be modified by environmental and biological variables such as wind direction and severity of storms, number of predators present and the availability of eggs to predators, the type of substrate on which eggs are deposited, height of tidal fluctuation, water temperature, and air temperature. The degree to which these modifiers of direct mortality affect survival depends largely on the characteristics of the habitat used for egg deposition. Because it is not practical to measure all sources of morality each year, total embryo survival models will be used to relate mortality to more easily measured or estimated environmental and biological variables and habitat selected.

Objectives:

1. Estimate the biomass of spawning herring in PWS using SCUBA diving spawn deposition survey techniques such that the estimate is within $\pm$ 25% of the true value 95% of the time.

2. Quantify egg loss rates (the proportion of eggs removed through time) from spawning areas due to wave action, predation, dessication, or fungal infections between the time of egg deposition (spawning) and the time of hatching. Quantify egg loss by habitat type and egg density.

3. Incorporate egg loss and egg survival estimates with results from previous studies and revise the models as necessary.

4. Describe herring spawning habitat with respect to temperature, salinity, depth, gradient, substrate, vegetation, and exposure to wave action. Map habitat historically utilized for spawning. Estimate habitat specific abundance and distribution of adult herring and eggs. Test a model of the relationship of spawn timing, spawner density and abundance to egg distribution and density.

5. Incorporate egg loss and survival data with physical oceanograpic and meterological data to formulate and test a model of the relationship of meteorological conditions to wave height and egg desiccation.

6. Test a model of the relationship between predation, wave action, desiccation, fungal infections, egg density, and habitat utilized.

7. Test a model relating sound-wide embryo survival to habitat utilized, egg density, and meteorological conditions.

8. Test a model relating historic recruitment success to biological and environmental variables.

Methods:

Biomass estimation based on spawn deposition surveys consisted of three major components: (1) a spawn deposition survey; (2) age-weight-length (AWL), sex ratio, and fecundity sampling; and (3) egg loss determination.

Spawn Deposition Surveys. Survey design was described in detail by Biggs and Funk (1988), and follows closely the two-stage sampling design of similar surveys in British Columbia (Schweigert et al. 1985) and Southeast Alaska (Blankenbeckler and Larson 1982, 1987). Surveys will use random sampling for the first stage (transects) and systematic sampling for the second stage (quadrats within transects). Surveys will be stratified by area to account for geographic differences and the potential for discrete herring stocks.

Mean egg densities along each transect will be combined to estimate an average egg density by area. Spawning bed width along each of the transects will be used to calculate average spawning bed width by area. Average width, average density, and total spawning bed shoreline length will be used to estimate total number of eggs deposited in each area. Average fecundity, sex ratio, and estimates of total number of eggs deposited will be used to calculate herring population numbers and biomass. Confidence intervals will be calculated assuming a normal distribution of total egg estimates.

The general location of spawning activity will be determined from milt observed during scheduled aerial surveys. This information will be used to randomly select and locate transects. Each transect will be assigned a sequential number and charted on waterproof field maps.

Diving on herring spawn will begin after spawning has ceased. Two three-person dive teams will complete approximately 6 to 12 transects each day to achieve sample goal of about 100 transects. The sample goal of selected transects will be established based on the total length of beaches recieving spawn and variability observed in previous surveys.

Using a 0.1 m^2 PVC pipe frame for a sampling quadrat, the number of eggs, substrate, and vegetation type will be estimated for quadrat locations systematically spaced every 5 meters along a transect until the apparent end of spawn. Samples of eggs and vegetation will be used to correct for diver bias. These diver calibration samples will be collected throughout the dive survey and stratified by diver, vegetation type, and by egg density.

Estimates of the biomass of spawning herring will be calculated from estimates of deposited eggs, fecundity, sex ratio, average size, and age composition similar to methods described by Biggs and Funk (1988) and Biggs et al. *(in press)*. Predictions of returning biomass in the following year will be estimated using methods similar to those described by Funk (1994).

Herring Age, Weight, Length, Sex, and Fecundity. This portion of the project is part of an existing agency program that is conducted annually by ADF&G. AWL information will be collected from major concentrations of herring spawning in each area (Baker et al. 1991a, Baker et al. 1991b, Wilcock et al. *in press*). AWL sampling will be stratified by date and area for each commercial fishery and for test fishing catches in each spawning area. A sample size of 450 herring per stratum will be set to ensure acceptable levels of precision and accuracy. Fecundity samples will be subsampled from among female herring AWL samples and stratified by fish length. Egg and gonad weights will be measured and used to calculate average fecundity at an average female weight. Gonad weight will be used to estimate gonadal somatic index (GSI), a measure of relative maturity defined as the percentage of total herring weight accounted for by gonad weight.

Mean weight and sex ratio will be estimated from AWL samples collected from each of the five spawn deposition summary areas. AWL samples collected during peak spawning in each area will be pooled to estimate mean weight and sex ratio for that area. Average weight and sex ratio for PWS will be estimated as a weighted average of estimates from all areas. Average weight and sex ratio for each area will be weighted by the escapement biomass estimate based on spawn deposition surveys for that area.

Egg Loss. Egg loss was studied during 1990 and 1991in PWS (Biggs et al. *in press*) and an average daily egg loss rate of 2.1% and an average total egg loss of 50.4% over the 22.5 day incubation period were reported. Previous studies did not include collection of data to relate egg loss to habitat type, environmental conditions, or predation. The current study will include modifications to sampling design to improve understanding of these mechanisms behind egg loss. This information and previous results will be used to model embryo survival. Egg loss transects will be established in two areas chosen to represent major spawning areas and will be located within areas to represent typical habitats selected for spawning. PVC pipe grids of 5 x 2 permanent 0.1 m^2 quadrats will be placed along each transect at depths within the range of usual herring spawn. Each transect will be visited every three to four days and divers will make estimates of egg density within each 0.1 m^2 quadrat.

A sample containing about 200 eggs will be collected adjacent to each frames during each visit and depth. Live/dead ratios will be estimated and the eggs will be examined for any signs of egg desiccation and fungal infection. Just prior to hatch, a subsample of live embryos collected for live/dead examination will be immersed in preservative for later evaluation of morphological abnormalities and cytogenetics.

Exclusion frames of approximately 1 m^3 in volume will be placed at representative transect locations to exclude avian predators. The total count of eggs within each frame will be estimated each time the site is visited to estimate the number of eggs consumed by birds. These data will contribute prey availability information to the avian predation on herring roe component of SEA.

Physical measurements including air and water temperature, salinity, precipitation, wind speed and direction, and tide height will be collected at each site during each visit. Measurements of gradient, substrate and vegetation will be collected once when the site is set up. Regional meteorological and oceanographic data will be obtained from shipboard surveys, moored instrumentation, and existing data products from government agencies. These measurements will be used to model the effect of meteorological conditions on egg loss and embryo survival.

Egg Loss Data Analysis. An exponential decay model will be used to estimate loss in numbers of eggs over time corrected for diver bias. Egg loss and egg survival estimates will be synthesized into an embryo survival model that incorporates habitat type and predation. Preliminary analysis of previous egg loss data and embryo survival modeling will be completed in FY94 and will be used to formulate specific sampling design modifications for FY95.

Relevant Literature.

Baker, T.T., S. Sharr, and D.L. Crawford. 1991a. Stock assessment and management of Pacific herring in Prince William Sound, Alaska, 1989. Technical Fishery Report 91-11, Alaska Department of Fish and Game, Juneau, 46 pp.

Baker, T.T., J.A. Wilcock, and B.W. McCracken. 1991b. Stock Assessment and management of Pacific herring in Prince William Sound, Alaska, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 91-22, Juneau.

Biggs, E.D., and F. Funk. 1988. Pacific herring spawning ground surveys for Prince William Sound, 1988, with historic overview. Regional Information Report 2C88-07, Alaska Department of Fish and Game, Anchorage, 73 pp.

Biggs, E.D., T.T. Baker and J.W. Short. *In press*. Studies on Pacific Herring *Clupea pallasi* spawning in Prince William Sound following the 1989 *Exxon Valdez* oil spill, 1989-1992. NRDA Fish/Shellfish Study Number 11. Final Report for the EVOS Trustee Council, 645 G. St., Anchorage.

Wilcock, J.A., T.T. Baker, and E.B. Brown. In Press. Stock assessment and management of Pacific herring in Prince William Sound, Alaska, 1991. Technical Fishery Report 93-xx, Alaska Department of Fish and Game, Juneau.

Schedule:

Jul - Sept 94	Egg loss data analyis and embryo survival modeling
Aug 94	Complete Detailed Project Description
Dec 94	Complete FY94 progress report
Nov 94 - Feb 95	Initiate vessel charter bids and contract
	Secure divers, ensure certification requirements are met or in progress
	Complete data review and sample design for egg loss study
	Complete sample design for diver calibration
Mar 95	Complete any necessary diver certifications
	Order laboratory supplies and field supplies
	Hire personnel to maintain and assemble dive gear
1-5 Apr 95	Complete all hiring of field personnel and arrange for arrival of divers
	Vessel arrives on site for inspection
1-4 Apr 95	HazMat, CPR/First Aid and Dive Safety training; Project orientation
	Set up laboratory
5-15 Apr 95	Initiate diving/field data collection (at onset of spawning)

	Set up egg loss sites and begin diving
1-15 May 95	Complete field activities
	Begin lab processing of calibration, fecundity, and egg loss samples
30 May 95	Complete data entry of diver estimates
May-Jun 95	Maintain, repair, and store gear
15 Jun 95	Complete calibration sample processing
30 Jun 95	Data entry of calibration samples
	Initiate data analysis
15 July 95	Complete egg loss sample processing and data entry
15 Aug 95	Preliminary biomass estimate
1 Sep 95	Finalize estimate of spawning biomass
15 Nov 95	Finalize projection of 1995 run biomass
Dec 95	Complete annual reports

Technical Support:

ADF&G regional and headquarters biometric staff will assist in project planning, review, and reporting for this project. They will also provide primary assistance for analysis of spawn deposition data and generation of biomass estimates using partial funding from this project. Additional biometric and modelling assistance for egg loss data analysis will be abtained through hiring and half time funding for a Biometrician I with ADF&G. Remaining biometric and modelling assistance will be contracted through a Cooperative Service Agreement (CSA) or a Reciprocal Service Agreement (RSA).

Primary databases and analytical files will be stored on the local area network (LAN) of the Cordova ADF&G office and technical assistance for database management for FY94 will be provided by the Cordova office network administrator. Some database management needs will accommodated through funding for a research analyst or equivalent part time position beginning in FY95. In addition, we will coordinate with the SEA plan data managers to ensure that future incorporation and integration with their system can be accomplished.

Laboratory services will be completed at the Cordova ADF&G office with the exception of some collections of intertidal invertebrates and fishes, and samples collected for cytogentic analysis. The intertidal predator samples will be transferred to the Copper River Delta Institute of the USFS to complete their research objectives. Analysis of cytogenetic samples will be subcontracted in FY95.

Location:

This project will be conducted entirely within PWS and it is expected that project results will directly affect the management of PWS herring fisheries. The communities directly affected that house fishermen, vessels involved in the fisheries, processing plants, and support services for the fisheries include Cordova, Seward, Valdez, and Whittier. The subsistence harvests of the native villages of Tatitlek and Chenega will also be directly affected.

PROJECT IMPLEMENTATION

ADF&G has the experience and resources to perform the field work associated with this project. Regular ongoing herring research activities conducted by ADF&G are an integral part of the data collection. Biometric assistance and laboratory analysis will be provided by ADF&G staff or obtained through a RSA with the University of Alaska, Juneau, through Dr. Terrence Quinn. A major component of egg loss, avian predation, will be estimated through a companion project conducted by the Copper River Delta Institute (Dr. Maryanne Bishop) as a component of SEA.

Dr. JoEllen Hose, Occidental College, Los Angeles, CA will be contracted to perform cytogenetic analysis of herring larvae. Dr. Hose developed the techniques used to analyze oil spill damage to PWS herring and is the logical choice for this contract due to her experience with these data.

Digitizing of historic spawn maps may be done by Dr. David Scheel with the Prince William Sound Science Center under a CSA or obtained through competitive bid process.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The proposed study is a continuation of damage assessment studies begun in 1989. In addition, it is a major component of the integrated Prince William Sound Ecosystem Assessment (SEA) investigation initiated in 1994. This project provides the basic estimate of population abundance necessary to completion of most other herring research components. Estimates of total embryo survival from modeling of egg loss/mortality studies, habitat studies, and an avian predation study form the initial inputs for herring life history based models integral to SEA. Herring recruitment modeling portions of the proposed study will provide information about critical life stages needed to refine project design of the juvenile herring trophics and habitat partitioning study component of SEA.

This project will also share information and resources with the herring genetic stock identification study.

Integration of research will require data sharing and coordination with PWS forage fish studies. Because herring are an important forage species, their abundance and distribution information must be integrated with the composition, abundance, and distribution information of other fish species. Because herring and other forage fish may be potential predators, competitors, and prey for each other at various stages throughout their life histories, understanding their respective population structures will improve our understanding of herring early life history and recruitment.

Two other projects, disease impacts on PWS herring populations and reproductive impairment of PWS herring will require sharing of research platforms and extensive exchange of data and results.

PUBLIC PROCESS

As a part of SEA, this program has received significant public involvement and support. Because spawn deposition surveys have been viewed as the best available technique for estimating herring population abundance, there is considerable local support for this study. PWSFERG meetings, during which the SEA plan and its program elements are discussed, are open to the public and advertised at other PWS localities.

PERSONNEL QUALIFICATIONS

1. Project Leader - John A. Wilcock

John A. Wilcock, Herring Fisheries Research Biologist, Alaska Department of Fish & Game, P.O. Box 669, Cordova, Alaska 99574. **Education**: Bachelors of Science, Fisheries, University of Washington, 1978. **Professional Experience**: Fisheries Area Research Biologist, ADFG, 1992-1993; Fisheries Research Project Biologist, ADFG, 1982-1991; Fisheries Technician and Assistant Project Biologist, ADFG, Statewide Stock Biology Section, 1981-1982; Scientific Aide, Washington Department of Fisheries, 1979; Research Aide, Fisheries Research Institute, 1978-1979. **Research Projects**: EVOS injury to PWS herring, 1992-1993; Prince William Sound Eshamy District scale patterns analysis stock identification study, 1992-1993; Project Leader, Yukon River chum salmon scale pattern analysis feasibility study, 1988-87; Project Leader, Yukon River chinook salmon stock biology project 1982-1989. **Selected Publications**: Wilcock, J. A., *Annual Reports 1983-1987. Origins of Chinook Salmon in the Yukon River Fisheries.* Technical Fishery Reports. ADF&G, Juneau, Alaska; Wilcock, JA, TT Baker, ED Brown. *Stock Assessment and Management of Pacific Herring in Prince William Sound, Alaska, 1991.* Technical Fishery Report. ADF&G. Juneau, Alaska (1993). **Member**: American Fisheries Society, Alaska Chapter.

2. Project Co-Leader - Evelyn Brown

Evelyn D. (Biggs) Brown, M.S., Herring Fisheries Research Biologist, Alaska Department of Fish and Game, P.O. Box 669, Cordova, Alaska 99574. **Education**: Masters of Science, Fisheries and Aquacultural Engineering, Oregon State University, 1980; Bachelors of Science, Zoology and Chemistry, University of Utah, 1977. **Professional Experience**: Herring Research Project Leader, ADFG, 1988-1993; Sonar Project Leader-Mullet Project, Florida Department of Natural Resources, 1987-1988; Sonar Project Leader-Copper River, ADFG, 1985-1987; Marine Biologist-Shipboard Duty, NOAA, 1983; Fisheries and Marine Biologist for Metlakatla Indian

Community, Annette Island, Alaska, 1980-1982. Currently, she is the project co-leader for the spawn deposition program and a representative for herring on the science committee for PWSFERG and SEA. **Research Projects**: Principal Investigator for Injury to PWS Herring After the Oil Spill, 1989-1993; Spawn Deposition Survey-Underwater Research Program, 1988-1992; Mullet Study using Hydroacoustics, Manistee River, Florida, 1987-1988; Miles Lake Salmon Enumeration Sonar, 1985-1987; Marine Mammal-Japanese Fleet Interaction Research, 1983; Annette Island Crab and Abalone Subsistence Harvest Plan, 1981; Annette Island Environmental Impact Statement for Timber Harvest Activities, 1981-1982; Annette Island Herring Management Plan, 1981-1982; Annette Island Salmon Stream Inventory and Recommended Escapement, 1981-1982; Annette Island Oyster Culture Commercial Feasibility Project, 1980-1981; **Selected Publications:** Recently submitted a paper for the EVOS symposium proceedings to be published in 1995 entitled *The Exxon Valdez Oil Spill and Pacific herring in Prince William Sound: a summary of injury from 1989 - 1994* co-authored by the damage assessment research team. Biggs, E.D. et al.; Biggs, E.D. and F. Funk, *Pacific herring spawning ground surveys for Prince William Sound, 1988, with historic overview.* ADFG Regional Informational Report, 2C88-07. Anchorage, Alaska. 45 p (1988). **Member**: American Fisheries Society, Alaska Chapter.

3. Biometric Support:

David Evans, Biometrician I, CFMDD, ADF&G, Anchorage. 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.

(Still need biographies Terry Quinn and JoEllen Hose. Scheel?)

FY95 BUDGET

Line Item	Cost	Comment
Personnel	$172,426	Fish and Game Salaries
Travel	$ 4,800	
Contractual		
RSA-Quinn (Component B)	$ 80,000	Includes 20% overhead
GIS Mapping and Processing	$ 36,000	
Cytogenetic Abnormalities	$ 59,000	
Vessel Charter	$ 64,000	
Misc.	$ 59,600	
TOTAL	$249,600	
Supplies	$ 11,900	
Equipment	$ 5,100	Includes seine and CTD
Capital Outlay	$ 00	
Total	$443,826	
General Administration	$ 49,510	
Grand Total	$493,336	

Factors Affecting the Recovery of Prince William Sound Pigeon Guillemot Populations

Project Number: 95173

Project Leader: D. Lindsey Hayes

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $337K (includes $55K for FY 95 report preparation)

Project Start-up/Completion Dates: 1/95-3/96

Project Duration: Five years, depending on frequency and duration of forage fish project.

Geographic Area: Prince William Sound

Contact Person: David Irons
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3681 or 786-3376

B. Introduction

The population of pigeon guillemots (*Cepphus columba*) in Prince William Sound (PWS) has decreased from about 15,000 in the 1970s (Isleib and Kessel 1973) to about 3,000 in 1993 (Sanger and Cody 1993). There is evidence (Oakley and Kuletz 1993) suggesting that this population was in decline before the *Exxon Valdez* oil spill in March of 1989. An estimated 2,000 to 3,000 pigeon guillemots were killed throughout the spill zone during that event (Piatt et al. 1990). Censuses of guillemots conducted before and after the spill indicated that pre-spill counts (ca. 2,000) in the study area (Naked Island and vicinity) monitored during Bird Study Number 9 (Oakley and Kuletz 1993) were roughly twice that of post-spill counts (ca. 1,000). Also, relative declines in the populations of guillemots were greater along oiled shorelines than unoiled shorelines. Latent effects from the spill might still be affecting the population because guillemots do not breed until three or four years of age.

Adult guillemots delivered schooling fish, particularly sand lance (*Ammodytes hexapterus*), to their chicks less frequently after than before the spill (Oakley and Kuletz 1993) suggesting a possible food-related component to their decline. Predation of eggs and chicks, apparently not important previously (Oakley 1981), might now play a greater role in the lower reproductive success of guillemots observed by Oakley and Kuletz (1993).

This study is a continuation of the pigeon guillemot Recovery Monitoring Project (No. 94173), and an extensive survey of pigeon guillemot colonies in PWS (Project No. 93034;

Sanger and Cody 1993). Bird Study Number 9 (Oakley and Kuletz 1993), begun in 1989 immediately after the oil spill, compared various population and reproductive parameters of pigeon guillemots measured both before (Oakley and Kuletz 1979; Kuletz 1981, 1983; Oakley 1981) and after the spill.

The goal of the present study is to determine whether food, predation, direct toxicity from oil, or adult mortality is limiting the recovery of the pigeon guillemot population in PWS. Information on the abundance and distribution of schooling fish collected by the forage fish project (No. 94163), in conjunction with our own studies of the guillemots' diet and foraging habits, will help us address the question of food as the limiting factor.

C. Need for the Project

Considerable baseline data on pigeon guillemot populations and foraging and reproductive ecology in PWS have been collected both before and after the oil spill. Continuation of these efforts is essential to determine what factors are limiting the recovery of this species. Food supply, predation, or oil toxicity might limit reproductive success. This project will evaluate the relative importance of these three factors.

D. Project Design

1. Objectives:

(a) Determine if the availability of food is limiting reproductive success by:

i) Measuring breeding phenology, egg volume, chick growth rates, fledgling weights, and reproductive success at colonies on Naked Island and at least one other area determined in the 1994 field season.

ii) Measuring diet and provisioning rates of chicks, duration of foraging trips by parents, and location of foraging areas.

iii) Assessing forage fish abundance in guillemot feeding areas (forage fish project).

(iv) Assessing abundance of nearshore demersal fishes.

(b) Determine if predation on eggs or chicks is limiting reproductive success by measuring relative rates of predation during the egg and chick stage, in different nesting habitats, and at different colonies.

(c) Determine if direct toxicity of oil is limiting reproductive success by determining if there is persistent oiling of guillemot eggs.

(d) Determine if adult survival and recruitment is limiting recovery of the PWS guillemot population by observing returns of color-marked birds.

2. Methods

Reproductive success will be monitored using standard field techniques involving periodic nest checks. Morphometric data for determining growth rates will be acquired at regular intervals during the chick-rearing period.

Provisioning rates and diets of chicks will be determined whenever possible throughout this period by observing them from strategically located blinds. Radio-tagged birds will be tracked to their foraging grounds.

Predation rates will be recorded for all known nests. Time-lapse videography or that triggered by infrared sensors will be used in an attempt to document predation and identify predators as well as monitor activity budgets of chick-rearing guillemots.

An approved protocol will be used to collect unhatched eggs to be stored and shipped in sealed jars for hydrocarbon analysis. Estimates of adult survival will require the successful marking of breeding adults with color bands during the 1994 and 1995 (and any future) field seasons. Because of the high degree of nest-site fidelity in pigeon guillemots, known breeding birds not sighted the following season will be assumed to be dead. Marked birds are also useful in determining sex, activity budgets, and reproductive histories of individual birds.

3. Schedule

January - April: Prepare for field work
May - August: Data collection
September - November: Data analysis
December - January: Report writing
February 15: Draft report
March 31: Final report

4. Technical Support:

Hydrocarbon analysis will be contracted to Texas A&M University.

6. Location:

Naked Island and vicinity, which is surrounded by a shallow shelf, supports only about one fourth of the PWS Pigeon Guillemot population. Because the 1993 pigeon guillemot colony survey showed that Naked Island is not representative of all habitats utilized by guillemots in Prince William Sound (Sanger and Cody 1993), at least one other area selected during 1994 field season will be studied. The other study area(s) will be chosen based on the following criteria: (1) existence of a relatively large number of breeding guillemots, (2) accessibility of nest sites for monitoring, and (3) bathymetric characteristics (deep water relative to that of Naked Island).

E. Project Implementation

The USFWS is the most appropriate entity to conduct this project. The USFWS has conducted marine bird surveys and research in Prince William Sound, including studies of guillemots at Naked Island, since the 1970's, and is therefore well qualified to conduct this study. Barge transport of field equipment from Whittier to Naked Island, and hydrocarbon analysis are the only aspects of this project considered appropriate for contract bidding.

F. Coordination of Integrated Research Effort

This project is integrally related to the NOAA forage fish project (No. 94163), and a proposed study of prey energetics that will be conducted via NOAA's Broad Agency Assessment (BAA). The forage fish project will assess the abundance of forage fish in key foraging areas, while the energetics project will provide information on the effects on guillemots of their feeding on prey of varied energetic values. Data from the present study, and the proposed kittiwake and puffin studies, will provide a three-pronged approach to addressing the question of food limitations on marine bird population recovery.

The guillemot project will share a field camp with some of the personnel from the proposed marbled murrelet, kittiwake, and puffin studies. Transport of equipment, communications with Anchorage, and data collection will be shared among these three projects. A coordinated effort among all the projects is expected throughout the lives of these biologically related studies.

G. Public Process

The public will be invited to comment on this project if it becomes part of the FY95 work plan. If funded, results will be presented at Trustee Council-sponsored workshops each winter.

H. Personnel Qualifications

Project Leader: D. Lindsey Hayes

Lindsey received his B.S. in marine biology from the University of Hawaii in 1978. He then obtained an M.S. in health physics/radioecology in 1983 from Colorado State University and worked as an environmental health physicist for a while before returning to school. He received another M.S. (in zoology) from the University of Maine in 1993. Lindsey spent two field seasons in the Gulf of Maine studying the behavioral ecology of black guillemots and their interactions with sympatrically-breeding gulls. Specifically, he looked at the effects of kleptoparasitism by herring gulls and predation by great black-backed gulls on the chick-provisioning capabilities of guillemots. He also supervised a project during the 1993 field season working on the breeding and feeding ecology of numerous species of seabirds in the Semidi Islands, Alaska. Lindsey has been involved in other seabird projects in the central and south Pacific and presented the results of his graduate research at the 1993 Pacific Seabird Group meeting.

Pertinent reports and publications:

Hayes, D.L. 1993. Kleptoparasitism and predation of Black Guillemots (*Cepphus grylle*) by gulls in the Gulf of Maine. Unpublished M.S. thesis. Univ. of Maine. 79 pp.

Assistant Project Leader: Mary Cody

Mary Cody received her B.A. in 1987 from the University of Michigan. Mary has worked with the USFWS Migratory Bird Management Division since 1989. After working on the effects of the oil spill on black oystercatchers, she joined the 1990 USFWS marbled murrelet and pigeon guillemot damage assessment study. In 1990, she conducted extensive habitat surveys for the murrelet restoration study in PWS and continued guillemot work on Naked Island. In 1992, she supervised pigeon guillemot and marbled murrelet research on Afognak Island, Alaska, and assisted on seabird surveys. In 1993, she was the assistant project leader on the PWS pigeon guillemot colony survey, and has co-authored several publications and reports on pigeon guillemots, marbled murrelets, and other seabirds.

Pertinent reports and publications:

Cody, M.B., and G.A. Sanger. 1994. Survey of pigeon guillemot colonies in Prince William Sound, Alaska. Abstract. Pacific Seabird Group Bulletin.

Cody, M.B., and T.P. Gerlach. 1993. Distribution and activity levels of marbled murrelets at coastal and inland sites on Afognak Island, Alaska. Biological Report. U.S. Fish and Wildlife Service, Anchorage, Alaska. 15 pp.

Cody, M.B., J. Fadely, and T.P. Gerlach. 1993. Population estimates of nesting seabirds along the northern and southwestern coast of Afognak Island, Alaska. Biological Report. U.S. Fish and Wildlife Service, Anchorage, Alaska. 33 pp.

Cody, M.B., J. Fadely, and T.P. Gerlach. 1993. Population status and distribution of pigeon guillemots along the northern and southwestern coast of Afognak Island, Alaska. Biological Report. U.S. Fish and Wildlife Service, Anchorage, Alaska. 27 pp.

Fadely, J., T.P. Gerlach, and M.B. Cody. 1993. Distribution and population estimates of marine birds in the near-shore and pelagic waters of Afognak Island, Alaska. Biological Report. U.S. Fish and Wildlife Service, Anchorage, Alaska. 18pp.

I. Budget ($K)

Personnel	$185.0
Travel	10.0
Contractural	85.0
Commodities	15.0
Equipment	25.0
Capital Outlay	0.0
Subtotal	$320.0
General Admin.	33.7
Total	$353.7

J. Literature Cited

Isleib, M.E.P., and B. Kessel. 1973. Birds of the north Gulf Prince William Sound region, Alaska. Biol. Pap. Univ. of Alaska 14:1-149.

Kuletz, K.J. 1981. Feeding Ecology of the Pigeon Guillemot (*Cepphus columba*) at Naked Island, Prince

William Sound, Alaska and surveys of the Naked Island complex. U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska. 23 pp.

Kuletz, K.J. 1983. Mechanisms and consequences of foraging behavior in a population of breeding Pigeon Guillemots. Unpub. M.S. Thesis. Univ. of California, Irvine. 79 pp.

Oakley, K.L. 1981. Determinants of population size of Pigeon Guillemots *Cepphus columba* at Naked Island, Prince William Sound, Alaska. Unpublished M.S. Thesis. U. Alaska, Fairbanks. 65 pp.

Oakley, K.L., and K.J. Kuletz. 1979. Summer distribution and abundance of marine birds and mammals near Naked Island, Alaska. U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska. 95 pp. + appendices.

Oakley, K.L., and K.J. Kuletz. 1993. Population, Reproduction and Foraging ecology of Pigeon Guillemots at Naked Island, Prince William Sound, Alaska, Before and After the *Exxon Valdez* Oil Spill. Bird Study No. 9. 65 pp.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek, and D.R. Nysewander. 1990. Immediate impact of the 'Exxon Valdez' oil spill on marine birds. Auk 107:387-397.

Sanger, G.A., and M.B. Cody. 1993. Survey of Pigeon Guillemot Colonies in Prince William Sound, Alaska. U.S. Fish and Wildlife Service. Final Report. 58 pp.

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Closeout: Pigeon Guillemot Recovery Monitoring (94173)

Project Number 95173 (closeout)

Project Leader: D. Lindsey Hayes

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $55.2K

Project Start-up/Completion Dates: 10/1/94 - 03/31/95

Project Duration: N/A

Geographic Area: N/A

Contact Person:

Catherine Berg
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3598

B. Introduction

This project is the closeout of 94173 - Pigeon Guillemot Recovery Monitoring. The purpose of this project was to identify factors which might be causing pigeon guillemot population declines in Prince William Sound by monitoring productivity and studying the birds' diets and foraging habits.

C. Need for the Project

Not applicable.

D. Project Design

1. Objectives:

The purpose is to analyze 1994 project data and prepare a final report. The report will be prepared for the peer-review process and presentation to the Trustee Council.

2. Methods

Not applicable.

3. Schedule

October - December: Data analysis
December - January: Report writing
February 15: Draft report
March 31: Final report

4. Technical Support:

Not applicable.

6. Location:

Report preparation will occur at the Fish and Wildlife Service Regional Office in Anchorage, Alaska.

E. Project Implementation

The USFWS is the most appropriate entity to analyze the data and write the report.

F. Coordination of Integrated Research Effort

Not applicable.

G. Public Process

This project was reviewed by the public as part of the FY94 Work Plan.

H. Personnel Qualifications

Not applicable.

I. Budget ($K)

Personnel	$47.0
Travel	1.0
Contractual	0.0
Commodities	0.0
Equipment	0.0
Capital Outlay	0.0
Subtotal	$48.0
General Admin.	7.0
Total	$55.4

J. Literature Cited

Not applicable.

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Investigating and Monitoring Oil Related Egg and Alevin Mortalities (Field Study)

Project Identification Number: 95191a

Lead Agency: ADF&G **Cooperating Agencies:** NOAA

Cost of Project, FY95: $ **Cost of Project, FY96:** $

Project Startup Date: 3/1/94 **Duration:** 5 years

Geographic Area: Prince William Sound

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 average from 10-15 million fish annually. These huge outmigrations of wild pink salmon and subsequent adult returns play a major role in the 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. Salmon egg mortalities were 67%, 51%, 96%, 79%, and 59% higher in oiled streams than in comparable and nearby unoiled streams in 1989, 1990, 1991, 1992, and 1993, respectively. 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.

The proposed damage assessment and resource monitoring study is a continuation of past EVOS Trustee Council funded work conducted by the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS). It will consist of field and laboratory studies conducted in western PWS and additional laboratory studies at the NMFS Research facility at Little Port Walter in southeastern Alaska. Results of the project will direct future restoration efforts for pink salmon and may impact future harvest management strategies in PWS fisheries.

The project will continue to monitor egg mortalities in the oiled and unoiled wild pink salmon streams previously studied, examine stream characteristics unrelated to oiling which may partially or completely explain the observed differences in egg mortality, and provide a laboratory evaluation of the 1989 and 1990 field results. The laboratory evaluation will also test the hypothesis that oil contamination during incubation can result in functional sterilization.

C. Need for the Project

Information gained from this study will provide resource managers insight to the magnitude and persistence of damages sustained by wild pink salmon due to EVOS. Efforts to restore damaged pink salmon populations depend upon the fishery manager's abilities to identify sources of reduced survival and to monitor their persistence. Information on the potential of long term oil exposures to cause genetic damage is needed so spawning escapement goals can be reevaluated and adjusted if necessary. In addition, verification of the genetic hypothesis would provide the first evidence that reproductive capacity of fish exposed to chronic or acute sources of oil pollution would be compromised.

D. Project Design

1. Objectives:

Component A - Recovery Monitoring of Injury to Pink Salmon Embryos in PWS

a. Estimate the density, by tide zone, of embryos in 31 streams using numbers of live and dead eggs and fry.

b. Estimate mortality of pink salmon embryos in both oil contaminated and unoiled (reference) streams.

c. Assess any loss in adult production from changes in embryo mortality using results of past NRDA studies.

Component B - Evaluation of Injury to Pink Salmon Gametes in PWS

a. Determine whether the increased pink salmon embryo mortalities observed in oil contaminated streams in 1989, 1990, 1991, 1992 and 1993 can be attributed to the physical characteristics of study streams.

Component C - Laboratory Evaluation of Injury to Pink Salmon Embryos and Preemergent Fry Exposed to Oiled Incubation Substrate

a. Determine survival, genetic damage, hydrocarbon uptake, mixed function oxidase activity, and sublethal teratogenic effects from long term exposures to oil in eggs exposed from fertilization to emergence.

b. Determine growth characteristics from each exposure group from juvenile stage to maturity.

c. Assess whether differences exist among exposure groups with respect to fecundity, fertilization rate, genetic damage, and sub-lethal teratogenic effects in the second generation progeny through swim-up.

Combining Field Observations and Laboratory Results

a. Determine in the elevated embryo mortalities in 1989 and 1990 were potentially caused by oil in the environment.

b. Determine if the elevated embryo mortalities in oil contaminated streams in 1991 and 1992 were potentially caused by genetic damage to 1989 and 1990 embryos.

2. Methods:

Component A - Recovery Monitoring of Injury to Pink Salmon Eggs and Preemergent Fry in PWS

A systematic sampling program stratified by stream and tide zone will be used to collect egg, embryo density and survival data from 10 oil contaminated and 15 reference sites sampled previously in NRDA Fish/Shellfish Study 2, Restoration Science Study R60C, and Restoration Science Study 93003. Sampling will consist of embryo sampling conducted in late September and early October. Egg and embryo data will be summarized by date, stream, level of hydrocarbon impact, and stream zone. Density estimates will be used to assess adult spawning success. Relative numbers of live and dead embryos will be used to test for continued reductions in survival in oil contaminated streams.

Component B - Evaluation of Injury to Pink Salmon Gametes in Prince William Sound

This project will continue to monitor the incubation of the Intra-stream crosses made during Restoration Science Study 93003. Embryos from the crosses will be incubated through hatching in a controlled laboratory environment. Egg mortalities will be compared for all crosses. Crossing results will be compared to results from field studies to determine the effect of stream characteristics on egg mortality differences previously observed between oiled and unoiled sites.

Component C - Laboratory Evaluation of Injury to Pink Salmon Eggs and Preemergent Fry Exposed to Oiled Incubation Substrate

This project will evaluate the degree of damage to embryos incubating in oiled substrate and determine the subsequent effects on fertility. Incubating pink salmon embryos will be exposed to oiled gravel in incubators from fertilization to emergence. Surviving fry will be grown to maturity and crossed with partners incubated under the same dose of oil. Relationships between dosage and fertility will be observed in addition to relationships between dosage and developmental success.

Finally, the screening for petro-chemical incuced microlesions and macrolesions will be completed on individuals of known oiling history (including unoiled controls). Emphasis will shift away from flow cytometric analyses this project year to focus on the techniques of 1) haploid androgenesis and 2) DNA sequencing of rapidly evolving regions of DNA. A contractor will screen for deletrious recessive mutations (recessives are to be expected in the tetraploid-derived genome) using haploid androgenesis. Peer reviewers have recommended that we use a PCR-based approach to sequence the control region of mtDNA to maximize the probability of detecting genetic damage. Other regions of DNA will be targetted based upon the results of the control-region screen.

3. Schedules:

Component A:

Oct 1-15 1994	In stream embryo sampling	
Oct 30-Dec 30 1994	Analysis of embryo data and completion of	FY93
final report		

Component B:

Oct 1-Nov 15 1994	Monitor incubators and collect data
Nov 15 1994-Jan 30 1995	Analyze data and prepare annual report

Component C:

Time Period	1992 Brood Year	1993 Brood Year
1 Sept 94 - 15 Apr 95	Incubate F1	Culture in netpens
15 Apr - 1 Sept 95	Analyze incubation data from F1, prepare report	Spawn mature adults

1 Sept 95 - 15 Apr 96	N/A	Incubate F1
15 Apr - 1 Aug 96		Analyze incubation data
from F1,		prepare final
report		

4. Technical Support:

The project biometrician will ensure that the study design will provide a reasonable chance of reaching a defendable conclusion.

A DNA technician will ensure proper tissue collection and preparation procedures, operate the flow cytometer, and perform sequencing.

Gary Thorgaard, Washington State University, will provide the laboratory and technical expertise to perform the androgenetic screen.

A chemist is required to establish a dosing protocol, determine hydrocarbon concentrations, and evaluate results of hydrocarbon analysis.

Contracts will be required for histopathological and mixed-function oxidase work. It is essential that the results of this controlled experimentation be consistent with the results gathered under NRDA.

5. Location:

Component A. All embryo and preemergent fry monitoring will take place in Prince William Sound.

Component B. The experiment designed to evaluate the effects of environment on egg mortality will collect gametes from streams in Western Prince William Sound and incubate the resulting embryos at the Armin F. Koernig hatchery in Prince William Sound.

Component C. The experiment designed to test the effects of oil contaminated incubation substrate on gamete viability will be performed at the National Marine fisheries Service Laboratory at Little Port Walter, Baranof Island, southeastern Alaska.

Work dealing with the assessment of genetic damage will be performed in the Genetics Laboratory at the Regional Fish and Game Office in Anchorage unless performed by Washington State University under contract.

E. Project Implementation

This will be a joint project between ADF&G and NMFS. ADF&G will be the lead agency for overall program management and genetic damage determinations. ADF&G will be responsible for field monitoring, gamete fertilization, and incubation in Components A and B. NMFS will be responsible for oil exposures, chemistries, fish culture, and hydrocarbon end points in Component C. Both agencies will have statistical analyses responsibilities, particularly with the experimental designs. Both agencies will have joint responsibilities for meshing the lab and field results to reach a conclusion in the study. ADF&G and NMFS have both successfully completed their responsibilities for this project in prior years and their results have been reported in a thorough and timely manner.

The ADF&G is the logical agency to conduct Components A (field monitoring) and B (evaluation of injury to gametes) of this project. They have a statutory obligation to manage Alaska's wild salmon resources and have conducted field monitoring studies of embryos and pre-emergent fry since 1961 as part of their pink and chum salmon forecasting program. They also have a long history of expirmental fish culture in PWS, they have a highly qualified group of geneticists on staff in a well equiped genetics laboratory, and their biometrics staff is particularly suited to analyzing appled fisheries data.

The facilities and staff of the NMFS make this the logical agency to conduct Component C of this study. The Auke Bay Laboratory and Little Port Walter field station personnel have extensive experience with fish related hydrocarbon dose response experiments, hydrocarbon chemical analyses, and culturing salmon from embryos to mature adults. The expirimental incubation system is already in place for a dose response expiriment at Little Port Walter and the pen rearing set up which NMFS currently uses to rear chinook to the mature adult stage at that facility are equally well suited to pink salmon.

F. Coordination of Integrated Research Effort

The foundations for this project date back to the original NRDA F/S Study 2 (Injury to Salmon Eggs and Preemergent Fry). NRDA F/S Study 2 was equivalent to the field monitoring portion of this project (Component A) and was conducted in 1989, 1990, and 1991. The same project was continued as Restoration Study R60C in 1992. Two additional elements (Components B and C) were added to Restoration Study R60C during the summer of 1992. These additions were designed to assess the genetic damage hypotheses raised through NRDA F/S Study 2. All three components were present in the 1993 project, Restoration Study 93003. This project, 95191, is the continuation of work started in Restoration Study R60C and continued in Restoration Study 93003.

Several past NRDA and present Restoration projects have been and continue to be intimately related to this project. The 1989 and 1990 NRDA F/S Study 4 demonstrated reduced growth and survival for salmon which reared in oiled areas. NRDA F/S Study 1 in 1989, 1990, and 1991 and subsequent Restoration Study R60B in 1992, investigated oil damage to adult pink salmon spawning populations and provided valuable improvements in escapement estimation procedures used by fisheries managers to monitor and protect injured wild pink salmon populations. NRDA F/S Study 3 in 1989, 1990, and 1991 and subsequent Restoration studies R60A in 1992 and 93185 in 1993 provided hatchery and wild catch contribution estimates. This information was used by fisheries managers to reduce fisheries exploitation rates on injured wild pink salmon and also provided survival estimates for groups of fish examined by NRDA Study 4. The 1989, 1990, and 1991 NRDA F/S Study 28 and a subsequent Restoration study in 1992, incorporated data from all the previous studies into life history and run reconstruction models. These models were used to extrapolate losses in adult pink salmon production from injuries observed in earlier life history stages.

The field data collection for Component A of this project is very specific to individual wild pink salmon streams and precedes or follows most field activities of the PWS Sound Ecosystem Assessment program (SEA) and other pink salmon related projects consequently extensive coordination of field activities is not feasible. However, the vessel used by this project does collect physical and biological oceanographic data for the ADF&G, PWSAC, and University of Alaska Cooperative Fisheries and Oceanographic Study and these data will be utilized by several SEA studies.

The field portion of Component B includes streams that are also listed for sampling by the proposed pink salmon genetics study. Tissue samples from carcasses of fish sacrificed for eggs and sperm in these streams will be collected for genetic analyses.

Component C of this project occurs at Little Port Walter on Baranof Island in Southeast Alaska and there is little opportunity for coordination with other projects with respect to data collection.

Final edited data from all three components of this project will be stored electronically as computer databases and final versions will be provided annually to the Information Modeling portion of SEA for incorporation into a centralized ecosystem database.

G. Public Process

Many of the field procedures used in the field monitoring portion (Component A) of this project have been employed as part of the data collection activities for preemergent fry indices used in PWS pink salmon forecasts for more than 30 years. The procedures have been presented and reviewed at a multitude of workshops and scientific meetings, are widely understood by the fishing industry, and have undergone peer review through the NRDA process. Field monitoring methodologies were presented at the 1991 Pink and Chum Workshop in Parksville, British Columbia, Canada. Field monitoring results from 1989, 1990, 1991, and 1992 were presented at the 1993 meeting of the Alaska Chapter of The American Fisheries Society in Valdez, Alaska, the 1993 Oil Spill Symposium in Anchorage, Alaska, and the 1993 Pink and Chum Workshop in Juneau, Alaska. Abbreviated operational plans for 1989 through

1994 egg and alevin mortality studies have been published annually in EVOS Trustee Council work plans which incorporate public comment.

H. Personnel Qualifications

Fisheries Biologist III - 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 Finfish 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 and has been the Principal Investigator for those projects since their inception.

Principal Geneticist - James E. Seeb

Jim Seeb earned a B.S. in Biology (1974) from the University of Puget Sound, an M.S. in Fisheries (1982) and a Ph.D. in Fisheries (1987) from the University of Washington. Jim has worked as a Fish Biologist for the Washington Department of Fisheries (1978-1980) and Pacific Fisheries Research (1980-1982), as a Graduate Research Assistant at the University of Washington (1982-1986), a Research Assistant Professor at the University of Idaho (1987-1988), and as an Assistant Professor at Southern Illinois University (1988-1990). Presently, Jim is the Principal Geneticist for FRED Division of the Alaska Department of Fish and Game and has overall responsibility for fisheries genetic issues throughout Alaska. Dr. Seeb has published extensively in the Fisheries and Genetics Literature. He has worked with many fish species on numerous genetic topics including but not limited to genetic marking and its use to assess stock dynamics and management programs, genetic variation and postglacial dispersal of populations, the use of genetic structure in the enforcement of fishing regulations, and the measurement of DNA content using flow cytometry.

GS-14 Physiologist - Stanley D. Rice

Received BA (1966) and MA (1968) in Biology from Chico State University, and Ph. D. (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader, and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay

Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chem labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

Biometrician II - Brian G. Bue

Brian Bue has a Bachelor of Science in Biology and a Bachelor of Science in Fisheries from the University of Alaska, Fairbanks. He also possesses a Masters degree in Fisheries with an emphasis on quantitative studies from the University of Alaska, Fairbanks. Brian has worked with the Alaska Department of Fish and Game from 1974 through present in many capacities. He has worked as a consulting biometrician on oil spill damage assessment projects since the first days of the *Exxon Valdez* spill.

GS-13 Chemist - Jeffrey Short

Mr. Short is an analytical chemist at the Auke Bay Laboratory (ABL), and leads the hydrocarbon analysis facility at ABL, which is one of the two laboratories analyzing *Exxon Valdez* NRDA hydrocarbon samples. Mr. Short holds a B.S. in biochemistry and an M.S. in physical chemistry from the University of California. He is principal investigator (PI) of NRDA project Subtidal Study #3, and was among the first scientists to collect samples 7 days after the spill: he was awarded both individual and unit citations from NOAA for these efforts. Mr. Short has conducted extensive research on the effects of Alaskan crude oils to Alaskan marine biota over a period of 10 years prior to the *Exxon Valdez* oil spill.

GS-11 Fisheries Biologist (Research) - Ron A. Heintz

Ron Heintz has a Bachelor of Science in Ecology from the University of Illinois (1979), and a Masters degree in Fisheries from the University of Alaska, Fairbanks (1987). He has worked for the National Marine Fisheries Service since 1985 concentrating his efforts on salmon enhancement research. He is the principal investigator and co-investigator on several salmon genetics projects.

Fisheries Biologist II - Gary Miller

Gary Miller is the flow cytometry specialist for the Alaska Department of Fish and Game Genetics Laboratory in Anchorage. Gary has a Bachelor of Science in Fisheries Biology from the University of Washington, a M.S. in Zoology from Southern Illinois University - Carbondale, and is currently pursuing his Ph.D. from the University of Washington. He has worked periodically for the Alaska Department of Fish and Game since 1981. He has a strong background in genetics and developmental biology and has conducted research and co-authored projects in hybridization, polyploid induction, allozyme expression, and growth performance of triploid salmonids and other fishes. He has extensive laboratory experience with techniques including flow cytometry, protein starch gel electrophoresis, protein and molecular marker analysis, and fluorescent antibody testing of pathogens.

I. BUDGET

	ADF&G	NOAA	TOTAL
Personnel	245.6	213.6	459.2
Travel	10.1	11.0	21.1
Contractual	58.1	60.0	118.1
Commodities	27.0	41.0	68.0
Equipment	2.1	13.0	15.1
Capital Outlay	0.0	0.0	0.0
Sub-total	342.9	338.6	681.5
General Administration			
Project Total			
NEPA Compliance	0.0	0.0	

Injury to Salmon Eggs and Pre-emergent Fry Incubated in Oiled Gravel (Laboratory Study)

Project Number: 95191-B

Project Leaders: Stanley D. Rice, National Marine Fisheries Service
Ron Heintz, National Marine Fisheries Service
Jeffrey Short, National Marine Fisheries Service

Lead Agency: National Marine Fisheries Service

Project Cost: FY95 $165.5K FY96 $324.0K

Start Date: October 1, 1994

Finish Date: September 30, 1995

Geographic Area of Project: Little Port Walter, Alaska

Contact Person: Bruce Wright
National Marine Fisheries
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, AK 99821
907-789-6600

B. INTRODUCTION

The purpose of this study is to provide laboratory verification of the Pink Salmon egg mortalities from field observations presented by Sharr et al. (1991), and test the hypothesis that exposure of pink salmon eggs/alevins to an oiled incubation habitat will result in the functional sterilization of these animals at sexual maturity. This study, currently underway, utilizes controlled laboratory oil exposures to fertilized eggs in a simulated intertidal gravel environment in order to mimic environmental exposures of 1989 and 1990 (link to NRDA Study FS2). Measurements of survival, abnormalities, growth and hydrocarbon uptake will be made during exposure and rearing to sexual maturity, but the most important observation is the evaluation of gamete viability by crossing fish once they have matured.

Pink salmon were affected by the oil spill in 1989, at several life stages. Impacts to eggs, alevins, and fry were measured. With the crash of stock abundance in 1993, there was elevated concern for the long lasting effects of oil exposure, and if exposure to oil would create long lasting effects that would impact recovery. Genetic damage after oil exposures has not been observed in other oil spills, but the unique life history of intertidal spawning provides a long term oil exposure (8 months) to the developing eggs and larva. The observations of elevated egg mortalities in oiled intertidal streams long after the spill (1990 through 1993) suggest that long lasting effects, no longer from direct oil exposure may be occurring. The 1993 ADFG experiment that measured elevated egg mortalities from oiled streams in spawn removed to a hatchery environment (where the environment is the same for each stock) gives the long lasting effects hypotheses more credence.

This is a continuing project that was started in 1992 with the spawning of the 1992 brood year, and was repeated with the 1993 brood. This project should continue through the spawning of the 1992 brood in 1994, and the spawning of the 1993 brood in 1995, with an evaluation of the progeny viability and survival through hatch in 1996.

C. NEED FOR THIS PROJECT

Information gained from this study will provide resource managers insight to the magnitude and persistence of damages sustained by wild pink salmon due to EVOS. Efforts to restore damaged pink salmon populations depend upon the fishery manager's abilities to identify sources of reduced survival and to monitor their persistence. Information on the potential of long term oil exposures to cause genetic damage is needed so spawning escapement goals can be reevaluated and adjusted if necessary. In addition, verification of the genetic hypothesis would provide the first evidence that reproductive capacity of fish exposed to chronic or acute sources of oil pollution would be compromised.

D. PROJECT DESIGN

The functional sterility hypothesis of Sharr et al. (1991) will be evaluated by crossing mature fish with known oil exposure histories. Fertilized pink salmon eggs will be incubated in oiled gravel, and the surviving fry will be reared to maturity. Mature fish exposed to oiled gravel as eggs/larvae will be crossed and the effects of oiled incubation substrate on gamete viability and offspring survival will be examined. If incubating in oiled gravel is shown to deleteriously affect gamete viability or offspring survival, then the plausibility of the functional sterility hypothesis will be established. This experiment will take place over two brood year cycles, starting in 1992 and ending in 1996 when the evaluations are completed.

1. Objectives in 1995

a. 1992 brood: Spawning of the 92 brood should occur in Sept 1994, or possibly October 1992. Adults will be examined for dose related differences in marine survival (net pens), growth, fecundity, and fertility. The spawn will be incubated in separate family groups for evaluation of survival and abnormalities through hatching.

b. 1993 brood: Juvenile fish will be cultured through the winter until sexual maturity in September or October of 1995. Dose related effects on growth, and overwinter marine survival will be evaluated.

c. Complete biological and chemical analyses of the oil exposure phases for both brood years. Integrate biological observations, chemical analyses, and contracted measurements into reports and manuscripts on the impacts through emergence.

2. Methods

This experiment began with a controlled oil exposure/gravel incubation simulation of an intertidal spawning environment. Fertilized eggs from brood years 1992 and 1993 were placed on oiled substrate and incubated to emergence. Several oil doses were utilized in both exposures. Biological responses (e.g. survival, timing of emergence, growth, size, hydrocarbon loads) to the oiled substrate were evaluated during the incubation period for both brood years, and will be updated in 1994. The surviving fry are currently being cultured to maturity and their gametes will be collected, crossed and incubated in a clean environment. Adults from the 1992 brood will mature in September 1994. Differences in gamete fertilization rates, and embryo survival will be attributed to different oil exposures in the parental generation beginning in November 1994. Fish from the 1993 brood will mature in September 1995, and similar evaluations will follow.

3. Schedule (see figure)

1992 Brood Year - Periods to Complete Tasks

Jul 15 - Sep 15 1992
Oil gravel, set up incubators
Sep 15 1992 - Sep 15 1993
Spawn pink salmon, and culture fry.
Sep 15, 1993
Write first interim report
Sep 15, 1993 - Sep 15 1994
Culture tagged fish in netpens spawn second generation.
Sep 15 1994
Write second interim report
Sep 15 1994 - May 15 1995
Incubate second generation,
May 15 - Aug 15 1995
Analyze and integrate data collected from culture of 1992 pink salmon and their progeny.
Sep 15 1995
Write third interim report

1993 Brood Year - Periods to Complete Tasks

Jul 15 - Sep 15 1993
Oil gravel, set up incubators

Sep 15 1993 - Sep 15 1994
Spawn pink salmon, culture fry.
Sep 15, 1994
Write second interim report
Sep 15, 1994 - Sep 15 1995
Culture tagged fish in netpens spawn second generation.
Sep 15 1995
Write third interim report
Sep 15 1995 - May 15 1996
Incubate second generation.
May 15 - Aug 15 1996
Analyze and integrate data collected from culture of 1993 pink salmon and their progeny.
Aug 15 - Sep 15 1996
Write final report

4. Technical support

NMFS Auke Bay Laboratory will provide all laboratory facilities for fish culture, hydrocarbon analyses, and computer facilities for data analysis and management. Histopathology (93) and MFO (94) contracts were let on the 1992 brood samples. ADFG genetics staff are conducting the genetics analyses (aberrations) on the lab samples provided by us and on the PWS field samples provided by the field component of ADFG. ADFG statisticians/biologists have been involved in the design and implementation of the crosses.

5. Location

Project will take place at Little Port Walter, located on Baranof Island in southeastern Alaska, using nearby intertidal stocks.

E. PROJECT IMPLEMENTATION

This project is currently underway at the NMFS research facility at Little Port Walter, and is managed by Auke Bay Lab.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is a component of Restoration Study 94191, a cooperative project between NMFS and ADFG. Previously implemented contracts have involved the University of California, Davis and the Woods Hole Oceanographic Institute.

G. PUBLIC PROCESS

An interim report describing the initial results for the 1992 brood year, after incubation and early culture, was submitted to the Chief Scientist in October 1993. Briefings for the Public Advisory Group and CDV are planned for the Summer of 1994. Results from the 1992 brood year will be presented at the 1995 Pink and Chum Workshop.

H. PERSONNEL QUALIFICATIONS

GS-14 Physiologist - Stanley D. Rice

Received BA (1966) and MA (1968) in Biology from Chico State University, and PhD (1971) in Comparative Physiology from Kent State University. Rice has researched oil effects problems since 1971. He has conducted and managed soft funded projects since 1974 , including the Auke Bay Laboratory Exxon Valdez damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chemistry labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, and establishment of hydrocarbon database management,

GS-13 Research Chemist - Jeffrey Short

Mr. Short is an analytical chemist at the Auke Bay Laboratory (ABL), and leads the hydrocarbon analysis facility at ABL, which is one of the two laboratories analyzing Exxon Valdez NRDA hydrocarbon samples. Mr. Short holds a B.S. in biochemistry and an M.S. in physical chemistry from the University of California. Mr. Short has conducted extensive research on the effects of Alaskan crude oils on Alaskan marine biota over a period of 10 years prior to the Exxon Valdez oil spill.

GS-11 Fisheries Biologist (Research) - Ron A. Heintz

Ron Heintz has a Bachelor of Science in Ecology from the University of Illinois, and a Masters degree in Fisheries from the University of Alaska. He has worked for the National Marine Fisheries Service since 1985 concentrating his efforts on salmon enhancement research and salmon genetics. He is the principal investigator and co-investigator on several salmon genetics projects.

I. BUDGET

A. Project - $165.6K (FY95)

Personnel $ 89.0K

Travel	29.0K
Contractual	0.0K
Commodities	32.2K
Equipment	2.0K
Capital Outlay	0.0K
Sub-total	152.2K
General Administration	13.4K
TOTAL	$165.6K

B. Comprehensive Reporting - $133.5K (FY96)

Personnel	$ 93.5K
Travel	12.5K
Contracts	0.0K
Commodities	13.5K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	119.5K
General Administration	14.0K
TOTAL	133.5K

Public Access

Project Number: 95200

Project Leader:	Dennis Daigger
Lead Agency:	Alaska Department of Natural Resources
Cooperating Agency:	U.S. Forest Service
Cost of Project:	FY 95: $154,700 FY 96: $256,100 Total: $902,200
Start-up Date:	1 Nov 94
Completion Date:	30 Sep 98
Duration:	4 years
Geographic Area:	Prince William Sound and Kodiak Island Borough
Contact:	Dennis Daigger Technical and Data Support Unit Division of Land Alaska Department of Natural Resources 3601 C Street, Suite 1122 Anchorage AK 99510 762-2660

B. INTRODUCTION

The Alaska Native Claims Settlement Act (ANCSA) provided for identification of easements to access public land. They were identified in the conveyance process and recorded in conveyance documents, but have not been depicted graphically in any publication.

The proposed project has two phases:

Phase I. Identification and mapping of easements in atlases for public distribution for the Prince William Sound area and Kodiak Island Borough.

Phase II. Marking of easements in Prince William Sound to accurately locate them and to preserve continued right of access.

This project directly addresses the Trustee Council's concern about public access in the habitat protection process. Furthermore, the clear, graphic depiction in a single-source document of the location of legal access to public land will expand and enhance public recreation opportunities.

Phase I of this project was proposed in FY 94 as 94200. It was disapproved by the Trustee Council with the recommendation that "ADNR coordinate with the federal agencies on the development of a recreation plan for the spill area and expenditure of state criminal funds." Trustee Council action preceded recent concerns about public access in the habitat protection process. Nonetheless, in compliance with the Trustee Council's recommendation, ADNR has submitted to Alaska State Parks a request for state restitution funds for preparation of easement atlases for Prince William Sound and Kodiak Island Borough. A decision is not expected until late Summer 1994.

C. NEED FOR THE PROJECT

Access is a critical element for management and use of land whether federal, state or privately owned. Completion of the Prince William Sound Access Atlas and an acess atlas for the land within the Kodiak Island Borough will provide restoration teams, scientists, negotiators for land acquisitions and recreational users with graphic depiction of land ownership and the legal public access at a scale of 1" to a mile as well as written narratives of each easement. The atlases will be available for use by governmental agencies and the public if funding becomes available for collecting and entering information into GIS as well as project completion.

An easement atlas for the Kenai Peninsula Borough was published in December 1993 as part of the Kenai Area Plan for State Lands.

D. PROJECT DESIGN

Objectives

1. Create 1:63,360-scale maps of the following data for Prince William Sound and the Kodiak Island Borough:
   a. land ownership;
   b. ANCSA 17(b) easements across private land;
   c. roads, trails, docks and airports that provide public access; and
   d. navigable waterbodies.

2. Ensure continued right of access in Prince William Sound under 43 CFR by marking ANCSA 17(b) easements.

Methods

Phase I - Identification and Mapping (Lead agency: ADNR)

1. The U.S. Forest Service will produce a printout of their records for confirmation of easements before the Prince William Sound Atlas is printed.

2. The Alaska Department of Natural Resources will:

   a. Enter all ANCSA 17(b) easements across private land in Prince William Sound and the Kodiak Island Borough into GIS using ARC/INFO.
   b. Inventory and enter into GIS all roads, trails, docks and airports that provide public access.
   c. Edit land ownership coverages.
   d. Inventory and enter into GIS all navigable waterbodies.
   e. Create 1:63,360-scale maps of the data.
   f. Prepare map color separations on an electrostatic plotter.
   g. Print and distribute easement atlases.

Phase II - Marking (Lead agency: USFS)

The easements that need to be marked include 45 trails and 37 site easements along the coast of Prince William Sound, 20 roads and trails and 13 sites around the town of Cordova, and 5 trails and 4 sites near Miles Lake. Additional easements are expected to be withheld in pending conveyance documents. About 15 miles of trail and 10 to 12 sites can be completed in a season. In Phase II of this project, the U.S. Forest Service will:

1. Identify conflicts that must be resolved..

2. Verify in the field the usability of easement locations and other proposed resolutions of conflicts.

3. Mark easements, survey them using GPS coordinate system for easy incorporation into GIS datasets, and place signs for public recognition.

Schedule

Phase I, identification and mapping of easements, will be completed by the end of FY 95. Phase II, marking easements within Prince William Sound, will begin in FY 96 and continue through FY 98.

Phase I - Identification and Mapping

Prince William Sound

Confirmation of easements	Nov 94
Color separations to printer	Dec 94
Easement atlas distributed	Jan 95

Kodiak Island Borough/AK Peninsula	
Complete data entry	Feb 95
Complete public/agency meetings	Apr 95
Edit and finalize data	Jun 95
Complete check plots	Jul 95
Color separations to printer	Aug 95
Atlas distributed	Sep 95

Phase II - Marking

Identification of conflicts.	FY 95
Field verification.	FY 95
Easements marking and surveying.	FY 96-98

Technical Support

The easement atlases will be printed under contract with a private firm. Estimated csot is $48,000.

Location: Atlases will be prepared for Prince William Sound and Kodiak Island Borough. Easements will be marked in Prince William Sound only.

E. PROJECT IMPLEMENTATION

This project would be implemented by ADNR and the USFS. ADNR maintains GIS datasets for this information and can efficiently and effectively complete the project. The USFS manages most of the ANCSA 17(b) easements in Prince William Sound.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will complement and provide input to the habitat protection process. It will also provide data and information for two projects proposed for FY 95: the Information Management project and the Terrestrial Habitat Protection Project.

G. PUBLIC PROCESS

Communities , land management agencies, and cooperating agencies within the project areas will have the opportunity to review the easement atlases before publication.

H. PERSONNEL QUALIFICATIONS

Phase I of the project will be managed by Dennis Daigger, chief of ADNR's Technical and Data Support Unit. He has supervised production of easement atlases for five other regions of the state. Cartographic support will be provided by the following ADNR personnel:

Susan Peck, ADNR's GIS project cartographer, who designs and develops ARC/INFO projects.

Elaine Thomas, ADNR's lead cartographer who supervises a staff of four who prepare manual maps, prepares volumes for publication and prepares automated maps using ARC/INFO.

Mario Ayerdis, who has been performing ARC/INFO data entry and editing for nearly four years for the Division of Land.

Phase II of the project will be managed by the U.S. Forest Service. The following personnel will be assigned to the project:

Don Rivers, Forest Engineer
Leo Keeler, Lands
Randy Schrank, Survey
Field crew on temporary assignment

I. FY 95 BUDGET

		ADNR	USFS	TOTAL
100	Personnel	40.3	30.0	70.3
200	Travel	2.5	3.0	5.5
300	Contractual Services	52.0	10.0	62.0
400	Commodities	0.0	2.0	2.0
500	Equipment	0.0	0.0	0.0
600	Capital Outlay	0.0	0.0	0.0
	Subtotal	94.8	45.0	139.8
	General Administration	9.7	5.2	14.9
	Total Cost	104.5	50.2	154.7

Harbor Seal and Sea Otter Cooperative Population and Harvest Assessment

Name of project leader: James A. Fall

Lead agency: Alaska Department of Fish and Game

Cost of project: $71.5K

Project Start-up/Completion Dates: 10/1/94 - 9/30/95

Geographic area of project: Prince William Sound and the Lower Kenai Peninsula

Contact Person: James A. Fall
Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518
907-267-2359

B. INTRODUCTION

The goal of the project is to work cooperatively with subsistence hunters to assess the impact of subsistence harvests of harbor seals and sea otters, and other factors, on the recovery of these species, and to identify ways to reduce these impacts. This project began in FY 94 (Project Number 94244). The work plan for FY 94 called for a summary of subsistence harvest data, collection of traditional knowledge about these populations, and compilation of biological data. To reach the project goals described in the FY 94 restoration work plan, we propose to continue this project into FY 95 to 1) complete compilation all of the available information; 2) gather additional data as needed; 3) analyze and interpret the data, in cooperation with the appropriate agencies and native groups; and 4) if necessary, produce a set of recommendations regarding harbor seal and sea otter harvesting to guide subsistence users who want to voluntarily change their harvesting practices to help these two species recover. Added to the set of objectives is an informational program, either in a slide or video format, that can be used to inform the public, including subsistence users, about the current status and trends in harbor seal and sea otter populations.

C. NEED FOR THE PROJECT

The populations of harbor seals and sea otters in Prince William Sound and adjacent waters were injured as a result of the Exxon Valdez oil spill. The U. S. Fish and Wildlife Service estimates that between 3,500 and 5,500 sea otters were killed by oil in the first months after the spill, and sea otters were still being injured by oil in the environment three years later. The case for a population level oil spill injury to harbor seals is less clear. Harbor seal populations throughout the Gulf of Alaska are known to have been in decline before the oil spill. This decline has continued, but it is difficult to determine how much, if any of it is due to the effects of oil in the environment. However, it is known that harbor seals were exposed to Exxon Valdez crude oil in Prince William Sound. They suffered some direct mortality although the number of harbor seals killed is unknown. Harbor seals also suffered sub-lethal effects, including corneal damage, nerve damage, and brain lesions.

Many subsistence hunters within the spill area, concerned about the decline they have observed in the numbers of harbor seals and sea otters, have voluntarily reduced their take of these species in an effort to help their recovery. However, at present, there is no mechanism in place to evaluate the effectiveness of these efforts.

Some data are available on marine mammal harvests in the spill area and are being summarized for the first year of the project. The Division of Subsistence, Alaska Department of Fish and Game has collected information on the numbers of harbor seals and sea otters harvested by subsistence users living in several communities in the spill region for both pre-and post-spill years. In 1993, the Division of Subsistence, in cooperation with the National Marine Fisheries Service and Ruralcap, also undertook a project to collect more detailed information on the timing and composition of subsistence harvests of harbor seals and sea lions (but not sea otters), including figures for those animals struck and lost. This project will continue into FY 95. The U.S. Fish and Wildlife Service runs a sea otter tagging program, which gathers information on sea otter harvests, including the location where animals are taken.

There is also some information available on harbor seal and sea otter populations in the region. The Division of Wildlife Conservation, Alaska Department of Fish and Game, working with the National Marine Fisheries Service has conducted a count of harbor seals in both the oiled and unoiled areas of Prince William Sound, along with other research aimed at assessing the health of the harbor seals (restoration project number 93046). The U.S. Fish and Wildlife Service has continued to monitor the recovery of sea otters in oiled areas, by determining their abundance, distribution and mortality (restoration project number 93043).

This project constitutes a step towards involving subsistence hunters in the resource management process, and may lead to an on-going exchange of information and consensus building with regard to the management of harbor seals.

D. PROJECT DESCRIPTION

1. Objectives:

Project objectives include: a compilation of available data on harbor seal and sea otter populations and trends; conducting a meeting of marine mammal biologists and subsistence users to evaluate and discuss the data; production of an informational program, either in a slide format or a video, which can be used as an educational tool about harbor seal and sea otter populations and trends; production of a set of recommendations for subsistence users of harbor seals and sea otters based upon study findings and workshop results; and harvest location data to supplement that collected in 1994.

2. Methods:

The project will involve compiling information from a variety of sources. Sea otter tagging data collected by the U.S. Fish and Wildlife Service will be used to estimate both the number of sea otters taken, and the locations in which they were hunted. The Division of Subsistence is administering a survey (funded by the National Marine Fisheries Service) in the oil spill impacted communities to gather information on the numbers of harbor seals harvested, including a breakdown by life stage and sex of the animal, and an estimate of the number struck and lost. It is anticipated that this project will continue. A section will be added to the questionnaire on location of harvest for this species. Information collected by the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service on the biology and population characteristics of harbor seals and sea otters in the oil spill impact area will also be used. In 1994, the Division planned to enter into a cooperative agreement with the Alaska Sea Otter Commission to assist in the interpretation of the biological and population data, and the potential effects of the harvest on the health of the populations, as such interpretation is outside of our expertise.

Following the compilation and analysis of the data, an ad hoc committee would be convened to evaluate the accumulated information and make recommendations to subsistence users. Such a committee would be composed of representatives of appropriate agencies, including the Alaska Department of Fish and Game, the US Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration, and native organizations, including the Alaska Sea Otter Commission, Ruralcap, the Chugach Regional Resources Commission, and the village and traditional councils of the area. Recommendations of the ad hoc group would be presented to subsistence users both in an informational newsletter, and in community meetings. Any changes to the harvest would be voluntary, as the ad hoc group would have no authority to compel any changes. Following this meeting, additional workshops in communities would occur to summarize and discuss the findings. Additional data collection for harvests taking place in late 1994 and 1995 would take place.

Ideally, the recommendations of the ad hoc group should become part of the harbor seal recovery plan.

4. Technical Support:

The project will not require any technical support as defined in the instructions for this document.

5. Location:

The study area will include Prince William Sound and the lower Kenai Peninsula. Primary marine mammal hunting communities in this area include Cordova, Tatitlek, Chenega Bay, Nanwalek, Seldovia, and Port Graham. Hunters in other communities, such as Valdez and Homer, will also be included in the project.

E. PROGRAM IMPLEMENTATION

This project will take advantage of several existing programs, both within the Alaska Department of Fish and Game, and other agencies. These other programs are described above. The Division of Subsistence will need to contract out for someone to assist in the analysis and interpretation of the biological and population data. This kind of work is outside the expertise of the staff of the Division of Subsistence, and the Division of Wildlife Conservation will not have any personnel available for this task. We would prefer to continue the co-operative agreement the Alaska Sea Otter Commission for this service, because their ties to the Alaska Native communities and their experience with these issues will be of benefit to the project. There will also be a need for a second contract to produce the informational program.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will incorporate information on the numbers, distribution and degree of recovery of the populations of harbor seals and sea otters from restoration projects 94064 (Harbor Seal Habitat Use and Monitoring) and 94246 (Sea Otter Recovery Monitoring Project). It will also provide information on seal and sea otter harvest in Prince William Sound and the Lower Kenai Peninsula to help the marine mammal researchers to evaluate the impacts, if any of the harvest on the recovery of those populations.

G. PUBLIC PROCESS

This project will incorporate public input from community meetings. Representatives of the communities of Prince William Sound and the Lower Kenai Peninsula will be included as members of the ad hoc body evaluating the data and making recommendations. The recommendations of the ad hoc body will be disseminated to the communities by means of an informational newsletter as well as in community meetings.

H. PERSONNEL QUALIFICATIONS

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

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

Craig Mishler: Dr. Mishler has been a Subsistence Resource Specialist with the Division of Subsistence since 1989, with primary responsibility for Kodiak Island. He is project leader for the division's seal and sea lion harvest monitoring program.

Ronald Stanek. As a Subsistence Resource Specialist with the division since 1980, Mr. Stanek has extensive experience working with communities of the Cook Inlet region. Among other things, he has conducted research on marine mammal uses in these communities.

Charles Utermohle. Dr. Utermohle is the division's data management section leader. He has been responsible for compilation of harbor seal harvest data.

Additionally, an individual will be hired to fill a vacant SRS position in Anchorage; this position will be partially supported through this project.

I. BUDGET

Personnel	$42,513	
Subsistence Resource Specialists (6 months) (Stanek, Mishler, vacant position) Regional Program Manager (Fall) (1 month) Research Analyst (Utermohle) (1 month)		
Travel		$15,000
General Administration	3,000	
Contractual	10,000	
Sea Otter Commission Cooperative Agreement ($5,000) Informational Program Production ($5,000)		
Supplies	1,000	
TOTAL	$71,513	

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Kenai River Sockeye Salmon Restoration

Project Number: 95255

Project Leaders: Kenneth E. Tarbox, Lisa W. Seeb, James E. Seeb

Lead Agency: ADF&G

Cost of Project: TBD

Project Start-up/Completion Dates: 10/1/94 - 6/30/96

Project Duration: One year remaining of five years

Geographic Area: Upper Cook Inlet; field work to be based out of Soldotna; laboratory work to be conducted in Anchorage

Contact Person: Kenneth E. Tarbox
Commercial Fisheries Management and Development
34828 Kalifornsky Beach Road, Suite B
Soldotna, AK 99669 (907) 262-9368

Lisa W. Seeb
James E. Seeb
Genetics Laboratory
Alaska Department of Fish and Game
333 Raspberry Road
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B. Introduction

Sockeye salmon *Oncorhynchus nerka* which spawn in the Kenai River system were injured by the Exxon Valdez oil spill (EVOS). Greatly reduced fishing time in Upper Cook Inlet (UCI) due to EVOS caused sockeye salmon spawning escapement levels in the Kenai River to exceed that desired by three times. The biological impact of EVOS on Kenai River sockeye salmon stocks may be one of the most serious documented. Data collected by NRDA Fish/Shellfish Study 27, *Sockeye Salmon Overescapement*, indicated greatly reduced survival of juvenile sockeye salmon during the winter-spring rearing period beginning with the 1989 parent year. The extremely high escapement may have initially produced more rearing juvenile sockeye salmon than could be supported by nursery lake productivity. In general, when rearing salmon abundance greatly exceeds lake carrying capacity, the species and size composition of prey resources are altered which affects all trophic levels. Because of such changes, juvenile sockeye growth is reduced, freshwater mortality is increased, greater proportions of fry remain in the lake for another year of rearing, and smolt condition is reduced and marine mortality is increased. Limiting sockeye salmon fry production by closely regulating the number of spawning adults may be the only way to restore the productivity of these rearing areas. Sockeye smolt outmigrations in the Kenai River were severely reduced in 1991 (1989 parent year) and continued to decline through 1993. The number of adult sockeye salmon returning from the 1989 overescapement in the Kenai River is expected to be low. Starting in 1994, a reduction of Kenai River sockeye salmon harvests may be necessary to ensure adequate escapements.

C. Need for the Project

Sockeye salmon harvested from the mixed-stock fishery of Cook Inlet include fish from the Kenai, Kasilof, and Susitna Rivers. In order to effectively manage the harvest of EVOS-damaged stocks, Restoration Science Studies R53/R59/93012/93015/94255 were implemented in 1992 and 1993. This proposal is the continuation of those projects through fiscal 1995. These studies use Genetic Stock Identification (GSI) techniques to identify Kenai River stocks in mixtures within the Kenai River itself and within Cook Inlet marine areas. Area managers will use this information to estimate relative abundances and modify fishery management to protect the EVOS-damaged Kenai River stocks. In addition, genetic information from Kenai River stocks is critical in the planning of many restoration options currently under consideration for the Kenai River.

GSI techniques rely on genetic variation to discriminate between populations of organisms. This method has proven to be extremely effective for allocating and adjusting the harvest of fish stocks intercepted in mixed-stock fisheries such as those that occur in Cook Inlet. Once a data base has been established, GSI techniques should provide an ongoing mechanism for in-season management. This will allow managers to control the harvest of Kenai River sockeye salmon and facilitate their recovery.

A comprehensive allozyme genetic database has been developed with collections originating from over 36 populations of sockeye salmon from the Kenai, Kasilof, and Susitna drainages as well as western Cook Inlet. Significant genetic heterogeneity has been detected not only among major regions, but also within the larger drainages. Extensive numerical analyses are being conducted to evaluate the identifiable genetic units and to test the accuracy and precision of the resulting classification model. Analyses to date indicate that although many stocks can be identified with a high level of precision, the very large spawning aggregations in the mainstem of the Kenai River require additional baseline genetic information.

A pilot fishery study was conducted during 1993 using allozyme data. Stock proportions from two fishery samplings were estimated using the genetic baseline collected during the 1992 field season. In both cases the laboratory and statistical analysis were completed within 48 hours. Routine fishery monitoring in-season can begin once the GSI model has been adequately refined and evaluated.

D. Project Design

1. Objectives

The goal of this project is to restore Kenai River sockeye salmon injured by the oil spill. This will be accomplished through improved stock assessment capabilities, more accurate regulation of spawning levels, and modification of human use. The specific objectives are to:

1. Obtain baseline allozyme genetic data (during 1992-1995) from all significant spawning stocks contributing to mixed-stock harvests of sockeye salmon in Cook Inlet.

2. Use Genetic Stock Identification (GSI) algorithms to estimate the relative proportion of Kenai River stocks within the mainstem Kenai River and in marine mixed stock fisheries of Cook Inlet. Estimates will be made from adult, smolt, and fry samples. These data will allow managers to estimate relative abundances and genetic relatedness of Kenai River stocks to aid in restoration planning and to allow managers to modify area and time of harvest.

3. Investigate the added utility of DNA-level markers to discriminate among Cook Inlet populations.

4. Provide more accurate estimates of abundance of Kenai River sockeye salmon within Cook Inlet through hydroacoustic assessment techniques.

2. Methods:

Stock Identification

Over the last two years we have developed a comprehensive genetic database of sockeye salmon stocks in Cook Inlet. In 1992 we collected baseline genetic data using allozyme analyses from 28 subpopulations from Cook Inlet including the Kenai, Kasilof, and Susitna Rivers. The majority of these were resampled in 1993 along with an additional eight populations. During 1994 we will focus our efforts in two areas: 1) refining and evaluating the model, and 2) applying the resulting model to freshwater and marine mixed stock analyses.

We proposed to refine our characterization of the large spawning aggregations within the Kenai River and to complete collections for several other Cook Inlet systems inadequately sampled in the preceding years. Target sample sizes for allozyme baseline collections will be 100 individuals to adequately characterize spawning populations. We will also analyze freshwater mixed stock samples to examine the accuracy and precision of the GSI model. Approximately 200 sockeye salmon each will be collected at least twice from fishwheels operating at the Kenai River, Kasilof, and Crescent escapement enumeration sites during the summer of 1994. A composite sample with individuals from throughout Cook Inlet will be constructed and analyzed "blind" by the genetics laboratory.

The resulting GSI model will be applied to both freshwater and marine mixed stock samples. Mixed stock samples of adult sockeye salmon will be collected from selected drift fisheries openings occurring during the July fisheries (maximum of two; 1995-1996). Sample sizes will be set at 400 to minimize the confidence intervals surrounding the estimates. Fishery composition estimates will be available within 48 hours following the fishery so that management decisions can be based on the actual composition of the fisheries. In addition, mixture samples from the Kenai River of outmigrating smolts and fry will be collected during Restoration Project 94258 to determine stock composition and provide information on production and rearing dynamics. Estimation of the relative contribution of the Russian River populations will be particularly valuable, as it is possible that the Russian River will be the major stock component within the Kenai River in future years. Results to date indicate that the Russian River stock is genetically quite distinct and can be estimated with an accuracy greater than 0.90.

Muscle, liver, heart, and eye tissue will be taken from individual fish and examined by protein electrophoresis (allozyme analysis) for discriminating gene markers. Genotypic and allelic frequency estimates will be calculated from allozyme electrophoretic data for each baseline and mixed-stock sample at every gene locus examined and will be used to identify discrete spawning populations. Stock components of mixed fishery samples will be estimated using a conditional maximum likelihood algorithm.

We have also identified mitochondrial DNA (mtDNA) polymorphisms within Cook Inlet sockeye salmon populations that potentially could further discriminate among stocks. We will continue to collect these mtDNA markers from selected Cook Inlet populations. Total genomic DNA will be extracted and amplified through PCR (polymerase chain reaction) techniques utilizing various mitochondrial primers. Restriction analyses will be conducted, and maximum likelihood simulation studies will be performed to test the additional resolution that could be provided by the DNA-level data. DNA data will be collected from the fishery samples as scientifically and logistically feasible. We also propose to continue developmental work to identify additional nuclear DNA genetic markers through the competitive bid process.

Offshore Test Fish Program

The sockeye salmon total run to UCI has been estimated early during the season by test fishing between Anchor River and Red River delta. Northward migrating sockeye salmon are captured with a drift gill net at a series of stations. Salmon are identified to species and sex, and length measurements are recorded. Estimates of total sockeye salmon return are made several times during the season by estimating expected total test fishery catch per unit of effort for the season and catchability of sockeye salmon in the test fishery. Analysis of historical data has indicated that existing sampling effort and catch has not been proportional to abundance. To assess run size more accurately, additional sampling effort will be added to the existing program.

In 1992 and 1993 hydroacoustic equipment and techniques were tested in UCI offshore waters. Results of this work indicated that hydroacoustic techniques could detect salmon and provide a population estimate for "in season" management use. However, the primary limitations identified in the study were limitations (signal/noise ratio) of the hydroacoustic gear due to rough sea conditions or shallow water in the northern portion of UCI. In 1993, 12 orthogonal transects sampled over 48 hours within Cook Inlet provided a useable estimate of adult salmon abundance. In addition to this effort the vessel and hydroacoustic gear was deployed for six days in conjunction with the existing AD&G test fish vessel at Anchor Point. Estimates of salmon abundance were correlated with test fish catches under calm weather conditions and development of a program to estimate sockeye salmon hydroacoustic targets is encouraging.

3. Schedule

Finish baseline sample collection	October, 1994
Laboratory analyses of 1994 baseline & mixture samples	October, 1994 - March, 1995
Prepare, advertise, and award contract for UCI hydroacoustic survey and DNA marker development	Jan. - April, 1995
Final report from hydroacoustic survey contractor, FY94	February, 1995
Draft status report for FY94	March, 1995
Numerical analyses of stock structure; modelling of 1994 fishery samples	March - Sept., 1995
Baseline sample collection; fry and smolt collections	March - Sept., 1995
Fishery sample collection and in-season analysis	June - July, 1995
Hydroacoustic assessment	July, 1995
Final status report for FY94	Sept., 1995
Numerical analyses of stock structure	Sept., 1995 - Feb., 1996
Final report from hydroacoustic survey and DNA contractors	Feb., 1996
Draft status report for FY95	March, 1996
Final status report for FY95	Sept., 1996

4. Technical Support

Administrative support is provided by the Administrative, Habitat, and Commercial Fisheries Development and Management Divisions staff of the Alaska Department of Fish and Game. The project leaders are fully funded with general funds from the State of Alaska. Project assistants are fully or partially funded by this project. Laboratory support is provided by the ADF&G Genetics Program which includes facilities for tissue archival, allozyme analysis, PCR-based and other DNA analyses, and data analyses. These studies are integrated with ongoing studies by the Commercial Fisheries Division for efficiency in completing the objectives.

5. Location

Upper Cook Inlet, north of a line from Anchor point to the Red River Delta--Field work will be inlet wide and based out of Soldotna; lab and a portion of the data analyses will be conducted in Anchorage.

E. Project Implementation

The allozyme and mtDNA data collection and all data analyses will be conducted by the Alaska Department of Fish and Game. Continued research and development of DNA markers will be accomplished through contractors chosen through the competitive bid process (value not to exceed $20,000).

A sole source contract is proposed (value not to exceed $50,000) to be awarded to *BioSonics Inc.* for continuing work in UCI with hydroacoustic equipment. *BioSonics Inc.* has been awarded the contract since 1992 through competitive bid procedures. The experience gained and the recent purchase of *BioSonics Inc* equipment for this project make them the logical contractor for the continuation of these studies.

F. Coordination of Research Effort

Field efforts for this project are coordinated with Restoration Project 94258 (Kenai River Overescapement), and the collection of fry and smolt samples is organized between the two projects. DNA analyses for this project are integrated with those of projects 94320D (population genetics of pink salmon) and project 94191 (study of oil-related embryo mortalities in Prince William Sound pink salmon).

G. Public Process

This project was originally conceived through the peer review process. In 1991, reviewers of other proposed EVOS genetics projects recommended that the population structure analysis of Cook Inlet sockeye salmon take priority. This project also has had strong support from the Cook Inlet fishing community since it was first drafted in 1991.

Project results have also been presented for public review in an array of appropriate fora. Scientific presentations were made at the 1993 annual meeting of the Alaska Chapter of the American Fisheries Society, held in Fairbanks, Alaska, and at the 1993 annual meeting of the American Fisheries Society in Portland, Oregon. The results were also presented for review at the January, 1994, meeting of the Cook Inlet Regional Planning Team (a group composed of Cook Inlet fishermen and regional fisheries professionals).

H. Personnel Qualifications

Kenneth E. Tarbox
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
34828 Kalifornsky Beach Road, Suite B
Soldotna, Alaska 99669
(907) 262-9368

EMPLOYMENT:

May, 1980 to Present. Upper Cook Inlet Research Project Leader, Alaska Department of Fish and Game, Soldotna, Alaska. Responsibilities include planning, implementing, supervision, and reporting on various salmon related research and management projects. These involve hydroacoustic enumeration of salmon in glacial systems, defining salmon migratory behavior in both salt and fresh water, evaluation of potential impacts of resource development on habitat and populations, management of the UCI commercial salmon fisheries, stock identification studies using scale or genetic markers, and life history studies of sockeye salmon.

March, 1972 to May, 1980. Project manager and Senior Biologist, Woodward Clyde Consultants, Anchorage, Alaska. Responsibilities included supervision and research for a number of projects. These included an evaluation of existing methodologies for determining instream flow requirements for Alaskan fishes, determining the biological impact of a dredging projects located in lower New York Harbor and Lake Michigan, fishery investigations in the Zayandeh River, Iran, impact assessment of various oil related projects in Virginia, North Carolina, Texas, and Prudhoe Bay, Alaska, and studies and evaluation of impacts associated with nuclear power plants in New Jersey, Louisiana, Indiana, and Pennsylvania.

July, 1970 to March, 1972. Research Assistant, Louisiana Co-operative Fishery Unit, Louisiana State University, Baton Rouge, La. Responsibilities included the design and conduct of a one year investigation of juvenile fish behavior in an estuarine environment.

EDUCATION:

M.S. in Fisheries, 1974. Louisiana State University, Baton Rouge, La.
B.S. in Fisheries Science. 1970. University of Washington, Seattle, Wa.

CERTIFICATIONS:

Fisheries Scientist, Certificate 1165, American Fisheries Society, 1976.

PUBLICATIONS:

Available on request

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

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

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

SELECTED PUBLICATIONS:

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

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

Seeb, J.E., L.W. Seeb, D.W. Oates, and F.M. Utter. 1987. Genetic variation and postglacial dispersal of populations of northern pike (*Esox lucius*) in North America. Can. J. Fish. Aquat. Sci. 44:556-561.

Utter, F.M., and J.E. Seeb. 1990. Genetic marking of fishes: overview focusing on protein variation. Am. Fish. Soc. Sym. 7:426-438.

Seeb, J.E., G.H. Kruse, L.W. Seeb, and R.J. Weck. 1990. Genetic structure of red king crab populations in Alaska facilitates enforcement of fishing regulations. Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant, Fairbanks, AK. pp 491-502.

Seeb, J.E., and G.D. Miller. 1990. The integration of allozyme analyses and genomic manipulations for fish culture and management. *In*: D.H. Whitmore, Editor. Electrophoretic and Isoelectric Focusing Techniques in Fisheries Management. CRC Press, Boca Raton, pp 266-279.

Gharrett, A. J. B. Riddell, J. Seeb, and J. Helle. 1993. Status of the Genetic Resources of Pacific Rim Salmon. In: J. Cloud, Editor. Genetic Conservation of Salmonid Fishes. Plenum Press, New York. pp. 286-292.

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

Lisa. W. Seeb (L. Wishard), Statewide Geneticist

Division of Commercial Fisheries Management and Development
Alaska Dept. of Fish and Game
Anchorage, Alaska 99518 (907) 267-2249

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

PROFESSIONAL EXPERIENCE:

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

SELECTED PUBLICATIONS:

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

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, L. W. and D. R. Gunderson. 1988. Genetic variation and population structure of Pacific ocean perch (*Sebastes alutus*). Can. J. Fish. Aquat. Sci. 45:78-88.

Seeb, L. W., J. E. Seeb, R. L. Allen and W. K. Hershberger. 1990. Evaluation of adult returns of genetically marked chum salmon, with suggested future applications. American Fisheries Society Symposium 7:418-425

Seeb, L. W., J. E. Seeb and A. J. Gharrett. 1990. Genetic marking of fish populations. pp 223-239 *in* D. H. Whitmore, ed. Electrophoretic and isoelectric focusing techniques in fisheries management. CRC Press, Boca Raton, FL.

Seeb, L. W., J. E. Seeb and J. J. Polovina. 1990. Genetic variation in highly exploited spiny lobster *Panulirus marginatus* populations from the Hawaiian Archipelago. Fishery Bulletin 88:713-718.

Seeb, L. W. and A. W. Kendall. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

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I. Budget

Personnel	
Travel	
Contractual Services	
Commodities	
Equipment	
Capital Outlay	
General Administration	
TOTAL	

Sockeye Salmon Overescapement

Project Number: 95258

Name of project leader(s): Dana Schmidt and Ken Tarbox

Lead agency: ADF&G

Cooperating agencies: USFWS and NBS

Cost of project/FY 95: $975

Project Start-up/Completion Dates: October 1, 1993 / September 30, 1994

Geographic area of project: Kodiak Island and the Kenai Peninsula

Contact Person: Dana Schmidt

B. INTRODUCTION

This study is a continuation of the oil spill damage assessment program initiated in 1990 (Schmidt and Tarbox, 1993; 1994 (in review). The continuing program reflects modifications based on the FY93 study results. Recommendations provided by an international review team of sockeye salmon experts provided at a March 15, 1993 meeting at Vancouver, B.C. have been incorporated.

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

Overly large spawning escapements may result in poor returns by producing more rearing juvenile sockeye than can be supported by the nursery lake's productivity (Kyle et al. 1988). In general, when rearing fish abundance greatly exceeds the lake's carrying capacity, prey resources are altered by changes in species and size composition (Mills and Schiavone 1982, Koenings and Burkett 1987, Kyle et al. 1988) with concomitant effects on all trophic levels (Carpenter et al. 1985). Because of such changes, juvenile sockeye growth is reduced, mortality increases, larger percentages holdover for another year of rearing; and the poor quality of smolts increases marine mortality. Where escapements are two to three times normal levels, the resulting high juvenile densities crop the prey resources to the extent that more than one year is required to return to normal productivity. Rearing juveniles from subsequent brood-years suffer from both the poor quality of forage and from the increased competition for food by holdover juveniles (Townsend 1989; Koenings and Kyle 1991). This is the brood-year interaction underlying cyclic variation in the year class strength of anadromous fish.

This project continues examining the effects of large 1989 spawning escapements on the resulting progeny and associated foraging habitat for a select subset of the above mentioned sockeye nursery lakes. Three impacted lake systems where the 1989 escapements were more than twice the desired levels (Kenai/Skilak in Upper CI; Red and Akalura lakes on Kodiak Island) were selected. Beginning in 1994, Frazer Lake has been used for future comparisons of a system receiving normal escapement. Because this lake has undergone detailed study in the past (Kyle et al. 1988) and has continued funding from other sources, minimal funding is necessary to provide for data collection to insure comparisons with Akalura and Red lakes. Similarly, Tustumena Lake on the Kenai Peninsula received normal escapements and is used as a control for the Kenai River systems. This lake differs primarily in the increased natural turbidity levels and a history of modest stocking of sockeye salmon fry.

Schmidt and Tarbox (1993) report the results through 1992 on these ongoing investigations. In addition, the study proposal reflects results of data collected in the spring of 1993. These studies suggest continued poor smolt production from the Kenai River, despite normal smolt production from Tustumena Lake, the control for this system. The 1992 and 1993 (preliminary) data indicate Red Lake zooplankton communities and nutrient levels have recovered to the level measured in 1986, prior to the oil spill (Schmidt and Tarbox, 1993). Smolt numbers appear to be lagging but adult forecasts for returns in 1994 suggest escapement goals will be met; therefore management actions will be used as the primary method for restoration. Smolt numbers will be used to forecast future returns and provide assistance to managers in future harvest management decisions. Akalura Lake demonstrated poor zooplankton densities with low smolt numbers. The 1994 adult run is not expected to meet escapement requirements. A restoration plan for Akalura lake will be produced during the winter of 1993-94 based on analysis of data collected to date.

The 1993 smolting information from the Kenai system lakes indicate poor smolt production. In addition, the Russian River smolt project indicated very poor production, suggesting this system may also be below production expectations. This system was first identified as having suspect production when the 1992 smolt count from the lower Kenai failed to produce sufficient numbers of age 2 smolt to account for historic Russian River smolt migrations. This project suggests further investigations into the Russian River are warranted.

C. NEED FOR THE PROJECT

The proposed studies will provide the needed data to determine the most appropriate action for recovery of these ecosystems. The monitoring of fry and smolt from the systems provide a response variable by which natural recovery through return to normal escapements can be monitored. The nutrient status, water chemistry, physical data, and the temporal and spatial distribution of the zooplankton community provide the necessary data to determine the effects of natural climatic variation, as well as response to changes in sockeye salmon densities. These data are essential to determine the type of future activites that may be required to restore the system. A pilot research/restoration project is proposed separately to examione the feasability of more interventive types of restoration. The recent workshop on the development of restoration strategies found that this research and monitoring effort received a high priority.

D. PROJECT DESIGN

The studies are located on Kodiak Island and the Kenai Peninsula. Recent findings (Schmidt and Tarbox, 1993; 1994 -In review) have suggested major economic damage to commercial, subsistence, and sport fisheries may result because of the over-escapement event associated with the fisheries closures on the Kenai River sockeye salmon stocks caused by the 1989 oil spill. Smolt numbers emigrating from the Kenai River in the spring of 1992 and 1993 were less than one-fiftieth the numbers estimated in 1989. This suggests a likely possibility of future returns below existing escapement goals. Red River smolt numbers from the 1989 escapement on Kodiak Island are estimated to return at rates which will provide for minimal commercial harvests if average marine survival occurs.

In addition to monitoring the damage extent, the mechanism that lead to the collapse requires definition. These studies essentially follow the pattern established in the original 1990 study plan but with significant modifications to accommodate recent findings.

1. Objectives:

The following objectives are altered based on input from peer reviewers of the 1992 progress report and proposed revisions to the 1994 study program..

a. Estimate critical biological attributes (number, age, size) of both resident and migrant juvenile sockeye in overescaped and normal escaped sockeye salmon nursery lakes of the Kenai Peninsula and Kodiak Island.

b. Determine effects on smolt production and subsequent adult returns caused by large escapements resulting from fishery closures after the EVOS. These effects will be inferred by studying the changes in the rearing capacity of selected nursery lakes which were either affected or unaffected by the oil spill. Data used for these inferences include:

(1). age and growth of juveniles and smolts
(2). nursery area nutrient budgets and plankton populations.
(3). seasonal, diel, and vertical distribution of zooplankton species which are the known prey of sockeye salmon in Skilak, Kenai, and Tustumena Lake; and
(4). seasonally available zooplankton biomass in these lakes and the relationship of this biomass to ambient temperature and light.

c. Develop a pilot research project to determine experimentally the cause of the decline and potential restorative actions.

ADF&G in cooperation with the regional research staff of the U.S. Fish and Wildlife Service and the Refuge staff of the Kenai National Wildlife Refuge has developed a pilot research project to further define the mechanism of sockeye salmon decline and determine the feasibility of alternative restoration opportunities. This is submitted separately but depends on data obtained through these investigations.

2. Methods:

From the inception, these investigations have used an ecosystem approach to determine factors limiting the recovery of the affected sockeye salmon population.

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

For each of the lake systems identified, the response (abundance, growth, and freshwater age) of rearing juveniles will be studied. Because of the significance and magnitude of the findings on Red Lake, and on Skilak/Kenai lakes, these studies will continue until observed effects on growth and the limnetic community of the lake ecosystems recovers to pre-spill conditions.

The total number of juvenile sockeye in the Kenai Peninsula lakes will be estimated through hydroacoustic surveys conducted during all years up until recovery of the system is observed. Age and size information will be obtained from samples of juvenile sockeye collected from concurrent mid-water trawl netting surveys. Survey transect designs for hydroacoustic sampling and tow-netting have been established for Kenai and Skilak lakes (Tarbox and King 1989) and Tustumena Lake (Kyle 1992). Depending on densities of rearing juvenile sockeye salmon, estimates of fish densities will be made for each transect either by echo integration or by echo counting. Total fish population estimates will be computed, by summing transect populations, along with 95% confidence intervals (Kyle 1989). Additional studies of the vertical distribution of Skilak Lake sockeye will be conducted simultaneously with population estimates with an additional sampling period, for vertical sampling only, in November, 1993.

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

The total number of smolt migrating from each system will be estimated with a mark-recapture study using inclined plane traps after Kyle (1983), and King et al. (1991). Smolt will be captured in traps, sampled for age and size information, marked with Bismark Brown Y (a biological dye), and transported upstream of the traps and released for subsequent recapture (Rawson 1984). Periodic retesting will determine the capture efficiency of the traps under changing river conditions during the spring. Total population estimates (with 95% confidence intervals) will be made using catch efficiencies, and weekly number weighted smolt size and age information will be calculated using a computer spreadsheet developed by Rawson (personal communication, 1985). Smolt programs consistent with those for the study lakes are continuing for Tustumena Lake (Kyle 1992).

On the Kenai River, the smolt operation will require expansion to include the Russian River. This lake system apparently now is the dominant producer of sockeye salmon smolt and is upriver from the current smolt project on the mainstem Kenai River. To determine the production of smolt from the Kenai River mainstem, estimates of smolt production from the Russian River lake system must be completed to separate normal Russian River production from the smolt production of sockeye salmon rearing in Skilak and Kenai lakes. These methods are being established to insure current projections of smolt production from the Kenai River lake systems are not an artifact of some unknown sampling bias.

In 1993 we fished one trap in the Russian River to estimate the smolt migration. We caught few fish (less than 5000) and the catch rate was 5%. In 1994, increased trap catch rates will be required to insure we are not missing fish in this clear water system.

The current length frequency data on sockeye smolts at the Kenai mainstem river smolt traps indicates that we may be missing a portion of the Russian River smolt outmigration. With the excellent genetic separation of Russian River sockeye from mainstem Kenai fish we should be able to separate these two components in the catch. This will allow for a better total smolt estimate and verification of the Russian River smolt trap data.

Because the smolt data for 1993 indicated that the Russian River lake systems may be experiencing similar declines in production as the mainstem Kenai River. The 1989 escapement into this system was 138,000 adults, which is far in excess of the minimum 30,000 goal. Therefore, to evaluate the current production potential and impacts of large escapements, limnological and fry hydroacoustic/tow net surveys of the Russian lakes are proposed. Techniques duplicate those used on other systems.

In the two Kenai Peninsula lakes, early spring and late fall sampling of fry will be conducted. The reason for the additional sampling period is that approximately 50% of the weight gain from fry to smolt in the Kenai River system occurs outside of the current sampling regime. If poor survival is occurring because of limitations in rearing habitat quality during this period, these data are crucial for determining the validity of fry density causing decreased over-wintering survival. Based on peer review comments, hydro-acoustic studies of fry abundance will be conducted into the fall, 1994 to track and sample the juvenile fish until cold weather prevents further studies. This is based on the assumption that most of the density dependent mortality occurs in early winter (peer review comments, Hyatt and Hilborn).

Studies on Kodiak Island will be reduced because of recent findings. These include elimination of the smolt weir counts on Red River; relying on mark/recapture studies with smolt traps will be used to estimate smolt abundance in 1994. In 1992 the hydro-acoustic surveys were eliminated on these lakes because of interference of stickleback with the population estimates. Samples of fall fry for age, weight, and length will continue to be collected. The variation and differences in Upper Station lakes suggest this system is inadequate as a control for Red Lake and Akalura Lake. Therefore, Frazer lake will be used as a control in the future. Monitoring of this system is primarily conducted by general fund expenditures of the Alaska Department of Fish and Game. A minor modification will be made to the program to insure compatibility with the monitoring continuing on Akalaura and Red lakes. Funding from these studies will be used to augment the regular smolt monitoring program. A second inclined plane trap will be used to ensure that adequate samples are obtained for more accurately describing smolt population numbers and AWL characteristics to insure similar precision with the Red and Akalura lakes studies. The continued poor smolt production in the spring of 1993 (600,000 Red Lake, 90,000 Akalura Lake) suggest continued monitoring of these systems is warranted.

Limnological data will be collected to monitor the response of the lakes to high juvenile rearing densities and their recovery once escapement levels decline. Table 1 provides a time-line of these studies with and reflects the integration with the fisheries investigations previously discussed. These data will be used to estimate carrying capacity parameters of euphotic volume, nutrient budgets (carcass enrichment), and zooplankton biomass, body-sizes, and composition shifts. Approximately six limnology surveys will be conducted at two or more stations, to determine zooplankton species abundance and body-sizes, nutrient chemistry, and phytoplankton abundance for Kenai/Skilak, Tustumena, Red, and Frazer lakes. Methods for limnological studies are detailed in Koenings et al. (1987).

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

The holistic approach proposed here involves several evaluation procedures to assess the effects of sockeye salmon overescapement. First, fresh-water production from the 1989 escapements will be assessed in Kenai/Skilak, Red, and Akalura lakes. This will be accomplished through analysis of growth, freshwater survival (in particular over-winter survival), and freshwater age of sockeye smolt populations. Any anomalies will be determined by analysis of freshwater growth recorded on archived scales, historical freshwater age composition, and modelled freshwater survivals; and from results of previous studies as well as the smolt characteristics from each of the study systems. Also, planktonic food sources will be assessed through estimation of zooplankton prey biomass and diversity of species. Some of these analyses have been completed (Schmidt and Tarbox, 1993).

Although in the Kenai River system smolt enumerations and fall fry estimates during 1991, 1992 and the spring of 1993 produced very low numbers, zooplankton biomass estimates in Skilak Lake, the major sockeye salmon producer, has not undergone similar levels of decline. Limited stomach samples evaluated recently from 1987 indicate a possible major switch in diet, further supporting limited food availability as a likely factor in the decline (Schmidt and Tarbox, 1994-In review). Further investigation into plankton availablity and growth rates following the methods of Schmidt and Tarbox (1993) will continue.

Experimental and empirical sockeye life history/production models (Koenings and Burkett 1987, Koenings et al 1989) will be used to compare salmon production by life-stage at escapement levels consistent with management goals to the 1989 escapements. These models will be refined by use of food availability data obtained through the vertical sampling studies initiated in 1992 and to be continued through 1995.

Additionally, in the case of the Kenai system, the 1989 escapement effects will be viewed independently of the effects on previous brood years with high escapement.

Consult Schmidt and Tarbox (1993; 1994-In reveiw) for further discussion of analyses and methods used to date in progress reports on these investigations.

3. Schedule:

The timeline of the 1995 studies is outlined on Table 1. This table depicts the sampling schedule for the integrated limnological studies and fisheries studies on the Kenai Peninsula and Kodiak Island.

4. Technical Support:

Administrative support is provided by the Administrative Division, Habitat Division, and Commercial Fisheries Management and Development Division staff of the Alaska Department of Fish and Game. The project leaders and their assistants are not funded by this project and are supported with general funds from the State of Alaska. Most laboratory analyses are conducted by the limnology laboratory in Soldotna. These studies are integrated with ongoing studies by the Commercial Fisheries Management and Development Division on Kodiak Island and the Kenai Peninsula. These studies have different objectives, i.e. to manage, enhance, and rehabilitate common property salmon fisheries, but use the same techniques and data collection methods. Consequently the EVOS investigations have been integrated into the normal operations of these Divisions for efficiency in completing the objectives of these studies and the general mission of these agencies.

5. Location:

Study locations are on Kodiak Island and the Kenai Peninsula. Specific sampling locations are identified in Schmidt and Tarbox (1993).

Table 1. 1994-95 work schedule.

NRDA STUDIES- OCTOBER 1994-SEPTEMBER 1995

	October	November	December	January	February	March	April	May	June	July	August	September
Kenai Smolt												
Russian R. Smolt												
Kasilof Smolt												
Kenai Hydro												
Skilak Hydro- pop est												
Skilak Hydro- diel dist												
Tustumena Hydro												
Skilak Growth												
Skilak Lipid												
Skilak Stomachs												
Kenai Growth												
Kenai Lipid												
Skilak Limno												
Kenai Limno												
Skilak Diel Zoo												
Kenai Diel Zoo												
Tustumena Diel Zoo												
Other Zoo												
Kenai Smolt Acoustics												
Russian River Genetics												
Russian Lakes pop est, twnt, lim												
Kodiak Frazer, Red and Akalura												

Field activities | Construction, preseason/postseason activities | Data analysis

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E. PROJECT IMPLEMENTATION

The projects have been implemented in the past through the Alaska Department of Fish and Game. Considerable infra-structure was established and the programs are dovetailed into existing agency programs to insure cost effectiveness. Although continuation of the projects could be completed by any public or private organization with the proper expertise, the Trustees need to weigh the effectiveness of such a process with the disruption of the existing program.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The Alaska Department of Fish and Game has ongoing commercial fisheries research operations on the Kenai and Kasilof River, Frazer Lake, Red River, Akalura Lake, Upper Station Lake, and Afognak Lake. In addition, the Division has ongoing data collection activities from Hidden, Karluk, and Spiridon lakes relating to the limnology of these systems. These data are integrated into statewide or regional data bases that are use to directly assess the impacts of the oil spill or are used as controls to measure the response of the studies proposed in this plan, against. In addition, the area research and management biologists for the Division of Commercial Fisheries management and development, the principal limnologist, the regional limnologist, and numerous administrative and support staff are supported by general funds provided by the Alaska legislature. To date, most of the data analysis and reporting for the Sockeye Salmon Over-escapement project has been provided for from contributions of the State of Alaska from these general funds. Total funding for these programs exceeds $1 million. The following is a synopsis of projects in the areas that are covered by State of Alaska general funds: In addition, additional coordinated research projects with the National Biological Survey are planned, to further determine the efficacy of alternative restoration activities.

Kodiak Island	
Kodiak Bio Rehabilitation	$174.1
Spiridon Lake Assessment-	$42.8
Frazer Lake /smolt operation	$36.6
Kodiak Finfish research	$154.4
Kodiak Frazer/Upper Station	
In-season forecasting	$31.5
Kodiak Major System Weirs-	$168.2
Total	$607.6
Kenai Peninsula	
Statewide Limnology Staff (Part)	$160
Limnology & Estuarine Studies	$100
Cook Inlet Aquaculture Association	
Contracts (Hidden Lake-Others)	$18
Kenai River Sonar	$45.4
Kasilof River Sonar	$28.7
Soldotna Research Staff	$203.1

Stock Identification, Upper Cook Inlet	$56.9
Total	$612.1
Grand Total	$1219.7

The studies proposed provide for data collection and field sampling programs. As such no environmental effect of these programs occurs beyond that of traditional fisheries management data collection activities and is within existing collecting permits or Federal special use permits issued to the Department of Fish and Game for scientific data collection activities. New programs on the National Wildlife Refuge are updated through permit amendments as needed. No other permits or other coordination activities are involved.

The investigations of Kodiak and Kenai River sockeye salmon have been integrated with long term research efforts by the Alaska Department of Fish and Game on these stocks. In addition, studies by the limnology laboratory and the fisheries development staff on Kodiak Island on these systems are included in data analysis. Study design and methodology builds off of earlier efforts. Planning and permitting of research activities and future rehabilitation efforts are coordinated through the USFWS Refuge staff in Soldotna and on Kodiak Island. Consultation and planning is conducted with the newly formed National Biological Survey Fisheries Research Laboratory staff in Anchorage. Development of restoration strategies on the Kenai Peninsula are through a review process with the regional planning teams and with an ADF&G review committee including the Sport Fish Division, when adjustments of management policies, such as escapement goals are involved. In addition, studies results from the Coghill Sockeye Salmon investigations in Prince William Sound are reviewed and integrated into the data analysis process for determining the response of the Kenai Peninsula ecosystem to restoration measures.

G. PUBLIC PROCESS

The proposed investigations have been subject to extensive review through the scientific community as well as the public process. Presentations have been made to the Soldotna Rotary Club, the Cook Inlet Regional Planning Team, Upper Cook Inlet Drift Netters Association, and the Alaska Sportfishing Association. The Board of Fisheries has been briefed on the process. Scientific presentations have been made at the Oil Spill symposium and the 1992 Gut Shop. The initial results of the investigations have been through peer review and are to be published in the proceedings of these two symposia. In addition, technical aspects of the studies findings to date and future plans have been reviewed by a panel of international sockeye salmon researchers in a special half day session of the Kokanee and Sockeye Salmon workshop sponsored by the Northern Pacific International Chapter of the American Fisheries Society at Vancouver, B.C. in March, 1993.

The peer review process has also included review of the progress reports by the Trustee Council peer reviewers. These studies have also been included in the discussion of the Trustee sponsored restoration workshop.

H. PERSONNEL QUALIFICATIONS

Dana Charles Schmidt
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:

October, 1991 to Present. Limnologist III, Principal Limnologist, FRED Division, Alaska Department of Fish and Game, Soldotna, AK. Responsibilities include establishing research objectives for the Statewide limnological investigations of the Commercial Fisheries Management and Development Division. This section provides direction for other components of the Division for determination of stocking rates for sockeye salmon in lakes and in the application of fertilization. This section also provides input to the commercial fisheries division for determination of the escapement goals for sockeye salmon. Supervise the limnology laboratory which completes water quality and plankton analysis for water samples taken from several hundred lakes statewide.

April, 1985 to October, 1991: Fishery Biologist IV, Regional Research Biologist, Westward Region, Alaska Department of Fish and Game. Responsible for establishing research objectives and priorities for the Westward Region Commercial Fisheries Division. This Division has management authority over extensive salmon and herring stocks on the Alaska Peninsula and Kodiak Island, in addition to management of the major shellfish stocks in the Gulf of Alaska and the Bering Sea. Annual ex-vessel value of these fisheries is several hundred million dollars, Research highlights included studies of crab larvae settling rates in the Gulf of Alaska and investigations on the effects of oil spill overescapement on the sockeye salmon production of major lakes on Kodiak Island.

May, 1982 to September, 1985 Acting F.B. IV, Susitna River Aquatic Studies Coordinator, Alaska Department of Fish and Game. The entire program under supervision included approximately 25 permanent and 50 seasonal employees. During this interim period, responsible for reorganizing the studies into a more efficient structure to meet the long term monitoring needs for determination of the effects of the Susitna project on the aquatic resources of the Susitna River. Supervised development of operational plans for 18 technical study programs on the Susitna River, assignment of priorities of tasks, and review of the technical merit of the programs proposed. Prior to January 1985. F.B. III, Resident and Juvenile Anadromous Project Leader, Su-Hydro Aquatic Studies Program, Alaska Department of Fish and Game. Supervised research programs on resident and juvenile anadromous fish in the Susitna River that may be impacted by development of the Su-Hydro Project. Technical studies included development of models of sport fishery exploitation on arctic grayling populations, modelling instream flow responses of juvenile salmon habitat, development of baseline population parameters of resident fish and juvenile salmon and development of projections of supersaturated gas dissipation below the proposed dam sites.

January, 1981 to May, 1982: Fishery Biologist, Terrestrial Environmental Services, Anchorage, Alaska. Responsible for field and office review of the aquatic studies programs of the Alaska Power Authority for the Susitna Hydro-Electric Program. This responsibility included assisting the Alaska Department of Fish and Game in study plan development, providing preliminary assessment of impacts of the project on aquatic resources and presenting to the public progress of the aquatic studies programs.

May, 1980 to October 1980: Fishery Biologist, U.S. Fish and Wildlife Service, Soldotna, Alaska. Assisted on a radio-telemetry project and juvenile salmon habitat survey on the Kenai River, 6-mile Creek and the Deshka River in the Cook Inlet area. Activities included tagging and radio tagging chinook and coho salmon, collection of juvenile salmon and measurements of associated habitat, and assisting in the analysis of scale patterns from Kenai River chinook salmon. Other activities included statistical analysis of data, report review and preparation of a publication on the Kenai River chinook for Alaska magazine.

EDUCATION:

Ph.D. in Fisheries 1973
Major Field - Fisheries- Minor Field Pharmacology,
Oregon State University, Corvallis, Oregon
M.S. in Biology, 1970 Major Field - Aquatic Biology Minor Field - Sanitary Biology,
University of Utah, Salt Lake City, Utah
B.S. in Wildlife Biology, 1968, University of Montana, Missoula, Montana

Ken Tarbox
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
34828 Kalifornsky Beach Rd, Suite B
Soldotna, Alaska 99669

EMPLOYMENT:

May, 1980 to Present. Upper Cook Inlet Research Project Leader, Alaska Department of Fish and Game, Soldotna, Alaska. Responsibilities include planning, implementing, supervision, and reporting on various salmon related research and management projects. These involve hydroacoustic enumeration of salmon in glacial systems, defining salmon migratory behavior in both salt and fresh water, evaluation of potential impacts of resource development on habitat and populations, management of the UCI commercial salmon fisheries, stock identification studies using scale or genetic markers, and life history studies of sockeye salmon.

March, 1972 to May, 1980. Project manager and Senior Biologist, Woodward Clyde Consultants, Anchorage, Alaska. Responsibilities included supervision and research for a number of projects. These included an evaluation of existing methodologies for determining instream flow requirements for Alaskan fishes, determining the biological impact of a dredging projects located in lower New York Harbor and Lake Michigan, fishery investigations in the Zayandeh River, Iran, impact assessment of various oil related projects in Virginia, North Carolina, Texas, and Prudhoe Bay, Alaska, and studies and evaluation of impacts associated with nuclear power plants in New Jersey, Louisiana, Indiana, and Pennsylvania.

July, 1970 to March, 1972. Research Assistant, Louisiana Co-operative Fishery Unit, Louisiana State University, Baton Rouge, La. Responsibilities included the design and conduct of a one year investigation of juvenile fish behavior in an estuarine environment.

EDUCATION:

M.S. in Fisheries, 1974. Louisiana State University, Baton Rouge, La.
B.S. in Fisheries Science. 1970. University of Washington, Seattle, Wa.

CERTIFICATIONS:

Fisheries Scientist, Certificate 1165, American Fisheries Society, 1976.

Stan R. Carlson
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
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Soldotna, Alaska 99669

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.

I. BUDGET

Personnel	$681.4
Travel	$13.3
Contractual	$77.4
Commodities	$63.6
Equipment	$40.0
Capital Outlay	0.0
Sub-total	$875.7
General Administration	$107.6
Project Total	$983.3
NEPA Compliance	(State contributed)

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RESTORATION OF THE COGHILL LAKE SOCKEYE SALMON STOCK

Project Number: 95259

Name of Project Leader(s): Mark Willette, ADFG
Kate Wedemeyer, USFS

Lead Agency: Alaska Department of Fish and Game (ADFG)

Cooperating Agency: U.S. Forest Service (USFS)

Cost of Project/FY95: $324,615

Cost of Project/FY96: $324,615

Cost of Project/FY97 and beyond: $324,615

Project Start-up/Completion Dates: October 1, 1994 - September 30, 1998

Project Duration: Five Years

Geographic Area of Project: Prince William Sound

Name of Project Manager: Joe Sullivan

B. INTRODUCTION:

This project will restore the natural productivity of Coghill Lake and the resident sockeye salmon (*Oncorhynchus nerka*) population through lake fertilization. Coghill Lake is located on the eastern side of Port Wells in the northwest region of Prince William Sound (PWS). The Coghill Lake sockeye salmon stock historically supported important sport and commercial fisheries. Returns have declined in recent years from a historical average of 250,000 to only 25,000 in 1991. Damage assessment studies on juvenile salmon suggest that the Exxon Valdez oil spill may have contributed to the decline of the Coghill sockeye stock. Salmon migration patterns indicate that juvenile sockeye smolt from Coghill Lake likely migrated through oil-contaminated areas in western PWS. Juvenile salmon similar in size to Coghill smolts utilized oiled nearshore nursery habitats. The growth and survival of juvenile salmon utilizing these habitats was reduced by oil contamination from the Exxon Valdez spill. The Coghill Lake stock is presently at dangerously low levels. Action must be taken to restore the stock before any further decline occurs. The communities of Anchorage, Whittier, Valdez, and Cordova will benefit from this project. Coghill Lake sockeye have been heavily utilized by sport fishermen travelling from Whittier by boat and from Anchorage by air. Commercial fishermen from all of these communities have historically fished the Coghill Lake sockeye salmon stock. Restoration of Coghill Lake sockeye salmon will further improve management of important sockeye and chum salmon stocks returning to hatcheries in western PWS.

C. NEED FOR THE PROJECT:

This project will restore an important natural resource and resource service in the Exxon Valdez oil-spill area. Restoration of the Coghill sockeye stock will further provide natural resource services to replace those once provided by other injured stocks. Damage assessment studies on juvenile salmon suggest that the Exxon Valdez oil spill may have contributed to the decline of the Coghill sockeye stock. Lake fertilization techniques have been successfully applied in Alaska and elsewhere to restore the productivity of sockeye salmon rearing lakes. The production of sockeye salmon populations is closely linked to the productivity of lakes where the fish rear for one to three years. The availability of food in rearing lakes determines the growth and size of smolts that emigrate to sea. Smolt size in turn determines ocean survival and subsequent adult returns. The fry food resources in Coghill Lake are currently very low (Edmundson et al. 1992). As a result, the lake cannot support large numbers of fry, and the smolts are very small. Fertilization is needed to increase lake productivity and boost fry food abundance until natural nutrient input from salmon carcasses is restored.

D. PROJECT DESCRIPTION:

The goal of this project is to restore the natural productivity of Coghill Lake and the resident sockeye salmon population through use of established lake fertilization techniques. The USFS will apply fertilizer to the lake each summer for five years. The ADFG will conduct limnological and fisheries studies needed to monitor and refine the fertilization program. These studies will focus on the effects of fertilization on primary and secondary production and the growth and survival of juvenile sockeye salmon in the lake.

1. Objectives

The ADFG component of the project will achieve the following objectives each year:

1. Apply liquid fertilizer to Coghill Lake between June and September,

2. determine the response of lake nutrient levels, primary and secondary production, and plankton species composition to lake fertilization,

3. determine if the prey composition, growth, and overwinter survival of sockeye salmon fry changes in response to lake fertilization, and

4. estimate the effect of fertilization on lake carrying capacity and smolt-to-adult survival.

2. Methods

Objective 1:

Lake fertilization is recommended for one sockeye life cycle (5 years) to elevate the productivity of the lake and the resident sockeye salmon population. A pharmaceutical-grade liquid fertilizer will be applied to the lake by releasing it from a low-flying aircraft. Application will consist of six to nine passes of five-minute duration one day each week. Approximately 3,000 kg of fertilizer will be applied each day. Fertilizer will be applied over the middle third of the lake comprising an area of 3.9 km^2. Twenty-three thousand kilograms of liquid fertilizer (20-5-0) containing 20% nitrogen and 5% phosphorus will be applied from mid-June to August 1. Thirty-one thousand kilograms of nitrogen fertilizer (32-0-0) comprising equal portions of ammonium, nitrate-nitrite, and organic nitrogen will be applied from August 1 to early September. People reserving the cabin at Coghill will be notified of the fertilization schedule. Notices will also be posted in the cabin. Fertilizer will be applied no closer than a mile and a half from the cabin and lagoon where most recreational activity takes place. The pilot will not drop fertilizer in a portion of the application area if anyone is within that area.

Objective 2:

Limnological sampling will be conducted twice each month at two stations. Dissolved oxygen concentrations will be measured from the surface to a depth of 40 m. Eight liter water samples will be collected from the 1m stratum, chemocline, and monimolimnion. Replicate vertical zooplankton tows will be taken using a 153-μm mesh conical net. Water samples will be analyzed for the following parameters: conductivity, alkalinity, calcium, magnesium, turbidity, total iron, filterable reactive phosphorus, total phosphorus, nitrate and nitrite, total Kjeldahl nitrogen, total nitrogen, and reactive silicon (Koenings *et al.* 1987). Yearly phosphorus loading will be estimated after Vollenweider (1976). Euphotic zone depth and algal standing crop will be estimated after Schindler (1971) and Strickland and Parsons (1972), respectively. Zooplankton abundance will be estimated from triplicate counts of organisms in 1 ml subsamples. Zooplankton dry weight and biomass will be estimated by regression analysis using body length measurements on 10 individuals from each taxa (Koenings *et al.* 1987). Light penetration will be measured at 1 m increments from the surface to a depth equivalent to 1% of the subsurface light. Water temperature in the epilimnion and water level will be continuously monitored by electronic recorders moored at 5, 15, and 25 m depth.

Objective 3:

The habitats used by sockeye salmon fry in the lake will be determined from visual surveys, beach seine and tow net catches, and hydroacoustic surveys conducted in June, August, and October. A 120-Khz echosounder will be used to determine the vertical distribution of fry in the lake during the day and at night (Kyle 1990). Twenty samples (n=10) of ten sockeye salmon fry will be collected from various habitats during each survey for later analysis of stomach contents and otolith growth.

Stomach analysis will be conducted on sockeye fry collected during each survey. Prey items in the stomach will be identified to the lowest possible taxonomic level. Prey body weight will be estimated by regression analysis using body length measurements on 10 individuals from each taxa (Koenings *et al.* 1987). Stomach contents weight will be estimated by the product of abundance and mean body weight for each taxa. Chi-square analysis will be used to test for differences (P=.05) in the proportion of stomach contents weight in each taxonomic group between three time periods. Analysis of covariance will be used to test for differences (P=.05) in stomach contents weight between three time periods.

Otolith microstructure analysis will be conducted on sockeye fry (n=200) collected during each survey. Thin sections of the otoliths will be prepared using methods developed by Volk et. al. (1984). A computer image analysis system will be used to collect data from the otoliths. A modified Fraser-Lee back calculation procedure will be used to reconstruct fish growth histories during weekly time periods (Campana 1990). Weekly growth estimates obtained from otoliths will be regressed against weekly mean water temperatures obtained from electronic temperature recorders. Analysis of covariance will be used to test for differences (P=.05) in temperature-specific growth between Coghill Lake sockeye and fish fed an excess ration (Brett et al. 1969). Comparison of regression slopes will be used to determine if fry growth in Coghill Lake is limited by food abundance (Brett et al. 1969). This information will be used to monitor the growth response of the fish to fertilization and determine the carrying capacity of the lake.

The overwinter survival of juvenile sockeye will be estimated from fall fry and spring smolt population estimates. Fall fry population size will be estimated with a 120 Khz echosounder towed along 10 randomly selected transects (Kyle 1990). A mid-water trawl will be used in conjunction with the hydroacoustic surveys to determine species composition, age, and size of fish targets. Sockeye salmon smolts emigrating from Coghill Lake will be enumerated using incline-plane traps (Kyle 1983). The traps will be operated continuously from early May through June. The catch efficiency of the traps will be determined by mark/recapture analysis. Age composition and size will be estimated from a sample of 40 smolts collected each day. Chi-square analysis and analysis of variance will be used to test for differences (P=0.05) in age composition and smolt size between years, respectively. A representative sample of smolts will be coded-wire tagged to enable later estimation of smolt-to-adult survival in the commercial fishery. The combined results from these investigations will be compiled in an annual report describing the success of the fertilization program and recommending refinements to the methodology.

Objective 4:

The effect of lake fertilization on lake carrying capacity will be evaluated using techniques developed by Koenings and Burkett (1987). The mean annual zooplankton biomass for Coghill Lake will be used as the independent variable in a regression model relating zooplankton biomass in Alaskan lakes to smolt biomass. Actual smolt biomass in Coghill Lake will be compared with expected smolt biomass from the regression model to evaluate growth and mortality of sockeye fry in Coghill Lake. The effect of lake fertilization on smolt-to-adult survival will be also be evaluated using techniques developed by Koenings (pers. comm.). The mean size of Coghill Lake smolt will be used as the independent variable in a regression model relating mean smolt size in Alaskan lakes to smolt-to-adult survival. Actual smolt-to-adult survival will be estimated when the fish return as adults one to three years after outmigration.

3. Schedule

This project will be conducted over a five year period which corresponds to the generation time for Coghill Lake sockeye salmon (Edmundson et al. 1992). Lake fertilization is expected to elevate lake productivity until carcasses from adult spawners can once again contribute significantly to the nutrient load in the lake. Project activities will take place throughout each year (Table 1).

Table 1: Annual schedule of project activities (1993-1997).

DATE	ACTIVITY
May - June	Enumerate outmigrant smolts and estimate smolt age and size
June - October	Apply fertilizer each week and conduct limnological sampling
June, Aug., Oct.	Determine fish habitat use and sample for otolith and stomach analysis
October	Estimate fall fry population size using hydroacoustic techniques
June - October	Conduct laboratory analyses of limnological, otolith, and stomach samples
October-Dec.	Analyze data and prepare annual report

4. Technical Support

Hydroacoustic fish abundance estimates in Coghill Lake will be provided by the Prince William Sound Science Center (PWSSC). The staff of the PWSSC have considerable expertise in quantitative hydroacoustic techniques including work at Coghill Lake in FY94. Their continued participation in this project will provide of consistency in hydroacoustic techniques and thus valid interannual comparisons of fry abundance estimates.

5. Location

This project will be conducted at Coghill Lake which is located in northwest PWS on the east shore of Port Wells. The Coghill Lake sockeye salmon population migrates through several fishery distícts in western PWS.

E. PROJECT IMPLEMENTATION

The ADF&G will collect field samples of juvenile salmon for this project. The ADF&G is responsible for managing the sockeye salmon resource in the PWS area. In addition, the ADF&G is responsible for the development, oversight, and evaluation of salmon enhancement projects in PWS. The ADF&G has conducted limnological and sockeye salmon smolt studies in Alaska during the past twenty-five years. The PWSSC will conduct hydroacoustic surveys of Coghill Lake to estimate fry abundance. The staff of the PWSSC have considerable expertise in quantitative hydroacoustic techniques including work at Coghill Lake in FY94.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be integrated the project Coded-wire Tag Recovery of Other Salmon Species. This project will provide estimates of fishery catches of Coghill Lake sockeye salmon that are needed to estimate the total return of salmon to Coghill Lake and smolt-to-adult survival.

G. PUBLIC PROCESS

This project was developed through several months of planning by the ADF&G, USFS, and Prince William Sound Aquaculture Corporation (PWSAC). The Prince William Sound/Copper River Regional Planning Team has reveiwed and endorsed the project plan.

H. 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.

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.

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.

I. BUDGET

Table 1: Budget summary for the Restoration of Coghill Lake Sockeye Salmon in FY95.

Line Item	FY95
Personnel	126,543
Travel	2,140
Contractual	154,300
Supplies	11,850
Equipment	0
Capital Outlay	0
Total	294,833
General Admin	29,782
Grand Total	324,615

References:

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Vollenweider, R. A. 1976. Advances in defining critical loading levels for phosphorus in lake eutrophication. Mem. Ist. Ital. Idrobiol. 33:53-83.

Project 95266: Shoreline Assessment and Oil Removal; (Analysis and Report Writing for FY 1994 Field Work)

Project Number: 95266 (closeout)

Name of Project Leader or Principal Investigator:
National Biological Survey (DOI): Dr. Gail Irvine
Alaska Department of Environmental Conservation: Ron Bruyere

Lead Agency: DOI and ADEC.

Cost of Project: $93,800
NBS: $22,500
NOAA: $32,800
DEC: $38,500

Project Start-up/Completion Dates (month/year): Field Work began in summer 1994. This project is analysis and report writing for that field work. The draft report will be submitted by April 15, 1995. The final will be submitted as soon thereafter as possible.

Project Duration (number of years): FY 95 (field work); FY 96 report writing).

Geographic Area: The field work was in Prince William Sound, and in Kenai Fjords and Katmai National Parks. The analysis and report writing will be in Juneau and Anchorage.

Contact Person:

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B. Introduction

On January 31, 1994, the Trustee Council authorized $365,000 for Project 94266, Shoreline Assessment and Oil Removal. The authorization funded summer field costs and analysis for Fiscal Year 1994 which ends September 30th. This project requests $93,800 for three of the Trustee agencies to complete analysis and report writing for the 1994 field work.

National Biological Survey Component. This summer, during FY 94, National Biological Survey personnel conducted a shoreline assessment of the chemical and physical degradation of oil at six sites along the Kenai and Alaska peninsulas adjacent to national park lands. These sites were established in 1992 and will be revisited and sampled this summer in order to establish rates of chemical degradation and changes in the persistence of the oil. Unlike most oiling in

Prince William Sound, oil that was stranded in these study areas arrived in the form of mousse. Monitoring will study the changes through time for this type of shoreline oiling. In FY 95, funding is needed for chemical analysis of oil samples taken at the sites, as well as data analysis and report writing to complete the study.

Alaska Department of Environmental Conservation Component. Residual surface oil has important social and economic consequences for subsistence and recreation. It affects the safety of subsistence resources, residents' perception of the quality of subsistence resources, and subsistence use of resources on beaches with remaining surface oil. In addition, recognizable surface oil reduces the quality of recreation use of oiled beaches. This summer, during FY 94, department personnel in conjunction with Chenega Bay will accomplish light-duty manual treatment of surface oiling at approximately a dozen critical sites in western Prince William Sound in order to accelerate natural degradation of the surface oil and help restore natural and human use of the resources at those sites. They will also collect oil samples on beaches selected for cleaning. During FY 95, funding is needed for data analysis and report writing, and to disseminate information concerning the results of the study. The data analysis will also provide information about residual oil including the fingerprint, weathering patterns, and degradation of the oil.

C. Need for the Project

National Biological Survey. The recovery objective for oiled sediments is to return sediments to pre-spill oil concentrations. This can occur by removing oil physically or by weathering. Weathering refers to the natural breakdown of oil which removes the toxic component of oil and leaves an inert component.

This project helps to achieve the objective in several ways. NBS has located several "hot spots" of EVOS oil on beaches. The weathering of the oil on these sites has been characterized by study of its chemical and physical degradation in the last five years. Moreover, the geomorphology of the sites' regions have been documented. This project focuses on how geomorphology affects retention and rate of degradation of oil. Linking the geomorphology with the rate of weathering of oil will produce refinement of shoreline sensitivity designations. The research may allow prediction of areas with remaining contamination (useful for assessing any further restoration needs as well as indicating areas likely to retain oil in future spills).

Alaska Department of Environmental Conservation Component. Recreation and subsistence are affected by the visual recognition of oil. The objective for subsistence restoration adopted by the Trustee Council reads in part, "Subsistence will have recovered when...people are confident that the resources are safe to eat." The recreation objective reads in part, "Recreation and tourism will have recovered...[in part]...when recreation use of oiled beaches is no longer impaired..." Accelerating degradation of surface oil from beaches which subsistence and recreational indicate affects their use of the resources will help restore subsistence and recreational use.

D. Project Design.

1. Objectives. This project will help determine the status of shoreline recovery and accelerate the rate of natural recovery at beaches with service oiling. The more specific objectives are:

1. (NBS) To monitor the chemical and physical degradation of oil at permanently marked sites along the Kenai Fjords and Katmai National Park coastlines in order to establish rates of degradation.
2. (NBS) To evaluate existing conceptual models of shoreline geomorphology and oil persistence using data from this project to refine our understanding of shoreline sensitivity. This analysis may also allow identification of other sites of persistent oil contamination that may warrant restoration.
3. (DEC) To accelerate the rate of natural recovery on beaches with surface oiling.
4. (DEC) To maintain the oil spill record and help users understand the state of the resources they depend on. In addition, it will provide information about the fingerprint, weathering patterns, and degradation of surface oil.

2. Methods. Not applicable.

3. Schedule. Draft Report April 15, 1995; Final Report as soon thereafter as possible.

4. Technical Support. Hydrocarbon analysis (GC/MS) will be needed for the oil samples collected by the National Biological Survey, and by the Alaska Department of Environmental Conservation. It will be run on 16 samples from the NBS (12 from the sites and 4 historical samples), and approximately 20 samples collected by ADEC. These samples will be analyzed by NOAA's Auke Bay Laboratory for consistency of comparison, using methods that have been in use since the time of the spill.

5. Location. The field work was in Prince William Sound, and in Kenai Fjords and Katmai National Parks. The analysis and report writing will be in Juneau and Anchorage.

E. Project Implementation--Who should implement the project

Because this proposal covers the synthesis of data already collected by the NBS and ADEC, the reports are most logically written by the agency which has collected the information. For chemical analysis of samples, previous work for this project has been done by NOAA's Auke Bay Lab and therefore, for consistency of comparison, the Auke Bay Lab should analyze the remaining samples. Auke Bay Laboratory's chemist Jeff Short will do a comprehensive examination of all samples to identify fingerprint, weathering patterns, and degradation.

F. Coordination of Integrated Research Effort

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

G. Public Process.

Distributing the results is an important part of this project. Subsistence and recreation users should know the status of surface oil on their beaches. Resource managers and the public that is interested in national park lands should know the status of surface oiling in Katmai and Kenai Fjords National Parks. To avoid inundating interested citizens with an overload of independent announcements, the public description of the results of this study should be distributed with those other oil spill studies. In addition, the data and specific results of this project needs to be available to the interested public, and to scientists working on other projects.

H. Personnel Qualifications.

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

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

Jeffrey Short holds a B.S. in biochemistry and an M.S. in physical chemistry from the University of California. Mr. Short is an analytical chemist at the Auke Bay Laboratory, and leads the hydrocarbon analysis facility at the lab, which is one of the two laboratories analyzing *Exxon Valdez* NRDA and Restoration environmental hydrocarbon samples. He was the principal investigator of NRDA project Subtidal Studies #3 and #8, was among the first scientists to collect samples seven days after the spill, and is the resource chemist for all samples (>30,000) in the *Exxon Valdez* hydrocarbon database. Mr. Short conducted extensive research on the effects of Alaskan crude oils to Alaskan marine biota over a period of 10 years prior to the *Exxon Valdez* oil spill and has numerous publications resulting from this research.

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

Ron Bruyere has a B.S. in mathematics from the State University of New York, and is the project manager for the Shoreline Assessment portion of this project for DEC. He has nine years experience in a variety of project manager positions.

Diane Munson was an Environmental Specialist with the *Exxon Valdez* Oil Spill Response Center and Restoration Team (May 1989 through October 1993) and conducted shoreline assessments for DEC during those years. She has compiled data and wrote reports on hundreds of sites impacted by the *Exxon Valdez* spill, trained environmental technicians to act as shoreline monitors for the treatment of spill. Additional, she was the principal surveyor and project supervisor for the 1993 Restoration Shoreline Survey and report, primary author of the 1992 Shoreline Evaluations Contaminations Sites Report, and principal author of the 1989 through 1991 Prince William Sound Treatment Report. She has a B.A. in biological sciences.

I. Budget (figures in thousand dollars)

	NBS	NOAA	DEC
Personnel	$17.2	$25.5	$27.7
Travel	$ 2.5	$0.0	$3.6
Contractual Services	$ 0.0	$0.0	$1.5
Commodities	$ 0.3	$3.5	$0.7
Equipment	$ 0.0	$0.0	$0.0
Capital Outlay	$ 0.0	$0.0	$0.0
Subtotal	$20.0	$29.0	$33.5
General Admin.	$ 2.5	$3.8	$5.0
Project Total	$22.5	$32.8	$38.5

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Chenega Chinook Release Program

Project Number:	95272
Project Leader:	Jeff Olsen, PWSAC Operations Manager
Lead Agency:	AK. Dept. of Fish and Game (ADF&G)
Cost of Project, FY95:	$38.7; **FY96** $39.1
Start/Completion:	January, 1995 - September, 1995
Project Duration:	0.75 yr.
Geographic Area:	Crab Bay near the Chenega village on Evans Island in PWS
Contact Person:	Jeff Olsen, Operations Manager PWSAC, P.O. Box 1110, Cordova, AK 99574 (907) 424-7511

B. Introduction

In June 1994, PWSAC began a chinook salmon smolt release program at Crab Bay adjacent to the village of Chenega Bay in cooperation with the Alaska Department of Fish and Game (ADF&G) and the residents of Chenega Bay, to establish local salmon runs to restore damaged resources resulting from the Exxon Valdez oil spill in 1989. Funding for this project was provided through the EVOS Trustee Council.

The FY95 proposed Chenega chinook salmon smolt release project will continue the 50,000 smolt release program initiated in 1994. This program is planned to eventually result in a return of adult chinook salmon to Crab Bay reaching a projected 2,000 salmon.

C. Need for Project

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

D. Project Design Objectives, Methods, Schedule and Location

1. Objectives

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

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

2. Methods

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

In the spring of 1994, 50,000 chinook smolt were taken from WNH and transported via barge and fry/smolt transport tanker to Crab Bay. This operation is proposed to continue in 1995. The smolt will be released into a 350 m^3 (40 ft X 40 ft X 5 ft) net pen anchored in Crab Bay. Smolts will be reared for approximately two to three weeks at the site for imprinting and additional growth prior to release. Technical support for the incubation, hatching and feeding of the smolts will be provided by PWSAC. Residents of Chenega village will be contracted, trained in smolt feeding and rearing, and paid for services.

3. Schedule

Activity	Begin	Complete
Rearing (smolt)	**4/94**	5/95
Outmigration (fry)	3/95	4/95
Install net pen	5/95	5/95
Feed and imprint smolt	5/95	6/95
Release smolts	6/95	6/95
Dismantle/Remove net pen	6/95	6/95
Eggtake	7/95	8/95
Incubation	8/95	**3/96**

4. Technical support

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

5. Location

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

E. Project Implementation

PWSAC will implement the project; residents of Chenega will be contracted by PWSAC to feed the smolt rearing at Crab Bay.

F. Coordination of Integrated Research Effort

This project is not proposed as research, but is a program directed at resource replacement.

G. Public Process

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

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

H. Personnel Qualifications

Jeffrey B. Olsen

Work Experience

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

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

1986-1988: WNH assistant manager, PWSAC.

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

Education

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

I. Budget FY95

100	Personnel		$1.0
200	Travel		$0.0
300	Contractual Services		$35.9
	Administration		$1.8
400	Commodities		$0.0
500	Equipment		$0.0
		TOTAL	$38.7

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Subsistence ~~Restoration Project~~ FOOD SAFETY TESTING

Project Number: 95279

Lead Agency: ADF&G

Cooperating Agencies: None

Cost of Project, FY95: $ K

Project Startup Date: 10/94

Duration: 1 years

Geographic Area: Field work will be conducted on Prince William Sound, the Kenai Peninsula, and Kodiak Island. Newsletters will be written and printed in Anchorage. Samples will be examined, and results analyzed in various locations, including Seward, Juneau and Anchorage.

INTRODUCTION

Subsistence uses of fish and other wildlife constitute a vital natural resource service that was injured by the Exxon Valdez oil spill. Data collected by the Alaska Department of Fish and Game's Division of Subsistence demonstrated this injury. Annual per capita subsistence harvests declined dramatically (from 4 percent to 77 percent decline compared to pre-spill averages) in ten of the communities in the path of the spill during the first year after the event. In subsequent years, levels of subsistence harvests, ranges of uses, harvest effort, and the sharing of resources have gradually increased in all of the spill area communities. Some subsistence users reported renewed confidence in traditional foods after receiving information and health advice from the Oil Spill Health Task Force. Others returned to using subsistence foods despite their misgivings because of economic and cultural reasons. Still others have traveled to unoiled areas to harvest resources. A view persists in the communities in the oil spill area, that the natural environment has changed in ways that still pose a potential threat to their health and their way of life. This view is partly fueled by observed abnormalities in resource species, and scarcity of some resources.

We propose to continue a subsistence restoration project involving the following communities; Chenega Bay, Tatitlek, Cordova, Valdez, Nanwalek, Port Graham, Seldovia, Kenai, Seward, Larsen Bay, Karluk, Old Harbor, Akhiok, Port Lions, Ouzinkie, Kodiak City, Chignik Lake, Chignik, and Chignik Lagoon.

In 1993 and 1994 the Exxon Valdez Trustee Council provided funding to restore the subsistence uses of fish and wildlife damaged by the Exxon Valdez Oil Spill. Community meetings were held in order to identify and map the specific areas and resources of continued concern to subsistence users. Samples of those subsistence species cited in community meetings as being of continued concern were collected from harvest areas identified during the mapping, with community representatives assisting in site selection, as well as the collection of samples. The samples were analyzed for the presence of hydrocarbon contamination, at the National Oceanic and Atmospheric Administration/National Marine Fisheries laboratory in Seattle. Community representatives were transported to the lab and given a tour of the facilities. The results of the tests, along with findings from other damage assessment and restoration studies, were interpreted by the Oil Spill Health Task Force, and reported to the communities in an informational newsletter and community visits.

At this point, there is little we can learn about subsistence food safety from additional hydrocarbon testing, and barring unforseen circumstances, we will not be doing any further testing of this kind. The 1995 project will continue efforts to communicate information on subsistence food safety to the communities, throught the Subsistence Restoration Newsletter. The Newsletter will also be used to report information on other restoration projects, putting the information into context for subsistence users. In addition we will put in place a system for getting samples of abnormal resources from subsistence users to biologists and pathologists for study, and will report the findings of the scientists to subsistence users.

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

PROJECT DESCRIPTION

1. Resources and/or Associated Services: The goal of the project is to restore the subsistence uses of fish and wildlife damaged by the Exxon/Valdez Oil Spill. It is expected that by responding to the specific oil spill related concerns of subsistence users through testing of those resources, and reporting accurate health information back to the affected communities in clear, understandable language and in one on one discussions, the confidence of subsistence users in the resource can be restored. Past efforts in this direction have been partially successful.

2. Objectives: This is anticipated to be the final year of a three year project. The following dates refer to the completion of activities for fiscal year 1995. Sampling kits will be in place in the communities by January 15, 1995, and the participating scientists will have been recruited by the same date. Four issues of the Subsistence Restoration Newsletter will be produced. The last round of community meetings will take place in September 1995.

3. Methods: Community meetings will be held in the following eleven communities, Chenega Bay, Tatitlek, Nanwalek, Port Graham, Seward, Larsen Bay, Karluk, Old Harbor, Akhiok, Port Lions, and Ouzinkie, to identify any continued oil spill related concerns of subsistence users. Other communities may be added if such concerns are noted by Subsistence Division researchers during community visits. Those communities where no concern is

indicated in either the community meetings or by other communication will be dropped from the study.

A system will be put in place whereby subsistence users can send samples of abnormal resources that they encounter to biologists and pathologists to be examined. This will involve identifying, ahead of time, scientists willing to examine different types of specimens, and how each type of specimen needs to be handled, packaged and shipped. Community residents will need to be trained to properly preserve the different types of samples for shipping. Sampling kits will be placed in each community, and an account will be set up with an air carrier to transport samples from the communities to Anchorage. The training of subsistence users and the assembling of kits will be contracted out on a competitive basis. Reporting the information from the scientists to the subsistence users will be done by the Division of Subsistence.

Communication of health advice and information on restoration projects to residents of the impacted communities would require the production of a quarterly Subsistence Division newsletter. It is important that the findings of restoration studies be integrated into this communication effort. As this information is released it is likely to cause renewed concern among subsistence harvesters. It is not always possible to anticipate the effect a technical report, or the media accounts derived from it, will have in these communities. The newsletter will serve to put this information in context for subsistence users, following an evaluation of the information by the Oil Spill Health Task Force. It will also be important to follow distribution of the newsletter with community visits. These can involve informal visits to households and/or formal meetings. The purpose will be to further the dialogue between researchers and the communities regarding study findings.

By involving subsistence users in decisions affecting mitigation, and the monitoring, enhancement and replacement of the natural resources, we can accelerate the recovery of the resources subsistence users rely upon. There is a need in these communities to actively participate in restoration of the environment. This project provides for such involvement.

4. Location: Field work will be conducted on Prince William Sound, the Kenai Peninsula, and Kodiak Island. The communities of Chenega Bay, Tatitlek, Nanwalek, Port Graham, Seward, Larsen Bay, Karluk, Old Harbor, Akhiok, Port Lions, and Ouzinkie will be involved. Other communities may be added if similar concerns are identified.

5. Technical Support: Technical support will be needed from biologists and pathologists with various state and federal agencies. Some have already indicated their willingness to participate in such a project.

6. Contracts: The training of subsistence users to collect samples and the assembling of collection kits will be contracted out on a competitive basis. Typesetting and printing of four issues of an informational newsletter will also be contracted out. These task involve specific skills, and can be more efficiently completed by a professional.

SCHEDULES

JANUARY 1995 Informational newsletter issued, community meetings.
MARCH 1995 Training complete, kits in place in communities, scientists lined up.
APRIL 1995 Informational newsletter issued
JULY 1995 Informational newsletter issued
AUGUST 1995 Informational newsletter issued
APRIL 1996 Final report on fiscal year 1994 activities

Throughout the duration of the project,there will be periodic village visits as appropriate, and samples will be processed as they come in.

ADF&G PROJECT PERSONNEL

James Fall

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

Rita Miraglia

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

Craig Mishler

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

EXISTING AGENCY PROGRAM

The Division of Subsistence, Alaska Department of Fish and Game maintains an ongoing program monitoring subsistence harvests in communities throughout Alaska, including the area affected by the Exxon Valdez oil spill. The Division is currently compiling results of a joint project with the U.S. Minerals Management Service, which involved administering two surveys, one on subsistence and personal use harvests, and the other on social effects of the Exxon Valdez oil spill. We are able to use information from this joint study to guide our subsistence restoration efforts.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

This project is categorically excluded under NEPA guidelines.

Permits will not be needed to collect the samples of abnormal resources, because they will be taken from animals killed by subsistence hunters for food.

PERFORMANCE MONITORING

Four informational newsletters will be produced, summarizing project findings and test results. A final report and data summary will also be provided at the conclusion of fiscal year 1995 activities.

BUDGET ($K)

100	117.0
200	17.0
300	53.8
400	1.9
500	0.0
Subtotal	189.7
General Admin	
Total	

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Hydrocarbon Data Analysis, Interpretation, and Database Maintenance for Restoration and NRDA Environmental Samples Associated with the *Exxon Valdez* Oil Spill

Project Number: 95290

Project Leaders: Sid Korn, National Marine Fisheries Service
Jeffrey Short, National Marine Fisheries Service
Stanley D. Rice, National Marine Fisheries Service

Lead Agency: National Marine Fisheries Service

Cost of Project: FY95 $72.2 FY96 $91.9

Start Date: October 1, 1994

Finish Date: September 30, 1995

Geographical Area: Entire Oil Spill Area

Contact Person: Bruce Wright
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, AK 99821
907-789-6021

B. INTRODUCTION

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

1) Sample collection information for >41000 samples including major sample types of sediment, tissue, water, and oil.
2) Hydrocarbon analysis information for >12000 samples, each sample analyzed has results for 73 analytes plus quality assurance data.
3) Bile and HPLC analysis for >2400 samples.

4) Data in support of NRDA and restoration projects over the period 1989-1994.

This project will provide the following:

a) Continued use and access of 1989-94 NRDA and Restoration hydrocarbon data

b) Expansion of the hydrocarbon database with new hydrocarbon and collection information for current Restoration studies collecting samples, requiring analysis and data archival.

c) Interpretation of past and current hydrocarbon results for PI's managers, and the public.

d) Continued quality control of sample storage, and hydrocarbon analyses, and data archival.

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

C. NEED FOR THE PROJECT

All restoration projects that collect samples for hydrocarbon analysis need archival of collection information, sample storage, and chemical analysis. In addition, they usually need interpretation support of the chemical analysis for reports. In many cases biologists are not qualified to interpret hydrocarbon results. Many restoration projects need access to hydrocarbon results and interpretations to make resource decisions and are benefited by these services. The trustee's and public are also benefited by permanent archiving of hydrocarbon sample collection and analytical results in a database.

D. PROJECT DESIGN

1. Objectives

The objective of this project is to apply and extend hydrocarbon interpretation methods and data archival developed in NRDA assessments to samples analyzed for the Restoration effort, and to insure the comparability of analytical and interpretive results with those of the NRDA effort.

2. Methods

Procedures developed during the NRDA effort will be followed in this project. Incoming samples are inventoried and collection information is entered into a database located at Auke Bay, AK. Hydrocarbon data will be evaluated using methods described in the final reports of *Exxon Valdez* NRDA project Subtidal #8. These methods were developed specifically for *Exxon Valdez* NRDA hydrocarbon data. Data associated with hydrocarbon samples will be added to the existing *Exxon Valdez* database. Principal investigators from all projects collecting hydrocarbon samples will be assisted by this project through archival, interpretation, and mapping of their data. Data archival will include maintenance of a Rbase database with sample collection information and hydrocarbon results. This database allows inventory of hydrocarbon sample collection, and retrieval of collection and hydrocarbon results for PI and management use. Rbase will be replaced with Oracle database to allow remote access to the data as needed. Data interpretation will include examination of the data for evidence of systematic bias, which will provide the basis for an evaluation of data quality, and a probability based determination of sources of hydrocarbons found in samples. Finally, maps of specific hydrocarbon samples will be provided on request by principal investigators, government agencies, or the general public.

3. Schedule

This project is an ongoing service task and therefore has few set milestone dates. All of the methods, including computer software written specifically for these tasks, have already been developed, tested, and applied. The requested funds are entirely for continuation of these services for additional data that will be produced by Restoration projects. Data is distributed to PI's and other interested parties as requested. Final reports will be completed in April of 1995 for 1994 activities and in April 1996 for 1995 efforts.

4. Technical Support

All technical support is on site. This includes hydrocarbon analytical facilities, computer services, database management and mapping services. The facility just acquired a CDC unix computer with Oracle database software that is connected on the internet with potential access of all users.

5. Location

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

E. PROJECT IMPLEMENTATION

There are alternative agencies that could implement the project. These include State, University and private agencies that could be contracted to manage the database and provide chemical interpretive services. However, since ABL has established procedures, expertise, and equipment, costs would be higher and time for switching of the project would have to be accounted for. There are only a few places in the country that have the chemical expertise of Auke Bay.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

All PI's collecting samples for hydrocarbon analysis will be given materials and training to incorporate their samples into the database. We work closely with an PI's requesting interpretive or mapping services.

G. PUBLIC PROCESS

All principal investigators are encouraged to use interpretive services from this project. Since this is a very technical projects we do not expect public participation, but have queried the database for the public, and directed them to appropriate agencies, and PI's who had data that they were interested in. We expect to service all questions to the database from PI's and the public.

H. PERSONNEL QUALIFICATIONS

GS-11 Fishery Biologist - Sid Korn

Education:
BA 1966, Nasson College
Graduate Studies 1967, Institute of Marine Biology, University of Miami
Graduate Studies, 1967-68, Humboldt State University
Numerous additional coursework including, fish physiology, Dbase programming, project management, supervision.

Relevant Experience:
1989-1990 Assisted Jim Price in development of the NRDA database and the management of incoming samples and database management.

1990-present Is the database manager of NRDA and restoration hydrocarbon data after the departure of Jim Price. Responsibilities include: supervision of data entry of sample and analytical data; processing and dissemination of data for principal investigators use; database management and design; setup and maintenance of GIS mapping system.

GS-13 Research Chemist - Jeffrey W. Short

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

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

GS-14 Physiologist - Stanley D. Rice
Principal Investigator, ABL Habitat Program Manager

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

Relevant Experience:
1971-present: Employed at Auke Bay Fisheries Laboratory as a research physiologist, task leader, and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chem labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of

hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

I. BUDGET

A. Project - $72.2K (FY95)

Personnel	$ 55.4K
Travel	4.0K
Contracts	0.0K
Commodities	4.5K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	63.9K
General Administration	8.3K
TOTAL	$ 72.2K

B. Comprehensive Reporting - $91.9K (FY96)

Personnel	$ 76.0K
Travel	4.0K
Contracts	0.0K
Commodities	0.5K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	80.5K
General Administration	11.4K
TOTAL	$ 91.9K

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Salmon Growth & Mortality

Project Number:	95320-A
Name of project leader(s):	Mark Willette
Lead agency:	Alaska Department of Fish and Game
Cost of project/FY 95:	$378,564
Cost of project/FY 95:	$378,564
Cost of Project/FY 96 and beyond:	$378,564
Project Start-up/Completion Dates:	October 1, 1994 - September 30, 1998
Project Duration:	Five Years
Geographic area of project:	Prince William Sound
Name of project manager:	Joe Sullivan

B. INTRODUCTION

This project is a component of the Prince William Sound System Investigation (PWSSI) program. PWSSI 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). This project will compare growth rates of juvenile pink salmon among years (1989-1995), track the migration of juvenile salmon in PWS, evaluate the carrying capacity of PWS for juvenile salmon and other age 0 fish, and develop techniques for estimating pink salmon mortality within the PWSSI study area.

C. NEED FOR THE PROJECT

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 these salmon run failures. Low returns of hatchery-produced salmon in both years indicates that the failures were likely caused by processes occurring during the juvenile lifestage. 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. The proposed project will focus primarily on the growth and mortality of 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). The proposed project 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 the project Forage Fish Influence on Recovery of Injured Species. The data from both of these projects will be used to evaluate the carrying capacity of PWS for juvenile fishes.

The proposed project will also develop techniques for estimating the mortality of pink salmon in PWS and the Gulf of Alaska. This information is needed to determine if recent run failures are caused by processes occurring within the PWSSI study area or outside of this region.

D. PROJECT DESCRIPTION

This project will track the migration of juvenile salmon through PWS, estimate juvenile salmon growth, contribute to carrying capacity studies, and develop techniques for estimating mortality within the PWSSI study area. The project will complement other components of PWSSI by providing essential data needed to improve our understanding of the mechanisms regulating the ecosystem. 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. 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 1995, and test for differences in growth rate among years (1989-1995).

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

3. Estimate diet composition of juvenile pink salmon in PWS in 1995, test for differences in diet composition among years (1989-1992, 1994, 1995), and collect juvenile fish stomach samples for the project Forage Fish Influence on Recovery of Injured Species.

4. Determine if the growth rate of juvenile salmon was likely limited by low food abundance in 1995.

5. Test for differences in the relationship between juvenile salmon growth and fry-to-adult survival among years (release years 1989-1994).

6. Develop techniques to estimate the mortality of juvenile pink salmon within the PWSSI study area.

2. 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. 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. A portable tube CWT detector will be used to isolate CWT juvenile salmon from untagged fish in the catch. All CWT salmon will be retained for later analysis of growth. The total number of fish in the catch will be estimated volumetrically. 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. 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.

Coded-wire tags will be extracted and interrogated as they are recovered in the field. This will enable specific treatment groups to be targeted. Methods developed by the ADF&G CWT Laboratory for extracting and interrogating CWTs will be employed. 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. Condition of CWT juvenile salmon will be examined to evaluate feeding and growth conditions.

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.

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, and habitat type. 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. Whenever possible, samples of other juvenile fishes (forage fish) will be collected along with samples of juvenile salmon.

Stomach contents analysis will be conducted later in the laboratory. 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 contents weight will be measured to an accuracy of 0.1 mg. 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.

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 1995 (Willette 1994). 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. Feeding times in excess of available daylight will indicate that the fish may not have acquired the maximum daily ration.

Objective 5:

The relationship between juvenile growth rates and fry-to-adult survival will be evaluated from recoveries of CWT juveniles and adults. The Pink Salmon Coded-wire Tag Recovery project will provide data on survival rates of CWT pink salmon released in 1994. 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.

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 PWSSI 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 1996 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 1996, 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. Feasibility studies conducted in 1994 and 1995 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 Juvenile Salmon & Herring Integration component of the PWSSI program.

3. Schedule:

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 1995 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>	
7/1/95 - 12/31/95	Conduct stomach contents analysis.
1/1/96 - 3/31/96	Analyze data and prepare annual report.

4. Technical Support:

Hydroacoustic assessments of juvenile salmon distribution and abundance will be provided by the Nearshore Fish component of PWSSI. 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 PWSSI.

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 economic health of the communities (Whittier, Valdez, Cordova) in this region is dependent on the salmon resource. The proposed project will focus sampling effort in western PWS which is known to be a major migratory pathway for juvenile salmon exiting the Sound.

E. PROJECT IMPLEMENTATION

The ADF&G will collect field samples of juvenile salmon for this project. The ADF&G is responsible for managing the pink salmon resource in the PWS area. In addition, the ADF&G is responsible for the development, oversight, and evaluation of the salmon enhancement program. The recent decline in salmon survival in PWS has jeopardized the viability of the salmon enhancement program. The ADF&G has conducted field studies on juvenile salmon in PWS during the past five years. Stomach contents analyses of juvenile salmon will be conducted by the National Marine Fisheries Service, Auke Bay Laboratory (Molly Sturdevant) and the University of Alaska Fairbanks (Steve Jewitt). The proposed project will also collect samples that will be analyzed within the project Forage Fish Influence on Recovery of Injured Species.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be highly integrated with several other components of the PWSSI Program as well as other projects in the FY95 workplan. Within the Physical Oceanography component of PWSSI, conductivity, temperature, depth (CTD) profilers will be deployed from vessels working under Salmon Growth and Mortality. Within the Zooplankton component of PWSSI, 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 Forage Fish Influence on Recovery of Injured Species. 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 proposed Otolith Mass Marking Project 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 PWSSI.

G. 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 PWSSI. A workshop will be held in the fall of 1994 to review the first year's results from Salmon Growth and Mortality and other components of PWSSI. Results reviewed at the workshop will be preliminary, because all samples from the 1994 season will not be processed before December 31, 1994.

H. 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.

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.

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.

I. BUDGET

Table 2: Budget summary for the Juvenile Salmon Growth and Mortality component of the PWSSI program in FY95.

Line Item	FY95
Personnel	223,043
Travel	2,125
Contractual	87,000
Supplies	22,850
Equipment	4,000
Capital Outlay	0
Total	339,018
General Admin	39,546
Grand Total	378,564

References:

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Conover, W.J. and R.L. Iman. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. Amer. Stat. 35(3): 124-129.

Coyle, K.O., A.J. Paul and D.A. Ziemann. 1990. Copepod populations during the spring bloom in an Alaskan subarctic embayment. J. Plankton Res. 12(4): 759-797.

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

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

Willette, T.M. 1994. Impacts of the Exxon Valdez oil spill on the migration, growth, and survival of juvenile pink salmon in Prince William Sound. In: Proceedings of the Exxon Valdez Oil Spill Symposium, February 1993, Anchorage, Alaska, (in press).

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Prince William Sound Pink Salmon Stock Identification and Monitoring Studies

Project Number: 95320-B

Principal Investigator: Samuel Sharr (ADF&G)

Lead Agency: ADF&G **Cooperating Agencies:** Prince William Sound Aquaculture Corp. Valdez Fisheries Development Assoc.

	Cost of Project, FY95: $456.4K (Total)	Cost of Project, FY96: $456.4K (Total)
Trustees	$248.6K	$248.6K
ADF&G	$ 81.6K	$ 81.6K
PWSAC	$100.0K	$100.0K
ADF&G	$ 26.2K	$ 26.2K

Project Startup Date: 10/93 **Duration:** 2 years

Geographic Area: Prince William Sound

Contact Person:
Samuel Sharr
Ak. Dept. Fish & Game
P.O. Box 669
Cordova, Ak. 99574
Phone: 907-424-3212

B. Introduction

In the decade preceding the Exxon Valdez Oil Spill (EVOS) production of pink salmon *Oncorhyncus gorbuscha* in Prince William Sound (PWS) ranged from 10 to 15 million fish and represented an important component of the commercial fishery on salmon. Much of the spawning for pink salmon (up to 75% in some years) occurs in intertidal areas. These areas are susceptible to marine contaminants and there is strong evidence the March 24, 1989, *Exxon Valdez Oil Spill* (EVOS) adversely affected spawning success and early marine survival in Prince William Sound (Sharr et. al. 1993, Willette and Carpenter 1993).

Salmon populations impacted by the EVOS are heavily exploited in commercial, sport, and subsistence fisheries and their restoration can most effectively be achieved through more sensitive management of the commercial fishery. The populations (stocks) in areas heavily impacted by the EVOS are present in fisheries dominated by hatchery fish. The management of this mixed stock fishery has historically been based on maintaining good temporal and spatial distribution of spawning escapement for groups of stocks in eight major fishing districts. The success of this management strategy relies upon the manager's ability to control stock-specific exploitation rates. Restoration premised on stock - specific management of the commercial fishery will require accurate inseason estimation of the stock composition of the catch if different harvest rates are to be achieved for damaged wild stocks versus hatchery stocks. This project will provide those estimates.

The foundations for this project were firmly established in feasibility studies which were conducted beginning in 1986 and extending through 1988. 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. Tag recovery efforts for wild and hatchery pink salmon were funded by damage assessment funds in 1989, 1990, and 1991 and by restoration funds in 1992. 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. Prince William Sound Aquaculture Corporation, Valdez Fisheries Development Association, and the Alaska Department of Fish and Game pooled their resources to come up with approximately half of the funds required to field a full fledged pink salmon tag recovery effort in 1993, with the Trustee Council providing matching funds. This proposal is to request the same matching funds for the 1995 season.

C. Need For Project

Populations of wild pink salmon in PWS which were injured by the EVOS continue to experience poor reproductive success. These populations must be protected from other sources of injury or mortality which could further reduce their long term reproductive success.

Adult returns from injured wild populations mingle with other wild and hatchery populations in PWS waters and all are heavily exploited by commercial fisheries. Successful restoration of injured populations will require that they be exploited at a lower rate in these fisheries until their reproductive rates return to historic average levels. Minimizing the exploitation of injured wild populations will insure that sufficient numbers adults from enter streams to spawn. This project provides fisheries managers with real time estimates of the numbers of wild and hatchery fish in commercial harvests. These estimates enable managers to identify areas where exploitation of wild populations can be minimized while permitting the timely harvest of economically important hatchery returns.

D. Project Design

This project is designed to provide estimates of hatchery and wild fish contributions to commercial and cost recovery fisheries of pink salmon in Prince William Sound. The project is funded by the Alaska Department of Fish and Game, Prince William Sound Aquaculture Corporation, Valdez Fisheries Development Association, and the Oil Spill Trustee Council. The project will be administered and supervised by the Alaska Department of Fish and Game.

1. Objectives:

(1) 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;

(2) provide timely in season estimates of hatchery and wild stock contributions to harvests by time and area to fisheries managers;

(3) use data from fully decoded tags recovered from commercial catches, cost recovery harvests, and hatchery brood stock to verify or adjust in season contribution estimates;

(4) estimate marine survival rates for each uniquely coded hatchery release group and;

(5) 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 specific to each hatchery release group, and fisheries management actions taken to reduce the exploitation on wild stocks based on in season estimates of the stock composition of fisheries harvests.

2. Methods:

Tag recoveries will be made from a stratified random sample. Fisheries will be stratified by district, discrete time segments and processor. For each stratum, 15% of the pink salmon commercial harvest and the cost recovery harvest will be scanned for fish with a missing adipose fin. Catch sampling will be conducted in processing plants located in Cordova, Valdez, Anchorage, Whittier, Kenai and on floating processors. Brood stock sampling will also occur at all 4 PWS pink salmon hatcheries. A minimum of 50% of the daily brood stock requirements at each hatchery will be scanned for fish with missing adipose fins.

In the catch, cost recovery and brood stock samples, the total number of fish scanned and the total number of fish with missing adipose fins will be recorded. The heads of fish with missing adipose fins will be removed, labelled and shipped to the Tag Lab in Juneau for tag removal and decoding. Tag recovery, scanning, and catch data will be merged in a computer data base and returned to Cordova for analysis.

3. Schedule:

Date(s)	Activity
June 20 - Sept 15, 1995	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 30, 1995	Draft Report
Jan 30, 1996	Final Report

4. Technical Support:

ADF&G will supply biometrics support to ensure that project methods and data analyses will provide inseason stock contribution estimates at levels of accuracy and precision required for management of wild stocks in PWS.

5. Location:

Sampling of salmon catches from commercial and cost recovery fisheries will occur in shore based processing plants in Cordova, Valdez, Whittier, and Kodiak and on floating processors in PWS. Extraction and decoding of tags will be accomplished by the ADF&G coded wire tag lab in Juneau. All data analyses will be completed in Cordova with assistance from Anchorage based Alaska Department of Fish and Game biometrics staff.

E. Project Implementation

This project is applied research which has direct and immediate applications to ADF&G's statutory obligation to manage fisheries. Feasibility studies for the massive coded wire tagging and recovery operations required to manage PWS pink salmon were conducted by ADF&G and the local, private aquaculture associations for two years prior to the EVOS. These agencies developed the methods described for this project, they have the infra-structure (e.g. the ADF&G coded wire tag laboratory) in place for large scale tagging and tag recovery operations, and they are the logical choice for conducting this project.

The project is proposed as a cooperative effort to be funded by the Trustee Council, ADF&G, and PWS aquaculture associations. Coded wire tags recovered by this project are presently applied by Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) at their expense. The annual cost of tag application by these private non-profit corporations is approximately $160 thousand. Funds provided by the EVOS

Trustee Council for tag recovery activities will be matched in part by ADF&G, PWSAC and VFDA. Funds from the latter two sources will be conveyed to Alaska Department of Fish and Game through cooperative agreements.

F. Coordination of Integrated Research Effort

The monitoring, research and restoration objectives of this project are integral to the success of ecosystem research and restoration efforts described by the Sound Ecosystem Assessment (SEA) plan. It is an integral part of a package of proposed projects including the SEA (95320), the Salmon Otolith Marking (95320c), and the Pink Salmon Egg and Alevin Mortality (95191) 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 (95191) 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) the dependence of pink salmon survival on sea surface temperatures, and other oceanographic features of PWS during the fry and juvenile life stages.

2) the dependence of pink salmon survival on the 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 . 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 95320 provide all tagging, fry release, sales harvest, and brood stock data necessary for data analysis. Aquaculture associations also provide room, board, and logistics support for brood stock 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.

G. 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 annual peer and 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.

H. 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 research conducted by the Division of Commercial Fisheries Management and Development in PWS. He designed and was the project leader for pink salmon coded-wire studies conducted by ADF&G prior to the EVOS. He 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; 93137, 93184, and 93191 in 1993 and 94137, 94191, 94320 and 94320c in 1994. He has been the Principal Investigator for all of those projects and co-authored all final reports. 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.

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.

I. Budget

	PWSAC	VFDA	ADF&G	TRUSTEES	TOTAL
Personnel	100.0	26.2	81.6	175.1	382.9
Travel	0.0	0.0	0.0	12.0	12.0
Contractual	0.0	0.0	0.0	26.6	26.6
Commodities	0.0	0.0	0.0	14.7	14.7
Equipment	0.0	0.0	0.0	4.0	4.0
Capital Outlay	0.0	0.0	0.0	0.0	0.0
Sub-total	100.0	26.2	81.6	232.4	440.2
General Administration	0.0	0.0	0.0	28.1	28.1
Project Total	100.0	26.2	81.6	260.5	468.3
NEPA Compliance	0.0				

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Otolith Thermal Mass Marking of Hatchery Reared Pink Salmon in Prince William Sound

Project Number:	95320-C
Name of project leader(s):	Mark Willette Samuel Sharr
Lead agency:	Alaska Department of Fish and Game
Cost of project/FY 95:	$649,000
Cost of project/FY 96:	$292,700
Cost of Project/FY 97 and beyond:	$494,500
Project Start-up/Completion Dates:	October 1, 1994 - September 30, 1998
Geographic area of project:	Prince William Sound

Contact Person: Mark Willette, Alaska Dept. of Fish and Game, CFMD Div., P.O. Box 669, Cordova, Alaska 99574 (907)424-3214

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.

PWS pink salmon returns originating from brood years subsequent to the 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.

Pink salmon returns to PWS are dominated by hatchery produced fish. 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. 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. Approximately 1 million coded-wire tags must be applied to pink salmon fry each year to obtain catch contribution estimates 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 desired. Coded wire tags are also intrusive, tags can be shed, and tagging may affect subsequent survival. Tag loss through shedding and differential mortality of tagged individuals affects subsequent estimates of adult returns based on tag recoveries. There is also recent evidence that poor placement of coded-wire tags may cause salmon to stray.

Because of the cost and problems associated with coded wire technology, other alternatives for 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 mark-recapture population and straying rate estimates.

C. NEED FOR THE PROJECT

Development of a precise and less expensive stock separation tool will benefit wild salmon. Fishery managers will obtain a more powerful tool for use in reducing fishery exploitation on damaged wild stocks. The reduced cost of otolith marking compared with coded-wire tagging will allow restoration of salmon stocks with less impact on funds available for other species. The technique will initially be developed for pink salmon in Prince William Sound, but will likely be used for other salmon species in the EVOS impact area in the future. The communities of Homer, Seward, Valdez, and Cordova will be most affected by this project, since the economy in these communities is based on the salmon resource.

The tetracycline marking component of this 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 are vital to the health of the marine, freshwater, and terrestrial portions of the PWS ecosystem and to the fishing industry which is the cornerstone of the area economy.

D. PROJECT DESCRIPTION

This project will develop otolith mass marking as an inseason stock separation tool for salmon. This data is essential information used by fishery managers to reduce fishery exploitation rates on damaged wild salmon stocks. Coded-wire tags are presently used for this purpose, but otolith marking is expected to provide more accurate information at a lower cost. Recognizing the need to develop mass marking technology for pink salmon in PWS, the Alaska Department of Fish and Game (ADF&G) and Prince William Sound Aquaculture Corporation (PWSAC) reviewed the feasibility of otolith thermal marking at PWS hatcheries as well as otolith recovery in the commercial fisheries (Geiger et al. 1994).

Otoliths are small bones in the inner ear of fish. These bones can be marked through systematic changes in water temperature during egg incubation. The resulting marks are bands of light and dark material in the otolith similar to the bands in a tree. These induced marks can be used to identify hatchery-produced salmon in the fishery. Because all hatchery-produced salmon are marked using this technique, the cost of catch sampling is expected to be reduced, and the precision of inseason stock composition estimates are expected to be improved.

This project will be conducted cooperatively by the ADF&G, PWSAC, and Valdez Fisheries Development Association (VFDA). In 1994, PWSAC and VFDA will install the necessary equipment and otolith mark all pink salmon embryos in the Armin F. Koernig (AKF), Wally H. Noerenberg (WHN), Cannery Creek (CCH), and Solomon Gulch (SGH) hatcheries. The equipment will be installed in the summer of 1994, and marking will begin after the embryos have passed the eyed stage of development. Heated water will be introduced at the hatchery head troughs allowing treatment of millions of pink salmon embryos simultaneously.
The project will be conducted over two pink salmon lifecycles, marking both odd- and even-broodline fish. This approach is necessary because (1) 35% and 75% of odd- and even-broodline spawners utilize intertidal habitats, respectively, and (2) experience with two complete lifecycles is needed to fully develop a program that integrates induced banding code quality, otolith processing rates and costs, and statistical designs for catch sampling. Cyclic temperature changes in salmon redds associated with the semi-diurnal tide produce natural otolith banding patterns in intertidal-spawning pink salmon. Embryos rearing in upstream redds are exposed to less regular stream temperature changes. Interannual differences in the proportion of upstream and intertidal spawners and natural stream temperature flucuations may produce very different natural otolith banding patterns in wild pink salmon populations in different years. It is essential that the relationship between wild salmon otolith banding patterns, induced otolith banding-code quality, otolith processing rates, and catch sampling design be fully integrated in the program. The quality of induced otolith banding-codes and natural banding patterns in wild populations will affect the ability of otolith readers to identify 'marked' fish. A reduction in the reader's ability to identify marked fish will affect the sample sizes needed to estimate stock composition, the total cost of otolith processing, and ultimately the efficacy of the program.

The feasibility and cost-effectiveness of sampling the commercial catch for otoliths will depend upon whether a representative sample can be collected from the fishery. Estimation of stock composition in commercial catches has always been important for effective fisheries management. Several sampling techniques will be evaluated in 1995 using fin-clip experiments to determine if a truly random sample is obtained from each tender load.

When otolith marked fish return as adults in 1996 and 1997, approximately 13,000 pink salmon otoliths will be processed in each year to estimate stock composition and corresponding confidence levels in PWS fisheries. The catch sampling program will also evaluate the variation in stock composition among tenders as well as between processors. A cost function for catch sampling will also be developed. This information will be used to produce an optimum allocation of sampling resources among tenders and processors. Monte Carlo simulation techniques will be used in conjunction with the data collected in this study to assess sampling power and refine sample sizes.

The ADF&G Otolith Laboratory has the expertise required to rapidly process large numbers of otoliths. Approximately 250 otoliths can be processed and decoded by a single experienced technician within a working day. In 1993, the Otolith Laboratory processed 2,300 otoliths. These otoliths were recovered from Hawk Inlet commercial fishery catches and were used to estimate pink salmon contributions from the Gastineau Hatchery operated by DIPAC near Juneau.

A component of this study (*objective 4*) 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). 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 may also provides a powerful tool for investigating straying among wild populations.

1. Objectives:

The following objectives will be achieved during the project:

1. Develop engineering designs and install otolith thermal marking equipment in the AFK, WHN, CCH, and SGH hatcheries.

2. Apply otolith thermal marks to all pink salmon embryos rearing in the AFK, WHN, CCH, and SGH hatcheries.

3. Collect voucher samples and evaluate the quality of otolith thermal marks applied to pink salmon embryos at AFK, WHN, CCH, and SGH hatcheries.

4. Identify a feasible methodology for otolith marking wild pink salmon outmigrant fry using tetracycline.

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

2. Methods:

Objective 1:

Project concept designs will be developed for water heating systems at AFK, WHN, CCH, and SGH hatcheries. Key physical constraints and biological parameters considered in development of the designs will include: (1) the hatchery floor plan and incubation water system, (2) historic pink salmon development and water temperature data, (3) current equipment on site, (4) approximate thermal marking schedule, and (5) an assumed temperature increase of 3.5° C at each incubator. It is expected that the equipment needed for water heating will be installed in a module attached to the outside of each hatchery. This approach will eliminate the need to take up valuable space within each hatchery for thermal marking equipment. Concept designs will include a boiler with a self-contained glycol system and heat exchanger housed in a portable skid-mounted covered module. Fuel, water, and electricity will be provided to each thermal marking module. Designs for plumbing and electrical installation will vary among hatcheries due to differences in the utility configuration at each site.

Otolith marking technology has been developed at the Gastineau Hatchery operated by DIPAC in Juneau, Alaska. The DIPAC thermal marking system has been successfully used to mark 120 million pink and chum salmon embryos in the hatchery. The DIPAC system cannot mark all embryos simultaneously, but the hatchery operators have worked around the limitations to produce quality thermal marks. The experience gained at DIPAC will facilitate successful development of thermal marking technology at PWS hatcheries.

Pink salmon will be marked during the egg-to-hatch stage at PWS hatcheries. This approach will eliminate the need to degass the incubation water. Gas saturation is usually not a problem for salmon embryos prior to hatch. Salmon eggs maintain a positive internal pressure which allows them to tolerate total dissolved gases (TDG) up to 110-116%. It would be uncommon to have TDGs of greater than 110% in incubation process water, but it may be possible to drive TDGs this high through aggressive heating. TDGs will be monitored during the thermal marking process. After hatch, gas supersaturation may cause salmon alevins to develop gas bubble disease. Expensive degassing equipment would be required to otolith mark pink salmon alevins.

Objective 2:

A unique otolith thermal banding code will be used for each pink salmon hatchery in PWS. A unique hatchery mark will provide consistency in both application and recovery of the mark. The thermal mark will be applied in the eyed-egg to hatch zone of the otolith. The eyed-egg to hatch window occurs between October and December with an average length of 35 days. Approximately 22 days will be required to apply the thermal banding code at each hatchery. The hatchery-specific codes will be composed of 5-7 thermal rings (Table 1). A single code for each hatchery will allow estimation of survival rate by hatchery. However, hatchery operators may also need to estimate survival rate for three treatment groups within each hatchery. In this case, a treatment-group code composed of three thermal rings will be applied in addition to the hatchery-specific basemark to distinguish among treatment groups.

Table 1: Proposed basemarks for PWS pink salmon hatcheries. The thermal schedule describes the actual temperature regime. The letter "H" refers to the relatively Hot water, and "C" refers to Cold; the difference between the two temperature levels being 3.5 degrees Centigrade. The number directly before the thermal level is the number of rearing-hours at that level. Numbers in parenthesis before an "X" denote the number of repetitions.

Facility	Thermal Schedule	Banding Pattern
Cannery Cr.	(3X)48H:24C,(1X)96H:24C,(3X)48H:24C	**III IIII**
WHN	(4X)48H:24C,(1X)96H:24C,(2X)48H:24C	**IIII III**
AFK	(5X)48H:24C	**IIIII**
VFDA	(7X)48H:24C	**IIIIIII**

Objective 3:

Quality control during mark application is an important part of the otolith thermal marking program. Quality control is related to mark decoding, since it will largely determine a reader's ability to properly identify the mark. The placement of the thermal banding code on the otolith is critical to mark quality. The banding code will be applied by *lot* (group of eggs taken on a single day) or groups of lots, when the embryos are at the appropriate stage of development. Each incubating appliance will be sampled to ensure the mark was correctly applied. We expect that developmental stage and thus basemark placement will differ among lots within the hatchery. Temperature recorders will be installed at various points in the incubation system during mark application to document temperature changes.

A stratified-random sampling design will be employed to estimate the proportion of unmarked otoliths at each PWS pink salmon hatchery (Cochran 1977). One month after mark application, a random sample of alevins will be taken from each lot, preserved in 100% ethanol, and sent to the ADF&G Otolith Laboratory in Juneau. Sample sizes will be selected in proportion to lot size, but a minimum of 100 alevins will be taken from each lot. At least thirty alevins will also be collected from each of 20 streams during the annual pre-emergent fry survey conducted by ADF&G. The samples will be used initially to validate that each hatchery-specific code was properly applied. Blind tests will then be conducted to estimate the proportion of alevins marked at each hatchery. A reader's ability to distinguish hatchery-specific codes, and marked otoliths among unmarked otoliths will used to determine the proportion marked. The set of otoliths for the blind tests will be obtained from a random subsample of alevins (n=300) taken from each hatchery sample combined with 600 wild alevins (total 1800 otoliths). Samples from all sources will be randomly combined to construct six test sets of otoliths (n=300). This test design will result in a composition of otolith types very similar to that encountered in samples taken from the commercial fishery when the fish return as adults. Two blind tests will be conducted with each of three readers.

Blind tests will be conducted at the ADF&G Otolith Laboratory in Juneau. After the otoliths are extracted from the alevins, they will be fixed to a glass slide with thermo-plastic cement. A grinding wheel will be used to remove material from one side of the otolith and expose the internal structures. The depth of grinding will be monitored by repeated viewing under a dissecting microscope. After the internal bands are exposed, the thermal mark will be decoded under a compound microscope.

Objective 4:

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.

a. 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, this dose has been used with success in chum salmon (Short personal communication National Marine Fisheries Service, Auke Bay Laboratory). 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 of stress 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 3, 6, 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. (1994c) 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 be 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 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, 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 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.

b. 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 (18 hours at 8° C) 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 are marked 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 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.

c. Testing Effects of Tetracycline

If results of the marking study indicate that tetracycline is a suitable marking agent for use on wild pink salmon an FDA permit will be acquired 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 effects 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}).

3. Schedule

This project will be conducted over one pink salmon life cycle for both the odd- and even-broodline populations. Embryos will be otolith marked in the fall of 1994 and 1995. The adult fish from the 1994 and 1995 year classes will return to PWS as adults in the summers of 1996 and 1998.

Table 2: Schedule of activities for otolith thermal marking program over the duration of the project (FY 1994-1997).

Date	Activity
2/94- 8/94	Install water heating equipment at PWS pink salmon hatcheries
10/94-12/94	Apply otolith banding codes to even-broodline embryos at hatcheries
2/95- 4/95	Apply coded-wire tags to even-broodline pink salmon fry at hatcheries
4/1/95	Submit annual project report for FY 1994
7/95- 9/95	Develop a method to collect random otolith samples from tender boats
10/95-12/95	Apply otolith banding codes to odd-broodline embryos at hatcheries
2/96- 4/96	Apply coded-wire tags to odd-broodline pink salmon fry at hatcheries
4/1/96	Submit annual project report for FY 1995
8/96-10/96	Recover thermally marked even-broodline adults from the commercial fishery
8/96-12/96	Determine optimal allocation of sampling effort and refine sample sizes
4/1/97	Submit annual project report for FY 1996
8/97-10/97	Recover thermally marked odd-broodline adults from the commercial fishery
8/97-12/97	Re-evaluate optimal allocation of sampling effort and sample size estimates
4/1/98	Submit annual project report for FY 1997

Table 3: Schedule of activities for tetracycline marking component in 1994.

Dates	Activity
4/5 - 5/5	Apparatus set up at Cannery Creek Hatchery, marking immersion treatments, and rearing of treatments and controls
5/5 - 5/15	Dismantle and remove equipment at Cannery Creek and ship otolith samples to Otolith Lab
5/15 - 9/15	Process otoliths at Otolith Lab
4/1/95	Submit annual project report for FY 1994

4. Technical Support:

Data archiving services will be required to insure that all information obtained from this project is adequately documented and catalogued. 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 Laboratory will supply otolith mass processing expertise.

5. Location:

This project will be conducted in the PWS region. Embryos will be thermally marked at the AFK, WHN, CCH, and SGH hatcheries operated by the PWSAC and VFDA. Otolith code development and quality control work will be conducted at the ADF&G Otolith Laboratory in Juneau. In future years, an otolith catch sampling program will be developed. Catch sampling will likely occur in all PWS communities, as well as, Anchorage, Kenai, and Kodiak. Data analyses and reporting will be completed by ADF&G staff in Cordova and Anchorage. The tetracycline marking component of the project will be conducted at the CCH Hatchery.

E. PROJECT IMPLEMENTATION

The ADF&G will oversee installation of thermal marking equipment in PWS hatcheries and develop otolith catch sampling designs. The ADF&G is responsible for managing the pink salmon resource in the PWS area. In addition, the ADF&G is responsible for the development, oversight, and evaluation of the salmon enhancement program. The ADFG has considerable experience in large-scale fish marking programs including the PWS coded-wire tag program. The existing ADF&G fishery management program in PWS will provide salmon catch data needed to complete this project. The PWSAC and VFDA will install and operate otolith thermal marking equipment at four pink salmon hatcheries in PWS. These organizations are the operators of these facilities.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The Otolith Mass Marking Project (94187) will be highly integrated with several other salmon restoration projects in PWS. This project will complement the Sound Ecosystem Assessment (SEA) program (Project 94320). 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. Otolith marked fish will provide a valuable tool for examining interactions between wild and hatchery salmon during the early marine period. The Salmon Growth component of SEA will utilize otolith marked juvenile pink salmon to (1) evaluate habitat overlap between wild and hatchery salmon, (2) compare size composition of wild and hatchery salmon in mixed schools, and (3) develop a tagging program to estimate juvenile salmon mortality within PWS and in the Gulf of Alaska. The Salmon Predation component of SEA will utilize otolith marked juvenile salmon to determine if predators select wild or hatchery salmon. Projects 94185 (Wild Salmon Straying) and 94192 (Hatchery Salmon Straying) were deferred in 1994 to allow for development of otolith thermal marking and tetracycline marking technologies in PWS. 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 salmon populations would be possible. Therefore, the monitoring, research and restoration objectives of this project are related to several other projects including the Pink Salmon Genetics project (94189), and the Pink Salmon Egg and Alevin Mortality (94191) projects.

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 this project 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.

This project is partially sponsored by the PWSAC which is the regional aquaculture association for PWS. PWSAC is composed of fishermen, processors, and community representatives from the PWS region. 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/CR 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 of directors and the PWS Regional Planning Team have endorsed the development of otolith thermal mass marking of hatchery salmon in PWS.

J. PERSONNEL QUALIFICATIONS

MARK WILLETTE
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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.

EDUCATION: 1985 Master of Science, Fisheries Oceanography, University of Alaska Fairbanks. 1983 Bachelor of Science, Fisheries Science, University of Alaska Fairbanks.

SAMUEL SHARR
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Commercial Fisheries Management and Development Division
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EMPLOYMENT: Mr. Sharr 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.

EDUCATION: 1968 Bachelor of Science, Biology, University of Washington.

K. BUDGET

Table 2: Budget summary for the Otolith Mass Marking project in FY95, FY96, and FY97 and beyond. Budgets for FY96 and beyond may change as information from the first year of the project is applied to refine cost estimates.

Line Item	FY95	FY96	FY97 and beyond
Personnel	19.7	74.5	337.5
Travel	0.0	1.5	31.3
Contractual	568.0	135.8	48.8
Supplies	10.4	3.2	22.9
Equipment	8.2	57.0	0.0
Total	606.3	272.0	440.5
Indirect Costs	42.7	20.7	54.0
Grand Total	649.0	292.7	494.5

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Prince William Sound Pink Salmon Genetics

Project Number:	95320-D
Project Leaders:	James E. Seeb and Lisa W. Seeb
Lead Agency:	Alaska Department of Fish and Game
Cost of Project, FY95:	$218.2K
Cost of Project, FY96:	$130.0K
Project Start-up Date:	4/94
Project Completion Date:	6/96
Duration:	2 years, 6 months
Geographic Area:	Prince William Sound
Contact Person:	James E. Seeb, 333 Raspberry Road, Anchorage, AK 99518 (907) 267-2385

B. INTRODUCTION

Historically, approximately five-hundred-million wild pink salmon fry 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, raising the specter of petro-chemical induced genetic damage. 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. Wild-stock run failures in the Southwest area of the Sound have continued through the 1992 and 1993 fishing seasons.

Prince William Sound is the center of one of the State of Alaska's largest aquacultural industries. Alaska Department of Fish and Game has admittedly 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 regional aquaculture association are facing serious financial challenges due to the alterations in management imposed resulting from declines in abundance of wild pink salmon stocks.

C. NEED FOR THE PROJECT

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.

D. PROJECT DESIGN

1. Objectives:

a. define the genetic structure of pink salmon stocks in the EVOS-affected area in order to better direct harvest management decisions made for restoration purposes on a stock-specific rather than species-specific basis.

b. provide information needed for genetic risk assessment and genetic monitoring of supplementation programs (e.g., as a result of Restoration Science Project R105) to guide stock-specific restoration and enhancement.

2. Methods:

Tissues for baseline genetic data will be collected from up to 100 individuals from each of 30 spawning aggregations each year. This will include two hatcheries and 28 wild-stock streams in the affected areas of Prince William Sound. Pink salmon have a two-year life cycle. Even and odd-year pink salmon are genetically distinct, so both must be sampled. Sampling will be designed to include both early and late stocks and inter-tidal and upstream-spawning stocks. 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, suitable samples from odd-year stocks are already available from tissue collections made as a part other studies. Samples for even-year stocks would be collected as a part of Restoration Science Study 94192.

Genetic data will be collected using the techniques of allozyme electrophoresis on all samples. 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. A pilot study using DNA techniques will be conducted on a subset of samples. ADFG anticipates contracting the laboratory analyses of the allozyme portion of the study to a qualified bidder. Data analyses will be conducted by ADFG, and data will be merged into the state and federal inter-agency databases.

3. SCHEDULE:

Activity	Inclusive Dates	
Advertise and award contract for allozyme analyses	June 1994	August 1994
Lab analyses (odd-year samples)	August 1994	April 1995
Data analyses	December 1994	June 1995
Additional field collections	July 1994	August 1994
Draft status report FY 94	March 1995	
Final status report FY 94	August 1995	
Lab analyses (even year)	March 1995	February 1996
Data analyses	September 1995	May 1996
Draft status report FY 95	May 1996	
Final report	September 1996	

4. Technical Support:

Administrative support is provided by the Administrative, Habitat, and Commercial Fisheries Development and Management Divisions staff of the Alaska Department of Fish and Game. The project leader is fully funded with general funds from the State of Alaska. Project assistants are fully or partially funded by this project. Laboratory support is provided by the ADFG Genetics Program which includes facilities for tissue archival, allozyme analysis, PCR-based and other DNA analyses, and data analyses. These studies are integrated with ongoing studies by the Commercial Fisheries Division for efficiency in completing the objectives.

5. Location:

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

E. PROJECT IMPLEMENTATION

The research direction, DNA pilot study, and data analysis will be done at the Alaska Department of Fish and Game Genetics Laboratory. We have extensive experience with genetic stock identification projects, we conducted the pre-oilspill genetic analysis of area populations, and we have developed software to handle acquisition, management, and analysis of large data sets.

The allozyme analysis portion of this project will be contracted to a qualified bidder following the state bidding process. The allozyme portion will not be done in house in order to optimize use of Department staff and facilities on projects in progress (such as the genetic analysis of Cook Inlet sockeye salmon, EVOS study 94255).

We have already implemented a screen for mtDNA variation on six populations using an analysis of restriction fragment length polymorphisms. Data from 16 restriction endonucleases confirm earlier allozyme results that showed that even- and odd-year pink salmon have discrete population structure. These preliminary results also suggest structure separating eastern and western Prince William Sound populations.

Sample collection for fiscal year 1995 will be accomplished by ADFG staff from the Cordova office. Funds for the necessary air charter were originally a part of the budget of one of the Cordova-based projects that was deferred by the *Exxon Valdez* trustee council. This project budget includes $30.0K to replace those costs.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT:

Some sample collections were opportunistically conducted by personnel working on pink salmon egg/fry survival projects during 1991 and 1992. Additional sample collections in 1994 will be integrated between 94191 (oil-related embryo mortalities) and this project in order to most efficiently utilize resources. Collections will represent populations of concern identified in part by coded-wire-tag project 94184.

DNA analyses for this project are integrated with those of Trustee Council projects 94255 (Kenai River sockeye salmon) and project 94191.

No funds are requested for biometrics support of this project. Biometrics will be integrated into the responsibilities of the genetics staff biometrician who is primarily funded from general funds and partially funded from project 94255.

G. 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.

H. PERSONNEL QUALIFICATIONS

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

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

PROFESSIONAL EXPERIENCE:

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

SELECTED PUBLICATIONS:

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

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

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Utter, F.M., and J.E. Seeb. 1990. Genetic marking of fishes: overview focusing on protein variation. Am. Fish. Soc. Sym. 7:426-438.

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

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

PROFESSIONAL EXPERIENCE:

1991- Statewide Geneticist, ADF&G, Anchorage
1991- Affiliate Associate Professor, U. 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

Seeb, L. W. and D. R. Gunderson. 1988. Genetic variation and population structure of Pacific ocean perch (*Sebastes alutus*). Can. J. Fish. Aquat. Sci. 45:78-88.

Seeb, L. W., J. E. Seeb, R. L. Allen and W. K. Hershberger. 1990. Evaluation of adult returns of genetically marked chum salmon, with suggested future applications. American Fisheries Society Symposium 7:418-425

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Seeb, L. W., J. E. Seeb and J. J. Polovina. 1990. Genetic variation in highly exploited spiny lobster *Panulirus marginatus* populations from the Hawaiian Archipelago. Fishery Bulletin 88:713-718.

Seeb, L. W. and A. W. Kendall. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

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

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

EDUCATION:

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

PROFESSIONAL EXPERIENCE:

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

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

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

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.

Seeb, L. W., J. E. Seeb, C. Habicht. 1993. Population genetic analyses facilitate restoration of sockeye salmon stocks damaged by the *Exxon Valdez* oil spill. Presented at National Chapter American Fisheries Society, Portland, OR.

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

Habicht, C., J. E. Seeb, R. B. Gates, I. R. Brock, and C. A. Olito. 1994. Triploid salmon outperform diploid and triploid hybrids between coho salmon and chinook salmon during their first year. Can. J. Fish. Aquat. Sci. (Revised version accepted and in press).

I. BUDGET ($K)

Personnel	38.4
Travel	5.0
Contractual Services	140.0
Commodities	15.0
Equipment	0.0
Capital Outlay	0.0
Sub-total	198.4
General Administration	19.8
Project Total	218.2
NEPA Compliance	0.0

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Juvenile Salmon & Herring Integration

Project Number:	95320-E
Name of project leader(s):	Mark Willette
Lead agency:	Alaska Department of Fish and Game
Cost of project/FY 95:	$1,491,969
Cost of project/FY 96:	$1,491,969
Cost of Project/FY 97 and beyond:	$1,491,969
Project Start-up/Completion Dates:	October 1, 1994 - September 30, 1998
Project Duration:	Five Years
Geographic area of project:	Prince William Sound

Contact Person: Mark Willette, ADFG, CFMDD, Box 669, Cordova AK 99574. Phone 424-3212, FAX 424-3235

B. INTRODUCTION

This project is a component of the Prince William Sound Systems Investigation-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). This project is a continuation of the Salmon Predation component of the SEA program expanded in scope in 1995. The name of the project has been changed to reflect the level of integration between this project and the other components of SEA; as well as, the greater emphasis placed on collection of juvenile herring samples in FY95.

The primary purpose of this project is to determine to what extent variations in predation affect the survival of juvenile pink salmon, and identify and describe the mechanisms that cause variations in predation. The project will also collect samples for the following projects: (1) Juvenile Herring Growth and Habitat Partitioning and (2) Forage Fish Influence on Recovery of Injured Species. Vessel charters for all shared research platforms, including the critical Physical Oceanography and Zooplankton in the Ecosystem studies of SEA, are also included in this project.

C. NEED FOR THE PROJECT

The pink salmon return to PWS failed in 1992 and 1993. At the present time, it is not clear to what extent oil-spill impacts or environmental conditions may have contributed to these salmon run failures. The proposed project will determine to what extent changes in the PWS ecosystem may have contributed to the run failures. Low returns of hatchery-produced salmon in both years indicates that the failures were likely caused by processes occurring during the juvenile lifestage. 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. 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. This project will focus on the fish 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*) and coho salmon (*Oncorhynchus kisutch*).

Additionally, since this project provides platforms and sample collection for several core SEA projects, it is critical to the overall success of SEA.

D. 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.

1. Objectives:

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

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

2. Estimate the juvenile salmon consumption rate of fish predators in Prince William Sound.

3. Determine the relationship between juvenile salmon predation rate and macrozooplankton abundance.

4. Determine the relationship between juvenile salmon predation rate and juvenile salmon abundance.

5. Collect samples for the following projects (1) Herring Growth and Habitat Partitioning and (2) Forage Fish Influence on Recovery of Injured Species.

6. Provide shared sampling platforms for the SEA Program.

2. Methods:

Objective 1:

Five broad-scale predator surveys will be conducted to determine the spatial distribution, abundance, and species and size 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. 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. Fish samples will be processed to estimate species and size composition of hydroacoustic targets. The age composition of potential fish predator populations will be estimated from otolith analysis and length-frequency data.

Objective 2:

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 Juvenile Salmon & Herring Integration component of SEA will estimate predator species and size composition, food consumption rate, and diet composition.

Field studies will be initiated on March 10 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. 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. 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. Two purse seine vessels will sample salmon predators in nearshore areas using small-mesh seines. A stratified random sampling program will be employed 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). The daily ration of salmon predators will be estimated from diel feeding periodicity studies conducted once during each ten-day sampling period.

Objective 3:

Multiple regression analysis will be used to provide an assessment of the macrozooplankton-dependent predation hypothesis. Juvenile salmon predation rate will be used as the dependent variable in the model with macrozooplankton abundance (from the Zooplankton component) as the independent variable. Data from paired predator stomach and macrozooplankton samples will be used in the analysis.

Objective 4:

Multiple regression analysis will be used to provide an assessment of the density-dependent predation hypothesis. Juvenile salmon predation rate will be used as the dependent variable in the model with juvenile salmon abundance (from the Nearshore Fish component) as the independent variable. Paired estimates of juvenile salmon density (hydroacoustic) and juvenile salmon predation rate will be used in the analysis.

Objective 5:

Fish samples will be collected for two proposed FY95 projects: (1) Herring Growth and Habitat Partitioning, and (2) Forage Fish Influence on Recovery of Injured Species. Samples of juvenile herring will be collected in nearshore and offshore habitats in passages in PWS. Data files will be provided to the Herring Growth and Habitat Partitioning project detailing the distribution, size, and age of herring collected in the study area. Fish samples will be provided to the Forage Fish Influence on Recovery of Injured Species project for analysis of stomach contents.

Objective 6:

Two vessels will be chartered to provide a shared sampling platforms for the SEA program. A mid-water trawl vessel will conduct mid-water trawling, CTD sampling, vertical plankton net sampling, and hydroacoustic surveys for fish. A smaller vessel will accompany the trawler to provide a platform for ADCP, OPC, Tucker Trawl sampling, and high frequency hydroacoustic sampling.

3. Schedule:

The field season for this project will be from March 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 15 - April 25	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	
March 10 - March 31	Western PWS Survey
April 5 - April 14	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	
6/1/95 - 12/31/95	Conduct stomach contents analysis and read otoliths.
1/1/96 - 3/31/96	Analyze data and prepare annual report.

4. 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.

6. 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.

E. PROJECT IMPLEMENTATION:

The ADF&G will conduct field sampling and laboratory processing of fish predators collected by this project. The ADF&G is responsible for managing the pink salmon resource in the PWS area. In addition, the ADF&G is responsible for the development, oversight, and evaluation of the salmon enhancement program. The recent decline in salmon survival in PWS has jeopardized the viability of the salmon enhancement program. The ADF&G has conducted field studies on juvenile salmon in PWS during the past five years. This project will collect samples that will be analyzed within two additional projects (1) Herring Growth and Habitat Partitioning and (2) Forage Fish Influence on Recovery of Injured Species. Sample and data analysis in these projects will be contracted to the University of Alaska.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be highly integrated with several other components of the SEA Program. The Physical Oceanography, Nearshore Fish, Zooplankton, and Phytoplankton components of SEA will share research platforms with the Juvenile Salmon & Herring Trophics & SEA Vessel Support. 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 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 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 the Juvenile Salmon & Herring Integration project will be provided to the Information and Modeling component of SEA.

G. 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.

H. 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.

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.

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.

I. BUDGET

Table 2: Budget summary for the Juvenile Salmon & Herring Integration component of the SEA program in FY95.

Line Item	FY95
Personnel	392,464
Travel	3,300
Contractual	860,500
Supplies	156,900
Equipment	6,500
Capital Outlay	0
Total	1,419,664
General Admin	72,305
Grand Total	1,491,969

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SEA Plankton Dynamics: Phytoplankton and Nutrients

Project Number: 95320-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: FY95 $297.3K

Start Date: 1 October 1994

Completion Date: 30 September 1995

Geographic Area: Prince William Sound

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 is 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 ecological consequence of these alternate conditions is a high biomass of large zooplankton in 'lake' years that become 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).

While middle-out/top-down is the principal hypothesis being tested by SEA research, ecological theory provides another possibility, that of 'bottom-up' control, where the production of upper trophic level species is modulated by variations in nutrient-driven phytoplankton production. In this hypothesis the structure and composition of the zooplankton community can be determined by variations in phytoplankton primary production and 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. Variations in the timing of phytoplankton populatons have been previoulsy suggested to be a control of ecosystem events in Prince William Sound (McRoy 1988). 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 and test the bottom-up hypothesis.

A central tenet of the SEA hypothesis is the 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 and production. Strong advection may confound the effects of in situ primary production in the Sound. To further test the hypotheses, 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. We will also take over the moored instrument array (C-LAB) that has been gathering continuous relevant data for the past 2 years.

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, there has been almost no work on phytoplankton in Prince William Sound since the earliest impact studies in the 70's (Goering et al. 1973a &1973b; Alexander & Chapman 1980) and it was not until 1993 that a complete cycle of phytoplankton was measured (via the C-LAB buoy). Throughout the oil spill recovery period there has been no measurement of ambient nutrient conditions or phytoplankton biomass and production, consequently, 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 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. The analyses from this project also provide the patterns of response of phytoplankton and primary production to oceanographic and climate changes that can be used by all projects to test ideas about good vs. bad years in fluctuations of other target species.

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 production and populations are transferred to the zooplankton and that such variations are a function of oceanographic conditions that control the supply of inorganic nutrients and light.

The specific objectives are:

1) To measure the timing, and biomass of phytoplankton cycles;
2) To measure the primary production of phytoplankton;
3) To determine the spatial and temporal patterns in phytoplankton distribution using satellite imagery;
4) To determine the species structure of phytoplankton communities;
5) To measure the distribution and quantity of major inorganic nutrients including nitrate+nitrite, ammonium, phosphate, silicate and iron;
6) To maintain the moored instrument array (C-LAB) to collect time series data on phytoplankton (fluorescence) and related oceanographic and climate data;
7) 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 need for 2 people on each cruise to accomplish the work program. If sufficient vessel time is not available, we will conduct a portion of the work from a shore base at the PWSAC Esther Island hatchery. Timing of the field work must be arranged to cover the time of spring phytoplankton increase. Based on the limited historical data and the excellent record obtained in 1993-94 by the C-LAB buoy the sampling period should begin in mid-March and extend to July. Discrete sample times can be integrated with the assistance of the continuous chlorophyll record obtained from the C-LAB 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 (0.5 to 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 biomass 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 & Parsons 1972) with more recent modifications to avoid contamination (Fitzwater et al. 1982; Chavez & Barber 1987).

Field sampling will be based at PWSAC hatcheries or, when available, conducted on board 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 can 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). In 1995, we will monitor the distribution of phytoplankton and other particulates using a WET Labs Dual Path Absorption and Attenuation Meter. The WET Labs comapny is the only company currently manufacturing a spectral diffuse attenuation and chlorophyll absorption meter. This instrument can 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 silica and iron -- 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 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 in our laboratory in Fairbanks. Iron will be determined in the field using Hach chemical apparatus.

f) Moored Instrument Array: The C-LAB Buoy

In 1995 this project will take over the C-LAB moored instrument program developed by Dr. Cooney with support from the Alaska Science and Technology Foundation (ASTF). The ASTF support ends in 1994. The moored instruments have provided two years of continuous data from the Sound that has seminal value to all SEA projects (e.g. Figure 1). Here we will assume the responsibility for maintaining and upgrading the mooring to insure qualtiy data are available to SEA. The buoy will continuously acquire wind speed and direction, barometric pressure, air temperature, sea surface temperature, chlorophyll fluorescence, and ocean temperature at 10 depths. The moored instruments provide a mechanism to integrate other discrete observations collected from ships. The winter data are especially valuable since no other sampling is done at this time. The data presented (Fig. 1) are but a small subsample of those available; they show the spring increase in phytoplankton (i.e. chlorophyll fluorescence) and corresponding air temperature that has an obvious effect on the timing and pattern of the phytoplankton bloom. The budget reflects the costs for assuming the C-LAB mooring. Actual replacement cost would be more than 5 times the amount included here.

g) 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 are 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:

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Goering, J.J., W.E. Shiels, and C.J. Patton. 1973b. Primary production. Pp. 225-248, in D.W. Hood, W.E. Shiels and E.J. Kelley. Environmental studies of Port Valdez. Institute of Marine Science, University of Alaska, Fairbanks.

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Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. A Manual of Chemical and Biological Methods of Seawater Analysis, Pergamon 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 in biological oceanography from the University of Washington in 1966 and a doctoral degree in marine science 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 was an invited visiting professor at San Francisco State University, the University of Tokyo, Aarhus University (Denmark)and the University of Hawaii. He is a member of 12 professional societies and received the Diamond Award from the Botanical Society of the America. Dr. McRoy teaches marine ecology and biological oceanography in the Graduate Program in Marine Science and Limnology at UAF. He was chief scientist and/or director of three large, inter-disciplinary, multi-university, international, NSF-sponsored projects: Seagrass Ecosystem Study (SES), Processes and Resources of the Bering Sea Shelf (PROBES), and, recently, the Inner Shelf Transfer and Recycling (ISHTAR) program. Dr. McRoy published over 70 papers in the refereed literature, edited 3 books and authored 12 book chapters.

Dr. David Eslinger received his Ph.D. from Florida State University in 1990. He was a National Research Council Research Associate at the NASA/Goddard Space Flight Center from 1990 to 1992. He is Assistant Professor at the University of Alaska, Institute of Marine Science since 1992. Dr. Eslinger teaches biological oceanography and satellite oceanography in the Graduate Program in Marine Science and Limnology 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 h
as 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 UAF.

K. FY95 Budget($K)

Personnel	143.5
Travel	16.2
Contractual	26.7
Commodities	16.0
Equipment	43.4
Capital Outlay	0.0
Sub-total	247.7
General Administration	49.6
Project Total	297.3

SEA-ZOO: THE ROLE OF ZOOPLANKTON IN THE PRINCE WILLIAM SOUND ECOSYSTEM

Project Number:	95320-H
Project Type:	Research and Monitoring
Project Leader:	R. Ted Cooney, University of Alaska Fairbanks
Lead Agency:	University of Alaska Fairbanks
Cooperating Agency:	Alaska Department of Fish and Game
Cost of Project:	FY95 $380,054
Start Date:	1 November 1994
Duration of Project:	2-5 years
Geographic Area:	Prince William Sound
Project Leader:	R. Ted Cooney
Project Manager(s):	Jerome Montague; ADF&G

B. INTRODUCTION

This proposal requests funding in FY95 to continue studies of the role of large zooplankton in the trophic ecology of Prince William Sound as part of year two (2) for the EVOS-sponsored Prince William Sound System Investigation (94320).

A major hypothesis for the overall integrated program is that levels of predation on 0-class pink salmon and herring are modulated each year by the amount of macrozooplankton present during the critical months of April and May. During years of high macrozooplankton abundance, all consumers (including 0-class fishes) probably derive substantial nutrition from plankton. Under these conditions, juvenile salmon and larval/post-larval herring are "sheltered" from predation, and losses to larger fishes are minimized. In contrast, during years (and seasons) when macrozooplankton populations are weak, consumers shift to piscivory, and losses of 0-class fishes (including salmon and herring) to predation are elevated.

Data from other studies of the region indicate that flushing rates of the Sound's upper layers in April apparently modify amounts of large zooplankton (*Calanus/Neocalanus*) comprising a predictable early-season bloom. When the flushing rate is high, forge for juvenile pink salmon and herring is depleted by washout from the region. In contrast, when wind-forced flushing rates are low, the Sound retains these forage populations in higher densities. Seeding of the Sound with overwintering forms in the summer from the adjacent deep ocean is also implicated in determining the amounts of springtime zooplankton in the surface layers.

Understanding how prey-switching is influenced by wind and buoyancy-forced transport (collaboration with the Physical Oceanography component), and relating levels of plankton-modulated predation during the early and critical life stages of pink salmon and herring to subsequent adult production provides a crucial benchmark for judging other factors (including oil related) that may be limiting the recovery of these (and other) injured species.

C. PROJECT DESCRIPTION

1. Resources and Associated Services:

Pink salmon and herring populations in Prince William Sound are listed by the EVOS Trustee Council as injured resources that are not recovering. This proposal, in collaboration with the other components of the PWSSI in FY95, will provide the Trustees and their agents with information on ecosystem dynamics that can be used to more accurately evaluate damage to injured species and to design appropriate restorative measures. Unless the dynamics of the PWS ecosystem are well understood, actions taken to restore pink salmon, herring and other non-recovering species may be inappropriate, ineffectual, or even damaging to the system.

2. Relation to Other Damage Assessment/Restoration Work:

This project is one of the continuing multi-component Prince William Sound System Investigation, designed to assess the production status and reasons for non-recovery of pink salmon and herring populations. Results from zooplankton studies will be shared with programs addressing questions about the relationship between forage fishes and other apex predators (marine birds and mammals).

3. Objectives:

The goals of SEA zooplankton studies are central to initiation of quantitative investigations and formal tests of hypotheses associated with the Lake/River Program, the Prey/Predator Program, the Herring Overwintering Program, the Wild/Hatchery Stock Interaction Program and the Modeling Program (see the PWSSI preface document). The objectives of the FY95 research on zooplankton are:

1) Use continuing PWSAC hatchery zooplankton watch collections to describe the timing, duration, magnitude and species composition of springtime upper-layer (20 m) zooplankton stocks in northern, western and southern Prince William Sound.

2) Use shipboard collections of zooplankton to describe how ontogenetic and diel shifts in vertical distribution influence trophic coupling between juvenile fishes and higher-level consumers (collaboration with Prey/Predator studies).

3) Provide direct measures of the species composition and indices of abundance for macrozooplankton swarms and layers detected simultaneously with high-frequency acoustics and optical plankton counting techniques (collaboration with Nearshore Fish component).

4) Work cooperatively with the "phytoplankton" component to describe how timing, magnitude and duration of the plant bloom influences the timing, duration, magnitude and developmental rates of upper-layer macrozooplankton populations.

5) Work cooperatively with all other components of the PWSSI program to affect formal tests of Lake/River and Prey/Switching hypotheses.

6) Provide taxonomic assistance (when requested) to ADF&G personnel at the Soldotna Limnological Laboratory, and establish a voucher collection of major zooplankters and life stages.

4. Methods

Zooplankton populations will be sampled with nets, including 60-cm bongo nets, 1-m opening-closing NIO nets, 1/2-m closing ring nets, 1/2-m open ring nets and a MOCNESS system. Most nets will fish 0.333-mm Nitex mesh to assure that the early stages of target populations will be collected. For larger macrozooplankton and micronekton (euphausiids, shrimps, amphipods) a larger mesh - 0.505 or 1.000-mm may occasionally be used. The MOCNESS (multiple opening-closing net environmental sensing system) will be used to census deep overwintering macrozooplankton populations and will also fish 0.333-mm Nitex nets.

When appropriate, these nets will be equipped with calibrated flow meters to measure the volumes filtered for each collection. Depth of sampling will be determined by cable telemetry (MOCNESS; pressure transducer), and time-depth recorder and meter wheel (scope). Discrete depth samples will also be obtained by closing vertical tows activated by messenger from the surface. All nets will be carefully rinsed and collections preserved in 10 percent or less seawater formalin for later laboratory analyses.

In the laboratory, collections will be screened for large or otherwise obvious zooplankters (direct counts) and then subsampled (splitter of Stempel pipet) for the more numerous organisms. Between 100 and 150 animals will be counted in subsamples to assure representativeness. In the case of the larger calanoids, copepodite stages will be enumerated separately. Samples will be analyzed at the ADF&G Limnology Laboratory at Soldotna, Alaska and at the University of Alaska, Fairbanks.

Sufficient replication will be undertaken to measure field sampling error, and levels of variability associated with day:night, location and cruise (date). Differences will be examined using ANOVA and other parametric and nonparametric statistical techniques.

Important data on continuous seasonal changes in upper-layer plankton stocks (species composition and abundance) will be obtained from the PWSAC hatchery plankton watch program. Samples are collected twice-weekly at locations adjacent to each facility (Evans Island, Esther Island, Cannery

Creek and Main Bay) in open 20-m vertical tows. After the hatcheries have measured the settled volumes of these collections, the samples are preserved in 10 percent formalin and stored for analysis at UAF. The hatchery watch program monitors upper-level plankton fields from 1 March through 30 June of each year.

Net samples will be taken to identify zooplankton fields associated with layers or swarms of acoustically censused or optically counted plankton. Sufficient direct sampling will be undertaken to assure the identity of the major species and to provide indices of their abundance and biomass.

A twice-monthly series of closing vertical tows in the deep region near Lone Island will provide profiles of upper-layer and deeper populations to track ontogenetic migrations. Sufficient sampling will be conducted at night from the ship to describe diel behavior and the extent to which day/night vertical movement influences the hypothesized prey-switching mechanism.

Sampling at least twice weekly at designated hydrographic stations along acoustic transects will provide a comparison with hatchery measured zooplankton in all regions. Particular attention will be paid to documenting the period when late-stage oceanic copepods (*Neocalanus* spp.) leave the surface waters (late May, early June). This abrupt decrease in upper-layer macrozooplankton provides a "river-like" experiment each year against which the degree of planktivory or piscivory can be judged. Knowing when the *Neocalanus* spp. descend from the surface is crucial to testing shifts in consumer prey fields.

A late fall or winter (November/December) cruise (R/V *Alpha Helix*) is planned to census deep-water overwintering macrozooplankton following expected "seeding" events in late summer. This cruise will be undertaken at approximately the same time each year so that interannual variations in overwintering stocks can be monitored. The *Alpha Helix* will fish a MOCNESS at a sufficient number of deep stations to assure reliable estimates of stock size and vertical/horizontal distributions in the Sound.

D. LOCATION

Sampling in Prince William Sound in FY 95 will emphasize regions adjacent to hatcheries and along the migratory corridor used by juvenile pink salmon to leave the Sound. Some samples will be obtained in Hinchinbrook Entrance and Montague Strait. The fall/winter MOCNESS sampling will be conducted in the deep central and western basin of the sound where overwintering stages of the large calanoids concentrate.

E. TECHNICAL SUPPORT

None

F. CONTRACTS

A float plane charter will be established from Anchorage (or Cordova) to retrieve samples collected during the field season for immediate processing in Fairbanks. Five (5) days of R/V Alpha Helix time will be needed for the deep macrozooplankton overwintering study.

G. SCHEDULES

Table 1. Annual schedule of project activities (FY95).

October-January	Complete FY94 data analysis Begin staging for FY95
November/December	5-day Alpha Helix cruise in Prince William Sound
January-February	Complete staging for FY95 Process Alpha Helix samples Initiate FY96 planning
March-July	Conduct FY95 field work Continue FY96 planning
August-September	Analyze field data and prepare preliminary reports for workshop

H. EXISTING AGENCY PROGRAM

This proposal seeks funding for a second year of study as part of the EVOS-sponsored continuing Prince William Sound System Investigation (94320).

I. ENVIRONMENTAL COMPLIANCE/PERMITS/ COORDINATION STATUS

None

H. PERFORMANCE MONITORING

This research will be supervised by Dr. R. Ted Cooney, Professor of Marine Science, University of Alaska Fairbanks.

J. BUDGET

	FY95
Personnel	217,170
Travel	11,505
Contractual[1]	74,000
Commodities	8,477
Equipment	500
Capital Outlay	0
Tuition	5,060
Subtotal	316,712
Indirect (20% Total Project Costs)	63,342
Total	$380,054

[1]Includes $50,000 for R/V Alpha Helix

SEA: Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers

Project Number: 95320-I(l)

Project Type: Research and Monitoring

Project Leader: Donald M. Schell, University of Alaska Fairbanks

Lead Agency: University of Alaska Fairbanks

Cooperating Agency: Alaska Dept. of Fish and Game

Cost of Project: $100,093

Start Date: 1 October 1994

Duration of Project: 24 months

Geographic Area: Prince William Sound

Project Leader:
Donald M. Schell, P. I.

Project Manager(s):
Jerome Montague
Habitat Division
Alaska Dept. of Fish and Game

B. Introduction

This project contributes to an ongoing effort by Alaska Department of Fish and Game personnel to determine the reasons for the decline of harbor seal and steller sea lion populations in Prince William Sound. In addition, the project seeks to better describe the trophic interactions and trophic status of marine mammals, birds and their prey species in the Prince William Sound ecosystem. The integrating methodology for the range of tasks is the use of stable isotope ratios as natural tracers of carbon and nitrogen transfers through the food webs. Carbon isotope ratios serve as conservative tracers of energy supply between trophic levels (phytoplankton to zooplankton to fishes to top consumers). Seals, cetaceans, birds etc., acquire the isotope ratios in proportion to the amount of food derived from each differing source. This, in turn, is reflected in the composition of body tissues and in keratinous tissues (claws, feathers, baleen, whiskers) as a temporal record when multiple sources of food are consumed over time and space. This allows the discerning of important habitats and food resources in animals that seasonally migrate or undergo periods of hyper- and hypotrophy.

Nitrogen isotope ratios reflect both the food sources and the trophic status of the animal. As nitrogen in food is consumed and assimilated by a consumer, the heavy isotope is enriched by approximately 3°/oo. This enrichment occurs with each trophic step and thus allows the construction of conceptual models and food webs within the ecosystem and the assignment of trophic status to species for which field data on diet are sparse.

In cooperation with Dr. T. Kline, who is focusing on the fishery resources of the PWS pelagic food webs, we are collecting a suite of samples aimed at allowing us to model the trophic structure of the PWS and the habitat dependencies. Over the past year we have collected offshore forage fishes and tissues from marine mammals. This collection program is now again under way and a large collection of samples for isotope ratio analysis has been obtained. After reviewing the results of this effort, we will focus on areas of data gaps and on refining our understanding of ecosystem processes controlling distributions of isotope ratios.

C. Project Description:

1. Resources and Services - - This study focuses on harbor seals, sea birds and the cetaceans of Prince William Sound. Although the major effort is concerned with harbor seals, other marine mammal tissues will be collected opportunistically in cooperation with those agencies handling or collecting those species. Our principal cooperating agency is the AK Dept. of Fish and Game.

2. Relation to Other Damage Assessment Work - - This study is closely coordinated with the modeling efforts and the pelagic food web studies being undertaken by the Prince William Sound Science Center personnel. Dr. Kline is responsible for most pelagic collections of food base organisms and is sharing these data to help construct the food web models. Stable isotope data provide an excellent means for validating models and testing food web linkages. This aspect of the work will be cooperative with many components of the SEA project.

3. Objectives:

The objectives to be completed during the period of this proposal include:

1. Collect samples of harbor seal vibrissae through cooperative work with the Alaska Department of Fish and Game in Prince William Sound;

2. Collect samples of harbor seal prey species including forage fishes, sälmon and herring in the vicinity of major haul-outs and high population densities. Samples of seal tissues will be

collected from native hunters. These samples will be obtained through assistance by ADF&G personnel monitoring harvests.

3. Perform stable isotope ratio analyses on tissues and organisms collected during the sampling program. Through the use of carbon isotope data on taxa collected over geographical regions, the presence/absence of isotopic gradients useful in sorting out habitat dependencies will be determined.

4. Through the use of nitrogen isotope ratios in collected taxa, assign trophic status to species in each region. Compare trophic status with predictive models based on conceptual food webs.

5. Determine temporal changes in harbor seal trophic status and food dependencies by comparing isotope ratios along the lengths of vibrissae with prey availability and their isotope ratios.

6. Compare the isotope-ratio derived food web models to predictions by the "lake- river" hypothesis of the SEA project as an independent means of validation.

4. Methods

The primary work will be divided into the sampling program and the subsequent analytical and synthesis tasks. Sampling of tissues for stable isotope analysis has been described for both bulk tissues (muscle, blubber) and temporally variable tissues (whiskers, claws etc.) (Schell et al., 1989; Michener and Schell, 1994).

4.1 Analytical - - The samples obtained are dried and powdered for homogeneity and the isotope ratios of carbon and nitrogen determined with a Europa 20/20 mass spectrometer system. The sample is combusted at high temperature and the nitrogen and carbon dioxide gases separated and purified by gas chromatography. These are subsequently led into the mass spectrometer by capillary and the isotope ratios determined.

4.2 Synthesis of data - - The plots of isotope ratios of carbon and nitrogen along the lengths of vibrissae from sea lions are known to show oscillations in isotope ratios in response to dietary changes over the seasons (Schell, unpublished data). As new data with supporting natural history information are acquired, the values at specific intervals will be compared with potential prey for likely matches. These will be compared with observational data and known feeding habits. From this information, sampling can be constrained to the most probable food sources and further directed analyses performed to confirm or deny conceptual food web structure.

D. Location:

The research effort will be conducted in Prince William Sound with contrasting data obtained from samples from the Kodiak Island area and in the coastal Gulf of Alaska near

Cordova.

E. Technical Support:

This project is integrated closely with the ADF&G program on marine mammals in the Prince William Sound and adjacent areas. Other collaborators in NMFS and the University of Alaska will contribute samples from their programs to this project.

F. Contracts:

No subcontracts will be conducted through this study. Close cooperation with T. Kline and his stable isotope research on the pelagic system will be conducted throughout the program. We will continue to share data and integrate our findings.

G. Schedules:

1 Nov 94 - 15 Feb 95	Prepare and analyze isotope ratio samples
15 Feb - 31 March	Synthesis and coordination for sampling
Apr - August	Field work and sampling
Aug - Sept	Post field analysis and planning for 96

H. Existing Agency program

This project is a continuation of work begun in Spring 1994 as part of the EVOS-sponsored Prince William Sound Ecosystem Assessment (SEA), funded in FY94.

I. Environmental Compliance/Permit/Coordination Status
(none required)

J. Performance Monitoring

Dr. D. M. Schell will oversee the Quality Assurance/Quality Control aspects of this project. We have established protocols for sampling and our working standards are cross-calibrated with other nationally recognized laboratories. Primary standards are from the National Technical Standards Service. Our mass spectrometer technician has been well-trained and has over eight ears experience on three mass spectrometers.

K. Budget

Personnel	$57.0
Travel	6.2
Contractual	9.8
Commodities	0.0
Equipment	0.0
Capital Outlay	5.4
Tuition	5.0
Subtotal	83.4
Indirect (20% Total Direct Costs)	16.7
Total	100.1

Literature Cited

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.

Schell, D. M., S. M. Saupe, and N. Haubenstock. 1989. Bowhead growth and feeding as indicated by $\delta^{13}C$ techniques. *Mar. Biol.* 103:433-443.

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SEA: Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers - Food Webs of Fishes

Project ID Number: 95320-I(2)

Project Type: Research/Monitoring

New/Continuing SEA Project: Continuing

Name of Project Leader: Dr. Thomas C. Kline, Jr.

Lead Agency: Prince William Sound Science Center

Cooperating Agencies: University of Alaska Fairbanks
Alaska Department of Fish and Game

Cost of Project: (FY95 Total): $196.1 K

Project Start-up Date: 1 November 1995

Duration of Project: 2-5 years

Geographic Area: Prince William Sound

Project Manager: Jerome Montague
Habitat Division
Alaska Department of Fish and Game

B. Introduction.

Stable isotope ratios of carbon can serve as effective tracers of energy supply in Prince William Sound (PWS) due to conservative transfer of carbon isotope ratios between the lower tropic levels (phytoplankton to zooplankton to forage fishes, etc.) up to the top consumers. Isotope ratio analysis of fishes, their prey and their predators can provide insight into habitat usage and assist in quantifying diet 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 0.34% with each trophic level and thus can accurately indicate the relative trophic status of species within an ecosystem. The data obtained from these measurements are unique in that they trace material actually assimilated and thus can be used for more accurate ecosystem modeling.

The availability of macrozooplankton forage for salmon, herring, and their predators varies in space and time because of changes in physical processes in Prince William Sound. 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 may 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 fishes.

It can be postulated that natural stable isotope abundance of PWS biota will reflect changes in trophic level, food web structure, and primary production, 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 provides 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 these elements between levels. One focus is to build 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.

Observations made during Leg 1 of SEA cruise 1 of 1994 confirms the concept that Prince William Sound is a pelagic system. The principal midwater predator was pollack utilizing macrozooplankton (euphausids, copepods, squid, and isopods) as prey with occasional use of fishes. Shortly after commencement of pink salmon release at Lake Bay, approximately one in 15 pollack sampled in Wells Passage preyed upon salmon fry, and this predation was exclusive. At this time pollack were widely dispersed in the area suggesting opportunistic feeding depending on encountering salmon.

C. Project Description.

1. Resources and Services: Herring and Pink Salmon

2. Relation to Other Damage Assessment Work:

The Stable Isotope study is part of the integrated Prince William Sound System Investigation initiated in FY94. The Stable Isotope study will integrate with virtually all other aspects of SEA and the Prince William Sound System Investigation.

With SEA (Project 320):
Salmon Growth and Mortality: Stable isotope data of growing salmon will be compared to available forage fields to ascertain flow of nutrients to salmon. Stable isotope data will be used to assess significance of salmon prey to salmon predators.
Salmon Predation: Stable isotope data of predators will be used to assess their role in affecting salmon and herring recruitment.

Phytoplankton and Nutrients: Stable isotope data of zooplankton will be used to infer changes in the availability and flow of nutrients at the bottom of the food chain.
Zooplankton in Ecosystem: Stable isotope data of zooplankton will be used to assess their trophic levels and infer the dynamics within the zooplankton-pelagic community.
Information Systems-Modeling: Stable isotope data will be used to determine canonical trophic levels and to reconstruct food webs. This information will be incorporated into models. Isotopes shifts will be used as empirical spatial and temporal inputs.
Physical Oceanography: Stable isotope data of pelagic food webs recorded in temporal and spatial context will be compared with physical oceanographic data to ascertain the relationship of circulation patterns with changes in food web dynamics.
Nearshore Fish: Stable isotope reconstruction of pelagic food chains will be related to predator and prey fields as ascertained by hydroacoustic measurement and netting.
Avian Predation on Herring Spawn: Stable isotope analysis of herring predators will be used to asses role of herring spawn to avian diets in Dr. D. Schell's related studies. The isotopic signature of herring and alternative avian marine prey will be derived in the fish food web component.
Herring natal habitats: Stable isotopic chemistry of natal habitat predators will be used to assess their herring roe predation role.
Juvenile herring growth and habitats: Stable isotopic chemistry of juvenile herring will be used to assess their trophic status in relation to growth rate in different habitats.
Herring predation by humpbacks: The established isotopic database of herring and other potential humpback prey will be used to assess the isotopic chemistry of any humpback samples that become opportunistically available (e.g. from sloughed skin or carcasses).

With related studies:
CWT Recovery: Stable isotope data of salmon with CWT can be used to assess ecosystem utilization by this subpopulation with respect to other species and pink salmon in general.
Pink Salmon Genetics: Stable isotope data can be correlated with genetic data to expose ecological and genetic relationships, e.g. the question of whether carrying capacity effects are the cause of dwarfing in pinks.
Harbor Seals (Trophic Interactions): Stable isotope data from the fish food web component will provide the spatial and temporal background data needed to interpret isotope data of seals.
Trophic-Stable Isotopes: Stable isotope data from this component will support Dr. D. Schell's investigation on seal and avian predation.
Bald eagle diet: Analysis of eagle feathers and samples of eagle prey will rely this isotopic database for interpretation.
Larval and juvenile herring in PWS: Interpretation of isotopic analysis of juvenile herring will augment the larval and juvenile herring study.

3. Objectives: (see Schedule for temporal objectives)

3.1 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.

3.2 Specific objectives of this project are:

3.2.1. 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.

3.2.2. Determine isotope ratios of prey species that are 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 life span. Drs. Schell and Kline expect to consult with each other frequently to exchange data to develop this and other parts of the stable isotope program.

3.2.3. Synthesize the data obtained in context with conceptual food webs to validate feeding models and expand the natural history information.

3.2.4. 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.

4. Methods.

4.1 Strategy.

1. Collect synoptic samples from the greater PWS using the available fleet (ADF&G et al.) sampling effort. Under other SEA projects, these same individual samples will receive additional analyses (e.g. stomach content analysis) in addition to 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

4.2 Analytical methods.

The methodology involved in the isotopic analyses and the interpretation of the data are well established and documented in several publications resulting from prior work of the Principal Investigator. The UAF Stable Isotope Facility has three isotope ratio mass spectrometers including a new automated system which facilitates faster sample processing and allows 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. Predator isotopic data will be compared with values obtained from prey species in the same habitats. Where samples of prey species are missing or 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 existing data on isotope ratio values (published and unpublished) to establish a trophic model.

D. Location.

The sampling will be carried out throughout PWS as part of the cruise plan. Analytical work will be carried out using the stable isotope facility at UAF. Sample preparation for stable isotope analysis and data interpretation will take place at the Prince William Sound Science Center.

E. Technical Support.

Alaska Department of Fish and Game - Vessels and sampling
University of Alaska Stable Isotope facility: Dr. D. Schell will receive prepared samples from Dr. Kline. Dr. Schell will supervise the isotopic analysis and reporting of data to Dr. Kline.

F. Contracts. None

Schedules.

Fall 1994 - Conduct fall field sampling cruise on Alpha Helix. 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.

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 close 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. Planning for FY96 will take place.

Existing Agency Programs:

This project is part of the EVOS-sponsored Prince William Sound System Investigation, funded in FY94.

I. BUDGET (Amounts shown in thousands).

	FY95 PWSSC	UAF	FY96 PWSSC	UAF
Personnel	$65.1	$0.0	$65.1	$0.0
Travel	$9.3	$0.0	$9.3	$0.0
Contractual	$5.0	$45.0	$5.0	$45.0
Commodities	$9.0	$0.0	$9.0	$0.0
Equipment	$30.0	$0.0	$0.0	$0.0
Total direct costs	$118.4	$45.0	$88.4	$45.0
Indirect costs (20%)	$23.7	$9.0	$17.7	$9.0
sub-totals	$142.1	$54.0	$106.1	$54.0
Project Total		$196.1		$160.1

SEA: Purchase of Isotope Radio Mass Spectrometer: (SEA: Confirming Food Web Dependencies in the Prince William Sound Ecosystem Using Stable Isotope Tracers)

Project Number: 95320-I(3)

Project Type: Research and Monitoring

Project Leader: Donald M. Schell. P.I.

Lead Agency: University of Alaska
Water Research Center, Inst. of Northern Engineering

Cooperating Agency: Alaska Dept. of Fish and Game

Cost of Project: $257.4K

Start Date: 1 October 1994

Duration of Project: 12 months

Geographic Area: Prince William Sound

Project Manager: Jerome Montague
Habitat Division
Alaska Dept. of Fish and Game

B. Introduction

The increased demand for stable isotope ratio analyses associated with studies of ecosystem dynamics in Prince William Sound has currently filled our analytical capabilities almost to capacity. Projected demands for the FY95 year and beyond indicate that a major increase will occur in the number of samples associated with oil-spill related studies. This may mean substantial delays in data acquisition even if no serious machine breakdowns or personnel problems occur. The sample load from the SEA projects coupled with other proposed studies by both the Prince William Sound Science Center and the research institutes at the UAF indicate that a substantial increase in load in the order of several thousand samples will occur next year.

C. Purchase/Project Description

This proposal seeks funds to purchase a Europa isotope ratio mass spectrometer and support a technician to accomplish the projected analysis load in a timely fashion and to provide a buffer in case of a serious machine breakdown or personnel delays with our current system. The system proposed for purchase will analyze carbon and nitrogen isotope ratios simultaneously and will allow efficiency of operation through the use of common components. We currently operate a Europa ANCA 20/20 machine and will aim at acquiring a similar piece of equipment.

We are also requesting funds for a technician to operate the equipment. Our mass spectrometer technician, N. Haubenstock, is fully occupied in keeping the current equipment operational and with sample processing, data entry and associated tasks. She would be unable to maintain and operate two machines simultaneously without technical assistance. The enclosed budget provides for that assistance.

We propose to house the system in the Water Research Center as part of the UAF Stable Isotope Ratio Mass Spectrometry Facility. The Water Research Center has room in the air conditioned laboratory to house the instrument and the required regulated power and ancillary facilities such as a sample preparation laboratory.

D. Equipment Requested.

We request the funds to purchase a Europa automated mass spectrometry system complete with automated sample combustion system and the data handling capabilities. The price quoted for this system is approximately $145,000 with an additional $15,000 requested for the start-up materials including a Cahn electromicrobalance, high-purity gases, additional primary standards and a small bench-top grinder for homogenizing samples.

We identify this equipment in order to take advantage of a consolidated supply of spare parts and expendables and, more importantly, the accumulated knowledge of operational details gained over the past years with our present Europa system.

E. Operation and Maintenance

The mass spectrometer will be operated as part of the UAF Stable Isotope Mass Spectrometry Facility which is jointly supported by the Water Research Center, Institute of Northern Engineering and the Institute of Marine Science. We have successfully operated this facility since 1985 and steadily expanded our services and capacity to the University community. The proposed instrument is anticipated to be fully occupied with samples generated by the SEA project and related EVOS Trustee Council-funded studies. There will be no singular dedication of the machine to these samples as all samples are run in order of receipt and by sample type. Set-up for a particular sample type will include all incoming compatible samples on that machine. Analysis fees will be charged for all samples as they reflect usage of expendables (high purity oxygen and helium, replacement combustion tubes, combustion tube packing, computer supplies, sample cups, etc.). They do not reflect operator costs which are budgeted separately.

F. Environmental Compliance/Permit/Coordination Status

(none required)

G. Schedules:

1 Nov	Order mass spectrometry system
15 Feb	Anticipated receipt and installation
1 Mar and continuing	Attain operational status and commence isotope ratio analyses on samples

H. Existing Agency program

This purchase is a result of work begun in Spring 1994 as part of the EVOS-sponsored Prince William Sound Ecosystem Assessment (SEA), funded in FY94. Administration of this project is by the Alaska Department of Fish and Game. Additional stable isotope work on harbor seals and marine mammals in adjacent waters to Prince William Sound is being undertaken with ADF&G, the US. Forest Service and through the Coastal Marine Institute of the University of Alaska.

I. Performance Monitoring

Dr. D. M. Schell will oversee the purchase, installation, operation and maintenance of this instrument. We will operate the mass spectrometry system using established protocols for sample handling and analysis. Our working standards are cross-calibrated with other laboratories and standards from the National Technical Standards Service. Ms. Norma Haubenstock, the mass spectrometer technician has been well-trained and has over eight years experience on three mass spectrometers. Installation and acceptance of the instrument will be accompanied by factory training and demonstration of satisfactory operation using samples typical of those being collected.

J. RECENT PUBLICATIONS RELEVANT TO PROPOSAL

Michener, R. H. and D. M. Schell. (in press) The use of stable isotopes in tracing marine aquatic food webs. In: R. Michener and K. Ljatha (eds.). *Stable Isotopes in Ecology* Blackwell Scientific Publications.

Gu, Binhe, D. M. Schell, and V. Alexander. (in press) Stable carbon and nitrogen isotope analysis of a plankton food web in a subarctic lake. Can. J. of Fisheries and Aquatic Sciences.

Oswood,M. W., J. G. Irons III, and D. M. Schell. (in press) Dynamics of dissolved and particulate carbon in a tundra stream in arctic Alaska. In J. Reynolds and J. Tenhunen (eds.), *Landscape function: Implications for Ecosystem Response to Disturbance*, Ecological Studies, Springer- Verlag.

Schell, D. M., S. M. Saupe and N. Haubenstock. 1989. Bowhead whale growth and feeding as indicated by $\delta^{13}C$ techniques. *Mar. Biol.* 103:433-443

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Schell D. M. 1993. Bomb radiocarbon in arctic Alaskan aquatic and terrestrial biota. In: *Radioactivity and environmental security in the oceans: new research and policy priorities in the Arctic and North Atlantic* (V. Adushkin and G. Krasilov, eds.) Woods Hole Oceanographic Inst. Woods Hole MA. Pp 135 - 144.

Saupe, S. M., D. M. Schell and W. Griffiths. 1989. Carbon isotope ratio gradients in western arctic zooplankton. *Mar. Biol.* 103:427-432.

Dunton, K. H., S.M. Saupe, A. N. Golikov, D. M. Schell, and S.V. Schonberg. 1989. Trophic relationships and isotopic gradients among western Arctic Ocean fauna. *Marine Ecol. Prog. Ser.* 56:89-97.

K. FY95 Budget($K)

Personnel	$ 45.3
Travel	0.0
Contractual	0.2
Supplies	5.0
Equipment	164.0
Sub-total	**214.5**
Administrative Costs	42.9
Total	**257.4**

Sound Ecosystem Assessment (SEA) - An Ecosystem Study for Prince William Sound : Information Systems and Model Development (SEADATA)

Project Number: 95320-J

Project type: Research/Monitoring

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

Lead agency: Prince William Sound Science Center (PWSSC)

Cooperating agencies: Prince William Sound Aquaculture Corporation (PWSAC)
University of Alaska Fairbanks (UAF)
National Biological Survey (NBS)
Alaska Department of Fish & Game (ADF&G)
National Oceanic and Atmospheric Administration (NOAA)

Cost of project/FY 95: $1,575.1K

Cost of Project/FY 96: $1,430.9K

Project Start-up/Completion Dates: FY95: October 1, 1994 - September 30, 1995

Geographic area of project: Prince William Sound and North Gulf of Alaska

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

B. INTRODUCTION

Subsystems and their quantitative representation

The Information Systems and Model Development Project (SEADATA) in FY95 will be a continuation of the FY94 project started in April 1994. The long term mission of this project is to provide an information system appropriate for the SEA Program and to develop the modelling resources needed to achieve the ecosystem objectives of SEA. The goal of the FY94 effort is to implement the first phase of a basic set of functions and to bring these resources on-line incrementally throughout the field season. The FY94 effort is now underway. The majority of the accomplishments to date are in the areas of system configuration and implementation. Resources that have been brought on-line include an Xmosiac home page for the SEA Program, accessible on the Internet at the URL address http://avl.umd.edu:5555.

The objectives of SEA and a plan for their realization are described in The Sound Ecosystem Assessment (SEA) Project Plan (November 1993). The SEA Plan 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 identifies the predators, the competitors, the prey, and the physical and chemical environmental variables that affect these populations. The objective of SEA is the quantitative understanding of how these two subsystems function and how this functioning is reflected in the strength or weakness of the commercial fishery. Toward that end the SEA Plan describes a set of hypotheses regarding the functioning of the two subsystems, the methods and the technology whereby these systems can be measured and monitored, and outlines for system models that will ultimately provide the necessary predictive capabilities.

The SEA plan for measurement and monitoring consists of the SEA field survey together with data acquisition from other sources. Collectively the FY94 SEA projects are now acquiring the following information about the state of the system (items marked with * will be operational later in FY94 or FY95):

From the SEA field survey (buoys, surface vessels, aircraft*):

- ocean current vectors, temperature, salinity, sea state, fronts;
- plankton densities, distribution, species and cohort composition;
- fish densities, distribution, size and species composition, diet;
- bird and mammal counts, distribution, predation.

From the satellite downlink site:

- sea surface temperature (Advanced Very High Resolution Radiometer - AVHRR))
- ocean color and derived values (Sea viewing Wide Field of view Sensor - SeaWiFS*)
- meteorological data*

There is a similar but much less comprehensive list for historical data. Aspects of that record that are not yet available in a format suitable for SEA are being addressed during FY94 as part of the SEADATA project.

The SEADATA project will provide the means by which these data can be readily used and understood. This objective is addressed through five subprojects:

(1) Field data communications;
(2) Data management;
(3) Descriptive model;
(4) Numerical models;
(5) Sampling technologies.

The first and the last of these five address problems associated with the timeliness of the data and the costs and efficiency of the data acquisition methods. It is necessary to include these issues for they are critical aspects of any predictive capability. The second, third and fourth tasks deal more directly with the relationship between measurement and an ecosystem assessment.

The Field Data Communications subproject (item (1)) addresses the problem of the timeliness of the data, that is, near realtime physical and biological information from survey vessels, fixed monitoring stations, and monitoring equipment on ships of opportunity. This project also addresses the problem of immediate access to composite information from multiple sources from any vessel on the sound. During FY94 a prototype system will be set up providing near realtime data for selected data sources from a single survey vessel, from a single prototype buoy station, and from an automated sensor for a ship-of-opportunity.

The Sampling Technologies subproject (item (5)) addresses the use of new technologies to reduce the cost and increase the resolution and scope of ecosystem monitoring. For FY94 a new platform and optical sensing method for zooplankton was added that accomplishes all three of these objectives. In addition a report on the applicability of acoustic tomography will be completed in FY94.

Data Management (item (2)) refers to more than the issue of managing a database. This subproject addresses the coordination required to function with a multiplicity of data sources and data users. It encompasses all of the data services, including data ingestion from both realtime and archival sources, data storage, quality control, relational management systems, and security. It is responsible for providing and maintaining wide area network access, specifically worldwide access via the Internet. It also provides the local area access necessary to support the needs of the communities served through the Restoration programs.

Finally, and to a large degree most importantly for the data user, it addresses the issue of access to the data. It provides the resources by which the users access, query, and, through the use of on-line analysis and visualization tools, address the question of the meaning of the data. This last function marks the boundary between the Data Management subproject and the Descriptive Model (item (3)) subproject. The term "descriptive model" is a misnomer in the sense that it is what one does in the absence of a model. In such a case one often turns to methods to "see" the data in the context of all the other data, that is, to use the data to describe the state of the system. Achieving this for the three dimensional spatial domain of the pelagic system of Prince William Sound and for time intervals with rapidly varying environmental variables requires the use of advanced data interface and data visualization tools.

The fifth subproject is in effect the "assessment" part of SEA. The Numerical Models subproject addresses the issue of quantitative representations of the state of the ecosystem and its subsystems. It addresses the means by which past observations are understood (hindcasting). It addresses the means by which we are able to know the present state of affairs given limits on the amount of information we have from the past (nowcasting), and how far ahead we can anticipate events (forecasting). Some level of capability for one or more of these is implied by the very notions of ecosystem assessment, restoration, recovery, and response to perturbations.

C. NEED FOR THE PROJECT

The SEADATA project is the means by which data from individual projects becomes an ecosystem assessment. The SEA program at the project level is a coordinated effort of primarily discipline-specific projects. These projects address issues associated with specific system components and processes coupling specific components. These projects are organized into an interdisciplinary ecosystem study by the SEA Science Plan.

The SEADATA project has a large role in implementing the Science Plan at the system level. At the basic data level it is responsible for ingesting as rapidly and cheaply as possible data from disparate and intensive surveys and monitoring efforts, and for integrating these into system representations. These representations include the spatial and temporal coordination of data for multiple trophic levels and the computation of trophic level interaction rates derived from such data. These roles are addressed in the Field Data Communications, Sampling Technologies, Data Management, and Descriptive Modelling subprojects. For FY94 and FY95 the goals of these subprojects are all within the range of existing technology yet are quite aggressive in regard to scope, schedule, and the degree to which advanced technology is required to meet the objectives.

The goal of SEA is more than ecosystem scale data. Rather, it is a quantitative representation of subsystem function sufficient for the prediction of the impact of significant perturbations to that system, whether natural or man-made. This goal is addressed in the Numerical Models subproject. Although this ultimate goal is beyond current ecosystem science, major components necessary to achieving that goal are currently available. These components are addressed in FY94 and FY95 according to the maturity and availability of suitable methods.

D. PROJECT DESCRIPTION

The objectives and methods for each of the five subprojects of SEADATA for FY95 reflect the transition from an emphasis on data and communications to an emphasis on the its use and the modelling.

#1. Field data communications.

The effort planned is based upon the assumption that the FY94 effort will achieve its goals for each of the three applications areas, a single survey vessel, a single buoy, and an autonomous system. Given this status, it is appropriate technically to consider expanding this capability to additional survey vessels and to begin planning for a network of realtime in-situ stations. However, to contain costs for FY95 this subproject will continue at a much lower level. No further in situ realtime stations will be added. No major effort for an expanded ship of opportunity program will be undertaken. The only FY94 effort to continue will be that of real time data from survey vessels. One, and possibly, two survey vessels will be fitted with some degree of realtime data capability.

There will, however, be an effort to track and to utilize new developments in the Prince William Sound region as the appear. During FY95 cellular phone service will become available, but for a limited region. Also, a privately funded communications satellite has been announced. The costs and benefits of such new technologies will be evaluated.

#2. Data management

All data related tasks are collected into the Data management project which, in turn, has seven subprojects.

2.1. Coordination: This subproject will continue to provide coordination of the Data management project with the needs and interests of the SEA participants and the Trustee Council.

2.2. SEA data services: In FY95 data services will have reached a basic level of function. For most areas the effort will continue at a maintenance level. Two areas will receive significant attention: the mass storage and implementation of an extended relational database. A redundant array mass storage system will be implemented in FY95.

A major focus in FY95 will be the implementation of a scientific database. During FY94 the Prince William Sound Science Center and the Advanced Visualization Laboratory, University of Maryland, were awarded dual grants by Xidak, Inc., of Palo Alto, California, of their scientific database and data server software (list value $50,000). Under this grant, the parties will undertake a cooperative development effort to address database and data server issues specific to the SEA Program. Xidak in addition is supporting a graduate student engaged in the project. This grant and the codevelopment effort is significantly accelerating the implementation of a scientific data system for SEA.

2.3. Site access: The subproject will continue to maintain both the wide area and the local area connectivity. Wide area communications, including access to the Internet, are essential not only to the SEA investigators but also to the larger community served by and interested in the Restoration effort. In addition, this communication is necessary for activities such as the codevelopment with Xidak and the University of Maryland. An important component of the local area network support is the development of services associated with the Restoration effort for members of the nearby communities.

Activities associated with remote sensing, remote data sources and historical data will increase during FY95 as computer and communication access is fully implemented.

2.4. Remote sensing data: This effort will continue to provide Advanced Very High Resolution Radiometry (AVHRR) for sea surface temperature (SST) and acquire Sea viewing Wide Field of View Sensor (SeaWiFS)images for ocean color data. There are three subprojects that will be ongoing: 1) Downlink and archive, providing for data collection from the satellites; 2) SEA data product, reviewing available images for use in SEA; and 3) Distribution, adding the image data to online SEA databases. This subproject will be conducted by Dr. David Eslinger in collaboration with the Geophysical Institute.

2.5. Remote data sources: These are data sources for current data other than SEA data and satellite data, including detailed meteorological data.

2.6. Historical data: The objectives of this subproject are to 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; and 3) select high priority data resources and complete necessary data processing to integrate these data in the SEA database. Progress was made toward these objectives in 1994, but further historical data remains to be
collated. Historic AVHRR satellite imagery will be acquired primarily from the NOAA archive in Washington, D.C. A time-series, to date back to 1985, will be constructed over 13 biweekly intervals April 1 through October 15 annually (weather permitting). Each fiscal year should
provide funding for acquisition and processing of 3 years of historical data. Imagery will be processed to provide data on temperature (marine and terrestrial) and indices of primary productivity (terrestrial only). These data layers may be integrated with other data sources, e.g. fish returns, marine primary productivity, etc., to identify interactions between terrestrial and marine ecosystem components in Prince William Sound. Data layers will be transferred to the Prince William Sound Science Center for masssster archiving and wide area accesss.

2.7. SEA data tools: This subproject will provide accessibility and utility of the SEA data, models, and forecasts for the SEA investigators and for those using the results of the investigations. These will include browse tools, help tools, and higher level research tools. These efforts will increase during FY95 with cost sharing from the Xidak grant.

#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 overall objective is to continue development of an interface to existing data that provides for display, query, and the computation of further variables that are functions of the state of the system.

3.1. Visualization: Visualization interfaces will be developed relating temperature, salinity, ocean currents, densities with respect to volume (biomass per unit volume), size, 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.

3.2. Support for adaptive sampling: Adaptive field sampling strategies require accurate and near real-time information. This subproject will provide 1) near real-time support; 2) transmission of reduced data to the field and decision aid tools for field use; and 3) short term forecasts.

#4. Numerical models

The work of this subproject is the development of numerical models. The ultimate 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. Modeling objectives for 1995 are continued development and testing of 1) ocean circulation model; 2) physical-biological model; and 3) model frameworks for observations of feeding, dispersion, mortality, and growth.

4.1. Ocean circulation model: Every biological process relevant to SEA depends on the ocean state variables. It is not possible to predict anything about the time evolution of the biology without a prediction of the ocean state.

During the first half of FY95, Dr. Chris Mooers will implement the Mellor ocean circulation model to Prince William Sound. He will bring online a continuously running, three dimensional, wind driven, circulation model. The model output will be accessible over the Internet.

4.2. Physical-biological model: 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. They are hybrid models combining ocean circulation models with biological models for foraging, natural mortality, regeneration. These models 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. For 1995, this modeling effort will continue
the evaluation of lower-level model development to identify the simplest mechanistic model that adequately describes the state of the system. Implementation of a data driven model of the time evolution of the plankton populations will begin. Dr. David Eslinger, UAF/IMS, will be contracted to conduct this effort, in coordination with the SEA project for in situ measurements of the phytoplankton population and nutrient concentrations.

4.3. Nekton ecological processes: The observed distribution of nekton can be modelled as a response to the present distribution relative to alternative distributions. A simple formulation consists of a "preference" measure for an environmental variable such as temperature, light level, or temperature gradient (thermal front). 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.
This effort in 1995 will focus on implementation of the "plus/minus 1" subsystem models (i.e., the predators, competitors, and the prey) for each postlarva life stage of pink salmon and herring; continuation of model development for dispersion for each of the populations in the "plus/minus 1" subsystem; numerical solutions for the implemented models and the simulation

of diel, seasonal and geographic variation; and model refinement for foraging, growth, and predation mortality. These models will draw upon the collective knowledge of SEA regarding the distribution and behavior of specific populations, the interpretation of observed overlapping distributions, and results from field studies of diet and foraging. Dr. Doran Mason, University of Wisconsin Limnology Laboratory, will collaborate with Dr. Vince Patrick in the development of distribution-feeding-growth models. Dr. Ricardo Nochetto will also collaborate as an expert in numerical methods for the classes of equations used in this project.

SD94#5. Sampling technologies

The efficiency and cost effectiveness of the SEA monitoring effort will depend on using cost-effective sampling technologies. This subproject has two ongoing objectives. First, to serve as the vehicle whereby available technological advances can, on a selective and prioritized schedule, be introduced to SEA. Second, to provide the means whereby newly available advances or emerging technologies can be reviewed and evaluated. Technologies under consideration at the time of writing include: high frequency acoustics adapted to the Chelsea Aquashuttle and realtime data from acoustic tomography.

E. EXISTING AGENCY PROGRAMS

This proposal is a continuation of project 94320-J, SEA Information Systems and Model Development. As such, it is integrated with other SEA programs and is a component of a program for interaction with other EVOS-sponsored research (e.g., forage fish program).

F. 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 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.

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.

G. 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. Continued public involvement in all aspects of SEA is solicited through the activities of the PWSFERPG, as well as supported under the objectives of SEA PLAN in both 1994 and 1995.

H. PERSONNEL QUALIFICATIONS

This project will be conducted by an expert staff from academic, management and industry sectors. These experts will be recruited by the Prince William Sound Science Center through broad area and directed advertisement. The Science Center is an equal opportunity employer.

Project Leader: Vincent Patrick, Ph.D.

Education:
1967 B.A. Physics Thiel College, Greenville, Pennsylvania
1982 M.A. Mathematics University of Maryland, College Park.
1987 Ph.D. Mathematics University of Maryland, College Park.

Professional Experience:

ACADEMIC	Research Associate, Institute for Systems Research, University of Maryland 1993-present
	Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1992-1993
	Research Associate, Advanced Visualization Lab, University of Maryland 1991-1992
	Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1988-1991
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 1982-86

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 ate. Fisheries 17(2):23-35. (includes journal cover)

C. A. Berenstein and E. V. Patrick. 1992. Exact deconvolution for multiple convolution perators-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.

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 Visualization 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.

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. and W.G. Sprules. 1988. Effects of prey composition on the feeding of Chaoborus flavicans larvae. Verh. Internat. Verein. Limnol. 23:2165-2169.

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)

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.

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.

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, CA C

Project staff: Doran M. Mason, Ph.D.

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. 993. 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.

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

Selected Publications:
Author/Editor: 9 books
About 120 papers
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'.

Project Staff: Ricardo Nochetto

Education:
1983 PhD Mathematics, University of Buenos Aires

Professional Experience:
1983-1985 Post-doctoral fellow, University of Pavia
1986 Visiting professor, University of Maryland and Institute for Mathematics and its Applications
1987- University of Maryland, currently Associate Professor

Publications and Awards
Author of more than 40 reserach articles.
Editor of SIAM Journal on Numerical Analysis.
Awarded the 1993 International Giovanni Sacchi Landriani Prize, in recognition for his contributions in several areas of numerical analysis and nonlinear partial differential equations, particularly his work on free boundary value problems, the two-phas Stefan problem, and L-infinity estimates for various classes of linear problems.

Project Staff: Roy Murray

Education
1982 Bachelor of Electrical Engineering, Georgia Institute of Technology

Professional Experience
System Dynamics Incorporated, Systems Engineer, 1/89 - 7/89
Georgia Institute of Technology, Georgia Tech Research Institute (GTRI), Research Engineer 1983-1988
Cooperative Student, 1979 - 1981

Publications
"HAWK Radar Systems Engineering Support," Final Report, Contract DAAH01-87-D-0082, Delivery Order 0018, GTRI Project A-4810, January 1988.
"Clutter Analysis and Modeling," Final Report, Contract DAAH01-83-D-A013, Delivery Order 0117, GTRI Project A-4591, April 1987.
"HAWK Clutter Measurements/Effects Program Support," Final Report, Contract DAAH01-83-D-A013, Delivery Order 0110, GTRI Project A-4536, February 1987.
"HAWK Clutter Measurements/Effects Program Support," Final Report, Contract DAAH01-83-D-A029, Delivery Order 0049, GTRI Project A-4257, March 1986, coauthor.
"HAWK Clutter Measurements/Effects Program Support," Final Report, Contract DAAH01-83-D-A029, Delivery Order 0013, GTRI Project A-4102, June 1985.
"Phase III PIPs," Final Report, Contract DAAH01-83-D-A013, Delivery Order 0095, GTRI Project A-4075, May 1985, coauthor.
"Clutter Measurements/Effects Program Support," Final Report, Contract DAAH01-83-D-A013, Delivery Order 0033, GTRI Project A-3628, October 1984, coauthor.
"HAWK Continuous Wave Acquisition Radar (CWAR) System Simulation Support," Final Report, Contract DAAH01-83-D-013, Delivery Order 0063, GTRI Project A-3800, November 1984, coauthor.
"Effects of Bistatic Clutter on Low Altitude Air Defense Missile Systems," Milestone Report, Contract DAAH01-81-D-A003, Delivery Order 007, GTRI Project A-2847, January 1981, contributor.

I. BUDGET: See attached

PWSAC - PWS System Investigation - Experimental Fry Release

Project Number:	95320-K
Project Leader:	Jeff Olsen, PWSAC Operations Manager
Lead Agency:	AK. Dept. of Fish and Game (ADF&G)
Cost of Project, FY95:	$48.1; **FY96** $48.6
Start/Completion:	January, 1995 - July, 1995
Project Duration:	0.75 yr.
Geographic Area:	Prince William Sound
Contact Person:	Jeff Olsen, Operations Manager PWSAC, P.O. Box 1110, Cordova, AK 99574 (907) 424-7511

B. 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.

C. Need for Project

SEA focuses on processes and mechanisms that regulate losses of fry and juveniles to predators after emergence from nearshore natal habitats. Research suggests that fry size is an important determinant of survival during early marine residence. The pink salmon fry release project supports **SEA** research to investigate this hypothesis.

D. Project Design Objectives, Methods, Schedule and Location

1. Objectives

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 at these same hatcheries.

2. Methods

AFK and WNH hatchery pink salmon fry begin exiting the incubators volitionally at an average weight of 0.23 grams in mid March. Following enumeration, the pink fry are conveyed to saltwater rearing pens. Approximately 8 million fry will be loaded in two rearing pens of 4 million each at the two hatchery locations. Coded Wire Tags (CWT) will be applied to approximately 1 out of every 200 fry in the experimental groups.

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.

3. Schedule

Feb 1995-Apr 1995: Oversee development of incubating pink salmon eggs and perform routine eggcare and incubation environment monitoring.

Mar 1995-Jun 1995: Enumerate, CWT, rear and release pink salmon fry.

Apr 1995-Jun 1995: Coordinate/communicate rearing and release of hatchery pink salmon fry with **SEA** research team.

4. 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.

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.

E. Project Implementation

PWSAC will implement the project in conjunction with ADF&G as the lead agency.

F. Coordination of Integrated Research Effort

This project is part of the **SEA** program research initiated in 1994 and proposed for continuation in 1995 as a powerful test of the influence of ocean-entry timing and of fry size at ocean entry on losses to predators.

G. Public Process

PWSAC is a regional salmon enhancement association comprised of representatives from 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. The PWSAC Board of Directors 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 **SEA** ecosystem study.

H. 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

I. Budget FY95($K)

100	Personnel	$1.0
200	Travel	$0.0
300	Contractual Services	$0.0
	Administration	$2.7
400	Commodities	$40.4
500	Equipment	$4.0
	TOTAL	$48.1

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 Number: 95320-M

Project type: Research/Monitoring

Name of project leader(s): Dr. David K. Salmon, Oceanographer, Prince William Sound Science Center (PWSSC), and Affiliate Assistant Professor, Institute of Marine Science, University of Alaska Fairbanks (IMS/UAF)

Lead agency: Prince William Sound Science Center

Cooperating agencies: University of Alaska Fairbanks (UAF), U.S. Coast Guard, National Oceanic & Atmospheric Administration (NOAA), Alaska Department of Fish and Game (ADF&G), National Biological Survey, U. S. Fish and Wildlife Service

Cost of project/FY 95: $824.4K

Project Start-up/Completion Dates: 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

Introduction

SEA Observational Physical Oceanography in Prince William Sound and the Gulf of Alaska in FY 1995

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 management to promote a healthy ecosystem, increasing public information about the state of the ecosystem). 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 initial phase of SEA was funded during the last half of FY 1994.

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 Gulf of Alaska (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 through both differential availability of important food resources (calanoid copepods) and 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 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. In addition, measurements made in the observational physical oceanography program will be useful in other EVOS Trustee Council funded research efforts aimed at understanding interactions between other species and their environment.

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.

Need for the Project

An understanding of how to best restore resources damaged by EVOS hinges upon knowledge of both how the PWS ecosystem functions naturally and how it functions under stresses (such as EVOS) induced by human beings. The natural variability in the system is so dominant that we must ascertain that variability in order to understand how smaller perturbations (in the long run) such as EVOS and the effects of salmon hatcheries propagate their effects through the ecosystem. The EVOS Trustee Council has sanctioned an ecosystem approach to the restoration of injured resources, and as a result has initiated ecosystem level studies aimed at understanding how the PWS ecosystem functions. This project is a continuation of the ecosystem level studies that are aimed at guiding restoration efforts. In addition, at recent restoration workshops held by the Trustee Council, it has been universally agreed upon, that an essential element of all restoration research and monitoring projects is a study aimed at characterizing the physical environment in terms of oceanography and meteorology. Therefore, this particular project (physical oceanography) is a cornerstone of the entire suite of marine ecosystem level studies.

It is essential for placing the PWS ecosystem within the broader context of the climatic factors that constrain both its structure and function.

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 area. Physical and zooplankton sampling in the southwestern Sound will be conducted in close coordination with predator and juvenile salmon sampling. Time series of oceanographic parameters begun in 1990 during the CFOS program will be continued during the SEA program. These time series are the only ones of this resolution and duration for PWS.

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 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 in both the MS and HE/GOA regions, and will be deployed aboard a seining vessel. 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 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 will be approximately 2 nautical miles. Two ADCPs will be utilized, one aboard a vessel and one moored in the HE region.The moored deployment will begin in September 1994 and continue over the winter months to determine the flow field in response to intense atmospheric forcing, and the presence/absence of biological scattering layers. The period of deployment will be 4 to 6 months, after which the data will be retrieved and the instrument redeployed for a similar duration. 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 will be obtained in a nearly continuous fashion from the CFOS meteorological buoy moored within PWS. This buoy is also equipped with oceanographic sensors (fluorometer, thermistor chain). 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.

Vessels of opportunity will also be employed in obtaining large scale physical and biological oceanographic data in the SEA program. During FY 1994, a thermosalinograph was installed on the tanker T/V Keystone Tonsina as part of the SEA physical oceanography program. This vessel transits PWS and the Gulf of Alaska four times a year and will provide continuous measurements of temperature and salinity through these regions.

In addition to directly measured oceanographic and atmospheric variables, SEA physical oceanography will use prepared data products. In particular these will include satellite imagery (e.g. AVHRR, CZCS, and possibly SAR) when available, as well as 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).

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 1995 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.

Project Implementation
This PWS Science Center will be the lead organization in the implementation of this project. The Principal Investigator (D. Salmon) has extensive knowledge and experience in PWS, and proposed some of the ideas that have guided the development and implementation of the research program to date. In addition, Salmon has hired a very capable and motivated staff to undertake the 1994 program and carry it out into the future. State and federal agencies involved in the Trustee Council process do not have ongoing oceanographic programs of this nature in the region. The continuity and integrity of the program depend on successful implementation by the group that is presently involved, as well as highly qualified and motivated to perform the work to the high standards required to successfully undertake and complete the effort.

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 PI has contacted personnel with USFWS and NMFS in order to coordinate efforts undertaken in the NOAA forage fish study in PWS. In summary we will work with all personnel who have an interest in the oceanography of the region for use in their research, and to strengthen the interdisciplinary nature of the research proposed to be continued from the FY94 field season.

A cooperative investigation involving the chemistry of mussel tissue, seawater and sediments has been initiated during FFY94 by the Auke Bay Laboratory (NOAA) and the PWS Science Center. The investigation stems from NOAAs ongoing mussel watch program, but has been endorsed by the SEA program because the results of the mussel sampling program are pertinent to the hypotheses generated for the initial phase of SEA. It is envisioned that the mussel collection and interpretation can be broadened as part of the SEA field studies. At the very least, SEA investigators will provide support for data collection within the Sound during any periods when field sampling is underway. Support of future proposals involving the Auke Bay mussel sampling program is sought from the EVOS Trustee Council because the results of these studies are relevant to the ecosystem perspective that has been adopted for examining ecological problems within PWS and the EVOS impacted region.

PUBLIC PROCESS

Sound Ecosystem Assessment 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.

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
Assistant Director, Prince William Sound 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:
Spent nearly 60 days in the Sound during 1994 SEA field season, collecting physical and chemical data and assiting in the collection of biological sampoles of fish and zooplankton.
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 the 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.

Research Assistant:
James Murphy, Fisheries Oceanographer
Prince William Sound Science Center

Education:
B.S., 1988, Fish and Wildlife Management, South Dakota State University
M.S., 1994, Fisheries Science, University of Alaska, Fairbanks (chair: Dr. J. Collie)

Professional Experience:
5/94----- Fisheries Oceanographer, Prince William Sound Sci. Cen., Cordova, AK
8/93-12/93 Adjunct Faculty, University Alaska, Southeast, Juneau, AK
2/91-10/93 Fisheries Research Biologist, Auke Bay Laboratory (NMFS), Juneau, AK
5/90-8/90 Fisheries Biologist, AK Dept. Fish and Game, Delta Junction, AK
5/89-8/89 Fisheries Tech. III, AK Dept. Fish and Game, Juneau, AK
5/86-8/86 Fisheries Tech., SC Wildlife and Marine Res. Center, Charleston, SC

Selected Presentation:
Patterns in the Spatial Distribution of Salmon (Oncorhychus spp.) Captured in the Pacific Driftnet Fishery for Flying Squid (Ommastrephes bartrami), a Thesis Defense. Juneau Center for Fisheries and Ocean Sciences. January, 1994.

Salmon-Seamount Interactions in the North Pacific. Juneau Center for Fisheries and Ocean Sciences. September, 1992.

Salmonid Spatial Patterns Near the North Pacific Subarctic Frontal Zone. Annual Meeting of the American Fisheries Society, Alaska Chapter. November, 1991.

Publications:
Murphy, J.M. 1994. Patterns in the Spatial Distribution of Salmon (Oncorhychus spp.) Captured in the Pacific Driftnet Fishery for Flying Squid (Ommastrephes bartrami), a Masters Thesis. University of Alaska Fairbanks.

Ignell, S.I., and J.M. Murphy. 1993. Salmonid spatial patterns near the North Pacific Subarctic Frontal Zone. N. Pac. Com. 53II:253-271.

Ebberts, B.E., J.M. Murphy, S.I. Ignell. In Press. Physical Oceanographic Data Report of the R/V Acania in the Central North Pacific. INPFC Doc. xx-xx.

Research Assistant:
Shelton M. Gay III, Physical Oceanographer
Prince William Sound Science Center

Education:
B.S. 1976, Biology, Virginia Polytechnic Institute (VPI&SU).
Graduate Student, 1978-79, Wildlife Management and Forest ecology, West Virginia University.
M.S. 1984, Biology, Northern Arizona University.
Graduate Coursework, 1991 - 1993. Marine Biology, Physical Oceanography, University of Alaska, Fairbanks.

Professional Experience:
5/94 - present, Physical Oceanography, Prince William Sound Science Center
8/92 - 5/94, Physical Oceanography, Institute of Marine Science, University of Alaska , Fairbanks.
5/91 - 8/92, Marine Biology - Exxon Valdez Oil Spill Damage Assesment Project, Institute of Marine Science, University of Alaska, Fairbanks.
11/90 - 3/91, Science Technician, OSV Peter W. Anderson, (EPA Research Vessel), Physical/ Biological Oceanography of select locations from the Gulf of Mexico to the lower Hudson River.

Budget for SEA Physical Oceanography and Marine Meteorology Program FFY95

Personnel	$337.7K
Travel	$16.6K
Equipment	$245.4K
Commodities	$11.5K
Contractual	$76.3K
Total Direct Costs	$687.5K
Indirect Costs	$136.8K
Total Costs	$824.4K

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

Project ID number: 95320-N

Lead organization: Prince William Sound Science Center (PWSSC)

Cooperating agencies: University of Alaska Fairbanks (UAF)
Alaska Department of Fish and Game (ADF&G)
Prince William Sound Aquaculture Corporation (PWSAC)
Copper River Delta Institute, U.S. Forest Service (CRDI/USFS)
U.S. Fish and Wildlife Service (USF&WS)
National Biological Service (NBS)
Prince William Sound Oil Spill Recovery Institute (OSRI), National Oceanic & Atmospheric Administration (NOAA)

Cost of Project/FY 95: $ 1,192.4K
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Name of Project Leader: Dr. G.L. Thomas, Prince William Sound Science Center

INTRODUCTION

Sound Ecosystem Assessment - Nearshore Fish (SEA-FISH)

The central scientific goals of SEA-FISH are to:

(1) Increase understanding of the processes that determine the abundance of key animal populations in Prince William Sound (PWS), focusing initially on pink salmon and Pacific herring.

(2) Develop and apply new methods and technologies for evaluating life history parameters of key marine and occurring populations important to evaluating the productivity and ecological health of Prince William Sound.

(3) Improve the ability to predict how the abundance of key animal populations change.

The dynamics of ocean ecosystems is poorly understood (GLOBEC 1991a,b,c), which makes the prediction of changes in marine animal populations impractical (Cullen 1989). The dynamics in composition and production of the plankton/nekton assemblage that resides in Prince William Sound (PWS) is no exception despite intensive assessment after the EXXON VALDEZ oil spill.

Although there are some long term databases on the commercially harvested fish populations (ADF&G 1994) little is known about the abundance of sandlance, smelt, pollock, tomcod and other fishes that have been observed to be at high abundance in the past. 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, salps, jellyfish, squid and other marine invertebrates also have been observed at high abundance.

Since the growth and survival of a species are functions of physical conditions and prey, competitor, and predator abundance (SEAPLAN 1993), SEAFISH is cooperatively working with SEAOCEAN, SEAPLAN, and several other SEA programs to collect the necessary information to improve predictions of two selected species, pink salmon and herring. The SEAFISH measurement program has focused on the route and timing of juvenile pink salmon and herring migrations in the Sound to overcome the inherent problems with acquiring a representative sampling of the fish populations and their environment. Similar to GLOBEC (1991a,b,c), SEAFISH incorporates optical and acoustic technologies in a large-fine scale survey design to acquire the quasicontinuous data necessary for describing spatial and temporal characteristics of physical structure and biological patchiness. Acoustic and optical targets will be subsampled with a variety of nets and other seatruthing capabilities to collect biological information. The seatruthing is a principal task of other cooperating SEA projects, primarily those conducted by ADF&G (Mark Willette, personal communication).

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. Data from SEAFISH and SEAOCEAN will be assimilated into an ecosystem pathway model by the SEADATA project.

1. 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 proposals submitted by the PWS Science Center.

2. 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 concern flushing of prey from the Sound (the river-lake hypothesis) and 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 macrozooplankton 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, 18.6 years have a dominant influence on marine productivity and fish recruitment (Trenberth 1990; Royer 1989, 1993; Salmon 1992; Thomas and Mathisen 1993). Shifts in predator populations in response to climatic events have also been shown to have pronounced impacts on key marine fish populations. 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.

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 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 manipulation 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 approaches that will be taken with both pink salmon and Pacific herring.

SEA's conceptual framework is similar to GLOBEC (1991c), a National Science Foundation sponsored program titled Global Ocean Ecosystems Dynamics. 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:

$$dN/dt = Birth - Death - Immigration + Emigration$$

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, physiology of the fish, and physical-chemical structure of environment.

- *Immigration* is the transport (advection) or straying (diffusion) of fish 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 physiological/behavioral conditions affect each variable and their subvariables in time and space. The importance of trophic state is not emphasized above, but can dominate *dN/dt*. To understand the local rate of change in any pelagic population one must reliably quantify these processes in the context of trophic state. SEA plans to improve predictions of pink salmon and herring abundance by assimilating the data acquired on large and fine scale surveys with technologies into numerical models.

METHODS

1. 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 and development of new hardware and software.

The SEA field program will utilize the conceptual experimental design of GLOBEC (1991c), which involves nesting 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. 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.

2. 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.

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 (4) remote sensing with acoustical and optical technologies. SEAFISH will rely heavily on the knowledge and skills of commercial fishers to prestratify surveys to areas preferred by the fishes, and for the capture of 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 high frequency, scientific echosounders (HFSE) and an optical plankton counter (OPC). Initially, the program will use 120 and 420 kHz for macrozooplankton assessment, then add 720 kHz and 1 mgHz as they become available. Initially, BioSonics ESP software will be used to integrate the acoustic backscatter and determine target strengths. Ultimately, new code will be developed with the use of the multibeam digital sonars. Interactive Data Language (IDL) and Advanced Visual Systems (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.

Objective 2 - nekton

Large scale measurements of fish distributions will be made using 38, 70 and 120 kHz BioSonics digital dual/split beam echosounders. Initially, the program will use a 120 kHz dual beam, and shift to 38 and 70 kHz digital dual/split beam systems as they become available. The BioSonics ESP and IDL code 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. The sonars will be deployed from surface vessels in the western Sound for salmon work and throughout the Sound for herring. High resolution video, panchromatic, compact airborne, spectrographic, imager and or other aerial optical techniques will be used to map Sound wide concentrations of nearshore fishes. These surveys will help stratify fine scale survey efforts for nearshore herring 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. 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.

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 integration of the data is budgeted under the SEADATA project. 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 (GIS) 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 with standard techniques. Acoustic, physical, ground truth, and seasonal measurements will be used to develop discriminate functions for patch identification. 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 nowcasting and short term forecasting. Sensitivity and risk analysis approaches will be used to prioritize tasks, such as choice of sampling protocols to resolve biological and physical questions.

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