Archival Tags for Tracking King Salmon at Sea Reveal Migrations, Biology, and Oceanographic Preferences in Prince William Sound

Project Number:	~~new proposal~~ 01404
Restoration Category:	Research
Principal Investigator:	Dr. Jennifer L. Nielsen Alaska Biological Science Center USGS-Biological Resources Division 1011 E. Tudor Rd. Anchorage, Alaska 99503
Lead Trustee Agency:	DOI-USGS
Cooperating Agencies:	na
Alaska Sea Life Center:	Yes
Project Duration:	1st year, 2-year project
Cost FY 01:	$136,500
Cost FY 02:	$ 61,300
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	King salmon

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ABSTRACT

Archive tags with temperature and light-geolocation sensors will be monitored for post-smolt king salmon (*Oncorhynchus tshawytscha*) in Prince William Sound. Light/location relationships specific to the Gulf of Alaska developed under EVOS study #00478 (FY00) will be applied in this study of movement and migration paths for king salmon during maturation in ocean environments in Prince William Sound. Archival tags can provide estimates of geolocation, vertical movements, and ambient and internal temperatures for individual fish for long periods of time (up to three years). Recent tag developments allow the application of internal archive tags in smaller fish making this technology appropriate for the study of post-smolt salmonids in marine environments where tag recoveries can be obtained from sport fishery, commercial harvest, and/or captures of tagged fish in spawning migrations. The opportunity to test the development and application of this tag technology for the first time in king salmon is available in collaboration with a new Alaska Department of Fish and Game chinook hatchery on Ester Island, Prince William Sound. Tagging chinook reared in the hatchery environment to the required size (~30 cm) will allow us to test efficiency and accuracy of this technology in the study ocean use and movement patterns for king salmon throughout the Gulf of Alaska. Archive tagged fish will be used to document king salmon use of marine habitats, maturation routes, contribution to the sport fishery, and hatchery/wild interactions for chinook in Prince William Sound. Information on temperature and light from archive tags can be integrated with tidal stream data, glacier discharge, hydrographic records, and sea surface satellite imagery to help track salmon distribution and migration routes throughout Prince William Sound. Our understanding of marine habitat use, feeding patterns, coastal and deepwater migrations, and maturation rates will greatly enhance EVOS recovery efforts and planning in future conservation efforts. Recovery of tags in a growing sport fishery out of Wittier and at the hatchery release site will facilitate collecting tags from different life history stages of chinook salmon within Prince

INTRODUCTION

Our previous EVOS study (#00478) tested light-based geoposition estimates for archive tags in the Gulf of Alaska. Part of this study will continue these efforts to gain accuracy of geoposition estimates on the local scale within the Gulf of Alaska and to monitor local geography, climatic, and water quality conditions leading to errors in these estimates. To that end we will complete one year's collection of *in situ* data from tag arrays mounted on a stationary buoy at the entrance of Resurrection Bay (2001) and develop a new stationary array under this study at a different latitude in Prince William Sound (2002). Analytical analyses of light-based data for geoposition estimates will be honed and adjusted based on comparisons made between the two latitudes and between years. Tags recovered from salmonids with different ocean movement patterns will allow us to develop accurate correction factors to adjust for light attenuation at depth and special conditions for Prince William Sound.

The application of archive tag technology in ocean-going fish species has been underway for several years and is an effective tool for estimates of open-ocean migration pathways and to ascertain basin-scale movements along parts of the continental shelf (Welch and Eveson 1999; R. W. Brill, personal communications). Recent developments in the architecture and size of these tags have made them appropriate for use in maturing salmon such as steelhead, sea trout, Atlantic salmon, and Arctic charr (Welch and Eveson 1999; M.A. Svenning, and F. A. Voegeli pers. comm.) Life history investigations of oceanic behavior by salmonids will be greatly enhanced by using archive tags to trace migratory patterns of individual fish during their development at sea. Crepuscular diving behavior has been demonstrated in many pelagic marine species using archive tags, but the mechanisms driving this behavior remain unknown, i.e. reaction to light scatter at dawn and dusk and/or a search for uniquely available prey items at depth during these intervals (B. Block et al. 1998; Lutcavage et al. 1999). It is interesting that this behavior has been documented in both the Atlantic and Pacific Oceans for multiple species, including Atlantic salmon (J. Sturlaugsson, pers. comm.) It is unknown if Pacific salmon in open seawater exhibit this behavior, and if they do how they react to long crepuscular conditions in the Gulf of Alaska.

King salmon (*Oncorhynchus tshawytscha*) from the Copper River support significant commercial, sport and subsistence fisheries in the Gulf of Alaska. The distribution of chinook post-smolts and sub-adults from the Copper River throughout saltwater habitats in the Gulf of Alaska is unknown. The development of new tagging technologies can be used to document the distribution and migration patterns of important salmonid populations in saltwater habitats. The development of effective application and protocols for these technologies under local conditions, however, require initial studies in non-critical populations. Alaska Department of Fish and Game (ADFG) assumes no natural production of chinook within Prince William Sound. A new hatchery program is being developed by ADFG for the release for king salmon into Prince William Sound where a dramatic increase in sport fishery is anticipated as a result of the new road opening auto traffic to Wittier (L. Peltz, ADFG, pers. comm.) We propose to use this chinook stock for initial tagging studies using archive tags. We will be able to raise hatchery salmon post-smolts in captivity to the threshold size (~30 cm) necessary for successful surgically application of archive tag recorders. This study will monitor initial movements away from the release location, migrations between near-shore and open ocean habitats, and critical marine habitats for hatchery king salmon from post-smolt to maturation (1-2 years).

Finding where and when king salmon go at sea and their temporal and spatial use of specific marine locations critical to oil spill management and recovery are important steps to identifying factors potentially contributing to survival and fitness under different environmental conditions. Data developed from archive tags on hatchery chinook will provide inference on hatchery vs. wild fish interactions, "hot-spots" of chinook production within Prince William Sound, migration paths and critical ocean habitat, and spawning fidelity of hatchery fish within the basin. All of these data will set baseline structure and sampling protocols for future implementation of archive tags on wild salmonid stocks within the Gulf of Alaska, including potential studies of endemic cutthroat trout (*O. clarki clarki*), Dolly Varden (*Salvelinus malma*), and Cooper River chinook and coho (*O. kisutch*) salmon. Our studies of these hatchery stocks will provide valuable information to ADFG on the management and stability of hatchery production in this area and its contribution to the local fishery.

The definition of "critical habitat" in the marine environment for anadromous and pelagic fishes is essential to the development of reserves or protected areas (Anonymous, NOAA, 1999). In Alaska, the relationship of aquatic protected areas to subsistence, commercial, or sport fisheries is a critical factor in considerations of design and implementation of reserves. Resource protection and strategic use are not incompatible concepts when a sound foundation of scientific knowledge on the distribution and abundance of key species is incorporated into reserve planning and resource use, and if local community-based natural resource management is included in the analyses of such data (Getz et al. 1999). This proposal continues to test the application and deployment of a new technology, archive tags, in investigations into the temporal and spatial distribution of key anadromous and marine fish species in the Gulf of Alaska. Many aquatic species that fall under the jurisdiction of the Trustee Council in their efforts to restore the resources and services injured by the spill may benefit from the development and local adaptation of this technology. Monitoring of critical habitat use by Gulf of Alaska fish species will allow the organisms to speak directly to the managers of the resource during the development, implementation and applications of recovery or enhancement activities.

For many commercially important anadromous and marine fish species ocean-use and critical habitat remain uninvestigated with little or no scientific evidence to support distribution on temporal or spatial scales. The use of radio telemetry and satellite-linked tracking for studying fishes has experienced a recent exponential growth in the development of technologies and applications (Lucas et al. 1993; Eiler 1995; Sibert 2000). In addition to critical habitat designation, physiological telemetry can now be used to monitor energy expenditure, life history migrations, stage of life cycle, and environmental conditions critical to improving and validating habitat-use models for pelagic fishes (B. Block et al. 1998). Archival technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found in the Gulf of Alaska. The critical advantage to this new technology is that it allows documentation of habitat use that is independent of harvest or fishing effort. Conventional identification tags have been used on fish since the early 1900s. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration in salt water. In the late 1980's the first generation of archive tags was developed and deployed on marine fish.

Recovery rates for archive tags in the open ocean are typically low (~30%). It is unclear, however, if these poor recoveries are due to differences in survivorship of the fish, differences in tagging technique, tags location, or tag failure. In studies with an active fishery and where fish carrying carry an external identification tag can be collected at terminal spawning locations, archive tag recoveries can be quite successful (60-80%, D. Welch, pers. comm.) Testing tag recovery rates and efficiencies in a hatchery stock released into Prince William Sound provides the best possible conditions for initial archive tag studies using this technology in the Gulf of Alaska.

Data archived by these tags include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude (geoposition) for tag location at any given time from light intensity, temperature, and accurate temporal measurements of dawn and dusk (Hill 1994). The longitude determination is equally accurate throughout the year and at all locations except those where no dawn and dusk events are recorded. Latitude determinations are most accurate at the solstices and useless at the equinoxes. This is clearly a problem in Alaska waters where long crepuscular periods (winter) are followed by intense solar periods (summer). The accuracy of light-level measurements, duration of crepuscular events, atmospheric aberrations, and individual fish behavior can all impact the accuracy of geoposition estimates. A current error rate of 50-60 miles is not uncommon in the analyses of these data from temperate waters. We expect a much lower error rate in Alaskan waters based on current studies of light sensors and data analyses adapted to local light conditions (EVOS #00478).

Data from archive tags can be made available at the time of recovery to any user group after developed algorithms translate sequence data stored on tags into temperature, pressure, and light information. Successful integration of archive tag data into the EVOS Trustee Council's Gulf Ecosystem Monitoring (GEM) program will allow the development of a unique and continuous information base on natural use of critical marine habitat by king salmon caught in the Whittier sport fishery and during spawning migrations. These data will allow estimates of ocean use, migrations, development rates, and movement of hatchery fish into natural salt and freshwater habitats in Prince William Sound. This proposal suggests that data collected from archive tags deployed in the Gulf of Alaska be made available to local communities and interest groups through internet web links with a USGS/BRD web site dedicated to this study. This proposal is intended to test the accuracy and efficiency of archive tags for estimates of geoposition and ocean use by king salmon in the Gulf of Alaska. If successful these data can provide an effective database for sampling protocols and analyses of critical habitat use by post-smolt and maturing wild king salmon in Alaska waters.

Additional research on cost-effective tagging regimes for this area need to follow our development of efficient light-based geoposition estimates using archive tags. These analyses will investigate species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology on tag recovery and data collection, and the effects of fish mortality and tag mortality on the interpretation of results. These objectives will require integration of satellite tag data with other significant geological, oceanographic, and climatic databases for this area. Alaska Department of Fish and Game will benefit from this study by an analysis of hatchery fish adaptation to and use of critical marine habitats in Prince William Sound. These data will allow interpretation of hatchery fish interactions with local fish stocks (both predators and prey) and other aquatic resources such as

marine mammals at different locations or habitats. These data will provide information important to the development of hatchery supplementation programs and conservation strategies in this area.

This proposal requests funding to undertake archive telemetry studies on Prince William Sound king salmon incorporating four program elements:

1) Initiate an *in situ* array of archive tags on a stationary buoy in Prince William Sound and monitor light data reflecting natural solar conditions at various depths for one year. These data will be incorporated with light sensor information developed in Resurrection Bay (EVOS#00478) to provide data from two latitudes for different years. These data will serve as the baseline data against which we will develop geoposition algorithms specific to local conditions in the Gulf of Alaska.
2) Rear chinook salmon at ADFG's hatchery facilities until they reach critical size for surgical implants of archive tags (~30 cm). Implant tags in 40 king salmon before live release at ADFG's Ester Island facility on Prince William Sound. Since king salmon typically spend 1-2 years at sea and have a three year life cycle, recoveries from the sport fishery and in spawning habitats will be monitored in 2001 and 2002, with a final report submitted by April 15, 2003.
3) Monitor tag recoveries in the fishery, at the hatchery release site, and adjacent streams. Analyze data on individual fish behavior for two years post-release using geoposition estimates developed specifically for Gulf of Alaska.
4) Plot estimates of geoposition, movement, critical habitat use, and maturation cycles from archive tags collected from king salmon in Prince William Sound. Draw inference from these data for chinook use of ocean conditions, migration paths, stray rates, and critical habitat needs for king salmon in Prince William Sound. These data will be incorporated into the GEM database and provide information on sport fishery effects in marine systems, hatchery enhancement effects on other marine organisms, and critical marine habitat needs of chinook salmon in the Gulf of Alaska.

NEED FOR THE PROJECT

A. Statement of Problem

Knowledge of the marine distribution of individual fish over time and space within the Gulf of Alaska ecosystem is needed to make sound management decisions for recovery, management of the resource, and for the development of reserves and/or protected areas in marine ecosystems. Without sound scientific support, recovery and conservation activities in marine systems will remain controversial among diverse user groups, especially in species governed by such diverse interests as chinook salmon. Including local community based information in the deployment and recovery of these scientific data will be an effective tool in resource management. Documentation of individual fish behavior in economically and ecologically important species within the Gulf of Alaska will aid in the development of a common-ground database on fish

distributions over time and space during the development and implementation of management units within the marine systems where frequent conflict-of-interest problems are expected to arise.

The marine environment imposes severe constraints on the type of tags that can be used to monitor the behavior of fish in their natural environment. Seawater is highly conductive and radio waves do not propagate well in this medium. Recently marine biologists have developed new technologies in an effort to address this problem. Archive tags are internally positioned in the fish's abdomen with light and temperature sensors extending outside the fish on a thin antenna. Sensors are programmed to collect data at set intervals for up to three years. To date this technology has been applied to many important marine species including cod and anadromous salmonids (primarily in Atlantic waters) and in Canadian steelhead populations (D. Welch, pers. comm.) The developmental approach used in the acquisition and analyses of light data generated by archive tags is the same as that used for pop-up tags (EVOS #00478) with the same need for adaptation to local climatic and solar conditions.

Additional research needs to be undertaken on cost-effective and efficient tagging regimes for this new technology, especially in salmon species. The implications of the successful application of archive tags in salmon for documentation of ocean use are enormous. Documentation of changes in salmonid ocean migrations, marine habitat use, and their reaction to critical production variables in the marine environment are necessary for our understanding of salmonid response to decadal shifts in ocean conditions and larger climatic cycles of ocean productivity. This study would facilitate investigations of species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology and local climate on light data, recovery probability for different terminal captures and tag types (i.e. sport fishery and weirs with archive tags vs. satellite pop-up tags), and the effects of fish mortality and tag mortality on the interpretation of results. We will also develop a platform for data exchange, crossover studies, and data archive capacity for ecosystem scale marine habitat analyses in the Gulf of Alaska. This latter objective will require integration of archive tag data with other significant geological, oceanographic, and climatic databases for this area

Potential future applications directed at discovery and monitoring of ocean habitat use by king salmon are broad. A clear understanding of marine life history and ocean forage migrations in salmonids will only become available with the development and appropriate application of this technology. Understanding temporal and spatial use of marine habitats by critical marine species will contribute significant information to fisheries resource management decisions in the Gulf of Alaska.

B. Rationale/Link to Restoration

Information collected during this study will contribute to our ability to use new technology to assess recovery and impediments to recovery (critical habitat) for an economically and ecologically important fish species found in Prince William Sound and the Gulf of Alaska, king salmon. The proposed work represents an initial scientific approach to increase our technological capacity to investigate the factors that affect population dynamics on multiple temporal and spatial scales. If successful, this technology will help in the definition of critical habitat for proposed marine reserves in the Gulf of Alaska. Without an understanding of the

general underlying patterns of habitat use that dictate population change and species interaction within marine units or areas, we can not prescribe or limit specific activities within the reserve based on species distribution. Analysis of critical habitat use, hatchery/wild interactions, and interspecific competition for different life history stages of key species will allow integration of sustainable use or limited harvest in the conservation and management of these species within critical marine areas sensitive to anthropomorphic changes over time. The development of archive tag technology offers a promising window on this type of information.

Archival tag technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found in the Gulf of Alaska. The critical advantage to this new technology is that it allows documentation of habitat use based on actual fish movement and behavior in areas and at times where human observations are impossible. Conventional identification tags have been used since the early 1900s, but individuals must be recaptured before information is obtained. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration. In 1996 the first generation of archive satellite "pop-up" tags were developed and deployed on pelagic fish, but these tags are currently limited to very large fish (~70 lbs). Implant archive tags allow recovery of data from much smaller individuals including salmon post-smolts. The data archived by these tags can include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude and longitude for tag location at any given time from changes in light intensity (see proposal #00478). Approaches developed from studies of satellite pop-up tags in the previous proposal are transferable to analyses of data collected from implant archive tags in salmon post-smolts and young adults from the Gulf of Alaska.

C. Location

Data to be compiled will come from tags deployed in Prince William Sound. Initial physiological data concerning tagging effects and efficiencies of light intensity data will be assessed using a limited number of fish in captivity at ADFG hatchery facilities. Tagging of 40 post-smolts with archive tags will take place in collaboration with ADFG and the local sport fishing community. Tag array disposition on a stationary buoy in the Prince William Sound will parallel our previous efforts in Resurrection Bay (proposal #00478). Tag recoveries will employ local sport fishers (yr 1 & 2), collection of spawning adults at the release site (yr 1 & 2), and incidental recoveries in other sport, commercial and research fisheries in and around Prince William Sound.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All efforts will be made throughout the project to incorporate participation in and provide local involvement in the implementation and development of this project in relation to target populations and tagging localities. Project staff will be available to present information to local communities, internet access to real-time data from satellite tags will be made available at the local level as it becomes available to the PI. All articles, video, or photographs of the tagging study will be made available to the Trustee Council. The nature of the tagging study and the

charismatic character of the fish subject make this a potentially high profile public relations project for the recovery and Trustee Council.

PROJECT DESIGN

A. Objectives

1) Initiate an *in situ* array of archive tags on a stationary buoy in Prince William Sound and monitor light-data reflecting natural solar conditions at various depths in this area.
   A. These data will be incorporated with light sensor information developed in Resurrection Bay (EVOS#00478) to provide data from two latitudes over two years. These data will serve as the baseline data against which we will develop geoposition algorithms specific to local conditions in the Gulf of Alaska.

2) Rear chinook salmon at ADFG's hatchery facilities until they reach critical size for surgical implants of archive tags (~30 cm).

   A. Cooperation and contribution of resources by ADFG has been promised by Larry peltz, Hatchery Manager ADFG. The hatchery stock used in this program is the same Willow Creek stock used for release by ADFG in Resurrection Bay.

3) Implant tags in 40 king salmon followed by live release at ADFG's Ester Island facility on Prince William Sound.

4) Monitor tag recoveries in the sport fishery and at the hatchery release site and analyze data on individual fish behavior for two years post-release using geoposition estimates developed specifically for Gulf of Alaska and Prince William Sound.

5) Plot estimates of geoposition, movement, critical habitat use, and maturation cycles from archive tags collected from Prince William Sound king salmon.

   A. Draw inference from these data for chinook use of ocean conditions, migration paths, stray rates, and critical habitat needs for king salmon in Prince William Sound. These data will be incorporated into the GEM database and provide information on sport fishery effects in marine systems, hatchery enhancement effects on other marine organisms, and critical marine habitat needs of chinook salmon in the Gulf of Alaska.

B. Methods

A total of 120 archive tags will be deployed under various conditions to gather and analyze data on estimates of geolocation for free ranging king salmon in the Gulf of Alaska. The PI will monitor surgical tag implantation effects on a test population (N=20) with at least two veterinary scientists. Tests will include anesthetic effects, physiological stress during and after tagging, and stability of implantation over time.

Several features of the archive tags will be tested from an array of tags deployed from a stationary buoy located in Prince William Sound. This tag array will be used to test efficiency of light sensors at different latitudes within the Gulf of Alaska, temperature cycles at depth, stability of pressure sensors at depth, and effective recovery of data over time. Estimates of actual fish location will be obtained from data collected from fish captured in the fishery and recovered at the site of release. These data will then be compared and analyzed for rigor of geoposition estimates based of our findings from previous captivity light studies and the stationary tag array in the Gulf of Alaska.

Conversion of archive data to position and movement cycles for individual fish will be made using adaptations of existing conversion algorithms available from the vendor and our initial field trials of tags in the Gulf of Alaska. New approaches to estimating geoposition from light data using time series analyses will be used in this study (R. Hill, Wildlife Computers, pers. comm.) Data for location and position for individual tags collected in the wild will be plotted on digitized maps of the Gulf of Alaska (two dimensional) incorporating any bathymetric data (three dimensional) available for this area using standard telemetry and GIS mapping methods (Baltz 1990; Cressie 1991; Thompson et al. 1992).

This study will continue the development and implementation of the internet link to Gulf of Alaska tagging studies and results will run parallel to the ongoing field studies and tagging data development. The web site will be posted on the USGS/BRD Alaska Biological Science Center's home page.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal relies on a number of significant research collaborators including ADFG's Larry Peltz and Bob Clark. Many unnamed collaborations will develop during the implementation of this project (i.e. commercial or sport boat captains, fishing volunteers, and community internet links). Known collaborators include: Dan Mulcahy, DVM, USGS/BRD fish and wildlife veterinarian; Riley Wilson, DVM Anchorage Zoo; Roger Hill, Wildlife Computers; Dr. Paul Howey, Microwave Telemetry, Inc. Lee Hulbert of the National Marine Fisheries has volunteered collaboration on the analysis of light data collected from their shark pop-up tag study. All technical and clerical staff will be employees of USDGS/BRD Alaska Biological Science Center or qualified individuals contracted directly for this project.

SCHEDULE

A. Measurable Project Tasks for 2000 - 2003

Funding 2001 (EVOS)

Oct. 00 – Mar. 01: Purchase of archive tags, dummy tags and tags for buoy array. Establish holding facilities for king salmon from FY00 broodstock from Willow Creek for use in implant studies (site determined by ADFG).

April 2001 Control tests for surgical implants with dummy tags for estimates of

survival and delayed mortality in king salmon.

May – June:	Surgical implants of archive tags in release groups and release of fish into Prince William Sound.
June - July:	Deploy light sensor tag array on stationary buoy in Prince William Sound.
May – Nov.	Monitor tag recoveries from sport fishery out of Wittier (implement reward program) and from streams near release site for possible early returns of spawning fish (jacks) with tags in natural stream environments.
Sept. - Dec.:	Collect and analyze first data sets from sport fishery. Develop Web Page for study results and plot initial data. Consult on tagging applications and data interpretation. Develop oceanic temperature and bathymetry database for Prince William Sound.
Dec. 01 – Jan. 02:	Prepare initial data presentation and attend restoration meeting.

Funding 2002 (EVOS)

Jan. – Apr.:	Compile data and write annul reports from first year's results.
April 15:	Annual report due to EVOS.
May – Oct.	Monitor tag recoveries from sport fishery out of Wittier (reward program)
June - July:	Recover light sensor tag array on stationary buoy.
Aug. - Nov.:	Collect tags from king salmon spawning recoveries in streams in vicinity of release site using nets, hook-and-line, and carcass recoveries.
Nov. – Dec.	Analyze final data sets from sport fishery, spawning recoveries, and second buoy array.
Dec. 02 – Jan. 03:	Integrate light data sets from all recoveries and plot fish movements over time using geolocation estimates.

Funding 2003 (USGS/BRD)

Jan. 2003:	Prepare final data presentation and attend restoration meeting.
Feb – Apr. 2003:	Integrate analyses from parallel studies of pop-up tags in Gulf of Alaska.
April 15:	Submit final report to EVOS on study results.

B. Project Milestones and Endpoints

All EVOS costs for this project will be billed in 2001-02, with primary tagging costs in 2001.

Due to timing of salmonid life cycle (up to two years at sea) data analyses will continue into FY2003.

Project will be completed upon submission of the final report prior to April 15, 2003.

C. Completion Date

All project objectives billed to EVOS will be met before the end of Sept. 2002.

PUBLICATIONS AND REPORTS

Preliminary report submitted to EVOS April 15, 2002. A final report of activities will be submitted to the Restoration Office on or before 15 April 2003.

Manuscript containing final results and recommendations will be submitted to a peer-reviewed scientific journal for publication in FY03.

Website development and maintenance of our tagging database will be available FY00-03. At the end of the project we will transfer the internet site to a webmaster designated by the Trustee Council.

PROFESSIONAL CONFERENCES

International workshop on tracking salmon at sea FY01 (British Columbia, CA)
Fourth Conference on Fish Telemetry - June 2001 (Trondheim, Norway)
American Fisheries Society - Aug 2001 (Phoenix, AZ)

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research provides fundamental information needed for the implementation and development a new technology dedicated to the identification of critical marine reserve areas in Prince William Sound and the Gulf of Alaska. The definition of critical marine habitat for economically

and ecologically important fish species will serve as a cornerstone for future Trustee sponsored conservation and use management proposals under the GEM program. The major objectives of this work require interaction with several other investigators and integration of all available data that are relevant to the question of critical marine habitat in the Gulf of Alaska.

PRINCIPAL INVESTIGATOR

Dr. Jennifer L. Nielsen
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3670
FAX: (907) 786-3636
jennifer_nielsen@usgs.gov

PERSONNEL QUALIFICATIONS

Jennifer Nielsen is Fisheries Supervisor and Research Biologist (GS14) with the Alaska Biological Science Center, USGS Biological Resources Division. She has conducted salmonid and fisheries research throughout the western Pacific for the past 22 years. Dr. Nielsen is an Associate Professor at the University of Alaska, Fairbanks in the School of Fisheries and Ocean Sciences. From 1995 - 1999 she was a visiting scientist at Hopkins Marine Station, Stanford University, where the first experiments on satellite pop-up tags were conducted on blue fin tuna. From 1995 - 1999, she was an Adjunct Professor in Ichthyology and Fisheries at the University of California, Berkeley and Moss Landing Marine Laboratory, and served on the Scientific Review Board for the Monterey Bay Aquarium. Dr. Nielsen has published over 30 peer-reviewed journal publications and book chapters, numerous technical reports, and gives frequent national and international presentations at scientific meetings addressing research issues in fish conservation, behavior, evolution, and genetics. Her work on salmonid fishes is recognized internationally for its contribution and focus in fisheries conservation and management.

KEY COOPERATORS

Larry Peltz
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, AK 99518
267-2157

Dr. Dan Mulcahy, DVM
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, AK 99503
(907) 786-3451

Dr. Dave Douglas
Alaska Biological Science Center
1011 East Tudor Road

Anchorage, AK 99503
(907) 786-3473

Dr. Roger D. Hill
Wildlife Computers
16150 NE 85th St. #226
Redmond, WA 98052
(425) 881-3048
tags@wildlifecomputers.com

Dr. Keith Stoodley
LOTEK Marine Technologies Inc.
114 Cabot St.
St. John's NF
Canada A1C 1Z8
kstoodley@lotek.com

Leland B. Hulbert
NMFS, Auke Bay Laboratory
Juneau, AK
(907) 786-6056

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Actual FY 2000	Proposed FY 2001
Personnel		$56.7
Travel		$7.4
Contractual		$5.2
Commodities		$0.9
Equipment		$57.4
Subtotal		$127.6
General Administration		$8.9
Project Total		$136.5
Full-time Equivalents (FTE)		2.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS	
Estimated FY 2002	Estimated FY 2003
$61.3	$0.0

Dollar amounts are shown in thousands of dollars.

USGS/BRD will provide salary for PI,staff veterinarian and systems scientist throughout the study and support all activities for completion of project in FY03.

FY01

Prepared:4/5/00

Project Number: ~~new proposal~~ 01404
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs*:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
J. Nielsen*	Fisheries Supervisor	GS14/01	3.0	7.2		0.0
TBA	Fisheries Project Leader	GS9/01	12.0	3.1		37.1
D. Mulcahy*	Fish/Wild. Veterinarian	GS13/05	0.5	6.8		0.0
D.Douglas*	Fish/Wild Scientists	GS12/05	0.5	6.0		0.0
TBA	Field technician	GS7/01	4.0	2.7		10.8
TBA	Field technician	GS5/01	4.0	2.2		8.8
						0.0
						0.0
*all personnel costs will be covered by USGS/BRD						0.0
						0.0
						0.0
	Subtotal		24.0	28.0	0.0	
					Personnel Total	$56.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Anchorage-Whittier for sampling	240.0	4	40	160.0	7.40
PI & veterinarian travel at USGS/BRD costs					0.00
					0.00
					0.00
					0.00
					0.00
					0.00
					0.00
					0.00
					0.00
				Travel Total	7.40

FY01

Prepared:4/5/00

Project Number: new proposal
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:		Proposed
Description		FY 2000
Tag data consultation and data recovery fees		1.2
Research vessel lease (private) - 4 days		4.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$5.2

Commodities Costs:		Proposed
Description		FY 2000
Materials and supplies - misc.		0.9
	Commodities Total	$0.9

FY01

Prepared: 4/5/00

Project Number: new peoposal
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS

FORM 3B
Contractual &
Commodities
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2000
Archive tags (light/temp) (40 @ 1300 ea.)	40	1.3	52.0
Dummy tags (20 @ 120 ea.)	20	0.1	2.4
Buoy array tags (6 @ 500 ea)	6	0.5	3.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$57.4

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

EXXON VALDEZ OIL SPILL DETAILED PROJECT DESCRIPTION

Project Title: Harlequin duck population dynamics

Project Number:	01407
Restoration Category:	Monitoring
Proposer:	Alaska Department of Fish and Game
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	USFWS, USGS-BRD
Alaska SeaLife Center:	No
Duration:	3 years
Cost FY01:	$79,400
Cost FY02:	$75,000
Cost FY03:	$75,000
Geographic Area:	Prince William Sound
Injured Resource:	Harlequin ducks

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EXXON VALDEZ TRUSTEE COUNCIL

ABSTRACT

Harlequin duck (*Histrionicus histrionicus*) populations in Prince William Sound (PWS) have not recovered from the effects of the *Exxon Valdez* Oil Spill. Populations are declining in oiled areas while increasing in unoiled areas. Proposed late-winter boat surveys have been designed to assess the recovery of ducks inhabiting oiled areas. Population structure, abundance, and recruitment will be compared between oiled and unoiled areas in PWS to assess trends, population dynamics, and the progress of recovery. As part of the Gulf Ecosystem Monitoring program this survey will help identify changes to the Gulf of Alaska ecosystem and improve our ability to differentiate between natural and man-caused population changes. This will be the second year of this project.

INTRODUCTION

Harlequin duck (*Histrionicus histrionicus*) populations in Prince William Sound (PWS) have not recovered from the effects of the *Exxon Valdez* Oil Spill. Populations are declining in oiled areas while increasing in unoiled areas (Rosenberg and Petrula 1998). This lack of recovery may be a result of continued oil exposure. Ducks in oiled areas exhibit elevated levels of cytochrome P450 induction, indicating continued oil exposure and adult female winter survival was lower on oiled than unoiled areas (Holland -Bartels et al. 1999). These two studies provide strong evidence that harlequin ducks have not recovered from the effects of the *Exxon Valdez* oil spill (*Exxon Valdez* Oil Spill Trustee Council 1999).

Harlequin ducks occur year-round in intertidal zones of PWS (Isleib and Kessel 1973). At least 1,298 harlequin ducks were estimated to have died as a direct result of oil exposure following the Exxon Valdez oil spill (J. Piatt pers. comm.). Oil spill studies of harlequin ducks in western Prince William Sound (PWS) from 1990-93 found consistently low numbers of birds during the breeding season, little breeding, low productivity, and an apparent decline in post-breeding molting birds (Patten et al. 1998a, Patten et al. 1998b). In 1995, six years after the Exxon Valdez oil spill there was no sign of recovery (Exxon Valdez Oil Spill Trustee Council 1996).

As a result of the 1990-1993 findings and the lack of recovery, ADF&G initiated population monitoring in 1994 (Rosenberg and Petrula 1998). These studies, conducted from 1994 through 1997, found no difference in population structure between oiled and unoiled areas; no brood production in the spill area; and a decline in molting populations. Similar population structures, a positive finding, indicated that the population was in a position to recover. However, the declining trend in numbers during autumn surveys for the oiled areas of western PWS remained a concern, especially since populations in unoiled eastern PWS increased. This indicated that recovery has not occurred.

Other studies have collaborated our findings. Winter survival of adult female harlequin ducks was lower on oiled areas than unoiled areas in PWS (Holland-Bartels et al. 1999). Modeling efforts based on this data predicted a declining population in the oiled area and a stable population in the unoiled area. Lower survival rates may be related to continued oil exposure (Holland-Bartels et al. 1999). Results of USFWS marine bird surveys were more ambiguous. These surveys show no evidence of population recovery based on summer surveys. However their March surveys show an increase in densities in both oiled and unoiled areas, although the comparative increase between the oiled and unoiled area does not meet their criteria for recovery (Lance et al. 1999).

Sea duck populations, in general, are composed of relatively long-lived birds with delayed sexual maturity. Productivity may be limited to a few favorable years and population levels may change slowly. Long-term population stability depends on high adult survival coupled with a few years of successful reproduction. Initial high losses of adults, especially females, may result in a long and slow recovery period, especially if initial causes of mortality are still influential.

We propose to continue our winter survey that is comparing population trends and structure in the same oiled and unoiled areas surveyed in project \427 (Rosenberg and Petrula 1998) and

expanded in this project. By expanding geographic coverage we will improve our ability to compare regional differences in population trends within oiled and unoiled areas, increase statistical power, and detect long-term changes in the marine ecosystem.

Harlequin ducks occur year-round in the nearshore environment, feed on benthic invertebrates, exhibit site-fidelity, are relatively long-lived, and are widely dispersed in the Gulf of Alaska. These characteristics make them unique among nearshore avian predators and ideal candidates for monitoring ecosystem change.

With modifications, this is a continuation of Project /427 Harlequin Duck Recovery Monitoring conducted from 1995-1997. A March survey was conducted in 1997. No fieldwork was conducted on project /427 in FY98 or FY99. This project will continue to monitor harlequin duck populations in oiled and unoiled areas of PWS. Surveys will be conducted in March. March is a period when pair bonds are well formed, and there is relative stability in both numbers and movements of harlequin ducks.

NEED FOR THE PROJECT

A. Statement of Problem

Harlequin ducks have not recovered from the effects of the *Exxon Valdez* oil spill. Populations in oiled areas are continuing to decline (Rosenberg and Petrula 1998). Declining molting populations, coupled with low female survival, and exposure to hydrocarbons in oiled areas are all indicative of a lack of recovery and continued oil spill effects. Residual oil is still present in the nearshore environment (Pat Harris, NMFS, pers. comm.) and it has the potential to interfere with physiological processes (Holland -Bartels et al. 1999). Two main hypotheses have been presented to explain population declines: (1) ingested oil is continuing to cause either mortality and/or sublethal impairment of reproduction; and/or (2) initial mortality caused significant losses to the western PWS population which may result in a protracted recovery period.

The greatest biological problem in identifying the effects of the EVOS was our lack of basic knowledge on harlequin duck life history, ecology, distribution, and abundance. Poor knowledge of harlequin duck life history at the time of the spill made it difficult to design effective damage assessment and monitoring programs. Scant baseline data on population size made assigning injury and recovery based on pre-and post-spill comparisons tenuous because of a low sample size, high variability, and data that was collected many years before the spill. Poor understanding of regional differences within PWS confounded interpretations of differences between oiled and unoiled areas. This clearly pointed out the need to have good baseline information and time-series data on numbers, distribution, population structure, and a variety of life history events.

Identifying and establishing the cause of population declines depends on knowledge of the status of the resource immediately prior to environmental perturbations and an understanding of the inter-annual variability or the normal variation between years in periods of little perturbations in the larger physical system. Thus, our ability to detect departures from natural variation is necessary if we are to accurately evaluate the effects of major environmental perturbations

whether natural or man-caused. This requires numerous samples, distributed through time, preferably focusing on long-lived species that tend to show less natural variability. Without time-series data on harlequin duck abundance and abiotic and biotic ecosystem changes we lack the ability to interpret the affects of natural or man-induced processes.

B. Rationale/Link to Restoration

This proposed work represents a relatively simple, workable approach to the long-term monitoring of harlequin duck populations that will allow us to assess recovery from the spill, detect long-term ecosystem changes, gather basic life history information, and improve management.

We propose a survey that will have the power to detect trends in populations in oiled and unoiled areas, provide information on population demographics, and give insight into geographic differences within PWS. This study is directly linked to the recovery objectives for harlequin ducks in the EVOS Restoration Plan (Exxon Valdez Oil Spill Trustee Council 1999). This project will provide winter population trends; compare population structure, and provide an index of recruitment between oiled and unoiled areas.

Harlequin ducks are highly philopatric to breeding, molting, and wintering sites. This is an adaptive strategy in natural situations and predictable environments. It is not favorable in the face of dramatic environmental perturbations or rapidly changing land-use practices. It does not favor rapid recovery and colonization of new undisturbed sites. This strong philopatry may result in continued exposure to residual oil or delays in pioneering new nest sites once populations stabilize. Monitoring provides a direct approach to assess recovery.

Information from this project will aid in the development of a population model. A population model is central to monitoring harlequin duck recovery. The model must include demographic parameters and identification of critical periods of the annual cycle that may limit recovery from the *Exxon Valdez* oil spill. This will allow researchers to predict population trends and rate of recovery. While some of this information has been collected for PWS populations (Rosenberg and Petrula 1998, Holland-Bartels et al.1999) and harlequin ducks in North America (Goudie et al. 1994, Robertson and Goudie 1999), many specifics are still lacking, including data on productivity, recruitment, dispersal, and subadult survival.

Detecting trends in abundance and productivity from natural year-to-year variation will be met sooner with increased sampling. Results of this work will have a direct bearing on assessing the status and outlook for this resource and help guide agency programs and policies related to public uses, especially subsistence and recreational hunting, land-use practices, and wildlife viewing.

C. Location

The proposed project will be conducted in the oil spill area of western Prince William Sound and unoiled eastern PWS between Valdez and Cordova and northern Montague Island. March

surveys will repeat areas surveyed in /427 Harlequin Duck Recovery Monitoring (Rosenberg and Petrula 1998). Additional survey sites in PWS will be located on Montague Island, following the sampling scheme of project \025 Nearshore Vertebrate Predator Project (Holland-Bartels et al. 1999), and southwestern PWS.

Surveys in the spill area will focus on Knight Island, Applegate Island, Foul Bay, Main Bay, Eshamy Bay, Crafton Island, Chenega Island, Green Island, Naked Island, and Bainbridge, Evans, and LaTouche islands in southwestern PWS. Surveys in non-oiled areas will include portions of Hinchinbrook Island, Simpson Bay, Sheep Bay, Port Gravina, Landlocked Bay, Bligh and Busby islands, Galena Bay and Valdez Arm, and Montague Island.

Communities affected by the project include Chenega Bay, Tatitlek, Whittier, Valdez, and Cordova.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The project will continue to inform and coordinate our community involvement activities. This effort began with project /427 (Harlequin duck recovery monitoring) and a TEK report is included in Rosenberg and Petrula (1998). This effort was continued with project /273 (Scoter life history and ecology: linking satellite telemetry with traditional ecological knowledge).

Efforts have and will continue to be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project. Information gathered from this project will be shared with local communities. Study plans and results of project /427 and project /273 have been presented in the oil spill communities of Tatitlek, Chenega Bay, Cordova, Port Graham, Nanwalek, and Seldovia and at meetings of community facilitators. We will continue to present information to local communities and prepare articles or photographs for Trustee Council publications.

Boat and air charter contracts, and other services will continue to be contracted from local sources when possible.

PROJECT DESIGN

1. Surveys

A. Objectives

1. Compare population structure (number of breeding pairs, subadult males, adult males, and females) between oiled and unoiled areas during March.

2. Estimate density for oiled and unoiled survey sites in March.

3. Compare annual changes in density and population structure for oiled and unoiled survey sites.

4. Compare annual changes in density and population structure *within* oiled and unoiled survey sites during March.

5. Compare results with EVOS project /427 Harlequin Duck Recovery Monitoring.

6. Add to our knowledge of harlequin duck life history

7. Integrate data with other long-term monitoring surveys to detect long-term changes in marine ecosystems

B. Methods

This study will test the following hypotheses:

1. Objective 1.
   H_o: The ratio of males to females; total ducks to subadult males; and breeding pairs to total ducks is the same for oiled and unoiled populations during March.

   H_1: The ratio of males to females; total ducks to subadult males; and breeding pairs to total ducks is different for oiled and unoiled populations during March.

A generalized logit model (Agresti, 1990) will be used to test differences in population structure for oiled versus unoiled survey sites for winter and late-summer for objectives 1 and 2. Male:female ratios for individual survey periods will be compared by estimating proportions using cluster sampling (flocks) (Cochran, 1977).

2. Objective 2. No hypothesis is being tested.

3. Objective 3.
   Ho: The rate and direction of population change between years is the same for oiled and unoiled survey sites.

   H_1: The rate and direction of population change between years is different for oiled and unoiled survey sites.

Density changes will be tested by regression and population structure will be tested with logistic regression (Agresti, 1990).

4. Objective 4.
   H_o: The rate and direction of population change between years is the same within oiled and unoiled survey sites.

H_1: The rate and direction of population change between years is different within oiled and unoiled survey sites.

Density changes will be tested by regression and population structure will be tested with logistic regression (Agresti, 1990).

5. Objective 5. No hypothesis is being tested.

6. Objective 6. No hypothesis is being tested.

7. Objective 7. No hypothesis is being tested.

March surveys. Surveys will be conducted in representative portions of oiled areas in western PWS and unoiled areas in eastern PWS. FY 95-97 transects will be repeated (Rosenberg and Petrula 1998) and new transects will be established in areas of northern Montague Island and southwestern PWS. Surveys will be conducted from approximately March 20 through 30. Repeat surveys will not be conducted and surveys in oiled and unoiled areas will not be conducted simultaneously because population flux is expected to be minimal at this time of year.

All harlequin ducks will be recorded along each survey route. Observations will be recorded as pairs or by sex, and males will be divided into two age groups using predetermined criteria (Rosenberg and Petrula 1998). Surveys will be conducted from open skiffs up to 20 feet long. Each skiff will have two observers. Surveys will be conducted from within 30 meters of shore along predetermined routes. A pace and course will be chosen that will assure complete coverage of the survey area and maximize the opportunity to see ducks. All transects will be mapped and all observations will be recorded by date and location and mapped by flock. Exxon Valdez oil spill beach segment modifiers (oiled areas), habitat associations, time, and weather will be noted.

Population composition and annual changes in density will be compared to test whether harlequin duck populations are exhibiting similar growth trends or the oiled (injured) population is exhibiting a different direction or rate of change. We will continue to test whether low reproductive success in oiled areas has resulted in changes in population age and sex structure. The proportion of first-year males to total males will be used as a measure of past reproductive success. Proportions of paired birds and male:female ratios will be compared for oiled and unoiled sites to indicate breeding propensity. Surveys will be used to detect changes in abundance and compare the direction and rate of change between years for the two survey areas. Surveys within oiled and unoiled areas will be compared to determine if geographic differences are detectable. Data from FY95-FY97 surveys will be incorporated into the analysis when applicable.

Sufficient power to test the hypotheses presented above (detecting a significant difference in slopes) is expected for this project based on the power generated from project \427, Harlequin Duck Recovery Monitoring (Rosenberg and Petrula 1998). Using similar survey techniques and time frames that project was able to reject the null hypothesis (no difference in rate of population change between oiled and unoiled areas) with the following power:

Power at alpha = .05	**.80**
Power at alpha = .10	**.88**

C. Cooperating Agencies, Contracts, and Other Agency Assistance

ADF&G personnel will conduct all data collection and analysis. Winter surveys and contracts for vessel support for winter surveys will be coordinated with related EVOS projects. Private sector contracts for winter vessel support will be solicited.

SCHEDULE

A. Measurable Project Tasks for FY 2001

October 2000	Project start-up. Interagency coordination. Plan logistics and personnel for winter surveys. Contract for vessel support.
Jan. –Feb. 2001	Hire seasonal technicians for March survey. Prepare field equipment. Finalize field logistics.
March 2001	Conduct winter surveys in PWS.
April – May 2001	Create databases, GIS. Analyze field data and begin report preparation. Maintain equipment.
June - July 2001	Analyze data
July-Aug-Sept 2001	Analyze data and begin report preparation
April 2002	Annual Report submitted

B. Project Milestones and Endpoints

FY01

October-February:	Coordinate and plan surveys, prepare equipment, contract for vessel support, hire personnel.
March:	Conduct population surveys.
April-September:	Data analysis and report preparation, maintain equipment.
April 15:	Submit annual report.

FY02

October-February:	Coordinate and plan surveys, prepare equipment, contract for vessel support, hire personnel.
March:	Conduct population surveys.
April-September:	Data analysis and report preparation, maintain equipment.
April 15:	Submit annual report.

FY03

October-February:	Coordinate and plan surveys, order transmitters, prepare equipment, contract for vessel support, hire personnel.
March:	Conduct population surveys.
April-September:	Data analysis and report preparation, maintain equipment.
April 15:	Submit annual report.

This is a minimum three-year monitoring program designed to assess the recovery of an injured species. Each project objective will be assessed annually for oiled and unoiled areas then compared with each other and with data collected in subsequent years. Year to year trends will first be compared in 2000 and then each year after. At the end of each year results will be compared with the restoration goals to assess whether recovery has occurred.

C. Completion Date

Under present guidelines, harlequin ducks will have recovered when breeding- and nonbreeding-season densities return to prespill levels. An increasing population and decreasing exposure to hydrocarbons in oiled parts of PWS will indicate that recovery is underway (Exxon Valdez Oil Spill Trustee Council, 1999).

This project will compare harlequin duck population structure and abundance between oiled and unoiled areas and within geographic areas. Until further information is gathered it will not be possible to predict when densities will return to prespill levels and oiled populations exhibit a positive trend, indicative of a population increase comparable to unoiled areas. This project may also discover new information that will suggest changes to the Recovery Objectives and it meets the objectives of the Gulf Ecosystem Monitoring program. If continued for the long-term, this survey will help identify changes to the Gulf of Alaska ecosystem and improve our ability to differentiate between natural population changes and those induced by human intervention.

PUBLICATIONS AND REPORTS

Annual reports will be presented to the Chief Scientist by April 15. Reports will include survey areas, population structure and abundance and movements and timing of marked birds. A final report will be prepared at the end of the proposed monitoring schedule unless continued monitoring is warranted or when recovery objectives are met. Special reports (publications) will be prepared during the course of the monitoring effort if warranted. Publications will be prepared

for peer-review journals when sufficient data has been collected to warrant manuscript preparation.

PROFESSIONAL CONFERENCES

Second North American Duck Symposium and Workshop. Saskatoon, Saskatchewan, Canada October 11-15, 2000.

NORMAL AGENCY MANAGEMENT

There are no other agency or non-agency contributions to this project. ADF&G is not required to conduct these surveys by statute or regulation. Limited staffing and funding precludes ADF&G from undertaking these surveys as part of normal operations and in the past ADF&G has not conducted marine bird surveys in PWS as part of its normal waterfowl management functions.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research relies on incorporation of methods and information from other EVOS Trustee sponsored research, including projects /427, and /025. Equipment purchased by /427 and /273 will be used to conduct this research. Location of research sites, and data collection and analysis will follow previously established protocols. All efforts will be made to coordinate surveys and share vessel support and equipment with other EVOS projects. Personnel with ADF&G and USGS-BRD will assist each other when possible.

This project will be integrated with ongoing studies or findings of past studies including project \052B Traditional Ecological Knowledge; project \025 Nearshore Vertebrate Predator Project; project \427 Harlequin Duck Recovery Monitoring; and project \159 Prince William Sound Marine Bird and Mammal Surveys.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

No major changes from FY2000. This is the second-year of this project..

PROPOSED PRINCIPAL INVESTIGATORS

Dan Rosenberg
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518
(907) 267-2453
FAX: (907) 267-2433
danr@fishgame.state.ak.us

PERSONNEL QUALIFICATIONS

Dan Rosenberg has been a waterfowl biologist for The Alaska Department of Fish and Game (ADF&G) since 1985. From 1980-1983 Mr. Rosenberg conducted field research in Alaska as a waterfowl biologist for the U.S. Fish and Wildlife Service and from 1983-1984 as a Habitat Biologist for ADF&G. Mr. Rosenberg received a Bachelor of Science degree in Wildlife Management from Humboldt State University, Arcata, CA in 1979.

Mr. Rosenberg has conducted harlequin duck population (age and sex structure) and production surveys in Prince William Sound since 1994 as the Principle Investigator of a Trustee sponsored restoration project. Mr. Rosenberg is currently the principal investigator on EVOS Trustee sponsored project \273 Surf Scoter Life History and Ecology: Linking Satellite Telemetry with TEK to Conserve the Resource. He has conducted extensive waterfowl population monitoring and habitat assessment surveys on the Copper River delta, Stikine River delta, Kenai wetlands, upper Cook Inlet, Aleutian Islands, and Kodiak Island. As project leader, Mr. Rosenberg has assessed impacts to waterfowl and wildlife populations from hydroelectric development, urban expansion, habitat alterations, chemical pollutants, timber harvest, and surface mining.

OTHER KEY PERSONNEL

Mike Petrula, Wildlife Biologist, ADFG. Field logistics, surveys, data analysis, and report preparation. Mr. Petrula has an MS degree in wildlife Biology from the Univ. of Alaska, Fairbanks. He has been working on EVOS projects \427 Harlequin Duck Recovery Monitoring and \273 Surf Scoter Life History and Ecology: Linking Satellite Telemetry with TEK to Conserve the Resource.

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel	$34.8	$42.2
Travel	$2.8	$0.8
Contractual	$18.1	$22.1
Commodities	$1.6	$2.8
Equipment	$0.0	$3.6
Subtotal	$57.3	$71.5
General Administration	$6.5	$7.9
Project Total	$63.8	$79.4
Full-time Equivalents (FTE)	0.6	0.7

LONG RANGE FUNDING REQUIREMENTS

			Estimated FY 2002		
			$75.0		

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments:

Note: Additional cost for this request from the amount originally estimated for FY01 is for major hull repair to one skiff, equipment purchases, and additional staff time required by this project.

FY01

Prepared:4/6/00

Project Number: 01407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
Name	Position Description		Step	Budgeted	Costs	Overtime	FY 2001
D. Rosenberg	WBIII, Principal Investigator		18J	3.0	6.5		19.5
Mike Petrula	WBII, survey and data analysis		16B	3.0	4.5		13.5
C. Barnhill	Cartographer II		16L	0.5	5.2		2.6
2 F&G Tech.	F&G Tech. III, Field Technician		11F	1.5	3.7	1.0	6.6
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		8.0	19.9	1.0	
						Personnel Total	$42.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Whittier parking, 2 vehicles- 12 days					0.2
Whittier Tunnel Toll Fees, 2RT boat and trailers, 1 RT vehicle					0.2
Per diem Whittier			4	0.1	0.4
Travel to NA Waterfowl Symposium (Incl. in project 273CLO)					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.8

FY01

Prepared:4/6/00

Project Number: 01407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
Boat and outboard motor repair and maintenance (incl. major hull repair to fix cracks)	4.5
Photo processing, presentation productions	0.4
Air charter for field support 4 hrs @ $270/hr	1.0
Trailer and boat moorage Whittier	0.1
Vessel support for March surveys 12 days @1300/day	15.6
Truck Leasing Costs	0.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$22.1

Commodities Costs:	Proposed
Description	FY 2001
Boat fuel 350 gallons @ $2.00/gal	0.7
Boat supplies- replacement parts, props, fuel lines, fuel filters, water filters, battery, absorbent rags, oil, emergency provisions	1.0
Field survey supplies- rite-in-rain notebooks/paper, nautical charts, batteries,	0.3
Computer software for analysis, graphing, mapping, SAS licensing	0.8
Radio antenna for skiff	0..2
Commodities Total	$2.8

FY01

Prepared:4/6/00

Project Number: 01407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual &
Commodities
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2001
Canon Image Stabilized Binoculars	2	1.5	3.0
Survival Suits	2	0.3	0.6
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$3.6

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
20 ft. Caribe rigid hull inflatable	1	ADFG
17 ft. Boston Whaler	1	ADFG
10x40 binoculars	4	ADFG
Spotting Scopes	2	ADFG
Survival Suits	2	ADFG
Outboard Motors/various hp	6	ADFG
Magellan GPS	3	ADFG
Marine VHF radios	4	ADFG

FY01

Project Number: 01407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

Prepared:4/6/00

Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring

Project number:	01412
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	No
Duration:	1st year, 1-year project
Cost FY 01:	$52,800
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring

APR 12 2000

ABSTRACT

Pacific herring population crashes in the past decade have been linked to mortality due to disease. Young of the year herring metamorphose in July, well after the spring zooplankton bloom, and have to forage in a stratified water column low in nutrients. Prey availability and nutrition affect herring condition which dictates vulnerability to disease and overwintering survival. Studies have found that Gulf of Alaska (GOA) derived carbon may be transported into Prince William Sound neritic environments, influencing food webs. We propose to analyze the importance of central PWS and GOA zooplankton to juvenile herring diets from archived samples collected in neritic and central PWS from the spring of 1996 and 1997.

INTRODUCTION

Multiple recruitment failures of Prince William Sound (PWS) Pacific herring (*Clupea pallasi*) in the past decade have prompted research directed towards the habitat and condition of both juvenile and adult herring. The population crashed in 1993, suspending commercial harvest from 1993 until present with the exception of the winter of 1996 – 1997 when a limited fishery took place. In 1994, the Sound Ecosystem Assessment (SEA) program was established by the EVOS Trustee Council in part to study the processes influencing the recovery of herring populations in PWS. In 1999, a recruitment failure again resulted in the closure of all commercial fishing. The cause of the 1993 population crash has been speculated to be the result of high incidence of disease within the adult population (Marty et al. 1998). The disease is likely one of many mechanisms of mortality within the herring population that is directly linked to the condition and nutritional status of the fish (Pearson et al. 1999).

The availability of prey for juvenile herring is critical to their survival and subsequent recruitment to the fishery. In 1997 low zooplankton production and a change in zooplankton species composition brought on by large temperature fluctuations in nursery areas led to significant decreased feeding in juvenile herring (Foy and Norcross in prep a). Juvenile herring weight at age was significantly smaller in October of 1997 and March of 1998 as a result (Stokesbury et al. 1999). Although more juveniles survived the winter due to warmer temperatures, they were smaller than previous years and of lower condition. The incidence of disease was significantly higher in 1998 (14 %) (G. Marty personal communication) and the population crashed consequently in the spring of 1999.

Pacific herring nursery areas in PWS have been described as nearshore areas, primarily within bays and fjords (Stokesbury et al. 2000). Significant levels of mortality and causes of mortality have been described during their juvenile stage (Foy and Paul 1999, Paul and Paul 1998, Paul et al. 1998, Stokesbury et al. in review, Patrick et al. in prep). Overwinter mortality of juvenile herring was a result of low food availability, energetic condition in the fall, and winter duration (Foy and Paul 1999, Paul et al. 1998, Patrick et al. in prep.). Temporal variability in energy density of juvenile herring revealed that age 0 fish often have difficulty overwintering because it is difficult for them to store enough energy during their first growing season (Paul et al. 1998). Knowledge of variability of prey composition in nursery areas would provide insight into the potential for young of the year herring to store enough energy to overwinter. Higher energy dense prey have been found to be important for first feeding age 0 herring that have been starving during there first overwinter period (Foy and Paul 1999). Currently it is unknown if these prey are produced by the neritic PWS plankton community or are transported from the GOA and until this is clarified it is impossible to determine the importance of physical transport processes to the success of juvenile herring.

Spatial differences in energy density of juvenile herring suggested that food composition was different among bays (Kline and Paul in press, project 97320-I and project 97320-U). Carbon stable isotopes also showed that fish with higher energy density were depleted in ^{13}C corresponding to Gulf of Alaska derived carbon. Subsequently, spatial and temporal differences were found in diet compositions of juvenile herring confirming the spatial difference in prey

composition and availability (Foy and Norcross 1999). Herring assimilation rates based on stomach content energy density were also different among bays suggesting variable energy density of prey ingested. Gradients in species composition and abundance of zooplankton taxa have been found among and between bays (Foy and Norcross in prep b).

One objective of the Juvenile Herring Distribution and Habitats project (\320-T) within the SEA program was to model the nursery habitats of juvenile herring. In particular, the feeding ecology of juvenile herring and prey compositions found in four bays within PWS were described (Foy and Norcross 1999, Stokesbury et al. 1998, Stokesbury et al. 1997,). Juvenile herring and vertical zooplankton tows were collected in Eaglek, Simpson, Whale, and Zaikof Bays in the spring of 1996 and 1997. Zooplankton were also collected from central PWS locations in the spring of 1996 and 1997 by EVOS funded project \320-H. We propose to compare these two datasets to describe the interaction of nearshore (within bays) zooplankton communities with that of offshore (central PWS) sites. Timing and the degree of influence that larger zooplankton communities have on nearshore environments may be important for the survival of juvenile herring.

In order to facilitate the understanding of trophic links between juvenile herring nursery areas and central PWS, stable isotope data previously collected for juvenile herring and macrozooplankton will be utilized. We will assess, with existing data, the importance of Gulf of Alaska carbon in the Spring of 1996 and 1997 to herring nursery areas by comparing the isotope signatures and the species compositions.

One hypothesis addressed by this proposal is the SEA river/lake theory. Years of large upwelling events in the Gulf of Alaska provide PWS with zooplankton biomass but it is not known if this biomass or energy is transported to the nursery areas of herring. Therefore, until we know if the bays have outside sources of zooplankton, the benefit of increased zooplankton biomass in PWS to juvenile herring is unknown.

Detecting physical attributes of nearshore areas that contribute to enhancing or preventing the transport of zooplankton into nursery areas is important for assessing the importance of exogenous prey. Physical variables have been collected that may account for the distributions of zooplankton prey in the nearshore areas (Gay and Vaughan in prep.). The extent of GOA and central PWS zooplankton influence on herring nursery areas may then become predictable based on environmental conditions.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring has been listed as a "Recovering Resource." In order to understand the dynamics of continued recovery and estimate future success of the population, the condition of nursery areas must be quantified. Therefore, knowledge of the link between nursery areas and processes adjacent to the bays and PWS is necessary.

A. Rationale/Link to Restoration

This project examines the importance of carbon transport into juvenile herring nursery areas. With changing environmental conditions in the North Pacific Ocean, it will be necessary to predict the condition of pre recruit herring in order to manage future fisheries. Knowledge of the relative importance of food sources derived outside nursery areas to the success of the herring population will enhance management's predictive capabilities since there will be a better understanding of the consequences of high and low transport rates of GOA water into PWS. Better management of the population will act to enhance the recovery of Pacific herring. Herring are also important forage species for several sea birds, mammals, and fishes that were impacted during the 1989 oil spill, and improving the understanding of herring recruitment processes will be valuable to managers and these resources.

A. Location

The location of sampling was Prince William Sound. Results of this project will be applicable to and have consequences for trophic relationships of other "Recovering" and "Not Recovering" resources as well. The importance of high energy dense prey availability to rearing juvenile fish could be applicable to a large range of species that rear in fjords and bays. Also, the importance of prey availability on the condition of juvenile herring may be important for understanding the incidence of disease encountered in the population.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The data collected for this proposed project was a part of the SEA project. Traditional knowledge of herring distribution was used in the original sampling design. Local commercial fishing vessels were used in our sample collections. Local Cordovans and other Alaska residents were employed as technicians and vessel crew. Supplies, fuel, and equipment were purchased locally. Information resulting from this project will be made readily available to local fisheries managers.

PROJECT DESIGN

A. Objectives

The research objectives of this project are:

1. Analyze species composition and local biomass of nearshore and offshore zooplankton communities from previously collected data.

2. Combine data from previous studies to relate isotopic signatures of juvenile fish in the bays to species composition found in the diets.

3. Examine the importance of physical features within four sites to the influence of central PWS species assemblages on juvenile herring nursery areas.

B. Methods

We hypothesize that some zooplankton species found in central PWS will be transported to the nearshore environment and will play important roles in local food webs. In particular, juvenile herring will be dependent on this food source for high energy content prey. We also hypothesize that carbon from Gulf of Alaska sources will also be transported to the bays in the same manner where it will play a critical role in the energetics of age 0 herring.

In order to test these hypotheses, we will mine current databases from projects \320-T and \320-H for zooplankton composition, abundance, and biomass. Species taxa will be grouped according to ordination techniques on Bray Curtis dissimilarities to examine zooplankton composition. Ordination axes will then be compared to sampling location in an analysis of variance. It may be necessary to look at time lags between samples to detect delayed occurrences of species to the nearshore environment accounting for sampling periods.

Data representing the central PWS zooplankton will be collected from a database containing 22 stations. Two stations include data from March, April, May and June 1996. A single station includes data from March, April, May and June 1997. The remaining 19 stations include data collected April, May, and December 1996 and May 1997. Data representing the nearshore zooplankton will be collected from a database containing 12 stations. Three sites within four bays were sampled in May, June and December 1996 and May 1997.

Local physical data (temperature, salinity, and currents) collected during the previous sampling cruises will be used to suggest mechanisms for central PWS influence on the nearshore environments. Also, previously published stable isotope data will be compared to the species distributions found in the herring nursery areas and may account for the origin of carbon utilized in nearshore food webs.

Cooperating Agencies, Contracts, and Other Agency Assistance

The University of Alaska Fairbanks is the only entity in this proposal, however, data collected by the PWS Science Center staff during the SEA program will be included in the analysis.

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000 – September 30, 2001)

October 1 – November 1:	Mine databases from previous projects to complete solid design for statistical comparison
March 1 – March 31:	Write and submit manuscript to peer reviewed journal

April 15:	Submit annual report

B. Project Milestones and Endpoints

November 1 – December 31:	Objective 1: Analyze zooplankton composition data
January 1 – February 28:	Objective 2 and 3: Compare physical data and stable isotope data from the database and published articles to the species composition results

C. Completion Date

March 31, 2001

PUBLICATIONS AND REPORTS

Final Report (April 15, 2001)

Influence of exogenous zooplankton assemblages on the nursery areas of juvenile herring. Foy, R. J. and A. J. Paul. *Canadian Journal of Fisheries and Aquatic Sciences.*

PROFESSIONAL CONFERENCES

During FY01 we will attend a national meeting to present current findings.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will address a series of questions raised from previous and continuing Restoration projects about the mechanisms that supply energy to the food web that supports injured and slowly recovering species. Information regarding transport of carbon resources to nearshore environments will enhance the findings about species interdependence and energy flow derived in the SEA, NVP, and APEX projects. We will attempt to identify the linkage between the Gulf of Alaska derived carbon and nearshore environments as was suggested by stable isotope analyses in project \320-I. This project will also utilize the biological data already collected in PWS to enhance the interpretation of food web dependencies which may be useful to project \393.

PROPOSED PRINCIPAL INVESTIGATORS

A. J. Paul
University of Alaska Fairbanks
Seward Marine Center
Institute of Marine Science

School of Fisheries and Ocean Sciences
Seward, Alaska 99664
Phone: 907-224-5261
E-mail: ffajp@aurora.alaska.edu

Robert J. Foy
University of Alaska Fairbanks
Institute of Marine Science
School of Fisheries and Ocean Sciences
Fairbanks, AK 99775-7220
Phone: 907-474-5184
E-mail: foy@ims.alaska.edu

A. J. Paul
Dr. Paul will be responsible for data analysis and initial production of the journal paper.

Biographical Sketch of
Augustus John Paul
SS# 066–38–3686

Born:
19 July 1946; Oneida, New York

Education:
Ph.D. 1987 Hokkaido University, Hokkaido, Japan
M.S. 1973 University of Alaska
B.S. 1969 University of Massachusetts, Amherst

Publications:
Paul, A. J. and J. M. Paul. 1999. Interannual and regional variations in body length, weight and energy content of age-0 Pacific herring from Prince William Sound, Alaska. *J. Fish. Biol.* 54:996-1001.

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Robert J. Foy

Robert Foy will be responsible for gathering previously collected and archived data from the appropriate databases. He will assist data analysis and publication efforts arising from this study.

Biographical Sketch of
Robert James Foy
SS# 377–94–4435

Education:

M.S. University of Alaska Fairbanks, Fairbanks, Alaska, 1996 (Area of specialization: Fisheries)
B.S. University of Michigan, Ann Arbor, Michigan, 1993 (Area of specialization: Biology)

Work Experience:

Research Associate, University of Alaska Fairbanks; 8/15/99 - present
Ph.D. Graduate Student, University of Alaska Fairbanks; 07/01/96 – present
Research Assistant, University of Michigan, Ann Arbor, Michigan; 05/01/92 – 06/01/93
Laboratory Assistant, University of Michigan, Ann Arbor, Michigan; 08/01/91 – 05/01/92

Publications:

Foy, R. J. and A. J. Paul. 1999. Winter feeding and changes in somatic energy content for age 0 Pacific herring in Prince William Sound, Alaska. Transactions of the American Fisheries Society. 128: 1193-1200.

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$0.0
Travel		$0.0
Contractual		$49.3
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$49.3
General Administration		$3.5
Project Total	$0.0	$52.8
Full-time Equivalents (FTE)		0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY01

Prepared:

Project Number: 01412
Project Title: Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$35.9						
Travel		$1.4						
Contractual		$1.5						
Commodities		$0.7						
Equipment		$0.0						
Subtotal	$0.0	$39.5				Estimated FY 2002		
Indirect		$9.8						
Project Total	$0.0	$49.3						
Full-time Equivalents (FTE)		0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

The indirect rate is 25% TDC as negotiated by the T/V *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

FY01

Prepared:

Project Number: 01412
Project Title: Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring
Name: A.J. Paul

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	Paul, AJ	Professor	0.3	7.8		2.3
	Foy, RJ	Research Associate	6.0	5.6		33.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	6.3	13.4	0.0	
					Personnel Total	$35.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	R/T Kodiak to Anchorage	0.6	1	4	0.2	1.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$1.4

FY01

Prepared:

Project Number: 01412
Project Title: Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring
Name: A.J. Paul

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
Communication, duplication, publication	1.5
Contractual Total	$1.5

Commodities Costs:	Proposed
Description	FY 2001
Project Supplies (telephone, copying, postage, software, etc.)	0.7
Commodities Total	$0.7

FY01

Prepared:

Project Number: 01412
Project Title: Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring
Name: A.J. Paul

FORM 4B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	

FY01

Project Number: 01412
Project Title: Overlap of Offshore and Neritic Zooplankton Assemblages: Implications for Juvenile Herring
Name: A.J. Paul

FORM 4B
Equipment
DETAIL

Prepared:

Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators

Project Number:	01423
Restoration Category:	Research and Monitoring
Proposers:	Jim Bodkin, Dan Esler, Tom Dean, Brenda Ballachey, Randall Davis
Lead Trustee Agency:	DOI--USGS
Cooperating Agencies:	
Alaska SeaLife Center:	Yes
Project Duration:	3rd year, 5-year project
Cost FY 01:	$504,700
Cost FY 02:	$477,200
Cost FY 03:	$250,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Sea Otter, Harlequin Duck

ABSTRACT

Sea otters and harlequin ducks have not fully recovered from the EVOS, based on population-level demographic differences between oiled and unoiled areas. Further, in oiled areas, both species show elevated cytochrome P4501A (CYP1A) through 1998, almost certainly reflecting continued exposure to oil. We propose to explore links between oil exposure and the lack of population recovery, with the intent of understanding constraints to full recovery of these species and the nearshore environment generally. We also will monitor the progress of recovery of the species and the system. Proposed work consists of field and captive components for both species. For sea otters, field studies include aerial surveys of distribution and abundance, estimation of abundance and sizes of green sea urchins, estimation of age-specific survival rates, and monitoring of CYP1A expression. For harlequin ducks, field studies will examine the relationship between survival and CYP1A and, further, will serve to monitor these key parameters. Captive experiments on both sea otters and harlequin ducks will examine the relationships between oil exposure and CYP1A induction, and the metabolic and behavioral consequences of exposure to oil.

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EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

INTRODUCTION

The nearshore environment of Prince William Sound (PWS) received about 40% of the oil spilled after the *Exxon Valdez* ran aground (Galt et al. 1991). Concerns about nearshore recovery and restoration resulted in a suite of studies sponsored by the *Exxon Valdez* Oil Spill Trustee Council, including the Nearshore Vertebrate Predator project (NVP). Principal findings of NVP include an apparent lack of population recovery for sea otters (*Enhydra lutris*) and harlequin ducks (*Histrionicus histrionicus*), both invertebrate feeders in the nearshore ecosystem (Bodkin et al. 1999; Esler et al. 1999). Over a three year period, harlequin ducks residing in oiled areas had poorer survival than those in unoiled areas (Esler et al. 2000a). Sea otters also experienced poor post-spill survival through 1998, based on modeling of ages-at-death (Monson et al. 2000). Further indication of increased mortality (or higher rates of emigration) of sea otters in oiled areas compared to their counterparts in unoiled areas is provided by inferences based on capture data (Bodkin et al. 1999). Additionally, both species show evidence of continuing exposure to hydrocarbons, based on higher levels of the biomarker cytochrome P4501A (CYP1A), in oiled areas than unoiled (Ballachey et al. 1999). Elevations in CYP1A are not explained by background or natural hydrocarbon sources, as these were found to be negligible in intertidal areas of PWS (Short and Babcock 1996), nor by area differences in PCB contamination (Trust et al. 2000; USFWS unpub. data), leaving continued exposure to residual *Exxon Valdez* oil as the most plausible explanation. Residual oil is still stranded in intertidal areas of PWS (Babcock et al. 1996; Hayes and Michel 1999).

Conceptual links have been drawn describing mechanisms by which oil exposure could have population-level demographic impacts on sea otters and harlequin ducks. However, these links, and thus the processes that may limit full recovery, remain speculative. Therefore, we propose to build on the base of knowledge gained through previous research to (1) explore the relationships between oil exposure, individual health, and demographic attributes that could have population level effects, and (2) monitor the parameters identified in previous work that are effective and statistically powerful in describing population status and lend insight into the process of recovery of sea otters and harlequin ducks, and the nearshore environment generally.

We are proposing two additions to Project 01423, beyond what was approved in 00423. These include a CYP1A biomarker monitoring component for sea otters and a controlled sea otter oiling experiment with the Alaska Sealife Center. We are also requesting funds to maintain involvement of the sea urchin PI during the year when no sea urchin work is projected. The costs for all components are identified in a table under "Explanation of changes in continued projects".

Sea Otters

The NVP study provided several lines of evidence indicating that sea otters in the most heavily oiled portions of western Prince William Sound (WPWS), at northern Knight and Naked islands, have not recovered from oil-related injury (Bodkin et al. 1999; Dean et al. 2000; Monson et al. 2000). The sea otter population at northern Knight has not increased between 1993-99 (the

period for which we have aerial survey data), with numbers remaining at about half the estimated pre-spill abundance. Sea otters in oiled areas show reduced survival, relative to prespill rates (Bodkin et al. 1999; Monson et al. 2000). Levels of CYP1A are higher in sea otters from Knight Island than from unoiled reference areas, suggesting continued exposure to residual oil may be affecting recovery of the species. Additionally, increased proportions of larger-sized individuals of several sea otter prey species were identified at northern Knight, consistent with reduced predation and lack of recovery of the sea otter population in that area (Dean et al. 2000).

The sea otter component of this proposal builds on previous EVOS research (93045, 95025-99025) to develop a statistically sensitive and cost-effective program that will continue to track the WPWS sea otter population and nearshore ecosystem recovery, and investigate the effects of oil exposure on sea otters. We will address the following questions: (1) are sea otters increasing in abundance in the most heavily oiled areas, and in western PWS overall? (2) what are the ecological interactions between sea otters and green urchins, a preferred invertebrate prey of sea otters? (3) has survival of sea otters returned to pre-spill rates? (4) has exposure of sea otters to residual oil declined over time? and (5) are there metabolic consequences of oil ingestion that provide a mechanism for poor survival and lack of sea otter population recovery?

Question 1 will be answered by continued aerial surveys of sea otter abundance at appropriate intervals to monitor the population and test predictions of a previously developed sea otter population model (Restoration study 99043; Udevitz et al. 1996). Surveys were done in 1999 and 2000, and will be conducted again in 2001, 2002 and 2003. Question 2 will be answered by monitoring abundance and size of intertidal green sea urchins, a key invertebrate species, which will allow an independent assessment of sea otter recovery through predicted responses in a prey population. The urchin monitoring was done in 1999 and 2000, and will be repeated again in FY2002. *These two elements are a continuation of work proposed and approved in Project 99423, and initiated in Project 99423.*

Question 3, regarding survival rates of sea otters, involves a modeling effort that utilizes ages-at-death of sea otters recovered as carcasses on beaches (Monson et al. 2000). This element was not initially included as part of Project 99423, but due to the compelling evidence of long-term injury provided by the modeling results in late 1999, the carcass surveys were added for FY2000 (supplementary funding provided in February 2000). We propose that carcass surveys be conducted again in 2001.

Question 4 is a new element for FY2001, which will be addressed by monitoring CYP1A expression in sea otters in WPWS for comparison with 1996-98 data. Depending on results of surveys and year 2001 measures of CYP1A, it may not be necessary to continue CYP1A measures beyond 2001. Finally, Question 5 will be addressed through an Alaska SeaLife Center captive study of sea otters, to examine metabolic rates and CYP1A expression in sea otters exposed to known quantities of oil. A major benefit of the captive study is the development of efficient methods for measuring metabolic rates in free-ranging sea otters, potentially providing an additional approach for study of mechanisms inhibiting recovery in wild sea otter populations. The captive study will extend through FY2001 and 2002.

Harlequin Ducks

The most concerning result from NVP harlequin duck studies was the detection of significantly lower survival probabilities of adult females in oiled areas of PWS than in unoiled areas (Esler et al. 2000a). Analyses revealed that history of oil contamination was a more likely explanation for the survival difference than intrinsic differences between oiled and unoiled study areas. Further, projections of population trends using models incorporating these survival probabilities predicted declining populations on oiled areas and increasing populations on unoiled areas. This pattern was observed during Alaska Department of Fish and Game surveys (EVOSTC Project /427), suggesting that differences in survival were a likely mechanism for observed differences in population trends. Also, harlequin duck densities were lower on oiled Knight Island than on unoiled Montague Island, after accounting for intrinsic habitat differences; this is the pattern that would be predicted given high site fidelity and poorer survival on oiled areas. Finally, higher levels of CYP1A induction were detected on oiled areas.

Results from these recent studies lead to speculation that continued exposure to oil could result in poorer survival of harlequin ducks, which in turn would result in differences in population trends and densities. There are reasonable explanations for how oil may be related to survival (see Statement of Problem below). Unfortunately, however, these links are drawn from a wide array of sources, with limited inference to wild harlequin ducks in PWS. Thus, we propose studies that will explore the relationship between oil exposure and survival using both field and captive bird approaches. These will serve to examine mechanisms or processes that may continue to limit harlequin duck population recovery. These studies also will monitor the most critical elements revealed in previous studies to gauge the progress of recovery.

The specific questions that will be asked by the harlequin duck components of this study are: (1) what is the relationship between levels of oil exposure and CYP1A induction, and what levels of oil exposure result in CYP1A values similar to those measured in PWS? (2) are there metabolic or behavioral consequences of oil exposure that could be a mechanism by which harlequin duck survival is compromised? (3) is oil exposure (as indicated by CYP1A induction) related to survival of harlequin ducks in the wild? and (4) is contaminant exposure declining over time and, similarly, are survival rates on the oiled area improving through time? Questions 1 and 2 will be addressed using captive birds at the Alaska SeaLife Center during winters 2000-01 and 2001-02. Questions 3 and 4 will be addressed by biosampling and radio telemetry work during winters 2000-01, 2001-02, and 2002-03. *These studies are a continuation of work proposed and approved in Project 00423.* This work will examine both the process of recovery (through understanding of the mechanisms constraining population demography) and will monitor the progress of recovery by sampling survival and CYP1A induction of wild birds starting 3 years subsequent to the last work done as part of NVP (winter 1997-98). Proposed survey work by the Alaska Department of Fish and Game would aid interpretation of field studies and would also monitor population recovery.

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters and harlequin ducks occupy an invertebrate-consuming trophic level in the nearshore and are conspicuous components of the nearshore ecosystem. In 1995, the NVP Project was initiated to examine the status of recovery of nearshore vertebrates (including sea otters, harlequin ducks, river otters and pigeon guillemots), and to evaluate possible causes for the apparent lack of recovery. Results of the NVP project clearly suggest that complete recovery has not occurred for sea otters and harlequin ducks, and the lack of recovery may be related to continued exposure to oil. This proposed work follows up on the critical elements revealed by the NVP studies, in particular the relation between population status and oil contamination, and evaluation of population status.

In addition to observations made directly on predator species, as part of the NVP project, we have observed an apparent response among several invertebrates to reduced sea otter densities. This finding represents a shift in the ecological processes structuring the nearshore community and provides a unique opportunity to test predictions related to sea otter recovery and their prey. We also have an opportunity to test the application of this novel approach as a tool for monitoring predators through prey that may have broader ecological applications.

Sea Otters

The sea otter population in WPWS was injured as a result of the spill. Estimates of sea otter mortality due to the spill range from 750 to 2,650 individuals (Garshelis 1997, Garrott et al. 1993). A population model (Udevitz et al. 1996) predicted recovery of the WPWS sea otter population in 10 to 23 years, projecting maximum annual growth rates from 0.10-0.14. Surveys to date (1993-1998) have shown a significant increasing trend in the WPWS sea otter population, averaging about 4% per year since 1993 (power > 0.80 to detect a 1% annual change in 5 annual WPWS surveys). In contrast to the western Sound overall, at northern Knight Island sea otter numbers remain below pre-spill estimates and do not show a significant increasing trend (Figure 1; Bodkin et al. 1999; Dean et al. 2000; USGS unpub. data), although our power to detect change is lower for these surveys.

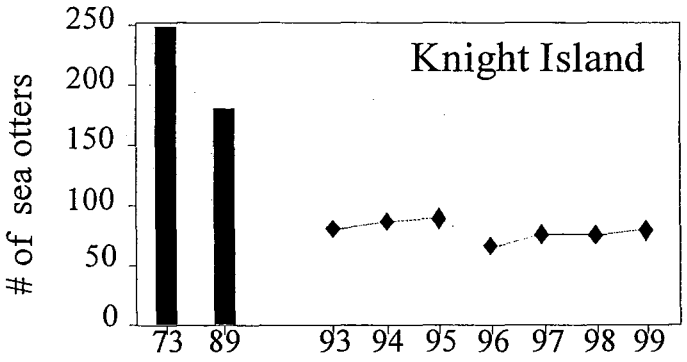

Figure 1. Estimated sea otter abundance at northern Knight Island.

Aerial survey data of sea otter abundance have provided the foundation for assessment of recovery status in WPWS. However, pre-spill data of abundance are few, and there are known biases in pre-spill estimates that preclude using pre- vs. post-spill comparisons in making a definitive quantitative assessment of the extent of recovery. Furthermore, recovery status could not be based solely on post-spill comparisons of oiled and unoiled areas because there are recognized differences in habitat between these areas, and it is uncertain whether sea otters in oiled areas could ever achieve population densities observed in unoiled parts of the Sound. As a result, in the NVP study, we examined prey populations as an ancillary means of assessing recovery.

This approach was based on the knowledge that sea otters have a profound and predictable effect on the structure of prey populations (reviewed in Riedman and Estes 1990). Generally, as sea otters reoccupy an area, they first consume the largest members of the most energetically profitable prey, eventually switching to smaller sizes and different species as preferred species and the larger size classes become rare (Estes and Palmisano 1974, Duggins 1980, Estes and Duggins 1995). Based on these findings, we hypothesized that a reduction in otter abundance would be accompanied by an increase in the abundance and average size of prey. We concluded that the status of recovery of impacted populations of sea otters might therefore be assessed by examining the abundance and size-distributions of prey within impacted areas, and by comparing these with estimates from an unaffected area where otters and their prey were considered to be in equilibrium. Full recovery would be indicated by similar abundances and size distributions of prey in oiled and unoiled areas.

NVP comparisons of most invertebrate prey populations between Knight Island (oiled) and Montague Island (unoiled) identify differences in prey population structure consistent with lack of recovery of the sea otter population at the oiled site (Dean et al. 1999). At the sites where sea otter populations were greatly reduced, we found significantly greater proportions of large individuals among most species of clams, urchins and mussels. Continued prey assessment provides a unique opportunity to complete the testing of an innovative approach for estimating the status of a predator population. When sea otter populations near complete recovery, we predict that differences in prey sizes between areas should diminish. Thus, we propose to continue monitoring the abundance of sea otters and the size and abundance of sea urchins in oiled and unoiled areas of WPWS to assess the recovery status of sea otters.

Sea otter carcasses have been recovered from beaches in WPWS since 1976, thus providing one of the few long-term baseline data sets for evaluating post-spill injury. Carcass surveys initially were not proposed as part of Project 99423. However, in 1999 we applied recently developed modeling techniques (Doak and Morris 1999) to estimation of sea otter survival rates, utilizing the distribution of otter ages-at-death as the basis for the model. The results provide compelling evidence of long-term injury from the EVOS (Monson et al. 2000). Briefly, the model involves a comparison of observed vs. predicted ages-at-death of sea otters prespill and postspill, using data from carcasses collected during 1976-98. Postspill survival of sea otters in the western Sound was poor relative to prespill rates, and by 1998, survival rates had not yet returned to prespill values. However, survival rates of younger age otters were increasing, suggesting that conditions

were normalizing. These results are consistent with other observations of sea otters in western PWS, which suggest that the population in the most heavily oiled areas has not yet recovered (Figure 1). Carcass collections and modeling efforts based on age-at-death data may provide one of the most efficient tools for monitoring recovery of sea otters. Thus, we propose that carcass surveys (and subsequent modeling to estimate survival rates) be continued in 2001, as an additional tool for monitoring sea otter recovery in PWS.

The NVP study identified elevated expression of CYP1A in 6 species that inhabit the nearshore areas of WPWS, indicating continued exposure to residual EVOS oil (Ballachey et al. 1999). Sea otters were sampled in 1996-98, and in all years, animals from Knight and Naked islands (oiled area) had elevated CYP1A, compared to those from Montague Island (unoiled area; Figure 2). Further, levels at Montague were similar to those measured in otters from a relatively clean area in southeast Alaska with no known exposure to oil or other contaminants (USGS unpub. data). In 1998, the mean value of CYP1A in the oiled study area was lower than means for 1996 or 1997, suggesting exposure to residual oil is diminishing over time. We propose to resample the wild sea otter population for CYP1A in summer 2001, to determine if hydrocarbon exposure continues, and if so, if it has declined relative to levels measured in 1996-98. Sea otters in the most heavily oiled areas of WPWS will be targeted for sampling, with particular effort to capture those residing in the vicinities of known persistent oiled shoreline and bivalve populations (Hayes and Michel 1999, Fukuyama et al. in press) and oiled mussel beds (Harris et al. 2000), potentially enabling us to make a link between biomarker levels in sea otters and petroleum contaminants in mussels and sediments of their nearby habitat. Sea otters from Montague Island will also be captured to provide a non-exposed reference sample.

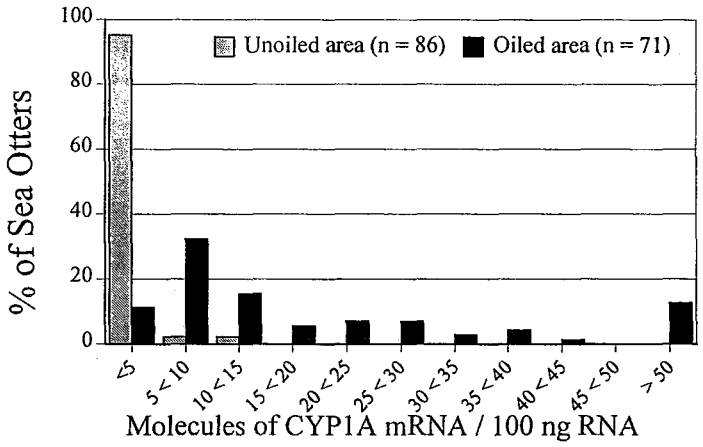

Figure 2. Measurement of cytochrome P4501A induction (RT-PCR technique) in sea otters in western Prince William Sound, 1996-98.

Although a distinct difference was seen between sea otters in oiled and unoiled areas in levels of CYP1A, the biological significance of this observation has been difficult to establish, particularly as we have no quantitative data on level of oil exposure required to induce the biomarker. However, evidence of poor survival over a long-term period and the lack of population growth in heavily oiled areas suggest a link between chronic oil exposure and individual health. Potential mechanisms by which oil exposure could have population-level demographic impacts on sea otters include hepatic dysfunction, anemia and increased metabolic rate (Williams and Davis 1995, Ballachey et al. 1999).

Restoration studies to date have focused on free-ranging sea otters. However, detailed metabolic studies are needed to more completely interpret field data, including CYP1A levels, and assess the energetic consequences of chronic, low-level oil exposure. A comparison of metabolic rates of sea otters in the area impacted by the oil spill with control areas where the population is stable or growing may provide additional insight into the long-term ecological impacts of the spill and potential for population recovery. Before working with free-ranging sea otters, however, captive studies are needed to assess the relations between oil exposure, biomarker induction, hematology and serum chemistry, metabolic rates and behavior of sea otters. This component of our project would provide valuable information for understanding mechanisms by which oil exposure might be adversely affecting health of the otters, and in addition, would validate a new technique for monitoring metabolic rate in sea otters which could then be applied to assessment of wild populations.

In the past, estimating metabolic rate for sea otters has been based on average food or energy ingested in captivity and expressed as a percentage of body weight of food consumed per unit time. A few studies have used indirect calorimetry or doubly-labeled water to estimate metabolic rates of sea otters under different conditions of activity or thermoregulatory stress (Morrison et al. 1974; Costa and Kooyman 1982, 1984; Davis et al. 1988). However, these techniques are difficult to apply in the field and, in the case of doubly-labeled water, expensive to use with free-ranging sea otters over extended periods of time.

A new technique using a miniature, implantable heart rate and temperature data logger (HRTDL) can provide details on metabolic rates for periods of up to one year (Woakes et al. 1995). When combined with a time-depth recorder, it can also be used to estimate the metabolic cost of different activities of animals in their natural environment. This heart rate technique (Butler 1993; Bevan et al. 1994, 1995a) has been used to determine the energy cost of specific activities, such as foraging during the breeding period, of a number of top predators in the Southern Ocean, e.g., black-browed albatrosses and fur seals (Bevan et al. 1995b; Boyd et al. 1999), as well as those of the migratory flights of Svalbard barnacle geese (Butler et al. 1998). A first step in using this technique is calibration on sea otters in captivity using indirect calorimetry (i.e., measuring oxygen consumption in conjunction with heart rate). We propose to test the heart rate recorder in sea otters at the Alaska SeaLife Center during controlled studies involving low-level dosing with crude oil. This study will provide the basis for using this technique on free-ranging sea otters to assess the effects of chronic oil exposure on metabolic rate, as well as providing valuable information on the relation between oil exposure and CYP1A induction, and mechanisms by which chronic exposure to residual oil may be constraining recovery of sea otters in heavily oiled areas of western PWS.

In summary, we propose continued monitoring of sea otter distribution and abundance, survival rates and oil exposure (CYP1A), in concert with monitoring of prey populations (in 2002) in WPWS. These studies will be valuable in documenting actual recovery time for the nearshore system including sea otters, and providing long-term population trend data which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills. In addition, we propose a captive study of sea otters to assess relations among oil

ingestion, CYP1A, metabolic rates and behavior, and to validate the feasibility of implantable heart rate monitors and time-depth recorders for assessing chronic oil exposure on metabolic rates in free-ranging sea otters.

Harlequin Ducks

Harlequin ducks were, and remain, particularly vulnerable to deleterious effects of the oil spill. Much of the oil from the *Exxon Valdez* was deposited in the nearshore intertidal and shallow subtidal zones (Galt et al. 1991), the coastal habitats where harlequin ducks occur. Also, Goudie and Ankney (1986) suggested that harlequins were near the lower limit of body size for sea ducks occurring in environments similar to Prince William Sound in winter. Because harlequin ducks exist close to an energetic threshold, any perturbation (e.g., an oil spill) that either affects health or condition directly (via toxic effects or increased metabolic costs) or indirectly (via food abundance) could have significant consequences for the population.

Also, among ducks, sea duck life histories are particularly K-selected (Eadie et al. 1988). Harlequin ducks typically defer reproduction for 3 years, have relatively low annual investment in reproduction, and are long-lived (Goudie et al. 1994). Species with these characteristics have relatively low potential rates of population change and, thus, following a perturbation such as an oil spill, require many years in the absence of continued adverse effects to recover to previous population levels. Further, population dynamics of animals with this life history strategy are particularly sensitive to variation in adult survival (Goudie et al. 1994, Schmutz et al. 1997).

Sea ducks have a general pattern of high philopatry throughout their annual cycle (e.g., Limpert 1980, Savard and Eadie 1989) and harlequin ducks follow this pattern, having high fidelity to molting and wintering sites (Robertson 1997; Esler, unpubl. data). High site fidelity could result in vulnerability to population effects because: (1) if residual oil spill damages exist, birds from oiled areas are vulnerable to spill effects as they return to those areas annually (i.e., these birds are affected disproportionately and are subject to cumulative effects), and (2) if dispersal and movements among areas are limited, recovery of groups of birds in oiled areas can occur only through demographic processes specific to that group (i.e., numbers are not enhanced through immigration from other areas). High site fidelity is an adaptive behavioral strategy in natural situations and predictable environments (Robertson 1997), but does not accommodate movement to undisturbed sites in the face of human-caused perturbations.

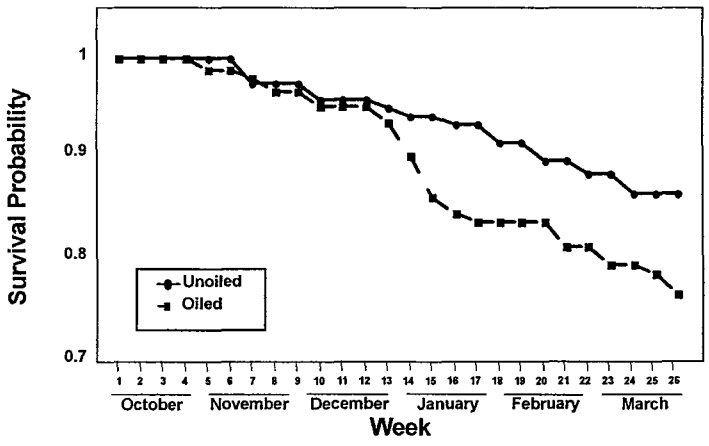

Figure 3. Survival probabilities of harlequin ducks.

Evidence from recent studies (NVP and /427) suggests that, as might be predicted from their vulnerability, harlequin duck populations have not fully recovered and, in fact, continue to suffer deleterious effects from the oil spill. Over the course of 3 winters, survival probabilities differed between oiled and unoiled areas (Figure 3). Survival probabilities were high, and similar between areas, in fall. However, survival diverged between areas during mid-winter, presumably the period during which conditions are most difficult for harlequin ducks. Also, differences in CYP1A induction were detected between populations from oiled and unoiled areas (Figure 4; Trust et al. 2000), although this was measured on different birds than those for which survival data were collected. Further, body mass during winter showed a slight, negative relationship with CYP1A level.

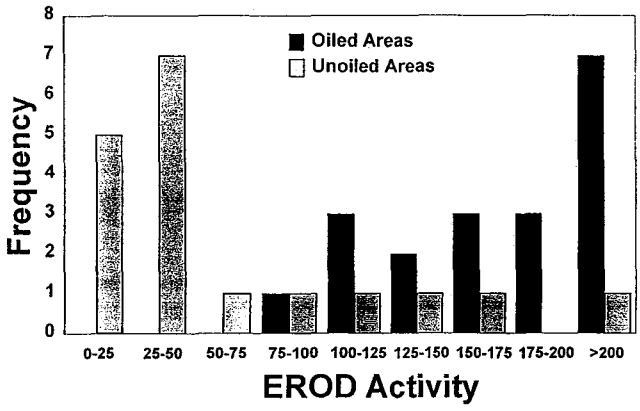

Figure 4. Comparison of CYP1A induction (hepatic EROD activity) in harlequin ducks from Prince William Sound.

One can speculate on mechanisms by which continued exposure to oil could be related to differences in survival probabilities. Most lab studies have shown that mallards are tolerant of internal ingestion of oil, with toxic effects not evident until very high doses. These studies have been used to suggest that harlequin ducks should, similarly, be unaffected by residual Exxon Valdez oil (Stubblefield et al. 1995, Boehm et al. 1996). However, other studies have found that, with addition of other stressors such as cold temperatures, oiled ducks in the lab suffered considerably higher mortality than unoiled (Holmes et al. 1978, 1979). This seems to be a much more appropriate analog for wild harlequin ducks. Particularly given their vulnerability to spill effects and hypothesized existence near an energetic threshold, harlequin ducks may not be able to handle additive effects of the oil spill, even if relatively small.

To fully understand the process of harlequin duck population recovery from the oil spill, it is important to address these speculated links between oil exposure and survival probabilities, and subsequently population trends. The research proposed here is designed to explore these potential mechanisms constraining population recovery through field studies of winter survival and CYP1A induction and captive studies of metabolic, behavioral and CYP1A responses to controlled oil exposure. Further, because of their susceptibility to spill effects and high site fidelity, harlequin ducks are an ideal species for monitoring recovery of the nearshore environment.

B. Rationale/Link to Restoration

Sea otter and harlequin duck restoration requires assessments of population recovery status and definition of impediments to recovery. For harlequins and sea otters, the proposed work incorporates monitoring activities which, given the "baseline" data collected in NVP and other

post-spill studies, will allow us to gauge recovery status. Additionally, the research components proposed herein represent a comprehensive approach to understanding the factors that affect population dynamics and definition of critical bottlenecks to recovery. Without an understanding of the underlying processes that dictate population change, we can not prescribe specific activities to enhance recovery. The project directly addresses the restoration objectives both by examining the processes affecting recovery and by monitoring the progress of recovery, including survival rates and contaminant exposure.

Sea Otters

Recovery of sea otters will be complete when population size returns to estimated pre-spill abundance, and there is no further evidence of continuing exposure to residual oil. Sea otter restoration requires an understanding of population status and the processes affecting changes in population status. Continued monitoring of sea otter distribution, abundance, survival rates and prey populations in WPWS will provide insight into recovery and improve future recovery models, and potentially allow us to document the actual recovery time for the nearshore system, including sea otters. A further benefit of these project components is provision of long-term population trend data and monitoring tools which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills.

Harlequin Ducks

Harlequin duck restoration will be complete when densities have recovered to prespill levels and birds no longer show evidence of oil contamination. Poor survival in oiled areas is the most plausible cause for lack of recovery to prespill densities; restoration requires an understanding of the factors that affect survival rates, in particular the effects of oil exposure. The restoration objectives for harlequin ducks are addressed both by examining the processes affecting recovery and by monitoring the progress of recovery, in particular contaminant exposure.

C. Location

Studies will be conducted in PWS. Specific study sites for the sea otter components will be northern Knight Island and Port Chalmers/Stockdale at Montague Island, as used in the NVP project. Harlequin duck study sites also will be those used in previous NVP work: unoiled Montague Island and oiled Green Island, Crafton Island, Main Bay and Foul Bay. Captive studies will be done at the Alaska SeaLife Center in Seward. Communities affected by the project include Chenega, Whittier, Cordova and Seward.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The project will continue to inform and coordinate our community involvement activities, including the collection of indigenous knowledge with Dr. Henry Huntington, TEK specialist Chugach Regional Resources Commission and Hugh Short, Community Coordinator, EVOS

Restoration Office. We will continue to solicit advice from the above parties and gather information on TEK through local community facilitators and residents.

Efforts have and will continue to be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project. Information gathered from this project will be shared with local communities. Project staff has and will continue to present information to local communities or prepare articles or photographs for Trustee Council publications. Boat and air charter contracts, and other services will be contracted from local sources when possible.

PROJECT DESIGN

A. Objectives

Sea Otters

Field Studies

1. Estimate of sea otter abundance and population trends over time in WPWS overall, and in oiled and unoiled study areas within WPWS.

2. Estimate abundance and size class composition of green sea urchins in oiled and unoiled study areas (not proposed for 2001).

3. Monitor progress of sea otter population recovery via tracking of survival rates and CYP1A induction in oiled and unoiled areas.

Captive Studies

4. Measure CYP1A expression in oil-dosed, captive sea otters.

5. Determine the effects of chronic, low-level oil ingestion on the metabolism of captive sea otters.

6. Calibrate the use of the heart rate and temperature data logger (HRTDL) to estimate metabolic rates of sea otters.

Harlequin Ducks

Field Studies

1. Estimate winter survival rates of harlequin ducks in relation to area (history of oil contamination) and indices of oil exposure (CYP1A induction).

2. Monitor progress of harlequin duck population recovery via tracking of survival rates and CYP1A induction in oiled and unoiled areas.

Captive Studies

1. Measure the CYP1A response in oil-dosed, captive harlequin ducks.

2. Quantify the metabolic and behavioral consequences of oil exposure.

B. Methods

The proposed research employs both field studies and experimental work with captive sea otters and harlequin ducks at the ASLC. This represents an ideal solution to the need for controlled work to look explicitly at the effects of oil exposure on hypothesized mechanisms of mortality and field work to document the relevance of those mechanisms under wild conditions. With captive studies, we propose quantifying metabolic and behavioral responses to known regimes of oil exposure. Also, captive studies will indicate the level of oil exposure that corresponds to CYP1A induction detected in the field. Field studies are necessary to understand the relevance of these relationships to animals in the wild, and to monitor population and system recovery.

Sea Otters

Field Studies

The proposed sea otter work employs aerial surveys to track population abundance and growth, and sampling of intertidal green sea urchins to assess sea otter-prey interactions. These approaches will provide information on recovery status of the population, assessed by growth rates and prey structuring. Additional components proposed for 2001 are collection of carcasses for determination of ages at death, to be used in estimation of survival rates, and monitoring of CYP1A levels in sea otters as an indication of chronic oil exposure.

Sea otter population monitoring--We will continue to use previously developed aerial survey techniques which employ counts along systematic transects, and intensive search units (ISU's) to estimate a correction factor for each survey (Bodkin and Udevitz, 1999). We will conduct a single survey of the entire PWS every two years beginning in 1999, and in alternate years, conduct a survey of WPWS. From the combination, we will obtain an estimated population size for WPWS annually. We will continue annual replicate surveys (5 or more replications per survey) of the smaller NVP study sites, initiated in 1999.

Invertebrate prey population monitoring--In 1999, 2000, and 2002 (no sampling planned for 2001 or 2003) we will focus on sampling intertidal populations of green sea urchins (*Strongylocentrotus drobachiensis*). We selected this species because they are a preferred sea otter prey and have populations that are centered in the intertidal zone and can therefore be sampled efficiently, providing adequate power to detect change.

Sampling will be conducted from within Herring Bay and Bay of Isles on Knight Island, and along the Stockdale Harbor and Port Chalmers portions of Montague Island. Density estimates will be obtained from systematically selected transects along the shorelines in each area. For sea urchins, size distribution data will be supplemented by sampling in preferred sea urchin habitats. The details of site selection and sampling methods are given in Holland-Bartels et al. (1998).

Recovery of sea otter populations will be assessed by comparing the size distributions and biomass of sea urchins at Knight Island vs. Montague Island. A lack of significant differences between oiled and reference (unoiled) sites would be indicative of recovery. The data from 2001 will be combined with similar data from 1996-1999 to assess possible trends in recovery, as indicated by converging size distributions and abundances at the two sites.

Carcass surveys--Age specific survival estimates will be generated based on age distributions of the dying portion of the population, will be evaluated through recovery of beach-cast sea otter carcasses in western PWS. Beaches will be surveyed once during late April or early May after snow melt but prior to summer revegetation, which may hide carcasses washed high on the beach by winter storms. Data recorded for each carcass include: (1) relative location of carcass on the beach, 2) relative condition and completeness of carcass, (3) position of remains relative to previous year's vegetation, (4) relative age (adult, subadult, pup), (5) sex, and (6) specimens collected (e.g., entire carcass, skull, baculum, none). Skulls (when present) will be taken from all carcasses and a tooth extracted for aging (Bodkin et al. 1997). Any fresh carcasses collected will be necropsied as soon as possible and tissue samples collected for potential toxicology and histopathology studies.

Cytochrome P450 1A--In summer 2001, we will capture 30 sea otters in oiled and unoiled areas (15 per area). We will capture in the same general locations (Knight and Montague islands) that were sampled in the NVP project so that data can be directly compared to previous (1996-98) results. In addition, we will attempt to capture otters in the vicinity of shorelines known to be contaminated with oil (Hays and Michel 1999; Fukuyama et al. in press) and mussel beds being monitored as part of Restoration Project 00090 (Harris et al. 2000). Capture and handling methods will be similar to those employed previously (Bodkin et al. 1999). Sea otters will be sedated, body measurements taken, a tooth collected for age determination, and a blood sample taken by jugular venipuncture. Each otter will be tagged with two color-coded, numbered flipper tags. Following reversal, sea otters will be released in the same vicinity as captured.

In the NVP study, the RT-PCR assay (quantitative reverse transcriptase PCR assay; Vanden Heuvel et al. 1993, 1994) was adapted to measure CYP1A levels in sea otters. This assay quantifies the messenger RNA (m-RNA) that codes for the CYP1A protein. Initially, the RT-PCR assays required the isolation, cloning and sequencing of the PCR product, and the development of sea otter specific primers for CYP1A (Snyder et al. 1999); that work is now complete. Results of the assay are reported as the molecules of mRNA per 100 ng of RNA. We will continue to use peripheral blood mononuclear cells collected from live otters for the assay. The peripheral blood lymphocytes will be isolated by a ficoll gradient technique, cryopreserved in liquid nitrogen and shipped to Dr. Paul Snyder at Purdue University for analyses. In addition, duplicate slides of whole blood will be made for hematology, and an aliquot of blood from each

otter will be processed to obtain serum, which will be frozen and later submitted for serology analysis.

Captive Studies

Animals-- Six adult sea otters will be captured and transported to the ASLC for long-term holding. Two otters will be caught in spring of 2001, and 4 in summer 2001. The otters will be allowed several weeks to accommodate to captivity before beginning the study. The husbandry and veterinarian staff at the ASLC will care for the otters. The otters will be fed crude oil in gelatin capsules placed in food during the chronic, low-level dosing phase of the study. The quantity of crude oil fed to the otters will be determined by measuring the CYP1A biomarker in the blood (RT-PCR technique; Snyder et al. 1999) to achieve a level of exposure equivalent to that of wild otters in oiled areas of WPWS. Initial doses will be very low, and will be gradually increased until we reach a level that induces CYP1A expression similar to that seen in the wild. Blood will be sampled every 7-10 days for CYP1A assays; additional blood will be collected for hematology and serum chemistry. Measurements of oxygen consumption will be made before and during exposure to crude oil. In addition to CYP1A and blood parameters, appetite, body mass, and overall behavior will be monitored for health-related effects of crude oil exposure as described by Williams and Davis (1995). At the end of the experiments, when surgery is performed to recover the heart rate monitors, a liver biopsy will be collected for histopathological and toxicological analysis.

Design and surgical implantation of the heart rate and temperature data logger (HRTDL)--The miniature HRTDL is 38 x 17 x 12 mm in size and weighs 11g. It has 16 Mbytes of memory for recording heart rate, ambient pressure and body temperature (0-50° C range). Heart rate is calculated from beat count and period. Each detected beat triggers a low power radio pulse (range ~1m, on ~120MHz) to help with the implantation of the ECG electrode. Sampling interval for each data channel is programmable. Each channel can be set to either: 1) an initial delay before logging starts of up to 1 year with 1h resolution, or 2) logging in a sampling cycle, with 1h-10 days on and 1h-100 days off. Running a simple continuous program over one year will allow heart rate and pressure to be recorded about every 5 s, with temperature every 30s. Larger memory chips may become available shortly which should halve the sampling periods. Veterinarians at the ASLC will surgically implant the HRTDL in the abdomens of the sea otters with the assistance of experienced personnel from the USGS-BRD. Techniques for the surgical implantation of data loggers such as time-depth recorders in sea otters are well established and have been used for over ten years (Monson et al. 1999). The otters will be allowed to recover from surgery for several weeks before beginning the experiments. We anticipate no major problems, but the otters' health will be monitored through periodic blood samples for signs of disease or other health-related problems.

Design for measurements of oxygen consumption--After the otters recover from surgery, we will begin oxygen consumption measurements during different types of activities and levels of exertion before and during chronic, low-level ingestion of crude oil. Most of these measurements will be made in one of the concrete pools at the ASLC. We will measure oxygen

consumption for basic activities such as resting on the surface of the water, diving to obtain food placed in a bucket at the bottom of the pool, feeding at the surface, grooming, and swimming at different speeds. The concrete pool will be covered with plywood except for a lexan dome that will be large enough for the otter to float at the surface. Air will be pumped through the dome at a known rate and the otter's oxygen consumption measured using the methods of Davis et al. (1985). Basically, a sample of air leaving the dome will be dried and the carbon dioxide removed before entering a Sable Systems FC-1 oxygen analyzer. The analyzer will record percent oxygen once per second on a personal computer. Oxygen consumption will be calculated for specific activities by visually monitoring the behavior of the animal. For swimming metabolic measurements, a large pump will be used to circulate water in the circular tank at different speeds up to about 1 m s^{-1}. The otter will swim against the current and surface inside the dome to breathe. Each swimming trial will last about 20 min or until the otter shows signs of fatigue. Three to five practice sessions will be conducted before a measurement to allow the otter to become accustomed to the swimming protocol. At least five measurements lasting 30 min or longer will be made for each type of activity or swimming speed for each otter. Measurements of oxygen consumption for each behavior will be correlated with heart rate and body temperature when the heart rate data loggers are surgically removed at the end of the measurements.

Harlequin Ducks

Field Studies

The key data for field studies are paired CYP1A and survival data, which will allow for explicit tests of the hypothesis that mortality and oil exposure are related in wild harlequin ducks. We intend to collect survival and exposure data from 50 birds in each of 3 years by capturing them during early winter, conducting surgeries to both implant transmitters and biopsy livers, and monitoring subsequent winter survival. These types of data have been successfully collected during NVP studies.

This research requires capture of flighted harlequin ducks during early winter, after they have been on wintering sites long enough to be potentially exposed to residual oil, yet before the mid-winter period when survival probabilities diverged during NVP studies (Figure 3). The mid-winter period is presumably the time of greatest stress and thus the period when oil spill effects would be most likely to be expressed as differences in survival probabilities. The interval between capture and the critical mid-winter period must allow for at least a 2-week censor period to ensure that survival data are not biased by effects of capture, handling, or surgery (Esler et al. 2000b; Mulcahy and Esler 1999). Thus, we propose capturing birds during a 3-week period in November to generate both survival data and exposure data from the same individuals.

We will use floating mist nets (Kaiser et al. 1995) to catch flying birds in oiled (Knight Island, Green Island, Crafton Island, Main Bay, Foul Bay) and unoiled (Montague Island) study areas. Use of the same study areas as the NVP project allows for direct comparisons of results. The floating mist net capture technique was used successfully during NVP studies. However, this technique does not allow handling of as many birds as molt drives, so age and sex cohorts used in

survival estimation will not be as restricted as in NVP studies. We will radio birds of both genders and all age classes older than hatch-year. Age and sex parameters will be included in all analyses to account for any survival differences due to these effects. Captured birds will be banded with uniquely coded USFWS bands, aged by bursal probing (Mather and Esler 1999), and sexed by plumage characteristics.

To estimate survival probabilities of harlequin ducks, we will use implantable radio transmitters with external antennas (Korschgen et al. 1996). Implanted transmitters have been successfully used in waterfowl studies (e.g., Olsen et al. 1992, Haramis et al. 1993), and an increasing body of literature suggests that radio transmitters implanted into wild waterfowl are less disruptive than external methods of attachment, based on differences in survival or return rates (Ward and Flint 1995, Dzus and Clark 1996), behavior (Pietz et al. 1993), and reproductive rates (Pietz et al. 1993, Rotella et al. 1993, Ward and Flint 1995, Paquette et al. 1997), especially for diving ducks (Korschgen et al. 1984). NVP studies (Esler et al. 2000b) demonstrated that recapture probabilities of radio-marked harlequin ducks were not lower than unradioed individuals. Surgeries will be conducted by certified veterinarians experienced in avian implant surgeries, following procedures outlined in Alaska Biological Science Center, USGS Biological Resources Division standard protocol. Transmitters will weigh approximately 18g, which is $\leq 3\%$ of the body mass of the smallest wintering female harlequin ducks captured during NVP studies. Transmitters will be equipped with mortality sensors; the pulse rate will change from 45 to 90 beats per minute when a mortality is indicated. Mortality status will be confirmed by either carcass recovery or detection of signals from upland habitats, which are not used by harlequin ducks during nonbreeding periods.

We will conduct radio telemetry flights at approximately weekly intervals from the capture and marking period through the end of March. Survival data entry and general description will follow procedures outlined in Pollock et al. (1989a, 1989b), as modified by Bunck et al. (1995). We will examine effects of area, season, and CYP 1A on survival by comparing AIC_c values (Burnham and Anderson 1998) among models with different combinations of these effects. The AIC_c indicates the most parsimonious model by balancing the goodness-of-fit of each model (from the maximum likelihood) with the number of parameters to be estimated. Under this approach, the model with the lowest AIC_c indicates the combination of parameters that are best supported by the data, which we will interpret as the factors related to variation in survival. Survival estimates and variances will be calculated by iterative solution of the likelihood using program MARK (White and Burnham 1999).

CYP1A induction will be measured by EROD activity. Small liver biopsies (approximately 0.1 g) will be surgically removed and immediately frozen in a liquid nitrogen shipper. EROD activity analyses will be conducted in a contracted lab following standard procedures (Trust et al. 2000). Plumage swabs (Duffy et al. 1999) will be used to assess presence of external oil.

For field studies, work in FY00 includes ordering radios (and designing a transmitter that avoids problems with extrusion [Mulcahy et al. 1999]), building winter traps, and other preparations (i.e., researching boat and air charter options, etc.). Field work will begin in early FY01 (November 2000).

Captive Studies

Captive bird studies will examine metabolic, behavioral, and biomarker responses to known oil-dosing regimes. This work is designed to experimentally test effects of oil exposure on parameters that are hypothesized to influence dynamics of wild harlequin duck populations; these effects are impossible to assess under field conditions.

Harlequin ducks to be used in captive studies will be captured during wing molt from unoiled parts of PWS. During molt, harlequin ducks congregate and are susceptible to capture by herding flocks of flightless birds into pens (Clarkson and Goudie 1994). Birds will be banded with USFWS bands and with individually coded plastic tarsus bands. Tarsus bands will be oriented to be read from bottom to top as the bird is standing. Sex will be identified based on plumage characteristics and age class determined by bursal probing (Mather and Esler 1999). Body mass of all birds at capture will be measured.

Following capture, birds will be flown to the Alaska SeaLife Center in Seward. We intend to use approximately 20 birds each year for 2 years (winters 2000-01 and 2001-02). Captured individuals will undergo quarantine and adjustment periods prior to any experimental manipulation or dosing. Captive birds will be housed in outdoor pens to expose them to natural climatic and photoperiod conditions. Dosing will be designed to simulate long-term, intermittent exposure, which is likely similar to exposure experienced by wild birds. Numbers of dosing levels, amounts of doses, and frequency of dosing will be determined as part of literature review efforts proposed for FY00. Dosing will continue through the critical mid-winter period and behavioral and metabolic measures will be taken throughout the winter. Because CYP1A sampling requires a liver biopsy, we will get only 1 measure of induction, taken in late winter. Following a 2-week post-surgery recovery period (without any dosing), captive birds will be released in the area of their original capture.

Behavior of captive birds will be quantified using time-activity observations throughout winter for all dosing levels. Behavioral categories will follow those used in studies of wild harlequin ducks (Goudie and Ankney 1986, Fischer 1998), e.g., feeding, resting, swimming, courtship, etc. Time-activity budgets will be contrasted among dosing groups.

Metabolic consequences of oil exposure will be quantified using two approaches: doubly-labeled water to estimate daily energy expenditure (DEE) and oxygen consumption to estimate basal metabolic rate (BMR). This approach will allow different views into the metabolic effects of exposure. DEE is a measure of existence costs over longer (1-3 day) time periods. DEE incorporates all of the metabolic costs during this time; elevated DEE in exposed birds would be consistent with a hypothesis of oil exposure increasing existence costs with potential survival implications. Similar DEE among treatments but different activity levels (see above) also would have implications for survival under natural conditions. BMR estimates metabolism without costs of thermoregulation, digestion, and activity; these data will assess whether background metabolic costs are higher in dosed than undosed birds. Body mass of all individuals also will be measured at all handling events; these data will be interpreted in light of metabolic and behavioral measurements.

DEE estimation using doubly-labeled water requires injection of water with both the oxygen and water isotopically-labeled. As the hydrogen is lost only through water and oxygen through both water loss and carbon dioxide production, the difference in turnover rates between marked hydrogen and oxygen can be used to estimate metabolism. BMR will be measured using a flow-through respirometer to measure oxygen consumption. A metabolic chamber for harlequin ducks will be built during FY00 preparations; an oxygen analyzer is on site at the Alaska SeaLife Center. BMR of all birds will be measured throughout the winter, including prior to any dosing to establish background rates.

CYP1A induction of all captive birds will be measured at the end of the experiment by EROD activity, described above. EROD activity will be compared among all treatments.

FY00 effort will include research to determine appropriate dosing regime, preparation of facilities at the SeaLife Center to house birds and conduct experiments, construction of an appropriate metabolic chamber for oxygen consumption measurements, field work to catch birds to establish the first winter's captive flock, and refinement of the experimental design and protocol. Experimental work will commence in early FY01 (fall 2000).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

USGS-BRD personnel will be responsible for directing and conducting sea otter and harlequin duck studies. Dr. Randall Davis of Texas A&M University will be a collaborator and co-principal investigator on the captive sea otter studies, with primary responsibility for the metabolic rate measurements.

Contract with Coastal Resources (Dr. Tom Dean) for sea otter invertebrate prey monitoring component.

Contract with Dr. Paul Snyder at Purdue University for assays of RT-PCR CYP1A, sea otter CYP1A monitoring (WPWS population and captive sea otters at ASLC).

SCHEDULE

A. Measurable Project Tasks for FY01

Sea Otters

December-March:	Coordinate and plan aerial surveys, carcass collections, capture and captive experiments, community involvement, prepare equipment. Obtain marine mammal permit for Alaska SeaLife Center experiments.
April:	Collect carcasses for survival estimates; capture 2 otters for initial Alaska SeaLife Center work.

Collection of beach-cast carcasses for survival estimates.

May-July: Acclimation of sea otters to captivity; initial testing of heart rate data logger to validate methods.

July: Aerial surveys of sea otters in PWS.
Capture of sea otters in WPWS for biosampling, to monitor CYP1A.
Capture remaining 4 otters for Alaska SeaLife Center work.

Aug-Sept: Acclimation and initial experiments with heart rate data loggers in captive sea otters.

Harlequin Ducks

Oct-March: Conduct studies of captive flock at the Alaska SeaLife Center, with birds captured during late FY00.

November: Capture harlequin ducks for field studies of survival and CYP 1A. induction.

Nov-March: Monitor radioed birds for survival study.

March: Surgically biopsy livers of captive birds for EROD activity; after a recovery period, birds will be released at the original capture site.

April - August: Prepare for field studies (e.g., order radios, contact boat charter operators, build winter trap, contact biosample contractors, etc.).

Prepare for year 2 captive bird studies (coordinate with Alaska SeaLife Center personnel, determine year 2 dosing regime, arrange boat and air charters, etc.).

August - Sept.: Capture birds during wing molt for creation of year 2 captive flock and initiate adjustment period.

B. Project Milestones and Endpoints

This is a projected five-year research and monitoring program (initiated FY99, with completion of all objectives by FY03; see below) designed to assess the recovery of two injured species. Project objectives will be assessed annually. At the end of each year results will be compared with the restoration goals to assess whether recovery has occurred. The reporting schedule is described below, and is consistent with EVOS Trustee Council guidelines.

Sea Otters

FY01-03: Field studies (aerial surveys, carcass surveys, CYP1A monitoring) are scheduled to occur from April through July, 2001. Aerial surveys will be repeated in the summers of 2002 and 2003, and sea urchin monitoring is scheduled for the summer of 2002. Carcass surveys and CYP1A monitoring will be repeated in April and July 2002, if warranted based on previous years of data. Captive sea otter experimental work is scheduled for April 2001 through April 2002.

Harlequin Ducks

FY01-03: Field studies are scheduled to occur from November through March, winters 2000-01, 2001-02, and 2002-03. Captive bird experimental work is scheduled for winters 2000-01 and 2001-02.

C. Completion Date

All project objectives will be met by FY03.

PUBLICATIONS AND REPORTS

Annual reports will be presented to the Chief Scientist by April 15. An annual report of FY01 activities will be submitted to the Restoration Office on or before 15 April 2002. A final report will be prepared at the end of the proposed work unless continued monitoring is warranted or when recovery objectives are met. Special reports (publications) will be prepared during the course of the study if warranted. Publications will be prepared for peer-review journals when sufficient data have been collected.

PROFESSIONAL CONFERENCES

D. Esler attendance at 2nd North American Duck Conference, 11-15 October, Saskatoon, Saskatchewan, to present a paper entitled, "Harlequin Ducks and the *Exxon Valdez* Oil Spill: Collision of a Sensitive Life History and a Major Anthropogenic Perturbation." B. Ballachey attendance at Environmental Toxicology and Chemistry meeting, session: "Effects and Trends of Contaminants in Marine Mammals", 12-16 November 200, Nashville, TN, to present on comparison of techniques for measuring cytochrome P4501A in sea otters exposed to petroleum hydrocarbons.

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

As described in the Introduction, this research relies on incorporation of data from other Trustee sponsored research, including projects /025 and /427. Equipment and commodities purchased under /025 will be used to conduct the proposed research and data collection and analysis will follow previously established protocols and standards.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

In 1998, the EVOS Trustee Council first approved funding for Restoration Project 99423, "Patterns and Processes of Population Change in Sea Otters", an extension of the NVP project. The objectives of the project included sea otter aerial surveys of PWS, replicate surveys of sea otters at Knight and Montague Islands and sampling of sea urchin populations. In 1999, the Trustee Council approved the addition of harlequin duck studies to 00423 with the revised project title "Patterns and Processes of Change in Selected Nearshore Vertebrates". Those studies included relating harlequin survival to oil exposure and captive studies to assess responses to controlled oil exposure. In February 2000, the Trustee Council approved an amendment to 00423, to fund carcass recovery surveys in WPWS, to collect data on sea otter ages at death for estimation of survival rates.

Differences in this 01423 proposal from projections in the 00423 proposal include increases in salary: three additional months for Dan Esler, PI on the harlequin ducks studies (as per correspondence of July 1999, D. Bohn and S. Schubert), to more accurately reflect the time needed to supervise and conduct this research, and one month for Tom Dean, PI on the sea urchin component, to support data analyses and interpretation, and preparation of the annual report.

The 01423 proposal also includes two new components not included in 00423. These components include a sea otter biomarker (CYP1A) monitoring component and an Alaska SeaLife Center component to evaluate biomarker and metabolic responses to controlled oil exposure for sea otters. In addition, the carcass recovery surveys, approved as an amendment to 00423, are proposed again for 2001.

Each of the components and their associated costs are identified in the following table. Each component is largely independent of the others, although minor revisions to the budgets might be required if all components are not funded. Within the excel budget, line items are coded to provide greater detail in the cost of each component. The codes are as follows:

ss = sea otter surveys (previously approved)
sb = sea otter biomarkers
sw = sea otter carcass surveys (approved as an amendment for FY00)
hd = harlequin duck field and captive studies (previously approved)
su = sea urchins

ssl = sea otter Alaska SeaLife Center experiments

The proposal has been prepared to allow the reader to consider each new component with its associated budget independently. A breakdown of the budget by the various project components is presented below:

Table 1. Summary of 01423 study component costs (**so survey** [sea otter] and **hadu** [harlequin] components were previously approved). Remaining components (so biomarker, so carcass, sea urchins and so sealife center) are new and may be considered independent of one another and previously approved components.

Category	so surveys	hadu	so biomarker	so carcass	sea urchins	so sealife center	Totals (K)
Personnel	36	112	21	0			169
Travel	4.5	5	5.2	1.5			16.2
Contracts	17.6	84.5	32.5	12	7.2	94.6	248.4
Commodities	0	23.2	5	0			28.2
Equipment	0	0	1	0			1
Subtotal	58.1	224.7	64.7	13.5	7.2	94.6	462.8
General admin.							42.7
Total							505.5

PROPOSED PRINCIPAL INVESTIGATORS

James Bodkin
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, Alaska 99503
PHONE: (907) 786-3550
FAX: (907) 786-3636
james_bodkin@usgs.gov

Dan Esler
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
PHONE: (907) 786-3485
FAX: (907) 786-3636
daniel_esler@usgs.gov

Tom Dean
Coastal Resources Associates, Inc.
1185 Park Center Drive, Suite A
Vista, CA 92083
PHONE: (760) 727-2004
FAX: (760) 727-2207
coastal_resources@compuserve.com

Brenda Ballachey
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, Alaska 99503
PHONE: (907) 786-3512
FAX: (907) 786-3636
brenda_ballachey@usgs.gov

Dr. Randall Davis
Dept. Marine Biology
Texas A&M University at Galveston
Galveston, TX 77553
PHONE: 409-740-4712
FAX: 409-740-5002
davisr@tamug.tamu.edu

PRINCIPAL INVESTIGATOR QUALIFICATIONS

Jim Bodkin, Research Wildlife Biologist, and team leader for coastal ecosystem in Alaska for the Alaska Biological Science Center of USGS, Biological Resources Division. He has over 20 peer-reviewed scientific publications and directs an active coastal marine research program. He has studied and published on sea otter foraging ecology and community structuring since 1988 and has been principal investigator for sea otter survey methods development. He earned a M.S. from California State Polytechnic University in 1986.

Dan Esler is a Research Wildlife Biologist with the Alaska Biological Science Center, USGS Biological Resources Division. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 11 years. Since 1995 he has served as project leader for harlequin duck studies as part of the EVOSTC-sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A & M University in 1988 and is currently enrolled as a doctoral candidate at Oregon State University. He has authored over 20 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird conservation.

Thomas A. Dean is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista CA. Dr. Dean has over 20 years of experience in the study of nearshore ecosystems, and has authored over 25 publications, including several dealing with impacts of the *Exxon Valdez* oil spill on subtidal populations of plants and animals. He has extensive experience in long-term monitoring studies, and has played a major role in both intertidal and subtidal EVOS investigations since 1989. Dr. Dean is currently a co-principal investigator for the Nearshore Vertebrate Predator Project (NVP), and is examining the relationships between prey abundance and the recovery of sea otters, river otters, harlequin ducks, and pigeon guillemots.

Brenda Ballachey is a Research Physiologist at the Alaska Biological Science Center of USGS, Biological Resources Division. She was Project Leader for sea otter NRDA studies from 1990 through 1996, and has been involved in all aspects of post-spill research on sea otters, including the Nearshore Vertebrate Predator (NVP) project, with primary responsibilities for examining effects of residual oil on biomarkers and health of sea otters and other NVP study species. She received her M.S. in 1980 at Colorado State University, and Ph.D. in 1985 Oregon State University. She has authored or coauthored over 25 peer-reviewed publications.

Randall Davis, Ph.D., specializes in the physiology and metabolism of marine mammals. He is a Professor of Marine Biology at Texas A&M University and has worked in this field for over 20 years. In 1989, Dr. Davis was the Project Leader for Exxon's Oiled Sea Otter Rehabilitation Program in Prince William Sound.

KEY COOPERATORS

Sea Otters

Daniel Monson
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
PHONE: (907) 786-3449
FAX: (907) 786-3636

daniel_monson@usgs.gov

Paul W. Snyder, DVM, PhD.
Department of Veterinary Pathobiology
Purdue University
West Lafayette, IN 470907-1243
PHONE: (765) 494-9676
FAX: (765) 494-9830
pws@vet.purdue.edu

Collaboration on instrumentation of sea otters with the heart rate and temperature data loggers (a letter of collaboration from Dr. Butler to Dr. R. Davis re: collaboration on this project component is on file and available if needed):
Drs. P.J. Butler and A.J. Woakes
School of Biosciences
University of Birmingham
Birmingham, UK
PHONE: (0)121 414 5470
FAX: (0)121 414 5466
p.j.butler@bham.ac.uk

In addition, there are several PhD students and Research Assistants in the Davis laboratory at Texas A&M University who also will participate on this project.

Harlequin Ducks

Kim Trust
U. S. Fish and Wildlife Service
Ecological Services
605 W. 4th Avenue, Room G62
Anchorage, AK 99501
(907) 271-2783
kim_trust@mail.fws.gov

Daniel Mulcahy, DVM, PhD.
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3451
daniel_mulcahy@usgs.gov

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel	$19.3	$169.0						
Travel	$4.6	$16.7						
Contractual	$30.8	$246.2						
Commodities	$1.2	$29.2						
Equipment	$0.6	$1.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$56.5	$462.1			Estimated FY 2002	Estimated FY 2003		
General Administration	$3.5	$42.6						
Project Total	$60.0	$504.7			$477.2	$250.0		
Full-time Equivalents (FTE)		2.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
J. Bodkin (ss)	Research Wildlife Biologist	GS 13-4	1.5	7.2		10.8
D. Monson (ss)	Research Wildlife Biologist	GS 9-02	6.0	4.2		25.2
B. Ballachey (sb)	Research Physiologist	GS 12-4	3.0	7.0		21.0
						0.0
D. Esler (hd)	Research Wildlife Biologist	GS 12	9.0	6.8		61.2
K. Trust (hd)	Biologist	GS 11	2.0	5.3		10.6
Biotechnician (hd)	Biotechnician	GS 7	8.0	3.3		26.4
D. Mulcahy (hd)	Veterinarian	GS 13	1.0	6.0		6.0
Biotechnician (hd)		GS 5	3.0	2.6		7.8
						0.0
						0.0
						0.0
	Subtotal		33.5	42.4	0.0	
					Personnel Total	$169.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Anch/Cord/Anch (ss)	0.3	5	30	0.1	4.5
Field crew/gear to Whittier (sb/sw)	0.1	10	20	0.1	3.0
Boat transportation to Whittier (sb)	0.7	1			0.7
ASLC- Seward (ssl)			30	0.1	3.0
					0.0
Esler - Seward (hd)			25	0.1	2.5
Field crew/gear to Whittier (molt) (hd)	0.5	1			0.5
Field crew/gear to Whittier (winter) (hd)	0.5	1			0.5
Meetings (1 hd, 1 so)					2.0
					0.0
					0.0
					0.0
				Travel Total	$16.7

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:		Proposed
Description		FY 2000
Aircraft charter 80 hrs @ 220/hr (ss)		17.6
Cytochrome P450 assays, Purdue University - 58 @ $125 (sb, ssl)		7.25
4A Linkage #1	Coastal Resources Associates (su)	7.2
4A Linkage #2	Texas A&M University (ssl)	94.6
Blood assays, CCL Portland - 60 @ $50 (24 - ssl, 30 - sb)		3.0
Charter vessel, sea otter beach walks - 10 days @ $1200 (sw)		12.0
Charter vessel, sea otter capture - 15 days @ $1200 (sb)		18.0
Aircraft charter - transport otters to Seward - 8 hours @ $250 (sb)		2.0
Doubly-labelled water assays - 20 @ $350 (hd)		7.0
EROD activity - 70 @ $140 (hd)		9.8
Charter vessel, duck capture (late summer) - 9 days @ $1500 (hd)		13.5
Aircraft charter - transport birds to Seward - 10 hours @ $250 (hd)		2.5
Charter vessel (winter) - 21 days @ 1150 (hd)		24.2
Plumage swab analysis - 50 @ 100 (hd)		5.0
Air charter - survival monitoring - 90 hrs @ $250 (hd)		22.5
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$246.2

Commodities Costs:	Proposed
Description	FY 2001
Misc field/office supplies (sb - 3.0, hd 1.0)	4.0
Fuel (sb)	2.0
Vet supplies (hd - 3.5, ssl - 1.0)	4.5
Oxygen consumption materials (hd)	1.0
Biosampling materials (hd)	0.8
Kayak rental - 6 @ $150 (hd)	0.9
Molt trap maintenance (hd)	0.5
Captive flock maintenance - 6 months @ $450 (hd)	2.7
Winter trap maintenance (hd)	0.5
Radio transmitters - 50 @ $225(hd)	11.3
Metabolic chamber materials (hd)	1.0
Commodities Total	$29.2

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3B
Contractual & Commodities
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2000
Equipment maintenance and repair (sb)			1.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$1.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001
Personnel		$4.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$4.0
Indirect		$3.2
Project Total	$0.0	$7.2
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments: COASTAL RESOURCES INC.
Indirect costs calculated as follows:
Indirect costs = Overhead + General and Administrative costs + Fee
Overhead = 59.5% of personnel costs
G&A = 12.85% of personnel + overhead + other direct (excluding contractual)
Fee = 4% of Total Direct + Indirect (excluding contractual)

No overhead or fees are charged on contractual costs

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS --contract to Coastal Resources, Assoc.

FORM 4A
Non-Trustee
~~SUMMARY~~

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	T. Dean	Biologist	0.5	8.0		4.0
	Indirect costs					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	0.5	8.0	0.0	
					Personnel Total	$4.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$0.0

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Personnel & Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001
Personnel		$27.1
Travel		$37.5
Contractual		$0.0
Commodities		$13.9
Equipment		$0.0
Subtotal	$0.0	$78.5
Indirect		$16.1
Project Total	$0.0	$94.6
Full-time Equivalents (FTE)		1.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments: TEXAS A & M indirect costs on funds received from federal agencies: 22% flat rate.

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--contract to Texas A&M University

FORM 4A
Non-Trustee
~~SUMMARY~~

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	R. Davis	Principal Investigator	1.0	7.5		7.5
	Vacant	Graduate Research Assistant	6.0	1.2		7.2
	Vacant	Graduate Research Assistant	6.0	1.2		7.2
						0.0
	Fringe Benefits:					0.0
	R. Davis		1.0	1.6		1.6
	Vacant (student)		6.0	0.3		1.8
	vacant (student)		6.0	0.3		1.8
						0.0
						0.0
						0.0
						0.0
		Subtotal	26.0	12.1	0.0	
					Personnel Total	$27.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	Houston-Anchorage	0.8	4	198	0.1	23.0
	(note: per diem is actually projected at 396 days at $50.00/day but entered as above because of rounding of $ values in spreadsheet)					0.0
	UK-Anchorage (cooperators: P.J. Butler and A.J. Woakes)	1.7	2	63	0.1	9.7
	Car rental			48	0.1	4.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$37.5

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--Texas A&M Univ. contract

FORM 4B
Personnel & Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2001
Heart rate data loggers	5.0
Expendable supplies and chemicals	8.0
Shipping	0.3
Telephone	0.6
Commodities Total	$13.9

FY01

Prepared: April 14, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--contract to Texas A&M Univ.

FORM 4B
Contractual
&
Commodities

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:		Number	Unit	Proposed
Description		of Units	Price	FY 2001
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.			**New Equipment Total**	$0.0

Existing Equipment Usage:		Number
Description		of Units

FY01

Prepared: April 14, 2000

Project Number:
Project Title:
Name:

FORM 4B
Equipment
DETAIL

Project Number: 01430

Restoration Category: Habitat Restoration and Monitoring of the Kenai River and Russian River

Proposer: Youth Restoration Corps

RECEIVED
APR 14 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Lead Agency: USFS

Cooperating Agency: ADEC, ADF&G, USFS, NOAA, USFWS

Duration: Nov 1, 2000 through Oct 30, 2001
The request is for the 1st year of a 2 year restoration project.

Cost FY 01: $ 53,500.00

Geographic Area: Kenai Peninsula River systems located in the Chugach National Forest on the Kenai Peninsula

Injured resources: Sockeye Salmon, Pink Salmon, Dolly Varden, Cultural Resources, Recreation

ABSTRACT

The Kenai Peninsula provides unlimited resources to those living here as well as those visiting this pristine area. An estimated two hundred & sixty thousand fishermen walk the riverbanks of the Kenai and Russian Rivers annually *(according to records ADF&G)*. This excessive use has caused the deterioration of the protective vegetation, resulting in bank erosion, widening of the river channel, and degradation of fish habitat.

Youth Restoration Corps will provide 16-19 year-old youth, hands-on training in riparian ecosystems, and work experience using a variety of bio-restoration techniques. The program emphasizes the use of low cost locally available, natural materials and implements a variety of techniques that can be used on sites that are accessible only by foot.

By the conclusion of this project, 1600 lineal feet of riverbank along the sanctuary of the Kenai and Russian River and along the Kenai River at the Kenai River Center will be restored and monitored to ensure stability.

INTRODUCTION

Youth Restoration Corps was established as a non-profit in March 1997. Its primary mission is to restore critically damaged habitat in identified areas with the help of youth. As a result of these efforts, habitat is restored, and youth are educated about natural resources, restoration and aquatic life. Through this hands-on approach between YRC and other participating state agencies, the youth become environmental stewards for future generations.

Through the cooperating efforts of various state agencies, Youth Restoration Corps (YRC) has been able to restore over 4,900 lineal feet on the Kenai River, Russian River and Little Susitna River since its inception.

YRC received $20,000 of EVOS funding in FY00 through the AK. Dept of Fish and Game that was used to restore part of the 1905 lineal feet YRC restored along the Russian River.

YRC is requesting funds form EVOS for FY2001, however, YTC will be submitting a second proposal for funds to be used in FY 2002. FY2001 funding from EVOS will be used to partially finance three different entities within YRC; two restoration programs and one monitoring/public user education program

1. *"YRC Upper Kenai River Restoration Program"* – which is located in the National Wildlife Refuge at the confluence of the Kenai and Russian Rivers.
2. *"YRC Peninsula Rivers Restoration Program"* – which is located on the Kenai Peninsula Borough at the Kenai River Center, just on the outskirts of Soldotna.
3. *"Kenai River Stream Watch Program"* - which is designed to protect, maintain, and help monitor previously restored stream bank through education of the public users and fencing to restrict use or recently restored areas until the sites are completely stabilized.

The focus of the two restoration programs is to annually stabilize stream banks and riparian habitat in the Kenai River Special Management Area that has been identified by the Alaska Department of Fish and Game as critical.

NEED FOR THE PROJECT

A. Statement of Program

The Kenai River system supports natural populations of Chinook, Coho, Sockeye, Chum and Pink salmon populations, as well as healthy native Rainbow Trout and Dolly Varden populations. This premier fishing destination is ideal for boating and bank fishermen as well as hiking enthusiasts. Currently, this system supports a commercial salmon fishing industry and a robust sport-fishing industry with an economic income of 75 million dollars annually. The proximity to the metropolitan areas of Anchorage coupled with good road systems, airport accessibility and adequate public facilities, has resulted in an increased public use.

In 1997, the Alaska Department of Fish & Game estimated 757,000 anglers purchased fishing licenses in South Central Alaska. This increased pressure has caused the department concerns,

thereby closing 12 miles of riverbank to bank fishing in order to protect the riparian habitat of the Kenai River and its tributaries. The decimation of the area is visually clear: increased foot traffic has resulted in eroded banks, litter, waste, unsanctioned campsites and foot trails that have destroyed natural vegetation, Destroying the riparian habitat and threatening aquatic life and bank stability. With an annual population of 62,000 residents on the Kenai Peninsula, the popularity of this river system has grown 10 fold in the past ten years, and is expected to continue growing.

B. Rationale/ Link to Restoration

The Kenai River drainage system originates from the Kenai Lake in the Chugach National Forest on the Kenai Peninsula. From here, the river travels 82 miles to discharge into Cook Inlet in south central Alaska. The Kenai River is bordered by Chugach National Forest and managed by U.S Forest Service, the U.S Fish & Wildlife, and the National Wildlife Refuge. It flows through the City of Kenai, the City of Soldotna, the Kenai Peninsula Borough, tribal lands, and through numerous private parcel of lands. It is managed as a state park from its headwaters to the Cook Inlet.

Since 1995, the AK Dept. Fish & Game and cooperating agencies have conducted habitat and erosion studies on the Kenai River and its tributaries to determine the rate and causes of damage to the riparian habitat and to set up protection measures to protect them from further damage. Consequently, 13.5 miles of critically impacted land on the peninsula river systems have been identified. In 1999, agency representatives from the Chugach National Forest, the AK Dept. Fish & Game, and the US Forest Service and the YRC Director selected and designed projects for restoration on the Kenai River. As a result, 1905 lineal feet riverbank was restored along the Russian and Kenai river systems. If restoration efforts do not continue, the destruction of natural fish habitat by human contact will continue, reducing the runs of salmon back into the river. Without monitoring efforts to oversee restoration efforts, there is no assurance that the restoration work will not damaged, nor will there be time for the vegetation to secure itself without human contact.

Additionally, the peninsula river systems have been a source of subsistence living for the Dena'ina, Salamatof and Kenaitze Indian tribes. Archeological barabara sites discovered along the river systems demonstrate that this area has served as a place where Natives traditionally obtained their summer's catch of fish for the winter. These historical sites are in danger of being destroyed without protective monitoring measures.

YRC's FY01 restoration efforts of the project area will include 1,800 lineal feet of re-vegetated riverbank with native species of plant life, root wand, and coirlog structures. It is estimated that semi-growth of willows will take approximately 24 months to secure. Temporary fencing will be installed around the newly restored areas to avoid disruption. FY02 proposal includes final restoration of FY01 footage, fencing and monitoring of the project areas by the Stream Watch Program.

C. Location

The specific site areas of the *Upper Kenai Restoration Program* and the *Peninsula River Restoration Program* will be determined and designed by YRC and AK. Dept. of Fish and Game in August, 2000.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

YRC's community involvement is the key ingredient that has made the program so successful. Presently, all board members represent diverse educational and business backgrounds. They have lived in the community for a significant length of time, and all maintain a strong commitment to the community. The YRC director, who envisioned the YRC concept, is an avid fisherman and has lived in the area for 20 years.

Presently, the YRC Board of Directors are:

- Kelly Wolf, Chair; Alaskan resident for 24 years; retired general contractor; 6.5 years in habitat restoration.
- Bob Scott, Vice-Chair; Alaskan resident for 63 years; CEO of Salamatof Seafoods;
- Jim Segura, Secretary/Treasurer; life-long Alaskan resident; President of Salamatof Native Association.
- Dan Krogseng, life-long Alaskan resident; general contractor, President of A.A. Dan's Construction, Inc.
- Ron Swanson, 54 year Alaskan resident; owner of Ron's Oil Field Service/Equipment Rental Company.
- Gaye Dawkins, 25 year Alaskan resident; Kenai Branch Manager for First National Bank of Anchorage.

YRC solicits youth for the project by contacting local high schools each spring. Twelve youth are chosen for their commitment and enthusiasm to restoration and are paid $7.00/hr. Presently, 10-15% of the participating youth are Alaskan Natives. Group leaders accompany the youth on project sites and are hand selected based on education, experience and ability to work with teenage youth. They receive an hourly wage of $12/hr. All youth and group leaders receive training on habitat restoration, aquatic life, and archeological preservation. YRC utilizes a soil scientist representative from the Chugach National Forest to teach the youth about restoration methods. A biologist from the AK Dept. of Fish and Game to educate the youth about aquatic life; and a representative from the US Fish and Wildlife to teach youth about the archeological history of the area. At the completion of the program, YRC sponsors a Youth Appreciation Day and awards one youth a $500 scholarship to advance their education. Community members, legislative and local lawmakers are invited as well as representatives from all supporting agencies.

Each YRC program requires public support and sponsorship. Each year, YRC produces a video that demonstrates YRC's restoration and educational efforts. The video is shown on Exploring Alaska's Outdoors which airs Sunday's @ 4:00 PM on ABC statewide. Through this media coverage, YRC has developed strong Alaska congressional support from Senator Ted Stevens who was in the YRC Little Susitna Video in 1999.

YRC has received several commendations which emphasizes its community involvement including:

- July 1998- Legislative Citation from the Alaska 20th State Legislature;
- May 1999-National Rise to the Future Award, Washington, D.C.;
- February 1998-Spirit of the Youth Award, presented by Lt. Governor Fran Ulmer;
- April 2000-1998 Acknowledgement commending the programs efforts from the first lady Mrs. Hillary Rodham Clinton.

PROJECT DESIGN

A. Objectives

YRC Upper Kenai River Restoration Program - FY2001

1: Restore 1,600 lineal feet of riparian habitat utilizing 12 youth per project site and provide monitoring of the restored areas.

2: Document 20% of youth time receiving education on restoration methods.

3: Document 20% of youth time receiving education on aquatic life.

4: Document 10 hours of archeological education to YRC youth.

5: Document 1,500 public contacts and 300 volunteer hours through the June 12th through August 15th fishing season to educate the public on restoration practices.

6: Document 1,500 contacts with school age youth receiving education on restoration practices and aquatic life through video distribution.

YRC Peninsula Rivers Restoration Project - FY2001

1: Restore 800 lineal feet of riparian habitat utilizing 12 youth per project site and provide monitoring of restored areas.

2: Document 20% of youth time receiving education on restoration methods.

3: Document 20% of youth time receiving education on aquatic life.

4: Document 5 hours of archeological education to YRC youth.

5: Document 5 hours of water quality education to YRC youth.

6: Document 300 volunteer hours involving monitoring and 1,500 public contacts to anglers during the fishing season.

7: Document 1,500 contacts with school age youth receiving education on restoration practices and aquatic life through video distribution.

B. Methods

The Kenai River vegetation contains many different types of plant life. From the ordinary high water (OHW) mark to the topside of the riparian zone, the vegetation consists of overhanging grasses, mainly Blue Joint. Woody plant life includes willows, alders, and mature cottonwood and spruce trees. In developing this restoration project, we will be using many of these types of native plants to restore riverbanks. Due to the composition of soil and rock that comprise the base of these riverbanks, the likelihood of erosion increases when natural events like above

OHW levels occur or man's impact on the vegetative habitat of the Kenai River damages the drainage system and its tributaries.

The shoreline vegetation provides a number of functions that helps keep our river systems healthy, including providing habitat and food for wildlife, bank stabilization, and the filtering of surface runoff. Consequently, repairing and maintaining the riparian habitat is an important element of the ecosystem. A terrestrial and aquatic monitoring program, which included transacts, was established in 1996 and 1998 as a baseline to record changes in plant community composition cover and fish habitat. These sites will be inventoried yearly to determine the restoration value of the different techniques being used on the Kenai River System. This information may be used by state and federal agencies to better improve restoration practices in South Central Alaska.

These methodologies for restoration were chosen because they compliment the existing composition of soil and vegetation, and are indigenous to the area and have been approved by the Alaska Department of Fish and Game. Past experience with these methodologies has resulted in successful restoration.

Restoration techniques

- Restoration work will consist of planting dormant and live willows.
- Sod layering will be developed above OHW to quick-start new vegetation growth. These sod pieces are extremely valuable as they are made up of native species of plant material, such as Blue Joint (Calamagrostis Canadenis), which form tussocks of creeping rhizome roots develop and spread over an area up to 6 square feet.
- Soil or dirt bags made of untreated burlap material filled with soil will be used to reform riverbanks in an irregular fashion similar to a natural riverbank. The U.S. Soil and Water Conservation Corps first used these techniques in Wisconsin in the late 30's and early 40's. It was proven to be very successful as a low-impact restoration method.
- Erosion mats will cover all exposed soils, helping to provide better germination of the grass seed spread throughout the entire project.
- Root wad structures (tree stumps) placed on their side will be used to deflect the hydraulic energy flow of the river and also provide habitat. These are commonly used in areas that high a rate of bank erosion is occurring. Until last year, root wad structures had never been installed with out the use of heavy equipment.
- Coirlogs, made of coconut material will be used to establish base toes for restoration projects. They look similar to a large worm, are 12"x 20' in size, and weigh approximately 120 pounds.
- Haylogs, a new product on the market and approved by the Kenai River Center, will be used on the terraces on the Kenai River sanctuary project.

General Specifications for YRC Restoration Projects

These specifications have been developed over the past four years to assure successful project outcomes.

1. All erosion fiber mats shall touch the mineral soil and be stapled firmly to the ground to ensure no slippage or movement. Fiber mats will be anchored under existing vegetation where possible and around the edges.

2. Rooted transplants shall consist of a mixture (depending on availability) of alder, birch, aspen, and cottonwood. They shall be planted in the designated location within 36 hours of the time they are extracted from their original site. They will be covered to keep moist until they are planted. It would be preferred that they be planted immediately after they are pulled or that they are packed in sawdust or peat until they are planted. Care shall be taken to retain as much soil as possible around roots when they are removed for transplanting. These plants shall be longer no than 10 inches in height above ground and shall have a majority of their original root mass when they are planted.
3. All rooted transplants shall be planted at about an 18 inch spacing, except in hedge layers or unless specified differently in the site specifications.
4. Construction of all log terraces shall start at the bottom of the slope.
5. All terraces shall consist of a log that ranges from six to ten inches in diameter laid horizontally across the slope staked with wooden 2x2x36 inch stakes on the lower side to tightly hold it in place. If wooden stakes will not penetrate the soil because of rocks ½" re-bar may be used. The metal stakes can be inserted in notched holes on the side of the logs. The logs should be trenched into the soil slightly for better attachment. There shall be a minimum of two stakes per terrace and one stake for an average of every five feet of log when they are longer than 10 feet. The tops of the stakes shall be cut off flush with the top of the log. All proposed terraces shall be identified on photographs and located on the ground by the agency representative
6. Back filling terraces shall consist of using mineral soil so the finished product will be level from the top of the log barrier to the adjacent up-slope. Sites have been designated where extra mineral soil may be obtained if there is not enough on site.
7. All hedge layers shall have from 15 to 20 plants per yard of a mixture of willow, cottonwood, alder, birch, and aspen. Up to 50% of the plants may consist of non-rooted cuttings. The plants shall be placed so the roots are buried in mineral soil behind the logs and the tops extend out over the top of the logs.
8. The cuttings shall be from either cottonwood (*Populus balsamifera* or *trichocarpa*) or willow (*Salix alaxensis* or *comutata*). The agency representative shall identify collection sites. The cuttings shall be between ½ to 2 inches in diameter and from 2 to 6 feet long when collected. They can be cut to size at the time of installation. At least ¾'s of the total length of each cutting shall be buried in mineral soil. They shall have at least two buds exposed on the upper ¼ of the stem. A piece of re-bar (1/2-3/4 inch) can be driven into the soil to make a hole for the cutting. The soil then shall be packed around the cutting and watered to assure good soil contact with plant. Dormant cuttings shall be cut when the temperature is below 31 degrees Fahrenheit and refrigerated or stored under the snow where it is damp until installation. Cuttings that are stored in the snow should be wrapped in a tarp with the ends left open to reduce the potential of mold.
9. Only enough stored cuttings shall be removed from cold storage, which can be installed in a 24-hour period. The cuttings shall be soaked in the river for a minimum of eight hours before planting.
10. Restoration sites will be temporarily fenced around the entire perimeter, including the water edge, to keep the public out.
11. The cuttings will be monitored throughout the summer to determine if they need watering. Watering may be done by use of a pump and screened inlet water from the Russian River. All watering will be done to provide moisture deep enough in the soil to retain the soil moisture.

12. The soil will be seeded at the rate of ¼ pound /1000 sq. ft. under all fiber mats. The ADF&G approved sites will also be fertilized at a rate of 1 pounds /1000 sq. ft. with 8-32-16 fertilizer per ADF&G requirements.
13. Dirt bags will consist of a biodegradable untreated burlap material filled with topsoil, associated plants, and organic debris. Those that are above ordinary high water levels will have some grass seed and willow cuttings placed in them to stabilize the soil with roots once the bag has degraded.
14. Spruce tree cabling, cut green spruce trees (base diameter 3" to 4") are cabled to the riverbank tightly as to avoid movement from water flow. This method provides stabilization and temporary habitat protection for juvenile salmon.

C. Cooperating Agencies, Contacts, and Other Agency Assistance

YRC's restoration efforts are a joint collaboration between existing agencies. Duties and responsibilities include:

Chugach National Forest (USFS)
Mr. Dean Davidson (Soil Scientist)
3300 C St. 3rd floor Suite 300
Anchorage, Alaska 99503
(907) 271-2537

Chugach National Forest will provide a soil scientist who will provide a class on bio-restoration to participating youth (hydrology, ecology and fauna education).

Karen Kromrey
Seward Ranger District
P.O. Box 390, Seward AK. 99664
(907) 224-3374

Chugach National Forest's Stream Watch Program will provide trained volunteers to monitor and project the current restoration efforts along the river.

Aquatic Education Coordinator
Mr. Fritz Kraus (Education Fishery Biologist)
Alaska Department Fish & Game
333 Raspberry Rd
Anchorage, Alaska 99518-1599
(907) 267-2265

ADF&G will provide a biologist to educate the youth on the life cycle and migration patterns of salmon and basic aquatic education.

Permit Center
Kenai River Center
Mr. Gary Liepitz (Habitat Biologist for ADF&G)
36130 Kenai Spur Hwy
Soldotna, Alaska 99669
(907) 260-4882

The Kenai River Center will provide information and education on outreach on habitat restoration to participating YRC youth.

U.S Fish & Wildlife Service
Mr. Bill Kent
P.O Box 2139
Soldotna, Alaska 99669
(907) 262-7021

The U.S. Fish and Wildlife Service will provide archeological resource education to the youth.

AK Dept. Environmental Conservation
Mr. Kent Patrick Riley
555 Cordova St 3rd Floor
Anchorage, Alaska 99501
(907) 269-7554

The Alaska Dept. of Environmental Conservation will provide education to the youth on water quality.

SCHEDULE:
Measurable project task for FY 2001

Nov 1, 2000:	Begin design and planning of YRC projects on the Kenai Peninsula
February 5-12, 2001:	IECA conference in Las Vegas to make a presentation on the restoration methods developed by YRC
April 2, 2001:	Distribute applications to area high schools for youth employment
April 13-15, 2001:	Present a display at the Anchorage Sportsman Show using the videos from pervious years to develop further community support
May 1, 2001:	Youth interviews begin
May 28, 2001:	1st day of the YRC Upper Kenai River Restoration Program
June 18, 2001:	1st day of the YRC Peninsula River Restoration Program
June 22, 2001:	Last day of the YRC Peninsula River Restoration Program
July 13, 2001:	Last day of the YRC Upper Kenai River Restoration Program

Upper Kenai River Restoration Program FY2001

Objective 1: Restore 800 lineal feet of riparian habitat utilizing 12 youth along the sanctuary of the Kenai River.

Start/Completion Dates: June 18, 2001-July 13, 2001

Participating Individuals: Crew of 12 YRC youth, group leaders, YRC Director.

Description: Undercut riverbank will be restored by establishing a rock toe, coirlogs with soil wraps and soil bags from top of toe to top cut of bank. Dormant willow will be layered at top with a spacing of 2"-3" on center. The root wad structures will be placed and anchored by duckbill earth anchors. Riverbank restoration will resemble the soil layers and existing vegetation to as close as possible. Temporary fencing will be put up to allow vegetation to take hold along these restored sites. Disturbance of existing soil will be limited in these areas.

Product: 800 lineal feet of re-vegetated riverbank consisting of native plant species, root wads, and coirlog structures on Kenai Peninsula Borough land.

Responsible Staff: YRC Director

Objective 2: Document 20% of project time towards youth receiving education on restoration methods.

Start/Completion Date: June 18, 2001- July 13, 2001.

Participating Individuals: Crew of 12 youth, group leaders and YRC director.

Description: Participating youth will receive course training on Bio-restoration 101 using techniques approved for habitat restoration projects in Alaska.

Product: This education will quantify general practices used to restore habitat and how habitat works in unity with the environment.

Responsible Staff: YRC Director, Dean Davidson - Soil Scientist for CNF.

Objective 3: Document 20% of project time with youth receiving educational on aquatic life.

Start/Completion Date: June 18, 2001

Participating Individuals: Crew of 12 youth, group leaders and YRC Director.

Description: Participating youth will receive education on juvenile salmon that migrate from the lake and the micro-vertebras that supply the Russian River system with the food source.

Product: The education will bring home the realization that the work the youth are doing is adding real benefit to the ecosystem of the watershed, teaching them environmental stewardship.

Responsible Staff: YRC Director, Fritz Kraus - ADF&G Aquatic Educator

Objective 4: Document 5 hours of education to youth regarding cultural resource protection.

Participating Individuals: 12 YRC youth, group leaders, YRC Director

Description: Provide education on past/present cultures using river systems, archeological sites, and preservation of sites.

Product: This education will demonstrate past/present practices and encourage stewardship of culture.

Responsible Staff: YRC Director, Mr. Bill Kent, US Fish and Wildlife Service

Objective 5: Document 2 hours of water quality education to youth.

Participating Individuals: 12 YRC youth, group leaders, YRC Director

Description: Provide education on water quality to enhance their restoration efforts as it relates to aquatic life.

Produce: This education will demonstrate the impact water quality has on environmental ecosystems.

Responsible Staff: YRC Director, Kent Patrick Riley – AK. D.E.C.

Objective 6: Document 300 volunteer hours and 1,500 public contacts through the June 15th-August 15th fishing season.

Start/Completion Date: June 15th-August 15th, 2001

Participating Individuals: Stream Watch Program volunteers

Description: Train volunteers to meet and educate the public about reducing their impacts while fishing. Maintain temporary fencing around closed areas of streambank.

Product: Protection of habitat and newly restored areas, and education of anglers.

Responsible Staff: YRC Director, Karen Kromrey-Stream Watch Program

Objective 7: Document 2,500 contacts with school age youth receiving education on FY00/01 restoration practices and aquatic life through video distribution.

Start/Completion Date: September, 2001- Nov 1, 2001

Participating Individuals: YRC Director, Kenai River Center, KPB area schoolchildren.

Description: Upon production of video, all YRC sponsors will receive a copy of the video. The video will also be available to schools through the YRC office and the Kenai River Center.

Product: A professional video paid for through YRC funds describing each restoration project.

Responsible Staff: YRC Director

Objective 8: Produce a video for statewide viewing on "Exploring Alaska's Outdoors".

Start/Completion Date: May 2001- Dec 2001

Description: The same video described above will be aired quarterly ABC's Exploring Alaska's Outdoors, which airs statewide on Sundays @ 4:00 PM.

Product: Neilson ratings estimate that 615,000 viewers watch the program annually.

YRC Peninsula Rivers Restoration Program FY2001

Objective 1: Restore 800 lineal feet of riverbank along the Kenai River Center.

Start/Completion Date: May 28, 2001-June 22, 2001

Participating Individuals: Crew of 12 YRC youth, group leaders, YRC Director.

Description: Undercut riverbank will be restored by establishing a rock toe, coirlogs with soil wraps and soil bags from top of toe to top cut of bank. Dormant willow will be layered at top with a spacing of 2"-3" on center. The root wad structures will be placed and anchored by duckbill earth anchors. Riverbank restoration will resemble the soil layers and existing vegetation to as close as possible. Temporary fencing will be put up to allow vegetation to take hold along these restored sites. Disturbance of existing soil will be limited in these areas.

Product: 800 lineal feet of re-vegetated riverbank restored with native plant species, root wads, and coirlog structures on Kenai Peninsula Borough land.

Responsible Staff: YRC Director

Objective 2: Document 20% of youth time receiving education on restoration methods.

Start/Completion Date: May 28, 2001- June 22, 2001

Participating Individuals: Crew of 12 youth, group leaders and YRC director.

Description: Participating youth will receive course training on Bio-restoration 101 using techniques approved for habitat restoration projects in Alaska. This includes explanation of healthy habitat and the soils that border the Russian River and Kenai River systems.

Product: This education will quantify general practices used to restore habitat and how habitat works in unity with the environment.

Responsible Staff: YRC Director, Dean Davidson - Soil Scientist for CNF.

Objective 3: Document 20% of project time with youth receiving education on aquatic life.

Start/Completion Date: May 28 –June 22, 2001

Participating Individuals: Crew of 12 youth, group leaders and YRC Director.

Description: Participating youth will receive education on juvenile salmon that migrate from the lake and the micro-vertebras that supply the Russian River system with the food source.

Product: The education will bring home the realization that the work the youth are doing is adding real benefit to the ecosystem of the watershed, teaching them environmental stewardship.

Responsible Staff: YRC Director, Fritz Kraus - ADF&G Aquatic Instructor

Objective 4: Document 5 hours of education to youth regarding cultural resource protection.

Participating Individuals: 12 YRC youth, group leaders, YRC Director

Description: Provide education on past/present cultures using river systems, archeological sites, and preservation of sites.

Product: This education will demonstrate past/present practices and encourage stewardship of culture.

Responsible Staff: YRC Director, Gary Sonnevil, US Fish and Wildlife Service

Objective 5: Document 5 hours of water quality education to youth.

Participating Individuals: 12 YRC youth, group leaders, YRC Director

Description: Provide education on water quality to enhance their restoration efforts as it relates to aquatic life.

Produce: This education will demonstrate the impact water quality has on environmental ecosystems.

Responsible Staff: YRC Director, Kent Patrick Riley – AK. D.E.C.

Objective 6: Document 300 volunteer hours and 1,500 public contacts through the June 15th-August 15th fishing season.

Start/Completion Date: June 15th-August 15th, 2001

Participating Individuals: Stream Watch Program volunteers

Description: Train volunteers and utilize their time to walk along the rivers and talk with people about reducing their impacts while fishing. Maintain temporary fencing around closed areas of stream bank.

Product: Protection of habitat and newly restored areas, and education of anglers.

Responsible Staff: YRC, Karen Kromrey-Stream Watch Program

Objective 7: Document 2,500 contacts with school age youth receiving education on FY01/02 restoration practices and aquatic life through video distribution.

Start/Completion Date: September, 2001- Nov 1, 2001

Participating Individuals: YRC Director, Kenai River Center, area school children.

Description: Upon production of video, all YRC sponsors will receive a copy of the video. The video will also be available to schools through the YRC office and the Kenai River Center.

Product: A professional video paid for through YRC funds describing each restoration project.

Responsible Staff: YRC Director

Objective 8: Produce a video for statewide view on "Exploring Alaska's Outdoors".

Start/Completion Date: August 2,000-June 2001

Description: The same video described above will be aired quarterly ABC's Exploring Alaska's Outdoors, which airs statewide on Sundays @ 4:00 PM.

Product: Neilson ratings estimate that 615,000 viewers watch the program annually.

C. Completion Date

Objectives and associated tasks for the FY2001 project will be completed by July 23, 2001. We are proposing to continue these projects in FY2002, which will be completed by the close of the fishing season. By the completion of the projects in FY2002, 3200 lineal feet of riparian habitat will be restored. Timelines for completion of FY02 specific tasks will be determined in April 2001.

PUBLICATIONS AND REPORTS

Though no manuscript will be submitted with the completion of the grant, YRC will comply with all requirements for annual reporting as required by the Trustee Council.

PROFESSIONAL CONFERENCES

YRC's budget includes $2,900 in travel to the International Erosion Control Conference, February 5th-10th, 2001 in Las Vegas. Mr. Wolf will make a presentation entitled "Riparian Habitat Restoration". An abstract has already been submitted.

NORMAL AGENCY MANAGEMENT

Not Applicable

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Youth Restoration Corps is a successful program because it depends on the support of other agencies such as CNF, ADF&G, US Fish and Wildlife and the River Watch Program.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

YRC's mission is to promote environmental stewardship through our youth, as well as restore the riparian habitat for future generations to enjoy. Our past experience demonstrates a commitment to the restoration of endangered areas. Our objectives in this proposal are the same as in FY00, with the exception of different project locations within the same river system.

All milestones, endpoints and completion dates were met or exceeded.

PROPOSED PRINCIPAL INVESTIGATOR, IF KNOWN

Kelly Wolf
Executive Director
P.O. Box
Kenai, AK. 99611
(907) 283-1032
(907) 283-4324
yrc@gci.net

PRINCIPAL INVESTIGATOR

Kelly Wolf has been a resident of the Kenai Peninsula for 21 years. He is an avid fisherman and outdoorsman, and believes in the viability of our youth. He has over 20 years of experience in the construction business as a general contractor, specifically 6 years in habitat restoration.

Mr. Wolf will be the principal investigator for overseeing the project objectives and tasks for the entire program, for both requests in FY01 and FY02.

OTHER KEY PERSONNEL

Karen Kromrey, is an employee for the Chugach National Forest, and coordinates the Stream Watch Program in Seward, Alaska.

Dean Davidson, has been a soil scientist for Chugach National Forest, and has participated in YRC's program for the last 4 years. Mr. Davidson will be responsible for providing the youth with a bio-restoration course that covers the essentials of restoration.

Fritz Kraus, a biologist for ADF & G, provides the aquatic education for YRC youth. He has also participated in the program for the past 4 years. He will educated the youth on aquatic life.

Gary Sonnevil is an employee for the US Fish and Wildlife Service, and provides archeological resource education to the public.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$0.0						
Travel		$0.0						
Contractual	$20.0	$50.0						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$20.0	$50.0			Estimated FY 2002	Estimated FY 2003		
General Administration	$1.4	$3.5						
Project Total	$21.4	$53.5			$53.5			
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: Three phase project: stream bank restoration of the Russian River, Stream bank restoration at the Kenai River Center, and the stream watch program.

FY01

Prepared: 4/12, KEH

Project Number: ~~01YRC~~ 01430
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Agency: US Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2000
Name	Position Description					
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2000
Description					
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY01

Prepared:

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Agency: US Forest Service

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2000
Description	
4A Linkage	50.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$50.0

Commodities Costs:	Proposed FY 2000
Description	
Commodities Total	$0.0

FY01

Prepared:

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Agency: US Forest Service

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases:			
Description	Number of Units	Unit Price	Proposed FY 2000
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:		
Description	Number of Units	Inventory Agency

FY01

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Agency: US Forest Service

FORM 3B
Equipment
DETAIL

Prepared:

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$40.0
Travel		$0.0
Contractual		$10.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$50.0
Indirect		
Project Total	$0.0	$50.0
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2002	Estimated FY 2003		
		$50.0			

Dollar amounts are shown in thousands of dollars.

Comments:

FY01

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Name: Youth Restoration Corp (YRC)

FORM 4A
Non-Trustee
SUMMARY

Prepared:

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2000
	Stream watch	Supervisor and crew	1.0	10.0		10.0
	Kenai River	Supervisor and crew	1.0	15.0		15.0
	Peninsiula rivers	Supervisor and crew	1.0	15.0		15.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	3.0	40.0	0.0	
					Personnel Total	$40.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2000
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$0.0

FY01

Prepared:

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Name: Youth Restoration Corp (YRC)

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2000
Video production (Kenai River)	5.0
Video production (Peninsula Rivers)	5.0
Contractual Total	$10.0

Commodities Costs:	Proposed
Description	FY 2000
Commodities Total	$0.0

FY01

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Name: Youth Restoration Corp (YRC)

FORM 4B
Contractual & Commodities DETAIL

Prepared:

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2000
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY01

Project Number: 01YRC
Project Title: Habitat Restoration and Monitoring of the Kenai River and Russian River
Name: Youth Restoration Corp (YRC

FORM 4B
Equipment
DETAIL

Prepared:

Pink Salmon Hatcheries in Prince William Sound: Enhancement or Replacement of Natural Production?

RECEIVED
APR 14 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number:	01440
Restoration Category:	
Proposer:	Alex C. Wertheimer NMFS, Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice NOAA Project Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agencies:	University of AK Fairbanks, Prince William Sound Aquaculture Corporation
Alaska Sea Life Center:	No
Duration:	1st Year, 1-year project
Cost FY 01:	$46,900
Geographic Area:	Juneau and Cordova
Injured Resource/Service:	Pink salmon

ABSTRACT

This project will examine pink salmon production models to determine if hatchery production in PWS enhances or replaces wild production. Pink salmon catches in PWS are at historical highs, with most of the catch produced by hatcheries. A recently published study supported in part by Exxon asserts that >90% of the current production would have been attained by wild stocks in the absence of hatchery production and implies that hatcheries are the cause of decline and lack of recovery of wild pink salmon. This project will critically examine these assertions, determining if historical patterns of abundance or population dynamic models indicate replacement rather than enhancement of PWS pink salmon and consider alternate models.

INTRODUCTION

The Trustee Council considers wild pink salmon in Prince William Sound a resource that was injured by the *Exxon Valdez* oil spill, and that is now recovering from that injury. Total pink salmon production in Prince William Sound is currently at historical highs; catches over the past decade have averaged 27 million fish a year. Over 85% of this production is from a system of large hatcheries. These hatcheries are considered by some to be a tremendous success (Pinkerton 1994; Kron 1995; Smoker and Linley 1997); protection of the hatcheries was one of the highest priorities in the spill response in 1989 (Anon. 1989). However, there has also been concern that hatchery production may have negative impacts on wild pink salmon in Prince William Sound, complicating management and the achievement of escapement goal and reducing productivity (Peltz and Geiger 1992; Geiger 1994; Tarbox and Bendock 1996). A recent analysis sponsored in part by Exxon asserts that >90% of the current production would have been attained by wild stocks in the absence of hatchery production and concludes that hatcheries are the cause of decline and lack of recovery of wild pink salmon (Hilborn and Eggers 2000). These conclusions have far-reaching implications about the status and management of wild pink salmon in Prince William Sound, for restoration of wild pink salmon, and for the Trustee Council's efforts to increase understanding of the processes limiting survival of pink salmon and ecologically related species in Prince William Sound.

NEED FOR THE PROJECT

A. Statement of Problem

Catches of pink salmon in Prince William Sound and in other regions of the Alaska are at record levels. Most (>85%) of the pink salmon caught in Prince William Sound are produced by hatcheries. While some authors attribute the increases in Prince William Sound to hatchery production (Kron 1995; Smoker and Linley 1997), Hilborn and Eggers (2000) argue that the increases in Prince William Sound are reflective of wide scale responses of pink salmon populations to climate change and ocean conditions, and not to hatchery production. They assert that hatchery fish are depressing wild production, and that wild stocks would be capable of producing almost the same number of fish if hatchery fish were not present. They base these assertions on regional comparisons of pink salmon production, analysis of escapement trends, and a population dynamic model incorporating hatchery releases as a parameter limiting wild production. A critical assessment of these conclusions is now central to evaluating status and restoration of wild pink salmon, and understanding the ecosystem processes that limit survival and recruitment of pink salmon.

There are some obvious problems with the Hilborn and Eggers (2000) replacement hypothesis. Catch data time series indicate much larger expansion of catch in Prince William Sound than in other regions in relation to prior historical peaks of abundance (Figure 1); also, Hilborn and Eggers (2000) estimate of wild stock productivity is dependent on returns per spawner that are

far outside the range of observed values in Prince William Sound (Figure 2). However, Hilborn and Eggers do show that observed returns per spawner have declined in Prince William Sound in recent years while increasing in other regions, and that the increased magnitude of hatchery releases is statistically associated with this reduced productivity. Concurrent with the decline in wild stock productivity has been a decline in hatchery survival rates (Figure 5 in Hilborn and Eggers 2000). Two alternate explanations of these declines are competitive interactions of juvenile pink salmon, or changes in the Prince William Sound environment that have resulted in density-independent reductions in survival. Willette et al. (1999) have found that survival of hatchery fish is actually inversely related to numbers released, which may indicate that predator/prey interactions are more important for pink salmon productivity than intraspecific competition. A review of the arguments for enhancement versus replacement of the pink salmon resource must take these issues into account to provide insight into appropriate research priorities and management choices.

B. Rationale/Link to Restoration

In the FY2001 solicitation, the Trustee Council has called for proposals on conceptual models of production of pink salmon, including the examination of historical time series of abundance and the forecasting of recruitment to the fisheries. Such models will contribute to the ability to manage, enhance, or otherwise restore pink salmon in Prince William Sound. This proposal directly addresses these issues, and will attempt to link population dynamic models to process studies of ecosystem function relevant to pink salmon that have been developed by SEA. This issue also is of critical importance in assessing the recovery status of wild pink salmon. Injury to pink salmon was established by NMFS and ADFG research with support of the Trustee Council. The resource is now considered to be recovering, but its restoration may be directly impacted by the types and degree of interactions with hatchery production.

C. Location

This project consists of two parts: an analytical component and a workshop. The analytical component will be carried out in Juneau; the workshop will be in Cordova.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

A major component of this project is a workshop in Cordova to inform the fishing community and other local constituencies about diverse scientific views on the net benefits of hatchery production of pink salmon and their possible effects on wild stock productivity, and to seek their input into research priorities on this issue. The PWSAC will be an active participant in the project, providing workshop logistics. Input will be solicited from SEA project scientists, including scientists from the Prince William Sound Science Center, ADFG, and University of

Alaska, who have been conducting research on factors affecting the production of pink salmon in the Prince William Sound ecosystem. Representatives of the Regional Plan Team, the Cordova Fishermen's Union, and the United Seiners Association will be solicited for participation on the workshop steering committee.

PROJECT DESIGN

A. Objectives

1: Analytical critique of the assertion that most of the hatchery production of pink salmon in Prince William Sound has been a replacement rather than an enhancement of wild productivity.

1.a. Determine statistical correspondence of trends in catch (as an index of abundance) of pink salmon among four regions of Alaska: Southeast, Prince William Sound, Kodiak, and South Alaska Peninsula.

1.b. Determine proportional changes in catch among regions relative to historical peaks in abundance, both including and excluding hatchery production.

1.c. Determine sensitivity of escapement trends to changes in management strategies, and sensitivity of predicted catches to escapement levels.

1.d. Examine sources of bias in H&E model, including measurement error; interpretation of residual error as process error; and double accounting for productivity trends.

1.e. Examine alternate population models, including density independent responses of wild populations to environmental variables and density dependent response to hatchery releases

2: Convene a workshop focused on the issue of enhancement vs replacement of pink salmon in PWS.

2.a. Invite participation from scientists and constituent groups to present the different perspectives on the issue.

2.b. Identify and invite an expert panel of reviewers for the workshop, with the responsibility of producing a report summarizing their reviews, recommendations for research, and management implications of their findings.

3: Synthesize results of analytical component and workshop summary and recommendations into a final report for the Trustee Council.

B. Methods

Historical time series of pink salmon catch will be examined for correlation among four regions of Alaska: Southeast, Prince William Sound, Kodiak, and South Alaska Peninsula. Short-term (annual) variability will be examined using annual catch data; long-term trends will be evaluated by correlating the data smoothed by a ten year running average. Statistical significance of the correlations of smoothed data using adjustments for autocorrelation (Pyper and Peterman 1998). Proportional changes in abundances will be compared among regions relative to previous historical maximums related to climatic regime shifts (Downton and Miller 1998). Proportional changes will be evaluated both for total pink salmon catch (hatchery and wild) and for wild pink salmon.

Trends in escapement of pink salmon in Prince William Sound will be examined on a region-wide and district specific basis. The influence of economic forces (strikes) and improvements in management strategies on escapement trends will be evaluated. The effect of escapement declines in wild stock (whether an artifact of improved management precision or unintentional due to hatchery effects) on catch and production will be quantified using both the Hilborn and Eggers (2000) population model including hatchery interactions, and a simple Ricker model with no hatchery effect.

Sources of bias for the Hilborn and Eggers model will be investigated. Three sources of error will be examined: measurement error; interpreting all residual error as process error or environmental effect; and double accounting for regional trends. Measurement error Two sources of measurement error will be considered: (1) error in determining spawning escapements; and (2) error in allocating hatchery and wild components of the catch. Spawning escapements are based on aerial survey counts and estimation of reed life of spawners. Accuracy and precision of these parameters have been estimated by Bue et al. (1998) and Hilborn et al. (1999). Information on precision and accuracy of catch estimation will be solicited from ADFG. The effect of measurement error of spawning abundance on model parameters will be estimated using the methods of Ludwig and Walters (1981). Measurement error in both catch and spawner data is more problematic (Quinn and DeRiso 1999); for this analysis, we will be limited to estimating the magnitude of such error and identifying possible analytical approaches. Bias in interpretation of all residual error as process error will be examined by comparing average predicted values of the Hilborn and Eggers model with their adjustments for residual error as an environmental process. Double-accounting of effects of regional trends will be examined by comparing predicted average returns per spawner of the model with historical returns per spawner, with and without the 18% adjustment used by Hilborn and Eggers to account for regional trends.

Alternate population models incorporating environmental variates will be identified and tested.

Environmental variates will be identified that are ecologically relevant to pink salmon, based on life history and process studies such as SEA. Environmental variates will be added to a Ricker stock recruit model with the general form (Quinn and Deriso 1999):

$$R = \alpha S e^{-\beta S + \gamma_1 X_1 + \cdots + \gamma_p X_p}$$

where R represents recruits, S represents spawners, X represents an environmental variate, and α,β, and γ are constants. This is the same form as used by Hilborn and Eggers, with hatchery smolt releases as the X parameter. In this form, smolt releases function as a density independent parameter affecting the productivity of the wild pink salmon population. If density-dependent processes during the juvenile rearing period are affecting the survival of wild pink salmon (one of two possible mechanisms of a hatchery effect proposed by Hilborn and Eggers (2000)), then a more appropriate model is:

$$R = \alpha S e^{-(\beta - \gamma X)}$$

where the number of smolts released affects the carrying capacity for wild spawners. The form of the model will affect both the predicted recruits in the absence of smolts and the estimate of optimum spawning escapement.

The workshop component of the project will be held in Cordova. PWSAC will handle local arrangements. A steering committee will set an agenda, invite speakers, and identify and invite an expert panel of reviewers. The steering committee will be comprised of Wertheimer, Heard, Smoker, the PWSAC general manager or his designee, and invited representatives from the Regional Plan Team (e.g., Tim Joyce, ADFG), the Prince William Sound Science Center, Cordova District Fishermen United, and the Alaska Marine Conservation Council. The expert panel will be comprised of 3-4 experts in population dynamics who will be expected to review the model of Hilborn and Eggers (2000), the critique produced as an outcome of the analytical component of this project, and relevant data sets; attend the workshop to hear presentations on the interactions of hatchery and wild pink salmon in Prince William Sound; and produce a report summarizing their reviews, recommendations for research, and management implications of their findings.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This project consists of two parts: an analytical component and a workshop. NMFS and University of Alaska scientists will collaborate on the analytical component. These scientists will also identify and invite speakers for the workshop, including the expert panel that will provide a workshop summary and research recommendations. PWSAC will provide local support for the workshop. NMFS will provide $10,100 of in-kind labor to facilitate this project.

SCHEDULE:

A. Measurable Project Task for FY01

Oct 31: Complete analysis and comment of H&E paper
Invitation to workshop participants
Contract expert panelists

Nov 30: Submit comment paper for to *Transactions of the American Fisheries Society* for consideration for publication and for rebuttal by Hilborn and Eggers

February: Cordova Workshop.

March 31: Workshop summary finalized, including recommendations and priorities for research, identification of management implications.

May 31: Final report to Council, including recommendations for research.

B. Project Milestones and Endpoints

October 31, 2000: Completion of analytical component (Objective 1).

February, 2001: Workshop held in Cordova. (Objective 2).

March 31, 2001: Workshop summary from expert panel completed. (Objective 2).

May 31, 2001: Final Report to Trustee Council summarizing analytical and workshop components (Objective 3).

PUBLICATIONS AND REPORTS:

1. Pink salmon hatcheries in Prince William Sound: enhancement or replacement of natural production? Comment for submission to *Transactions of the American Fisheries Society*, October 31, 2000.

2. Summary of findings and recommendations from the Workshop "Pink salmon hatcheries in Prince William Sound: enhancement or replacement of natural production?". Report to the Trustee Council, March 31, 2001.

3. *Exxon Valdez* Trustee Council Final Report. Submission by May 31, 2001.

PROFESSIONAL CONFERENCES

Annual Meeting, Alaska Chapter of American Fisheries Society. Present paper on "Pink salmon hatcheries in Prince William Sound: enhancement or replacement of natural production?"

NORMAL AGENCY MANAGEMENT

NMFS is not directly involved or responsible for determining optimum yield from wild and enhanced pink salmon in Prince William Sound. ADFG has the responsibility for determining escapement levels necessary for optimum sustained yield and the for permitting enhancement operations, but does not incorporate ecosystem interactions of wild and hatchery fish into their management models. In the FY2001 solicitation, the Trustee Council has called for proposals on conceptual models of production of pink salmon, including the examination of historical time series of abundance and the forecasting of recruitment to the fisheries, and for the linkage of such models to process studies of ecosystem function relevant to pink salmon that have been developed by SEA. The Trustee Council's interest and support of this type of research has been effective in augmenting normal agency function and responsibility, and advancing interagency and institutional collaboration.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project relies upon ADFG and PWSAC data to evaluate population dynamic models for pink salmon in Prince William Sound. It will use results of SEA research and PWSAC and UAF environmental monitoring to develop links between population dynamic models and ecosystem processes driving the productivity of the managed species, in this case pink salmon. The analysis will draw on SEA, ADFG, PWSAC, UAF, and NMFS research results and data series collected with direct support of Restoration funding, as well as EXXON sponsored modeling and analysis. The workshop will invite participation from all these entities to work towards identification of data needs, research and modeling priorities, and management recommendations.

PROPOSED PRINCIPLE INVESTIGATOR

Alex Wertheimer
National Marine Fisheries Service
11305 Glacier Highway
Juneau, AK 99801
(907) 789-6040 FAX 789-6601
Alex.Wertheimer@noaa.gov

PRINCIPLE INVESTIGATOR

Alex Wertheimer
BS Fisheries Science, Oregon State University (1979); MS Fisheries Science, University of Alaska (1984). Currently employed by National Marine Fisheries Service, Auke Bay Laboratory as a Supervisory Fishery Biologist, Team Leader of Early Ocean Salmon Research. Author/coauthor of over 30 peer-reviewed publications and 35 agency reports on various aspects of the biology and culture of Pacific salmon. Research on Pacific salmon has included determining early marine growth, distribution, and migration; in nearshore habitat utilization; predator/prey relationships; by-catch mortality; the association of early marine conditions with year-class success of salmon; salmon aquaculture and genetics; status of stocks; the effects of hydrocarbon contamination on juvenile salmon in the marine environment; and effects of oiled incubation substrate on straying and survival of pink salmon. Serves as member of Chinnok Technical Committee of the Pacific Salmon Commission. Past-President, Alaska Chapter American Fisheries Society. Associate Editor *Transactions of American Fisheries Society.* Principle Investigator *Exxon Valdez* NRDA Fish/Shellfish 4, NMFS Component, 1989 through project completion in 1993. Principle Investigator *Exxon Valdez* Restoration Project 076, 1996 through project completion in 1999.

OTHER KEY PERSONNEL

Dr. William Smoker

Responsibilities for this project: Collaborate on analytical component, member of organizing committee for Workshop.

Professor of Fisheries on the UAF School of Fisheries and Ocean Sciences Faculty and has been at the School's Juneau Center since1978. His research and teaching focuses on the biology and conservation of Pacific salmon. He's been author or co-author of more than 30 papers in fisheries science. He is a graduate of Carleton College (BA Biology '67) and Oregon State University (MS Oceanography '70, PhD Fisheries '81) and a veteran of the US Coast Guard's Alaska Patrol (Cutter Storis '70 - '71). He serves as a member of the Board of Directors of the Prince William Sound Aquaculture Corporation, as a member of the Northwest Power Planning Council's Independent Science Review Panel, and as a member of the Hatchery Reform Science Review Group for western Washington.

William R. Heard

Responsibilities for this project: Collaborate on analytical component, member of organizing committee for Workshop.

B.S. Zoology, Oklahoma A.& M. College (1955); M.S. Fisheries Science, Oklahoma State University (1959). Currently Program Manager, Marine Salmon Interactions, National Marine Fisheries Service Auke Bay Laboratory. Author or coauthor of 45 peer-reviewed publications (including Heard 1991, Life History of Pink Salmon) and over 40 other agency reports on a wide variety of freshwater, marine, warm water and cold water fisheries issues. Research areas have included contributions to life history and behavioral science for a variety of fishes including buffalo fishes, lampreys, cottids, pigmy whitefish, spotted bass, sockeye, pink, coho, and chinook salmon, development of technology for salmon enhancement involving fry-to-smolt culture in floating raceways and estuarine net pens, incubation systems for high quality salmon fry, and barriered lakes for natural smolt rearing systems in Alaska. Iinitiated use of coded wire tags as a research tool for salmonids in Alaska. Past-Member of Governor's Fisheries Council; Past-President, Alaska Chapter American Fisheries Society; Past-Chairman, National AFS Resolutions Committee; Past- Member NPFMC Plan Development Team and Alaska Mariculture Technical Working Group. Present member of NOAA/ NMFS Aquaculture Task Force and Secretary General for U.S. participation in the U.S.-Japan Natural Resources Aquaculture Panel.

LITERATURE CITED

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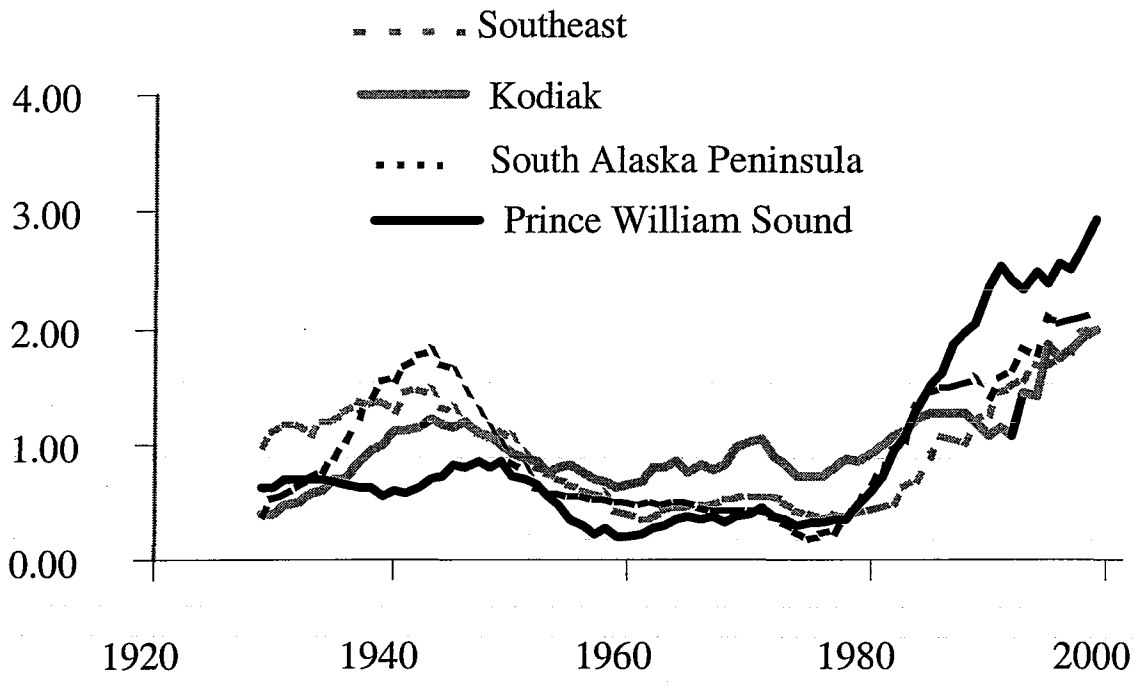

Figure 1. Standardized 10-year running average catch of pink salmon in four regions of Alaska from 1929-1999. Catches are standardized for each region by dividing annual averages by the average catch for the entire time series.

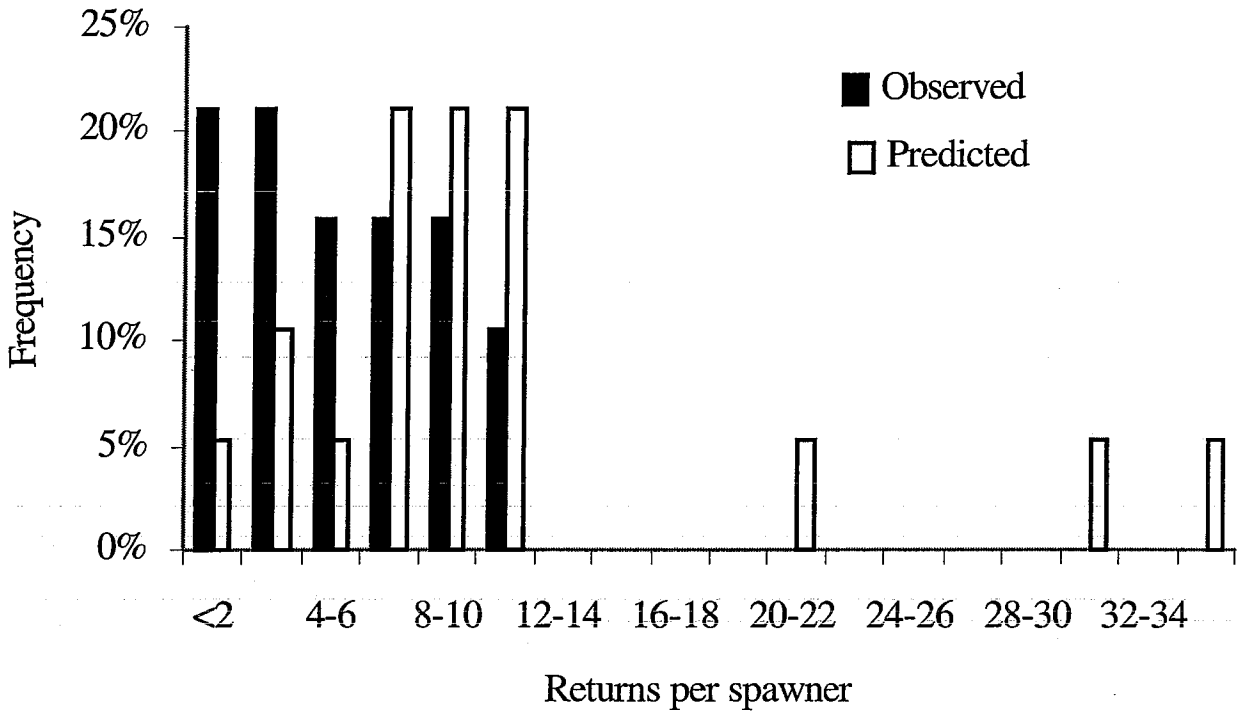

Figure 2. Frequency distribution of pink salmon returns per spawner in Prince William Sound for the 1977 through 1995 brood years, based on observed and predicted values presented in Table 5 of Hilborn and Eggers (2000). Predicted values are Hilborn and Egger model output for observed escapements, prior to being adjusted upwards 18% to account for regional trends in returns per spawner.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$9.6
Travel		$4.6
Contractual		$29.2
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$43.4
General Administration		$3.5
Project Total	$0.0	$46.9
Full-time Equivalents (FTE)		0.08
Other Resources		$10.1

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

INOAA Contribution

Two weeks salary, W. R. Heard. Program Manager, Marine Salmon Interactions. GS 14/10: $5.7 K

Two weeks salary, A. C. Wertheimer, Fisheries Research Biologist. GS 13/07 4.4

TOTAL In-Kind $10.1 K

FY01

Prepared:4/11/00

Project Number: 01440

Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?

Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
Name	Position Description		Step	Budgeted	Costs	Overtime	FY 2001
Alex Wertheimer	Fishery Biologist (Research)	13/7	13/07	1.0	9.6	0.0	9.6
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
						0.0	0.0
		Subtotal		1.0	9.6	0.0	
						Personnel Total	$9.6

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Wertheimer Juneau-Cordova	0.3	2	7	0.2	2.0
Heard Juneau-Cordova	0.3	1	3	0.2	0.9
Wertheimer Juneau-Anchorage	0.4	1	4	0.1	0.8
Wetheimer Juneau-Fairbanks	0.5	1	4	0.1	0.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.6

FY01

Prepared:4/11/00

Project Number: 01___
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:		Proposed FY 2001
Description		
	Prince William Sound Aquaculture Association: Cordova Workshop Logistics	5.0
4A Linkage	University of Alaska Fairbanks: Dr. W. R. Smoker salary support and travel	9.2
	Travel and honarium costs for expert panel at workshop	15.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$29.2

Commodities Costs:		Proposed FY 2001
Description		
	Commodities Total	$0.0

FY01

Prepared:4/11/00

Project Number: 01___
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY01

Prepared:4/11/00

Project Number: 01___
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Agency: NOAA

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$4.1
Travel		$2.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$6.1
Indirect		$3.13
Project Total	$0.0	$9.2
Full-time Equivalents (FTE)		0.04

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$0.0		

Dollar amounts are shown in thousands of dollars.

Other Resources								

Comments:

FY01

Prepared:4/11/00

Project Number: 01___
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Name: Univ of AK - Dr. William Smoker

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	Dr. William Smoker	Professor of Fisheries	0.5	8.2		4.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	0.5	8.2	0.0	
					Personnel Total	$4.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	Smoker-Juneau-Cordova	0.3	2	7	0.2	2.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.0

FY01

Prepared:4/11/00

Project Number: 01____
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Name: Dr. Bill Smoker- Univ of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Prepared:4/11/00

Project Number: 01___
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Name: Univ of AK- Dr. William Smoker

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2001
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY01

Project Number: 01____
Project Title: Pink Salmon Hatcheries in PWS: Enhancement or Replacement of Natural Production?
Name: Univ of AK Dr. William Smoker

FORM 4B
Equipment
DETAIL

Prepared:4/11/00

Project Title: Harbor Seal Recovery. Phase III: Effects of Diet on Lipid Metabolism and Health.

Submitted Under BAA No. 52ABNF800034

Project Number:	01441
Restoration Category:	Research
Proposer:	Randall Davis, Ph.D., Texas A&M University at Galveston
Lead Trustee Agency:	Alaska Dept. of Fish and Game
Cooperating Agencies:	
Alaska SeaLife Center:	Yes
Duration:	3rd year, 3-year project
Cost FY 01:	$ 163,800
Geographic Area:	Prince William Sound and Alaska SeaLife Center
Injured Resource:	Harbor seals

APR 1 2000

ABSTRACT

The harbor seal (*Phoca vitulina richardsi*) population in Prince William Sound has not recovered and may continue to decline. An underlying hypothesis is that ecosystem-wide changes in food availability could be affecting harbor seal population recovery. To better understand the results from field studies of harbor seal health, body condition and feeding ecology, we need data for seals on diets that vary in nutritional composition. Working with the Alaska SeaLife Center, we will determine how fatty acid profiles in the blubber of captive harbor seals change over time during controlled diets of herring and pollock. In addition, we will assess the aerobic capacity and lipid metabolism of skeletal muscle in harbor seals fed controlled diets and for wild harbor seals in Prince William Sound. The results will augment already funded investigations of diet and health to provide a more in depth understanding of the nutritional role and assessment of dietary fat for harbor seals.

ACCOMPLISHMENTS FOR THE FIRST 18 MONTHS (OCT. 1998 TO MARCH 2000)

Feeding trials for eight harbor seals began in early September 1998 at the Alaska SeaLife Center. Six seals (two groups of three) received an alternating diet of either herring or pollock. To date, four feeding trials have been completed and the fifth is ongoing. Six feeding trials are planned. A separate control group of two seals will receive a mixed diet of half herring and half pollock throughout the study.

CROSS-OVER REPEATED MEASURES FEEDING TRIALS FOR HARBOR SEALS

Period	Feeding Trail #	Herring Diet	Pollock Diet
Sept-Dec 1998	1	Seals A,B,C	Seals D,E,F
Jan-April 1999	2	D,E,F	A,B,C
May-Aug 1999	3	A,B,C	D,E,F
Sept-Dec 1999	4	D,E,F	A,B,C
Jan-April 2000	5	A,B,C	D,E,F

At the mid-point and end of each feeding trial, blubber samples only were taken at two sites from each seal. Skeletal muscle samples were also taken at the end of each trail. Half of each muscle sample was placed in fixative, and the remainder along with the blubber samples were frozen at -70° C. The muscle samples were sent to the University of California at San Diego where analysis (% fiber type, volume density of lipid droplets and mitochondria, lipid enzyme activities, and myoglobin concentration) is underway. Blubber samples are being analyzed for fatty acid profiles at Texas A&M University. In June of 1999, we obtained extensive muscle, blubber and splanchnic organ samples from eight harbor seals through the BIOSAMPLING Program in Prince Williams Sound. These samples are under analysis at Texas A&M University and will form the basis for two Doctoral and one Masters dissertation. Preparations have been made for obtaining additional harbor seal samples from the BIOSAMPLING Program in June 2000. This collaborative effort with the Native community has been very successful for our program.

INTRODUCTION

Understanding the feeding ecology and nutritional status of harbor seals is an essential component of ecosystem-based research on the recovery of species impacted by the Exxon Valdez oil spill in Prince William Sound. Until recently, determinations of prey preferences for pinnipeds have been based on stomach content and fecal analyses, both of which can only yield information on the most recent meals and may be biased due to differential rates of passage of food items. A new technique using fatty acid profiles of blubber can provide details on cumulative dietary history. It can also, in some cases, be used to determine foraging habitat. In pinnipeds, as with other carnivores and monogastric animals, dietary fatty acids generally remain intact through the digestion process and are deposited in adipose tissue with little or no modification (1). As a result, differences in the fatty acid composition of carnivore blubber can be used to infer dietary differences between individuals or populations and perhaps even species

composition of the diet.

Previous research has shown that fatty acid signatures are significantly affected by spatial or temporal heterogeneity in habitat and food webs (1). In a study of harbor seal foraging ecology (Project 117-BAA; Harbor seal blubber and lipids) supported by the Restoration Program, Iverson, et al (2) were able to distinguish individual species of fish using fatty acid signatures. They also found fatty acid composition of these prey items to be correlated with body size as well as location within a study area. Hence, analysis of fatty acids in pinnipeds and their prey should provide details on the spatial scales of foraging and habitat use of both individuals and populations. Evaluating how harbor seal blubber fatty acids change with diet during controlled feeding studies where species composition of diet is known will improve the spatial and temporal interpretation of fatty acid profiles of wild seals whose diet composition is unknown.

Muscle condition and metabolic function can be used as indicators of the health status of marine mammals. Important indices of muscle function and health are aerobic capacity, the ability to store oxygen in the form of oxy-myoglobin and the size of lipid stores. In a preliminary study conducted by our laboratory (3), we observed that the volume density of mitochondria, myoglobin concentration and citrate synthase activity in the swimming muscles of harbor seals were elevated relative to terrestrial mammals and appeared to be an adaptation for aerobic metabolism during diving. One objective of this study is to study the effect of diet on the aerobic capacity, myoglobin concentration and lipid stores of skeletal muscles in harbor seals. In addition, we will measure the activities of citrate synthase and *B*-hydroxyacyl CoA dehydrogenase (an enzyme important for lipid metabolism) as indicators of aerobic capacity and the *B*-oxidation of fatty acids, respectively.

The Restoration Program has supported the population monitoring component of health assessment, diving behavior and food preferences of harbor seals in Prince William Sound. Now, with controlled feeding studies of harbor seals underway at the Alaska SeaLife Center, we will continue our studies of the effects of diet on fatty acid signatures in blubber and the metabolic function of muscle, especially with regards to lipid. The results will improve our understanding of harbor seal feeding ecology and the effects of diet on health and metabolism.

NEED FOR THE PROJECT

A. Statement of Problem

The Restoration Program has supported three harbor seal studies in Prince William Sound (Project 001- Harbor seal condition and health status; Project 064- Monitoring habitat use and trophic interactions of harbor seals; Project 117-BAA- Harbor seal blubber and lipids). One objective of these studies has been to measure health and body condition indices related to metabolic alterations that might occur in animals that were food deprived. Although these studies collected much useful information, some researchers realized that controlled dietary studies were needed to more completely interpret field data. In 1997, the Restoration Program funded a captive study (Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) at the Alaska SeaLife Center that will quantify the nutritional value of several key Alaskan fish species for harbor seals and will follow health indices over time in both healthy and

rehabilitation animals. That project, which has been underway at the Alaska SeaLife Center for 18 months, will feed controlled diets of fish to harbor seals to examine changes in body condition, health, assimilation efficiency and blood chemistry biomarkers. Of particular interest will be the health and body condition effects of diets containing nutritionally poor (compared to herring) fish such as pollock, the so-called "junk food" hypothesis for explaining the decline of certain pinniped stocks. In the current study, we will continue (four feeding Trials are completed and the fifth will be completed in May 2000) to take advantage of the controlled feeding studies at the Alaska SeaLife Center to examine the effects of diet on: 1) fatty acid markers in the blubber, 2) muscle condition and 3) lipid metabolism. In addition, we will use samples of blubber and muscle obtained by the BIOSAMPLING Program in Prince William Sound for comparison with captive seals fed known diets. This important work will augment already funded investigations of diet and health to provide a more in depth understanding of the nutritional role and assessment of dietary fat for harbor seals.

B. Rationale

The harbor seal population in Prince William Sound has not recovered and may continue to decline. An underlying hypothesis is that ecosystem wide changes in food availability could be affecting harbor seal population recovery. To better understand the behavioral and physiological results obtained from field studies of harbor seal health, body condition and feeding ecology supported by the Restoration Program, we need comparable data for seals on diets that vary in nutritional composition. In 1998, a captive study was begun at the Alaska SeaLife Center to quantify the health effects of feeding several key Alaskan fish species to harbor seals. We propose to augment this study by examining changes in fatty acid profiles in seal blubber and muscle lipid content during controlled feeding studies where fish species composition is known. In addition, we will quantify the aerobic capacity and activities of enzymes that are crucial for muscle lipid metabolism and which may be affected by nutritional stress.

C. Location

The experiments for this project will be conducted at the Alaska SeaLife Center in Seward. We will collaborate with existing projects that will examine the detailed metabolic alternations in stable isotope ratios (Schell/Project 170) and changes in body condition and health indices (Castellini/Project 341) in harbor seals that occur under different feeding regimes.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Native communities have assisted Field studies of harbor seals in conjunction with the BIOSAMPLING program (Project 96244). We will continue that collaboration by analyzing samples of muscle, blubber and other tissues taken as part of subsistence hunting.

PROJECT DESIGN

A. Objectives

1. Determine how fatty acids in the blubber of captive harbor seals change over time during controlled diets of herring and pollock.

2. Measure the content and composition of lipid in muscle of captive harbor seals fed controlled diets and for wild harbor seals in Prince William Sound.

3. Assess the aerobic capacity and lipid metabolism of skeletal muscle in harbor seals fed controlled diets and for wild harbor seals in Prince William Sound.

B. Methods

1. Hypotheses to be Tested.

1. Null hypothesis: Fatty acid profiles in the blubber of harbor seals are not affected by the fatty acid composition of the diet.

   Alternative hypothesis: Fatty acid profiles in the blubber of harbor seals will be directly affected by the fatty acid composition of the diet and will change as the diet is altered.

   Methodology: Feed controlled diets of different fish species to captive harbor seals. Assess temporal changes in the fatty acid composition of the blubber by taking serial biopsies. Compare with samples obtained from the BIOSAMPLING program of wild harbor seals in Prince William Sound.

2. Null hypothesis: Mitochondrial volume density, myoglobin concentration, lipid content, and the enzymatic activities of citrate synthase and *B*-hydroxyacyl CoA dehydrogenase are not affected by diet.

   Alternative hypothesis: These variables of muscle condition and function are affected by changes in diet.

   Methodology: Feed controlled diets of different fish species to captive harbor seals. Assess temporal changes in these variables by taking serial muscle biopsies. Compare with samples obtained from the BIOSAMPLING program of wild harbor seals in Prince William Sound.

2. Harbor Seal Feeding Trials Conducted at the Alaska SeaLife Center (ASLC).

Animals. Eight harbor seals have been acquired by the ASLC for the feeding trials that began in September 1998. Dr. Michael Castellini developed dietary protocols for EVOS Project 99341. During the staggered feeding trials, the diet will be changed every four months. During these

dietary manipulations, we will obtain serial blubber samples every two months and muscle biopsies every four months from two sites on each animal.

Design for Feeding Trials. A detailed matrix of the feeding schedule developed by Dr. Castellini is shown below. The procedure will use a cross-over repeated measures approach and will allow statistical comparisons within any one group of seals between diet and season. Statistical software (SYSTAT) will be used to analyze the cross-over method. However, there are several considerations that must be addressed using this matrix.

CROSS-OVER REPEATED MEASURES ANOVA FEEDING TRIALS
FOR HARBOR SEALS

Period	Herring	Pollock	Condition
Sept-Dec 1998	Seals A,B,C	Seals D,E,F	Molting
Jan-April 1999	D,E,F	A,B,C	Spring
May-Aug 1999	A,B,C	D,E,F	Breeding
Sept-Dec 1999	D,E,F	A,B,C	Molting
Jan-April 2000	A,B,C	D,E,F	Spring
May-Aug 2000	D,E,F	A,B,C	Breeding

This feeding matrix allows each group of seals to experience a different diet at similar physiologically relevant times of the year. Group A,B,C for example, will receive a herring diet during the molting season in Year 1 and a high pollock diet in Year 2. After training during the summer of 1998, the seals accepted a pollock diet that was 100% pollock. Two additional control seals will receive a diet of half herring and half pollock throughout the study.

A problem with cross-over ANOVA designs is that residual or carry-over effects from previous treatments can complicate the analysis. We correct for this with long test periods and phased cross-overs. That is, since each feeding trial will last for four months, several weeks of diet switching will be allowed. This provides the additional advantage of allowing us to study the impact of the phased switch on blubber and muscle lipid content and composition, and on muscle lipid metabolism.

Blubber Biopsies. Blubber samples will be obtained through the full depth of blubber layer with a 6-mm punch biopsy inserted through a small incision in the skin. Samples will be immediately transferred to liquid nitrogen and stored at -70° C until analysis. Total lipids will be extracted in chloroform according to Folch et al. (4) as modified by Iverson (5). Fatty acid methyl esters (FAME) will be prepared from the purified lipid extracts using the Hilditch reagent (0.5 N H_2SO_4 in methanol). FAME for fish in the controlled diets will be obtained similarly from homogenates of individual food items. The methyl esters will be analyzed by temperature-programmed capillary gas-liquid chromatography. FAME will be identified and quantified using a combination of standard mixtures, including those identified using chromatography and an ion-trap mass detector. Individual fatty acids, expressed as weight percent of the total fatty acids,

will be analyzed using classification and regression trees (CART) in S-plus (StatSci, Seattle), a non-parametric multivariate technique for classifying data. CART uses a series of algorithms to split data into groups as differently as possible, based on measures of deviance; the splitting continues in a tree-like form until a classification is made at a terminal node.

Muscle Biopsies. Two muscle samples of approximately 50 mg each will be collected with a 6 mm biopsy cannula (Depuy, Warsaw, Indiana) from both the swimming (*M. longissimus dorsi*) and non-swimming (*M. pectoralis*) muscles. Control samples will be collected from the *M. soleus*, a predominantly slow oxidative muscle, of laboratory rats (*Sprague Dawley*) euthanized by cervical dislocation after 2-3 min of carbon dioxide anesthesia. Muscle samples will be placed either into 2% glutaraldehyde fixative or frozen in liquid nitrogen immediately upon collection. Samples will remain in the fixative for a minimum of 48 hours but no longer then 14 days before being transferred and stored in 0.1 M cacodylate buffer pH 7.4. Frozen samples will be stored at -70 ° C until analysis for citrate synthase activity, *B*-hydroxyacyl CoA dehydrogenase activity and myoglobin concentration.

Electron Microscopy of Muscle Samples. Fixed muscle samples will be rinsed in cacodylate buffer and post-fixed for 2 hours in a 1% solution of osmium tetra oxide. They will be stained 'en bloc' with 2% uranyl acetate overnight in a refrigerator. After dehydration with increasing concentrations of ethanol (50-100%), they will be passed through propylene oxide and increasing concentrations of epoxy (50-100%). The samples are finally embedded in fresh epoxy and allowed to polymerize overnight at 60 ° C. Thick sections (1 mm) will be cut with a Leica Ultratome and stained with toulidine blue to determine fiber orientation. Ultrathin (50-70 nm), transverse sections will be cut and contrasted with lead citrate from four randomly chosen blocks per muscle. Micrographs will be taken with a Phillips 201 transmission electron microscope. The number of micrographs per muscle analyzed will range from 25 and 40, yielding relative standard errors of less than 10% in all muscles. Determination of the volume density of mitochondria, myofibrils and lipid droplets will be performed at a final magnification of x19,250 using standard point counting procedures (6, 7).

Citrate Synthase, B-hydroxyacyl CoA dehydrogenase and Myoglobin Assays of Muscle Samples. Frozen muscle samples will be weighed and then homogenized at 0° C in 1 ml of buffer containing 1 mmol L^{-1} EDTA, 2 mmol L^{-1} $MgCl_2$, and 75 mmol L^{-1} Tris-HCl, pH 7.6 at 25 ° C (8). The homogenates will be spun at 2,900 g for 30 minutes at 4° C. 500 ml from each supernatant will be prepared for myoglobin assay and the rest will be used for the analysis of citrate synthase. Citrate synthase and *B*-hydroxyacyl CoA dehydrogenase will be assayed on a Beckman DU series 64 spectrophotometer according to the method of Reed et al. (1994). Assay temperature will be maintained at 37 ° C using a constant temperature water bath and a water-jacketed cuvette holder. The assay conditions for citrate synthase (CS; EC 4.1.3.7) will be 50 mmol L^{-1} imidazole, 0.25 mmol L^{-1} 5,5-dithiobis (nitrobenzoic acid, DTNB), 0.4 mmol L^{-1} acetyl CoA, and 0.5 mmol L^{-1} oxaloacetate, at pH 7.5; DA_{412}, e_{412} = 13.6 (8). For *B*-hydroxyacyl CoA dehydrogenase (HAD; EC 1.1.1.35), the assay conditions will be 50 mmol L^{-1} imidazole, 1 mmol L^{-1} EDTA, 0.1 mmol L^{-1} acetoacetyl CoA, and 0.15 mmol L^{-1} NADH, pH 7.0 at 37° C; DA_{340}, e_{340} = 6.22 (9). Enzyme activities (mmol min^{-1} g^{-1} wet mass muscle) will be calculated from the rate of change in absorbance at the maximum linear slope. Myoglobin will be assayed according to the method of Reynarfarje (1963) with the following modifications. A portion (500 ml) of the supernatant is further diluted with 1 ml of phosphate buffer (0.04 M, pH 6.6). The resulting mixture is centrifuged

for 50 min at 28,000 g at 4°C. The supernatant is bubbled with carbon monoxide for three min. Spectrophotometric absorbance will be measured at 538 and 568 nm, and the concentration of myoglobin in milligrams g^{-1} wet mass of muscle will be calculated as:

$$(Abs_{538} - Abs_{568}) \times 5.865 [(1.5/0.5) \times (\text{mass of sample})]$$

Statistical Analysis. Results will be expressed as the mean ± one standard error. We will use a cross-over repeated measures approach that will allow statistical comparisons within any one group of seals between diet and season. Statistical software (SYSTAT) will be used to analyze the cross-over method. The relative proportions of fatty acids from blubber samples of seals in the controlled feeding study will be used as a basis for generating tree-based models (using S-Plus; StatSci, Seattle) of groups or classes of samples such that new samples (obtained via BIOSAMPLING) can be compared with the modeled classes to decide their membership, i.e. obtain a classification of their "diet". Similarly, classification and regression trees will be used to screen the set of prey fatty acids and choose a subset of those fatty acids which can be used to classify the "diets" of seals based the patterns of fatty acid proportions in their blubber.

3. Blubber and Muscle Samples Obtained from the BIOSAMPLING Program in Prince William Sound.

Samples from the main swimming muscles, blubber and splanchnic organs of 16 harbor seals will be obtained during BIOSAMPLING Program. The entire muscle will be removed and weighed, and three transverse sub-samples will be taken along the muscle bundle. Each sub-sample of the swimming muscle will be precisely labeled for its orientation and location within the animal. These will then be further sub-sampled along points on a circular grid using a stainless steel borer, averaging 35 samples per muscle section. Cores of tissues weighing 200 and 300 mg will be removed for assay. A spectrophotometric technique will be used to determine myoglobin, citrate synthase, and *B*-hydroxyacyl CoA dehydrogenase concentration (see above for details). Detailed contour maps and statistical tests for all concentrations will be made using a PC based program S-Plus (Stat-Sci, Seattle). Blubber samples will also be obtained from the same approximate anatomical location as on animals used in the captive studies and stored frozen at -70 °C. Blubber samples will be analyzed according to the protocols described in Section 2 of this proposal. Samples will also be taken from the liver, kidneys, stomach, small intestine, diaphragm and brain. They will be analyzed using the same techniques as the muscle samples.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 - September 30, 1999), FY 00 (October 1, 1999 - September 30, 2000) and FY 01 (October 1, 2000 – September 30, 2001)

Each feeding trial will take four months beginning in September, 1998.

1998	
September	Set up fatty acid analysis and muscle lipid and enzyme analysis
September-December	Trial 1 of staggered feeding protocol at ASLC. Obtain blubber and muscle biopsies. Status- completed on schedule.
1999	
January-April	Trial 2 of staggered feeding protocol. Obtain blubber and muscle samples. Status- completed on schedule.
May-August	Trial 3 of staggered feeding protocol. Obtain blubber and muscle samples. Status- completed on schedule. Obtain blubber and muscle samples from wild harbor seals in Prince William Sound in conjunction with BIOSAMPLING Program. Status- completed on schedule.
September-December	Trial 4 of staggered feeding protocol at ASLC. Obtain blubber and muscle biopsies. Status- completed on schedule.
2000	
January-April	Trial 5 of staggered feeding protocol. Obtain blubber and muscle samples. Status- underway and on schedule
May-August	Trial 6 of staggered feeding protocol. Obtain blubber and muscle samples. Planned and on schedule Obtain blubber and muscle samples from wild harbor seals in Prince William Sound in conjunction with BIOSAMPLING Program. Planned and on schedule.
September-December	Complete analysis of blubber and muscle samples.
2001	
January-September	Analyze data and prepare Final Report. Prepare and submit manuscripts. Two manuscripts are anticipated at this time.

B. Project Milestones

FY 99:	Obtain blubber and muscle samples during first four feeding studies at ASLC and the BIOSAMPLING Program in Prince William Sound.
FY 00:	Continue to obtain blubber and muscle samples during feeding studies at ASLC; obtain blubber and muscle samples from seals in Prince William Sound in conjunction with BIOSAMPLING Program.
FY 01	Complete analysis and prepare Final Report and manuscripts by September.

C. Completion Date

This project will finish on September 30, 2001.

PUBLICATIONS AND REPORTS

Since this is a new project, there are no current publications from the proposed research. However, the results from a preliminary study of the aerobic capacity and lipid content of muscles from harbor seals in Prince William Sound were be published in the Journal of Applied Physiology in April 1999. We do not anticipate any referred articles in FY 00. However, by FY 2001 most of the data will be analyzed and manuscripts in preparation. Because samples will continue to be collected through September 2000, we request an additional year (Oct. 2000 to September 2001) to complete data analysis and prepare the Final Report and manuscripts. We anticipate at least two publications by 2001 on the effects of diet on fatty acids in blubber and the aerobic capacity and lipid metabolism in harbor seal muscle.

PROFESSIONAL CONFERENCES

The PI requests funds to attend the annual EVOS workshops each year.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We are working in close coordination with Dr. Michael Castellini (PI on Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) and staff at the Alaska SeaLife Center (see attached letter). Dr. Castellini is supervising the controlled diet studies. We have coordinated our blubber and muscle samples with the veterinary staff at ASLC. Samples obtained from the BIOSAMPLING program will be coordinated with Ms. Monica Riedel of the Alaska Native Harbor Seal Commission.

PROPOSED PRINCIPAL INVESTIGATOR

Dr. Randall Davis
Dept. Marine Biology
Texas A&M University at Galveston
Galveston, TX 77553
Phone: 409-740-4712
Fax: 409-740-5002
email: davisr@tamug.tamu.edu

PRINCIPAL INVESTIGATOR

Randall Davis, Ph.D., specializes in the physiology and metabolism of marine mammals. He is a Professor of Marine Biology at Texas A&M University and has worked in this field for over 20 years. In 1989, Dr. Davis was the Project Leader for Exxon's Oiled Sea Otter Rehabilitation Program in Prince William Sound.

Publications by Dr. Randall Davis relevant to the proposed research:

Kanatous SB, Davis RW, DiMichele LV, Cowan DF. (1999) High aerobic capacities in the skeletal muscles of seals, sea lions and fur seals: An adaptation to diving hypoxia.

Journal of Applied Physiology 86:1247-1256

Davis RW (1995) Cleaning and Restoration of the Fur. In: Emergency Care and Rehabilitation of Oiled Sea Otters: A Guide for Large and Small Oil Spills Involving Fur-bearing Marine Mammals. (TM Williams and RW Davis, eds). University of Alaska Press.

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Davis RW, Williams TM, Kooyman GL. (1985) Swimming metabolism of yearling and adult harbor seals (Phoca vitulina). Physiol Zool 58:590-596.

Davis RW. (1983) Lactate and glucose metabolism in the resting and diving harbor seal (Phoca vitulina). J Comp Physiol 153:275-288.

OTHER KEY PERSONNEL

Dr. Odile Mathieu-Costello is a Research Physiologist at the University of California at San Diego. She is internationally recognized for her research on ultrastructure and function of skeletal muscle. Her role will include the electron microscopic determination of mitochondrial volume density and lipid droplet density in muscle samples. No salary is requested as she is supported by other funding.

Dr. Shane Kanatous is a NIH Post-doctoral Fellow at the University of California at San Diego. He has conducted research on the aerobic scope and enzymatic adaptations in the skeletal muscles of marine mammals. His role will be to measure the enzyme activities of citrate synthase and *B*-hydroxyacyl CoA dehydrogenase in muscle samples. No salary is requested because he is supported on a NIH Post-doctoral Fellowship.

Students (TBA). There are several students (Ph.D.) and Research Assistants in the Davis laboratory who will participate on this project.

LITERATURE CITED

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3. Kanatous SB, Davis RW, DiMichele LV, Cowan DF. (in press) High aerobic capacities in the skeletal muscles of seals, sea lions and fur seals: An adaptation to diving hypoxia. Journal of Applied Physiology.

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$0.0						
Travel		$0.0						
Contractual		$153.1						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$153.1				Estimated FY 2002		
General Administration		$10.7						
Project Total	$0.0	$163.8				$0.0		
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Prepared:

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$67,449.0
Travel		$11,770.0
Contractual		$15,600.0
Commodities		$11,500.0
Equipment		$0.0
Subtotal	$0.0	$106,319.0
Indirect @ 44% ($106,319)		$46,780.0
Project Total	$0.0	$153,099.0
Full-time Equivalents (FTE)		1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect costs are calculated at 44% of Modified Total Direct Cost. The indirect cost rate is a predetermined rate established by the Department of Health and Human Services date 06/24/98.

Fringes are calculated at 15.5% of Salaries and Wages for the Principal Investigator and Research Assistant. 8.25% is the calculation for the Graduate Research Assistant. Included in the fringe category is a fixed rate for medical insurance. The rate is a calculation based on the percentage of effort. The Principal Investigator is calculated at $412/mo. The Research Assistant and Graduate Research Assistant are calculated at $331/mo.

FY01

Prepared: 4/11/00
Project No.: 01-441

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
R. Davis	Principal Investigator		3.0	9100.0		27,300.0
To Be Named	Research Assistant		12.0	2338.4		28,061.0
To Be Named	Graduate Research Assistant		.3125/FTE	1611.7		12,088.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		15.0	13050.1	0.0	
					Personnel Total	$67,449.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2001
To Anchorage, AK for EVOS Workshop		1200.0	2	8	140.0	3,520.0
To Fairbanks, AK to coordinate Final Report with M. Castellini		1500.0	2	10	130.0	4,300.0
To National Scientific Meeting to present results		1200.0	2	10	155.0	3,950.0
(Destination and role yet to be determined)						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$11,770.0

FY01

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 04/11/00
Project No.: 01-441

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
Electron Microscope Analysis (To Be Named)	5,000.0
Gas Chromatograph Analysis (To Be Named)	10,000.0
Communications - Long Distance Phone Charges	600.0
Contractual Total	$15,600.0

Commodities Costs:	Proposed
Description	FY 2001
Expendable supplies and chemicals	10,000.0
Shipping of frozen samples	500.0
Publications and Page Charges (Includes $200 for Report Writing)	1,000.0
Commodities Total	$11,500.0

FY01

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B
Contractual & Commodities DETAIL

Prepared: 04/11/00
Project No.: 01-441

New Equipment Purchases:	Number	Unit	Proposed

Description	of Units	Price	FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY01

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B
Equipment
DETAIL

Prepared: 04/11/00
Project No.: 01-441

Summary of the Status of Pacific Salmon Populations in the Region Affected by the Exxon Valdez Oil Spill (SUBMITTED UNDER THE BAA)

RECEIVED
APR 14 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number:	01450
Restoration Category:	
Proposer:	Alaska Chapter, American Fisheries Society
Lead Trustee Agency:	NOAA
Cooperating Agencies:	
Alaska Sea Life Center:	No
Duration:	1st Year, 2-year project
Cost FY 01:	$52,500
Cost FY 02:	$52,500
Geographic Area:	Juneau and Cordova
Injured Resource/Service:	Commercial, recreational, and subsistence fishing

ABSTRACT

This project will provide a comprehensive survey of the current status of salmon populations in the region affected by the EVOS. Status will be evaluated using a hierarchical approach, proceeding from large-scale geographic resolution to the fine scale of analysis of escapement data for specific spawning aggregates. The evaluation will use both catch and escapement data. Results will be georeferenced so that summary maps can be produced with a GIS program, and the status review will be published in the peer reviewed journal Fisheries. The status review will provide an important benchmark by which to measure the effectiveness of management policies to sustain and conserve salmon as environmental and anthropogenic changes occur.

INTRODUCTION

The region of Alaska affected by the *Exxon Valdez* oil spill contains some of the most productive anadromous salmon habitat in the world. The average annual salmon catch from the spill region over the years 1988-1997 has been over 65 million fish, some 40% of the total for Alaska (Byerley et al. 1999). These resources are intensively managed for commercial, recreational, and subsistence utilization. Recent perspectives on the status of Alaska salmon throughout the state have indicated the overall condition of the resource is good (Gharrett et al. 1993; Meacham and Clark 1994; Wertheimer 1996), and catch trends throughout the region are at historical highs. However, these have been general overviews; a comprehensive evaluation of the status of the stocks and spawning aggregates that are the basis for this productivity is lacking. In light of the decline of Pacific salmon throughout large portions of their range, and the widespread listings of Pacific salmon under the Endangered Species Act, there has been increased interest for an evaluation of the analysis of the status of salmon populations in Alaska that can be used as a historical benchmark and for comparisons with resource status in other regions of the Pacific rim. The Alaska Chapter of the American Fisheries Society has provided such an analysis for southeastern Alaska (Baker et al. 1996). This proposal would extend the status evaluation to the spill area, from Prince William Sound to the Alaska Peninsula, identify data gaps, further development of geographic information system (GIS) interfaces with survey data, and provide recommendations for sampling strategies for slystematic, regular monitoring of status. Reflecting the support for this project in the fishery science community in Alaska, the Alaska Chapter of the American Fisheries Society will provide oversight and structure for the project, and will contribute $10,000 in direct support in FY01. The National Marine Fisheries Service, the Alaska Department of Fish and Game, the U. S. Fish and Wildlife Service, and the University of Alaska Fairbanks will provide $25,000 of in-kind support in FY01 for professional participation on the oversight committee.

NEED FOR THE PROJECT

A. Statement of Problem

Status reviews of Pacific salmon populations have been recently published that cover the geographic range from California to Southeast Alaska. The decline of Pacific salmon throughout much of the Pacific Northwest and California has been well documented (e.g., Nehlsen et al. 1991; Yoshiyama et al. 1998; Williams et al. 1999). In contrast, recent surveys of escapement records in British Columbia, Yukon Territory, and Southeast Alaska (Slaney et al. 1996; Baker et al. 1996) found that most stocks or spawning aggregates in these regions that could be evaluated were healthy and not at risk of decline or extinction. However, these studies did find evidence of some extinctions and stocks at risk extinction, which were often associated with habitat development such as hydropower and urbanization. They also identified significant information gaps in survey and inventory data.

Comparable analyses of the current status of salmon populations of Southcentral Alaska are lacking. Over 3,000 anadromous waters have been catalogued in the region. Escapement records for these regions were analyzed by Konkel and McIntyre (1987) as part of a coastwide assessment of spawning populations. For Alaska, they identified mostly increasing trends for pink, sockeye, and chinook salmon, but found that decreasing trends were more frequent for coho and chum salmon. This analysis is dated, in that it considered escapement records through 1984, and escapement records were available from only about 550 locations. Substantially more escapement data have been collected since that time. A comprehensive survey of the current status of the resource at this time will provide an important benchmark by which to measure the effectiveness of management policies to sustain and conserve salmon as environmental and anthropogenic changes occur.

B. Rationale/Link to Restoration

In the FY2001 solicitation, the Trustee Council has called for proposals to develop tools and strategies to improve monitoring of resources of interest to the Council. Pacific salmon populations and the services they provide were among resources damaged by the *Exxon Valdez* oil spill. Current monitoring of these populations is directed at managing exploitation and site-specific habitat impacts. A comprehensive survey will provide a benchmark by which to measure the effectiveness of management policies to restore, sustain, and conserve salmon as environmental and anthropogenic changes occur.

C. Location

This project will be based out of ADFG regional headquarters in Anchorage, with data collection and verification occurring at ADFG field offices throughout the spill region.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Local knowledge is an essential component of a comprehensive survey of the salmon resources in the spill area. The contractor will interface with biologists at the local level to verify data and confirm which data series are appropriate for trend analyses. The contractor will also solicit information from Alaska Native communities in the area affected by the spill for information

PROJECT DESIGN

A. Objectives

Objective 1: Evaluate status of Pacific salmon in the area affected by the oil spill, including Prince William Sound, Kenai Fiords, Cook Inlet, Kodiak Island, and South Alaska

Peninsula.

Objective 2: Link results to a geographical information system for graphical presentation and interpretation of the status review.

Objective 3: Identify data gaps and recommend sampling strategies for assessing status of Pacific salmon resources over broad geographic regions.

B. Methods

The Alaska Chapter of AFS will manage the project using an approach similar to the Chapter's successful review of Southeast Alaska salmon population status. The Chapter will establish an ad-hoc Steering committee of fisheries professionals with expertise in fisheries management, genetics, salmon enhancement, and resource inventory. The Steering Committee will: (1) define the criteria for status evaluation; (2) contract for a program manager to compile a data base of catch and escapement data, and analyze the data according to the defined criteria; (3) review the contractor report; (4) produce a synthesis report in cooperation with the program manager for publication in the AFS journal *Fisheries*. While the program manager will be the lead author of this publication, the Steering Committee members will participate as co-authors. This will ensure Chapter oversight of the final product.

The Chapter will contract with the Alaska Department of Fish and Game (ADFG) for a program manager. The ADFG has developed and maintains the Status of Alaska Salmon Populations Geographic Information System (SASPop GIS), a database of georeferenced salmon escapement and harvest data. This information system will be the major data source for the evaluation of status. By contracting ADFG, the Chapter will have access and system support for SASPop. This approach also ensures access to the district biologists that are most familiar with the data sources and ancillary information on the resource. The Chapter used a contractual arrangement with ADFG for the Southeast Alaska status review, and believes this is the most cost and time efficient method.

Status of salmon populations in the regions of interest will be evaluated using a hierarchical approach, proceeding from large-scale geographic resolution to the fine scale of analysis of escapement data for specific spawning aggregates. The evaluation will use both catch and escapement data. Escapement data will provide information of current status for a limited suite of spawning aggregates; this information can be evaluated for direct comparisons with similar analyses in Southeast Alaska, British Columbia, and the Pacific Northwest. But such information is available for only a small proportion of the total spawning aggregates in the State, and for only a relatively limited time period.

Catch data can provide perspective on the sustained production of broader geographic areas where escapement data may be sparse or lacking, and can also provide a longer historical perspective at this coarser scale. Catch data have been used extensively to effectively document

long-term declines of salmon populations (e.g., Williams et al. 1999; Yoshiyama et al. 1998); to relate production to environmental variability (e.g., Beamish and Bouillon 1993); and to document sustained productivity (e.g., Meacham and Clark 1994; Wertheimer 1996). Escapement data will be analyzed at the management unit and spawning aggregate levels, following Baker et al. (1996). Spawning aggregates are escapement estimates or indices at a particular spawning location; management units are geographic regions for which fisheries are managed to achieve escapement goals or ranges. Trends in escapement relative to the long-term average will be determined to classify management units and spawning aggregates as: *normal*, escapement trends increasing or stable; *depressed*, escapement trends declining; *critical*, escapement trends in precipitous decline; *extinct*, fish once observed regularly but no longer present; or *unknown*, presence noted but information insufficient for evaluation.
Escapement data for spawning aggregates will also be classified for risk of extinction, using the classification system developed by Nehlson et al. (1991), as modified by Baker et al. (1996) and Slaney et al. (1996). This will allow direct comparison of status with other surveys along the eastern Pacific rim. The categories will be *low risk*, stable or increasing escapements with short-term mean escapements five times the minimum high-risk threshold number of spawners; *moderate risk*, declining or precipitously declining escapement trends and short-term mean escapement between 1-5 times the minimum high-risk threshold number of spawners; *high risk*, precipitously declining escapement trends and short-term mean escapements less than the minimum high-risk threshold number of spawners. The minimum high-risk threshold was 200 for all species except pink salmon; the threshold for pink salmon was 600 to account for their lack of age structure. Spawning aggregates that have been identified but which had insufficient records for trend analysis will be categorized as *unknown*.

The assessment data and the analyses will be compiled into a database compatible with ArcView geographic information system (GIS) software. This will allow graphical presentation of the analyses and the underlying data structure.

C. Cooperating agencies, Contracts, and Other Agency Assistance

This project will be managed by the Salmon Stock Status Committee of the Alaska Chapter of the American Fisheries Society. The Chapter will provide $10,000 in direct support of the project in FY01. Representation on this committee includes biologists from the National Marine Fisheries Service, the Alaska Department of Fish and Game, the U. S. Fish and Wildlife Service, and the University of Alaska Fairbanks. These institutions are providing $25,000 of in-kind support of professional participation of Committee members in this process. The Alaska Department of Fish and Game will be the primary contractor for the compilation of data and initial analyses of salmon population trends.

SCHEDULE:

A. Measurable Project Tasks for FY01

November 15, 2000:	Definition of criteria and statistical approach for evaluation
December 31, 2000:	Formalize contractual agreement for data compilation and analysis.
Jan. 1-Apr. 30, 2001:	Status evaluation, Prince William Sound
Apr. 30-Aug. 31, 2001:	Status evaluation, Kenai Fiords and Cook Inlet

B. Project Milestones and Endpoints

November 15, 2000: Steering Committee produces report defining evaluation criteria and statistical approach.

December 31, 2000: Contract for data compilation and analysis according to defined criteria and statistical approach.

April 30, 2001: Progress report due from Contractor to Committee on Prince William Sound analysis.

August 31, 2001: Progress report due from Contractor to Committee on Kenai Fiords and Cook Inlet analysis.

December 31, 2001: Progress report due from Contractor to Committee on Kodiak and South Alaska Peninsula analysis. Completion of Objective 1.

January, 2002: Presentation of preliminary results at Trustee Council workshop.

March 31, 2002: GIS linkage (Objective 2) completed; maps produced summarizing analytical results.

June 30, 2002: Data gaps, sampling recommendations completed (Objective 3). Summary manuscript completed and submitted for publication in *Fisheries*.

September 30, 2002: Final report submitted to Trustee Council.

PUBLICATIONS AND REPORTS:

Status of Pacific Salmon in Southcentral Alaska. Submission to *Fisheries*, June 30, 2002.
Exxon Valdez Trustee Council Final Report. Submission by September 30, 2002.

NORMAL AGENCY MANAGEMENT

Various agencies, including NMFS, ADFG, and USFWS, have overlapping responsibilities for management of the salmon resources of Alaska. However, individual agency management is

targeted at the statutory responsibilities of the agency, and overall assessment of status at a regional or landscape view is lacking. The Trustee Council's interest and support of this type of research has been effective in augmenting normal agency function and responsibility, and advancing interagency and institutional collaboration. This project will contribute to a broader perspective that can be used to monitor resource status and evaluate the success of management policies

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be a coordinated effort involving fishery scientists from the National Marine Fisheries Service, the Alaska Department of Fish and Game, the U. S. Fish and Wildlife Service, and the University of Alaska Fairbanks. The Alaska Chapter of the American Fisheries Society will provide oversight and structure for the project. The project will be dependent on catch and escapement data collected and compiled by the Alaska Department of Fish and Game, plus ancillary information on salmon resources in the spill area identified at the local or district level.

PROPOSED PRINCIPLE INVESTIGATOR

Alex Wertheimer
Alaska Chapter AFS
Stock Status Steering Committee Chair
11305 Glacier Highway
Juneau, AK 99801
(907) 789-6040 FAX 789-6601
Alex.Wertheimer@noaa.gov

PRINCIPLE INVESTIGATOR

Alex Wertheimer
BS Fisheries Science, Oregon State University (1979); MS Fisheries Science, University of Alaska (1984). Currently employed by National Marine Fisheries Service, Auke Bay Laboratory as a Fishery Research Biologist, Team Leader of Early Ocean Salmon Research. Author/coauthor of over 30 peer-reviewed publications and 35 agency reports on various aspects of the biology and culture of Pacific salmon. Research on Pacific salmon has included determining early marine growth, distribution, and migration; in nearshore habitat utilization; predator/prey relationships; by-catch mortality; the association of early marine conditions with year-class success of salmon; salmon aquaculture and genetics; status of stocks; the effects of hydrocarbon contamination on juvenile salmon in the marine environment; and effects of oiled incubation substrate on straying and survival of pink salmon. Serves as member of Chinook Technical Committee of the Pacific Salmon Commission. Past-President, Alaska Chapter American Fisheries Society. Associate Editor *Transactions of American Fisheries Society.* Chair, Salmon Stock Status Committee, Alaska Chapter American Fisheries Society. Principle Investigator *Exxon Valdez* NRDA Fish/Shellfish 4, NMFS Component, 1989 through project completion in 1993. Principle Investigator *Exxon Valdez* Restoration Project 076, 1996 through project completion in 1999.

OTHER KEY PERSONNEL

The following individuals are members of the Salmon Stock Status Committee, which will coordinate the project, define evaluation criteria and statistical approaches, contracting the program manager, and be responsible for producing a synthesis report in cooperation with the program manager for publication in the AFS journal *Fisheries.*

Tim Baker. Alaska Department of Fish and Game. 333 Raspberry Road, Anchorage, AK 99518-1599. (907) 267-2240. timb@fishgame.state.ak.us.

Hal Geiger. Alaska Department of Fish and Game. 1255 W. 8th Street, P.O. Box 25526, Juneau, AK 99802. (907) 465-6115. halg@fishgame.state.ak.us.

Dr. Tony Gharrett. University of Alaska, Fairbanks. Juneau Center Fisheries and Ocean Sciences. 11275 Glacier Hwy. Juneau, AK 99801. (907) 465-6445. ffajg@uaf.edu.

Dr. Jim Reynolds. University of Alaska, Fairbanks.School of Fisheries P.O. Box 757220 Fairbanks, AK 99775-7220. (907) 474-7824. ffjbr@uaf.edu.

Rodney C. Simmons. US Fish and Wildlife Service. Fairbanks Fishery Resource Office 101 12th Ave. Box 17, Fairbanks, AK 99701. (907) 456–0219. rod_simmons@fws.gov.

LITERATURE CITED

Baker, T. T., and eight co-authors. 1996. Status of Pacific salmon and steelhead escapements in Southeastern Alaska. Fisheries 21(6): 6-18.

Beamish, R. J., and D. R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50: 1002-1016.

Byerley, M., B. Brooks, B. Simonson, H. Savikko, and H. J. Geiger. 1999. Alaska commercial salmon catches, 1878-1997. Alaska Department of Fish and Game Regional Information Report 5J99-05.

Gharrett, A. J., B. E. Riddell, J. E. Seeb, and J. H. Helle. Status of genetic resources of Pacific rim salmon. Pages 295-301, In J. G. Cloud and G. H. Thorgaard (eds.). Genetic conservation of salmonid fishes. Plenum Press, New York, NY.

Konkel, G. W., and J. D. McIntyre. 1987. Trends in spawning populations of Pacific anadromous salmonids. U. S. Fish and Wildlife Service Technical Report 9.

Meacham, C. P., and J. H. Clark. 1994. Pacific salmon management-the view from Alaska. Alaska Fish. Res. Bull. 1: 76-80.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2): 4-21.

Slaney, T. T., K. D. Hyatt, T. G. Northcote, and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(6): 20-35.

Wertheimer, A. C. 1996. The status of Alaska salmon. Pages 179-197 *In* D. J. Stouder, P. A. Bisson, and R. J. Naiman (eds), Pacific salmon and their ecosystems: status and future options. Chapman Hall, New York.

Williams, R. N., and twelve co-authors. 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24(3): 10-19.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. North American Journal Fisheries Management 18: 487-521.

Financial

Savings 200
Windows 1314
soffits 424
Barnes and Noble 91.66
Easton Press 149.00
Trip 3000.00
Breadloaf 2810.00
Fred Meyer 200

School

Spring
BreadLoaf
British

Health

Work

Crabs - 92	HAPC	NSRAA - 99
Spatial - 95	Dispersants	Sandlance - 98
Predation - 99	Toxicity	Myxobolus - 88

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$0.0
Travel		$0.0
Contractual		$49.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$49.1
General Administration		$3.4
Project Total	$0.0	$52.5
Full-time Equivalents (FTE)		0.00
Other Resources		$35.0

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$52.5		

Dollar amounts are shown in thousands of dollars.

Comments:

In Kind Matching Funds:

Alaska Chapter American Fisheries Society (To cover part of $7.0 K in-state travel expense)	5.0
Western Division American Fisheries Society (To cover rest of instate travel, software, and misc. expenses)	5.0
4 weeks salary, A. C. Wertheimer, NMFS Fisheries Research Biologist.	8.6
2 weeks salary, Dr. J. Reynolds, University of Alaska Fairbanks	4.4
4 weeks salary, H. Geiger, ADFG Biometrician (includes agency personnel administration)	8.0
2 weeks salary, R. Simmons, USFWS Fishery Biologist	4.0
TOTAL IN-KIND	35.0

FY01

Prepared: 4/11/00

Project Number: 01 450

Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS

Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
					0.0	0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY01

Prepared: 4/11/00

Project Number: 01_____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:		Proposed FY 2001
Description		
4A Linkage	Alaska Chapter AFS, for subcontract of Program Analyst	49.1
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$49.1

Commodities Costs:		Proposed FY 2001
Description		
	Commodities Total	$0.0

FY01

Prepared: 4/11/00

Project Number: 01____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:			
Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:		
Description	Number of Units	Inventory Agency

FY01

Prepared: 4/11/00

Project Number: 01____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Agency: NOAA

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$45.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$45.0
Indirect		$4.05
Project Total	$0.0	$49.1
Full-time Equivalents (FTE)		0.75
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$49.1		

Dollar amounts are shown in thousands of dollars.

Comments:

FY01

Prepared: 4/11/00

Project Number: 01____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Name: AK Chapter - American Fisheries Society

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
		FB-III Program Manager	9.0	5.0		45.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	9.0	5.0	0.0	
					Personnel Total	$45.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$0.0

FY01

Prepared: 4/11/00

Project Number: 01_____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Name: AK Chapter - American Fishereis Society

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Prepared: 4/11/00

Project Number: 01____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Name: AK Chapter - American Fisheries Society

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2001
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units
Description	

FY01

Prepared: 4/11/00

Project Number: 01____
Project Title: Summary of Status of Pink Salmon Populations in Region Affected by the EVOS
Name: AK Chapter - American Fisheries Society

FORM 4B
Equipment
DETAIL

Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA

Project Number: 01452-BAA

Restoration category: Research

Proposer: Prince William Sound Science Center

Lead Trustee Agency: NOAA
Cooperating Agencies: ADF&G (matching), OSRI (matching)

Alaska SeaLife Center: No

Duration: 1st year of 2

Cost FY01: $46.3K
Cost FY02: $66.0K

RECEIVED
APR 14 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Geographic Area: Prince William Sound

Injured Resource/Service: Walleye pollock, pink salmon fry, Pacific herring

ABSTRACT

Residents of Prince William Sound (PWS) have repeatedly voiced the complaint that pink salmon populations in the spill-area suffered long-term impacts from the oil spill. Estimates of spring macrozooplankton prey and pollock predators are the primary biological data input to the pink salmon fry models developed by researchers over the past decade. We propose to expand the current spring predator prey- surveys that are supported by OSRI, SERVS, PWSAC and ADF&G to increase survey coverage, conduct more data analysis and add new optical sampling devices to further reduce the dependence of the surveys on expensive and less-representative, discrete net sampling.

INTRODUCTION

In 1989, the National Science Foundation GLOBEC program defined the limitations of observing and predicting animal population change in marine ecosystems (Cullen 1988) One of the primary failures in past marine research was identified as the use of sparse, discrete measurements with nets to estimate abundance. GLOBEC recommended the combination of acoustical and optical quasi-continuous measurement technologies with discrete net sampling to resolve confounding temporal and spatial variation (GLOBEC 1990a). Thomas (1992) concluded that implementation of such methods were the single most important improvement that could be made to improve fisheries science and management. Today, the use of discrete sampling to estimate fish and plankton abundance is no longer scientifically acceptable (Thomas and Kirsch 2000; Kirsch and Thomas 2000).

Since 1994, the Nekton and Plankton Acoustics program implemented a large-scale acoustics program to improve population-level measurement and the understanding of population responses to ecosystem change (SEA 1993). The immediate goal was to develop a new generation of observation data for management and research purposes. The long-range goal was to assist in the development and testing of numerical models to predict herring and salmon population changes in Prince William Sound. The absence of knowledge about the abundance and distribution of predator and prey densities in the marine environment has been a major limitation to accurate forecasting of salmon abundance (Thomas and Mathisen 1993). In the past eight years, we developed echointegration-optical-plankton net techniques to measure spring prey and predator abundances along the pink salmon outmigration path in PWS (Thomas and Kirsch 2000; Kirsch and Thomas 2000). Previously, the absence of predator and prey information has limited research in its efforts to discern the underlying mechanisms that affect population change and develop the new and improved predictive tools.

In FY00, OSRI and ADF&G initiated a program to begin observing spring predator and prey densities along the pink salmon outmigration path. This proposal requests matching funds from the EVOSTC to expand this program to include greater survey coverage in time and space, more in-depth data analysis and further development of the technique.

We propose to use both local fishing vessels and vessels of opportunity (USCG and SERVS) to conduct surveys between April 1 and July 1 each year. We will use a towed, sensor array and conduct surveys of the eastern and western corridors of Prince William Sound using line-transect sampling strategies to the provide coverage needed to represent the populations and minimize sampling variance (Kirsch and Thomas 2000; Steinhart et al. submitted, Kirsch et al. submitted). The sensor package will consist of a towed vehicle with various combinations of high frequency acoustic sensors; optical video recording and appropriate nets for ground truthing the targets. The acquisition and transfer operations for near-real time output of observation data and input to nowcast-forecast models are a long-term goal.

We propose to acquire:

- Spring estimates of macrozooplankton density, distribution and abundance using echointegration-optical-plankton net techniques,
- Synoptic estimates of pollock predators,
- Predict present and future recruitment events for pink salmon based upon the above information.

Pink salmon is a valued resource to the residents of the Sound and the spring abundance of macrozooplankton prey is an indicator of their annual productivity (Cooney 1993; Kirsch and Thomas 2000). Furthermore, adult pollock are recognized as the primary predator of, and competitor with juvenile fishes for macrozooplankton prey in the spring (Willette et al 1993, 1999; Thomas et al. 1997; Steinhart et al. submitted). Thus, initiating monitoring of macrozooplankton prey and predators are likely key data needed to assess changing marine survival, which makes this research both timely and relevant to issues concerning the future GEM, GLOBEC and North Pacific research initiatives.

Since 1994, we have developed new methods and an understanding of the Sound's complex ecosystem. We know that pollock is the dominates pelagic predator of pink salmon fry in the spring and that it filter feeds on the same zooplankton the fry depend on for growth and survival. We have developed new acoustic-optical-net sampling techniques that give us synoptic and representative estimates of these prey and predators and application of the new methodology and information is to apply it to make annual estimates and use it for forecasting fry survival. Recognizing the importance of pink salmon to the Sound ecosystem, we have developed a collaborative program between OSRI, ADF&G, local fishers and industry to monitor annual changes in the macrozooplankton prey and predator densities. Partnership is natural because the EVOS TC supported much of the past methods development and research and the importance of spring productivity to fish and wildlife survival.

NEED FOR THE PROJECT

A. Statement of the problem

One of the original questions sought by the SEA program was to explain why the survival of juvenile salmon fluctuated dramatically after the oil spill (SEA 1993). Pink salmon suffered major declines in 1992 and 1993. Declines in abundance may have resulted from changes to habitat, food supply, predator and competitor populations, genetic degradation, the commercial fishery and management, or unknown natural events. With the development of the new population measurement techniques and survival models, it should be possible to hind-cast, now-cast and forecast conditions that will aid the interpretation of past damage assessments, present status and future risks (GLOBEC 1990c). However, abundance of spring prey and predators is critical input for making empirical and developing mechanistic assessment of marine survival. Improving predictive capability is the path for designing restoration activities that promote the conservation and sustainable use of the pink salmon stocks of Prince William Sound.

In 1989, when the GLOBEC program defined the limitations of predicting animal population change in marine ecosystems, the EXXON VALDEZ oil spill occurred (Cullen 1989; Wolf et al. 1991). Armed with the only tools available, the state and federal agencies, and industry, began a massive, expensive and controversial damage assessment program. In 1994, the EVOS Trustee Council made a commitment to invest some resources into improving observation and prediction capabilities in the region.

The development and testing of predictive models require accurate and precise observational data. The new measurement tools developed in the past eight years are useful to both research and management since they are accurate and precise, which helps in the verification of predictions, and they are cost-effective. This proposal requests EVOS Trustee Council partnership in the continued observation of spring predators and prey of juvenile pink salmon.

B. Rationale/Link to Restoration

This project provides the observational data that is necessary to track annual changes in the marine survival of pink salmon and study survival mechanisms. It also provides "best-available" technology and information to agencies and industry for management purposes (Thomas and Kirsch 2000). Successful restoration of pink salmon would promote the recovery of the commercial fishery and related services. The long-term goal of the observation program is to increase the capability to predict natural changes that are occurring with the pink salmon populations. This capability is a prerequisite to the assessment of anthropogenic impacts, such as those caused by an oil, assessment of restoration, and prediction of pollock recruitment. Ultimately, the relevance of this research will be measured in its contribution to establishing a healthy salmon that once again provides the production to support abundant seabirds, marine mammals and human use. Furthermore, with synoptic measures and representative estimates of spring prey and predators the development of survival models for other dominant pelagic fishes in the Sound, such as herring and pollock, become practical. With implementation of predator-prey assessments to estimate survival is a step in developing a new ecosystem management approach.

We are looking for a two-year partnership with EVOS Trustee Council to complete the transition from the research program to a fully operational model-based monitoring program. Initially, the emphasis of the plankton-nekton monitoring will be to continue development of optical observation techniques. Subsequently, the verification and standardization of predictive techniques will follow. Concurrent with the biological observation and modeling program will be the development of the physical now-casting efforts by the OSRI, EVOSTC, RCAC, Industry cooperation that already is in place. This is critical because this program provides the spatially and temporally variable physical conditions that interact with prey availability that affect the pink salmon fry bioenergetics. Implementation of both biological and physical sampling to determine juvenile fish survival was the original GLOBEC program goal.

C. Location

Research will be conducted in Prince William Sound. Communities that may benefit include Whittier, Valdez, Cordova, Tatitlek, Chenega Bay, Port Graham, Kodiac, Homer and Nanwalek. All communities in the oil spill area could benefit by development of a successful restoration technique.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Local, traditional and scientific knowledge have led to the development of this proposal. Such knowledge may provide further insight during the course of this work. Due to the importance of this resource to local and native communities, we feel it is appropriate as well as beneficial to the project to recruit some of our research assistants from the local and native communities. The project work force and budget are designed with this intent.

The following procedures have worked well for the SEA program and the Prince William Sound Science Center and will be followed for this project: 1) consulting with community facilitators in local communities during the conception and design of the project to seek input; 2) advertising all boat hires and employment opportunities in communities near where the work is to be performed; 3) visiting local communities during the course of the field work and, where appropriate, base field work out of the villages using local lodging and/or boats; 4) providing a written report in non-technical language on project results after the second year and upon completion of the project; 5) acknowledging all local contributions appropriately, and 6) applying the results of the research in ways designed to benefit local communities, people, and cultural practices.

PROJECT DESIGN

A. Objectives

Implement a cost-effective observational program to annually estimate the distribution, abundance of spring macrozooplankton prey and predators of pink salmon fry.

B. Methods

Integrate digital acoustic and optical technologies that have been support by past EVOSTC and OSRI programs, into a multi-sensor package that allows for cost-effective measurement of abundance and model input variables (Thomas and Kirsch 2000; Kirsch and Thomas 2000; Kirsch et al. submitted). Implement, analyze and review survey data and model simulations to develop the most cost-effective program to now-cast and

forecast pollock population changes.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

OSRI, PWSAC and SERVS are providing approximately 120K per year to conduct the FY00 surveys, which is scheduled to continue for at least one year and definitely for two with EVOSTC partnership. This program makes extensive use of the measurement and computing equipment purchased and used on past EVOS TC research at minimal costs to upgrade and maintain.

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000 - September 30, 2001)

Oct. 1 - Dec. 31:	Review of databases and models for program and survey design; design and begin refinements of optical and acoustic systems, design and begin assembling processing system for making near-real time estimates of abundance, obtain NEPA categorical exclusion
January 2001:	Attend EVOS workshop in Anchorage
Jan 1 - Mar 31:	Continue data analysis and development of near-real time information system
Apr 1 - Jun 30:	Implementation of field surveys and continue data analysis.
July 1 - Sep 30:	Report, evaluate and refine survey design, make initial predictions of recruitment, and modify sampling for second year implementation

B. Project Milestones and Endpoints

FY01 Report on the spring 2001 predator-prey surveys with prediction of future pink salmon survival.
FY02 Report on the spring 2002 predator-prey surveys with estimates of future pink Survival.

C. Completion Date

FY02 (September 2002) with annual report on April 15, 2001.

PUBLICATIONS AND REPORTS

An annual report will be prepared to meet the Council's requirements for work done in 2001. Several peer-reviewed articles are anticipated from past pollock work and some may incorporate this first year's work as well. In the second year, we will prepare manuscripts presenting results of the first two years of work for publication in professional journals.

PROFESSIONAL CONFERENCES

Presentations are planned for the International Council for Exploration of the Seas: Fisheries Acoustics Symposium, PICES, the American Fisheries Society Meetings and the World Fisheries Congress.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will make use of preceding Council research through the designation of common field sites and sampling design. This project will also make use of data generated in the SEA, APEX and NSP projects as well as seek the input of researchers involved in other projects within the region.

PRINCIPAL INVESTIGATORS

Richard E. Thorne, Senior Scientist
Gary Thomas, Ph.D., Senior Scientist
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574
tel: (907) 424-5800
fax: (907) 424-5820
e-mail: loon-, thorne@pwssc.gen.ak.us

Responsibilities: Dr. Thorne will be responsible for project administration and acoustic sampling, analysis and writing. He has been working as a PI on research projects for over 25 years while at the University of Washington and at BioSonics Inc. He participated as a subcontractor to the University of Alaska Fairbanks on the APEX research program.

Dr. Thomas will be responsible for project coordination, field logistics, data analysis and writing running and refinement of the Nekton model. He has worked as a PI on past EVOS TC research programs.

C.V.s for both investigators are attached. Please address all correspondence related to this proposal to Richard E. Thorne.

KEY PERSONNEL

Project biologist/field manager (staff):	Primary responsibility for field scheduling and logistics, equipment and data management, assists with analyses and report writing.
Field assistants (staff):	Assists with all aspects of fieldwork and sampling.

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CURRICULUM VITAE

Richard E. Thorne, Ph.D.
P.O. Box 1331, Cordova, Alaska 99574
(907) 424-3117, -5800 (work), -5820 (fax)

Employment History

BioSonics, Inc. 4027 Leary Way NW Seattle, WA 98107 (206) 782-2211	Vice President 1996-1999 Manager Technical Services 1991-1999 Senior Scientist 1988-1999
University of Washington School of Fisheries Fisheries Research Institute Seattle, WA	Affiliate Research Professor 1991-Present Research Professor1981-1990 (LOA 1988-1990) Research Associate Professor 1976-1981 Senior Research Associate 1970-1976
Commercial Fisher (salmon and albacore)	1957-1968

Academic Background

Ph.D., Fisheries-1970, University of Washington, School of Fisheries
MS Degree-1968, University of Washington, Department of Oceanography
B.S. Degree-1965, University of Washington, Department of Oceanography

PUBLICATIONS:

Thorne, R.E. 1998. Review: experiences with shallow water acoustics. Fish. Res.35:137-141, Elsevier Science, Amsterdam

Tarbox, K.E. and R.E. Thorne, 1996. Assessment of adult salmon in near-surface waters of Cook Inlet, Alaska. ICES Journal of Marine Science 53:397-401.

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CURRICULUM VITAE

G.L. Thomas, Ph.D.
P.O. Box 1331, Cordova, Alaska 99574
(907) 424-3117, -5800 (work), -5820 (fax)

Education

B.A., 1970, California Western University, San Diego, CA.
M.S., 1973, California State University, San Diego, CA.
Ph.D., 1978, University of Washington, Seattle, WA.

Professional Experience

1997 to present - Prince William Sound Oil Spill Recovery Institute (Executive Director)
1995 to present - University of Miami (Affiliate Full Professor)
1992 to present - Prince William Sound Science Center (President)
1993 to 1995 - University of Alaska Fairbanks (Affiliate Associate Professor)
1992 to 1996 - Prince William Sound Oil Spill Recovery Institute (Acting Director)
1990 to 1992 - Prince William Sound Science Center (part-time Director)
1990-1992 School of Fisheries, University of Washington (part-time research faculty)
1984-1989 Coop. Fisheries Res. Unit, University of Washington (Administrator/research faculty)
1981-1983 Fisheries Research Institute, University of Washington (Research Assistant Professor)
1977-1980 - Fisheries Res. Institute, U. of Washington (Fisheries Biologist/Research Associate)
1973 to 1976 - University of Washington (Pre-doctoral Research Associate)
1971 to 1973 - Scripps Institute of Oceanography (Research Associate)

Academic Honors

1974 - Tacoma Sportsmen's Scholarship
1976 - Ellis Memorial Scholarship
1986 - Outstanding Service Award, North Pacific International Chapter of the American Fisheries Society
1990 - Outstanding Service Award, U.S. Fish and Wildlife Service
1999 - Outstanding Service Award, Prince William Sound Science Center

Professional Memberships

American Fisheries Society (life member)
American Institute of Fisheries Research Biologists
American Association for the Advancement of Science

Publications

Thomas, G.L. and Richard E. Thorne. 2000. Combining echointegration and infrared technologies to monitor marine mammal and seabird feeding on overwintering herring in Prince William Sound. PICES 2000 (in preparation).

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Technical Reports: I am author on over 100 technical reports (titles provided upon request).

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$0.0						
Travel		$0.0						
Contractual		$46.3						
Commodities		$0.0						
Equipment		$0.0						
Subtotal		$46.3		Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
General Administration		$3.2						
Project Total	$0.0	$49.5		$72.0	$0.0	$0.0		
Full-time Equivalents (FTE)		2.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 01

Prepared:

Project Number: 01452 BAA
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$22.9
Travel		$3.4
Contractual		$4.5
Commodities		$1.2
Equipment		$5.0
Subtotal	$0.0	$37.0
Indirect		$9.3
Project Total	$0.0	$46.3
Full-time Equivalents (FTE)		2.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
$66.0				

Dollar amounts are shown in thousands of dollars.

Comments:

*Salary rate for G.L. Thomas reflects research time at 20% reduction from administrative costs

**OSRI, SERVS, PWSAC and ADF&G are contributing approximately $120,000 to this program for better than a two-thirds matching rate

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
G.L. Thomas	co-Principal Investigator		0.5	10.9		5.5
R.E. Thorne	co-Principal Investigator		1.0	10.5		10.5
TBN	Technician		1.0	6.9		6.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.5	28.3	0.0	
					Personnel Total	$22.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2001
Annual Meeting		0.5	1	5.0	0.2	1.5
EVOS and collaborative workshops		0.5	1	7	0.2	1.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3.4

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed FY 2001
tele, communications, fax, etc.	0.4
maintenance	0.1
Vessel Charters	4.0
Contractual Total	$4.5

Commodities Costs:	Proposed FY 2001
supplies	1.2
Commodities Total	$1.2

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities
DETAIL

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2001
Description			
420 kHz Transducer	1	5.0	5.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$5.0

Existing Equipment Usage:	Number of Units	
Description		

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

Pink Salmon Recovery: Evidence and Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats

RECEIVED
APR 14 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number:	01454
Restoration Category:	Research
Proposer:	Stanley Rice, Mark Carls, Ron Heintz NMFS Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice NOAA Project Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agencies:	-
Alaska SeaLife Center:	-
Duration:	2 years *(Final year of a 2 year project)*
Cost FY01:	$103,200
Geographic Area:	Prince William Sound, and Little Port Walter on Baranof Island (Southeast Alaska)
Injured Resource:	Pink salmon

ABSTRACT

Reports of persistent oil contamination in natal pink salmon streams in Prince William Sound (PWS), and adverse biological effects at parts per billion oil concentrations stimulated this study in FY00. Preliminary results demonstrate evidence of continued hydrocarbon contamination in some previously oiled streams. Fry from PWS and experimentally dosed fish have been collected for examination of a biomarker, cytochrome P4501A. When analyses are completed, data will be inspected for correlations between the biomarker, growth, predator avoidance, and marine survival. These results will be integrated with past research to reexamine the recovery status of pink salmon and their spawning habitat.

INTRODUCTION

The recovery status of pink salmon in Prince William Sound (PWS) is problematic, because population levels as a whole are relatively high and include fish from large areas with little or no oil-exposure history), while the banks of specific natal streams remain contaminated with oil (Murphy et al. In press). Part per billion sensitivities to oil have been documented in early life stages (Heintz et al. 1999), and elevated egg mortalities in oiled streams were reported by ADF&G as late as 1997. Recovery at the stream level is unknown, and the definition of recovery for pink salmon needs to be re-examined. This proposal will "close the loop" on past pink salmon oil toxicity research by examining the status of oil contamination and egg/alevin exposure at oiled benchmark streams. The use of the biomarker P4501A will be used in field and laboratory tests, and the biological significance of the biomarker will be determined in short-term responses (tissue abnormalities), intermediate responses (growth of cultured fish), and in returning adult pink salmon from previous exposures (brood year 1998).

This project is designed to examine the natal habitat of pink salmon in PWS for evidence of exposure to polynuclear aromatic hydrocarbons (PAHs) derived from *Exxon Valdez* oil. When the project was initiated in FY00 we suggested that direct measurement of biologically available PAHs in the natal habitats 10 years after the spill would be difficult, but possible with the proposed detection technology (plastic membrane devices). Two types of plastic membrane devices (PMDs) were used, semi-permiable membrane devices (SPMDs) and low density polyethylene (LDPE) strips[1]). Preliminary PMD results indicate that oil is present in at least 2 of 6 previously oiled PWS streams. Confirmatory analysis of naturally spawned eggs for PAH is in progress, and sediments will also be analyzed.

Further, we will look for biological evidence of oil exposure by measuring cytochrome P4501A in pre-emergent alevins collected from the streams in spring 2000. These measurements will be the first complete set of observations of this kind made in the oil-contaminated streams. The measurement of oil in the stream banks [repeating the Murphy et al. (1999) study] will permit the extension of the habitat contamination recovery model by 4 years. Demonstration of detectable amounts of PAHs in these environments (or their absence) will provide a direct basis for relating earlier field studies to recent laboratory studies aimed at cataloging the effects of incubating in oiled stream environments. In addition, examination of the incubating environments for evidence of contamination will provide the Trustees with a rational basis for evaluating the recovery status of pink salmon at the stream level, rather than be dependent on population levels that include hatchery production and many streams with little or no oil-exposure history.

Biomarkers like P4501A have been used before as biological evidence of oil exposure (e.g., Wiedmer et al. 1996), but the biological significance of induction is seldom known. We

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[1]The SPMDs are commercially produced samplers that consist of an LDPE tube enclosing a triolene reservoir. The LDPE strips had the same surface area as the SPMDs. LDPEs and SPMDs were always deployed in groups, so that sampling results were directly comparable.

propose to measure cytochrome P4501A activity in emergent fry from oil-contaminated streams and compare to measurements of fry with known exposures and known biological consequences. By using fish from graded exposures and following them through the delayed impacts on marine growth, we can ascribe a biological significance (consequence) to the P4501A measurements. The experimental exposures are nearly complete; fry emerging from the incubators are being sampled and ponded for growth study. Further, by sampling emergent fish from project 99426 in spring 1999, we can correlate marine survival and reproductive fitness to the three exposure doses that will be released to the field (returning as adults in fall 2000). In past laboratory studies, aqueous PAH concentrations as low as 4 ppb induced cytochrome P4501A activity (Marty et al. 1997), and embryo mortality was elevated at 1 ppb (Heintz et al. 1999). However, none of these experiments were designed to identify a lowest effective concentration (LOEC) for P4501A induction, and these studies did not establish the biological meaning of exposure by relating induction to demonstrable effects. We will relate differing levels of P4501A activity to long-term effects on salmon growth because growth is a relatively inexpensive criterion to measure, and it effectively integrates most of the long-term effects that are likely to be experienced by those fish that survive the exposure period.

Lastly, the definition of pink salmon recovery, relative to habitat contamination and biological consequences will be examined. The project here will synthesize the present study results, along with other concurent and past studies to give a definitive status of pink salmon recovery.

NEED FOR THE PROJECT

A. Statement of the Problem

The definition of pink salmon recovery in PWS, currently based on broad geographic populations that include fish from hatcheries and streams with little or no oil-exposure history, is not compatible with measurements of persistent oil effects in wild salmon streams. This study will provide field and laboratory evidence of pink salmon exposure in natal streams, where oil impacts have been measured as late as 1997. Interpretation of results will help to determine if wild pink salmon in PWS continue to be contaminated by EVO, or if they have recovered.

This project examines two questions: are the natal habitats of pink salmon still being contaminated by PAHs derived from the *Exxon Valdez*, and can biomarkers index injury as well as identify exposure. The first question derives from three important observations. First, pink salmon mortalities have been shown to increase at aqueous TPAH concentrations as low as 1.0 ppb (Heintz et al. 1999). Second, oiled gravel is still recoverable near several pink salmon streams in the affected sections of PWS, and third, elevated embryo mortality in oil-contaminated streams was identified as late as 1997. These observations suggest that oil from the *Exxon Valdez* may still be injuring pink salmon in contaminated streams. Consequently, pink salmon are only classified as a recovering species, despite apparently healthy escapement levels in the southwestern district. This project seeks to examine the potential for ongoing injury by quantifying the exposure experienced by pink salmon in their natal streams and identifying what sort of injury can be expected from the observed exposure levels.

The question of continuing exposure in pink salmon streams is examined in three ways. First we have measured the availability of PAHs to incubating pink salmon by measuring the levels of contamination in interstitial waters; stream sediment and streambanks will also be analyzed. Second, evaluation of the uptake of PAHs in eyed pink salmon eggs collected from oiled streams is in progress. Finally, fry from oil-contaminated streams will be examined for evidence of PAH exposure by measuring cytochrome P4501A activity in their tissues and the biological significance of these exposures will quantified with laboratory studies.

B. Rationale/Link to Restoration

Pink salmon are listed as a recovering species, and before they can be added to the list of recovered species evidence for continued exposure to oil from the *Exxon Valdez* must be considered. The original criterion the Trustees proposed to use for listing the recovery of pink salmon was the absence of demonstrable effects for two complete reproductive cycles. In 1994 through 1996, pink salmon embryos in oiled and unoiled streams had similar mortality rates, suggesting they had recovered. However, since the criterion was established it has become clear that oil can still be found near natal habitats, and that pink salmon embryos are significantly more sensitive to PAHs than previously believed. These factors may explain the elevated embryo mortalities in oiled streams observed in 1997. Thus, the original criterion for recovery should be reconsidered. We propose to ascertain the recovery status by determining if exposures are still taking place and by relating observed exposures to those known to cause injury.

Direct measurement of PAH concentrations in the natal pink salmon environments in FY00 has demonstrated the plausibility of an exposure mechanism proposed by Heintz et al. (1999), and measurements in pink salmon tissues will likely demonstrate exposure. The hypothesized exposure mechanism suggests that PAHs leach from oil reservoirs buried in beaches alongside and above the stream channels into salmon redds via interstitial water flow. This mechanism has not previously been verified in the field, and PAH concentrations in pink salmon tissues have not been monitored.

The final field research, study of hydrodynamics at two representative PWS streams, will be completed in summer 2000. The purposes of the hydrological survey are to 1) map the physical characteristics of two representative PWS streams, 2) characterize hydraulic gradients, and 3) provide evidence of water exchange between sediment in stream banks, stream water, and salmon redds. Before analysis in PWS, a local stream in Southeast Alaska will be sampled to test and refine sampling techniques. Although we expect the rates and volume of exchange between stream water and bank water will vary among streams, exchange of water between banks and stream may be generalized from a single stream.

The activity of cytochrome P4501A in pre-emergent fry is an alternative method for demonstrating exposure to PAH. Cytochrome P4501A is an important enzyme system used by fish to metabolize PAHs. Elevated cytochrome P4501A activity was identified in fish taken from oiled streams as late as 1991 (Weidmer 1996) indicating exposure occurred despite the absence of detectable PAHs in the streambed gravel (Brannon et al. 1995). Although activity of P4501A was verification that salmon embryos were exposed, the relationship between P4501A

induction and injury has not been evaluated. Thus, we initiated a study in FY00 to examine the relationships between P4501A induction, TPAH exposure concentration, and biological response of salmon embryos under laboratory conditions.

C. Location

Field samples have been collected from the spill zone in western PWS. The laboratory phase of this project is underway at Little Port Walter (LPW), a research hatchery operated by NMFS in southeastern Alaska. This laboratory has been the site of many of the Trustee laboratory studies on oil toxicity to pink salmon. The facility at LPW provides easy access to the intertidally spawning pink salmon stock that has been the subject of previous experiments. In addition, the exposure apparatus requires a simulated intertidal environment and such a system is in operation at LPW.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Field collections were dependent on chartering vessel and air support. Contaminated pink salmon streams have been identified by local residents. We will continue to provide information to interested public (primarily fishermen) who visit our laboratory.

PROJECT DESIGN

A. Objectives

This project has three main themes, each with specific objectives. *(Progress to date is indicated in italics.)*

1. Examination of persistent *Exxon Valdez* oil in natal habitats of pink salmon in PWS, and evaluation of current contamination of eggs and alevins.
    - A. Determine how rapidly the incubating environments are recovering
        1. Measure oil in banks adjacent to bench-mark streams last sampled in 1995 by fast-screening procedures to extend the recovery model to 2000. *(Samples have been collected.)*
        2. Measure the availability of PAHs in the incubating environment *(Analysis of PMDs indicates 2 of 6 PWS streams remain contaminated by oil.)*
    - B. Measure oil in stream sediment by gas chromatography and mass spectrometry (GC/MS) to verify there is little or no contaminant directly in the stream.
        1. Measure aqueous oil contamination in salmon redds with buried PMDs to verify oil transport interstitially to salmon redds. *(Analysis of PMDs indicates 2 of 6 PWS streams remain contaminated by oil.)*
        2. Verify method sensitivities by measuring oil in a stream with a known natural oil seep. *(Initial sampling failed; devices were destroyed by water flow or bear activity.)*

C. Measure exposure of eggs and fry to PAH
   1. Directly measure oil concentrations in eggs by GC/MS, and compare to concentrations in SPMD's. *(Hydrocarbon analysis of eggs is in progress.)*
   2. Inspect eggs for indirect evidence of exposure to oil using the biomarker cytochrome P4501A as an index of exposure and compare to PAH concentrations in eggs and SPMD's. *(Pre-emergent fry were collected in March 2000; those most likely to be exposed to oil will be examined for P4501A activity.)*

2. Examination of the usefulness of the biomarker cytochrome P4501A as a predictor of the biological impacts of oil exposure
   A. Controlled laboratory test with graded oil doses to establish a dose-response curve at part per billion levels. *(Dosing is nearly complete. Fry are emerging from incubators. Mortality measurement at eyeing suggests eggs were sensitive part-per-billion PAH concentrations. Supportive hydrocarbon analyses are underway.)*
   B. Influence of exposure level on the prevalence of cytochrome P4501A activity and embryo tissue
      1. Inspect emergent fry for gross and histological lesions *(Sample collection is in progress.)*
      2. Determine P4501A induction in organ tissues. *(Tissue mounting is in progress.)*
   C. Initiation of cytochrome P4501A activity in developing pink salmon
      1. At one dose, measure P4501A response at four developmental stages to determine the onset of induction. *(Sample collection is nearly complete.)*
   D. Relation between cytochrome P4501A activity and short and long-term effects
      1. Relate P4501A induction to growth of experimental fish cultured at LPW (brood year 99) from the graded series of oil exposures. *(Experimental fish are being ponded for additional growth and predation study.)*
3. Relate P4501A induction to ocean survival (brood year 98) and reproductive fitness of returning adults to parts per billion exposures from the companion pink salmon toxicity study 99476.
   A. Synthesis of this project, and long-term impact data from other projects, to redefine pink salmon recovery in PWS, and provide a status of that recovery. *(This task will be completed after completion of sampling and data analysis.)*

The first theme provides a basis for testing the hypothesis that pink salmon, incubating in previously oiled streams, continue to be exposed to PAHs derived from the *Exxon Valdez*. Testing this hypothesis entails three major tasks: 1) determine how rapidly oil reservoirs are being depleted by sampling gravel from the deltas of streams identified as benchmarks in 1989 and resampled again in 1995 (Murphy et al. In press); 2) measure the availability of PAHs in the incubating environment by sampling the water flowing through salmon redds for PAHs using PMDs, and characterizing the PAH levels in gravels alongside, above, and in the stream channels; 3) establish the availability of PAHs to the eggs by measuring PAH concentrations in eyed eggs and activity of cytochrome P4501A in emerging fry. This latter task will be limited to those sites identified with highest risk as determined by fast screening methods. Each of these

tasks will be performed in oiled and unoiled streams selected on the basis of their contamination histories. In addition, the sensitivity of these approaches will be examined by duplicating these approaches in a stream outside PWS, but known to contain a natural oil seep. The seep stream will be an "oiled control."

The second theme tests the hypothesis that increasing PAH levels increase the prevalence of cytochrome P4501A activity and result in long-term injury. P4501A has long been known to document exposure, but the biological consequences are unknown. This hypothesis requires a laboratory study designed to determine 1) when cytochrome P4501A activity becomes detectable in developing embryos, 2) how exposure level influences the prevalence of cytochrome P4501A activity in specific tissues, and 3) the relationship of P4501A activity to both short- and long-term biological response. We propose to incubate pink salmon eggs in variety of TPAH concentrations and examine them periodically for evidence of cytochrome P4501A activity. Prevalence is defined as the product of the intensity of staining and occurrence in histologic sections of tissue examined for P4501A activity by immunochemical staining. The first task is required, because the time of onset may be a better predictor of long-term effects than prevalence at emergence. Induction prevalence will be related to the dosing histories to develop a dose-response curve. The relationship between long-term effects and prevalence will be examined by holding fish from the same exposure groups in captivity and examining them for dose related differences in growth rate.

Synthesis of the first two research themes will provide a rational basis for judging whether or not wild pink salmon stocks in PWS have recovered from the *Exxon Valdez* oil spill. The study will determine if pink salmon eggs are currently being exposed to hydrocarbons in oil-contaminated streams, and how quickly these sensitive environments are recovering. In addition, the development of a relationship between cytochrome P4501A activity and long-term effects will provide a basis for further evaluating the severity of the exposures indicated by P4501A activity in salmon embryos in first two years after the spill.

B. Methods

Theme 1. Examination of persistent *Exxon Valdez* oil in natal habitats of pink salmon in PWS, and evaluation of current contamination of eggs and alevins.

Determine how rapidly the incubating environments are recovering

Gravel samples from each of the 9 oiled index sites identified in Murphy et al. (In press) were collected using the procedures described in that report. In addition, oil reservoirs identified in 1995 were sampled to determine how rapidly they are weathering. All samples were collected from sites sampled in 1989 and 1995. All the gravel samples will be analyzed by ultraviolet fluorescence, a fast screening procedure that can be used to identify samples with sufficient amounts of oil to warrant more detailed analysis by GC/MS. The fast screening results as well as the more detailed analyses can be compared to similar data collected in 1995. These data will be combined with those reported by Murphy et al (1999) to extend their recovery model.

Measure the availability of PAHs in the incubating environment

Exposure levels in streams contaminated by the *Exxon Valdez* oil spill were monitored previously 6 streams identified with high embryo mortality rates in 1997. The Katalla slough stream, which has a naturally occurring oil seep (Bue et al. 1998) was also sampled, but water flow or bear activity destroyed the samplers. The existence of oil in Katalla slough will provide a measure of the sensitivity of our analyses for detecting petrogenic PAHs in interstitial waters and pink salmon tissues.

Sampling protocols applied to each stream followed the general procedure of Bue et al. (1996). Streams were divided into four sections based on their position above mean lower low water, and sampling transects were established in each section using maps developed by Bue et al. (1998). Transect locations coincided with those used in 1997. Personnel with ongoing experience conducting egg-dig transects in PWS were contracted (i.e., the same crew that ADF&G uses).

Sampling began prior to the arrival of adult pink salmon in 1999. Gravel samples were collected from the stream banks 1 m upstream from either end of each transect and from the streambed in the center of each transect. Dissolved PAHs were sampled by burying SPMDs and LDPEs in two pits dug into the streambed along each transect. All PMDs were recovered about 54 d after installation. The depths of sampler burial were similar to the depths of redds constructed by pink salmon.

PAH levels membrane sample devices was determined by gas chromatography and mass spectrometry (GC/MS) using the methods described by Short et al. (1996). Prior to analysis, sediment samples will be fast-screened to determine the concentrations of total petroleum hydrocarbons (PHCs) by ultraviolet fluorescence. Samples with detectable levels of PHCs will be further analyzed by GC/MS. PAH levels in stream bank sediments and streambed gravels will be used to map the distribution of oil in the incubating habitat, while PAH observations collected from membrane devices will be used to examine the transport of PAHs to incubating habitats.

Measure exposure of eggs and fry to PAH

Availability of PAH's to eggs and fry will be measured in two ways, by PAH concentration in egg tissue, and induction of cytochrome P4501A. Measurement of PAH uptake is in progress for eyed eggs sampled along the PMD transects. In October 1999, each transect was visited to collect eyed eggs. The procedure was repeated in March 2000 to obtain a set of pre-emergent fry for analysis of cytochrome P4501A activity and hydrocarbon concentrations. Eyed eggs and pre-emergent fry will be obtained by hydraulic sampling along the established transects using methods described by Pirtle and McCurdy (1977). Preferred samples of eyed eggs and pre-emergent fry will come from locations nearest each of the SPMDs. The eyed eggs were frozen immediately after collection to be examined for PAHs by GC/MS. Pre-emergent fry were preserved in formalin in individual cassettes for later processing to determine cytochrome P4501A induction using immunohistochemical staining. Samples will be analyzed blind.

The only samples of eyed eggs and pre-emergent fry to be processed will be those with the greatest likelihood of having detectable PAHs or P4501A induction. Sample sets will be selected on the basis of the analytical results of oil deposits in associated streambank gravel and PMD samples. Levels of PAH observed in eyed eggs will be used to demonstrate exposure levels and these will be compared with those observed in laboratory studies described by Heintz et al. (1999).

Theme 2. Examination of the usefulness of the biomarker cytochrome P4501A as a predictor of the biological impacts of oil exposure

Controlled laboratory test with graded oil doses

Developing pink salmon eggs were exposed to oil contaminated water using the laboratory methods described in Marty et al. (1997). Approximately 18,000 eggs were exposed to each of 5 doses, in order to provide sufficient numbers of fry for examining long-term affects on growth. Procedures used to determine embryo mortality rates and quantify exposure levels will follow previously described methods (Marty et al. 1997).

Influence of exposure level on the prevalence of cytochrome P4501A activity and organ tissue

Emerging fry are being counted, inspected for gross lesions and sampled to examine the presence of cytochrome P4501A activity. Aliquots of 12 fry from each dose will be retained for analysis of cytochrome P4501A induction with immunohistochemical staining. Fry will be retained in individual cassettes in buffered formalin and shipped to UC Davis for processing. Histological sectioning and determination of cytochrome P4501A induction will follow the procedures described in Marty et al. (1997). Sections of preserved fry will be cut to ensure staining of at least the gill, pharynix, kidney, intestine, heart, liver epidermis and yolk sac. Scores for staining intensity and occurrence will be compared by regression to exposure history to determine which tissue or combinations of tissues are the best indicators of exposure level. Additional specimens are being preserved in alcohol for genetic analysis.

Initiation of cytochrome P4501A activity in developing pink salmon

Alevins from the highest exposure level have been sampled across time to determine when cytochrome P4501A activity is initiated during development.

Relation between cytochrome P4501A activity and long-term effects

Two methods will be used to relate induction of P4501A to long-term biological effects, including marine survival (1998 brood year) and growth of cultured fish (1999 brood year). Marine survival and reproductive fitness of returning adults will be determined for fish in a previous experiment (study number 99476), where the number of oil exposures was limited to two, but P4501A induction will be determined in eyed eggs and emergent fry sampled prior to release (spring 1999).

Experimental fry from the 1999 brood year are being cultured in net pens for 3-4 months to determine the value of P4501A activity for predicting long-term effects of embryonic exposure to PAHs on marine growth. Fry are being transferred to separate containers depending on their exposure histories and cultured until they are large enough to tag with passive integrated transponder (PIT) tags. Fry transferred to the culture containers will be measured to determine each group's average weight and length. At tagging the length and weight of each individual will be recorded and growth will be calculated as the difference in the logs of the weight at tagging and the group's initial mean weight divided by the number of elapsed days. After tagging, individual growth records for each fish will be developed by periodically sampling the tagged population. Mean growth rates for each exposure group will be compared to their exposure history and the average combined score for intensity and occurrence for cytochrome P4501A activity in the given exposure group at emergence.

C. Cooperating Agencies, Contracts and Other Agency Assistance

No field trips are necessary for the second year of this close-out project. Analysis of cytochrome P4501A will be completed by contract with UC Davis.

SCHEDULE

April 1999	Completed collection of emergent fry for P4501A analysis from exposed fish (brood year 98)
Aug 1999	Completed deployment of samplers in stream beds, sediment collection, and laboratory experimental setup.
Fall 1999	Completed collection of SPMDs and eyed eggs from PWS streams. Completed collection of eyed eggs to determine onset of P4501A activity (lab)
Winter 99/00	Nearly completed GC/MS analysis of PMDs. GC/MS analysis of eggs and sediment is underway. Completed collection of experimental alevins for P4501A induction.
Spring 2000	Completed collection of PWS fry samples for P4501A Nearly completed is collection of emergent fry for final P4501A samples and evaluation of surviving fry (laboratory). Begin analysis of fry for cytochrome P4501A activity, and growing out fry exposed in laboratory.
Summer 2000	Monitor growth of experimentally exposed fry. Complete predator studies using experimentally exposed fry.

Fall 2000	Complete GC/MS analysis of remaining samples, and complete analyses of growth. Complete histopathologica/MFO analysis of fry
Jan 2001	Report preliminary results at Trustee workshop
Winter 2001	Complete data analysis.
Spring 2001	Draft manuscripts complete.
Summer 01	Submit manuscripts for publication
Oct 2001	Submit final report.

B. Project Milestones

Fall 2000:	Complete sample analyses
Jan. 2001:	Report to Trustees
Summer 01:	Submit manuscripts to journals
Oct 2001	Submit final report.

C Completion Date

Final Report will be submitted on Oct 1, 2001.

PUBLICATIONS AND REPORTS

Final Report

Peer-reviewed manuscripts:

Carls, M.G. et al. 2001. Hydrocarbon contamination and recovery of pink salmon spawning areas a decade after the *Exxon Valdez* oil spill. Journal unknown.

Carls, M.G. et al. 2001. Persistent exposure of pink salmon to *Exxon Valdez* oil a decade after the spill. Journal unknown.

Heintz, R. et al. 2000. Feasibility of using biomarkers to regulate water quality. Journal Unknown.

Heintz, R. et al. 2001. Relation of P4501A biomarker in alevin pink salmon to long-term growth and reproductive fitness. Journal unknown.

Lilly, M. 2001. Hydraulic relationships between stream and intertidal ground water. Journal unknown.

Marty, G.D. et al. 2001. Developmental appearance of P4501A biomarker in pink salmon eggs and larvae. Journal unknown.

Rice, S.D. et al. 2001. Long-term biological and ecosystem recovery for pink salmon after the *Exxon Valdez* oil spill. Journal unknown..

Rice, S.D. et al. 2001. P450: Biomarker of exposure or predictor of impacts?

PROFESSIONAL CONFERENCES

Attendence of the SETAC conference is planned in FY01, and travel to 2001 Trustee workshop is included.

NORMAL AGENCY MANAGEMENT

This project seeks to determine the recovery status of pink salmon through a cooperative relationship between NMFS and the Trustees. There is no charge for project support costs which include management of the LPW facility and project budget.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The design of this project has been coordinated with the work performed in the past by ADF&G under Restoration 191A, and the work performed by NMFS under 191B and 194. Investigators and agencies will coordinate by sharing data. NOAA/NMFS will coordinate with the Trustees by providing labor requirements and laboratory overhead. This project also coordinates with pink salmon reproductive fitness project 99426 by collecting emergent fry for P4501A analysis (brood year 98).

PRINCIPAL INVESTIGATOR

Name	Dr. Stan Rice
Affiliation	NMFS
Address	Auke Bay Laboratory 11305 Glacier Hwy. Juneau, AK 99801
Phone	907-789-6020
Fax	907-789-6094

E-mail jeep.rice@noaa.gov

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. 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 100 papers, including over 75 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 chemistry 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, direct input into agency decisions, interaction with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.), and lead editor of the first Trustee symposium proceedings.

PRINCIPAL INVESTIGATOR

Name	Mark G. Carls
Affiliation	NMFS
Address	Auke Bay Laboratory
	11305 Glacier Hwy
	Juneau, AK 99801
Phone	(907) 789-6019
Fax	(907) 789-6094
email	mark.carls@noaa.gov

Mark G. Carls (GS-12 Fishery Biologist)

Received BA (1975) in Biology from Gustavus Adolphus College, St. Peter, MN, and MS (1978) in Biological Oceanography from Dalhousie University, Halifax, Nova Scotia. Mark has been employed at the Auke Bay Fisheries Laboratory since 1979. His principal involvement has been in research of petroleum hydrocarbon toxicology to marine fish and invertebrates, including egg, larval, and adult life stages. Mark has published 17 papers, and has 5 *Exxon Valdez* damage assessment papers in preparation or pending publication. Since 1989, he has been involved as a principal investigator and co-investigator on several studies resulting from the *Exxon Valdez* oil spill involving Pacific herring, pink, and chum salmon, and mussels.

PRINCIPAL INVESTIGATOR

Name	Ron A. Heintz
Affiliation	NMFS
Address	11305 Glacier Hwy.
	Juneau, AK. 99801
phone	907-789-6058
Fax	907-789-6094
email	ron.heintz@noaa.gov

Ron A. Heintz (GS-12 Fishery Biologist)

PRINCIPAL INVESTIGATOR

Ron Heintz obtained his BS in Ecology, Ethology & Evolution from the University of Illinois in 1979 and his MS Fisheries Science from the University of Alaska in 1986. He has worked for the National Marine Fisheries Service, Auke Bay Laboratory since 1985 and been actively involved with Trustee sponsored research since 1992. He is a co-investigator in two pink salmon studies, the first examines the effects of incubating in oiled gravel on reproductive capacity, and the other examines the effects on homing fidelity. The first of these projects established the plausibility of effects on pink salmon fry observed in the Sound after the EVOS, including the existence of long-term effects on growth, marine survival and reproductive ability. He was also a co-author of the final report for Subtidal 8, which examined all of the Trustee Hydrocarbon data for the presence of EVO. This work is of substantial importance to the trustees, by providing evidence for the presence of oil on the beaches of PWS. His efforts in this project led to a detailed understanding of the utility of multi variate methods for analyzing GC/MS data.

OTHER KEY PERSONNEL

Jeff Short will assist in data collection, analysis, and interpretation. Robert Bradshaw is responsible for culturing fish through the summer 2000.

LITERATURE CITED

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Bue, B. G., S. Sharr, S. D. Moffitt, and A. Craig. 1996. Injury to salmon eggs and preemergent fry due to the T/V *Exxon Valdez* oil spill. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B. A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Craig, A.K., B.G. Bue, and T.M. Willette. 1997. Injury to salmon embryos and preemergent fry in Prince William Sound, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 96170), Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Anchorage, Alaska.

Heintz, R. A. , M. Wiedmer and S. D. Rice. 1995. Laboratory Evidence for Short and Long-term

Damage to Pink Salmon Incubating in Oiled Gravel. Proceedings of the 16th Northeast Pacific Pink and Chum Workshop. Bellingham Wa.

Heintz, R., Short, J. W., Rice, S. D. (1999). Sensitivity of Fish Embryos to Weathered Crude Oil: Part II. Incubating downstream from weathered *Exxon Valdez* crude oil caused increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos . Env. Tox. And Chem. 18(3):494-503.

Marty, G. D., J. W. Short, D. M. Dambach, N. H. Willits, R. A. Heintz, S. D. Rice, J.J. Stegeman and D. E. Hinton. 1997. Ascites, premature emergence, increased gonadal cell apoptosis, and cytochrome P4501A induction in pink salmon larvae continuously exposed to oil-contaminated gravel during development. Can. J. Zool. 75:989-1007.

Murphy, M. L., Heintz, R. A., Short, J. W., Larsen, M. L., Rice, S. D. (In press). Recovery of pink salmon spawning areas after the *Exxon Valdez* oil spill. Trans. Am. Fish. Soc.

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

Short JW, Jackson TJ, Larsen ML, and Wade TL. 1996. Analytical methods used for the analysis of hydrocarbons in crude oil, tissues, sediments, and seawater collected for the natural resources damage assessment of the Exxon Valdez oil spill. *Proceedings,* Exxon Valdez Oil Spill Symposium. Anchorage, AK, USA, February 2-5, 1993. pp 140-148.

Wiedmer, M, Fink, M. J., Stegeman, J. J., Smolowitz, R., Marty, G. D., and Hinton, D. E. 1996. Cytochrome P-450 induction and histopathology in preemergent pink salmon from oiled spawning sites in Prince William Sound. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B. A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel	$41.7	$74.0
Travel	$2.9	$3.5
Contractual	$1.5	$6.2
Commodities	$3.0	$8.0
Equipment		$0.0
Subtotal	$49.1	$91.7
General Administration	$6.4	$11.5
Project Total	$55.5	$103.2
Full-time Equivalents (FTE)		0.9
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2002					

Dollar amounts are shown in thousands of dollars.

Comments:
This project is a closeout project. The budget reflects the need for sample collection, analysis and manuscript preparation

NOAA Contribution: Research Chemist, Marie Larsen 1 months @ 7K; Fishery Biologist Mark Carls 2.0 0 mo @ 16.4K, Chemist, Larry Holland .5 mo @ 3.5K and Fishery Biologist Ron Heintz 1 mo @ 7.7K for a total NOAA contribution of 34.6 K

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2001
Name	Position Description					
Rice	Program Manager	GS/14	0.5	12.2		6.1
Carls	Fishery Biologist	GS12/6	2.8	8.2		23.0
Heintz	Fishery Biologist	GS12/5	1.0	7.7		7.7
						0.0
Holland	Chemist	GS11/7	1.0	7.0		7.0
Larsen	Chemist	GS11/7	1.0	7.0		7.0
Lunasin	Chemist	GS 9/7	4.0	5.8		23.2
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		10.3	47.9	0.0	
					Personnel Total	$74.0

Travel Costs:		Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2001
Description						
						0.0
RT Juneau - Anchorage	EVOS Trustee workshop	0.4	2	4	0.2	1.6
						0.0
SETAC meeting		1.0	1	2	0.2	1.4
registration				1	0.5	0.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3.5

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed FY 2001
Description	
Dr Gary Marty	2.2
Dr. Robert Thomas	2.0
Michael Lilly	2.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$6.2

Commodities Costs:	Proposed FY 2001
Description	
Supplies for the hydrocarbon analysis in the chemical laboratory - chemicals and glassware	8.0
Commodities Total	$8.0

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
GCMS		NOAA
HPLC		NOAA
LPW Facility		NOAA

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Equipment
DETAIL