99472

Growth Rates of Cutthroat Trout and Dolly Varden in Prince William Sound, Alaska: Comparison of Populations in Oiled and Unoiled Sites with Similar Geographic Features

Project Number: 99 472

Restoration Category: Monitoring and Research

Proposer: USFS, Pacific Northwest Research Station

Lead Trustee Agency: USFS

Cooperating Agencies: Dept. of Fisheries and Wildlife, Oregon State University

Duration: 3 years

Cost FY 99: $242.7

Cost FY 00: $230.

Cost FY 01: $80.

Geographic Area: Prince William Sound

Injured Resource/Service: Dolly Varden
Cutthroat Trout

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APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

Dolly Varden and cutthroat trout are listed as injured resources whose recovery is unknown. They were originally listed as injured because studies following the oil spilled found that growth rates of populations in oiled areas were less than those of populations in unoiled areas. We are proposing to examine growth rates of populations in oiled and unoiled areas by comparing sites with similar geographic features. Results from this study will determine the status of these species.

INTRODUCTION

Dolly Varden (*Salvelinus malma*) and cutthroat trout (*Oncorhynchus clarki clarki*) are important fish resources in Prince William Sound and are listed as injured resources whose recovery is unknown. These species were believed to be negatively impacted by the oil spill based on differences in growth rates between fish from oiled and unoiled sites. Recovery is assumed to occur when growth rates in oiled and unoiled areas, after considering geographic differences, are similar. Results from the our proposed work on comparison of growth rates will help determine if these species have recovered.

NEED FOR THE PROJECT

A. Statement of Problem

Dolly Varden and cutthroat trout are important ecological and recreational resources in Prince William Sound. Populations of each species are found throughout Prince William Sound (Mills 1988). There are resident and anadromous (i.e. sea-going) forms of each species. Anadromous individuals spend varying amounts of time in freshwater (up to 4 years) before going to the marine environment (Scott and Crossman 1979). There, both species feed in nearshore and estuary areas (Scott and Crossman 1979, Morrow 1980). Dolly Varden feed on crustaceans, small invertebrates, and fish (Armstrong 1971) and cutthroat feed on fish (Narver and Dahlberg 1965).

Areas used by these fish were impacted by petrogenic hydrocarbons from the *Exxon Valdez* oil spill. Benthic organisms in nearshore areas are particularly susceptible to petrogenic hydrocarbons (Teal and Howarth 1984). In Prince William Sound, the size of epifauna and numbers of amphipods, which are food sources for Dolly Varden, decreased in areas exposed to the spill (Jewett and Dean 1993, Jewett et al.1993). Hepler et al. (1993) found that Dolly Varden and cutthroat trout populations in oiled areas had slower growth rates compared to populations in unoiled streams from 1989 to 1990, the year of the spill. A similar pattern was observed for cutthroat trout in 1990 to 1991. However, growth rates of Dolly Varden in oiled areas did not differ from those in unoiled areas during that period (Hepler et al. 1993). Survival rates for each species from 1989 to 1990 were less in oil impacted areas than in unimpacted areas (Hepler et al. 1993). Hepler et al. (1993) hypothesized that chronic starvation and/or direct exposure to petrogenic hydrocarbons were responsible for the differences in growth and survival of the species in oiled and unoiled areas. The *Exxon Valdez* Oil Spill (EVOS) Trustee Council officially lists these species as injured resources whose recovery is unknown.

B. Rationale/Link to Restoration

Reduced growth and survival rates could have long-term impacts on populations of Dolly Varden and cutthroat trout in areas exposed to oil. These species may live up to 8 years (Morrow 1980) and the expected persistence of oil in the nearshore environment (Lee et al. 1979) suggests the potential exists for long-term impacts to these species. Decreased survival would have obvious population implications. The extent would depend on population size; smaller populations would be most susceptible to eventual extinction (Rieman et al. 1993). There may be less obvious impacts also. Potential for loss of genetic variability, which is needed for long term adaptation, increases as population size decreases (Nelson and Soule 1987). Reduced growth rates of individuals can lead to increased susceptibility to mortality and decreased reproductive potential (Adams 1990). If any of these impacts were to occur for extended periods, even at low levels, affected populations would face increased probability of extinction.

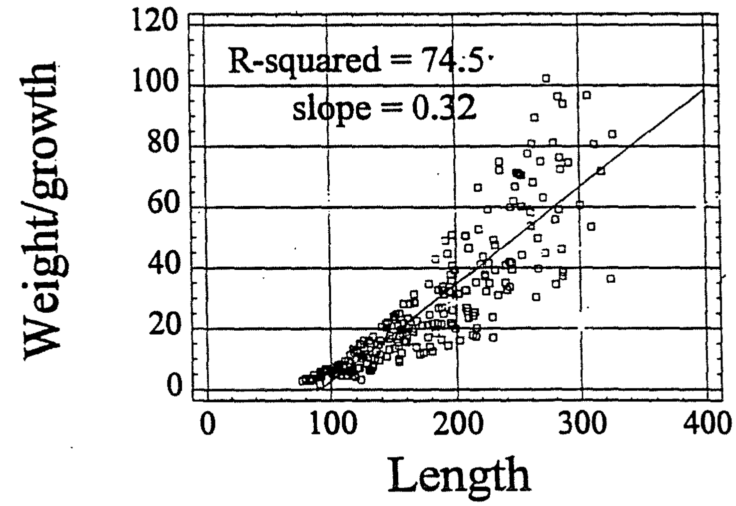
Initial assessments of the oil spill effects suggested that Dolly Varden and cutthroat trout populations in oiled areas were negatively affected. Original damage determinations were made by comparing populations in unoiled sites at Makaka Creek and Boswell Bay (Hithchen Island) in eastern PWS with populations in oiled areas at Rocky Bay (Montegue Island), Green Island, and Eschamy Bay. The latter two are in western PWS. Hepler et al. (1993) found that populations of both fish in oiled areas had slower growth rates from 1989 to 1990 than populations in unoiled areas. Similar results were found for cutthroat trout from 1990 to 1991 (Hepler et al. 1993). Growth rates of Dolly Varden were similar during the same period, however. No formal studies of growth have been conducted since then.

The general criteria for recovery was that growth rates of each species in oiled areas will be the same as that in unoiled areas. Recently, the criteria was amended so that variation related to geographic differences among areas must be considered.

We collected Dolly Varden and cutthroat trout in FY 96 and 97 from sites throughout PWS as part of Project 97145, which is examining relations among populations of these species. We have made some preliminary examinations of otoliths from cutthroat trout in unoiled sites in different parts of PWS to determine growth rates. We compared growth rates of fish from eastern PWS with those of fish from western PWS (Fig. 1). Slopes of the relation between size and age are different for the two areas. Fish from eastern PWS grow at a faster rate than those from western PWS. A closer examination of fish from comparable sites is shown in Fig. 2. Fish from Milton Lake (eastern PWS) were consistently larger at a given age compared to fish from Unakwik Inlet (western PWS). These preliminary results suggest that conditions for growth are better in eastern PWS and simply comparing growth rates of populations in oiled and unoiled sites may not be appropriate.

Determination of growth rates was not an objective of the original proposal for Project 97145. We initiated examination of growth rates after working in PWS for two summers (FY 96 and 97). We observed wide variation in conditions across PWS that believed that this could influence growth rates. Eastern PWS has more well developed intertidal areas than western PWS. Intertidal areas in eastern PWS are also shallower and more extensive than those in western PWS. Environmental conditions that influence growth appear to be more favorable in eastern PWS. The growing season in western PWS is 4-6 shorter than that in eastern PWS (K. Holbrook, US Forest Service, Anchorage, AK). Air temperatures are also cooler in western PWS.

A. Prince William Sound- Eastside



B. Prince William Sound- Westside

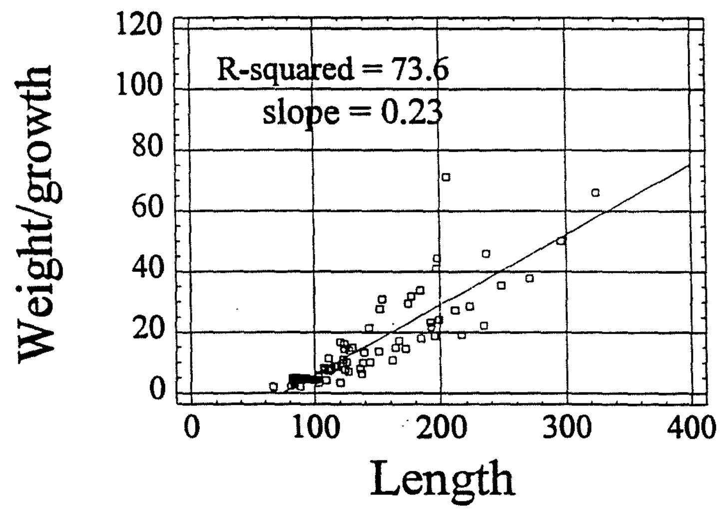


Fig. 1. Estimated growth rates of cutthroat trout from unoiled sites in eastern (A) and western (B) Prince William Sound. Growth rates are from otoliths. Fish were collected in FY 96 as part of Project 97145.

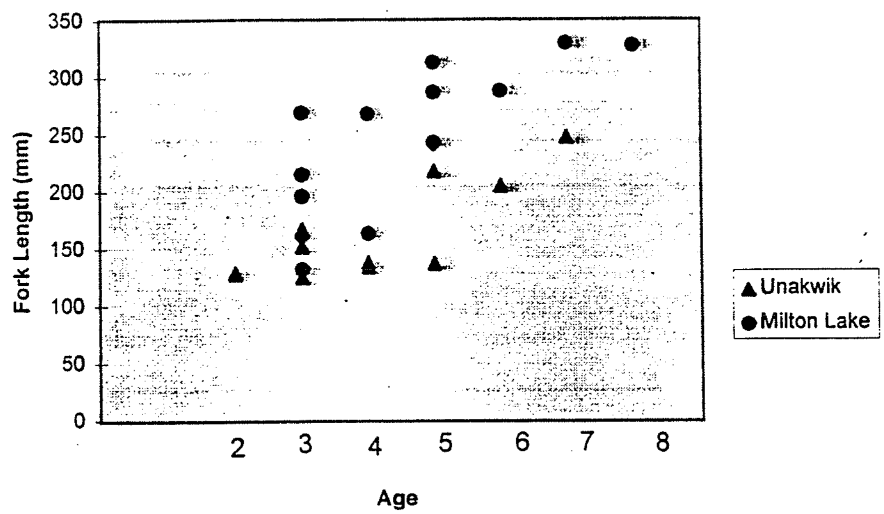


Fig. 2. Comparison of estimated size at age of cutthroat trout from Milton Lake (eastern Prince William Sound) and Unakwik Inlet (western Prince William Sound). Both sites are unoiled. Growth rates are from otoliths. Fish were collected in FY 96 as part of Project 97145.

These results are preliminary and should not be construed that growth rates are actually different between eastern and western PWS. These data have limitations. A primary one is that we did not have individuals from all age/size classes in a population. Project 97145 focused collection efforts in intertidal areas and lower portions of watersheds. Consequently, few small, younger-aged fish were collected. A valid comparison of growth rates must include all age-classes.

C. Location

This study will examine sites located throughout Prince William Sound. Benefits should be realized in communities throughout the Prince William Sound.

COMMUNITY INVOLVEMENT

We quartered out of Cordova, AK for field collections in Project 97145 and will continue to do so for this study. Cordova provided a central location from which to access study sites, had good facilities, and allowed us access to additional field equipment and persons with knowledge of streams in Prince William Sound. We will continue to communicate with people in Cordova on an individual basis about our work and will make presentations on results when they become available. We will charter planes and boats for transport to field locations, secure lodging, and purchase food and other supplies in Cordova in FY99 if the proposal is funded.

PROJECT DESIGN

A. Objectives

The objective of this proposed study is to:

1. Determine growth rates of Dolly Varden and cutthroat trout in oiled and unoiled areas with similar geographic features based on analysis of otoliths.

We will test the following hypotheses:

1. Populations of each species from oiled and unoiled areas with similar geographic features have similar growth rates.

B. Method

In order to distinguish between differential and equal growth rates in fish from "oiled" and "un-oiled" areas, it is necessary to distinguish 1) marine growth from freshwater growth and 2) to be able to measure growth over a standard time interval. Our approach is to use sagittal otoliths as an internal "record collector" of an individual's prior environmental history and its prior growth rate.

Marine growth

Elemental concentrations in otoliths have been shown to vary with numerous environmental variables including temperature (Radtke, 1989; Townsend et al., 1995), salinity (Secor et al., 1995), water chemistry (Mugiya et al., 1991) and significant life history events such as the migration from freshwater to marine environments (et al., 1996; Secor and Piccoli, 1996). Elemental concentrations also vary with ontogenetic variables such as size or age (Edmonds et al., 1992; Hoff and Fuiman, 1993; Campana and Gagne, 1994) and growth rate (Kalish, 1989; Sadovy and Severin, 1992, 1994). In addition, genotype may influence elemental concentrations, as levels at the otolith core can differ between fish from distinct geographic regions (Campana and Gagne, 1994; Thresher et al., 1994) or between anadromous and resident salmonids (Kalish, 1990). These studies suggest that in general:

$$C_{oncentration} = E_{nvironment} + O_{ntogeny} + G_{enotype} + 0_{rror},$$

that is, the concentration of an element in the otolith is dependent upon the combined influences of environment, ontogeny, genotype, and error. The relative importance of these four factors is likely to vary among elements and among species. Because several factors may influence otolith composition, interpretation of natural variation can be difficult.

Natural variation in element concentrations has been interpreted primarily in two ways. Variation along a transect from otolith core to margin has been interpreted as a record of environmental experience in temperature (Radtke et al. 1989; Townsend et al. 1995) and salinity (Radtke et al. 1996; Secor and Piccoli, 1996). Differences among individuals have been used to infer stock or population structure (Mulligan et al., 1987; Edmonds et al., 1989, 1992; Campana and Gagne, 1994; Campana et al., 1994). Because this study also includes a measure of genetic relatedness (see above), as well as age, transect variation in otolith composition could be a useful approach for studying movements of migratory anadromous salmonids.

We propose to compare natural variation in element concentration with age, genetics (stock origin) and environmental conditions at time of capture. We assume that otolith element concentrations at the edge of the otolith were deposited under the environmental conditions at capture and that the correlation of core concentrations to edge concentrations reflect the individual's inherent physiological/genetic bias to deposit that element. Consequently, it will be important to 1) sample individuals in different habitats, 2) establish relative changes within an individual and 3) to corroborate signals with other evidence such as genetics and age information. Although we expect strontium to be the best indicator of marine residence (Kalish, 1990), our study will independently demonstrate which elements are good indicators of marine residence. Transects across the otolith will then help reconstruct a picture of marine and freshwater residence of an individual.

Growth and age

If successful, otolith element concentration can distinguish the relative proportion of the otolith produced in freshwater from that produced in salt water. In general, faster growing fish produce larger rings, but body growth does not necessarily show a linear relationship with otolith growth (Mosegaard et al. 1988, Bradford and Geen, 1992). For this study, we must be able to partition growth as well as time. We need to know 1) how long a fish has been in the marine environment and 2) how well it grew. For this study we will compare "oiled" and "un-oiled" fish hierarchically. Genetically similar fish (same stock) of the same age found in both areas constitute the most powerful comparison, followed by similar age/ different stocks and different age/similar stocks, followed by all fish combined. We will assume that sub-annular marks are non-randomly deposited and the number of sub-annular marks measures time in the marine environment. Differential growth in the "oiled" and "un-oiled" areas will be measured as otolith dimension (radius or area) produced in saltwater normalized by time in salt water.

Proposed Work Plan

Growth documentation: Samples must be collected in fresh water and in salt water. In both cases the timing of collections should be such that specimens collected are likely to have been in the habitat for several months. Saltwater collections will be made in July, 1999 and freshwater in September, 1999. A minimum of 50-60 specimens per site per year will be collected for this purpose and "edge analysis" of otolith microchemistry will be used to evaluate the concordance of otolith chemical signals and habitat at capture. Specimens will be approximately half adults and half juveniles.

Differential growth: Microchemistry transect analyses will be used to identify the most recent portion of the otolith that was deposited in a marine environment. We will assume that fish in the "oiled" area did not spend time in the "un-oiled" area. Differential growth will be evaluated as time normalized otolith growth in the marine environment. We will make paired comparisons of each oiled site (e.g., Rocky Bay (Montegue Island), Green Island, and Eschamy Bay) with a nearby unoiled site. We will also determine growth rates from an unoiled site in eastern PWS.

Study limitations

Unvalidated time measurement. We assume that sub-annular marks are deposited non-randomly and have a temporal component. If there is individual variation in deposition rate and if there is a bias with that variation and presence in "oiled" or "un-oiled" areas, our results will be spurious. We expect to find individual variation but we do not expect to find that variation correlated with marine habitat. Spurious environmental correlation. Otolith size - fish size relationships have an important temperature component (Mosegaard et al,, 1988). If temperature regimes in "oiled" and "un-oiled" areas differ significantly, the metabolic signal associated with higher temperature in otolith deposition will mask growth differences.

Prior to initiation of the study it is not possible to determine the level of differences we might be able to detect. Small effects of 5-10% are unlikely to be detected whereas order of magnitude effects are highly likely to be detected.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

We will develop a cooperative agreement with the Dept. of Fisheries and Wildlife, Oregon State University (OSU), Corvallis, OR to complete growth analysis. We will pursue this avenue to save overhead costs. If the EVOS Trustee Council were to contract the grant directly to the university, overhead would be approximately 40%. The USFS has a cooperative agreement with the university that charges 8% for overhead. The growth laboratory at OSU has been involved in numerous studies involving a variety of salmonids for more several years.

We will need to renew our permit from ADFG that is required to collect for fish if the growth proposal is funded. Scientific studies of a limited nature, such as this one, can be exempted from NEPA requirements. We will persue this exemption by filing a Catagorical Exclusion. This document will be prepared by the USFS, Cordova District in FY99, as they did in FY96 and FY97 for Project 97145.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 - September 30, 1999)

October 1998:	Develop cooperative agreement with OSU
November - December 1998:	Identification of field sites Application for collection permit from ADFG
March 1999:	Secure charter vessel for field sampling Assemble required field gear and ship to Cordova
October 1998 - : June 1999	Preliminary analysis of otolith from previously collected fish Development of analysis protocols
July 1999:	Collection of adults in saltwater and juveniles in freshwater
August 1999:	Initiate analysis of fish collected in July
September 1999:	Collect samples of adults in freshwater Prepare progress report

B. Project Milestones and Endpoints

Major tasks and dates over the projected duration of the study are as follows:
July and September 1999: Collect samples

March 2000:	Report Initial Analysis
July and September 2000:	Collect second year samples
May 2001:	Present preliminary results
September 2001:	Present final results and report Submit papers on results to peer-reviewed journals

C. Completion Date

This project is scheduled to be completed in FY01. At that time, we will provide information on the growth rates of each species and determine if recovery has occurred.

PUBLICATIONS AND REPORTS

It is unlikely that we will be preparing or submitting any manuscripts to peer-reviewed journals until the study is completed in FY01.

PROFESSIONAL CONFERENCES

Because data collection and analysis will be incomplete, we do not plan to make any presentations on results from the study until FY01.

NORMAL AGENCY MANAGEMENT

Determination of growth rates of fish is generally not required by statute or regulation for management responsibilities of the USDA Forest Service. Consequently, the agency does not normally fund this type of research, even though it is valuable in planning and development of management programs. For this study, the USFS is contributing the salary of one of the principal investigators (G. H. Reeves), and assistance with lab work.

There will be no additional injury to Dolly Varden and cutthroat trout populations from the oil spill itself if this study is not funded. However, the status of these species is currently unknown. This study will provide that information. While this project has application in applied and basic science arenas, it is not clear what agency or organization would be interested in funding this project or one like it in the near future.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We will coordinate with ADFG and USFS to identify sampling sites and will review the sites before sampling begins in FY99 to insure that we do not impose unnecessary damage on any population. We had arrangements with the USFS, Cordova Ranger District, for use of boats and other equipment in Project 97145 and expect that would happen with this study. We are not aware of any comparable study that ADFG has or plans at present.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This is a new proposal that has grown out of Project 97145.

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL

The core personnel for this proposal are eminently qualified to implement this project. Gordon H. Reeves, Co-principal Investigator, is a research fish biologist with the USFS, Pacific Northwest Research Station, Corvallis, OR. He has been in that capacity for 10 years and has worked on anadromous salmonids research in streams throughout the Pacific Northwest and southeast Alaska. He has been involved with the development of conservation and restoration for anadromous salmonids in the Pacific Northwest. He is currently directing a study that is determining the relation of coastal cutthroat trout populations throughout their distributional range. He has published several articles on the ecology of anadromous salmonids and their freshwater habitat in peer-reviewed journals.

Douglas F. Markle, would be a the Co-principal Investigator if the new objective is funded. Dr.

Markle is currently a professor in the Dept. of Fisheries and Wildlife, Oregon State University. He has been involved with numerous studies of life-histories and growth of a wide variety of marine and freshwater fishes. He has done some the most cutting-edge work on otolith and growth and has published several articles on the subject. He will supervise the growth comparison objective of this study.

Brief resumes for each of these individuals follow.

GORDON H. REEVES
USDA Forest Service, Pacific Northwest Research Station, Oregon State University, Corvallis, OR 97331.

Education:
B.A. - Biology, State University of New York, Oswego. 1973.
M.S. - Fisheries Science, Humboldt State University. 1978.
Ph.D. - Fisheries Science, Oregon State University. 1985.

Experience:
Assistant Professor, Department of Fisheries and Wildlife, Oregon State University. 1987 to present.
Courtesy Assistant Professor, Department of Fisheries. Humboldt State University. 1986 to present.
Research Fishery Biologist, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 1986 to present.
Commercial Fisherman, Trinidad , California. 1978-79.
Research Biologist, New York State Research Foundation. State University of New York, Oswego. 1973-1976.

Professional Societies:
American Fisheries Society, North American Benthological Society. Sigma Xi National Honor Society

Professional Activities:
President, Oregon Chapter of the American Fisheries Society. 1989.
President-elect, Oregon Chapter of the American Fisheries Society. 1988.

Honors and Awards:
Certificate of Merit, USDA Forest Service. 1984
Certificate of Merit and Quality Step Increase, USDA Forest Service. 1986, 1989, and 1994.
Ethics in Science Award, USDA Forest Service. 1989.
Oldfield Team Award, College of Agriculture, Oregon State University. Award given for outstanding research by the Stream Team. 1991.
USDA Forest Service Rise to the Future Award for outstanding contributions in fishery research. 1991.

Conservationist of the Year Award, Pacific Rivers Council. 1992 and 1994.
USDA Secretary's Award for outstanding contribution to research contributing to understanding of aquatic ecosystems. 1995.

Special Assignments

Member Scientific Panel on Late-Successional Forest Ecosystem - formed by the Agriculture Committee and the Merchant Marine and Fisheries Committee of the U.S. House of Representatives to develop and evaluate alternatives for managing and conserving late-successional forest and aquatic ecosystems on federal lands in northern California and western Oregon and Washington. 1991.

Co-Leader PacFish Team - responsible for developing and evaluating alternatives for managing freshwater habitat of anadromous salmonids on federal lands in northern California, Oregon, Washington, Idaho, and Alaska. 1992-1993.

Member Scientific Assessment Team - develop management strategy for maintaining biodiversity of federal lands in northern California and western Oregon and Washington at request of U.S. Federal Circuit Court Judge. 1992.

Co-leader of Aquatic Group of Forest Ecosystem Management and Assessment Team -responsible for developing and evaluating alternatives for managing federal lands in northern California and western Oregon and Washington. 1993.

Selected Publications

Reeves, G. H., F. H. Everest, and J. D. Hall. 1987. Influence of water temperature on interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdneri*). Canadian Journal of Fisheries and Aquatic Sciences 44:1603-1613.

Hankin, D. G. and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:833-844.

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Sedell, J. R., G. H. Reeves, F. R. Hauer, J. A. Stanford, and C. P. Hawkins. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711-724.

Reeves, G. H., J. D. Hall, T. D. Roelofs, C. O. Baker, and T. Hickman. 1991. Habitat enhancement and rehabilitation for anadromous salmonids. Pages 519-557. American Fisheries Society Publication No. 19.

Bisson, P. A., T. P.Quinn, G. H. Reeves, and S. V. Gregory. 1992. Best management practices, cumulative effects, and long-term trends in fish abundance in Pacific Northwest river systems. Pages 189-232. in R.J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer-Verlag, New York.

Reeves, G. H. and J. R. Sedell. 1992. An ecosystem approach to the conservation and management of freshwater habitat for anadromous salmonids in the Pacific Northwest. Transactions of the 57th North American Wildlife and Natural Resources Conference 1992:408-415.

Thomas, J. W. , G. H. Reeves, and others. 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest: the report of the Scientific Analysis Team. USDA Forest Service, Portland, OR 530 p.

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1993. Diversity of juvenile anadromous salmonid assemblages in basins in coastal Oregon with different levels of timber harvest activities. Transactions of the American Fisheries Society 122:309-317.

Thomas, J. W., G. H. Reeves, and others. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. USDA Forest Service, Portland, OR

Hicks, B. J. and G. H. Reeves. 1994. Restoration of stream habitat for fish using in-stream structures. Pages 67-92. in K. J. Collier, editor. Restoration of aquatic habitats. Selected papers from the second day of the New Zealand Limnological Society 1993 Annual Conference. New Zealand Department of Conservation, Wellington, New Zealand.

Reeves, G. H., L. E. Benda, P. A. Bisson, and J. R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionary significant units of anadromous salmonids in the Pacific Northwest. Pages 334-349. *in* J. L. Nielsen, ed. Evolution and the aquatic ecosytem: defining unique units in population conservation. American Fisheries Society Symposium 17.

DOUGLAS F. MARKLE

Dept. of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331

Education

Ph.D. College of William and Mary (1976).

M.S. College of William and Mary (1972).

B.S. Cornell University (1969).

Experience

Professor, Oregon State University (1991-present)

Associate Professor, Oregon State University (1985-1991)

Research Scientist, Huntsman Marine Laboratory, Canada (1977-1985)

Research Assistant, Virginia Institute of Marine Science (1973-1977)

Marine Scientist, Virginia Institute of Marine Science (1971-1972).

Professional Service

American Society of Ichthyologists and Herpetologists, Editorial Board member, 1987, 1989-present; Board of Governors, member, 1990-1994.

The American Fisheries Society, Associate Editor of Early Life History Section, 1988-1990.

Selected Publications

Toole, C. L., D. F. Markle and C. J. Donohoe, in press. Settlement timing, distribution and abundance of Dover sole (Microstomus pacificus) on an outer continental shelf nursery area. Can. J. Fish. Aquat. Sci.

Markle, D. F. and D. C. Simon, in press. Numerical dominance and origin of exotic fathead minnows in Upper Klamath Lake, Oregon. N. Amer. J. Fish. Management.

Melendez, R. C. and D. F. Markle, in press. Phylogeny and zoogeography of Laemonema and Guttigadus (Pisces; Gadiformes; Moridae). Bull. Mar. Sci.

Markle, D. F., in press. Audubon's hoax: Ohio River fish described by Rafinesque. Archives of Natural History.

Logan, D., E. L. Bibles, and D. F. Markle, 1996. Recent collections of exotic aquarium fishes in the freshwaters of Oregon and thermal tolerance of oriental weatherfish and pirapatinga. Calif. Fish Game 82:66-80.

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Lattin, J. D., A. Liston and D. F. Markle. 1995. Systematic collections at Oregon State University. Association of Systematics Collections Newsletter.

Toole, C.L., D.F. Markle and P.M. Harris, 1993. Relationships between otolith microstructure and early life history events in Dover sole, Microstomus pacificus. U. S. Fish. Bull., 91:732-753.

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Markle, D.F., P.M. Harris and C. L. Toole, 1992. Metamorphosis and an overview of early-life-history stages in Dover sole (Microstomus pacificus). U. S. Fish. Bull. 90:285-301.

Markle, D. F., T. N. Pearsons and D. T. Bills, 1991. Natural history of Oregonichthys (Pices: Cyprinidae) with a description of a new species from the Umpqua River of Oregon. Copeia, 1991 (2): 277-293.

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Campana, S. E., and J. A. Gagne. 1994. Cod stock discrimination using ICPMS elemental assays of otoliths. *In* D. H. Secor, J. M. Dean, and S. E. Campana, (eds.), Recent developments in fish otolith research. University of South Carolina Press, Columbia, S.C.

Campana, S. E., A. J. Fowler, and C. M. Jones. 1994. Otolith elemental fingerprinting for stock identification of Atlantic cod (*Gadus morhua*) using laser ablation ICPMS. Can. J. Fish. Aquat. Sci. 51:1942-1950.

Edmonds, J. S., M. J. Moran, and N. Caputi. 1989. Trace element analysis of fish sagittae as an aid to stock identification: pink snapper (*Chrysophrys auratus*) in western Austrailian waters. Can. J. Fish. Aquat. Sci. 46:50-54.

Edmonds, J. S., R. C. J. Lenanton, N. Caputi, and M. Morita. 1992. Trace elements in the otoliths of yellow-eye mullet (*Aldrichetta forsteri*) as an aid to stock identification. Fish. Res. 13:39-51.

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FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$108.0						
Travel		$19.4						
Contractual		$91.2						
Commodities		$1.5						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$220.1		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration		$22.6						
Project Total	$0.0	$242.7		$230.0	$80.0			
Full-time Equivalents (FTE)		3.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Prepared:4/7/98, KEH

Project Number: 99~~000~~472
Project Title: Growth Rates of CT/DV in PWS
Agency: U S Forest Service (PNW)

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
Vacant	Research Assistant		12.0	4.0		48.0
Vacant	Technicians		24.0	2.5		60.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		36.0	6.5	0.0	
					Personnel Total	$108.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Travel to Cordova (3 people)	1.3	6	42	0.2	16.2
					0.0
Travel to Anchorage to attend workshop (2 people)	1.0	2	6	0.2	3.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$19.4

FY 99

Prepared:

Project Number: 99000
Project Title: Growth Rates of CT/DV in PWS
Agency: U S Forest Service (PNW)

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Charter Boat 26 days @ $1.2/day	31.2
Otolith Analysis - OSU	60.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$91.2

Commodities Costs:	Proposed
Description	FY 1999
Misc. collecting supplies	1.5
Commodities Total	$1.5

FY 99

Prepared:

Project Number: 99000
Project Title: Growth Rates of CT/DV in PWS
Agency: U S Forest Service (PNW)

FORM 3B
Contractual &
Commodities
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

FY 99

Project Number:99000
Project Title:Growth Rates of CT/DV in PWS
Agency:U S Forest Service (PNW)

FORM 3B
Equipment
DETAIL

Prepared:

99474

Endowment of the Environmental Restoration Center at the University of Alaska Anchorage

Project Number:	99474
Restoration Category:	Reserve Account / General Restoration
Proposer:	University of Alaska Anchorage
Lead Trustee Agency:	
Cooperating Agencies:	
Duration:	Perpetuity
Cost FY 99:	$2,200,000
Cost FY 00:	$0
Cost FY 01:	$0
Cost FY 02:	$0
Geographic Area:	All regions affected by the *Exxon Valdez* oil spill
Injured Resource/Service	Multiple resources

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

Proposed is a plan for the establishment of an endowed environmental restoration center for research and community education at the University of Alaska Anchorage. The program will be created within the School of Engineering. Establishing the center will achieve two goals. First, it will provide a mechanism for funding continuing recovery work and community education long after 2002 when funds are no longer received by Alaska. Such activities will help Alaska develop local expertise and permanent solutions for the protection and restoration of areas affected by the *Exxon Valdez* oil spill. Establishment of the center will also serve as a test program that will allow the Trustee Council to resolve existing questions for endowment of research centers and chairs.

INTRODUCTION

A similar proposal for establishing an endowed research center at the University of Alaska Anchorage (UAA) was submitted two years ago. Events since that time have emphasized the need and benefits of endowed research centers and chairs at the University of Alaska. Consequently, the proposal has been updated to reflect the growing interest and support for creating endowed research centers and chairs.

Proposed is the endowment of an environmental restoration center for research and community education within the School of Engineering at UAA. Within this environment, the facilities of UAA can be utilized to continue restoration and protection of the oil damaged areas from the *Exxon Valdez* oil spill in perpetuity.

Since many questions currently exist about how to create endowed research centers or chairs at the University of Alaska, the exact mechanism of how to do it cannot be described at this time. In fact, the intent and purpose of this proposal is to provide the critical starting point which is needed if creating endowments are to be successful.

One endowed center is proposed. The proposed plan is intended to serve as a model. It would assist in the review of future proposals for multiple endowments which will most likely be submitted. As a model for endowments, the proposed center would greatly assist the planning of other centers or endowed chairs at any of the University of Alaska campuses. Moreover, the proposed work helps attain the goals for restoration and preservation while serving the educational needs of the community.

The proposed plan establishes a center that will conduct restoration research for oil damaged areas. An emphasis of the proposed plan is to create marketable research and educational opportunities for the Alaska community as well as the world. A main objective is to establish a mechanism for generating income so as to eventually become self-supporting. In this manner, the objectives for restoration, preservation, monitoring, and study of spill damaged areas can be continued in perpetuity.

Personnel are well suited for implementing the proposed plan and making it a success. UAA School of Engineering faculty are experienced in applicable research for oil spill cleanup and restoration. Principle investigator Dr. Grant C. Baker has conducted research on chemical redistribution in soils and seawater, has received several awards recognizing his teaching, and is a commercial fisherman. Co-principle investigator Dr. Herbert P. Schroeder is creator and Director of ANSEP (Alaska Native Student and Engineering Program), and has worked in the oil industry for 16 years prior to his arrival at UAA. Oil cleanup related environmental research is ongoing at the UAA School of Engineering.

UAA has an ideal location for creating an endowed research center. It is closely located to the newly created Seward SeaLife Center at the southern end of Prince William Sound. In addition, the road to Whittier is currently being constructed and is scheduled to open about the year 2000. When done, northern Prince William Sound will be only about 45 minutes from Anchorage. Thus, the spill damaged areas of Prince William Sound and Cook Inlet will be very accessible from Anchorage.

Support for establishing endowed research centers or chairs at the University of Alaska is gaining support. A recent news article in the April 9, 1998 Anchorage Daily News reported on establishing an endowed University chair as one possible idea for using part of the $140,000,000 dollar reserve account (attached). Support from former and current legislators is growing. Also, UAA Chancellor Lee Gorsuch has offered his support and help in a letter to the Council dated April 9, 1998 (attached).

Although it is clear that complete recovery from the *Exxon Valdez* oil spill will not occur for decades, annual payments from the Exxon Corporation will end in the year 2002. Implementing a plan that enables restoration and protection efforts to continue beyond 2002 is a serious challenge facing the Trustee Council and all Alaskans.

As currently proposed, the center would consist of research, community education/technology transfer, and student education branches. The flowchart shown in Figure 1 lists some of the major areas of activity that would be conducted by each branch. These include:

- Research and development activities for improved recovery and remediation techniques.
- Courses on oil spill technology and recent developments in remediation techniques by national experts.
- Distance delivery course presentations to high schools, universities, and industry.
- Outreach mentoring programs to surrounding areas.
- Student education and internships on oil spill recovery projects.
- Cooperative efforts with other University departments as well as state and federal agencies.

There are many benefits to the communities effected by oil spills from the establishment of endowed academic centers and chairs. Since the exact mechanism for implementation of endowed research centers is not known, many concerns and questions exist. Establishing an academic center at UAA as a working pilot program will allow the Trustee Council to find answers to the outstanding questions about the use of settlement funds for funding endowed research centers or chairs.

NEED FOR THE PROJECT

A. Statement of the Problem

It has become apparent restoration efforts need to continue beyond 2002. As an initial response, the Trustee Council established the Reserve Account to aid in the recovery of affected areas after 2002. This account will eventually total approximately $140 million. Presently, the State receives about 70 million per year. Thus, the Reserve Account represents less than two years of payments.

The threat of another oil spill is a major concern to Alaskans. In the case of the *Exxon Valdez* oil spill, a settlement was reached between Alaska and Exxon in a relatively short period. It cannot be assumed that another spill will result in a similar amount of funds so soon after a spill. In addition, the next spill could result in a legal battle with Alaska for many years. Alaska needs to be prepared to recover from another spill, and a mechanism is needed for preparing the State to respond to future spill events.

In fact, since the initial submittal of this proposal in 1996, another oil spill occurred along the Alaskan coast. Last year, the vessel *Kuroshima* ran aground in Dutch Harbor. It was beached for several months and threatened the surrounding ecosystems. The full extent of the damage has not yet been determined.

New approaches are needed to make the most of the remaining *Exxon Valdez* funds. One mechanism is for the Trustee Council to fund an endowment that will support research and education activities relevant to oil spill cleanup and ecosystem recovery for the foreseeable future. Such a commitment of funds would guarantee that the State will continue recovery efforts in areas damaged by the *Exxon Valdez* oil spill and develop its capabilities to respond to future oil spills in a timely and economic manner.

B. Rational/Link to Restoration

As shown in Figure 1, the proposed center will have research, community education, and student education components. The center will incorporate the objectives of the *Exxon Valdez* settlement for restoration and protection of the areas affected by the spill by conducting research and education programs that will enhance Alaska's ability to restore oil damaged areas from the Exxon Valdez Oil Spill as well as improve cleanup methods for future oil spills.

In addition, oil spill research has the potential to generate income through patents for oil cleanup processes, publication, and distance delivery courses. In fact, a University of Alaska faculty was recently awarded a patent for a cold region road design which was reported as having a tremendous potential for financial benefit to the University of Alaska. Similarly, patented processes for oil spill cleanup would have a worldwide market especially in cold climates such as along the coastlines of oil rich Russia. In addition, as the recent grounding of the *Kuroshima* highlighted, oil cleanup techniques for Alaska would be of particular interest wherever marine traffic occurred regardless of the originating country of the vessel. Consequently, the proposed endowed center has a high potential to be financially self-sustaining and provide restoration in perpetuity.

The University of Alaska Anchorage has an ideal location to serve the areas affected by the *Exxon Valdez* oil spill. With the construction of the road to Whittier currently planned to be open in about the year 2000, Prince William Sound will be very accessible to Anchorage. Thus, the facilities at the University of Alaska Anchorage can be readily utilized to conduct research and restoration efforts. In addition, Anchorage is a traffic center for airlines servicing many of the rural areas affected by the spill. These factors make UAA a natural hub for cooperative spill recovery efforts.

The School of Engineering is located in the Engineering Building at the main University of Alaska Anchorage campus. It houses over 26,500 square feet of classrooms, laboratories, and a modern computer facility. Laboratories are conveniently available for the study of fluids, soils, materials, surveying structures, environmental quality, and cold regions engineering.

Modern distance delivery facilities are also available on the main University of Alaska Anchorage campus. Facilities include equipment for video production, broadcast and delivery, interactive presentations, and reproduction. Thus, video production of techniques for improved recovery, course development for students, and technological short courses for presentation to industry can be readily performed and distributed.

Utilization of existing facilities and personnel can be a substantial help in extending recovery efforts. The proposed plan incorporates the objectives of the Trustee Council through the use of these resources. In addition, structure of the proposed plan implements a mechanism that results in recovery efforts to become self-supporting with growth in a relatively short period of time.

C. Location

All areas affected by the *Exxon Valdez* oil spill will benefit from the proposed plan. In fact, the objectives of the Trustee Council are to be incorporated into the charge of the endowed center. Thus, recovery and protection of affected areas can continue long after 2002 when funds are no longer received by Alaska.

COMMUNITY INVOLVEMENT

Involvement of the community is a major objective of the proposed plan. This includes the development of outreach programs for recruiting and education of high school students, research positions for students, as well as the incorporation of existing high school and university programs such as ANSEP (Alaska Native Student Engineering Program), AISES (American Indian Science and Engineering Society), and other mentoring programs. Also, high school programs such as the Youth Area Watch could easily be incorporated. In this manner, students from the community can obtain a technical education while also gaining valuable work experience with a variety of state and federal agencies.

PROJECT DESIGN

A. Objectives

The following are objectives of the proposed program:

1. Establish an endowed environmental restoration center at the University of Alaska Anchorage School of Engineering.

2. Establish the infrastructure and activities of the endowed center to achieve the objectives of the Trustee Council for restoration, enhancing, and protection of areas affected by the spill.

3. Establish community and student education opportunities.

B. Methods

The proposed plan calls for $200,000 the first year to establish the infrastructure needed for the center. An additional, $2,000,000 will be placed in an endowment fund of the UA Foundation.

Three UAA engineering faculty in conjunction with Trustee Council, UA Foundation, UA Board of Regents, and UAA administration will coordinate the establishment of the endowed center. The exact mechanism for implementation will be determined that will achieve the goals of the Trustee Council. Initial efforts would include the preparation of laboratory facilities to conduct research on oil spill remediation and establishing education needs.

Endowment funds managed by the UA Foundation have earned an average of about 13% over the past 5 years. The maximum withdrawal rate on an annual basis is limited to 5%. Thus, if a conservative 10% average earnings is assumed, the <u>principal</u> of a $2,000,000 endowed fund would grow by about $130,000 each year after about 5 years. In addition, another $130,000 would be available to conduct the work of the center.

Moneys received through the foundation will be matched whenever possible with external funding from agencies such as National Science Foundation (NSF). Also, part of the proposed plan is to develop processes for patent. Patented recovery processes, such as for beach remediation and containment, will be marketed to oil producers throughout the world. The patent licensing facilities of the University of Alaska can provide the needed expertise and services. Thus, the proposed plan will provide unique mechanisms for enhancing the principal beyond the usual inflation proofing techniques.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

It is foreseen that several agencies will be utilized to accomplish the work of the endowed center. These include local and rural high schools, Alaska SeaLife Center, Alaska Department of Fish and Game (ADF&G), Alaska Department of Environmental Conservation (ADEC), in addition to other state and federal Agencies.

SCHEDULE

A. Measurable Project Tasks for FY99

Oct. 1 - Nov. 1, 1998:	Academic center committee is formed. Schedule is set for needed reviews by Trustee Council, UA Foundation, UA Board of Regents, University and Trustee Legal Councils, and UAA administration.
Nov. 1- Dec. 1, 1998:	Exact criteria and structure for endowed center is established in cooperation with Trustee Council.
Dec. 1 - March 1, 1999:	Research and education plans completed.
March 1 - April 1, 1999:	Final report with recommendations is prepared for Trustee Council and research and education activities begin.
Beyond April 1, 1999:	Annual report on recovery work with financial updates.

B. Project Milestones and Endpoints

October 1, 1998:	Approval and commitment by the Trustee Council for establishment of endowed center.

Feb. 1, 1999:	Center is established.
April 1, 1999:	Final presentation of results to Trustee Council.

C. Completion Dates

The initial work to establish an endowed center will be completed by April 1999. The work of the endowed center is intended to be self-supporting and continue in perpetuity.

PUBLICATIONS AND REPORTS

It is foreseen that substantial contact with the Trustee Council members and advisory boards will occur as the proposed plan is developed and implemented. By April 1999, a complete report will be presented to the Trustee Council. The report will present the status of the center and provide answers to the questions confronting the Trustee Council concerning the establishment of additional endowed academic centers and chairs.

PROFESSIONAL CONFERENCES

Research and other activities funded by the endowed center will be presented in the many usual forums available to faculty at the University of Alaska. These forums include presentation of papers at conferences, publication of books and research journal articles. Also, student work will be presented in papers through professional student organizations at national competition.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Part of the proposed plan is to determine the best avenues for incorporation of Trustee Council objectives for restoration with the activities of the endowed center. It is expected that these efforts will be reported to the Trustee Council throughout FY99 until the best working mechanism is determined and approved by the Trustee Council.

PROPOSED PRINCIPLE INVESTIGATORS

Dr. Grant C. Baker - Director, Student Education and Research
School of Engineering
University of Alaska Anchorage
3211 Providence Drive
Anchorage, Alaska 99508
Phone: (907) 786-1056
Fax: (907) 786-1079
E-Mail: afgcb@uaa.alaska.edu

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E-Mail: afhps@uaa.alaska.edu

PERSONNEL

Dr. Grant C. Baker, Assistant Professor of Civil Engineering at the University of Alaska Anchorage. He has eight years of university teaching experience. Dr. Baker has conducted research in chemical treatment of soils, development of oil refining catalysts, corrosion prevention engineering, and is active in program development of engineering courses within the School of Engineering. He has received both UAF and UAA engineering professor of the year awards, and was recently selected for the WHO's WHO Among America's Teachers and for the WHO's WHO in the West. Dr. Baker holds a B.S degree in Chemical Engineering, M.S. in Mining Engineering, and a Ph.D. in Geophysics. He has commercially fished in Prince William Sound, Kodiak, and Togiak starting in 1979.

Dr. Herbert P. Schroeder, Associate Professor of Civil Engineering at the University of Alaska Anchorage. Dr. Schroeder is Chairman of ANSEP (Alaska Native Science and Engineering Program) at UAA. Dr. Schroeder worked more than 15 years in the Alaska oil industry prior to joining the faculty in 1991. He holds a B.S. in Mechanical Engineering from UAF, an M.S. in Civil Engineering, Construction Engineering and Management from Oregon State University, and a Ph. D. in Civil Engineering, Construction Engineering and management from the University of Colorado Boulder.

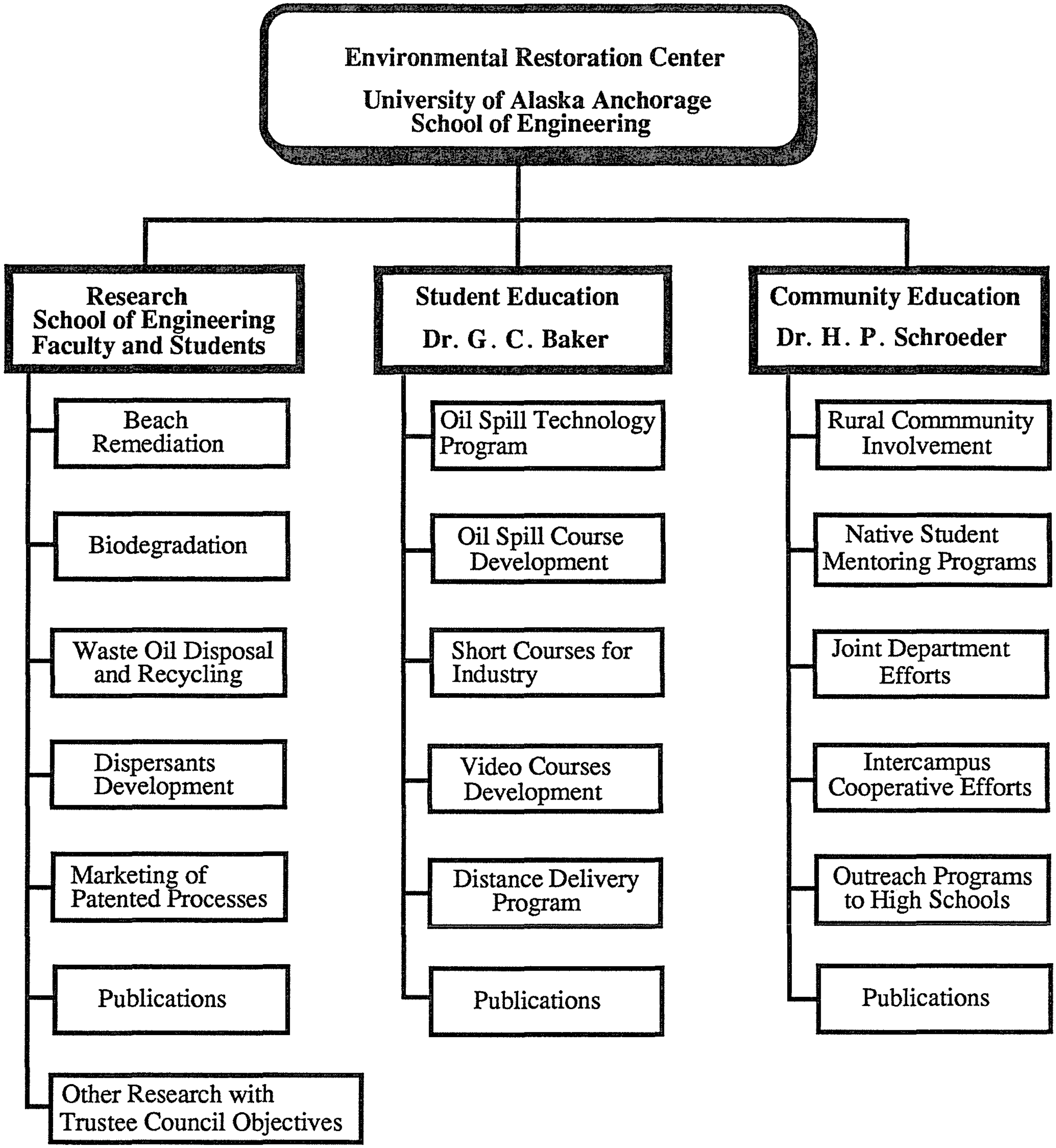

Figure 1: Flowchart illustrating the multiple disciplinary functions of the proposed endowed Environmental Restoration Center at the University of Alaska Anchorage

Council mulls use of oil spill money

By NATALIE PHILLIPS
Daily News reporter

How do you spend a leftover $140 million?

Some ideas offered so far: Buy land. Do more research. Monitor the environment. Endow a university chair.

The money will be what's left, in the year 2001, after the rest of the $1 billion Exxon oil spill settlement has been spent. Between now and the end of the month, the Exxon Valdez Oil Spill Trustee Council is seeking public comment on what to do with it.

The money has been set aside in a reserve fund, a combination of annual payments and whatever interest it earns between now and the year 2001. Public meetings are being held around the state, including one in Anchorage at 7 tonight at the Restoration Office at 645 G St. Written suggestions will be accepted until the end of the month.

Several dozen people have testified at the public hearings held in March and earlier this month in coastal communities affected when the tanker Exxon Valdez spilled 11 million gallons of oil in Prince William Sound in 1989. And about 90 people have submitted written comments, according to Molly McCammon, executive director of the Trustee Council.

"I think there has been a lot of support expressed for doing some kind of endowment rather than spending it all in a fixed period of time," McCammon said. The coastal communities support continued research and monitoring as a way to better understand the marine environment, she added.

Others have supported using the money to buy more land, McCammon said. People in the coastal communities support buying smaller parcels, but "there's been a mixed bag on whether there should be any more large parcel purchases."

In 1991, the state and federal governments settled lawsuits against Exxon when the oil company agreed to pay $1 billion in 10 yearly installments. Since that time, the bulk of that money, nearly $400 million has been spent or earmarked for purchasing land and protective easements in the spill area. The council hopes that the protected land will provide habitat and give some of the species injured by the spill a chance to rebound. About $150 million has been tapped for scientific studies.

In 1994, at the urging of former state Sen. Arliss Sturgulewski and others, the Trustee Council began setting aside $12 million annually to establish a reserve fund.

"Right from the beginning, I wanted to see a foundation set up that would do basic research as well as applied research," Sturgulewski said. "At the time of the Exxon

Please see Page B-3, SPILL MONEY

SPILL MONEY: Council ponders surplus

Continued from Page B-1

Valdez spill, we had very little information on the status of the marine environment. I kind of kept at it."

The reserve money could be spent on one project or divided up among many. The Trustee Council also has to decide whether it should stay in existence to make and oversee spending decisions or whether a new oversight structure should be established.

Many environmental organizations want the council to keep open the option of using some of the money for more land purchases, said Pamela Brodie of Homer, who represents the Sierra Club and sits as one of 16 public advisers to the Trustee Council.

James G. King, a retired waterfowl biologist in Juneau and another public adviser, said, "I think it would be a good idea to put a major portion into the University of Alaska for the establishment of endowed chairs who would continue the study of the damaged resources."

King said there is considerable support for this idea, including from a number of conservation groups. But the parties interested in buying more land are more organized in their lobbying efforts, he said.

But some are not anxious to spend more for land.

The most vocal opposition has come from U.S. Sen. Frank Murkowski and state Sen. Loren Leman, R-Anchorage.

"My preference is that we not be investing so much money in buying land unless we have a plan for it," Leman said. "I would prefer to see legitimate marine research that can help benefit the affected area. There may be some cases of property or habitat that need to be purchased in the future.

"I am not willing to slam the door completely, but by and large, I think we have spent an incredible amount of money buying up property."

UNIVERSITY OF ALASKA ANCHORAGE

OFFICE OF THE CHANCELLOR

3211 Providence Drive
Anchorage, Alaska 99508-8060
(907) 786-1437 – FAX (907) 786-6123
AYCHANC

– Grant Baker

– x1079

April 9, 1998

Fax Transmittal: (907) 276-7178

FAXED 4/9/98

EVOS Trustee Council
645 G Street, Suite 401
Anchorage, Alaska 99501

Dear Trustees:

I would like to lend support for establishing a research endowment as well as endowed chairs within the University of Alaska system. This is an excellent opportunity for the university and the council to continue work together to accomplish our mutual objectives and goals.

For example, an endowed research chair at UAA would provide a means to continue spill-related research in perpetuity. Additional income could be obtained from the patenting of processes for spill restoration and cleanup techniques. Development of educational courses for spill prevention, restoration, and preservation techniques would also serve the needs of our communities, including spill damaged areas, as well as generate additional income from other oil-damaged areas throughout the world also needing similar expertise.

There are numerous faculty on UA campuses prepared to continue to work with the council in advancing its long-term objectives. A research endowment as well as endowed chairs would generate significant long-term value, not only to Prince William Sound, but to our overall understanding of marine ecosystems and their potential response to oil spills. Numerous benefits exist for everyone and I will do all I can to support this endeavor.

Sincerely,

Edward Lee Gorsuch
Chancellor

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1999 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Budget Category:	Authorized FFY 1998	Proposed FFY 1999						
Personnel		$46.5						
Travel		$0.0						
Contractual		$2,000.0						
Commodities		$1.0						
Equipment		$152.5	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$2,200.0	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003	Estimated FFY 2004	
Indirect								
Project Total	$0.0	$2,200.0						
Full-time Equivalents (FTE)		9.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
This proposal requires a one-time payment of $2,200,000 to support an endowed academic center at the University of Alaska Anchorage. Of this amount, $2,000,000 will be deposited in an endowment fund of the UA Foundation. The remaining $200,000 will be used for initial establishment of the Center (salaries and equipment) in the first year. This preliminary budget is contingent upon approval by the UAA business office.

1999

Prepared: 1 of 4

Project Number: 99474
Project Title: Endowed Academic Center
Name: University of Alaska Anchorage

FORM 4A
Non-Trustee
SUMMARY

4/15/98

1999 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FFY 1997
Dr. G. Baker	Program Coordinator		4.7	4.8		22.6
Dr. H. Schroeder	Program Coordinator		4.5	5.3		23.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		9.2	10.1	0.0	
					Personnel Total	$46.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1999
					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

1999

Prepared: 2 of 4

Project Number:
Project Title: Endowed Academic Center
Name: University of Alaska Anchorage

FORM 4B
Personnel
& Travel
DETAIL

4/15/98

1999 EXXON VALDEZ TRUS[obscured by hole-punch] COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FFY 1999
Endowment Fund	2,000.0
Contractual Total	$2,000.0

Commodities Costs:	Proposed
Description	FFY 1999
Preparation materials for multiple reports and presentations.	1.0
Commodities Total	$1.0

1999

Prepared: 3 of 4

Project Number:
Project Title: Endowed Academic Center
Name: University of Alaska Anchorage

FORM 4B
Contractual &
Commodities
DETAIL

4/15/98

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1999
Equipment appropriate for establishment of Center's facilites as approved by Trustee Council			152.5
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$152.5

Existing Equipment Usage: Description	Number of Units	

1999	Project Number: Project Title: Endowed Environmental Restoration Center Name: University of Alaska Anchorage	FORM 4B Equipment DETAIL

99476

Project Title: **Effects of Oiled Incubation Substrate on Pink Salmon Reproduction**

RECEIVED
APR 14 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number: 99476

Restoration Category: Research

Proposer: Ron Heintz
NMFS, Auke Bay Laboratory
ABL Program Manager: Dr. Stan Rice
NOAA Program Manager: Bruce Wright

Lead Trustee Agency: NOAA

Cooperating Agencies: ADF&G

Alaska SeaLife Center: No

Duration: 3 years

Cost FY99: $74.1K

Cost FY00: $63K

Cost FY01: $36K

Geographic Area: Little Port Walter, Baranof Island, Southeast Alaska

Injured Resource: Pink salmon

ABSTRACT

This project examines the effects of oil exposure during embryonic development on the gamete viability of pink salmon that survive to spawn. The objective is to determine if exposure to oil during incubation could explain the reduced gamete viability reported for pink salmon in Prince William Sound under Restoration Study 191A. In that study gametes taken from pink salmon returning to oiled streams had higher mortality rates than gametes taken from salmon in unoiled streams. These data suggest a dramatic effect of oil on vertebrate reproduction that has not previously been described. The plausibility of reduced gamete viability is indicated the by effects demonstrated by 191B which include reduced marine survival and growth of returning adults, however this effect still requires unequivocal demonstration. This study is designed to make the

demonstration and complete a model of life cycle impacts from incubating eggs in oiled gravel.

INTRODUCTION

This experiment tests the hypothesis that incubation in oiled gravel produces adult pink salmon with reduced reproductive capacity. After the Exxon Valdez oil spill (EVOS), pink salmon embryos developing in oiled streams experienced increased mortality (Bue et al. 1995). Further experiments reported by Bue et al. (In press) indicated that adult fish returning to oil contaminated streams had reduced gamete viability. In these experiments, gametes were collected from adults returning to oil contaminated and uncontaminated streams before they could be they could be exposed to oil and incubated in a hatchery. Despite the identical uncontaminated incubating environments, the gametes derived from oil contaminated streams consistently produced fewer viable embryos than gametes derived from uncontaminated streams. This difference was thought to result from differences in the incubating environments experienced by the adults contributing the gametes and therefore suggested a previously undescribed long term effect of oil on reproductive ability.

Demonstrating a long term effect of oil on pink salmon reproduction has important implications for managers in PWS as well as managers seeking to restore wildlife populations in other locations. The effects observed in pink salmon after the EVOS were a direct result of their dependence on the intertidal environment for early development. This implies that other species with similar dependencies were also at risk. Furthermore, the exposure levels shown to be capable of causing long term impacts on growth and marine survival in pink salmon are less than or equal to the Alaska State water quality standards which are among the most rigorous in the United States. This suggests that water quality standards in locations outside Alaska may limit the potential for restoring salmon populations in streams located near hydrocarbon sources such as those exposed to urban runoff.

The intent of this experiment is to examine the effects of oil exposure on pink salmon reproduction under controlled laboratory conditions. Environmental exposures will be mimicked by incubating embryos in gravel with a known concentration of oil from fertilization to emergence in a simulated inter-tidal environment. Surviving fish will be marked and released. Upon maturity, returning adults will be recovered and the viability of their gametes will be compared to those taken from unexposed, but similarly handled, fish.

The procedure proposed here repeats the experiments performed under Restoration 191B, but with the sole purpose of testing the hypothesis that incubating in oiled gravel impairs the reproductive ability of salmon that survive to maturity. Consequently, we propose limiting the exposure to a single dose, releasing sufficient numbers of fish to guarantee an adequate number of returning adults and marking the fish externally so that exposure levels can be readily observed prior to spawning the fish. These procedures significantly reduce the cost of the study to the extent that NOAA/NMFS can contribute labor without impairing normal agency objectives.

The earlier project was successful in measuring oil impacts to marine survival and straying, but the coded-wire tags required to identify the treatment groups in that study had to be recovered and decoded before adult pairs could be matched for mating. The delays encountered while decoding hundreds of tags that were not useful for mating led to reduced gamete viability for all the treatments which may have masked any oil related effects. This follow-up study uses external marks to alleviate that problem and is designed specifically to test for oil effects on gamete viability.

NEED FOR THE PROJECT

A. Statement of the Problem

Field and laboratory work conducted after the EVOS by Restoration Study 191A suggested that pink salmon in contaminated streams had reduced fitness when they were exposed to extremely low concentrations of polynuclear aromatic hydrocarbons (PAH). Field evidence for reduced fitness included observations of increased embryo mortality in contaminated streams (Bue et al. 1995) and reduced viability in gametes taken from adults returning to contaminated streams (Bue et al. In press). These data have been supported by laboratory studies (Heintz et al. 1995 and Wertheimer et al. 1996) that have shown the susceptibility of pink salmon embryos to water contaminated with very low concentrations of oil.

The laboratory studies provided a basis for estimating the total reduction in fitness for pink salmon exposed to water contaminated with oil at concentrations near the Alaska State water quality standard. The reductions in embryo survival, growth, and marine survival can be integrated to calculate a total reduction in the average fitness for exposed populations of nearly 50%. However, reduced gamete viability among individuals as reported by Bue et al. (In Press) has not been adequately demonstrated among the survivors of the laboratory exposures. In 1995, gametes taken from fish exposed as embryos in the 1993 experiments appeared to have reduced viability, but inadequate numbers of fish prevented statistical verification of this observation. In 1997 we recovered sufficient numbers of fish that had been exposed as embryos in 1995 experiments, however high mortality rates were observed in all the treatment groups including the controls, possibly masking elevated mortality rates in the exposed groups. The source of these high mortality rates is unknown, but is probably related to the time required to hold the gametes prior to spawning in order to find sufficient numbers of mates among all the returning fish.

The effects already described for pink salmon that incubate in oil gravel indicate the plausibility of reduced gamete viability. The long term effects that have been described for those individuals that survive incubating in oiled gravel include effects on fitness related characters such as growth and marine survival. In addition, histopathological examination of fry emerging from oiled gravel demonstrated an effect on gonad development (Marty et al. 1997). Previous attempts at demonstrating gamete viability have provided results that are highly suggestive of oil related effects, and have generally included a number of doses so that dose response curves could be generated. In the study proposed here, the design is solely aimed at demonstrating an effect on gamete viability. Thus, we have limited the number of treatments so that we can maximize the number of fish that survive to adult, and we will mark fish externally to identify exposure level which will minimize the holding time for gametes prior to mixing them.

B. Rationale/Link to Restoration

Pink salmon are an ideal species for identifying prolonged population effects resulting from embryonic oil exposure. Pink salmon have been widely studied because of their commercial value and relatively simple life history, and their dependence on the intertidal for incubating in PWS made them a premier sentinel species for detecting oil damage after EVOS. Consequently, a large amount of effort and money was expended towards understanding how oil effected pink salmon populations. This work has led to important advances in our understanding of the scope and mechanisms of oil toxicity and has led to developing a model describing the average reduction in reproductive fitness of exposed populations. Laboratory confirmation of Bue et al.'s claim of an oil effect on gamete viability is the last piece of data required to construct a new paradigm for oil toxicity.

Confirmation of the field observations of reduced gamete viability (Bue et al. 1995) will provide managers with a more comprehensive model for the long-term effects of oil on pink salmon. This information is important to managers working to restore salmon populations in PWS as well as locations in less pristine locations. Concentrations found to be effective at reducing average fitness (Heintz 1995) are significantly lower than the Alaska State water quality standard and typical of concentrations in urban locations (Maltby et al. 1995). Of additional value is the demonstration that oil has life long effects for organisms exposed during sensitive life stages. Both the exposure mechanism and scope of the effects described in this work represent significant advances in the understanding of oil toxicity.

C. Location

This project will take place at Little Port Walter (LPW), a research hatchery operated by NMFS in southeastern Alaska. This location is appropriate because it has been the site of these studies since their inception. The facility 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

This project will take place in southeastern Alaska, but depends on contract labor for marking fish for a period of 6 weeks in the spring of 1999. All efforts will be made to advertise our labor requirements from the spill zone. We will continue to provide information to interested public (primarily fishermen) who visit the station; we will be displaying at the facility the posters developed for the Restoration Workshop for 97191B and 97076 as interpretative tools.

PROJECT DESIGN

A. Objectives

1. Determine the effect of incubating in oiled gravel on reproductive capacity of pink salmon.

2. Complete the model of life cycle impacts from incubation in oiled gravel.

We propose testing the hypothesis that incubating in gravel contaminated with oil leads to reduced gamete viability. This test will provide information for completing a life-history model for oil toxicity which allows us to quantify the effect of oil on each of the major life-history stages of pink salmon in terms of reduced survival. Thus far, we have demonstrated that embryos developing in oil contaminated gravel have reduced survival, and fry that survive incubation have reduced growth and reduced survival to maturity. These observations account for a 50% reduction in the average survival of a population of pink salmon exposed to PAH concentrations equal to the Alaska State water quality standard. The proposed study will refine the model by providing an estimate for the specific loss in reproductive ability in exposed individuals. To our knowledge this type of analysis does not exist for any vertebrate and these effects occur at concentrations that are commonly seen in urban locations.

B. Methods

The exposure mechanism and fish culture procedures will follow those described in previous proposals for Restoration Study 191B. Gametes will be taken from an intertidally spawning pink salmon stock, transferred to our hatchery at Little Port Walter where they will be incubated. The eggs will be exposed to effluent from either oil-coated or untreated gravel. Approximately 75,000 surviving fry from each exposure group will be marked by excising the adipose fin and one pelvic fin depending on exposure regime. Marked fish will be held for a short period while they recover from the marking procedure and then released. Exposures will begin in September of 1998 and between 50 and 500 mature fish representing each treatment will return two years later in September 2000.

All pink salmon returning to the Sashin Creek weir will be inspected for marks during the 2000 escapement period. Marked fish will be sorted by treatment groups into holding pens since the external marks will provide for immediate identification of exposure level. On a given spawning date, sufficient numbers of fish will be removed from each pen and spawned, ensuring minimal holding times for gametes prior to spawning. Previously, we have released fish representing multiple treatments which has necessitated the use of coded-wire tags for identifying them when they return. This approach has allowed us to quantify oil effects on growth and marine survival, and homing fidelity but not gamete viability because of the long time periods associated with recovering and decoding the tags on a given spawning date.

Gamete viability will be determined for the oil treatment and the control groups. Three experiments will be performed to evaluate the reproductive viability of the parents. The objective of the first experiment will be to determine the average offspring survival of parents exposed to oil during incubation and the objective of the second experiment will be to estimate how much of the variability in offspring survival is due to individual variation. The objective of the third experiment is to identify the genetic component to variability or heritability of offspring survival. The benefit of the first experiment is that all the possible crosses within an exposure group can be made and the overall average survival measured, however the primary source of variation will be measurement error and no information will be available on individual variation. The benefit of the second experiment is determine individual variability and thus provide control for the interpretation of the results of the first experiment. The benefit of the third experiment besides demonstrating a genetic effect of oil, is that calculation of the genetic heritability of the damage provides a basis for calculating how long the effect will persist in the exposed population. In all experiments survival will be measured to fertilization, eyeing, and emergent fry stages. The numbers of defective or dead progeny will be compared between treatment groups. Because these gametes will not be incubated in an oiled environment, any observed increases in mortality or defective individuals can be attributed to oiling effects upon the first generation.

First Experiment

Average offspring survival will be estimated in the first experiment by measuring the survival in pools of gametes comprising all the possible pairwise crosses. On each day of spawning, 2 embryo pools will be formed per treatment. Upon formation of an embryo pool, 6 subsamples, each of approximately 150 embryos, will be randomly selected and incubated in an individual cell within a Heath tray. On a given day, pools will be formed by randomly assigning half the males and females from a treatment group to one of two subgroups. Each female in a subgroup will contribute approximately 900 eggs to a common pool, the pool will be mixed and the mixture divided into a number of aliquots equal to the number of males in the subgroup. Each male in the subgroup will fertilize one aliquot, and the fertilized eggs will be recombined in a common container, mixed and divided into six aliquots that will be incubated in randomly assigned locations. Thus, the average survival of a treatment group on a given day will be the mean of the average survivals in each of the two subgroups.

The estimates of mean survival of the treatment groups will be compare with t tests after assuming that variability between groups of like-treated incubators is negligible. A t test between, for example, treatment 1 and 2, when there are d spawning days, q treatments, p subgroups per treatment, and r cells per subgroup will have the following form:

$$t_{((p-1)*q*d)df} = \frac{\frac{1}{d}[\overline{sv_{11}} + \ldots \overline{sv_{1d}} - \overline{sv_{21}} \ldots - \overline{sv_{2d}}]}{\sqrt{\frac{1}{d^2} * \frac{s_c^2}{p*r} * 2 * d}}$$

where,

$\overline{sv_{ij}}$ = Survival rate for treatment *I* on day *j*

s^2_c = Combined Between-Pools Mean Square obtained by ANOVA.

Comparisons will be made between each of the doses and the control and the overall α will be maintained at 0.05.

Second Experiment

For the second experiment, fish from the oil and control doses will be mated using a fully-crossed half-sib design (Falconer 1981). In this design, the remaining eggs from an exposed female and a control female are each split into two aliquots. One aliquot from each female is fertilized with aliquots of sperm from the same oil-exposed male, and one aliquot from each female is fertilized with aliquots of sperm from the same control male. This 2 x 2 breeding matrix will be replicated so that every female is represented in a breeding matrix or until there are 30 breeding matrices for each treatment, whichever is greater. Each half-sib family will be incubated in an individual container.

Third Experiment

The third experiment will be performed under contract by the University of Alaska using gametes collected at the same time as those used in the previous experiments. The fish will be used to produce ten 2 x 3 mating sets: 'oiled' females crossed with oiled males and ten 2 x 3 mating sets: 'unoiled' females crossed with unoiled males. Within each set, eggs from each female will be separately fertilized using semen from 3 males. Therefore, each set will produce 6 families, resulting in a total of 60 oiled families and 60 unoiled families (oiled and unoiled F1). Each family will be divided in 2 parts, each of which will be randomly placed in an incubator compartment. Data to be collected for each of the 240 incubator compartments includes: mortality rate at eye, hatch, and emergence, and developmental rate to eye, hatch, and emergence.

Additive genetic, maternal, non-additive genetic, and phenotypic variances will be estimated and heritabilities, and ratios of maternal and nonadditive genetic variances to phenotypic variances will be calculated using an animal model solved by applying a derivative free technique for estimating variance components employing restricted maximum likelihood (Graser et al., 1987). The derivative-free restricted maximum likelihood (DFREML) analysis procedure of Meyer (1988) will be utilized. The technique has been utilized to analyze data from breeding experiments of fish (Crandell and Gall, 1993). Heritability estimates may be used to predict expected genetic change due to natural selection for a range of selection intensities (Van Vleck, 1987).

C. Cooperating Agencies, Contracts and Other Agency Assistance

The Alaska Department of Fish and Game (ADF&G) and University of Alaska will be contracted to perform Experiment 3. The statistical analysis of the results for experiment 1 have been designed by ADF&G.

SCHEDULE

A. Measurable Tasks for FY 99 (October 1, 1998 - September 30, 1999)

Sept. 1998: Set-up exposure apparatus and take eggs.

Fall 1998: Evaluate effects of oil incubation on survival to eyed embryo stage. Collect samples for quantifying exposure levels.

Spring 1999: Mark and release surviving fry from the control and exposed groups.

B. Project Milestones

Sept. 1998: Set-up exposure apparatus, collect gametes begin exposures.

May 1999: Release marked fry

Sept. 2000: Examine oil effect on gamete viability by recovering and spawning marked adults when they return to weir.

Aug 2001: Complete analysis of gamete viability.

C. Completion Date

Final Report will be submitted on August 15, 2001 in FY 2001.

PUBLICATIONS AND REPORTS

FY 99: Annual Report describing the doses, exposure apparatus and effects on early incubation.

FY 00: Final Report
Other manuscripts planned:
Heintz, R. 2000. Effect of incubating in oil on pink salmon reproductive capacity. Journal Unknown.

Heintz, R. 2000. Incubating in oiled gravel damages the entire life-history of pink salmon. Journal Unknown.

PROFESSIONAL CONFERENCES

No conferences planned in FY 99, travel to 1999 Oil Spill Symposium is covered in other Proposed Project Plans.

NORMAL AGENCY MANAGEMENT

This project will complete the work begun under Restoration 191B which has been performed cooperatively between the Trustees and NMFS from the outset. However, NMFS proposes providing most labor requirements for this project and seeks funding for primarily contractual labor and commodities. There is no charge for project support costs which include management of the LPW facility and project budget, production of reports or hydrocarbon chemistry to verify dosing. There is no charge for setting up the experiment in FY98 and early FY99, NMFS will cover costs associated with setting up the exposure apparatus, spawning pink salmon, and maintaining the incubation for 9 months. In outlying years, NMFS will cover costs associated with spawning the returning fish, and evaluating their gamete viability.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be coordinated with continuation of ADF&G research and monitoring efforts regarding pink salmon embryo survival under Restoration 191A. This study also coordinates the results of Restoration 191B and 076 by completing a life-history model for oil effects on pink salmon. Investigators and agencies will coordinate by sharing data. NOAA/NMFS will coordinate with the Trustees by providing labor requirements and laboratory overhead.

PROPOSED PRINCIPAL INVESTIGATOR

Name: Ron Heintz
Affiliation: NMFS
Address: Auke Bay Laboratory
11305 Glacier Hwy.
Juneau, AK 99801
Phone: 907-789-6058
Fax: 907-789-6094
E-mail: ron.heintz@noaa.gov

PRINCIPAL INVESTIGATOR

Ron Heintz

Education:
BS 1979, University of Illinois, Urbana (Ecology, Ethology , Evolution)
MS 1986, University of Alaska-Juneau (Fisheries)

Ron Heintz has been involved in examining the effects of *Exxon Valdez* oil on pink salmon since 1992. He has developed the methods proposed for this project, published 2 papers has another in review and 1 and preparation. In addition, he has presented results of these studies at 8 professional meetings.

OTHER KEY PERSONNEL

Alex Wertheimer will assist in experimental design.
Robert Bradshaw will assist in all the fish culture and logistics.
Stan Rice and Jeff Short will assist in data interpretation.

LITERATURE CITED

Bue, B. G., S. Sharr, S. D. Moffitt, and A. Craig. 1995. 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.

Bue, B. G., S. Sharr and J. E. Seeb. In press. Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the *Exxon Valdez* oil spill. Trans. Am. Fish. Soc.

Crandell, P.A. and G.A.E. Gall, 1993. The genetics of body weight and its effect on early maturity based on individually tagged rainbow trout (Oncorhynchus mykiss). Aquaculture, 117:77-93

Falconer, D. S. 1981. Introduction to Quantitative Genetics. Longman House, Essex, United Kingdom.

Graser, H.U., Smith, S.P. and Tier, B., 1987. A derivative-free approach for estimating variance components in animal models by restricted maximum likelihood. J. Anim. Sci., 64:1362-1370.

Heintz, R. , S. D. Rice and J. W. Short. 1995. Injury to pink salmon eggs and preemergent fry incubated in oiled gravel (Laboratory Study). Restoration Project 94191-2 Annual Report. *Exxon Valdez* Trustee Council, Anchorage, AK.

Maltby, L., D. M. Forrow, A. B. A. Boxall, P. Calow and C. I. Betton. 1995. The effects of motorway runoff on freshwater ecosystems: 1. Field Study. Env. Tox and Chem. 14:6 1079-1092.

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.

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Wertheimer, A. C., S. D. Rice, A. G. Celewycz, J. F. Thedinga, R. A.Heintz, R. F. Bradshaw, and J. Maselko. 1996. Effects of oiled incubation substrate on straying and survival of wild pink salmon. Restoration Project 95076 Annual Report. *Exxon Valdez* Trustee Council, Anchorage, AK.

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Budget Category:	Proposed FFY 1998	Authorized FFY 1999						
Personnel		$19.8						
Travel		$6.0						
Contractual		$33.0						
Commodities		$10.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$68.8	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2003	Estimated FFY 2004	Estimated FFY 2005	
General Administration	$0.0	$5.3						
Project Total	$0.0	$74.1	$63.0	$36.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources		$58.0	$50.0	$10.0				

Comments:

NOAA Contribution:
Principle Investigator R. Heintz, 3 mo = $19.8k
Fishery Research Biologist, R. Bradshaw 4.0 mo = $19.3K
Fishery Research Biologist, J. Maselko 2 mo. = $8.9k
Additional Operating Costs of Little Port Walter Field Station = $10.0k

Total NOAA/NMFS Contribution = $58.0k

1999

Project Number: 99~~000~~476
Project Title: Oil Effects on Pink Salmon Reproduction
Agency: National Oceanic & Atmospheric Administration

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:4/10/98

1999 EXXON VALDEZ TRUSTEE C[hole punch]CIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1999
R Heintz	Co-PI: Fishery Research Biologist	12/3	3.0	6.6		19.8
						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		3.0	6.6	0.0	
					Personnel Total	$19.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1999
Little Port Walter Filed Station -- 4 staff, 6 crew, multiple trips					0.0
Beaver Charters	1.0	6			6.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.0

1999

Project Number: 99000
Project Title: Oil Effects on Pink Salmon Reproduction
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Personnel
& Travel
DETAIL

Prepared:4/10/98

1999 EXXON VALDEZ TRUSTEE [COU]NCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FFY 1999
NOAA Contract Labor (marking crew)	6.6
1 x 16.50 x 400h	26.4
6x$16.00x300h	0.0
	0.0
	0.0
	0.0
	0.0
	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$33.0

Commodities Costs:	Proposed
Description	FFY 1999
groceries	5.0
gloves, anaesthetic, fish food, buckets,spawning supplies	5.0
Commodities Total	$10.0

1999

Project Number: 99000
Project Title: Oil Effects on Pink Salmon Reproduction
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Contractual &
Commodities
DETAIL

Prepared:4/10/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1999
			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: Description	Number of Units	Inventory Agency
tagging tables	1	NOAA
nets	4	NOAA

1999

Project Number: 99000
Project Title: Oil Effects on Pink Salmon Reproduction
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Equipment
DETAIL

Prepared:4/10/98

99479

Effects of food stress on survival and reproductive performance of seabirds

Project Number:	99 479
Restoration Category:	Research (new)
Proposed By:	USGS, University of Washington
Lead Trustee Agency:	DOI
Cooperating Agencies:	N/A
Alaska SeaLife Center:	yes
Duration:	1st year, 4-year project
Cost FY 99:	$98,100
Cost FY 00:	$125,200
Cost FY 01:	$129,600
Cost FY 02:	$75,000
Geographic area:	Cook Inlet, Gulf of Alaska
Injured resource:	Common Murre, Black-Legged Kittiwake

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ABSTRACT

Traditional field methods of assessing effects of food stress on the survival and reproductive performance of seabirds may give equivocal results. Here we propose to apply an additional tool: The rise in blood levels of stress hormones such as corticosterone in response to a standardized stressor: capture, handling and restraint. This well-known response (found throughout vertebrates from fish to mammals) provides a strong assessment of whether or not a free-living population is chronically stressed or, if baseline levels of corticosterone appear normal, the stress-induced increase in corticosterone indicates potential for stress. This "field endocrinology" approach provides exact information on current stress status and the potential for stress in relation to quality and abundance of food. To apply these techniques we will investigate seabirds breeding in Lower Cook Inlet and also use captive birds for controlled experiments at the ***Alaska SeaLife Center***. The hormone assay techniques and collection methods in the field are well established in the laboratories of a cooperator, who is the internationally recognized leader of the "field endocrinology" approach. Pilot studies conducted in 1996 and 1997 in the proposed study area have already validated the techniques, provided conclusive results, and underscore the necessity and importance of the more extensive investigations proposed here. This study provides a unique opportunity for a concurrent field and captive study of the behavioral and physiological consequences of stress in seabirds. Moreover, it will provide the basis for management of seabird populations in the areas affected by the *Exxon Valdez* oil spill, and it will have broader applications for seabird monitoring programs.

INTRODUCTION

During the last decade, reduced productivity, increased mortality and subsequent population declines occurred among some seabirds and marine mammal species in the Gulf of Alaska. It has been suggested that declines in food availability resulted in food-related stress (Merrick *et al.* 1987, Piatt & Anderson 1996). Oil pollution from the Exxon Valdez oil spill may have exacerbated these stress-related effects. In this context, nutritional stress can be defined as changes in the physiological conditions of individuals that experience a long-term shortage of food or rely on low quality and/or contaminated food resources that impair their ability to reproduce successfully. Alternatively, less severe food shortages may allow reproduction to proceed, but additional stress such as from anthropogenic sources may precipitate reproductive failure. It is frequently difficult, or impossible, to detect these possible types of perturbations by using traditional field methods (Piatt & Anderson 1996).

An approach using well characterized responses of hormones to stress can provide a sensitive indicator of chronic stress in the environment, or the potential impact of future stressors (Wingfield et al. 1997). Food-related stress is associated with elevated levels of corticosteroids (also known as "stress hormones") in the peripheral system of affected animals (Axelrod & Reisine 1984; Wingfield, 1994). In seabirds, corticosterone levels were elevated in free-living Magellanic penguins exposed to oil pollution (Fowler et al. 1995), and in Black-legged Kittiwakes breeding under poor foraging conditions (Kitaysky et al., submitted *a*). Chronically elevated corticosteroid levels are known to result in regression of the reproductive system, suppression of memory and immune systems, lead to muscle wasting and cause neuronal cell death (e.g. Sapolsky 1987; Wingfield 1994). Exposure to oil pollution and decreased food availability can have similar debilitative effects on foraging and reproductive behaviors in seabirds. The effects of the stress can be detected and monitored through measurements of baseline plasma levels of corticosterone in the peripheral system of potentially affected seabirds. The pattern and extent of a corticosterone increase following application of a standardized stressor such as capture, handling and restraint then indicate potential for stress effects. Furthermore, experimental manipulations with corticosterone levels in wild and captive seabirds provide a way to examine the mechanisms by which increased mortality and decreased reproduction are expressed.

The factors regulating seabird populations are poorly understood. Variations in mortality of adult birds and reproductive success due to natural fluctuations in the availability of food and anthropogenic impacts are probably among the most important factors (Cairns 1992). Life-history theory predicts that in long-lived animals, an increase in parental investment in current reproduction may impair post-breeding survival of parents and the probability of their successful reproduction in the future (Williams 1966, Charnov & Krebs 1974, Stearns 1992). Being long-lived animals, with an estimated life span of about 25-30 years (e.g., Ydenberg 1989), seabirds might buffer the cyclic variability of food resources by pursuing long-term reproductive strategies (Ricklefs 1990). For example, some seabirds can maintain their investment in reproduction at a constant level despite a large variation in foraging conditions (Pugesek 1981, Bolton 1995, Kitaysky 1996). This parental strategy can result in large fluctuations in reproductive success but relatively small variations in the post-breeding survival of parent seabirds. Other seabirds are known to adjust their effort in current reproduction in relation to foraging conditions during a particular breeding season (Burger & Piatt 1990, Shea & Ricklefs 1985, Shea & Ricklefs 1996, Kitaysky 1996, Kitaysky et al. submitted *b*). For example, if feeding conditions are poor, adults should increase foraging effort to raise young. This parental strategy results in relatively low variation in bird reproductive success, but large variation in post-breeding survival of parent seabirds. In both scenarios, a trade-off between reproduction and survival must be balanced to maintain populations.

In contrast to regular, natural fluctuations in food availability, anthropogenic impacts such as oil pollution or commercial fisheries are unpredictable. These may also shift the balance between the processes of reproduction and survival in seabird populations. We hypothesize that the shift in the balance between reproduction and survival is responsible for the marked decline of some seabird populations in the Gulf of Alaska. It is also well known that unpredictable events in the environment have the potential to be severely stressful in terms of increased secretion of corticosteroids. Thus circulating levels of corticosterone in seabirds indicate not only current stress state, but the pattern of secretion in response to capture and handling also provides a simple test of vulnerability of the population to stress as well. We predict that the patterns in reproduction and survival of the affected population of seabirds can be altered in two possible ways. First, low reproductive rates can result from the decreased post-fledging survival of juvenile seabirds that have experienced long-term food shortages or were fed poor quality or oil-contaminated food during their development. Second, the post-breeding survival of parent seabirds that reproduced during food shortages or an oil spill may be decreased.

In this study we propose to examine the possible consequences of food-related stress by measuring circulating levels of plasma corticosterone as an indicator of current and potential stress. Although the impacts of stress on behavior and physiology of individuals are potentially very important to the processes of reproduction and mortality in seabird populations, the physiological mechanisms underlying these relationships are not known. We also propose to investigate the influence of the foraging and parental behaviors altered by stress on survival and reproduction of several species of seabirds that breed in the Gulf of Alaska and have been affected by the *Exxon Valdez* oil spill. In addition to examining effects of stress, we propose to investigate the rate of recovery from the effects of the stress by different species. For this we plan to carry out an experimental study of captive individuals in the facilities of the Alaska SeaLife Center. This center offers a unique possibility to study seabirds under conditions that closely resemble the natural settings of marine environments. The results of captive experiments will provide insight into pollution-related processes in the affected populations of seabirds. The results of our pilot studies of 1996 and 1997 show clearly that the hormone aspects of the proposed study are effective and will be powerful indicators of current stress state and equally important, may point to populations that are vulnerable to future stress.

NEED FOR THE PROJECT

A. Statement of the Problem

Immediate and potential long-term effects of food-related stress on foraging and reproductive behavior in seabirds are not completely known. Recent declines of seabird populations in the Gulf of Alaska may be a result of a decrease in reproductive success due to an elevated mortality of food-stressed chicks after fledging, and/or the increased mortality of parents that rear their young under poor feeding conditions. Traditional field methods of assessing potential pollution-related stress on the survival and reproductive performance of seabirds may give equivocal results. Lack of knowledge of the long-term effects of pollution-related stress on physiology and behavior prevent us from developing a successful rehabilitation program for seabird populations in the areas affected by the *Exxon Valdez* oil spill. The basic problem is that we do not know the mechanisms of how and at what stage of a bird's life the effects of stress might most strongly affect survival and reproductive performance. Furthermore, we know even less about the recovery of populations from stressful episodes in their life cycles. The latter is critical if we are to implement future programs to successfully manage seabird populations.

B. Rationale/Link to Restoration

Long-term effects of pollution and stress on seabird reproductive biology are poorly known mostly because, to date, there have been no possibilities for a concurrent study of stress and the monitoring of foraging conditions in seabirds; and no facilities available where relationships between physiological conditions and behavior can be studied under controlled semi-natural conditions. A critical concurrent assessment of variation in foraging conditions in Lower Cook Inlet will be provided by Dr. Piatt and co-workers through the on-going project that is designed specifically for this purpose (APEX project 98163M). An ideal natural experiment to study effects of food stress can be conducted in Cook Inlet because seabirds at one study colony (Chisik Island) are chronically deprived of food, while seabirds at another study colony (Gull Island) have a surplus of food.

The Alaska SeaLife Center provides a unique opportunity to carry out long-term physiological and behavioral experiments where the physiology of a bird and variation in the environment can be easily manipulated. These experiments, if carried out in parallel to the already initiated experimental work at seabird colonies in Lower Cook Inlet, will enhance our understanding of the effects of oil pollution on seabird populations and the potential for seabird recovery in the polluted area. Measurements of corticosteroid levels in blood of young and adult birds, and experimental manipulations of this hormone will facilitate our understanding of the crucial relationships among stress physiology, behavior and population dynamics. An additional component will assess the recovery of populations from stress - especially in relation to a role of stress hormones. This is a well established approach, indicated in stress physiology literature (e.g. reviewed in Wingfield and Romero 1998), but has yet to be applied to seabird recovery programs.

C. Summary of Major Hypotheses and Objectives

We propose to investigate whether profiles of corticosterone in free-living seabirds reflect stress status and vulnerability to environmental stress, and how increased corticosterone levels affect parental care, reproductive success and survival of individual seabirds. The specific questions to be addressed in the field experiments include:

1. Are the baseline levels of corticosterone high in populations under nutritional stress? Both chicks and adults will be sampled and contrasted between food-deprived (Chisik Island) and food-rich (Gull Island) colonies.
2. When artificially stressed, do circulating levels of corticosterone of seabirds increase more rapidly in populations under low level stress? In other words, are the populations under nutritional stress more vulnerable to future potential stresses? Again, both chicks and adults will be sampled at food-poor and food-rich colonies.
3. Do the amount and extent of parental care change when parents or their chicks are treated with hormonal implants imitating the effects of stress? Both chicks and adults will be manipulated.
4. How does the induced change of parental reproductive behavior affect reproductive success and survival of individual parents? Reproductive success and post-breeding survival of manipulated adults will be monitored (already being done by Restoration Project 98163M).
5. Do seabirds which possess different parental provisioning strategies show different patterns of reproductive success and survival in response to the experimental treatment? Adults of several species will be manipulated.
6. Do patterns of corticosterone release and baseline levels indicate degree of recovery and how quickly they recover from episodes of stress?

To address these questions we will investigate hypotheses and predictions on the relationships among stress physiology, behavior and reproduction in seabirds that breed in the areas affected by the *Exxon Valdez* oil spill. The first set of hypotheses states that the observed decline in populations of some seabirds in the Gulf of Alaska is caused by an increase in post-fledging mortality or by a delay in sexual maturity of birds that have experienced a long-term dietary stress during their development in the nest. These hypotheses predict that: (a) increased levels of corticosterone in food-stressed chicks impair their learning performance so that the affected young are less efficient in learning foraging techniques, have low foraging efficiency, and thereby suffer greater post-fledging mortality compared to the unaffected animals; (b) increased levels of corticosterone impair development of the reproductive system of young seabirds so that they experience delayed sexual maturation compared to the control animals. Additionally we ask what implications these effects have for recovery of individual seabirds following amelioration of environmental conditions.

The second set of hypotheses states that the observed population declines are due to a decrease in post-breeding survival or reduced reproductive performances of adult seabirds that reproduce in the areas affected by the *Exxon Valdez* oil spill. In particular, parent seabirds that rear their chicks in the area affected by pollution complete the reproductive season in poorer physiological conditions and suffer greater post-breeding mortality compared with birds that rear young under favorable environmental conditions. These hypotheses predict that: (a) pollution-related stress results in chronically elevated concentrations of corticosterone in the peripheral system of parent seabirds; (b) prolonged increases in concentration of corticosterone affect provisioning behavior of parent seabirds, causes reproductive failure, an increase in the post-breeding mortality, and a decrease in the future reproductive performance of the affected birds; (c) increased levels of corticosterone in stressed chicks cause an increase in parental effort in chick-provisioning which results in the elevated post-breeding mortality of parents.

A third set of hypotheses states that the recovery of seabirds from pollution or food-related stress depends on: (a) species-specific responses to stress in general; (b) the degree to which individuals are stressed and how debilitated they may become by exposure to chronically high corticosterone levels; and (c) foraging conditions after exposure to stress.

Thus, our overall objectives are to explore the relationship between foraging conditions and endocrinological parameters of seabirds that breed in the areas affected by the *Exxon Valdez* oil spill; model the physiological and behavioral responses of individual seabirds to the pollution-related stress through the experimental manipulations of corticosterone concentrations in wild and captive seabirds; and assess recovery from stress— particularly high circulating levels of corticosterone.

D. Location

The proposed field experiments will be based out of Homer, Alaska. Studies will be conducted at the colonies of Gull Island in Kachemak Bay, and Chisik Island in western Cook Inlet. Captive-rearing, learning, and foraging efficiency trials, and observations of sexual maturity and reproductive performances of the captive birds will be carried out at Alaska SeaLife Center.

COMMUNITY INVOLVEMENT

This project would allow us to create captive populations of several species of seabirds that breed in the Gulf of Alaska and have been affected by the *Exxon Valdez* oil spill. The captive birds and experimental manipulations with them will be exhibited to the public at the Alaska SeaLife Center. The unique opportunity of the concurrent experimental studies of seabird foraging and reproductive behaviors in captivity at the SeaLife Center and at the colonies in Lower Cook Inlet will allow local high-school, undergraduate and graduate students to carry out research projects under guidance of seabird researchers from the University of Washington and U.S. Geological Survey.

PROJECT DESIGN

A. Background and Results of Pilot Studies

Decreases in the availability of food can account for the increased mortality of seabird chicks in nests. Nevertheless, a high tolerance of juvenile seabirds to intermittent or low rates of food provisioning by their parents can buffer against an immediate loss in reproductive success (Kitaysky 1996). Juvenile seabirds possess an ability to retard growth processes in response to the dietary restrictions and might fledge successfully despite severe food shortages during their development (Θyan & Anker-Nilssen 1996). Controlled experiments have shown that food-related growth retardation can account for the lower body mass and smaller body size of the young at fledging when compared to the young raised on *ad libitum* nutritional regimes (Kitaysky 1996). However, low body mass of young seabirds at fledging is not a reliable predictor of post-fledging survival (Lloyd 1979, Hedrgren 1981, Harris & Rothery, Harris et al. 1992). Potential deleterious effects of retardation in morphological development (other than effects of low body mass at fledging) on post-fledging survival and reproductive performances of food-stressed individuals have never been studied in seabirds. Chronic stress in mammals affects hippocampal regions of the brain (Sapolsky et al. 1986) which can result in less efficient learning of new behavioral methods, e.g. foraging techniques, by stressed young. Long-term effects of food-related stress during early development in Zebra finches (*Poephila guttata*) include reduced body size and possibly lower reproductive success during the adult stage of their life (Boag 1987, Boag & Grant 1981, Zink 1983). Thus, there is a possibility that food-stress in young seabirds results in: (1) increased post-fledging mortality due to a low ability of the retarded young to learn foraging techniques and/or a reduction in their foraging efficiency; (2) low reproductive performances during the adult stage of their life (e.g., delayed maturity and low reproductive success).

Results of EVOS-funded studies in 1996 and 1997 revealed that the types and quantities of different forage fish available to seabird parents can affect the physiological condition of their young at fledging. Black-legged Kittiwake chicks that were raised on restricted amounts of food, or poor-quality diets (APEX Project 98163N), had significantly elevated levels of corticosterone compared to the control chicks (Fig. 1). In addition, corticosterone appears to be involved in the regulation of begging behavior by young Black-legged Kittiwakes (Kitaysky et al., submitted *c*). An increase in begging intensity among the stressed chicks (Fig. 2 a) influences food-provisioning behavior of their parents (Fig. 2 b) and might result in an increase in the parents' investment in foraging for the young. An increase in parental investment in current reproduction can potentially decrease post-breeding survival of parent birds and the probability of their successful reproduction in the future (e.g., Jacobsen et al. 1995, Pugesek & Diem 1990, Golet et al., in press).

Studies of the effects of food shortages on parental behavior of seabirds have shown that the duration of the chick-rearing period may be extended if food conditions are poor (e.g., Harris & Rothery 1985, reviewed in Ydenberg 1989). Changes in food availability, for instance food shortages that follow El Niño events, did not affect growth of young seabirds suggesting that parents were able to compensate for a decrease in food availability by adjusting their efforts in chick-provisioning for the changed feeding conditions or pursuing brood reduction strategy (Shea & Ricklefs 1996). An increase in the duration of parental care and a possibility of additional investment of parent seabirds in reproduction during food shortages might lead to an increase in post-breeding mortality. For example, results of field experiments indicated that parent Atlantic puffins that were experimentally exposed to a prolonged chick-rearing period were in poor physiological condition at the end of breeding season compared to control birds (Erikstad et al. 1997). This raises a possibility that seabirds which reproduce during seasons of food shortages would suffer a greater post-breeding mortality compared to the birds that reproduce under conditions that are favorable for reproduction.

Results of our pilot studies have shown that parent Black-legged Kittiwakes and Common Murres respond to a standardized stressor such as capture, handling and restraint, by increasing plasma levels of corticosterone. These results indicated that the hormonal response of adult seabirds can be used to assess susceptibility to stress as might be expected during food shortages. Specifically, in 1997, when Black-legged Kittiwakes nesting on Chisik Island showed the first signs of food shortages at the egg-laying stage they also modulated their stress response compared with those of birds in the egg-laying on Gull Island colony (Fig. 3 a). Continued food shortages resulted in a further significant elevation of circulating levels of corticosterone (Fig. 4) and a suppression of stress response in kittiwakes breeding on Chisik Island (Fig. 3 b). Black-legged Kittiwakes failed to produce any chicks on Chisik Island in 1997 (Piatt et al., unpublished). Using endocrinological parameters alone, we could predict this failure at the egg-laying stage of their reproductive season (Kitaysky et al., submitted *a*).

On the other hand, chick-rearing under favorable foraging conditions does not alter the physiological condition of parent Black-legged Kittiwakes. In particular, exposure to the standardized stressor did not indicate a significant difference in the hormonal response of birds raising young compared to those with experimentally removed chicks (Fig. 5). This raises a possibility that not chick-rearing *per se*, but an additional effort in foraging for the young during food shortages can alter the physiological conditions of parent Black-legged Kittiwakes and result in decreased post-breeding survival of adults. Moreover, the pattern and extent of a corticosterone increase following application of the standardized stressor allows us to assess changes in physiology of a parent in relation to its normal effort in reproduction as opposed to changes associated with food-stress (Kitaysky et al. submitted *a*).

In 1997, we did not find an increase in circulating levels or a suppression of stress levels of corticosterone in breeding Common murres at early stages of reproduction on Chisik Island compared to Gull Island (Fig. 6). However, we observed a rapid increase in circulating levels of corticosterone during the chick-rearing stage, and this increase occurred earlier in a season among Common murres breeding on Chisik Island than on Gull Island (Fig. 6). The phenology of reproduction was similar between the colonies suggesting that, in addition to the species-specific seasonal increase of corticosterone secretion, food shortages affected the physiological condition of parent Common murres on Chisik Island. The experimental manipulation revealed that parent

Common murres respond to elevation of corticosterone by fledging their young (Table 1). To verify this result, we compared the age of fledglings between Chisik and Gull Islands and found that parent murres fledged their young at earlier age at Chisik Island, where feeding conditions are poor (Fig. 7). We also manipulated the corticosterone levels in Common murre chicks but did not find an effect of the experimentally elevated corticosterone levels on the age of chicks at fledging (Fig. 8). Thus, parent Common Murres can avoid food-related stress during reproduction by fledging their young at an early age. Therefore, it is less likely that a population decrease of Common Murres on Chisik Island is related to high mortality of adult birds breeding under poor foraging conditions. It can, however, result from a low recruitment of young at this colony because of either low survival of chicks that left nests at an early age or a delay in reproductive maturation of young birds that experienced nurtitional stress during early development. However, the effects of stress on future survival, foraging behavior and reproduction of food-stressed Common murre chicks have yet to be investigated.

Overall, the results of our pilot studies in 1996 and 1997 provide a strong background for the proposed research on the effects of food-related stress on foraging and reproductive behaviors of seabirds. Our findings fully justify the general assumption of the proposed research that experimental manipulations with hormones will allow us to simulate the effects of the stress on reproductive biology of seabirds in areas affected by the *Exxon Valdez* oil spill.

B. Objectives

1. Establish whether populations at Gull and Chisik Islands are chronically stressed. Determine baseline levels of corticosterone in relation to varying foraging conditions.

2. Investigate the potential for future stress in populations at Gull and Chisik Islands. Measure circulating levels of corticosterone in response to a standardized stressor: capture, handling and restraint.

3. Examine the effects of stress levels of corticosterone on the begging behavior of young and the chick-provisioning behavior of parents at Gull Island. Model the effects of stress with corticosterone implants.

4. Determine the effects of stress levels of corticosterone on the post-breeding survival and future reproductive performance of parents at Gull Island. Monitor survival and reproduction of the manipulated individuals during subsequent reproductive seasons.

5. Determine the effects of food-related stress on post-fledging learning abilities and foraging efficiency of juveniles in captivity.

6. Investigate the effects of food-related stress on sexual maturation of seabirds in captivity.

7. Examine the role of stress hormones in the recovery of seabirds from stress in captivity.

C. Methods

The proposed research utilizes a unique combination of field and captive experiments, and laboratory analyses. We will focus on the comparison of the endocrinological characteristics of seabirds breeding at Gull Island, where foraging conditions were continually good during the last few years with those nesting under poor feeding conditions at Chisik Island. In this study we plan to use Black-legged Kittiwakes and Common Murres as the study organisms. Baseline levels and stress-induced increases of corticosterone will be also be determined in Horned Puffins, Tufted Puffins and Pigeon Guillemots breeding elsewhere in Lower Cook Inlet. Multi-species comparison of the physiological and behavioral aspects of stress will ultimately allow us to predict responses of seabird communities to variability in food supplies or to oil-spills, and to develop efficient programs for their rehabilitation.

1. Correlations among corticosterone levels, reproductive stage and varying foraging conditions.

To assess whether seabirds from different populations are chronically stressed or not, we will determine baseline levels of corticosterone in relation to the reproductive stages, pre-incubation, incubation and chick-rearing. Adult birds will be captured at the breeding colonies by using a noose pole. We will collect a blood sample (approximately 100-150 μL) from the brachial vein of the wing immediately after capture. To determine the potential for stress in different populations we will measure circulating levels of corticosterone in response to a standardized stressor, capture, handling and restraint. For that, additional samples of blood (15-30 μL) will be collected from the same birds over a period of 1 h after capture (at 5, 10, 30 and 60 min intervals). To collect blood samples from chicks we will use similar methods as for adult birds, except that the first sample will be smaller (30-50 μL).

The results of our pilot study indicate that a sample size of N>7 (per each group of birds) was sufficient to detect significant inter- and intra-specific differences in baseline concentrations of corticosterone in adult birds (Figures 1-6). Therefore, approximately 7-10 adult birds and chicks will be sampled at each colony at every stage of the reproductive period (total 25-30 birds of each species per colony/year). After sampling, adult birds will be released at the colony and chicks returned to their nests. Previous field and captive studies indicate that taking blood does not affect the physiological condition or behavior of birds (J. Wingfield, personal observations). In 1996, Black-legged Kittiwakes released after bleeding at Gull Island were sighted at the nests within 1-10 min period. Similarly, bleeding captive seabird chicks does not appear to affect their behavior or development (A. Kitaysky and M. Romano, personal observations).

2. Field manipulations with stress levels of corticosterone.

To test whether corticosterone affects begging by chicks and provisioning of food by parent seabirds we will experimentally manipulate the concentration of this hormone in plasma of birds at Gull Island. We plan to use two experimental treatments (10 nests each) where either the chicks or their parents will be given subcutaneous implants of corticosterone (sealed plastic tubes filled with the crystallized hormone, for details see Wingfield & Silverin 1986) during the first week after hatching. The control birds will be given empty implants. The following parameters will be measured to record a change in the behavior of birds due to the hormonal treatment: chick-feeding rate (assessed as #feedings/day per chick) and nest attendance by the parents (in minutes per day). Recording of behavior will be accomplished by direct observation from blinds established at the colony. Blood samples will be taken on a weekly basis from all young and parent birds to monitor concentrations of corticosterone in plasma of manipulated and unmanipulated birds.

Results of the experiment in 1997 at Gull Island show in six experimental and six control nests of Black-legged Kittiwakes on Gull Island (Kitaysky et al., submitted *c*), that chicks with subcutaneous corticosterone implants beg more frequently than controls with empty implants (Fig. 2 a). Parent kittiwakes then respond to the change in begging by the chicks by providing more food (Fig. 2 b). Thus, parents provide more or less food in response to the physiological condition of their offspring as indicated directly by chick begging behavior. However, feeding conditions were exceptionally good for kittiwakes breeding on Gull Island in 1997 (Piatt et al. Unpublished), and the observed behavioral response of parent kittiwakes can change if parent kittiwakes experience food shortages. Therefore, the experiment will be repeated during breeding season of 1999 and 2000, when potential food shortages related to the El Niño of 1997/98 are expected.

All experimental birds will be individually marked with a unique combination of color bands and standard aluminum USFWS rings. Individual markings will allow us to identify the birds during the experiments and to monitor their survival after breeding and future reproductive performances during the following breeding seasons. Both Black-legged Kittiwakes and Common Murres have strong nest site and mate fidelity and their breeding performance and survival are relatively easy to monitor over a period of several years (Coulson & Thomas 1983). Golet and co-authors (Golet et al., in press) showed that the difference in post-breeding survival between Black-legged Kittiwakes raising their young with those with experimentally removed chick was possible to detect with sample sizes of about 100 nests per treatment. As indicated by the pilot studies, chick-rearing per se does not cause stress to a parent under favorable environmental conditions. However, poor foraging conditions as an additional stressor would impair parents' physiological condition. Thus we expect a considerable difference in survival due to the manipulations with stress levels of corticosterone. We anticipate that a sample size of 30 nests (60 birds per experimental treatment) would allow us to make a conclusive statement about the relationships among survival, reproduction and stress in Black-legged Kittiwakes and Common Murres in Lower Cook Inlet. This component of the study will complement, and be coordinated with, a larger study of adult survival at Gull and Chisik Islands (Restoration Project 98338).

3. Captive study of food-related stress, post-fledging survival and sexual maturation.

To test whether the food/pollution-related stress affects post-fledging learning abilities and foraging efficiency of young seabirds, we will raise Black-legged Kittiwakes and Common Murre chicks on three different nutritional regimes in captivity during 1999. For the experimental treatments (15 chicks per each treatment) we will use the methods described by Romano and co-authors (Romano et al., unpublished) where either quantity and quality of the chick diets will be altered or a supply of mineral oil will be given to chicks with food. In particular, one group of young will be raised on reduced quantities of the high quality food (sandlance, *Ammodytes hexapterus*, and capelin, *Mallotus villosus,* or herring, *Clupea harengus*). Chicks from the second experimental treatment will be raised on sufficient amounts of food of poor quality (juvenile pollock, *Theragra chalcograma*). Birds from the third experimental treatment in addition to the *ad libitum* feeding by the food of high quality will be given small quantities of oil. Chicks from the control group will be raised on the food of high quality (sandlance and capeline) given *ad libitum.*

After fledging of the experimental chicks, captive trials on their learning abilities and post-fledging foraging efficiency will be conducted at the facilities of the SeaLife Center. Birds will be housed in the exhibition aviaries, consisting of a cliff and a tank that will be separated by a removable glass wall, and trained to feed on their own on fresh fish given to them in the tank. Duration of the weaning period (a period from the fledging time until the beginning of self-foraging) will be used to characterize a bird's ability to learn the foraging technique. To wean the young, we first will place dishes with food floating on the surface of the tank. Next, fresh food items (small pelagic fish and invertebrates, the same diet for all experimental treatments) will be placed in a container that will be established at the surface of the tank. Birds will be housed in mixed groups (equal proportions of stressed and non-stressed birds) to provide a required social element in the learning of foraging techniques by young.

During foraging efficiency trials, we will use a long (across the whole tank), narrow (50-60 cm width), and shallow watertank (40-50 cm depth) for surface-feeding kittiwakes, and deep tank (100-150 cm depth) for the pursuit-diving foraging alcids, were food items will be placed. Food availability, as determined by prey density and abundance, will be regulated by the number of food items placed in the container and the current speed at which the food items will pass through the tank. Prior to foraging efficiency trials, experimental birds will be denied food during eight hours (by closing the removable wall between the cliff and tank). Then fasting birds will be allowed to access the food placed in the container at the surface of the tank and their foraging efficiency will be determined for each bird individually. Foraging performance of each bird will be tested individually. The number of foraging attacks and the foraging success (number of the captured prey items) will be recorded to quantify the foraging efficiency of the birds under different conditions of the food availability. Foraging efficiency of the birds will be determined under three different foraging conditions: low (low density of food and high current velocity), intermediate (medium density of food and current speed), and high (high density of food and low current velocity) availability of food. To avoid an "observer effect", the foraging behavior of birds will be recorded as a series of short-term duration (15-20 minutes) trials recorded on a high-speed video-camera established in the aviary. To monitor body and physiological conditions of the captive birds we will measure their body mass and collect blood samples during the post-fledging period of their life (at a weekly interval). To assess the recovery rate of juveniles from the stress, we will repeat the foraging efficiency trials as the birds age.

Age of sexual maturation of the food-stressed birds will be examined in the facilities of Alaska SeaLife Center. Usually, Black-legged Kittiwakes become sexually mature at 3-4 years of age. Most alcids reach sexual maturity probably at the same age (e.g., Golovkin et al. 1989). Kittiwakes and alcids readily breed in captivity at aquaria if they are raised there as chicks. Therefore, we expect that the captive birds will start to breed at the Alaska SeaLife Center facilities as soon as they have reached sexual maturity. If this is not the case, the morphological development of gonads will indicate the onset of maturity in captive birds. As known for many species of birds that do not breed in captivity, the processes of gonadal development still occur and can be used to determine the onset of the sexual maturity (Wingfield & Farner 1993). Gonadal development will be measured by using the laparotomy technique (Wingfield & Farner 1976). In addition to the observation of morphological development of gonads, periodical sampling of blood from the captive birds will be used to monitor concentrations of gonadotropic hormones in the peripheral system of the captive animals (Wingfield & Farner 1993). Thus, onset of maturation can be first detected at age 2 in some birds.

4. Captive trials on recovery from stress.

To investigate recovery from stress in birds of different species we will model the stress by manipulation with concentrations of corticosterone in the peripheral system of wild and captive birds. In particular, we will monitor survival/return rates of parent birds following stressful incident (as described above) at Gull Island. Comparison of recovery rates between chronically stressed and control juveniles birds will be also performed in captivity.

5. Laboratory analyses.

In parallel to the field and captive research we will conduct the laboratory analyses of blood samples taken from the birds during the experimental manipulations. All blood samples will be taken from the brachial vein of the wing, blood plasma will be separated from blood cells and then frozen at -10°C. All plasma samples will be transported to the laboratory at the University of Washington and processed according to the radio-immuno assay techniques (see Wingfield et al. 1991 for the details).

D. Contracts and Other Agency Assistance

The field and captive experiments, and laboratory analyses will be carried out by Dr. Alexander Kitaysky, a research associate in the Zoology Department at University of Washington, Seattle, with the aid of one full-time assistant and two field volunteer-assistants. Dr. John Piatt of the US Geological Survey will serve as field supervisor, providing logistical support and hiring the assistant and volunteers. Radio-immuno assay analyses of blood samples collected during the proposed research will be conducted in Dr. Wingfield's laboratory at UW. Dr. Wingfield will provide the supervision of laboratory analyses, and provide logistical support.

SCHEDULE

A. Project Tasks for FY 99 (October 1, 1999 - September 30, 1999)

January-April: preparation for field work, hiring personnel

May-June:	blood sampling during pre-incubation stage, setting study plots for the experimental work
July:	blood sampling during incubation stage, study plot monitoring
August:	blood sampling during chick-rearing stage, colony work: implanting birds with the hormonal implants, monitoring parental feeding rates and chick survival
July-September:	chick-rearing in captivity at the Sealife Center at Seward
September-October:	transfer captive birds to the SeaLife Center at Seward, start captive trials on foraging efficiency of juveniles
October-April:	laboratory analyses of blood samples, data analysis
February:	Annual Report on FY 99 results
March-April:	preparation for FY00 research
May:	begin field work for FY00

B. Project Milestones and Endpoints

The ultimate goal of this study is to assess whether or not populations of seabirds breeding in Lower Cook Inlet are chronically stressed and to quantify potential for stress at different stages of a bird's life-cycle under varying foraging conditions. Objectives 1 and 2 will require at least three years of field and laboratory work to quantify the relationships between baseline levels of corticosteroids and foraging conditions before final conclusions can be made. Objectives 3 and 4 will be accomplished after three reproductive seasons. Objectives 5 through 7 will be assessed after 3 years of work with captive animals.

If the objectives are achieved, it should be possible by year 2002 to evaluate current status and potential for stress at the colonies in Lower Cook Inlet. Moreover, it will reveal how effects of stress on reproduction and survival are expressed in seabird populations. This will provide the basis for management of seabird populations in the areas affected by the oil spill.

C. Completion Date

The study will be completed in December of 2002, after three reproductive seasons at the colonies in Lower Cook Inlet, three years of captive trials on post-fledging foraging efficiency and recovery from stress at Alaska SeaLife Center, laboratory analyses and sufficient time for analyses of results and preparation of manuscripts for publication.

PUBLICATIONS AND REPORTS

February 15, 2000:	Annual report on work accomplished in summer-fall period of 1999, and preliminary results.
February 15, 2001:	Interim report on work accomplished in summer-fall period of 1999, extensive analyses of results and preliminary conclusions.
February 15, 2002:	Annual report on work accomplished in summer-fall period of 2001, and preliminary results.
February 15, 2003:	Draft Final report on work accomplished and results obtained, 1999-2002.

We also plan to publish interim and final results of this study in conference proceedings and scientific journals. Note that some results of pilot studies in 1996 and 1997 have already submitted to peer-reviewed journals for publication.

NORMAL AGENCY MANAGEMENT

None of the proposed research described here would normally be conducted by the USGS, or any other government agency.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This study addresses a number of questions related to conservation and management of Alaskan seabirds. The proposed research will allow to create captive populations of several species of seabirds that breed in the Gulf Of Alaska and affected by the *Exxon Valdez* oil spill. The proposed research will be coordinated with on-going projects being supported by the Exxon Valdez Oil Spill Trustees and US Geological Survey.

PRINCIPAL INVESTIGATORS

Principal Investigator and Project Leader - Dr. Alexander S. Kitaysky, Research Associate with the University of Washington, Seattle. Obtained a Ph.D. in Ecology and Evolutionary Biology from University of California in 1996 (dissertation on behavioral, physiological and reproductive responses of seabirds to environmental variability). Since 1986, studied seabird behavior and physiology at colonies in Okhotsk Sea and on the Aleutian Islands, and foraging behavior of seabirds at sea in Bering Sea, Aleutian Islands and in Gulf of Alaska.

Dr. John F. Piatt (Research Biologist GS-13, Alaska Biological Sciences Center, USGS, Anchorage, AK) obtained a Ph.D. in Marine Biology from Memorial University of Newfoundland in 1987. His dissertation involved seabird-forage fish interactions. Since 1987, he has studied seabirds both at colonies and at sea in the Gulf of Alaska, Aleutian Islands, and Bering and Chukchi seas. His is an author on over 50 peer-reviewed scientific publications about seabirds, fish, marine mammals, and effects of oil pollution on marine birds.

OTHER KEY PERSONNEL

Professor John Wingfield (University of Washington, Seattle). Financial and logistic support for laboratory analyses in his lab at UW. He is an author on over 250 scientific publications (see attached CV).

Research assistants:
- Biotech (12 month, vacant)

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Kitaysky A.S., J.C. Wingfield, and J.F. Piatt. (*a*) Food availability, body condition and the adrenal stress response in breeding kittiwakes. Submitted to *Gen. Comp. Endocr.*

Kitaysky A.S., G.L. Hunt, E.N. Flint, M.A. Rubega, and M.B. Decker. (*b*) Does reproductive performance reflect population size in high latitude seabirds? Submitted to *J. Anim. Ecol.*

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Table 1. Behavioral response of parent Common murres to the experimental increase in curculating levels of corticosterone. At the experimental nests (n=6, chick age = 13.5 (SD=2.51) days after hatching) parents were implanted subcutaneously with two 25 mm silicon tubes filled with the cristallized cotricosterone, parents at the control nests (n=6, mean chick age = 13.0 (SD=2.45) days after hatching) were implanted with empty tubes. Direct observations (during two days between 7 a.m. and 21 p.m.) were carried out 24 hours after the implantation. By that time, implanted parents fledged their chicks, whereas most of controls stayed with their chicks at the colony (difference between the treatments is statistically sugnificant: $\chi^2 = 8.57$, p=0.003).

Experimental treatment	Behavioral response of parents	
	Fledged their chicks	Stayed at the nest with chicks
Controls	1*	5
Implanted	6	0

* - number of nests where parents were manipulated.

Figure 1. Black-legged Kittiwake chick that were raised on restricted (low daily energy intake), or poor quality diets (low lipids to proteins ratio, Romano M., unpublished data), had significantly elevated levels of corticosterone (mean ± SE). Analysis of covariance with the diet composition as a factor and the energy intake as a covariate has shown significant effects of both, diet composition ($F_{2,39}$=3.38, p=0.04) and energy intake ($F_{1,39}$=28.77, p<0.001). Post-hoc analyses revealed that chicks that were fed pollock at 373 kJ day-1 had significantly elevated baseline levels of corticosterone compared to chicks that were fed herring at the same rate (t_{16}=2.741, p=0.015).

Figure 2. Behavioral responses of Black-legged Kittiwake chicks (**a**) and parents (**b**) to the experimentally increased circulating levels of corticosterone in chicks (mean ± SE; n=6 nests per treatment). (**a**) Chicks increase begging in response to the increased levels of corticosterone (Kruskal-Wallis ANOVA: *H*=8.49, *P*<0.01); (**b**) parents increase feeding of their young in response to the corticosterone-increased begging rate of chicks (independent samples t-test: *t*=3.969, *P*<0.01, n=12). At experimental nests chicks were implanted with a single 25 mm silicon tube filled with crystallized corticosterone. Behavioral observations were conducted over a two day period beginning 24 hours after implant placement

Figure 3. Comparison of stress response to handling between Black-legged Kittiwakes breeding under poor foraging conditions at Chisik Island (solid circles and bars represent mean ± SE, sample sizes are 7 and 7 individuals in the egg-laying and chick-rearing stages, respectively) and under favorable conditions at Gull Island (open circles, n=10 and n=8 in the egg-laying and chick-rearing stages, respectively). At Chisik Island, breeding kittiwakes modulated their response to a standardized acute stressor compared to those of birds at Gull Island (repeated measures ANOVA, time after capture x colony effect: $F_{4, 112}$=6.64, p<0.001).

Figure 4. In 1997, baseline levels of corticosterone were significantly elevated in birds breeding at Chisik Island (poor foraging conditions) compared to those of birds breeding at Gull Island (favorable foraging conditions) (colony effect: $F_{1, 55}$=13.24, p=0.001).

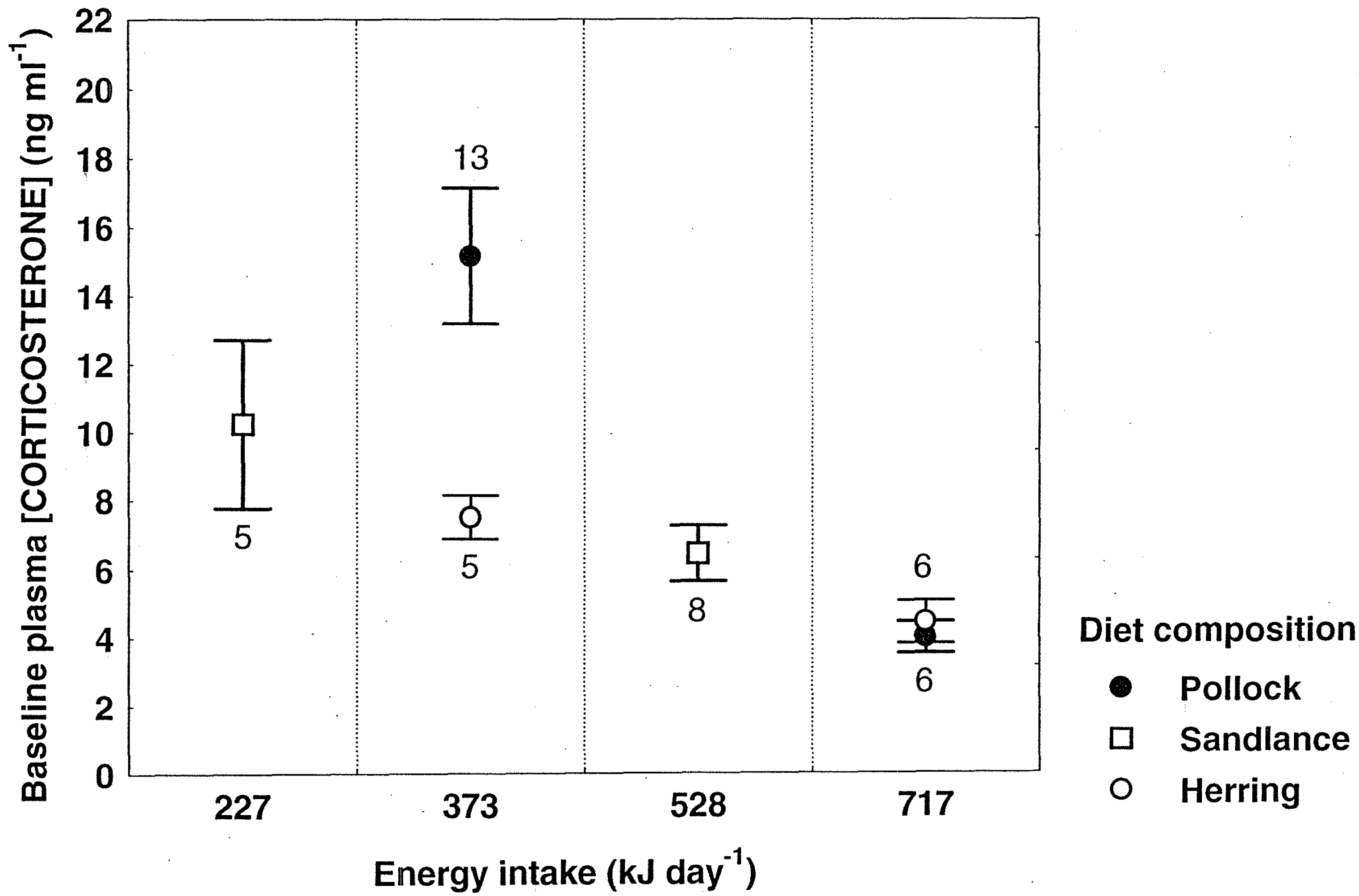
Figure 5. Stress response to handling of Black-legged Kittiwakes rearing their chicks and those with experimentally removed chicks (J.C. Wingfield and G. Golet, unpublished data). This comparison suggests that, chick-rearing under favorable foraging conditions is not a stressfull event in the Black-legged Kittiwake.

Figure 6. In 1997, increase in baseline levels of corticosterone occurred earlier in Common murres breeding at Chisik Island that in those at Gull Island (mean ± SE).

Figure 7. In 1997, Common murre chicks were fledging at a younger age at the food-poor colony on Chisik Island compared to food-rich colony on Gull Island (mean ± SE).

Figure 8. The experimental increase in circulating levels of corticosterone does not change a duration of chick development in the nest in the Common Murre (mean ± SE). Experimental

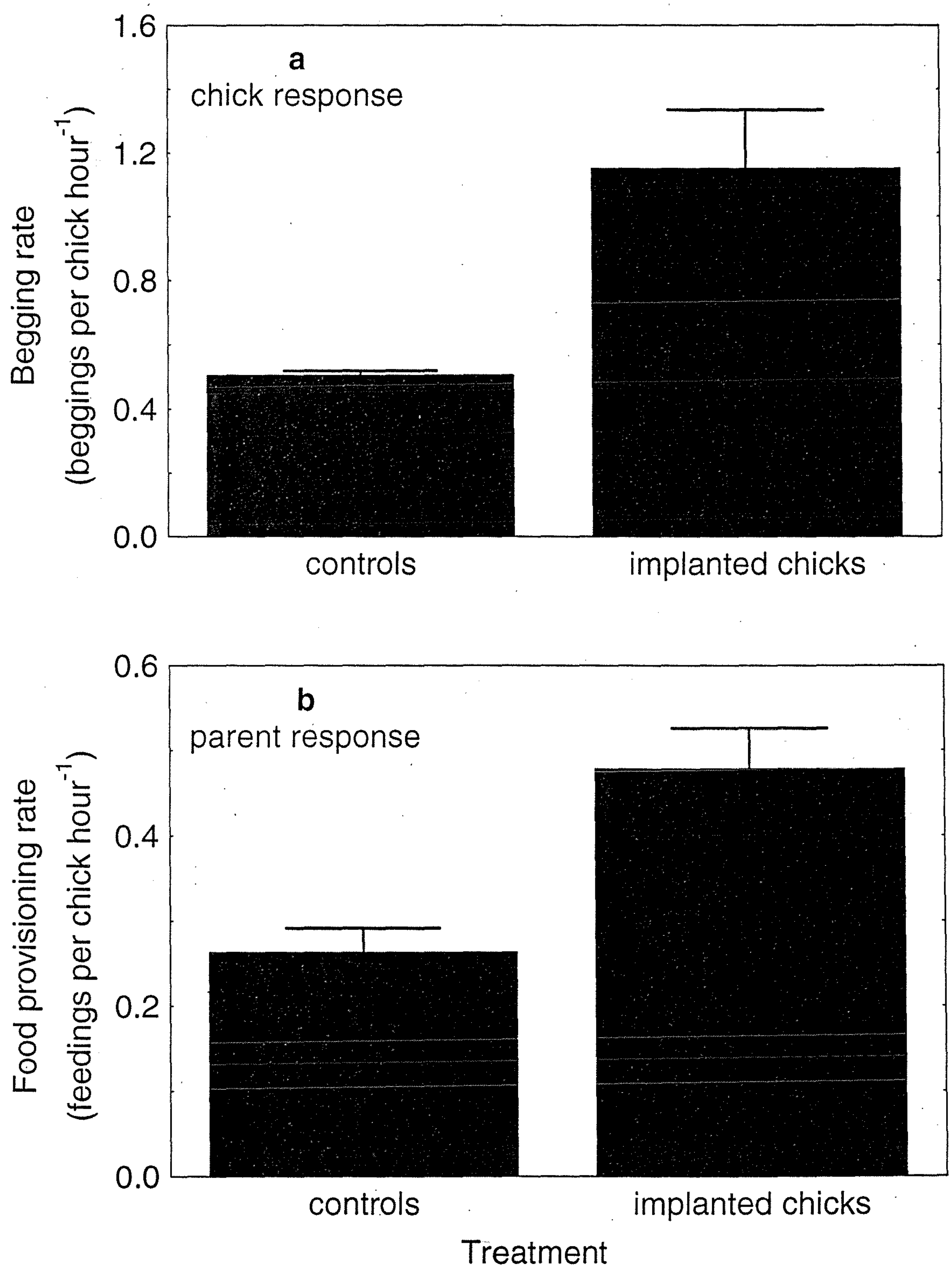
chicks were implanted subcutaneously with one silicon 25 mm tube filled with the crystallized hormone. Controls were implanted with empty tubes.



Baseline plasma [CORTICOSTERONE] (ng ml⁻¹)
22
20
18
16
14
12
10
8
6
4
2
0
13
5
5
8
6
6
227
373
528
717
Energy intake (kJ day⁻¹)
Diet composition
Pollock
Sandlance
Herring

Fig. 1

Fig. 2



1.6
1.2
0.8
0.4
0.0
a
chick response
Begging rate
(beggings per chick hour^{-1})
controls
implanted chicks
0.6
0.4
0.2
0.0
b
parent response
Food provisioning rate
(feedings per chick hour^{-1})
controls
implanted chicks
Treatment

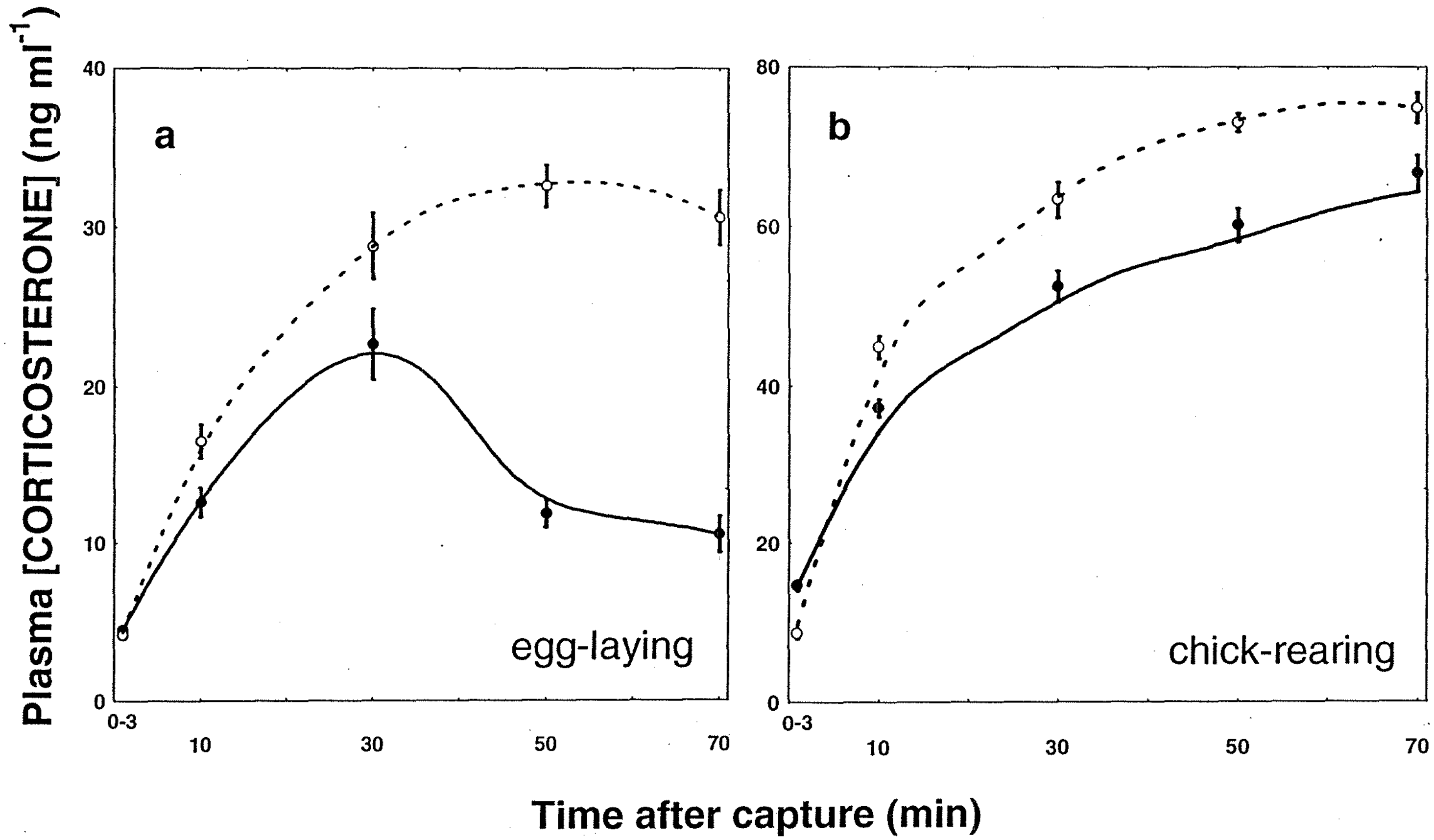

Plasma [CORTICOSTERONE] (ng ml-1)
a
egg-laying
b
chick-rearing
0
10
20
30
40
0
20
40
60
80
0-3
10
30
50
70
0-3
10
30
50
70
Time after capture (min)

Fig. 3

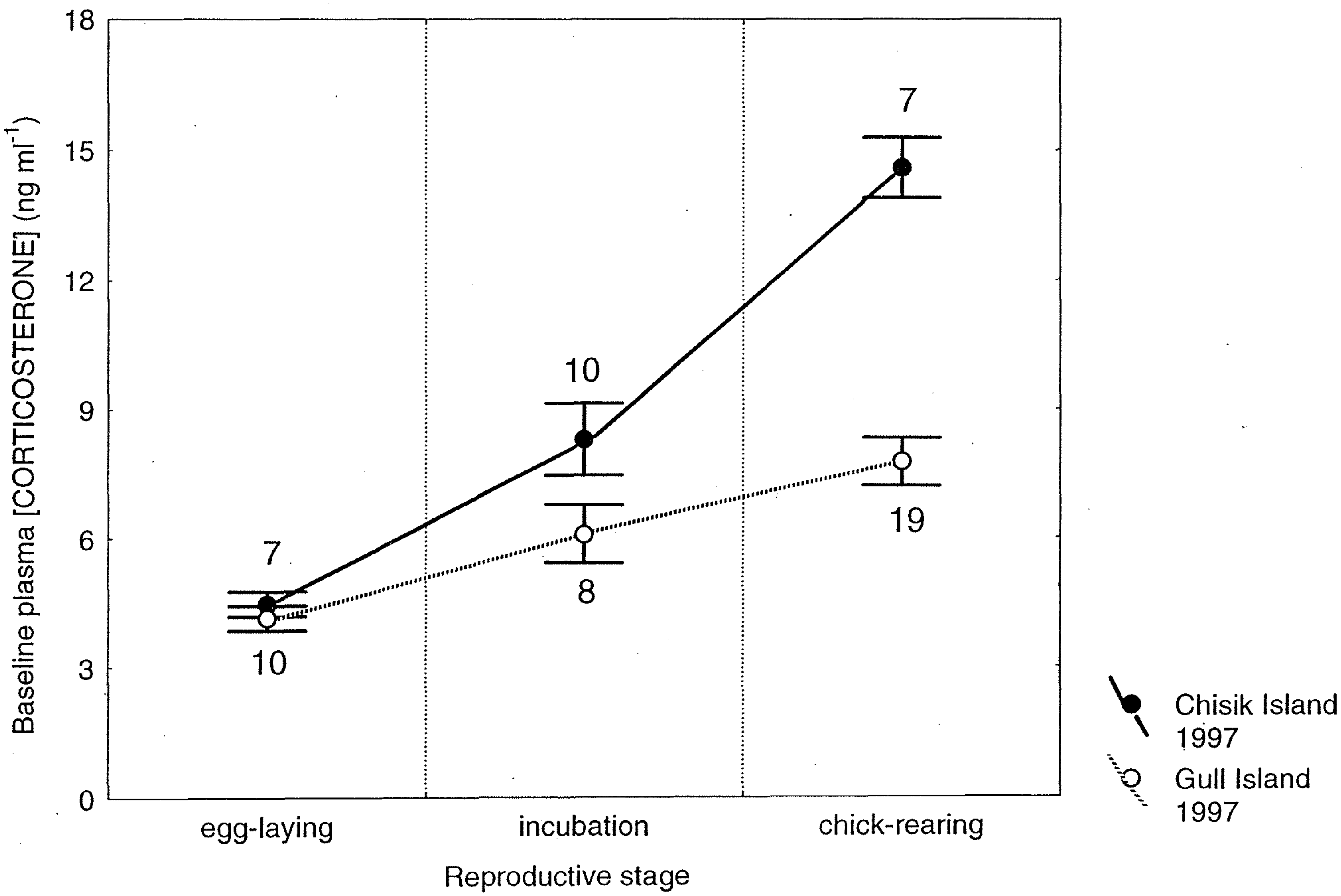
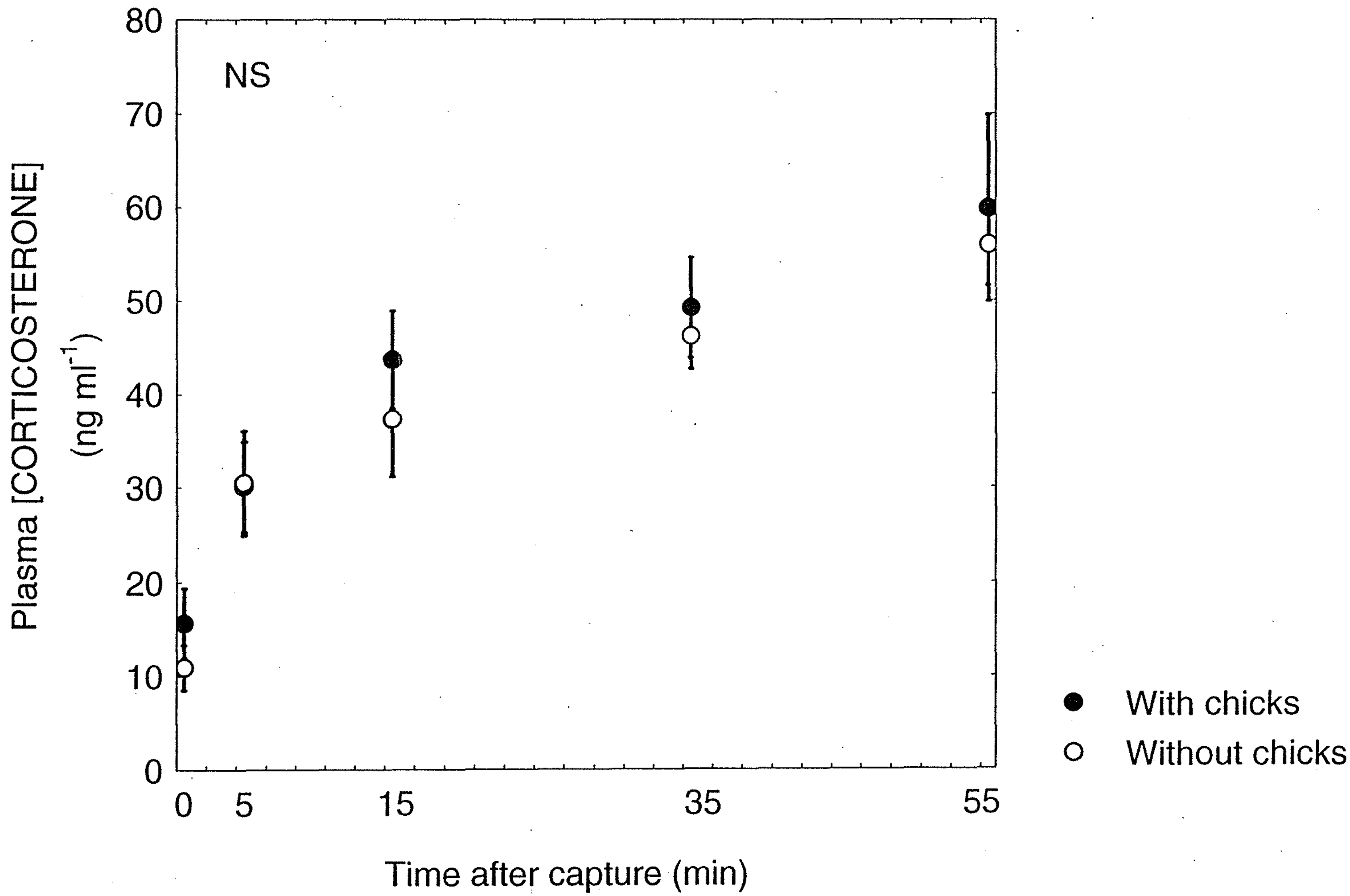

18
15
12
9
6
3
0
Baseline plasma [CORTICOSTERONE] (ng ml-1)
7
10
7
10
8
19
10
7
egg-laying
incubation
chick-rearing
Reproductive stage
Chisik Island
1997
Gull Island
1997

Fig. 4


NS
Plasma [CORTICOSTERONE]
(ng ml-1)
80
70
60
50
40
30
20
10
0
0
5
15
35
55
Time after capture (min)
With chicks
Without chicks

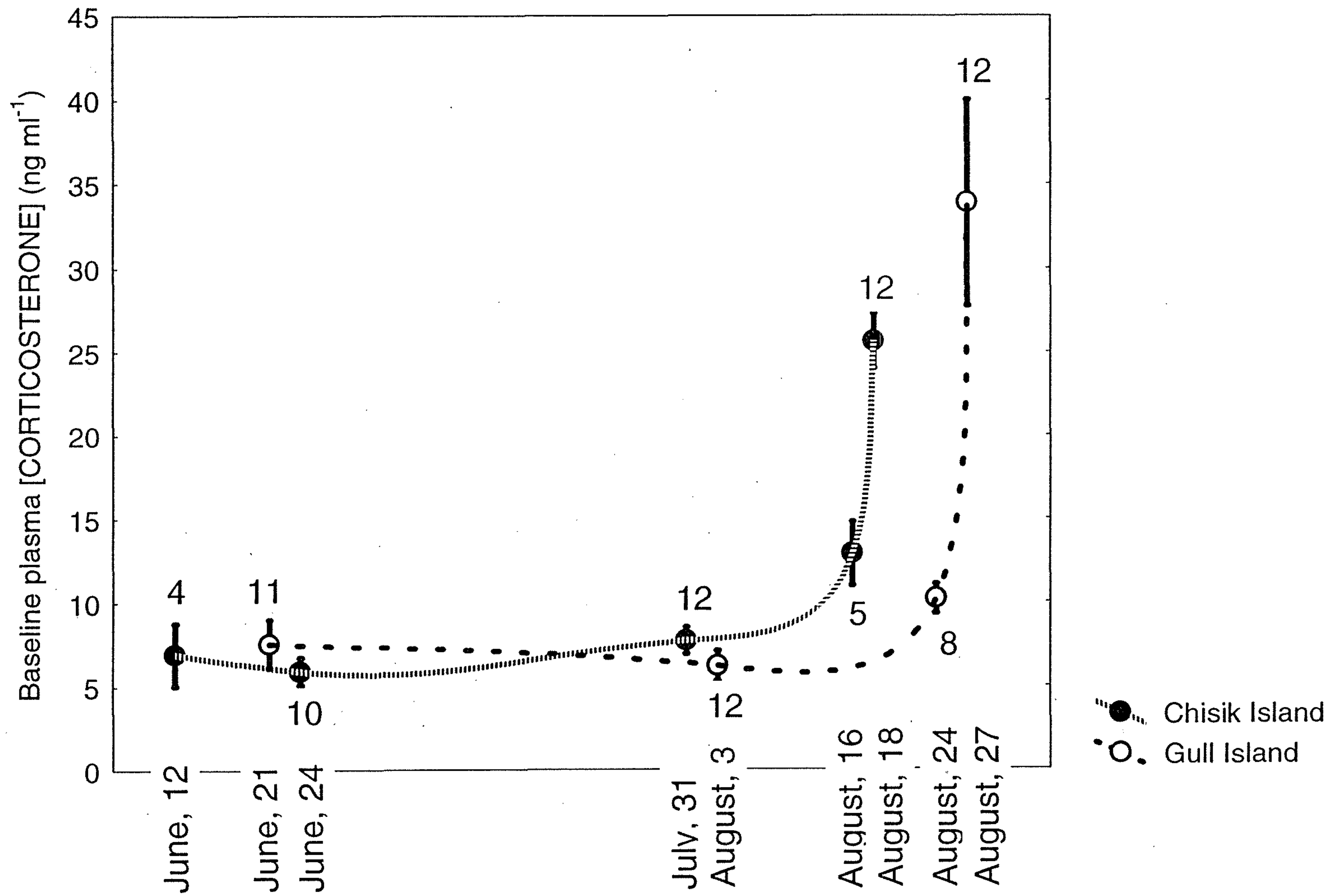

Baseline plasma [CORTICOSTERONE] (ng ml-1)
45
40
35
30
25
20
15
10
5
0
4
11
10
12
12
5
12
8
12
June, 12
June, 21
June, 24
July, 31
August, 3
August, 16
August, 18
August, 24
August, 27
Chisik Island
Gull Island

Fig. 6

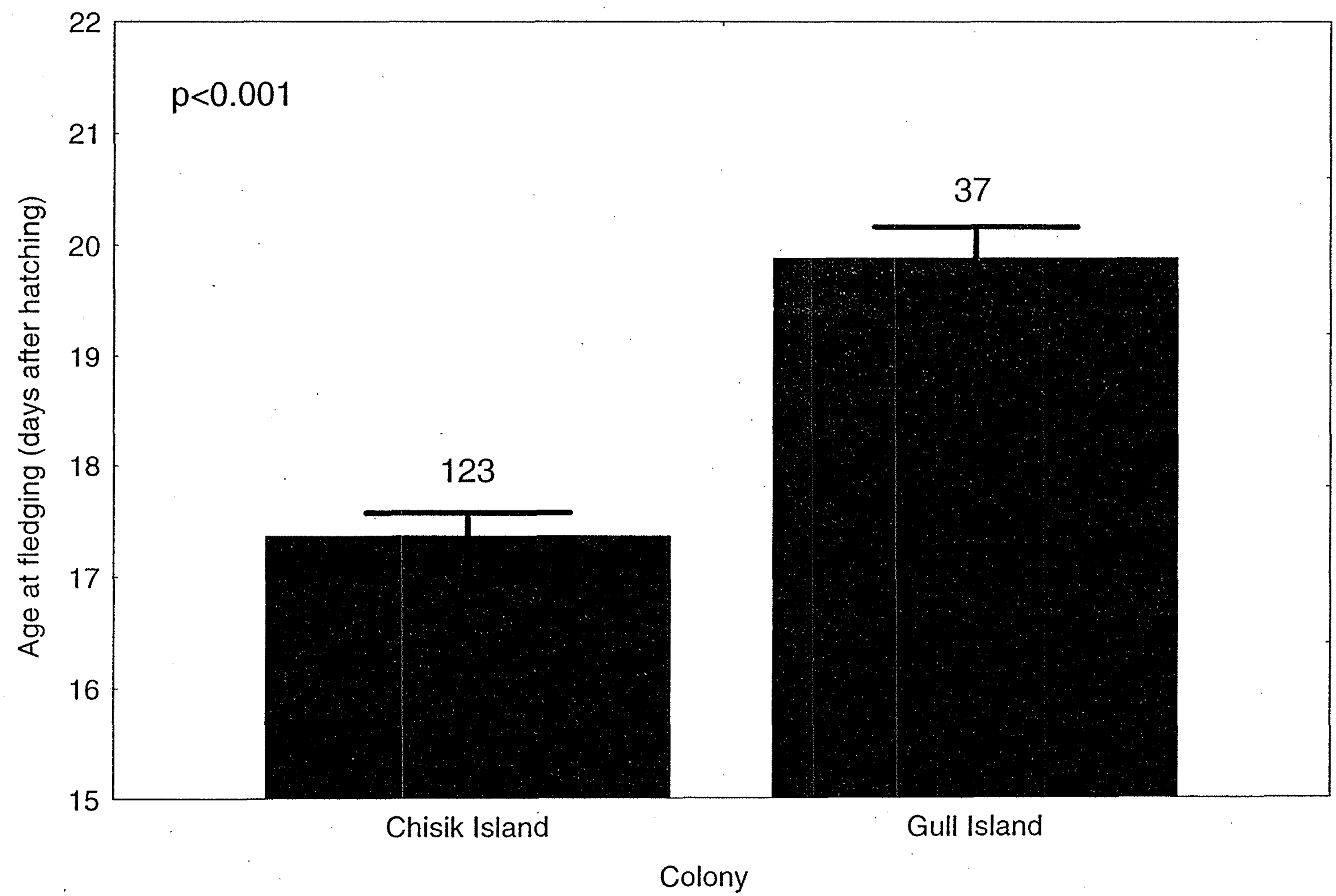
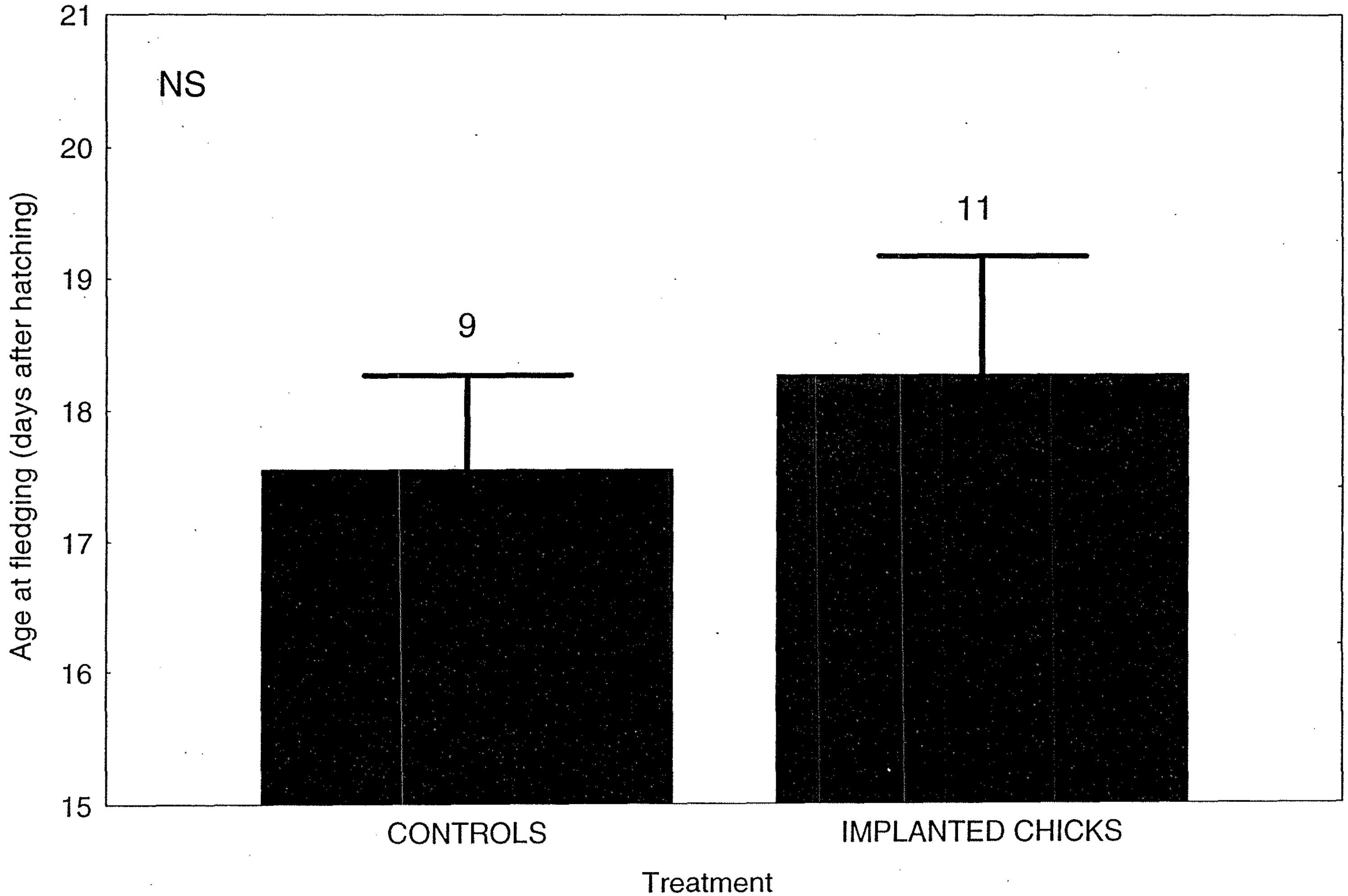

p<0.001
123
37
Age at fledging (days after hatching)
Chisik Island
Gull Island
Colony
22
21
20
19
18
17
16
15

Fig. 4



NS
21
20
19
18
17
16
15
Age at fledging (days after hatching)
9
11
CONTROLS
IMPLANTED CHICKS
Treatment

Fig. 8

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$9,561.6
Travel		$11,600.0
Contractual		$47,000.0
Commodities		$5,000.0
Equipment		$22,500.0
Subtotal	$0.0	$95,661.6
General Administration		$2,386.7
Project Total	$0.0	$98,048.3
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	Estimated FY 2003	
	$125,200.0	$129,600.0	$75,000.0	$0.0	

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Prepared:

Project Number: 99 479

Project Title: Effects of food stress on survival and reproductive performance of seabirds

Agency: U.S. Geological Survey

FORM 3A TRUSTEE AGENCY SUMMARY

1998 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
Vacant	Biotech	GS-5	4.8	1992.0		9,561.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.8	1992.0	0.0	
					Personnel Total	$9,561.6

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Per Diem, while working at Sea Life Center					2,400.0
Volunteer (2)					2,400.0
Volunteer (2)	900.0	2			1,800.0
Seattle-Anc	500.0	10			5,000.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$11,600.0

1999

Prepared:

Project Number: 99______
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs: Description	Proposed FY 1999
University of Washington Research Work Order	47,000.0
Post-doc Salary - 35K	
Benefits and fees - 12K	
When a non-trustee organization is used, the form 4A is required. Contractual Total	$47,000.0

Commodities Costs: Description	Proposed FY 1998
Food	3,000.0
Fuel	2,000.0
Commodities Total	$5,000.0

1999

Prepared:

Project Number: 99______
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency; U.S. Geological Survey

FORM 3B
Contractual
&
Commodities

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Field Centrifuge			2,000.0
Laptop Computer			3,000.0
Mobile freezer			1,500.0
Misc Scientific field supplies			2,000.0
Laboratory supplies for Radio-immunoassay			14,000.0
			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		$22,500.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
All boat, lodging, field laboratory, and logistic support provided by APEX project 98163M (Cook Inlet Seabirds). Equivalent value of about 25K.		
University of Washington, research laboratory of Dr. John Wingfield. Equivalent value of complete laboratory support beyond supplies for radio-immunoassy (above) is about 100K		

1999

Prepared:

Project Number: 99______
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3B
Equipment
DETAIL

4/14/98

99480

Project Title: Abundance and Reproductive Success of Black Oystercatchers in Prince William Sound

Project Number: 99480
Restoration Category:
Proposer: Migratory Bird Management, U. S. Fish and Wildlife Service
Lead Trustee Agency: U. S. Department of the Interior, Fish and Wildlife Service
Cooperating Agencies: None
Alaska SeaLife Center: no
Duration: 1-year project
Cost FY 99: $36,100
Geographic Area: Prince William Sound
Injured Resource/Service: Black Oystercatcher

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

The black oystercatcher (*Haematopus bachmani*) was determined to be injured by the *Exxon Valdez* oil spill and the status of their recovery is unknown. We propose to survey shorelines on Knight, Green, and Montague islands to determine breeding pair occupancy and productivity. We will use this information to compare with data gathered from 1991 to 1993 along the same shorelines. Additional information will be collected on predator densities and invertebrate prey densities to determine the influence of these factors on occupancy and productivity. Data collected in 1999 will demonstrate recovery of black oystercatchers if 1) more pairs are occupying Knight Island in 1999 than in 1993, 2) the population on Green Island is increasing or stable, and 3) if productivity is similar, when accounting for predation pressure and food availability, between Green and Knight Island.

INTRODUCTION

The black oystercatcher (*Haematopus bachmani*) is a large (500-700 g) shorebird that nests and feeds exclusively along marine shorelines and is a common breeder in the Prince William Sound, Alaska (Isleib and Kessel 1973). Because black oystercatchers are dependent upon marine shorelines for their life's requirements, they were vulnerable to disturbances caused by shoreline oiling. In fact, shoreline and nearshore bird species were one of the guilds most negatively influenced by the initial effects of the *Exxon Valdez* oil spill (Wiens et al. 1996). Studies conducted in Prince William Sound were consistent in identifying an initial, negative effect of the spill (Murphy et al. 1997) on oystercatcher population size (Klosiewski and Laing 1994, Andres 1996), reproduction (Andres 1997), and habitat occupancy (Andres 1997, Day et al. 1997). Thus, oystercatchers were negatively affected by all possible pathways of oil spill influences described by Wiens (1995) and were determined by the Trustees to be an injured resource.

The persistence of oil in some mussel beds (*Mytilus trossulus*) raised questions about the continued exposure of black oystercatchers in Prince William Sound. From studies conducted from 1991 to 1993, nesting and foraging territories of black oystercatchers breeding in the Knight Island archipelago, Prince William Sound, were found to overlap oiled mussel beds, and some pairs were susceptible to exposure to persistent shoreline oil (Andres 1998a). However, adult oystercatchers exhibited no dramatic behavioral or physiological changes (indirectly measured by egg volume, clutch size, and ability to renest) that were indicative of oil ingestion (Andres 1998a). Reduced parental care and other reproductive impairments have been observed in other oil-dosed marine birds (e.g., Ainley et al. 1981, Trivelpiece et al. 1984, Butler et al. 1986, Fry et al. 1986, Butler et al. 1988).

Despite the lack of evidence of negative effects of oil ingestion on adults, oystercatcher chicks were directly, and possibly indirectly, affected by the presence of persistent shoreline oil in the territories where they were raised. Slower growth rates of chicks were apparent across areas of persistently oiled shorelines on Knight Island and corresponded to sediment hydrocarbon concentrations at specific nest sites. The pronounced effect of oil ingestion on growth rates of young chicks has been documented in other marine birds (Butler and Lukasiewicz 1979, Boersma et al. 1988) and like these studies, growth rates between oil-affected and unoiled oystercatcher chicks converged as chicks aged. As a result, the initial reduction in growth rate in oystercatcher chicks did not translate into a overall reduction in productivity. In fact, egg and chick predation appeared to have a larger influence on productivity than did persistent shoreline oil (Andres 1998a).

Concurrent with work on the effects of persistent shoreline oil on oystercatchers, Andres (1996) found that reoccupation by oystercatchers of habitats disturbed by the *Exxon Valdez* oil spill varied spatially across Prince William Sound and might be related to habitat quality independent of oiling severity (a pattern similar to species studied under the Nearshore Vertebrate Predator project). Whereas, population size and productivity increased dramatically between 1989 and 1993 on Green Island (oiled in 1989), breeding pairs inhabiting Knight Island (oiled) decreased 8% between 1991 and 1993 and productivity remained low (Andres 1996). These findings questioned the recovery status of black oystercatchers.

Therefore, we propose to investigate patterns of habitat occupancy and reproductive success between two previously oiled areas of Prince William Sound. Comparison between these areas in 1999 and with patterns observed between 1991 and 1993 will enable us to fully assess the recovery status of black oystercatchers. Additionally, we will collect information on predation pressure and available food resources to help explain differences that might exist between these two areas.

NEED FOR THE PROJECT

A. Statement of the Problem

The black oystercatcher was injured by the oil spill and their recovery is not completely known. Evidence from Prince William Sound suggests that reproductive success and reoccupation varied spatially among oiled areas. Although some work is being conducted in 1998, this study is inadequate to fully answer the question of recovery because of insufficiencies in the 1) temporal effort across the breeding season of oystercatchers, and 2) spatial effort across the amount of shoreline nesting areas.

Because predation, and possibly food, could be limiting population growth on Knight Island, information on these factors is critical to assess whether populations have recovered to pre-spill levels. If these factors have a large influence on productivity, pairs inhabiting Knight Island might never reach the levels of productivity experienced by pairs on Green Island or at other unoiled sites (reasonable comparisons given the lack of pre-spill information).

If the oystercatcher population on Green Island is continuing to increase, this population might serve as a source for reoccupation of Knight Island. Previous work indicates that Green Island might provide higher quality breeding habitat to oystercatchers than Knight Island (Andres 1998a). In the interim since surveys were last conducted on Knight Island in 1993, pairs dispersing from Green Island might have had enough time to reoccupy Knight Island and return it to a "pre-spill" population level.

B. Rationale/Link to Restoration

Recovery of black oystercatchers will be achieved when populations, productivity, and chick growth rates have reached pre-spill levels. In the absence of pre-spill information, recovery parameters are often compared between oiled and unoiled sites or among oiled sites. Work by Andres (1998a) suggests that initial differences in growth rates between chicks living at oiled and unoiled sites has no effect on fledging success. This finding indicates that chick growth rate is either not a useful measure to assess recovery of oystercatchers, or oystercatchers have recovered with respect to this metric. Indeed, many aspects of oystercatcher reproduction suggest that their populations are no longer affected by the *Exxon Valdez* oil spill (Andres 1997, 1998a). The outstanding questions involve differential pair occupancy and productivity between oiled areas of Prince William Sound. The proposed study will address these factors and will answer the question of unknown recovery status for black oystercatchers.

C. Location

The study will be conducted along shorelines in Prince William Sound. Specifically, effort will be focused on: 1) the Knight Island Archipelago, 2) the vicinity of Green Island, and 3) Montague Island (around Port Chalmers). Areas sampled in 1999 were surveyed by the principal investigator from 1991 to 1993.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The principal investigator is willing to participate in any village or city meetings that would be appropriate. The periodic nature of the project likely limits the participation of local communities and does not require the use of local contractors.

PROJECT DESIGN

A. Objectives

1. Determine the number of black oystercatchers pairs breeding along shorelines in the vicinity of Green, Montague, and Knight Island that were surveyed during 1991-1993.

2. Assess productivity of pairs along these shorelines.

3. Determine effects of predation and food availability on productivity of pairs breeding along these shorelines.

B. Methods

1. Study Area

The study will include shorelines of: 1) the Knight Island Archipelago (Eleanor, Disk, Ingot, and Knight Island [including all small islands on the western side]), 2) Green Island (including Little Green and Channel islands), and 3) Montague Island (from southern Stockdale Harbor to 5 miles south of Port Chalmers). All areas surveyed from 1991 to 1993 (Andres 1994) will be re-surveyed in 1999.

2. Survey Methods

Four survey trips, each lasting 5 days, will be made to Prince William Sound during 1999 (beginning 17 May, 14 Jun, 5 Jul, and 26 Jul). Two-person crews will search shorelines by boat, or on foot, to determine the presence of breeding oystercatchers. All shorelines surveyed during 1991-1993 will be surveyed in 1999. For each oystercatcher detected, the location, breeding status (single, pair, pair with nest), and number of eggs or chicks will be recorded. Nests will be approached cautiously to avoid attracting aerial predators, and most nests were approached from the water to avoid attracting mammalian predators. Every nest site will be checked on each trip until its final fate is determined. Shorelines will be carefully searched for additional nesting pairs during June and early July surveys.

Foraging sites of most pairs have been delineated in previous work and prey information from the foraging area closest to the nest will be collected for every pair. Mussel and limpet densities will be determined by counting individuals $\geq$10 mm, in situ, in 2 randomly selected, circular plot (177 cm^2) placed with within the *Fucus* zone of the foraging site. Substrates of the foraging sites will be recorded as gravel (mixed sand and gravel beaches, gravel beaches) or rocky (sheltered rocky shores, exposed rocky shores, exposed wave-cut platforms). Prey information will be collected once during the May trip.

Complete surveys of the shorelines around each nest site will be made on the first July trip to determine the density of avian predators (common ravens [*Corvus corax*] and bald eagles [*Haliaeetus leucocephalus*]). Based on island size where oystercatchers are breeding, we will assign an index of access to mammalian predation (1 [low] - 3 [high]) to each nest site. All observations of mammalian predators will be recorded.

3. Analyses

Numbers of breeding pairs occupying Green, Montague, and Knight islands in 1999 will be compared to numbers occupying these sites from 1991 to 1993. Because of the small number of years (4), trajectories can only be compared qualitatively. Nevertheless, this will give an indication of whether or not pairs are recolonizing Knight Island.

The ultimate outcome of each pair's nesting effort, which resulted from either the first or second nesting attempt, will be used to determine productivity (number of young/nest). Productivity within island groups will be compared to information previously collected. Nest sites will be combined along natural boundaries (see Andres 1998b) to examine the relationship (via a GLM approach) between productivity and covariates of avian predator density, mammalian predator access, and invertebrate prey density. The number of spatially aggregated nest-site units would allow for a model that includes this number of parameters.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

All equipment, including watercraft, for this project will be provided by the U. S. Fish and Wildlife Service. Logistics schedules of this project will be timed with other U. S. Fish and Wildlife Service Projects to ensure optimal efficiency. Invariably, project reporting efforts will extend beyond FY99; the U. S. Fish and Wildlife Service is willing to provide the time beyond FY99 for the principal investigator to fully complete this project.

SCHEDULE

A. Measurable Tasks for FY 99

1 March - 16 May:	Arrange logistics for field work

17 May - 1 August:	Conduct field surveys
2 August - 30 September:	Prepare data, analyze data, write report

B. Project Milestones and Endpoints

The proposed project extends a single year and will be completed by the end of calender year 1999.

C. Completion Date

December 31, 1999.

PUBLICATIONS AND REPORTS

September 1999	Prepare report
October 15, 1999	Draft report to Oil Spill Coordinator
October 31, 1999	Draft report to peer review
December 15, 1999	Report returned to principal investigator
December 31, 1999	Final report complete

PROFESSIONAL CONFERENCES

The principal investigator will attend Trustee sponsored workshops and conferences and may present results at regional or national ornithological conferences.

NORMAL AGENCY MANAGEMENT

This project is not part of normal agency management for the U. S. Fish and Wildlife Service in Alaska. The project is being proposed to answer a specific question about a migratory bird that was negatively affected by the *Exxon Valdez* oil spill and does not incorporate ongoing Service projects. Since the Trustees first funded black oystercatcher work, the Service has contributed, and will continue to contribute, personnel hours and logistic support to ensure project completion.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Because the principal investigator communicates with numerous other investigators of other Trustee migratory bird projects, sharing of logistic expenses, and results of the project, will be easily accomplished. The principal investigator of the project has a history of providing information to other Trustee researchers.

EXPLANATION OF CHANGES TO CONTINUING PROJECTS

N/A

PROPOSED PRINCIPAL INVESTIGATORS

Dr. Brad A. Andres
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PRINCIPAL INVESTIGATOR

A. Project Leader - Brad A. Andres, Ph.D., Wildlife Biologist, GS-12

Brad A. Andres received his B.S. in Biology at the Pennsylvania State University and went on to earn a M. S. and Ph. D. in Zoology from the Ohio State University. His master's and doctoral research was completed in Alaska where he studied migrant shorebirds on the North Slope and breeding black oystercatchers in Prince William Sound. He has been employed by the Nongame Migratory Bird Management unit of the U. S. Fish and Wildlife Service in Anchorage, Alaska, since 1991. He is involved in several field projects on landbirds and shorebirds in Alaska and serves as chair of the Boreal Partners in Flight Working Group and the Alaska Shorebird Working Group. He has several published several papers on his research and monitoring findings and is currently involved with conservation planning for landbirds and shorebirds in Alaska. Below are listed oral presentations and written reports pertinent to shorebirds:

B. Scientific Accomplishments

1. Oral Presentations on Shorebirds

Andres, B. A. May, 1994. *Exxon Valdez* oil spill injury to black oystercatchers — A final note. Alaska Bird Conference, Cordova, Alas.

Andres, B. A. June, 1993. Prey-mediated habitat selection by post-breeding arctic shorebirds. American Ornithologists' Union, Fairbanks, Alas.

Andres, B. A. June, 1993. Trophic level interactions of black oystercatchers affected by the *Exxon Valdez* oil spill, American Ornithologists' Union, Fairbanks, Alas.

Andres, B. A. February 1993. Effects of the *Exxon Valdez* oil spill on black oystercatchers. Pacific Seabird Group meeting, Seattle, Wash.

Andres, B. A. November 1991. Shorebirds in the outer Colville River Delta. Alaska Bird Conference, Anchorage, Alas.

Andres, B. June, 1990. The hyperphagic race: foraging patterns of arctic shorebirds. Wilson Ornithological Society/Association of Field Ornithologists, Norton, Mass.

2. Written Reports on Shorebirds

Andres, B. A. *in review*. Effects of persistent shoreline oil on breeding success and chick growth of black oystercatchers. Auk.

Andres, B. A. *in review*. Black oystercatcher. *Exxon Valdez* Restoration Notebook Series, *Exxon Valdez* Trustees, Anchorage, Alas.

Andres, B. A. 1998. Habitat requirements of breeding black oystercatchers. J. Fld. Ornithol. (*in press*).

Andres, B. A. 1998. Effects of persistent shoreline oil on reproductive success, chick growth rates, and foraging ecology of black oystercatchers. *Exxon Valdez* Restoration Project Final Report (Restoration Project 92103C, 93035), U.S. Fish Wildl. Serv., Anchorage, Alas. 38pp.

Andres, B. A., and B. T. Browne. 1998. Spring migration of shorebirds on the Yakutat Forelands. Wilson Bull. (*in press*).

Andres, B. A. 1997. The *Exxon Valdez* oil spill disrupted the breeding of black oystercatchers. J. Wildl. Manage. 61:1322-1328.

Andres, B. A. 1996. Consequences of the *Exxon Valdez* oil spill on black oystercatchers inhabiting Prince William Sound, Alaska. Ph.D. Diss., Ohio State Univ., Columbus. 98pp.

Earnst, S. L., and B. A. Andres. 1996. Population trends of breeding birds of Ohio. Ohio Biol. Surv. Misc. Contrib. No. 3. 125pp.

Andres, B. A., and G. A. Falxa. 1995. Black oystercatcher (*Haematopus bachmani*). *In* The Birds of North America (A. Poole and F. Gill, Eds.). Philadelphia: Academy of Natural Sciences; Washington, D. C.: The American Ornithologists' Union. 20pp.

Andres, B. A. 1994. Coastal zone use by postbreeding shorebirds in northern Alaska. J. Wildl. Manage. 58:206-213.

Andres, B. A. 1994. The effects of the *Exxon Valdez* oil spill on black oystercatchers breeding in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Bird Study No. 12/Restoration Study No. 17), U.S. Fish Wildl. Serv., Anchorage, Alas. 26pp.

Andres, B. 1989. Littoral zone use by post-breeding shorebirds on the Colville River delta, Alaska. M.Sc. Thesis, Ohio State Univ., Columbus. 116 pp.

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Ainley, D. G., C. R. Grau, T. E. Roudybush, S. H. Morrell, and J. M. Utts. 1981. Petroleum ingestion reduces reproduction in Cassin's Auklets. Mar. Poll. Bull. 12:314-317.

Andres, B. A. 1998a. Effects of persistent shoreline oil on reproductive success, chick growth rates, and foraging ecology of black oystercatchers. *Exxon Valdez* Oil Spill Sate/Federal Restoration Project Final Report (Restoration Project 92103C, 93035), U.S. Fish Wildl. Serv., Anchorage, Alas. 38pp.

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Boersma, P. D., E. M. Davies and W. V. Reid. 1988. Weathered crude oil effects on chicks of fork-tailed storm-petrels. Arch. Environ. Contam. Toxicol. 17:527-531.

Butler, R. G. and P. Lukasiewicz. 1979. A field study of the effect of crude oil on herring gull (*Larus argentatus*) chick growth. Auk 96:809-812.

Butler, R. G., D. B. Peakall, F. A. Leighton, J. Borthwick, and R. S. Harmon. 1986. Effects of crude oil exposure on standard metabolic rate of Leach's Storm-Petrels. Condor 88:248-249.

Butler, R. G., A. Harfenist, F. A. Leighton, D. B. Peakall. 1988. Impact of sublethal oil and emulsion exposure on the reproductive success of Leach's Storm-Petrels: short and long-term effects. J. Appl. Ecol. 25:125-143.

Day, R. H., S. M. Murphy, J. A. Wiens, G. D. Hayward, E. J. Harner, and L. N. Smith. 1997. Effects of the *Exxon Valdez* oil spill on habitat use by birds in Prince William Sound, Alaska. Ecol. Appl. 7:593-613.

Fry, D. M., J. Swenson, L. A. Addiego, C. R. Grau, and A. Kang. 1986. Reduced reproduction of Wedge-tailed Shearwaters exposed to weathered Santa Barbara crude oil. Arch. Environ. Contam. Toxicol. 15:453-463.

Isleib, M. E., and B. Kessel. 1973. Birds of the North Gulf Coast - Prince William Sound Region, Alaska. Biol. Papers Univ. Alaska, No. 14, Fairbanks. 149pp.

Klosiewski, S. P. and K. K. Laing. 1994. Marine bird populations of Prince William Sound, Alaska, before and after the *Exxon Valdez* oil spill. *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Bird Study No. 2), U.S. Fish Wildl. Serv., Anchorage, Alas.

Murphy, S. M., R. H. Day, J. A. Wiens, K. R. Parker. 1997. Effects of the *Exxon Valdez* oil spill on birds: comparisons of pre- and post-spill surveys in Prince William Sound, Alaska. Condor 99:299-313.

Trivelpiece, W. Z., R. G. Butler, D. S. Miller, and D. B. Peakall. 1984. Reduced survival of chicks of oil-dosed adult Leach's Storm-Petrels. Condor 86:81-82.

Wiens, J. A. 1995. Recovery of seabirds following the *Exxon Valdez* oil spill: an overview. Pp. 854-893 *in* P. G. Wells, J. N. Butler, and J. S. Hughes, eds. ASTM STP 1219. Am. Soc. Testing Materials, Philadelphia, Pa.

Wiens, J. A., T. O. Crist, R. H. Day, S. M. Murphy, and G. D. Hayward. 1996. Effects of the *Exxon Valdez* oil spill on marine bird communities in Prince William Sound, Alaska. Ecol. Appl. 6:828-841.

FY 99 EXXON VALDEZ TRU[illegible] COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$21.7						
Travel		$1.8						
Contractual		$3.0						
Commodities		$2.6						
Equipment		$3.5	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$32.6		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration		$3.5						
Project Total	$0.0	$36.1						
Full-time Equivalents (FTE)		0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: One month of PI salary for data analysis and report writing. Additional costs incurred outside of FY99 for report writing/revision or for presentation will be provided by FWS (about $5.0). This project will use $80.0 of FWS equipment to accomplish objectives.

FY 99

Prepared: 14 April 1998

Project Number: 99480
Project Title: Black Oystercatchers
Agency: DOI-FWS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRU[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
B. Andres	Wildlife Biologist	GS-12-03	2.5	5.7		14.3
P. Cotter	Wildlife Biologist	GS-9-01	2.0	3.7		7.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.5	9.4	0.0	
					Personnel Total	$21.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Anchorage to Whittier to transport boat	1.0	1			1.0
Anchorage to Whittier - personnel	0.1	4			0.4
Whittier per diem			4	0.1	0.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.8

FY 99

Prepared: 14 April 1998

Project Number:
Project Title: Black Oystercatchers
Agency: DOI-FWS

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRU[...]. COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs: Description	Proposed FY 1999
Maintenance and repair of 25' boat and 14' inflatable	2.0
Delivery of equipment and fuel to field site (split with other FWS projects)	1.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$3.0

Commodities Costs: Description	Proposed FY 1999
Food for 2 people for 20 days @ $15/person/day	0.6
Gas and oil for inflatable and 25' boat - 250 gal/trip, 4 trips @ $1.50/gal	1.5
Raingear and boots for 2 people	0.5
Commodities Total	$2.6

FY 99

Prepared:

Project Number:
Project Title: Black Oystercatchers
Agency: DOI-FWS

FORM 3B
Contractual &
Commodities
DETAIL

FY 99 EXXON VALDEZ TRU[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
35 hp outboard motor	1	3.5	3.5
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$3.5

Existing Equipment Usage: Description	Number of Units	Inventory Agency
25' Boston Whaler	1	FWS
14' inflatable and motor	1	FWS
tents, binoculars, and other camp equipment	2	FWS

FY 99

Prepared: 14 April 1998

Project Number:
Project Title: Black Oystercatchers
Agency: DOI-FWS

FORM 3B
Equipment
DETAIL

99483

Seldovia Village Tribe

P.O. Drawer L
Seldovia, Alaska 99663
(907) 234-7898 Fax: (907) 234-7637

Number: 99483

Title: **Seldovia Coho Salmon Enhancement**

Geographic Area: **Seldovia Bay**

Subsistence, commercial and sport fisheries were severely disrupted by the oil spill. This project is intended to enhance subsistence resources by permitted releases of coho salmon at designated locations near Seldovia in order to provide a long term subsistence resource for the residents of Seldovia.

Subsistence harvests of all salmon resources have declined considerably since the oil spill and continue to be affected by it. This project would enhance the recovery of the salmon resources and provide a means of lessening the impacts of other subsistence resources injured by the spill.

Objective would provide for the purchase of coho salmon smolt from an Alaskan hatchery. Smolt transported to Seldovia and held and feed in net pens at the release site for two weeks prior to release.

Requesting technical assistance

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

99484

Project 99484

CHIGNIK LAKE VILLAGE COUNCIL
EXXON VALDEZ OIL SPILL PROPOSAL
FY '98
BUDGET

EXTENDED BUILDING		$282.364.00
Add on to Subsistance Building	$250.000.00	
Labor Construction		
$18/hr x 288/hrs x 6/people	$ 31,104.00	
$ 75/day x 2/days x 2/trucks	$ 300.00	
$ 15/hr x 16/hrs x 4/people	$ 960.00	
ALEUT SOD HOUSE REPAIR		$ 40,000.00
fence around sod house	$ 5,000.00	
banyou (steam bath)	$ 10,000.00	
cache	$ 1,500.00	
double ender(skiff)	$ 7,000.00	
kyak	$ 5,000.00	
molded dogs w/sled	$ 10,000.00	
fish rack	$ 1,500.00	
	GRAND TOTAL	**$322,364.00**

Requesting technical assistance

contact: Virginia Aleck

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

99485

Port Graham Youth Subsistence Education Project

Project Number:	99485
Restoration Category:	Subsistence
Proposer:	Port Graham Village Council
Lead Trustee Agency:	DOI
Cooperating Agencies:	None
SeaLife Center:	No
New or Continued:	New
Duration:	1st year of 2 year project
Cost FY 99:	$10,000
Cost FY 00:	$10,000
Geographic Area:	Port Graham
Injured Resource/Service:	Subsistence

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

This project will assist in a summer education program aimed at the revitalization of subsistence in Port Graham. Three groups of youth, teens, pre-teens, and elementary aged children will be involved in a week-long course teaching life skills with regard to subsistence. These subjects will include conservation of resources, hunting and gathering techniques, survival skills in the wilderness, safety in outdoors activities, and traditional knowledge regarding gathering. The program would take place on the lower Cook Inlet, in the vicinity of Port Graham.

EVOS funds would assist in bringing specialized speakers to the program to talk about kayak safety and life skills, as well as other aspects of subsistence. Additionally, the funds would go toward the acquisition of supplies needed to have the week-long education program, such as camping gear, cooking gear, educational supplies, and other miscellaneous items. Port Graham Village Council would obtain the other needed funding from other sources.

INTRODUCTION

The Exxon Valdez oil spill caused a severe disruption in the passing of subsistence knowledge to the current generation of children. Because of fear of contamination, lack of resources, and other local concerns, residents have depended on store bought foods more often and entrenched the current dilemma of the failure of this generation to learn their traditional methods of harvesting sustenance . The elders of the community have long recognized this problems and have decided to begin the revitalization of subsistence knowledge to the youth.

The village council has held similar programs like these in past summers, but because of budget constraints, could not fully accomplish their goals. For the summer of 1999, the village council is planning an extensive week-long program for local youth, with two to three follow-up weekend sessions. In order to fulfill at the objectives of the program, the Port Graham Village Council is seeking modest funding support for the program from the *Exxon Valdez* Oil Spill Trustee Council for two years.

NEED FOR THE PROJECT

A. Statement of Problem

As previously mentioned, the oil spill has created a lapse of passing on traditional subsistence knowledge to the local youth. As time passes, resources are beginning to rebound and fear of contamination is fading. Because of the lapse in subsistence knowledge, the threat to the traditional way of life of the Alutiiq people is in jeopardy.

B. Rationale/Link to Restoration

The oil spill caused a lapse in the passing of traditional subsistence knowledge. This program intends to deter that trend and revitalize subsistence harvesting.

C. Location

This program will take place in Port Graham and it's surrounding land.

COMMUNITY INVOLVEMENT AN TRADITIONAL KNOWLEDGE

This project will be strictly managed by the village council and traditional knowledge bearers will be utilized extensively.

PROJECT DESIGN

A. Objectives

1) To revitalize the subsistence knowledge within the community of Port Graham through the education of the youth.

2) To pass on traditional knowledge from the elders to youth.

B. Methods

The program will be held during the summer of 1999. The youth will be split up into three groups, teens, pre-teens, and elementary aged children. These groups will have three separate curriculum set up to go into the field and study different aspects of subsistence harvesting, conservation, survival skills, safety in mountains, and camping skills. The week-long program will focus on different species of fish and game that have been traditionally utilized by the region. Two follow-up weekend excursions will take place as well to wrap up the knowledge previously gone over.

Additionally, the village council will hire specialists in kayak making and safety and other traditional skills to come to the workshop. The EVOS funding would help for transportation costs, per diem, pay, and equipment and supplies needed. It would also go toward the purchase of outdoor equipment. This would include tents, cooking gear, binoculars, and other items.

Item	**Unit(s)**	**Unit $**	**Total**
Outdoor equipment	20	$250	$5000
Guest presenters	5	$750	$3750
Supplies (paper, etc.)	1	$1250	$1250
Total	26	$2250	$10,000

C. Cooperating Agencies, Contracts, and Other Agency Assistance

None

SCHEDULE

A. Measurable Project Tasks for FY 99

January 1999 - May 1999	Work on curriculum, fundraising, and other aspects
June 1999	Set dates for programs
June 1999 - September 1999	Complete program
October 1999	Final report to Trustee Council

B. Project Milestones

See above

C. Completion Date

September 1999

PUBLICATIONS, AND REPORTS, PROFESSIONAL CONFERENCES

Only the Trustee Council final report.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

None

PROPOSED PRINCIPAL INVESTIGATOR

Elenore McMullen, First Chief
Port Graham Village Council
P.O. Box 5572
Port Graham, AK 99603

1998 EXXON VALDEZ TRUS[hole punch]COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998						
Personnel		$0.0						
Travel		$0.0						
Contractual		$10.0						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$10.0		Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
General Administration		$0.7						
Project Total	$0.0	$10.7		$10.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1999

Prepared: 4-14-98

Project Number: 99485
Project Title: Port Graham Youth Subsistence Project
Name: DOI

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
						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 1998
					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

1999

Prepared: 4-14-98

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: DOI

FORM 3B
Personnel
& Travel
DETAIL

1998 EXXON VALDEZ TRUST[hole punch]OUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1998
Contract with Port Graham Village Council	10.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$10.0

Commodities Costs:	Proposed
Description	FY 1998
Commodities Total	$0.0

1999

Prepared: 4-14-98

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: DOI

FORM 3B
Contractual &
Commodities
DETAIL

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			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: Description	Number of Units	Inventory Agency

1999

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: DOI

FORM 3B
Equipment
DETAIL

Prepared: 4-14-98

/98

1998 EXXON VALDEZ TRUS[…] COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998						
Personnel		$0.0						
Travel		$2.5						
Contractual		$1.3						
Commodities		$1.3						
Equipment		$5.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$10.1		Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
Indirect		$0.0						
Project Total	$0.0	$10.1		$10.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1999

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: Port Graham Village Council

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4-14-98

4/15/98

Personnel Costs:

Name	Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1998
					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:

Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1998
Unknown - Port Graham	0.5	5			2.5
				Travel Total	$2.5

1999

Prepared: 4-14-98

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: Port Graham Village Council

FORM 4B
Personnel
& Travel
DETAIL

[illegible]5/98

Contractual Costs:	Proposed FY 1998
Port Graham Village Council will contract 5 presenters	1.3
Contractual Total	$1.3

Commodities Costs: Description	Proposed FY 1998
Telephone, paper, coincidentals	1.3
Commodities Total	$1.3

1999

Prepared: 4-14-98

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: Port Graham Village Council

FORM 4B
Contractual &
Commodities
DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
Outdoor equipment	20	0.3	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: Description	Number of Units	

1999

Project Number:
Project Title: Port Graham Youth Subsistence Project
Name: Port Graham Village Council

FORM 4B
Equipment
DETAIL

A Computerized *C*olony, *E*nvironment and *S*eabirds-at-*S*ea Database *(ACCESS)*

Project Number:	99 488
Restoration Category:	Research (new)
Proposed By:	USGS
Lead Trustee Agency:	DOI
Cooperating Agencies:	N/A
Alaska SeaLife Center:	NO
Duration:	1st year, 3-year project
Cost FY 99:	$116,320
Cost FY 00:	$116,320
Cost FY 01:	$90,000
Cost FY 02:	$0
Geographic area:	Gulf of Alaska, North Pacific
Injured resource:	Seabirds

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

A number of large databases, yet to be synthesized, contain detailed information on the pelagic distribution of seabirds in Alaska. If compiled into A Computerized Colony, Environment, and Seabirds-At-Sea (*ACCESS*) database, this information could be used to monitor recovery of seabirds from oil spills, assess impacts of commercial fisheries on marine birds, monitor long-term changes in marine ecosystems, plan and manage marine reserves, model and predict the impact of future oil spills on seabird colony populations, and estimate population sizes of rare or threatened species. A directed effort is required to complete a database archive and retrieval system that can be easily accessed by specialists or non-expert user groups. EVOS Trustee funded pelagic seabird data should be archived in *ACCESS*.

INTRODUCTION

A number of large databases, yet to be synthesized, contain detailed information on the pelagic distribution of seabirds in Alaska and elsewhere in the North Pacific. A preliminary subset of this data was used to assess the immediate impact of the *Exxon Valdez* oil spill on marine birds (Piatt & Lensink 1989, Piatt et al. 1990, Ford et al. 1995) by overlaying the trajectory of the spill on known densities of birds at sea. Computerized data of seabird abundance and distribution can also be used to assess recovery of populations from oil spill impacts (Klosiewski and Laing 1994), monitor impacts of commercial fisheries on marine birds, assess long-term changes in marine ecosystems (Piatt & Anderson 1996), plan and manage marine reserves (e.g., Pribilof Islands, Glacier Bay National Park, Beringia International Park and Preserve), identify large-scale features of marine ecosystems (e.g., areas of high production, water mass boundaries; Elphick & Hunt 1993), model and predict the impact of oil pollution on seabird colony populations (Ford et al. 1982, 1987), estimate population sizes of rare or threatened species that are difficult or impossible to census using traditional methods (Piatt & Ford 1993), examine seasonal movements and habitat use by seabirds (Piatt & Naslund 1995), and finally, as a tool for disseminating natural history information to the general public, educators, and the tourism industry.

NEED FOR THE PROJECT

A. Statement of the Problem

Nearly 10 years after the *Exxon Valdez* oil spill, we still do not have an easily accessible, uniform database of seabirds at sea in Alaska (or anywhere else on the west coast except California-- see Ford 1995). Limited progress has been made in compiling various data sets, but a directed effort, with committed funds, is required to complete a database archive and retrieval system that can be easily accessed by specialists or non-expert user groups. The original cost of obtaining and digitizing these data (ship and aircraft time, person-years) easily approaches 100 million dollars. The total funds committed to archiving and analyzing these data during the past 15 years has been virtually nil. While several EVOS Trustee sponsored projects and a number of agencies and universities continue to collect pelagic seabird data in Alaska, we still do not have an archiving and analysis system to effectively manage the data we have.

The need for comprehensive geographic data on the pelagic and colony distribution of seabirds in Alaska has long been recognized. During the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the 1970's, unprecedented efforts were undertaken to gather and assimilate these data. Additional data were routinely collected on environmental conditions at sea (e.g., weather, temperature, salinity), and on marine mammals. This work culminated in two atlases which are still widely used today by researchers and management agencies around the world (despite being woefully out of date). The "Catalog of Alaskan Seabird Colonies" (Sowls et al. 1978) documented the distribution and species composition of all seabird colonies in Alaska. Shortly thereafter, Gould et al. (1982) published the atlas of "Pelagic Distribution and Abundance of Seabirds in the Gulf of Alaska and Eastern Bering Sea" which documented the at-sea distribution and abundance of 16 common seabird species in one degree latitude-longitude blocks. In addition to this landmark work, reports by other key investigators (e.g., Hunt et al. 1981) laid the foundation for our understanding of the pelagic biology and distribution of seabirds in Alaska.
Since these atlases were produced, a considerable amount of new data has been collected on the

pelagic distribution of seabirds in Alaska and the North Central Pacific (e.g., Hunt & Harrison 1990, Piatt et al. 1991, 1993, 1997; Schauer 1992, Elphick & Hunt 1993, Hunt et al. 1993, Gould & Piatt 1993, Klosiewski & Laing 1994). The USFWS maintains and updates a detailed colony database for Alaska and Russia. Population estimates for all colonies can be readily included in *ACCESS* (which will not duplicate the FWS database, but rather will just use most recent point estimates of colony sizes to place on GIS maps of seabird distribution at sea).

B. Rationale/Link to Restoration

The impetus behind the collection of data on seabirds at sea during the OCSEAP years was that these data would be critical in planning for oil and gas development on the continental shelf, and invaluable for assessing impacts of oil pollution. In more recent years, the EVOS Trustees have invested considerable effort in assessing the damage and recovery of seabirds in Prince William Sound by comparing pelagic densities observed on annual censuses conducted after the spill with densities observed prior to the spill. These include extensive damage assessment surveys (e.g., Klosiewski and Laing 1994), and recovery surveys (Restoration Projects 102, 142-BAA, 159, and several subprojects in 163).

To date, none of these various datasets have been archived or made readily accessible to anyone other than expert users or to the specific scientists who collected the data. We propose to combine all available datasets into a single, uniform, digital catalog that can be accessed and used for many purposes by experts and non-experts alike. Once compiled, data collected in the future can easily be added to *ACCESS* and the database can be maintained at relatively low cost.

C. Location

The project largely involves the compilation and synthesis of existing databases. No special facilities or equipment are required beyond those found in a normal office environment. Databases will be archived and distributed on CD-ROM disks, which will be produced at the offices of R.G. Ford Consulting Co. (Portland OR). The Alaska Biological Sciences Center (ABSC) and Migratory Bird Management, USFWS, are located in the same building in Anchorage, which will facilitate compilation of their datasets. The ABSC has its own server, and data/metadata will be made available through our WWWeb site.

COMMUNITY INVOLVEMENT

None required.

PROJECT DESIGN

A. Objectives

The overall objective is to compile all available datasets on the distribution of seabirds at sea into one accessible database. This will be done in phases:

1. Gather existing digital datasets on seabirds at sea, including environmental data and colony population estimates. Proof for accuracy.

2. Locate and compile non-digital datasets, and get those keypunched for addition to the final database. Check for errors, and proof for accuracy.

3. Transform all existing datasets into a uniform format (we propose to use the original OCSEAP format). Proof for correct transformation.

4. Compile uniform datasets into one database. Proof for accuracy and compatibility by all contributors to the database. This product is the final archive database.

5. Develop a program for filtering the archive database (e.g., by year, location, investigator, etc.) and outputting sub-datasets for use in GIS mapping or statistical analyses.

6. Publish a CD-ROM disk of archived data and filtering software (with accompanying user manual) and distribute to all interested users.

7. Develop a web-site interface for online query and mapping of seabird distribution, colony and environmental data.

8. Publish a hard-copy atlas of pelagic seabird distribution in Alaska and the North Pacific (funded by sources other than the EVOS Trustee Council).

B. Methods

We will compile a data archive and develop a computerized GIS mapping system for analyzing and displaying pelagic seabird data in Alaska and other areas of the North Pacific. The original atlas by Gould et al. (1982) included about 5,500 shipboard and 1,900 aerial transects conducted in Alaska mostly between 1976 and 1981. We need to re-compile these original data, adopt a standard database format (the original OCSEAP format), and integrate more recent databases from agency and private sources (including tens of thousands more transects in the Aleutians, Bering Sea, Chukchi Sea, Cook Inlet, Prince William Sound, Southeast Alaska, and North Central Pacific Ocean). Some of these data are already accessible for expert use (e.g., Piatt & Ford 1995). At present, the major technical task is to format all the different databases into a common archive format, proof these databases, and develop some programs for adding future data into the database (at present, most seabird researchers in Alaska are using a common data entry program [called DLOG] developed by R.G. Ford Consulting Co.).

Over the last four decades, bird survey data collected in Alaskan waters have been stored in a variety of formats and on a variety of media. Some of these data remain on paper data forms, but most have been entered into various computer systems. Much of the earlier data was archived on 9 track tapes written by UNIX or DEC operating systems and were stored without accompanying documentation relating to the tape structure. We have considerable experience in reading and interpreting these tapes, and so far have encountered little difficulty importing files to newer media. More recent data exist on a variety of PC based media such as floppy disks, tape cassettes, Bernoulli cartridges, and ZIP drives.

Over the years, a number of different data structures have been implemented by seabird researchers. Initially, the most common structure was that developed by the National Oceanic Data Center (NODC). This format was based on punched cards as input, and was designed around a hierarchical sequence of 80 byte records. For each transect, there existed a header card and a number of optional cards describing the source of the data, the methodology of data collection, and environmental conditions. These were followed by a variable number of records describing observations of birds seen during the transect. After the OCSEAP program ended, users abandoned this hierarchical format in favor of a flat format in which every record had the same set of fields, usually a subset of the original NODC fields. Flat files were bulkier but much more compatible with standard data analysis software than the original hierarchical arrangement. More recently, researchers have taken to entering data directly into database programs such as FOXPRO, EXCEL, PARADOX or ORACLE.

In the overwhelming majority of cases, researchers collected data using similar field techniques so that the data are directly comparable and can potentially be stored and accessed using the same software for all data sets. But before a common interface can be constructed, all the data sets must be placed in a common format. This process is time consuming because of the different media and storage formats. In some cases, as with FOXPRO files, the conversion is straightforward; in other cases it is necessary to write simple programs to carry out the conversion. We have carried out this process with many similar datasets and do not expect difficulties with these new data.

Once data are stored in a common format, we will construct an interface that will allow users to access and view subsets of the database using logical masks for date, geographic area, species, etc. Users will be able to view the data as observations, isopleths of density, or as rectangular blocks scaled for density. Data subsets will be exportable as ASCII, DBASE, or EXCEL type files. Geographic objects such as isopleths of density or grids will be exportable in ASCII or ArcView compatible formats. The interface will be similar to one written for MMS to access seabird and marine mammal data in California, however the code will be updated from FORTRAN 77 running under DOS to FORTRAN 90 code running under Windows 95.

Once all survey data are archived in a common format and the interface software is completed, a manual for use of the filtering software and generation of specific data sets will be compiled. Ultimately, the entire database and filtering software will be made available on CD-ROM. For now, we will focus on data from the Gulf of Alaska (including Prince William Sound and Cook Inlet) and Bering Sea. With additional funding in the future, we would like to include available data sets for Russia, British Columbia, Washington, Oregon, California (compiled, Ford 1995), and the North Central Pacific (partly compiled). R.G. Ford Consulting Co. (see below) has recently been awarded a contract from MMS to compile all data for Oregon and Washington.

Intended uses for the database include EVOS Trustee supported scientists, the U.S. Fish and Wildlife Service, National Park Service, U.S. Geological Survey, Minerals Management Service, University of Alaska, Prince William Sound Science Center, outside universities, private consultants, and the general public. In the first phase of the project, we anticipate producing a CD-ROM which will contain all the archived data as well as software for filtering data for the specific needs of users. This will be distributed to DOI resource and land management agencies, other Federal agencies, state and local governments, universities, and non-federal organizations. Information about ACCESS will be entered into various meta-databases (eg., NOAA Bering Sea Meta-database, BRD Prince William Sound Meta-database, Exxon Valdez Oil Spill Trustee Meta-database, and the BRD NBII Metadata Clearinghouse). During the last phase of the project we will develop software for an interactive program which will allow users to access and analyze data through the Alaska Biological Sciences Center WWWeb site. In the final phase of the project, we will publish a high-quality catalog to include maps of the pelagic distribution of seabirds in Alaska and the North Pacific, with details about the marine ecology of selected species. This last product will entail a collaborative effort with contributers to the database, and we will locate sources of funding other than the EVOS Trustees to publish the hard-copy atlas.

C. Cooperating Agencies, Contracts and Other Agency Assistance

A contract will be established with R.G. Ford Consulting Co. (Portland OR) to accomplish many of the objectives identified above.

Collaboration for this project has already taken place. Databases current to 1994-1996 have been, or can be, provided by the USFWS (Alaska Maritime National Wildlife Refuge, Kodiak National Wildlife Refuge, Migratory Bird Management), the National Oceanographic Data Center (Washington D.C.) and from various universities (notably, Univ. California, Irvine). Further collaboration will occur with respect to analyses of data, and production of a data archive and web site. We are attempting to find other partners willing to help fund this project. We anticipate that if EVOS Trustee funding is secured, we will be able to attract other participants to leverage the project over the full term required (FY99-01). At present, the following partners are providing technical assistance and in-kind contributions of time and data:

G. Vernon Byrd, USFWS, Alaska Maritime National Wildlife Refuge, 2355 Kachemak Bay Drive, Homer AK 99603, (907) 235-6546, FAX 235-7783, vernon_byrd@fws.gov

Dr. George L. Hunt, Jr., Dept. of Ecol. and Evol. Biology, University of California, Irvine, CA 92717, (714) 497-1914, FAX 725-2181, glhunt@uci.edu

Dr. David Irons, USFWS, Migratory Bird Management, Marine and Coastal Bird Project, 1011 E. Tudor Rd, Anchorage, AK 99503, (907) 786-3376, david_irons@fws.gov

SCHEDULE

A. Project Tasks for FY 99 (October 1, 1999 - September 30, 1999)

We propose to completer objectives 1-3 in the first year.

October 30	Establish Contract with R.G. Ford Consulting Co.
May 30	Gather and proof available digital pelagic seabird databases. Keypunch and verify non-digital datasets.
September 30	All datasets transformed into common format files.

B. Project Milestones and Endpoints

All available dataset will be gathered, proofed and formatted for compilation into a common database by September 30, 2000.

C. Completion Date

Objectives 1-3 will be completed in FY99, objectives 4-5 in FY00, and objectives 6-7 in FY01. The final product for the EVOS Trustees will be a CD-ROM and user manual, which will be published and distributed in FY01.

PUBLICATIONS AND REPORTS

Annual reports will consist of progress reports on the status of the database, detailing which datasets have been obtained, proofed, and converted for use in the final database, with examples showing the range of data from each dataset. The final report will consist of the CD-ROM product. We anticipate producing a color atlas of seabird distribution in Alaska and North Pacific in collaboration with major contributors, but we will seek independent sources of funding for this product.

PROFESSIONAL CONFERENCES

We do not anticipate a need to attend any conferences in order to develop *ACCESS*.

NORMAL AGENCY MANAGEMENT

One might be tempted to conclude that the development of a pelagic seabird database and atlas would be within the normal scope of agency activity (e.g., the USFWS or USGS). In fact, we have argued repeatedly that it *should* be, and over the past 10 years we have attempted to obtain funding for this project from a number of agencies (e.g., USFWS, USGS, NOAA, MMS). However, neither the USFWS or USGS (and its previous incarnations as USFWS and NBS) have ever been convinced that any obligation exists with regard to such data beyond the analysis required for individually funded projects; and indeed, no obligation exists by statute or regulation. Data collected by agencies during the OCSEAP years (1976-1980) were required by regulation to be archived in approved formats, but no such requirements have existed since that time. The wisdom of that requirement is evident today: Anyone interested in data collected under the OCSEAP program can call the NODC in Washington D.C. *today* and have the original archived data within a week (we did this).

This leaves us with the current state of affairs, where we have many different datasets developed on different projects— all of which are in the hands of agency or university scientists, but otherwise inaccessible (e.g., *all* the EVOS funded survey data from PWS and the Gulf of Alaska; *all* surveys conducted for murrelets in PWS, SE Alaska, and Cook Inlet by MBM and Ecological Services of the USFWS; *all* surveys conducted by NBS/USGS in Cook Inlet and the Gulf of Alaska and funded by MMS and the EVOS Trustees from 1988-1997; *all* surveys conducted annually in the Kodiak Archipelago by the Kodiak National Wildlife Refuge from 1982-1997; etc.). As time passes and individual scientists from these agencies move on to other jobs or retire, these data will become increasingly difficult to obtain.

Why should the Trustee Council be the source of funds for this project? Because no agency has come forward to do the job, and *the Trustee Council has a vested interest in seeing that data collected for damage assessment and recovery studies are properly archived and accessible to future investigators*. The fact that data from non-EVOS Trustee funded studies (e.g., in the Gulf of Alaska) would also be archived in the database is also demonstrably beneficial to EVOS Trustee interests.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Coordination with other EVOS Trustee funded seabird projects is already ongoing in some cases, and will be developed in others. For example, we have already obtained raw data files of pelagic surveys conducted by MBM (from Dave Irons) in Prince William Sound between 1989 and 1995. Conversely, we provided Irons with 'lost' data from surveys he conducted in PWS during the 1980's after retrieving it from a FWS database obtained from old Data General tapes held in storage at FWS in Anchorage. We will coordinate with all other Trustee investigators (e.g., Kathy Kultez, Bob Day, Bill Ostrand, Steve Klosiewski, etc.) to obtain, format and compile all existing datasets.

PRINCIPAL INVESTIGATORS

Dr. John F. Piatt, Biological Resources Division, USGS, Alaska Biological Science Center, 1011 E. Tudor Rd., Anchorage, AK 99503. (john_piatt@usgs.gov). Dr. Piatt obtained his Ph.D. in Marine Biology at Memorial University of Newfoundland, and has 20 years experience in the North Atlantic and Pacific oceans conducting research on the pelagic ecology of seabirds. He is past Chairman of the Pacific Seabird Group, and has authored over 60 peer-reviewed publications on seabirds, fish, marine mammals, oil pollution, and marine ecology. Since 1987, he has studied seabirds at colonies and at sea in the Gulf of Alaska, Aleutians, Bering and Chukchi Seas, and in the North Central Pacific. He will contribute more than 5000 transects and oceanographic data to *ACCESS*, collected between 1988 and 1997 in the North Pacific, and including transects conducted in Cook Inlet with funding from MMS and the EVOS Trustees.

Dr. Glenn Ford, Ecological Consulting Inc., 2735 N.E. Weidler St., Portland, OR 97232. (eci@teleport.com). Dr. Ford was trained in mathematical ecology at University of California, Berkeley, and did post-graduate work in the laboratories of Drs. John Wiens at Oregon State University and George Hunt at the University of California, Irvine. His company, R.G. Ford Consulting Co., specializes in computer mapping of natural resources and analyses of risks of oil spills. As a member of the Unocal EIR team led by Chambers Group, Dr. Ford conducted analyses of oil spill risk to resources from tanker traffic in San Francisco Bay and off the northern California coast. He has conducted similar analyses for the central California coast for the U.S. Coast Guard, and has developed a rapid, computer-based oil spill contingency plan and emergency response system for marine sanctuaries around the California Channel Islands and Florida Keys (Marine and Estuarine Management Division, NOAA). He has conducted studies and analyses under contract with the Minerals Management Service, the U. S. Fish and Wildlife Service, the National Marine Sanctuary Program (NOAA), the U. S. Coast Guard, the U. S. Department of Justice, State governments in California, Washington, and New Jersey, the National Audubon Society, The Nature Conservancy, World Wildlife Fund, the Oil and Gas Industry, Oil Spill Clean-up Cooperatives, and Public Utilities.

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1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$41,868.0						
Travel		$5,460.0						
Contractual		$60,000.0						
Commodities		$1,500.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$108,828.0		Estimated FY 2000	Estimated FY 2001	Estimated FY 2001		
General Administration	$0.0	$7,492.7						
Project Total	$0.0	$116,320.7		$116,320.0	$90,000.0	$0.0		
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

1999

Prepared: 1 of 4

Project Number: 99488
Project Title: A Computerized Colony, Environment and Seabirds-At Sea Database (ACCESS)
Agency: USGS (BRD)

FORM 3A TRUSTEE AGENCY SUMMARY

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
Piatt	Research Biologist	GS-13	0.5	6456.0		3,228.0
Vacant	Wildlife Biotech/ Programmer	GS-7/9	12.0	3220.0		38,640.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.5	9676.0	0.0	
					Personnel Total	$41,868.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
RT Portland - Anchorage (Ford)	620.0	2	6	130.0	2,020.0
RT Anchorage - Portland (Biotech)	620.0	2	20	110.0	3,440.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$5,460.0

1999

Prepared: 2 of 4

Project Number: 99___
Project Title: A Computerized Colony, Environment and Seabirds-At Sea Database (ACCESS)
Agency: USGS (BRD)

FORM 3B
Personnel
& Travel
DETAIL

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs: Description	Proposed FY 1999
Contract with R.G. Ford Consulting Co. (includes costs for subcontracting for data entry- 20 K)	60,000.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$60,000.0

Commodities Costs: Description	Proposed FY 1998
Misc. computer supplies (storage media, software, etc.)	1,500.0
Commodities Total	$1,500.0

1999

Project Number: 99___
Project Title: A Computerized Colony, Environment and Seabirds-At Sea Database (ACCESS)
Agency: USGS (BRD)

FORM 3B
Contractual &
Commodities
DETAIL

Prepared:

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
None			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: Description	Number of Units	Inventory Agency
Computer facilities at USGS and R.G. Ford Consulting		

1999

Prepared: 4 of 4

Project Number: 99___
Project Title: A Computerized Colony, Environment and Seabirds-At Sea Database (ACCESS)
Agency: USGS (BRD)

FORM 3B
Equipment
DETAIL

4/15/98

99489

Crude Oil Exposure Effects on Salmon Smolts

Project Number:	99~~xxx~~ 489
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	yes
Duration:	1st year, 5-year project
Cost FY 99:	$98,900
Cost FY 00:	$113,400
Cost FY 01:	$114,800
Cost FY 02:	$111,200
Geographic Area:	Resurrection Bay
Injured Resource/Service:	Salmon

ABSTRACT

Crude oil exposure has previously been shown to alter thyroid hormone levels differently in fish, depending on the species and developmental stage. We will determine to what extent exposure to crude oil affects neural and endocrine systems during and after smoltification. The normal changes in these systems are vital for survival in the sea and return to natal stream. These studies will provide information regarding the impact, if any, of crude oil exposure on salmon during this critical period of development, which may explain survival and return-rate problems following the *Exxon Valdez* oil spill.

INTRODUCTION

In 1989, the *Exxon Valdez* oil spill affected many species in streams and coastal waters. Salmon were exposed to crude oil at critical periods of development. We know that pink salmon embryo mortalities increased in oiled streams following the spill and that these elevated rates of mortality persisted through the 1993 field season. To what extent such exposure at the smolt stage affects future development, survival and migration is not known. The proposed work will partially answer this question. We know that exposure to crude oil significantly alters neurotransmitter concentrations in the brain of coho smolts (Ebbesson et al., unpublished, see below), but effects on survival and migration are not known. The fish ladder at the Alaska Sealife Center (ASLC) will be used to answer this question. Other experiments will elucidate brain responses to crude oil exposure. These studies will complement other ongoing studies funded by the EVOS Trustee Council on the effects of crude oil exposure on the egg stage and subsequent development, migration and straying.

NEED FOR THE PROJECT

A. Statement of Problem

While data on salmon embryo mortality due to crude oil exposure is known and effects on development and straying are being studied, little is known about the effects of crude oil exposure at other developmental stages. We propose to carefully examine the effect of oil exposure on salmon during and after parr–smolt transformation, which our laboratory has previously shown to be a critical period of brain development. One preliminary study of the effect of crude oil exposure on the brain chemistry of coho salmon smolts showed significant decreases in content and turnover of two neurotransmitters essential for brain development and hormone regulation, dopamine (DA) and norepinepherine (NE). The question is: does such brief exposure and alteration in brain chemistry permanently damage the brain, making marine survival and proper, nonstraying migration impossible? We will test this by briefly exposing smolts to 1 part per million of crude oil before release and determine if this affects return rate.

We also propose to repeat the neurotransmitter experiment described above before publication, and to explore further possible mechanisms of hormone and brain alterations that might explain the eventual outcomes of the migration experiments.

B. Rationale/Link to Restoration

Understanding effects of crude oil exposure on salmon hormonal and neural systems (and future survival) will greatly enhance our knowledge about crude oil toxicity. All vertebrates undergo at least one critical period of development during which the necessary neural and endocrine foundations which will dictate their subsequent fitness, growth, life strategy and survival are established (Browman 1989). In some salmonid species, parr–smolt transformation (smoltification) is one such critical period with environmentally triggered, specific, synchronized neural and endocrinological changes that stimulate physiological and behavioral changes. These changes enable the salmon to imprint on their natal stream, to migrate downstream to the ocean, to osmoregulate in saltwater, to return to their natal stream as adults, and ultimately, to reproduce successfully; all of which are essential to fulfill the life cycle of their ancestors (Hoar 1988, Chaudhuri 1994, Lam 1994). Critical periods of neural development are characterized by an increase in neural plasticity which allows connections to form and be lost depending on cellular, endocrine, physiological and environmental inputs (Ebbesson 1980, Browman 1989). Thyroid hormones are essential regulators during critical periods of development (Porterfield and Hendrich 1993, Bernal and Nunez 1995) and crude oil exposure in fish affects thyroid hormones (Alkindi et al. 1996, Stephens et al. 1997a, Stephens et al. 1997b).

The thyroid hormones thyroxine (T_4) and triiodothyronine (T_3) are known to differentially influence morphological, physiological, endocrinological, neural, and cellular mechanisms in development and in adults (Bernal and Nunez 1995, Garcia-Segura et al. 1996). For example, in salmonids, thyroxine stimulates body silvering (Hoar 1988) and the loss of retinal ultraviolet photosensitivity during smoltification (Browman and Hawryshyn 1994), whereas triiodothyronine is thought to be responsible for most of the other changes that occur during smoltification (Hoar 1988). The production of T_4 is most likely controlled by the brain, via the hypothalamus–pituitary–thyroid axis. The subsequent regulation of T_4 availability to tissues, the conversion of the less biologically active T_4 to the more active T_3 by monodeiodinase activity, and specific tissue regulation of thyroid hormone receptors are controlled by a complex endocrine feedback mechanism involving not only thyroid hormones, but also growth hormone (GH) and other factors (Hoar 1988).

The rearing environment of anadromous salmonids during smoltification includes elements such as photoperiod, water temperature, lunar cycle, and diet, all of which can have profound effects on thyroid hormone and/or GH levels (Grau et al. 1981, Björnsson et al. 1989, Björnsson et al. 1995, McCormick et al. 1995). An abnormal rearing environment, resulting in unnatural hormone levels during critical developmental stages (i.e., hatching, smoltification and seawater entry in salmon) can lead to abnormal brain development, as well as abnormal phenotypic expressions of hormone receptors and cells in the pituitary (Lloyd et al. 1990, Tam et al. 1996). These alterations can irreversibly affect future behavior, sexual maturation and the normal life cycle. The importance of "normal" hormone levels on establishing the necessary endocrine and neural foundation during smoltification in salmonids is still unknown, but the evidence available in other vertebrates should give some indication of their significance (Timiras 1988, Cooke et al. 1992, Porterfield and Hendrich 1993, Bernal and Nunez 1995). The consequences of these unnatural hormone patterns on neural and endocrine development in salmon is still unclear and therefore should be a major focus of research to ensure the future of both natural and enhanced salmon populations.

Exposure to various fractions of crude oil have previously been shown to alter thyroid hormones in fish (Stephens et al. 1997a, Stephens et al. 1997b). Stephens and co-workers (1997) demonstrated that turbot larvae exposed to the water soluble fraction (WSF) of crude oil had increased whole body total thyroxine levels but no effect on whole body triiodothyronine levels. However, in flounder (*Pleuronectes flesus*), exposure to the WSF decreased plasma thyroxine levels but not triiodothyronine levels. These data demonstrate that WSF alters thyroid hormone levels but that discrepancies exist between either the species' developmental life stage and/or the dose of exposure. Recent studies on the characterization of the thyroid hormone system in salmon, in particular, thyroxine availability during induced hypothyroidism, smoltification, and circadian studies suggest that the timing of thyroid hormone influence during development is in part regulated by an increase in thyroxine-binding proteins which allow an increase in T_3 during the scotophase (Ebbesson et al. 1997, Ebbesson et al. 1998, L. Ebbesson unpublished observations). Any change in the production of thyroxine and/or the binding to the binding proteins during critical phases of development such as smoltification and seawater entry could have a dramatic influence on the survival and return of the salmon.

Thyroid hormones have been associated with brain changes during smoltification in salmon, including behavioral changes, olfactory imprinting (Hasler and Scholz 1983, Morin et al. 1989, Dittman et al. 1994, Dittman et al. 1996) and downstream migration (Iwata 1995); structural changes, circuit reorganization (Ebbesson and Bazer 1990, Holmqvist et al. 1994) and receptor changes (Ebbesson et al. 1990, Ebbesson et al. 1996a); and chemical changes, neurotransmitter fluctuations (Ebbesson et al. 1992, Ebbesson et al. 1994, Ebbesson et al. 1996b) and gene expression (Parhar and Iwata 1996). Salmon brain development during smoltification is time limited by environmental cues that mediate the sequence of physiological and behavioral changes. A change in this sequence of events, caused by altered thyroid hormone levels and rearing environment during critical periods, could result in the retainment of unwanted nerve fiber connections (neural circuits) and/or the lack of certain necessary nerve fiber connections due to competition among nerve fibers and target cells in the brain and pituitary. These "unnatural" connections could have profound effects on the behavioral, physiological and hormonal response to environmental stimuli, such as reduced growth rates, premature sexual maturation or altered migrational behaviors.

As salmon progress through smoltification, specific neurotransmitters surge sequentially in the brain (Ebbesson et al. 1996b). These monoamine neurotransmitters (e.g., dopamine and serotonin) possess multifunctional roles influencing behavior (Blanchard et al. 1993), physiology (Cruz and Corona-Ortega 1997) and neuroendocrine regulation (Nilsson et al. 1992), as well as brain development (Levitt et al. 1997). In mammals, norepinephrine increases monodeiodinase activity which converts thyroxine to triiodothyronine, the active thyroid hormone (Brezezinska and Slebodzinski 1993). We have previously shown that exposure to crude oil decreases levels in content and turnover of two neurotransmitters essential for brain development and hormone regulation, dopamine (DA) and norepinepherine (NE) (Figure 1; unpublished observations).

In other vertebrates, thyroid hormones are vital during critical developmental periods for proper morphological and neurodevelopmental changes which allow the organism to continue its established life cycle. Hypothyroidism during critical periods of development and adulthood can result in brain dysfunction (Timiras 1988, Ahmed et al. 1993, Figueiredo et al. 1993, Porterfield and Hendrich 1993). Hypothyroidism during brain development affects numerous important factors that contribute to normal brain development, including the slowing down of cell migration, neurite outgrowth, acquisition of neuronal polarity, synaptogenesis and myelin formation, as well as increased glial cell proliferation and neuronal cell death (Timiras 1988, Ahmed et al. 1993, Figueiredo et al. 1993, Porterfield and Hendrich 1993, Bernal and Nunez 1995). In addition, inappropriate immature projections to the controlateral cortex in rats are retained because of TH dependency on normal fiber elimination (Gravel and Hawkes 1987, Gravel and Hawkes 1990), suggesting that hypothyroidism contributes to a failure of ontogenetic parcellation in this system. Nerve fiber proliferation followed by selective fiber elimination appears to be a principal feature of brain development in neonatal mammals, the metamorphosing frog, and smolting salmon. This "parcellation" (Ebbesson 1980) of fiber input results in a neural reorganization dependent on the strength of the selective pressures encountered.

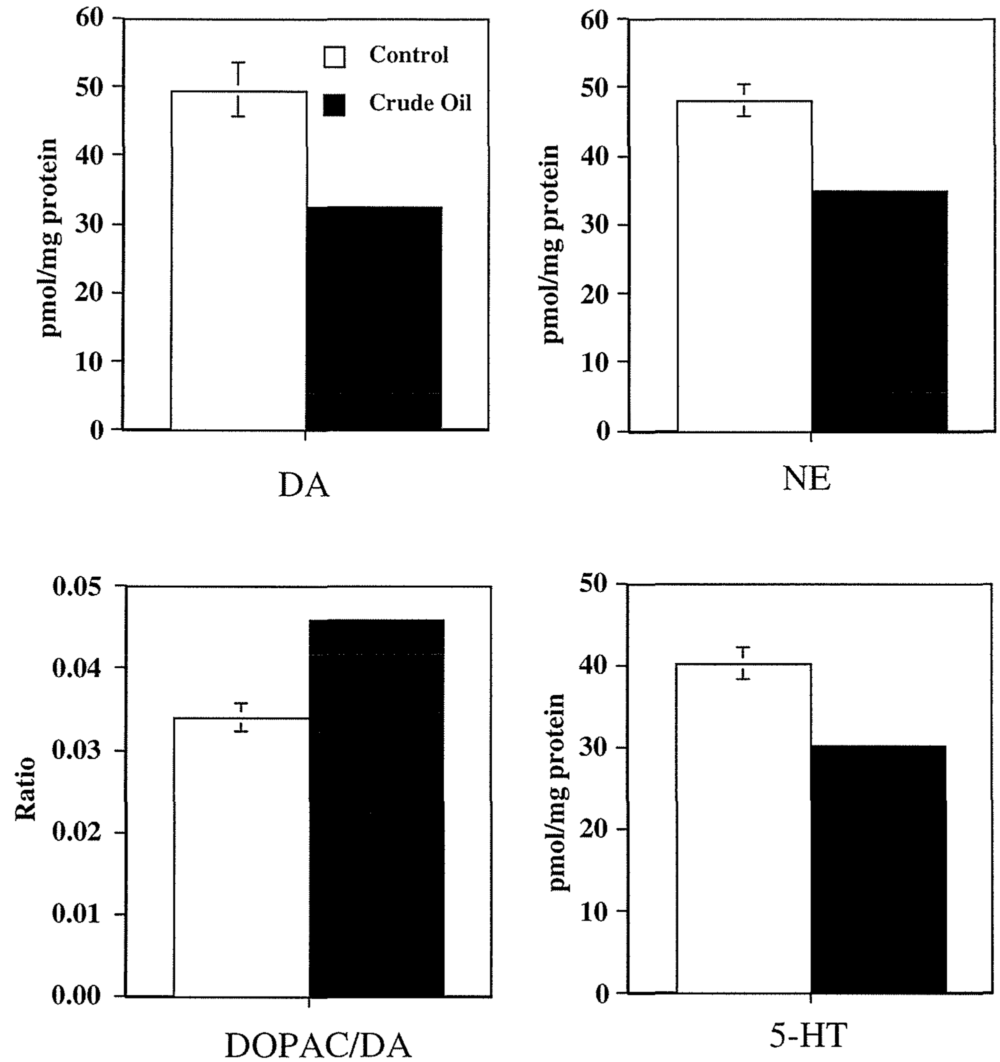

Figure 1. Exposure to crude oil (1 ppm) decreased total brain content in dopamine (DA; $p \leq 0.007$) and norepinephrine (NE; $p \leq 0.006$) and increased DA turnover rate (DOPAC/DA; $p \leq 0.02$) in post-smolt coho salmon. Note: serotonin (5-HT; $p \leq 0.059$) had a 25% decrease in total brain content, whereas 5-hydroxyindoleacetic acid (5-HIAA), glutamine (Gln), glutamate (GLU), gamma-amino-butyric acid (GABA), glycine (GLY) and aspartate (ASP) showed no significant change in total brain content. Data represent 5 salmon per group (mean ± s.e.m.). Statistical differences between groups were determined using Student-t test and were considered significant with $p < 0.05$.

In teleosts, growth hormone is multi-functional, acting on major physiological processes, such as growth, osmoregulation and reproduction, which impact various lifestages (see review by (Björnsson 1997)). Parr–smolt transformation in salmon is a critical period of development, whereby the life strategy is dictated by synchronized neuroendocrine changes that affect growth, behavior and survival (Gross 1987). In several salmonid species, including coho salmon, size and growth rate have been shown to be critical for the initiation and completion of smoltification (Thorpe et al. 1982, Clarke and Shelbourn 1986, Skilbrei 1988) and subsequent marine survival. If a species or stock's specific threshold size is not obtained by the individual salmon at some critical time of the year (usually late summer or autumn in species completing smoltification in the spring), the salmon will remain in freshwater until the next smolting opportunity (Thorpe 1987). Furthermore, once in the ocean, fast growth is essential in order to avoid predation (Powell and McKeown 1986, Irvine and Ward 1989, Holtby et al. 1990). Recent studies on wild salmon post-smolts (Levings et al. 1994; N.A. Hvidsten and S.O. Stefansson, unpublished results) show that the fish feed actively during migration from the river and in the early marine phase. Likewise, coho salmon are known to feed and grow very rapidly after they reach the marine environment (Sandercock 1991). Laboratory experiments confirm that scope for growth increases in Atlantic salmon smolts in seawater (Handeland et al. 1997), concurrent with an increase in circulating levels of GH (Björnsson et al. 1997), suggesting that fast growth is essential for salmonids during smolting and migration.

These data emphasise the importance of "normal" hormone levels during this critical period of neurodevelopment to ensure the development of completely viable smolts. These "normal" levels maximize growth and ability to survive during ocean migration and return to natal streams as adult spawners. Deprivation or alterations of specific hormonal and neural factors during this period could have dramatic effects on behavior, on the proper formation of the hypothalamic–pituitary axis, and on brain development as a whole. The proposed studies will elucidate the effect of crude oil exposure on specific brain and hormonal systems important for ocean survival and successful homeward migration.

C. Location

Salmon will be obtained from the Trail Lake Hatchery, Moose Pass, Alaska, and the research will be carried out at the Alaska SeaLife Center using available fish tanks, raceways and the fish ladder. Hormonal and histological work will be done at the Seward Marine Station. Some chemical studies will be done at the University of Lund, Sweden, and the High Technology Centre, University of Bergen, Norway.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The motivation for the proposed studies comes from recognition that we have very limited available knowledge about environmental factors that affect the return and straying of salmon, which are a major economic variable for Alaska Natives, commercial fisheries and sport fisheries. Accidental pollution can clearly affect fish populations, but the mechanisms of damage need to be determined. The results of the proposed studies will be published in scientific journals and communicated to the public at large using both the media and the resources at the ASLC.

PROJECT DESIGN

A. Objectives

1. Determine the effects of a brief exposure to crude oil upon seawater entry on plasma-free thyroxine, total thyroxine, triiodothyronine, growth hormone and fatty acids levels.

2. Determine, by repeating a preliminary experiment, whether neurotransmitters are affected by the smolts being briefly exposed to crude oils.

3. Determine the effects of a brief exposure to crude oil, upon seawater entry, on brain development.

4. Determine if brief exposure to crude oil, upon seawater entry, affects salmon smolt survival and ability to complete the ocean migration.

FY99: Maintain coho salmon during smoltification at the Alaska Sealife Center to determine hormone (FT_4, TT_4, TT_3, GH) and physiological changes (gill Na/K ATPase activity, plasma fatty acids, seawater tolerance) for this stock of salmon reared under these conditions. Two groups of salmon smolts, control and oil exposed, will be placed in seawater tanks to determine what effects brief exposure to crude oil upon seawater entry will have on the above factors. These endocrine and physiological data are vital for the brain and crude oil exposure studies in year 2.

FY00: Repeat the endocrine and physiological studies (see above) and include brain studies: tracing (olfactory and retinal), neural proliferation and survival, neurotransmitter levels, immunocytochemistry (serotonin, tyrosine hydroxylase, vimentin, PCNA, GAP-43), and *in situ* hybridization (thyroid hormone receptors [TR], estradiol receptors [ER] and nitric oxide synthase [NOS] mRNA). These neural markers, all of which determine different aspects of brain development, will be used to study the effects of crude oil exposure on the brain upon seawater entry. Two groups of salmon, control and oil exposed, will be released this year to determine return rates.

FY01: Process and evaluate material from year 2. Repeat studies from year 2 to verify the results.

FY02: Process and evaluate material from year 3. Conduct other studies based on previous results to further elucidate mechanisms of action of crude oil exposure.

FY03: Process and evaluate material from year 4. Complete all manuscripts and reports.

B. Methods

During FY99, hormonal and physiological affects by crude oil exposure at the smolt stage will be defined using standard methods.

The FY99–00 experiments will test the following hypotheses:

1. Brief exposure to crude oil affects plasma hormone and fatty acid levels in salmon smolts upon seawater entry.

2. Osmoregulation in salmon smolts is affected by exposure to crude oil upon seawater entry.

3. Neurotransmitter levels are affected by a brief exposure to crude oil in salmon smolts upon seawater entry.

The following hypotheses will be tested during FY01–03:

4. A brief exposure to crude oil affects normal brain development in salmon smolts upon seawater entry.

5. A brief exposure to crude oil, upon seawater entry affects salmon smolt survival and ability to complete the ocean migration.

The following methods will be used:

Hypothesis 1: Hormone levels will be measured either by commercially available radioimmunoassay (RIA) kits (FT_4, TT_4, TT_3 (Ebbesson et al. 1998), or specific RIA methods (GH) (Björnsson et al. 1994). Plasma fatty acid levels will be measured according to Parkinson et al. (1994).

Hypothesis 2: Gill Na/K ATPase activity and plasma sodium levels will be performed according to McCormick et al., 1995.

Hypothesis 3: Neurotransmitter levels will be measured by high performance liquid chromatography, standard methods in our laboratory (Ebbesson et al. 1996b).

Hypothesis 4: Brain development will be monitored and assessed, using standard protocols, in our laboratory: immunocytochemistry of 5HT, TH, GAP-43, Vimentin, and PCNA (Ebbesson et al. 1992, Ekström et al. 1992); *in situ* hybridization of NOS, TR, ER, Apoptosis–Tunnel technique; tract tracing using DiI and Co-Lys (Ebbesson and Bazer 1987, Ebbesson et al. 1991, Holmqvist et al. 1992); and proliferation using ^{3}H-thymidine and BrdU incorporation (Zupanc and Maler 1997).

Hypothesis 5: Thirty thousand coho salmon with thermal-marked otoliths and clipped adipose fins will be exposed to 1 ppm crude oil in a tank at 5°C at the Alaska Sealife Center, and released into Resurrection Bay one week after exposure. The oil will be rapidly depleted from the water in the flow-through tank. The control group of 30,000 smolts with differently marked otoliths and clipped adipose fins will be released on the same day as the experimental group. The return of these two populations of salmon will be expected in July–September of the following year at the ASLC's fish ladder, where they will be identified and counted, sexed and measured. Since the treatment may affect return dates, early and late returnees will be looked for. Since normally reared salmon (control populations) return at a rate of approximately 5%, we will potentially have 3,000 returning salmon in the summer of 2001.

In FY01, we will repeat the experiment of FY00 and whatever needs to be repeated from the FY99 experiment.

In FY02, we will receive and tabulate the returnees of FY01 release.

In FY03, we will complete the analysis and publications of our findings.

Statistical methods
Statistical differences between time periods during smoltification will be determined using one-way analysis of variance (ANOVA) followed by Fisher's least significant difference test ($n = 6$ per sample point). Data will be considered significant at $p < 0.05$. Student-t tests will be used to determine significant differences among treatment groups upon seawater entry ($n = 10$).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

No other trustee agency is requesting funds on this project. However, the proposed research will continue ongoing an ongoing collaboration with scientists at the University of Lund, Sweden.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 – September 30, 1999)

October 1–April 1:	Transfer 2,000 coho smolts to Alaska SeaLifeCenter to obtain baseline physical, physiological and endocrine data on plasma
April 1–June 30:	Collect plasma samples weekly before, during and after smoltification
June 1–June 7:	Expose one population of 400 fish to 1.0 ppm crude oil and collect plasma and brain samples daily for one week
June 30–September 30:	Do chemistries and histology on collected specimens

B. Project Milestones and Endpoints

September 2000:	Objectives 1 and 2 completed
September 2002:	Objective 3 completed
September 2003:	Objective 4 completed

C. Completion Date

September 30, 2003

PUBLICATIONS AND REPORTS

These will include annual reports and annual reporting of significant findings in the peer-reviewed literature.

PROFESSIONAL CONFERENCES

Results from one or more elements will be reported at the annual meeting of the American Fisheries Society.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The fish will be maintained at the Alaska SeaLife Center and the processing of salmon plasma and brains will be carried out at the Seward Marine Center, the Department of Zoology, University of Lund, Sweden, and the High Technology Centre, University of Bergen, Norway.

PROPOSED PRINCIPAL INVESTIGATOR

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Sven O. E. Ebbesson

EDUCATION

Southwestern College, Winfield, KS	B.A., 1957
Tulane University, New Orleans, LA	1957–1960
University of Maryland, Baltimore, MD	Ph.D., 1964

PROFESSIONAL EXPERIENCE

1958–1960, Assistant of Anatomy, Tulane University
1962–1965, Neuroanatomist, Department of Neurophysiology, Walter Reed Army Institute of Research, Washington, D.C.
1965–1965, Instructor of Anatomy (part-time), University of Maryland
1966–1969, Assistant Professor of Anatomy (part-time), University of Puerto Rico
1965–1969, Senior Scientist and Head of Comparative Neurology Section, laboratory of Perinatal Physiology (the present Caribbean Primate Research Center), National Institute of Neurological Diseases and Stroke
1969–1972, Associate Professor of Neurological Surgery and Anatomy, University of Virginia
1972–1976, Professor of Neurological Surgery and Anatomy, University of Virginia
1976–1979, Associate Dean, Professor of Anatomy, Director of the Graduate Program, University of Puerto Rico Medical School
1979–1983, Professor of Anatomy and Special Assistant to the Dean, Ponce School of Medicine, Ponce, Puerto Rico
1983–1985, Professor of Anatomy, LSU School of Medicine, Shreveport, LA
1985–1987, Professor of Medical Science, University of Alaska Fairbanks
1987–Present, Professor of Neuroscience and Marine Science, University of Alaska Fairbanks
1987–Present, Professor, Institute of Marine Science, University of Alaska Fairbanks
1992–1993, Acting Director, Institute of Circumpolar Health Studies, University of Alaska
1988–Present, Director of Alaska-Siberian Medical Research Program

MILITARY SERVICE

1961–1965, United States Army, Private to Captain
1965–1969, United States Public Health Service, Lieutenant Commander to Commander

HONORS

1965, Army Commendation Medal for Exceptional Meritorious Service
1970–1975, NIH Career Development Award
1972–1974, President, Virginia Chapter of Society for Neuroscience
1976, President and Founder, Puerto Rico Chapter of Society for Neuroscience
1979, Doctor of Science (*Honoris causa*), Southwestern College
1980, Humboldt Prize
1983–1984, President, Shreveport Chapter of Society for Neuroscience
1981–1986, Council Member, International Society for Neuroethology
1988–1993, President and Founder, Alaska Chapter of Society for Neuroscience
1992, Member, Royal Physiographic Society
1993, 1997, Regional Editor, Arctic Medical Research
1993–1996, President, American Society for Circumpolar Health

1993–1996, Council Member, International Union of Circumpolar Health
1993, Foreign Member, Russian Academy of Medical Science

PUBLICATIONS

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2. Ebbesson, S.O.E. 1963. A quantitative study of human superior cervical sympathetic ganglia. *Anat. Rec.* 146:353–359.
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5. Ebbesson, S.O.E. and D.B. Tang. 1965. A method for estimating the number of cells in histological sections. *J. Roy. Microscopy Soc.* 84:449–464.
6. Ebbesson, S.O.E. 1966. Ascending fiber projections from the spinal cord in the tegu lizard (*Tupinambis nigropunctatus*). *Anat. Rec.* 154:341–342.
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8. Ebbesson, S.O.E. and D.B. Tang. 1967. The sampling of structural cell populations. *Stereologia* 6:15–16.
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10. Ebbesson, S.O.E. 1967. Retinal projections in two species of sharks (*Galeocerdo cuvieri* and *Ginglymostoma cirratum*). *Anat. Rec.* 157:238.
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12. Ebbesson, S.O.E. 1968. Quantitative studies of superior cervical sympathetic ganglia in a variety of primates including man. I. The ratio of preganglionic fibers to ganglionic neurons. *J. Morphol.* 124:117–132.
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14. Ebbesson, S.O.E. 1968. Retinal projections in two teleost fishes (*Opsanus tau* and *Gymnothorax funebris*. An experimental study with silver impregnation methods. *Brain, Behav. Evol.* 1:134–154.
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17. Voneida, T.J. and S.O.E. Ebbesson. 1968. Pallial commissural systems in the tegu lizard (*Tupinambis nigropunctatus*). *Anat. Rec.* 160:445.

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23. Campbell, C.B.G. and S.O.E. Ebbesson. 1969. The optic system of a teleost: *Holocentrus* re-examined. *Brain, Behav. Evol.* 2:415–430.

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64. Distel, H.-J. and S.O.E. Ebbesson. 1975. Efferent projections of the thalamus in the monitor lizard. Abstracts of the Society for Neuroscience.

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71. Ebbesson, S.O.E. 1978. Somatosensory pathways in lizards: The identification of the medial lemniscus and related structures, p. 91–104. *In:* P. MacLean and N. Greenberg (eds.), *Behavior and Neurology of Lizards*. DHEW Publications No. (ADM) 77–491.

72. Vanegas, H. and S.O.E. Ebbesson. 1980. Projections of the teleostean telencephalon, p. 117–127. *In:* S.O.E. Ebbesson (ed.), *Comparative Neurology of the Telencephalon*. Plenum, New York.

73. Ebbesson, S.O.E. 1980. On the organization of the Telencephalon in elasmobranchs, p. 1–16. *In:* S.O.E. Ebbesson (ed.), *Comparative Neurology of the Telencephalon*. Plenum, New York.

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75. Ebbesson, S.O.E. 1980. A visual thalamo telencephalic pathway in a teleost fish (*Holocentrus rufus*). *Cell and Tissue Res.* 213:505–508.

76. Ebbesson, S.O.E. and D.E. O'Donnell. 1980. Retinal projections in the electric catfish (*Malaperurus electricus*). *Cell and Tissue Res.* 213:497–503.

77. Ebbesson, S.O.E. and D.L. Meyer. 1980. The visual system of the guitar fish (*Rhinobatos productus*). *Cell and Tissue Res.* 206:243–250.

78. DeOlmos, J., S.O.E. Ebbesson and L. Heimer. 1980. Silver methods for the pregnation of degenerating axoplasm, p. 117–170. *In:* L. Heimer and M. Robards (eds.), *Anatomical Methods for Tract Tracing*. Plenum Press, New York.

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82. Northcutt, R.G. and S.O.E. Ebbesson. 1980. Ascending spinal pathways in the sea lamprey. Abstracts of the Society for Neuroscience, p. 332 (214.2).

83. Ebbesson, S.O.E. and H. Ito. 1980. Bilateral retinal projections in the black piranha (*Serrasalmus niger*). *Cell and Tissue Res.* 213:483–495.

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96. Gerwerzhagen, K., M.J. Rickman, D.L. Meyer and S.O.E. Ebbesson. 1982. Optic tract cells projecting to the retina in the teleost, *Pantodon buchholzi*. *Cell and Tissue Res.* 225:23–28.

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1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$65.0
Travel		$4.1
Contractual		$2.0
Commodities		$8.0
Equipment		
Subtotal		$79.1
Indirect		$19.8
Project Total		$98.9
Full-time Equivalents (FTE)		1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$113.4	$114.8	$111.2		

Dollar amounts are shown in thousands of dollars.

Comments:

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

FY 99

Project Number: 99~~xxx~~ 489
Project Title: Crude Oil Exposure Effects on Salmon Smolts
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/14/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:							
Name	Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Ebbesson, S.	Principal Investigator/Professor		2.5	12.3		30.8
Ebbesson, L.	Research Associate		9.0	3.8		34.2
	Subtotal		11.5	16.1	0.0	
					Personnel Total	$65.0

Travel Costs:					
Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Fairbanks to Anchorage – EVOS annual meeting	0.3	1	5	0.1	0.8
Sweden to Seward – for P. Ekström to help with processing specific sampling groups, including the proliferation studies	1.0	1	20	0.1	3.0
Adjustment to recognize rounding					0.3
				Travel Total	$4.1

FY 99

Project Number: 99xxx
Project Title: Crude Oil Exposure Effects on Salmon Smolts
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/14/98

1999 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs: Description	Proposed FY 1999
Communications	2.0
Contractual Total	$2.0

Commodities Costs: Description	Proposed FY 1999
Chemicals – includes radioimmunoassay kits, fatty acid standards, HPLC chemicals, histological supplies, anesthetics, etc.	4.0
Glassware - includes slides	2.0
Fish food	2.0
Commodities Total	$8.0

FY 99

Project Number: 99xxx
Project Title: Crude Oil Exposure Effects on Salmon Smolts
Name: University of Alaska Fairbanks

FORM 4B
Contractual &
Commodities
DETAIL

Prepared: 4/14/98

1999 EXXON VALDEZ TRUS[...] COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	

FY 99

Project Number: 99xxx
Project Title: Crude Oil Exposure Effects on Salmon Smolts
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL