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

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Restoration Category:	Monitoring
Proposers:	Jim Bodkin and Dan Esler Alaska Biological Science Center USGS-Biological Resources Division 1011 E. Tudor Rd. Anchorage, Alaska 99503
	Dan Rosenberg Alaska Dept. of Fish and Game 333 Raspberry Road Anchorage, Alaska 99503
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Alaska Sea Life Center:	No
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Cost FY 00:	$484,900
Cost FY 01:	$387,300
Cost FY 02:	$315,800
Geographic Area:	Prince William Sound
Injured Resource/Service:	Sea otter; Harlequin duck.

ABSTRACT

Our prior research has identified sensitive variables for assessing recovery of the nearshore ecosystem in western Prince William Sound through populations of sea otters, their invertebrate prey and harlequin ducks. Core data collection includes annual surveys of sea otter distribution and abundance, estimates of abundance and size classes of key sea otter prey, and annual assessment of harlequin duck numbers, population structure, and survival. Additional, but independent, components are proposed to expand the spatial scale of P450 sampling of sea otters and to examine adult sea otter female survival, movements, and foraging energetics. This project will monitor both injured populations and ecological processes to address questions central to recovery of the nearshore ecosystem and will test new approaches to ecosystem monitoring.

INTRODUCTION

The nearshore environment of Prince William Sound (PWS) received about 40% of the oil spilled after the *Exxon Valdez* ran aground (Galt et al. 1991). Concerns about nearshore recovery and restoration have resulted in a suite of studies sponsored by the Exxon Valdez Oil Spill Trustee Council (EVOSTC), including the Nearshore Vertebrate Predator project (NVP). Principal findings include an apparent lack of recovery among sea otters and harlequin ducks, both invertebrate feeders in the nearshore ecosystem. Additionally, we identified a common pattern among several sea otter prey species consistent with reduced predation, through increased proportions of large individuals where sea otters populations were reduced. We are proposing to continue those components of previous research that were most effective and statistically powerful at identifying if, where, and how recovery may be constrained in the nearshore. We address the need to refine and focus efforts on study components that provide the greatest resolution to ecosystem function.

We focus on sea otters (*Enhydra lutris*), interactions between sea otters and key invertebrate prey, and harlequin ducks (*Histrionicus histrionicus*), as these species (1) were injured by the oil spill and continue to show evidence for lack of a full recovery, (2) are presumably reflective of the health and recovery status of the nearshore system generally, and (3) are represented by abundant postspill information that can be utilized for long-term restoration monitoring. For both sea otters and harlequin ducks, we propose base monitoring programs that track both the patterns of population demographics and the processes underlying change in the nearshore system.

We propose two additional components, one to address the NVP finding of elevated levels of cytochrome P450 in sea otters and another to estimate adult female sea otter mortality and foraging energetics. This proposal has its origin within the NVP project, and is presented as a single proposal. However, the sea otter and harlequin duck components, as well as elements under each species, are clearly identified and include independent budgets allowing consideration of each element independently (Appendix I).

Sea Otters

Studies conducted in 1996 and 1997 as part of the NVP program provided evidence that sea otters in western Prince William Sound (WPWS), in at least the area of northern Knight Island, had not fully recovered from oil spill injury (Holland-Bartels et al. 1997, Holland-Bartels et al. 1998). Shortly after the spill, in April 1989, a total of 33 sea otters were captured or recovered from Herring Bay, a heavily oiled embayment on northern Knight Island (Bodkin and Udevitz 1994). Fourteen aerial surveys conducted in 1996 found a maximum of 11 sea otters (mean = 3) in this same location. Constraints to recovery most likely are demographic, either through reduced survival among residents, or higher emigration from the oiled area.

This proposal builds on previous EVOS research to develop a statistically sensitive and cost-effective program that will continue to track WPWS sea otter population and nearshore ecosystem recovery through two avenues. First, continued aerial surveys of sea otter abundance at appropriate intervals will allow population monitoring and testing of the predictions of a

previously developed EVOSTC sea otter population model (Udevitz et al. 1996). Second, monitoring abundance and size of three key invertebrate species will allow an independent assessment of sea otter recovery through predicted responses in prey populations.

Continued exposure to environmental contaminants, indicated by a 4-fold increase in the biomarker cytochrome P4501A (CYP1A), in sea otters from oiled areas relative to those from the reference area (Holland-Bartels et al. 1998), may be contributing to delayed recovery of sea otter populations. The second element of the sea otter component will expand the scope of bioindicator monitoring to assess the scale and significance of previously observed differences in CYP1A between oiled and unoiled study sites.

The third element of the sea otter study addresses two compelling questions that have arisen from NVP findings. One was the cause for an apparent lack of population growth (particularly in the oiled area, Fig. 1), suggesting lower survival or higher emigration rates. The other resulted from a foraging energetics model which predicted a significantly lower foraging time requirement for otters at our oiled site (10.8 hours/day at Knight Island compared to 14.6 hours/day at Montague; Holland-Bartels et al. 1998). These two questions can be answered most efficiently in combination, as they both require telemetry and surgical implantation procedures. We propose to address the survival/emigration issue by instrumenting a sample of adult females from oiled and unoiled areas in WPWS with VHF radios equipped with temperature mortality switches. Simultaneously, we will implant time-depth recorders that provide long-term data on dive attributes and unbiased estimates of the time allocated toward recovering caloric requirements in each area. The former will allow estimation of adult female survival and dependent juvenile survival, and the latter will provide empirical data to test our previous conclusion of greater foraging efficiency at the oiled area (where predation was reduced and prey are larger).

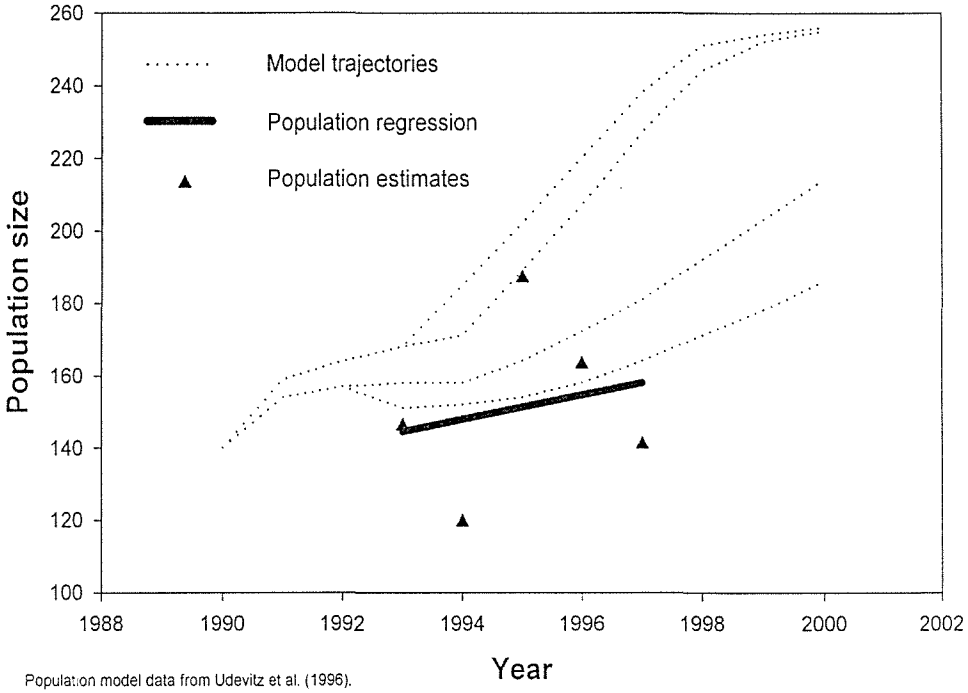
Information obtained from these three components will be valuable for differentiating between demographic and health-related causes for the current lack of recovery in the WPWS sea otter population as well as aiding our understanding of processes involved in recovery of the nearshore system to major perturbations such as the EVOS.

Harlequin Ducks

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

Evidence from recent NVP and monitoring studies indicates continued lack of full recovery of harlequin ducks from the oil spill and identifies critical data for tracking both the progress and process of recovery. Declines in the numbers of harlequin ducks during wing molt have occurred within the oil spill zone in PWS, whereas numbers have not declined on unoiled areas; these

Fig. 1 Four sea otter population recovery trajectories (assuming N = 140 in 1990) and estimates from 4 aerial surveys from northern Knight/Naked Island study area (slope of regression not different from zero).



Population model data from Udevitz et al. (1996).

surveys offer the most powerful information on harlequin duck population trends available (Appendix II). High levels of molt and winter site fidelity observed as part of NVP studies suggest that differences in numerical trends represent real changes in the core wintering populations. Further, different winter survival rates of adult females between oiled and unoiled areas offer a clear, highly plausible mechanism driving observed differences in population trends. Thus, we propose monitoring population numbers and structure and survival probabilities to track the pattern and process of harlequin duck recovery.

Central to monitoring harlequin duck recovery is derivation of a comprehensive population dynamics model that (1) incorporates demographic parameters, (2) identifies critical periods of the annual cycle that may be limiting recovery from the *Exxon Valdez* oil spill (EVOS), and (3) predicts population trends and recovery times. The population model will be modified from existing efforts (Goudie et al. 1994; Robertson 1997) and, like most waterfowl population models, will emphasize females, under the assumption that males are non-limiting.

Critical data necessary to build population models for oiled and unoiled areas of Prince William Sound include: adult survival, subadult survival, recruitment, and dispersal (immigration and emigration). Previous EVOSTC funded research (projects -427, -161, and -025) will provide some of the data necessary for modeling. Other parameters will be estimated under specific objectives described in this proposal. Finally, proposed population monitoring will test population demographics predicted by the model.

March Demographic Surveys

As a result of the 1990-1993 findings and the recovery objectives of the 1994 EVOS Recovery Plan, studies were initiated in 1994 to begin the process of assessing population structure and breeding propensity as well as trends in abundance (Rosenberg 1995; Rosenberg et al. 1996; Rosenberg and Petrula 1997; Rosenberg and Petrula 1998, in prep.). These studies, conducted from 1994 through 1997, found no difference in population structure between oiled and unoiled areas; no brood production in the spill area; and a decline in molting populations. We attribute lack of production in the spill area to little suitable breeding habitat in western PWS. We do not view this as an impediment to recovery. Similar population structures, a positive finding, indicated that the population is in a position to recover. However, the declining trend in numbers during autumn surveys for the oiled areas of western PWS remains a concern, especially since populations in unoiled eastern PWS increased. This indicates that recovery may not be underway.

Two other studies have been monitoring the survival and population trends of harlequin ducks in PWS. The USFWS marine boat surveys (Agler et al. 1995; Agler and Kendall 1997) have been monitoring marine birds, including harlequin ducks, throughout PWS since 1989. FWS surveys have been designed to first assess damages following the *Exxon Valdez* oil spill and then monitor abundance to assess recovery of injured species. These surveys gather information on abundance and distribution only, they have not gathered information on population structure, information necessary for the development and testing of a population model. Their findings show harlequin ducks in July remaining relatively stable in oiled areas and increasing in unoiled areas. In March, their surveys show a slight increase in the number of ducks inhabiting oiled sites. This compares with a much greater rate of increase for unoiled areas. This increase in oiled populations appears encouraging, but we believe it does not truly represent changes in density. The USFWS surveys

have insufficient sample size, yield poor power, and cannot detect small changes in population density. Thus, their surveys cannot be used to measure the recovery of harlequin ducks. We have compared USFWS survey methods (Agler and Kendall 1977) with ADF&G methods (Rosenberg and Petrula 1997)(see below and Appendix II).

Sea duck populations, in general, are composed of long-lived birds with delayed sexual maturity, low annual production rates, and "boom and bust" years. Big population fluctuations may be normal and detecting true population trends may require patience. We propose to conduct a winter survey that will compare population trends in the same oiled and unoiled areas surveyed in project \427 (Rosenberg and Petrula 1997). In addition, we propose expanding the geographic coverage of the survey to allow us to compare regional differences in population trends within oiled and unoiled areas. Thus, we will compare trends for different geographic regions within oiled and unoiled areas in an attempt to determine geographic effects. This is proposed because it can be done for little additional cost.

This project component is essentially a continuation of Project /027 Harlequin Duck Recovery Monitoring. This project will continue to monitor harlequin duck populations in oiled and unoiled areas of PWS. However, we will now conduct surveys, one per year, during March. Throughout much of the year, harlequin duck populations are in a state of flux as birds move to and from breeding areas. Subadults may also be quite mobile in a quest to find mates. Winter is the period of maximum and stable numbers of harlequin ducks. By March, pair bonds are well formed, and there is relative stability in both numbers and movements of ducks. March surveys will provide information on population size, structure (sex-and age-ratios, number of breeding pairs), trends and recruitment. Recruitment is a particularly difficult parameter to estimate. Population monitoring will allow estimation of recruitment via age structure variation. The proportion of young birds in a population is a function of production of young, immigration of young, and survival of young and will constitute our estimate of recruitment into the local population.

Annual Survival

Variation in female survival has profound influences on population dynamics of harlequin ducks. Results of NVP studies suggest differences in survival probabilities between oiled and unoiled study sites. We propose tracking this critical parameter through annual marking and recapture during wing molt. This effort builds upon the large number of marked individuals already in the population that were banded as part of NVP work since 1995. This technique provides age-specific annual survival and can be used to track trends in survival over a series of years and, also, can be used to partition seasonal survival when considered with results of radio telemetry studies. Also, annual mark and recapture of birds will allow determination of molt site fidelity. These data will be used to calculate probabilities of movements, by age class. between oiled and unoiled areas and the subsequent effects on population size and structure.

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters and harlequin ducks occupy a common trophic level in the nearshore and are a conspicuous component of the nearshore ecosystem. In 1995, the NVP Project was initiated to examine the status or recovery of nearshore vertebrates (including sea otters, harlequin ducks, river otters and pigeon guillemots), and to examine possible causes for the apparent lack of recovery. Results of the NVP project, although not complete, clearly suggest that complete recovery may not have occurred, for at least the invertebrate-feeding sea otter and harlequin duck. This may reflect similarities in trophic dynamics or perhaps simply greater power to detect differences or change with these species. Additionally, we have observed an apparent response among several invertebrates to reduced sea otter densities. This finding represents a shift in the ecological processes structuring the nearshore community and provides a unique opportunity to test predictions related to sea otter recovery and their prey. We also have an opportunity to test the application of this novel approach as a tool for monitoring predators through prey that may have broader ecological applications.

Sea Otters

Sea otter populations in WPWS were injured as a result of the *Exxon Valdez* oil spill (EVOS). Estimates of sea otter mortality due to the spill range from 750 to 2,650 individuals (Garshelis 1997, Garrott et al. 1993). A population model (Udevitz et al. 1996) predicted recovery of the WPWS sea otter population in 10 to 23 years, projecting maximum annual growth rates from 0.10-0.14. Surveys to date (1993-1997) have not shown a significant increasing trend in the WPWS sea otter population, despite adequate power to detect relatively small changes (1- > 0.80 to detect a 1% annual change in 5 annual WPWS surveys). In particular, the northern Knight and Naked Island area numbers remain below pre-spill estimates, and do not show a significant increasing trend (Fig. 1; Holland-Bartels et al. 1998) though our power to detect change is lower for these surveys.

The status of sea otter recovery has been assessed, in part, by conducting aerial surveys of sea otter abundance in WPWS, comparing pre- and post-spill estimates of abundance, and comparing estimates of abundance in oiled and unoiled parts of the Sound. While these data provided a foundation for assessment of recovery status, there were few pre-spill data and there were known biases in pre-spill estimates that precluded using pre- vs. post-spill comparisons in making a definitive quantitative assessment of the extent of recovery. Furthermore, recovery status could not be based solely on post-spill comparisons of oiled and unoiled areas because there are known differences in habitat between these areas, and it is uncertain whether sea otters in oiled areas could ever achieve population levels observed in unoiled parts of the Sound. As a result, in the NVP study, we examined prey populations as an ancillary means of assessing recovery.

This approach was based on the knowledge that sea otters have a profound and predictable effect on the structure of prey populations (reviewed in Riedman and Estes 1990). Generally, as sea otters reoccupy an area, they first consume the largest members of the most energetically profitable prey, eventually switching to smaller sizes and different species, as preferred species and the larger size classes become rare (Estes and Palmisano 1974, Duggins 1980, Estes and

Duggins 1995). Prey of the size preferred by sea otters generally are rare in areas where sea otters are abundant (Estes et al. 1978). There have been no prior studies of the impacts of reductions in the number of otters on the structure of prey populations. However, based on the work summarized above, we hypothesized that a reduction in otter abundance would be accompanied by an increase in the abundance and average size of prey. We concluded that the status of recovery of impacted populations of sea otters might therefore be assessed by examining the abundance and size-distributions of prey within impacted areas, and by comparing these with estimates from an unaffected area where otters and their prey were considered to be in equilibrium. Full recovery would be indicated by similar abundances and size distributions of prey in oiled and unoiled areas.

NVP comparisons of most invertebrate prey populations between Knight Island (oiled) and Montague Island (unoiled) identify differences in population structure consistent with lack of recovery of the sea otter population at the oiled site (Fig. 2; Holland Bartels et al. 1998). At the sites where sea otter populations were greatly reduced, we have found significantly greater proportions of large individuals among most species of clams, urchins and mussels. Size distributions of sea urchins (Fig. 2) and intertidal littleneck clams were strongly skewed toward smaller size classes Montague Island, and there were substantially higher abundances of large urchins and clams per otter at Knight Island (15 to 50 times more urchins and 5 to 6 times more clams per otter at Knight than at Montague).

Continued prey assessment provides a unique opportunity to complete the testing of an innovative approach for estimating the status of a predator population. When sea otter populations near complete recovery, we predict that differences in prey sizes between areas should diminish. We propose to continue to monitor the abundance of sea otters and the size and abundance of selected sea otter prey in oiled and unoiled areas of PWS to assess the recovery status of sea otters.

Highly significant differences in CYP1A between sea otters in oiled and unoiled habitats indicate some type of contaminant exposure continues at Knight Island (mean value for CYP1A measured by RT-PCR was 4-fold higher for the 1996 Knight Island samples; Holland-Bartels et al. 1998). Consistent results for river otters, Barrow's goldeneyes and masked greenlings confirm that the contamination, likely from residual EVOS oil, is affecting a range of vertebrate species, although the biological significance of this exposure is unknown. We propose to expand the geographical area for evaluating sea otter CYP1A levels. Samples will be collected from otters in areas known to be relatively clean (south-east Alaska) and relatively contaminated (California), providing data on "baseline" levels of CYP1A, the relative severity of continued exposure in WPWS, and the extent to which contaminants may be constraining sea otter recovery. Furthermore, we believe that CYP1A, as a bioindicator of residual oil and other contaminants in the ecosystem, may have potential for long-term monitoring. However, before it can be applied as a monitoring tool, the variation among individuals and populations in expression of this biomarker must be characterized.

A lack of sea otter population growth in the heavily oiled area at Knight Island indicates either lower reproduction, higher mortality, or higher emigration. Reproduction does not appear to differ between the Montague and Knight study areas (Holland-Bartels et al. 1998). Mortality and emigration/immigration have not been addressed. Results of sea otter foraging studies between

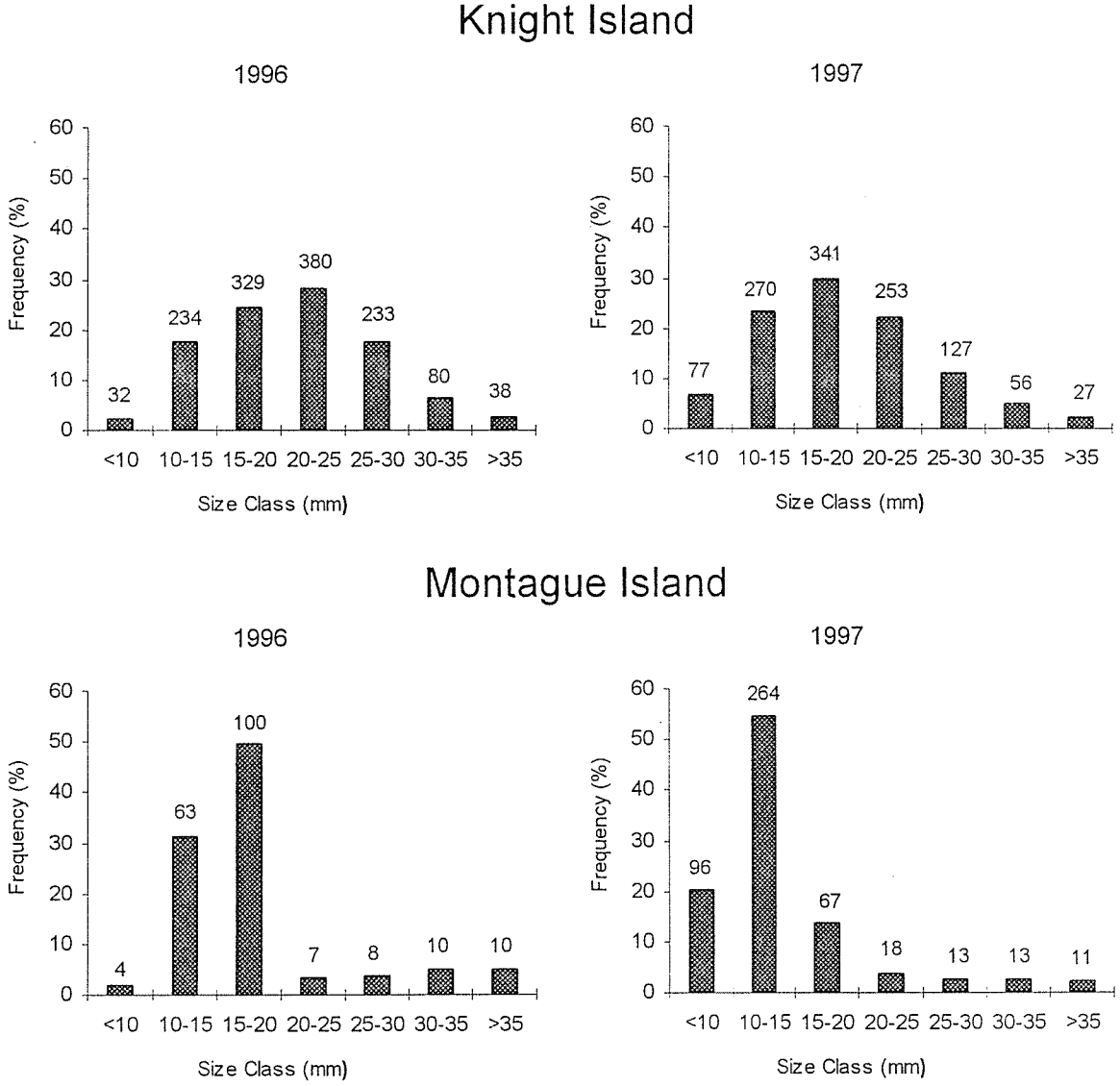


Fig. 2 Size class distributions of green sea urchins at Knight and Montague Islands, PWS

areas resulted in an energetics model that identified significantly greater foraging efficiency at Knight Island (Holland-Bartels et al. 1998). However, differences in habitat (bathymetry, substrate) between sites are recognized and differences in sea otter diving energetics between sites may exist. New technology, employing time-depth recorders, recently applied to sea otters (J.L. Bodkin, unpubl. data), provides an opportunity to test the energetics model with empirical data not previously available and may provide information on the effects of habitat differences among areas.

In summary, continued monitoring of sea otter distribution and abundance and otter prey populations in WPWS along with geographically expanded monitoring of sea otter P450 levels, and estimates of survival and foraging energetics will be valuable in (1) providing insight into potential demographic constraints to recovery which may improve future recovery models, (2) documenting actual recovery time for the nearshore system including sea otters, (3) evaluating the extent to which continued exposure may be constraining sea otter recovery, and (4) providing long-term population trend data which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills.

Harlequin Ducks

Harlequin ducks occur year-round in intertidal zones of PWS (Isleib and Kessel 1973). Nearly 1,300 harlequin ducks were estimated to have died as a direct result of oil exposure following the spill (John Piatt, USGS-BRD, pers. comm). Postspill studies suggest potential continuing constraints to recovery from the spill, based on differences in winter survival between oiled and unoiled areas (Esler, unpubl. data), declines in numbers of molting birds within the spill zone (Rosenberg, unpubl. data), and detectable levels of hydrocarbons in harlequin ducks and their prey from 1989-1993 (Patten 1995). Nearly seven years after the *Exxon Valdez* oil spill harlequin ducks had not recovered (Exxon Valdez Oil Spill Trustee Council 1996).

The US Geological Survey–BRD(USGS-BRD), as part of the EVOS Nearshore Vertebrate Predator project (project \025), has been monitoring the over-winter survival of female harlequin ducks in PWS. They also report differences between oiled and unoiled populations. Female harlequin ducks in oiled areas of western PWS have lower survival rates than females living off the west coast of Montague Island (Dan Esler, USGS-BRD, pers. comm.). However, rates for both areas translate into declining populations. This presents difficulties in interpretation, but the divergence is real and apparent. There appears to be no differences in food availability that can be associated with differential survival. The small area of Montague used as the control sites opens speculation to geographic differences (local climate, marine processes) contributing to these differences rather than lingering oil contamination and its physiological effects.

As a result of the mixed findings of all three studies, there remains some uncertainty about the recovery of harlequin ducks. We believe our analysis of ADF&G and USFWS surveys will shed some light on a portion of this discrepancy. Still, one commonality of all three is the divergence between oiled and unoiled populations. Harlequin duck populations in oiled areas (WPWS) are consistently "under-performing" populations in unoiled areas (EPWS). Yet, questions remain as to whether survey results primarily reflect lingering effects of the oil spill, intrinsic factors such as local geography and climate that influence survival independently of oil, or survey design. Other factors warrant speculation, but these appear most likely.

Some aspects of harlequin duck life history suggest that they may be particularly susceptible to oil spill effects and that recovery should be expected to be a long process. Harlequin ducks are inextricably linked to the nearshore marine environment, spending most of their annual cycle along rocky coasts, headlands, or cobble beaches. This was the environment where much of the spilled oil from the *Exxon Valdez* was deposited. Diets of harlequin ducks in marine areas consist largely of intertidal and shallow subtidal benthic invertebrates, including amphipods, limpets, snails, chitons, and mussels (Goudie and Ankney 1986, Goudie and Ryan 1991, Patten 1995). Harlequins appear to be highly philopatric to their molting and wintering sites; this is an adaptive strategy in natural situations and predictable environments, but does not accommodate moving to undisturbed sites in the face of human-caused perturbations. Also, Goudie and Ankney (1986) suggested that harlequins were on the lower end of body size for surviving in harsh environments similar to Prince William Sound in winter. Because harlequin ducks exist close to an energetic threshold, any perturbation (i.e., an oil spill) that either affects health or condition directly (via toxic effects) or indirectly (via food abundance) could have significant consequences for the population.

Data gaps exist in our understanding of the effects of the oil spill on harlequin duck population dynamics. Sea duck populations, in general, are composed of long-lived birds that have delayed sexual maturity, low annual production rates, and "boom and bust" years. Consequently, sea duck population dynamics are quite sensitive to adult female survival rates, size of the breeding component, and variable breeding propensity (% of adults breeding annually). Recruitment is a particularly difficult parameter to estimate. We do not know where PWS harlequin ducks breed and subsequently we know few specifics about productivity outside of PWS. Population monitoring will allow estimation of recruitment via age structure variation. Under the best conditions, recovery from population perturbations may take years. We intend to address the data gaps by identifying the processes that affect harlequin duck populations, assessing differences in the processes between oiled and unoiled areas, and predicting recovery times.

Harlequin ducks are in a position to recover but are not recovering. Populations in oiled areas are continuing to decline (Rosenberg and Petrula 1998, in prep.). Monitoring population trends and structure is necessary to determine the status and recovery potential of harlequin ducks. The survey described below is intended to continue the process of establishing quantifiable restoration goals and providing a measure of recovery. Proposed surveys will provide trend indices to assess recovery of harlequin duck populations and determine demographic factors inhibiting or contributing to recovery and restoration. Results will be compared with 1997 results and prior years when applicable. We have designed a survey that has the power to detect trends in oiled populations, give us valuable information on population demographics, and possibly shed insight into geographic differences within PWS.

Comparison of ADF&G and USFWS Monitoring Studies

One difficulty in interpreting the results from studies monitoring the recovery of harlequin ducks has been conflicting results from two different monitoring programs. The ADF&G has been conducting monitoring surveys for harlequin ducks in PWS since 1994 (project /427) and as part of their marine bird and mammal surveys, the USFWS has been monitoring the recovery of harlequin ducks since 1989. In an attempt to better interpret the results of the two surveys we

have compared the survey methods and results. This detailed comparison is presented in Appendix II. A summary follows:

USFWS employed random surveys. A very high percentage of their transects were located in poor or marginal harlequin duck habitat. For a species like harlequin ducks, that have a clumped distribution, it requires intensive surveying to get a sufficient sample size in marginal habitat. Without sufficient survey coverage in oiled areas, they observed a relatively few birds. Thus, effective sample size was low, translating into low power and inability to detect a change. Marginal or poor habitat is the most difficult place, if possible at all, to detect injury or recovery.

The ADF&G harlequin duck surveys have much better ability to detect differences in slopes (population trends) between oiled and unoiled locations in PWS. Biologically, this is because harlequin ducks are not uniformly distributed throughout PWS, but have a patchy distribution, which concentrates relatively large numbers of birds in relatively few areas of suitable habitat. We designed our surveys to include sites that supported high densities (good habitat) of harlequin ducks. This gives us a more powerful data set that puts us in a better position to measure recovery.

B. Rationale/Link to Restoration

Sea otter and harlequin duck restoration requires assessment of population health and definition of impediments to recovery. This proposed work represents a comprehensive approach to understanding the factors that affect population dynamics and definition of critical bottlenecks to recovery. Without an understanding of the underlying processes that dictate population change, we can not prescribe specific activities to enhance recovery.

Population modeling is a powerful tool for describing population fluctuation and for identifying critical periods of the annual cycle (e.g., Lebreton and Clobert 1991, Schmutz et al. 1997). Previous work (Udevitz et al. 1996) has resulted in a population model for sea otters in PWS which may be tested with continued monitoring. For harlequin ducks we will use linked matrix models (Caswell 1989), building on exisitng harlequin duck models (Goudie et al. 1994, Robertson 1997), to incorporate spatial structuring in this exercise, to allow spatial variation, movements, and comparisons between oiled and unoiled areas.

Sea Otters

Sea otter restoration requires an understanding of changes in population status and the processes affecting that change. Continued monitoring of sea otter distribution and abundance and otter prey populations in WPWS along with geographically expanded monitoring of sea otter P450 levels, and estimates of survival and foraging energetics will be valuable in (1) providing insight into potential demographic constraints to recovery which may improve future recovery models, (2) documenting actual recovery time for the nearshore system including sea otters, (3) evaluating the extent to which continued exposure may be constraining sea otter recovery, and (4) providing long-term population trend data which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills.

Harlequin Ducks

This proposed work represents a relatively simple, workable approach to the long-term monitoring of harlequin duck populations that will allow us to assess recovery from the spill. This study is directly linked to the recovery objectives for harlequin ducks in the EVOS Restoration Plan (Exxon Valdez Oil Spill Trustee Council 1996). As written in the plan, harlequin duck restoration and recovery requires assessment of population densities, production, and population age- and sex structure while taking into account geographic differences. As proposed, this project will provide this information as well as provide insight into understanding factors affecting population dynamics and inhibiting recovery.

When we began this study, the existing information we inherited from post-spill studies concluded that there were population declines during the breeding season, a declining trend in the molting population, and very poor production of young in western PWS. We designed a monitoring plan that would build on this information and address the recovery objectives in the 1994 EVOS Restoration Plan. As a result of our early findings the Recovery Objectives in the Restoration Plan were modified in 1996 to: "Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway". We have made great progress toward understanding the life history of harlequin ducks and our past monitoring efforts have shown similar age- and sex-structure in oiled and unoiled areas. Harlequin ducks are in a position to recover but are not recovering. We have designed a survey that has the power to detect trends in oiled populations, give us valuable information on population demographics, and possibly shed insight into geographic differences within PWS.

Focus on these population parameters is necessary to determine the status and recovery potential of harlequin ducks; determine if recovery objectives are being met; and suggest factors limiting recovery. The proposed monitoring effort will also allow us to modify recovery objectives, as new information becomes available. This will provide a more reliable basis for restoration planning and be consistent with an adaptive management approach that allows more efficient allocation of efforts and enrichment of knowledge over time (e.g. for a long-term monitoring program). A continued decline in harlequin duck populations in western Prince William Sound may lead to a significant reduction or loss of this resource from the area and beyond. It is important to know if populations are continuing to decline, and if so, understand the factors responsible for limiting recovery.

Populations are declining in oiled areas. It takes a minimum of three years before population trends can be determined. Lack of good prespill data and our review of USFWS surveys preclude pre- and postspill population comparisons as proposed by the Recovery Plans. Long-term monitoring is the most straightforward approach to determining recovery. Therefore, monitoring should begin as soon as possible. Annual monitoring is proposed. Populations may vary considerably from year to year. Detecting upward or downward trends in abundance and productivity from year to year variations will be met sooner with increased sampling. Results of this work will have a direct bearing on assessing the status and outlook for this resource and guide agency programs and policies related to public uses, especially subsistence and recreational hunting, land-use practices, and wildlife viewing.

C. Location

Studies will be conducted in PWS (with the exception of CYP1A sampling, see below). Specific study sites for some components will be those used in previous and ongoing Trustee-sponsored research and monitoring programs to capitalize on previously collected data and populations of marked individuals. For evaluation of CYP1A levels, expansion to areas outside the Sound (sampling sea otters captured as part of other, non-EVOS studies) will provide information on the scale and significance of previously documented differences between oiled and unoiled sites within PWS.

The proposed harlequin duck monitoring component will be conducted in the oil spill area of western Prince William Sound and unoiled eastern PWS between Valdez and Cordova and northern Montague Island. Survey sites in PWS will be located in the same areas used for the harlequin duck component of project \025 Nearshore Vertebrate Predator Project and project \427 Harlequin Duck Recovery Monitoring (Rosenberg and Petrula 1998, in prep.), with some additional sites in southwestern PWS. Surveys in the spill area will focus on Knight Island, Applegate Island, Foul Bay, Main Bay, Eshamy Bay, Crafton Island, Chenega Island, Green Island, Naked Island, and Bainbridge, Evans, and LaTouche islands in southwestern PWS. Surveys in non-oiled areas will include portions of Hinchinbrook Island, Simpson Bay, Sheep Bay, Port Gravina, Landlocked Bay, Bligh and Busby islands, Galena Bay and Valdez Arm, and Montague Island.

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

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The project will continue to inform and coordinate our community involvement activities, including the collection of indigenous knowledge with Dr. Henry Huntington, TEK specialist Chugach Regional Resources Commission and Hugh Short, Community Coordinator, EVOS Restoration Office. We will continue to solicit advice from the above parties and gather information on TEK through synthesis workshops, local community facilitators, and residents. Traditional ecological knowledge has been solicited is currently an ongoing part of project -427, Harlequin Duck Recovery Monitoring.

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

PROJECT DESIGN

A. Objectives

Sea Otters

1. A. Compare estimates of sea otter abundance and population trends over time and between oiled and unoiled areas within WPWS.

   B. Estimate abundance and size class composition of key sea otter prey in oiled and unoiled study sites.

2. A. Establish baseline values and assess variability of expression of CYP1A in sea otters, using RT-PCR assay.

   B. Measure CYP1A levels in sea otters with known exposure to oil and known tissue hydrocarbon levels.

3. A. Compare adult female survival between oiled and unoiled areas within WPWS.

   B. Compare adult female activity-time budgets and dive attributes between oiled and unoiled areas within WPWS.

Harlequin Ducks USGS-BRD

1. Compare harlequin duck population structure and numbers between oiled and unoiled areas within and among years.

2. Estimate critical demographic parameters, including: survival, immigration and emigration, and recruitment of harlequin ducks.

3. Quantify the relationships between oiling and demographic parameters.

4. Derive a population model that identifies critical demographic parameters and predicts population trends and recovery times.

Harlequin Ducks ADFG

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

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

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

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

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

B. Methods

Sea Otters

Sea otter population monitoring--We will continue to use previously developed aerial survey techniques which employ counts along systematic transects, and intensive search units (ISU's) to estimate a correction factor for each survey (Bodkin and Udevitz, in press). We will conduct a single survey of the entire WPWS every two years beginning in 2000, and continue annual replicate surveys (5 replications per survey) of the smaller NVP study sites, beginning in 1999. Alternate year, Sound-wide surveys do not diminish our power to detect population changes in the greater WPWS area. However, increasing replicate survey intervals for the smaller NVP study areas greatly reduces our power to detect changes. It may require 8 years of annual replicate surveys (ie., 4 additional years beginning in 1999) to provide adequate power to detect a minimum of a 6% annual increase. The time required to detect this same change may extend to 12 years if the survey interval is increased to every two years (3 additional surveys).

Invertebrate prey population monitoring--In 1999, we will focus on sampling intertidal populations of three important sea otter prey, green sea urchins (*Strongylocentrotus drobachiensis*), littleneck clams (*Protothaca staminea*), and mussels (*Mytilus trossulus*). We selected these species because they are preferred sea otter prey and have populations that are centered in the intertidal zone and can therefore be sampled efficiently, providing adequate power to detect change.

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

Recovery of sea otter populations will be assessed by comparing the size distributions and biomass of prey at Knight Island vs. Montague Island. A lack of significant differences between oiled and reference (nonoiled) sites would be indicative of recovery. The data from 1999 will be combined with similar data from 1996-1998 to assess possible trends in recovery, as indicated by converging size distributions and abundances at the two sites.

Cytochrome P450 1A--In the NVP study, Dr. Paul Snyder at Purdue University applied the RT-PCR assay (quantitative reverse transcriptase PCR assay; Van den Heuvel et al. 1993) to sea otters for measurement of CYP1A. This assay quantifies the messenger RNA (m-RNA) that codes for the CYP1A protein. Initially, the RT-PCR assays required the isolation, cloning and sequencing of the PCR product, and the development of sea otter specific primers for CYP1A

(Holland-Bartels et al. 1998; Snyder et al. unpubl.); that work is now complete. Results of the assay are reported as the number of copies of mRNA per cell for cells isolated from individual otters. To date, we have used blood lymphocytes (peripheral blood mononuclear cells) collected from live otters for the assay.

We will continue to use RT-PCR to quantify the number of copies of m-RNA in blood lymphocytes collected from live sea otters. Otters will be captured and sedated, and blood collected by jugular venipuncture. The peripheral blood lymphocytes will be isolated by a ficoll gradient technique, cryopreserved in liquid nitrogen and shipped to Dr. Snyder for analyses.

Sea otters will be captured and sampled in two locations outside PWS: (1) southeast Alaska, a relatively clean area (n=20), and (2) California, a relatively contaminated area (n=20). These capture operations are part of ongoing research projects not related to the EVOS, and costs for capture are not included in this proposal. Sea otters will also be captured in PWS: (1) in north-west PWS, in the vicinity of Port Wells (n=20), an area with high sea otter densities and considered to be relatively clean of environmental contaminants, and (2) in oiled and nonoiled areas of WPWS, as part of the proposed adult female survival study (n=40 in 1999; see below).

An additional element of the cytochrome P450 component will be RT-PCR quantification of CYP1A in frozen liver samples, archived from 1989. These samples were collected from sea otters that died subsequent to the spill, and time of death and extent of oiling on the pelage are known. Many of these otters were exposed to large quantities of oil, and we anticipate CYP1A levels could be markedly elevated. Further, concentrations of hydrocarbons have been measured on aliquots of the same samples (Ballachey and Kloecker 1997a, b), and in many cases (where otters were heavily oiled), concentrations were well above method detection limits. We propose to analyze 20 liver samples, including samples from both heavily oiled sea otters from PWS, and from sea otters in southeast Alaska, not exposed to oil. In contrast to other sea otter components, the CYP1A work is scheduled primarily for FY99 and FY00.

Adult female survival--We will use established methods to capture and surgically instrument adult females with radio telemetry transmitters (Ralls et al. 1989). Eighty female sea otters (40 each in the oiled and reference sites) will be instrumented over 2 years (20 in each area each year). This should allow detection of a 10% difference in survival rates (1- >0.70) over 3 years. Radio transmitters (ATS Inc., Isanti, MN) will include mortality switches to increase the probability of early detection and recovery of dead otters. In addition, we will mark captured otters with a unique combination of colored plastic tags (Temple Tags, Temple, TX) attached to the hind flippers for visual identification. Mass, length and girth will be measured as an index of condition, and blood collected for CYP1A analyses. We will also extract a pre-molar tooth for age estimation (Bodkin et al. 1997).

We will attempt to obtain bi-weekly relocations of instrumented individuals, and record location, and reproductive status (with/without a pup). If mortalities occur, the carcass will be collected, and if fresh, a necropsy performed by a certified veterinary pathologist.

Foraging energetics--At the time sea otters are captured for radio instrumentation, they will be equipped with an implantable time-depth recorder (TDR). TDR's (Wildlife Computers, Woodinville, WA) have 2MB of memory equaling more than 2220 hours of continuous depth

data at 4 second intervals and can store data for up to 10 years. We will program the units to duty cycle for 7 days each month which will allow sampling of activity and dive data over the entire year. The TDR's require recapture and removal to download the data. Therefore, we will recapture instrumented otters in year 2 following initial capture with the intent of recovering 30% of the units after one year's deployment. Field work in year 3 of the study will concentrate on recapture and collection of remaining TDR's.

During the first two summer field seasons we will attempt to obtain forage observations on marked individuals during the active TDR cycle times for each individual (cycle times may be staggered such that some TDR's will always be active). Concurrent observational and TDR data will maximize our ability to correlate foraging activity and dive attributes. During forage observations we will record time, location, and reproductive status of the individual along with dive times, surface times, and number, size and type of prey retrieved.

Harlequin Ducks

Survival Estimates--Measuring survival requires capture of birds. Harlequin ducks, like nearly all Anatids, molt their wing feathers (primaries and secondaries) simultaneously, rendering them flightless. During the molt, harlequin ducks congregate and are susceptible to capture by herding flocks of flightless birds into pens. This method will be employed to capture harlequin ducks for this study. Capture methods follow those used successfully by researchers in British Columbia and Washington, and by the Nearshore Vertebrate Predator project (Clarkson and Goudie 1994). Sea kayaks will be used to slowly herd molting flocks towards a trap. The trap consists of two 100' wings which lead birds into a holding pen in shallow water. The trap location will be noted daily on marine navigation charts.

Captured harlequin ducks will be removed from the trap, placed in holding pens, and transported by boat to the main vessel for processing. Birds will be banded with USFWS aluminum bands and with individually coded plastic tarsus bands. Sex will be identified based on plumage characteristics and age will be determined by bursal probing (Mather and Esler, unpubl. ms). Body condition of all radioed birds will be estimated using condition indices derived as part of the NVP project. Diagonal tarsus length and culmen length will be measured to the nearest 0.1 mm using digital calipers. Using a wing board, we will measure, to the nearest mm, wing length from the wrist notch to the end of ninth and tenth primaries, length of the ninth and tenth primaries from their intersection with the wing, and wing stub, the distance from the wrist notch to the end of the wing flesh. The status of the wing, i.e., whether it is a molting wing, old wing, or fully formed new wing, will be recorded to ensure that only molting birds are used in analyses. Body mass will be measured on an electronic balance to the nearest gram. Mark and recapture data will be analyzed to estimate annual survival rates (Lebreton et al. 1992) by age and sex cohort and by area.

March Population Demographic Surveys

This study will test the following hypotheses:

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

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

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

2. Objective 2. No hypothesis is being tested.

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

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

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

4. Objective 4.

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

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

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

4. Objective 5. No hypothesis is being tested.

Surveys will be conducted in representative portions of oiled areas in western PWS and unoiled areas in eastern PWS. FY 95-97 survey routes will be repeated (Rosenberg and Petrula 1997). Surveys will be conducted from approximately March 8 through 20. Repeat surveys will not be conducted and surveys in oiled and unoiled areas will not be conducted simultaneously because population flux is expected to be minimal at this time of year. New surveys will be established in areas with known concentrations of birds. All harlequin ducks will be recorded along each survey

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

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

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

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

C. Cooperating Agencies, Contracts, and Other Agency Assistance

USGS personnel, led by Jim Bodkin and assisted by Brenda Ballachey and Daniel Monson, will be responsible for aerial surveys, capture and handling of sea otters for sample collection and instrumentation, radiotracking, foraging observations, and interactions with Dr. T. Dean on monitoring of invertebrate prey.

USGS personnel, led by Dan Esler, will be responsible for annual capture of molting harlequin ducks, assessment of survival, and derivation of population models.

Alaska Department of Fish and Game personnel, led by Dan Rosenberg, will be responsible for March surveys of harlequin duck population numbers and structure.

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

Collaboration with Purdue University (Dr. Paul Snyder, School of Veterinary Medicine) for assays to measure CYP1A; data analysis and interpretation.

Boat charter and air charter services will be contracted to the private sector, usually from the local Prince William Sound region.

SCHEDULE

A. Measurable Project Tasks for FY 99

B.

Sea Otters

Winter 98-99	Collect southeast AK liver samples, CYP1A analyses
June - August	Sea otter capture and instrumentation, aerial survey, prey monitoring
August - October	Foraging observations of instrumented otters
Sept - October	Collect PWS liver samples

Harlequin Ducks

December 1998	Project start-up. Interagency coordination. Plan logistics and personnel for winter surveys. Contract for vessel support.
Jan. –Feb. 1999	Initiate hiring process for seasonal technicians. Prepare field equipment. Finalize field logistics.
March 1999	Conduct winter surveys in PWS. Attend 10th Anniversary Symposium.
August -September	Mark/recapture for survival estimation
April – June 1999	Create databases, GIS. Analyze field data and begin report preparation.
April 2000	Annual Report submitted

B. Project Milestones and Endpoints

Sea Otters

FY00

CYP1A work will be completed.
Capture and instrumentation will be completed.

FY00 - 02

Conduct all other proposed objectives annually.

Harlequin Ducks

FY99

October-February:	Coordinate and plan surveys, community involvement, prepare equipment.
March:	Conduct population surveys
August –September	Mark/recapture for survival estimation
April-September:	Data analysis and report preparation. Coordinate with local communities.

FY00

October-February:	Coordinate and plan surveys, community involvement, prepare equipment.
March:	Conduct population surveys
August –September	Mark/recapture for survival estimation
April-September:	Data analysis and report preparation. Coordinate with local communities.
April 15:	Submit annual report.

FY01

October-February:	Coordinate and plan surveys, community involvement, prepare equipment.
March:	Conduct population surveys
August –September	Mark/recapture for survival estimation
April-September:	Data analysis and report preparation. Coordinate with local communities.
April 15:	Submit annual report.

FY02

October-February:	Coordinate and plan surveys, community involvement, prepare equipment.
March:	Conduct population surveys
August –September	Mark/recapture for survival estimation
April-September:	Data analysis and report preparation. Coordinate with local communities.
April 15:	Submit annual report and manuscripts for publication.

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

C. Completion Date

All project objectives will be met following FY02.

Under present guidelines, Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to estimated prespill levels. A normal population age- and sex-structure and reproductive success, accounting for geographic differences, will

indicate recovery is underway (Exxon Valdez Oil Spill Trustee Council 1996). This project will compare harlequin duck population structure and abundance between oiled and unoiled areas and within geographic areas. This study will be completed when oiled and unoiled populations exhibit similar structure and population trends (accounting for geographic differences) and the oiled population is no longer declining. Until further information is gathered it will not be possible to predict when densities and reproductive effort will return to prespill levels or similar population structure and behavior is attained. This project may also suggest changes to the Recovery Objectives.

PUBLICATIONS AND REPORTS

Annual reports will be presented to the Chief Scientist by April 15. An annual report of FY99 activities will be submitted to the Restoration Office before 15 April 2000. A final report will be prepared at the end of the proposed monitoring schedule unless continued monitoring is warranted or when recovery objectives are met. Special reports (publications) will be prepared during the course of the study if warranted. Publications will be prepared for peer-review journals when sufficient data has been collected to warrant manuscript preparation. Because FY99 is the first year of this project, journal publications will not be generated until later years.

PROFESSIONAL CONFERENCES

None in FY99.

NORMAL AGENCY MANAGEMENT

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

As described in the Introduction, this research relies on incorporation of data from other Trustee sponsored research, including projects /427. /161, and /025. Equipment purchased under those projects will be used to conduct the proposed research and data collection and analysis will follow previously established standards.

PROPOSED PRINCIPAL INVESTIGATORS

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

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

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

OTHER KEY PERSONNEL

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

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

Dan Monson
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, Alaska 99503
PHONE: (907) 786-3449
FAX: (907) 786-3636
daniel_monson@usgs.gov

Paul Snyder
Purdue University
Department of Veterinary Pathology
1243 Veterinary Pathology Building
West Lafayette, IN 47907
PHONE: (317) 494-9676
FAX: (317) 494-9830

Mike Petrula
Alaska Department of Fish and Game
333 Raspberry Rd.
Anchorage, AK 99518
PHONE: (907) 267-2159
FAX: (907) 267-2433
mikep@fishgame.state.ak.us

PERSONNEL QUALIFICATIONS

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

Dan Esler is a Research Wildlife Biologist with the Alaska Science Center, USGS Biological Resources Division. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 9 years. Since 1995 he has served as project leader for harlequin duck studies as part of the Trustee sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A & M University in 1988 and is currently enrolled as a doctoral candidate at Oregon State University. He has 11 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird conservation.

Dan Rosenberg has been a waterfowl biologist for The Alaska Department of Fish and Game (ADF&G) since 1985. From 1980-1983 Mr. Rosenberg conducted field research in Alaska as a waterfowl biologist for the U.S. Fish and Wildlife Service and from 1983-1984 as a Habitat

Biologist for ADF&G. Mr. Rosenberg received a Bachelor of Science degree in Wildlife Management from Humboldt State University, Arcata, CA in 1979.

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

Brenda Ballachey is a Research Physiologist at the Alaska Science Center of USGS, Biological Resources Division. She was Project Leader for sea otter NRDA studies from 1990 through 1996, and has been involved in all aspects of post-spill research on sea otters. She has authored or coauthored over 40 journal articles and technical reports. She earned a M.S. in 1980 from Colorado State University, and a Ph.D. in 1985 from Oregon State University.

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

Daniel Monson is a Research Wildlife Biologist at the Alaska Science Center of USGS, Biological Resources Division, with over 10 years of experience in sea otter research in Alaska and California. He earned a M.S. from the University of California at Santa Cruz in 1995.

Paul Snyder is an Assistant Professor of Pathology and Immunotoxicology and Director of the Clinical Immunology laboratory of the Department of Veterinary Pathology, Purdue University. He is also Diplomate of the American College of Veterinary Pathologists. His research interests are in the area of mechanism based studies on the pathology and immunology of xenobiotics on biological systems. He has an NIH-funded project related to the immunobiology of environmental contaminants.

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

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APPENDIX I

Breakdown of budgets (in thousands of dollars) by species, objective, and fiscal year.

	FY99	FY00	FY01	FY02
Sea Otters				
Population and Invertebrate Monitoring	105.9	105.9	105.9	105.9
CYP1A Assessment	60.0	54.0	21.0	0.0
Survival/Forage Energetics	162.3	171.3	108.2	63.6
SEA OTTER TOTAL	328.2	331.1	235.1	169.5
Harlequin Ducks				
Population Monitoring (ADFG)	52.0	53.0	57.0	57.0
Survival Estimation (BRD)	62.3	65.3	65.3	64.3
HARLEQUIN DUCK TOTAL	114.3	118.3	122.3	121.3
General Administration				
DOI-BRD	28.5	28.5	21.9	17.0
ADFG	6.0	7.0	8.0	8.0
TOTAL	477.0	484.9	387.3	315.8

APPENDIX II

Comparison of ADF&G and USF&WS Harlequin Duck Surveys

The U.S Fish and Wildlife Service (USFWS) conducted shoreline and offshore surveys of all marine birds in Prince William Sound, Alaska during March and July in most years from 1989 through 1998 (EVOS project /159). We compared USFWS harlequin duck survey data from 1989 through 1996 (Agler and Kendall 1997) with our survey data (EVOS project /427) from 1995 through 1997 (Rosenberg and Petrula 1998 in prep.). Because harlequin ducks utilize shoreline habitats, we excluded offshore transects surveyed by the USFWS from our comparisons.

We thank the USFWS for providing their survey data. We have not provided them the courtesy of reviewing this proposal prior to submission to the EVOS Trustee Council, because of insufficient time before the proposal deadline. We will present it to them for review and comment. They employ a different survey design and analytical techniques, based on different goals and objectives. The following discussion is intended to compare harlequin duck survey techniques employed in EVOS studies in order to find the best method to assess the recovery of this injured resource and clarify some of the uncertainty surrounding the current status of harlequin ducks in PWS.

Comparison of Results

Comparisons of ADF&G and USFWS survey coverage for July and March survey periods in PWS are presented in Table 1. The USFWS surveyed approximately 50% 50% less shorline in March then they surveyed in July. ADF&G surveys cover less shoreline, but we survey identical transects during fall (July) and winter (March). Compared to USFWS surveys, our shoreline coverage is divided more evenly between oiled and unoiled areas. We surveyed during 3 periods in the fall (July, August, September). Our first fall survey (late July) is conducted at approximately the same time as the USFWS July survey. These surveys coincide with molting and brood rearing. We conducted only one winter survey (March 1997).

ADF&G transects in oiled areas are centrally located in western PWS (WPWS) while those in unoiled eastern PWS (EPWS) extend from Valdez to Cordova and include Hinchinbrook Island. Areas of overlap exist between ours and USFWS surveys, however, unlike the USFWS, we do not survey in unoiled areas of northwestern PWS or oiled areas of southwestern PWS. Unlike the USFWS, we did not differentiate between partially oiled and oiled sites when selecting our transect locations. If any portion of a transect was oiled, we considered the entire transect as oiled. USFWS survey techniques are presented in Agler and Kendall (1997).

Comparisons of ADF&G and USFWS survey results for July and March survey periods are presented in Table 2. ADF&G surveys had higher densities of harlequin ducks. With few exceptions, transects were located in habitat that supported relatively high densities of harlequin ducks. Ducks were more equally distributed between oiled and unoiled survey areas for ADF&G surveys than for USFWS surveys.

Comparison of USFWS July survey with ADF&G Fall Surveys

We compared results of July surveys conducted by the USFWS for transects located in western and eastern PWS with results of our surveys for the same time and general survey area (Table 3). We selected all USFWS transects within ADF&G's survey regions for EPWS and WPWS. Shoreline coverage overlapped for some transects. Again, ADF&G selected transects in habitats with greater densities of harlequin ducks. Harlequin duck densities were almost 2.5 times greater on ADF&G's unoiled transects and over 5 times as great for our oiled transects.

Table 1. Comparisons of ADF&G and USFWS survey coverage for harlequin ducks during July and March survey periods in Prince William Sound.

Treatment	Length Shoreline Surveyed (km)[1]		% of Survey Within Treatment		No. Surveys/Year		No. Years Surveyed	
	July	March	July	March	July	March	July	March
USFWS Marine Bird Surveys								
Oiled	355	186	31	31	1	1	5	5
Unoiled	689	360	63	63	1	1	5	5
Partially Oiled	67	34	6	6	1	1	5	5
Total	1111	580	100	100	1	1	5	5
ADF&G Harlequin Duck Recovery Monitoring								
Oiled	302	302	54	54	1	1	3	1
Unoiled	257	257	46	46	1	1	3	1
Partially Oiled	0	0	0	0	0	0	0	0
Total	559	559	100	100	1	1	3	1

1. USFWS census plots (area) were converted to linear shoreline length.

Table 2. Comparisons of the number, density, and location by treatment (oiled and unoiled areas) of harlequin ducks during July and March for ADF&G and USFWS surveys in PWS.

Treatment	No. Ducks (All Surveys and Years)		Average Density/Survey (Ducks/km)		% of Ducks within Treatment	
	July	March	July	March	July	March
USFWS Marine Bird Surveys						
Oiled	1,838	2,501	1.04	2.69	18	26
Unoiled	8,170	6,157	2.37	3.42	80	64
Partially Oiled	205	962	0.62	5.66	2	10
Total	10,213	9,621	1.84	3.32	100	100
Annual Range	982-2707	1410-2402	-----	-----	-----	-----
ADF&G Harlequin Duck Recovery Monitoring						
Oiled	2,637	1,677	2.92	5.60	41	59
Unoiled	3,812	1,183	4.91	4.90	59	41
Partially Oiled	0	0	0	0	0	0
Total	6,449	2,860	3.85	5.12	100	100
Annual Range	808-1,338	1,183-1,677	-----	-----	-----	-----

To compare data collected by ADF&G and USFWS, we performed similar trend analysis on both data sets (Table 4). Within a study, transects that were in close proximity were combined to form a region. Density of harlequin duck was regressed against year to generate separate slopes for each treatment group, region, and study. Regional estimates were weighted (based on total number of ducks counted in the region for all years of the study) and combined to estimate the mean slope for each treatment group within each study. A 2-sample t-test was used to test for differences in the rate of change in duck density for USFWS survey data and for our survey data. The power of the test was then calculated for several levels of difference in slopes between oiled and unoiled areas for each study.

Table 3. Comparison of results of ADF&G and USFWS July surveys within coincidental geographic areas for EPWS and WPWS.[1]

Treatment	Total Ducks -All Surveys and Years (Range/Year)	Shoreline Length Surveyed (km/year)	Average Density/Survey (Ducks/km)
USFWS Marine Bird Surveys			
WPWS	959(120-261)	335	0.57
EPWS	2,424 (298-710)	242	2.00
ADF&G Harlequin Duck Recovery Monitoring			
WPWS	2,637 (808-938)	301	2.92
EPWS	3,812 (1210-1338)	258	4.91

1. 22% of USFWS transects are within the boundaries of ADF&G's EPWS (unoiled) Study Area and represent 24% of the ducks observed by USFWS. 33% of USFWS transects are within the boundaries of ADF&G's WPWS (oiled) Study Area and represent 10% of the ducks observed by USFWS.

Table 4. Comparison of ADF&G fall surveys (July, August, and September) with USFWS July surveys for harlequin ducks in oiled and unoiled areas in Prince William Sound following the Exxon Valdez Oil Spill.

	ADF&G		USFWS	
TEST	**OILED**	**UNOILED**	**OILED**	**UNOILED**
Slope (ducks/km/yr.)	-(0.6411)	0.2476	0.1325	0.2753
Standard Error	0.258	0.165	0.0698	0.084
Significant Trend (alpha=.05)?	Yes	No	No	Yes
Difference in slopes?	**Yes** (p=0.006)		No (p=0.238)	
Power of Test (alpha=.05)	0.803		0.189	

Trend analysis for eastern PWS (unoiled), using ADF&G survey data indicates that the harlequin duck population in this region has remained stable. Survey data from the USFWS for EPWS generated a similar slope of 0.2753 ducks/km/year (S.E. = 0.084), however, a significant increasing trend was detected. For western PWS, our survey data suggests that the harlequin population is decreasing (slope = -0.6411, S.E. = 0.258). Survey data from the USFWS for WPWS detected no trend, therefore, no density change was detected for harlequin ducks in oiled areas when analyzing USFWS survey data. Based on a 2-sample *t*-statistic, the slopes generated from our survey data for western and eastern PWS were significantly different (p = 0.006) with an observed power of our test at 0.803 (alpha=.05). For USFWS data, we found no significant difference between slopes in western and eastern PWS (p=0.238) with an observed power of 0.189 (alpha=.05).

We also analyzed the entire data set for USFWS July surveys using the same analytical technique (Table 5). The power of the USFWS surveys is low.

Table 5. Trend analysis comparing all USFWS July surveys for harlequin ducks in oiled and unoiled areas in Prince William Sound following the *Exxon Valdez* Oil Spill.

	USFWS	
TEST	**OILED**	**UNOILED**
Slope (ducks/km/yr.)	0.027	0.316
Standard Error	0.760	0.142
Significant Trend (alpha=.05)?	No	Yes
Difference in slopes?	No (p=0.723)	
Power of Test (alpha=.05)	0.056	

USFWS March Surveys

ADF&G has conducted only one March survey so trends and power analysis cannot be compared with USFWS results. Using the same methods described above for July surveys, we calculated the slopes and power of the USFWS March survey data. The USFWS surveys just 184 km of oiled shoreline in March (Table 1). Twenty-six percent of the ducks counted were in oiled transects (Table 2). Slightly over 20% of the ducks counted by the USFWS on these oiled transects were observed on Montague Island. Montague Island is used as an unoiled control site by other EVOS projects.

The USFWS surveys report little observed difference between slopes for oiled and unoiled transects (Table 6). This little difference in slopes results in low power for this test. We believe this small observable difference is because relatively few ducks occur in their oiled transects.

Table 6. Trend analysis comparing USFWS March surveys for harlequin ducks in oiled and unoiled areas in Prince William Sound following the *Exxon Valdez* Oil Spill.

	USFWS	
TEST	**OILED**	**UNOILED**
Slope (ducks/km/yr.)	0.393	0.415
Standard Error	0.067	0.097
Significant Trend (alpha=.05)?	**Yes**	**Yes**
Difference in slopes?	No (p=0.853)	
Power of Test (alpha=.05)	0.052	

Why the Disparity?

The disparate findings of the two surveys result from the following: 1) differences in the allocation of survey effort among oiled and unoiled areas; and, 2) at least for western PWS, the failure of random multi-species surveys to obtain sufficient sample size for species that exhibit a patchy rather than uniform distribution.

The allocation of the USFWS's survey effort in unoiled areas (63%) is twice as large as it is for oiled areas (31%), however, the relative abundance of ducks counted on unoiled transects exceeds that in oiled transects by fourfold in July and threefold in March. (Tables 1 and 2). The USFWS has relatively few plots in oiled areas. These plots are located in marginal or poor harlequin duck habitat where we would only expect to see small changes in density. Many transects contained no or very few ducks. Because they are usually counting low numbers of ducks, they generally detect little variation between annual surveys. Surveying in areas of low density yields poor power and an inability to detect these small changes in population density.

Our survey effort is similarly distributed between eastern and western PWS and is allocated in approximate proportion to the relative abundance of ducks observed in each area (Table 1). Comparing similar geographic areas, shoreline surveyed by the USFWS, within ADF&G's eastern PWS study area, comprised 22% of their total unoiled survey coverage and accounted for a similar proportion of the total ducks (24%). In contrast, for USFWS transects in western PWS within our study area, shoreline surveyed by the USFWS comprised 33% of their total survey coverage, but only accounted for 10% of their total number of harlequin ducks. This indicates that low-density (marginal habitat) areas are being surveyed.

This is especially critical when using this survey to measure recovery. The potential for densities to increase in marginal habitat is very limited, as there were likely no or few ducks there prior to the spill and it will be the last habitat to exhibit an increase (or decrease) if change occurs. Theoretically, with a tighter SE, the USFWS does not need to observe as big a change as we must observe. However, if ducks

are injured, the greatest injury, and eventual recovery, will occur in primary habitat. If they are looking in poor or marginal habitat they won't detect that change. The apparent differences in slopes they report between oiled and unoiled sites are attributed to a small sample size due to insufficient survey coverage in the oiled areas. Their two data sets cannot be adequately compared for July or March surveys.

In EPWS (unoiled) the ADF&G and USFWS surveys have similar slopes because here, the USFWS sampled sufficient shoreline to record enough ducks. This is due to their more extensive survey coverage in EPWS. Here, they include better habitat or observe more ducks through sheer "volume" (more km of transects). The EPWS surveys are more representative of good harlequin habitat which, in turn, is represented by no trend differences in our two data sets.

The difference between slopes in eastern and western PWS is much larger for our survey data and based on a substantially larger number of ducks. The relatively larger difference between slopes is, for the most part, why we have greater power to detect differences between locations. We believe that the number of harlequin ducks sampled by the USFWS in oiled areas of western PWS are insufficient to predict population trends and explains why variability during their surveys is lower. A species-specific survey conducted in high-density areas over consecutive years is more likely to generate meaningful trend data.

Summary of Comparisons

USFWS employed random surveys. For a species like harlequin ducks, that have a clumped distribution, it requires intensive surveying to get a sufficient sample size in marginal habitat. Without sufficient survey coverage in oiled areas, they observed a very small percentage of birds, because a very high percentage of transects were located in poor or marginal harlequin duck habitat. Thus, effective sample size was low, translating into low power and inability to detect a change.

The ADF&G harlequin duck surveys have much better ability to detect differences in slopes (population trends) between oiled and unoiled locations in PWS. Biologically, this is because harlequin ducks are not uniformly distributed throughout PWS, but have a patchy distribution, which concentrates relatively large numbers of birds in relatively few areas of suitable habitat. We designed our surveys to include sites that supported high densities of harlequin ducks. This gives us a more powerful data set that puts us in a better position to measure recovery.

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999	PROPOSED FY 1999 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$58.0			$419.0	
Personnel	$0.0	$139.7						
Travel	$0.0	$17.5						
Contractual	$0.0	$193.4						
Commodities	$0.0	$91.9						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$442.5		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration	$0.0	$34.5						
Project Total	$0.0	$477.0		$484.9	$387.3	$315.8		
Full-time Equivalents (FTE)	0.0	3.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0		

Comments:

1999

Prepared: 1 of 9

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: USGS-DOI

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

4/15/98

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$32.8
Travel		$1.3
Contractual		$15.6
Commodities		$2.3
Equipment		$0.0
Subtotal	$0.0	$52.0
General Administration		$6.0
Project Total	$0.0	$58.0
Full-time Equivalents (FTE)		0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$60.0	$65.0	$65.0		

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Prepared: 2 of 9

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/15/98

1998 EXXON VALDEZ TRUST 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
D. Rosenberg	WBIII, Principle Investigator	18J	1.5	6.5		9.8
Mike Petrula	WBI, survey and data analysis	14C	2.5	4.2	2.0	12.5
Dave Crowley	WBI, survey	14D	0.5	4.3	1.0	3.2
C. Barnhill	Cartographer II	16L	0.5	5.2		2.6
1 F&G Tech.	F&G Tech. III, Field Technician	11F	1.0	3.7	1.0	4.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		6.0	23.9	4.0	
					Personnel Total	$32.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Portage-Whittier Alaska Railroad vehicle,boat, and 1 psng.	0.4	1			0.4
Portage-Whittier Alaska Railroad vehicle and psng.	0.2	2			0.4
Portage-Whittier Alaska Railroad Psg. fare	0.1	1			0.1
Per diem Whittier			4	0.1	0.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.3

1999

Prepared: 3 of 9

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

4/15/98

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

Contractual Costs:	Proposed
Description	FY 1999
Boat and outboard motor repair and maintenance	1.0
Photo processing, Workshop presentation productions	0.3
Air charter for field support 4 hrs @ $250/hr	1.0
Trailer and boat moorage Whittier	0.1
Vessel support for surveys 12 days @1100/day	13.2
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$15.6

Commodities Costs:	Proposed
Description	FY 1999
Boat fuel 270 galllons @ $1.50/gal	0.4
Boat supplies- replacement parts, props, fuel lines, fuel filters, water filters, battery, absorbent rags, oil, emergency provisions	0.8
Field survey supplies- rite-in-rain notebooks/paper, nautical charts, batteries,	0.3
Computer software for analysis, graphing, mapping,	0.8
Commodities Total	$2.3

1999

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: ADFG

FORM 3B
Contractual & Commodities DETAIL

1998 EXXON VALDEZ TRUS[illegible]OUNCIL 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
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
20 ft. Caribe rigid hull inflatable	1	ADFG
17 ft. Boston Whaler	1	ADFG
10x40 binoculars	4	ADFG
Spotting Scopes	2	ADFG
Achilles 8 ft inflatable dinghy	2	ADFG
Remington Shotguns	2	ADFG
Survival Suits	2	ADFG
Outboard Motors/various hp	6	ADFG
Magellan GPS	3	ADFG
Marine VHF radios	4	ADFG

1999

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: ADFG

FORM 3B
Equipment
DETAIL

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$106.9
Travel		$16.2
Contractual		$177.8
Commodities		$89.6
Equipment		$0.0
Subtotal	$0.0	$390.5
General Administration		$28.5
Project Total	$0.0	$419.0
Full-time Equivalents (FTE)		2.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$424.9	$322.3	$250.8

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Prepared: 6 of 9

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: USGS-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/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Name	Position Description					
SO-B. Ballachey (P450)	Wildlife Biologist	GS12	4.0	5.3		21.2
SO-Biologist (Pop. Monitoring)	Wildlife Biologist	GS9	6.0	4.0		24.0
SO-Biologist (Surv./Forage)	Wildlife Biologist	GS9	6.0	4.0		24.0
SO-Technicians	Biological Technicians	GS5	7.0	2.6		18.2
HD-Technicians	Biological Technicians	GS5	7.5	2.6		19.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		30.5	18.5	0.0	
					Personnel Total	$106.9

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Description					
SO-Personnel to Whittier (12 Monitoring, 12 Surv./Forage)@$12					0.3
SO-Vehicles to Whittier (2 Monitoring, 2 Surv./Forage)	0.2	4			0.8
SO-Whaler to Whittier (1 Monitoring, 1 Surv./Forage)	0.5	2			1.0
SO-Personnel to Cordova (7 Monitoring, 5 P450, 15 Surv./Forage)	0.3	27			8.1
SO-Per Diem ($500 Monitoring, $500 P450, $1500 Surv./Forage)					2.5
SO-Personnel From Purdue	1.0	2			2.0
HD-Vehicles to Whittier	0.2	2			0.4
HD-Whaler to Whittier	0.5	1			0.5
HD-Per Diem					0.5
HD-Personnel to Whittier					0.1
					0.0
					0.0
				Travel Total	$16.2

1999

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: USGS-DOI

FORM 3B
Personnel & Travel DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
SO-Coastal Resources Associates (Monitoring)	57.3
SO-Air Charter (Monitoring)	16.0
SO-Vessel Charter (P450 and Surv./Forage)	18.0
SO-Purdue University (P450)	12.0
SO-Veterinarian Contract (Surv./Forage)	7.0
SO-Air Charter (Surv./Forage)	36.0
HD-Vessel Charter	31.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$177.8

Commodities Costs:	Proposed
Description	FY 1999
SO-Lab Materials ($1500 Monitoring, $3000 P450)	4.5
SO-Fuel ($1500 Monitoring, $3000 Surv./Forage)	4.5
SO-Radio Transmitters (Surv./Forage)	15.0
SO-Time/Depth Recorders (Surv./Forage)	48.0
SO-Miscellaneous ($2000 Monitoring, $2000 P450, $4000 Surv./Forage)	8.0
HD-Kayak Rental	1.8
HD-Trap Maintenance	1.3
HD-Whaler Maintenance	2.0
HD-Training	1.0
HD-Fuel	1.5
HD-Miscellaneous	2.0
Commodities Total	$89.6

1999

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: USGS-DOI

FORM 3B
Contractual & Commodities DETAIL

1998 EXXON VALDEZ TRUS OUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

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

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
This work relies on a large inventory of existing equipment, both from previous EVOSTC-funded research and USGS base research, including boats, motors, computers, capture gear, radio receivers, binoculars, radios, etc.		

1999

Project Number: 99426
Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators
Agency: USGS-DOI

FORM 3B
Equipment
DETAIL

Description of Rockfish Distribution and Habitat Preference Based on Underwater Video From Prince William Sound and Surrounding Areas

Project Number:	99425
Restoration Category:	Research
Proposer:	Audra L. J. Brase NMFS, Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice NOAA Program Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska Sea Life Center:	No
Duration:	1st year, 2-year project
Cost FY 99:	$36,900
Cost FY 00:	$36,900
Geographic Area:	No field work anticipated
Injured Resource/Service:	Rockfish species

ABSTRACT

Rockfish (Scorpaenidae) are one of the least understood commercially important species in Prince William Sound (PWS) due to their inaccessibility of their habitat. Submersible videotape exists from a 1989 *Exxon Valdez* oil spill (EVOS) damage assessment study and may be a valuable resource for understanding the ecology of rockfish and other demersal species. The videotape from the 1989 study has never been analyzed for the ecological information it may provide. This study will analyze the archived video tapes and accompanying data-sheets and produce a report on rockfish and other demersal species and their association and utilization of both substrate and epifauna.

INTRODUCTION

In the summer of 1989, in response to the concerns of fishermen that large amounts of oil had coated the bottom of PWS, a $300,000 submersible survey was undertaken in the oil spill area. The study confirmed that oil had not reached the bottom in visual quantities. The video tapes and data-sheets from those deep surveys were never analyzed for species distribution and habitat typing. This study proposes analyzing these data, comparing species and habitat parameters, and combining into a GIS database.

Although the data were collected in response to an oil threat, the analysis of these data may provide baseline data on species and habitat types, information useful in ecosystem management. A total of 64 dives were completed at 16 sites in PWS and 11 sites outside of PWS. The video transects, in depths of 0-350 meters, observed many species and habitat types. The most common species observed, using the forward camera, were searchers and shrimp (pink, spot, sidestripe). Many species of rockfish were observed (Pacific ocean perch, yellow-eye, dusky, harlequin, short-raker, widow, rose-thorn, tiger, rough-eye, and quill-back). There are scattered observations of juvenile rockfish, octopus, crabs, and other invertebrates. Habitat structures are also visible, including features such as sand, mud, boulders and macroalgae, as the second video camera was pointed straight down, to view the substrate. Other sampling methods would be superior for population estimates; nonetheless, these videos are unique, and will offer the chance to measure species interactions and use of specific substrates.

With the influx of boats and tourists when the Whittier road is completed, there may be considerable new fishing pressure on rockfish, particularly in the months when salmon are not abundant. Future ecosystem discussions will be inevitable for rockfish and their habitat; should there be protective closures, are there essential fish habitats that need protection. Given the general poor understanding of rockfish distribution, species composition, ecology, habitat requirements, and the unknown impacts from the spill —the resulting fish/habitat GIS information may prove to be valuable.

NEED FOR THE PROJECT

A. Statement of the Problem

In Prince William Sound, rockfish ecology is poorly understood and the impacts of fishing pressure unknown. Rockfish were injured by oil in PWS, however the level of impact was never fully documented. Direct toxicity did not seem likely, as large quantities of oil did not sink to normal rockfish depths. Following the spill there was increased commercial pressure on the PWS rockfish population. When the road opens to Whittier, rockfish and other deep species are likely to be impacted by increased fishing pressure coming with the influx of small boats, especially during the months of low salmon availability.

In Prince William Sound, like most areas of Alaska, the relationship of demersal fish species to substrate and epifauna is largely unknown. The analysis of this archival video data may increase our understanding of rockfish populations before the spill. The results of this analysis will

provide rare baseline deep water ecosystem data which may be used to develop strategies for managing species and habitat protections. This analysis will document species and habitats *in-situ* —information that could prove useful in understanding rockfish and their habitat requirements in future years.

B. Rationale

The original 1989 study contracted a submersible to make the observations, costing over $300,000. That study confirmed that oil had not reached the bottom in quantities that were visually observed, and no further analyses were conducted. Now, we propose to analyze these data of transects from inside and outside of PWS, to study the relationship between species and specific habitats. No new field work or charters would be conducted, only an in-depth analysis of the video tapes and dive data-sheets.

Analysis of the data would include identification of target species (fish and invertebrates), enumeration, and documentation of depth, temperature and all habitat structural features that are apparent from the dual camera angles. A report will be produced which will provide a general overview of rockfish distribution in relation to benthic and demersal features.

If appropriate, a proposed second year component will be performed in which these data would be entered into a GIS database and integrated with other PWS data-sets, analyzed on a spatial scale, and be available for other comparative measurements. These data will be useful to understand species and habitat relationships, identification of essential fish habitat, and in the future, may have an influence on ecosystem management issues.

C. Location

Submersible transects were followed throughout Prince William Sound, off of Kodiak Island, the Seward Peninsula, and the Alaska Peninsula. However no further field work is projected for this component of the study.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

No participation by residents of PWS is anticipated for this compilation and analysis study.

PROJECT DESIGN

A. Objectives

Year 1

1. Describe distribution and overlap of target species with depth and location.

2. Describe physical substrate structure associated with the target species.

3. Describe the epifauna structure (including macroalgae) associated with the target species.

4. Produce a database or other format compatible with ArcView GIS input.

5. Produce a synthesis report describing the ecological data from these data in terms of the Prince William Sound deepwater ecosystem.

Option Year 2

1. Input data into a graphical interface form utilizing GIS software.

2. Produce interactive GIS database.

3. Produce a final report summarizing the ecosystem data in terms of essential rockfish habitat.

B. Methods

Year 1

1. Preliminary examination of dive sheets to determine which dive videos contain the most valuable data.

2. Determine appropriate descriptions of various habitat types.

3. Review tapes, catalog fish species by habitat (macroalgae, substrate, temperature and depth).

4. Describe other biological observations (behavioral interactions, etc..).

5. Create a database including the above information.

Option Year 2

1. Enter into an ArcView GIS database.

2. Produce a public accessible data-set containing information on the distribution and abundance of rockfish species within PWS.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The first phase and proposed second phase of this study will include use of NOAA facilities, including use of computer hardware, software and audio-visual equipment.

SCHEDULE

A. Measurable Project Tasks for FY 98 (October 1, 1998-September 30, 1999)

Year 1

October 1998-March 1999: 1) Catalog data from videotapes.

	2) Produce a database compatible with ArcView GIS software. 3) Produce first year synthesis report describing the ecological data from these tapes in terms of the Prince William Sound deepwater ecosystem. In this report determine whether results from first year suggest continuance of second year.
March 1999:	EVOS Annual meeting, PI attend and present first year results in poster format.

Option Year 2

October, 1999-March 2000:	1) Input database into ArcView and produce interactive graphical representation of distribution of Rockfish and other demersal species within PWS. 2) Produce a public accessible data-set (via Internet or CD-ROM).
March, 2000:	Final Reports/ Products due.

B. Project Milestones and Endpoints

Year 1

Milestone:	Describing consistent habitat descriptions for targeted species.
Endpoint:	Producing usable database for GIS component. Produce first year synthesis report.

Option Year 2

Milestone:	Integrating database into ArcView GIS.
Endpoint:	Producing public accessible data-set.

C. Completion Date

For first year: March, 1999.
For option second year: March, 2000.

PUBLICATIONS AND REPORTS

Year 1

1) Analyze data from the video tapes and data-sheets (depths, substrate types, temperatures, fish species, etc..), develop a database compatible with an ArcView GIS system.

2) Prepare a synthesis report and/ or NOAA technical report describing the ecological data from these tapes in terms of the Prince William Sound deepwater ecosystem. Types of organisms and physical structure (fish, inverts, macroalgae, substrate types, temperatures) will be listed. Also

included in the report will be: overall frequency of occurrence of these fauna, frequency of occurrence by depth distributions and frequency of occurrence by substrate types. This report will also include any interesting biological observations such as inter- and intra-species interactions.

Option Year 2

*1) The final product of this project will be a graphical-interactive GIS database describing habitats, fish species and locations, if possible this would be distributed on a CD or posted on the World Wide Web for interested parties to access.

*2) A final report summarizing the ecosystem data in terms of essential rockfish habitat.

*These components will only be produced if this proposal is funded for the full two years.

PROFESSIONAL CONFERENCES

The PI will attend the EVOS Annual Meeting in March, 1999. A poster summarizing the first year results of this study will be presented.

In the proposed second year of this study (February, 2000) the PI will attend the Western Groundfish Conference in Sitka, Alaska and present a poster of the final results.

NORMAL AGENCY MANAGEMENT

NOAA/NMFS has statutory stewardship for most living marine resources; however, if the oil spill had not occurred, NOAA would not be conducting this project. NOAA/NMFS/ABL proposes to make a significant contributionto this study by providing all technical equipment and on-eite software necessary for completion of this.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

These data will be made accessible to ADF&G fishery management biologists who may find them useful for managing rockfish species in the area.

PROPOSED PRINCIPAL INVESTIGATOR

Audra L. J. Brase
Auke Bay Laboratory, NMFS
11305 Glacier Highway
Juneau, Alaska 99801-8626
(907)789-6057
E-mail: Audra.Brase@noaa.gov

PRINCIPAL INVESTIGATOR

Audra Brase

Audra Brase has been employed in the fisheries field for 5 years. She holds a Bachelor of Science degree in Biology (1993) and a Master of Science degree (1996) in Fisheries from the University of Alaska Fairbanks. The majority of her past work has been in the field of trophic ecology. Audra's background includes a thorough understanding of the development, management and maintenance of relational databases. She has also worked on the EVOS Alaska Predator Ecosystem Experiment (APEX) forage fish component (163C) for over 1 year.

FY 99 EXXON VALDEZ TRUSTE[illegible]UNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$30.8
Travel		$1.5
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$32.3
General Administration		$4.6
Project Total	$0.0	$36.9
Full-time Equivalents (FTE)		0.5
Other Resources		$7.5

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$31.9				

Dollar amounts are shown in thousands of dollars.

Comments:

NOAA Contribution:

Fishery Research Biologist K, Krieger 1 mo @ 7.5 K.

Video equipment and computer and software will be provided by NOAA.

FY 99

Project Number: 99425
Project Title: Description of Rockfish Distribution and Habitat Preference Based on Underwater Video Footage From PWS....
Agency: NOAA/ ABL

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:4/10/98

FY 99 EXXON VALDEZ TRUSTE[illegible]UNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Name	Position Description					
Audra Lee Janiak Brase	Fisheries Research Biologist	GS / 9 / 1	7.0	4.4	0.0	30.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		7.0	4.4	0.0	
					Personnel Total	$30.8

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Description					
RT to Anchorage to attend annual meeting (March, 1999)	0.5	1	5	0.2	1.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.5

FY 99

Project Number: 99___
Project Title: Description of Rockfish Distribution and Habitat Preference Based on Underwater Video Footage From PWS....
Agency: NOAA/ ABL

FORM 3B
Personnel & Travel DETAIL

Prepared:4/10/98

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

Contractual Costs:	Proposed FY 1999
Description	
none	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
none	
Commodities Total	$0.0

FY 99

Project Number: 99___
Project Title: Description of Rockfish Distribution and Habitat Preference Based on Underwater Video Footage From PWS....
Agency: NOAA/ ABL

FORM 3B
Contractual & Commodities
DETAIL

Prepared:4/10/98

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
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
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
N/A		

FY 99

Project Number: 99___
Project Title: Description of Rockfish Distribution and Habitat Preference Based on Underwater Video Footage From PWS....
Agency: NOAA/ ABL

FORM 3B
Equipment
DETAIL

Prepared:4/10/98

Prototype modeling products: transition, alpha testing, and benefit-to-cost analysis for products from project 320

Project Number:	99431
Restoration Category:	Research; Monitoring; General Restoration
Proposer:	Vincent Patrick
Lead Trustee Agency:	National Oceanic and Atmospheric Administration
Alaska Sea Life Center:	
Duration:	first year of a one year effort
Cost FY 99:	$320K
Cost FY 00:	
Cost FY 01:	
Cost FY 02:	
Geographic Area:	Prince William Sound and adjacent Gulf of Alaska
Injured Resource/Service:	Commercial fishing, Recreation and tourism, Subsistence

ABSTRACT

Throughout the implementation of the Restoration Plan, the Trustee Council has expressed the objective of fully developing the findings and technologies of the Restoration projects into applications with long term, continuing utility and benefit for the spill-effected region. This project addresses that objective. The project plan identifies a first set of Restoration results that in FY99 will be appropriate for application prototyping and performance trials. A pivotal issue is the benefit-to-cost ratio for any set of the applications. This project will configure a selected set of products for prototyping and target a maximally broad constituency, the goal being economically viable products and support system based on a strong benefit-to-cost ratio.

INTRODUCTION

By all indications the Restoration Plan of 1994 (EVOSTC, 1994) will be a significant success. One of the components of that Plan is the effort to model and track the production processes of Prince William Sound. Restoration Project 320 will likely achieve the primary goals of the original science plan by the time development activity ceases this fall. It will also end having successfully addressed a second goal that was not part of the original plan, the goal of demonstrating that results with long running benefit to the injured resources and services could by rapidly transitioned from research to an application with direct utility for resource users and managers. Several such applications have been identified and are being prepared for prototype implementations. A number of these have already been implemented and are providing on-line services to the region. One example is the *Sound Report* web site

`www.pwssc.gen.ak.us/sea/weather/realtime.html`

The Restoration Plan of 1994 did not back away from the fundamental problem presented by the spill; instead it seized the opportunity to solve the problem. The crisis of the spill had brought into strong relief the problem of major missing pieces in the understanding of the marine production processes of Prince William Sound. Major economies of the region had for some time been based on the use of that production process primarily as a black box. What was unknown and unexplained about the process had been sufficiently consistent, except for earthquakes. There was little urgency to open the black box and no resources with which to do it. The spill provided the urgency. After the spill, each and every event observed in the marine system was another necessary and unwanted confrontation with the unknown: why did this happen? how did it happen? what would happen next? The spill settlement, the Restoration Plan, and the ensuing process provided the resource, focus, and direction —— figure out how the marine production system works, make it quantitative and predictive, do it fast, and just as fast turn the findings into applications and products that help the recovery of the injured resources and lost services.

The success of the efforts begun by the Restoration Plan has already been recognized. The Restoration Plan is a case study and a chapter in the Interagency Ecosystem Management Task Force Report (IEMTF, 1995). More recently, the GLOBEC Northeast Pacific Implementation Plan (GLOBEC, 1996, p 46) identifies the EVOS Trustee Council as a collaborator because of its projects measuring and modeling the ecosystem dynamics of Prince William Sound.

In March 1999 Project 320 is to deliver the final report on the five year effort for the models and procedures that explain the production processes for two of the injured resources. A fundamental purpose of these models is to provide the means to track the production processes, that is, by means of measurements and models numerically simulate the changes throughout the system as the production process proceeds. Simply stated, Project 320 models are to provide the answers that were not available at the time of the spill —— why something is happening, how it is happening, and what to expect to happen next.

This tracking of the marine production processes requires that selected measurements and the numerical simulations are executed "continuously", that is, updated at regular time steps. One terminology for these models is nowcasting/forecasting.

Project 320 will close with a basic operational issue still open.

> Can the cumulative benefits to all stakeholders derived from all services provided by a continuously running physical-biological nowcast/forecast model result in a sufficiently strong benefit-to-cost ratio for the nowcast/forecast system to be maintained and operated as a continuously running near realtime information resource?

This question is important because the models have no value unless used. The models cannot provide the "why, how, what next" answers for some troubling event five years hence if they have not been used during the intervening five years. First, there would be no real confidence in the answer, and, second, the models would not have been tracking the process and would not know where to start. If an unusual change in the system is suspected, it is then too late to start tracking the system.

The Chief Scientist and the scientific review committee have for several years added the further project requirement of "applications" and "products." These products can provide, given a favorable benefit-to-cost ratio for the products, the means to establish the support required for the measurements and operations needed to keep the models used and running and "making and delivering" the products.

During the past two years a strong set of products have been developed. Although we expect to see more and better products as we work more closely with those served by the products, we believe that there is at this time a sufficiently strong set of products, sufficient demand for the products, and sufficient probability of a good benefit-to-cost ratio to begin the first prototype runs during 1999. The purpose of this project is to make the transition from the R&D operations to a prototype product operation, conduct initial or "alpha" prototype runs, test and evaluate the products, and determine more fully the benefit-to-cost ratio.

A brief summary of the products to be prototyped in this effort are shown in Table 1.

Table 1. Products ready for prototypes. Summary listing by product group.

pink salmon fry	projected survival: by hatchery and by release date or pen code; absolute; relative within hatchery, between releases
pink salmon fry	projected survival: by hatchery, all releases; absolute; relative between hatcheries

pink salmon fry	optimization of survival: optimized hatchery procedures developed from model merging hatchery processes and ecosystem production processes
pink salmon fry	harvest optimization: return path projections
pink salmon fry	harvest optimization: extensions of hatchery based projections to wild stock
Pacific herring	extension of ADFG ASA model to include age 0, 1, 2
Pacific herring	projection of relative magnitude of stock formation in PWS versus outer Kenya and lower Cook Inlet
Pacific herring	spring and fall surveys for adult stock assessment
other commercial fisheries	pollock: projection of relative magnitude of stock formation within versus outside PWS
other commercial fisheries	pollock: spring survey for adult stock assessment
circulation model	general nowcast/forecast information, targeted applications include: emergency response planning, search and rescue; information to bridge displays – tanker, fishing; iceberg tracking and prediction; information contributing to evaluations of dispersants; currents in HE region.
GLOBEC, OCC related	advectively determined zooplankton processes into and within PWS

These products have been reviewed and commented on by the intended users. In many cases the users are participants in the development of the product. The following table lists the intended users and those with oversight responsibility who have thus far reviewed Project 320 or specific products.

Table 2. Evaluations of Project 320. r = review p = assist in product specification

reviewer or user group	proj 320	fry model	fry optim	herr ASA	herr stock	herr survey	w poll stock	w poll survey	circ applic
EVOS Trustees	r								
EVOS sci review	r	r							r

reviewer or user group	proj 320	fry model	fry optim	herr ASA	herr stock	herr survey	w poll stock	w poll survey	circ applic
OSRI board	r								r
PWSAC board	r	r							
PWSAC exec com	r	r	p						
CDFU	r	r				p		p	p
Valdez Port Managers for:									
BP									p
ARCO									p
SeaRiver									p
SERVS									p
RCAC board	r								p
ADFG									
hatchery mgr, Cdv		r	p						
herring mgr, Cdv				p	p	p			
pollock mgr, Anc								p	
State Ch. Scientist	r	r		r	r		r		

A basic feature of Project 320 was the use of a "regional host" in conjunction with a coordinated, collaborating group of investigators from institutions and agencies distributed throughout Alaska and the United States. This structure has many features that contributed to the effectiveness of the research project.

The transition to close-out is going well for the investigators, for many of the group have located and begun new projects. Two mid-career investigators have left academic centers and relocated to new positions and new organizations: one to a for-profit, the other to a new international research center. One investigator moved to a tenure-track position in another university. One mid-career tenure track investigator has made a temporary relocation in response to a research invitation.

Without exception each of investigators remains committed to the project. The responsiveness of the group is reduced, however, as time is split across commitments. The project management is now more difficult. Some situations are awkward as new organizations enter the scene.

Considerable effort is required to oversee the integrity of the collaboration. Table 2 shows the organizations of investigators contributing to 320 and the extent and distribution of the "corporate knowledge."

Table 3. Organizations of investigators contributing to Restoration project 320

organization	fry	herring	plankton; adult fish; other biology	circ	remote sensing	meteor.	info system	network
Trustee Agencies								
ADFG	■		■					
USFWS					■			
AK State Operations Network Services								■
Universities								
UAF-IMS		■	■		■			
UMD-AVL							■	■
RSMAS				■		■		
U. Wisc.	■	■						
Private								
PWSSC	■	■	■	■		■	■	■
PWSAC	■							

This proposed project will address the following tasks.

- A first objective of this project is to oversee the maintenance and stabilization of the "corporate knowledge" of the group in Table 2 so that it continues to remain in tact and accessible beyond March 1999. In particular, the purpose is to retain this knowledge as a functional asset, one that is needed to undertake the goal of product prototypes. Of particular importance is the knowledge associated with the modelling and data systems. One part of the approach is to keep open the modelling and information systems office at the regional host.

- Establish a business plan and model scope. The business plan will reflect what products are economically viable. The model scope refers to the extent of the models to be maintained and also to any new extensions of models to meet product requests.

- Establish a scope for the 1999 prototype products in conjunction with the products proposed for support by the Oil Spill Recovery Institute (OSRI).

- Organize a subset of the contributors in Table 2 for the prototype product trials in 1999 and for information distribution.

- Coordinate the review of the prototype products. Plan for prototype #2 if successful.

- Include a "hard" publication schedule for the group in Table 2 as an important part of a viable business plan for the products.

- Develop, in concert with EVOS, OSRI, RCAC and other contributing end-users, a review, coordination, and consultation process that is appropriate for the period of prototype or pre-operational products.

NEED FOR THE PROJECT

A. Statement of the Problem

The project address the resources, services, and enhancements shown in Table 4. Also listed in Table 4 are the communities, economies, and agencies associated with those resources and services that the project is intending to benefit.

Table 4. Resources, services, communities, economies, and agencies targeted.
Entries for injured resources, lost services, enhancement or entities linked to any of those indicated by bold text

resources & services and entities linked	fry	herring	plankton; adult stks; other linked	circ	related data resources	info systems
Economic						
Commercial fishing						
hatcheries	■		■			
fleet	■	■	■	■	■	■
Oil shipping				■	■	■
Alyeska terminal				■	■	■
SERVS				■	■	■
recreation & tourism			■	■	■	■

resources & services and entities linked	fry	herring	plankton; adult stks; other linked	circ	related data resources	info systems
Community services						
education	■	■	■	■	■	■
search and rescue				■	■	■
Protection & oversight org., economic interest groups						
RCAC				■	■	■
AK Coastal Management.				■	■	■
CDFU	■	■	■	■	■	■
State management, local service						
ADFG	■	■	■	■	■	■
ADEC	■	■	■	■	■	■
Federal agencies, local services						
NOAA NOS				■	■	■
NOAA NMFS	■		■	■	■	■
USFS					■	■

B. Rationale/Link to Restoration

The development of the products has been guided by the recognition that the injured resources are viewed differently by the different interest groups, management agencies, and users of the resources. The following three perspectives were found to encompass all cases, and in particular cover all of the perspectives represented in Table 4.

1. conservation and the sustained availability of the resource;
2. optimization of the benefit from the resource; and
3. protection of the resource from decrements due to other activities with potentially chronic or episodic side effects that reset the state variables or the control parameters of the production process for the resource.

In regard to resource management, the three perspectives, in very approximate terms, correspond to the perspectives of ADFG, ADNR, and ADEC, respectively. Because the work and the models of Project 320 focused primarily on production processes, the products in many cases contribute to but do not directly apply to the first category. Two products, however, do apply directly to the

first category, the acoustic survey methods for Pacific herring and walleye pollock. The survey product development is the topic of a separate proposal. This project will help with these surveys as products in collaboration with the technical development and methodology development that continues.

Except for the surveys, the products make the biggest contribution to categories 2 and 3. In Table 4 the contribution to the protection of the resource is not included as a restoration related product. However, the contribution is shown to better show the full extent of the impact of the products. In some situations "management" is equated to conservation. The items in Table 4 make clear that Restoration Plan research products will contribute to all three perspectives regarding the resource.

C. Location

Table 4 shows the interest groups in the region that will be the primary targets for the first prototype products. The products serving commercial fishing relate to interests in Cordova (PWSAC, CDFU) but they also contribute to the Valdez Fisheries Development Association (VFDA) and the Solomon Gulch hatchery in Valdez. The products serving shipping relate to many interests in Valdez and Anchorage, but there is a strong and supporting interest in Cordova as well. The EVOSTC activities have contributed much to the *Discovery Room* program of USFS and PWSSC. Though based in Cordova, this education program has special programs provided to all native communities of the sound.

Because much of the product effort will be for interests in Valdez, it is expected that there will be much more involvement in Valdez, possibly jointly with the RCAC office in Valdez, than has been the case during the R&D phase of Project 320. Because of support from PWS RCAC and joint product development with that organization and industry offices in Anchorage, it is anticipated that there will be increased exchange with groups in Anchorage as well. In general, the addition of the oil industry and oil-related organizations as product users has significantly increased the geographic involvement and coordination beyond what had been the case for Project 320.

The additional users in Table 4 show that the location of the prototyping in PWS has the advantage of increasing the likelihood that a favorable benefit-to-cost ratio can be developed for these Restoration products. In particular, this proposal is made with the intent that the set of products in Table 1 will be capable of a very favorable benefit-to-cost ratio. The goal is to use the tasks of the this one year project to establish a product set that is regionally useful and provides benefit well in excess of costs to any one user group. Prudent choices for scope and an investment promptly in publications in the scientific and engineering literature are both to be used to further the objective of a viable benefit-to-cost ratio.

The definition and prototyping of the first set of products creates the opportunity to include other areas in the process. The first prototypes are obviously not yet ready for export. However, this period is appropriate for beginning to better understand the similarities and differences in

operations at the Kitoi hatchery of Kodiak Regional Aquaculture, at Tutka Bay Lagoon Hatchery of Cook Inlet Aquaculture Association, and at the Northern Southeast Aquaculture hatchery.

The product for the Pacific herring stock formation is intended to provide the regular tracking of the advection that is needed by the herring biologists to determine when and how PWS is a potential source for juvenile stocks on the outer Kenya, Cook Inlet, and Kodiak.

COMMUNITY INVOLVEMENT

Community involvement is an important function of the "regional host" organization. The presence and availability in the community provides the critical two-way access and it adds an important component of accountability and responsibility that sets the standard for all collaborators. The first function is participation in the important events related to the resources: the board meetings of PWSAC, RCAC, and OSRI; the periodic meetings of the Regional Planning Team (RPT); and Board of Fish Science Advisory Committee meetings. This participation is a basic part of communicating results and, conversely, is essential for the early development of relevant and valuable products throughout the development cycle.

An example of an applied study that linked research underway to a timely requirement in the community was the study to establish local knowledge of currents in the region of the Copper River Delta and Flats. In January 1996 Owens Coastal Consulting, under contract to ARCO Marine, extended to PWSSC the offer that PWSSC conduct a survey of local knowledge of Cordova fisherman regarding the ocean currents in the vicinity of the Copper River Delta and Flats. J. R. Allen of the Information Systems project and R. Doane-Irving conducted the study with the assistance of S. Vaughan and C. N. K. Mooers. This opportunity provided by ARCO made it possible to understand the issues quickly and in depth. The results of the study are described in the technical report "Survey of Cordova Based Fishermen Regarding Observations on Current Flow in the Vicinity of the Copper River Delta and Flats" (J. R. Allen, *et al*, 1996).

The Copper River study was the means by which the investigators where introduced to all of the participants of all of the interest groups that have been active in the development of the state spill contingency plans. The contacts and dialogue have been maintained. A recent example is the distribution to all interest groups in the region the results of drifter studies conducted by S. Vaughan. Although the drifter studies were designed to address SEA issues, when findings looked to be of interest to the region there were established lines of communication to the various groups. In this case the use of a regional host made it possible not only to recognize the likely regional interest in the results, but also to be able to distribute the results in a manner that is appropriate for such a regional center.

The significance of this is that the extensive product structure presented in this proposal relating to the use of the circulation model and oceanography information started from a an application of the research in community involvement.

This same is the case for all of the products. Each has evolved from joint development in the community. The hatchery optimization products are the result of direct involvement with PWSAC, especially meetings with the hatchery managers and with Jeff Milton, and with the Cordova office of ADFG, in particular joint work with Mark Willette and Tim Joyce. The herring products are the result of continuing dialogue with John Wilcock of ADFG. The involvement regarding pollock and the increased interest in ground fish has come for a very extended community involvement. It is community involvement and learning from the community that is the genesis of the products.

The product delivery is both direct, as in the board meetings mentioned above, and on-line. The structuring of the delivery system is the subject of a separate proposal from J. R. Allen. A prototype of that delivery system is the *Sound Report* web site.

For the period of product prototype trials, the Internet will be used for two way communication with users. Specifically, it will be used to establish and open, regional process for contributing to the specification, performance, and features of products. It will also be used for performance evaluation of products and to assist in establishing a basis for benefit-to-cost assessments.

PROJECT DESIGN

A. Objectives

1. Establish a structure whereby the "corporate knowledge" and the essential participation of the developing investigators can be retained for the product prototyping process. There are four sub-objectives.

    a. Provide for continuation of the essential network services, model compute servers, data servers, and information servers at the regional host;

    b. Determine jointly with all developing investigators a first draft for the scope of the first prototypes for each of the products.

    c. Based upon the draft scope establish the scope of the collaborating technology required for the draft prototypes.

    d. Draft business plan and draft plan for the benefit-to-cost determination.

2. Jointly with end-users develop the prototype product details; revise draft scope.

3. Complete a first set of prototype product runs with information delivery.

4. Prototype review and evaluation with draft for prototype #2.

5. Contingent upon success and favorable benefit-to-cost results, establish a minimal operating structure appropriate for technical integrity and product scope. Incorporate hard publication requirements within business plan.

B. Methods

The approach to establishing the goals in item 1 is to hold one or two major teleconferences or workshop in conjunction with the collaborations and meetings occurring as part of the Project 320 synthesis. At that time the results of the OSRI nowcast/forecast competition and this EVOS FY99 competition will be know. If one or the other fails, then almost surely there will be no product prototyping and no means to find a stable post-project collaboration.

Assuming success, then the workshop will resolve the issues in item 1. The question of scope must be addressed jointly by the developers, the end-users, and the sponsors, because there are conflicting requirements over the extent of the domain. Industry, OSRI, and RCAC are interested in domains beyond PWS, whereas the EVOS initial products require only PWS as the model domain. The extended domain diverts effort from products in favor of investigations. It will be a challenge to reach a consensus, for the resources do not appear sufficient for both.

The resolution of the domain will provide the specificity to fix funding requirements and to address the issue in a precise manner. Similarly, the domain will largely fix the scope and the collaborative needs for the first prototype year.

Since these issues are largely driven by the sponsoring organizations rather than the groups that will directly use the results, the direct involvement of the sponsoring groups in a joint dialogue with the developers would be very welcome.

Item 2 refers a second refining of the prototype plan and procedures. This is the specification development with those who will be using the product, a process that will refine the conclusions from item 1 on scope but considerably sharpen the present draft status of the product.

For pink salmon the work will be principally with PWSAC and potentially VFDA hatchery managers and operators. A significant period of joint development of the first prototype will be required.

The herring and pollock surveys are the subject of the acoustic project and described in a separate proposal. The surveys are required model parameters.

The herring and pollock stock formation information is a product based on spawning surveys (time and locations) and circulation model simulations (plus all of the input data – meteorologic, oceanographic, thermal). The specification for herring has a first draft that will be revised by the herring project. The specification for pollock will be established jointly with ground fish managers of ADFG.

Item 3 consists of applying the modelling resources that are available for the product run as of approximately March 1999. The goal is to track the system for the fry releases, herring larval

drift, pollock spawning and egg advection, zooplankton advection and plankton bloom, thermal time series, for the 1999 production season.

The two fry survival optimization products were never anticipated but were the result of the "ecosystem" component of Project 320. Because a process model for the marine production has been developed it is possible to put it together with the production models for the hatchery operations. With this the combined models are in a form that is appropriate for many conventional methods to pursue optimization – including simple exploratory searches for optimum as a rough first examination. The product projecting return direction is the result of an observation by Willette from the work of Vaughan (Vaughan, 1998). The product here is circulation information during the later stages of the fry outmigration as an indicator for use in run strength assessments made by ADFG to determine when and where harvest can be made. The product is conjectured to provide improved early run strength estimate accuracy.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The organizations and agencies collaborating in Project 320 will be those the project will look to again for partnering and collaboration. Table 3 is expanded somewhat for this project.

The project intends to work more closely with ADNR, in particular with Ms. Carol Fries and the new applications of GIS envisioned for the near future. These new applications will provide a popular and widely used interface for a number of these products.

There will be increased involvement with PWSAC and with CDFU.

If the prototyping is successful there will be in the near future an increased need to further refine wind forcing models. Help from an investigator at the UAF GeoPhysical Institute has been discussed. In this area there is a shared interest with USFS regarding recent, high accuracy elevation data sets.

SCHEDULE

A. Measurable Project Tasks for FY 99

Oct 1998 - Nov 1998	Objective 1
Nov 1998 - Jan 1999	Objective 2
Mar 1999 - Aug 1999	Objective 3
Aug 1999 - Sep 1999	Objectives 4, 5

B. Project Milestones and Endpoints

Nov 30 1998	Objective 1 completed
Jan 31 1999	Objective 2 completed
Aug 31 1999	Objective 3 completed
Sep 30 1999	Objectives 4, 5 completed

C. Completion Date

September 30. 1999

PUBLICATIONS AND REPORTS

The first and second quarters of FY99 will have the SEA synthesis document and publication and one or two companion publications as priorities.

COORDINATION AND INTEGRATION

Discussed in prior sections.

PRINCIPAL INVESTIGATOR

E. Vincent Patrick
Prince William Sound Science Center
PO Box 705, 300 Breakwater Ave

Cordova, AK 99574
phone: 907-424-5800
fax: 907-424-5820
email: patrick@grizzly.pwssc.gen.ak.us

E. Vincent Patrick, Ph.D.

Director of Information Management Systems
Prince William Sound Science Center
P.O. Box 705, Cordova, Alaska 99574

EDUCATION

1967 B.A. Physics Thiel College, Greenville, Pennsylvania
1982 M.A. Mathematics University of Maryland, College Park.
1987 Ph.D. Mathematics University of Maryland, College Park.

PROFESSIONAL EXPERIENCE

Academic

Research Associate, Institute for Systems Research, University of Maryland 1993-present

Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1992-1993

Research Associate, Advanced Visualization Lab, University of Maryland 1991-1992

Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1988-1991

Non-profit

Affiliate Scientist, Prince William Sound Science Center, Cordova, Alaska, 1993-present

Industry

Senior Engineer, AIMS, Inc., Rockville, Maryland 1991-1992

Government

Physicist, Center for Night Vision & Electro-Optics, U.S. Army ECOM, Ft. Belvoir, VA 1982-86

SELECTED PUBLICATIONS

Allen, J.R. and Patrick E.V. (1997) The SEA Intranet: Story of a long-distance collaboration. Presented at 48th AAAS Arctic Division Science Conference, Valdez Alaska, September, 1997.

Allen, J.R., Patrick, E.V. and Thomas, G.L. (1997) Scientific visualization in model-based study of a marine ecosystem. Presented at 127th Annual Meeting American Fisheries Society, Monterey CA, August, 1997.

Allen, J.R., Patrick, E.V. and Cooney, R.T. (1997) The SEA Intranet: Scientific collaboration in a shared information space by a multidisciplinary, geographically distributed research team. In preparation.

Patrick, E.V., Mason, D., Kulkarni, R. and Allen, J.R. (1996) The SEA evolution equation model for pink salmon fry: Results and visualization of the subecosystem of northwest Prince William Sound. Presented at AGU 1996 Spring Meeting, San Diego, February 1996

Thomas, G.L., Patrick, E.V., Kirsch, J. and Allen, J.R. (1996) Development of an ecosystem model for managing the fisheries resources of Prince William Sound. Presented at Second World Fisheries Congress, Brisbane Australia, August 1996.

Allen, J.R., Kulkarni, R. and Patrick, E.V. (1995) Visualizing data and processes for a marine ecosystem. Presented at the 46th Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, AK, September 1995.

D. M. Mason and E. V. Patrick. 1993. A model for the space-time dependence of feeding for pelagic fish populations. Trans. Am. Fisheries Soc. 122(5):884-901.

B. J. Rothschild and E. V. Patrick. 1993. Generation of a phytoplankton maximum in a grazing-extended logistic model, Fisheries Oceanography 2(3/4):223-230.

S. B. Brandt, D. M. Mason and E. V. Patrick. 1992. Spatially explicit models of fish growth ate. Fisheries 17(2):23-35. (includes journal cover)

C. A. Berenstein and E. V. Patrick. 1992. Exact deconvolution for multiple convolution operators-an overview, plus performance characterizations for imaging sensors. Proceedings of the IEEE, Special Issue on Multidimensional Signal Processing 78:723-734.

S.B. Brandt, D.M. Mason, E.V. Patrick, R.L. Argyle, L. Wells, P. Unger and D.J.Stewart. 1990. Acoustic measures of the abundance and size of pelagic planktivores in Lake Michigan. Canadian Journal of Fisheries and Aquatic Sciences 48:894-908.

OTHER KEY PERSONNEL

Mark Willette, ADFG
Tim Joyce, ADFG
John Wilcock, ADFG

Jeff Milton, PWSAC

J. R. Allen, PWSSC
S. B. Bodnar, PWSSC
S. L. Vaughan, PWSSC
G. L. Thomas PWSSC

C. N. K. Mooers, RSMAS

K. Stokesbury, UAF-IMS
B. Norcross, UAF-IMS
A. J. Paul, UAF-IMS

J. Wang, IARC

LITERATURE CITED

Allen, J. R., R. Doane-Irving, and E. V. Patrick. Survey of Cordova Based Fishermen Regarding Observations on Current Flow in the Vicinity of the Copper River Delta and Flats, April 1996. Technical Report, Prince William Sound Science Center, Cordova, AK

EVOSTC (1994). *Exxon Valdez* Oil Spill Restoration Plan. Anchorage, AK

IEMTF (1995). Interagency Ecosystem Management Task Force Report: The Ecosystem Approach. Volume II: Implementation Issues; Volume III: Case Studies, Chapter 6: Prince William Sound. NTIS publication #PB95-265575.

Vaughan, S. L. (1998) Circulation in Prince William Sound from Satellite Tracked Drifting Buoys, February 1998, Technical Report No, 9801, Prince William Sound Science Center. Presentation at the AAAS 48th Arctic Division Science Conference, September 24–27, 1997, Valdez AK

FY 99 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$319.9
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$319.9
General Administration		$18.9
Project Total	$0.0	$338.8
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$0.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared: 4/13/98

Project Number: 99431
Project Title: Prototype modeling products
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$149.5
Travel		$20.8
Contractual		$75.0
Commodities		$5.3
Equipment		$16.0
Subtotal	$0.0	$266.6
Indirect		$53.3
Project Total	$0.0	$319.9
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

Pending support :

OSRI $100 K (requested)

RCAC $ 26 K (approved)

FY 99

Prepared: 4/14/98

Project Number:
Project Title: Prototype modeling products
Name: Vince Patrick
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Vince Patrick	Fry #1	5.5	9.0		49.5
	Mark Willette	Fry #2	4.0	9.0		36.0
	John Willcock	Herring #1	2.0	9.0		18.0
	TBN	Herring #2	2.0	9.0		18.0
	Stephen Bodnar	network/systems analyst	4.0	7.0		28.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	17.5	43.0	0.0	
					Personnel Total	$149.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
						0.0
	Cordova-Anchorage	0.2	6	24	0.2	6.0
	Cordova-Maryland	1.2	2	16	0.2	5.6
	Cordova-Miami	1.2	2	16	0.2	5.6
	Conference	1.0	2	8	0.2	3.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$20.8

FY 99

Prepared: 4/14/98

Project Number:
Project Title: Prototype modeling products
Name: Vince Patrick
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
Circulation model subcontract, Christopher Mooers, RSMAS, University of Miami	50.0
Network/connectivity	20.0
Phone/fax/postage	5.0
Contractual Total	$75.0

Commodities Costs:	Proposed
Description	FY 1999
Computer supplies	3.3
Office supplies	2.0
Commodities Total	$5.3

FY 99

Prepared: 4/14/98

Project Number:
Project Title: Prototype modeling products
Name: Vince Patrick
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON DEZ TRUS COUNCIL PROJECT BUDGET

oer 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			0.0
Product data storage	1	6.0	6.0
Information server equipment	1	5.0	5.0
Information compute equipment	1	5.0	5.0
			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**	$16.0

Existing Equipment Usage: Description	Number of Units	

FY 99

Prepared: 4/14/98

Project Number:
Project Title: Prototype modeling products
Name: Vince Patrick
Agency: NOAA

FORM 4B
Equipment
DETAIL

Proximate and Ultimate Effects of Crude Oil on the Intertidal Fish, *Anoplarchus purpurescens*

Project Number:	99~~xxx~~ 432
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	yes
Duration:	1st year, 3-year project
Cost FY 99:	$62,100
Cost FY 00:	$34,600
Cost FY 01:	$45,000
Geographic Area:	Prince William Sound, Resurrection Bay
Injured Resource/Service:	High cockscomb

ABSTRACT

The high cockscomb (*Anoplarchus purpurescens*) is an abundant intertidal fish of Prince William Sound (PWS) that had elevated hepatic P-4501A levels after the 1989 oil spill. This study's first objective is to examine possible continued sublethal effects by determining hepatic P-4501A levels in PWS cockscombs 10 years after the spill. Sublethal exposure to oil is often lethal in the long term because it reduces an organism's fitness though altered reproduction. Elevated P-4501A levels in PWS cockscombs were primarily due to living on oiled sediment, therefore the second objective is to determine how living on oiled sediment affects spawning behavior, maternal care of the eggs, and embryonic development.

INTRODUCTION

There are several areas in the *Exxon Valdez* oil spill region where oil still persists in the intertidal sediments (Babcock et al., 1996; Spies et al., 1996). This oil remains toxic for several years and is particularly detrimental to eggs of fish that incubate in the intertidal zone, such as herring, *Clupea pallasi* (Brown et al., 1996; Hose et al., 1996), and pink salmon, *Oncorhynchus gorbuscha* (Wiedmer et al., 1996). Embryonic mortality may persist even after a dramatic reduction in oil contamination (Bue et al., 1996), while embryos that do survive can transmit genetic damage to future generations (Bue et al., 1998). All of these studies, however, have been restricted to commercially important species. Throughout the EVOS region, numerous small fishes live in the intertidal zone under rocks. These species in particular are continually being exposed to the oil that is still trapped in the sediments. A variety of fish species make up this neritic community, but one of the most common is the high cockscomb, *Anoplarchus purpurescens* (Stichaeidae) (Hart, 1973; Eschmeyer et al., 1983).

Woodin et al. (1997) found that, one year after the EVOS, Prince William Sound (PWS) cockscombs had significantly elevated levels of hepatic P-4501A enzymes, which convert polycyclic aromatic hydrocarbons (PAH) into non-toxic and carcinogenic forms (Stegeman and Lech, 1991). This study's first objective is to assess long-range impacts of the EVOS on *A. purpurescens* by documenting hepatic P-4501A levels in PWS fish 10 years after the spill in 1999.

Fitness is a measure of the genes contributed to succeeding generations, typically measured by the number of surviving offspring (Alcock, 1989). Sublethal effects of oil contamination are often lethal in the long term because they reduce an organism's fitness (Blaxter and Ten Hallers-Tjabbes, 1992). Previous work has demonstrated that the EVOS reduced various measures of fitness in pelagic species whose eggs incubate in the intertidal zone (Brown et al., 1996; Bue et al., 1996, 1998; Hose et al., 1996; Wiedmer et al., 1996), yet little is known about such an effect in species that live in the intertidal. Woodin et al. (1997) found that living on oiled sediment, rather than ingesting oil-contaminated food, was responsible for the elevated P-4501A levels in Prince William Sound *A. purpurescens*. This study's second objective is to determine whether living on oiled sediment affects spawning behavior, maternal care of the eggs, and embryonic development of high cockscombs.

NEED FOR THE PROJECT

A. Statement of Problem

This study will help to understand whether oil persisting in the intertidal sediments affects the fitness of a common intertidal fish. Not only will the results help us to understand what needs to be done to restore *A. purpurescens*, but our findings will also be applicable to the entire suite of intertidal fishes in PWS that share its habitat. Many of these fishes are important food items for sea birds such as pigeon guillemots (Oakley and Kuletz, 1996).

B. Rationale/Link to Restoration

Although a recent paper by Woodin et al. (1997) documents that *A. purpurescens* had not recovered from the EVOS in 1990, nothing is known about any potential long-term effects of

that spill on these common fish. Previous work has demonstrated elevated P-4501A levels 20 years after a spill in a temperate environment (Teal et al., 1992). PAHs still persist in PWS (Babcock et al., 1996; Spies et al., 1996), so elevated P-4501A levels are anticipated in this study.

Little is known about how elevated P-4501A levels affect the fitness of the adult phase of intertidal fishes, although it is well documented that embryonic development of pelagic species that incubate in the intertidal zone is severely affected (Brown et al., 1996; Bue et al., 1996, 1998; Hose et al., 1996; Wiedmer et al., 1996). Previous work has demonstrated reduced fitness in a wide variety of fishes due to oil contaminants (reviewed in Blaxter and Ten Hallers-Tjabbes, 1992), so impaired reproductive success is anticipated in this study as well.

This study will help recovery by providing evidence of whether the EVOS is continuing to have a sublethal effect on an abundant intertidal fish previously documented to have been impacted by the spill. Throughout PWS there are many areas where oil persists in the intertidal sediments (Babcock et al., 1996; Spies et al., 1996). Because of its widespread abundance the high cockscomb is ideally suited to serve as a model for oil pollution impact on intertidal fishes several years after the spill. If an effect is found, it will suggest that further studies on the whole suite of small fishes (many of which are food items of injured sea birds such as pigeon guillemots; see Oakley and Kuletz, 1996) that inhabit the intertidal zone, should be initiated. Conversely, if P-4501A is not elevated, and no reproductive impairment is identified in this study, such studies may not be warranted.

C. Location

Live fish will be collected in Prince William Sound and Resurrection Bay. The histology and reproductive experiments will be conducted at the Alaska SeaLife Center.

Determination of hepatic P-4501A levels in this widely distributed fish will benefit the intertidal community of PWS by providing evidence of either continued effects of oil contaminants, or of recovery. Thus, all EVOS communities may be affected by the results of this project.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The EVOS Trustee Council produces newsletters that provide the results of all EVOS projects to local communities. Posters will be presented at the annual EVOS workshops. Non-technical presentation of the study will be offered to visitors by appointment. Local charter services will be used for access to Prince William Sound. Although the technical aspects of this project preclude most of the work being done by non-scientists, Area Youth Watch and local students will be able to participate in the collection of fish from Resurrection Bay. The behavioral data collected on The Observer® can also be transferred to videotape so that the students will have the opportunity to observe the behavioral interactions at any time. These videotapes could also be used as a teaching tool for instruction on recording quantitative behavioral data. Local residents will also be queried for locations of PWS beaches that have both oil in the intertidal zone and high cockscombs in common.

PROJECT DESIGN

A. Objectives

There are two research objectives for FY99. One is to determine hepatic P-4501A levels in PWS cockscombs 10 years after the EVOS. The other objective is to quantitatively describe courtship and spawning behaviors, maternal care of the eggs, and embryonic development in high cockscombs.

The research objective for FY00 and FY01 is to determine how living on oiled sediment affects spawning behavior, maternal care of the eggs, and development of the fry.

B. Methods

P-4501A hypothesis. H_0: hepatic P-4501A levels in cockscombs collected from an oiled site (Knight Island) are currently no different than in fish collected from an unoiled site (Resurrection Bay). The data needed to test this hypothesis are a series of immunohistochemically prepared slides containing hepatic tissues stained for P-4501A from an oiled site (Knight Island) and an unoiled site (Resurrection Bay).

Fitness hypothesis. H_0: cockscombs living on oiled sediment will show no difference in spawning behavior, maternal care of the eggs, or embryonic development when compared with cockscombs living on clean sediment. Four things are needed to test this hypothesis:

1. A complete quantitative description of normal spawning behaviors and maternal care in high cockscombs.

2. A morphological description of embryonic development.

3. A data set covering all frequencies, durations, and other aspects of reproduction in high cockscombs in an experimental group (oiled sediment) and a control group (clean sediment).

4. Determination of PAHs in the experimental sediment (done by an outside lab such as the NMFS lab at Auke Bay).

Summary. Immunohistochemical techniques described by Woodin et al. (1997) will be used to generate the data for the P-4501A experiment. Reproduction in high cockscombs will be described quantitatively using The Observer.

P-4501A hypothesis

Cockscombs and sediment will be collected during May 1999 from the Knight Island sites sampled by Woodin et al. (1997), i.e., fish from ADEC Site KN211 and sediment from ADEC Site KN213. Both the fish and sediment will be transported to the SMC by float plane. Twenty fish (10 male and 10 female) will be sacrificed for immunohistochemistry, while additional fish (approximately 30 of each sex) will be held alive for subsequent histology (if necessary), or for behavioral experimentation in FY00. Similar numbers of control fish will be collected from the intertidal zone in Seward, which was not markedly affected by the EVOS.

Immunohistochemical techniques initially described by Smolowitz et al. (1991), and later modified for use in *A. purpurescens* by Woodin et al. (1997), will be used to determine hepatic P-4501A content. Briefly, these methods can be summarized as follows:

1. Sacrifice fish; extract livers.

2. Place sections of liver in 10% neutral buffered formalin; embed in paraffin.

3. Mount 5 µm sections of liver on slides, deparaffinate and hydrate.

4. Incubate sections in 1% normal horse serum in PBS (1% NHS/PBS) for 1 hr.

5. Incubate matching serial sections with 150 µL of 1-12-3p6 monoclonal antibody against scup P-4501A1 at 1.5 µg/ml in 1% BSA in PBS; rinse.

6. Incubate for 20 min with 150 µL of 3 µg/ml biotinylated horse anti-mouse IgG; rinse.

7. Incubate with 150 µL of a 1/2000 dilution of horseradish peroxidase conjugated streptavidin in 1% NHS/PBS.

8. Counterstain with Mayer's hematoxylin.

Staining intensities between ADEC site KN211 and control fish will be scored according to the criteria of Woodin et al. (1997). The data will be analyzed with SigmaStat ANOVA. Differences between sexes will also be analyzed. The data will then be presented graphically with SigmaPlot.

Fitness experiment

Some aspects of reproduction in *Anoplarchus purpurescens* have been described previously. Schultz and DeLacy (1932) first reported that female cockscombs guard their eggs by coiling around them. These researchers also provided some modest quantitative data on the eggs themselves.

Coleman (1992) described reproduction in high cockscombs in somewhat greater detail. He found that the sexes are dimorphic, that assortative mating occurs with respect to size, and that the number of eggs in the mass increases linearly with female size (weight or length). He made several additional laboratory observations: agonistic behaviors displayed by male cockscombs toward other males include changes in fin coloration and lateral and spasm displays. In addition, he described "courtship" behaviors in which the male positions himself upside down, pressing his genital area against the female and performing a spasm; occurrence of polygyny; and hatching of eggs at 29 days, at which time the larvae immediately swim to the surface and maternal care ceases.

The Ph.D. student in this project (Charles Adams) successfully spawned high cockscombs at the Seward Marine Center (SMC) in 1998. "Courtship" behaviors described by Coleman (1992) were terminated in the presence of any human observer, which illustrates the necessity of a remote observational system such as The Observer for quantifying behavior. Eggs appeared in our laboratory the third week of March. Our larvae are expected to hatch the third week of April, several days after the submission of this proposal.

Reproductive behavior in high cockscombs will be quantified with standard methodology (Farwell and Green, 1973; Green et al., 1987; Martin and Bateson, 1989). Until remote observation of the full suite of reproductive behaviors displayed in *A. purpurescens* can be collected, the following list of behaviors that will be quantified must be viewed as tentative:

1. Frequency, total occurrence, mean duration, total duration, and circadian frequency of lateral display.

2. Frequency, total occurrence, mean duration, total duration, and circadian frequency of spasm display.

3. Frequency, total occurrence, and circadian frequency of lateral display.

4. Does the height of the cranial cockscomb predict the winner?

5. Does the intensity of dorsal red predict the winner?

6. Does the first male to bite predict the winner?

7. Frequency, total occurrence, mean duration, total duration, and circadian frequency of genital apposition.

8. The mean number of days between first genital apposition and appearance of the eggs.

9. How many females can a male successfully fertilize?

10. Frequency, total occurrence, mean duration, total duration, and circadian frequency with which the female is coiled around the eggs.

11. Frequency, total occurrence, mean duration, total duration, and circadian frequency of fanning the eggs.

12. Number of larvae that hatch.

With these baseline data, a variety of hypotheses could be tested in FY00 and FY01. The following list provides a series of questions that will be explored:

1. Is aggressive coloration changed on oiled sediment?

2. Is the intensity of agonistic encounters changed on oiled sediment?

3. Does oiled sediment reduce the ability of males to spawn with multiple females?

4. Is female mate choice altered while living on oiled sediment, and in what ways?

5. Do females fan their eggs more on oiled sediment?

6. Are females more likely to abandon their eggs on oiled sediment?

7. Is embryonic development altered on oiled sediment?

8. Is larval behavior upon hatching altered on oiled sediment?

9. How does maternal investment on oiled sediment the first year affect reproductive success the second year, either on oiled or clean sediment?

Morphological descriptions of embryonic development in *A. purpurescens* will be done with standard methodology (Trinkhaus, 1951; Naplin and Obenchain, 1980; Blood et al., 1994). Briefly, these methods can be summarized as follows:

1. Collect egg mass from 2 females.

2. Verify fertilization by presence of perivitelline space.

3. Apportion eggs into 21 jars filled with seawater.

4. Change half of water in jars once per day *or*
   Preserve 30 eggs in 5% phosphate buffered formalin every 2–3 hours during first 24 hours; every 6 hours after that until larvae hatch.

5. Examine eggs with dissecting microscope to determine following stages:

   a) precell
   b) 2 cell
   c) 4 cell
   d) 8 cell
   e) 16 cell
   f) 32+ cell
   g) blastodermal cap
   h) early germ ring
   i) germ ring 1/4 down yolk
   j) germ ring 1/2 down yolk
   k) germ ring 3/4 down yolk
   l) late germ ring
   m) early middle (blastophore closure)
   n) middle middle (appearance of pigment)
   o) late middle (tail bud thickens)
   p) early late (tail bud lifts from yolk)
   q) tail 5/8 around yolk
   r) tail 3/4 around yolk
   s) tail 7/8 around yolk
   t) full circle around yolk
   u) tail 1 1/8 around yolk

Endpoint, midpoint, and duration of each stage will be calculated in hours.

The statistically significant results reported by Woodin et al. (1997) were achieved with an N = 5 of mixed sex fish. To ensure sufficient power and robustness we will use N = 10 mixed sex fish.

N = 10 is also the minimum sample size for behavioral studies (Martin and Bateson, 1989), so we will use an N = 30 for the behavioral experiments to allow for mortalities, etc.

Woodin et al. (1997) developed immunohistochemical techniques for detecting P-4501A in various tissues of *Anoplarchus purpurescens*. As the Ph.D. student has previous experience with this form of histology, we have opted for this method. Furthermore, it will make our results directly comparable with those from the previous study by Woodin et al. (1997).

Fluctuating tide and weather conditions will make *in situ* observations unreliable. Furthermore, turning over rocks will result in gross behavioral disturbances. *In situ* television monitoring could be done, but it will be much more costly than using the The Observer system at the Alaska SeaLife Center.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

None

SCHEDULE

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

October 1–December 18:	Coursework in Fairbanks (will begin before FY99, on September 4)
December 19:	Adams travels to back to Seward
December 20–31:	Collect cockscombs at low tide around Seward; temporarily hold at SMC
January 1–10:	Set up wet lab at Alaska SeaLife Center
January 10–April 30:	Courtship, spawning, maternal care, and embryonic development observations
March 23–27:	Attend EVOS 10th Anniversary Symposium
May 1–31:	Collection of Knight Island cockscombs for P-4501A experiment
June 1–July 31:	P-4501A immunohistochemistry
August 1–31:	P-4501A data analysis
September 1–30:	Preparation and submission of P-4501A paper to peer-reviewed journal

B. Project Milestones and Endpoints

The P-4501A objective will be met by 30 September 1999. The reproductive objective will be met by 30 September 2001.

FY 99

October–December:	Coursework in Fairbanks (will begin before FY99, on September 4)
December–April:	Courtship, spawning, maternal care, and embryonic development observations
May–August:	P-4501A experiment

September:	Preparation and submission of P-4501A paper to peer-reviewed journal

FY 00

October:	Analysis of spring 1999 reproductive data
November:	Preparation and submission of courtship/spawning paper to peer-reviewed journal
December:	Preparation and submission of maternal care paper to peer-reviewed journal
January–April:	Courtship, spawning, maternal care, and embryonic development experiment – oiled vs. unoiled sediment
May:	Preparation and submission of embryonic development paper to peer-reviewed journal
June:	Analysis of spring 2000 reproductive data
July–September:	Preparation and submission of various oiled vs. unoiled reproduction papers to peer-reviewed journals

FY 01

October–December:	Dissertation preparation
January–April:	Advanced reproductive observations
May:	Dissertation defense and graduation
June–September:	Final manuscript preparation and submission

C. Completion Date

All objectives will be completed by September 30, 2001 (FY01).

PUBLICATIONS AND REPORTS

A manuscript on hepatic P-4501A levels of PWS cockscombs 10 years after the *Exxon Valdez* oil spill will be submitted to a peer-reviewed journal such as the *Marine Pollution Bulletin*, *Aquatic Toxicology*, or *Environmental Science and Technology* by September 30, 1999.

PROFESSIONAL CONFERENCES

The tenth anniversary EVOS symposium will be attended on 23–27 March 1999. A poster on courtship and spawning behavior in *Anoplarchus purpurescens* will be presented. As the entire reproductive season will not be completed by the time of this meeting, a full paper would be premature.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Results will be shared with other investigators through e-mail, attendance at the annual EVOS symposiums, and publication in peer-reviewed journals.

PROPOSED PRINCIPAL INVESTIGATOR

Augustus J. Paul
University of Alaska Fairbanks
Seward Marine Center
Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 730
Seward, AK 99664
Phone: 907-224-5261
Fax: 907-224-3392
E-mail: ffajp@uaf.edu

PRINCIPAL INVESTIGATOR

A. J. Paul has been involved in marine ecosystems research since 1980. He has worked on the PROBES, APPRISE, FOCI, and SEA projects, in which he examined food web interactions, trophic phasing cycles, and secondary production. In addition to this biological oceanographic research, he leads a group that specializes in the study of fish and invertebrate bioenergetics and reproduction with captive organisms at the Seward Marine Center.

OTHER KEY PERSONNEL

The Ph.D. student, Charles F.Adams, will work full time on the project under the advisement of Dr. Paul. Mr. Adams obtained an M.S. in zoology from the University of British Columbia in 1995, and has been working in Dr. Paul's laboratory since that time. He has published two papers in peer-reviewed journals on different aspects of animal behavior, and is currently preparing a third publication.

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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		$25.5
Travel		$2.0
Contractual		$5.8
Commodities		$4.3
Equipment		$14.6
Subtotal		$52.2
Indirect		$9.9
Project Total		$62.1
Full-time Equivalents (FTE)		1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$34.6	$45.0			

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.

Personnel costs for Ph.D. student include two semesters of resident tuition ($2,916).

FY 99

Project Number: 99~~xxx~~ 432

Project Title: Proximate and Ultimate Effects of Crude Oil on the Intertidal Fish, *Anoplarchus purpurescens*

Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/12/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Paul, A. J.	Principal Investigator/Assoc. Professor	0.5	8.2		4.1
	Adams, C.	Ph.D. Student	12.0	1.8		21.6
		Adjustment to recognize rounding				-0.2
		Subtotal	12.5	10.0	0.0	
					Personnel Total	$25.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Seward to Anchorage – EVOS meeting	0.1	1	5	0.1	0.6
	Washington DC to Seward – service rep for The Observer training	0.9	1	3	0.2	1.5
	Adjustment to recognize rounding					-0.1
					Travel Total	$2.0

FY 99

Project Number: 99xxx
Project Title: Proximate and Ultimate Effects of Crude Oil on the Intertidal Fish, *Anoplarchus purpurescens*
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/12/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Float plane charter to Knight Island	1.5
Communications	0.2
Shipping	0.5
Instruction fee for The Observer	0.6
Sediment analysis at Auke Bay Lab, 5 samples @ $600/sample	3.0
Contractual Total	$5.8

Commodities Costs:	Proposed FY 1999
Description	
Immunochemicals	1.8
Fish food (two 50-lb bags)	0.1
Components for aquaria set up	2.4
Commodities Total	$4.3

FY 99

Project Number: 99xxx
Project Title: Proximate and Ultimate Effects of Crude Oil on the Intertidal Fish, *Anoplarchus purpurescens*
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

Prepared: 4/12/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Pentium 300 series CD-rom computer with monitor	1	2.0	2.0
The Observer® Video Pro	1	9.5	9.5
Additional camera package	1	3.1	3.1
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$14.6

Existing Equipment Usage: Description	Number of Units	

FY 99

Project Number: 99xxx
Project Title: Proximate and Ultimate Effects of Crude Oil on the Intertidal Fish, *Anoplarchus purpurescens*
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 4/12/98

East Amatuli Island Remote Video Link Project

Project Number:	99434
Restoration Category:	Education, Research and Restoration Monitoring
Proposer:	Pratt Museum
Lead Trustee Agency:	None, but in cooperation with DOI-FWS
Cooperating Agencies:	DOI-FWS
Alaska SeaLife Center:	No
Duration:	1 Year
Cost FY 99:	$75,000
Cost FY 00:	
Cost FY 01:	
Geographic Area:	East Amatuli Island in the Barren Islands
Injured Resource/Service:	Seabirds and mammals injured by the oil spill; will benefit from long-term monitoring of many species.

ABSTRACT

A microwave link will transmit live images and audio from East Amatuli Island to the Pratt Museum, in Homer. Two cameras on the island will be used to test remote collection of data on seabird breeding parameters (e.g., nest attendance) as a supplement to monitoring programs, provide a vehicle for student involvement in restoration monitoring and allow members of the general public to view spill area resources and restoration research projects. Users at the Pratt Museum will pan, tilt and zoom cameras to observe murres and kittiwakes. The cameras' computer control system can be programmed to store precise nest locations that can be revisited upon command, or automatically at specified intervals, to record images on video tape.

INTRODUCTION

The goal of this proposal is to install and test a remote video camera system in the Barren Islands in cooperation with U.S. Fish and Wildlife Service scientists. The project will provide an opportunity to evaluate the effectiveness of the system in collecting supplementary data on Common Murres (*Uria aalge*) and Black-legged Kittiwakes (*Rissa tridactyla*), two species being studied as part of the Alaska Predator Ecosystem Experiment (APEX) and as a tool to increase public access to EVOS-supported research programs. Cameras installed in the Barren Islands will be programmed to record images of birds at precise coordinates at selected times of day, unhampered by weather and sea conditions. Transmitting live video images from East Amatuli Island to the Pratt Museum presents tremendous potential for teaching a wide and diverse public about seabirds. Museum visitors, school groups and ultimately, via the Internet, researchers and audiences throughout the world will be informed by the project.

For many years Pratt Museum programs have enhanced formal and informal marine science education in Alaska. *Darkened Waters: Profile of an Oil Spill,* the exhibition documenting the *Exxon Valdez* oil spill and the *Sperm Whale Project*, an award-winning, five-year collaboration with Homer High School, are notable examples of projects that have successfully increased scientific and technological literacy and promoted ocean conservation. The new *Kachemak Bay Discovery* project focuses on educational programs outside the classroom, in the field and at the Museum. The Museum's Marine Gallery will be modified into a Discovery Lab starting in the fall of 1998. Installation of advanced technology such as an interactive remote video monitoring terminal will provide "hands-on" exhibitry which will help students and other Museum visitors learn about the marine environment, scientific methodology and the restoration effort.

In April 1998 a prototype remote video system began transmitting live images from Gull Island to the Pratt Museum, a distance of eight miles. Daniel Zatz, robotics designer and owner of Broadcast Services of Alaska (BSA) installed three cameras on the Island in Kachemak Bay. One camera transmits an overview perspective, another equipped with a 64-power telephoto lens provides extreme close-up views and a third camera is mounted underwater in the intertidal zone. Visitors in the Pratt Museum enjoy views of seabirds by using a joy stick and camera selection buttons to manipulate the direction of the cameras and the zoom lens. In this way people are able to observe and monitor the seabird rookery without disruption to the birds. Having a working prototype allows BSA and the Pratt Museum to field test and fine tune the equipment all summer. Based on the success of the Gull Island installation, BSA and the Museum are exploring the feasibility of installing a signal relay on Mt. Augustine in early summer so that by August we will be ready to field test a longer range transmission from McNeil River, via Mt. Augustine, to the Museum in Homer.

NEED FOR THE PROJECT

A. Statement of Problem

Development of remote video data collection techniques could enhance the capacity of field researchers to collect monitoring data at study sites that are difficult to access because of topography or weather and sea conditions. These techniques could also be used to collect valuable supplementary data at study sites in years when field teams are not present or at other, secondary sites that could be compared with primary monitoring sites (e.g., in the future, data on certain seabird parameters could be collected at Gull and Chisik Islands for comparison with data collected at the Barren Islands).

Developing the general public's awareness of spill area resources and promoting understanding and appreciation of the nature and value of long-term research at remote sites can be a daunting task. For the most part, access to remote areas is unavailable to people, and their presence in the field could be disruptive in any event. Yet public outreach and the ability to involve students in research projects have been identified as important parts of the restoration process.

The East Amatuli Island Remote Video Link project will provide researchers with an opportunity to test proven remote video technology as a cost effective method for collecting long-term data on seabirds and sea mammals at remote sites. Data collection via remote video link offers a practical way to supplement and optimize work done by field crews. The link will also provide unobtrusive public access to the study area and to the research process itself. Location of the control center in the Pratt Museum will provide an optimum environment for involving students in EVOS-supported restoration research and monitoring projects.

B. Rationale/Link to Restoration

Remote video cameras have the potential to supplement field observations in monitoring studies. To be useful, these systems must be reliable (able to send high quality data adequate distances on predictable schedules). Since 1999 is the last year of field data collection in the APEX project, it is a good time to test the reliability and cost effectiveness of this system for data collection on seabirds in the spill area. The Barren Islands provide a site where long-range transmission capabilities can be tested (to the Pratt Museum in Homer), where extreme weather conditions will test the system's durability and where ongoing APEX studies can be enhanced (e.g., the cameras could be used to increase sample sizes of parameters such as adult attendance at nest sites). If the system proves to be reliable and cost effective, it will be useful as a part of a proposed EVOS long-term monitoring program.

Although this pilot project will test the use of the video system at East Amatuli Island, it has potential applications throughout Lower Cook Inlet, the Northeast Gulf of Alaska and Prince William Sound. Experience gained from this project could be applied to supplement studies of Pigeon Guillemots, puffins and other seabirds and sea mammals throughout the spill area. Examples of EVOS-sponsored APEX projects that might ultimately benefit from testing the East Amatuli Island Remote Video Link include the Barren Islands seabird studies (Project 99163J), Black-legged Kittiwake studies in Prince William Sound (Project 99163E), Pigeon Guillemot studies in Prince William Sound (Project 99163F) and Cook Inlet seabird studies at Gull and Chisik Islands (Project 991673M). The system might also benefit studies of harbor seals in Prince William Sound (e.g., by providing remote viewing of pupping and haul-out areas).

One potential advantage of the remote video system is the ability to make observations at predetermined plots at optimum times of day, irrespective of sea or weather conditions. Video footage can be analyzed by research staff under controlled conditions and remain available as an archival record for future use by other investigators.

The EVOS Trustee Council has recognized the importance of disseminating information to the public about EVOS-sponsored research. They also believe that it is important for the general public and students to be involved in the research. With its control center located in the Pratt Museum, the East Amatuli Island Remote Video Link project will provide an outstanding vehicle for accomplishing these two goals. The Museum's marine science education programs associated with the *Darkened Waters* exhibit, the *Sperm Whale Project* and *Kachemak Bay Discovery* already tend to focus on issues of spill recovery and restoration. By incorporating the East Amatuli Island Remote Video Link into our *Kachemak Bay Discovery* program over 40,000 Pratt Museum visitors annually, students from all parts of Alaska, and in time, anyone viewing the Museum Web Site can be exposed to restoration research on seabirds.

There are strong incentives for starting the East Amatuli Island Remote Video Link project during the 1999 fiscal year:

> Proven technology will be available. By the end of September 1998, the Pratt Museum will have completed development and testing of the prototype remote video system on Gull Island in Kachemak Bay.
>
> The presence of experienced field crews on East Amatuli Island during FY99 will allow "ground-truthing" of the remote video system by comparison of data gathered by remote camera with data obtained by other methods.
>
> The major expense associated with remote video data collection is incurred during development and testing of its applications to research, public outreach and education. By completing this process during FY99, as much as a 60% reduction in costs can be realized by projects utilizing the system during subsequent years.

C. Location

Two cameras will be located at the East Amatuli Island, Light Rock Colony, in the Barren Islands.

COMMUNITY INVOLVEMENT

Over the last two years the Pratt Museum has been involved in a dialog with the local community and visitors from elsewhere regarding the nature of exhibits and programs they feel would best

suit their needs. This has included two visitor surveys (one focused on locals, one on tourists), a series of town meetings and ongoing input from the Museum's Community Advisory Council. A common theme is the desire to see more interpretation of the marine environment, greater use of interactive exhibits and more opportunities for students to become involved in some kind of scientific research. This input is helping shape the Museum's benchmark exhibit renovation program and the direction which the *Kachemak Bay Discovery* project will take. The East Amatuli Island Remote Video Link Project is a result of this planning which offers a multitude of possibilities for ongoing community involvement. Live footage taped for scientists can be used to demonstrate to students and the public how data is collected and interpreted. Museum visitors will be able to add their observations and thoughts to the video log. Student aids and interns can help visitors use the system. Local audiences and, ultimately, anyone viewing the Museum Web Site will be able to learn about EVOS Trustee Council-supported seabird research and view areas damaged by the spill that might otherwise be inaccessible.

PROJECT DESIGN

A. Objectives

1. Test the potential of remote video technology to supplement and support data collection by field crews for long-term monitoring of species injured by the spill.

2. Test the remote video system under some the harshest field conditions in Alaska and over long distances in preparation for other long-range monitoring projects.

3. Develop public programs and educational opportunities using remote video technology for real-time observations of wildlife and student research projects.

4. Provide interaction between students and researchers.

B. Methods

The East Amatuli Island Remote Video Link Project is composed of three interrelated elements: 1) remote video technology; 2) research applications of the technology; 3) public outreach and educational applications of the technology. The project is designed to test whether remote video technology is: 1) advanced enough to function dependably for long periods under harsh conditions; 2) a dependable and cost-effective way to augment the work of field crews in monitoring seabirds (and potentially sea mammals); 3) a powerful mechanism for educating the public and involving students in EVOS-supported research and monitoring projects. The following discussion of methodology is divided into three sections reflecting project structure.

Remote Video Technology

The remote video link will transmit live video and audio from East Amatuli Island to the Pratt Museum. Researchers and visitors at the Pratt will have full control of the camera via a PC

computer and digital transmission link. Operators will pan, tilt, zoom, clean dirty lenses and put the system to sleep from over 60 km away.

Cameras will be located to view some of the same seabird study plots observed by EVOS Trustee funded USFWS crews during FY99. Equipped with 100 X telephoto capability, two cameras will provide clear images of seabirds and nest sites. The system will offer preset positions allowing researchers to point the camera at pre-selected nest sites at the push of a button. Researchers may also instruct the computer to "visit" selected nests at desired intervals during all daylight hours and automatically record the video on a VCR for later analysis.

The system will consist of two video cameras enclosed in water-proof housings and mounted on motion control units. Digital command signals from the Pratt Museum will be decoded to move the selected camera and live pictures will be transmitted via a microwave transmitter. Power will be provided by an array of solar panels and a small wind generator. Camera lens and solar panels will be cleaned upon command by operators at the Pratt Museum control panel.

Because line-of-sight between East Amatuli Island and Homer is not possible, a relay station will be installed east of Port Graham. This relay will consist of a microwave receiver and transmitter capable of handling video and audio signals, and a digital data receiver and transmitter to handle control information.

The remote video link will be assembled between January and April 1999, and tested between April 15 and May 15, 1999 in Kachemak Bay. These tests will include installation and operation of the relay station. In late May 1999, the remote video system will be installed on East Amatuli Island. Installation will require several days, followed by testing. The system will be removed in mid-September as the USFWS crew departs the island.

Research Applications

Remote observations of seabirds on plots at the East Amatuli Island study site will be recorded on video tape at the Pratt Museum. Data will also be collected on the same plots by APEX Project 99163J researchers using standard Project 99163J protocols. After the field season is completed, data obtained by both methods will be compiled and compared and the effectiveness of the remote system as a research tool for use during long-term monitoring studies will be evaluated.

Public Outreach and Education

The Pratt Museum will incorporate the East Amatuli Island Remote Video Link as an exciting new part of the Museum's marine exhibits and science education curriculum. The remote video control station will be added to the Museum's marine gallery with appropriate explanatory signage. Museum staff, volunteers and student interns will be trained to interpret and assist visitors in operating the system during periods when it is not occupied with specific research functions. The project Outreach Coordinator will work with the project Educator and *Kachemak Bay Discovery* partner organizations to develop regular interpretive programs for the general

public. The project Educator will: 1) integrate use of the video system with visiting school groups; 2) work with the project Biologist to develop opportunities for student monitoring.

Science educators have long seen observation skills as the most basic to the study of science -- the very foundation for carrying out other scientific processes such as classifying and making inferences. Science educator and researcher Dorothy Gabel has stated that, "Teaching children to become discriminating observers is one of the major objectives of science education...". For many years, Pratt Museum educational activities have focused on developing observational skills. Each year over 4,300 students from all around Alaska are given an opportunity to participate in interactive lessons involving sea life in the aquariums, plants and animals in our gardens and on the forest trail and a wealth of artifacts throughout the Museum. The East Amatuli Island Remote Video Link is a natural extension of this already powerful learning experience.

Data needed to evaluate the effectiveness of remote video technology as a tool for informing and educating the public and students will be generated in a variety of ways. Museum staff will observe and track visitor attendance and response to the remote video exhibit. People attending the exhibit will be encouraged to enter their observations and reactions in the video log book at the control kiosk. Additional statements will be reviewed and compiled from Museum comment cards available to visitors throughout the galleries. Staff will periodically conduct informal interviews with visitors. The Pratt Museum Community Advisory Council will provide ongoing input. Teachers who bring their classes to the museum will provide feedback on whether or not their use of the remote video system engages students and enhances and supports the school curriculum and how its use might be improved.

Complicated statistical analysis of such data is not foreseen. Simple compilation, review and summary of responses and observations will make clear whether or not the video system is an effective tool for outreach and education. Outcomes will be summarized and presented at professional conferences and through publication of articles in selected informal and formal education journals.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Broadcast Services of Alaska will design, install and maintain technical equipment and licensed video control signals for the Pratt Museum. The system will be removed by a USFWS crew in mid-September. USFWS staff will assist the Pratt Museum with development of public outreach and education projects.

Pratt Museum's *Kachemak Bay Discovery* partners include Alaska Department of Fish and Game, Kenai Peninsula College, Alaska SeaLife Center, Nanwalek Elementary/High School, Center for Alaskan Coastal Studies, National Museum of Natural History, Chugachmiut, Port Graham School, Cook Inlet Keeper, Susan B. English Elementary/High School in Seldovia, *Exxon Valdez* Oil Spill Trustee Council, University of Alaska Fairbanks, Homer High School, Alaska Maritime National Wildlife Refuge, and Homer Junior High School.

SCHEDULE

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

June 15 - August 15, 1998:	Conduct initial surveys of East Amatuli and relay station site.
January 1 - April 15, 1999:	Customize and specialize system for Barren Islands use.
February 1 -April 15, 1999:	Modify Pratt Museum exhibits to accommodate receiver station.
April 15 - April 30, 1999:	Assemble transmitter and receiver station at Pratt. Begin testing transmitters, receivers and motion control systems.
May 1 - May 15, 1999:	Install relay station. Establish two-way link from relay station to Pratt. Transmit live pictures from relay station to Pratt. Transmit digital control signals to relay station.
May 15 - May 31, 1999:	Install cameras, transmitter and receiver at East Amatuli site. Transmit live pictures to relay station and Pratt. Receive control signals from Pratt.
May 28 - June 3, 1999:	Intensive testing of system. Installation crew remains on East Amatuli while control signals from Pratt move cameras through the initial test program.
June 10 - 15, 1999:	Travel to East Amatuli with USFW crew. Inspect and provide necessary maintenance for remote camera system.
June - August, 1999:	Education programs at the Pratt Museum.
June 25 - August 25, 1999:	Travel to East Amatuli as necessary to maintain system. Estimate two trips.
September 15, 1999:	Remove system from East Amatuli. Remove relay equipment from relay site.
October - December, 1999:	Evaluate project.
April 15, 2000:	Submit reports.

B. Project Milestones and Endpoints

April, 1999:	Install receiver station at the Pratt Museum and relay station.
May, 1999:	Install video system at Barren Islands.
October - December, 1999:	Analysis and evaluation of data.
April 15, 2000:	Submit report to chief scientist.

C. Completion Date

A final report documenting and evaluating use of the video system by the public and local schools and evaluating the systems capabilities for collecting seabird data will be submitted to the chief scientist on April 15, 2000.

PUBLICATIONS AND REPORTS

A short report will be produced by the USFWS that will evaluate the video system's capabilities for collecting data on seabirds. The Pratt Museum will prepare a similar report on findings which relate to public outreach and education.

Due to the uniqueness of the remote video project, the Pratt Museum plans to submit articles about the project for inclusion in Museum publications such as *Current: the Journal of Marine Education* (a publication of NMEA), *Curator* (a publication of AAM), *Informal Science Review* (a publication of Informal Science Inc. in Washington DC), and *Network* (a publication of Museums Alaska).

PROFESSIONAL CONFERENCES

Museums Alaska is a statewide museum association that will be meeting in Anchorage in September of 1998. They produce the publication *Network.* The Pratt Museum will help host this conference and will arrange to incorporate a presentation on the East Amatuli Island Video Link into the agenda.

As a part of this proposal, the Pratt Museum has requested funding for staff attendance and presentations at one of the following conferences (to be selected pending determination of conference agendas).

ASTC (Association of Science-Technology Centers) "is a non profit organization of science centers and museums that are dedicated to furthering the public understanding of science. ASTC encourages excellence and innovation in informal science learning by serving and linking its members worldwide and advancing their goals." They will be meeting in the spring of 1999.

NMEA (National Marine Educators Association) "brings together those interested in the study and enjoyment of the world of water." They produce the publication *Current: The Journal of Marine Science.* Their conference will take place in the fall of 1999.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The project will be coordinated with the APEX Project 99163J and the Alaska Maritime National Wildlife Refuge.

PROPOSED PRINCIPAL INVESTIGATOR, IF KNOWN

Name:	Michael O'Meara
Affiliation:	Pratt Museum, *Kachemak Bay Discovery* Project Director
Mailing address:	3779 Bartlett Street, Homer, Alaska 99603

Phone number: 907/235-8635
Fax number: 907/235-2764
E-mail address: pratt@alaska.net

PRINCIPAL INVESTIGATOR

Michael O'Meara is responsible for general project management including oversight of contractors and key personnel to assure: 1) fiscally responsible budget administration; 2) integration of technological, scientific, interpretive and educational components of the project; and 3) coordination among collaborating agencies. Mr. O'Meara is also Special Projects Coordinator at the Pratt Museum. He is a former public school teacher who came to the Pratt Museum in 1989 as Guest Curator for *Darkened Waters: Profile of an Oil Spill*. Extensive experience in research, curriculum development and project design make him at home with the hands-on work of exhibit production, planning and project administration. Mr. O'Meara administers three projects at the Museum: *Darkened Waters*, *The Kenai Peninsula Forest Ecology Project*, and *Kachemak Bay Discovery*, and is Curator of *Darkened Waters* exhibit. He holds a B.A. in Art/Social Sciences and M.A. in Art/Education from California State University in Los Angeles.

OTHER KEY PERSONNEL

Carol Goodspeed Harding, Outreach Coordinator

Ms. Harding will assist the Principal Investigator with integration of technological, scientific, interpretive and educational components of the project. Her responsibilities include: 1) oversight of design, installation and integration of the East Amatuli video system into the Museum's Marine Room; 2) development, supervision and evaluation of relevant public programming; and 3) responsibility for news releases, advertising and other public outreach for the project. She is also the Director of Exhibitions at the Pratt Museum. She has been a museum professional for over 20 years in natural history, science, art and childrens' museums. She worked for 12 years at the Milwaukee Public Museum as a graphic designer, illustrator, designer and project manager for major science projects. She has served as project director of the award-winning Homer High School/Pratt Museum collaborative *Sperm Whale Project*, working with students to articulate a sperm whale skeleton and create a public exhibition. Ms. Harding received an Associate Degree in Commercial Art from the Milwaukee Technical College and B.A. from Coe College.

Gail Parsons, Educator

Ms. Parsons will develop, implement and evaluate a program of educational activities which integrate the East Amatuli video system into the Pratt Museum's marine science education curriculum. The Educator will coordinate with the Science Supervisor to develop programs to involve students with researchers through remote video observation and data gathering. She is also the Director of Education at the Pratt Museum. She has taught K-12 art in public and private

schools and also teaches as an adjunct instructor at the University of Alaska. Ms. Parsons received her B.S. from Skidmore College and her M.A. in Education from the University of Hartford, Connecticut.

Daniel Zatz, Remote Video Designer/Technician

Mr. Zatz is a two-time Emmy award-winning videographer specializing in remote wildlife photography. He is owner of Broadcast Services of Alaska, based in Homer, and his work is broadcast on CBS, CNN and National Geographic Television. In 1991, he designed and built the first in series of robotics camera systems designed for remote wildlife filming. The system captured images of nesting snowy owls for CBS Sunday Morning, Peregrine Falcons feeding chicks for the National Park Services and Bald Eagle chicks learning to fly for National Geographic. In April 1998, Mr. Zatz installed a remote camera system with a microwave link on Gull Island in Kachemak Bay. The system includes three cameras (one underwater) and offers Museum visitors live pictures and control of cameras. The system was completed one year ahead of schedule. His professional awards include two Emmy awards, Joey award, three first places in the International Wildlife Film Festival and many others.

Dave Roseneau, Scientific Supervisor

Mr. Roseneau will be responsible for coordination and integration of the East Amatuli remote video link project with other research and monitoring projects associated with the restoration effort. His responsibilities include: 1) development, administration and evaluation of a program for testing the remote video system as a supplemental research tool; 2) supervise field personnel; 3) advise the Outreach Coordinator and the Educator periodically to assure the scientific validity of public outreach/interpretive and educational programs; and 4) evaluation and interpretation of the data and writing of a report on the outcome of the experiments. Mr. Roseneau is a wildlife biologist who received his B.S. degree in wildlife management and M.S. degree in biology from the University of Alaska Fairbanks in 1967 and 1972 respectively. His thesis research was on the numbers and distribution of Gyrfalcons, *Falco rusticolus*, on the Seward Peninsula, Alaska. He joined the U.S. Fish and Wildlife Service in January 1993 and was project lead for an EVOS-sponsored Common Murre restoration studies at the Barren Islands during 1993-1994 (Projects 93049 and 94039). Mr. Roseneau was also principal investigator of the APEX Barren Islands seabird and large fish as samplers studies during 1995-1997 (Projects 95163J, 95163K, 96163J, 97163J and 97163K) and the murre population monitoring work at the Barren Islands in 1996-1997 (Projects 96144 and 97144). Currently, he is co-principal investigator for APEX project 98163J and principal investigator of APEX project 98163K and the Chiswell Islands murre population monitoring study (Project 98144). Prior to 1993, Mr. Roseneau worked as a consulting biologist for 20 years, conducting and managing marine bird, raptor and large mammal projects in Alaska and Canada for government agencies and private-sector clients. He has been involved in several large-scale murre (*Uria* spp.) monitoring projects. During 1976-1983, as co-principal investigator of NOAA/OCSEAP Research Unit 460, he conducted monitoring studies of murres and Black-legged Kittiwakes (*Rissa tridactyla*) at Capes Lisburne, Lewis and Thompson in the Chukchi Sea and St. Lawrence, St. Matthew and Hall Islands in the Bering Sea. He also studied auklets (*Aethia* spp.) at St. Lawrence and St. Matthew Islands and

participated in murre and kittiwake projects at Bluff in Norton Sound. In 1984-1986, he participated in follow-up studies of murres and kittiwakes in northeastern Chukchi Sea and during 1987-1988, 1991-1992 and 1995-1997 he helped conduct additional murre and kittiwake work at Chamisso and Puffin Islands and Capes Thompson and Lisburne. Mr. Roseneau is experienced in collecting and analyzing data on numbers, productivity and food habits of seabirds, relating trends in numbers and productivity to changes in food webs and environmental parameters (e.g., air and sea temperatures, current patterns) and assessing potential impacts of petroleum exploration and development on nesting and foraging marine birds. During his career, Mr. Roseneau has authored and co-authored over 75 reports and publications, including about 25 on Alaskan seabirds.

Selected Seabird Publications

Murphy, E.C., A.M. Springer and D.G. Roseneau. 1991. High annual variability in reproductive success of kittiwakes (*Rissa tridactyla* L.) at a colony in western Alaska. J. Anim. Ecol. 60: 515-534.

Springer, A.M., E.C. Murphy, D.G. Roseneau, C.P. McRoy and B.A. Cooper. 1987. Paradox of pelagic food webs in the northern Bering Sea - I. Seabird food habits. Cont. Shelf Res. 7: 895-911.

Murphy, E.C., A.M. Springer and D.G. Roseneau. 1986. Population status of *Uria aalge* at a colony in western Alaska: results and simulations. Ibis 128: 348-363.

Springer, A.M., D.G. Roseneau, D.S. Lloyd, C.P. McRoy and E.C. Murphy. 1986. Seabird responses to fluctuating prey availability in the eastern Bering Sea. Marine Ecol. Prog. Ser. 32: 1-12.

Springer, A.M. and D.G. Roseneau. 1985. Copepod-based food webs: auklets and oceanography in the Bering Sea. Marine Ecol. Prog. Ser. 21: 229-237.

Murphy, E.C., D.G. Roseneau and P.J. Bente. 1984. An inland nest record for the Kittlitz's murrelet. Condor 86: 218.

Springer, A.M., D.G. Roseneau, E.C. Murphy and M.I. Spinger. 1984. Environmental controls of marine food webs: food habits of seabirds in the eastern Chukchi Sea. Can. J. Fish Aquat. Sci. 41: 1202-1215.

Arthur Kettle, Field Team Leader

Mr. Kettle will work with the Designer/Technician to install and test the use of the remote video system at the selected field site. The Field Team Leader will coordinate the work of the field research team with other key personnel. Mr. Kettle received his B.A. degree in Human Ecology from the College of the Atlantic in 1984. Since that time, he has participated in several large-scale seabird projects at remote locations. He joined the U.S. Fish and Wildlife Service in May

1993 and was camp leader for the 1993-1994 EVOS Barren Islands Common Murre restoration studies (Projects 93049 and 94039). He also served as field team leader during the 1995-1997 APEX Barren Islands seabird studies (Projects 95163J, 96163J, 97163J) and participated in the 1996-1997 Barren Islands murre population monitoring projects (Projects 96144 and 97144). Mr. Kettle is currently the field team leader for APEX project 98163J. During his work 1993-1997 work at the Barren Islands, he was responsible for logistics and data collection at Amatuli Voce camp and for ensuring that data were obtained according to study design. His broad knowledge of boat-mooring systems and technical rock climbing techniques allowed him to safely collect productivity and chronology data from a series of study plots he established on East Amatuli Island (a different technical task not accomplished during any previous pre- or post-spill study). Mr. Kettle also collected productivity data and censused birds at East Amatuli Island during the Exxon-sponsored University of Washington studies in 1990-1992. In addition to this work, he participated in large-scale University of Washington studies of Magellanic Penguins (*Spheniscus magellanicus*) in Argentina during 1987-1991, and Tufted Puffins (*Fratercula cirrhata*) and Fork-tailed Storm-Petrels (*Oceanodroma furcata*) at the Barren Islands colonies in 1990-1992. Mr. Kettle has over 17 years experience safely operating small boats in the north Atlantic and Pacific oceans (e.g., Maine and Alaska), including eight consecutive field seasons running outboard-powered craft at the Barren Islands.

Selected Seabird Publications

Boersma, P.D., J.K. Parrish and A.B. Kettle. 1995. Common murre abundance, phenology and productivity on the Barren Islands, Alaska: The *Exxon Valdez* oil spill and long-term environmental change. Pp. 820-853 in *Exxon Valdez* Oil Spill: Fate and effects in Alaskan waters, ASTM STP 1219, P.G. Wells, J.N. Butler and J.S. Hughes (eds), Amer. Soc. for Testing and Materials, Philadelphia, PA.

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(Selected Bibliography)

Roseneau, D.G., A.B. Kettle and G.V. Byrd. 1996. Barren Islands seabird studies, 1995. Appendix J *in* Apex: Alaska Predator Ecosystem Experiment (D.C. Duffy, Compiler), *Exxon Valdez* Oil Spill Restoration Proj. Annual Rept. (Restoration Proj. 95163), Alaska Natural Heritage Program, Univ. of Alaska, Anchorage, AK.

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Culotta, E. (1990) "Can Science Education be Saved?" *Science* 250: 1327-1330.

Feher, E., and Rice, K. (1985). "Development of Scientific Concepts Through the Use of Interactive Exhibits in a Museum." *Curator* 28/3: 245-258.

Kool, R., and Trayner, K. (1990). "The JASON Project: An Evaluation." *Curator* 33/4: 261-271

Ucko, D.A. (1985). "Science Literacy and Science Museum Exhibits." *Curator* 28/4: 287-300

Conner, J.L. (1991). "Promoting Deeper Interest in Science." *Curator* 34/4: 245-260

Abruscato, J. (1992). "Teaching Children Science" (3rd ed). Boston: Allyn and Bacon.

Gabel, D. (1984). "Introductory Science Skills." Prospect Heights, IL: Waveland Press.

Trowbridge, J. (1997). "Agassiz's Influence on Marine Science Teaching: Promoting Nature Study by Direct Observation." *Current* 14/3.

Watkins, J. (1997). "A New Agenda for Science Education." *Current* 14/3.

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$75.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$75.1
General Administration		$5.3
Project Total	$0.0	$80.4
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Dollar amounts are shown in thousands of dollars.					

Comments:
Included under Form 4A Non-Trustee Agency Summary.

FY 99

Project Number: 99434
Project Title: East Amatuli Island Remote Video Link Project
Agency:Pratt Museum in cooperation with DOI-FWS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 14-Apr-99

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
						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 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

FY 99

Prepared:

Project Number:
Project Title:
Agency:

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
4A Linkage	75.1
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$75.1

Commodities Costs:	Proposed
Description	FY 1999
Commodities Total	$0.0

FY 99

Project Number:
Project Title:East Amatuli Island Remote Video Link Project
Agency:Pratt museum in cooperation with DOI-FWS

FORM 3B
Contractual & Commodities DETAIL

Prepared: 14-Apr-99

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

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

FY 99

Project Number:
Project Title:
Agency:

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel		$17.0						
Travel		$3.3						
Contractual		$45.0						
Commodities		$2.5						
Equipment		$3.5						
Subtotal	$0.0	$71.3						
Indirect		$3.8						
Project Total	$0.0	$75.1						
Full-time Equivalents (FTE)		4.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1. Salaries under contractual costs are for system modification and specialization for Barren Island conditions.
2. Indirect costs are general administration, project accounting, facility overhead, phone, fax, repair, copying, clerical support and contract monitoring.
3. NEPA compliance; This is an unobtrusive project and does not require any permits.
4. The Pratt Museum has received a $175,000 grant from the Howard Hughes Medical Institute for the Kachemak Bay Discovery Program. The Museum has also received a $10,000 grant from the Alaska Dept. of Environmental Conservation and the Environmental Protection Agency.

FY 99

Project Number:
Project Title: East Amatuli Island Remote Video Link Project
Name: Pratt Museum in cooperation with Dept. of Interior - Fish and Wildlife Service

FORM 4A
Non-Trustee
SUMMARY

Prepared: 14-Apr-99

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Michael S. O'Meara	Principal Investigator		0.8	3.6	0.0	2.9
Carol G. Harding	Outreach Coordinator		1.0	3.6	0.0	3.6
Gail Parsons	Educator		1.0	3.3	0.0	3.3
Dave Roseneau	Scientific supervisor/Wild. Biol. (GS-11/5)		0.5	4.9	0.0	2.5
Arthur Kettle	Biol. Tech. (GS-7/1)		1.0	3.1	0.0	3.1
Richard Kleinleder	Staff Technician		0.5	3.2		1.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.8	21.7	0.0	
					Personnel Total	$17.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
Travel to Anchorage for EVOS workshop (2 people)		0.3	1	4	0.2	1.1
Travel to ASTC in Washington D.C. (2 people)		1.2	1	5	0.2	2.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3.3

FY 99

Project Number:
Project Title: East Amatuli Island Remote Video Link Project
Name: Pratt Museum in cooperation with Dept. of Interior / Fish and Wildlife Service

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 14-Apr-99

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:				Proposed FY 1999
Description				
Contract to;	Broadcast Services of Alaska			
Contract for;				
	Lease of equipment, licenses for video and control signals.			15.0
	Equipment includes video, audio, motion control, transmit and receive equipment.			
	Salary Daniel Zatz and assistant engineer	January through May 1999		22.5
	Installation including transportation of personnel and equipment	via boat	3.7	
		via helicopter	1.3	5.0
	Maintenance June through September 1999			2.5
			Contractual Total	$45.0

Commodities Costs:	Proposed FY 1999
Description	
Computer and video supplies and misc. cables. Supplies and services to modify exhibit space to accommodate control system and video monitor.	2.5
Commodities Total	$2.5

FY 99

Project Number:
Project Title:East Amatuli Island Remote Video Link Project
Name:Pratt Museum in cooperation with Dept. of Interior / Fish and Wildlife Service

FORM 4B
Contractual & Commodities DETAIL

Prepared: 14-Apr-99

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
Computer with Monitor	1	2.1	2.1
Printer	1	0.6	0.6
Video Monitor	1	0.6	0.6
VCR	1	0.2	0.2
			0.0
The computer system will be used by the educator to provide educational aids and			0.0
communicate with the collaborating organizations and the public schools.			0.0
The VCR and the monitor will be used in setting up a remote video control and monitoring station.			0.0
Video images for research review will be recorded using this equipment.			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:	Number	
Description	of Units	
No existing equipment.		

FY 99

Project Number:
Project Title:East Amatuli Island Remote Video Link Project
Name: Pratt Museum in collaboration with Dept. of Interior / Fish and
Wildlife Service

FORM 4B
Equipment
DETAIL

Prepared: 14-Apr-99

Oceanography of Prince William Sound, Alaska. Submitted Under the Broad Agency Announcement.

Project Number:	99435-BAA
Restoration Category:	Research
Proposer:	Prince William Sound Science Center
Sponsoring Agency:	NOAA
Duration:	Two years
Cost FY 99:	$ 199.0K
Cost FY 00:	$ 170.0K
Cost FY 01:	$ K
Cost FY 02:	$0 K
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring and

ABSTRACT

Oceanographic measurements in 1994-1997 showed that in some seasons, some aspects of the circulation and water mass properties of PWS are fairly predictable and geostrophic. More variability exists in April, May and June, corresponding to the months before, during, and after the peak zooplankton bloom. Since zooplankton are a major food source for many species juvenile fish, which are also forage fish for other species, the general health of PWS depends on the abundance and availability of zooplankton. The SEA program documented seasonal and some interannual relationships between zooplankton abundance and physical processes, but the effects of longer time scale processes, such as El Nino or regime shifts, were not addressed. To understand plankton variability on interannual and decadal time scales, a time series of physical and biological oceanographic properties needs to be created. This proposal is for implementing a prototype measurement system in PWS to relate plankton distribution and abudance to physical processes on longer time scales.

INTRODUCTION

Large scale hydrographic cruises were conducted in Prince William Sound (PWS) in 1994 - 1997 as part of the SEA observational oceanography program (320-M). Measurements of temperature (T), salinity (S), oxygen, and current velocities were made with simultaneous measurements of fluourescence and zooplankton abundance. Repeat ADCP transects, made during periods of maximum flood and maximum ebb tide at critical transport regions in Hinchinbrook Entrance and Montague Strait, allowed sections of velocity to be created without the tidal contribution. In addition to the large scale hydrographic cruises, a time series of current velocity was obtained from an upward looking ADCP mooring deployed in Hinchinbrook Entrance from June 1995 to October 1995, and from September 1996 to May 1997. The goal of this project was to document the seasonal and interannual variability of the water mass properties and circulation in PWS, and to determine the factors that influence plankton and nekton distributions on those time scales.

The coldest, saltiest, and most homogeneous water occurs in March. The warmest, freshest, and most stratified water occurs in September. Mid-depth temperature minima and maxima occur as a result of seasonal surface warming and cooling. Density is primarily determined by salinity. The flow is generally thought to be inward at Hinchinbrook Entrance and outward at Montague Strait (Niebauer, Royer and Weingartner, 1994; Royer, Hansen and Pashinski, 1979), but seasonal changes in wind forcing and precipitation produce departures from this general pattern. Instanteous current velocities are dominated by tides.

No indication of intrusion of Gulf of Alaska (GOA) water into the central Sound was found in April or May 1995-1997. Intrusion was indicated in June 1996, but not in June 1994 or 1995. In May 1997, the water at both Montague Strait and Hinchinbrook Entrance resembled the GOA water at the surface, and PWS water at depth. T/S plots for stations throughout Montague Strait show that the exchange took place at southern Montague Strait and Hinchinbrook Entrance, rather than in through Hinchinbrook, around Montague Island, and out through Montague Strait. An easterly wind burst occurred during this time that may have pushed water in the surface Ekman layer into these entrances.

In September of all years, the Sound seems to be sealed off from the GOA entirely. The dominant circulation feature in September is the cyclonic gyre in the central Sound. In December 1996, several processes seemed to be acting simultaneously. Indentifying these processes will require further investigation.

Transports were calculated from the ADCP mooring time series (40 hour low-passed filtered) and comparted to those calculated by Niebauer et al (1994). Results suggested that conditions during the late 1970s and mid-1990s were similar. At Hinchinbrook Entrance the summer months were characterized by outflow above 150m and inflow below. The fall and early winter months were characterized by inflow above 150m and weak outflow below. Late winter and early spring months were characterized by more barotropic flows. Finally, strong easterly wind

events in 1996 and 1997 caused upper layer inflow velocity bursts down to the Ekman depth. Associated with the Ekman layer inflow, were periods of outflow a deeper depths. It is not clear if the surface inflow penetrated far into the central or northern Sound, or if it was limited to just north of Hinchinbrook Entrance.

Satellite tracked drogued drifting buoys released in August 1996 and May 1997 showed that the summer (1997) circulation in the central Sound was cyclonic. Also the summer/early fall circulation can be southward at Hinchinbrook Entrance and northward through Montague Strait at the drogue depth (15m). One drifter exited the Sound at Hinchinbrook Entrance and moved east almost to Kayak Island before returning west to Montague Strait. Two drifters exited at Hinchinbrook Entrance and moved west, south of the Kenai, to Cook Inlet.

Warming and stratification started earlier in 1996 than in 1995. Stratification was greater in May 1996 than in May of either 1995 or 1997. In May 1996, there were greater numbers of zooplankton and less fluorescence than in May 1997. In May 1996, the low numbers of phytoplankton in the stratified layer may have resulted from nutrients being depleted and not renewed. The deep mixed layer in May 1997 may have allowed phytoplankton growth and zooplankton dispersal.

The relative backscatter calculations also suggested that zooplankton abundance was reduced in May 1997, and that April 1996 values were increased. Backscatter was lower in the central Sound in May 1997 than in May 1995, and higher in April 1996 than in April 1995. Backscatter was also higher in May 1995 than in April 1995. Backscatter was high over the `black hole' in the northwest Sound in June 1995. This maximum was not present in June 1996.

The spatial distribution of the zooplankton, as inferred from relative backscatter, changed seasonally. In April and especially May of both 1995 and 1997, more zooplankton were in the northern Sound, in regions of increased surface stratification. By June, more zooplankton were found in the southern Sound, in regions of reduced stratification. The movement of zooplankton from regions of high stratification to low stratification as the seasons progress is in agreement with theoretical primary productivity curve dynamics.

Spring of 1996 was the most productive year for zooplankton. May 1996 was unusually calm and warm. A strongly stratified surface layer formed. It is unclear whether the large number of zooplankton observed resulted from this mixed layer formation, or from favorable conditions in a prior season, like increased zooplankton abundance over the `black hole' diapausing region in the previous June (1995).

In some seasons, some aspects of the circulation and water mass properties of PWS are fairly predictable and geostrophic. Especially in the fall, the dynamics of the Sound seem fairly stable. More variability exists in April, May and June. These transition months correspond to the period of highest biological activity, and even small changes may effect phytoplankton and zooplankton growth rates and distributions.

NEED FOR THE PROJECT

A. Statement of the Problem

Many species of fish, birds, and mammals continue to be listed as injured and non-recovering. Since zooplankton are a major food source for many species juvenile fish, which are also forage fish for other species, the general health of PWS depends on the abundance and availability of zooplankton. The SEA program documented seasonal and some interannual variability, but the effects of longer time scale processes, such as El Nino or regime shifts, were not addressed. To understand plankton variability on interannual and decadal time scales, a time series of physical and biological oceanographic properties needs to be created. This proposal is for implementing a prototype measurement system in PWS to relate plankton distribution and abudance to physical processes on longer time scales.

B. Rationale/Link to Restoration

Without understanding how environmental and ecological factors might be influencing the recovery of injured species, there is no clear means for predicting changes in abundance. Further, restoration and management activities undertaken in the absence of knowledge about ecosystem function could conceivably cause more damage than they are intended to remedy. Over the long term, as understanding of the Prince William Sound ecosystem improves, the risks associated with proactive restoration and resource management activities will become much less uncertain.

C. Location

This project has been designed for Prince William Sound. All communities that utilized the marine resources of Prince William Sound will benefit from this research.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Local fishing vessels and ships will be chartered for oceanographic cruises in FY99 and FY00. This project will contribute information to local news letters and newspaper articles. Scientific results will be posted on a web page, and will eventually be accessible by the public.

PROJECT DESIGN

A. Objectives

The main objective of this project is to begin creation of a multi-year time series of physical (temperature, salinity, current velocity, wind velocity) and biological (zooplankton abundance,

fluoresence) variables for PWS. This will provide a baseline of oceanographic and meteorological conditions, or climatology, for PWS, that other researchers (especially APEX and NVP) and resource managers (ADF&G) can view their findings in the context of. The relationships between plankton and nekton production and physical processes will be documented on longer time scales. The mooring at Hinchinbrook Entrance will allow correlations with wind events and with zooplankton seeding from the Gulf to be examined. The time series will also provide initial conditions (temperature, salinity, and inflow at Hinchinbrook Entrance) for a numerical circulation model of PWS. In the past, research has focused on how the Gulf of Alaska influences PWS. The drifter part of this project will also provide answers about how fish species originating in PWS are transported to regions east (Kayak Island) and west (Kenai bays and fjords, Cook Inlet, and Kodiak Island) of the Sound.

Specific goals for FY99 are:

1. Start creation of a time series of physical and biological oceanographic conditions in PWS.

2. Obtain time series of current velocity at Hinchinbrook Entrance.

3. Document circulation patterns in PWS and in the coastal Gulf of Alaska, east and west of PWS.

B. Methods

1. Oceanographic surveys, collecting hydrographic, current velocity, and biological data will be conducted in May and September of 1999 and 2000. May was chosen because of the spring bloom. September was chosen because it coincides with the period of maximum freshwater runoff. Temperature, salinity, and oxygen as a function of depth will be collected using a CTD lowered from the ship. Current velocity as a function of depth will be collected using a downward looking ADCP mounted in a tow body and towed from the ship. Zooplankton distributions will be obtained from an towed optical plankton counter (OPC). Temperature, salinity, and fluorescense will be obtained from an Aquapack mounted on the OPC tow body. This data will be combine with the data collected during the SEA years (September 1994, 1995, 1996, and May 1995, 1996, 1997) to create a time series of oceanographic conditions.

2. An upward looking ADCP mooring (150kHz) will be deployed in Hinchinbrook Entrance in September 1999, and retreived in May 2000. This time of year includes the early spring, when Gulf zooplankton may be entering the Sound. Changes in levels of relative backscatter often indicate the presence of biological organisms. The time series will provide the Hinchinbrook Entrance boundary conditions for the PWS circulation model.

3. Five ARGOS satellite tracked drifting buoys, drogued at approximately 15m, will be

deployed in central PWS on the May 1999 cruise to document circulation patterns. In previous deployments, the drifters have exited the Sound and moved both eastward and westward. Two drifters were periodically swept into the bays and fjords along the Kenai and retained for several days. These data will help reveal if this retention is typical or anomalous.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Vessel charters will contracted to the private sector through competitive bid.

SCHEDULE

A. Measurable Project Tasks for:

FY 99

October 1998-March 1999:	Organize SEA oceanographic data into time series format
March 1999:	EVOS Workshop - Anchorage
April 1999:	FY98 Annual Reports submitted
May 1999:	May oceanographic cruise
May-September:	Analyze data, combine with SEA data
September 1999:	September oceanographic cruise, deploy mooring

FY00

October 1999-May 2000:	Analyze data, combine with SEA data
January 2000:	EVOS Workshop - Anchorage
April 2000:	FY99 Annual Reports submitted
May 2000:	May oceanographic cruise, retreive mooring
May-September:	Analyze data, combine with SEA data
September 2000:	September oceanographic cruise
April 2001:	FY00 Annual Reports submitted

B. Project Milestones and Endpoints

FY99

April 1999:	FY98 Annual Reports submitted
May 1999:	May oceanographic cruise
September 1999:	September oceanographic cruise, deploy mooring

FY00

April 2000:	FY99 Annual Reports submitted
May 2000:	May oceanographic cruise, retreive mooring

September 2000:	September oceanographic cruise
April 2001:	FY00 Annual Reports submitted

C. Completion Date

The completion data of this project is April 15, 2001.

PUBLICATIONS AND REPORTS

Manuscripts submitted:

1. Comparison of the circulation and water mass properties in PWS between the periods 1995-1997 and 1999-2000.

2. Relationship between water mass properties and zooplankton abundance.

PROFESSIONAL CONFERENCES

Travel is requested to present results at the EVOS Workshop in March 1998 in Anchorage.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research will be coordinated with all components of the SEA program. This project will also cooperate with APEX, NVP, and other EVOS-sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

PROPOSED PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
Prince William Sound Science Center
P. O. Box 705
Cordova, Alaska 99574
(907) 424-5800 Office
(907) 424-5820 Fax
vaughan@grizzly.pwssc.gen.ak.us

PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
Physical Oceanographer, Prince William Sound Science Center

Education:

B.S., University of Miami, May 1981, Physics (major)/Mathmatics (minor)

M.S., University of Miami, May 1986, Physics

Ph.D., University of Miami, Rosenstiel School of Marine and Atmospheric Science (RSMAS), May 1993, Meteorology and Physical Oceanography (MPO), Kevin D. Leaman, advisor

Professional Experience (since 1986):

1986 - 1993: Research Assistant, University of Miami, RSMAS, MPO, Miami, Florida

1993 - 1995: Postdoctoral Associate, University of Miami, Cooperative Institute for Marine and Atmospheric Studies, a cooperative institute between RSMAS and NOAA's Atlantic Oceanographic and Meteorologica Laboratory (AOML), Miami, Florida, Robert L. Molinari, supervisor

Sept. 1995 - present: Physical Oceanographer, Prince William Sound Science Center, Cordova, Alaska

Recent Refereed Journals:

Vaughan, S. L. and K. D. Leaman, 1995: The Role of Small-Scale Cells in the Mediterranean Convection Process. J. Phys. Oceanogr., 25 (10), 2423-2436.

Vaughan, S. L. and R. L. Molinari, 1997: Temperature and Salinity Variability in the Deep Western Boundary Current. J. Phys. Oceanogr., 27 (5), 749-761.

OTHER KEY PERSONNEL

Shelton M. Gay:	cruise staging, instrument calibration and maintenance, data acquisition and analysis, contribute to journal publications.
Loren Tuttle:	collect and analyze mainly OPC and Aquapack data, maintenance ofOPC,contribute to journal publications.

LITERATURE CITED

Niebauer, H.J., 1985: Southern Oscillation/El Nino Effects in the Eastern Bering Sea. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

Royer, T.C., D.V. Hansen, and D.J. Pashinski, 1979: Coastal Flow in the Northern Gulf of Alaska as Observed by Dynamic Topography and Satellite Tracked Drogued Drift Buoys. {\em J. Phys. Oceanog.}, {\bf 9}, 4, pp 785-801.

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$195,114.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$195,114.0
General Administration		$3,914.8
Project Total	$0.0	$199,028.8
Full-time Equivalents (FTE)		18.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$170,000.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99435-BAA
Project Title: Oceanography of Prince William Sound, Alaska
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$103,200.0						
Travel		$3,195.0						
Contractual		$40,400.0						
Commodities		$3,300.0						
Equipment		$12,500.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$162,595.0		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Indirect (20.0%)		$32,519.0						
Project Total	$0.0	$195,114.0		$170,000.0	$0.0			
Full-time Equivalents (FTE)		18.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Prepared:

Project Number:
Project Title: Oceanography of Prince William Sound, Alaska
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Shari Vaughan	Physical Oceanographer (PI)	6.0	7100.0		42,600.0
	Shelton Gay	Physical Oceanographer	6.0	5300.0		31,800.0
	Loren Tuttle	Biological Oceanographer	6.0	4800.0		28,800.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	18.0	17200.0	0.0	
					Personnel Total	$103,200.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	EVOS Workshop - Anch. - March 98	170.0	1	5	140.0	870.0
	1r/t Cordova-Fairbanks	400.0	1	3	140.0	820.0
	1r/t Miami-Cordova for mooring technician on Sept. cruise	945.0	1	4	140.0	1,505.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3,195.0

FY 99

Prepared:

Project Number:
Project Title: Oceanography of Prince William Sound, Alaska
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
Phone, fax, copying	800.0
Mail, freight, shipping	800.0
Vessel charter (2 cruises, 5 days each, $3000/day)	30,000.0
Equipment calibration	2,000.0
ARGOS fee (drifter tracking service - through NOAA) - 5 drifters @ $10/day for 60 days each	3,000.0
Network costs and maintenance ($100/computer-month)	1,800.0
Professional services - mooring technician	2,000.0
Contractual Total	$40,400.0

Commodities Costs:	Proposed
Description	FY 1999
Office supplies	400.0
Computer supplies	400.0
Marine supplies	2,500.0
Commodities Total	$3,300.0

FY 99

Prepared:

Project Number:
Project Title: Oceanography of Prince William Sound, Alaska
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
Description			
Satellite tracked drifting buoys	5	2500.0	12,500.0
			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**		$12,500.0

Existing Equipment Usage:	Number of Units	
Description		

FY 99

Prepared:

Project Number:
Project Title: Oceanography of Prince William Sound, Alaska
Agency: NOAA

FORM 4B
Equipment
DETAIL

BUDGET JUSTIFICATION: FY99 (Oct. 1, 1998 - Sept. 30, 1999)

Project Number:

Title: Oceanography of Prince William Sound, Alaska

Proposer: Prince William Sound Science Center

Total Cost FY99: $199.0 K

Salary: 6 months of salary each is proposed for Vaughan, Gay, Tuttle, to stage and conduct 2 oceanographic cruises, with a mooring deployment, process data, and analyze results.

Travel: Travel for 1 round trip to EVOS Workshop in March 1999.
Travel for 1 meeting in Fairbanks for 3 days to discuss data synthesis.
Travel from Miami to Cordova for mooring technician to stage and participate in September cruise, 4 days off ship.

Services: Funding is requested to cover phone, fax, and copying charges, and to cover mail, freight, and shipping charges.
Vessel charter is for one 5 day cruise in May near spring bloom, and one 5 day cruise in September, with mooring deployment.
Equipment calibration is for CTD and OPC calibration.
ARGOS fee is a charge from to transmit data from the drifting buoys to the ARGOS land based distribution center (roughly $10 per day per drifter for 60 days each).
Network costs and maintenance is for internet connection, $100/computer/month.

Supplies: Funding is requested to cover office and computer supplies.
Funding is requested to cover marine supplies for cruises and mooring deployment.

Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino. Submitted Under the Broad Agency Announcement.

Project Number:	99436-BAA
Restoration Category:	Research
Proposer:	Prince William Sound Science Center
Sponsoring Agency:	NOAA
Duration:	Three years
Cost FY 99:	$98.6 K
Cost FY 00:	$98.0 K
Cost FY 01:	$98.0 K
Cost FY 02:	$0 K
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific Herring

ABSTRACT

Strong warm episode El Nino conditions, comparable to the 1982-83 episode, have persisted in the tropical eastern Pacific since June 1997. Abnormally warm and dry atmospheric conditions, and unusually warm ocean waters are present along the entire southern coast of Alaska (CPC). Coupled biological and physical data have been collected for 4 bays in Prince William Sound since 1995. Water mass properties and currents in these bays have been found to be extremely complex and seasonally variable. Recently, it has been hypothesized that water mass changes associated with the 1997-98 El Nino event could effect zooplankton abundance and juvenile herring metabolic rates, thus altering their nutritional status and survival (K. Stokesbury and A.J. Paul). This proposal is for support to continue measurements of water mass properties (temperature and salinity), current velocities, zooplankton densities, and fluorescence in FY99, FY00, and FY01. These data, when combined with the SEA nearshore data from 1995-1998, will provide a time series of oceanographic conditions spanning the years before and after the recent El Nino episode, which can be compared to juvenile herring distribution, abundance, and energy content.

INTRODUCTION

Strong warm episode El Nino conditions have persisted in the tropical eastern Pacific since June 1997. Sea surface temperature anomalies reach 4.5C in December 1997 (Climate Prediction Center (CPC), Climate Diagnostics Bulletin web page). Below normal 500mb heights have been observed over the eastern North Pacific, and there has been reduced storm activity across southern and central Alaska (CPC). Abnormally warm and dry atmospheric conditions, and unusually warm ocean waters are present along the entire southern coast of Alaska (CPC). Maximum temperature anomalies were observed at 250 m at the GAK1 station in January 1998 (T. Royer, personal communication). While temperatures are decreasing in the equatorial Pacific, anomalies in April 1998 are still around 2.5C. CPC forecasts indicate that strong warm episode oceanic conditions will continue through June 1998. This El Nino is comparable to the 1982-83 event, if not stronger.

After the 1982-83 El Nino, increased sea surface temperatures and sea level heights were observed along the Pacific coast of North America from California to British Columbia (e.g. Tabata, 1985; Hamilton and Emery, 1985). Less than normal abundances of the usual species of fish and zooplankton were observed off Oregon and Washington (Miller et al, 1985; Pearcy et al, 1985). Warming was also observed in the Bering Sea (Niebauer, 1985) and in the Gulf of Alaska (Royer, 1985). Brodeur and Ware (1992) found a near doubling of zooplankton in the Gulf of Alaska from 1956-1962 to 1980-1989. Whether this doubling was related to the 1982-83 El Nino is uncertain.

From October 1995 to March 1998, measurements of temperature, salinity, oxygen, current velocity, fluorescence, and zooplankton data were collected in 4 bays and fjords around PWS (Whale, Eaglek, Simpson, and Zaikof) by SEA Physical Oceanography (320-M) and Oceanography of PWS Bays and Fjords (98297) in support of the SEA Herring project (320-T). It was hypothesized (SEA project) that overwinter survival was the dominant factor in the recruitment process. The goal of both oceanographic support projects was to determine habitat overwintering quality for juvenile herring, and identify retention mechanisms in the nearshore regions.

Recently, it has been hypothesized that water mass changes associated with the 1997-98 El Nino event could effect zooplankton abundance and juvenile herring metabolic rates, thus altering their nutritional status and survival (K. Stokesbury and A.J. Paul). This proposal is for support to continue measurements of water mass properties (temperature and salinity), current velocities, zooplankton densities, and fluorescence on October and March cruises in FY99, FY00, and FY01. To document the variability of the temperature in each bay as a function of time, deployment of temperature logger moorings (3 per bay) is proposed. These data, when combined with the SEA nearshore data from 1995-1998, will provide a time series of oceanographic conditions spanning the years before and after the recent El Nino episode, which can be

compared to juvenile herring distribution, abundance, and energy content.

NEED FOR THE PROJECT

A. Statement of the Problem

Pacific herring resources continue to be listed as injured and non-recovering. A goal of the SEA project has been to understand which biological and physical factors in the environment might be constraining the recovery of this species (320-T). Coupled biological and physical data have been collected for 4 bays in the Sound since 1995. Water mass properties and currents in these bays have been found to be extremely complex and seasonally variable. It is not known what effect the current El Nino will have on physical oceanographic conditions, on primary and secondary productivity, and on juvenile herring growth and survival. The proposed project will continue the observations previously funded under SEA Oceanography (320-M) and Oceanography of PWS Bays and Fjords (98297), and perform the analysis necessary to understand critical processes.

B. Rationale/Link to Restoration

Pacific herring is a main food source for numerous fish, birds, and mammals in PWS. Without understanding how environmental and ecological factors, including climatic changes such as El Nino events, might be influencing the recovery of Pacific herring, there is no clear means for predicting changes in production. Further, restoration activities undertaken in the absence of knowledge about ecosystem function could conceivably cause more damage than they are intended to remedy. Over the long term, as understanding of the Prince William Sound ecosystem improves, the risks associated with proactive restoration activities will become much less uncertain.

C. Location

This project has been designed for Prince William Sound. All communities that utilized the marine resources of Prince William Sound will benefit from this research.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Local fishing vessels and ships will be chartered for oceanographic cruises in FY99-FY01. This project will contribute information to local news letters and newspaper articles. Scientific results will be posted on the SEA web page, and will eventually be accessible by the public.

PROJECT DESIGN

A. Objectives

The main objective of this research is to extend the work done by SEA Observational Oceanography (320-M) and Oceanography of PWS Bays and Fjords (98297) in support of SEA herring (320-T) into FY01. The overall goal of both SEA 320-M and this project is to identify the dominant physical processes (tides, storms, water temperature, salinity, etc.) that influence Pacific herring production in PWS. This project will allow the effect of the 1997-98 El Nino to be examined. Specific goals for FY99 are:

1. Document the seasonal and interannual changes in water mass properties (temperature, salinity, and density), current velocity patterns in Eaglek Bay, Whale Bay, Simpson Bay, and Zaikof Bay, in conjunction with juvenile herring measurements.

2. Correlate fluorescence and zooplankton distributions with water mass properties, stratification, current velocities, and mixing.

3. Identify physical retension mechanisms (fronts, eddies, etc.) within the bays.

4. Obtain time series of temperature changes throughout winter (Oct. - March) in each bay for use in the herring bioenergetics model.

B. Methods

1. Temperature, salinity, and current velocity data will be collected with a CTD and a hull mounted ADCP on cruises in October and March of each year. The fish acoustics sonar (SEA will be operated from a seining vessel. The ADCP and the fish sonar can not be operated simultaneously because of acoustic interference. To obtain both current velocities and fish abundances, funding for a separate vessel to operate the ADCP (and the CTD and OPC) is requested.

2. In addition to the CTD and ADCP, the Aquashuttle will be flown from the oceanography vessel. The Aquashuttle consists of an OPC to measure zooplankton, and an Aquapack to simultaneously measure temperature, salinity, oxygen, and fluorescence. Zooplankton densities and fluorescence will be correlated with water mass properties, and current velocities.

3. Potential physical retension mechanisms have been identified in FY95-FY98 field data. Density fronts were documented by the CTD and Aquapack surveys. Regions of strong velocity shears and eddies were documented by the ADCP. These features do not appear at all bays in all times of year. Continued CTD and ADCP measurements will allow more confident predictions of when and where these retention mechanisms occur.

4. Moored temperature loggers at 5, 25, and 50 meter depths, will be deployed at the head, middle, and mouth of each of the 4 bays to provide a continuous time series of temperature from October to March of each year. Previous results have indicated substantial differences in current velocities and water mass properties between the head and the mouth of some bays. Three moorings positioned along the bay axis will provide a coarse estimation of the spatial variations in temperature.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Vessel charters will contracted to the private sector through competitive bid.

SCHEDULE

A. Measurable Project Tasks for FY 99

October 1998:	October herring cruise
October 1998:	Deploy temperature loggers
Oct. - Jan. 1999:	Analyze field data
March 1999:	EVOS Workshop - Anchorage
March 1999:	March herring cruise
March 1999:	Retrieve temperature loggers
March - Sept.:	Analyze field data
April 1999:	Annual Report submitted

B. Project Milestones and Endpoints

FY99
September 1999: Complete observations and analysis of El Nino event.

FY00
September 2000: Complete observations and analysis of first year after El Nino event.

FY01
September 2001: Complete observations and analysis of second year after El Nino event. Submit final report and primary publicaiton.

C. Completion Date

The completion data of this project is September 30, 2001.

PUBLICATIONS AND REPORTS

Manuscripts submitted by the end of FY01:

1. El Nino conditions in the nearshore regions of Prince William Sound, Alaska.

2. Time series of mean hydrographic conditions before and after the 1997-98 El Nino.

PROFESSIONAL CONFERENCES

Travel is requested to present results at the EVOS Workshop in January 1998 in Anchorage.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research will be coordinated with all components of the SEA program. This project will also cooperate with APEX, NVP, and other EVOS-sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

PROPOSED PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
Prince William Sound Science Center
P. O. Box 705
Cordova, Alaska 99574
(907) 424-5800 Office
(907) 424-5820 Fax
vaughan@grizzly.pwssc.gen.ak.us

PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
Physical Oceanographer, Prince William Sound Science Center

Education:

B.S., University of Miami, May 1981, Physics (major)/Mathmatics (minor)
M.S., University of Miami, May 1986, Physics
Ph.D., University of Miami, Rosenstiel School of Marine and Atmospheric Science (RSMAS), May 1993, Meteorology and Physical Oceanography (MPO), Kevin D. Leaman,

advisor

Professional Experience (since 1986):

1986 - 1993: Research Assistant, University of Miami, RSMAS, MPO, Miami, Florida

1993 - 1995: Postdoctoral Associate, University of Miami, Cooperative Institute for Marine and Atmospheric Studies, a cooperative institute between RSMAS and NOAA's Atlantic Oceanographic and Meteorologica Laboratory (AOML), Miami, Florida, Robert L. Molinari, supervisor

Sept. 1995 - present: Physical Oceanographer, Prince William Sound Science Center, Cordova, Alaska

Recent Refereed Journals:

Vaughan, S. L. and K. D. Leaman, 1995: The Role of Small-Scale Cells in the Mediterranean Convection Process. J. Phys. Oceanogr., 25 (10), 2423-2436.

Vaughan, S. L. and R. L. Molinari, 1997: Temperature and Salinity Variability in the Deep Western Boundary Current. J. Phys. Oceanogr., 27 (5), 749-761.

OTHER KEY PERSONNEL

Shelton M. Gay:	cruise staging, instrument calibration and maintenance, data acquisition and analysis, contribute to journal publications.
Loren Tuttle:	collect and analyze mainly OPC and Aquapack data, maintenance ofOPC,contribute to journal publications.

LITERATURE CITED

Brodeur, R.D. and D.M. Ware, 1992: Long-term Variability in Zooplankton Biomass in the Subarctic Pacific Ocean. *Fish. Oceanog.*, **1**, 32-38.

Hamilton, K. and W. J. Emery, 1985: Regional Atmospheric Forcing of Interannual Surface Temperature and Sea Level Variability in the Northeast Pacific. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

Miller, C.B., H.P.Batchelder, R.D. Brodeur, and W.G. Pearcy, 1985: Response of the Zooplankton and Ichthyoplankton Off Oregon to the El Nino Event of 1983. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

Niebauer, H.J., 1985: Southern Oscillation/El Nino Effects in the Eastern Bering Sea. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

Pearcy, W., J. Fisher, R. Brodeur, and S. Johnson, 1985: Effects of the 1983 El Nino on Coastal Nekton Off Oregon and Washinton. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

Tabata, S., 1985: El Nino Effects Along and Off the Pacific Coast of Canada During 1982-83. In El Nino North, Wash. Sea Grant Prog., Wooster and Fluharty, eds., 312 pp.

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$96,710.4
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$96,710.4
General Administration		$1,946.7
Project Total	$0.0	$98,657.1
Full-time Equivalents (FTE)		10.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$98,000.0	$98,000.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99436-BAA
Project Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino.
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$54,600.0
Travel		$870.0
Contractual		$21,100.0
Commodities		$2,600.0
Equipment		$1,422.0
Subtotal	$0.0	$80,592.0
Indirect (20.0%)		$16,118.4
Project Total	$0.0	$96,710.4
Full-time Equivalents (FTE)		10.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$98,000.0	$98,000.0			

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number:
Project Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino.
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Shari Vaughan	Physical Oceanographer (PI)	2.0	7100.0		14,200.0
	Shelton Gay	Physical Oceanographer	4.0	5300.0		21,200.0
	Loren Tuttle	Biological Oceanographer	4.0	4800.0		19,200.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	10.0	17200.0	0.0	
					Personnel Total	$54,600.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	EVOS Workshop - Anch. - March 98	170.0	1	5	140.0	870.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$870.0

FY 99

Prepared:

Project Number:
Project Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino.
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Phone, fax, copying	200.0
Mail, freight, shipping	1,000.0
Vessel charter (2 cruises, 7 days each, $1350/day)	18,900.0
Network costs and maintenance ($100/computer-month)	1,000.0
Contractual Total	$21,100.0

Commodities Costs:	Proposed
Description	FY 1999
Office supplies	200.0
Computer supplies	400.0
Marine supplies	2,000.0
Commodities Total	$2,600.0

FY 99

Prepared:

Project Number:
Project Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino.
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
Description			
Temperature loggers (9 replacements)	9	158.0	1,422.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$1,422.0

Existing Equipment Usage:	Number of Units	
Description		

FY 99

Prepared:

Project Number:
Project Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino.
Agency: NOAA

FORM 4B
Equipment
DETAIL

BUDGET JUSTIFICATION: FY99 (Oct. 1, 1998 - Sept. 30, 1999)

Project Number:

Title: Oceanography of PWS Bays and Fjords: Effects of the 1997-98 El Nino

Proposer: Prince William Sound Science Center

Total Cost FY99: $98.6 K

Salary: Four months salary is requested is requested for 2 research associates to collect and analyze CTD and ADCP data (S. Gay), and OPC and Aquapack data (L. Tuttle). Two months salary is requested for PI to analyze data.

Travel: Travel is requested for one researcher to present results at EVOS Workshop in Anchorage in March 1999.

Services: Vessel charter for 2 cruises in FY99, Oct. 1998 and March 1999, 7 days each @ $1350 per day, to collect ADCP, CTD, and OPC/Aquapack data.

Funding is requested to cover minimal phone, fax, and copying charges, and mail, freight, and shipping charges.

Network costs and maintenance is for internet connection, $100/computer/month.

Supplies: Funding is requested to cover minimal office, computer, and marine supplies.

Equipment: Temperature logger moorings will be deployed in 4 bays in PWS (Eaglek, Whale, Simpson, and Zaikof Bays), at the head, middle, and mouth of each bay, to document winter conditions.

Project 99437

Sandra Schubert

From: John N Alden
To: Sandra Schubert
Subject: Restoration proposal for FY99
Date: Tuesday, April 14, 1998 7:29PM

The following proposal for selection and propagation of spruce beetle resistant trees from the Kachemak Bay area is for your review. The proposal is not in final form as requested on pages 40-49 of the invitation. My telephone is 907-474-7652 -6184 (fax). I will be away from the office from April 20 to about June 15, however, but can be reached after hours at 603-788-2495 or 802-276-3095. Copies of the proposal will be forwarded to the Kenai Borough Spruce Beetle Task Force, Division of Forestry and Reforestation Council for their collaboration.

A PROPOSAL FOR SELECTING AND PROPAGATING LOCAL SPRUCE (Picea A. Dietr.) RESISTANT TO THE TREE KILLING SPRUCE BEETLE (Dendroctonus rufipennis Kirby). > TITLE

by

J.N. Alden, PH.D.
Affiliate Research Professor, Forest Genetics
UAF, Forestry Sciences Department
to
Exxon Valdez Oil Spill Trustee Council
Anchorage, Alaska 99501-8012
for
The Alaska Reforestation Council
Tree Improvement Cooperative
PO Box 757200, Fairbanks, AK 99775-7200

Introduction:

The scale of recent spruce bark beetle activity in south central Alaska is unprecedented in recent historical records. Maturing of over stocked spruce forests, instability of the recent natural Lutz spruce (Picea xlutzii Little) hybrid, and climate warming leading to temperature and moisture stresses, and earlier attacks by adult beetles are among several major causes of the current spruce beetle epidemic.

Foresters have long recognized that vigorous, rapid growing trees express differential resistance or susceptibility to the spruce beetle, other herbivore insects, and pathogens. Although host resistance has been studied since the nineteenth Century, insect resistance in plants, such as resistance to the bark beetles, has only recently been defined. Most insect resistant mechanisms remain unknown, however. Recently, Beck (1965) defined host resistance as the collectable heritable characteristics of plant species, races, or individuals that reduce the utilization of the plant by an insect species, race, biotype, or individual.

Since the 1960's, entomologists and other scientists have described various mechanisms and types of host resistance. Selection and breeding of agricultural crop species have demonstrated that many resistance mechanisms are genetically controlled and highly heritable. When heritabilities are high, phenotypic resistance is a good indicator of genetic resistance. Depending on degree of genetic control, resistance mechanisms are useful in restoring and stabilizing forest health following insect epidemics.

Objective:

The objective of selecting and propagating spruce beetle resistant trees is to secure and maintain a long term stable balance in the Picea-spruce beetle relationship. A stable host-spruce beetle relationship dampens periodic build-up of insect populations and reduces chance of catastrophic loss in mature forests. Improving spruce beetle resistance requires selection and reproduction of all resistant mechanisms (traits) in the host species. If the resistance is controlled by many polygenetic traits, stable resistance is assured because many favorable mutations must occur simultaneously in the spruce beetle in order for it to overcome all resistant mechanisms in the host. A broad genetic base in resistance includes not only all possible resistant traits, but the full complement of genes required for expression of each trait.

Resistant traits include 1) presence of toxins that prevent the insect from completing its life cycle; 2) presence of chemical repellents or absence of attractants normally produced by the host; 3) vigor of the host including its ability to maintain a carbohydrate reserve for production of resin and toxic chemicals on attack, and for tolerance or recovery from attack; 4) absence of food materials that are essential to the insect's life cycle; and 5) morphological, anatomical, and phenological characteristics of the host that reduce insect attacks.

The resistance of conifers with preformed resin systems to bark beetle attack depends on the chemical composition of their resins (Paine et al 1997). Resistance also depends on resin pressure, flow, and crystallization. Abundant flow and rapid crystallization of the resins can be lethal to spruce beetles and their eggs.

Induced defense of resistant conifers to wounding by bark beetles spawns cellular desiccation, removes nutrients essential for growth of the beetle larvae, and saturates the wounded tissue with toxins and protein digestibility-reducing compounds in resins excreted by traumatic resin ducts formed in the wounded phloem and xylem (Cates and Alexander 1982). In the Alaskan spruces (Picea glauca Moench Voss, P. xlutzii Little, and P. sitchensis (Bong.) Carr.), reaction zone resins include increased production of the beetle toxic or repellent 4-allyl anisole, and the monoterpenes, limoncene, myrcene, 3-carene, and beta-phellandrene, while the non-toxic pheromone precursors alpha and beta pinene decrease (Werner and Illman 1994; Werner 1995). Trees with high rates of resin flow are also more resistant to colonizing beetles. High rates of resin flow depend on resin reserves and pressure in the resin ducts.

Procedure:

The 1995-97 spruce beetle epidemic in south central Alaska killed up to 90 percent of the mature seed producing trees in many stands. Most of the survivors were not attacked while near neighbors were assaulted and killed by hundreds of beetle pairs. Thus trees that survived the epidemic may exhibit resistance by chemically repulsing the beetles from attacking. These trees could form the basis of a resistant population for regenerating the next spruce forest.

To regenerate the spruce forest and assure genetic gain in beetle resistance, a resistant population of trees exhibiting superior growth and vigor will be selected and propagated into a breeding orchard or plantation (archive). As the breeding archive matures and produces pollen and seed, a breeding program can be initiated to identify resistance mechanisms, and to determine their genetic control and heritability. Resistant seed can also be collected from the archive for reforestation of denuded natural spruce forests.

Procedures for demonstrating spruce beetle resistance in trees, and eventual steps in elucidating the resistant mechanisms and securing genetic gains:

I. A literature review.

A literature review of an estimated 1000 publications on host resistance to bark beetles, and beetles of agriculture crops, i.e., Colorado potato beetle (Leptinotarsa decemlineata)is needed for identifying and propagating spruce beetle resistant mechanisms. The titles will be published as a bibliography with abstracts of findings pertinent to host resistance.

Estimated Cost: $7500.

II. Selection of resistant spruce populations.

Fifty to 100 resistant or escape trees will be selected from stands with 80 percent or more mortality in each of four to six breeding zones ranging from 500 to 1000 feet in elevation each. The breeding zones will be located in the Kachemak Bay area in seed zones 040111-Anchor River to Homer, 040112-Fox River, and 020507-Kachemak Bay (Alden 1991). Minimum number of selections will be 200, and the maximum number 600.

The following selection criteria will be applied in stands with 80 percent or more mortality of mature spruce trees:

1) Sexually mature trees that repelled or avoided spruce beetle attack in the presence of lethal attacks and severe infestations on eight or more near neighbors will be selected as first priority.

2) Mature trees with tolerance or evidence of recovery from attack will be selected as second priority.

A) Trees with pitch tubes.

B) Trees with high levels of toxic monoterpenes.

3) The selections will be screened for high levels of the toxic monoterpenes, limonene, myrcene, 3-carene, and beta-phellandrene, and low levels the pheromone precursors, alpha and beta pinene. Five resin samples will be extracted from each selection and analyzed quantitatively by gas chromatography for toxic vs attractant monoterpene ratios at the Forest Products Laboratory, U.S. Forest Service, Madison, WI. The samples will also be analyzed for the stilbenes and their precursors which accompany the tannins found in spruce bark. The stilbenes are known to inhibit blue stain pathogens, and may also contribute to first level spruce beetle resistance (Personal communication, 4/14/98, Dr. Barbra Illman, Forest Products Laboratory, U.S. Forest Service, Madison, WI).

4) Other selection criteria.

A) Exceptional tree growth and vigor, i.e., height, diameter, high stem diameter/height ratio, and harvest index.

B) Smooth bark varieties.

Each tree will be measured for age, stem diameter, height, crown class, and distance to the live crown. The location of each tree will be referenced to a permanent land mark and mapped by G.P.S. for future scion and seed collect, and tree breeding. The ease at which each tree can be climbed for scion and seed collection, and tree breeding will be documented.

Estimated costs:

A) Tree selection: $20,000.

B) Monoterpene analyses: $10,000.

III. Seed collection.

Ten pounds of open-pollinated seed will be collected, extracted and stored for each breeding zone at the first better than average seed crop. The seed will be used for reforestation, root stock, and controls (checks or standards) in tree breeding experiments, progeny tests of seed parents, and in toxic or attractant chemical tests.

Estimated cost: $10,000.

IV. Propagation.

Collect cuttings(scions)from each selection and a) graft onto rootstocks produced from the seed collected in III above; or b) root the

cuttings in a soilless growing medium. The most efficient method of propagating mature Lutz and Sitka spruce is unknown. A UAF Horticulture Department graduate stipend of $25,000 is suggested for developing rooting and grafting technologies. With cloning technologies, it is necessary to construct, or lease a small greenhouse in the Homer area for propagating the spruce beetle resistant selections, either by rooting or grafting the cuttings, or both. To prevent drying and loss of vigor before rooting or grafting, the scions should be propagated within 4 hours of collection. Thus propagation is best accomplished in the immediate tree selection area. Both grafting and rooting may be necessary because some trees are difficult to graft successfully, and others are difficult to root, or fail to root entirely.

The greenhouse will be equipped with a fog chamber for rooting the cuttings. After they have rooted, the cuttings must be grown in containers for an additional one to two years before out planting. Root stocks, on the other hand, must be grown for one to two years before they can be grafted.

Estimated costs:

A) Scion collection: $10,000.
B) Rooting technology: $25,000.
C) Propagating 200-400 selections: $30,000.

V. Establishing a breeding archive or orchard.

Four hundred spruce beetle clones of about six ramets each will be transplanted either in the Homer Demonstration Forest, or in another maritime site on State or Borough property in the Homer area. The archive site may require preparation and fencing before planting.

Estimate cost: $15,000.

VI. Tree breeding.

A breeding program (disconnected diallel without reciprocal crosses) will be conducted at the earliest seed crop in the field and archive. Objectives of the breeding program are to 1) estimate additive and dominant gene contributions to tree growth, vigor, bark characteristics, resin production, production of each monoterpenes, and toxic/nontoxic monoterpene ratios; 2) identify parents with high general combing ability for multiple gene dominated growth and resistant traits; and 3)identify parents with specific combining ability for single gene dominated resistant traits.

Resistant mechanisms expressed by single genes may serve as gene markers. Single genes, or closely linked multiple genes may be easily isolated for genetic engineering and tissue cultures to generate highly resistant strains. Trees with high general combining ability can be mated at random, and trees with specific combining ability can be mated in pairs to improve tree growth, spruce beetle resistance, and forest health.

The diallel crossing program can only be carried out on trees that are easily climbed in the field, but must be delayed until trees that can not be climbed efficiently flower in the clonal archive.

Estimated cost of the initial breeding program: $25,000.

The clonal archive will serve as a research center for identifying natural resistant mechanisms, and determining their genetic control and heritabilities as described for procedure VI above. The archive will also produce resistance seed for future reforestation programs. It will be maintained by the owner of the site on which it is established. The Alaska Reforestation Council, Tree Improvement Cooperative will assist the Kenai Borough and/or State Division of Forestry in maintaining the archive. The Kenai Borough Spruce Beetle Task Force may also be interested in maintaining the archive after plans for controlling the epidemic and restoring impacted forests are complete.

Estimated costs, and date of completion for each procedure described above are summarized in Table I.

Table I. A summary of procedures for demonstrating host spruce beetle resistance, resistant mechanisms, and genetic gains in tree growth, beetle resistance, and forest health.

Procedure	Estimated cost	Expected completion
I. Bibliography	7,500.	December, 2000
II. Tree selection	30,000.	December, 2000
III. Seed collection	10,000.	First seed crop1
IV. Propagation	65,000.	July, 2002
V. Archive	15,000.	September, 2002
VI. Breeding	25,000.	First flowers1
Total project costs	152,500.	
Administration cost2	10,000.	
Total all costs	162,500.	

1 Procedures III and VI can be delete from the proposal if the selections and their clones fail to flower before the final contract date.
2 Project assignments and accounting will be accomplished by the Alaska Reforestation Council and Tree Improvement Cooperative.

References:

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Footnotes:

Heritability (h2) is the proportion of phenotypic variation among trees in a population that is cause by additive gene effects. One minus h2 is the proportion of variation that is caused by the environment.

Harvest index is the harvested biomass relative to the total biomass of the plant.

Rough bark varieties are usually the first trees attacked by the spruce beetle and smooth bark trees are usually the last (Personal communication, 4/10/98, Dr. Ed Holsten, Entomologist, USFS, Anchorage, AK). Rough bark provides niches that shelter adult spruce beetles from weather and predators as they tunnel into the phloem. Resin blisters, usually present on the surface of smooth bark trees, may also impede the adult beetles.

More than 50 percent of the seed bearing capacity of the cone usually contains viable seed during better than average seed years.

Post-El Nino changes in the Pacific herring and walleye pollock biomass in Prince William Sound. Submitted under the BAA

Project Number: 99438-BAA

Restoration category: Research

Proposer: Prince William Sound Science Center

Lead Trustee Agency: NOAA
Cooperating Agencies:

Alaska SeaLife Center:

Duration: 1st year of 2

Cost FY99: $197.9K
Cost FY00: $200.0K

Geographic Area: Prince William Sound

Injured Resource/Service: Pacific herring, pink salmon, harbor seals, river otters, sea lions, murres, murrelets, auks, guillemots and all other birds and mammals that feed on juvenile herring and pollock.

ABSTRACT

We propose to conduct post El Nino surveys of the prespawning herring and pollock in their winter refuges in FY99. These surveys will all the assessment of recruitment anomalies that occur after 1997. We will provide estimates of herring and pollock abundances to NOAA, ADF&G, and to local fish processors. We will work with these management agencies to evaluate changes occurring to the populations since El Nino.

INTRODUCTION

In 1994, 1995, 1996 and 1997, a large scale fisheries and oceanography observational and modeling program was carried-out in Prince William Sound (PWS), the Sound Ecosystem Assessment Program (SEA). Using a public process to determine its goals, the SEA program set out to improve the predictive capability for changes in pink salmon and Pacific herring population size. Two coupled hypotheses were developed as the primary mechanisms for determining the survival of these two species: the river-lake hypothesis and the prey-switching hypothesis. The river-lake hypothesis focuses on the physical forcing mechanisms: (water temperature, salinity, turbulence and currents) that influence fish survival directly via bioenergetics and transport mechanisms, and indirectly via affects on the availability of food and behavior of predators.

In 1997, the SEA-Ocean observation program measured warmer ocean temperatures than in 1994-96 (Shari Vaughan, 1998 annual report). This has now been confirmed as a major El Nino (ENSO) event. Measurements of salinity, mixing and currents are ongoing. If these parameters are consistent with water temperature, the physical and biological conditions observed in 1997 that we consider most integral to the survival and growth of the Pacific herring, pink salmon and walleye pollock may have been the most anomalous encountered in the four years of study (1994-1997).

Concurrent with the SEA observation program is the building of numerical models to estimate fish survival. To validate model estimates of fish survival, we have developed and applied new acoustic survey procedures to estimate the biomass of prespawning herring and pollock in PWS. With this development, we have made the first repeatable biomass estimates ever for a stock of Pacific herring and walleye pollock (Thomas et al. 1997). Since we have tracked the recruitment of herring and pollock for SEA model verification, we not only have made repeatable measurements but we have also shown that the recruitment process is consistent with our understanding of the stock dynamics, showing that recruitment of a population is primarily an over the summer process for Pacific herring. We have prespawning estimates of Pacific herring in 1993-1998 and of walleye pollock in 1995, 97 and 98. This is a major improvement upon the visual estimation techniques by expert observers used by ADF&G to estimate herring abundance and the bottom trawl surveys conducted every three years by NMFS.

FY97 was the last field year for the SEA program. FY98 is dedicated to data analysis and publications. Personnel on this project are funded for roughly five months in FY98. Funding is not dedicated to future prespawning surveys. In 1993, neither the ADF&G or the EVOS Trustee Council funded herring assessment and the population had collapsed. In subsequent years, funding has been intermittent, with the fall surveys of herring being omitted the last two years and despite a decline in abundance. The same situation has prevailed for pollock with only three of the last six years being acoustically surveyed. Given the importance of these two species to the ecology of the Sound, and to the North Gulf of Alaska, they should be the last items to be omitted from the observations made by the EVOS restoration program. Knowledge of their biomass informs researchers on the health and productivity of the Sound

with respect to the forage available to fishes and wildlife. The information on Pacific herring and walleye pollock biomass are prerequisites for understanding restoration.

NEED FOR THE PROJECT

A. Statement of the problem

Pacific herring (Clupea pallasi) and walleye pollock (Theragra chalcogramma) are the two dominant pelagic fish in the in Prince William Sound, so their fry provide the major source of prey fishes to other fish and wildlife. Both the herring and the pollock are likely affected by changing conditions brought about by the ENSO event last summer. Increased temperatures, up to 2 deg C, result in larger herring larvae at hatching, but also increased consumption needs due to larger size and decreased yolk supply of the larvae (Bailey and Incze 1985). In addition, previous studies have shown changes in zooplankton abundance, distribution, and species composition (Miller et al. 1985). Macrozooplankton is the primary food source for herring and pollock in Prince William Sound (Cooney 1997). During years when macro-zooplankton densities are low, fish may have a difficult time obtaining adequate food and may experience reduced growth and survival, and/or may switch their diets to include other prey items, such as juvenile fish. Increased competition from vertebrate predators could compound these effects.

Since forecasting the stock abundance of herring and pollock is inaccurate at this time, direct measurement by acoustic surveys may be the only way to document possible effects of this FY97 warming event on fish stocks. Since 1993, the Prince William Sound Science Center has been conducting herring and pollock stock assessments in Prince William Sound (Thomas et al. 1997). Simultaneous observations on the population level are rare, and to continue observations on the herring and pollock populations in Prince William Sound in FY98 gives us an unprecedented opportunity to look at climate forcing effects on three of the most dominant and ecologically interactive and important fish in the North Pacific. In addition, the biomass information is needed as input and to verify SEA modeling efforts.

B. Rationale/Link to Restoration

This project provides the monitoring that is necessary to understand quantitative changes in the dominant pelagic fish populations in PWS. Successful restoration of Pacific herring, pink salmon and many damaged wildlife species depend upon the forage provided by young pollock and herring. Until better predictive tools are developed that can reliably forecast population changes, direct observations are critical to all phases of restoration, management and general understanding of natural processes. In addition to the direct monitoring of changes that this information provides, it also contributes to the development and improvement of new predictive tools.

Basically, we are looking at a two year program to complete the transition from the research program to a fully operational model-based monitoring program. Losing these years after the

most significant climate anomaly of the century occurred in 1997 would be a serious error in decision-making. This research will also help standardize nekton sampling protocols and allow for the training of new acousticians. Concurrent with the monitoring will be the SEA now-casting efforts that will refine the physical-biological and nekton models.

C. Location

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

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

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

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

PROJECT DESIGN

Objectives

We propose to conduct a survey of the prespawning herring and pollock in FY99, to determine if any of the physical and biological anomalies that occur in 1997 are manifested by time-lagged anomalies in the growth and survival in the Pacific herring or walleye pollock populations. Given that there are five strong year classes of herring, two of pollock (1984 and 1994 cohorts), and one for pink salmon, we have eight tests for anomalies in growth and survival for the five year study period.

Methodology

Hydroacoustics have been used to quantitatively measure fish populations for more than two decades (Thorne 1983; Thomas 1992). However, in recent years the standard survey applications have undergone significant improvement in Prince William Sound (Thomas et al. 1997). Prespawning aggregations of herring and pollock will be located with the assistance of the commercial fishing fleet and the Alaska Department of Fish and Game monitoring activities. Once the fish aggregations are located, they will be surveyed using series of parallel transects. These surveys will be repeated to determine the precision of the biomass estimates. Echo-square integration will be used to estimate fish density from the acoustic signals.

Concurrently with the acoustic surveys, we will use purse seining for herring and mid-water trawling for species, length, weight, age verification and to collect samples for cooperating projects (Kline- stable isotopes, Paul- bioenergetics and Kocan - disease). In addition, we conduct CTD casts in each survey to measure water temperature and salinity by depth. The oceanographic data can be used to provide inputs for bioenergetics models (Hewett and Johnson 1992; Paul 1997) to provide growth estimates for pollock and herring.

Deliverables

We will provide estimates of herring and pollock abundances for 1999 to NOAA and to local fisheries managers. We will analyze observations of growth, abundance and behavior relative to observed changes in physical conditions. These results will be presented in a report, at scientific meetings, and peer-reviewed publications.

Relevant Areas of Interest

The anomalous physical events in Prince William Sound during FY97 are not known to be caused by local or ENSO forced events. Other studies are working to determine this (Vaughan - physical oceanography). However, funding of this project will make it is possible to have concurrent observations of physical conditions that influence fish survival and growth, and estimates of fish abundance and growth. One of the most important aspects of climate change is its impact on fish populations, and the opportunity to collection high quality population data concurrent with such events is a way to improve our understanding of climate forcing on fish production.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposed project will work with the following ongoing and proposed projects:

Sound Ecosystem Assessment (SEA). Funded by Exxon Valdez Oil Spill Trustee Council (EVOSTC) since 1994. Chief Scientist: Dr. Ted Cooney.

Acoustic surveys of PWS Herring. Funded intermittently by ADF&G, EVOSTC and Cordova District Fishermen United (CDFU). Cooperators are John Wilcock, ADF&G and Shari

Shaw, CDFU, in Cordova

Acoustic surveys of PWS Pollock. Funded by ADF&G, Alaska Draggers Association, North Pacific Processors and local fishers.

Alaska Predator Experiment (APEX). Funded by Exxon Valdez Oil Spill Trustee Council (EVOSTC) since 1995. Chief Scientist: Dr. David Duffy.

SCHEDULE

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

Oct. 1 - Dec. 31:	Implement fall survey of Pacific herring to evaluate age 0 survival and distribution.
January - March:	Implement winter survey of walleye pollock and spring survey of Pacific herring.
March:	Attend EVOS meeting in Anchorage
fall-spring 99-00:	Repeat schedule

C. Completion Date

End of FY00 (September 2000).

PUBLICATIONS AND REPORTS

An annual report will be prepared to meet the Council's requirements for work done in 1999. Peer-reviewed articles are anticipated from the first year's work since there has been pre-El Nino surveys conducted from fall 1993.

PROFESSIONAL CONFERENCES

Presentations are planned for the International Council for Exploration of the Seas: Fisheries Acoustics Symposium in 1999 and the World Fisheries Congress in 2000.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will make use of preceding Council research through the designation of common field sites and sampling design. This project will also make use of data generated in the SEA, APEX and NSP projects as well as seek the input of researchers involved in other projects within the region.

PRINCIPAL INVESTIGATORS

Gary Thomas, Ph.D., Remote sensing specialist
Jay Kirsch, Electrical Engineer
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574
tel: (907) 424-5800
fax: (907) 424-5820
e-mail: loon-, or kirsch@grizzly.pwssc.gen.ak.us

Responsibilities: Dr. Thomas will be responsible for project administration, analysis and reporting. Jay Kirsch, EE, will be responsible for acoustic data acquisition and processing. Both Gary and Jay have been working as PIs on the SEA program for the past three years.

C.V.s for both investigators are attached. Please address all correspondence related to this proposal to Gary Thomas.

LITERATURE CITED

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MacLennan, D.N. and E. John Simmonds. 1992. Fisheries Acoustics. Chapman & Hall. London. 325pp.

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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		$0.0
Travel		$0.0
Contractual		$197.9
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$197.9
General Administration		$13.9
Project Total	$0.0	$211.8
Full-time Equivalents (FTE)		7.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$200.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99438-BAA
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$69.0
Travel		$9.8
Contractual		$61.5
Commodities		$6.0
Equipment		$12.0
Subtotal	$0.0	$158.3
Indirect		$39.6
Project Total	$0.0	$197.9
Full-time Equivalents (FTE)		7.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$200.0				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number:
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
G.L. Thomas	co-Principal Investigator		2.5	13.6		34.0
Jay Kirsch	co-Principal Investigator		5.0	7.0		35.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		7.5	20.6	0.0	
					Personnel Total	$69.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
EVOS Annual meeting	0.2	3	10	0.2	2.6
CDV-Fairbanks	0.4	4	6	0.2	2.8
CDV-(IEEE/AFS meeting)	1.0	3	14	0.1	4.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$9.8

FY 99

Prepared:

Project Number:
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
vessel charter, purse seiner for 30 days @1500/day	45.0
vessel charter, purse seiner for 5 days @600/day	3.0
fabrication services: towfins	3.0
fabrication services: electronic cables	2.0
network support and software lisc.	6.0
maintenance	2.5
Contractual Total	$61.5

Commodities Costs:	Proposed
Description	FY 1999
field supplies	1.0
office supplies	1.0
video and acoustic storage	1.0
software upgrades	1.0
hardware replacement	2.0
Commodities Total	$6.0

FY 99

Prepared:

Project Number:
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
100 m acoustic cable for digital sounder	2	2.0	4.0
underwater video camera/plankton	1	2.0	2.0
pentium 2 - 333 MHz+ PC for transmitter/receive control	1	6.0	6.0
			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**	$12.0

Existing Equipment Usage:	Number	
Description	of Units	
digital and analog echosounding systems		
Research Vessel: Orca Challenger		
Sum computers		

FY 99

Prepared:

Project Number:
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

Acoustic assessment of Pink salmon predators, macrozooplankton prey and juvenile herring in PWS. Submitted Under the Broad Agency Announcement.

Project Number: 99439

Restoration Category: Research

Proposer: Prince William Sound Science Center

Sponsoring Agency: NOAA

Duration: One

Cost FY 98: $70 K

Geographic Area: Prince William Sound

Injured Resource/Service: Pink salmon, Pacific Herring and the fish and wildlife resources that depend upon them as prey.

ABSTRACT

This proposal requests funding to support the processing, analysis and reporting of FY96-97 surveys of salmon predators, macrozooplankton prey and juvenile herring in Prince William Sound. This request is consistent with other projects (SEA Oceanography 320M and SEA Isotopes, 320I) who already have been compensated for additional field and analytical work that occurred with the expansion of the juvenile herring growth and habitats project (320T). Scheduled analysis and reporting of the Nekton and Plankton Acoustics Project (320N) has been delayed because of this increased work load. Also, the funds that are requested were originally budgeted for the Nekton and Plankton Acoustics Project but were under spent in FY96-97. We were asked to submit a new proposal to recapture these funds after requesting a no-cost extensions.

INTRODUCTION

The small runs of Prince William Sound pink salmon in 1992 and 1993, and the collapse of the herring population in 1993, prompted the people in the region to ask the EVOS Trustee Council to support more fundamental fisheries research. About the same time, a National

Science Foundation group of scientists working on the Ocean Ecosystem Dynamics Program (GLOBEC) concluded that our inability to predict changes in marine fish populations prevented us from separating natural and anthropogenic impacts (Cullen 1991). Acknowledging this situation, the EVOS Trustee Council initiated ecosystem-level studies to develop a better ecological understanding of these populations and improve the existing predictive tools. In 1993, the Sound Ecosystem Assessment science plan was developed by a group of scientists, fishermen and concerned citizens using the GLOBEC program as a guide. Funding of research began in the spring of 1994.

This is the fourth year of the Sound Ecosystem Assessment program (SEA), which is a long-term (5-8 years) ecosystem study to improve prediction of changes in abundance of pink salmon and Pacific herring in Prince William Sound. The pink salmon survival study focuses, but not exclusively, on hatchery fish since they represent over 90% of the juvenile salmon in the Sound during the spring. The herring in Prince William Sound are assumed to be a distinct stock. Both stocks are part of the EVOS Trustee Council restoration program.

The SEA program is developing (1) a subecosystem numerical model that predicts returning number of adult pink salmon spawners by indirectly estimating marine mortality of juvenile pink salmon in the spring and, (2) a subecosystem, numerical model that predicts recruitment of juvenile herring into the adult spawning population by directly estimating over-summer and over-winter mortality of sub-adult Pacific herring (ages 0, 1,2, 3 and 4) from fall and spring stock assessment surveys.

The development and operation of numerical models and the testing of hypotheses requires accurate assessment information on the distribution, density and size of specific animal populations. The nekton-plankton acoustics project (96320-N) is evaluating and applying acoustic measurement technology to collect this information. The assessment problem is complex for the development and operation of ecosystem-based models because they require estimates of dominant nekton and plankton predators and prey populations, which are often found in mixed aggregations. The measurement problem is simplified for juvenile herring in the winter when a time series of stock assessment surveys on the target species are possible, and mixed predator and prey assemblages are minimal.

To date, we have made significant progress toward our goals. For the ecosystem-based, numerical model for pink salmon we have: (1) identified adult walleye pollock as the dominant pelagic fish predator of nekton and plankton in the Sound, (2) made quantitative estimates of adult pollock biomass in the winter (in cooperation with commercial fishermen, Alaska Draggers Association and Alaska Department of Fish and Game, ADF&G), (3) made quantitative estimates of the distribution and density of adult walleye pollock in mixed layers of plankton prey in the spring, (4) made a first estimate of zooplankton distribution and

density. Tasks we are working on in 1996-98 are: (1) continue adult pollock biomass estimation with the fishing industry and ADF&G, (2) evaluate error in the estimate of spring-feeding adult pollock biomass, (3) evaluate the accuracy of zooplankton distribution and density estimates as a surrogate for prey availability, (3) determine the feasibility of assessing the spring salmon fry density and distribution along the shoreline, (4) determine the feasibility of assessing the spring density and distribution of subadult pollock biomass along the shoreline and their role as salmon fry predators and, (5) determine the feasibility of assessing the fall and winter biomass of subadult pollock distribution and abundance. Annual estimates of adult pink salmon returning each year are provided by ADF&G.

For the population-based numerical model for herring we have: (1) made quantitative estimates of adult herring biomass in the fall and spring (in cooperation with commercial fishermen, Cordova District Fishermen United (CDFU) and ADF&G) and, (2) made first run estimates of fall juvenile herring distribution and abundance. Tasks that we are working on in 1996-98 are: (1) continue making estimates of the adult herring biomass in the fall and/or spring with the fishing industry and ADF&G and (2) evaluate the accuracy of fall and spring, juvenile herring distribution and abundance estimates.

NEED FOR THE PROJECT

Statement of the Problem

Pink salmon were damaged by the spill but are now listed as a recovering resource, while herring is still listed as non-recovering. However, we do not have the ability to tie the changes observed in these populations to natural or anthropogenic impacts. Thus, the justification to continue SEA remains to develop better predictive tools. SEA has made significant progress in two years towards developing a better understanding of the ecosystem, improving the data management, analysis and modeling tools and maintaining communication and cooperation amongst a diverse group of organizations and researchers. In addition, some byproducts of the SEA program have already made important contributions, such as the application of acoustic survey techniques to make estimates of adult Pacific herring in 1993, 1994 and 1995 and adult walleye pollock in 1995.

Pacific herring were damaged by the spill and were showing some signs of recovery until this spring when only 24,000 tonnes were measured on the acoustic-purse seine survey. The ecological, economic and cultural importance of Pacific herring to PWS and the North Gulf of Alaska is unparalleled. The Tlingit called herring the "grass of the sea." Herring are the main source of prey for numerous fish, birds, and mammals in PWS. Without understanding how environmental and ecological factors, including climatic changes, might be influencing the

recovery of Pacific herring, there is no clear means for predicting changes in production. Furthermore, restoration activities undertaken in the absence of knowledge about ecosystem function could conceivably cause more damage than they are intended to remedy. Over the long term, as understanding of the Prince William Sound ecosystem improves, the risks associated with proactive restoration activities will become much less uncertain.

B. Rationale

Baseline data on animal abundance is limited when used for determining the impact of and recovery of anthropogenic disruptions on dynamic populations. This is because animal population abundance is seldom stable. In contrast, it is often in a state of fluctuation, either increasing or decreasing as a result of purely natural events. Therefore, the development of models that predict animal population change as a result of natural conditions is mandatory to accurately assess recovery from an anthropogenic disturbance. The Nekton-Plankton Acoustics project is providing the baseline data on animal abundance that is also essential data for developing and evaluating the predictive models.

In addition, restoration activities undertaken in the absence of the ability to predict change are controversial because they could cause more damage than they are intended to remedy. Almost every biological remedy fits into this class: fish hatcheries, animal rehabilitation, bioremediation, etc. However in the short-term, the Nekton-Plankton Acoustics project development of improved stock assessment techniques and their application to building and evaluating numerical models of the herring and pink salmon ecosystem has already improved our knowledge of the stocks and provided new tools for harvest management. Over the long term, as the SEA program obtains a better understanding of ecosystem form and function in Prince William Sound, the risks associated with proactive restoration activities will be reduced.

C. Summary of Major Hypotheses and Objectives

The underlying mechanisms of the ecosystem-based, numerical models are the coupled hypotheses: river-lake and prey-switching. River-lake hypothesizes that the climate-forced flushing rates of the Sound are negatively correlated with the availability of zooplankton prey to fishes in the spring. Prey-switching hypothesizes that during years of low zooplankton prey availability (a river year), the predators switch to feed on the age 0 fishes rearing in the Sound and age 0 fish survival is low. The combination of age 0 fish survival being positively correlated to lake year conditions and negatively correlated to predation is proposed as the mechanism that produces large year classes of fishes in the Sound.

The Nekton-Plankton Acoustics project is contributing to the testing of the river-lake and

prey-switching hypotheses by providing zooplankton and fish distribution and density information. After two years of SEA research, there is increasing evidence to support that these hypotheses are mechanisms that dominate the Sound's production processes. With dominant mechanisms providing the framework for the modeling effort, there is an excellent chance to develop better predictive models for pink salmon and herring recruitment.

D. Completion Date

1. Phase I (FY94-95): Infrastructure development, implementation of standard fisheries measurement technologies to study population-level predator-prey relationships, stock assessment of dominant fish species (a cooperative program with industry and management), initiation of zooplankton measurement program using digital echosounders and the development of new 4D visualization techniques with acoustic data.
2. Phase II (FY96-98), Continued stock assessment of dominant fish species (a cooperative program with industry and management), model development to describe predator-prey dynamics relative to physical conditions, advancement of quantitative 4D visualization techniques with acoustic data, implementation of a new zooplankton measurement program, refinement of measurement and estimation techniques. Initiation of synthesis.
3. Phase II (FY99-2001): Completion of synthesis and implementation, testing and training for the monitoring phase in the transition from research and development to application. Researchers cannot be expected to become locked into the routine monitoring phase so education and training of post-graduate personnel will be necessary to bring them up to speed on the new measurement and analytical technologies and their application.

COMMUNITY INVOLVEMENT

The SEA Science Plan was developed using local knowledge from the community to establish goals for the science program. The Nekton-plankton acoustics project has integrated local knowledge of the fish populations into: (1) the design and implementation of fish stock assessment surveys, (2) the choice of procedures to subsampling specific acoustic targets, and (3) in the safe and effective operation of vessels used as sampling platforms. Several community presentations on different aspects of the project are presented to the local public in both invited and public seminars each year.

The PWS Science Center initiated a SEA newsletter, the Sound Waves radio program, established a home page on the world-wide web (http://www.pwssc.gen.ak.us/sea/sea.html) and is building a local area network to disseminate information throughout the Sound and to interested parties around and outside Alaska. Locally, we also use our Science Club, Science Discovery Room, Science outreach program and Science Summer Camp programs to disseminate information to the public. Although, the EVOS funding for this has been

discontinued, the Center is seeking other sponsors to continue the dissemination of research information to the public via presentations, newsletters, wide- and local-area networks, radio and possibly video communications. The Nekton-Plankton Acoustics Project has contribution to all of the above communications on research findings and acknowledges the EVOS Trustee Council for its generous support.

Location

This project has been designed for Prince William Sound. All communities that utilized the marine resources of Prince William Sound will benefit from this research.

PROJECT DESIGN

In the summers of 1996 and 1997, acoustic measurements of juvenile herring were collected in four bays and fjords around PWS (Whale, Eaglek, Simpson, and Zaikof) by SEA Nekton and Plankton Acoustics Project (320-N) in support of the SEA Herring project (320-T). It was hypothesized (SEA project) that condition at the onset of winter would play an important factor in the over-winter survival of the fish. These studies were designed to study the processes that affected the pre-winter condition of the herring.

The goal of the Nekton and Plankton Acoustics projects was to determine the site fidelity and the possible carrying capacity of winter refuge for juvenile herring. Also, to work with SEA Oceanographers (320M) to identify retention mechanisms in the nearshore regions and potential losses from PWS to the outer Kenai areas. Both of these mechanisms are supported by broad scale acoustic observations in the fall of 1995. We dedicated a full time acoustician to the juvenile herring project for the last two years to accomplish this task. We need to recapture unspent funds in the FY96-97 budgets to finish the analysis and processing that was postponed to collect the additional juvenile herring data.

Objectives

We are currently working on the macrozooplankton, predator and herring observation data bases for use in hypothesis testing of mechanisms that are the backbone of the SEA modeling development. We need to finish these so we can play an effective role in the synthesis of SEA data.

For our project 'deliverables', an easy way to separate tasks in fiscal years might be the resulting publications. So, first are the deliverables already completed by April 15, 1998:

1. The assessment of co-occurring predator and plankton densities submitted to the Canadian bulletin for publication (1994-95) and EVOS TC 1997 annual report.
2. The determination of errors in acoustic assessment of adult herring and pollock biomass (1993-1996), the dominant predators of salmon fry in PWS, and their implications towards multiple species management that was published in the Proceedings of the 2nd World Fisheries Congress and 1997 EVOS TC annual report.
3. The repeatability and accuracy of acoustic assessment of the adult herring and pollock in PWS (1993-1997), and implications in the 1997 annual report to the EVOS TC,
4. The assessment of the predation of salmon fry at AFK hatchery (1992-93) published in the 1995 annual report to the EVOS Trustee Council,
5. Broadscale distributions of juvenile herring in PWS in the fall of 1995 reported in the 1996 EVOS Trustee annual report.
6. Walleye pollock abundance and distribution along the outmigration route of pink salmon fry, PWS, (1994-95) that was published in the 1994-95 annual reports to the EVOS TC.
7. The preliminary assessment of the use of acoustics, optics and nets in the measurement of plankton density and distribution in PWS in the 1997 report to EVOS TC.

Second are the deliverables to be completed by April 1999 if extension is authorized:

1. A manuscript to a journal on the repeatability and accuracy of acoustic biomass estimation for herring and pollock in PWS (1993-1998) and their implications to inseason management, salmon fry model input and validation publication (latest version of the model). This includes incorporation of 1997-1998 data and analyses that are underway.
2. A manuscript submitted to a journal on the acoustic estimation of plankton density and distribution in PWS (1994-1996). This includes new processing of data that were just received from Ted Cooney.
3. A manuscript submitted to a journal on the broadscale distribution of juvenile herring in PWS (1993-1997). This includes new analyses that were just completed for the 1997 review and a merging of findings with the herring habitat project.
4. A manuscript on the pollock prey switching relative to plankton densities (1994-1996). This includes new high resolution spatial analysis that is being designed after the completion of the pollock and plankton co-occurrence paper.
5. A manuscript describing the SEA program and the synthesis of findings, which are being developed by the SEA P.I.'s.

Methods

The Nekton-Plankton Acoustics project is a multidisciplinary study that will rely on: (1) cooperative, model development to assist in sampling design, data analysis and interpretation,

(2) shared vessel and facilities for data collection and logistical support, (3) data sharing with the agency and university principal investigators, and (4) remote sensing with acoustical and optical technologies.

Synoptic sampling of both the biological and physical characteristics of the water column using samplers that operate on quasi-continuous, spatial and temporal scales are essential if SEA is to link small scale process measurements to population and ecosystem parameters (Thomas 1992, GLOBEC 1991b). In response to this, three core SEA projects (oceanography, nekton-plankton acoustics and data management and modeling) were designed to incorporate the necessary acoustical and optical measurement technologies and computer intensive analytical and communication tools. Recognizing the rapid evolution of technologies, a small component of each of these SEA projects will be used to match other funding sources to research and develop new techniques.

The SEA field program used the conceptual experimental design of GLOBEC (1991c), which involves the nesting of fine scale measurement programs within large scale ecosystem monitoring efforts. Ocean state monitoring required large scale surveys in the coastal buoyancy current and throughout the Sound, and fine scale monitoring along the western shorelines. Trophic state monitoring required large scale monitoring throughout the Sound for macrozooplankton, and finer scale monitoring in the central-western Sound and along its shorelines for nekton. Monitoring is concentrated in the western Sound because this area contains the primary migration route and feeding areas of juvenile and adult pink salmon and Pacific herring.

Macrozooplankton:

The primary temporal and spatial characteristics of the macrozooplankton bloom that are important to measure are: (1) the timing, (2) the amplitude and, (3) the horizontal distribution around the Sound. Finer scale measurements of inshore-offshore and vertical distribution of the prey relative to diel and tidal conditions are important to the development of the bioenergetics and foraging mechanisms. Understanding mechanisms is critical to making believable predictions.

Historically, the timing of the macrozooplankton bloom has been determined by systematically sampling with a vertical net at hatcheries over the season. Acoustic and optical measurement procedures are being used to make a more representative estimate of the macrozooplankton population in time and space.

In 1994-95, we developed more appreciation for the importance of the spring macro-zooplankton bloom to the juvenile fishes rearing in PWS. Measurement of the temporal and

spatial characteristics of the macrozooplankton bloom (timing, amplitude and geographic distribution) is a key aspect of 1995 SEA studies. The integrated volume of this distribution could positively correlate with flushing rate (river to lake conditions) and explain the majority of interannual variability in pink survival. Also, 1994-95 surveys suggested that the abundance of the primary salmon predator, walleye pollock, can be made coincidentally with macro-zooplankton assessment. Thus, one survey may provide the annual estimates of prey and predators affecting juvenile fish survival. Thus, some variation of the spring macrozooplankton survey could be the future monitoring tool used to estimate annual carrying capacity of PWS.

In 1996, the large scale distribution and information on density of the macrozooplankton was measured using multiple-frequency, digital, dual-beam echosounders, an optical plankton counter (OPC) and various plankton nets (Cooney, 320H). A four frequency (120, 420, 720 kHz and 1 MHz) echosounder system were used for offshore sampling and a two frequency system will be deployed inshore (120 and 420 kHz). Interactive Data Language (IDL) code and Advanced Visualization Systems (AVS) flowgrams were developed on a workstation for processing (including target strength and absolute density estimation), data integration and visualization.

The macrozooplankton catch in the closing net were used to sea truth the higher frequency acoustics and the optical measurements. The closing net, acoustic and optical measurements were taken at the same depth and time interval. The acoustics and optics will be cross calibrated, or size and density estimates of macrozooplankton will be compared between acoustics and optics to develop best sampling protocols. These analyses are ongoing.

The timing of the bloom may be of very short duration in river years (only three weeks) so the selection of sampling time is critical. The long term averages suggest that the peak macrozooplankton abundance is plus or minus a week around the 12th of May. Thus, the timing of the large scale surveys will be conducted to bracket this period.

Nekton:

Large scale measurements of fish distributions were made using 120 kHz (38 and 70 kHz if available) digital echosounders. The BioSonics ESP and DT software was be used to integrate the backscatter and isolate individual targets. IDL code and AVS flowgrams were developed on a workstation for processing (target strength and density), data integration and visualization. The sonars were deployed from surface vessels in the western Sound for salmon work and throughout the Sound for herring. Aerial surveys will help stratify acoustic survey efforts for nearshore herring assessment. During late spring and summer months sidelooking sonar was used in addition to downlooking echosounders to collect information

on nearsurface salmon fry and herring concentrations. These analyses are ongoing.

In 1994, we observed large variability in seasonal in- and offshore distribution of fish along the outmigration corridor of the pink salmon fry. In 1995, we conducted shoreline and offshore sampling at sites where juvenile pink salmon fry were concentrated to determine in- and offshore changes over diel and tidal cycles. Acoustic transects will be run perpendicular to the shoreline site and repeated several times during these surveys. In 1994 and 1995, the salmon fry tended to be patchily distributed, at the surface, and so tightly distributed against the shoreline that they were inside of the acoustic surveys of fry predators. In 1996, we explored the feasibility of measuring the distribution of salmon fry along the shoreline with sidelooking sonar. These analyses are ongoing.

Actual field sites will be determined by the Principal Investigators during field prelogistic meetings.

Data Acquisition and Processing

Acoustic Data Acquisition: Acoustic signals are currently acquired by the Echo Signal Processor software (version 3.0) from BioSonics. Two data sets are generated from each transect; a list of individual targets whose voltage peaks could be isolated from the transducer signals (via dual-beam), and a 2-dimensional array of relative density (via echo-squared integration) whose cells will be georeferenced with GPS information.

For the 120 kHz system, a noise threshold is determined which will remove smaller targets not of interest. For higher frequencies that are used to measure zooplankton, the noise level will establish the threshold. A TS of -70 dB typically marks the beginning of Rayleigh scattering for a 120 kHz system. We also perform passive listening so as to characterize the sonar's noise performance.

The number of echo integrator cell sizes is limited by hardware and software constraints. New software with the digital sonars are expected to reduce these limitations. The vertical size of cells was smaller near the surface to provide higher resolution (0.5 m). The horizontal size of cells was determined by the minimum number of pings which ranged from 8 to 60 pings (higher resolution was used for inshore surveying). Ping rates are logged so that individual targets can be referenced to their appropriate cell.

Geographical Logging: Each sonar system is equipped with a Magellan DX5000 GPS receiver and external antenna to indicate current position. We connect the GPS's NMEA0183 data output to the computer's COM1 input, after which the position data is read to the echo-integration files, yielding georeferenced density arrays. BIOMAP software is used as a realtime navigational aid. Maps are made by postprocessing data using the pwsplot procedure

in IDL. This data link is feasible only during minimal CPU use and often causes Windows to crash. This problem is under investigation by BioSonics and will be solved by next spring's field season.

Species verification with biological sampling: Fish are caught to determine species, measure physical lengths (to compare to acoustic measurements), and to analyze stomach contents. Over 1300 hundred purse seine, herring trawl and tucker trawl hauls were made in the summer of 1994 and 1995. Classification of acoustic targets by species using the composition of these net catches is ongoing.

Data Management and analysis

An acoustic tool box of software utilities have been developed in IDL and AVS for processing and analysis.

a) IDL - The Interactive Data Language (IDL) is an array-oriented programming environment which has been chosen for processing of electronic data. The PWS Science Center has hosted a number of acoustic R&D projects which have contributed to the development of a library of software procedures for expediting acoustic data analysis. Compiled versions of these routines are shared with cooperating researchers for specific projects as a service offered by the PWS Science Center.
b) AVS - Advanced Visualization System is a tool which allows scientists to connect block-diagram modules into flowgram networks. These modules include visualization, data I/O, and statistical functions, as well as any C programs written in-house. This makes it simple to use as well as expandable. Modules for data integration and geographical transformation have been developed at PWS Science Center on a number of R&D projects. Executable files for these routines are available for use by cooperating researchers.

Processing: An IDL data file is generated for each pass on a transect, and includes individual targets, spatial arrays of absolute density and average backscatter, georeferencing, bottom, and calibration information. The acoustic values are all recalculated from the raw voltage data, so that calibration parameters can be adjusted during post processing if necessary. .
a) Targets - A power function (Traynor and Ehrenberg, 1979) is currently used to simulate a transducer's beam pattern (ideally a Bessel function) so as to estimate TS. The target strengths are therefore compensated for off-axis location, and targets with angles greater than the mode in the angle distribution (usually about 3 degrees) are excluded so as to remove size bias (since off-axis targets require higher noise thresholds).

Some of the parameters in dual-beam estimation have a degree of variability which can cause error in TS. In particular, the wide beam dropoff is determined by a regression, and the range

of angles to include in its computation has not been standardized. We will investigate the use of the beam pattern as a discrete vector instead of a simulation. During processing, this will be more computationally expensive than a power function although much less than a Bessel function, and the cost in CPU time will be offset by the additional accuracy.

b) Densities - Absolute density is calculated spatially by dividing the relative density array (v^2) by the average target backscatter (sigma), then applying calibrations (SL, RG, PW, B^2).

Biological Analysis:

a) Problem definition - Classification of targets is a problem in Prince William Sound because of the diversity of marine life. While pollock, salmon, cod and herring are the dominant fish species, other organisms including zooplankton, squid, and jelly plankton are plentiful and capable of reflecting sound. Some separation of these species is possible because they often arrange themselves in layers but these layers have fuzzy boundaries relative to the sharp boundaries of discrete fish schools. This may be a function of the single-frequency analysis and should be resolved by multifrequency analysis. Also, different species can overlap in space and time, which we may use in predation analysis.
b) People and machines - Our first step in target classification is to develop criteria for interactively classifying species. An editor has been written in IDL which allows the user to select an aggregation of targets within an electronic echogram, and tag them based on TS, known spatial and temporal behavior of each species. Data from these are referenced to seine and trawl catches that were either directed at the targets or conducted in the vicinity of the acoustic transecting. Other classifications such as noise, bubbles, jellies, and false bottom can also be used so as to exclude those targets from the analysis.

Automation technology is often assumed to be an ultimate solution, without considering all of its implications. Quality control and assurance can easily suffer degradation when high quantity is the priority and automation is the primary tool. Although the volume of data collected is often immense (hundreds of transects per year), it is still to our advantage to use interactive techniques, as opposed to "faster" automated techniques. An interactive technique is one in which powerful computers and software allow the intelligent user to make decisions efficiently, with the labor performed by the CPU under the scientist's supervision. It is also faster than pure manual techniques. Automatic techniques to classify targets also require extensive parameterization and ground truthing, which although possible, will take a few years to develop fully.

c) N-dimensional signal processing - Work has been done in using 1-dimensional signals (individual pings) to determine school content (Rose and Leggett, 1988, Ramani and Patrick,

1992). However, the second spatial dimension (ping number) is relevant to species classification. Thus, the entire image will be analyzed as well as single ping information. We are currently using the electronic echograms mentioned above. We plan to expand earlier signal processing techniques to the distance dimension, so that image processing (2-dimensional signal processing) will direct our classification schemes.

Multifrequency Analysis:

Our plan for summer 1996 is to deploy, measure, and analyze multiple frequencies and to use inverse techniques (Greenlaw and Johnson, 1983) to determine biomass as a function of species. We have purchased 70kHz, 120kHz, 420kHz, 720kHz, and 1MHz systems. We plan to operate up to four of these frequencies simultaneously. Inversion is a mathematical technique where matrix algebra is employed to solve for several unknowns, given several equations. The fundamental equation states that acoustic scattering at a particular frequency is the total of the multiple of biomass per species by each species response at that frequency. Thus, by dividing the measured acoustic scattering matrix by the known frequency dependence of all species of interest, the result is the scattering as a function of species. This technique requires frequency response of each species to be accurately known, which is another justification for upgrading our calibration facilities to allow known targets to be tethered and ensonified. These mathematical techniques have been expanded to constrain solutions to be non-negative (Lawson and Hanson) , and to find solutions even when given fewer equations than unknowns. A portion of these inversion algorithms has been coded in IDL, and will be complete by summer 1996.

Estimation routines:

Estimates of fish biomass will be made from systematic transect designs and where replication is possible estimates of precision will be made. Procedures for estimation and sources of error are presented in MacLennan and Simmonds (1992). Hypotheses testing will be an integrated analysis step with the Numercial Modeling project (320J).

C. Discussion

Pink Salmon and Pacific herring models

The indirect estimation of marine mortality for the juvenile life history stage of pink salmon is necessary because they migrate to sea and are not seen until they return 12-14 months later as adults to spawn (Forester 1967). Since about 90% of marine mortality of pink salmon occurs as juveniles in the spring (Thomas and Mathisen 1992), we are attempting to model ocean and trophic state conditions as a surrogate to a direct measurement of the number of fish and

result in an estimate of survival. Ocean state conditions (water temperature and current velocities) directly affect the juvenile pink salmon survival via the bioenergetics mechanism (Beauchamp et al. 1989) and are postulated to indirectly affect the trophic structure by altering the distribution and abundance of prey, competitor and predator specie. Since climate forcing (cyclonic storms, El Nino events, etc.) results in significant annual variability in ocean state conditions, the survival of juvenile pink salmon fry are expected to fluctuate in a like manner (Thomas and Mathisen 1992).

The survival of herring larvae from egg deposition to recruitment as four year olds into the adult spawning population has been a topic of intensive investigations. Since the studies of herring eggs and larvae have not produced a reliable model to predict herring recruitment (reference), we are evaluating the capability to directly measure ages 0, 1, 2, 3 and 4 juvenile herring in the fall and spring to estimate survival over the summer and winter periods. Critical to this capability is the assumption that the subadult herring distribution is relatively stable within the Prince William Sound survey area. It is important to note that this is not a mechanistic model so it cannot tell you why the mortality has occurred.

The development of an ecosystem-based, numerical model that predicts herring recruitment by indirect estimation of over-summer and over-winter juvenile herring mortality is needed to assess why the mortality has occurred. Also, the over-summer and -winter model subcomponents may be useful if the stock assessment of juvenile herring proves not to be feasible. Between these two subcomponents, the over-winter survival model is most tractable since the predation and feeding/growth effects are minimal. The development of an over-summer survival model for herring is problematic since predation and feeding/growth effects are dominant processes and mortality rates are precipitous. Also, if the survey approach is successful at estimating survival from a time series of direct measurements, the development of the ecosystem-based, Numercial model will be more robust, if the ocean and trophic state conditions are known. Since there is a time lag and spatial separation between when age 0 pink salmon and herring are present in the Sound, additional ocean and trophic state measurements for herring are needed.

Since juvenile mortality rates for both pink salmon and Pacific herring are eventually used to estimate adult recruitment, accurate stock assessment of the adults is essential for the final testing of numerical models. Stock assessment of the returning adult pink salmon is a major management program that is conducted annually by ADF&G. Adults are counted in the catch and adult escapement into the streams is estimated by visual inspection via aerial overflights. To conduct stock assessment of herring, ADF&G relies on virtual population analyses, egg deposition surveys and aerial estimates of the length of shoreline that is discolored by herring milt. Working with the fishermen and ADF&G through grants from CDFU, we have developed an acoustic stock assessment survey that has tracked the population since fall 1993.

Since adult stock assessment is essential to the success of SEA but not a SEA task, we must continue to collaborate with management and industry to collect this information using acoustic techniques developed between 1993-95.

Multi-species exploitation rate model

Since the ecosystem-based models are long-term products, a short-term solution to restoration that has developed as an offshoot of the SEA and related stock assessment efforts is the development of a multiple-species (pink salmon, herring, walleye pollock) exploitation rate model. Again, this is a non-mechanistic approach to restoration and is offered only to consolidate and standardize ongoing single-species management efforts that independently set exploitation rates for these co-existing stocks.

Logistics of measurement and future monitoring

These endeavors are considered logistically possible only because: (1) the Sound is assumed to be a semi-enclosed, rearing area for the young salmon and herring, which places spatial limits to the extent of our study area, (2) it is assumed over ninety percent of the juvenile pink salmon mortality occurs in the spring, which places temporal limits on our study, (3) subadult herring are assumed to rear overwinter in the Sound or close by, and (4) we are implementing a synoptic large and small scale measurement program with quasi-continuous samplers (optics and acoustics) that allows us to simultaneously measure ocean and trophic state conditions.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Vessel charters will contracted to the private sector through competitive bid.

SCHEDULE

A. Measurable Project Tasks for FY 99

October 1998:	Analyze field data
March 1999:	EVOS Workshop - Anchorage
April 1999:	Annual Report submitted

B. Project Milestones and Endpoints

FY99

September 1999: Complete observations and analysis

C. Completion Date

The completion data of this project is September 30, 1999.

PUBLICATIONS AND REPORTS

Manuscripts submitted by the end of FY01: see objectives

PROFESSIONAL CONFERENCES

Travel is requested to present results at the EVOS Workshop in January 1998 in Anchorage.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research will be coordinated with all components of the SEA program. This project will also cooperate with APEX, NVP, and other EVOS-sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

PRINCIPAL INVESTIGATOR

Gary Thomas, Ph.D.
Prince William Sound Science Center
P. O. Box 705
Cordova, Alaska 99574
(907) 424-5800 Office
(907) 424-5820 Fax
loon@grizzly.pwssc.gen.ak.us

OTHER KEY PERSONNEL

Jay Kirsch, EE: Data processing and analysis
Geoff Steinhart:. Data processing and analysis

Nick Peters: Data processing and analysis

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FY 99 EXXON VALDEZ TRU[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$70.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$70.0
General Administration		$4.9
Project Total	$0.0	$74.9
Full-time Equivalents (FTE)		5.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$150.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99439
roject Title: Acoustic Analysis
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$48.2
Travel		$5.8
Contractual		$1.0
Commodities		$1.0
Equipment		$0.0
Subtotal	$0.0	$56.0
Indirect		$14.0
Project Total	$0.0	$70.0
Full-time Equivalents (FTE)		5.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$150.0				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number:
Project Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	G.L. Thomas	co-Principal Investigator	2.0	13.6		27.2
	Jay Kirsch	co-Principal Investigator	3.0	7.0		21.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	5.0	20.6	0.0	
					Personnel Total	$48.2

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	EVOS Annual meeting	0.2	2	8	0.2	2.0
	ICES Fish Acoustic Meeting	1.0	2	9	0.2	3.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$5.8

FY 99

Prepared:

Project Number:
Project Title: Post El Nino changes in Pacific herring and walleye pollock in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 1999
Description	
maintenance	1.0
Contractual Total	$1.0

Commodities Costs:	Proposed FY 1999
Description	
supplies	1.0
Commodities Total	$1.0

FY 99

Prepared:

Project Number:
roject Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRU 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
			6.0
			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	
Sum computers		

FY 99

Prepared:

Project Number:
roject Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

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

Submitted Under BAA No. 52ABNF800034

Project Number:	99441-BAA
Restoration Category:	Research
Proposer:	Randall Davis, Ph.D., Texas A&M University at Galveston
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	Yes
Duration:	1st year, 2-year project
Cost FY 99:	$123,011
Cost FY 00:	$123,011
Geographic Area:	Prince William Sound and Alaska SeaLife Center
Injured Resource:	Harbor seals

ABSTRACT

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

INTRODUCTION

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

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

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

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

NEED FOR THE PROJECT

A. Statement of Problem

The Restoration Program has supported three harbor seal studies in Prince William Sound (Project 001- Harbor seal condition and health status; Project 064- Monitoring habitat use and trophic interactions of harbor seals; Project 117-BAA- Harbor seal blubber and lipids). One objective of these studies has been to measure health and body condition indices related to metabolic alterations that might occur in animals that were food deprived. Although these studies collected much useful information, some researchers realized that controlled dietary studies were needed to more completely interpret field data. In 1997, the Restoration Program funded a captive study (Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) at the Alaska SeaLife Center that will quantify the nutritional value of several key Alaskan fish species for harbor seals and will follow health indices over time in both healthy and rehabilitation animals. That project will feed controlled diets of fish to harbor seals to examine changes in body condition, health, assimilation efficiency and blood chemistry biomarkers. Of particular interest will be the health and body condition effects of diets containing nutritionally poor (compared to herring and capelin) fish such as pollock, the so-called "junk food" hypothesis for explaining the decline of certain pinniped stocks. In the proposed research, we will take advantage of the controlled feeding feeding studies at the Alaska SeaLife Center to examine the effects of diet on: 1) fatty acid markers in the blubber, 2) muscle condition and 3) lipid metabolism. In addition, we will use samples of blubber and muscle obtained by the BIOSAMPLING Program in Prince William Sound for comparison with captive seals fed known diets. This important work will augment already funded investigations of diet and health to provide a more in depth understanding of the nutritional role and assessment of dietary fat for harbor seals.

B. Rationale

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

C. Location

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

(Castellini/Project 341) in harbor seals that occur under different feeding regimes.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

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

PROJECT DESIGN

A. Objectives

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

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

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

B. Methods

1. Hypotheses to be Tested.

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

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

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

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

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

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

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

Animals. Eight harbor seals have been acquired by the ASLC for the feeding trials. Dietary protocols are being developed, but the animals are currently on a controlled diet of herring. In the event that our proposed study is funded, Dr. Michael Castellini (Research Director at ASLC) has already agreed to obtain blubber and muscle biopsies from the seals during the controlled phase (herring only) of the dietary studies during the summer 1998. Beginning in FY99, we would begin direct participation in the feeding studies. During the feeding experiments, the diet will be changed to pollock and other ground fish for periods of not less than three months. During these dietary manipulations, we will obtain serial blubber and muscle biopsies of not less than once per month from two sites on each animal.

Blubber Biopsies. Blubber samples will be obtained with a 6-mm punch biopsy inserted through a small incision in the skin. Samples will be immediately transferred to liquid nitrogen and stored at -80° C until analysis. Total lipids will be extracted in chloroform according to Folch et al. (4) as modified by Iverson (5). Fatty acid methyl esters (FAME) will be prepared from the purified lipid extracts using the Hilditch reagent (0.5 N H_2SO_4 in methanol). FAME for fish in the controlled diets will be obtained similarly from homogenates of individual food items. The methyl esters will be analyzed by temperature-programmed capillary gas-liquid chromatography. FAME will be identified and quantified using a combination of standard mixtures, including those identified using chromatography and an ion-trap mass detector. Individual fatty acids, expressed as weight percent of the total fatty acids, will be analyzed using classification and regression trees (CART) in S-plus (StatSci, Seattle), a non-parametric multivariate technique for classifying data. CART uses a series of algorithms to split data into groups as differently as possible, based on measures of deviance; the splitting continues in a tree-like form until a classification is made at a terminal node. The analysis of blubber fatty acids is already being conducted in our laboratory in collaboration with Dr. Sara Iverson (University of Halifax) as part of a feeding ecology study of Steller sea lions. This collaboration will continue during the proposed harbor seal study.

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

Electron Microscopy of Muscle Samples. Fixed muscle samples will be rinsed in cacodylate buffer and post-fixed for 2 hours in a 1% solution of osmium tetra oxide. They will be stained 'en bloc' with 2% uranyl acetate overnight in a refrigerator. After dehydration with increasing concentrations of ethanol (50-100%), they will be passed through propylene oxide and increasing concentrations of epoxy (50-100%). The samples are finally embedded in fresh epoxy and allowed to polymerize overnight at 60 ° C. Thick sections (1 mm) will be cut with a Leica Ultratome and stained with toulidine blue to determine fiber orientation. Ultrathin (50-70 nm), transverse sections will be cut and contrasted with lead citrate from 4 randomly chosen blocks per muscle. Micrographs will be taken with a Phillips 201 transmission electron microscope. The number of micrographs per muscle analyzed will range from 25 and 40, yielding relative standard errors of less than 10% in all muscles. Determination of the volume density of mitochondria, myofibrils and lipid droplets will be performed at a final magnification of x19,250 using standard point counting procedures (6, 7). The electron microscopy will be conducted under the supervision of Dr. Odile Mathieu-Costello at the University of California at San Diego (see attached letter).

Citrate Synthase, B-hydroxyacyl CoA dehydrogenase and Myoglobin Assays of Muscle Samples. Frozen muscle samples will be weighed and then homogenized at 0° C in 1 ml of buffer containing 1 mmol L^{-1} EDTA, 2 mmol L^{-1} $MgCl_2$, and 75 mmol L^{-1} Tris-HCl, pH 7.6 at 25 ° C (8). The homogenates will be spun at 2,900 g for 30 minutes at 4° C. 500 ml from each supernatant will be prepared for myoglobin assay and the rest will be used for the analysis of citrate synthase. Citrate synthase and *B*-hydroxyacyl CoA dehydrogenase will be assayed on a Beckman DU series 64 spectrophotometer according to the method of Reed et al. (1994). Assay temperature will be maintained at 37 °C using a constant temperature water bath and a water-jacketed cuvette holder. The assay conditions for citrate synthase (CS; EC 4.1.3.7) will be 50 mmol L^{-1} imidazole, 0.25 mmol L^{-1} 5,5-dithiobis (nitrobenzoic acid, DTNB), 0.4 mmol L^{-1} acetyl CoA, and 0.5 mmol L^{-1} oxaloacetate, at pH 7.5; DA_{412}, e_{412} = 13.6 (8). For *B*-hydroxyacyl CoA dehydrogenase (HAD; EC 1.1.1.35), the assay conditions will be 50 mmol L^{-1} imidazole, 1 mmol L^{-1} EDTA, 0.1 mmol L^{-1} acetoacetyl CoA, and 0.15 mmol L^{-1} NADH, pH 7.0 at 37° C; DA_{340}, e_{340} = 6.22 (9). Enzyme activities (mmol min^{-1} g^{-1} wet mass muscle) will be calculated from the rate of change in absorbance at the maximum linear slope. Myoglobin will be assayed according to the method of Reynarfarje (1963) with the following modifications. A portion (500 ml) of the supernatant is further diluted with 1 ml of phosphate buffer (0.04 M, pH 6.6). The resulting mixture is centrifuged for 50 min at 28,000 g at 4°C. The supernatant is bubbled with carbon monoxide for three min. Spectrophotometric absorbance will be measured at 538 and 568 nm, and the concentration of myoglobin in milligrams g^{-1} wet mass of muscle will be calculated as:

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

Statistical Analysis. Results will be expressed as the mean ± one standard error. Statistical comparisons will be made among individuals using an analysis of variance (ANOVA, Bonferronni adjusted p-value 0.01). Comparisons between swimming and non-swimming muscles among individuals will be made using paired sample t-test (p-value $\leq$ 0.05).

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

The main swimming muscle of 10 harbor seals will be obtained during BIOSAMPLING Program. The entire muscle will be removed and weighed, and three transverse subsamples will be taken along the muscle bundle. Each subsample of the swimming muscle will be precisely labeled for its orientation and location within the animal. These will then be further subsampled along points on a circular grid using a stainless steel borer, averaging 35 samples per muscle section. Cores of tissues weighing 200 and 300 mg will be removed for assay. A spectrophotometric technique will be used to determine myoglobin, citrate synthase, and *B*-hydroxyacyl CoA dehydrogenase concentration (see above for details). Detailed contour maps and statistical tests for all concentrations will be made using a PC based program S-Plus (Stat-Sci, Seattle).

SCHEDULE

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

Planned feeding trials at the Alaska SeaLife Center will begin in the summer of 1998. Our project will commence after the seals have been adapted to a control diet and their health stabilized in captivity.

October 1998	Set up fatty acid analysis and muscle lipid and enzyme analysis
October 1998- March 2000	Obtain and analyze blubber and muscle biopsies during feeding trials at ASLC
June - July 1999	Obtain and analyze blubber and muscle samples in conjunction with BIOSAMPLING Program
April - September 2000	Analyze data and prepare reports and manuscripts

B. Project Milestones

FY 99: Establish protocols for feeding studies; obtain and analyze blubber and muscle samples during feeding studies at ASLC.

FY 00: Continue to obtain and analyze blubber and muscle samples during feeding studies at ASLC; obtain and analyze blubber and muscle samples from seals in Prince William Sound in conjunction with BIOSAMPLING Program; analyze all data and prepare reports and manuscripts

C. Completion Date

This project will finish on September 30, 2000.

PUBLICATIONS AND REPORTS

Since this is a new project, there are no current publications from the proposed research. However, the results from a preliminary study of the aerobic capacity and lipid content of muscles from harbor seals in Prince William Sound has been submitted to the Journal of Applied Physiology. We do not anticipate any referred articles in FY 99. However, by FY 2000 most of the data will be analyzed and manuscripts in preparation. We anticipate several publications by 2001 on the affects of diet on fatty acids in blubber and the aerobic capacity and lipid metabolism in harbor seal muscle.

PROFESSIONAL CONFERENCES

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We will be working in close coordination with Dr. Michael Castellini (PI on Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) and staff at the Alaska SeaLife Center (see attached letter). Dr. Castellini will be supervising the controlled diet studies. We will coordinate our blubber and muscle samples with the veterinary staff at ASLC. Samples obtained from the BIOSAMPLING program will be coordinated with Mr. Short, who is the Spill Area-wide Coordinator for the Trustee Council.

PROPOSED PRINCIPAL INVESTIGATOR

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

PRINCIPAL INVESTIGATOR

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

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

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

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

Davis RW, Beltz WF, Peralta F, Witztum JL. (1994) Role of Plasma and Tissue Lipids in the Energy Metabolism of the Harbor Seal. In: Recent Advances in Marine Mammal Science. (I Boyd, ed). Oxford University Press.

Williams, TM, Davis RW, McBain JF, Tuomi PA, Wilson RK, McCormick CR, Donoghue S. (1995) Diagnosing and Treating Common Clinical Disorders of Oiled Sea Otters. In: Emergency Care and Rehabilitation of Oiled Sea Otters: A Guide for Large and Small Oil Spills Involving Fur-bearing Marine Mammals. (TM Williams and RW Davis, eds). University of Alaska Press.

Castellini MA, Davis RW, Loughlin TR, Williams TM. (1993) Blood chemistries and body condition of Steller sea lion pups at Marmot Island. Marine Mammal Science 9:202-208.

Davis RW, Pierotti VR, Hubl, ST, Lauer SJ, McLean JW, Witztum JL, Young SG. (1991) Lipoproteins in Pinnipeds: Analysis of a High Molecular Weight Form of Apolipoprotein E. J Lipid Res 32:1013-1023.

Davis RW. Advances in Rehabilitating Oiled Sea Otters: the Valdez Experience. (1991) Wildlife J 13:30-41.

Davis RW, Castellini MA, Kooyman GL. (1991) Fuel homeostasis in harbor seals during submerged swimming. J Comp Physiol 160:627-635.

Davis RW, Williams TM, Thomas JA, Kastelein RA, Cornell LH. (1988) The effects of oil contamination and cleaning on sea otters II: metabolism, thermoregulation and behavior. Can J Zool 66:2782-2790.

Williams TM, Kastelein RA, Davis RW, Thomas JA. (1988) The effects of oil contamination and cleaning on sea otters I: thermoregulatory implications based on pelt studies. Can J Zool 66:2776-2781.

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

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

OTHER KEY PERSONNEL

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

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

Dr. Sara Iverson is on the faculty of the University of Halifax, Canada. She is a recognized expert in the field of fatty acid analysis. She will supervise the analysis of fatty acids in blubber samples obtained from harbor seals in this project. The analysis will be performed by a doctoral student in Dr. Davis' laboratory. No salary is requested for Dr. Iverson. However, we will need to purchase supplies for the analysis and provide travel for the student to work in Dr. Iverson's laboratory.

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

LITERATURE CITED

1. Iverson, S.J. Milk secretion in marine mammals in relation to foraging: can milk fatty acids predict diet. Zoological Symposium No. 66: 263-291, 1993.

2. Iverson, S.J., K.J. Frost, and L.F. Lowry. Fatty acid signatures reveal fine scale structure of foraging distribution of harbor seals and their prey in Prince William Sound, Alaska. Marine Ecology Progress Series, 151:255-271, 1997.

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7. Mathieu, O., R. Krauer, H. Hoppeler, P. Gehr, S. L. Lindstedt, R. M. Alexander, C. R. Taylor and E. R.Weibel. Design of the mammalian respiratory system. VII. scaling mitochondrial volume in skeletal muscle to body mass. *Resp. Phys.* 44: 113-128, 1981.

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9. Lindstedt, S. L., and R. G. Thomas. Exercise performance of mammals: an allometric perspective, in comparative vertebrate exercise physiology. In *: Unifying Physiological Principles.* (ed. Jones, J. H.) Academic Press. 1994.

10. Reynafarje, B. Method for the determination of myoglobin. *J. Lab. & Clin. Med.* 61: 138-145, 1963.

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$47,535.0
Travel		$21,200.0
Contractual		$5,300.0
Commodities		$10,800.0
Equipment		$0.0
Subtotal	$0.0	$84,835.0
Indirect @ 45% ($84,835)		$38,176.0
Project Total	$0.0	$123,011.0
Full-time Equivalents (FTE)		12.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$123,011.0				

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect Costs @ 45% of Modified Total Direct Cost. The indirect cost rate is a predetermined rate established by the the Department of Health and Human Services dated 9/9/97.

Fringes are calculated @ 15.5% of Salaries and Wages for Principal Investigator and Research Assistant. 8.25% is the calculation for the Graduate Research Assistant. Included in the fringe category is a fixed rate for medical insurnace. The rate is a calculation based on the percentage of effort. The Principal Investigator is calculated @ $370/mo. The Research Assistant and Graduate Research Assistant is calculated @ $298/mo.

FY 99

Prepared: 4/9/98

Project Number: 99441-BAA
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
						0.0
R. Davis	Principal Investigator		3.0	8412.3		25,236.9
Vacant	Research Assistant		6.0	2183.0		13,098.0
Vacant	Graduate Research Assistant		3.0	3066.7		9,200.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			12.0	13662.0	0.0	
					Personnel Total	$47,535.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
To Seaward, Alaska for research at Alaska SeaLife Center (4 people)	1200.0	4	120	100.0	16,800.0
Car Rental in Seaward, Alaska	40.0	30	0	0.0	1,200.0
To Anchorage, Alaska for EVOS workshop	1200.0	1	5	100.0	1,700.0
To Halifax, Canada for gas chromatograph analysis	1000.0	1	5	100.0	1,500.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$21,200.0

FY 99

Project Number:

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

Name: Texas A&M Research Foundation

FORM 4B
Personnel
& Travel
DETAIL

Prepared:4/9/98

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Gas Chromatograph analysis (To Be Named)	2,500.0
Electron Microscope analysis (University of California, San Diego)	2,500.0
Communications-Long distance telephone charges	300.0
Contractual Total	$5,300.0

Commodities Costs:	Proposed
Description	FY 1999
Expendable supplies and chemicals	10,000.0
Shipping of blood for analysis	300.0
Publication and Page Charges	500.0
Commodities Total	$10,800.0

FY 99

Prepared:4/9/98

Project Number:

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

Name: Texas A&M Research Foundation

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

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

FY 99

Prepared:4/9/98

Project Number:

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

Name: Texas A&M Research Foundation

FORM 4B
Equipment
DETAIL

POPULATION TRENDS AND PRODUCTIVITY OF KITTLITZ'S MURRELET IN PRINCE WILLIAM SOUND
Submitted Under the BAA

Project Number:	99442-BAA
Restoration Category:	Research/monitoring
Proposer:	ABR, Inc.
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	no
Duration:	1st year, 2-year project
Cost FY99:	$215,718
Cost FY00:	$251,163 (including publication of results)
Cost FY01:	$0
Cost FY02:	$0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Kittlitz's murrelet

ABSTRACT

We propose to conduct a fourth and fifth year of investigations on the status and ecology of Kittlitz's Murrelet, a rare seabird breeding in glaciated fjords of Prince William Sound (PWS). This study will emphasize evaluating population trends and productivity and will continue efforts from our previous project (98142) to evaluate the distribution and abundance, habitat use, and trophic position of this little-known seabird in northwestern PWS. Given uncertainty about population trends and productivity of this species, additional sampling is required to ensure its long-term conservation.

INTRODUCTION

This study will build on results of the existing study (98142) to emphasize investigating the population status and trends and reproductive performance of Kittlitz's murrelet (*Brachyramphus brevirostris*) in northwestern Prince William Sound (PWS). Secondarily, it will continue to investigate habitat use and feeding ecology of this species. We will evaluate primarily the abundance and productivity and secondarily the distribution, at-sea habitat use, and feeding ecology of this little-known seabird.

The primary reasons for this study are (1) the small population size and restricted distribution of this rare seabird, (2) uncertainty about impacts from the *Exxon Valdez* oil spill, (3) suggestions of declining population trends both before and after the spill, (4) a clear lack of production during the first two years of the present study, and (5) the occurrence of mixed-species pairs of Kittlitz's and marbled (*B. marmoratus*) murrelets, suggesting that reproductive isolating mechanisms in Kittlitz's murrelets may be weakening. The world population of Kittlitz's murrelets has been estimated to be as low as 20,000 birds, with the majority residing in Alaska (van Vliet 1993). (Although this estimate may be too low, the total world population still is quite small and on the order of several tens of thousands.) The magnitude of mortality of this species as a result of the oil spill is unknown, but one estimate was that 5-10% of the total world population may have been killed (van Vliet and McAllister 1994). Because of the van Vliet and McAllister paper and a lack of information on this species, the *Exxon Valdez* Oil Spill Trustee Council (1998) listed Kittlitz's murrelet as "injured with recovery unknown." The studies of Day and Nigro (1997, 1998) have addressed these concerns by investigating several aspects of the basic biology of this species, with the goal of identifying whether problems exist and, if they do, suggesting ways of rectifying those problems.

The population size of Kittlitz's murrelets in PWS is on the order of a few thousands of birds (Day and Nigro 1997, 1998), or a magnitude similar to that estimated by Agler and Kendall (1997). Evaluation of the population trend data on Kittlitz's murrelet presented in Agler and Kendall (1997) by Day and Nigro (1998) suggests that the Kittlitz's murrelet population in PWS *may* be declining; however, annual estimates of population change varied wildly, with one year even suggesting a substantial population increase. The population estimates for some of the PWS bays in which breeding was thought to occur by Day and Nigro also suggested a decline between 1996 and 1997; however, there were only two years of data to evaluate a population change. Hence, it is unclear at this time whether a population decline actually is occurring and, if it is, what the rate of change actually is.

In-depth knowledge about the nesting phenology and breeding biology of Kittlitz's murrelet anywhere in its range is poor. Recent research in PWS has found breeding failures in four bays in both 1996 and 1997 and has located historical information that suggested a breeding failure in Glacier Bay; however, it is unclear how frequently these failures occur (Day and Nigro 1997, 1998).

Food habits and feeding ecology of Kittlitz's murrelet also are poorly known, but the few specimens that have been examined in the Gulf of Alaska (all from one collection on Kodiak Island) fed on macrozooplankton (euphausiids) and the common forage fishes of the Gulf of Alaska (e.g., Pacific sandlance *Ammodytes hexapterus*, capelin *Mallotus villosus*, Pacific herring *Clupea harengus*; Sanger 1987, Vermeer et al. 1987). Observations of a few birds carrying

fishes in PWS in 1996 and 1997 suggested that they ate primarily sand lance, probably also capelin or herring, and perhaps other common forage fishes; these same fishes also seemed to be the primary prey of marbled murrelets foraging in the same bays, suggesting possible competition for food (Day and Nigro 1997, 1998).

Given this rare seabird's small global population and uncertainty about its population trends and threats, Kittlitz's murrelet currently is classified a Species of Special Concern under the Endangered Species Act (J. Fadely, USFWS, Fairbanks, AK, pers. comm.). This category includes species for which "the best available scientific and commercial information indicates that it might qualify for protection under the Endangered Species Act, but the Service needs additional information on vulnerability and threats before the qualifications for listing can be determined." The proposed research described here is designed to provide additional information on the population trends and productivity of the Kittlitz's murrelet that will be important for evaluating whether the PWS population actually is declining and for effective conservation of this species.

NEED FOR THE PROJECT

A. Statement of Problem

There two primary reasons for conducting this additional study involve population size and reproduction. First, an analysis of the available data has led Day and Nigro (1998) to suggest that the Kittlitz's murrelet population in PWS *may* be declining. Because the historical data are sparse or lacking and there appears to be much seasonal and interannual variation in numbers, the determination of whether a decline actually is occurring is difficult. The intensive data collected by Day and Nigro (1998) showed a ~9% decline in estimated overall population sizes in four bays from 1996 to 1997; however, there were only two data points, the 95% confidence intervals for the overall population estimates did overlap (so the decline was not significant), and there was great interannual variation in population estimates for individual bays. As a result, there was some evidence that the population might be declining, although confidence that a decline actually was occurring was not high and, if a decline was occurring, the actual rate of decline was unknown.

The second reason for conducting this study involves reproduction. Studies by Day and Nigro (1997, 1998) found only one juvenile produced in 1996 and none produced in 1997, suggesting that productivity of this population generally is low and/or that substantial production occurs only sporadically. Raising even greater concern, Day and Nigro (1998) observed several cases of mixed-species pairs of Kittlitz's and marbled murrelets in three of the four bays. Interspecific hybridization (and, presumably, attempts at hybridization) occurs more frequently in situations in which one species is dramatically outnumbered by another (see Friesen et al. 1993 and discussion therein). Such attempts usually occur because of an absence of mating stimuli for females of the rare species (Friesen et al. 1993). In the current PWS study area, Kittlitz's murrelets are outnumbered by marbled murrelets by a ratio of ~6:1 on nearshore surveys, ~5:1 on offshore surveys, and ~160:1 on pelagic surveys. Hence, the overall rarity of Kittlitz's murrelets may be resulting in these mixed-species pairs, decreasing the reproductive output of Kittlitz's murrelets even further.

B. Rationale/Link to Restoration

This extension of the existing study will be valuable because (1) it will enhance our ability to evaluate whether a population decline actually is occurring and, if so, what the rate of that decline is; and (2) it will enable us to determine whether any birds have been reproducing over a longer (5-year) period and to determine the extent and characteristics (e.g., relative sizes of individuals, plumages) of mixed-species pairs. The increased length of this study will enable us to provide reliable data to management agencies and will yield greater insights into management options that should be implemented for the protection and enhancement of Kittlitz's murrelet populations in PWS.

In addition to evaluating population trends and reproductive performance (the primary emphasis), we will collect additional data on other aspects of the biology of Kittlitz's murrelets. These secondary data will include those on habitat use and feeding ecology and will add to the existing database collected by Day and Nigro (1997, 1998).

C. Location

The study will be conducted in the glaciated fjords of northern and northwestern Prince William Sound, following the studies of Day and Nigro (1997, 1998). Communities that probably will realize financial benefits from this study include Valdez, Cordova, and/or Whittier. In FY96–98, we have chartered vessels out of Cordova, and we also would attempt to charter the FY99 and FY00 boats out of a local PWS community. To our knowledge, there will be no effects to local communities except financially.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

In FY99–00, we will charter a boat and crew from a local PWS community to provide berthing and logistical support. When requested, we will provide articles and photographs for the Trustee Council Newsletter and will be available to make public presentations of our study at appropriate forums. We already have assisted Jody Seitz of Cordova with interviews for public radio stations throughout the spill-affected area. These articles and presentations will disseminate information on the objectives and major findings of this study to the general public.

Although our understanding is that seabirds (and, because of their small size, probably Kittlitz's murrelets in particular) play a very small role in subsistence use by local Natives in Prince William Sound, we would be happy to draw on any local information that is available on this species and, especially, to be able to partake of samples from any Kittlitz's Murrelets that are killed for subsistence use. We have contacted Ms. Martha Vlasoff, Spill Area-Wide Coordinator for the Trustee Council, about locating any available information on this species from hunters in both Tatitlek and Chenega, since people from both villages hunt in the glaciated fjords. Information from these local hunters indicates that no one hunts Kittlitz's Murrelets for subsistence food (Vlasoff, pers. comm.).

PROJECT DESIGN

A. Objectives

The overall goals of this study are (1) to determine whether the Kittlitz's murrelet population is declining and, if so, what the rate of decline is; and (2) to measure productivity over two additional years and to determine the extent of mixed-species pairing. The primary objectives of this proposed research program are:

1. To conduct population surveys for Kittlitz's murrelets in four glaciated fjords (bays) in northwestern PWS.

2. To estimate population sizes and determine population trends of Kittlitz's murrelets for each bay and the northwestern PWS area as a whole.

3. To measure indices of reproductive performance of Kittlitz's murrelets in each bay and to determine the occurrence and characteristics of mixed-species pairs of Kittlitz's and marbled murrelets in each bay.

The secondary objectives of this proposed research program are:

4. To determine distribution and habitat use by Kittlitz's murrelets in each study bay.

5. To describe feeding ecology and trophic levels of Kittlitz's murrelets in each study bay.

B. Methods

This study proposes investigating aspects of the ecology of this species during two cruises in each of these two years of sampling, based on findings of the present study. All data collection will follow the sampling scheme followed in FY96–98 (Day and Nigro 1997, 1998), in that cruises will be conducted from approximately late May to mid-June (early summer; 21 days) and from approximately mid-July to mid-August (late summer; 25 days). During each cruise, we will sample four bays in northwestern PWS two times each: Unakwik Inlet, Barry Arm/Harriman Fjord, College Fjord, and Blackstone Bay (following Day and Nigro 1997, 1998). Each sample replicate will consist of two types of sampling (nearshore and offshore surveys) to measure population size, population trends, reproductive performance, and habitat use. In addition, pelagic surveys will be used to determine whether Kittlitz's Murrelets use waters outside of bays during the summer.

The following two primary hypothesis will be evaluated:

Hypothesis 1: Population size does not differ among years. Abundance data from nearshore and offshore surveys will be used to compare post-spill counts among years. In addition to population-level analyses conducted each year by Day and Nigro (1998), we will plot each year's population estimate and use regression analyses to calculate the probability that the population is declining. A 5-year data set should be enough to determine whether there is a consistent trend. For example, a population starting out with 1000 birds will end up with 815 birds after 4 more years if the rate of decline is 5%/year, will end up with 656 birds after 4 more years if the rate of

decline is 10%/year, will end up with 522 birds after 4 more years if the rate of decline is 15%/year, and will end up with only 410 birds after 4 more years if the rate of decline is 20%/year. Thus, if the declining trends are fairly consistent and average ≥5%/year, a declining trend should be highly apparent over the 5-year period of the 2 studies combined.

Hypothesis 2: Reproductive performance does not differ among years or among bays. In all nearshore and offshore surveys, we will classify birds into (1) breeding plumage; (2) molting plumage; (3) winter plumage; (4) juvenile plumage; or (5) unknown plumage, following Day and Nigro (1997, 1998). The percentage of birds in juvenile plumage and HY:AHY ratios during the late-summer cruise will provide an index of reproductive performance for comparison among years. Work by Kuletz and Kendall (in press) for marbled murrelets in this region suggests that the most appropriate comparison for developing a productivity index is the ratio of the number of juveniles divided by the number of adults seen in June. Differences among years and among bays will be evaluated following Day and Nigro (1997, 1998).

In addition to estimating and comparing productivity, we carefully will examine all murrelets to determine whether they occur in mixed-species pairs with marbled murrelets, as described by Day and Nigro (1998). Any mixed-species pairs will be studied carefully to determine their location, characteristics, vocalizations, and behaviors.

The following two secondary hypothesis will be evaluated:

Hypothesis 3: Habitat use by Kittlitz's Murrelets does not differ within and among bays. Habitat use will be examined by stratifying both individual sampling segments and a subsample of individual records of birds on surveys into four strata, following Day and Nigro (1997, 1998). We then will analyze differences in habitat use by standardized habitat type, ice cover, water clarity (secchi depth), sea-surface temperature, and sea-surface salinity, following Day and Nigro (1997, 1998). In addition, we probably will be adding water depth as another variable to be measured in FY98 studies; if we do, depth data also will be collected during the two years of this study. We also have added 40 hr of time for our graphics specialist to digitize and analyze our nearshore survey data points (the only ones that were mapped) for Kittlitz's murrelets.

Hypothesis 4: Feeding ecology and trophic level do not differ among years. Following Day and Nigro (1997, 1998), we will categorize all birds recorded on nearshore, offshore, and pelagic surveys by behavior and evaluate whether there are differences in proportions of birds feeding between/among survey zone, time of day, tidal stage, current strength, and habitat type. We also will attempt to identify and describe any prey items that Kittlitz's and marbled murrelets are seen holding.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

We will contract a research vessel and crew from a PWS community to provide berthing, logistic support, and a platform from which to conduct surveys. All field and office work will be conducted by ABR, Inc. We will follow FY96–98 study requirements and pay the USFWS for a Program Manager and for general administration. (These management costs will be funded directly from NOAA to the USFWS, which is how our original contract was set up. Hence, that management money is not listed on the enclosed budget.)

SCHEDULE

A. Measurable Project Tasks for FY99 (October 1, 1998-September 30, 1999)

January-March 1999:	Arrange logistics (boats, equipment, etc.)
~1-20 June 1999:	Conduct early summer cruise
~25 June-5 July 1999:	Conduct mid-summer cruise
~15 July-10 August 1999:	Conduct late summer cruise
August-November 1999:	Keypunch data and QA/QC
November-December 1999:	Data analyses
January-April 2000:	Preparation of Annual Report
January 2000:	Attend annual Restoration Meeting
15 April 2000:	Submit Annual Report on FY 96–99 research

B. Project Milestones and Endpoints

1. "To conduct population surveys for Kittlitz's Murrelets in four glaciated fjords (bays) in northwestern PWS." Field work will begin in FY99 and will continue during both years of the study (i.e., FY99–00).

2. "To estimate population sizes and determine population trends of Kittlitz's murrelets for each bay and the northwestern PWS area as a whole." Densities will be estimated and will be tested for annual differences during both years of the study; population sizes will be estimated during each year of study (FY99–00).

3. "To measure indices of reproductive performance of Kittlitz's murrelets in each bay and to determine the occurrence and characteristics of mixed-species pairs of Kittlitz's and marbled murrelets in each bay." Data on numbers of juveniles will be recorded, and an index of reproductive performance will be compared among fjords and among years each year of the study (FY99–00). Information on mixed-species pairs and their characteristics will be collected each year of the study (FY99–00).

4. "To determine distribution and habitat use by Kittlitz's murrelets in each bay." Mapped distributions and densities of birds in each habitat stratum will be compared each year for individual cruises. Habitat strata will be evaluated and revised each year, if necessary (FY99–00).

5. "To describe feeding ecology and trophic levels of Kittlitz's murrelets in each bay." Data on the proportion of birds feeding will be collected and analyzed by the strata discussed above. Any food samples that are collected opportunistically will be analyzed for each bay and habitat during each year (FY99–00).

C. Completion Date

Sampling for the project will be completed in FY00. Collection of the fifth year of data, data analysis, preparation of a Final Report that synthesizes all five years of sampling, and preparation of publications will be completed in FY00.

PUBLICATIONS AND REPORTS

We will submit Annual Reports during each year of the study. Each report will be submitted to the Chief Scientist no later than 15 April of the year following data collection and will cover data collected during that year. Those reports also will synthesize and compare results for that year and previous years. After the final year of data collection, we will submit a Final Report that will synthesize and compare results from all years of the study and will prepare a series of manuscripts reflecting the results of our studies. We will request funds for publication of results in the final year of the study (FY00).

PROFESSIONAL CONFERENCES

We do not plan to attend any non-EVOS scientific conferences in FY99 but plan to do so in FY00. The most probable meeting that we will attend in FY00 will be that of the Pacific Seabird Group, which usually is held in December (2000) or January (2001).

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

To our knowledge, no other Trustees studies are being conducted in these glaciated fjords of northwestern PWS. Hence, integration with existing studies will be difficult, in view of the differences between these fjords and other environments in PWS. We hope to be able to take advantage of information that the SEA study generates on the ecology and distribution of fish and invertebrate prey species.

We have no co-funding source for this project and anticipate none becoming available in FY99 and FY00.

This project will be valuable in that it will assist the USFWS in learning about a Species of Special Concern under their management and will provide information useful in the conservation of the species. The data on population trends will help in evaluating whether this species is declining in PWS. The data on reproductive performance will help in understanding possible causes for population changes (if the population is changing). Finally, investigating habitat use, reproductive performance, and feeding ecology and trophics will be the initial step in increasing the baseline knowledge of the biology of this poorly known species.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

All budgeted costs have been increased by approximately 5% to account for inflationary increases from estimated FY98 to FY99 costs; in the FY00 budget, costs have been adjusted upward by another 5%. In addition, we have added additional time for generation of an Annual Report that synthesizes all four years of data collection and additional money for fuel costs, which we have not budgeted for previously.

PRINCIPAL INVESTIGATOR

Robert H. Day, Ph.D.
ABR, Inc.
P.O. Box 80410
Fairbanks, AK 99708-0410
PH: 907-455-6777
FAX: 907-455-6781
E-mail: bday@abrinc.com

PRINCIPAL INVESTIGATOR AND KEY PERSONNEL

Dr. Robert H. Day will be the Principal Investigator for the project. Bob has conducted research on seabirds, marine ecology, impacts of marine pollution, and marine conservation topics in Alaska since 1975. His research topics have included the biology of poorly known seabirds in Alaska; the ingestion of plastic pollutants by seabirds in Alaska; the mortality of seabirds in the high-seas drift-gillnet fishery of the North Pacific; and the distribution, abundance, and decomposition of plastic pollution and other marine debris in the North Pacific. Recently, he conducted several years of research on impacts of the *Exxon Valdez* oil spill on habitat use by marine-oriented birds and on bird communities (sponsored by Exxon Company, USA). Bob has been contracted by the A.O.U. to write the species account of Kittlitz's Murrelet in the *Birds of North America* project. (This species account has been co-authored with Debora Nigro of ABR and with Kathy Kuletz of the USFWS.) Dr. Day also has provided expert consultation to the USFWS as a member of the Spectacled Eider Endangered Species recovery Team.

Dr. Day is employed by ABR, Inc. (formerly Alaska Biological Research, Inc.). ABR is an Alaskan-owned small business—headquartered in Fairbanks since its formation in 1976—that specializes in environmental research and services. During two decades of operation in Alaska, ABR has served a variety of clients, including private industry, state and federal government agencies, and the University of Alaska. During this time, ABR has developed a reputation for conducting objective research that provides the basis for sound management decisions. ABR remains committed to the goals of providing timely, accurate, and cost-effective information to those who manage or develop our natural resources.

OTHER KEY PERSONNEL

Dr. Day will be assisted in these studies by Debora Nigro, who has 10 years of experience in seabird research in Alaska. Her most recent work has been three years' worth of studies on Kittlitz's murrelets in Prince William Sound. Previously, she conducted several years of research on impacts of the *Exxon Valdez* oil spill on habitat use by marine-oriented birds and on bird communities (sponsored by Exxon Company, USA) and assisted with studies of marbled murrelets and studies of long-term population changes of seabird and marine mammal species in Prince William Sound (sponsored by the USFWS and the *Exxon Valdez* Oil Spill Trustee Council).

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1999 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

May 1, 1999 - April 30, 2000

Budget Category:	Authorized FFY 1998	Proposed FFY 1999						
Personnel	$159.0	$139.4						
Travel	$7.7	$6.3						
Contractual	$81.9	$70.2						
Commodities	$2.8	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$251.4	$215.9	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY2002	Estimated FFY 2003	Estimated FFY 2004	Estimated FFY 2005
Indirect	$0.0	$0.0						
Project Total	$251.4	$215.9	$251.2	N/A	N/A	N/A	N/A	N/A
Total Personnel Hours *	2,628	2,280						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

ABR,Inc. has used **Hourly Rates** instead of **Monthly Costs.** The hourly rate shown is an all inclusive rate. ABR, Inc. requested permission from EVOS Trustee Council and received verbal permission from **Sandra Schubert** on April 4, 1997 to substitute fully burdened hourly rates for monthly costs and indirect costs.

- Full-Time Equivalents (FTE's) have been changed to fully burdened Total Personnel Hours.

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Break Down of Project Costs FY 99

Report Writing	$ 525
Publications	$ 0
Professional Conferences	$ 1,875
Workshop Attendance	$ 1,640
NEPA Compliance	$ 0
Community Involvement	$ 0

1999

Project Number: 99~~1~~42

Project Title: **Population trends and productivity of Kittlitz's Murrelet in Prince William Sound**

Name: **ABR, Inc.**

FORM 4A
Non-Trustee
DETAIL

1999 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

May 1, 1999 - April 30, 2000

Personnel Costs:				* Hours	* Hourly		Proposed
	Name		Position Description	Budgeted	Costs	Overtime	FFY 1999
	Ritchie	R	Principal	4.0	$100.00	$0	0.4
	Murphy	S	Research Coordinator	16.0	$94.00	$0	1.5
	Day	R	Senior Scientist	1064.0	$75.00	$0	79.8
	DeLong	T	Office/Contracts Manager	12.0	$69.00	$0	0.8
	Smith	B	GIS Specialist	56.0	$57.00	$0	3.2
	Nigro	D	Research Biologist I	884.0	$48.00	$0	42.4
	Zusi-Cobb	A	Graphic Technician/GIS	172.0	$51.00	$0	8.8
	Harshburger	D	Word Processor/Administrative Assistant	40.0	$39.00	$0	1.6
	Staff		Clerk	32.0	$29.00	$0	0.9
			Subtotal	2280.0	N/A	0	
						Personnel Total	$139.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FFY 1999
	EVOS Meetings in Anchorage (FAI-ANC)	370	1	3	160	0.9
	Technical Review Meeting in Anchorage (FAI-ANC)	370	1	2	160	0.7
	Bus/train (Anchorage to Whititer)	120	4			0.5
	PSG Meeting	1,000	1	5	150	1.8
	Travel to/from Cruises (FAI-ANC)	370	4	4	160	2.1
	Fee (5%) on Contractual Costs					0.3
					Travel Total	$6.3

1999

Project Number: 99142

Project Title: **Population trends and productivity of Kittlitz's Murrelet in Prince William Sound**

Name: **ABR, Inc.**

FORM 4B
Personnel
& Travel
DETAIL

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
May 1, 1999 - April 30, 2000

Contractual Costs:	Proposed
Description	FFY 1999
1 Boat Charter for 46 days @ $1,365/day (includes food, water, and skiff)	62.8
2 Portable Thermosalinograph (46 days @ $10/day)- ABR Equipment Lease	0.5
3 Phone/Fax/Modem	0.3
4 Printing/Off-Site Photocopying/Slide Preparation	1.0
5 Misc. Gear and Supplies	2.3
6 Fee (5%) on Contractual Costs (excluding ABR Equipment Lease)	3.3
Contractual Total	$70.2

Commodities Costs:	Proposed
Description	FFY 1999
Commodities Total	$0.0

1999

Project Number: 99142
Project Title: **Population trends and productivity of Kittlitz's Murrelet in Prince William Sound**
Name: **ABR, Inc.**

FORM 4B
Contractual & Commodities DETAIL

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
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
1 Dissecting Laboratory	1
2 Library reference books	
3 Computer Resources	
4 GIS/Digitizing Station (s)	2
5 Office Space	
6 Equipment Storage	

1999

Project Number: 99142
Project Title: **Population trends and productivity of Kittlitz's Murrelet in Prince William Sound**
Name: **ABR, Inc**

FORM 4B
Equipment
DETAIL

99443

Salmon Fisheries Market Share and Market Value Recovery Program Submitted Under the BAA

Project Number:	99443-BAA
Restoration Category:	
Proposer:	Cordova District Fishermen United
Lead Trustee Agency:	NOAA
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, 3-year project
Cost FY 99:	$666,100
Cost FY 00:	$300,000
Cost FY 01:	$200,000
Geographic Area:	Prince William Sound and EVOS impacted area
Injured Resource/ Service:	Commercial Fishing

ABSTRACT

The project will develop a long-term marketing program designed to enhance the value and market share of commercially harvested salmon that were adversely impacted by the Exxon Valdez Oil Spill.

INTRODUCTION

The project is to develop a sustainable marketing and promotion program for commercial salmon species which have lost market share and value since the Exxon Valdez Oil Spill (EVOS). In 1988, pink salmon were worth 80 cents a pound for fishermen and sockeye salmon, above two dollars a pound. The EVOS interrupted the supply of fish and brought questions of product safety to consumers. The traditional value of salmon plummeted and the consumer market began to replace wild salmon with farm fish. Questions of product safety lingered while farmed salmon continued to erode the value and status of wild salmon in the marketplace. Meanwhile, commercial fishermen and the communities of Alaska were busy dealing with the immediate impacts of the spill, effectively diverted from the focus of managing the commercial fishing business. Although there are other contributing factors relating to the loss of market share and value, the decline in ex-vessel price in the years immediately following can be directly related to the EVOS. To help re-establish quality of life and provide viable opportunities to obtain a reasonable standard of living, the project will take a long term view of the industry's needs. It will develop sustainable funding options to include fishermen, the processing industry, and local, state and federal government entities.

NEED FOR THE PROJECT

A. Statement of Problem

The problem this project addresses is the reduced revenue generated by commercially harvested salmon in the Prince William Sound (PWS) region since the EVOS. The PWS region is still in need of viable opportunities to establish and sustain a reasonable standard of living post-EVOS. The impact of the EVOS on the commercial fishing industry is one of the best documented among the many adverse effects of North America's largest spill. The continued erosion of the value of herring and salmon in the marketplace has directly impacted the quality of life of the commercial fishers, and has made it difficult or impossible to preserve a fair standard of living. The commercial salmon fishing industry has been a large economic component of the PWS region for over one hundred years. Since the EVOS in 1989, the commercial fishing industry in the PWS region has struggled to survive. In particular, the public's negative perception of oil impacted waters has also played a part in the demise of the value and market share of wild harvested Alaska salmon. The latest "Salmon Industry Update" from the Division of Trade and Development dated April 1, 1998, states "As a sustainable and unique renewable resource, the salmon industry in Alaska holds great potential. Alaska must learn to adapt to the rapidly changing market conditions if it has any hopes of being competitive." The problem is how to restore and exploit that potential market and thereby increase the revenues to the fishermen and PWS region communities alike.

B. Rationale/Link to Restoration

Engagement in the recovery or restoration of the value of the salmon resources in the PWS and other affected areas is long overdue. The mission of the EVOS Trustees makes clear the "...need for viable opportunities to establish and sustain a reasonable standard of living." The primary objective is to positively influence the economic conditions of the commercial salmon industry in the impacted areas. This project will educate the domestic consumer about the health benefits associated with wild salmon, inform them that the Alaska Department of Fish and Game (ADF&G) has arguably the best salmon management in the world with record returning runs. It will help develop a long-term presence in the marketplace. A ten cent move in the price of salmon equates to a $4.5 million gain in state raw fish tax revenue alone. During her presentation at the 1998 Salmon Forum, Lt. Governor Fran Ulmer stated that even a one cent increase in the price of salmon would generate a $7 million addition to Alaska's economy. This could go a long way toward sustaining a reasonable standard of living for the coastal communities, a quality of life that has not existed since the EVOS of 1989.

C. Location

Field work will be done in the continental United States, analyses and administration will take place in Cordova.

COMMUNITY INVOLVEMENT

The PWS affected communities of Cordova, Valdez and Whittier will each hold a seat on the Advisory Board. These representatives will be able to bring ideas, questions and concerns to the director and staff from their community members. Advisory Board meetings will also be open to the public, and a newsletter will be published twice per year. The project will fund two, full-time positions in Cordova and six opportunities for consulting contracts.

PROJECT DESIGN

A. Objectives

The main objective of this project is to increase the value and market share of wild harvested salmon in the Prince William Sound region and other EVOS impacted areas. This project will also serve as a model for other oil impacted coastal communities to use in their own salmon market rehabilitation. During FY99, we are requesting initial start-up funding with a two year follow-up in EVOSTC supplemental funding. Therefore, in FY99 our objectives are:

1. Identify constraints and opportunities relating to the increase of value and market share for wild Alaska salmon.

2. Develop a model program for the expansion of market and increase in value of wild Alaska salmon.

3. Identify long-term sources of funding for a continued program outside EVOS.

B. Methods

The proposal requests support for a three year project. The following are thumbnail sketches of the methods that will be used during the first, second and third years of funding.

First Year:

1. Assessment of the salmon industry in the EVOS impacted areas - The assessment will include the quality of Alaska salmon products entering the market, salmon product trends, domestic market research and feasibility, competitive strategy project design, existing transportation and distribution networks and, "Wild Alaskan Salmon" promotions. These assessments will include the following contractual projects:

a.
Salmon product trends assessment - Whole frozen, head off and gutted fish are still one of the dominant salmon products leaving the state. Consumer preference and an evaluation of the trends in consumer demand will be evaluated. An assessment relating increases in demand for filets, boneless and portion controlled packs; packaging preferences and other "value added" options will be reviewed. Constraints and opportunities related to IQF portions will be identified.

b.
Market research and feasibility study - Identification of market opportunities and evaluation of market potential will be performed under this contract. An emphasis on areas other than the west coast will be stressed. Areas that already have a high per capita consumption of seafood will be examined as potential markets. Market area holding and distributing capacity would be evaluated.

c.
Distribution network assessment - Existing, emerging and un-utilized shipping and distribution networks will be evaluated. The ability of shipping and distribution options to maintain product quality will be a part of the criteria used to evaluate options. There will be an emphasis on identifying and evaluating options outside traditional channels.

d.
Salmon quality assessment - This contract will evaluate the quality of salmon products currently entering the marketplace. Fresh, fresh frozen, portions, bulk packs, smoked and canned products will be evaluated. Quality will be assessed at all phases involved in the harvest, tendering, receiving, processing, shipment, holding and sale of the products. Evaluation and recommendations related to "quality gaps" and areas where quality is lost or jeopardized will be a part of the process. Quality control points will be identified and appropriate intervention techniques to improve quality will be recommended. Loss of quality related to secondary processing of previously frozen products will be assessed.

e.
Competitive strategy project design - This project would work with the other contractors to develop a long term competitive strategy based on the above assessments. In addition, processors and distributors will play an important role in planning the programs to take advantage of market opportunity.

f.
Promotions - This project will develop materials, video scripts, presentations and other appropriate items to promote "Wild Alaska Salmon" products in the marketplace. The project would take into account the work described above and would target areas other than the Pacific Northwest and traditional markets. The emphasis would be on product identity and the differentiation of "Natural, Wild, Sustainable and Organic Alaska Salmon" in the marketplace, with an emphasis on the additional benefits of the product that is always "worth the premium" when compared to farmed varieties.

2. Regional identity project - The project will include identification of opportunities and constraints in the development of "Regional Brand Recognition," including organic and natural labeling and truth in labeling laws.

Second and Third Year:

1. FY 00 - Year two will include a "Premiere Quality" project, development of new distribution networks, new product and under-utilized product placement, domestic market expansion program, "Wild Alaskan Salmon" promotions and improvement of transportation options.

2. FY 01 - Year three will expand on product placement and promotional strategy, complete provisions for the sustained funding of the programs developed by the EVOS trustees project and a final report which includes progress made in the prior three years.

C. Cooperating Agencies, Contracts and Other Agency Assistance

None, however, this request will be reduced by amounts that we may receive from other sources. The Northwest Trade Adjustment Assistance Center has matching funds available for several of the studies and assessments. Local processors have indicated a willingness to contribute the funds they are eligible for ($150,000 to $200,000 for FY 99) if the required match is provided through this project. Northwest TAAC has suggested they will work with us on this basis. If successful, proposals for community development block grants, and other grants that are being developed will be used to offset the EVOS grant.

SCHEDULE

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

October 1 - November 1:	Staffing.
October 1 - November 15:	Issue RFP's for assessments, studies, strategy
project and	promotions.
November 20 - February 20:	Assessment fieldwork and reports.
February 20 - April 20:	Competitive strategies project (utilizing assessment fieldwork and reports).
December 1 - September 30:	Promotions project (ongoing).
April 20 - September 30:	Implementation of recommendations from
assessments and	competitive strategy project.
August 1 - September 30:	Project evaluation and report.

B. Project Milestones and Endpoints

April 20:	Completed fieldwork and identified areas of
opportunity for	increasing market share.
August 30:	Identified areas of strengths and weaknesses of the promotional and marketing program.
September 30:	Identified long-term sources of funding.

FY 00

December 1 - September 30:	"Wild Alaskan Salmon" Promotion (ongoing).
February 2000:	Governor's Salmon Forum III presentation.
May 15, 2000:	Utilize new distribution network.
May 15, 2000:	Initiate "Premiere Quality" program.
August 15, 2000:	Evaluate new product and under-utilized product placement.
September 30, 2000:	Evaluate expansion of domestic market.

September 30, 2000:	Obtain supplemental funding from sources other than EVOSTC.

FY 01

December 1 - September 30:	Product promotion and placement (ongoing).
February 2001	Governor's Salmon Forum IV presentation.
May 15, 2001	Additional funds outside EVOSTC obtained.
August 1 - September 30:	Final report and end of EVOS funding.

C. Completion Date

It is anticipated that this project will go on into perpetuity, however EVOS funding and participation will end on September 30, 2001.

PUBLICATIONS AND REPORTS

Each year, a written report inclusive of all relevant data will be completed and submitted for review to the EVOSTC, the Alaska Seafood Marketing Institute and the Governor's Salmon Forum.

PROFESSIONAL CONFERENCES

Each year of EVOS funding, a presentation will be made and materials will be available at the Governor's Salmon Forum, Kodiak ComFish and Fish Expo in Seattle.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Although we would love to integrate our program with other ongoing restoration efforts, we are unaware of any projects currently underway that would provide appropriate partnerships.

PROPOSED PRINCIPAL INVESTIGATORS (INTERIM)

Cheri Shaw
Cordova District Fishermen United Association
P.O. Box 939
Cordova, Alaska 99574

Robert J. Kopchak
Copper River Salmon Producers
P.O. Box 1649
Cordova, Alaska 99574

(907) 424-3447
(907) 424-3430
cdfu@ptialaska.net

(907) 424-3115
(907) 424-3116
kopchak@grizzly.pwssc.gen.ak.us

PRINCIPAL INVESTIGATORS

See attached resumes

OTHER KEY PERSONNEL

Program will be monitored by an advisory board consisting of:

William Gilbert	Norquest/Silver Lining Seafoods
Sylvia Lange	Cannery Row
William Webber, Jr.	Copper River Salmon Producers Association
Dave Cobb	Mayor, City of Valdez
Margy Johnson	Innkeeper/Former Mayor, City of Cordova
Whittier Seat	TBA
Jerry McCune	United Fishermen of Alaska
Mike Trafton	United Salmon Association
Mike Meints	Seine Fisherman
Torie Baker	Driftnet Fisherman
Gerald Masolini	Eyak Packing Company

spreadsheets and word processing.

1978 Safeway, Inc. Eugene, Oregon
Cashier Policy School
- One week class in policy for cashiers working for Safeway food store.

1976 Elkton High School Elkton, Oregon
High School Diploma
- Majored in journalism and business.

Community Activities

- Board of Director for Cordova Chamber of Commerce, third term.
- Fund raiser volunteer for Muscular Dystrophy Association.
- Member of newly established Site-based Goals Committee for Cordova Public Schools.
- Participated in first annual Governors's Salmon Strategy Forum

References

Margy Johnson, Former Mayor
City of Cordova
P.O. Box 150
Cordova, Alaska 99574

LeRoy Key, Superintendent
Cordova Public Schools
P.O. Box 140
Cordova, Alaska 99574

Gene Kubina, Representative
State Capitol
MS 3101, Room 502
Juneau, Alaska 99801-1182

Barbara Bellnap, Executive Director
Alaska Seafood Marketing Institute
P.O. Box D
Juneau, Alaska 99811

Cheri A. Shaw

P.O. Box 2319
Cordova, AK 99574

Home 907-424-3197

Experience

1996 - present Cordova District Fishermen United
Cordova, Alaska
Executive Director

- Serve as Executive Director to the Cordova District Fishermen United (CDFU) an organization comprised of persons and organizations involved in the commercial fisheries of Area E, State of Alaska. The mission of CDFU is to preserve and protect Alaska's fishing industry, fish habitat and fishing grounds, specifically in Prince William Sound and the Copper River Delta and Flats, and to promote safety at sea. At the Board of Directors' command, I accomplish CDFU's mission under many formats and in various arenas: media promotion, legislative contacts, monitoring and acting on local, statewide and national events affecting fisheries. I am an advocate for responsible oil industry activity, in particular, the safe transportation of oil. I function as secretary to the Board and maintain all financial records. My job is to carry out their directives and initiate from my position organized campaigns via committee, legislative action, and engage in personal intervention by written word and through travel to present public testimony at all levels of government and private industry. I am charged with maintenance of public relations, membership renewal, and promotional drives for our area fishing industry.

1994 - 1996 Cordova District Fishermen United
Cordova, Alaska
Fishing Vessel Administrator/Administrative Assistant

- Responsible for administering to 96 fishing vessels and all of their clerical needs, organizing training schedules and served as liaison to Alyeska Pipeline Service Corporation. Performed as receptionist and membership administrator to CDFU, an organization with over 250 members. Served on the Membership/Promotion Committee for CDFU. Worked with computer databases and spreadsheets, using Word, Word Perfect, Excel, In Touch, Filemaker Pro, Dynodex, PageMaker and Quatro Pro. Experienced in both PC and Macintosh systems.

1993 The Reluctant Fisherman
Cordova, Alaska
Receptionist and Office Clerk

- Responsible for night auditing, preparing cash banks, providing hotel customers with pleasant, efficient service, organizing clerical tasks effectively. Used computer databases and spreadsheets.

1988-1993 The Reluctant Fisherman
Cordova, Alaska
Bartender and Bar Manager

- Hired, trained and scheduled all bar help. Responsible for payroll, banking, banquet planning and scheduling and supply ordering. Served customers quickly and efficiently while maintaining a relaxed and pleasant atmosphere in the bar.

Education

1994 - 1997 SERVS, Prince William Sound Community College Valdez, Alaska
Annual Fishing Vessel Training, Hazwoper Certification

- Received annual training for fishing vessel owners and crew in oil spill prevention and response; one day in class and one day on water. After taking the initial 24 hour training in hazardous materials, I participate in the eight hour hazwoper refresher classes each year.

1995 APSC/SERVS Valdez, Alaska
SERVS Basic Training

- Received the three day SERVS Basic Training class in oil spill prevention and response, hazardous waste, wildlife capture and hazing.

1995 Prince William Sound Community
College Cordova, Alaska
Desktop Publishing Class

- One credit computer class in desktop publishing

1983-1984 Southwestern Oregon Community College Coos Bay, Oregon
Computer Science Classes

- Two quarter terms of computer science including learned programming, computer-assisted accounting,

Current

Work Experiences

Robert J. Kopchak

P.O. Box 1126
Cordova, AK 99574

Home 907-424-7178

Commercial Salmon and Herring Fisherman
- Prince William Sound, Alaska

Business Manager and Board Member
- Copper River Salmon Producers Association
- Developed by-laws, business plan, budget, and 1998 price negotiations program
- Representative to Salmon Forum II

Owner - R.J. Kopchak and Associates
- Builder/Designer
- Consultant, City of Cordova
- ICBO Certified Inspector # 91586

Treasurer - Oil Spill Recovery Institute
- Governor's Appointee to Board of Directors

Previous

Work Experience

Founding President, General Manager and Treasurer -

Prince William Sound Science Center
- Obtained initial funding and helped develop program of 0.0 dollars in 1989 to a $2,000,000 budget in 1996

Director, Copper River Fishermans Co-Op
- Developed annual business plans and corporate policy manual

General Manager and CEO, Eyak Corporation
- An Alaska Native Village Corporation

Founding President and Executive Director, Bidarki Corporation
- Non-Profit, family use services

Director of Public Works, City Administer
- City of Lowell, Oregon

Memberships

- Copper River Salmon Producers Association
- Cordova District Fishermen United
- United Salmon Association
- United Fishermen of Alaska

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$666.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$666.1
General Administration		$25.8
Project Total	$0.0	$691.9
Full-time Equivalents (FTE)		24.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$300.0	$200.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared: April 1998

Project Number: 99443
Project Title: Commercial Salmon Fisheries Market Recovery Program
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$104.4
Travel		$31.2
Contractual		$507.5
Commodities		$13.0
Equipment		$10.0
Subtotal	$0.0	$666.1
Indirect		
Project Total	$0.0	$666.1
Full-time Equivalents (FTE)		24.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$300.0	$200.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared: April 1998

Project Number:
Project Title: Commercial Salmon Fisheries Market Recovery Program
Name: Cheri Shaw, CDFU - Robert J. Kopchak, CRSPA
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
TBA	Director		12.0	5.4	0.0	64.8
TBA	Administrative Assistant		12.0	3.3	0.0	39.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		24.0	8.7	0.0	
					Personnel Total	$104.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
Director to Juneau		0.30	5	15	0.168	4.0
Director to DC		0.80	2	6	0.168	2.6
Director to Seattle		0.45	3	6	0.154	2.3
Director to Anchorage		0.15	4	10	0.140	2.0
Familiarization trips for Media:						0.0
	from East Coast	1.00	3	12	0.146	4.8
	from Midwest	0.80	3	12	0.146	4.2
	from West Coast	0.60	3	12	0.146	3.6
Trade show, East Coast		1.00	2	6	0.158	2.9
Trade show, West Coast		0.60	2	5	0.154	2.0
Trade show, Gulf Coast		1.00	2	6	0.130	2.8
						0.0
					Travel Total	$31.2

FY 99

Prepared: April 1998

Project Number:
Project Title: Commercial Salmon Fisheries Market Recovery Program
Name: Cheri Shaw, CDFU - Robert J. Kopchak, CRSPA
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Rent @ $500 per month	6.0
Utilities	5.0
Long Distance Telephone	6.0
Postage/Freight	3.5
Bookkeeping & Audit	15.0
Promotional Materials (printing, publication, visual aides & trade show materials, etc.)	59.0
Contract Project Services	
Quality Assessment Study	40.0
Salmon Product Trends Assessment Study	50.0
Distribution Network Assessment Study	40.0
Market Research & Feasibility Study	75.0
Competitive Strategy Project Design	75.0
Promotions Consultant	75.0
Video Development & Production	50.0
Website Development & Maintenance	8.0
Contractual Total	$507.5

Commodities Costs:	Proposed
Description	FY 1999
Communication Supplies	2.0
Supplies (consumable)	3.5
Computer @ 2x $3750	7.5
Commodities Total	$13.0

FY 99

Prepared: April 1998

Project Number:
Project Title: Commercial Salmon Fisheries Market Recovery Program
Name: Cheri Shaw, CDFU - Robert J. Kopchak, CRSPA
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
Description			
Copier	1	10.0	10.0
			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**		$10.0

Existing Equipment Usage:	Number of Units
Description	

FY 99

Prepared: April 1998

Project Number:
Project Title: Commercial Salmon Fisheries Market Recovery Program
Name: Cheri Shaw, CDFU - Robert J. Kopchak, CRSPA
Agency: NOAA

FORM 4B
Equipment
DETAIL