(19.08.01) (15 of 16)

Project Title: Port Dick Spawning Channel Information Transfer To Resource Managers and Manuscript Preparation- Submitted Under the BAA

Project Number:	**00539-BAA**
Restoration Category:	Research
Proposer:	Geoff Coble, Coble Geophysical
Lead Trustee Agency:	NOAA
Cooperating Agency:	United States Forest Service, Alaska Dept. of Natural Resources and the Alaska Department of Fish and Game
Alaska Sea Life Center:	No
Duration:	1st year, 1 year project
Cost FY 00:	$40,300
Geographic Area:	West Arm Port Dick Bay, Outer Gulf Coast of Southern Kenai Peninsula.
Injured Resource/Service:	Pink and Chum Salmon. Lost or reduced commercial fishing services.

ABSTRACT

The ongoing Port Dick Creek spawning channel data set (99139-A2) is generalized to refine design criteria for future gravel-bedded spawning channel restoration projects. This includes groundwater-surface water interaction modeling to define channel designs that maximize spawning area at times of minimum discharge. Numerical analyses also address infrequent maximum discharge events and their effects on gravel bedload transport rates, scour and deposition patterns in the spawning channels as well as the effects of stream morphology on overall spawning channel area. The minimum and type of field data to support new rehabilitation projects is defined. Transition to long term monitoring of the Port Dick Creek restoration project is the subject of a concurrent proposal (00540-BAA).

INTRODUCTION

The goal of this proposal is to provide restoration information for future salmon rehabilitation projects that may become necessary in the near future. This generalized goal developed from work on the Port Dick spawning channel rehabilitation project, which began in 1991. At that time, the Alaska Department of Fish and Game, (ADF&G) Commercial Fisheries Management and Development Division (CFM&D), conducted restoration surveys on the outer coast of the Kenai Peninsula to identify pink salmon (*Onchorynchus gorbusca)* and chum salmon (*Onchorynchus keta)* spawning systems that would benefit from instream habitat restoration. Port Dick Creek, located within Kachemak Bay State Wilderness Park approximately 25 miles southeast of Homer (Figure 1) was chosen because 1) it is considered one of the more important wild pink and chum salmon production streams in the Lower Cook Inlet area; 2) the 1964 earthquake caused an uplift of material within two tributaries of Port Dick Creek that virtually eliminated the available spawning habitat in existence prior to the earthquake; and 3) the total return of chum salmon to Port Dick Creek has declined in recent years.

The total return (catch & escapement) of Port Dick Creek Chum salmon has averaged only 4,600 fish for the ten year period (1989-1998) compared to the previous 15 year period (1974-1988) of 31,000 fish (Figure 2). A complete closure on directed commercial fishing for Port Dick Creek chum salmon has been in effect since 1994 and the biological escapement goal, established at 4,000 fish, has been met only twice since 1988. The primary species targeted is the native chum salmon of Port Dick Creek, although, pink salmon will also benefit from the instream restoration project.

While the goal of the Port Dick Creek restoration project (00139-A2) is to reverse the decline in chum and pink salmon stock abundance, the important generalization of results from that project to support future rehabilitation projects is the subject of this proposal. The streambed stability monitoring in support of the Port Dick project can now help to accomplish the larger goal of this proposal, which is to provide restoration information for future projects of this kind that may become necessary in the near future.

Research in the stability of salmon spawning grounds has been shown to be useful for assessing the Port Dick Creek restoration project. However, sediment and bedload transport in gravel-bedded rivers has received far less attention in the published literature compared to stream channels of finer grained sediments. One reason for this is that spawning gravel and cobbles are typically transported as bedload only by large and infrequent discharges (Andrews and Nankervis, 1995). This project will discern the effects of altering a gravel-bedded stream channel on sediment transport and deposition, which is useful for designing and efficient construction of future spawning habitat rehabilitation projects.

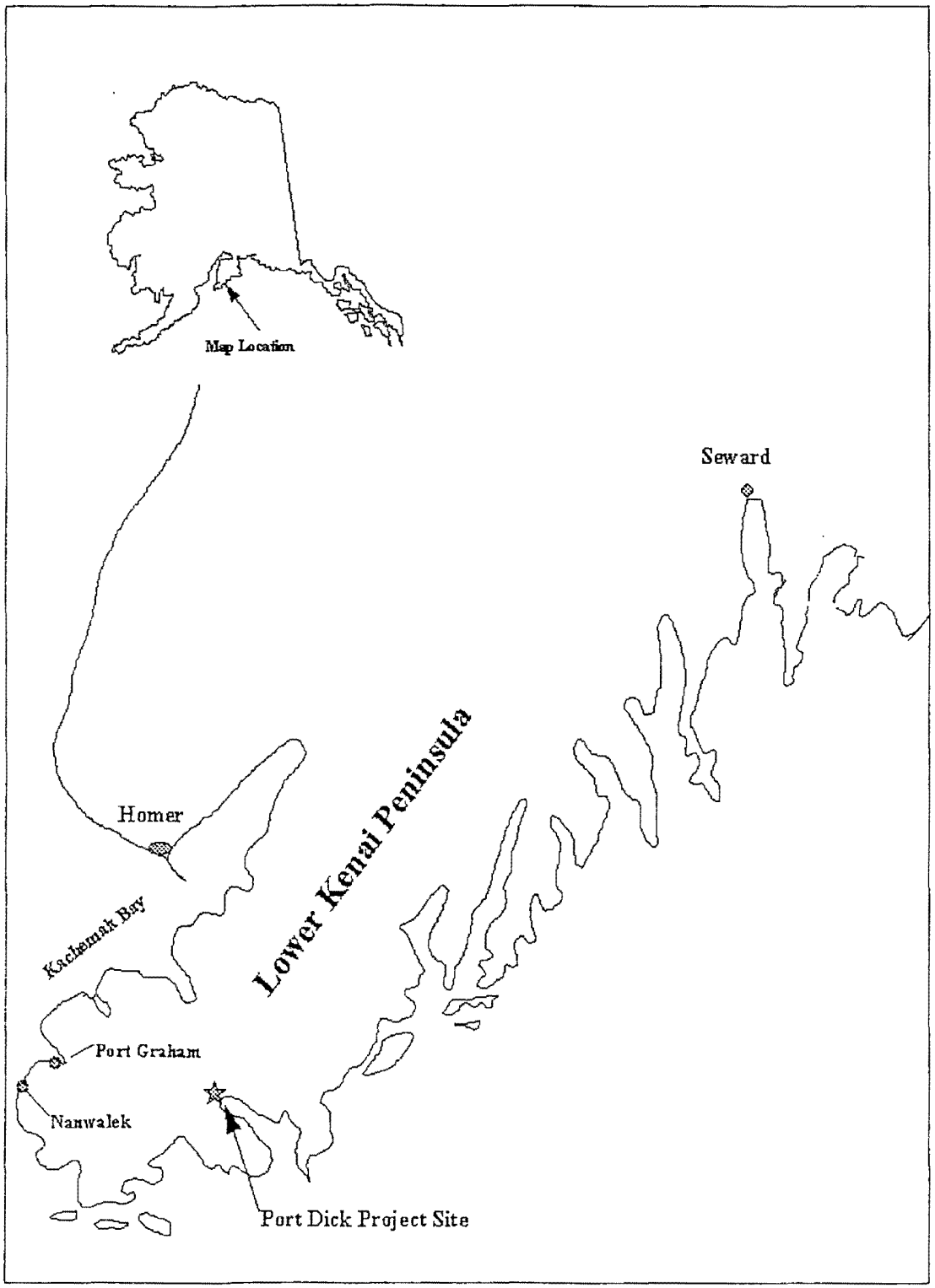


Figure 1. Map of the outer gulf coast of the Kenai Peninsula showing the location of the Port Dick Project site.

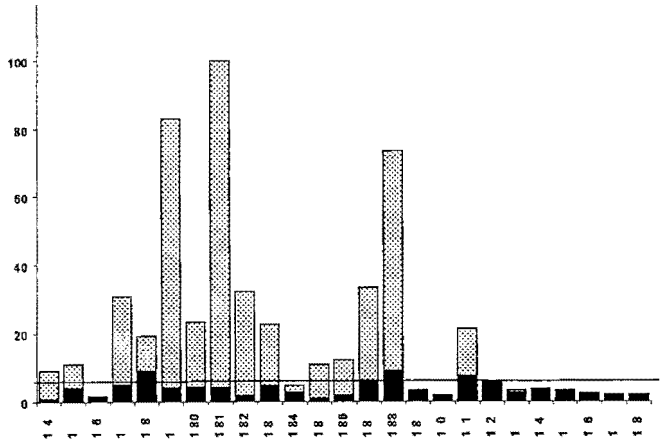


Figure 2. Total return (catch & escapement) of Port Dick Creek Chum Salmon, 1974-1998.

The stability of stream channels and banks substantially affects the quality of riparian and aquatic habitats. Stream stability is affected by channel morphology and channel material (Myers et. al., 1992), both factors of which were changed during spawning channel excavation. There is a direct impact from scour and deposition on spawning channel width, depth and consequently a variety of other hydrologic parameters. These facts and the Port Dick data set are combined with numerical modeling in this proposal to determine general spawning channel designs that maximize habitat for a given set of parameters.

The two constructed spawning channels are monitored for the Port Dick Creek restoration project, and designated as the primary and secondary tributaries as shown in Figure 3.

While the secondary channel is largely groundwater fed, both tributaries receive surface water at high discharge from a small lake of less than 4 ha. at an elevation of 300 m. In addition, a very large proportion of the primary channel discharge is obtained through baseflow. The variation in streambed gradient between the two channels makes the Port Dick data set invaluable for generalized modeling and model calibration.

A final topic of interest concerns what data should be collected in support of planning or evaluating new restoration sites. Feasibility studies for the Port Dick Project (00139-A2) conducted from 1991 through 1995 collected information on which to base a rehabilitation design using current practices. However, improvements in the collection of such background data are one of the important results of the Port Dick data set that could be useful to resource managers contemplating future spawning channel rehabilitation.

NEED FOR THE PROJECT

A. Statement of Problem

The problems that need to be addressed range from the human effects of declining salmon populations on Alaskan communities to the extinction of entire genetic stocks of salmon. Benefits realized from restored spawning habitat are potential acceleration of the recovery of depressed salmon stocks.

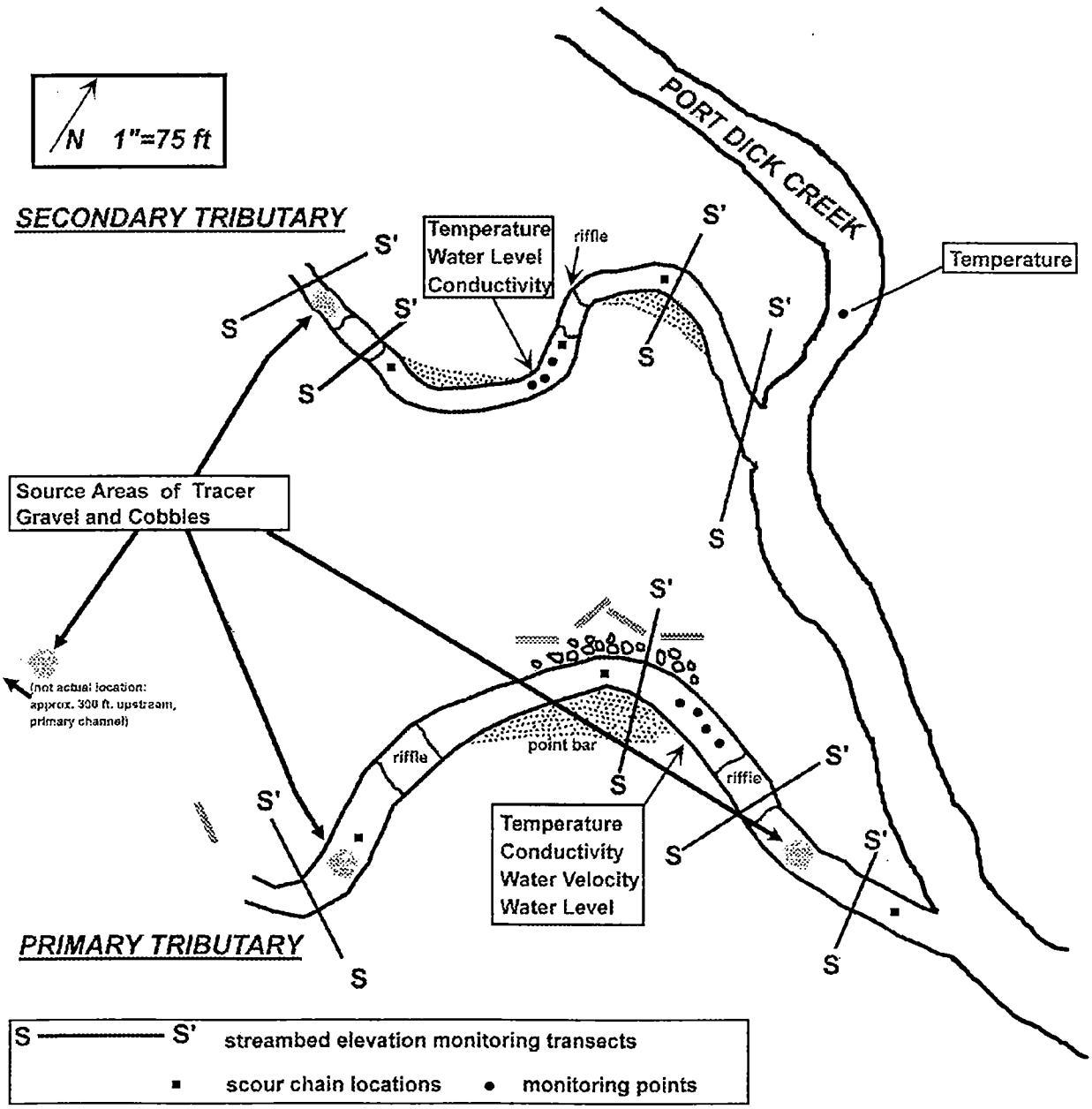
Success of the recently restored tributaries from which the optimization modeling will be calibrated depends on a wide variety of physical parameters. These monitored parameters play a large role in the stability of the created spawning habitat, as well as in the amount of spawning area created. Long term shifting of the spawning channel gravel and sediment is expected and important to characterize for the future of such projects. Therefore, numerical modeling will be used to link the physical systems (groundwater, surface water and sediment transport) in an effort to optimize the amount of long term spawning habitat created for any given spawning channel rehabilitation project.

B. Rationale/Link to Restoration

The ultimate goal of this project is to assist in restoring salmon stocks in general through research in spawning channel rehabilitation. The major hypothesis relates to the theory that the major salmon survival problem occurs during the instream incubation and residence period for both chum and pink salmon. It is theorized that survival problems are caused in part by the unstable nature of the spawning habitat within many small ecosystems. There has been a substantial investment, to date, by the EVOS Trustee Council and ADF&G to restore the spawning habitat at Port Dick Creek. This proposal will use the ongoing data set at Port Dick to determine optimal methods for salmon spawning channel restoration.

In order to fully achieve the goal of restoration through spawning channel rehabilitation, background information must be collected to evaluate the viability of a particular project. For example, discharge data is important in determining potential spawning habitat surface area for a prospective site. Another need for stable habitat arises from the fact that salmon eggs reside in the gravel substrate until fry emergence in the spring. Clearly the stability of the gravel substrate is an important habitat component that should be incorporated into the designs of future spawning channel restoration projects.

Figure 3. Primary and secondary spawning channel rehabilitation project showing hydrologic and sediment transport monitoring locations



C. Location

Port Dick Creek is located on the Outer Gulf Coast of the Kenai Peninsula on the exposed coastline of the Gulf of Alaska. The area is characterized and influenced by the warming effect of the maritime currents of the North Gulf Coast, and annual rainfall can exceed 60 inches (ADNR 1994). The predominate vegetation type of the Port Dick Creek drainage is Sitka Spruce and Western Hemlock forest. Sitka Spruce in this area commonly reach a diameter of 24 inches. The creek corridor is narrow (less than 250m) with adjacent slopes in excess of 30% grade. Port Dick Creek is a fresh water creek with the headwaters originating 2 miles to the west of tide water. The soil at the project site is alluvial and low in organic matter.

COMMUNITY INVOLVEMENT

The Alaska Department of Fish and Game is the lead trustee agency for the Port Dick Creek project. A scoping meeting was held in Anchorage at the Alaska Department of Fish and Game Office, 333 Raspberry Road on June 19, 1995. ADF&G (Commercial Fisheries Management and Development Division) communicated with the U.S. Forest Service and ADF&G (Habitat and Restoration Division).

This project was reviewed by the *Exxon Valdez* Trustee Council (TC) in April 1995 and approved the project pending federal NEPA requirements be satisfied prior to further funding. State of Alaska members on the Trustee Council include the Attorney General, and the Commissioners of ADF&G and the Department of Environmental Conservation (DEC). Federal agency members include representatives of the U.S. Departments of the Interior and Agriculture and the National Oceanographic and Atmospheric Administration (NOAA).

As part of the review process, the EVOS Trustee Council Public Advisory Group (PAG) reviewed this salmon instream habitat and stock restoration project in 1994 and 1995 prior to preparing recommendations to the Trustee Council. The PAG unanimously approved this type of project in 1994. In 1995, the PAG made no motion to approve or disapprove this project, however the project had received strong public support. In addition, conclusions from the Trustee Council Wild Stock Supplementation Workshop in January 1995 also supported this project. Questions concerning goals, linkage to injury and benefit/cost were addressed and incorporated into the proposal.

Stream rehabilitation projects typically inspire community involvement when not at remote sites. However, the remote location of this research project has proved to be an invaluable asset for research. Despite this efforts are made when possible for further community involvement in this project. Most recently, Mr. Wayne Biessel, Park Ranger for the KBSWP, visited the site on the invitation of Mr. Coble (January 8, 1999). Shana Loshbaugh of the Peninsula Clarion Newspaper has agreed to be a public liaison for aspects of the project that are of public interest (EVOS Conference, March 25, 1999).

PROJECT DESIGN

A. Objectives

(October 1, 2000 through September 31, 2001

The Port Dick primary and secondary spawning channels were excavated in June 1996. Objectives included in this proposal are to transfer information learned from the Port Dick spawning channel project to resource managers considering future rehabilitation projects of this kind. This transfer of peer-reviewed information will both be direct (in the form of a 'rehabilitation cookbook') as well as through manuscript publication as mentioned below. The objectives of optimizing spawning habitat will be accomplished through numerical modeling of groundwater-surface water interaction, surface water and gravel transport using the Port Dick data set for model calibration.

1. Analyze all data to support information transfer to resource managers for spawning channel rehabilitation projects, and to support numerical modeling.
2. Perform inverse modeling of data and calibrate to empirical methods.
3. Numerical modeling to optimize spawning channel design criteria by generalizing the Port Dick spawning channel data
4. Prepare annual report and manuscript for publication and peer review.

B. Methods

The methods to accomplish the comprehensive objectives of this proposal are in two parts. The first part would be to assist resource managers in site selection and planning for potential rehabilitation projects, while the second part is concerned with the design of the rehabilitation.

Part A, Data Needed to Support Spawning Channel Design

Because the Port Dick spawning channel monitoring program was comprehensive, it allows for an analysis of the important parameters to consider for background data collection. Most remote rehabilitation projects lack sufficient funds for appropriate data for planning, however by concentrating on the important parameters it is possible to achieve good results. Both biologic and sedimentologic considerations are necessary for a successful spawning channel design.

For example, salinity and temperature are known to affect salmon as cited in the literature. Salmon fry survival rates are correlated to temperature (e.g. Pauley, 1988; Wangaard, 1983), and salinity can interfere with fertilization of the eggs of chum salmon spawning in or near the intertidal zone. These events can cause early emigration of salmon fry. Figure 4 shows part of the Port Dick data set where an anamolous and early maximum of 14,000 fry emigrated due to a single tidal event. Because of such correlations it is possible to narrow the required data for planning a rehabilitation project down to a smaller set of information through analyses of the Port Dick data set.

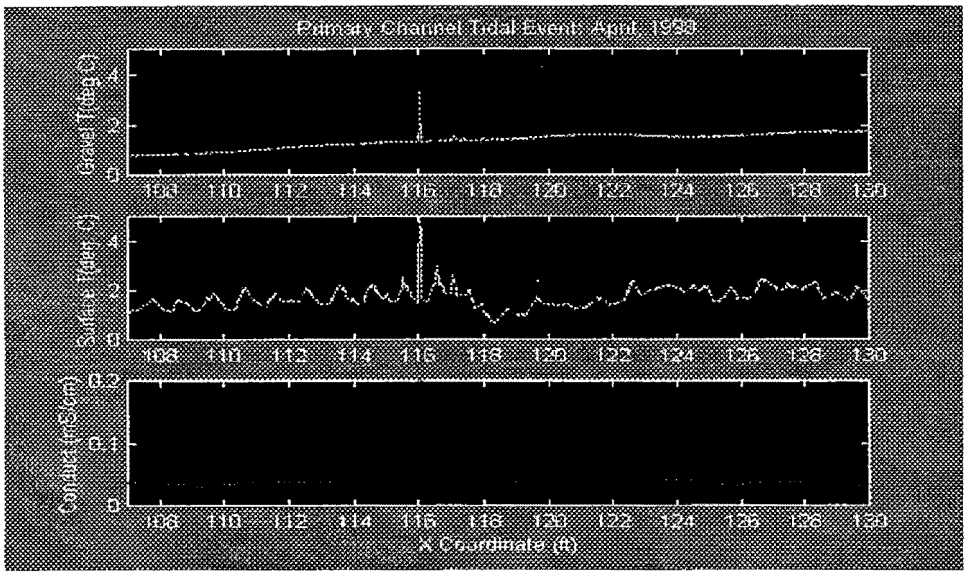


Figure 4. Tidal effects on the primary channel surface water and spawning gravel, which caused a large anomalous emigration of salmon fry (Coble and Dickson., 1999)

Water discharge records are extremely important for channel design, for bankfull discharge, low flow and to evaluate the catchment release capacity. The extensive discharge measurements taken in the Port Dick spawning channels (8 different water velocity cross sections for discharge calculations) allow an evaluation of discharge variations due to alluvial baseflow. This is may be an inexpensive yet important factor in determining the contribution of baseflow for planning a rehabilitation project.

An important and easily determined parameter that is useful in pre-determining the mobility of sediments at a potential rehabilitation site is the gravel size distribution of the onsite material. This is important to calculate along with the stream discharge record as it determines how the spawning channel will change due to flood discharges. This in turn plays a large role in the amount of long term spawning habitat, which is the subject of the second part of the objectives.

Intersecting water bodies must also be factored into rehabilitation planning. The importance of confluence waters from tides or a higher order stream on rehabilitation projects is shown in Figure 5 for the Port Dick data set. The higher the energy slope, the more potential there is for streambed scour and sediment transport. This data will be analyzed for possible advantages in planning spawning channel rehabilitation projects.

Finally, many other factors to consider have been monitored for the Port Dick project, and include the effects of offsite log jams, effects of vegetation, stream bed slope, type of riffle materials as well as general rehabilitation experience.

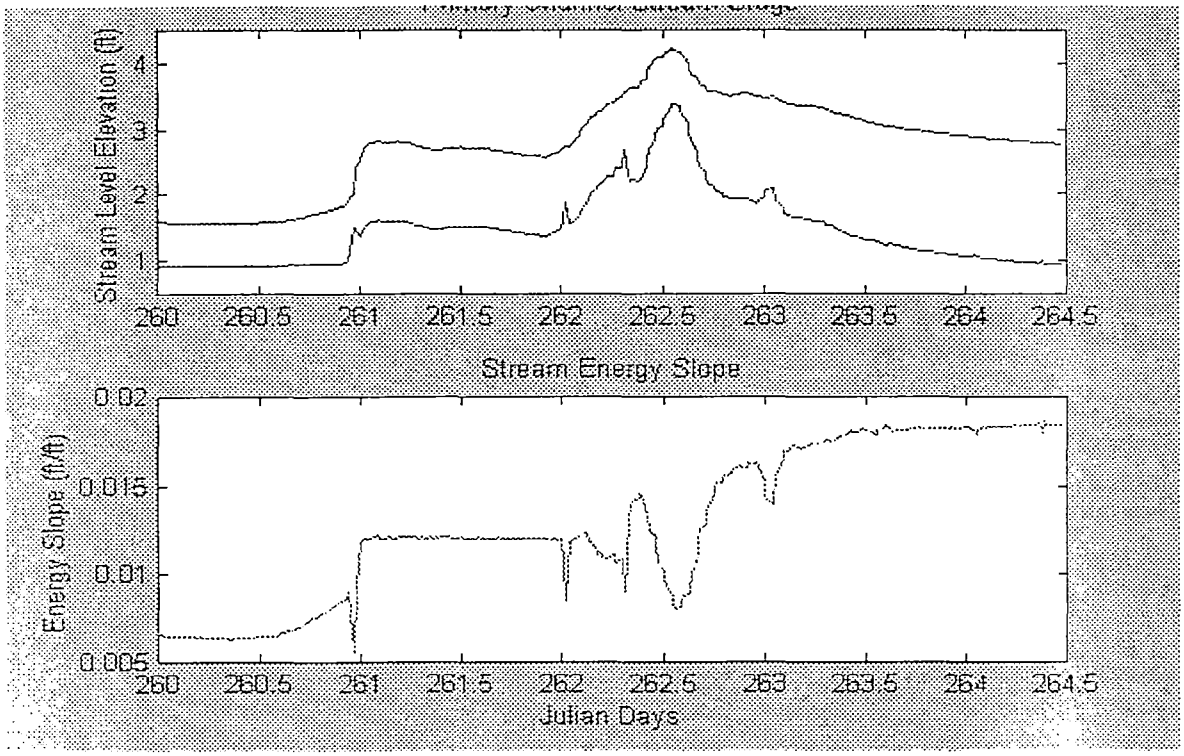


Figure 5. Tidal and confluence effects on the erosive power of the primary channel during flood stage, September 17 to 21, 1998.

Part B, Spawning Channel Design

Spawning channel design includes the overall channel design as well as that of specific features, including instream drop structures such as riffles and seepage face boundaries, bank stabilization methods and the use of native vegetation to achieve certain goals. The stability of different riffle and channel designs has been addressed in the Port Dick spawning channel data set through monitoring of the stability of drop structures of various designs which was important in helping

determine the performance of those designs. The different drop structure designs were determined by the available natural materials at Port Dick. This unique data set will provide an opportunity to generalize the methods that worked well at Port Dick to other sites.

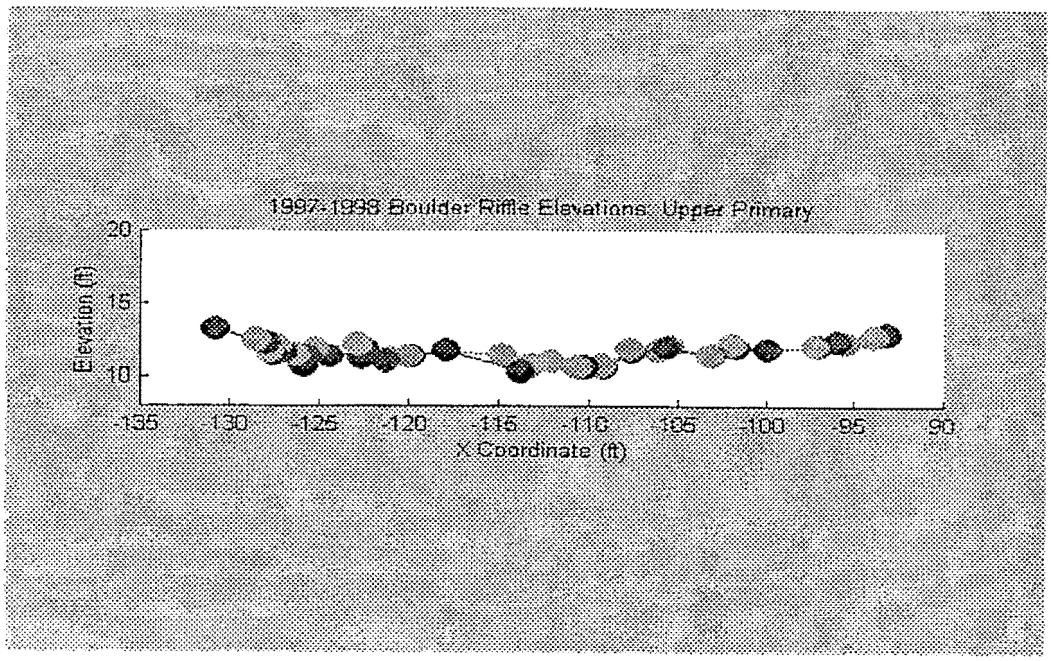


Figure 6. Upper primary channel boulder riffle showing only slight elevation differences between 1997 (light symbols) and 1998.

Figure 6 shows the evaluation of a boulder riffle structure at the head of the primary channel from the Port Dick data set. The stability of such riffle structures is extremely important to the success of rehabilitation projects, since movement in the riffle could increase the sediment supply and cause a relapse to pre-construction conditions.

Laursen et al. (1984) proposed a model for the size of riprap needed on the face of a sloping sill similar to the seepage face on the primary tributary. Elements of more specific papers on drop structures can also be useful in deriving models that describe sediment transport at drop structures (e.g. Humpherys, 1986; Fiuzat, 1987; Christodoulou, 1985). A related topic is streambank stability analyses (e.g. Chang, 1990).

Another subject of interest is studying the influence of small and large drop structures and their effect on gravel sediment transport in general. These topics often appear in the context of bridge construction, since bridges frequently must be founded on erodible material. The scour of a gravel-

bedded river is different at the location of a drop structure, so a variety of studies (e.g. Laursen et. al., 1984) indicate the stable sediment size at sloping sills and erosion depth directly below drop structures. Riffle construction techniques using available materials are therefore one of the topics for information transfer to resource managers.

However, the principle objective of this project is to provide designs for spawning channels that maximize spawning habitat for catchments with infrequent gravel transport. This will be accomplished through numerical modeling of high and low discharge events, which are the two regimes that affect gravel-bedded spawning channel morphology and spawning area, respectively.

MODELING INPUT

The Port Dick project provides a unique data set of infrequent gravel transport that will be used to define input parameters for numerical modeling.

Surface water parameters from the Port Dick data set include detailed discharge rating curves for both spawning channels, magnitude and frequency of streamflows, near-bed water velocity for estimation of shear stress, periodic wetted perimeter data, continuous stream stage and stream energy slope data.

Sediment transport monitoring at Port Dick has provided data for calibration of bed load transport models for gravel-bedded spawning channels. Bedload transport relationships are important to account for spawning channel stability. Gomez and Church, 1989, reviewed 12 bed load transport formulae including stochastic tractive force models (e.g. Einsteing bedload model) and stream power models (e.g. Bagnold, 1990). The advantages of each model depended on the model application. However, all 12 transport formulae make the assumption that transport is not size selective, so it is important to investigate that issue. Figure 7 shows that the gravel and cobble tracers that exhibited significant transport had only a slight preference to be lighter than all the tracers as a whole shown by an offset in their lognormal weight distribution.

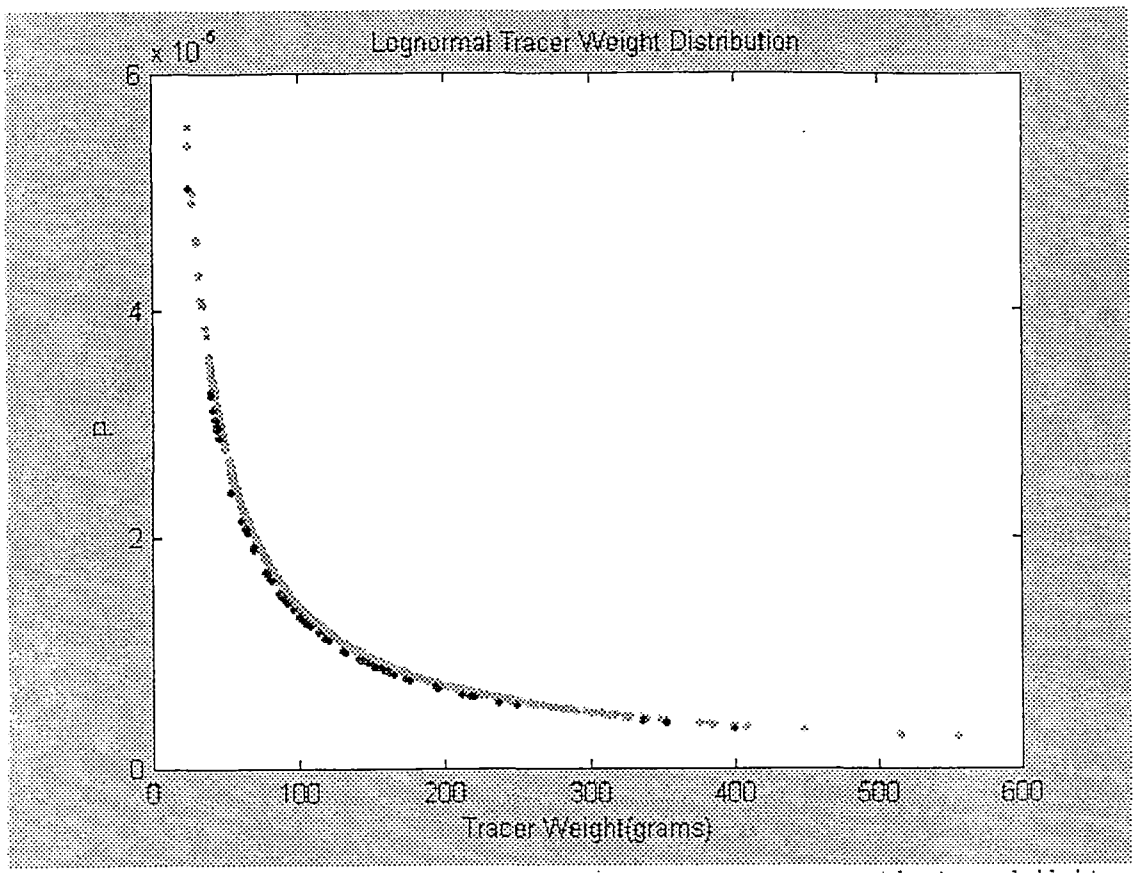


Figure 7. Lognormal distribution of tracers that exhibited significant movement (dark symbols) and lognormal distribution of all tracers (light symbols); data up to September, 1998.

Groundwater parameters rely on surveyed groundwater levels and topography, while changes in groundwater storage will be estimated from comparing the offsite and onsite discharge measurements during periods of low discharge.

Empirical data useful in calibration of the models includes the intensive tracer study of 700 gravel and cobble tracers spread equally among 4 source areas. The modeling will be able to take advantage of an additional 400 tracers beginning this spring placed in many more source areas. This data set is useful in determining the onset of transport for a given size distribution. Other empirical data useful for model calibration include eight periodically surveyed streambed cross sections, periodic surveying of the thalweg in both the primary and secondary channels (for streambed gradient), and scour chains.

Measuring the variation of parameters across a section of a stream channel as depicted in Figure 2 can be a very useful way to monitor streambed stability. Numerous studies have used this technique successfully, e.g. Jacobsen, 1995 in AGU Monograph 89. *Dietrich and Whiting 1989*

is an important surface water modeling parameter used to define the onset of sediment transport. By considering various channel cross sections and using the Port Dick data set for calibration to the real world, practical spawning channel designs that maximize spawning channel area (at low flows) can result.

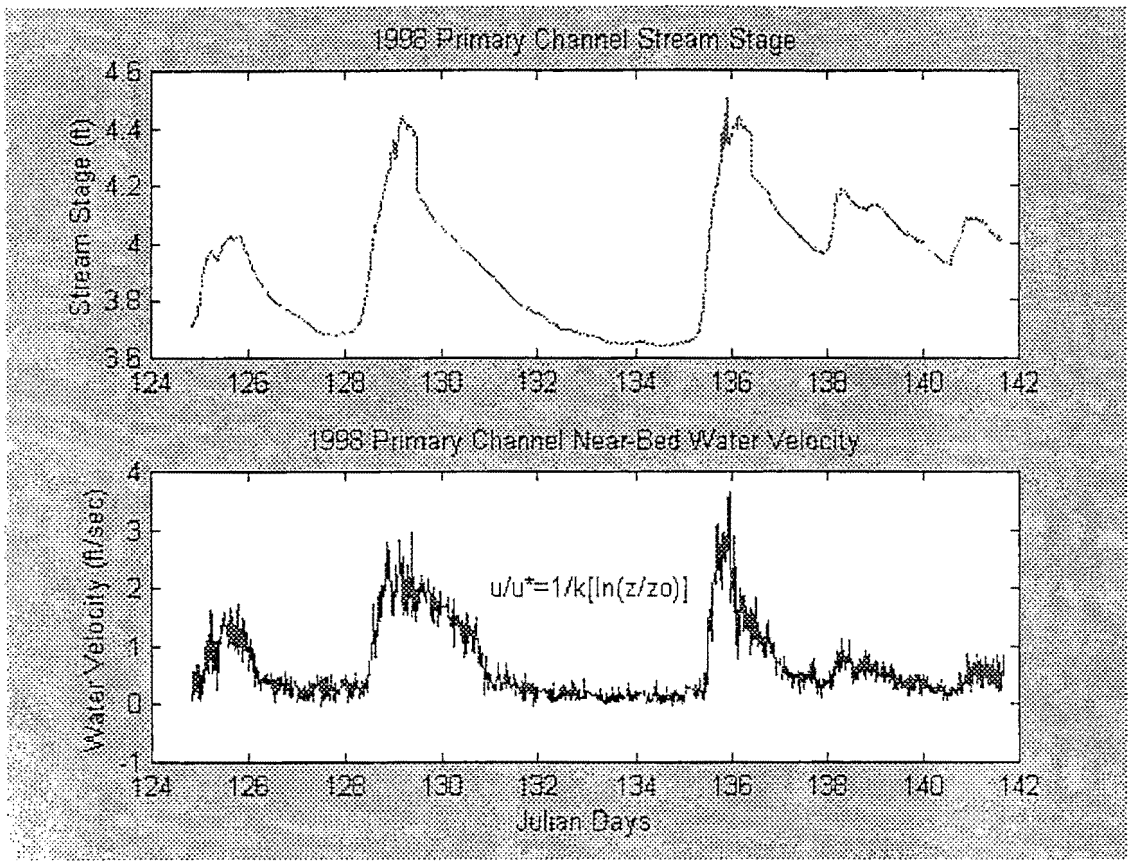


Figure 8. Near-bed water velocity correlated to stream stage for two minor flood events in May, 1998.

The public domain numerical model most used for this type of modeling is probably HEC-RAS, a USACE model that replaces the previous HEC-2 model. HEC-RAS accounts for stream cross section morphology and computes water surface profiles bsed on the stead, one-dimensional open channel flow equations. The model will be adapted to incorporate the sediment transport model(s) that calibrate best to the Port Dick data set. However, it must be stressed that gravel transport is much more a matter of research due to the lag times between transport events as mentioned previously. The surface water modeling will rely on the field work for empirical data on which to calibrate the model.

The HEC-RAS program can also be adapted to estimate scour at drop structures during high discharge events, another useful product for transfer to resource mangers as this relates to the design of stable riffles and seepage face boundaries.

Models that use the parameters for gravel-bedded streams are continually being refined, researched and published. For example, Bridge et al. recently published a basic sediment transport model for gravel-bedded streams that includes the critical discharge parameter, Hassan et al. proposed a model for gravel movement using tracer data (1991) and a model for the mixing of bedload downgradient from a source area (1994). Dietrich and Whiting (1993) have worked with models that include meanders in gravel bedded rivers, an important component at this site, and Pizzuto (1991) published an important model concerning gravel channel widening predictions and the importance of sediment supply from streambanks. In addition there are valuable published data sets for comparison studies available for gravel bedded flow, for example from laboratory flume studies (e.g. Pizzuto, 1990).

Mr. Coble has spent his 15-year hydrologic career as a specialist in numerical modeling, and looks forward to applying his knowledge and experience to the interesting problems presented by the Port Dick Project, as might be expected. Monitored hydrologic and sedimentologic parameters as they relate to the Port Dick Creek tributary salmon spawning habitat and stream channel construction are planned for publication in peer-reviewed publications such as Water Resources Bulletin, Hydrologic Sciences Journal and the Journal of Hydrology. Direct transfer of information to resource managers will be accomplished concurrently.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The Alaska Department of Fish & Game (ADF&G) Homer Office provides support by reducing travel expenses to Port Dick through shared travel, and most importantly by providing technical expertise for the concurrent biological aspects of the project.

SCHEDULE

A. Measurable Project Tasks for FY/00 (October 1, 1999 - September 30, 2000)

Continuous through FY/00:	Literature Review of salmon spawning channel rehabilitation projects, including inverse modeling and numerical modeling to further define the interrelationship of surface water-groundwater interaction, streambed stability and sediment transport.
10-1-99 to 1-1-00:	Analyses and inverse modeling of the Port Dick data to support general-case numerical modeling of spawning channel rehabilitation.
10-1-99 through 4-15-00	Numerical modeling, and preparation of materials for information transfer, as well as a manuscript for publication (tentative journal(s) *Journal of Hydrology, Water Resources Bulletin, Water Resources Research).*

4-16-00 through 9-31-00	Address editorial comments from the Chief Scientist and journal editors on draft report.

B. Project Milestones and Endpoints

Oct. 1, 99:	Begin data analyses in support of numerical modeling for the general restoration goals
April 15, 00:	Completion of numerical modeling and submittal of manuscript for publication.
Sept. 30, 00:	Complete information transfer to resource managers

C. Completion Date

Actual excavation of the tributaries occurred in June 1996, with post excavation evaluation and analysis to be completed in 2000. Additional monitoring of sediment transport parameters is proposed through 2002 to monitor channel stability as a basis for publication/research.

PUBLICATIONS AND REPORTS

For FY/00 we will have results showing the chronology of the newly restored Port Dick Creek tributary spawning habitat available for possible report publication. Monitored hydrologic and sedimentologic parameters as they relate to the Port Dick Creek tributary salmon spawning habitat and stream channel construction are planned for publication for FY/00 in *Transactions of the American Fisheries Society* and the *Journal of Hydrology*. The annual reports will be completed and submitted on April 15th.

PROFESSIONAL CONFERENCES

The conferences that we anticipate attending include the annual Exxon Valdez Oil Spill Trustee Council Restoration Workshop, the annual AWRA-Alaska conference (Mr. Coble will present more results at the April 12th, 1999 AWRA Conference in Juneau, Alaska) and the Fall 1999 American Geophysical Union (AGU) meeting. Results are also planned for presentation at an appropriate International Association of Hydrological Sciences symposium to be included in their well-known proceedings. The project team includes members of these organizations and other professional organizations.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This instream habitat restoration research is the only commercial fisheries EVOS related project on the Outer Gulf Coast of the Kenai Peninsula, however data collection, field communications, supplies, field help and logistics are always coordinated with the Commercial Fisheries Division of the Alaska Department of Fish and Game.

PRINCIPAL INVESTIGATOR

Geoff Coble, Project Geoscientist and Engineer; Project Manager

Mr. Coble is currently the owner and manager of CGS, a local firm specializing in water resources geophysics. Mr. Coble has a multi-disciplinary and academic approach to his career, combining three college degrees in Water Resources Science, Geology and Geophysics with water resources numerical modeling as a specialty. The fact that basic questions concerning transport of gravel in gravel-bedded streams remain unanswered, combined with the unique complexities of this site make it an ideal research project for Mr. Coble.

The Port Dick Creek sedimentology project was selected and defined based on the strengths of Mr. Coble and the value of the project for research. Mr. Coble has a long record of presenting his work for peer review, and has already made agreements for project review with other nationally published experts in hydrology and sediment transport.

OTHER KEY PERSONNEL

Mr. Coble corresponds regularly with colleagues that have similar research interests in numerical modeling, and will also be working closely with local biologists at the Alaska Dept. of Fish and Game for the biological aspects of this project.

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2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$40.3						
Travel								
Contractual								
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$40.3	Estimated FY 2001	Estimated FY 2002				
Indirect								
Project Total	$0.0	$40.3	$0.0	$0.0				
Full-time Equivalents (FTE)		0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This proposal is submitted under the BAA through NOAA for information transfer to resource managers.

FY00

Prepared: 4/7/99

Project Number: 00539-BAA
Project Title: Port Dick Spawning Channel Information Transfer
Name: Coble Geophysical Services

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2000
Numerical Modeling and Analysis						
G. Coble	Geophysicist III; Numerical Modeler		6.0	5.0		30.0
Final Report and Collaborative Journal Article(s)						
G. Coble	Geophysicist, Hydrologist		5.0	2.0		10.0
						0.0
		Subtotal	11.0	7.0	0.0	
					Personnel Total	$40.0

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

FY00

Prepared: 4/7/99

Project Number: 00539-BAA
Project Title: Port Dick Spawning Channel Information Transfer
Name: Coble Geophysical Services

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2000
Contractual Total	$0.0

Description	FY 2000
Commodities Total	$0.0

FY00

Prepared: 4/7/99

Project Number: 00539-BAA
Project Title: Port Dick Spawning Channel Information Transfer
Name: Coble Geophysical Services

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number	
Library and Computer Modeling Equipment, Including Bench Plotter, Software and Printers		

FY00

Prepared: 4/7/99

Project Number: 00539-BAA
Project Title: Port Dick Spawning Channel Information Transfer
Name: Coble Geophysical Services

FORM 4B
Equipment
DETAIL

Project Title: Port Dick Spawning Channel Long Term Sediment Transport Monitoring - Submitted Under the BAA

Project Number:	00540-BAA
Restoration Category:	Research
Proposer:	Geoff Coble, Coble Geophysical
Lead Trustee Agency:	NOAA
Cooperating Agency:	United States Forest Service, Alaska Department of Natural Resources and the Alaska Department of Fish and Game
Alaska Sea Life Center:	No
Duration:	1st year, 6 year project
Cost FY 00:	$20,300
Cost FY 01:	$17,300
Cost FY 02:	$17,300
Cost FY 03:	$17,300
Cost FY 04:	$17,300
Cost FY 05:	$40,300
Geographic Area:	West Arm Port Dick Bay, Outer Gulf Coast of Southern Kenai Peninsula.
Injured Resource/Service:	Pink and Chum Salmon. Information transfer of rehabilitation research to assist lost or reduced commercial fishing services.

ABSTRACT

The major project goal involves defining spawning channel rehabilitation design criteria of the Port Dick Creek salmon restoration project through aerial photogrammetry. This proposal continues the long-term stream stability monitoring program in FY01 to FY05 through a reduced program of long term sediment transport and streambed stability monitoring. Stream discharge attains infrequent threshold values due to the large size of the spawning gravel. The continued long term data collection program is necessary in order to evaluate long term effectiveness of spawning channel restoration, and to refine the minimum and type of field data necessary to support new rehabilitation projects. The continued monitoring will produce manuscripts for publication and information transfer documents.

INTRODUCTION

The Port Dick Creek spawning channel restoration project location is shown in Figure 1. Two tributaries were designed from data collected from the feasibility analysis to withstand two extremes, low and high water events, with a goal to sustain spawning channel stability. Project evaluation is limited to overall survivability, i.e. spawning success as measured by fry production. Additional project success is evaluated through long term monitoring and evaluation of the physical stability of the tributaries by evaluating sediment and bedload transport as well as the stability of riffles and streambanks in the project site area.

A comprehensive data set is being assembled concerning the stability and long term effectiveness of the Port Dick Project, which includes sedimentologic, hydrologic and biologic parameters. While the main project is scheduled to close out after the next fiscal year, projected long term monitoring of the sedimentologic parameters has long been recognized as being beneficial for future restoration projects. The long-term nature of the project is due to the fact that sediment transport rate is related to sediment particle size, where spawning gravels tend to move slowly overall, and require large and uncommon discharge events to initiate and sustain transport (Andrews and Nankervis, 1995). Long-term gravel transport is important to determine the stability of the constructed spawning channels both as a way to evaluate future design criteria and to assess the value (or stability) of current rehabilitation practices.

In order to accomplish this goal, a program of aerial photography tied to a ground survey is proposed in combination with most of the hydrologic parameters already being monitored. Matching funds will be sought to continue the remainder of the research program.

NEED FOR THE PROJECT

A. Statement of Problem

The targeted resource of the Port Dick spawning channel rehabilitation project is the wild pink and chum salmon stocks of Port Dick Creek, in the West Arm of Port Dick Bay. The total return of the Port Dick Bay chum salmon has averaged only 5,000 fish for the nine-year period (1988-1997) compared to the previous 15-year period (1974-1987) of 31,000 fish. The minimum spawning escapement goal at Port Dick Creek for chum salmon has been met only twice since 1988 (ADF&G. 1996).

Success of the created additional spawning habitat depends on a wide variety of physical parameters, and these have been monitored to assess the performance of the Port Dick project. Lessons learned from the necessary long term monitoring of gravel transport (Andrews and Nankervis, 1995) at this site can be used to assist future rehabilitation projects. Photogrammetric surveying is the least expensive detailed method that would provide data to support the ongoing modeling and research for better rehabilitation designs and practices.

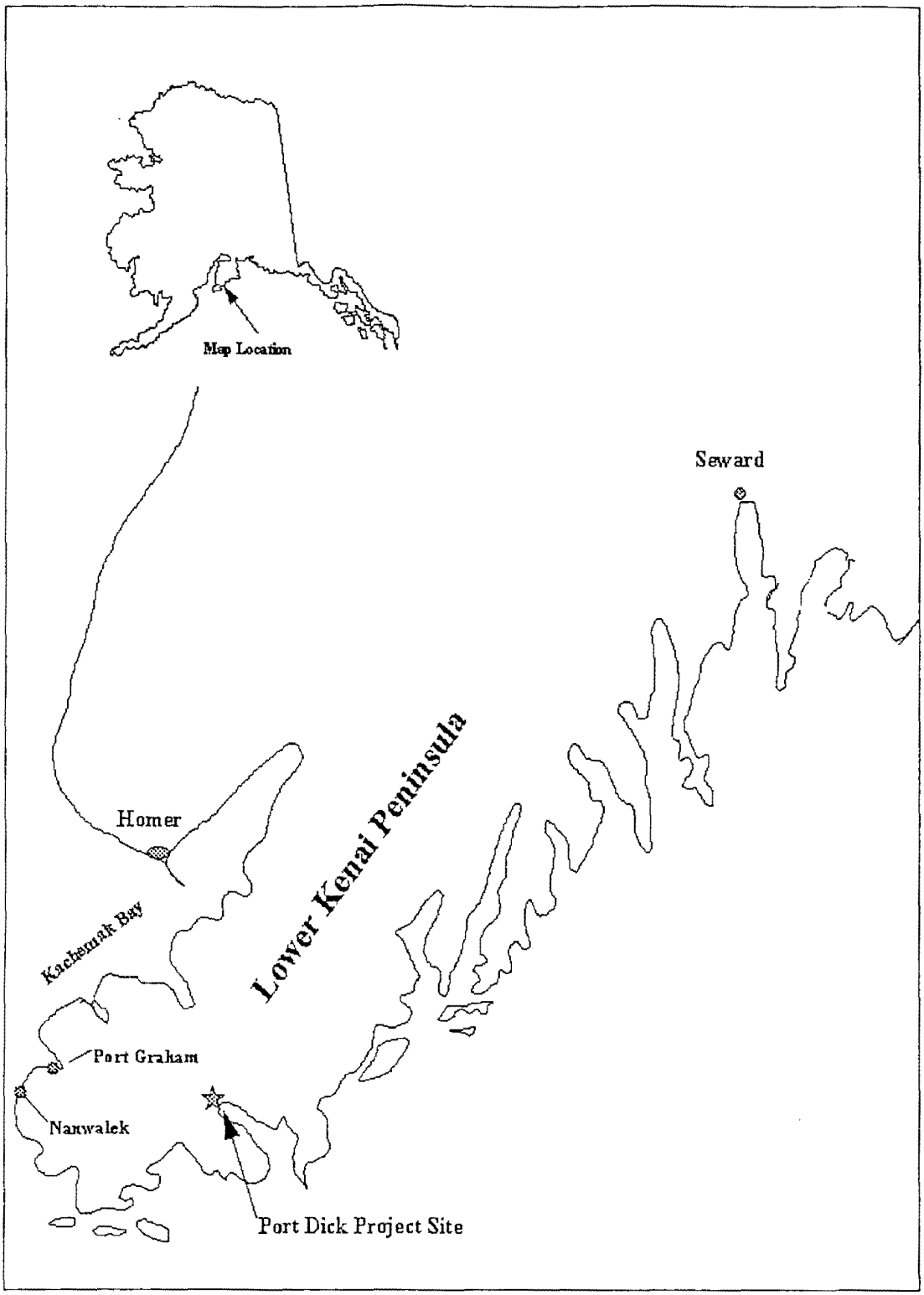

Figure 1. Map of the outer gulf coast of the Kenai Peninsula showing the location of the Port Dick Project site.

B. Rationale/Link to Restoration

The ultimate goal of this project is to provide improvements in salmon spawning channel rehabilitation designs and practices. This proposal assists that effort through monitoring of the wild pink and chum salmon spawning channel rehabilitation project, Port Dick Creek in support of numerical modeling and research into spawning channel designs that maximize habitat and long term stability at minimum cost.

Chum and pink salmon survival is dependent on the unstable nature of the spawning habitat within the mainstream of Port Dick Creek. The chum and pink salmon life history are similar, in that the females of each species migrate upstream to spawn in the summer and fall. They create a gravel cavity or redd and deposit their eggs. The eggs then reside in the gravel substrate until fry emergence in the spring. Clearly the stability of the gravel substrate is an important habitat component that should be evaluated to determine spawning channel performance in light of the changed post construction streambed hydraulic parameters (streambed slope, meander curvature, and the placement of riffles and point bars). There has been a substantial investment, to date, by the EVOS Trustee Council and ADF&G to restore the spawning habitat at Port Dick Creek. This proposal will continue to evaluate the effectiveness of this restoration project in support of improvements in spawning channel design. The projected importance of stream restoration projects in the future dictates a regular publishing cycle.

C. Location

Port Dick Creek is located on the Outer Gulf Coast of the Kenai Peninsula on the exposed coastline of the Gulf of Alaska. The area is characterized and influenced by the warming effect of the maritime currents of the North Gulf Coast, and annual rainfall can exceed 60 inches (ADNR, 1994). The predominate vegetation type of the Port Dick Creek drainage is Sitka Spruce and Western Hemlock forest; Sitka Spruce in this area commonly reach a diameter of 24 inches. The creek corridor is narrow (less than 250m) with adjacent slopes in excess of 30% grade. Port Dick Creek is a fresh water creek with the headwaters originating 2 miles to the west of tide water. The soil at the project site is alluvial and low in organic matter.

COMMUNITY INVOLVEMENT

The Alaska Department of Fish and Game is the lead trustee agency for the Port Dick Creek project. A scoping meeting was held in Anchorage at the Alaska Department of Fish and Game Office, 333 Raspberry Road on June 19, 1995. ADF&G (Commercial Fisheries Management and Development Division) communicated with the U.S. Forest Service and ADF&G (Habitat and Restoration Division).

This project was reviewed by the *Exxon Valdez* Trustee Council (TC) in April 1995 and approved the project pending federal NEPA requirements be satisfied prior to further funding. State of Alaska members on the Trustee Council include the Attorney General, and the Commissioners of ADF&G and the Department of Environmental Conservation (DEC). Federal agency members include representatives of the U.S. Departments of the Interior and Agriculture and the National Oceanographic and Atmospheric Administration (NOAA).

As part of the review process, the EVOS Trustee Council Public Advisory Group (PAG) reviewed this salmon instream habitat and stock restoration project in 1994 and 1995 prior to preparing recommendations to the Trustee Council. The PAG unanimously approved this type of project in 1994. In 1995, the PAG made no motion to approve or disapprove this project, however the project had received strong public support. In addition, conclusions from the Trustee Council Wild Stock Supplementation Workshop in January 1995 also supported this project. Questions concerning goals, linkage to injury and benefit/cost were addressed and incorporated into the proposal.

While the remote location of this research project has proved to be an invaluable asset for research, it is in some ways less accessible for community involvement. Despite this, efforts are made when possible for further community involvement in this project. Most recently, Mr. Wayne Biessel, Park Ranger for the KBSWP, visited the site on the invitation of Mr. Coble (January 8, 1999). Shana Loshbaugh of the Peninsula Clarion Newspaper has agreed to be a public liaison for aspects of the project that are of public interest (EVOS Conference, March 25, 1999).

P ROJECT DESIGN

A. Objectives

October 1, 2000 through September 31, 2001

Long term monitoring using low altitude aerial photography serves two main objectives:

1) Sedimentologic, in that the aerial survey provides microtopographic information important in evaluating sediment and erosion effects on spawning channel area at low water levels.
2) Dynamic, in support of the ongoing numerical modeling and research by determining the elevation of stream channel water levels at low discharge. This information in combination with offsite and onsite water discharge measurements already proposed would provide a more accurate picture of groundwater- surface water interaction. This information is very useful in calibration of groundwater- surface water interaction modeling used to optimize spawning channel designs for future rehabilitation projects.

The specific objectives of the proposed long term aerial photographic surveying include the continued evaluation of current rehabilitation practices, and assisting in the question of how to maximize salmon spawning channel area given certain key parameters (for example magnitude and frequency of high discharge events, and bedload gravel size distribution). This will be accomplished as follows:

a) Detailed aerial photographs tied to ground surveying photogrammetric controls obtained from both channels in order to compare sediment volume and spawning channel surface area with current and historic water levels.

b) Process this data to obtain comparisons with the historical data collected since spawning channel construction as a detailed method to measure effectiveness.

c) Prepare annual reports. Prepare the long term monitoring results for peer review and evaluation in preparation for publication.

B. Methods

Low altitude aerial photogrammetry has been used for small riparian study areas (e.g. Platts, 1987). Aerial photographs will be useful in the analysis of spawning channel streambed features at low water level. Low altitude photogrammetry is also useful in determining changes in the size and location of gravel bars, channel banks, and vegetation (Gordon et al, 1992). Because of the need for ground surveying and concurrent dynamic water level data during the aerial survey, accomplishing the objectives by helicopter would be expensive and impractical. Therefore a weather balloon technique will be used, which will be more than adequate for the protected area of the Port Dick Creek spawning channels.

The long term monitoring program currently active at the Port Dick Creek spawning channels would greatly benefit from the addition of long term aerial photographic surveys. This would give an accurate estimate of spawning channel area for any given stream stage (where stream stage is a point measurement). This data could then be used to augment the historic as well as future data, and would greatly improve the resolution of numerical models proposed for optimizing future rehabilitation efforts.

Part A, Aerial Photogrammetric Survey

Photogrammetric surveying of the spawning channels will be accomplished in a two step process. The first step will involve a comprehensive ground survey to establish control elevations and positions of stream channel boundaries, and thalweg elevations. These measurements are taken using a total station and referenced to 6 permanent surveying monuments installed in 1996 prior to construction of the spawning channels. Each surveyed point of the ground survey is then staked with visible markers referenced in a field book.

In the second step, low altitude photography will be accomplished using a camera-mounted weather balloon tethered at approximately 15 meters above land surface, but at exactly the same altitude for each photographed station across all stations. The digital camera has a remote shutter to allow complete control over the timing of each photograph. The photogrammetric survey will be done on calm, clear days with low water level and low light angle. Just prior to each photograph the dynamic water level at the stream margins will be surveyed and marked. Each photograph will be taken when the camera is vertically overhead of the photographic stations.

Total site coverage of the constructed spawning channels will be accomplished at high resolution (15 meters). The wider alluvium will be photographed at lower resolution to assist in mapping the flood plain, determining accurate boundary conditions for numerical modeling, and spawning channel rehabilitation research.

When aerial photographic surveys are done at low discharge and low light angles, the power for determining changes in streambed features between photographic surveys is very high. The low light angles combined with ground surveying and concurrent sediment transport monitoring should provide the most accurate data on sediment transport and spawning channel stability at this remote site. This new data would also correlate and strengthen the historic and ongoing stream transect elevation surveys, an example of which is shown in Figure 2 for pre-(light line) and post-(dark line) flood conditions for the flood event of September 21, 1998. The graph shows the dynamic nature of sediment scour and deposition, gravel bar formation and the effects these have on spawning channel wetted perimeter during periods of low discharge. The photogrammetric survey would expand the wetted perimeter data to spawning channel area, providing an accurate comparative assessment of total spawning habitat.

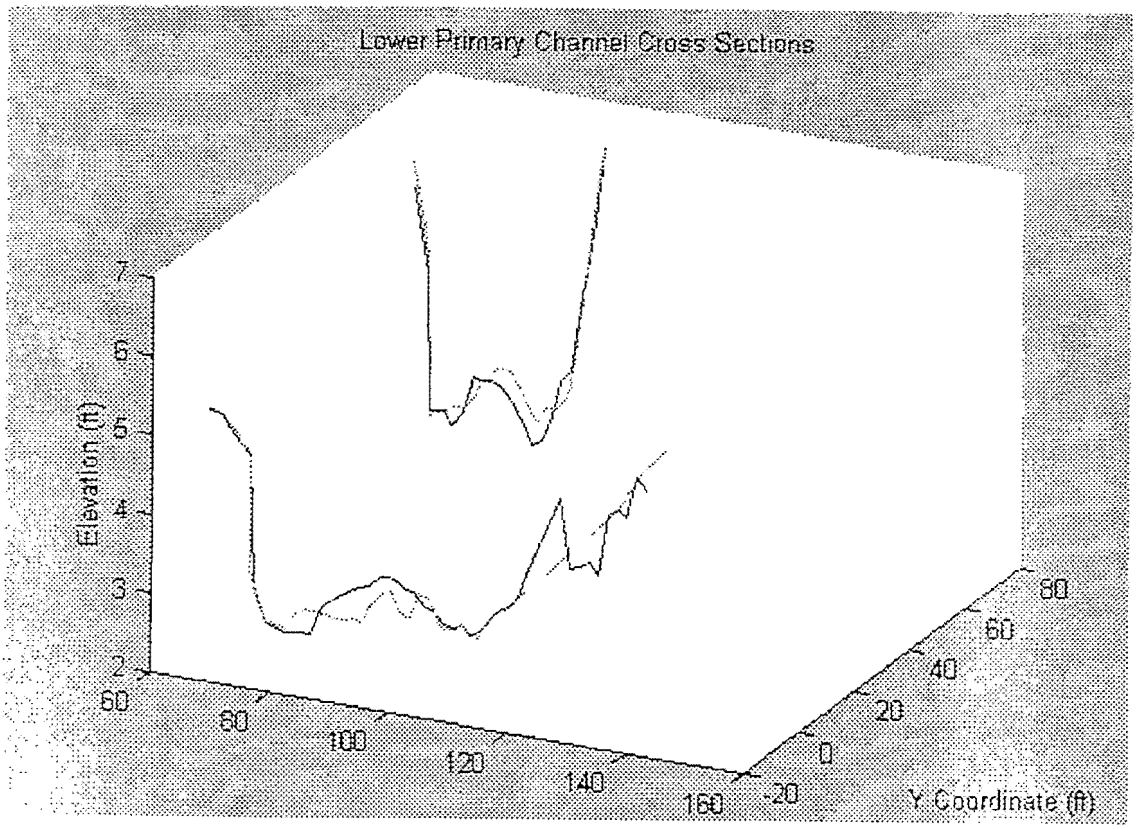

Figure 2. Two pre-(light line) and post-(dark line) flood conditions on September 21,1998.

Aerial photographic surveys would then be conducted through matching funds from FY01 to FY05 to assist the long-term assessment goals of this project. This aspect of the proposal would begin in FY01 however, and is contingent on the Restoration Reserve transition to long-term monitoring and research.

Part B, *Physical Parameter Monitoring*
The following parameters will be collected through matching funds from FY01 to FY05 to assist the long-term assessment goals of this project. This aspect of the proposal would begin in FY01, and is contingent on the Restoration Reserve transition to long-term monitoring and research. The four types of sensors proposed for long term hydrologic monitoring include water level, velocity, temperature and conductivity as shown in Figure 3. The implementation and justification of each technique is described in Proposal 00139-A2.

Part C, *Ongoing Sediment Transport Parameter Monitoring Modeling:*
The following parameters will be collected through matching funds from FY01 to FY05 to assist the long-term assessment goals of this project. This aspect of the proposal would begin in FY01, is in contingent on the Restoration Reserve tradition to long-term monitoring and research. The four additional methods proposed for long-term sediment transport monitoring include measurement and comparison of changes in surveyed stream transects, use and surveying of tracer cobbles and gravel, measurement changes in scour chain orientations and measurements of surface water energy slope (Refer to Figure 3.). The implementation and justification of each technique is described in Proposal 00139-A2.

C. Cooperating Agencies and Other Agency Assistance

The Alaska Department of Fish and Game (ADF&G) Homer Office provides support by reducing travel expenses to Port Dick through shared travel, and most importantly by providing technical expertise for the concurrent biological aspects of this project.

SCHEDULE

A. Measurable Project Tasks for FY/00 (October 1, 1999 - September 30, 2000)

Continuous through FY/00:	Perform aerial photogrammetric survey of the Port Dick Creek tributary spawning channels and related features. Coordinate field work with ongoing projects near and at Port Dick Creek.
10-1-99 to 1-1-00:	Quantify streambank and streambed changes and new features through comparison of aerial survey data to the historic project data set.
10-1-99 through 4-15-00	Preparation of draft report, and begin preparations for manuscript for the *Journal of Hydrology* or similar.
4-16-00 through 9-31-00	Address editorial comments from the Chief Scientist and journal editors on draft report.

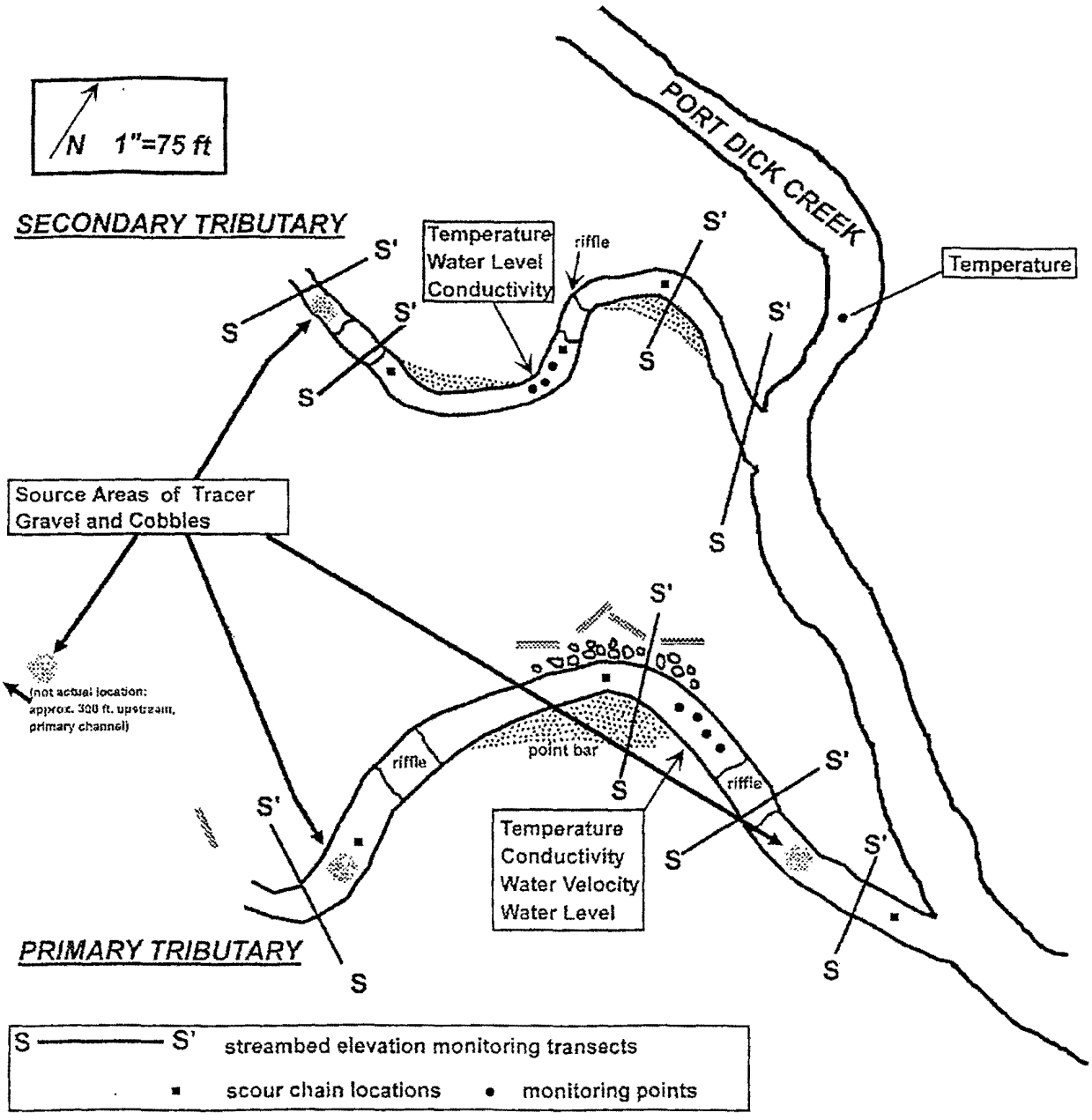

Figure 3. Hydrological and sedimentologic parameter monitoring locations, spawning channel rehabilitation project, Port Dick Creek.

B. Project Milestones and Endpoints

Nov. 30, 99:	Complete aerial photogrammetric survey of channels at low discharge
April 15, 00:	Complete comparison of initial spawning channel surveys to aerial photogrammetric survey and make estimates of channel movement, scour and deposition
Continuous through FY01:	Monitor physical and hydrologic parameters through matching grants
Nov. 30, 00:	Complete aerial photogrammetric survey of channels at low discharge
April 15, 01:	comparison of photogrammetric surveys; publish manuscript
Continuous through FY02:	Monitor physical and hydrologic parameters through matching grants
Nov. 30, 01:	complete aerial photogrammetric survey of channels at low discharge
April 15, 02:	comparison of photogrammetric surveys; research, submit manuscript for peer review
Continuous through FY03:	Monitor physical and hydrologic parameters through matching grants
Nov. 30, 02:	complete aerial photogrammetric survey of channels at low discharge
April 15, 03:	comparison of photogrammetric surveys; research, submit manuscript for peer review
Continuous through FY04:	Monitor physical and hydrologic parameters through matching grants
Nov. 30, 03:	complete aerial photogrammetric survey of channels at low discharge
April 15, 04:	comparison of photogrammetric surveys; research, submit manuscript for peer review
Continuous through FY05:	Monitor physical and hydrologic parameters through matching grants
Nov. 30, 04:	complete final aerial photogrammetric survey of channels at low discharge
April 15, 05:	comparison of photogrammetric surveys and all data at Port Dick research site; submit work for peer review

C. Completion Date

Long term monitoring of gravel transport parameters is proposed through 2005 to monitor channel stability as a basis for publication/research.

PUBLICATIONS AND REPORTS

For FY/00 the publishable results will consist of detailed changes of the spawning channels following construction. The manuscript will contain aerial photographic surveys tied to ground surveys, and consequently to all surveyed data at the Port Dick Creek research site. This evaluation of the project is planned for publication for FY/00 in the *Journal of Hydrology*. The annual report will be completed and submitted on April 15th.

PROFESSIONAL CONFERENCES

The conferences that the principal investigator anticipates attending include the annual Exxon Valdez Oil Spill Trustee Council Restoration Workshop, the annual AWRA-Alaska conference (Mr. Coble will present more results at the April 12th, 1999 AWRA Conference in Juneau, Alaska) and the Fall 1999 American Geophysical Union (AGU) meeting. Results are also planned for presentation at an appropriate International Association of Hydrological Sciences symposium to be included in their well-known proceedings. The project team includes members of these organizations and other professional organizations.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This instream habitat restoration research is the only commercial fisheries EVOS related project on the Outer Gulf Coast of the Kenai Peninsula. Initial data transfer and project communication for this project will be coordinated as always with the Commercial Fisheries Division of the Alaska Department of Fish and Game in Homer.

PRINCIPAL INVESTIGATOR

Geoff Coble, Project Geoscientist, Engineer; Project Manager
Mr. Coble is currently the owner and manager of CGS, a local firm specializing in water resources geophysics. Mr. Coble has a multi-disciplinary and academic approach to his career, combining three college degrees in Water Resources Science, Geology and Geophysics with water resources numerical modeling as a specialty. The fact that basic questions concerning transport of gravel in gravel-bedded streams remain unanswered, combined with the unique complexities of this site make it an ideal research project for Mr. Coble.

The Port Dick Creek sedimentology project was selected and defined based on the strengths of Mr. Coble and the value of the project for research. Mr. Coble has a long record of presenting his work for peer review, and has already made agreements for project review with other nationally published experts in hydrology and sediment transport.

OTHER KEY PERSONNEL

Mr. Coble corresponds regularly with colleagues that have similar research interests in data collection to support accurate numerical modeling. Mr. Coble will also be working closely with local biologists at the Alaska Dept. of Fish and Game for the biological aspects of this project.

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2000 EXXON VALDEZ TRL COUNCIL PROJECT BUDGET
October 1, 199 eptember 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$17.3						
Travel		$0.8						
Contractual		$2.2						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$20.3	Estimated FY 2001	Estimated FY 2002	Estimated FY 2003	Estimated FY 2004	Estimated FY 2005	
Indirect								
Project Total	$0.0	$20.3	$17,300.0	$17,300.0	$17,300.0	$17,300.0	$40,300.0	
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This proposal is submitted under the BAA through NOAA for information transfer to resource managers.

FY00

Prepared: 4/9/99

Project Number: 00540-BAA
Project Title: Port Dick Spawning Channel Long Term Monitoring
Name: Coble Geophysical Services

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET
October 1, 199$ ptember 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2000
Physical Parameter Monitoring						
G. Coble	Field Hydrogeologist/Technician		5.0	2.0		10.0
G. Coble	Geophysicist III		1.0	1.0		1.0
Final Report and Preparation of Manuscript						
G. Coble	Geophysicist, Hydrologist		3.0	2.1		6.3
						0.0
	Subtotal		9.0	5.1	0.0	
					Personnel Total	$17.3

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2000
Plane trip for surveying and aerial photography (Super Cub)		0.2	4			0.8
					Travel Total	$0.8

FY00

Prepared: 4/9/99

Project Number: 00540-BAA
Project Title: Port Dick Spawning Channel Long Term Monitoring
Name: Coble Geophysical Services

FORM 4B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed
Description	FY 2000
Spawning Channel Stability Evaluation	
1 Total Station, Tripods, Prism Rod, 300 Ft Surveyor's Tape, Rental	0.7
1 Weather Balloon Equipment, Including Camera with Remote Shutter Control	1.5
Contractual Total	$2.2

Description	FY 2000
Commodities Total	$0.0

FY00

Prepared: 4/9/99

Project Number: 00540-BAA
Project Title: Port Dick Spawning Channel Long Term Monitoring
Name: Coble Geophysical Services

FORM 4B
Contractual & Commodities DETAIL

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

Existing Equipment Usage:	Number	

FY00

Project Number: 00540-BAA
Project Title: Port Dick Spawning Channel Long Term Monitoring
Name: Coble Geophysical Services

FORM 4B
Equipment
DETAIL

Prepared: 4/9/99

Prince William Sound Isotope Ecology Dissemination, Submitted Under the BAA

Project Number:	~~00XXX~~ 00541-BAA
Restoration Category:	Research
Proposer:	Prince William Sound Science Center Cordova, Alaska
Lead Trustee Agency:	NOAA
Cooperating Agencies:	
Alaska SeaLife Center:	
Duration:	Year 1, 2-year project
FFY 00:	$ 32.2534K (exclusive of agency overhead
FFY 01:	$ 34.312K (exclusive of agency overhead)
Geographic Area:	Prince William Sound
InjuredResource/Service:	Fishes and their Injured Consumers, Fisheries: Commercial, Recreational, and Subsistence

ABSTRACT

A crucial part of the scientific research process is dissemination of the results to the scientific community. The P.I. has a paper that will soon be out (accepted by the CJFAS in September 1998) establishing the application of isotope methods for Prince William Sound. The P. I. is thus ready to prepare and submit a paper on salmon and one on zooplankton for publication by 2000. If these papers can be submitted within the year, they could be published sometime in 2001 depending on the queue at the journal.

INTRODUCTION

A crucial part of the scientific research process is dissemination of the results to the scientific community. This come is the form of papers given at meetings and through publication in the open literature. The process of dissemination generally requires a protracted schedule. This occurs for several reasons. One being that the process of reviewing, revising, and publication of a paper can take several years. Secondly, publication of one article may need to follow the publication of another. This has been the case for the P.I.'s restoration research. The keystone paper, number 4 in the list below, presently in press (accepted by the CJFASl in September 1998, Appendix 1) needs to be published before other papers that rely on concepts established there can be used. Given that the P.I.'s paper establishing isotopic applications for Prince William Sound will soon be out (#4 below, accepted by the CJFAS in September 1998), the P. I. is ready to submit a paper on salmon and one on zooplankton in 2000. If these papers can be submitted within the year, they could be published sometime in 2001 depending on the queue at the journal.

Results from prior work

The following contributions to the scientific literature were made by the P.I. based on EVOSresearch:

1. Kline, Thomas C. Jr. 1997. Confirming forage fish food web dependencies in the Prince William Sound ecosystem using natural stable isotope tracers. Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 9701. University of Alaska Fairbanks. P. 257 - 269.

2. Kline, Thomas C. Jr. 1998. Salmon Fry. In: T. A. Okey and D. Pauly (eds), A Trophic Mass-Balance Model of Alaska's Prince William Sound Ecosystem, for the Post-Spill Period 1994-1996. Fisheries Centre Research Reports 1998 Volume 6 Number 4. Fisheries Centre, University of British Columbia, Vancouver, Canada. p. 26-31.

3. Kline, Thomas C. Jr.. and Daniel Pauly. 1998. Cross-validation of trophic level estimates from a mass-balance model of, and $^{15}N/^{14}N$ data from, Prince William Sound. Proceedings of the International Symposium on Fishery Stock Assessment Models for the 21st Century -- Combining Multiple Data Sources. Alaska Sea Grant College Program Report. University of Alaska Fairbanks. IN PRESS

4. Kline, Thomas C. Jr. 1998. Temporal and Spatial Variability of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ in Pelagic Biota of Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences. 55 (Suppl. 2): IN PRESS

5. Kline, Thomas C. Jr. 1999. Carbon and Nitrogen Isotopic Composition of Prince William Sound Pelagic Biota Shift on Annual Time Scales: A Tool for Monitoring Changes in Oceanographic Forcing. In: Ecosystem Consideration in Fisheries Management. Proceedings of the International Symposium on Ecosystem Consideration in Fisheries Management. Alaska Sea Grant College program Report No. 99-01. University of Alaska Fairbanks. IN PRESS:

NEED FOR THE PROJECT

A. Statement of Problem

The Problem: There is need to disseminate results in the scientific community. The publication process facilitates this communication while the review process provides the credibility. The Trustee Council also gains credibility for its science through these publications.

B. Rationale/Link to Restoration

The restoration process should be based on valid science. Validation of a research project comes about through the anonymous peer review process that occurs with publication. The paper is examined critically by specialists in the field of the paper. Dubious results are rejected.

C. Location

Prince William Sound

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

PROJECT DESIGN

A. Objectives

1. A paper dealing with the experimental release of salmon from PWS hatcheries. Ascertaining whether differences in feeding may explain the differences in survival rate while exploiting the PWS isotope gradient described in paper #4 listed above:

proposed paper title

Pacific salmon early marine life-history trophic shifts based on $^{15}N/^{14}N$ and $^{13}C/^{12}C$ of hatchery-released fry implanted with coded wire tags in Prince William Sound, Alaska.

authors Thomas C. Kline, Jr. and T. Mark Willette

target journals CJFAS, MEPS, or JEMBE

2. A paper dealing with isotope gradients but expanded to all three *Neocalanus* cogeners (from just the one species in paper #4 listed above):

proposed paper title

Spatial Variability in the Stable Carbon and Nitrogen Isotopic Composition of three *Neocalanus* Cogeners from Prince William Sound and Adjacent Gulf of Alaska.

authors Thomas C. Kline, Jr. and John D. Williams

target journals L&O or MEPS

B. Methods

Draft papers will be sent to the journal for review. Reviews expected back in six months from date of submission. Revision expected to take one month. Revised paper will be reviewed within three months. Publication, about 6-12 months, depending on journal, from date of acceptance.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

N/A

SCHEDULE

A. MEASURABLE PROJECT TASKS for FYI (October 1, 1999 - September 30, 2000)

Oct. 99 - Jun. 00: Prepare drafts and submit them to journals
Oct. 00 - Dec. 00: Revise papers
Jun. 01 - Dec. 01: Papers published

B. Project Milestones and Endpoints

Jun. 2000:	Papers submitted to journals
Dec. 2000:	Revised papers sent to journals

Mar 2001:	Papers accepted by journals
Jan. 2000, 2001:	Attend Annual Restoration Workshop
Oct., 1999 - Sept. 2001:	Preparation for and dissemination of results at EVOS and other Symposia
Jan-April 2000, 2001:	Preparation of Annual Reports (to consist sole of manuscripts)
Jan-April 2001:	Draft Final Report preparation (to consist sole of manuscripts)
September 2001:	Final Report revisions (to consist of galley proofs or reprints)

C. Completion Date

September 2001 (Final Report)

PUBLICATIONS AND REPORTS

See objectives

PROFESSIONAL CONFERENCES

Travel is requested for the P.I. to present results at a national (or when appropriate, international) meeting such as ASLO or AGU and to attend workshops with collaborators. Travel to present project results at national meetings and to participate in collaborative workshops are essential to the project's success.

NORMAL AGENCY MANAGEMENT

N/A

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Collaboration with other EVOS investigators will continue, workshops and meetings will facilitate the exchange.

PROPOSED PRINCIPAL INVESTIGATOR

Thomas C. Kline Jr., Ph.D.
Prince William Sound Science Center

P. O. Box 705
Cordova, AK 99574
907-424-5800 (t)
907-424-5820 (f)
tkline@grizzly.pwssc.gen.ak.us

PRINCIPALINVESTIGATOR

T. Kline has been actively involved in stable isotope research since 1985. His has innovated applications of stable isotope analysis in fish ecology with emphasis on salmonid fishes in northern, western, south central and southeast Alaska. His techniques has enabled the quantification of the effect of salmon carcass nutrient input to juvenile sockeye salmon production. This research has been the first to provide direct evidence for the importance of salmon carcasses for juvenile salmon production (Kline et al. 1990) . His stable isotope models also enable the quantification of different sources of production important in salmon ecosystems (Kline et al. 1993). Dr. Kline also led an investigation relating feeding strategies to growth forms in North Slope salmonids (Kline et al. 1998). His on-going efforts include collaborations with ADF&G, the North Slope Borough, and BPX. The results of these projects have been presented in numerous scientific papers as well as in public forums (speaking to local groups and classes). T. Kline initiated project 320I which has been the first comprehensive project using natural stable isotopes in Prince William Sound. Through this project he has developed new models and application of natural stable isotope abundance methods (Kline 1997, Kline and Pauly 1998). He was the first to provide direct evidence of the importance of carbon from the Gulf of Alaska in Prince William Sound (Kline 1997, 1998).

OTHER KEY PERSONNEL

Fish Biologist: J. Williams. PWSSC. J. Williams received his Masters degree in Fisheries from Texas A&M University in 1995. While earning his degree, he spent one year conducting field research in a remote are of Venezuela, successfully incorporating native fishermen in his survey of reservoir fish populations. His research has been presented in a variety of forums and is currently under review for journal publication. J. Williams is a certified Rescue Diver, Divemaster and has eleven years of diving experience. He has recently become certified as a Scientific Diver, fulfilling American Academy of Underwater Science standards, in the PWSSC Scientific Diving Program. J. Williams is tasked with sample and data processing and data management for this project and will actively contribute to data synthesis.

Fish Biologist: M. Willette. M. Willette contributed data on the salmon for the proposed manuscript and so is included as an author as a courtesy. He will have an opportunity to review it and provide comments before it is sent anywhere with his name on it.

LITERATURE CITED

Kline, T.C. 1997. Confirming forage fish food web dependencies in Prince William Sound using natural stable isotope tracers. *In:* Forage Fishes in marine Ecosystems, Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program report No. 97-01. University of Alaska Fairbanks. Pp. 257-269.

Kline, Thomas C. Jr. 1998. Temporal and Spatial Variability of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ in Pelagic Biota of Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences. 55 (Suppl. 2): IN PRESS

Kline, T.C. and D. Pauly. 1998. Cross-validation of trophic level estimates from a mass-balance model of, and $^{15}N/^{14}N$ data from, Prince William Sound. Proceedings of the International Symposium on Fishery Stock Assessment Models for the 21st Century -- Combining Multiple Data Sources. Alaska Sea Grant College Program Report. University of Alaska Fairbanks. In Press.

Kline , T. C. Jr., J. J. Goering, O. A. Mathisen, P. H. Poe and P. L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I. $\delta^{15}N$ and $\delta^{13}C$ evidence in Sashin Creek, southeastern Alaska. Can. J. Fish. Aquat. Sci. 47:136-144.

Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, P.L. Parker, and R.S. Scalan. 1993. Recycling of elements transported upstream by runs of Pacific salmon: II. $\delta^{15}N$ and $\delta^{13}C$ evidence in the Kvichak River watershed, southwestern Alaska. Can. J. Fish. Aquat. Sci. 50:2350-2365.

Kline, T. C. Jr., W. J. Wilson, and J.J. Goering. 1998. Natural isotope indicators of fish migration at Prudhoe Bay, Alaska. Can. J. Fish. Aquat. Sci. 55: In Press.

APPENDIX 1.

E-mail to P.I. informing him of acceptance of paper #4 in list.

Comments: Authenticated sender is <cjfas@staff.mail.uoguelph.ca>
From: "Can. J. Fish. Aquat. Sci." <cjfas@uoguelph.ca>
Organization: University of Guelph
To: tkline@grizzly.pwssc.gen.ak.us
Date: Thu, 17 Sep 1998 13:04:18 +0000
MIME-Version: 1.0
Subject: Status of J14234
CC: doran@fnr.purdue.edu
X-Confirm-Reading-To: "Can. J. Fish. Aquat. Sci." <cjfas@uoguelph.ca>
X-pmrqc: 1
Priority: normal

Dear Dr. Kline:

Subject: J14234 -- Temporal and spatial variability of 13C/12C and 15N/14N in pelagic biota of Prince William Sound, Alaska

We have now received your revised manuscript and the accompanying enclosures that specify the revisions you have made as per the referees' challenges, and your rebuttals to the points with which you disagreed. Thank you for your detailed responses; this makes our job of evaluating the revisions so much easier.

We are pleased to tell you that we now find the work in acceptable form for publication. However, before your ms can be prepared for the Space, Time and Scale series, we must receive a copyright transfer form from you. The form may be found at www.nrc.ca/cisti/journals/coptrans.html and faxed to us at the number below.

We look forward to hearing from you soon.

Yours sincerely,

John C. Roff Moira Ferguson
Editor Editor

****
Can. Journal of Fisheries & Aquatic Sciences
University of Guelph
Department of Zoology
Building #006, Room 107
Guelph, Ontario N1G 2W1

Tel: (519) 824-4120 extension 2646
Fax: (519) 767-9798
Email: cjfas@uoguelph.ca
****
Comments: Authenticated sender is <cjfas@staff.mail.uoguelph.ca>
From: "Can. J. Fish. Aquat. Sci." <cjfas@uoguelph.ca>
Organization: University of Guelph
To: Tom Kline <tkline@grizzly.pwssc.gen.ak.us>
Date: Thu, 17 Sep 1998 14:32:43 +0000
MIME-Version: 1.0
Subject: Re: Status of J14234
X-Confirm-Reading-To: "Can. J. Fish. Aquat. Sci." <cjfas@uoguelph.ca>
X-pmrqc: 1
Priority: normal

Tom,

Copyright has been received. Thanks very much!

Holly

****
Can. Journal of Fisheries & Aquatic Sciences
University of Guelph
Department of Zoology
Building #006, Room 107
Guelph, Ontario N1G 2W1

Tel: (519) 824-4120 extension 2646
Fax: (519) 767-9798
Email: cjfas@uoguelph.ca
****

Two-Page Curriculum Vitae **THOMAS CLAYTON KLINE, JR.** April, 1999

Education

1991	Ph.D. in Oceanography, University of Alaska, Fairbanks AK 99775
1983	M.S. in Fisheries, University of Washington, Seattle WA 98195
1979	B.S. in Fisheries, University of Washington, Seattle WA 98195
1976	B.S. in Oceanography, University of Washington, Seattle WA 98195
1972-74	Coursework at Sophia University, Tokyo

Research Accomplishments

- Provided the first direct evidence of the role of salmon carcass-derived nutrients in freshwater ecosystems
- Developed a stable isotope technique for quantifying the role of salmon-derived nutrients in freshwater ecosystems
- Developed a stable isotope technique for monitoring fish migration on the North Slope of Alaska
- Developed a stable isotope technique that provided the first line of evidence that carbon derived in the Gulf of Alaska plays a significant role in Prince William Sound food webs
- Determined that there can be large interannual variation in pelagic stable isotopic signatures

Professional Experience

1994-99 Research Scientist, Prince William Sound Science Center

1995-99 Director and Diving Safety Officer, Prince William Sound Science Center Scientific Diving Program

1992-93 Instructor, University of Alaska Fairbanks

1991-94 Postdoctoral Fellow, University of Alaska Fairbanks

1985-91 Research Assistant, University of Alaska Fairbanks

Five Project-Related Research Papers

1999 Kline, Thomas C., Jr. Carbon and Nitrogen Isotopic Composition of Prince William Sound Pelagic Biota Shift on Annual Time Scales: A Tool for Monitoring Changes in Oceanographic Forcing. *In:* Proceedings of the International Symposium on Ecosystem Consideration in Fisheries Management. Alaska Sea Grant College Program Report No. 99-01. University of Alaska Fairbanks. IN PRESS

1998 Kline, Thomas C., Jr. Temporal and Spatial Variability of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ in pelagic biota of Prince William Sound, Alaska. Can. J. Fish. Aquat. Sci. 55(Suppl. 2). IN PRESS

1998 Kline, Thomas C., Jr. and Daniel Pauly. Cross-validation of trophic level estimates from a mass-balance model of Prince William Sound using $^{15}N/^{14}N$ data.

In: Proceedings of the International Symposium on Fishery Stock Assessment Models for the 21st Century -- Combining Multiple Data Sources. Alaska Sea Grant College Program Report No. 98-01. University of Alaska Fairbanks. IN PRESS

1998 Kline, Thomas C., Jr., William J. Wilson, and John J. Goering. Natural isotope indicators of fish migration at Prudhoe Bay, Alaska. Can. J. Fish. Aquat. Sci. 55:1494-1502.

1997 Kline, Thomas C., Jr. Confirming forage fish food web dependencies in the Prince William Sound ecosystem. *In*: Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 9701. University of Alaska Fairbanks. p. 257 - 269.

Five Other Research Papers

1999 Kline, Thomas C., Jr. and Ralph A. Lewin. Natural $^{15}N/^{14}N$ abundance as evidence for N_2 fixation by *Prochloron* (Prochlorophyta) endosymbiotic with didemnid ascidians. Symbiosis 26:193-198.

1997 Kline, Thomas C., Jr., John J. Goering, and Robert J. Piorkowski. The effect of salmon carcasses on freshwater systems. *In*: A. Milner and M. Oswood (eds.), Alaskan Freshwaters of Alaska, Ecological Synthesis. Ecological Studies 119:179-204, Springer-Verlag. New York.

1993 Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, P.L. Parker, and R.S. Scalan. Recycling of elements transported upstream by runs of Pacific salmon: II. $\delta^{15}N$ and $\delta^{13}C$ evidence in the Kvichak River watershed, southwestern Alaska. Can. J. Fish. Aquat. Sci. 50:2350-236.

1991 Kline, Thomas Clayton, Jr. The significance of marine-derived biogenic nitrogen in anadromous Pacific salmon freshwater food webs. Ph.D. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska, 114pp.

1990 Kline, T.C. Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, and P.L. Parker. Recycling of elements transported upstream by runs of Pacific salmon: I. $\delta^{15}N$ and $\delta^{13}C$ evidence in Sashin Creek, southeastern Alaska. Can. J. Fish. Aquat. Sci. 47:136-144.

Recent Collaborators

Cooney, R., Eslinger, D., Norcross, B., McRoy, C., Paul, A., Stokesbury, K. (Univ. Alaska Fairbanks), Bozanic, J., Patrick, V., Thomas, G., Vaughan, S.(PWS Science Center), Schmidt, D., Willette, M. (Alaska Dept. Fish and Game), Falkenberg, C. (Univ. Maryland), Mooers, C., Wang, J. (Univ. Miami), Mason, D. (Purdue Univ.), Bishop, M. (U.S. Forest Service), Cheng, L., Lewin, R. (Scripps Inst. Oceanogr.), Oakey, T., Pauly, D. (Univ. British Columbia)

Graduate and Post-Graduate Advisors

Chew, K. (M.S., Univ. Washington), Goering, J. (Ph. D., Univ. Alaska Fairbanks), Kelley, J. (Post-doctoral, Univ. Alaska Fairbanks)

2000 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$0.0						
Travel		$0.0						
Contractual		$32,253.4						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$32,253.4			Estimated FY 2001	Estimated FY 2002		
General Administration		$657.6						
Project Total	$0.0	$32,911.0			$40,145.0	$0.0		
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: long range estimates are based on 7% G.A.

FY00

Prepared:

Project Number: 00541-BAA
Project Title:Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TR :E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$21,368.8						
Travel		$3,209.0						
Contractual		$1,100.0						
Commodities		$1,200.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$26,877.8			Estimated FY 2001	Estimated FY 2002		
Indirect		$5,375.6						
Project Total	$0.0	$32,253.4			$34,312.0	$0.0		
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: Long range estimates do not include agency G.A.

FY00

Prepared:

Project Number:
Project Title: Prince William Sound Isotope Ecology Dissemination, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TR :E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2000
T. Kline	Principal Investigator		2.0	8174.3		16,348.6
J. Williams	Technician		1.0	5020.2		5,020.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	3.0	13194.5	0.0	
					Personnel Total	$21,368.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2000
National meeting		800.0	1	7	122.0	1,654.0
registration and car rental		250.0	1	5	50.0	500.0
EVOS and collaborative workshops		200.0	1	5	141.0	905.0
registration and car rental		0.0	1	3	50.0	150.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3,209.0

FY00

Prepared:

Project Number:
Project Title:Prince William Sound Isotope Ecology Dissemination,
Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TR :E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Contractual Costs:			Proposed
Description			FY 2000
PWSSC network charge by computer-months	computer months: 3	cost per: $100	300.0
photocopying			300.0
shipping			200.0
communications (fax and phone)			300.0
		Contractual Total	$1,100.0

Commodities Costs:	Proposed
Description	FY 2000
Office supplies miscl	500.0
Computer supplies and upgrades	500.0
Dyesub, photog. (presentation materials)	200.0
Commodities Total	$1,200.0

FY00

Prepared:

Project Number:
Project Title:Prince William Sound Isotope Ecology Dissemination, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TR EE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

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

Existing Equipment Usage: Description	Number of Units

FY00

Prepared:

Project Number:
Project Title: Prince William Sound Isotope Ecology Dissemination,
Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Equipment
DETAIL

Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA

Project Number: ~~00XXX~~ 00542-BAA

Restoration Category: Research

Proposer: Prince William Sound Science Center
Cordova, Alaska

Lead Trustee Agency: NOAA
Cooperating Agencies:

Alaska SeaLife Center:

Duration: Year 1, 3-year project

FFY 00: $ 90.6493K (exclusive of agency overhead)
FFY 01: $ 103.001K (exclusive of agency overhead)
FFY 02; $ 67.540 K (exclusive of agency overhead)

Geographic Area: Gulf of Alaska and Prince William Sound

InjuredResource/Service: Fishes and their Injured Consumers, Fisheries: Commercial, Recreational, and Subsistence

ABSTRACT

This project will use carbon and nitrogen natural stable isotope abundance measured in northern Gulf of Alaska biota as a tool to track biophysical coupling between zooplankton and juvenile fishes. The Sound Ecosystem Assessment (SEA) project demonstrated biophysical coupling between zooplankton and juvenile fishes using natural stable isotope tracers (Kline 1997, 1998, 1999). Isotopic signatures of zooplankton reflected the spatial processes occurring at the isotope-discriminating primary production level while isotopic patterns of juvenile pelagic fish reflected spatial and temporal coupling of secondary and tertiary production. This project will extend observations made in SEA into the northern Gulf of Alaska continental shelf by augmenting the existing Northeast Pacific GLOBEC project (T. Weingartner et al.). Zooplankton and juvenile

fishes were collected on GLOBEC project and Ocean Carrying Capacity project (J. H. Helle et al.) cruises from September 1997 and throughout 1998. Additional samples will be collected in 1999 and 2000 cruises. Samples will be analyzed for $^{13}C/^{12}C$ and $^{15}N/^{14}N$ natural abundance following the protocols developed in SEA including (1) assessment of spatial and temporal variability in the isotopic composition of specific zooplankton taxa and then (2) matching their signatures with the isotopic composition of juvenile fishes. The flow of carbon from plankton to fish will be deduced by comparing regional sources of carbon (measured in zooplankton while feeding) with potential sinks of carbon including juvenile fishes (consumers of zooplankton) and zooplankton undergoing diapause (at depth during winter). Thus, incorporation of potential coastal and oceanic carbon sources, which have been shown to have distinctive isotopic signatures, will be assessed at consumer production levels. Shifts in the dependency of oceanic versus coastal carbon sources deduced from isotopic data when paired with on-going oceanographic studies will provide direct evidence, linking effects of oceanic forcing upon biological processes, and given a long observational base, eventually linking climatic shifts with observed changes in marine populations.

INTRODUCTION

As part of the (Prince William) Sound Ecosystem Analysis (SEA) project, natural stable isotope tracers suggested a potential mechanism for biophysical coupling through changes in the advective regime connecting the northern Gulf with Prince William Sound which affected nutritional processes in fishes (Kline 1998). These natural tracers involved differing ratios of the two types of carbon [C] and two types of nitrogen [N] distinguished by their number of neutrons and known as stable isotopes. Stable isotope abundance data suggested that productivity derived from within the Gulf of Alaska can drive biological production in adjacent coastal waters such as Prince William Sound (Kline 1998). The flux of carbon was postulated to be in the form of oceanic zooplankton species since they were known to be transported onto the continental shelves of both the Bering Sea as well as Gulf of Alaska during the summer (Cooney and Coyle 1982, Cooney 1988). Stable isotope abundance data also showed that the proportion of Gulf of Alaska carbon in Prince William Sound pelagic biota can vary significantly among years. Variation in carbon flux across the continental shelf among years was postulated as a potential mechanism to explain how climate change may effect ecological regime shifts (Kline 1999). Climate change effects on ocean physics and consequential impact on biological processes and resources are a major concern. While the flux is difficult to observe directly, it can easily be inferred from the occurrence of oceanic species (Cooney and Coyle 1982, Cooney 1988) and oceanic isotopic signatures in biota of coastal waters (Kline 1998). Additionally, the depth of Prince William Sound provides significant diapause over-wintering habitat for the oceanic *Neocalanus* spp., a large proportion of which contained Gulf of Alaska isotopic signatures (Kline 1998).

Significant isotopic gradients exist in pelagic production within the northern Gulf of Alaska coastal region. Carbon in coastal water (Napp et al. 1996) found in Prince William Sound had $^{13}C/^{12}C$ values of -20 to -21 per mil (relative to the VPDB isotopic standard) while carbon in Coastal Current oceanic water was typically ^{13}C depleted. A 1994-96 time series of $^{13}C/^{12}C$ measured in juvenile pelagic fishes in Prince William Sound suggested a shift to greater dependency on oceanic carbon in 1995. Coincidentally, most of the copepod *Neocalanus cristatus* found in diapause in the deep basin of Prince William Sound in the fall of 1995 had oceanic isotopic signatures compared with adjacent years. The concomitant shifts in the isotopic composition of juvenile pelagic fishes and diapausing copepods in Prince William Sound provided evidence that fluctuations in carbon flux across the continental shelf occurred on annual time scales (Kline 1998). The foregoing investigation focused principally on Prince William Sound with only a small slice of the northern Gulf of Alaska included within the project scope. The large shifts among years in isotopic composition during the secondary production bloom occurred in the Gulf (Kline 1999) suggesting that the next step in the application of the method should be an expansion in space and time in Gulf sampling as this was the apparent source of the largest variability.

NEED FOR THE PROJECT

A. Statement of Problem

The Problem: Recovery of EVOS damaged species is uncertain in light of regime shifts

The timing of changes in the distribution and abundance of many populations of the North Pacific closely follow reversals in the Pacific Decadal Oscillation (PDO), a pan-Pacific mode of climate variability that operates under a preferentially inter-decadal time scale (Francis and Hare 1994, Anderson et al. 1997, Mantua et al. 1997, Francis et al. 1998, Hare et al. 1999, Clark et al. 1999). These reversals, called "regime shifts", most recently occurred during the winter of 1976-77 (Miller et al. 1994). There is growing belief that many of the abrupt changes seen in the Bering Sea the past few years herald the onset of a new regime.

Fish and shellfish population cycles have had dramatic effects on fisheries in the Gulf Coast region of Alaska (McDowell et al. 1979). Mechanisms connecting climatic fluctuations with fish production are poorly understood. Since natural stable isotope abundance can be performed on a wide range of taxa, e.g, phytoplankton to megafauna, it provides a common methodological thread enabling determination of carbon source within the spectrum of coastal resident species (e.g., Kline 1998). From these data it may be possible to infer how mechanisms involving changes in carbon source, trophic level, and regime shifts (Kline 1999).

B. Rationale/Link to Restoration

Shifts in carbon flow occurring as a result in variations in the physical environment represent fundamental changes in the way the PWS ecosystem supports commercially important species. The availability of macrozooplankton forage for fishes varies in space and time because of changes in physical processes in PWS. The NSI approach is unique in its ability to integrate time and spatial scales at mesoscale levels. No other technique currently available can generate such results. The natural tracer aspects of the approach emulates artificial tracer experiments without the burden of needing to generate signals or experimental artifacts. Tracking the effect of Gulf carbon inflow on pelagic production that appears to vary between years will be used to resolve the question of how oceanographic process affect fisheries recruitment. Finally, the value of the Ecopath modeling effort funded as restoration tool would be greatly enhanced through a incorporation of a proven model validation concept.

C. Location

Gulf of Alaska and Prince William Sound

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Community involvement and traditional ecological knowledge was incorporated into the SEA project that formed the basis the work being proposed here.

PROJECT DESIGN

A. Objectives

Approximately 1.1 % and 0.4 % of the carbon and nitrogen, respectively, in biological material consist of their heavy isotopes, ^{13}C and ^{15}N (e. g., Minagawa and Wada 1984). The amount of ^{13}C and ^{15}N varies slightly due to isotopic fractionation occurring in biochemical reactions. Plants discriminate in favor of the lighter isotopes during uptake of CO_2 and dissolved inorganic nitrogen and are the principal source for isotopic variation in aquatic food chains. Furthermore, isotopic composition is conserved in food chains, but with a predictable increase per trophic level. Thus variations in the stable isotope abundance initiated by primary producers can be measured in consumers. Since ^{15}N and ^{13}C increase per trophic level at a 3.4:1 ratio, changes due to food chain length (trophic level) or food chain source can be separated (Kline 1997, 1998, 1999, Kline et al. 1998).

Recent investigations are beginning to reveal isotopic patterns in fish production in the sub-Arctic Pacific. Differences in salmon returning to spawn may indicate whether the production they are derived from occurred in an upwelling area (since upwelling affects fractionation by phytoplankton) (Welch and Parsons 1993). Intermediate trophic level fishes, also known as forage fishes (juvenile herring and pollock) in the Prince William Sound region shift in isotopic composition on a year to year basis as a function of advective processes transferring zooplankton between the Gulf of Alaska and the Sound (Kline 1997, 1998, 1999). Meso-scale isotopic spatial (100s of km) gradients measured in zooplankton exist between and within the marginal seas of northern and western Alaska (Schell et al. 1998), near Prince William Sound (Kline 1998), and off the coast of British Columbia (Wu et al. 1997). These studies suggest that isotopic variation exists and probably varies spatially and temporally. A systematic assessment of this variation needs to be made. We need to know the persistence of gradients in areas and if a persistent gradient undergoes a sudden change concomitant to a climatic regime shift. The nature of trophic shifts can be made by comparing relative changes in ^{13}C and ^{15}N as well as with zooplankton values using methods developed by Kline (1997, 1998) and Kline and Pauly (1998).

Characterization of production regimes in Alaskan coastal seas using stable isotopes

Meso-scale gradients in the natural abundance of stable carbon isotopes have been characterized for much of the coastal waters of Alaska including the Bering, Chukchi, and Beaufort Seas (Schell et al. 1998), and Prince William Sound (Kline 1998). Because of the conservative transfer of carbon isotope ratios in food webs, it is possible to relate the dependency of consumers for production derived from these areas by matching their isotopic signatures with those of planktonic production sources (Schell et al. 1998, Kline 1998). Furthermore, the $\delta^{13}C$ values themselves may be reflective of the relative productivity of a given area. For example, Schell et al. (1998) found that the very productive "green belt" of the Bering Sea had the most positive $\delta^{13}C$ values within Alaskan Arctic coastal seas. Meanwhile, recent laboratory and field experiments suggest that high $\delta^{13}C$ values reflect high phytoplankton growth rates (Laws et al. 1995, Bidigare et al. 1997). Using $\delta^{13}C$ of bowhead whale baleen samples as a record of past productivity, Schell (http://www.uaf.edu/seagrant/issues/salmon_gone.html#winner, MS. in prep., pers. comm.) inferred that a decline of 40 percent in the carrying capacity of the Bering Sea ecosystem in the last 50 years may explain recent declines in penniped and salmon populations.

Mechanisms connecting the PDO with population cycles are not understood. For example, temperature cycles may be a manifestation of changes in upwelling or mixed-layer depth. Changes in both have been noted for the northern Gulf (Cooney and Kline et al. (unpublished data, MS in progress), Royer 1998). Increase in upwelling or deepening of mixed layer depth are expected to increase the rate at which nutrients are introduced into surface layers of the ocean. Increases in nutrient abundance will increase phytoplankton growth rates which also affects phytoplankton isotopic fractionation. The resulting in changes in isotopic signatures are then passed to consumers. Long-term changes in isotopic composition of whale baleen have been conjectured by Schell (see above) to reflect multi-decadal changes in oceanic productivity. Upwelling variability may also regulate cross-shelf transport of zooplankton in the northern Gulf of Alaska (Cooney 1988, Cooney and Coyle 1996).

Hypotheses

Fluctuations in the cross-shelf import of zooplankton is postulated to affect growth rate and thus survival of juvenile pink salmon (and other juvenile pelagic fishes) in the coastal Gulf of Alaska (U. S. GLOBEC 1996). This has been suggested using correlative information from which it was inferred that physical forcing in the form of environmental shifts caused corresponding long-term shifts in salmon production in the North Pacific (Francis and Ware 1994). The linking of measured changes in the physical environment using biological responses with data not dependent on population or biomass enumeration (often fishery catch statistics which are biased by fishing effort) are generally lacking. Chemical parameters measured in biota which are not sensitive to errors associated with estimation of population or biomass can provide evidence of linkages when these

parameters depend upon physical forcing. The ^{13}C content of phytoplankton which varies as a function of nutrient limited growth rate of phytoplankton (Bigidare et al. 1997) is one such chemical parameter since nutrient limitation arises from physical forcing (e.g., degree of vertical mixing). Regional isotopic gradients provide an indication of carbon production patterns which can be traced to higher trophic levels due to the predictable relationship in the isotopic composition of a consumer and its diet.

B. Methods

Collections on-hand for retrospective analysis to be funded by GLOBEC:

Zooplankton were sampled as one of the objectives of the Weingartner et al. GLOBEC project along the "Seward Line" that consists of stations GAK1 to GAK13 running from the mouth of Resurrection Bay (near Seward) southeast across the continental shelf break into the Gulf of Alaska (Figure 1). Zooplankton were also collected from select stations from the "Hinchinbrook Canyon Line" and from within Prince William Sound (Figure 1). Samples are on hand from collections made in 1997 and 1998 by P.I. Kline or technician J. Williams on GLOBEC cruises. Approximately 1500 samples were collected in October 1997, 2000 each in May and July 1998 and 500 in September 1998. These include zooplankton samples that were collected from the Hinchinbrook Canyon Line and from within Prince William Sound in May and June. These samples consist mainly of copepods (*Neocalanus* spp.) and euphausiids (*Thysanoessa* spp.). There are also a few amphipods, chaetognaths and fishes (mainly myctophids). Samples were collected, identified to species and frozen in the field in polyethelene vials. These were freeze-dried in the laboratory and archived at the Prince William Sound Science Center.

Juvenile salmon were sampled from stations along the continental shelf in the Gulf of Alaska as an objective the National Marine Fisheries Service Ocean Carrying Capacity (OCC) research program (J. H. Helle et al.). Helle et al. have provided P. I. Kline with ~ 300 juvenile pink salmon sampled in August 1998 from the North Gulf coast area in the vicinity of the Seward Line. These samples are presently archived frozen at the Prince William Sound Science Center.

Samples collected in 1997-1998 described above will be analyzed for carbon and nitrogen natural stable isotope abundance according to the methods described below. The goal is to analyze 250 zooplankters (individuals of large copepods and euphausiids and pairs of smaller copepods) from each fall cruise (they were less abundant then) and 600 zooplankters each from the May and July cruises for a total of 1700 samples. These samples are already freeze dried facilitating rapid selection and shipment to the University of Alaska Stable Isotope Facility (SIF) where they will be analyzed. Salmon will be processed as described below in greater detail and then sent to the SIF. Data from the SIF are expected in about nine months from the date they receive the processed samples. Therefore data interpretation, analysis and synthesis activities will be

concentrated in the second year of study. Data interpretation will follow protocols detailed below. Additional samples will be collected on Weingartner et al. GLOBEC cruises in 1999 and 2000 to facilitate making assessments of inter-annual variability which were shown to be significant in the 1994-1997 for the Gulf of Alaska adjacent to Prince William Sound (slightly east of the present GLOBEC study area). Funding for this additional sampling is being requested from the funding partners - North Pacific Marine Research (NPMR) initiative and *Exxon Valdez* Oil Spill Trustee Council (EVOS). Results from this project will be integrated with those of Weingartner et al.

Collections to be made in 1999 and 2000 (Funding from the Trustee Council and NPMR)

The Weingartner et al. GLOBEC and Helle et al. OCC projects will be carrying out sampling cruises in 1999 and 2000 in the same areas as in 1998. P.I. Kline anticipates collecting zooplankton samples on the Seward Line and obtaining salmon from Helle et al. Funding is being requested (to the NPMR fund) to augment the existing GLOBEC cruises to assure sampling within Prince William Sound and along the Hinchinbrook Canyon Line enabling continuation of the isotopic time-series started in SEA. In total there will be three years of data 1998 through 2000 (Fall 1997 and the whole of 1998 through the retrospective analysis). Within this time frame isotopic gradients will be assessed and matched to fish isotopic data. Additionally, the data will be merged with SEA project data that encompassed the 1994 -1997 period enabling assessment of isotopic shifts occurring in plankton in Prince William Sound. Diapause sampling at SEA22 (Figure 1) will be conducted in association with planned cruises by S. Vaughan, Prince William Sound Science Center (*Exxon Valdez* Oils Spill Trustee Council and Oil Spill Recovery Institute funding) needed to maintain an ADCP mooring in Hinchinbrook Entrance. Approximately 100 of each *Neocalanus* sp. will be sampled diapausing at SEA22.

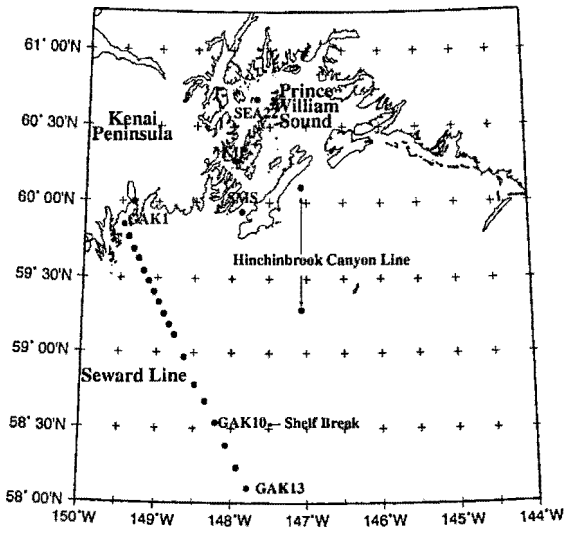

Figure 1. GLOBEC zooplankton sampling stations during 1997-98. Stations included those on the Seward Line (stations GAK1, 10 (at the shelf break) and 13 are labeled), two stations on the Hinchinbrook Canyon Line, and stations SMS and KIP in Prince William Sound. SEA project station SEA22 located within the 800m-deep Lone Island basin of Prince William Sound is also indicated.

Sampling methods

Zooplankton. Terminal feeding stage copepodids and late stage euphausiids were sampled with a MOCNESS on R/V *Alpha Helix* GLOBEC cruises in October 1997, May 1998, July 1998 and September 1998. The MOCNESS was towed of obliquely through the upper 60 m of water column consistently collecting adequate sample sizes satisfying analysis of covariance and variance statistical tests. The May cruise was timed to catch the peak in occurrence of *Neocalanus* spp. copepodite V. Briefly, a MOCNESS system, consisting of nine remotely and sequentially deployed nets, was lowered from the surface, using net #1 as a drogue net, to below the acoustically-determined (by GLOBEC P.I. K.O. Coyle) zooplankton layer (~ 30 - 40 m) and closed at 100m (i.e., below the zooplankton layer). Net #1 thus effectively sampled the upper water column from the surface to 100 m, while nets #2 to #9 were deployed to sample discrete depth zones of ~ 20 m thickness for use by Coyle in his analysis. Upon landing the MOCNESS on the vessel, the contents in the receiving bucket of net #1 were immediately sieved (stacked 30 cm diameter, 5 and 2 mm polyester mesh sieves and a polyethylene receiver pan, Nalgene) and sorted by species. Species identification was aided by low power (40 X) microscopic examination (Wild M3). Zooplankters were frozen, one sampling unit per vial, in small (4 mL) polyethelene vials (Wheaton Omni Vials). Samplings units consisted of single zooplankters for copepodite V *Neocalanus cristatus* , euphausiids, and

amphipods (when found) and two each for the smaller copepodite V of *N. plumchrus* and *N. flemingeri*. Frozen vialed samples were freeze-dried as previously described (Kline 1998). Future MOCNESS sampling for zooplankton on GLOBEC cruises is expected to follow a similar pattern. Diapause samples are collected using a 0.5 m-diameter 0.5 mm-mesh ring net that is lowered to 700 m at station SEA22 and brought to the surface at 1 m s^{-1}. Diapause samples are treated on the surface like MOCNESS samples.

Fishes. Fishes were sampled using trawls (October 1997 and July 1998) and gillnets (September 1998) with an occasional myctophid sampled in the MOCNESS. Salmon collected by the OCC project were sampled with a purpose-built trawl. Approximately 50 pink salmon (*Oncorhynchus gorbuscha*) were collected from each of six stations made between Prince William Sound and Kodiak Island encompassing locations from coastal waters to the continental slope. Otoliths of salmon collected in 1997 and 1998 by the OCC project suggest that a large proportion of these fish originated from hatcheries in Prince William Sound (J. H. Helle, Auke Bay Laboratory, pers. comm.). As all hatchery pink salmon are presently labeled by thermal markings on their otoliths, they can be distinguished from others in the sample. Therefore, otoliths will be extracted from salmon prior to processing for isotopic analysis to enable comparison between natural (no otolith thermal markings) and artificially propagated fish. Future sampling for salmon on OCC cruises is expected to follow a similar systematic pattern to that used in 1998 (J. H. Helle, pers. comm.)

Sample preparation. Samples will be thawed and cleaned up using distilled water in the laboratory prior to freeze-drying, i.e., removal of foreign material. Otoliths will be removed from salmon and saved. Samples will be freeze dried in a Labconco shelf freeze drier (designed for bulk samples). Fish samples will ground to a fine powder in a dental amalgamator. Powdered samples will be stored in polyethylene LSC vials (22 mL). Zooplankton samples will be freeze-dried and stored in the Omni Vials. Once the collection for a given area is ascertained, samples will be selected for mass spectrometry in accordance with the sampling scheme developed by Kline (1998). This consists of analyzing N=15 sampling units per species (when found) per station in the case of *Neocalanus* spp. and up to N=30 sampling units per station for euphausiids (in general, different euphausiid species were found at the stations in relationship to their location on the continental shelf). Salmon will be stratified by whether they were natural vs. artificially propagated for up to N=25 per stratum per station.

Isotopic analysis. Samples will be shipped to the University of Alaska Fairbanks Stable Isotope Facility (SIF) where replicate sub-samples of ~1.5 mg will be weighed to the nearest 1 μg (in the case of fish and large euphausiid samples) and loaded into tin combustion boats for mass spectrometric analysis. The sampling units of smaller zooplankton are designed to be ~ 2 mg dry weight, so the entire sample is weighed and loaded into a boat. Isotopic analyses will be performed using a semi-automated stable isotope analyzer (Europa Scientific 20/20 equipped with a Roboprep sample combustion

and purification unit). A single isotopic analysis generates the following data: $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios expressed in standard delta units, $\delta^{13}C$ and $\delta^{15}N$, respectively; and %C and %N. The conventional delta notation used to express stable isotope ratios will be reported relative to international standards (air for N and Vienna Peedee belemnite (VPDB) for C) and defined by the following expression:

$$(1) \qquad \delta^{15}N \text{ or } \delta^{13}C = \left(\frac{R_{sample}}{R_{standard}} - 1\right) \times 1000 \text{ ‰}$$

where $R = {}^{15}N/{}^{14}N$ or $^{13}C/^{12}C$. By definition, the isotope standards have delta values of zero, i.e. $\delta^{15}N = 0$ for atmospheric N_2. Typically, instrument replication is < 0.2 ‰. The %C and %N data will be used to calculate C/N atomic ratios. The data will consist of mean $\delta^{13}C$, $\delta^{15}N$ and C/N for all replicated samples. Samples will be re-run when replication is ≥ 0.6 ‰. Additionally, the SIF maintains rigid QA/QC methods including use of laboratory standards that are run between batchs of 5 samples. Based on recent experience, the average turn-around time for analysis at the SIF is nine months. This is taken into account in the project timeline.

Removal of lipid (DeNiro and Epstein 1977) and trophic level effects from $\delta^{13}C$ values of fish makes it possible to assess carbon source (Kline 1997, 1998). The method of McConnaughey and McRoy (1979) will be used to calculate lipid-normalized $^{13}C/^{12}C$ while the method of Kline (1997, 1998) will be used to normalize for trophic level. Details of these protocols are described in Kline (1997, 1998) and Kline et al. (1998). In general, normalization reduces sources of ^{13}C variability, enabling comparisons among fishes without the confounding effects of trophic level and lipid content. The expressions $\delta^{13}C$, $\delta^{13}C'$, $\delta^{13}C_{TL}$, or $\delta^{13}C'_{TL}$ will be used to denote $^{13}C/^{12}C$ abundance in relation to the international standard, normalized for lipid content, normalized for trophic level, and normalized for lipid content and trophic level, respectively. Whereas $\delta^{13}C'$, $\delta^{13}C_{TL}$, or $\delta^{13}C'_{TL}$ is used in accordance to a particular data analysis context, "^{13}C" is used to reflect generic $^{13}C/^{12}C$ isotopic trends irrespective of normalization.

Data archiving. Two types of data archiving are anticipated: NODC, and data published in the form of scientific publications.

Anticipated results: their relevance and expected significance. (including relationships to other projects including globec)

The recently noted population cycles in the Pacific are an enigma that requires a long-term study commitment for comprehension. A U.S. GLOBEC goal is to develop an understanding of how climatically variable physical forcing effects the biology and ecology of important zooplankton and fish taxa of the North Pacific. This project will determine, through isotope matching, the relationship of fishes to potential carbon

sources. This will provide the first line of evidence for a mechanism for explaining changes in marine populations in the North Pacific. This potential exists since decadal-scale changes in zooplankton abundance have been noted near continental shelf breaks (Brodeur and Ware 1992). A linkage to zooplankton abundance can be asserted if carbon derived from the continental shelf break area predominates in juvenile salmon. A long term anticipated result (given a continuum of funded projects) will be to provide a linkage to regime shifts through observing how juvenile salmon change in their hypothetical dependence on continental shelf break carbon when this source fluctuates in quantity.

The primary result of this project will be the description of the cross-shelf isotopic gradient with higher resolution than that obtained in the SEA project (13 stations vs. a maximum of 3 stations in the continental shelf sections). Because of the detailed nutrient profiles being made by T. Whitledge and D. Stockwell as part of the Weingartner et al. GLOBEC project, it will be possible to assess the relationship between nutrient depletion and isotopic ratios. This will be on the fine horizontal spatial scale afforded by GLOBEC Stations GAK1 to GAK13 (Figure 1). The picture will be extended to the broader Gulf area by the stations south and within Prince William Sound. Furthermore these relationships will be compared among years. Inter-annual variation in isotopic signatures was found to be significant in the 1994-1997 period (Kline 1999). An explanation for these temporal shifts may thus come through this project via integration with Weingartner et al.

Matching the isotope signatures of fishes with those of plankton after lipid and trophic level normalization suggested that the predominant carbon source for juvenile fishes in Prince William Sound came from the Gulf of Alaska (Kline 1998). The isotope matching approach will be used to assess carbon sources of juvenile salmon on the continental shelf. Because of the otolith thermal markings it will be possible to assess whether artificially propagated fish differ isotopically from natural fish, addressing an important GLOBEC-related concern (Cooney and Brodeur 1998). From any differences, we may be able to make inferences about their trophic inter-relationships. For example, if they are competing for the same carbon source they should have identical isotopic signatures.

This project is designed to dovetail with previous isotope studies in the area (Kline 1998) and interact with on-going investigations by the P.I. as well as the GLOBEC and OCC projects. There will thus be a synergism among these projects from isotopic results being generated here and those from other projects as well as other data types such as ocean nutrients and physics. This project will also provide a unique interface between the GLOBEC and OCC projects using the facility that isotopic ratios have for linking zooplankton and fish processes as shown recently by the P.I. (Kline 1998, 1999). The inferred transport of copepods into the deep area of Prince William Sound as well as the potential for temporal variability in inferred transport of shelf-break carbon from the isotopic composition of carbon in fishes will be useful for modelers as well. Empirical observations suggesting large inter-annual temporal variability in importance of Gulf

carbon in coastal fishes (Kline 1999) could be used to validate models that attempt to simulate plankton transport (Moores and Olson, RSMAS, 1999 GLOBEC Alaskan Coastal Modeling proposal). It is important to recognize that isotopic measurements represent an integration rather than instantaneous measurement that needs to be taken into account when comparing data to model results. For example the occurrence of copepods in diapause in the fall reflects an integration of the transport process. That the fraction of copepods from the Gulf diapausing with the Prince William Sound varied from year to year probably reflected year-to-year differences in transport currents integrated over the copepod downward (diapause) migration period (Kline 1998).

This project expands the P.I.'s long-term goal to expand our present state of knowledge in the field of fish production in relation to physical-chemical environmental variables. Through the SEA project, the P.I. has developed new models and applications of the natural stable isotope abundance method. He was the first to provide direct evidence of the importance of carbon from the Gulf of Alaska in Prince William Sound. The northern Gulf of Alaska region has major fisheries for salmon, herring, pollock, cod, sablefish, halibut, and rockfish. Understanding how oceanographic forcing is affecting the coastal productivity that supports Alaska's fisheries is of immense economic importance. Solidifying the connection between secondary productivity to fishes using stable isotope tracers will also be a significant scientific contribution.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

N/A

SCHEDULE

A. MEASURABLE PROJECT TASKS for FY00 (October 1, 1999 - September 30, 2000)

Oct. 99 - Jun. 00:	Preparation of samples collected during 1999 for mass spectrometry
Oct. 99 - Sep. 00:	Mass spectrometry at UAF (~ 9 month processing time)
Dec. 99 - Sep. 00:	Integrate new isotope data

B. Project Milestones and Endpoints

Oct. 2000:	All samples acquired and prepared for analysis
Jan. 2001:	Mass spectrometric analysis complete
Jan. 2000, 2001, 2002:	Attend Annual Restoration Workshop
Apr. 2002:	Data synthesis complete
Jun. 2002:	Data integration (1994 - 2000) complete
April 2002:	Draft final report complete

September 2002: Final Report revision complete

C. Completion Date

September 2002 (Final Report)

PUBLICATIONS AND REPORTS

Publications for work being proposed here will be prepared in year three of the project as part of data synthesis.

PROFESSIONAL CONFERENCES

Travel is requested for the P.I. to present results at a national (or when appropriate, international) meeting such as ASLO or AGU and to attend workshops with collaborators. Travel to present project results at national meetings and to participate in collaborative workshops are essential to the project's success.

NORMAL AGENCY MANAGEMENT

N/A

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Collaboration with other EVOS investigators will continue and facilitate relating carbon-source dependency. Results of analyses will be exchanged at workshops and by telecommunications. Sampling will be coordinated with other P.I.'s and within the auspices of other biota sampling programs. Pertinent data of each sample (i.e. data on each individual fish will be shared among components). Coordination in relation to specific objectives listed in project design section.

PROPOSED PRINCIPAL INVESTIGATOR

Thomas C. Kline Jr., Ph.D.
Prince William Sound Science Center
P. O. Box 705
Cordova, AK 99574
907-424-5800 (t)
907-424-5820 (f)
tkline@grizzly.pwssc.gen.ak.us

PRINCIPALINVESTIGATOR

The project team will consist of a Principal Investigator and a Technician. Dr. T. Kline will serve as Principal Investigator and will execute and supervise data interpretation. He will also supervise field sampling.

Kline is a Research Scientist and Diving Safety Officer (DSO)of the PWSSC Scientific Diving Program (see C.V. attached). T. Kline has been actively involved in stable isotope research since 1985. He has used stable isotopes for investigations on fish ecology including salmonid fish studies in northern, western, southcentral, and southeast Alaska. His innovative use of the techniques has allowed him to quantify the effect of salmon carcass nutrient input to juvenile sockeye salmon production. This research was the first to provide direct evidence for the importance of salmon carcasses for juvenile salmon production. He generated stable isotope models that enabled the quantification of different sources of production important in salmon ecosystems. Dr. Kline also led an investigation relating feeding strategies to growth forms in North Slope salmonids. His ongoing efforts include collaborations with the Alaska Department of Fish and Game, the North Slope Borough, and British Petroleum Exploration (for matching). The results of these projects have been presented in numerous scientific papers as well as in public forums. Kline initiated the first comprehensive project using natural stable isotopes in Prince William Sound. Through this project he developed new models and natural stable isotope abundance applications. He was the first to provide direct evidence of the importance of carbon from the Gulf of Alaska in Prince William Sound.

OTHER KEY PERSONNEL

John Williams will supervise sample preparation and data handling. John Williams is a Fisheries Ecologist with the Prince William Sound Science Center. He currently operates the laboratory at the Center, preparing samples for mass spectrometry among his duties. His familiarity with the method will contribute greatly to this project. He received his Masters degree in Wildlife & Fisheries from Texas A&M University in 1995. While earning his degree, he spent one year conducting field research in a remote area of Venezuela. He has extensive field data collection experience and has proven his capability in leading field work. His research has been presented in a variety of forums and is currently in press for journal publication. He will be involved with sample and data processing and data management and will actively contribute to data synthesis

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Two-Page Curriculum Vitae **THOMAS CLAYTON KLINE, JR.** April, 1999

Education

1991	Ph.D. in Oceanography, University of Alaska, Fairbanks AK 99775
1983	M.S. in Fisheries, University of Washington, Seattle WA 98195
1979	B.S. in Fisheries, University of Washington, Seattle WA 98195
1976	B.S. in Oceanography, University of Washington, Seattle WA 98195
1972-74	Coursework at Sophia University, Tokyo

Research Accomplishments

- Provided the first direct evidence of the role of salmon carcass-derived nutrients in freshwater ecosystems
- Developed a stable isotope technique for quantifying the role of salmon-derived nutrients in freshwater ecosystems
- Developed a stable isotope technique for monitoring fish migration on the North Slope of Alaska
- Developed a stable isotope technique that provided the first line of evidence that carbon derived in the Gulf of Alaska plays a significant role in Prince William Sound food webs
- Determined that there can be large interannual variation in pelagic stable isotopic signatures

Professional Experience

1994-99 Research Scientist, Prince William Sound Science Center

1995-99 Director and Diving Safety Officer, Prince William Sound Science Center Scientific Diving Program

1992-93 Instructor, University of Alaska Fairbanks

1991-94 Postdoctoral Fellow, University of Alaska Fairbanks

1985-91 Research Assistant, University of Alaska Fairbanks

Five Project-Related Research Papers

1999 Kline, Thomas C., Jr. Carbon and Nitrogen Isotopic Composition of Prince William Sound Pelagic Biota Shift on Annual Time Scales: A Tool for Monitoring Changes in Oceanographic Forcing. *In:* Proceedings of the International Symposium on Ecosystem Consideration in Fisheries Management. Alaska Sea Grant College Program Report No. 99-01. University of Alaska Fairbanks. IN PRESS

1998 Kline, Thomas C., Jr. Temporal and Spatial Variability of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ in pelagic biota of Prince William Sound, Alaska. Can. J. Fish. Aquat. Sci. 55(Suppl. 2). IN PRESS

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1998 Kline, Thomas C., Jr., William J. Wilson, and John J. Goering. Natural isotope indicators of fish migration at Prudhoe Bay, Alaska. Can. J. Fish. Aquat. Sci. 55:1494-1502.

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Five Other Research Papers

1999 Kline, Thomas C., Jr. and Ralph A. Lewin. Natural $^{15}N/^{14}N$ abundance as evidence for N_2 fixation by *Prochloron* (Prochlorophyta) endosymbiotic with didemnid ascidians. Symbiosis 26:193-198.

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Recent Collaborators

Cooney, R., Eslinger, D., Norcross, B., McRoy, C., Paul, A., Stokesbury, K. (Univ. Alaska Fairbanks), Bozanic, J., Patrick, V., Thomas, G., Vaughan, S.(PWS Science Center), Schmidt, D., Willette, M. (Alaska Dept. Fish and Game), Falkenberg, C. (Univ. Maryland), Mooers, C., Wang, J. (Univ. Miami), Mason, D. (Purdue Univ.), Bishop, M. (U.S. Forest Service), Cheng, L., Lewin, R. (Scripps Inst. Oceanogr.), Oakey, T., Pauly, D. (Univ. British Columbia)

Graduate and Post-Graduate Advisors

Chew, K. (M.S., Univ. Washington), Goering, J. (Ph. D., Univ. Alaska Fairbanks), Kelley, J. (Post-doctoral, Univ. Alaska Fairbanks)

F Timeline

Funding Source	GLOBEC	NPMR	EVOS	GLOBEC	NPMR	EVOS				GLOBEC	GLOBEC	GLOBEC	NPMR, EVOS	NPMR, EVOS	GLOBEC, NPMR, EVOS	GLOBEC, NPMR, EVOS
	Funding calendar by project year	Funding calendar by project year	Funding calendar by project year	Funding calendar by FY	Funding calendar by FY	Funding calendar by FY	**Actual Calendar**			Prepare, select and send archived samples to UAF-SIF	Mass spectrometry at UAF-SIF (9 month process. time)	Synthesis based on 1997- 1998 data	Acquisition and Preparation of new samples	Mass spectrometry at UAF-SIF (9 month process. time)	Synthesis of 1999 - 2000 data	Data Integration 1994-2000
	P-year	P-year	P-year	FY	FY	FY	**Year**	**month**								
							1999	**May**					Start			
	1	1		1999	1999		**1999**	**Jul**		Start			•			
	1	1		1999	1999		**1999**	**Aug**		•	Start		•			
	1	1		1999	1999		**1999**	**Sep**		•	•		•			
	1	1	1	1999	1999	2000	**1999**	**Oct**		•	•		•	Start		
	1	1	1	1999	1999	2000	**1999**	**Nov**		•	•		•	•		
	1	1	1	1999	1999	2000	**1999**	**Dec**		•	•		•	•		
	1	1	1	1999	1999	2000	**1999**	**Jan**		Complete	•		•	•		
	1	1	1	1999	1999	2000	**2000**	**Feb**			•		•	•		
	1	1	1	1999	1999	2000	**2000**	**Mar**			•		•	•		
	1	1	1	1999	1999	2000	**2000**	**Apr**			•		•	•		
	1	1	1	1999	1999	2000	**2000**	**May**			•	Start	•	•		
	1	1	1	1999	1999	2000	**2000**	**Jun**			•	•	•	•		
	2	2	1	2000	2000	2000	**2000**	**Jul**			•	•	•	•	Start	
	2	2	1	2000	2000	2000	**2000**	**Aug**			•	•	•	•	•	
	2	2	1	2000	2000	2000	**2000**	**Sep**			•	•	•	•	•	
	2	2	2	2000	2000	2001	**2000**	**Oct**			Complete	•	Complete	•	•	
	2	2	2	2000	2000	2001	**2000**	**Nov**				•		•	•	
	2	2	2	2000	2000	2001	**2000**	**Dec**				•		•	•	
	2	2	2	2000	2000	2001	**2000**	**Jan**				•		•	•	Start
	2	2	2	2000	2000	2001	**2001**	**Feb**				•		•	•	•
	2	2	2	2000	2000	2001	**2001**	**Mar**				•		•	•	•
	2	2	2	2000	2000	2001	**2001**	**Apr**				•		•	•	•
	2	2	2	2000	2000	2001	**2001**	**May**				•		•	•	•
	2	2	2	2000	2000	2001	**2001**	**Jun**				Complete		Complete	•	•
	3		2	2001		2001	**2001**	**Jul**							•	•
	3		2	2001		2001	**2001**	**Aug**							•	•
	3		2	2001		2001	**2001**	**Sep**							•	•
	3		3	2001		2002	**2001**	**Oct**							•	•
	3		3	2001		2002	**2001**	**Nov**							•	•
	3		3	2001		2002	**2001**	**Dec**							•	•
	3		3	2001		2002	**2001**	**Jan**							•	•
	3		3	2001		2002	**2002**	**Feb**							•	•
	3		3	2001		2002	**2002**	**Mar**							•	•
	3		3	2001		2002	**2002**	**Apr**							Complete	•
	3		3	2001		2002	**2002**	**May**								•
	3		3	2001		2002	**2002**	**Jun**								Complete
			3			2002	**2002**	**Jul**								
			3			2002	**2002**	**Aug**								
			3			2002	**2002**	**Sep**								

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$0.0
Travel		$0.0
Contractual		$90,649.3
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$90,649.3
General Administration		$1,825.5
Project Total	$0.0	$92,474.8
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		
		$120,511.2	$72,267.8		

Dollar amounts are shown in thousands of dollars.

Comments: long range estimates are based on 7% G.A.

FY00

Prepared:

Project Number: 00542 -BAA
Project Title: Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$33,134.1
Travel		$4,407.0
Contractual		$31,800.0
Commodities		$3,200.0
Equipment		$3,000.0
Subtotal	$0.0	$75,541.1
Indirect		$15,108.2
Project Total	$0.0	$90,649.3
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		
		$103,001.0	$67,540.0		

Dollar amounts are shown in thousands of dollars.

Comments: Long range estimates do not include agency G.A.

FY00

Prepared:

Project Number:
Project Title: Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRL_ . _E COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2000
	T. Kline	Principal Investigator	2.0	8723.1		17,446.2
	J. Williams	Technician	3.0	5229.3		15,687.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	5.0	13952.4	0.0	
					Personnel Total	$33,134.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2000
	National meeting	800.0	1	7	141.0	1,787.0
	registration and car rental	250.0	1	5	50.0	500.0
	EVOS and collaborative workshops	300.0	2	10	122.0	1,820.0
	registration and car rental	100.0	1	4	50.0	300.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4,407.0

FY00

Prepared:

Project Number:
Project Title:Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Contractual Costs:			Proposed
Description			FY 2000
PWSSC network charge by computer-months	computer months: 5	cost per: $100	500.0
Stable Isotope Analysis	number:	1000 cost per: $27	27,000.0
Freeze drier charge	number:	1000 cost per: $3	3,000.0
photocopying			300.0
shipping			500.0
communications (fax and phone)			500.0
		Contractual Total	$31,800.0

Commodities Costs:	Proposed
Description	FY 2000
Lab supplies miscl	500.0
Lab supplies: chemicals, vials, knives	1,500.0
Office supplies miscl	500.0
Computer supplies and upgrades	500.0
Dyesub, photog. (presentation materials)	200.0
Commodities Total	$3,200.0

FY00

Prepared:

Project Number:
Project Title: Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2000
Description			
Computer	1	3000.0	3,000.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$3,000.0

Existing Equipment Usage:	Number of Units
Description	

FY00

Prepared:

Project Number:
Project Title: Stable Isotope Biogeochemical Markers as Linkages Between Fishes and their Food Sources in Northern Gulf of Alaska Production Zones, Submitted Under the BAA
Name: Prince William Sound Science Center

FORM 4B
Equipment
DETAIL

LOWER COOK INLET SALMON ECOLOGY STUDY

Project Number: 00544

Restoration Category: Research

Proposer: Port Graham Hatchery, arm of Port Graham Village Council

Lead Trustee Agency:

Cooperating Agencies:

Alaska Sea Life Center: no

Duration:

Cost FY 00:

Cost FY 01:

Cost FY 02:

Geographic Area: Kenai Peninsula

Injured Resource/Service: Pink salmon

ABSTRACT

Improving existing knowledge of the survival mechanisms of pink, and sockeye salmon in South Eastern Lower Cook Inlet (LCI) is the main goal of the Lower Cook Inlet Salmon Ecology Study (LCISES). The main goal of this study will be to sample outmigrating salmon smolts for growth, marks (thermal marks or coded wire tags), stomach contents (for prey species identification) and timing (days since release or outmigration).

LOWER COOK INLET SALMON ECOLOGY STUDY

A) Abstract

Improving existing knowledge of the survival mechanisms of pink, and sockeye salmon in South Eastern Lower Cook Inlet (LCI) is the main goal of the Lower Cook Inlet Salmon Ecology Study (LCISES). The main goal of this study will be to sample outmigrating salmon smolts for growth, marks (thermal marks or coded wire tags), stomach contents (for prey species identification) and timing (days since release or outmigration). By sampling these variables the study will document the growth rate and outmigration timing of these two important salmon species in the spring of 1999, 2000 and 2001. Opportunistic sampling of smolts will occur when feasible with hopes of learning important staging areas and preferred beach habitat for both species. Plankton and sea surface temperature records will be collected for possible future correlation's with observed growth. Both pink and sockeye salmon are essential components of the subsistence and commercial fisheries in the Port Graham and English Bay drainage's (Port Graham Subdistrict).

B) Background

The subsistence fishery continues to be very important to the local villagers as it has been since the villages were first inhabited. Subsistence uses in the early 1980's showed that in Nanwalek, salmon made up 38% of the diet with 39.6% and 15.2% of the diet made up of other fish (mainly halibut) and marine mammals respectively. The useage for the same period in Port Graham was 38%, 39.6% and 15.2% respectively (Stanek, 1985, Technical Paper #104, ADF&G).

The sockeye salmon that this study will focus on originate from the English Bay River drainage and associated lakes near the Alutiiq native village of Nanwalek, Alaska (formerly English Bay). Nanwalek which is located near the southwestern tip of the Kenai Peninsula on lower Cook Inlet (59° 20'N, 151° 45'W) approximately forty kilometers southwest of Homer and is situated at the base of a narrow spit of land at the head of English Bay.

The English Bay Sockeye Enhancement Project officially began in 1990 when the Chugach Regional Resources Commission (CRRC) provided funding for the Alaska Department of Fish and Games (ADF&G), Fisheries Rehabilitation, Enhancement and Development Division (FRED), to develop a fry stocking program that would supplement wild fry production and help rebuild the depleted English Bay Sockeye run. Lake fertilization was not considered an option for increasing zooplankton production due to the rapid flushing rate of the drainage. After many meetings and discussions, it was decided that the principle goals for the project would be to use pen rearing techniques to produce over one million sockeye smolt annually. The fish are reared until release late in the fall when competition for food in the lakes would be at a minimum and low temperatures decrease feed requirements. Monitoring of the sockeye smolt out-migration was first started in 1988 and has occurred annually since then with many improvements.

Sockeye smolts will outmigrate from the English Bay river in May and June. A large percentage of the outmigrating smolts will be enhanced fish released from Nanwalek Sockeye Project net pens the previous November. Nanwalek Sockeye Project smolts will be identified by size seperation as well as coded wire tags

and or thermally induced otilith bands. Project smolts are about 3 times larger than the wild smolts and the only overlap will be from a normally small percentage of two year wild smolts.

The pink salmon that will be studied are from the Port Graham River stock. The hatchery is located in the village and namesake bay of Port Graham (Palu *'vik*). Port Graham village is situated on the northern shore of Port Graham about four miles east of Russian point and four miles south of Point Pogibshi near the confluence of Lower Cook Inlet and the outer reaches of Kachemak Bay. The neighboring village of Nanwalek is just around the point. Port Graham is located near the southwestern tip of the Kenai Peninsula on lower Cook Inlet approximately forty kilometers southwest of Homer (59° 20'N, 151° 45'W).

The Port Graham Hatchery program began in 1989 when the Port Graham Village Council worked together with the Chugach Regional Resources Commission (CRRC) to provide construction and operating funds for a hatchery to rebuild local pink salmon runs and provide for economic development opportunities for village residents. The hatchery program started out using a scientific/educational permit and then applied for a Private Non-profit Hatchery permit on July 3, 1991. The main hatchery building was located in the old cannery building until it was destroyed by fire on January 13, 1998 were both the pink salmon and sockeye eggs/alevin were also lost. The recently added rearing building for a coho enhancement program which is just beginning it's second year of operation survived the fire and is now the temporary hatchery until a new facility is built.

Documenting the growth, feed organisms and outmigration timing variables will help support EVOS restoration goals by providing important growth and migration timing information about pink and sockeye salmon smolts from the Port Graham/English Bay area. Additional information regarding prey organisms, predator interactions, staging areas and preferred staging area habitat will be collected and analysed.

C) Objectives/Hypotheses

The main objective of this project is to define observed growth, feeding behavior, stomach content and outmigration behavior and timing during the early life history of pink and sockeye salmon originating from the Port Graham and English Bay watersheds.

The specific study plan goals are as follows:

(1) Establish a comprehensive understanding of key interactive processes (both marine and freshwater) that regulate levels of pink and sockeye salmon production in Lower Cook Inlet.

(2) Use this information to more accurately understand the production limitations and mechanisms of pink and sockeye salmon in LCI.

(3) Develop a predictive matrix for tracking and potentially forecasting fishery responses to specific variables.

(4) Evaluate and define various levels of ecosystem disturbances, both natural and anthropogenic that would potentially cause limitations above and beyond natural fluctuations.

(5) Relate all program goals and format data to facilitate and interact with existing EVOS studies as well as other relevant studies and programs (both ongoing and concluded).

(6) Display all project results within a state of the art, visualization medium that will most clearly reveal the findings of this study being careful to distinguish known verified data against more subjective results.

The main premise behind this study is that the constraining processes affecting pink and sockeye salmon production (both natural and anthropogenic) can be described in sufficient detail such that they can be much more clearly understood, explained and possibly even predicted. Information about the variety of relationships influencing this delicate balance will help assess, describe and document trends as well as to clarify additional research needs as well as what effects, if any, may be coming from oil and gas industry activities.

The focus of this study is on the ecosystem structure and functions that influence both early and late life stages of pink and sockeye salmon. Specific questions regarding how survival to adulthood is influenced will be addressed, including: predation on juveniles, near shore temperature and weather, food availability, migrational patterns and possible pollutant exposure.

Major hypotheses include:
(1) Adult pink and sockeye survival is primarily dependent on early marine survival of juveniles
(2) Juvenile survival is primarily growth rate dependent and,
(3) This growth rate dependency is directly related to maximum achievable burst speed for successful predator evasion.
(2) Growth rate is primarily temperature and to a lesser extent food limited, and
(3) Variations in predatory composition and abundance further limit survival
(4) Warmer than average temperatures benefit juvenile salmon but may disrupt returning adult behavior.
(5) Chronic exposure to threshold levels of pollutants further limit salmon fry survival and may confuse imprint details for returning adults.

The primary avenues of investigation are:
- Juvenile pink and sockeye salmon growth and migration and
- Predator/prey studies, to identify preferential prey, critical relationships, and survival windows Ecosystem modeling and visualization, to develop mean of assessing likely effects of perturbations to the ecosystem.
- Near shore water column analysis for prey composition and abundance and chemical "purity"
- Review and coordinate with other relevant studies to determine potentially beneficial information, resources and logistics.
- Provide training for village project participants in sampling procedures

D) Methods/Analyses

Water and zooplankton samples will be collected from the entire water column in the shallow near shore regions depending on the abundance of associated deep and near surface zooplankton assemblages. Sampling will include CTD, ADCP, 20 meter vertical plankton tows and chemical measurements. Water chemistry samples will be collected following strict standardized procedures and sent to a reputable lab in Anchorage for analysis with splits potentially going to an agency or university lab.

In order to determine growth and survival rates specific to English Bay sockeye and Port Graham pink

salmon juveniles, a percentage of pink fry and sockeye smolts will be Coded Wire Tagged and all of the enhanced production will be marked with thermally induced bands on the otitliths. This will facilitate the ability to distinguish between the wild and enhanced groups. The CWT's will facilitate field detection and evaluation. Fry and smolt migration will be monitored and evaluated by tracking in boats and skiffs, using beach seines, fish attractant solutions, capturing fish and running them through a Northwest Marine Technologies Micro Wire Tag Quality Control Device which separates tagged and untagged individuals and counts the tagged ones.

Nearshore Sampling

Nearshore areas will be sampled from March through late August. The nearshore areas will be sampled by a 40 meter beach seine at a depth less than 4 meters and within 15 meters of shore. Five sites will be established for each species. A variable mesh gill net will be used for the nearshore predator evaluations. Visual records will be cataloged in chronological order as to basic site weather, predatory sightings, juvenile behavior etc.. For the sockeye, the sites will most likely be at or near Russian Pt. Shoreline, the 3rd set net site from the river mouth on the south shore, Flat Island, Point Bede and Point Adams. For the pinks the capture sites will likely be at Duncan Slough, old cannery cabin beach, Coal Cove, Passage Island and a site along the shore between Dangerous Cape and Point Pogibshi. All nearshore sample sites will be cooperatively run with effectively ten useful sites for both the sockeye and pink juveniles.

Each site will be sampled for migrating fry or smolts and predation twice a week from March through August.

Upon arrival at each site the following steps will be taken:

1. The variable mesh gill net will be deployed immediately upon arrival.
2. Beach seine for juveniles if fry or smolt are easily located and in sufficient abundance, otherwise go on with other sampling and keep an eye out for juveniles.
3. Deploy CTD at the deepest spot within the established site boundary (mark with small buoy)
4. Take surface, 5 meter and 10 meter water samples for laboratory chemical analyses.
5. Take and record Sechi Disk reading.
6. Take and record surface water temperature, Dissolved Oxygen and Salinity.
7. Take three replicates of twenty meter vertical plankton tows.
8. Beach seine juveniles if not already done.
9. Dip net all fish slowly through QCD for tagged fish detection, enumerating non tagged and other species simultaneously.
10. If the catch of target juvenile salmon is more than 500 fish, the catch will be subsampled and weighed for enumeration with 100 untagged juveniles retained.
11. All CWT tagged fish and up to 100 untagged juveniles will be kept seperate, placed on ice in whirl-pac bags and will be taken back live to the field lab for blotted wet weight, fork length sampling, tag removal and decoding.
12. Pull variable mesh gill net, remove catch, fix stomachs and prepare for transport back to field lab where samples will be processed and quantified.

Offshore Sampling

Two offshore sample sites will be established for the entire program. The exact location of the offshore sites will be determined by consulting with experts such as village elders and fishers, Bill Smoker (UAF), Ted Cooney (retired UAF), Alex Werthiemer (NMFS), and local ADF&G and study project

personnel. The offshore sites will be within 100 meters of and oriented to the shoreline with the transect lines covering depths of 10 to 25 meters. Normal daylight tows will be made once a week from late April to late September using a 6.1 meter wide by 3.0 meter deep surface trawl. Tows will be done at night, once a month instead of the normal daytime tow.

Two replicate tows will be made at each site using two boats (probably a contracted seine boat and seine skiff) and a trawl speed of 65 to 70 cm/s for 10 minutes. When the tow is complete a third boat (skiff) will be used to close the cod end of the trawl by retrieving and pulling a trailing purse line. The cod end will be hauled into a tote on the large vessel and the fish capture will be speciated, counted and checked for tags by passing them through the QCD. Fish will be processed as specified in the nearshore sample methods above, if the catch of target juvenile salmon is more than 500 fish, the catch will be subsampled and weighed for enumeration with 100 untagged juveniles retained.

For both near shore, offshore and any random non site samples collected the number of days in transit for pink and sockeye salmon juveniles will be determined from recoveries of tagged and untagged fish. For the tagged fish the number of days since release will be plotted along with the new length and weight. Residence and migration timing of untagged fish will be estimated using catch per unit effort (CPUE) from the normal station sampling. Growth rates will be determined for measured changes in length, weight and condition factors over the period of time since the fish was released. Growth will be described as an exponential model,

$$W_2 = W_1 * e^{bt}$$

where t is the time in days, b is the daily growth rate, and W_1 and W_2 are fish weights at the beginning and end of the time period. Using this model, weight can be expressed as a linear function of time,

$$Ln(W_t) = bt + In(W_0)$$

Linear regression will be used to fit the natural log of observed weight to this equation. The computed slope of the regression equation will represent the specific growth rate over the interval, which when multiplied by 100, can be expressed as percent body weight gained per day.

A spatial, migratory pattern model will be developed to calculate estimated travel trajectories and staging area residencies based on all data sets.

For tagged fish, the model will be used to determine estimated growth rates from the time the tag code was released to the time the last tagged fish are sampled. For untagged fish the model will be used to determine growth for both the nearshore and offshore samples. Otilith samples will be collected from 10% of the untagged fish and sent to the ADF&G otilith lab in Juneau for processing. This information will be used to determine whether the untagged fish is enhance or wild and to any degree possible which natural system the fish originated from if wild.

The specific study plan goals are as follows:

1. Conduct a literature review for existing information relating to various levels and components of ecosystem fluctuations that control the marine survival responses of pink and sockeye salmon in Alaska and Canadian marine environments.

2. Characterize preferred marine habitat (water quality, preferred beach types, plankton species diversity and abundance) in which the pink and sockeye salmon are found during the first three months of life in lower cook inlet.
3. Document observed growth rates and outmigration timing of wild and enhanced fish since release.

Major hypotheses:

1. Outmigrating juvenile pink and sockeye salmon can be successfully captured and sampled for growth and outmigration timing in South Eastern Lower Cook Inlet.

D) Methods/Analyses

The literature review will be conducted primarily by internet and bulletin board searches. Particular emphasis will be placed on procedures and equipment used in juvenile salmon capture projects in near shore marine waters of Alaska and Canada. Additional information will be collected regarding study plans, results and methodologies for salmon ecology studies conducted in the early marine environment. This information will be summarized and used in the "where do we go from here" section in the conclusion of the final report.

The early marine habitat will be characterized by documenting smolt abundance, beach habitat, depth and water quality of observed staging areas. The concentrations and apparent staging duration of smolts will be the key factor in determining principle staging areas. These habitats will be described using similar zonation and descriptive terminology used in the APPRISE study done in South East Alaska. Basic water quality sampling will be conducted including Salinity, Temperature and Dissolved Oxygen measurements (surface to 3 meters) and sechi depth readings.

In order to document growth rates and outmigration timing of the pink and sockeye smolts, two to four fixed "offshore" sample sites will be established for fixed tows with the trawl gear. These sites will be used primarily to systematically sample smolt "traffic" through a specific coastal segment. The fixed sites will serve as standardized sampling areas that the smolts continually pass through. This will facilitate achieving a sense for the migrational timing through the area by comparing catch numbers and compositions through time. Opportunistic sampling (trawl sets) will also be conducted when large concentrations of smolts are observed. The exact location of the offshore sites will be determined and probably modified based on early initial tow success, observed fry concentrations and consulting with experts such as village elders and fishers, Bill Smoker and Ted Cooney (UAF), Alex Werthiemer (NMFS), and local ADF&G staff and project personnel. The offshore sites will be within 100 meters of and oriented to the shoreline with the transect lines covering depths of 10 to 25 meters. Normal daylight tows will be made every ten days from late April to late September using a 6.1 meter wide by 3.0 meter deep surface trawl. Once a month tows will be done at night instead of the normal daytime tow.

Two replicate tows will be made at each site using two boats (probably a contracted seine boat and seine skiff) and a trawl speed of 65 to 70 cm/s for 10 minutes. When the tow is complete a third boat (skiff) will be used to close the cod end of the trawl by retrieving and pulling a trailing purse line. The cod end will be hauled into a tote on the large vessel and the fish capture will be identified to species, counted and sampled. One hundred juveniles will be sampled for length, weight and condition factor and then retained and preserved for stomach sampling (formalin). If the catch of target juvenile salmon is

more than 500 fish, the catch will be subsampled and weighed for enumeration. Some of the sockeye smolts will be coded wire tagged fish from the enhancement project.

For offshore and any random non site samples collected, the number of days in transit for pink and sockeye salmon juveniles will be determined from recoveries of marked fish. Growth rates will be determined for measured changes in length, weight and condition factors (relationship between length and weight) over the period of time since the fish were released. Migratory patterns and timing information will be plotted on maps and charts (GIS plots and marine charts) to calculate estimated travel trajectories and staging area residencies based on all data sets. Opportunistic sampling will provide additional migratory detail necessary to establish migration routes and timing.

E) Logistics

The program goals will be accomplished as follows:

1. **Literature Search**
   This initial segment will be collected primarily by electronic means (see methods section) and will focus on collecting pertinent literature and data which will facilitate this programs objectives and be used for the conclusion section of the final report.
2. **External Project Coordination**
   Any other relevant projects will be identified and appropriate lead personnel will be contacted with avenues of cooperation and coordination being explored and developed as appropriate.
3. **Personnel Acquisition and Structuring**
   The Principle Investigator (PI) and Co-Investigators (CI's) will be set up with the appropriate supportive staff structure.
4. **Pink and Sockeye Salmon Early Life History**
   - Local Public Preliminary Presentation and Traditional Review/Input Meeting
   - Existing Data Assessment and Consolidation
   - Establish Offshore Sites
   - Fry/Smolt Capture and Sampling
   - Fry/Smolt Predation Sampling
   - Data Acquisition and Synthesis
   - Secondary Presentation and Traditional Review/Input Meeting
   - Draft Preliminary Report (DPR)
   - Initial Peer Review and Comments for DPR
   - Draft Final Report

F) References

Barnard, D. R. 1981. Prey relationships between juvenile pink and chum salmon in Prince William sound, Alaska. M.S. Thesis, University of Alaska, Fairbanks. 72 pg.

Barraclough, W.E., D.G. Robinson, and J.D. Rulton. 1968. Data record. Number, size composition, weight, and food of larval and juvenile fish caught with a two boat surface trawl in Saanich Inlet, 23 April - 21 July 1968. Fish. Res. Bd. Can. MS Rep. 1004. 305pg.

Mortensen, D.G. and A. C. Wertheimer. 1988. Residency and growth of juvenile pink salmon (Oncorhynchus gorbuscha) in Auke Bay. 1987 APPRISE report.

Jewett, S.C. and Stark, T.C. 1994. Food and habitat utilization of juvenile hatchery pink salmon (Oncorhynchus gorbuscha) in Port Valdez, Alaska: 1989-92. 124 pg.

Willete, T.M. and Cooney, R.T. 1996, Processes affecting the survival or juvenile pink salmon in Prince William Sound. Sound Ecosystem Assesment.

G) Budget

Lower Cook Inlet Salmon Ecology Study, Phase I

	EVOS	CRRC	PGVC	AK State	Total
Personnel					
Carol Kvasnikoff, 6 mos	18,000	18,000			36,000
Jerry Robart, 6 mos	18,000		18,000		36,000
Paul McCollum, 6 mos	24,000		24,000		48,000
William Smoker, 2 mos	9,500		0	9,500	9,500
Ted Cooney, 1 mos	7,000		0	7,000	14,000
ADF&G NERRS 3 mos	9,000		0	9,000	18,000
Seasonal Crew 6 @ 6 mos	72,000		72,000	0	144,000
Total Personnel	**157,500**	**18,000**	**114,000**	**25,500**	**315,000**
Travel					
4 R/T Juneau-field office	2,000				
2 R/T Fairbanks-field office	1,000				
12 R/T Homer-field office	0	1,200			
1 R/T National Meeting	1,500				
Total Travel	**4,500**	**1,200**			**$5,700**
Services					
Communications					
Publications/page charges					
Equipment maintenance					
Site Prep					
Total Services	**12,000**				**$12,000**
Supplies					
Glassware					
Chemicals					
Office/Computer					
Tagging supplies		**3,000**			
Field supplies					
Total Supplies	**1,000**	**3,000**			**$4,000**
Equipment					
Tagging Equipment		7,000			
Beach Seine	1,000				
Surface Trawl	2,000				
Work Skiff		8,000			
CTD	10,000				
Vertical Water Sampler	1,000				
Thermal Marking	2,000				
Plankton Sampling Equip.		2,000			
Total Equipment	**16,000**	**17,000**			**$33,000**
Other Costs					
Contract Vessel @ 500/day	**10,000**				**$10,000**
Total Direct Costs	**$201,000**	**$39,200**	**$114,000**	**$25,500**	**$379,700**

H) Project Time-line **1999 (FY 99)**

Project Activities	Est. Start Date	Est. Date Finished	1rst Quarter	2nd Quar
Review and Verify Equipment and Supplies Needed	March 15	May 1		
Order Equipment and Supplies	April 1	May 15		
Literature Search	April 1	June 1		
External Project Coordination	April 1	June 1		
Personnel Acquisition and Structuring	April 1	May 15		
Early Life History Sites Established	April 1	April 15		
Preliminary Presentation and Traditional Review/Input Meeting	May 1			
Existing Data Assessment and Consolidation	April 1	May 15		
Early Life History Sampling	May 1	Sept. 30		
Secondary Presentation and Traditional Review/Input Meeting	June 15			
Data Acquisition and Synthesis	Sept. 1	Dec. 15		
Water Quality and Fish Tissue Analysis, Sites and Strategies	April 1	May 15		
Water Column Sampling	May 1	Sept. 30		
Fish Tissue Sampling	May 1	Sept. 30		
Data Acquisition and Synthesis	Sept. 1	Dec. 15		
Presentation and Traditional Review/Input Meeting	June 15			
Reports and Data Analysis				
Data Compilation	Oct. 15	Nov. 15		
Statistical Analysis and Visualization of Data	Oct. 15	Nov. 15		
Multi-Dimensional Matrix Input	Oct. 15	Nov. 15		
Mapping and Plotting	Oct. 15	Nov. 15		
Statistical Processing	Oct. 15	Nov. 15		
Visualization Processing	Oct. 15	Nov. 15		
Presentation and Traditional Review/Input Meeting	Nov 15			
Draft Preliminary Report (DPR)	Dec 15			
Initial Peer Review and Comments for DPR	Dec 15	Jan 15		
Draft Final Project Report	Jan 15			
Final Project Report Completion	Feb 15			

1998 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$157.5	$171.4
Travel	$4.5	$5.8
Contractual	$22.0	$22.0
Commodities	$1.0	$1.0
Equipment	$16.0	$19.0
Subtotal	$201.0	$219.2
Indirect		
Project Total	$201.0	$219.2
Full-time Equivalents (FTE)		5.3
Other Resources	$178.7	

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	

Dollar amounts are shown in thousands of dollars.

Comments:
Matching funds of approximately $178,700 will be available as in kind contributions to the proposed project.

1999

Project Number: 00544
Project Title: Lower Cook Inlet Salmon Ecology Study
Name: Port Graham Village Council

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Prepared:

4/15/99

1998 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:			Months	Monthly	
Name	Position Description		Budgeted	Costs	Overtime
William Smoker	Principle Investigator		2.0	4.8	
Ted Cooney	Project Advisor		1.0	7.0	
Alex Wertheimer	Project Advisor		1.0	4.8	
Paul McCollum	Project Coordinator		6.0	4.0	
Carol Kvasnikoff	Nanwalek Salmon Project Coordinator		6.0	3.0	
Nancy Yeaton	Nanwalek Natural Resources Specialist		3.0	3.0	
Jerry Robart	Port Graham Hatchery Assistan Manager		6.0	3.0	
Edgar Otis	Port Graham Natural Resources Specialist		3.0	3.0	
Field Assistants (6)	Project Research Assistants		36.0	2.0	
	Subtotal		64.0	34.6	0.0
					Personnel Total

Travel Costs:		Ticket	Round	Total	Daily
Description		Price	Trips	Days	Per Diem
Four RT Juneau Field Office		0.5	4	8	0.1
Two RT Fairbanks Field Office		0.5	2	4	0.1
Four RT Anchorage EVOS Office		0.3	4	4	0.1
					Travel Total

1999

Project Number:
Project Title: Lower Cook Inlet Salmon Ecology Study
Name: Port Graham Village Council

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Prepared:

4/15/99

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

Contractual Costs:
Description
Vessel Charter
Communications, Publications, Equipment Maintenance and Site Prep
Contractual Total

Commodities Costs:
Description
Glassware
Chemicals
Field Supplies
Commodities Total

1999	Project Number: Project Title: Lower Cook Inlet Salmon Ecology Study Name: Port Graham Village Council	FORM Contract Commo DETA

Prepared:

4/15/99

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

New Equipment Purchases: Description	Number of Units	Unit Price
Beach Seine	1	1.0
Surface Trawl	1	2.0
CTD	1	10.0
Vertical Water Sampler	1	1.0
Spectrophotometer	1	5.0

Those purchases associated with replacement equipment should be indicated by placement of an R. **New Equipment Total**

Existing Equipment Usage: Description	Number of Units
Thermal Marking System (Boilers, Heat Exchangers and Plumbing	1
Aluminum Work Skiff	1
Plankton Nets and Associated Gear	1
Coded Wire Tagging Equipment	1

1999

Project Number:
Project Title: Lower Cook Inlet Salmon Ecology Study
Name: Port Graham Village Council

FORM Equip DET

Prepared:

4/15/99

Observing (Monitoring) System Design for the PWS Nowcast/Forecast System, Submitted Under the BAA

Project Number: 00547-BAA

Restoration Category: Research

Proposer: University of Miami

Lead Trustee Agency: NOAA

Cooperating Agencies: None

Alaska Life Center: No

Duration: 1-year project

Cost FY00: $85.9K

Cost FY01: 0

Cost FY02: 0

Geographic Area: Prince William Sound and adjacent Alaska Shelf

Injured Resource/Service: Pacific herring, Pink salmon

ABSTRACT

A high-resolution, time-variable numerical circulation model for Prince William Sound (PWS) was developed (and partially validated) under the SEA Program and applied to ecosystem topics. With partial support from the Oil Spill Recovery Institute (OSRI), the model is being extended to form a real-time nowcast/forecast system that can be used for projecting the dispersal of oil spills, but which can also be used for projecting the dispersal of fish eggs, larvae, and juveniles, including larval Pacific herring and juvenile Pink salmon. Hence, this project is linked to Theme 2: Fisheries Dynamics and Theme 3: Coastal Oceans Ecosystem Processes of CIMAS, the NOAA Joint Institute at the University of Miami. A critical element in any nowcast/forecast system is the availability of a real-time observing system to help force the model. A real-time observing system can be expensive and should, accordingly, be designed carefully. Hence, the proposed effort aims (1) to analyze various existing observed time series and examine their impact in constructively constraining the model, and (2) to analyze model output to help guide the selection of which variables need to be observed at which locations for assimilation of data into the model.

INTRODUCTION

The time-varying (transient) circulation is a principal determinant in the dispersal of oil spills; the dispersal of fish eggs, larvae, and juveniles; the dispersal of glacial debris; and the functioning of the marine ecosystem at the trophic levels of phytoplankton and zooplankton. The variability of the circulation reflects the extrinsic forcing and intrinsic instability of the flow. The extrinsic forcing includes tidal forcing; wind-forcing by the weather cycle; seasonal heating/cooling, precipitation/evaporation, and local and regional snow and glacier melt; and short-term climate variability associated with ENSO (by oceanic and atmospheric teleconnections) and the interdecadal North Pacific Oscillation involving vacillations of the Alaskan Low. Some of the forcing is applied directly to PWS, while the remainder is applied indirectly; i.e., offshore of PWS (or even from equatorword sources of forcing whose effects are conveyed by coastally trapped waves to the offings of PWS) and manifested through dynamical links at Hinchinbrook Entrance (HE) and Montague Strait (MS). The intrinsic variability is caused by various dynamical instabilities that occur under the joint influence of the Earth's rotation, density stratification, and variable bottom topography. It is manifested as meandering jets, mesoscale eddies, and fronts, which are effective in transporting, dispersing, and concentrating fish eggs, larvae, and planktonic biota.

As part of the SEA Program, a high-resolution (1.2km x 1.2km horizontally; 15 vertical levels in sigma (terrain-following) coordinates; 1 min in time) circulation model was implemented for PWS per se which solved for the seasurface height, three velocity components, temperature, and salinity (and thus, density) as prognostic variables. A series of sensitivity studies (Mooers and Wang, 1998) were conducted as a function of different wind-forcings, density stratification, and throughflow conditions that illustrated a wide variety of circulation patterns. Simulations with tidal forcing (Wang, Mooers, and Patrick, 1997) indicated characteristic tidal flow patterns and the possible tidal residual (or rectified) circulation due to the time-averaged (nonlinear) effect of the strong tidal currents in PWS. The simulated advective-diffusive properties of PWS for a passive tracer released at HE have been synthesized into a simple two-compartment exchange model for the northern and southern PWS (Deleersnijder,Wang, and Mooers, 1998). For the final synthesis phase of the SEA Program, the model is being used to simulate the seasonal cycle of PWS. In parallel, there is a model validation effort in progress. The model implementation assumed that the throughflow could be specified at HE and MS but, for fully realistic situations, that has proved difficult due to the complexity and variability of the flow.

The SEA Program acquired several valuable time series, including from a bottom-mounted ADCP for velocity profiles at HE, the CFOS thermister array at mid-Sound for temperature, etc. profiles, and a few coastal meteorological stations, as well as significant amounts of ecological and fisheries data. There are also tide gauges at Seward, Whitter, and Valdez and three NDBC meteorological buoys and CMAN coastal stations. These existing observing elements need to be melded together to form an initial observing system that can be used to force the model, and that can be upgraded with strategically chosen additional elements. For example, some observing system elements at carefully chosen locations on the Alaska Shelf should compensate (in the extended model) for the incomplete information on the hard-to-observe throughflow at HE and MS. The applications of the proposed research to PWS ecosystem and fisheries issues are within the framework of Theme 2 (Fisheries Dynamics) and Theme 3 (Coastal Oceans Ecosystem Processes) of CIMAS (Cooperative Institute for Marine and Atmospheric Science) located at the University of Miami.

NEED FOR PROJECT

A. Statement of Problem

Modern numerical models of ocean circulation, if properly designed, implemented, and forced, offer vast amounts of information that would be unaffordable to produce by direct observation. However, the model physics must be validated by careful testing and the model output fields must be verified with strategic sets of synoptic observations. To operate in the noweast/forecast mode, the model needs to be driven by near-real time forcings and to assimilate repeated observations (at regular intervals in space and time) of dynamically significant variables. OSRI is partially supporting extension of the modeling effort developed by SEA to create a nowcast/forecast system for PWS. There is a need now to design the complementary observing system so that a cost-effective combined observing and modeling system will be available for long-term monitoring of the physical oceanography of PWS.

B. Rationale/Link to Restoration

Pacific herring and pink salmon are listed as recovering resources. Management of the PWS ecosystem to facilitate their recovery under plausible scenarios of climate variability and anthropogenic influences requires comprehensive information about the space-time variability of the circulation. In a separate effort, it is hoped to develop an extension of the circulation model to include an ecosystem model which will eventually allow a combined modeling-observing system approach for PWS ecosystem monitoring, too. With the modern tools of real-time observing systems and numerical models, powerful and efficient technologies will be available to:

- Conduct "what if?" studies for research and contingency planning (simulation)
- Reconstruct past events (hindcast)
- Synoptic pictures of the present (nowcast)
- Short-term projections (forecast)

All of which will improve the ability to manage the marine environment and ecosystem of PWS.

C. Location

The model-based observing system design will be focused on PWS, with extension to the nearby Alaska Shelf with which it interacts.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Scientific results will be posted on the SEA web page, and will be accessible to the general public.

PROJECT DESIGN

A. Objective

The main objective is to design an observing system in support of the PWS Nowcast/Forecast System which will have utility when applied to various issues; for example, of oil spill trajectories and Pacific herring larval transports. The specific objectives are to:

1. identify, catalog, and characterize existing time series in PWS, both delayed mode and real-time systems;

2. analyze the time-series in 1. for information on predominant time scales of variability plus for the spatial cross-correlation of one variable at different sites, and different variables at one site;

3. analyze the PWS circulation model output in a similar fashion as in 2. to determine if the model and observations have the same scales of variability and cross-correlation relationships; and

4. use the model output fields as an ideal ocean to determine the cross-correlation field between observable variables (e.g., coastal sea level at Seward) and subsurface variables (e.g., temperature at 200m over the Central Basin).

B. Methods

The circulation model will be run with nominal forcing functions that represent the space-time variability of tides, weather systems, and seasonal cycles of heating/cooling, runoff, etc. to generate test fields representing an ideal PWS. Model output will be extracted from the complete set of fields to represent simulated observing systems; e.g., velocity profiles from a bottom-mounted ADCP at HE, and sea level from tide gauges at Seward, Whittier, Valdez, and other potential locations. These extracted fields will then be used together with actual observations for observing system design.

Available observed time series (ADCP velocity profiles, CFOS temperature, tide gauges, and meteorological stations) will be subjected to spectrum analysis to determine the principal time scales, and multi-station/multivariate cross correlations and coherence and phase values will be evaluated to determine the statistical predictability as a function of horizontal position and depth and the ability to infer statistically one variable from another. Analogous model output will be subjected to similar analyzes.

Hypothetical observing systems will be proposed. The corresponding fields will be extracted from the ideal PWS simulations. They will be assimilated into the model for a parallel model run that assumes a different initial state to assess the ability of the hypothetical observing system to reduce model error and bring the parallel model run into alignment with the ideal PWS simulations.

Because one of the primary objectives for model application is the estimation of particle (e.g., oil spills or Pacific herring larvae) trajectories, the skill of the model in estimating SEA drifter trajectories will be examined as a function of the quality of the forcing information provided, including observing system components used for data assimilation.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This project will be performed in close concert with Dr. Shari Vaughan, PWSSC, who is responsible for the observing system aspects of the OSRI nowcast/forecast system, and who has been responsible for the physical oceanographic observations of the SEA Program and as proposed to EVOS. This project will also be symbiotic with the effort of Dr. Brenda Norcross, IMS/UAF to study the dispersal of Pacific herring in PWS under various climatic scenarios, as proposed to EVOS.

SCHEDULE

A. Measurable Project Tasks for FY00

November 1999:		PWS Observing System Design Workshop
March 2000	:	Mid-term Review of PWS Observing System Design
July 2000	:	Draft Report on PWS Observing System Design
September 2000:		Complete Technical Report on PWS Observing System

B. Project Milestones and Endpoints

1. December - Objective 1
2. March - Objective 2
3. March - Objective 3
4. June - Objective 4

C. Completion Date

30 September 2000

PUBLICATIONS AND REPORTS

Technical Report: 15 April 2001

PROFESSIONAL CONFERENCES

Participation in a PICES Workshop on the development of fisheries-related Global Ocean Observing System (GOOS) activities in the North Pacific is anticipated.

COORDINATION AND INTERGRATION OF RESTORATION EFFORT

This project will cooperate with all relevant and interested EVOS-sponsored projects, and it will serve as a link to OSRI. There will be strong interactions with Dr. Shari Vaughan, PWSSC on observing system issues and Dr. Brenda Norcross, IMS/UAF on Lagrangian modeling system issues as applied to Pacific herring larval transports.

PROPOSED PRINCIPAL INVESTIGATOR

Prof. Christopher N. K. Mooers
Ocean Prediction Experimental Laboratory
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098
(305)361-4088 (Office)
(305)361-4797 (FAX)
e-mail: cmooers@rsmas.miami.edu

PRINCIPAL INVESTIGATOR

CHRISTOPHER N.K. MOOERS

Educational History:

U.S. Naval Academy	Naval Science	B.S. w/Distinction	1957
Univ. of Connecticut	Physics	M.S.	1964
Oregon State Univ.	Physical Oceanography	Ph.D.	1969

Employment History:

1957-1964	U.S. Naval Officer	Various
1969-1970	NATO Postdoc	University of Liverpool/Oceanography
1970-1976	Assistant/Assoc. Prof.	University of Miami/RSMAS/Physical Oceanography
1976-1979	Associate/Professor	University of Delaware/CMS
1979-1986	Professor and Chairman	Naval Postgraduate School/Oceanography
1986-1989	Director/Scientific Advisor	UCAR/Institute for Naval Oceanography
1989-1991	Research Professor	University of New Hampshire/EOS
1991-1993	Chair	University of Miami/RSMAS/Applied Marine Physics
1991 to date	Professor	University of Miami/RSMAS/Applied Marine Physics
1991 to date	Coordinator	University of Miami/RSMAS/Coastal Ocean Sciences Program
1992 to date	Director	University of Miami/RSMAS/Ocean Pollution Research Center
1993 to date	Fellow	University of Miami/RSMAS/CIMAS

Public service:

Secretary, President-Elect, President, Ocean Sciences Section, AGU, 1978 to 1984
Chairman, Eastern Pacific Oceanic Conference, 1979 to 1986
Interim Councilor, The Oceanography Society, 1988 to 1989
Member, USNC/IUGG, 1991 to 1995
Chair, USNC/IUGG, 1996 to 1999
Chair, UNOLS Fleet Improvement Committee, 1994 to 1997
Co-Chair, PICES WG-10 on The Circulation and Ventilation of the Sea of Japan and Adjacent Waters, 1995 to 1998
Chair, AMS/STAC on Meteorlogy and Oceanography of the Coastal Zone, 1996 to 2002
Member, NRC-AIC/USA-Mexican Joint Working Group on Cooperative Ocean Science, 1995 to 1998
Chair, NODC Working Group on Coastal Ocean Data Acquisition, 1997 to 1999
Co-Chair, SCOR WG 111 (Coupling of Winds, Waves, and Currents in Coastal Models), 1998 to 2002

Editorial service:

Consulting Editor, Weatherwise (1978 to date)
Managing Editor, Coastal and Estuarine Studies, American Geophysical Union (1979 to date)
Editor, Journal of Physical Oceanography (1991 to 1996)

Recent Bibliography (Subset)

(1986) (with A.R. Robinson, J.A. Carton, and N. Pinardi) Dynamical Forecasting and Dynamical Interpolation: An Experiment in the California Current. *J. Phys. Oceanogr.*, 16, 1561-1579.

(1987) (with M.M. Rienecker and A.R. Robinson) Dynamical Interpolation and Forecast of the Evolution of Mesoscale Features off Northern California. *J. Phys. Oceanogr.*, 17, 1189-1213.

(1989) (with M.M. Rienecker) Mesoscale Eddies, Jets and Fronts Off Point Arena, July 1986. *J. Geophys. Res.*, 94, 12,555-12,569.

(1991) (with B.H. Jones and M.M. Rienecker, T.P. Stanton, L. Washburn) Chemical and Biological Structure and Transport of a Cool Filament Associated with a Jet/Eddy System Off Northern California in July 1986 (OPTOMA-21). *J. Geophys. Res.*, 96, 22,207-22,225.

(1991) COPS Overview of the Coastal Ocean Prediction Systems (COPS) Program. Anton Brunn Memorial Lecture, XVI Session of the IOC Assembly, *IOC Technical Series*, 39, 7-20.

(1994) (with D.S. Ko) Nowcast System Development for the Straits of Florida. In: (Eds. M.L. Spaulding, K. Bedford, A. Blumberg, R. Cheng, and C. Swanson). *Estuarine and Coastal Modeling III*, ASCE, pp. 158-171.

(1994) (with S. Jin and D.S. Ko) Preliminary Evaluation of a Gulf of Mexico Circulation Model at 92W. VII JECCS/PAMS Workshop Proceedings. *La Mer*, 32 (4), 307-324.

(1995) (with H.S. Kang) Initial Spin-Up of a Sea of Japan Numerical Circulation Model. In: Advanced Mathematics: Computations and Applications (eds. A.S. Alekseev and N.S. Bakhvalov). NCC Publisher, Novosibirsk, pp 350-357.

(1996) (with H.S. Kang) Preliminary Results from a Sea of Japan Numerical Circulation Model. Proceedings of the PICES Workshop on the Sea of Okhotsk and Adjacent Areas. PICES Scientific Report No. 6, pp. 202-214.

(1997) (with J. Wang and V. Patrick) A Three-Dimensional Tidal Model for Prince William Sound, Alaska. In: Computer Modelling of Seas and Coastal Regions III (eds. J.R. Acinas and C.A. Brebbia). Computational Mechanics Publications, Southampton, pp. 95-104.

(1997) (with J. Wang) Three-Dimensional Perspectives of the Florida Current: Transport, Potential Vorticity, and Related Dynamical Properties. *Dyn. Atmos. and Ocn.*, 27, 135-149.

(1998) (with G.A. Maul) Intra-Americas Sea Coastal Ocean Circulation. In: Global Coastal Ocean (eds. A.R. Robinson and K.H. Brink). *The Sea,* V. 11, John Wiley & Sons, NY, pp. 183-208.

(1998) (with J. Wang) On the Implementation of a Three-Dimensional Circulation Model for Prince William Sound, Alaska. *Con. Shelf Res.*, 18, 253-277.

(1998) (with E. Deleersnijder and J. Wang) A Two-Compartment Model for Understanding the Simulated Three-Dimensional Circulation in Prince William Sound, Alaska. *Con. Shelf Res.* 18, 279-287.

(1999) (Editor) Coastal Ocean Prediction, Coastal and Estuarine Studies, V. 56, AGU, Washington, DC, 526 pp.

(1999) (with H.S. Kang) Sensitivity Studies for Japan (East) Sea Circulation Modeling. *JGR-OCEANS* (under revision)

(1999) (with L. Gao, W. R. Johnson, and N. L. Guissiano, Jr.) A Coastally Trapped Transient Circulation Response Forced by a Tropical Cyclone Passage in the Gulf of Mexico. *JGR-OCEANS* (under revision).

(1999) (with G. Peng and H.C. Graber) Coastal Winds in South Florida. *J. Appl. Meteor.* (in press).

OTHER KEY PERSONNEL

A TBA Research Scientist is expected to join Prof. Mooers' research group this summer. The individual will be responsible for numerical implementation and data analysis under Prof. Mooers' supervision.

LITERATURE CITED

Wang, Mooers, and Patrick (1997) A Three-Dimensional Tidal Model for Prince William Sound, Alaska. In: Computer Modelling of Seas and Coastal Regions III (eds. J.R. Acinas and C.A. Brebbia). Computational Mechanics Publications, Southampton, pp. 95-104.

Mooers and Wang (1998)) On the Implementation of a Three-Dimensional Circulation Model for Prince William Sound, Alaska. *Con. Shelf Res.*, 18, 253-277.

Deleersnijder, Wang, and Mooers (1998) A Two-Compartment Model for Understanding the Simulated Three-Dimensional Circulation in Prince William Sound, Alaska. *Con. Shelf Res.* 18, 279-287

2000 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$41,280.0
Travel		$7,000.0
Contractual		$7,000.0
Commodities		$2,000.0
Equipment		$0.0
Subtotal	$0.0	$57,280.0
Indirect (50%)		$28,640.0
Project Total	$0.0	$85,920.0
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2001	Estimated FY 2002	Estimated FY 2003			
$150,000.0	$150,000.0	$150,000.0			

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect Cost Rate used is calculated at 50% of the modified total direct costs. Modified total direct costs equals the total direct costs minus any capital equipment.

2000

Prepared: 4/13/99

Project Number: 00547 - BAA
Project Title: Observing (Monitoring) System Design for the PWS Nowcast/Forecast System, Submitted Under the BAA
Name: University of Miami

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2000
	C. Mooers	Principal Investigator	2.0	12720.0		25,440.0
	vacant	Research Scientist	3.0	5280.0		15,840.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	5.0	18000.0	0.0	
					Personnel Total	$41,280.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2000
	Travel to Cordova, Alaska	1500.0	2	5	200.0	4,000.0
	Travel to Vladivostok, Russia-PICES Meeting (tentative)	1600.0	1	7	200.0	3,000.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$7,000.0

2000

Project Number:
Project Title: Observing (Monitoring) System Design for the PWS Nowcast/Forecast System, Submitted Under the BAA
Name: University of Miami

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/13/99

2000 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2000
Phone, fax, copying	2,000.0
Publication costs (reports)	2,000.0
Mail, freight, shipping	3,000.0
Computer network services	
Contractual Total	$7,000.0

Commodities Costs:	Proposed
Description	FY 2000
Office supplies	500.0
Computer supplies	1,500.0
Commodities Total	$2,000.0

2000

Prepared:
4/13/99

Project Number:
Project Title: Observing (Monitoring) System Design for the PWS Nowcast/Forecast System, Submitted Under the BAA
Name: University of Miami

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number	
Description	of Units	

2000

Project Number:
Project Title: Observing (Monitoring) System Design for the PWS Nowcast/Forecast System, Submitted Under the BAA
Name: University of Miami

FORM 4B
Equipment
DETAIL

Prepared: 4/13/99

Project Title: Internet-based Digital Index of Research Publications funded by the Exxon Valdez Oil Spill Trustee Council, 1990-present

Project Number:	00548
Restoration Category:	Research: Information Transfer
Proposer:	Dede Bohn
Lead Trustee Agency:	DOI, U.S. Geological Survey
Cooperating Agencies:	ARLIS
Alaska SeaLife Center:	No
Project Duration:	1st year, 1-year project
Cost FY 00:	$26,700
Geographic Area:	No field work
Injured Resource/Service:	

ABSTRACT

This project is designed to increase the usability of research literature that has been created for the *Exxon Valdez* Oil Spill (EVOS) Restoration program by creating a digital, interactive bibliography. The final product will be posted on the EVOS Restoration Internet site: http://www.oilspill.state.ak.us. Users will be able to select a geographic region from an image map of the spill area to view a list of corresponding publications. Users will also be able to select topics, such as resource clusters or species, and view a list of pertinent publications. This effort could be considered one of the initial steps in packaging the volume of research findings and literature for easier accessibility by land managers, policy makers, interested scientists, resource-users, and the private sector. A final step in FY00 would be to expand this product with the inclusion of the Topical Annotated Bibliography for Managers (Project xxx, being proposed in FY00 by Karen Murphy of the Chugach National Forest).

INTRODUCTION

A digital, interactive bibliography will greatly increase the usability for each of the user communities of a bibliographic list posted recently on the EVOS website ("Bibliography of Peer Reviewed Publications"). These 288 publication citations will be linked to both the geographic regions they cover and to their subject material, using the simple, straight-forward "point and click" technology of the Internet. The bibliographic listings can easily be updated as new publications and reports are produced, making this digital catalog an up-to-date public resource.

NEED FOR THE PROJECT

A. Statement of Problem

The current bibliography of peer-reviewed EVOS literature is cumbersome to use. Searches for relevant topics or for information on specific geographic areas are difficult since peer-reviewed scientific publications are sorted now only by alphabetical listing of the first author's last name. The user may not find what he is looking for, if the title doesn't name the specific topic the user is seeking. An interactive digital listing will improve the success of finding all studies pertaining to a specific geographic area, and all studies related to a specified topic in the peer-reviewed literature. It will provide users with greater accessibility to the scientific literature citations.

B. Rationale/Link to Restoration

This effort is one vital step in information management of the EVOS Restoration program; it provides an initial step towards the information transfer of research findings to user groups.

C. Location

No field work is planned for this project.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Remote communities in the oil spill region with Internet access, like other user groups, will be able to find sources of reports and publications more readily, once the digital index and catalog is completed and posted on the EVOS Restoration Office website.

PROJECT DESIGN

A. Objective

Provide an easy-to-use, interactive, updated listing on the EVOS Restoration Office website for all peer-reviewed scientific literature citations from the EVOS program.

B. Methods

Specific steps in the project design:

1. Determine the geographic coverage of each peer-reviewed scientific article, by examining each publication. Assist ARLIS in obtaining reprint copies for 83 articles which are not yet on file, as possible.

2. Determine which resource clusters and main species are addressed in which publications. Include listings for the following resource clusters: Pink Salmon Project, Herring Projects, Sockeye Salmon Program, Cutthroat and Dolly Varden Trout Projects, Marine Mammal Program, Subsistence Projects, Archeological resources, Recreation and Tourism, Sediments, Ecosystem Synthesis, Sound Ecosystem Assessment (SEA), Nearshore Ecosystem Projects, Seabird / Forage Fish Ecosystem Projects, Ecosystem Synthesis, Reducing marine Pollution, Habitat Protection Improvements, Habitat Protection Acquisition Support.

3. Create an image map of the spill area drawing from various available digital files. The file size of the resultant map image will then be reduced as much as reasonable, in order to provide a fast-download time for Internet users while maintaining image clarity.

4. Construct a network of nested rectangular overlays that frame geographic areas of interest in the oil spill area. These rectangles will provide both large- and small-scale coverage, to provide the user with maximum choice.

5. Using web technology, provide clickable links from each rectangle on the image map to a corresponding list of pertinent bibliographic citations.

6. Using web technology, prepare a list of cluster resources and species which links to appropriate references.

7. Link the geographic coverage and the resource cluster and species information to the bibliographic listings in an easy-to-use format on the web. The user will need no software in addition to a standard web browser in order to access and use this digital catalog.

8. Post the resultant product on the EVOS Restoration office website. This can be done either by posting on the Restoration office server, or by posting on the USGS server, with a

clickable link from the Restoration Office web page. Which server hosts the information would be transparent to the user; it is instead a design feature that can be guided by the desire of the Restoration Office staff.

9. Update bibliographic listings through the year, as new publications become available.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

An employee of the Alaska Resource Library Information Service (ARLIS), will provide technical guidance and updates during FY00 and will facilitate access to the peer-reviewed literature.

SCHEDULE

A. Measurable Project Tasks for FY 00

Oct.1--Jan.15:	Literature review to determine geographic and topical coverage
Jan. 15--Mar.15:	Create image map and nested rectangular overlays
Mar 15--May 1:	Develop web technology for linking geographic and topical coverage to image map and bibliography listings
June 30:	Post final product on website
July 1--Aug. 15:	Update final product with newly available listings
Sept. 30:	Link in "Topical Annotated Bibliography for Managers"

B. Project Milestones and Endpoints

The first publically available posting on the Internet of the Digital Index of Research Publications is scheduled for June 30, 2000. Upgrades to this Index will continue to be made until project funding is terminated on September 30, 2000.

C. Completion Date

September 30, 2000.

PUBLICATIONS AND REPORTS

The end product for this project will be hosted on the Internet. It will be available free to all users, and can be downloaded to print a hardcopy, as desired.

PROFESSIONAL CONFERENCES

NORMAL AGENCY MANAGEMENT

As this bibliographic listing comprises non-agency publications, it would not fall within normal agency management to increase its usability.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is being coordinated with a component of another FY00 proposal: "Exxon Valdez Oil Spill Information Transfer Program for Managers", by Karen Murphy, USDA-Forest Service. Coordination is targeted for the portion of that proposal on "Topical Annotated EVOS Bibliography for Managers". If both proposals are funded, we will combine our final products on the EVOS website.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

PROPOSED PRINCIPLE INVESTIGATORS

Dede Bohn
U.S. Geological Survey
Alaska Biological Science Center
1011 E. Tudor Rd.
Anchorage, AK 99503

Mary Whalen
U.S. Geological Survey
Alaska Biological Science Center
1011 E. Tudor Rd.
Anchorage, AK 99503

OTHER KEY PERSONNEL

Carrie Holba
Alaska Resources Library and Information Services
3150 C Street, Suite 100
Anchorage, AK 99503

Karen Murphy
Chugach National Forest
Anchorage, AK

PRINCIPLE INVESTIGATORS

Dede Bohn, B.S., M.S. Geology, University of Wyoming, is currently the USGS Liaison to the *Exxon Valdez* Oil Spill program. She is a structural geologist with research and scientific publications relating to the North Slope of Alaska and central Wyoming. She worked for four years at USGS headquarters in Reston, Virginia, preparing documents and presentations for national program budget justifications, and helping develop program themes for budget redirection. More recently, she has worked in Outreach and External Affairs for the USGS in Alaska.

Dede's role for this project: provide general oversight, facilitate project, provide design guidance, assist in operations.

Mary Whalen, B.S., M.S. Fisheries, University of Alaska Fairbanks, has been data manager for the past three years of the multi-faceted Nearshore Vertebrate Predators Ecosystem project. She has assisted scientists with data analysis and graphics preparation. She is one of the webmasters for the USGS Alaska Biological Science Center, and also serves as back-up network administrator and computer support.

Mary's role for this project: biologist who will perform the reviews of the research literature to document geographic coverage and topic covered; webmaster who will prepare and post the final product.

Additional contributors to this project:

Carrie Holba, ARLIS: provide guidance for design parameters, facilitate access to peer-reviewed publications, provide updates to publication list as they become available

Karen Murphy, Chugach National Forest: provide digital version of the Topical Annotated EVOS Bibliography for Managers that she is proposing to prepare in FY00

2000 EXXON VALDEZ TRL Ξ COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000	PROPOSED FY 2000 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$3.5			$23.2	
Personnel	$0.0	$23.2						
Travel	$0.0	$0.0						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$23.2			Estimated FY 2001	Estimated FY 2002		
General Administration	$0.0	$3.5						
Project Total	$0.0	$26.7			$0.0	$0.0		
Full-time Equivalents (FTE)	0.0	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:

FY00

Prepared: 4/15/99

Project Number: 00548
Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: DOI--U.S. Geological Survey

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

2000 EXXON VALDEZ TRL E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$20.2
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$20.2
General Administration		$3.0
Project Total	$0.0	$23.2
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

FY00

Prepared: 4/15/99

Project Number:
Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: DOI--U.S. Geological Survey

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TRU E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2000
						0.0
D. Bohn	Physical Scientist	GS-11	0.3	5.0		1.5
M. Whalen	Data manager, webmaster	GS-11	3.5	5.0		17.5
TBD	Technical support, USGS EROS field office, Anch.	GS-12	0.2	6.0		1.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.0	16.0	0.0	
					Personnel Total	$20.2

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

FY00

Prepared: 4/15/99

Project Number:
Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: DOI--U.S. Geological Survey

FORM 3B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRL E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed FY 2000
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2000
Description	
Commodities Total	$0.0

FY00

Prepared: 4/15/99

Project Number:
Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: DOI--U.S. Geological Survey

FORM 3B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number of Units	Inventory Agency
Description		

FY00

Project Number:
Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: DOI--U.S. Geological Survey

FORM 3B
Equipment
DETAIL

2000 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$3.0						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$3.0			Estimated FY 2001	Estimated FY 2002		
General Administration		$0.5						
Project Total	$0.0	$3.5						
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY00

Prepared: 4/15/99

Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: AK Dept of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2000
C. Holba	Librarian II	19F	0.5	6.0		3.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	6.0	0.0	
					Personnel Total	$3.0

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

FY00

Prepared: 4/15/99

Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present

Agency: AK Dept of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRU_ _ _E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed FY 2000
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0
Commodities Costs:	Proposed FY 2000
Description	
Commodities Total	$0.0

FY00

Prepared:

Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: AK Dept of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TRL E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2000
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			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

FY00

Project Title: Internet-based Digital Index of EVOS Research Publications , 1990 to present
Agency: AK Dept of Fish and Game

FORM 3B
Equipment
DETAIL

Prepared:

Exchange between Prince William Sound and the Gulf of Alaska. Submitted Under the Broad Agency Announcement.

Project Number: 00552-BAA

Restoration Category: Research

Proposer: Prince William Sound Science Center

Sponsoring Agency: NOAA

Duration: Three years

Cost FY 00: $153.4 K

Cost FY 01: $ 133.5 K

Cost FY 02: $ 107.0 K

Cost FY 03: $ 0 K

Cost FY 04: $ 0 K

Geographic Area: Prince William Sound, Alaska

Injured Resource/Service: pink salmon, Pacific herring

ABSTRACT

One of the least understood physical processes that influence the biological components of PWS is the exchange between the northern Gulf of Alaska (GOA) and Prince William Sound (PWS). The main objective of this proposal is to document the interannual variability in water mass exchange between PWS and the adjacent northern GOA at Hinchinbrook Entrance, and identify mechanisms governing this exchange. Support is requested to deploy an upward looking ADCP mooring in Hinchinbrook Entrance, and to collect and analyze temperature and salinity data from key stations in PWS. The mooring velocities will also provide boundary conditions for the PWS numerical circulation model.

INTRODUCTION

While pink salmon and Pacific herring are listed as the injured resources above, it is in fact the PWS ecosystem as a whole that has not fully recovered. The Sound Ecosystem Assessment (SEA), funded by the Trustee Council from 1994 to 1999, was aimed at understanding physical and biological factors affecting pink salmon and Pacific herring survival on an ecosystem level. The physical oceanographic component of SEA (320-M) identified three physical processes that most influence the biological components of PWS, particularly phytoplankton, zooplankton and juvenile fish: surface stratification and frontal formation; upper layer circulation; and exchange between the northern Gulf of Alaska (GOA), Prince William Sound (PWS) and the PWS nearshore regions.

New finding from SEA included initial stratification formation in March in the nearshore regions, and in April in the northern Sound (Vaughan et al, 1999). In April and May, maximum phytoplankton biomass was observed in the northern Sound in 1995 and 1996 (McRoy et al, 1998). A surface horizontal density front was observed in the central Sound in April through June (Vaughan et al, 1999). A stratified surface layer next to a well mixed region, may result in a prolonged phytoplankton bloom.

The spring and summer circulation in the central Sound could be either cyclonic or anticyclonic. The mechanisms responsible for this variability have not yet been identified. Whether a cyclonic circulation promotes transport to the nearshore regions more than an anticyclonic circulation is unclear. A robust feature of the central Sound circulation is the closed cyclonic gyre in September, which was accompanied by isopycnal doming. The closed circulation could retain biological organisms in the central Sound, and the weakened stratification in the center of the gyre might promote a secondary fall phytoplankton bloom.

Easterly offshore winds can cause Ekman layer inflow at both Hinchinbrook Entrance and Montague Strait. Deeper outflow accompanied the inflow at both locations, and it is not known how far the inflow penetrated northward. The density front in the central Sound may isolate the northern Sound from GOA influence in the upper layer. In the absence of the easterly wind forcing, the upper layer summer and early fall pattern seems to be outflow at Hinchinbrook Entrance and inflow at Montague Strait. Whether these exchanges seed PWS with GOA zooplankton, or flush PWS zooplankton out into the GOA is unknown.

SEA activities in FY94 through FY96 consisted mainly of data collection and processing. Efforts in FY97 and FY98 were focused more on data analysis and manuscript preparation. Efforts in FY99 were dedicated almost entirely to the SEA synthesis, which is nearing completion. This proposal is for a new project that will build upon what was learned in SEA, and also interface with two new research programs underway in this region.

Proposed efforts in FY00 through FY02 will focus on the interannual variability of exchange between PWS and the northern GOA. A bottom-mounted upward-looking acoustic Doppler current profiler (ADCP) mooring in Hinchinbrook Entrance will provide a time series of currents as a function of depth. Measurements of temperature (T) and salinity (S) at key locations in PWS will

allow identification of different water mass properties (i.e., PWS and GOA), and provide an independent description of exchange between PWS and the GOA.

GOA water mass properties will be collected as part of the GLOBEC Northeast Pacific (NEP) program. GLOBEC monitoring surveys in the northern GOA were completed in FY99 (Dr. T. Weingartner, P.I.), and are scheduled to continue in FY00 through FY04. Process studies in the northern GOA are scheduled for FY01 and FY03. A GLOBEC survey line of particular interest is the trench on the southeastern side of Montague Island, which is almost certainly the conduit of any dense water entering PWS. The mooring velocity time series at Hinchinbrook Entrance and the PWS water mass properties will provide the data necessary to identify mechanisms responsible for both deep and shallow exchange between the GLOBEC study area (northern GOA) and PWS. Both Dr. Weingartner and Dr. D. Musgrave from the University of Alaska have expressed interest in collaborating and sharing data sets.

Anther project underway in PWS is the development of a near real-time nowcast/forecast (N/F) system, partially sponsored by the Oil Spill Recovery Institute (OSRI). The main objective of this project is to develop a prototype N/F system that will be capable of calculating current velocity vector fields, particle trajectories, and the evolution of passive drifter concentrations. It will have three main components: a numerical circulation model for PWS (Dr. C. Mooers, P.I.); an observational network for collecting and storing real-time data (Dr. S. Vaughan, P.I.); and an information/data management system (Dr. V. Patrick, P.I.). The major differences between the N/F system and what was accomplished in SEA are the addition of real-time capabilities, plus data assimilation schemes, and improved forcing functions and boundary conditions. Funding has been secured for collecting current data using a downward looking ADCP towed from one of the Alyeska SERVS vessels, and for deployment of satellite-tracked drifting buoys. In addition to identifying exchange mechanisms, the mooring velocity time series at Hinchinbrook Entrance will provide the boundary condition needed for the numerical circulation model.

This proposal is also closely linked to two EVOS projects proposed for FY00. A numerical ciruculation modeling project is being proposed by Dr. C. Mooers to use cross-correlations of observations and model output to design an optimal monitoring sampling strategy (which variables should be observed at which locations) for model data assimilation. Another project is being proposed by Dr. T. Kline to examine the stable isotope signature of diapausing copepods in PWS. Samples will be collected on the mooring deployment cruises.

NEED FOR THE PROJECT

A. Statement of the Problem

Of the three physical processes listed above, the exchange between the northern GOA and PWS is perhaps the least understood. It is not clear quantitatively what controls the amount of throughflow at Hinchinbrook Entrance. In particular, it is not known what causes the baroclinic structure in summer and fall, and the transition to a barotropic structure in winter. The Hinchinbrook Entrance velocity data collected during the SEA program revealed significant spatial (horizontal and vertical) and temporal variability of the throughflow. To document the interannual variability of the

currents at Hinchinbrook Entrance and identify mechanisms that govern the exchange, a time series of velocity data at all depths is required. A time series of observations is also needed for continued analysis using the PWS circulation model.

B. Rationale/Link to Restoration

Juvenile fish in PWS rely on zooplankton as their food source. Exchange at Hinchinbrook Entrance could either seed PWS with zooplankton or flush zooplankton out, thereby regulating the amount of available food and possibly the number of copepods diapausing in PWS in winter. The observations proposed here will be used as initial and boundary conditions in the PWS ocean circulation model. The evolution of plankton and nekton distributions under realistic forcing conditions, simulated by modeled particle trajectories and passive tracer concentrations, will be useful to both resource managers and ecosystem researchers.

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 research vessels will be chartered for oceanographic cruises in FY00. This project will contribute information to local news letters and newspaper articles. Scientific results will be posted on the SEA web page, and will be accessible to the public.

PROJECT DESIGN

A. Objectives

The main objective of this proposal is to document the interannual variability in water mass exchange between PWS and the adjacent northern GOA at Hinchinbrook Entrance, and identify mechanisms governing this exchange. This proposal consists of three parts:

1. Deploy an upward looking ADCP mooring in Hinchinbrook Entrance;
2. Collect and analyze temperature (T) and salinity (S) data from key stations in PWS;
3. Participate in data exchange and co-authored manuscript preparation.

Transports calculated from the Hinchinbrook Entrance mooring and the T/S data will provide boundary conditions for the numerical circulation model. The velocity and the T/S data can be combined with the OSRI data, and compared to GLOBEC GOA T/S data to determine the northward extent of the Ekman layer inflow, and the conditions leading to deep water exchange. Finally, support is requested to provide physical oceanographic data collected in FY00 and in previous years (under SEA) to new projects proposed by EVOS researchers, to exchange data with GLOBEC researchers, and to prepare collaborative manuscripts. This is a three year proposal.

B. Methods

1. An upward-looking ADCP mooring (RDI 150 kHz broadband) will be deployed in Hinchinbrook Entrance in October 1999 and retrieved in May 2000. This time of year includes the early spring when Gulf zooplankton my be entering PWS. Also cruises aboard the SERVS vessels are planned as part of the OSRI N/F project for the summer months. Flow patterns at Hinchinbrook Entrance can be documented in summer by making repeat transects with a downward-looking ADCP towed from the stern of the ship and averaging the profiles (Vaughan et āl, 1998).

September is more preferable for mooring deployment, but because of availability of funds, the first deployment will have to be in October. Subsequent deployments will be in September, which will mean FY00 will include three mooring cruises. Deployment dates would be, for example:

October 1999 - May 2000
September 2000 - May 2001
September 2001 - May 2002

FY01 will include two mooring cruises each (May 2001 and September 2001). FY02 will include one mooring cruise (May 2002) unless continued funding makes additional deployments possible. A vessel with a crane, A-frame, or other equipment suitable for mooring deployments will be required. If one of the SERVS vessels has this capability, or funding can be secured from another source, no vessel charter support will be required in this proposal.

2. On the spring and fall mooring cruises, hydrographic and zooplankton data will be collected at SEA stations CFOS13, NS1, SEA22, SEA27, SEA32, and HE13 (see Figure). These stations were shown to be representative of conditions throughout PWS by the SEA study. Temperature, salinity and dissolved oxygen as a function of depth will be collected using a CTD lowered from the ship. In May, upper layer zooplankton samples will be collected with a ring net. In September, diapausing copepods will be collected using a ring net at stations deeper than 400m (see proposal by Dr. T. Kline). Diapausing copepods were collected at stations SEA22 and SEA27 in 1996. Hydrographic data collection using XCTDs is planned as part of the OSRI N/F project. These data sets will be combined and compared to the GLOBEC GOA hydrographic data and to atmospheric data to identify factors that modulate PWS/GOA exchange.

3. Considerable shared data analysis and co-authored manuscript preparation was completed under SEA. Still, new findings have suggested further collaboration. In addition to the GLOBEC activities, the following EVOS investigators have expressed interest in including past and future physical oceanographic data in their analysis, and in preparing co-authored manuscripts:

Dr. B. Norcross – proposal entitled Regional Analysis of Juvenile Herring in Prince William Sound (comparing within-bay herring distributions and physical characteristics, and using methods developed for Atlantic herring; e.g. Graham, 1972).

Dr. P. McRoy - correlation between phytoplankton distribution and water mass properties surrounding decadal scale regime shifts.

Ms. E. Brown - synthesis of data collected in the SEA Herring project (320-T), including aerial surveys, acoustic data, zooplankton data, and physical oceanographic data from 1995 to 1997.

In addition, investigators from EVOS sponsored APEX projects have expressed interest in utilizing physical oceanographic data from the nearshore bays and fjords. For example, since zooplankton and some forage fish form dense layers around the pycnocline, the depth of the mixed layer may determine how efficiently diving birds can feed.

C. Cooperating Agencies, Contracts and Other Agency Assistance

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

SCHEDULE

A. Measurable Project Tasks

FY00:

October 1999: Mooring deployment and PWS cruise
January 2000: EVOS Workshop - Anchorage
April 15, 2000: FY99 Annual Report due
May 2000: Mooring retrieval and PWS cruise
September 2000: Mooring deployment and PWS cruise
September 2000: Manuscripts submitted

FY01:

January 2001: EVOS Workshop - Anchorage
April 15, 2001: FY00 Annual Report due
May 2001: Mooring retrieval and PWS cruise
September 2001: Mooring deployment and PWS cruise

FY02:

January 2002: EVOS Workshop - Anchorage
April 15, 2002: FY01 Annual Report due
May 2002: Mooring retrieval and PWS cruise

FY03:

January 2003: EVOS Workshop - Anchorage
April 15, 2003: FY02 Final Report due

B. Project Milestones and Endpoints

Data processing of the hydrographic data from each cruise will be completed before the following cruise. Processing of the mooring data obtained in May of each year will be completed before the following September. Data exchange with other EVOS investigators will be completed by September 2000. The endpoint of each fiscal year will be marked by the Annual Report due date (April 15 of 2001, 2002 and 2003).

C. Completion Date

All project objectives will be completed in FY02 except for submission of the final report. The completion data of this project is April 15, 2003.

PUBLICATIONS AND REPORTS

Physical Processes Influencing the Pelagic Ecosystem of Prince William Sound, Fisheries Oceanography, October 1999.

Factors influencing Pacific herring larval retention within the bays and fjords of Prince William Sound (with B. Norcross), Fisheries Oceanography, September 2000.

Factors influencing nutrient and phytoplankton variability on decadal time scales (with P. McRoy), journal TBA, September 2000.

PROFESSIONAL CONFERENCES

Travel is requested to present results at the EVOS Workshops in January of each year in Anchorage.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be linked to the OSRI sponsored nowcast/forecast system development. It will be coordinated with the efforts of Dr. C. Mooers (numerical modeling), Dr. T. Kline (stable isotope analysis), and Drs. T. Weingartner and D. Musgrave (GLOBEC). There will also be continued collaboration with SEA investigators, particularly Dr. B. Norcross, Dr. P. McRoy, and Ms. E. Brown. This project will cooperate with APEX 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@pwssc.gen.ak.us

PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
Physical Oceanographer, Prince William Sound Science Center
(P.I. of SEA Physical Oceanography project 320-M)

Education:

B.S., University of Miami, May 1981, Physics (major)/Mathematics (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 Meteorological 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.

LITERATURE CITED

Graham, J.J., 1972: Retention of larval herring within the Sheepscot Estuary in Maine. *Fish. Bull.*, **70** (2), 299-305.

McRoy, C.P., A. Ward, E.P. Simpson, J. Cameron, K. Tamburello, S. McCullough, and P. Cassidy, 1998: Sound Ecosystem Assessment: Phytoplankton and Nutrients. *Exxon-Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 97320-G), Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

Vaughan, S.L., S.M. Gay, L.B. Tuttle, and K.E. Osgood, 1998: SEA: Observational Oceanography in Prince William Sound. *Exxon-Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 97320-M), Prince William Sound Science Center, Cordova, Alaska.

Vaughan, S.L., C.N.K. Mooers, J. Wang, S.M. Gay, and L.B. Tuttle,1999: Physical Processes Influencing the Pelagic Ecosystem of Prince William Sound. *Exxon-Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 98320-M), Prince William Sound Science Center, Cordova, Alaska.

2000 EXXON VALDEZ TI EE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$0.0
Travel		$0.0
Contractual		$153.4
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$153.4
General Administration		$10.7
Project Total	$0.0	$164.1
Full-time Equivalents (FTE)		0.7
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

FY00

Prepared:

Project Number: 00552-BAA
Project Title: Exchange between PWS and the Gulf of Alaska
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TI EE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$52.4						
Travel		$6.3						
Contractual		$56.6						
Commodities		$4.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$119.3			Estimated FY 2001	Estimated FY 2002		
Indirect (28.6%)		$34.1						
Project Total	$0.0	$153.4			$133.5	$107.5		
Full-time Equivalents (FTE)		0.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY00

Prepared:

Project Number:
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2000
Shari Vaughan	Physical Oceanographer (PI)		4.0	7500.0		30,000.0
Shelton Gay	Physical Oceanographer		4.0	5600.0		22,400.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	13100.0	0.0	
					Personnel Total	$52.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2000
EVOS Workshop - Anchorage - January 2000	185.0	2	5	140.0	1,070.0
1 r/t Cordova-Fairbanks	440.0	1	3	140.0	860.0
1 r/t Cordova-Miami	960.0	1		0.0	960.0
3 r/t Miami-Cordova	960.0	3	4	140.0	3,440.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.3

FY00

Prepared:

Project Number:
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2000
Vessel Charter (3 cruises, 5 days each @ $3000 per day)	45,000.0
Equipment calibration/repair	2,000.0
Network costs and maintenance ($100/computer-month)	2,000.0
Professional servies - mooring technician ($2000 per cruise)	6,000.0
Phone, fax, copying	800.0
Mail, freight, shipping	800.0
Contractual Total	$56.6

Commodities Costs:	Proposed
Description	FY 2000
Office supplies	500.0
Computer supplies	500.0
Marine supplies	3,000.0
Commodities Total	$4.0

FY00

Prepared:

Project Number:
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TF EE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number	
Description	of Units	
150 kHz RDI ADCP and mooring components (floatation, releases, hardware)	1	
150 kHz RDI ADCP and towbody	1	
SBE 911 CTD and rosette	1	

FY00

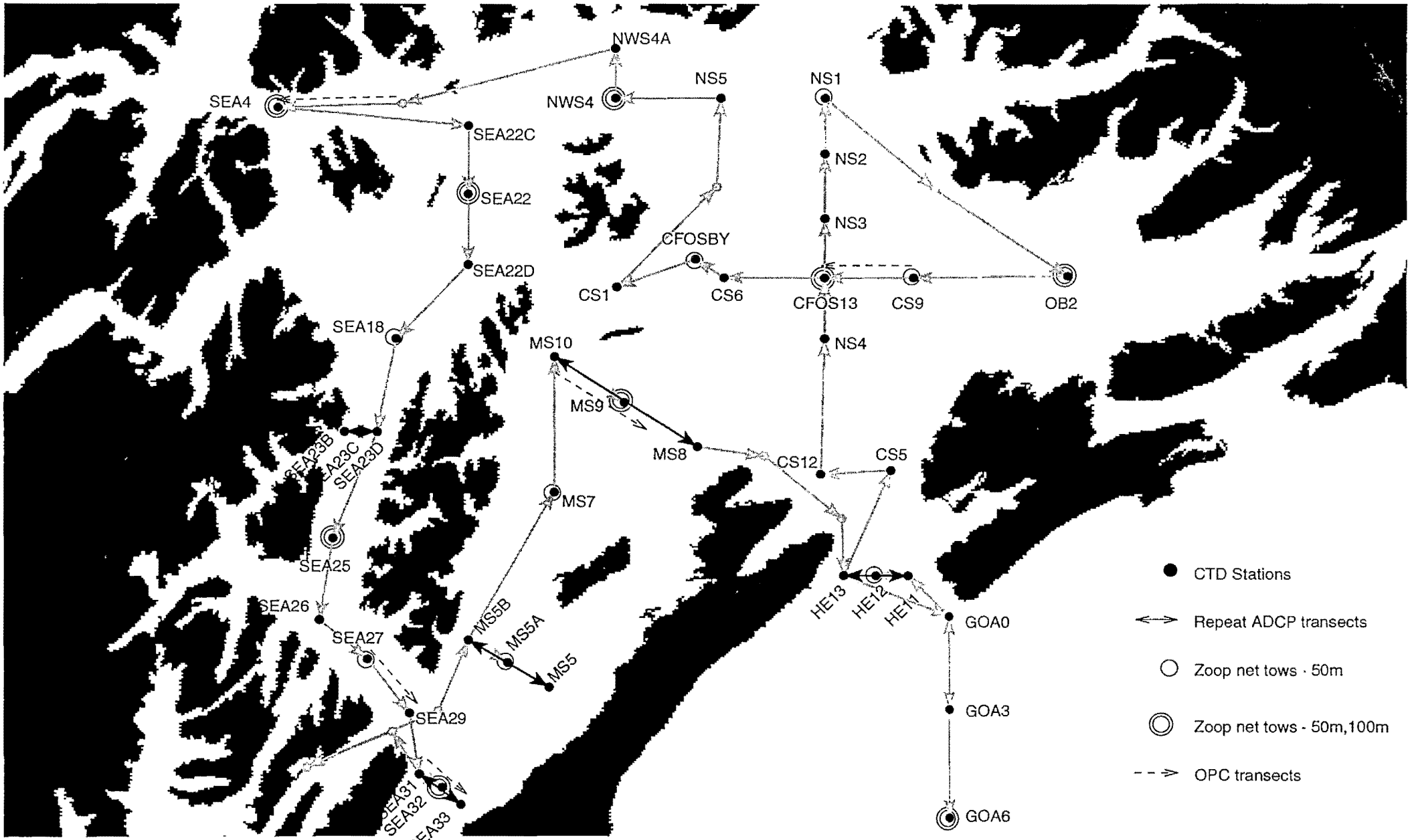
Prepared:

Project Number:
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

FORM 4B
Equipment
DETAIL

SEA Oceanography Cruise - June 1996

9609



00552

Project Title: Comparison of Cytochrome P450 1A Induction in Blood and Liver Cells of Sea Otters

Project Number:	00553
Restoration Category:	Research and Monitoring
Proposer:	Brenda E. Ballachey and Paul W. Snyder
Lead Trustee Agency:	DOI: U.S. Geological Survey
Cooperating Agencies:	
Alaska SeaLife Center:	No
Project Duration:	1st year, 2-year project
Cost FY 00:	$22,300
Geographic Area:	WPWS
Injured Resource/Service:	Sea otter

ABSTRACT

Sea otters in oiled areas of western PWS had elevated levels of cytochrome P450 1A (CYP1A), a biomarker of hydrocarbon exposure, measured in blood samples collected from otters in 1996-98. In summer 2000, as part of project 00423, we have proposed to resample CYP1A in blood from sea otters in oiled and unoiled areas of PWS. Herein we describe a complementary effort to project 00423. We propose also to sample liver from captured sea otters, for assays of CYP1A, and for examination of histopathological changes. Liver CYP1A levels will be compared to those measured in blood from the same individuals. We will also assay for CYP1A in archived frozen liver samples from sea otters that were oiled and died in 1989, to enable comparison of current levels of CYP1A induction with levels in sea otters that had a known, high degree of oil exposure. The results of this study will provide a basis for comparison of cytochrome P4501A induction in sea otters in 1989, in 1996-98, and in 2000, and will help determine if there is a decline over time in CYP1A levels.

INTRODUCTION

In the NVP project (/025), sea otters were evaluated for increased levels of cytochrome P450 1A (CYP1A) in blood (peripheral blood mononuclear cells), as a biomarker of exposure to environmental hydrocarbons. Data from 1996-98 show elevations of CYP1A in otters from oiled areas, compared to those from unoiled areas.

We do not have archived blood samples from previous years that are suitable for assays of CYP1A, and so cannot compare CYP1A levels currently observed to levels that would have been present in sea otters exposed to oil in the months immediately after the 1989 oil spill. We do, however, have archived liver samples from 1989, which should be suitable for the assay of CYP1A; most of those samples also have data on tissue hydrocarbon concentrations, collected as part of NRDA studies.

Further monitoring of CYP1A in sea otters, in the summer of 2000, is currently proposed as part of Project 00423. Our goal herein is to supplement measurement of CYP1A in blood from those otters with assays on liver biopsies from the same individuals, to establish the relation between CYP1A in the two tissue types. We further propose to assay archived liver samples collected from sea otters that died in the summer of 1989. The comparison of liver levels from 1989 and 2000 would give an indication of the relative levels of exposure, 11 years after the spill.

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters in the most heavily oild areas of western Prince William Sound (WPWS) have not yet recovered from the *Exxon Valdez* oil spill (Holland-Bartels et al 1998), based on several lines of evidence from studies conducted as part of the NVP project (95025-99025). Significant NVP results on sea otters include lack of population growth in the oiled study area, indications of increased mortality and/or emigration of sea otters from the oiled area at a higher rate than their counterparts in the unoiled study area, and increased induction of CYP1A in the oiled area. Elevations in CYP1A do not appear to be due to background or natural hydrocarbon sources, as these were found to be negligible in intertidal areas of PWS (Short and Babcock 1996). NVP studies on harlequin ducks also found that elevated CYP1A induction in oiled areas was not due to area differences in PCB exposure (D. Esler, unpubl. data), leaving continued exposure to residual *Exxon Valdez* oil as the most plausible explanation. Residual oil is still stranded in intertidal areas of PWS (Babcock et al. 1996), providing a continuing potential source of contamination. The extent to which continuing exposure to residual oil may be constraining sea otter population recovery is not known (Project 00423 contains objectives designed to address this question).

The NVP CYP1A data cover the period from 1996-98. At this time, comparable data on CYP1A induction in sea otters are not available from earlier post-spill years (1989-95). However, such data would be valuable as they would a benchmark for evaluation of degree of exposure seen in

samples collected presently to samples collected in the months post-spill, and thus a measure of the relative continuing exposure.

Measurement of CYP1A in sea otters in the NVP project used a quantitative RT-PCR technique on peripheral blood mononuclear cells. Although there are no archived samples of blood cells that would be suitable for the RT-PCR assay, the assay can also be applied to liver or other tissue samples, and archived frozen liver samples are available. These liver samples were collected from sea otters that died in 1989 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 showed histopatholgical changes (Lipscomb et al. 1993); CYP1A levels were probably markedly elevated. Further, hydrocarbons concentrations were 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 work in conjunction with the sea otter capture and CYP1A monitoring effort being proposed for the summer of 2000 in Project 00423. As part of that project, sea otters will be captured and blood samples taken for CYP1A evaluation. In this project, we propose to supplement the blood sampling/CYP1A effort with collection of liver biopsies from the same otters, also for analysis of CYP1A using the RT-PCR assay. This will enable us to establish the relation between CYP1A induction in blood and liver cells. We further propose to analyze 30 archived liver samples, including samples from heavily oiled otters.

The results of this study will provide a basis for comparison of cytochrome P4501A induction in sea otters in 1989, in 1996-98, and in 2000, and will help determine if there is a decline over time in CYP1A levels.

B. Rationale/Link to Restoration

This research will provide a means for us to relate present levels of CYP1A induction, measured in sea otters from oiled areas of PWS and other locations, with levels of CYP1A induction in oiled sea otters collected in 1989, after the spill, thus providing insight into the degree of exposure currently being experienced by sea otters. It also gives an opportunity for histological examination of liver tissues from sea otters in oiled areas, which may be informative in terms of understanding apparent differences in survival rates between areas. Additionally, adaptation of the assay for liver tissues will allow us to obtain samples from other sources (e.g., natural mortalities, subsistance hunters), for monitoring of CYP1A and comparison of oiled and unoiled levels.

C. Location

The samples will be collected in western PWS. Assays of CYP1A and histopathology will be done at Purdue University.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

We will interact with local communities in meetings to explain and discuss ongoing restoration projects (this effort coordinated with similar activities for project 00423).

PROJECT DESIGN

A. Objectives

1. Measure and compare CYP1A in blood (PBMC) and liver samples from sea otters captured in summer 2000.

2. Measure CYP1A in archived liver samples of oiled sea otters from 1989; compare liver CYP1A values from 2000 to 1989 samples.

3. Do histopathological examination of liver biopsies from 2000, to assess relation between CYP1A levels and histological change in the liver.

4. Relate CYP1A levels in 1989 liver samples with hydrocarbon concentrations measured previously, and histopathology collected previously on those samples.

B. Methods

In the NVP study, the RT-PCR assay (quantitative reverse transcriptase PCR assay; Van den Heuvel et al. 1993, Snyder et al. unpub. ms) was adapted to measure CYP1A levels in sea otters. This assay quantifies the messenger RNA (m-RNA) that codes for the CYP1A protein, and results are reported as molecules of mRNA per 100 ng of RNA. For sea otters, the assay has been applied only to peripheral blood mononuclear cells; we will adapt it for measurement of CYP1A in liver cells.

In summers of 2000, we have proposed (project 00423) to capture 60 sea otters (30 per area) in the same areas (Knight and Montague islands) that were sampled in the NVP project, so that additional data collected can be directly compared to previous (1996-98) results. Capture and handling methods will be similar to those employed previously (Holland-Bartels et al. 1998). Sea otters will be sedated, body measurements taken, a tooth collected for age determination, and a blood sample taken by jugular venipuncture. In addition, a liver biopsy weighing approximately .5 gm will be surgically collected from 20 otters per area, by a qualified veterinarian. One portion will be frozen in LN2 and a second fixed in formalin. Following reversal, sea otters will be released in the same vicinity as captured.

Samples (liver and blood cells) will be shipped to Purdue University for analysis in the laboratory of Dr. Paul Snyder. CYP1A will be measured by the RT-PCR assay, and liver samples in formalin will be examined for evidence of histological change.

The data will be used to determine the relation between CYP1A in blood and liver. We will compare mean CYP1A values in liver samples from 2000 and 1989. We will look for a correlation between CYP1A in liver and histopathological change in hepatic cells. We will also relate liver histopathology and CYP1A levels to serum chemistry, including serum enzymes, measured as part of work outlined in Project 00423. Finally, for the 1989 liver samples, we will correlate total hydrocarbons in liver (data from NRDA studies) and histopathology (Lipscomb et al. 1993) with CYP1A induction.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

SCHEDULE

A. Measurable Project Tasks for FY 00

July:	Capture and sampling of sea otters.
August-Sept.:	CYP1A analyses on liver samples from 2000 and from 1989, data analyses.

B. Project Milestones and Endpoints

1.	July 2000:	Collection of liver samples from live otters.
2.	Aug-Sept:	Analyses of new (year 2000) and old (year 1989) liver samples for CYP1A. Data analyses.
3.	April 15, 2001:	Report submission - April 15, 2001.

C. Completion Date

This is a one year project; work will be completed in FY2000 and a final report submitted by April 15, 2001.

PUBLICATIONS AND REPORTS

We will provide a final report to the EVOSTC office by April 15, 2001. We anticipate a manuscript on the results to be submitted to a scientific journal in the year 2001.

PROFESSIONAL CONFERENCES

None planned for FY2000.

NORMAL AGENCY MANAGEMENT

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is dependent on funding of sea otter capture as part of Project 00423; otherwise we cannot complete the stated objectives.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This is a new project proposal.

PRINCIPLE INVESTIGATORS

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

Paul Snyder, DVM, PhD
Purdue University
Department of Veterinary Pathobiology
West Lafayette, IN 47907-1243
PHONE: (765) 494-9676
FAX: (765) 494-9830
pws@vet.purdue.edu

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

Dr. Paul Snyder is an Assistant Professor of Pathology and Immunotoxicology and Director of the Clinical Immunology Laboratory of the Department of Veterinary Pathobiology, Purdue University. He is also a 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 been a PI on the Nearshore Vertebrate Predator project since 1995.

OTHER KEY PERSONNEL

LITERATURE CITED

Babcock, M. M., G. V. Irvine, P. M. Harris, J. A. Cusick, and S. D. Rice. 1996. Persistence of oiling in mussel beds three and four years after the *Exxon Valdez* oil spill. Am. Fish. Soc. Symp. 18:286-297.

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Holland-Bartels, L. et al. 1998. Mechanisms of impact and potential recovery of nearshore vertebrate predators. Exxon Valdez Oil spill restoration project annual report 97025. April, 1998.

Lipscomb, T.P., R.K. Harris, R.B. Moeller, J.M. Pletcher, R.J. Haebler and B.E. Ballachey. 1993. Histopathologic lesions in sea otters exposed to crude oil. Vet. Path. 30:1-11.

Short, J. W., and M. M. Babcock. 1996. Prespill and postspill concentrations of hydrocarbons in mussels and sediments in Prince William Sound. Am. Fish. Soc. Symp. 18:149-166.

Vanden Heuvel, J.P., G.C. Clark, C.L. Thompson, Z. McCoy, C.R. Miller, G.W. Lucier and D.A. Bell. 1993. CYP1A1 mRNA levels as a human exposure biomarker: use of quantitative polymerase chain reaction to measure CYP1A1 expression in human peripheral blood lymphocytes. Carcinogenesis 14:2203-2006.

2000 EXXON VALDEZ TRU E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$7.7
Travel		$2.7
Contractual		$9.5
Commodities		$0.6
Equipment		$0.0
Subtotal	$0.0	$20.5
General Administration		$1.8
Project Total	$0.0	$22.3
Full-time Equivalents (FTE)		0.1
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

No costs are included for NEPA compliance, technical review session attendance, restoration workshop attendance, report writing, publications, professional conferences, or community involvement.

FY00

Prepared: 15 April 99

Project Number: 00553
Project Title: Comparison of Cytochrome P450 1A Induction in Blood and Liver Cells of Sea Otters
Agency: DOI

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2000
B. Ballachey	Research Physiologist	GS 12 / 04	1.0	6.0		6.0
Technical support	Biologist	GS 7	0.5	3.3		1.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.5	9.3	0.0	
					Personnel Total	$7.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2000
Airfare & per diem, Indiana - Alaska RT (Snyder)	0.7	1	20	0.1	2.7
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2.7

FY00

Prepared: 15 April 99

Project Number:
Project Title: Comparison of Cytochrome P450 1A Induction in Blood and Liver Cells of Sea Otters
Agency: DOI

FORM 3B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRU : **COUNCIL PROJECT BUDGET**

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2000
4A Linkage	0.0
Assays of liver for cytochrome P450 1A, histopathology 70 @ $135	9.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$9.5

Commodities Costs:	Proposed
Description	FY 2000
Veterinary supplies	0.6
Commodities Total	$0.6

FY00

Prepared: 15 April 99

Project Number:
Project Title: Comparison of Cytochrome P450 1A Induction in Blood and Liver Cells of Sea Otters
Agency: DOI

FORM 3B
Contractual & Commodities
DETAIL

2000 EXXON VALDEZ TRU | **COUNCIL PROJECT BUDGET**

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

FY00

Project Number:
Project Title: Comparison of Cytochrome P450 1A Induction in Blood and Liver Cells of Sea Otters
Agency: DOI

FORM 3B
Equipment
DETAIL

Prepared: 15 April 99

2000 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Comments:

FY00

Prepared:

Project Number:
Project Title:
Name:

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:				Months	Monthly		Proposed
	Name	Position Description		Budgeted	Costs	Overtime	FY 2000
							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 2000
						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

FY00

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRU: COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed FY 2000
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2000
Description	
Commodities Total	$0.0

FY00

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Contractual & Commodities DETAIL

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

Existing Equipment Usage: Description	Number of Units	

FY00

Project Number:
Project Title:
Name:

FORM 4B
Equipment
DETAIL

Prepared:

Over-winter foraging ecology of injured marine piscivores in Prince William Sound, Alaska: the effects of winter-food limitation on recovery (submitted under BAA)

Project Number:	~~00XXX~~ 00557 -BAA
Restoration Category:	Research
Proposer:	Dr. David Scheel and Dr. G.L. Thomas, Prince William Sound Science Center
Lead Trustee agency:	NOAA
Cooperating agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, two year project
Cost FY00:	$198,700
Cost FY01:	$195,800
Geographic area:	Prince William Sound
Injured Resource/Service:	Focus on harbor seals, killer whales and common murres, with possible observations of common loons, cormorants (3 species), harlequin ducks, piegon gullemots, and marbled murrelets.

ABSTRACT

We propose to collect data during the winter in Prince William Sound, Alaska, where fish surveys over the past six years have found harbor seals, killer whales common murres and several other injured piscivores feeding on aggregations of forage fishes. The forage fishes, Pacific herring and walleye pollock, were found in just a few locations as large, discrete and segregated schools so the injured piscivores have a choice a choice of forage. We will make synoptic observations walleye pollock, Pacific herring, harbor seals, killer whales and common murres along with other injured species to evaluate overwinter feeding preference and success. These data will be used to address hypotheses about food limitation on the recovery of injured species during the season most critical to survival, the winter.

INTRODUCTION

Pinniped and seabird populations throughout the North Pacific Ocean are in decline (National Research Council 1996; Livingston et al. 1999). These declines were first detected off western Alaska during the 1970s and were later detected elsewhere (Alaska Sea Grant College Program 1993). A common characteristic of the species in decline is that they are all piscivorus (e.g. harbor seals, murres and kittiwakes). Due to the fact that mortality is highest in the winter season for these piscivores and the population declines are continuing, including for three EVOS-injured species (harbor seal, killer whales and common murres), there is an urgent need for data on the winter foraging ecology of these species

Correlations between many independent observations strongly suggest food limitation as the reason for these population declines but to date the underlying mechanisms have not been verified. Competition with commercial fisheries has been suggested as a mechanism, in part because the declines coincide with major growth in the fishing industry in the region (National Research Council 1996, Center for Marine Conservation 1997). However, climate change is also implicated in the changing production of many marine species (Hollowed et al. 1998) confounding the competition hypothesis. Other possible causes, such as direct mortality related to commercial fishing, increased predation, disease, human take, disturbance at rookeries, or mortality from pollution are not similarly implicated. Since the mechanism of food limitation is unclear one of the highest research priorities is for observational data on the foraging ecology of these piscivores when feeding is critical to survival. Overwinter survival is a critical determinant for population trends, thus overwinter feeding ecology is one of the highest priorities for observational research. Due to the logistic difficulties, observations of the winter feeding ecology of marine piscivores in the North Pacific represents a major gap in current knowledge.

In this proposal, we request support to collect such data during the winter in Prince William Sound (PWS), Alaska, where fisheries assessment studies in the past six years have found marine piscivores feeding on aggregations of over-wintering fish (Thomas et al. 1997). Our plan is to make synoptic observations of the distribution of walleye pollock *Theragra chalcogramma*, Pacific herring *Clupea harengus,* harbor seals, killer whales, common murres and associated piscivores to evaluate overwinter feeding preference and success. These data will be used to address competing hypotheses about the mechanism of food limitation in declining north Pacific piscivores.

Restrictions to commercial fisheries were imposed (National Marine Fisheries Service 1992) on the hypothesis that the depletion of pollock and other fish stocks has contributed to the declines. We refer to this idea as the "pollock-limited" hypothesis because of the inference that access to more pollock would reduce nutritional stress. This idea is also referred to as the depletion hypothesis. A competing hypothesis argues that marine regime shifts, possibly fueled by climate change, have resulted in an increase in pollock stocks at the expense of fat-rich fish (herring, sand lance, capelin). We refer to this as the "herring-limited" hypothesis. The herring-limited hypothesis encapsulates another well-known concept, the junk-food hypothesis, which holds that the available diet of pollock is insufficiently energy-rich to support population growth in these species (Alaska Sea Grant College Program 1993, Roby et al. 1999) with a prey-escape behavior

mechanism, the bait-ball hypothesis (Thorne and Thomas, 1988).

The mechanism of food limitation differs between the pollock- and the herring limited hypotheses. Pollock may have been depleted by fisheries or their distribution so disrupted by commercial fisheries that marine birds and mammals are starving for a lack of availability of this food (pollock-limited hypothesis). Alternatively, piscivores are feeding on an abundance of pollock in the absence of adequate herring, but pollock is nutritionally inadequate and too difficult to capture during at least one life stage critical for population growth (herring-limited hypothesis).

In addition to the EVOS Trustee Council's concerns for the recovery of injured species, the population declines of some marine bird and mammal species in the north Pacific are a major concern of conservation groups (Center for Marine Conservation 1997), management groups (Livingston et al. 1999), research groups (National Research Council 1996), the fishing industry, Alaska Natives and the general public. The leading hypotheses for understanding these declines across a broad suite of species focus on foraging ecology and the possible reciprocal changes in the abundance of low-energy pollock and fat-rich fishes such as the Pacific herring. We propose to document predator preference for prey species (pollock vs. herring) and school characteristics in an area where these two species occur as the dominant winter forage fishes.

NEED FOR THE PROJECT

A. Statement of Problem

Present state of knowledge

Schooling behavior of pollock & herring: When escaping predators, small schools of fat-rich fish break from the large school deep in the water column and flee to the surface forming high density, near-surface schools commonly referred to as "bait balls" (Thorne and Thomas 1988). It is our hypothesis that pollock do not behave in this manner, but instead may flee downward and disperse (they do not form bait balls at the surface). We suggest that foraging costs on pollock and herring differ due to these species-specific schooling and predator-avoidance behaviors, as well as to the different fat content of the fish. Under the pollock-limited hypothesis, the effects of reduction and dispersal of pollock schools by commercial fishing may be cumulative and reduce pollock availability as food. Under the herring-limited hypothesis, declines in herring may force piscivores to forage on pollock, a prey that is inadequate by virtue of both its low energy concentration and the high energy expenditure required to feed on deep and dispersed schools.

When herring (and other fat-rich fish) aggregate at the surface, they fall prey not only to deep diving predators but also to other predators which cannot dive deep. This surface-aggregating escape behavior of herring may reduce the cost of capture for predators and increase the difference in net energy intake between a diet of pollock and a diet of herring. Some catalyst may be required to disturb deep schools and cause the formation of near-surface bait balls. Possible catalysts may include commercial fishing, deep-foraging predators such as humpback

and killer whales, harbor seals, Steller sea lions, salmon sharks, cod, salmon and common murres and other diving birds (Chilton & Sealy 1987) that disturb deep schools and chase fish toward the surface. Such a catalyst has been suggested as a mechanism for increased foraging efficiency in mixed-species flocks of seabirds (Hoffman et al. 1981, Chilton & Sealy 1987). Predators that modify prey behavior in a manner that makes the prey more accessible to other predators are referred to as "facilitating predators" (Hoffman et al. 1981, Kotler et al. 1992). Thus the energy gains available to predators on herring schools may depend on the presence of one or more co-occurring facilitating predators. In any case, all predators benefit when the prey are at the surface and do not require the energy expenditure of a prolonged 100+ m dive.

Previous work & work-in-progress by the Principal Investigators

Each principal investigator brings a different strength to this proposal from previous work. Dr. Thomas is a fisheries scientist with over 20 years of experience in acoustic assessment of fish distribution, abundance and behavior. For the past six years he has studied the overwinter distribution of herring and pollock aggregations in Prince William Sound that we propose to study here. Dr. Scheel is an ecologist and modeler with fourteen years experience applying the techniques proposed here in studies of the foraging ecology of seabirds, killer whales, and African lions.

Overwinter refugia of Pacific Herring and walleye pollock

Since 1993, Dr. Thomas has conducted annual surveys of overwintering aggregations of herring and pollock in Prince William Sound (PWS). Thomas et al. (1997) demonstrated that by avoiding truncation of the schools during line transect surveys, estimation of the biomass of these aggregations can be highly repeatable. The fact that these aggregations of fish have appeared at the same locations every year and that these locations are the primary spawning areas suggests that the stocks are distinct to Prince William Sound. Irons and Piatt (1999) concluded that when forage fishes are predictable in their distribution, seabirds learn, remember and repeatedly return to these locations. Such observations are also true for killer whales and possibly other marine mammals (Thomas and Felleman 1991).

Six years of surveys combined with intensive ecosystem research (the Sound Ecosystem Assessment Program, SEA) in Prince William Sound have determined walleye pollock and Pacific herring to be the dominant fishes of the pelagic fish community (Thomas et al 1997; Thomas et al. 1999). These findings were corroborated by another large-scale research program, the Alaska Predator Experiment (APEX), which concluded that the offshore habitat of PWS was dominated by walleye pollock and nearshore habitat dominated by Pacific herring and sand lance *Ammodytes hexapterus* (Duffy 1999). Since the sand lance is restricted to nearshore habitats with sand and gravel substrates (Ostrand 1999) and this habitat is limited, we conclude from the overwinter biomass surveys that herring is the dominant fat-rich forage fish available to piscivores in PWS.

In summary, we have a study location that has been accessible to acoustic surveys of forage fish over the past six years during the winter. The forage fish species are two: the energy-poor walleye pollock and fat-rich herring, who together represent an ideal setting for testing hypotheses regarding whether piscivore energy gains are pollock-limited or herring-limited And

every year, harbor seals, murres, kittiwakes, sea lions, humpback whales and other seabirds have been observed feeding on these fish aggregations. These circumstances, combined with the methods and experience of the PIs make this research proposal uniquely able to answer some previously untested questions concerning overwinter utilization of forage fish by piscivores.

Foraging Ecology

Dr. Scheel has conducted three foraging studies directly relevant to the work proposed here. Two studies focused on mapping the distribution and behaviors of predators (Scheel & Hough 1997; Scheel et al. *in prep*). Scheel & Hough (1997) mapped the distribution of seabird aggregations using aerial surveys. Seabirds recorded during aerial surveys throughout Prince William Sound were significantly associated with spawning herring and hatchery release sites. The correlation of bird aggregations with the presence of these small fish indicates that concentrations of forage fish have an important influence on the distribution of birds at sea. Other studies have obtained similar results in PWS (Piatt & Irons 1999, Irons & Piatt 1999). Using a combination of field observations and published models of seabird energetics, Scheel & Hough (1997) estimated mortality to hatchery-released fry following fry release. Scheel et al. (*in prep*) mapped the distribution of killer whale pods in Prince William Sound and examined whale behavior to identify important foraging areas. Scheel is also developing estimates of harbor seal mortality from killer whale predation as a possible contributing cause to harbor seal population declines in Prince William Sound.

In earlier research work, Scheel examined the foraging ecology of African lions in Serengeti National Park, Tanzania (Scheel 1993a,b, Scheel & Packer 1991, 1995). Characteristics of preferred prey were determined using focal animal sampling and surveys of prey and predator distribution (Scheel 1993b, Scheel & Packer 1995). Diet optimization models were used to predict the diet of rate-maximizing lions (Stephens & Krebs 1986) and predictions were compared to field data (Scheel 1993b). These data were used to examine the influence of prey availability on habitat selection by lions (Scheel 1993b, Scheel & Packer 1995). Related work in the Serengeti has shown the importance of starvation among juvenile lions during the season of prey scarcity in limiting pride success (Packer et al. 1988, 1990, Hanby et al. 1995).

B. Rationale/Link to Restoration

The marine piscivores that are listed as "not recovering" and found in the overwinter areas of Pacific herring and walleye pollock are harbor seals, common loon, cormorants (three species), killer whales (AB pod) and pigeon guillemot. The marine piscivores that are listed as "recovering" and found in the overwintering areas of the Pacific herring and walleye pollock are common murres and marbled murrelets. The Pacific herring is also listed as "recovering."

The leading hypothesis for the lack of, or delayed recovery is nutritional limitation, but the mechanisms of limitation are unknown. Duffy (1999) summarized the findings of the APEX project and concluded that it is most likely the lack of fat-rich fish such as herring and sand lance (the junk-food hypothesis or herring-limited hypothesis) that is preventing the recovery of injured piscivores. This proposal seeks to examine the herring-limited versus the pollock-limited (depletion) hypothesis in the winter period that is most critical to the survival of these recovering

species by first examining their co-occurrence with forage fish to assess their preference for, and dependence on forage fish in the winter and describe their feeding ecology.

Relation to Other Damage Assessment/Restoration Work
This research will build on the foundations laid by Sound Ecosystem Assessment (SEA) to and the Alaska Predator Experiment (APEX) to understand the fisheries ecosystem and ecology of injured piscivores in Prince William Sound. However, neither program has directly examined the preference of winter foragers for schools of pollock vs. herring, which is the purpose of this study.

C. Location

This research will be conducted in Prince William Sound. Field work will be located in the southern Sound and analysis will occur at the PWS Science Center.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Based in Cordova, Alaska, and functioning as a regional host for research activities in the Sound, the Prince William Sound Science Center is guided by a diverse Board of Directors which includes many local representatives from Alaska Native, commercial fishing, conservation and business groups, as well as a group of distinguished marine scientists. This project will also charter vessels owned by local commercial fishermen and consult with subsistence hunters, local Alaska Natives, the Alaska Native Harbor Seal Commission and local, state and public researchers who have knowledge of herring, pollock, harbor seals and sea birds in this region.

PROJECT DESIGN

A. Objectives

In this proposal we request support to describe the physical-biological conditions in the winter foraging habitat of dominant marine piscivores in PWS (harbor seals, killer whales and common murres), measure co-occurrence with forage fishes and assess prey preference. This information will enable the future development of spatially explicit energetic models of foraging behavior and energy budgets under varying prey scenarios. These steps are prerequisites to understanding overwinter survival of these marine piscivores.

OBJECTIVE 1: The first year will be devoted to determining the characteristics of areas where predators aggregate, and especially whether they aggregate near schools of either pollock or herring. This will include three tasks. (1) We will map distributions of marine predators and prey on two scales: a broad regional scale (from north Montague Island to Port Bainbridge) and at a finer scale over aggregations of prey (likely within Zaikoff and Rocky Bays and Port Bainbridge). (2) We will describe the predator aggregations (age-sex composition and behavior) in foraging areas. (3) We will record detailed descriptions (biomass estimates, species

composition, depth) of fish in areas where marine piscivores aggregate.

Using these data, we will test the following hypotheses regarding predator preference for schooling prey. All hypotheses refer to marine piscivores in Prince William Sound in the winter.

HYPOTHESIS A (NULL): Predators exhibit no preference for either pollock or herring. Either (1) predators are distributed randomly with respect to schools of potential (i.e. they are not foraging), (2) they aggregate indiscriminately near fish schools without regard to school size or content (i.e. they are responding only to prey presence or absence), or they do not distinguish between prey types but still exhibit a preference for larger concentrations of prey (i.e. they form an ideal free distribution, IFD. Fretwell & Lucas 1970). An IFD may form (3) according to the energy content of alternative prey sources (e.g. if predators act as optimal foragers and energy in either prey species is equally available) or (4) according to the available biomass of prey (if predators act as "satisficers" (Stephens and Krebs, 1986) that rely on hunger cues alone to make foraging decisions).

HYPOTHESIS B (POLLOCK PREFERENCE): Predator aggregations occur disproportionately (relative to hypothesis A) near schools of pollock, regardless of the availability of herring.

HYPOTHESIS C (HERRING PREFERENCE): Predator aggregations occur disproportionately (relative to hypothesis A) near herring schools, regardless of the availability of pollock.

Both herring and pollock winter aggregations have been recorded in previous years within a few miles of each other in Prince William Sound. Marine piscivores are wide-ranging animals; and so testing predictions will be a matter of comparing predator aggregations over schools of each prey type. The six predictions are mutually exclusive. Failure to reject prediction A1 (not foraging) suggests that predators are not using PWS as winter foraging habitat; failure to reject A2 (presence/absence) suggests that predators are foraging but that differences between prey schools are not important; failure to reject A3 (IFD, optimal diet) would indicate that the energy content of a school is its only important characteristic; and failure to reject A4 (IFD, satisficing diet, Stephens and Kreb 1987) would suggest that predators are satisficing foragers only and that the energy content of their diet has not shaped foraging decisions. Failure to reject any of the predictions of the null hypothesis would not lend support to either the pollock-limited or the herring-limited hypothesis.

However, failure to reject prediction B (pollock preference) would support the idea that pollock are preferred prey. This in turn, would tend to discredit the herring-limited hypothesis. Conversely, failure to reject prediction C (herring preference) would support the idea that herring are preferred prey and tend to discredit the pollock-limited hypothesis.

Different schooling and escape behaviors of pollock and herring may affect predator foraging success on these prey (see above under Schooling Behavior). This is a hypothesis about the mechanism resulting in a preference for pollock or herring (hypotheses B and C), and leads us to our second objective:

OBJECTIVE 2: Describe the schooling and aggregate predator escape behaviors of pollock and herring using hydroacoustic data and 3-D visualization techniques.

As a prerequisite to understanding overwinter survival of the predators and to testing both the pollock and herring-limited hypotheses, it is necessary to contrast the behavior of these two prey during the winter. Using hydroacoustic data from repeated surveys of the same school, we will create 3-D visualizations of fish schools, following the progression of major aggregations over time (hours to days). Together with surface surveys of associated predators, we will test the hypothesis that aggregate escape behavior in response to predators results in the formation of dense surface schools (bait balls) by herring but not by pollock.

B. Methods

Our objective is to identify the preferred characteristics of marine piscivore winter habitat with respect to associated fish prey and co-occurring predators, and to test hypotheses for a preference for pollock vs. herring prey. We propose to conduct these surveys in southern PWS in December and January. The protected waters of the Sound will allow us to conduct surveys in the winter, which is not often possible in northern Pacific waters.

We identified three major data-collection tasks. First, we will use aerial surveys to record the regional distribution of fish-feeding marine birds and mammals in the study area. Second, we will used boat-based surveys to record the local occurrence and behavior of fish-feeding marine birds and mammals near larger aggregations of pollock and herring. Third, to record fish prey, we will use hydroacoustic surveys to document the size, location, biomass, and aggregate behavior of overwintering fish in the study area. These data will be used to test hypotheses about predator preference for pollock vs. herring, and about the escape behavior of the two fish species.

REGIONAL DISTRIBUTION OF PREDATORS: We will census marine mammals and birds during aerial surveys, using a survey plane equipped with a global positioning system (GPS) linked computer and following the methods used in Scheel & Hough (1995) and Brown (1999). Surveys will be flown at an altitude of 300 meters (1000 feet). Sea lions, whales, and aggregations of marine birds can readily be seen and identified from this altitude, although harbor seals and single birds will be missed. During each survey, two observers will record mammals and birds visible on either side of the plane out to a visual angle of about 30 degrees (600 m on either side). GPS-recorded flight paths and the locations of marine birds and mammals will be entered into a geographic information system along with the locations and characteristics of fish prey for spatial analyses.

LOCAL OCCURRENCE & BEHAVIOR OF OTHER PREDATORS: When aggregations of predators (marine mammals and birds) and prey (pollock or herring) are detected, we will conduct localized boat-based surveys to document the location and behavior (traveling, resting, diving) of predators. Whales consume large amounts of prey relative to harbor seals and murres, and may alter the behavior of large schools of fish, so that a particularly accurate count of whales is necessary. During these surveys, humpback and killer whales will be photographed for subsequent individual identification and verification of counts by North Gulf Oceanic Society (C.

Matkin).

DISTRIBUTION OF OVERWINTERING FISH: We will follow fish survey techniques developed over the past six years on the Sound Ecosystem Assessment program in cooperation with Alaska Department of Fish & Game. Surveys will be conducted between fall and spring using commercial fishing vessels (purse seiners for herring and mid-water trawls for pollock) to conduct sonar searches of large areas, run line-transects surveys over fish aggregations with a scientific echosounder and sample the fish targets with nets. A dual-beam scientific echosounder interfaced with a GPS provides geo-time coded data. Transducers are mounted on tow-fins in a down-looking configuration and towed at 6 knots at depths of 2 m. We will use purse seines ranging from 40 to 60 meters deep with mesh sizes of approximately 3.2 cm stretched. The midwater trawl will be a standard herring trawl (40 m x 28 m) fitted with a fine mesh bunt and cod end to retain small fishes, and equipped with a net sounder. The depth and location of the seining and trawling are directed toward the schools or layers of fish detected using acoustics. The length of trawl hauls will be approximately 30 minutes at a specific depth. Fish from the catch will be identified, weighed and measured.

The first stage of the survey design is reconnaissance surveys to locate aggregations of herring and pollock. In the past, this was done for pollock by the commercial fishing fleet that fished prior to our survey efforts, and for herring with the aid of the commercial fishing fleet in the fall and with aerial surveys in the spring. In the future, we will combine these reconnaissance sureveys of opportunity with our knowledge of the distribution of fish from surveys done between 1993 and 1999. On all surveys we will conduct zig-zag transects with search-light sonars and echosounders to map out the fish aggregations before designing and conducting the line-transect survey to estimate biomass. When estimating biomass of the aggregation, we will conduct a systematic series of parallel transects over an area large enough to represent the fish aggregations (Figure 2b). Surveys will be repeated, when possible, to estimate precision of the biomass estimates and determine aggregate fish behavior in relation to predator counts and activities. Net sampling will be conducted to collect biological information on the fish aggregation. In the past, overwinter aggregations were mono-specific so net catch information was primarily used to partition the biomass estimate into cohorts. The lengths of the fish in the catch were used to determine target strength using -20 log L -71.3 for herring (Thorne 1983) and -20 log L -66 for pollock (Traynor and Ehrenberg 1979).

Herring or pollock biomass will be calculated for each fish concentration that was surveyed by line-transect design. The calculation of biomass per unit volume is made using echo-integration. Biomass for a region of surface area is determined using a set of line transects across the region of known fish concentration, along which a series of point estimates of biomass per unit area is obtained (Seber 1973). For the herring biomass estimate, we follow Thorne (1983). Pollock biomass estimates are computed in a similar manner using the appropriate target strength (TS). The acoustic systems will be calibrated before each cruise using a tungsten-carbide ball of known target strength, suspended within the beam of the transducer (Foote and MacLennan 1982). Echointegration, dual-beam target strength (TS) and GPS data are stored on disk and backed up on a tape drive. Raw acoustic signals are stored on digital audiotape and printed on paper echograms. In-house software will be used to apply acoustic calibrations and correct for

absorption, remove untracked bottom, identify targets of interest, edit false targets, calculate biomass estimates, and produce images of fish distributions.

ANALYSES: We propose to identify preferred characteristics of piscivore winter habitat with regard to preference for associations with pollock or herring. We will overlay predator distribution with that of prey, and assign characteristics to each prey group mapped. Prey characteristics will include not only species composition, size, depth and aggregate behavior of school, but also associated predators, bottom depth, and bottom and shoreline contours (e.g. sea mount, canyon, plain, headland, bay, passage). Multivariate and spatial statistics will be used to examine which characteristics are associated with the presence of foraging predators.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

A subcontract would be issued to the North Gulf Oceanic Society (NGOS) regarding the identification and count confirmation of killer whales and humpback whales by individual photo identifications.

SCHEDULE

A. Measureable Project Tasks for FY 00 (October 1, 1999 - September 30, 2000)

Winter 1999 - 2000:	First series of synoptic surveys recording.
Fall 2000:	First paper and presentation on year 1 survey.

B. Project Milestones and Endpoints

Winter 1999 - 2000:	Field surveys of forage fish and piscivores.
Fall 2000:	Annual progress report and presentation.
Winter 2000-2001:	Field surveys of forage fish and piscivores.
Fall 2001:	Final report and presentation.

C. Completion Date

The project will be completed by the end of FY01 (September 30, 2001).

PUBLICATIONS AND REPORTS

Scheel, David S. and G.L. Thomas (2000), Overwinter feeding ecology of dominant piscivores in Prince William Sound. Animal Behavior.

PROFESSIONAL CONFERENCES

First year: 3rd Annual Conference of the World Fisheries Congress, Beijing, China.

Second year: ICES Fish Acoustics meeting, Paris, France.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project brings together the findings of the Sound Ecosystem Assessment (SEA) program and the Alaska Predator Experiment (APEX) program. APEX studies of injured piscivores in Prince William Sound were primarily limited to the summer-fall period. Many of these piscivores cannot go without feeding for more than a couple of weeks during the inclement winter weather so these observations are important to the assessment of overwinter survival. APEX has advanced the junk-food hypothesis as a limitation to recovery of injured species (Duffy 1999) and we feel the addition of the prey capture energetics related to the bait ball hypothesis will make this a more complete food-limiting mechanism. We envision the coupling of this food limited hypothesis with the patch-response/patch-dependence hypothesis that SEA verified for walleye pollock (Thomas et al. 1999) as a proposed mechanism for how climate change induces shifts in the North Pacific piscivore assemblage. There is no period more critical to examine this hypothesis than in the winter when mortality is highest. There is no period more opportunistic for examining this hypothesis in terms of having restricted forage fish distributions. We plan to encourage APEX investigators to write joint proposals in year two of this project that focus on specific injured species we find in abundance.

PRINCIPAL INVESTIGATORS - Personnel Qualifications - Attached

David Scheel, Ph.D.
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574

G.L. Thomas, Ph.D.
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574

OTHER KEY PERSONNEL

Jennifer Allen, visualization expert.
Jay Kirsch, acoustic expert
Craig Matkin, whale photo-identification expert

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BUDGET - Attached

2000 EXXON VALDEZ TR :E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$0.0
Travel		$0.0
Contractual		$198.7
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$198.7
General Administration		$13.9
Project Total	$0.0	$212.6
Full-time Equivalents (FTE)		1.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2001	Estimated FY 2002		
		$199.3			

Dollar amounts are shown in thousands of dollars.

Comments:

FY00

Prepared:

Project Number: 00557-BAA
Project Title: Overwinter feeding ecology of injured species
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$102.0						
Travel		$11.2						
Contractual		$31.4						
Commodities		$4.3						
Equipment		$5.6	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$154.5			Estimated FY 2001	Estimated FY 2002		
Indirect		$44.19						
Project Total	$0.0	$198.7			$195.8			
Full-time Equivalents (FTE)		1.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY00

Prepared:

Project Number:
Project Title: Overwinter feeding ecology of injured species
Name: D.Scheel and G.Thomas

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2000
	D. Scheel	Principal Investigator	4.0	6787.0		27,148.0
	G. Thomas	Principal Investigator	2.5	13205.0		33,012.5
	J. Allen	Analysis	2.0	6774.0		13,548.0
	J. Kirsch	Hydroacoustician	2.0	6595.0		13,190.0
	tba	Biologist	2.0	4569.0		9,138.0
	tba	Assistants	2.0	2985.0		5,970.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	14.5	40915.0	0.0	
					Personnel Total	$102.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2000
	Fisheries Congress, Bejing, China	1277.0	1	10	153.0	2,807.0
	Cor-Seattle	788.0	2	14	134.0	3,452.0
	Cor-NY	838.0	3	10	151.0	4,024.0
	car rental			30	30.0	900.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$11.2

FY00

Prepared:

Project Number:
Project Title: Overwinter feeding ecology of injured species
Name: D.Scheel and G.Thomas

FORM 4B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed

2000 EXXON VALDEZ TR :E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Description	FY 2000
Aerial surveys (20 hrs@250/hr)	5,000.0
Network costs (18 mos@$100/computer)	1,800.0
Telephone, mail, fax, copying, etc.	750.0
NGOS, Craig Matkin	3,800.0
Purse seine charter (20days@1000/day)	20,000.0
Contractual Total	$31.4

Commodities Costs:	Proposed
Description	FY 2000
tapes, disks, echogram paper, etc.	1,150.0
software updates and lisc.	750.0
field hardware and fowl weather gear	850.0
calibration	1,500.0
Commodities Total	$4.3

FY00

Prepared:

Project Number:
Project Title: Overwinter feeding ecology of injured species
Name: D.Scheel and G.Thomas

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TR..E COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2000
high speed laptop	1	3300.0	3,300.0
camera w/telephoto lens	1	2300.0	2,300.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R	**New Equipment Total**		$5.6

Existing Equipment Usage:	Number	
Description	of Units	
BioSonics dual beam scientific echosounder system		
Sun workstation and disublimation printer		
IDL signal processing software		

FY00

Prepared:

Project Number:
Project Title: Overwinter feeding ecology of injured species
Name: D.Scheel and G.Thomas

FORM 4B
Equipment
DETAIL

Project Title: Long-Term Monitoring and Research: Evaluation of study methodology for Surveys to Monitor Marine Bird Abundance in Prince William Sound

Project Number:	00559
Restoration Category:	Long-Term Monitoring
Proposer:	Migratory Bird Management, U. S. Fish and Wildlife Service
Lead Trustee Agency:	U. S. Department of the Interior, Fish and Wildlife Service
Cooperating Agencies:	None
Alaska SeaLife Center:	
Duration:	Two years
Cost FY 00:	$ 54.6
Cost FY 01:	$ 45.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	marine birds and sea otters

ABSTRACT

We propose to evaluate the current study design and analytical methods for project #00159, Surveys to Monitor Marine Bird Abundance in Prince William Sound, with the objective of transition into a long-term monitoring program. Six previous surveys have monitored population trends for >65 bird and 8 marine mammal species in Prince William Sound with the overall objective of monitoring recovery of injured populations. We propose to build upon these previous surveys, by use of computer simulations of different sampling strategies using data collected from previous surveys (1989-1998) to determine the optimal study design in regard to number of transects, transect length, habitat type, and stratification. We will use additional data collected in 2000 to continue to examine trends from summer 1989 through summer 2000 and from winter 1990 through winter 2000 with the goal of increasing the efficiency and precision of population estimates. The transition from monitoring recovery of injured populations in the short-term to a program of long-term ecological monitoring, requires methodologies which ensure precise and reliable population estimates which are capable of detecting population changes and trends.

INTRODUCTION

The waters and shorelines of Prince William Sound support abundant marine bird and sea otter populations throughout the year (Isleib and Kessel 1973, Hogan and Murk 1982, Irons et al. 1988a). Potential injuries to marine birds from exposure to the *T/V Exxon Valdez* oil spill included, but were not limited to, death, changes in behavior, and decreased productivity. U. S. Fish and Wildlife Service, Migratory Bird Management conducted boat surveys in Prince William Sound prior to the *Exxon Valdez* oil spill in 1972-73 (Dwyer et al. 1976) and 1984-85 (Irons et al. 1988a,b). After the oil spill, Natural Resource Damage Assessment Bird Study Number 2 (Burn 1994, Klosiewski and Laing 1994) was initiated to document damage from the oil spill on the marine bird and sea otter populations of Prince William Sound. Data from these surveys indicated that populations of sea otters (Burn 1994) and several marine bird species (Klosiewski and Laing 1994) declined in the oil spill area. Thus, restoration projects 93045 (Agler et al. 1994a), 94159 (Agler et al. 1995a), 96159 (Agler and Kendall 1997), and 98159 (Lance et al. In review) were initiated to continue monitoring marine bird and sea otter population abundance to assess recovery of injured species. Restoration projects 93045, 94159, 96159, and 98159 continued the original *Exxon Valdez* oil spill damage assessment study (Bird Study Number 2, Burn 1994, Klosiewski and Laing 1994) from 1989-91 with the objective of monitoring recovery of those populations injured by the oil spill.

Using data from previous boat surveys (see above), this project will evaluate the current study design and analyses methods with the objective of transition into a long-term monitoring program. This study by no means serves as a critique of the current study (00159) but rather expands the objective from one of monitoring recovery from the EVOS to one of efficient long-term monitoring (eg. 30+ year time scale) of the marine bird assemblages in PWS. This project will benefit restoration of Prince William Sound by evaluating if minor modifications can be made in survey and analytical methodology that will allow more efficient and precise tracking of marine bird populations in PWS for the long-term and at the same time provide data which is comparable to surveys conducted during the period 1989-2000. In addition, monitoring methodologies developed for PWS can be expanded to cover other areas in the NE Pacific effected by the oil spill (eg. Cook Inlet, Kenai Peninsula, Kodiak Island).

NEED FOR THE PROJECT

A. Statement of the Problem

Due to concern over the effects of a potential oil spill on marine birds, the U. S. Fish and Wildlife Service conducted marine bird surveys in PWS in 1972-73 (L. Haddock et al., unpubl. data) and again in 1984-85 (Irons et al. 1988). In 1989-91 surveys were initiated by the U.S. Fish and Wildlife Service to determine the population abundance of marine birds in PWS in the aftermath of the oil spill (Klosiewski and Laing 1994). Data from the 1989-91 surveys were used to assess natural resource damage from the EVOS and indicated that populations of several marine bird species declined in the oil spill area (Klosiewski and Laing 1994). Klosiewski and Laing (1994) documented overall declines in 15 species or species groups between 1972-73 (Dwyer et al. 1976)

and the years after the spill. When comparing population estimates with 1984-85 data, Klosiewski and Laing (1994) documented decline of 6 species or species groups attributable to the oil spill. As of this writing, the designated injured species list includes loons, cormorants (pelagic, red-faced, and double-crested), harlequin ducks, bald eagles, black oystercatchers, murres (common and thick-billed), pigeon guillemots, and murrelets (Kittlitz's and marbled) (*Exxon Valdez* Oil Spill Restoration Plan 1996). Surveys conducted by the U.S. Fish and Wildlife Service were continued in March (1993, 1994, 1996, and 1998) and July (1993, 1996, and 1998). These surveys were designed to monitor marine bird populations of Prince William Sound following the *T/V Exxon Valdez* oil spill to determine population trends, recovery or continued impacts, for those species injured by the oil spill (*Exxon Valdez* Oil Spill Restoration Plan 1996). Further, since the surveys collect data on all marine bird species, the study serves to monitor those marine bird populations not initially designated as impacted.

Burn (1994), using data from the boat surveys, documented declines in sea otter abundance in shoreline habitats of Prince William Sound following the spill. Burn (1994) detected a continuing pattern of significantly lower sea otter densities in oiled coastal areas, suggesting mortality in or displacement of sea otters from these areas.

Lance et al. (in review) examined whether marine bird and mammal species designated as injured by the *EVOS* trustee council had shown signs of recovery by 1998. Using the Homogeneity of Slopes test they found that none of the designated injured species showed evidence of recovery in either winter or summer. They did find, however, that winter densities of three of the designated injured species, harlequin ducks (*Histrionicus histrionicus*), bald eagles (*Haliaeetus leucocephalus*), and murrelets (*Brachyramphus* sp.) showed an increasing trend in the oiled areas of PWS. Bald eagles (*Haliaeetus leucocephalus*), an injured species designated as recovered, also showed an increasing trend in oiled areas of PWS. No other injured species or species groups showed any significant trends in the oiled areas of PWS. Densities of 5 other species previously not considered injured (scoters, mergansers, black-legged kittiwakes, oldsquaw, and goldeneye) showed trends consistent with an oil spill effect. Lack of significant trends would indicate that these populations have not fully recovered (Lance et al. in review).

These marine bird surveys have proven to be a powerful tool in restoration efforts by increasing our ability to reveal trends of recovery and continued impacts due to the *T/V Exxon Valdez* oil spill. Post-spill monitoring studies of Agler et al. (1994a, 1995a), Agler and Kendall 1997, and Lance et al. (In review) found additional marine bird populations that were not previously shown to be injured, populations that exhibit no trend of recovery, as well as populations which appear to be recovering.

There is now; however, a need to evaluate current study design and analytical methods in light of long-term monitoring goals. Long-term monitoring is fundamentally different in scope than looking for effects and recovery from a single perturbation such as an oil spill. In order to be effective, long-term population monitoring programs must provide efficient and reliable estimates of population changes and trends. As such, long-term population monitoring programs play a key role in conservation biology by providing the information needed to identify conservation problems as they arise and further suggest appropriate research and management directives.

However, determination of changes and trends in population size from count data are not straightforward. Numerous methods have been proposed, but there is currently no consensus on which is the most suitable (Thomas 1996). Current analytical methods for the survey are based on linear or log linear models which are appropriate for detection of trends over the relatively short time period, 1989-1999. However, marine bird populations will not continue to change in a linear or exponential manner in the long term, instead being more cyclical in nature. Population sizes may cycle about long-term trends and trends may reverse direction. Thus, long-term monitoring presents unique study design and analytical problems and challenges (Thomas 1996).

Marine bird populations lend themselves to long-term monitoring. Most marine birds are characterized by low reproductive rates, delayed sexual maturity, and high adult survival rates so that time scales appropriate for monitoring population processes are often very long. Also, many marine bird species are subjected to sporadic, major environmental perturbations (eg. El Nino, fluctuations of prey populations, disease, oil spills...etc.), that play themselves out over long time scales. Further, marine bird populations are inherently unstable, often increasing and decreasing greatly, particularly at the scale of most ecological studies. This latter attribute can complicate the ability of a study to accurately track a population in the long term, requiring changes in methodology, data management and/or analysis (Nisbet 1989). Thus, it is the objective of this study to evaluate the current study design and analytical methods with the ultimate objective of transition into a long-term monitoring program; building an efficient and reliable survey and analytical methodology that will allow the precise tracking of marine bird populations in PWS for the long-term.

Precision can be improved by increasing sample size and potentially improved by using stratification to minimize variances within strata (Kraft et al. 1995, Pojar et al. 1995). Estimates may also be improved by increasing effort where the majority of the species are found and reducing effort in areas of low density (Cochran 1977). Individual species may have their own particular stratification requirements. For example, Marbled Murrelets are believed to aggregate in areas of strong tidal mixing, thus it may be beneficial to stratify based on bathymetry. Rosenberg and Petrula (1998) increased the power in their study of Harlequin Ducks by stratifying transects within optimal habitat for the species; that is allocating effort based on bird abundance. In a multi-species survey, however, it is difficult to stratify in the most appropriate manner for all species. One alternative is to identify a suite of primary target species for long-term monitoring. These species would then determine the stratification providing the best precision.

Survey efficiency may be increased by optimizing transect length, without loss of precision. For example, pelagic transects in PWS are 5 nautical miles (nm) in length and were originally designed to be flown by fixed-wing aircraft. In contrast, surveys conducted in Cook Inlet (Agler et al. 1995) and SE Alaska (Agler et al. 1995) used average pelagic transect lengths of 2 nm and 1 nm respectively. Evaluating the optimal length of PWS transects (balance of efficiency and precision of estimate) may allow reduction in transect length, particularly in the coastal-pelagic and pelagic strata. Increased survey efficiency will translate into lowered project costs, the balance which can be used for extending survey coverage to other areas (eg. Cook Inlet, Kenai Peninsula), or other restoration needs. We estimate potential savings on the boat survey ~ $50,000/year due to more

efficient data collection (lowered personnel costs, contractual expenses, boat fuel....etc.).

B. Rationale/Link to Restoration

Restoration of marine bird and sea otter populations requires precise and reliable population estimates to determine changes and trends; whether recovery is occurring or if species are still affected by the oil spill. This project will benefit marine birds and sea otters by increasing our ability to reveal long-term trends for a diverse suite of species that utilize PWS. Agler et al. (1994a, 1995a), Agler and Kendall 1997, and Lance et al. (in review) found additional marine bird populations that were not previously shown to be injured. Survey data from these projects have also been used by investigators of other studies on pigeon guillemots (Lindsey Hayes, pers. comm.), marbled murrelets (K. Kuletz, pers. comm.), Kittlitz's murrelets (B. Day, per comm.), harlequin ducks (D. Rosenberg, pers. comm.), sea ducks (K. Laing and D. Esler, pers. comm.), black oystercatchers (B. Andres, pers. comm.), birds and forage fish (W. Ostrand, pers. comm.), herring (E. Brown, pers. comm.), and sea otters (Burn 1994). Data on long-term trends of marine bird populations will be invaluable in developing management and research decisions for PWS and the marine environment of the NE Pacific in general.

The proposed project is coupled to the Surveys to Monitor Marine Bird Abundance in Prince William Sound project and relates to the restoration objectives of several species. The *Exxon Valdez Oil Spill Restoration Plan* (*Exxon Valdez* Oil Spill Trustee Council 1994) lists each species' restoration objectives separately, and we have only included objectives relating to this project:

> Cormorants - "will have recovered when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway."
>
> Harlequin duck - "will have recovered when breeding and postbreeding season densities and production of young have returned to estimated pre-spill levels, or when there are no differences in these parameters between oiled and unoiled areas."
>
> Bald eagle -"will have recovered when their population and productivity return to pre-spill levels."
>
> Black oystercatchers - "will have recovered when populations attain pre-spill levels"
>
> Marbled murrelet - "will have recovered when population trends are increasing."
>
> Pigeon guillemot - "will have recovered when populations are stable or increasing."
>
> Sea otter - "will be considered recovered when population abundance and distribution are comparable to pre-spill abundance and distribution"

All of the above recovery objectives relate to determining the population abundance of injured species and the ability to determine trends over the long-term. This is critical to determining recovery for most species, as well as monitoring for future perturbations (both natural and anthropogenic).

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

We do not expect to use local community involvement for this project.

PROJECT DESIGN

In order to be effective, population monitoring programs must provide efficient and reliable estimates of population changes and trends. As such, population monitoring programs play a key role in conservation biology by providing the information needed to identify conservation problems as they arise and suggest further research directions or management suggestions. Determination of changes in population size from data are not straightforward. Numerous methods have been proposed, but there is currently no consensus on which is the most suitable.

A. Objectives:

The overall objective of this study is to improve the efficiency and precision of the current survey methodology in tracking marine bird populations in PWS. Our goal is to lower costs and increase the precision of population estimates in order to detect potential problems as they arise for the long-term. The specific objectives of this project include:

1. Use Irons (1988) shoreline habitat data to evaluate precision of population estimates based on post-stratification of survey data by habitat from 1989-1998.

2. Include more random transects from under-represented shoreline habitat types of the sound. Random sampling may at times under-represent some habitat types, resulting in an incomplete sampling window, from which inferences about the population as a whole may be limited. Determine coverages of various shoreline habitat types in PWS (GIS data base) and compare percent available habitat to percent sampled. If certain habitats are not adequately represented, randomly select more transects in those specific habitats. Repeat the later exercise on coastal-pelagic and pelagic transects in relation to coarse-scale oceanographic parameters (bathymetry, persistent fronts, ...etc.).

3. Evaluate data collected in March and July 1998 at finer scales based on GPS data (dlog). Evaluate precision of population estimates using more, shorter transects, spread over a wider area of the sound. For the most part this will be a computer simulation to resample existing transects at finer scales keeping track of bird locations based on GPS coordinates.

4. Compare results of current sampling design with results of new sampling design by collecting data during the March and July 2000 surveys using both methods. This comparative evaluation is crucial in order to facilitate a smooth transition to a new study design and sampling methodology based on long-term monitoring, ensuring data sets are comparable.

5. Evaluate current analytical methods in light of long-term monitoring goals. Long-term monitoring is fundamentally different than looking for effects and recovery from the oil spill. Current analytical methods have served well, however, these are based on linear models and real populations do not act in linear fashion in the long term, being much more cyclical in nature.

B. Methods

1. Study Area

Our study area includes all waters within Prince William Sound and all land within 100 m of shore. We exclude Orca Inlet, near Cordova, Alaska and the southern sides of Montague, Hinchinbrook, and Hawkins Islands (Klosiewski and Laing 1994).

2. Sampling Methods

Field sampling methods used will two-fold. The first method will be identical to that of previous surveys, as described in Agler and Kendall (1997) and DPD #00159. The only exception being the potential inclusion of additional transects in habitats that may be under-represented by the current random sampling protocol (see objectives #1 and #2). The second methodology will be based upon the results of project objectives #1, #2, and #3, including variations on transect length, strata, and habitat. We recommend sampling using both methodologies for 2-3 years to ensure data sets, and as a consequence, sampling designs are comparable.

3. Statistical Analyses

At present, the literature is replete with analytical methods for count data, both for estimating annual indices and for estimating population trends (Smith 1994). While numerous methods exist for deriving trends from time-series, the majority of analyses of bird count data, including the marine bird survey project, have focused on regression-based approaches Thomas 1996). These are comprised, but not limited to, linear models, Poisson-type models, additive models, and rank models. While conceptually simple and requiring measurement of a limited number of parameters, linear models (bird survey data) can be inaccurate if the prevailing tendency changes over time (eg. nonlinear trend). Poisson regression techniques allow for changes in trends over time, however, are susceptible to inclusion of inappropriate patterns such as population cycles (Thomas 1996). Additive models (eg. non-linear route-regression) have the advantage of making no assumptions about the shape of the trend, however, they suffer from difficulties in drawing

inferences about overall patterns of population change because they estimate many parameters. Similarly, rank models do not require the trend to be linear, however, since the ranks of counts are used, only the direction of a trend (increase or decline), not its magnitude is inferred from the model (Thomas 1996). Thus, each of the above methods has inherent strengths and weaknesses, the 'best' approach depending on the nature of the data and the question being asked.

In this project, a through literature review of current analytical methods for determining annual indices and monitoring long-term population change will be carried out early on. For example, Monte Carlo simulations provide a useful empirical tool in evaluating the methods inherent in various models of population change, and determining which method is most appropriate to test a given hypothesis (Manly 1991, Thomas 1996). Statistical power and design requirements for environmental monitoring will be reviewed including the voluminous literature arising from the USEPA Environmental Monitoring and Assessment Program (EMAP).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This project includes a contract for analytical collaboration from West, Inc.

SCHEDULE

A. Measurable Project Tasks for FY 00

October-February:	Analyze existing data from project #00159
March:	Collect additional data during March survey of PWS
April-June:	Return to Anchorage, enter data, continue analysis
July:	Collect additional data during July survey of PWS
August-September:	Return to Anchorage, enter data, continue analysis

B. Project Milestones and Endpoints

We will examine project objectives 1,3, and 4 prior to the March and July surveys and, if needed, incorporate findings into the March and July 2000 surveys.

C. Completion Date

Objectives 1,3, and 4 of this project will be completed by October 2000. Completion of analyses of data collected in March and July surveys 2000 (objective 3) and completion of a manuscript will need funding in fiscal year 2001.

PUBLICATIONS AND REPORTS

One professional publication is anticipated to arise from this work. This paper will be based on the computer simulations of optimal properties of monitoring designs for sea birds in Prince William Sound and elsewhere in the Gulf of Alaska. Included in the paper will be recommendations for statistical analysis of data arising from the anticipated design over the long term (30 to 50 years minimum). This paper should be appropriate for a journal such as The Auk.

PROFESSIONAL CONFERENCES

No funds are requested for attending meetings.

NORMAL AGENCY MANAGEMENT

This project is not a part of normal agency management for the U. S. Fish and Wildlife Service in Alaska. Although considered an important ecosystem within Alaska, surveys of Prince William Sound would not be as high a priority as funding for projects within other areas of the state.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Principle investigators from other EVOS trustee council funded projects have used our survey data in the past. Results from evaluation of survey methodology and data analysis would be helpful for the sea otter, harlequin duck, and pigeon guillemot portions of the nearshore vertebrate predator project (\025); the black-legged kittiwake, marbled murrelet (/231), and seabird foraging portions of the Alaska predator ecosystem experiment (\163); Kittlitz's murrelet status and ecology (\142); black oystercatcher monitoring (\159); and harbor seal monitoring (\064).

EXPLANATION OF CHANGES TO CONTINUING PROJECTS

This is a new project. It does, however, build upon the results from project 00159, Surveys to Monitor Marine Bird Abundance in Prince William Sound, expanding the objective from one of monitoring recovery from the EVOS to one of long-term monitoring of the marine bird assemblages in PWS. The data collected by project #00159 (6 survey years over a 10 year period) is invaluable as a springboard for development of a long-term monitoring program. Long-term population monitoring programs play a key role in conservation biology by providing the information needed to identify conservation problems as they arise and further suggest appropriate research and management directives.

PROPOSED PRINCIPAL INVESTIGATORS

Brian K. Lance
Department of Interior, U.S. Fish and Wildlife Service
Migratory Bird Management
1011 East Tudor Road
Anchorage, Alaska 99503
Phone: (907) 786-3896
Fax: (907) 786-3641
E-mail: Brian_Lance@fws.gov

David Irons
Department of Interior, U. S. Fish and Wildlife Service
Migratory Bird Management
1011 East Tudor Road
Anchorage, Alaska 99503
Phone: (907) 786-3376
Fax: (907) 786-3641
email: David_Irons@fws.gov

Lyman L. McDonald
West, Inc.
Cheyenne, Wyoming
Phone: (307) 634-1756
Fax: (307)
email: McDonald@west-inc.com

PERSONNEL

1. Co-Project Leader - Brian K. Lance, Wildlife Biologist, GS-9.

Brian Lance received his M.S. degree in Wildlife Biology from the University of Alaska, Fairbanks in 1996 and his B.S. degree in Wildlife and Fisheries Biology from Texas A&M University in 1981. He joined the U. S. Fish and Wildlife Service, Office of Migratory Bird Management in March 1998 as a Wildlife Biologist. Mr. Lance has conducted surveys of Prince William Sound and Lower Cook Inlet to determine abundance of marine birds and sea otters. Prior to joining Migratory Birds, he studied diet and nestling growth in Red-legged and Black-legged kittiwakes on St. George Island in the Bering Sea. Brian has been involved with numerous seabird studies in Alaska including: Nearshore Vertebrate Predator Program: Avian Predation on Blue Mussel and seabird colony surveys on the Pribilof Islands.

Brian has presented papers on diet and nestling growth in Red-legged and Black-legged kittiwakes at Pacific Seabird Group meetings and the Alaska Cooperative Fish and Wildlife Research Unit meetings in Fairbanks.

Boat Survey Publications:

Bishop, M. A., B. K. Lance, S. P. Green, J. Mason, and E. W. Lance. 1997. Results of avian and marine mammal surveys in the nearshore waters of northeast Orca Inlet. Unpupl. manuscript, Prince William Sound Science Center.

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Lance, B. K., D. B. Irons, S. J. Kendall, and L. L. McDonald. Submitted. Marine Bird Population Abundance of Prince William Sound, Alaska: Trends following the *Exxon Valdez* oil spill. Restoration Project No. 98159. Final Rep., U.S. Fish and Wildl. Serv., Anchorage, Alas.

Seabird Publications:

Lance, B. K. 1996. Diet and nestling growth in Red-legged and Black-legged kittiwakes: an interspecies cross-fostering experiment. Unpubl. Master's Thesis, University of Alaska, Fairbanks. 127 pp.

Lance, B. K. and D. D. Roby. In press. Diet and postnatal growth in Red-legged and Black-legged kittiwakes (*Rissa brevirostris* and *Rissa tridactyla*): an interspecies comparison. Colonial Waterbirds.

Lance, B. K. and D. D. Roby. in review. Diet and postnatal growth in Red-legged and Black-legged kittiwakes (*Rissa brevirostris* and *Rissa tridactyla*): an interspecies cross-fostering experiment. Auk.

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2. Co-Project Leader - David B. Irons, Ph.D., Wildlife Biologist, GS-12.

Dr. David Irons received his Ph.D from the University of California, Irvine in 1992. His dissertation was on the foraging ecology and breeding biology of the black-legged kittiwake in Prince William Sound. He received his M.S. from Oregon State University in 1982 where he studied foraging behavior of glaucous-winged gulls in relation to the presence of sea otters. Dr. Irons conducted marine birds and sea otter surveys in Prince William Sound in 1984 and 1985. He has been studying kittiwakes in Prince William Sound for 11 years and completed the *Exxon Valdez* oil spill kittiwake damage assessment study. Dr. Irons has overseen several seabird studies in the past few years, including marine bird and sea otter surveys of Prince William Sound and Cook Inlet, a seabird monitoring study on Little Diomede Island, and a cost of reproduction study on kittiwakes.

Selected Seabird Publications:

Irons, D. B. 1998. Foraging area fidelity of individual seabirds in relation to tidal cycles and flock feeding. Ecology 70:647-655.

Irons, D. B. 1992. Factors affecting black-legged kittiwake reproductive success. Unpubl. Ph.D Dissertation. Univ. of California, Irvine.

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Irons, D. B. In prep. Flexible foraging behavior in seabirds: short-term buffer and long-term tradeoff?

Irons, D. B. In prep. The role of food availability in sibling aggression and brood reduction of the blacklegged kittiwake.

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Hatch, S. A., G. V. Byrd, D. B. Irons, and G. L. Hunt. 1993. Status and ecology of kittiwakes in the North Pacific Ocean. Pages 140-53 *in* K. Vermeer, K. T. Briggs, K. H. Morgan, and D. Siegel-Causey, eds. The status, ecology and conservation of marine birds of the North Pacific, Can. Wildl. Serv., Spec. Publ., Ottawa, Canada.

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3. Consultant Dr. Lyman L. McDonald, Senior Biometrician, WEST, Inc., 2003 Central Avenue, Cheyenne, Wyoming 82001.

Dr. Lyman McDonald, B.S., M.S. Oklahoma State University, Ph.D. Colorado State University, is a Biometrician with 30 years of comprehensive experience in the application of statistical methods to design, conduct, and analyze environmental and laboratory studies. He has designed and managed both large and small environmental impact assessment and monitoring programs.

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2000 EXXON VALDEZ TRUS' :OUNCIL PROJECT BUDGET
October 1, 1999 - -,tember 30, 2000

Budget Category:	Authorized FFY 1999	Proposed FFY 2000
Personnel	$0.0	$9.4
Travel	$0.0	$0.0
Contractual	$0.0	$39.1
Commodities	$0.0	$2.0
Equipment	$0.0	$0.0
Subtotal	$0.0	$50.5
General Administration	$0.0	$4.1
Project Total	$0.0	$54.6
Full-time Equivalents (FTE)	0.0	0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 2001	Estimated FFY 2002		
$45.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments: U. S. Fish and Wildlife Service will provide 8 people to conduct the winter survey.

2000

Prepared:

Project Number: 00559
Project Title: Long-term monitoring and research: Evaluation of study methodology for Surveys to Monitor Bird Abundance in Prince William Sound
Agency: DOI - Fish and Wildlife Service

FORM 3A
AGENCY
PROJECT
DETAIL

4/14/99

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 2000
	Irons	Co-Project Leader	GS12-6	0.5	7,200		3.6
	Personnel	Biological Technicians for field work	GS-5	1.0	2,300		2.3
	Personnel	GIS Technician	GS-7	1.0	3,500		3.5
							0.0
							0.0
		Subtotal		2.5	13,000	0	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$9.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$0.0

2000

Project Number:
Project Title: Long-term monitoring and research: Evaluation of study methodology for Surveys to Monitor Bird Abundance in Prince William Sound
Agency: DOI - Fish and Wildlife Service

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed
Description	FFY 1996
Charter vessel (winter), 2 days	4.0
Charter vessel (summer), 2 days	4.0
West Inc. : to meet project objectives outlined in DPD	31.1
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$39.1

Commodities Costs:	Proposed
Description	FFY 1996
Field expenses (boat fuel, oil, food)	2.0
Commodities Total	$2.0

2000

Project Number:
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FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FFY 1996
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
Camping supplies		DOI -FWS
Survival suits	9	DOI -FWS
Mustang suits	9	DOI -FWS
Float coats	9	DOI -FWS

2000

Project Number:
Project Title: Long-term monitoring and research: Evaluation of study methodology for Surveys to Monitor Bird Abundance in Prince William Sound
Agency: DOI - Fish and Wildlife Service

FORM 3B
Equipment
DETAIL