Community-Based Harbor Seal Research

Project number:	99444
Restoration category:	Research
Proposer:	Alaska Native Harbor Seal Commission
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	Two Year
Cost FY 99:	$69,200
Cost FY 00:	$5,000
Cost FY 01:	0
Cost FY 02:	0
Cost FY 03:	0
Cost FY 04:	0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Harbor Seals, Subsistence

RECEIVED
APR 14 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

Harbor seal numbers in Port Gravina in eastern Prince William Sound (PWS) are showing strong signs of recovery while those at oiled sites in central PWS are not. This project is a one-year pilot project created with and accomplished by using the knowledge and expertise of local subsistence hunters. It is based in the believe that evaluating factors affecting harbor seals during the fall-winter-spring is critical for understanding factors affecting harbor seal recovery. Vessel-based surveys will be used to: (1) contrast seasonal use of each region by harbor seals, (2) contrast the age composition of seals in each region, (3) identify regional and ecological factors that may be associated with observed differences in harbor seal use, and (4) document potentially sensitive harbor seal habitats or temporal periods that may affect recovery.

INTRODUCTION

The numbers of harbor seals in Prince William Sound (PWS) have declined since the early 1980s (Pitcher 1989, Frost et al. 1997). Beyond annual population trend monitoring during the August-September molt, little has been done to investigate whether or not recovery has commenced and what factors might be associated with the recovery of harbor seals in PWS. Current research suggests that factors associated with winter survival of harbor seals may be contributing to the decline, however, knowledge of the seal's distribution and activities during the winter is poorly documented.

Members of the Alaska Native Harbor Seal Commission strongly believe that knowledge of factors affecting harbor seal distribution and survival during the fall, winter, and spring is essential for understanding reasons for the harbor seal's decline and lack of recovery. This project combines the knowledge and expertise of subsistence users with scientific research practices to investigate harbor seal decline and recovery in PWS. Subsistence hunters and biologists are involved in all phases of the project's design and implementation. The participation of subsistence hunters, trained in methods of scientific data collection, and already skilled in observing seals and traveling in PWS under adverse winter conditions, provides the expertise needed to conduct this study.

This study contrasts two regions, monitored by Project /064, that showed similar rates of decline prior to the oil spill but differing levels of recovery since the spill: (1) Port Gravina (sites 2-4) in eastern PWS which were not oiled and (2) central PWS (sites 12-17) which were moderately and heavily oiled. Table 1 shows the proportion of the mean numbers of seals counted in the early 1980s (either 1983 or 1984, whichever was greater) for central PWS and Port Gravina. By 1988 both sites declined to roughly 60% of the numbers counted in the early 1980s; in 1989 they continued to decline, the central PWS sites dropping to 32% of the numbers counted in the early 1980s and the eastern sites dropping to 43% of early 1980s counts. Since 1989, the numbers of seals at the central sites have fluctuated between 29%-42% of the early 1980s counts while those in the eastern sites have increased to 77%. Values adjusted for environmental conditions (Frost et al. 1997), show similar tendencies, indicating initial recovery in Port Gravina starting in 1993 while numbers at sites 12-17 remained low. This study investigates differences in the environmental conditions, the numbers of seals, and the age structure of seals for each region during the fall, winter, and spring. Surveys during the fall-winter-spring will complement ongoing aerial population trend surveys conducted during the late summer, satellite telemetry investigations and food habits studies being conducted by Project /064. This study also will provide information on seals during an important, but poorly understood period, when seals are feeding and young seals may have difficulty surviving.

Table 1. Population trends for two regions in PWS. Upper values in each cell represent the proportion of the mean numbers of seals counted in either 1983 or 1984 (whichever was higher) for designated sites (Pitcher 1989; Frost and Lowry 1994; Frost and VerHoef 1995; Frost et al. 1996, 1997; Frost pers. comm.). Lower values in each cell represent the proportion of 1984 counts, using values adjusted for environmental conditions (Frost et al. 1997).

Region	1983	1984	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Port Gravina (Sites 2-4)	67%	100% 100%	61% 82%	43% 58%	43% 56%	54% 55%	44% 44%	57% 64%	53% 57%	74% 78%	74% 74%	77%
Central (Sites 12-17)	100%	92% 100%	57% 81%	32% 47%	38% 50%	37% 42%	38% 48%	29% 33%	35% 38%	42% 42%	36% 39%	31%

Harbor seals spend fewer days on shore during the winter than in the summer, resulting in much lower counts than would be obtained during pupping and molting (e.g., see Frost et al. 1997). Because seals spend more time in the water during the winter, winter aerial surveys usually are not very effective for documenting the distribution or relative abundance of seals at that time. Vessel-based surveys, although more costly, provide greater opportunity to detect the presence and activity of seals in the water and to document concurrent environmental conditions. For instance, opportunistic observations of sites in eastern PWS taken in January 1998 showed unusually large numbers of seals using the eastern fjords during the winter (e.g., 115-140 seals during a complete survey of Port Gravina on 20 Jan 1998, N. Vlasoff (pers. comm.)). On 22-23 January 1998, J. Totemoff (pers. comm.) observed 23 seals during a partial survey of Port Gravina, Sheep Bay, and Simson Bay of which he categorized 83% as juveniles. Schooling fish and ducks also were abundant in the area. These observations were not controlled for tide or time of day but suggest large numbers of seals may be using the eastern PWS during the winter of which a high proportion may be small seals, estimated by J. Totemoff to be the size of yearlings.

Mechanisms resulting in apparent regional population declines include emigration, decreased reproductive effort/success, decreased haulout activity during the survey periods, and increased mortality. Satellite tagging studies conducted by Frost et al. (1997) document harbor seals moving to sites on the perimeter and outside of PWS for various lengths of time, especially during the winter. This behavior was particularly strong for pups of the year. Such exploratory behavior increases a seal's region of familiarity, and provides knowledge of alternative haulout and feeding areas. Experiences gained during such explorations also may influence the likelihood of young seals returning to their birth sites, especially if more favorable conditions are found elsewhere. If young female seals choose to remain at alternate sites, within or outside PWS, the future reproductive output of their birth sites would correspondingly be reduced, further adding to the birth site's rate of decline. Through direct observations of the winter location and activities of harbor seals, this study will attempt to identify or suggest means to identify which of the above factors affect the distribution of seals and which factors may be associated with the poor recovery of harbor seals at oiled sites in central PWS.

NEED FOR THE PROJECT

A. Statement of Problem

Harbor seal populations in Prince William Sound and the northern Gulf of Alaska were in decline before the oil spill for unknown reasons. The spill injured harbor seals by direct oiling and oiling of their habitat. Furthermore, numbers of seals at monitored oiled sites in central PWS have not increased in numbers whereas seals at unoiled sites in Port Gravina have shown strong signs of recovery since 1992. Harbor seals are a primary subsistence resource for the Alaska Native communities of the oil spill region. Subsistence harvests of harbor seals also have declined in many communities since the spill because of the harbor seal's reduced population size and the hunters' voluntary efforts to aid recovery by limiting takes. It is important, for the sake of understanding factors contributing to the harbor seal decline, and for restoring responsible subsistence use of harbor seals, to achieve a greater understanding of factors associated with the recovery of harbor seals that are lacking in areas not showing signs of recovery.

B. Rationale/Link to Restoration

The recovery objective for harbor seals states that recovery will have occurred when harbor seal population trends are stable or increasing. The recovery objective for subsistence states that recovery will have occurred when injured subsistence resources are healthy and productive and exist at pre-spill levels, and people are confident that the resources are safe to eat. Based on the findings from workshops conducted under project /244, meeting these recovery objectives will be enhanced by involving subsistence hunters in research efforts and developing recommendations for subsistence hunters about how they can help in harbor seal recovery.

Fundamental to understanding the cause of the harbor seal decline, the impact of subsistence takes and any mitigating measures that can be taken to reduce the adverse impacts of takes on harbor seal recovery, is knowledge of the seasonal distribution and activities of harbor seals, especially during the fall, winter, and spring when it is thought that harbor seal numbers are being reduced by natural factors. Scientists have repeatedly stressed a lack of understanding regarding the year-around movements and distribution of harbor seals. This information is needed to: (1) understand important habitats used at different times of the year, (2) document potentially sensitive locations or habitats, and (3) evaluate potential factors adversely affecting the harbor seal populations and contributing to the decline. This project also provides the opportunity to compare and contrast differences between a region showing evidence of recovery with oiled sites in central PWS that are not showing signs of recovery.

This project is the logical next step in the goal of involving subsistence users in restoration and co-management activities. It expands the participation of subsistence users in the restoration process from the formation of the Alaska Native Harbor Seal Commission (ANHSC) and participation in the biosampling project to the investigation of factors affecting harbor seal recovery. This project involves the expertise and knowledge within the Alaska Native community represented by the ANHSC to directly participate in and contribute to the scientific understanding of the winter activities and requirements of harbor seals and can be instrumental in identifying factors that may be hindering the recovery of harbor seals in Prince William Sound.

C. Location

The proposed studies will involve sites and communities in Prince William Sound, including Tatitlek, Cordova, Port Gravina, and harbor seal haulouts in central PWS.

COMMUNITY INVOLVEMENT

In May 1995, the Alaska Native Harbor Seal Commission (ANHSC) was formed to strengthen and increase the role of Alaska Native resource policy affecting harbor seals and their uses. The goals of the ANHSC include the following: educating and informing the public and scientists on the traditional and contemporary relationship between harbor seals and Alaska Natives, informing scientists about the type and extent of knowledge held by the local people about harbor seals, and involving Alaska Natives directly in the research, regulatory and management processes.

The ANHSC represents harbor seal subsistence communities throughout the oil spill area and can provide effective coordination and implementation of the proposed projects by: (1) contacting local communities about the project and soliciting their involvement, (2) contracting with local community members to collect data and provide locally available resources and equipment, including vessels, and (3) communicating the results of the studies through reports and newsletters identified in this project and through newsletters, workshops, and workshop proceedings identified in Trustee Council project 98244.

Winter survey studies of harbor seals are difficult because seals spend most of their time in the water and weather conditions often are poor. Vessel-based surveys are more effective than aerial surveys during the winter because boats travel slower thereby allowing the observer to locate seals as they surface. Vessel-based surveys also provide an opportunity for the observers to evaluate environmental conditions visible to them, such as sea-state, surface wind direction and velocity, local variations in tidal stage and current, incidences of schooling fishes and feeding birds and marine mammals, etc. We believe this project will be successful because of the knowledge, experience, resourcefulness, and proximity of local community members who, year-around, travel extensively throughout Prince William Sound and other coastal regions, and are very familiar with harbor seals and their activities.

Subsistence hunters and other community members are intrinsically involved with harbor seals and can provide important information about the winter location and abundance of seals, the condition of seals taken for subsistence purposes, seal activity and behavior, and relevant environmental conditions. Subsistence hunters are knowledgeable about sites used by harbor seals during the winter, methods for approaching seals without frightening them, and are skilled at observing seals and discriminating the size and condition of seals. They are also familiar with many other environmental parameters, including activities and distribution of potential harbor seal prey and winter weather conditions. Their life-long, year-around familiarity with harbor seals and their environment also gives hunters the ability to evaluate their observations in relation to observations made in previous years.

Local and traditional knowledge of Alaska Natives of the oil spill area is essential to the success

of this project. The ANHSC will itself and in collaboration with its subcontractor A. Hoover-Miller and the ADF&G, contract and train two observers to conduct fall-winter-spring harbor seal surveys; local vessels and crew will be used to conduct the surveys.

PROJECT DESIGN:

A. Objectives

1. Initiate a prototype fall-winter-spring survey program to investigate seasonal habitat use.

2. Contrast the age composition of seals and environmental conditions of areas showing evidence of population recovery and areas not showing signs of recovery within PWS.

3. Provide a forum for subsistence hunters and biologists to collect and review data and evaluate the program's effectiveness.

B. METHODS

Objectives 1 and 2. Initiate a prototype fall-winter-spring survey program to investigate seasonal habitat use and contrast the age-composition and environmental conditions of regions showing recovery (Port Gravina) and lack of recovery (central PWS, sites 12-17).

The proposed fall-winter-spring surveys comprise a one-year pilot program to develop techniques and demonstrate the feasibility of using modified traditional methods for documenting the fall-winter-spring distribution of harbor seals in two regions of Prince William Sound and for investigating the decline and recovery of harbor seals. Specific hypotheses we intend to address include testing: (1) whether the numbers of seals observed are distributed between the study areas in equal proportion to the proportions found during the preceding and subsequent molt surveys, (2) whether the proportion of adults and juveniles in central PWS equals that of Port Gravina, (3) whether environmental conditions (e.g., weather, haulout availability, apparent prey availability) observed in the central PWS are the same as in Port Gravina, and (4) whether any month or series of months shows particular characteristics that might be associated with more or less favorable conditions for harbor seals. Using these hypotheses, we intend to investigate whether sets of environmental conditions, that can be monitored by observers, are associated with increased or decreased numbers of harbor seals. We also will be evaluating changes in visible environmental parameters associated with any observed changes in the distribution, age composition, or activity of harbor seals within and between study areas.

This study involves conducting vessel surveys of two areas in Prince William Sound with contrasting habitats and summer population trends: (1) Central PWS (sites 12-17) where seal numbers have not recovered and Port Gravina where recovery has apparently been underway at Trend count sites 2-4 since 1992. Surveys will be conducted two times per month. During each period, the southcentral area will be surveyed twice, in opposite directions, in order to gather data at different tide and time periods. The southcentral survey is expected to take three days to complete, including travel time to and from port; the Gravina Bay site also will be surveyed over a three day period for which selected sites (probably Olsen Bay, Gravina Island, and Gravina

Rocks) will be examined twice per survey period. Surveys will document the location, estimated age of the seal (e.g., pup/yearling, juvenile, large adult) if it can be ascertained, whether the seal is on shore or in the water, the seal's activity if in the water, the existence and activity of other birds, marine mammals, or fishes in the area. In addition, information on the date, time of day, tide, currents, sea condition, and weather will be collected at specific stations and when it noticeably changes. Sightings of harbor seals will be recorded on field maps and related information recorded on data sheets. Verbal notes may be taken using tape recorders to supplement the data sheet records.

Observers will be trained by A. Hoover-Miller to conduct surveys using consistent methods from survey to survey that minimizes disturbance to seals. Vessel-based training will occur in October 1997. An effort will be made to standardize survey protocols between routes (e.g., identification of categorical data such as weather, sea conditions, behavioral descriptions).. The assignment of age categories for harbor seals can be very subjective and often cannot be made because of viewing opportunities. Surveys will be conducted using highly experienced observers who have life-long experience studying and hunting harbor seals. They have demonstrated skilled abilities in evaluating the age (adult, subadult, or pup) and sex of seals based on morphology and behavior. Nevertheless, each observer may use different cues to assign age/sex classes to seals. Criteria used by each observer to assign age/sex categories to seals will be identified before the first survey and after the completion of surveys the following spring. Although certain categories may be reached by consensus (e.g., large adult male, late-term pregnant female, small 0-1 year-old juveniles) other categories may not be reliably identified by all observers. After completion of all surveys, a critical assessment will be made of the potential biases in age composition data associated with observers and viewing opportunities. This assessment will be used to evaluate (1) whether sufficient age composition data can be gathered, (2) which age categories can be most reliably detected, and (3) under what conditions might direct comparisons be made between regions.

Although continuing surveys throughout the summer would be desirable, we believe, it is important to first statistically evaluate winter surveys, when the likelihood of observing seals is lowest and survey conditions are poorest. A primary purpose of the FY 99 surveys will be to provide information to test the feasibility of using winter surveys to monitor seal distribution, study habitat use during the winter months and contrast the distribution, numbers, age-composition and activities of seal in areas not showing signs of recovery, with areas showing long-term recovery.

Objective 3. Provide a forum for subsistence hunters to collect and review data and evaluate the program's effectiveness.

Preliminary analysis will be completed in March 1999 to determine whether vessel-based surveys provide adequate data for comparing the distribution and age composition of harbor seals and of environmental condition between central PWS and Port Gravina. Survey results will be used to estimate sample variances, develop sampling protocol for future surveys, estimate the statistical power of the FY 99 sampling program, and determine whether the quality of information derived from winter surveys warrants future funding.

Results of the preliminary analysis will be presented at the March 1999 Alaska Native Harbor Seal Commission meeting. Issues raised by the research can be reviewed and addressed by subsistence users throughout the State and additional interpretative information can be provided. This dialogue will be continued throughout the development of the final report in April, 2000. Any necessary modifications to the survey design will be discussed and evaluated and a determination as to the need for continuing the project beyond the initial year will be made at the March 1999 meeting. If the project is determined to be effective and providing valuable information, additional funding will be sought to support further studies in the FY 00 restoration proposal.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Consultation and technical assistance will be provided as in-kind contributions by the Alaska Sea Otter Commission, the Chugach Regional Resources Commission, Rural Alaska Community Action Program, the Indigenous People's Council for Marine Mammals, and the ADF&G, Division of Subsistence. The following contracts are planned:

1. Pacific Rim Research

A. Hoover-Miller at Pacific Rim Research will be contracted by the ANHSC as a biological consultant to develop methods, train observers, and analyze and report on the results of the fall-winter-spring field surveys.

Proposed Pacific Rim Research Contract: Budget

A. Hoover-Miller, Pacific Rim Research, will be contracted by the ANHSC	
$5,000/mo. for 4 months.	$20,000
Overhead (10% contract)	$2,000
Travel: Restoration Workshop (3d per diem + $700 air = $1,150)	
Cordova Training (4 d per diem + $850 air = $1,450)	$2,600
Total:	$24,600

(Note: an additional $5,000 contract for FY00 is projected for final report preparation).

2. Fall-winter-spring field surveys.

Three experienced subsistence hunters will be contracted by the ANHSC to conduct vessel-based surveys twice each month from mid-October through early April and record all sightings of harbor seals within specific routes on data maps and data sheets. Twelve vessel-based surveys of each region are expected to be conducted each year.

Proposed Fall-Winter-Spring Survey Contracts: Budgets

Two vessels, including observers, will be contracted to conduct 12, 3-day surveys: ((Fuel @ 100 gal/day X 72 survey days @$2/gal) + (Gally @ $40 /day X 72 survey days) + (Vessel operation assistant @ $100/day X 72 survey days)+ (Insurance and other misc. expenses $2,000/vessel X 2 vessels)	$28,480
Two observers @ $150/day will be contracted by the ANHSC ((Vessel surveys: 72 vessel-based person-days x $150/day) + (one day field training for all observers)+ travel for training ($500)	$11,600

SCHEDULE

A. Measurable Project Tasks for FY 99

Start-up to October 15:	Contract with Pacific Rim Research, observers, and research assistants. Apply for Marine Mammal Protection Act Section 104 permit for Level B harassment.
October 1998:	Hold village training sessions for fall-winter-spring survey program and community observation program.
October-April 1999	Conduct fall-winter-spring surveys
January 1999	Participate in the Trustee Council Restoration Workshop
Prior to May 1999	Participate in 99244 workshop, summarize and evaluate progress to date, make necessary changes to sampling protocol, and provide follow-up training, if needed.
September 1999:	Evaluate first year of program.

B. Project Milestones and Endpoints

1. Conduct workshops in Cordova to train observers: October 1998.
2. Begin fall-winter-spring surveys: October 1998
3. Participate in the Trustee Council Restoration Workshop: January 1999
4. Complete preliminary evaluation of fall-winter-spring surveys: March 1999

5. Participate in /244 workshop, review project to date, make recommendations for improvement in the study's design and implementation and decide whether to seek future funding: March 1999
7. Participate in the Trustee Council Restoration Workshop: January 2000
8. Complete final report for prototype surveys: April 15, 2000.

D. Completion Date

Community-based harbor seal research should continue as long as the Marine Mammal Ecosystem Research package is underway. Presently, fieldwork and data analysis for the prototype surveys through FY 99, with close-out in FY 00. The winter survey program will be evaluated for future funding for FY00.

PUBLICATIONS AND REPORTS

No manuscripts are planned for publication in peer-reviewed journals for FY 99.

Final report: April 15, 2000.

PROFESSIONAL CONFERENCES

Alaska Native Harbor Seal Commission Workshop
Indigenous People's Council for Marine Mammal Meetings
Arctic Science Conference

NORMAL AGENCY MANAGEMENT

Not Applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will supplement and use data about the population status, distribution, and degree of recovery of harbor seals collected by the Marine Mammal Ecosystem study package, including restoration project numbers 98001 and 98064. It also will draw on the results of research conducted by the Division of Subsistence under a contract with the National Marine Fisheries Service to monitor subsistence harvests. The project will provide information to researchers working on harbor seal restoration projects and aid their access to local and traditional knowledge of Alaska Native hunters. In addition this project will rely on the participation of community members and will coordinate activities with the Community Involvement project (98052) and the Youth Area Watch (98210).

The two regions selected for this study also have been involved in other scientific studies supported by the EVOS Trustees including the Sound Ecosystem Assessment Project (/320) and Alaska Predator Ecosystem Experiment (/163). In addition, Projects /001, /064, /117-BAA, and 170 provides extensive information on the pupping and molting abundance of seals as well as

information on the health, condition, movements, diving behavior, and food habits of harbor seals in Prince William Sound. Such studies will provide extensive data to aid the interpretation of our results. We also believe this project will provide valuable information to related projects.

PROPOSED PRINCIPAL INVESTIGATORS, IF KNOWN

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Alaska Native Harbor Seal Commission
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PRINCIPAL INVESTIGATORS

Monica Riedel, executive director (all of the below is provided as in-kind contribution from the ANHSC).

Responsibilities:

1. Oversight and management of entire project.
2. Establish contracts and manage funds associated with the project.
3. Contact hunters and community members to encourage and coordinate participation in the project.
4. Coordinate training, data collection, analysis, and reporting.
5. Be responsible for the development, storage, and maintenance of data sets originated by the project.
6. Participate in the evaluation of the project and facilitate needed improvements.
7. Present the progress and findings of the project at the EVOS Trustee Council Restoration Meeting and at the Alaska Native Harbor Seal Commission annual meeting.

LITERATURE CITED

Frost, K. J. and L. F. Lowry 1994. Habitat use, behavior, and monitoring of harbor seals in Prince William Sound, Alaska. Annual Report for *Exxon Valdez* Oil Spill Restoration Science Study 93064. Alaska Dep. Fish and Game, Div. Wildlife. Conserv., Fairbanks, AK. 99 pp.

Frost, K. J. and J. M. VerHoef. 1995. Habitat use, behavior and monitoring of harbor seals in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Projects 94064 and 94320-F), Alaska Department of Fish and Game, Division Wildlife Conservation, Fairbanks, AK. 88 pp

Frost, K. J., L. F. Lowry, R.J. Small, and S. J. Iverson. 1996. Monitoring, habitat use, and trophic interactions of harbor seals in Prince William Sound, Alaska. Ann. Rep. To the EVOS Trustee Council. Restoration Study No. 95064. 133 pp.

Frost, K. J., L. F. Lowry, J. M. VerHoef, and S. J. Iverson. 1997. Monitoring, habitat use, and trophic interactions of harbor seals in Prince William Sound, Alaska. Ann. Rep. To the EVOS Trustee Council. Restoration Study No. 96064. 115 pp.

Pitcher, K. W. 1989. Harbor seal trend count surveys in southern Alaska, 1988. Final Rep. Contract MM4465852-1 submitted to U.S. Marine Mammal Commission, Washington, D.C. 15pp.

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$64.7
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$64.7
General Administration		$4.5
Project Total	$0.0	$69.2
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$5.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared: 4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY 99

Prepared: 4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:		Proposed FY 1999
Description		
4A Linkage		64.7
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$64.7

Commodities Costs:		Proposed FY 1999
Description		
	Commodities Total	$0.0

FY 99

Prepared: 4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

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

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

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY 99

Prepared:4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$64.7
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$64.7
Indirect		
Project Total	$0.0	$64.7
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$5.0				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Name: Alaska Native Harbor Seal Commission

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Monica Riedel	Principal Investigator	0.0			0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$0.0

FY 99

Prepared:4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Name: Alaska Native Harbor Seal Commission

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 1999
Description	
Pacific Rim Research	24.6
2 Vessel Contracts	28.5
2 Observer Contracts	11.6
NOTE: Detailed explanation and budget breakdown is shown on pages 8 and 9 of the Detailed Project Description	
Contractual Total	$64.7

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared:4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Name: Alaska Native Harbor Seal Commission

FORM 4B
Contractual & Commodities DETAIL

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

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

FY 99

Prepared: 4/15/98

Project Number: 99444
Project Title: Community-Based Harbor Seal Research
Name: Alaska Native Harbor Seal Commission

FORM 4B
Equipment
DETAIL

99448

EVALUATING RECOVERY OF COASTAL RIVER OTTERS: GENDER-SPECIFIC RESPONSE TO THE EXXON VALDEZ OIL SPILL

Project Number:	99448
Restoration Category:	Research
Proposer:	Institute of Arctic Biology, University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	
Alaska Sealife Center:	yes (in conjunction with project # 98348)
Duration:	1st year, 2-year project
Cost FY 99:	$79,200
Cost FY 00:	$51,300
Cost FY 01:	$0
Geographic Area:	Western Prince William Sound
Injured Resource:	River Otters - recovery status: unknown

RECEIVED
APR 14 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

We propose to investigate diets of male and female river otters (*Lutra canadensis*) inhabiting oiled and unoiled areas of Prince William Sound, Alaska. We will ascertain diet composition using archived fecal samples from immediately post spill to the present, and determine gender classification of the feces by DNA analysis. Direct observations in previous studies suggested that male and female river otters may differ in their foraging strategies. with solitary females concentrating more on sedentary intertidal fish, whereas groups of males rely more on pelagic fish. Therefore, females may have increased susceptibility to disturbance of the intertidal zone leading to significant effects on population recovery. Moreover, in species with polygynous mating systems, such as river otters, female reproduction is the primary regulating factor of population size. We expect that shortly after the oil spill, females would show greater dietary differences between oiled and unoiled areas than males, and these differences will diminish over time as the coastal ecosystem recovers.

INTRODUCTION

River otters (*Lutra canadensis*) inhabiting marine environments forage in the intertidal and subtidal zones for marine fish and invertebrates (Larsen, 1984; Stenson et al., 1984; Woolington, 1984; Bowyer et al., 1994) and are therefore highly susceptible to oil contamination as well as other human disturbances (Duffy et al. 1993; Bowyer et al. 1994; 1995; Testa et al., 1994; Ben-David et al., 1996). Investigations in Prince William Sound following the *Exxon Valdez* oil spill revealed that river otters on oiled shores had lower body mass and elevated levels of bioindicators, than did otters living on nonoiled shores (Blajeski et al., 1996; Duffy et al. 1993; 1994a; 1994b; 1996). In addition, otters from oiled areas selected different habitat characters, had larger home ranges, and less diverse diets than those in unoiled areas (Bowyer et al. 1994; Bowyer et al. 1995). These observed differences between river otters from oiled shores and those from unoiled areas strongly suggest that oil contamination had an effect on physiological and behavioral processes in otters. Moreover, these effects have a potential to become chronic and may impede recovery of populations of river otter as hydrocarbon exposure continues.

Studies of coastal river otters in Prince William Sound also documented differences between males and females in several morphometric characters such as body weight, skull length, and distance between canines (Duffy et al., 1993; 1994; G. M. Blundell, unpublished 1996 and 1997 data). Previous research (Bowyer et al., 1995) indicated that male otters had larger home ranges than females (Fig. 1). In addition, direct observations suggested that male and female river otters inhabiting coastal areas differ in their foraging strategies. Females tended to forage alone and capture sedentary intertidal fish, whereas males commonly foraged in groups, usually on pelagic fish (Rock et al., 1994; Ben-David, pers. obs.). In addition, data from aerial telemetry obtained in the Nearshore Vertebrate Predator Project (NVP) indicate that spatial organization of males and females differ significantly (Fig. 2 and 3).

The sexual dimorphism and observed differences in foraging strategies between the genders of river otters in PWS, therefore, suggest that disturbances to the intertidal zone will more likely affect females (Fig. 4). Environmental perturbations will have significant implications for the recovery of populations post-disturbance (Fig. 4), because in species with polygynous mating systems, such as river otters (Erlinge, 1968; 1977; Powell, 1979; 1994), female reproduction is the primary regulating or limiting factor of population size (McCullough, 1979; Powell, 1979; Clutton-Brock and Albon, 1989; Robinson and Bolen, 1989). Bowyer et al. (1994) documented differences in diet composition of river otters inhabiting oiled and nonoiled areas in PWS; however, sexual dietary segregation was not explored. The differences observed by Bowyer et al. (1994) may be strongly driven by a bias towards samples from one sex without consideration of differential foraging strategies between the genders. Thus, our current interpretation of recovery status of river otters may suffer from a lack of understanding of important ecological attributes of this species regarding gender-specific differences. Bleich et al. (1997) noted that it was inappropriate to manage the environment for a species where the habitat and forage requirements of the sexes differed markedly.

In this study, we propose to investigate differences in dietary niche between male and female river otters from PWS by ascertaining diet composition using archived fecal samples for which the gender of river otters will be determined by DNA analysis. Recently, in a companion study (J. Dallas, P. Groves, and M. Ben-David, unpublished data), gender-specific primers for DNA of river otters have been isolated. The innovative use of these primers on fecal samples will, for the first time, enable us to explore dietary differences between the sexes of river otters and establish the basis for examining the gender-specific effects of disturbance. Furthermore, we intend to supplement data obtained from diet analyses with intensive aerial-tracking of river otters that were implanted with radio-transmitters in a companion study (NVP) in 1996 and 1997 (Blundell et al., in press; G. M. Blundell, unpublished data). These aerial-telemetry locations will provide data on foraging sites of males and females as well as group associations of individuals.

This investigation will not only finalize our examination of the recovery status of coastal river otters in PWS, where currently no evidence exists to suggest that food is limiting population recovery (T. Dean, pers. comm.), but also will elucidate the pathways of injury and recovery of these nearshore predators. An analysis of food habits is necessary because Bowyer et al. (1994) documented a delay in the onset of differences in diet following the oil spill (Fig. 5) for which no subsequent data are available. Additionally, population estimates for river otters inhabiting oiled and nonoiled areas of the Sound (Testa et al., 1994) may have been biased for or against one sex, thereby clouding our interpretation of recovery for this important resource. With a better understanding of how disturbance to the intertidal zone affects different segments of the population, we will be better equipped to monitor and mitigate future catastrophes.

We predict that diets of the sexes will differ through time from immediately post-spill to the present stage of recovery. Species diversity in diets of females in oiled areas will be markedly reduced compared with that of females from nonoiled areas. In comparison, we expect to document less difference in species diversity in diets of males inhabiting oiled compared with nonoiled areas, because of a greater dependence of this gender on pelagic fish. We expect these differences in diet composition for both sexes to diminish over time between oiled and nonoiled areas as the coastal ecosystem recovers.

Fig. 1 - Mean ± SE home range size for river otters in oiled and unoiled areas of Prince William Sound, Alaska, during summer 1990. (Adapted from Bowyer et al., 1995)

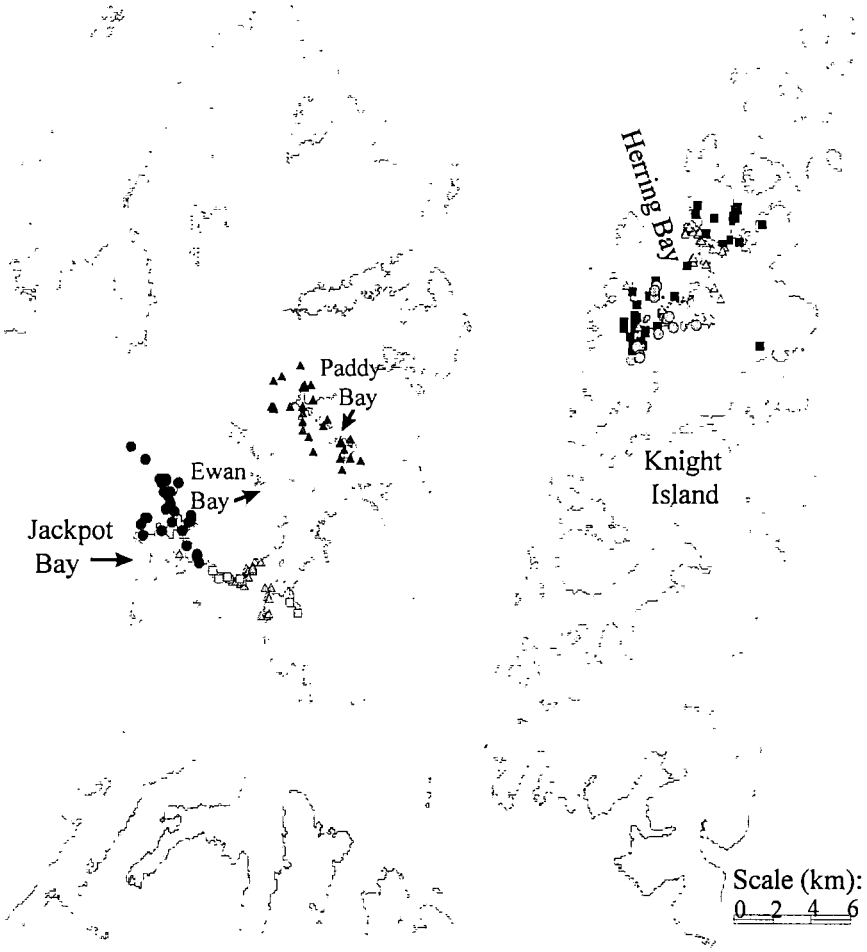

Fig. 2 - Spatial locations of female coastal river otters in Prince William Sound, Alaska, obtained from aerial-telemetry flights in 1997 and 1998. All otters were captured either in Herring Bay on Knight Island, or in Jackpot, Ewan, and Paddy bays. Each otter is represented by a different symbol. Note the distribution of locations for females presented in this figure as compared with locations of males in the next figure. This depicts a differential use of space by the two genders.

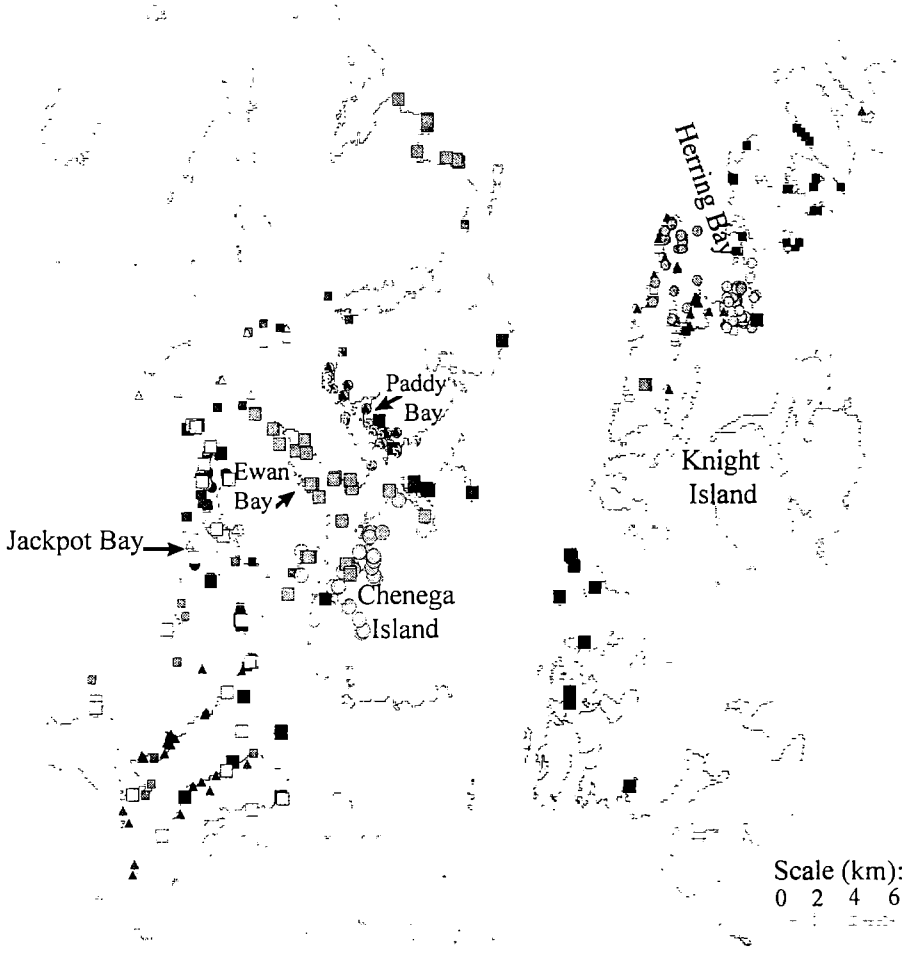

Fig. 3 - Spatial locations of male coastal river otters in Prince William Sound, Alaska, obtained from aerial-telemetry flights in 1997 and 1998. All otters were captured either in Herring Bay on Knight Island, or in Jackpot, Ewan, and Paddy bays. Each otter is represented by a different symbol.

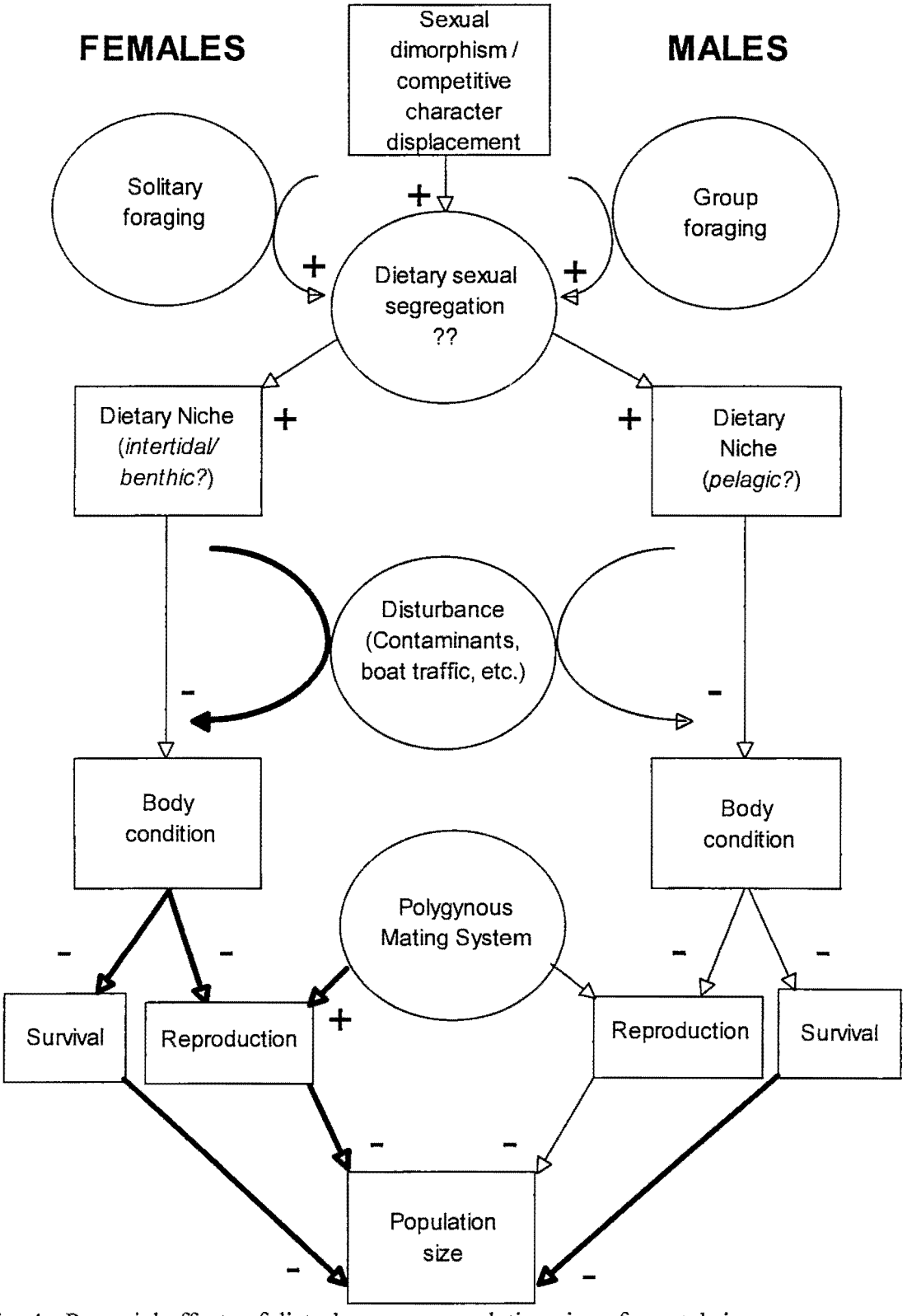

Fig. 4 - Potential effects of disturbance on population size of coastal river otters.

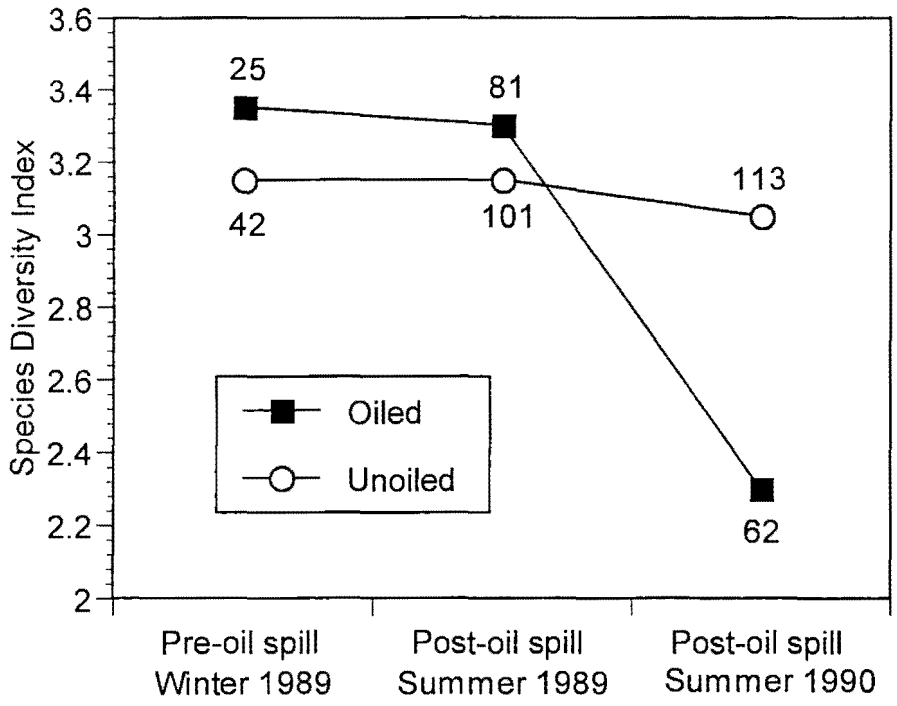

Fig. 5 - Differences in species diversity in diet between oiled and unoiled areas of Prince William Sound, Alaska. (Adapted from Bowyer et al., 1994)

NEED FOR PROJECT

A. Statement of Problem

The sexual dimorphism and observed differences in foraging strategies and home ranges between the genders of coastal river otters in PWS suggest that disturbance to or contamination of the intertidal zone will more likely affect females. Environmental perturbations will have significant implications for the recovery of populations post-disturbance, because in species with polygynous mating systems, such as river otters, female reproduction is the primary regulating or limiting factor of population size. Bowyer et al. (1994) documented differences in diet composition of river otters inhabiting oiled and nonoiled areas in PWS (Fig. 5); however, sexual dietary segregation was not explored. The differences observed by Bowyer et al. (1994) may be strongly driven by a bias towards samples from one sex, without consideration of differential foraging strategies between the genders. Thus, our current interpretation of recovery status of river otters may suffer from a lack of understanding of important ecological attributes of this species regarding gender-specific differences.

B. Rational/Link to Restoration

Effective implementation of the *EVOS* Trustee Council's policy that "Restoration should contribute to a healthy, productive and biologically diverse ecosystem...", is complicated by the diversity and trophic interdependence of the numerous injured resources within the nearshore system. River otters were designated as one of the injured species in the EVOS Restoration Plan. River otters from oiled areas showed "reduced diversity in prey species.....and increased territory size..." and "river otters will have recovered when .....and indices of habitat use are similar between oiled and unoiled areas."
This investigation will not only further examine the recovery status of coastal river otters in PWS, where currently no evidence exists to suggest that food is limiting population recovery (T. Dean, pers. comm.), but will also elucidate the pathways of injury and recovery of these nearshore predators. With a better understanding of how disturbance to or contamination of the intertidal zone affects different segments of the population, we will be better equipped to monitor and mitigate future catastrophes.

A. Location

Fecal samples of river otters were collected on oiled and unoiled shores of Prince William Sound during summer 1989, 1990, 1991, 1996 and 1997. The relationship between diet composition and remains of prey in feces will be established from samples collected from captive river otters that will be held in captivity at the Alaska Sealife Center and fed known diets.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

This project will involve analysis of samples collected in previous efforts that included community participation but community involvement in the research process will be limited. Nonetheless, we will contract local pilots to conduct the telemetry flights. We will also welcome opportunities to interact with local communities to present and discuss our findings.

PROJECT DESIGN

A. Objectives

In this study, we propose to investigate differences in dietary niche between male and female river otters from PWS by ascertaining diet composition using archived fecal samples for which the gender of river otters will be determined by DNA analysis. We predict that diets of the sexes will differ through time from immediately post-spill to the present stage of recovery. Species diversity in diets of females in oiled areas will be markedly reduced compared with that of females from nonoiled areas. In comparison, we expect to document less difference in species diversity in diets of males inhabiting oiled compared with nonoiled areas, because of a greater dependence of this gender on pelagic fish. We expect these differences in diet composition for both sexes to diminish over time between oiled and nonoiled areas as the coastal ecosystem recovers.

B. Methods

General

Bowyer et al. (1994) demonstrated that about 50 fecal samples per group were required to establish the full dietary spectrum for coastal river otters in Prince William Sound, Alaska. Fecal samples from river otters have been collected and archived for the years 1989 (n = 100), 1991 (n = 150), 1996 (n = 200), and 1997 (n = 715). For further analysis, fecal samples from 1989 and 1991 will be pooled to increase sample size and power (n = 250). Similarly, samples from 1996 and 1997 will be pooled and 250 fecal samples will be randomly selected for the analysis of gender and food habits. In addition, 50 samples will be collected from the captive otters at ALSC and subjected to the same procedures. This analysis will provide a correction factor for establishing the relationship between diet composition and remains of prey in feces.

DNA Technology

The polymerase chain reaction (PCR) amplifies selected portions of DNA extracted from small amounts of tissue using primers targeting specific regions of the molecule (Mullis and Faloona, 1987). Examination of this DNA can provide information on the genetic make-up of an individual, including determination of sex and identity. Recently, methods

have been established to extract DNA from the intestinal cells shed in feces (Höss et al., 1992). These methods allow DNA from an animal to be studied without having to handle the animal and is, thus, a non hazardous and economical method of DNA collection. Currently methods of fecal extraction are being optimized for use on river otter feces collected in Prince William Sound (P. Groves and M. Ben-David, unpublished data; Fig. 6).

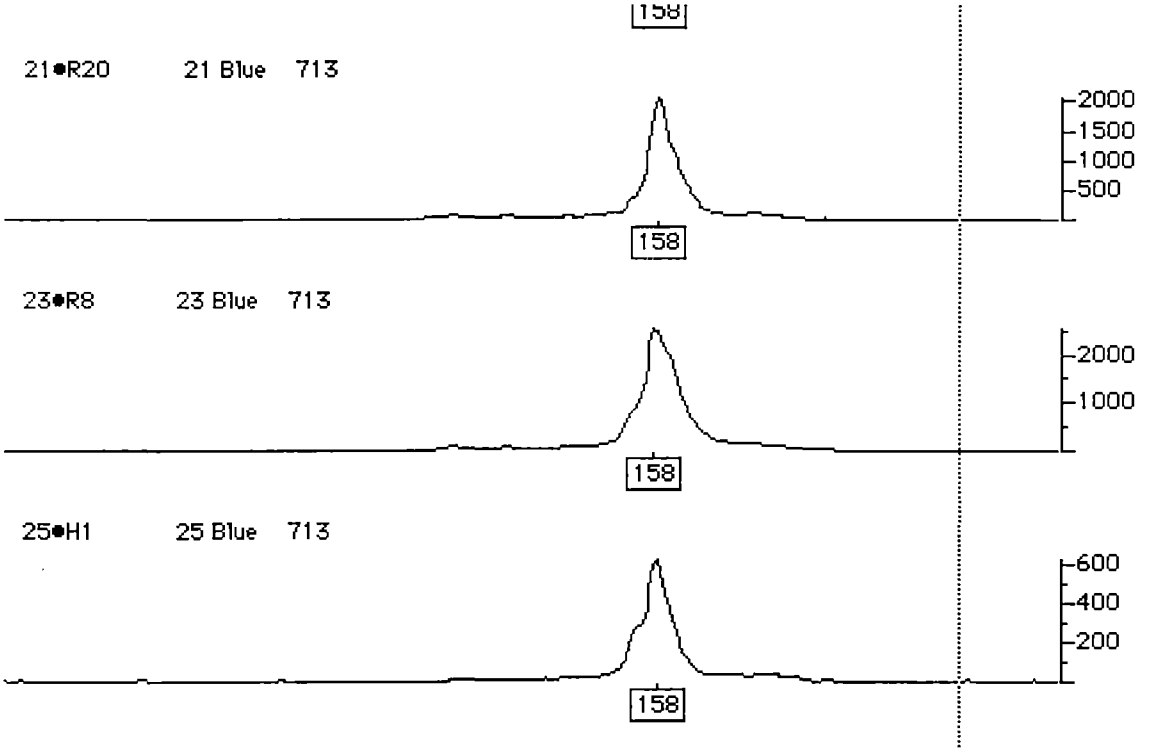

Fig. 6 - "Genotyper" results of river otter DNA (primer 713) extracted from blood samples (two top lines), and a fecal sample (bottom line). Similarly, the primer for the *Sry* gene has been isolated for river otters (P. Groves, pers. comm.).

The sex of an individual can be determined by amplifying a region of the Y chromosome. Because only males possess Y chromosomes, positive amplification of a region on this chromosome can verify male gender (Taberlet et al., 1993). The male sex-determining locus, *Sry*, has been widely used for sex determination and establishment of paternal lineages (Lundrigan and Tucker, 1994; Reed et al., 1997). The positive amplification of the *Sry* gene can be established by visualizing an aliquot of the PCR product in an agarose gel stained with ethidium bromide. Because the absence of the *Sry* fragment could be a false negative due to a failed PCR reaction, a second region of DNA, not specific to the Y chromosome can be co-amplified with the *Sry* gene as an internal positive control (Taberlet et al., 1993). These techniques have been used to reliably establish the sex of a variety of mammals including bears (*Ursus arctos*), seals (*Halichoerus grypus* and *Phoca vitulina*), and whales (*Physeter macrocephalus*) using hair, fecal and skin samples for the DNA source (Taberlet et al., 1993; Richard et al., 1994; Kohn et al., 1995; Reed et al., 1997).

Sry primers for the amplification of the *Sry* gene in European otters (*Lutra lutra*) have been developed (J. Dallas, University of Aberdeen, Scotland, pers. comm.). These primers have been tested blindly on the DNA of river otters of known sex from Prince William Sound. The 12 individual river otters tested were all sexed correctly (J. Dallas, pers. comm.). Thus, once DNA has been extracted from collected feces, we can establish the sex of individuals that produced the feces. Further validation of correct gender identification of feces will be accomplished by cross-referencing fecal DNA samples with DNA isolated from blood samples obtained from 51 additional river otters live-captured in a companion study (Blundell et al., in press) in the same areas during 1996 and 1997.

Analysis of food habits

Once fecal samples have been washed to extract genetic material, the remainder of the sample (primarily skeletal remains of fish and invertebrates, fish otoliths, mammalian hair, and avian feathers) will be sent to a laboratory specializing in identification of prey remains. These remains are compared with reference specimens and identified, when possible, to the species level following methods described by Bowyer et al. (1983; 1994). Skeletal remains of fish will be compared to reference specimens of known size and classified into three size categories (<8 cm, 8-15 cm, and >15 cm). These size categories correspond to data collected in a companion study (T. Dean, S. Jewett, and G. Blundell, unpublished data) using scuba-diving transects to quantify fish abundance and species composition in two study areas in PWS where most of the fecal samples were collected.

Radio-Telemetry

River otters occupy large home ranges (20 - 40 km) along the shoreline (Testa et al., 1994; Bowyer et al., 1995) and occasionally traverse overland between different bodies of water (G. M. Blundell, unpublished data). Therefore, aerial-tracking is the only feasible methodology for assessing spatial distributions and obtaining information on foraging locations of coastal river otters.

As part of a companion study, 37 otters were implanted with radio-transmitters. Currently, 8 females and 19 males are still transmitting radio signals in two areas in PWS where fecal samples were collected in 1996 and 1997. Up to 12 more otters will be implanted with radio-transmitters during spring 1998. We will obtain data on foraging locations of these otters from 52 aerial-tracking flights throughout the year. This will enable us to control for seasonal changes in foraging strategies. In winter, when prey may potentially be most limiting, differences between the genders should be most pronounced. Alternatively, during mating, denning, and the rearing of young, males and females may exhibit different foraging strategies. Telemetry data from spring and summer also will be representative of foraging strategies that coincide with the seasons in which the fecal samples were collected for DNA extraction and food habits analysis.

Once a telemetered otter is located, Geographic Positioning System (GPS) coordinates will be recorded for each otter by flying the plane directly over the location and recording UTM coordinates. Additionally, point locations for each otter will be plotted on USGS maps (1:63360 scale). When otters are observed foraging, their location, distance from shore, and group size will be recorded. During spring and summer 1997, 864 otter locations were obtained from 32 flights. Seventeen of these observations

included direct observations of foraging otters (5 females and 12 males; G. M. Blundell, unpublished data).

Statistical Analyses

After establishing species and size categories of fish for each fecal sample (n = 500), percent occurrence of intertidal fish will be calculated for each fecal sample. The mean percent and variance for males and females from oiled and nonoiled areas will be computed. Because data will be expressed as percent, a square root - arcsine transformation will be necessary to employ parametric techniques. We will use a two-way ANOVA on the transformed data to determine differences between sex and time periods (Zar, 1984), and compensate for making multiple tests with a Bonferroni correction (Rice, 1989).

To test the hypothesis that the difference in diet composition for oiled versus nonoiled females will be greater than that of the males, we will calculate estimated difference (oiled/nonoiled) in the percentage of intertidal fish in the diet. The resulting difference [i.e., Δ (males) and Δ (females)] and associated variances will be subjected to a two sample Z-test (Zar, 1984). Similar analysis will be performed for species diversity in the diet.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Determination of gender for each fecal sample will be contracted to Dr. Pamela Groves, Institute of Arctic Biology, University of Alaska Fairbanks. Dr. Groves has developed together with Dr. J.F. Dallas the primers for the *Sry* gene for river otters as well as the fecal extraction protocol.

Identification of diet components will be contracted to the Pacific Identification Lab which has extensive experience in identification of fish remains from feces of several marine mammals.

Telemetry flights will be contracted to Northwind Aviation, Homer, AK.

SCHEDULE

A. Measurable Tasks for FY 99

This project will begin in FY 99 and will be completed in 2000.

Oct. 1998 June 1999:	DNA analysis of fecal samples
June - Nov. 1999:	Fecal food habits analysis
Dec. 1999 - March 2000:	1. Data entry and analysis
	2. Attend Annual Restoration Workshop (Anchorage)
March - Sept. 2000:	completion of analysis, and write up

B. Project Milestones and endpoints

FY 99: Data collection

FY 00: Data collection and report submission

C. Completion Date

The work will be completed by Sept. 2000.

PUBLICATIONS AND REPORTS

All reports will be published in FY 00. We anticipate publishing at least 1 manuscript from this project. At this point, prior to data collection, we are unable to provide titles. We predict that manuscripts will be appropriate for submission to *Ecology*, where we have published our recent research on otters.

PROFESSIONAL CONFERENCES

The senior scientists on this project will likely present project results at various forums in 2000. Other than the annual *EVOS* meeting in January in Anchorage, however, presentations at professional conferences have not been identified or scheduled at this point. We propose to notify the Trustees of presentations and forums as they are scheduled. We have presented results of our work at an average of two professional meetings each year.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The project is closely linked with the river otter component of the NVP project. The fecal samples collected in 1996 and 1997 were part of the field work conducted through NVP. Data and analysis in this project will assist in interpretation of data collected in the river otter component of NVP. In addition, NVP provides salary support for FY 99 for one of the PIs and the graduate student involved in this project. This project is also closely tied to the river otter oil contamination study in the ALSC (project # 98348). This project will maximize the effort of conducting captive experiments by using the fecal samples obtained from the captive otters to calibrate the relationship between diet composition and remains of prey in feces. In addition, this project provides salary support for FY 99 for the lead-PI.

PRINCIPAL INVESTIGATORS

Dr. Merav Ben-David
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Merav Ben-David, Ph.D. is a research associate with the Institute of Arctic Biology University of Alaska Fairbanks. She has extensive experience in studying behavior of mammals and birds under captive conditions. Her research concentrates on mustelids and predatory behavior. She is currently funded for three projects one of which involves developing new DNA techniques to estimate population levels of river otters (ASTF). She is an active member of the IUCN/SSC otter specialist group. Her responsibilities in this project include project coordination, supervising all stages of work, and assistance in data analysis and report writing.

Dr. R. Terry Bowyer
Institute of Arctic Biology
University of Alaska Fairbanks
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Dr. R. Terry Bowyer, Professor of Wildlife Ecology, University of Alaska Fairbanks. Dr. Bowyer has an extensive publication record (70). He has conducted extensive research on river otters and impacts of *EVOS* on this species (10 publications).His responsibilities will include data analysis and assistance in report writing.

OTHER KEY PERSONNEL

Gail M. Blundell
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(907) 474-6688 ftgmb@aurora.alaska.edu

Gail M. Blundell is a Ph.D. student in Wildlife Biology. She has been the project leader for the river otter component of the Nearshore Vertebrate Predator Project since January 1996. Her responsibilities on this project will include data analysis and report writing.

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$68.6
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$68.6
Indirect		$15.6
Project Total	$0.0	$84.2
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$51.3				

Dollar amounts are shown in thousands of dollars.

Comments:
1. Indirect costs at 25% as agreed with the University of Alaska Fairbanks. For contractual work with another institution at cost between 25,000 and 250,000 (Pacific Identification lab) indirect cost at 5%.
2. 37% of direct costs will be spent on Community Involvement.

FY 99

Prepared:

Project Number: 99448
Project Title: EVALUATING RECOVERY OF COASTAL RIVER OTTERS: GENDER-SPECIFIC RESPONSE TO THE EXXON VALDEZ OIL SPILL
Name: Institute of Arctic Biology - University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Merav Ben-David	Principal Investigator - Coordination and write up	0.0	4.5		0.0
	R. Terry Bowyer	Principal Investigator - Analysis and write up	0.0	10.5		0.0
	Gail M. Blundell	Ph.D. Student - Analysis and write up	0.0	1.2		0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	0.0	16.2	0.0	
					Personnel Total	$0.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$0.0

FY 99

Prepared:

Project Number:
Project Title: EVALUATING RECOVERY OF COASTAL RIVER OTTERS: GENDER-SPECIFIC RESPONSE TO THE EXXON VALDEZ OIL SPILL
Name: Institute of Arctic Biology - University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

MPK 4/4/98

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

Contractual Costs:	Proposed FY 1999
Description	
DNA analysis - Genetics lab 500 samples @ $18.0 per sample	9.0
Fecal food habits analysis - Pacific Identification Lab 550 samples @ $60.0 per sample	33.0
Telemetry flights - Northwind Aviation 25 flights @ $1000.0 per flight	25.0
Duplication fees	1.0
Phone	0.6
Contractual Total	$68.6

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared:

Project Number:
Project Title: EVALUATING RECOVERY OF COASTAL RIVER OTTERS: GENDER-SPECIFIC RESPONSE TO THE EXXON VALDEZ OIL SPILL
Name: Institute of Arctic Biology - University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

MPH 4/7/98

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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
AutoSequencer	1
Telemetry receivers	2

FY 99

Prepared:

Project Number:
Project Title: EVALUATING RECOVERY OF COASTAL RIVER OTTERS: GENDER-SPECIFIC RESPONSE TO THE EXXON VALDEZ OIL SPILL
Name: Institute of Arctic Biology - University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

mott 4/7/98

99455

An Investigation of the Data System for

The EVOS Long Term Monitoring Program

Project Number: 99455
Restoration Category: Long-term monitoring and research
Proposer: Charles Falkenberg
Lead Trustee Agency:
Cooperating Agencies: ADNR
Alaska SeaLife Center: No
Duration: 1st year, 1-year project
Cost FY 99: $46,600
Geographic Area: No fieldwork
Injured Resource:

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

We are proposing a small project to investigate the issues relating to the creation of the data delivery system needed by the long-term monitoring and research program. In addition to data collection, data delivery will prove to be a critical component of the success of the long-term monitoring and research program. Therefore, as that program is planned the data delivery issues need to be integrated into the process. We are proposing to outline some of those issues and provide background research into existing systems that deliver similar data. We will not be proposing a specific design for this data system but rather presenting the data system issues that need to be included in planning process.

Introduction

In April of 1997 the Chief Scientist proposed a long-term monitoring and research program as part of the legacy of the Exxon Valdez Oil Spill. Although the details of this program are yet to be worked out it will include the collection of data from a variety of sources and the creation of a long-term data archive. The effective use of the data archive will depend, in no small part, on the effectiveness of the data system that will manage that archive and provide data access to the wide range of stakeholders. We are proposing to investigate the issues relating to that data system so that they might be included in the planning of the EVOS long-term monitoring and research program

This data system will need to provide a variety of users, access to many types of ecosystem data describing the shelf region of the northern Gulf of Alaska. The user community will likely include resource managers, earth system scientists, land use planners, local communities, educators, and other, as yet unidentified stakeholders, as well. It will contain data from the monitoring and research program and possibly include historical and pertinent federal and local data which would be critical to the long term tracking of the coastal ecosystems of Prince William Sound (PWS) and Lower Cook Inlet (LCI).

The single goal of building such a data system is to provide a vehicle that allows the most effective use of the data collected and maintained by the long-term monitoring and research program. The effectiveness of this program will depend not only on data collection, but on data delivery as well. If the stakeholders cannot find or understand the data and they are not used, the collection effort will have been under-utilized. An effective data delivery system increases the value of the data by increasing the long-term use of those data by the widest number of stakeholders and applications.

Scientific data systems are, however, an evolving technology. With the advent of the World Wide Web (WWW) many scientific disciplines have made data available to the public and to fellow researchers. Some of these systems have enjoyed the active involvement of members of the discipline and others have been less inspired and less effective. The successful systems have been well planned with a clear set of users and services in mind. We believe that these data system issues need to be part of the planning for the long-term monitoring program and that the first step is to examine some of these other data system and see how they have succeeded and failed.

We are proposing a small pilot project to investigate the data system issues that need to be considered as the long-term monitoring and research program is brought into focus. Although it is too early to proposing a specific data system design, we will present the data system issues and the ramifications of some of the choices that will be made in the planning phase of the program. We will used the most current description of the long-term monitoring program as a starting point and estimate the data and user requirements. Using this we will research several other scientific data systems and draw some conclusions about how those systems resolved similar issues. Finally we will present

some of the data system issues that will accompany the data which might be collected and the users that might access them.

Together, our experience spans many types of data and many existing data systems. We will use our experience with the Sound Ecosystem Assessment (SEA) project database to evaluate the challenges of managing particular datasets. We will also investigate several data system in the space sciences that have grown as both top down and bottom up systems. Finally we will review the variety of current data systems which have GIS and ecosystem data for the northern Gulf of Alaska region.

Need for the Project

A. Statement of Problem

In his position paper from April 1997 the chief scientist calls for a "permanent, adaptive, interdisciplinary monitoring and research program" designed to carry on a subset of the research and monitoring that has been supported by the EVOS Trustee Council. Over its extended lifetime this project will collect and assemble a large volume of biologic and physical data for use by a wide range of stakeholders. The data system that is used by these stakeholders to access these disparate data will be critical to the successful delivery of these data and the benefit of the monitoring program as a whole. The issues relating to this data system are therefore closely linked to the goals of the long-term monitoring program and need to be included as the program is planned and designed. These issues include the impact of certain types of data and groups of users on the overall design and scope of the data delivery system.

Although the dataset and data sources are still being evaluated the following general categories have been discussed:

- Physical data on the climate, hydrology, and oceanography of the region.
- Lower trophic level data on nutrients, and phytoplankton and zooplankton.
- Data on the growth and distribution of the nekton communities.
- Apex predator data, including birds and marine mammals.

The sources of these data are also of great importance to the operation of a data archiving system. Data policies, data format, lag time, and data ingestion may be quite different for different sources. A subset of the possible sources include the following:

- Previous EVOS funded projects and other focused research efforts.
- Repeated measurements made for monitoring purposes.
- Relevant Federal or State data including remotely sensed data and historical data
- Data from external research efforts that would like to utilize the archive facility.
- Results from models which describe or predict any of the relevant variables

Finally, the data system will likely manage two other critical types of data: GIS data, and text documents and reports. GIS data are maintained by several state and federal agencies and are an important component of most regional analysis. These data might be included in the archive or accessed from distributed archives through an interoperability layer. Many of the current scientific data systems are blending geographic data and measured data to provide context for science and enriched geographic analysis.

Published and unpublished text documents are already available electronically in large volumes and this trend will continue. Making final reports available, along with the data, is often the best data documentation possible. In addition, both GIS and text data can be extremely useful in finding relevant data. Data are often requested using specific geographic features, and if datasets are linked to electronic reports, full text search can be used to locate datasets of interest.

While the types and sources of data effect the operation and structure of the data system, the selection of groups that the long-term monitoring program intends to support will effect the functionality of data system. Although this targeted user community is also being defined, an early estimate might include:

- Earth system scientists who are analyzing the long-term trends in the region.
- Land use planners and managers who are granting permits and evaluating the impact of development.
- Applied scientists who support the local and state agencies with regional analysis.
- Local communities and fisherman who have a vested interest in the resources.
- Educators and students at the secondary or college level.
- Industrial stakeholders including Alyeska and tour operations.

The user base may or may not include any one of these groups but each one presents a unique set of challenges and requirements for the design of the data delivery system.

Although the combinations of these data types, sources, and user groups present a significant number of challenges, a data system that addresses these issues will be a key component of the success of the monitoring program as a whole. The potential benefit of the data collection effort will only be fully realized if those data are used by the widest number of users and applications. Without a thorough delivery system valuable data will loose its long-term value.

The design and goals of the collection effort will have a significant influence on the design of the data system and the impact of including particular types of data and groups of users will influence the data collection effort as well. Therefore we believe that a data delivery system plan needs to be part of the long-term monitoring and research plan.

B. Rationale

Effective planning for the data system should begin with clarifying goals of the system and reviewing the prior work done in this area. As those goals are set, the significance of each needs to be understood and supported with background research. Planning the

complete data system includes an analysis of the data supply and user demand, as well as the available technology that might be utilized, but our rational is to start small. The planning can begin with small steps that will help clarify the goals and the ramifications of setting those goals. One of the first steps is to frame the initial issues and consider design and success of similar data delivery systems.

We are proposing to conduct this background research and combine it with our EVOS related data collection and archiving experience into a final report of data system issues. These include questions about the user community, the data types and sources and the long-term administration of the archive. We cannot make recommendations about which data or users *should* be included in the program, but we will describe the challenges that will accompany various data types and sources, and the requirements that need to be considered as specific groups of users are included.

As an example, data on specific species that has been collected or recorded by hand may have a rich structure but it may include many errors related to manual entry. These data require additional effort as they are added to the database even though the volume can be quite manageable. On the other hand, measured data from remote or in situ instruments can be quite voluminous but and the errors tend to be more systematic in nature. These data may require additional meta-data and place special demands on disk capacity. In addition, similar data from different sources may be recorded with different levels of precision and may be submitted to the archive in different units and formats. The ability of the monitoring program to establish the desired formats will depend entirely on the data source. Monitoring efforts may be funded to produce data in a specific format but the researcher may define the format of the results from historic or ad hoc research.

The functionality of the system depends on the intended user community. Ecosystem and earth system scientists may want raw data along with complete documentation as to how, when, and where those data were collected. Resource managers on the other hand, are interested in some standard data products that can be used on a regular basis to evaluate he impact of ongoing management policies. Both groups may be interested in some level of on line analysis and GIS integration but the specifics are likely to be quite different.

The scientific community has developed a wide variety of data systems that address these problems to a lesser or greater degree. These include systems built by NASA, NOAA and NSF to display and distribute a wide range of data. NASA distributes both earth and space science data on a large scale and has funded a number of interesting centralized and grass roots data systems. NOAA maintains archives for fisheries and oceanographic data and has also funded several data systems. NSF has supported the Long Term Ecosystem Research (LTER) program as well as funding and initiative devoted to the issues of digital libraries. Other possible examples might be drawn from EPA, FOCI or Globec.

Unlike many of the federal data systems, the data system for the long-term monitoring program will likely be quite distributed in nature. Both scientific and GIS data for the northern Gulf of Alaska are maintained in many different federal, state, and local archives. This suggests that a successful data system could provide pointers to relevant

data in similar archives and not replicate data. However, on a long-term scale our current data will become historic data and some of the distributed data may need to be saved in order to provide proper context.

In order to come to an understanding of the possibilities for the data system and the potential impact of various choices, the system issues need to be exposed and similar data systems need to be evaluated. This is an initial small step but it can have a beneficial impact on the planning of the long-term monitoring program.

C. Location

Since this is a data system related project it is not tied to any particular region of the northern Gulf of Alaska. The work will be conducted at the DC offices of ECOlogic Corp. and at the EVOS meeting or ad hoc meetings in Anchorage.

Project Design

A. Objectives

We will produce a report containing the results of our investigation that includes our combined experience in building and evaluating scientific and spatial data systems for the northern Gulf of Alaska. We will not be making recommendations about which data or users the long-term monitoring program should include but rather the data system issues that will accompany those choices. Our report will include but may not be limited to the following topics:

- **Data types and Sources and the related issues.** These issues include data complexity and volume, policies for collection and submission, ingestion requirements, other sites with similar data, and data formats and interoperability.
- **Possible user groups and requirements.** User requirements can vary greatly and we will present some of the needs of specific user groups. These include datasets and regions of interest, data download or analysis requirements, and processing requirements during data delivery.
- **Other state and federal data archives.** We will review several existing archives and data systems and the ways in which these systems dealt with the challenges we have outlined.
- **Other Alaskan and EVOS related archives.** We will look at some of the existing efforts to archive ecosystem data for the State of Alaska and how those system have dealt with similar issues and how general interoperability might be achieved.

Secondary topics will include:

- **Potential functionality of data system.** The functionality can range from simple download of raw data to comprehensive query, visualization and analysis. We will discuss this range and use the existing data system examples.
- **Long-term archive administration.** The long-term administration will include the operational facilities and personnel required to maintain the system over its lifetime.
- **Software and hardware questions.** We will present some of the software and hardware issues including existing commercial software that may be available for particular types of data (e.g. GIS data)

B. Methods

We will start from the current discussion of the long-term archive and estimate the data types and sources which could be involved. In addition, this will provide insight into the likely or intended user community. We will add to this any possible datasets or user groups that may be included as the planning continues. These estimates will be the building blocks of the investigation.

Drawing on our experience with other EVOS projects and with non-EVOS data systems we will outline the issues that are associated with the data types and sources. In addition, we will describe the user groups and the framework in which they would best be able to utilize the data from the long-term monitoring and research program. From this point we will research existing data systems inside and outside the state of Alaska.

We will first look at the Long Term Ecological Research (LTER) archives that are funded by the National Science Foundation. This project is committed to long-term research and archiving and may provide a valuable reference point for another long-term archive. NASA and NOAA have also implemented several scientific data archives that will be useful. The NASA EOS program is focused on the problems of a large volume of remote sensing data but it may still have some relevance. In addition, NASA has overseen the development of several grass roots data systems including the Space Physics Data System (SPDS) and the Planetary Data System (PDS). These may both provide interesting examples of successful data systems, built by and for scientists. NOAA has several data archives including the National Oceanographic Data Center (NODC) and fisheries archives for the National Marine Fisheries Service (NMFS). These may provide good examples of relevant scientific archives as well as potential sources of data.

Other possible data archives include the Globec and FOCI projects, EPA funded environmental archives, and atmospheric and meteorological archives. Finally, an effort spawned by NSF has been researching the requirements of digital libraries. The Alexandria Digital library focuses on spatial data in digital form and will be a useful example. As this aspect of the project unfolds several other potential scientific archives will likely emerge and may be included in the investigation.

We will also examine the current state and use of the existing databases that maintain data on the northern Gulf of Alaska. Some of these will be EVOS funded projects including SEA, Apex and the hydrocarbon database. In addition, the Alaska Department

of Natural Resources and the Alaska Department of Fish and Game both have initiatives for state and regional archives of data. Interoperability with these databases or data systems will also be part of our research.

Many of the regional archives include GIS data and text. We will examine how these data type in specific are being managed and how they might be incorporated into the data system for long-term monitoring program. Some of this perspective will come from systems that manage other large scientific archives in conjunction with GIS data.

C. Cooperating Agencies and Groups

The project will be led by Charles Falkenberg from ECOlogic Corp. and include collaborators from the Prince William Sound Science Center and the Alaska Department of Natural Resources. The individuals from these groups bring a unique perspective to this project and their responsibilities are described in the section entitled "key personnel".

Schedule

A. Measurable tasks for FY99 (Oct 1 1998 – Sept 30, 1999)

December 31:	Complete plan for background research
March 23 - 27:	Attend 10th Anniversary Symposium. Meet with collaborators.
July 30:	Complete final report of data system issues and background.

B. Project milestones

We expect our effort will require about 3.5 person months of research, analysis and report writing. In that time we will be reviewing the existing systems, contacting individuals who can provide insight into particular data systems, and writing up the report. The report will be intended for the planners of the long-term monitoring and research program with the hope of adding insight to the planning process.

The research and analysis will be conducted on either side of the 10th Anniversary Symposium. The initial work will be done before the meeting and we will use that meeting as an opportunity for the collaborators to evaluate the research and outline the report. Any additional research will be done after the Symposium and final report will be produced by the end of July.

Reports

The final report for this project will include the results of our background research and the issues related to the data system for the long-term monitoring program.

Principal Investigator

Charles Falkenberg
ECOlogic Corp.
19 Eye Street, NW
Washington, DC 20001
Phone: 202-218-4100
Fax: 202-842-5088
Email: csfalk@ecologic.net

Charles Falkenberg has an MS in computer science and has been involved in building database systems since 1980. He was the principal developer of the archive and data system for the EVOS Sound Ecosystem Assessment (SEA) project. He has designed scientific data management systems for oceanographic data, NASA's Earth Observing System (EOS) data, and data for environmental assessment. ECOlogic Corp. is a software development and consulting firm, specializing in spatial data management for science and industry. It is currently working on three NASA projects developing tools and applications for EOS data archiving and analysis.

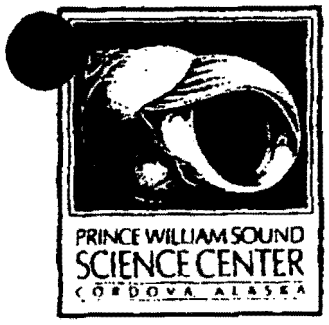
Other Key Personnel

Vince Patrick is a founding member of the SEA project and is the principal investigator for the SEA modeling effort as well as the SEA database. He has been involved with the data issues in SEA and brings a deep understanding of the challenges of ecosystem analysis. He will provide both historical context for the development of scientific data systems and insight into the challenges of creating and deploying a large ecosystem database. In addition, Vince has worked with fisheries managers and will assist in evaluating the needs of the resource management community.

Carol Fries is a Natural Resource Manager in the Office of Commissioner, EVOS at the Alaska Department of Natural Resources and has been involved in organizing the EVOS CD and GIS data for the EVOS region. ADNR is currently implementing an "Alaska State Geospatial Clearinghouse" funded with a grant from USGS. The Clearinghouse project will establish a National Geospatial Data Clearinghouse node at the Alaska Department of Natural Resources that will allow for the development of an electronic pathway to meet public and inter-agency demands for geospatial data. Data will be documented according to the FGDC requirements to ensure consistency and discovery on line. The ADNR Clearinghouse project focuses on state and local data and will complement the Alaska Geographic Data Clearinghouse site developed and maintained by USGS. Carol will provide a perspective on the GIS data that need to be accessed as well as wide variety of data that been collected as part of ongoing EVOS research.

Ravi Kulkarni developed the CDF scientific data format and has been involved with both space science data systems and visualization. He is currently working on a NASA project that is exploring techniques for standardizing the process of data publication. He

will evaluate several of NASA grass roots data systems and provide an analysis of potential data publishing techniques.



P.O. Box 705
Cordova, AK 99574
(907) 424-5800 FAX: (907) 424-5820

April 14, 1998

Charles S. Falkenberg
Ecologic Corp.
19 Eye Street N.W.
Washington, D.C. 20001

Dear Mr. Falkenberg:

This is to express my enthusiasm and support for your proposal and my interest and intention of collaborating on this effort. It is my sincere wish to see our work on the Sound Ecosystem Assessment (SEA) data system and the "corporate" knowledge gained be available to the Trustee Council and the southcentral Alaska region. This is an excellent opportunity to bring together the recent SEA experience, your new work at Ecologic, and the recent work of Ravi Kulkarni and Carol Fries.

Best regards,

Vincent Patrick

Vincent Patrick, Ph.D.
SEA Data Project Leader

University of Maryland at College Park

Advanced Visualization Laboratory

April 13, 1998

Mr. Charles Falkenberg
Ecologic Corp.
19 Eye St., NW, Washington DC 20001

Dear Charles,

With this letter I am affirming my intent to participate in the proposal entitled "An Investigation of the Data System for EVOSTC Long Term Research and Monitoring Program". A committment to a long term monitoring project such as is being contemplated by the EVOSTC requires a careful study of existing data systems, evolving technologies, and the types of data to be collected in the program. I would be happy to assist you in assessing the scope of such a project and the ability to leverage existing efforts in this area.

Sincerely,

Ravi Kulkarni

Ravi Kulkarni
Research Associate

Advanced Visualization Laboratory, University of Maryland, College Park, MD 20742
Tel: (301)405-1559 FAX: (301)405-0720 INTERNET: ravi@avl.umd.edu

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$20.8
Travel		$1.7
Contractual		$14.8
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$37.3
Indirect 25%		$9.33
Project Total	$0.0	$46.6
Full-time Equivalents (FTE)		0.17
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:
ADNR has agreed to administer the funds to ECOlogic.

FY 99

Prepared: 4/13/89

Project Number: 99455
Project Title: An Investigation of the Data System for Long-Term Monitoring
Name: Charles Falkenberg

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Charles Falkenberg	Project lead		2.0	10.4		20.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	2.0	10.4	0.0	
					Personnel Total	$20.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
10th Anniversary Symposium		0.8	1	6	0.15	1.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$1.7

FY 99

Prepared: 4/13/89

Project Number:
Project Title: An Investigation of the Data System for Long-Term Monitoring
Name: Charles Falkenberg

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Colaborator services	14.8
Contractual Total	$14.8

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared: 4/13/89

Project Number:
Project Title: An Investigation of the Data System for Long-Term Monitoring
Name: Charles Falkenberg

FORM 4B
Contractual & Commodities DETAIL

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

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

Existing Equipment Usage: Description	Number of Units	

FY 99

Project Number:
Project Title: An Investigation of the Data System for Long-Term Monitoring
Name: Charles Falkenberg

FORM 4B
Equipment
DETAIL

Prepared: 4/13/89

Evaluating Scientific Sampling conducted during the Exxon Valdez Oil Spill, Synthesizing Lessons Learned, and Incorporating them into Natural Resources Injury Assessments

Project Number:	99 456
Restoration Category:	Monitoring
Proposer:	Alaska Department of Environmental Conservation
Lead Trustee Agency:	Alaska Department of Environmental Conservation
Cooperating Agencies:	Alaska Departments of Law, Fish and Game, and Natural Resources, United States Department of Interior, Department of Commerce, and Department of Agriculture
Duration:	Two Years
Cost FY 98:	**T.D.**
Geographic Area:	Spill-Impacted Area
Injured Resource/Service:	All injured resources and services

RECEIVED
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EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

Since the Exxon Valdez Oil Spill, a tremendous amount of scientific research has been conducted on the impacts of the spill and the recovery of injured resources and services in the spill impacted area. Despite this wealth of information, there has been no comprehensive evaluation and compilation to determine which sampling methods, studies, and restoration projects were effective and which were not. This project will review scientific research findings from agencies, and where appropriate, the University of Alaska, Exxon, and private contractors, and create a scientific sampling protocol that most efficiently documents environmental impacts, and better prepares state and federal resource agencies to assess injuries in the event of another spill.

INTRODUCTION

This project is a cooperative effort between many resource agencies to review existing oil spill information and jointly determine which sampling methodologies were and were not effective in assessing injuries to natural resources and services. The review findings will be used to interpret "lessons learned" from the scientific research conducted since the Exxon Valdez oil spill. These lessons will be used to write scientific sampling guidelines for determining quantifiable injuries to sensitive resources and services in the event of future oil spills. Several of the state and federal cooperating agencies were extensively involved with assessing impacts from the EVOS. Their participation in this effort is pivotal. We will strive to produce sampling guidelines that incorporate all of the agencies "lessons". Our goal is to have a unified set of sampling guidelines that will assist all cooperating agencies when responding to future oil spills.

NEED FOR THE PROJECT

A. Statement of Problem

A tremendous amount of information on the effects of the EVOS has been generated in the past nine years. The agencies cooperating on this project recognize the importance of using this information to further our knowledge of ecosystem response and recovery and to focus our restoration efforts. Alaskan natural resources and services have been jeopardized by oil spills and have suffered long and short-term impacts. Depending on the nature of the injury, some impacts are clearly evident and can be easily quantified; oiled beaches, dead or harmed wildlife that have been recovered. Other oil spill impacts are difficult to quantify because they are not readily apparent. There is no consensus on the most effective methods of assessing these impacts. As a result the effectiveness of sampling efforts, especially in the initial stages of an oil spill response, are compromised.

Oil spills and near misses have continued to occur since the EVOS. Since 1991, the Alaska Department of Environmental Conservation has been accumulating statistics associated with oil and hazardous substance discharges from tanker and barge traffic initiated from the Port of Valdez. A total of 108 discharges have been reported along with 10 potential spills. The most significant spill occurred on May 21, 1994, when 8,400 gallons of crude oil discharged from the tanker vessel *Eastern Lion* as a result of a crack in the hull.

A near miss occurred on November 10, 1995, when the oil tanker *Kenai* took an outbound course from Port Valdez through the Valdez Narrows, a restricted waterway, and entered shallow waters near Entrance Island far removed from the established vessel route. It was loaded with a cargo of approximately 835,000 barrels of crude oil. The tanker was as close as 600 feet from shore and in water depths less than 100 feet. The tanker did not ground or spill oil and sailed out of Prince

William Sound unharmed. This event shows that future spills are a possibility, despite all our advances in the last ten years.

The need for a scientific contingency plan and sampling protocols during an oil spill response has also been recognized within the international response community. On February 15, 1996, the *Sea Empress* went aground at Milford Haven off the Pembrokeshire coast of South Wales, Great Britain. Between February 15 and 21 some 72,000 tons of Forties blend crude oil was released into the marine environment. A recent report with recommendations from the Sea Empress Environmental Evaluation Committee (SEEEC) confirm that, "although there are contingency plans at a national and local level for responding to oil spills, with the response action dependent on the scale of the spill and its overall impact, there are no comparable response plans for assessing environmental impact" (SEEEC, 1998). The SEEEC report indicates that "a more structured, coordinated approach, adopting clearly defined procedures and sampling and analytical protocols, and providing an assured funding base for its program, would have proved highly beneficial". The Scottish government reached a similar conclusion following the 1993 *Braer* oil spill whereby they proposed that a liaison group be established as soon as possible at all spills posing a significant threat to the environment.

B. Rationale/Link to Restoration

This project will help the agencies and the public in understanding how the injuries were measured, where they occurred, and what restoration measures have and have not worked. The review and analysis of research and scientific sampling and monitoring methodologies from Trustee sponsored projects will be helpful for linking science, oil spill management efforts and injury assessment for future spills in Prince William Sound and the Gulf of Alaska. This project directly builds on this synthesis and integration process. This project will specifically answer how we can respond more effectively to future oil and hazardous substances spills to assess potential impacts to the most vulnerable resources and those that experience the longest recovery periods. We will create a method for effectively measuring the impacts of oiling in cost effective ways. This project will develop methods and strategies for assessing injuries and restoration monitoring that needs to be implemented in advance of the next oil spill. A better ability to assess and restor injury during a future oil spill will assist in restoration of EVOS injured species.

Some of the key scientists involved with the EVOS agree that we must process and learn from the work conducted previously. "Realistic ecological assessment" of the recovery of resources and services injured by the *Exxon Valdez* oil spill "requires long-term monitoring of salient patterns and processes at appropriate spatial and temporal scales using sound sampling design and statistical analyses" (Michener 1997). This strategy was echoed by the Chief Scientist (Spies 1997) in his description of a "...permanent, adaptive, interdisciplinary monitoring and research program that would track, and eventually help predict ecosystem changes and provide a basis and mechanism for long-term restoration, enhancement, and wise management of marine resources in

the northern Gulf of Alaska".

This plan is supported by the Trustee Council's increased emphasis on "integration and synthesis of what has been and is being learned from various restoration projects and the earlier work conducted during the damage assessment phase". As stated in the Ecosystem Synthesis section of the 1999 requests for proposals (Exxon Valdez Oil Spill Trustee Council, 1998.) "The integration and synthesis of project results will enable the Council, the scientific community, and the public to view the effects of the oil spill and the long-term restoration and management of injured resources/services from broad, multi-project and ecosystem-level perspective. This will provide an improved framework for development of long-term restoration, research, monitoring, and management plans".

C. Location

This work will be conducted by principle investigators in Alaska, and by scientific reviewers throughout North America. The methods developed by this research project will emphasize use and implementation within Prince William Sound and the Gulf of Alaska. Project benefits will be realized throughout the Northern Gulf of Alaska area. Communities that may be affected by the project include: Anchorage, Nanwalek, Homer, Kenai, Nikiski, Ninilchik, Port Graham, Seldovia, Soldotna, Tyonek, Whittier, Tatitlek, Chenega, and Valdez.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Despite the wealth of information generated from studying the *Exxon Valdez* oil spill and other research efforts, the information has not been analyzed and synthesized into effective sampling protocols for state and federal agencies to follow in the event of another oil spill in Prince William Sound or the Northern Gulf of Alaska. The public needs to know that we have learned from the Exxon Valdez oil spill and that these lessons have been incorporated into agency policy to strengthen spill response efforts.

Although this project does not specifically address traditional ecological knowledge (TEK), TEK products could potentially be incorporated into the system. The TEK information that has been included in other projects and summarized in the synthesis reports will be included in the scientific sampling protocols.

PROJECT DESIGN

A. Objectives

1. Establish an interagency team (working group) that will serve as primary contacts, agency liaisons and peer reviewers for the duration of the project.

2. The working group will write a request for proposal and award and oversee a contract for a consulting company to conduct an evaluation of the sampling conducted during the EVOS and other oil spills.

3. Produce a report containing the findings of the contractors review and conduct an agency peer review of the report.

4. Create a set of sampling protocol guidelines that incorporates the best sampling techniques to use during future oil spill responses.

B. Methods

We will be approaching this project in phases. During phase one, which is the first year of the project, we will concentrate on objectives one and two. Each cooperating agency will be responsible for naming a representative to participate on the working group. Each agency representative will be responsible for assisting in writing the request for proposal, selection of the contractor, providing information to the contractor, participating in work group meetings, internal coordination within their agency, review of all contractor work products, evaluation of the final report, and participation in the drafting of the final sampling protocol guidelines.

An initial meeting of all work group members will be held to scope out topics for the request for proposal, agree to a schedule for contractor selection, and establish consistent review goals. Each agency representative will participate on the selection committee for a contractor. Each agency representative will assist the chosen contractor in their evaluation of the agency's sampling during the EVOS and other applicable oil spills by providing all pertinent information and contacts within their agency. The contractor, with the assistance of each agency representative, will evaluate the previous sampling to determine if it was effective in assessing injury and quantifying effects.

The Alaska Department of Environmental Conservation (ADEC) representative will be the primary contact to the contractor and will be responsible for ultimately overseeing the contractors work products. Throughout this process the ADEC representative will be tracking the contractors progress and routinely distributing work products to the working group for their review. The working group will determine a regular meeting schedule to discuss the projects progress and findings to date. Meeting topics to be addressed include: initial spill response vs. longer term sampling, species selection, food web effects, individual vs. population level effects, analytical methods and statistical study design, assessing effects on different habitat types, bioassay effectiveness, and others as needed. The ADEC representative will be responsible for

compiling minutes from the working group meetings. This iterative process will provide ongoing updates on the contractors reviews, capture the working groups areas of agreement and disagreement and help focus the areas that need refinement.

The Trustee sponsored EVOS data synthesis efforts will provide fundamental information that would otherwise not be compiled and can be used in the design of sampling and other guidelines. We plan to use the findings of the ecosystem effects to shoreline habitats by Charles Peterson, fishery effects by Phillip Mundy and Andrew Gunther, scientific findings by R. Spies, and trophic fluxes by D. Pauly and S. Pimm. These synthesis efforts will provide information on the sensitivity of and recovery rates for key species of interest and critical habitats in the spill area. For example, based on the information contained in the Peterson data syntheses the sampling protocol will be designed for use during the different stages of an oil spill (floating oil, shoreline contact, and particulate deposition on the seafloor). The sampling protocol will identify which habitats and species are most at risk during these stages and focus sampling efforts toward them. We propose to focus sampling efforts on the resources that were most injured by the EVOS since it is likely that future spills would effect the same resources (see Table 4. "Resources and Services Injured by the Spill" in the instruction booklet for 1999 restoration proposals). This emphasis will contribute to the continued recovery of injured resources.

The cooperating agencies will assist in directing the contractor review. We will identify which types of sampling was the most and least effective at quantifying injuries to natural resources and services. Some examples of key issues are: what trophic levels should be sampled, which species are best to target, what types of bioassays are effective, which sample matrix combination (air, water, soil, sediment, tissues) gives the best information on ecosystem effects, and others. We will compile all of these "lessons learned". These will form the basis of the sampling protocol guidelines on what should be sampled and how to do it.

We plan to incorporate existing applicable information into our effort whenever possible to minimize repetition of past efforts. Other existing sampling strategies for oil spills and releases of hazardous substances (NOAA, USFWS, Coast Guard, etc.) will be researched and reviewed by the contractor for applicability to Alaskan conditions and incorporated into the proposed sampling strategy if appropriate.

Phase two of this project (the second year) will focus on objectives three and four. We will incorporate the effective sampling strategies into draft preliminary scientific sampling guidelines. The guidelines will be a multi-tiered strategy that can expand in complexity and scope according to the nature and magnitude of the release of oil or hazardous materials. During a larger spill, or one involving the release of a highly toxic compound or mixtures of compounds, or that occurs in a sensitive area, a more extensive level of sampling (higher tier) may be required.

A multi-tiered sampling strategy will be adaptable to many types of oil and hazardous substance

releases. The guidelines will include recommendations for various spill scenarios: type of product, amount and location of spill; sensitivity of the effected habitats; how to estimate ecosystem impacts; assessment of customary and traditional subsistence harvest area; differing land uses in the spill area; and other key decision elements.

The sampling guidelines will propose protocols for the different time frames of spill response; the initial few weeks, and in larger or more serious spills, long term sampling. The sampling protocol will develop specific data collection methods for spills that occur in many habitat types: freshwater streams and lakes, marine coastline, open ocean, and terrestrial areas. Specific species representative of each habitat type will be identified for collection and monitoring. Sampling will be prioritized based on the sensitivity of habitats. Critical habitat definitions from Alaska Departments of Fish &Game and Natural Resources, Fish &Wildlife Service, Forest Service, Park Service etc. will be used.

The sampling guidelines will address statistical analysis of data, including the number of samples needed to achieve specific levels of statistical power. The tiered approach of this sampling plan will allow it to accommodate different levels of scientific rigor. The types of samples to collect for specific types of releases will be defined (tissue, sediment, water, air and soil). The sampling methods prescribed will be state of the science, standard methods that have been peer reviewed and widely accepted in the scientific community. Chain of custody procedures will be incorporated into all tiers.

A field manual will be written that describes sampling methods for collecting clean samples and includes a field equipment checklist. The analytical methods, detection limits, and quality assurance/quality control specifications will be identified. This portion of the guidelines will need to be updated periodically as improved analytical techniques are developed.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Funding for state and federal agencies will be determined prior to final submittal. Agency funding will be allocated from the contractual line item. If necessary, additional funding for ADF&G and ADNR can be provided by ADEC through reimbursable service agreements in FY 1999 and FY 2000.

The budget will be finalized in the near future.

SCHEDULE

A. Measurable Project Tasks for FY99

October: Establish a working group with representatives from all cooperating agencies. Have a kick-off meeting to scope the RFP, determine how agency reviews will be conducted, define consistent review procedures, and identify future meeting topics and schedules.

November- December: Write the RFP and advertise it.

January: Select the contractor and finalize the contract.

February: Meet with all cooperating agency representatives and the contractor to start the review of sampling information.

March – September: Contractor conducts reviews of sampling information. The working group meets at regular intervals to discuss findings and define areas of agreement and disagreement. On an ongoing basis, drafts of the contractors findings are distributed to cooperating agencies for review and comments.

Measurable Project Tasks for FY00

October-November: Complete a preliminary draft of the sampling guidelines

December-February: Circulate the preliminary draft of the sampling guidelines to the working group for review. Each working group representative conducts and internal agency review.

March-April: Obtain and consolidate comments received, incorporate comments and finalize preliminary draft of guidelines.

May-June: Conduct an peer review of the preliminary draft of guidelines with the EVOS peer reviewers and other experts.

July-August: Obtain and consolidate comments received, incorporate comments and finalize draft of guidelines.

September: Prepare final report for the project.

B. Project Milestones and Endpoints

Project Milestones and Endpoints are reflected above in the proposed schedule. MORE

INFORMATION TO BE PROVIDED

C. Completion Date
The guidelines will be finalized by October 2000.

PUBLICATIONS AND REPORTS

More information will be provided at a later date.

PROFESSIONAL CONFERENCES

The presentation of the scope of this project will be presented at the 10th anniversary EVOS conference. We may also submit papers to Arctic Marine Oil Program; International Oil Spill Conference, Society of Environmental Toxicology and Chemistry annual meeting in 2000, and possibly other conferences or workshops in Alaska.

NORMAL AGENCY MANAGEMENT

NEED TO WRITE THIS UP

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The aim of the proposed work is to synthesize data from projects funded by the Trustee Council and apply the findings to future oil spill response management associated with injury assessment.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Resume is attached.

OTHER KEY PERSONNEL

Selected state and federal department peer review representatives will be listed here.

LITERATURE CITED

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PROPOSED BUDGET:
Total Budget: 325K
Phase I - Fiscal Year 1999: 175K
ADEC Staff: Crook: 40K
ADF&G:
ADNR:
DOI:
DOC:
DOA:
Contractual: 120K (25-40K to be divided among agencies for services outlined in Methods Section)
Travel: 15K
Equipment: 0

Phase II - Fiscal Year 2000: 150K
ADEC Staff: Crook 30K
ADF&G:
ADNR:
DOI:
DOC:
DOA:
Contractual: 110K (25-40K to be divided among agencies for services outlined in Methods Section)
Travel: 10K
Equipment: 0

Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska

Project Number:	99459
Restoration Category:	Research/Monitoring
Proposer:	Dr. Gail V. Irvine DOI-BRD, Alaska Biolgical Science Center
Lead Trustee Agency:	DOI
Cooperating Agencies:	NOAA
Alaska Sea Life Center:	No
Duration:	One year, plus close-out
Cost FY 99:	$195.5
Cost FY 00:	$40
Cost FY 01:	0
Cost FY 02:	0
Geographic Area:	Kodiak/Alaska Peninsula, Kenai Peninsula
Injured Resource/Service:	Designated wilderness areas, mussels, intertidal communities

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ABSTRACT

For at least 5 years after the *Exxon Valdez* spill, oil mousse persisted on the exposed rocky shores of the Alaska and Kenai Peninsulas in a remarkably unweathered state. We propose to resample these boulder-armored beach sites that were last studied in 1994. In addition, we want to use the results of our previous work to predict, on the basis of geomorphology and oiling history, other locations in the oil spill area where oil is likely to be persisting in a relatively unweathered state. These sites will then be visited and sampled. In addition we also propose resampling several oiled mussel beds in the Gulf of Alaska that had relatively high levels of oiling in 1993, to compare residual oiling of these with oiled mussel beds in Prince William Sound.

INTRODUCTION

This proposal is focused on shoreline oiling in the Gulf of Alaska, the continued presence of subsurface oiling, and the situations that promote oil persistence and retard weathering of stranded oil. The continued contamination of shorelines and biotic communities by residual *Exxon Valdez* oil, especially slowly weathering oil, is a concern of direct relevance to the recovery status of injured resources and services. The *Exxon Valdez* oil spill directly affected the scientific and recreational values including wilderness characteristics of shorelines in Kenai Fjords National Park and Katmai National Park and Preserve. The injury to these values and characteristics is continued by the persistence of oil that degrades the "naturalness" of the coasts. These values and characteristics are clearly stated in both ANILCA (1980) and the Wilderness Act (1964). Additionally, the retention of oil by mussel beds in the Gulf of Alaska and its retarded weathering is of some concern, as the mussel beds are reservoirs of oil that could be released into the environment or contaminate foragers of the mussels.

The exposed Gulf of Alaska habitats where oil has persisted and mussel beds share some common features. They have complicated three-dimensional spatial structures, which allow stranding oil to penetrate into more protected sediments beneath an "armor" of boulders or mussels. Oil thus sequestered is slower to weather (Babcock et al. 1994, 1996, 1997; Irvine and Cusick 1995; Irvine et al. 1997; Short and Heinz 1997). In fact, oil sampled five years post-spill at sites along national park coasts distant from the spill point was negligibly different from 11-day old *Exxon Valdez* oil (Irvine et al. 1997). The oil contaminating these coasts was mousse, a water-in-oil emulsion that weathers more slowly internally (Payne and Phillips 1985) and can serve to transport less weathered oil over long distances (Irvine et al. 1997).

In general, the shorelines impacted by *Exxon Valdez* oil in the Gulf of Alaska region experience higher wave energy than those inside Prince William Sound (Hayes et al. 1977; Hayes and Ruby, 1979; Domeracki et al. 1981; Hayes 1986). Gravel beaches, those composed of mixtures of sand, pebbles, cobbles and boulders, are the most common type of non-bedrock shorelines in the Gulf of Alaska region (Hayes et al. 1976). Gravel beaches exposed to moderate and high wave energies characteristically develop a lag of boulders (stones > 25 cm in diameter) after smaller stones are winnowed away by waves. This boulder lag forms an "armor" that shields the gravel substrate from wave disturbance. Unaffected by all but the largest storm waves, the gravel substrate under a boulder armor can remain undisturbed for years. Observations in the study plots we have established to monitor the persistence of surface oil in Kenai Fjords and Katmai National Parks suggest that on 5 of 6 boulder-armored beaches, no shifting of the boulder armor occurred for 6 years post-spill (Mann et al. 1995).

The length of time that spilled oil remains on a shoreline is thought to depend on the vigor of wave action (Vandermuelen 1977; Gundlach 1983). Frequent large waves breaking on a beach cause vigorous natural cleaning and consequently a short residence time for stranded oil. However, the *Exxon Valdez* spill affected numerous gravel beaches, many possessing the boulder armoring just described. While high wave energy does seem to limit the persistence of surficial

oil on gravel beaches, it may have little effect on the persistence of subsurface oil. Subsurface oil can persist even within high wave-energy gravel beaches because the boulder armor prevents waves from stirring the beach substrate.

The amount of subsurface oil persisting on Gulf of Alaska shorelines has never been fully assessed. Exxon Corporation ran several studies whose results have never been published. Additionally, the Alaska Department of Environmental Conservation studied oiling profiles of beaches (including some boulder-armored beaches) in the Kodiak/Alaska region for several years following the spill (Endres et al. 1992). Results of our several-year study of surface-oil fate and persistence on beaches in Kenai Fjords and Katmai National Parks indicate sizable reductions in the amount of surficial oiling there. However, observations made in 1994 indicate that significant amounts of subsurface oil remain within gravel beaches along the Katmai coast of Shelikof Strait, even after these beaches were cleaned at the surface. Similar inferences emerge from the studies of Michel and Hayes (1993a, 1993b, 1994, 1996) and Neff et al. (1995) on the fate of shore-stranded oil on Prince William Sound shorelines.

We suspect that buried oil mousse is common on boulder-armored gravel beaches where heavy surficial oiling was observed after the oil spill. This study will continue our monitoring of surface oil in the Gulf of Alaska region and extend our examination of the extent, persistence and weathering of subsurface oil in gravel beaches of the region. We have constrained our study to coasts along the Gulf of Alaska, outside of Prince William Sound, where contamination was by oil mousse, in order to further reduce variability due to initial oiling parameters. We will use the results of our previous oil persistence study to predict the location of additional sites of residual oiling in the Gulf of Alaska based on the coincidence of armored beaches and initial oiling, and examine and sample those sites. We hypothesize that the combination of 3-dimensional heterogeneity and stability of an armoring substrate allows penetration of the oil, persistence of subsurface oil and impedes physical processes that weather the oil. We will develop measures or indices of stability that can be combined with assessments of geomorphology and oil weathering to generate further predictions of the site characteristics that promote oil retention and reduce weathering of stranded oil.

Study History:
Both the stranded oil persistence study and the oiled mussel bed study were previously funded by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC). The oil persistence study (R103B, 93090 94266) was funded for field work in 1992 and 1994. Six moderately to heavily oiled sites along the Gulf of Alaska coasts of Kenai Fjords National Park and Katmai National Park and Preserve were studied for both surficial and subsurface oiling changes, and oil samples were analyzed to examine the degree of weathering of the oil. Although five of these sites were very high energy beaches, oil mousse persisted in a remarkably unweathered state on these boulder-armored beaches. Mousse sampled in 1989, 1992, and 1994 showed negligible changes in polynuclear aromatic hydrocarbons compared to 11-day old *Exxon Valdez* crude (Irvine et al. 1997). Our findings also suggest that the low ecological sensitivity ratings previously applied to exposed, rocky shorelines need to be modified when boulder-armored beaches are present.

Because the weathering of the oil was so slight, we feel that a resampling of these beaches 10 years post-spill is desirable.

The study of oiled mussel beds in the Gulf of Alaska (R103B, 93090, 95090), was a companion to studies of oiled mussel beds in Prince William Sound being spearheaded by NOAA. The objectives of the previous study were to establish the geographical extent and intensity of the oiling of mussel beds, and to determine the rate of recovery of those beds that were oiled. We are proposing to resample the 3 sites sampled in 1995 that had the highest levels of oiling.

NEED FOR THE PROJECT

A. Statement of Problem

Oil from the wrecked T/V*Exxon Valdez* spread from Prince William Sound out into the Gulf of Alaska, stranding on coastlines of the Kenai and Alaska Peninsulas and the Kodiak Archipelago. As recently as 1993 and 1994, oil remained in particular types of locations in the Gulf of Alaska. These included boulder-armored intertidal beaches and mussel beds. As stated on page 19 of the Invitation to Submit Restoration Proposals, "The oil that remains in the environment and the extent and significance of any biological exposure to that oil continues to be an important concern of direct relevance to the recovery status of injured resources and services."

The persistence of oil on national park coastlines (sites are located on Kenai Fjords and Katmai National Parks) constitutes injury to the scientific, recreational, and wilderness values of the parks. While we intend to assess the significance of the oiling, we are also assessing the recovery of oiled sediments through natural processes of physical and chemical weathering of the oil.

Shoreline sediments were impacted by *Exxon Valdez* oil in an obvious way by oil stranded on the surface. However, the amount of oil seeping into or being buried in the substrate of beaches was never adequately assessed on shorelines in the Gulf of Alaska. Gravel beaches are widespread in the Gulf of Alaska region and most have an armor of lag boulders that prevents natural cleaning of subsurface oil. Boulder-armored gravel beaches potentially comprise a widespread situation fostering subsurface oil persistence. How much subsurface oil remains? What is its chemical weathering state? How fast is it disappearing through mechanical and chemical weathering?

The three-dimensional topography of mussel beds creates a situation similar to that of boulder-armored beaches, where oil has penetrated finer sediments beneath the mussels but is protected to some extent from disturbance and weathering processes. The same questions regarding the retention and weathering can be asked for mussel beds as for the boulder-armored beaches. Additionally, since predators feed on the mussels, there is the potential for exposure of the predators to hydrocarbons. In the Nearshore Vertebrate Predator project in PWS, invertebrate-feeding predators (sea otters and Barrow's goldeneye ducks) have shown elevated levels of

biomarkers that may indicate increased exposure of the animals to hydrocarbons, though the linkages to sources and the significance of the results are not known.

B. Rationale/Link to Restoration

This project has a very basic link to oil spill effects: we are studying the persistence and degradation of stranded oil. Elements of both research and monitoring are included in the project. The research element is the testing of the predictive power of previous results to indicate other areas where subsurface oiling continues, and, through analysis of oil samples taken at these new sites, evaluation of the exposure of the residual hydrocarbons to weathering processes. Another research element is the analysis of the disturbance rates of the boulder-armoring in order to interpret the present results and predict the long-term residence time of the sequestered oil.

The monitoring elements are straightforward reassessments of the persistence and degradation of oil on boulder-armored beach sites and in oiled mussel beds. On the oiled shorelines, we will continue to monitor surface-oil weathering at six sites already established in the Gulf of Alaska, as well as subsurface oiling. Both physical and chemical weathering of the oil will be assessed. The re-assessment of these previously sampled sites is the essential core of our proposal. Oiled mussel beds will be resampled at three locations using previously established techniques to determine the chemical weathering of hydrocarbons in both mussel tissue and sediments underlying the mussels. The results obtained will help describe the progress of recovery of oiled sediments and biota. Results will guide decisions about whether future restoration efforts are desirable and how they might be implemented.

Our results will also help predict the effects of future oil spills in this region and guide future oil-spill response efforts. In particular, our results suggest that a revision to the Ecological Sensitivity Indices (ESI's) for boulder-armored exposed rocky shores may be necessary, and that instead of being rapidly cleansed by wave action, these sites are locations where oil may persist for decades with minimal weathering. This revision could lead to changes in how these habitats are dealt with following spills.

C. Location

Sites that will be resampled are located in the Gulf of Alaska along Kenai Fjords and Katmai National Park coasts, and the outer Kenai Peninsula. Other study areas will be chosen on the basis of geomorphology and oiling conditions in 1989.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

At present, there are no communities in the vicinity of the study areas. We will be happy to present information to local communities and/or prepare lay abstracts of our work. Additionally, after we identify those sites where we expect subsurface oil to still be an issue, we will evaluate

their proximity to local communities and contact them for additional input and to keep them informed of our actions.

PROJECT DESIGN

A. Objectives

1. Monitor (a) surface and (b) subsurface oil at 6 previously established sites along the Gulf of Alaska coast. Determine the physical extent and chemical weathering of the oil.

2. Assess the rates of disturbance of the boulder armor at the 6 sites in (1).

3. Use previous geomorphological results and oiling history data to predict locations in the Gulf of Alaska where subsurface oil still persists. Examine a subset of the possible sites and establish new sites where appropriate. Sample as for the previously studied sites [in (1)]. The target is 6 new sites. Also, establish a set of 6 control sites comprised of non-armored, oiled sites with exposures similar to the armored sites.

4. Monitor recovery of a select subset (3) of previously sampled Gulf of Alaska oiled mussel beds.

B. Methods

Sampling methods at the boulder-armored beaches will include: relocation and resampling of permanently marked quadrats, resurveying of bolts on the boulder armor, gas chromatography/ mass spectroscopy (GC/MS) analysis of oiled sediment samples from each site, analysis of sub-surface oiling by sampling "dip stones". At the oiled mussel sites, 3 pooled samples each of mussels and sediments will be taken relative to a transect laid along the zone of heaviest oiling of the mussel bed.

The following section details the hypotheses and methods associated with each of the Objectives listed above.

1. a. *Monitor <u>surface</u> oil at 6 previously established sites.*
Continued monitoring of the fate of stranded surface oil on Gulf of Alaska shorelines indicates gradual disappearance of this oil. We hypothesize that surficial oil will have disappeared entirely by 1999 (5 years since the last sampling and 10 years post-spill).

Methods established in 1994 will be used to reassess the surficial oiling at the 6 sites previously established along the coasts of Kenai Fjords and Katmai National Parks. Oil percent cover will be estimated visually in the field within 10-25 quadrats per site previously set up and marked by rock bolts. Independent estimates by observers will be

compared and estimates modified until all observers agree on oil coverage within 5% (Dethier et al. 1993).

1. b. *Monitor <u>subsurface</u> oil at previously established GULF OF ALASKA sites (same sites as in 1.a).*
We hypothesize that oil trapped in the subsurface of boulder-armored gravel beaches will remain there for lengthy intervals and will weather slowly since it is shielded from both physical abrasion and evaporation. We intend to monitor the persistence and chemical weathering of the buried oil by systematically examining "dip stones" within the oiled area and by analyzing 2 samples of oiled sediments taken at each site via GC/MS. Both of these methods were used in 1994. Dip stones are elongate rocks protruding out of the surface but extending down into the subsurface oil layer. The ideal dip stone extends vertically below the lowest subsurface oil, illustrating the maximum depth of oiling at that spot.

2. *Assess the rates of disturbance of the boulder armor at the previously established sites.*
From observations at surface-oil monitoring sites in the GULF OF ALASKA region, we hypothesize that storms capable of shifting boulder armor and stirring the gravel substrate are infrequent (less than one per decade). Because the substrate of these beaches remain undisturbed, little weathering of buried oil occurs. We will test this hypothesis by tracking the positions of armoring boulders over the five year interval since our last sampling. At each site, resurveys of existing bolt markers will be made. At new sites, ten to twenty different armoring boulders will be tagged with rock bolts. The altitudes and horizontal positions of these boulders will be recorded to ± 2 cm. Resurveys of bolt locations in succeeding years will provide an accurate record of changes in the configuration of the boulder armor.

3. *Predict other locations in the Gulf of Alaska where subsurface oil persists based on geomorphology and oiling history. Establish and sample new test and control sites.*
Objectives 2 and 3 relate to our primary question, which is: "What are the roles of shoreline geomorphic stability and 3-dimensional complexity in oil persistence?" Our hypothesis is that a combination of 3-dimensional heterogeneity and stability are necessary for the long-term persistence of stranded oil.

Our current sites are all boulder-armored gravel beaches. This type of shoreline offers both 3-dimensional complexity, and, we believe, stability. In Objective 2 we are looking at the stability of the armoring substrate at our current sites. We would like to test our idea that this type of shoreline can act as a long-term storage site for subsurface oil contamination by examining other boulder-armored, gravel beaches known to have received moderate to heavy surface oiling in 1989. The new set will be termed the test sites. Control sites (non-armored, oiled beaches with similar exposure) will also be established and sampled.

A list of prospective test sites will be put together based on the co-occurrence of boulder-armored gravel beach and moderate to heavy surface oiling in 1989 (SCAT surveys). At least 6 beaches meeting these criteria will be examined, with the goal of establishing 6 test beaches. An equal number (6) of control sites will also be established. Since our hypothesis is that the armoring of the substrate is responsible for the persistence of the oil, the control beaches will be unarmored, oiled beaches of similar exposure to the test beaches.

Critical to the success of boulder-armored habitat in promoting the persistence of oil is the supposition that the armoring is stable. We will be developing indicators of stability based on: marking and resurveying bolts in boulders, the sorted structure of a beach, depth of chemical weathering pits on rock surfaces, and biological indicators such as the size of lichens. The sorted structure refers to the organization of substrates of different sizes in a 3-dimensional view of the beach. Biological indicators will be defined based on their elevation in the intertidal (high, middle, and low) and type and size of species present.

All of the sites will be assessed for the extent of surficial and subsurface oiling, using methods described above plus additional methods. At control sites, we anticipate that sediment samples may show no visible or odoriferous evidence of oil; such samples will be analyzed for hydrocarbons using uv-fluorescence (Krahn et al. 1991), a much more cost-effective method of screening for hydrocarbons than GC/MS. After setting up and assessing quadrats for the extent of surficial oiling, dip-stone sampling will be conducted. The location of maximal oiling, as revealed by the dip stones, will be the site of an excavation or test pit. One pit will be dug at each test and control site (none at the previously established sites). Pits will be dug to waterline during low spring tides. Profiles will be described by standard soil-science procedures (Soil Survey Staff 1993). Previous work has shown that buried terrestrial soils are often present and are important in oil retention. Sketches of buried oil distribution will be made (cf., Michel and Hayes 1994). The volume of oil in the excavated material will be estimated. At each site we will also assess the stability of substrates (marked boulders, geomorphic and biological indicators), and the chemical composition of oil.

4. *Monitor recovery of 3 Gulf of Alaska mussel beds previously sampled in 1993.* Previous sampling of oiled mussel beds along the Gulf of Alaska coast suggested that levels of hydrocarbons in mussels and in the sediments underlying the mussels were declining (Irvine and Cusick 1995; Babcock et al 1996, 1997). However, several mussel beds sampled in 1995 had levels of hydrocarbons above baseline levels (50 μg/g total petroleum hydrocarbons [TPH] wet weight in sediments and 0.09 μg/g total polynuclear aromatic hydrocarbons [TPAH] dry weight in mussels). These baseline levels are determined from the minimum detection limits of the analytical instruments and historical data from unoiled sites in Prince William Sound. We propose to examine three beds on the outer Kenai Peninsula (Tonsina Bay, Port Dick and Morning Cove) in order

to assess the recovery of these assemblages. We predict that levels should have declined further, perhaps to background levels. We will use the same methods as in previous years, and will take 3 pooled samples each of mussels and underlying sediments. Samples will be analyzed by GC/MS at the Auke Bay Fisheries Laboratory. NOAA is proposing a resampling of beds in PWS, and combination of PWS and GOA sampling should provide a broad picture of the recovery status of these oiled beds. The resampling of these beds can be done very efficiently in conjuntion with the sampling of the boulder-armored beaches.

Statistical Analyses

Shoreline Oil Persistence and Weathering:
Surficial Oil: Surface oiling is reassessed in marked quadrats by quantitative estimates of oil percent cover. Percent cover data for individual quadrats will be compared through time (1994 and 1999 data) via pair-wise tests. As for all tests discussed, the data will be tested for normality and the appropriate parametric or non-parametric test chosen. The power to detect change is usually increased when fixed quadrats are used as a sampling method, although the resulting inference is limited to changes within that particular quadrat. Since we have only one year of data, we cannot project the anticipated variability within quadrats over time.

Subsurface Oiling: Subsurface oiling will be quantitatively assessed through sampling of dip stones at each site. Means and ranges of the depth of oiling for each site will be compared through time. Also, comparisons of the means and ranges of oiling between groups of sites (original, test, and control) will be made.

Oil Weathering: The presence and relative abundance of polynuclear aromatic hydrocarbons (PAH) within samples will be compared, and a weathering index based on a first-order kinetic loss rate model of Short and Heinz (1997) will be used to compare the degree of weathering of different samples at the same and different sites. Samples where there is no obvious presence of oil will be analyzed via uv-fluorescence, and the resulting total petroleum hydrocarbons (TPH) can be compared.

Oiled Mussels:
The parameters described above to be used in comparing the oiled sediment samples (relative abundances of PAHs and an EVO weathering index) will be used to compare the oil in samples of mussel tissue and underlying sediment. The change in the percent phenanthrenes of samples in samples analyzed by GC/MS will also be compared (Babcock et al. in prep). Additionally, uv-fluorescence (Krahn et al. 1991) will be used initially to analyze sediments associated with the mussel beds. Data from individual sites will be compared through time using paired tests. The data from these outer Kenai Peninsula sites will also be compared to data from PWS. Power analyses from another mussel hydrocarbon monitoring study (Kinnetics 1993) suggests that triplicate sampling such as we propose could have the statistical power of 80% to detect a change

or difference of 60% (alpha = 0.05) at two sites or two sampling times at the same station.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

NOAA is a cooperating agency, as one of our Principal Investigators, Dr. Jeff Short, is allied with the NOAA's Auke Bay Fisheries Laboratory. We also expect to cooperate with the NOAA's Principal Investigators on the PWS Oiled Mussel project, although we are submitting separate proposals.

SCHEDULE

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

Start-up to February 1:	Selection of additional potential sites from Exxon, ADEC, and National Park Service documents.
February 1 to April 1:	Arrange charter boat contract, recruit field personnel
March 23-27:	Attend the 10th Anniversary Symposium
April 1 to May 1:	Assemble field gear and supplies.
May 1 to August 31:	Field work, starting in eastern Kenai Fjords and working westward to the Alaska Peninsula/Kodiak area.
Sept.1 to Oct.31:	Analysis of field data.
Jan. 15, 2000:	Receive results of hydrocarbon analyses.
April 15, 2000:	Submit annual report (FY99 findings).

B. Project Milestones and Endpoints

Objective 1: *Monitor surface and subsurface oil at 6 previously established sites along the Gulf of Alaska coast. Determine the physical extent and chemical weathering of the oil.*
Field monitoring should be completed during summer 1999. Analysis of data will be accomplished in the fall, but results of the hydrocarbon analyses are not expected until Jan. 2000.

Objective 2: *Assess the rates of disturbance of the boulder armor at the 6 sites in Objective 1.*
The disturbance rates will be assessed during the field work planned for the summer of 1999, with comparisons of 1999 and 1994 data made in the fall of 1999.

Objective 3: *Predict other locations in the Gulf of Alaska where subsurface oil persists based on geomorphology and oiling history. Establish and sample new test and control sites.*
The predictive work will be done during the winter of 1998-99, in advance of the field season, while the examination, establishment and sampling of sites will occur during the summer of 1999.

Objective 4: *Monitor recovery of 3 Gulf of Alaska mussel beds previously sampled in 1993.* The mussel beds will be sampled during the summer of 1999. Results of the hydrocarbon analyses are expected in Jan. 2000.

As stated in greater detail above, the field work for the project is expected to be completed in FY99, with data analysis the following fall, hydrocarbon analyses in the fall and winter, an annual report in April 2000, and manuscript preparation in FY 2000.

C. Completion Date

All of the projects objectives should have been met by the end of FY 2000.

PUBLICATIONS AND REPORTS

We do not anticipate submitting any publications in FY99. We have submitted a manuscript on the previous results to Marine Pollution Bulletin, and would anticipate submitting a manuscript on the FY99 field work in FY2000.

We will prepare an annual report by April 15, 2000 and final report in FY 2000.

PROFESSIONAL CONFERENCES

We do not anticipate presenting the results of this project at conferences until FY2000.

NORMAL AGENCY MANAGEMENT

This project is not at all part of any normal agency management. It is being proposed solely because the *Exxon Valdez* oil spill occurred and contaminated coastlines and biota.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is built on the framework of two previously funded EVOSTC projects that the Prinicpal Investigators have been involved with. One of our PI's is with NOAA's Auke Bay Laboratory, and we expect to coordinate data analysis and results of the oiled mussel samples with the NOAA PI's examining oiled mussels in Prince William Sound. Due to some mismatch of timing in the preparation of our respective proposals, we are not listed as cooperators on NOAA's oiled mussel proposal, even though we expect to coordinate.

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PRINCIPAL INVESTIGATORS

Gail V. Irvine

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

Relevant Experience:

1984-1990: Marine Biologist with the Minerals Management Service. Analyzed effects of potential oil spills in Alaskan marine waters. Technical advisor for post-spill studies

conducted by the Smithsonian Institution (with Minerals Management Service funding) in Panama, following the Galeta oil spill. (I had previously done research on coral reefs in Panama, including the Galeta reef).

1990- 1994: Coastal Resources Specialist with the National Park Service, Anchorage, Alaska. Coordinated and conducted coastal projects along marine coastlines of Alaskan national parks, including Kenai Fjords, Katmai and Lake Clark national parks. Involved in emergency response to potential oil spill in Glacier Bay National Park.

1992-1995: Principal Investigator on Oiled Mussel Project, Gulf of Alaska.

1992-1995: Project Manager, then a Principal Investigator on the study, "Fate and Persistence of Stranded Oil on National Park Coastlines".

1994- present: Research Ecologist with first, the National Biological Survey, then the U.S. Geological Survey, Biological Resources Division.

1995- present: Opportunistic cooperator with Principal Investigators of the Nearshore Vertebrate Predator Project. Studying recruitment dynamics of invertebrate species.

1995- present: Principal Investigator on a project to: "Develop coastal monitoring protocols and process-based studies to address landscape-scale variation in coastal communities of Glacier Bay National Park and Preserve, Katmai National Park and Preserve, and Wrangell-St. Elias National Park and Preserve.

Project Responsibilities: Project coordination, study design, field work, mussel sampling, data analysis, preparation of proposal, report and manuscript

Dan H. Mann

Education: B.A., 1976, University of Washington (Anthropology)
M.S., 1978, University of Washington (Entomology, ecology)
Ph.D., 1983. University of Washington (Quaternary geology, paleoecology)

Relevant Experience:

1983-1985: Postdoctoral Research Associate, University of Washington, studying coastal geomorphology and arctic soil genesis in Svalbard, arctic Norway.

1989-1991: Coastal geological consultant with Woodward-Clyde and Exxon Corporation. Worked as a coastal geomorphologist after the *Exxon Valdez* oil spill in Prince William Sound. Led teams assessing oil pollution and biological hazards on shorelines and prescribing cleanup methods. Developed methods for monitoring the fate of stranded oil on high wave-energy coasts. Advised Exxon managers on cleanup methods and priorities.

1992: Visiting professor, Alaska Quaternary Center, University of Alaska, Fairbanks.

1993-1995: Principal Investigator on *Exxon Valdez* Trustee project: "Fate and Persistence of Stranded Oil on National Park Coastlines".

1993-present: Research Associate, Institute of Arctic Biology, University of Alaska, Fairbanks.

Conducting a major study on "Coastal geomorphology and archeaeology in the Gulf of Alaska", with Dr. Aron Crowell of the Smithsonian Institution. Study is concentrated on marine coastlines of national parks ringing the Gulf of Alaska. Involved in other studies of Quaternary geology and paleoecology, including coastal processes.

Project Responsibilities: Geomorphology, study design, site selection, field work, analyze data, report and manuscript contributions

Jeffrey W. Short

Education: B.S., 1972, University of California, Riverside (Biochemistry and Philosophy)
M.S., 1982, University of California, Santa Cruz (Physical Chemistry)

Relevant Experience:

1989- present: Established and managed the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the *Exxon Valdez* NRDA effort (about 20%) of these samples were analyzed at ABL).

1989-1992: Principal Investigator, *Exxon Valdez* project Air/Water #3: Determination of petroleum hydrocarbons in seawater by direct chemical analysis and through the use of caged mussels deployed along the path of the oil spill.

1991-1996: Principal Investigator, *Exxon Valdez* project Subtidal #8: Development of computer-based methods for global examination of sediment and mussel hydrocarbon data produced for the *Exxon Valdez* NRDA effort for systematic bias, and for identificcation of probable sources of hydrocarbons. In addition, this project produced both hard-copy and computer display maps of all the sediment and mussel hydrocarbon data.

1994-1995: Initiated data analysis and pilot projects that established the role of pristane in Prince William Sound.

1996-1997: Principal Investigator, projects 96195 and 97195.

Project Responsibilities: Hydrocarbon analyses and interpretation, report and manuscript contributions

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

Budget Category:	Authorized FY 1998	Proposed FY 1999	PROPOSED FY 1999 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
								$24.2
Personnel	$0.0	$36.8						
Travel	$0.0	$3.6						
Contractual	$0.0	$138.8						
Commodities	$0.0	$1.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$180.2		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration	$0.0	$15.3						
Project Total	$0.0	$195.5		$40.0	$0.0	$0.0		
Full-time Equivalents (FTE)	0.0	0.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0		

Comments:

1998

Prepared: 1 of 13

Project Number: 99459
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Lead Agency: DOI-BRD

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$36.8
Travel		$3.6
Contractual		$116.2
Commodities		$1.0
Equipment		$0.0
Subtotal	$0.0	$157.6
General Administration		$13.7
Project Total	$0.0	$171.3
Full-time Equivalents (FTE)		0.7
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

1998

Prepared: 2 of 13

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: DOI-BRD

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/15/98

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
Dr. Gail Irvine	Marine Ecologist	GS-12/8	4.0	6.5		26.0
Vacant	Technician	GS-6	4.0	2.7		10.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.0	9.2	0.0	
					Personnel Total	$36.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Anchorage - Homer, RT	0.1	4	8	0.1	1.2
Anchorage- Kodiak, RT	0.4	4	8	0.1	2.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.6

1999

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: DOI-BRD

FORM 3B
Personnel
& Travel
DETAIL

Prepared:

4/15/98

Contractual Costs:	Proposed FY 1999
Description	
Boat charter (estimated 40 days @ $1500/day)	60.0
RWO with University of Alaska, Fairbanks	55.2
Film processing, duplication	0.4
Excess baggage, freight	0.4
Sample shipment	0.2
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$116.2

Commodities Costs:	Proposed FY 1999
Description	
Miscellaneous field gear, supplies	0.5
Sample jars	0.2
Rain gear/boots	0.3
Commodities Total	$1.0

1999

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: DOI-BRD

FORM 3B
Contractual & Commodities

Prepared:

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

Existing Equipment Usage: Description	Number of Units	Inventory Agency
GPS unit		
Cameras		
Surveying equipment		
Binoculars		

1999

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: DOI-BRD

FORM 3B
Equipment
DETAIL

Prepared:

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$22.6
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$22.6
General Administration		$1.6
Project Total	$0.0	$24.2
Full-time Equivalents (FTE)		0.0
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

1999

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

Prepared:

4/15/98

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

Contractual Costs:	Proposed FY 1999
Description	
Hydrocarbon analyses	
Shoreline component	
GC/MS analysis of 30 samples, @ $500/sample	15.0
uvf screening of 12 sediment samples, @ $75/sample	0.9
Mussel Bed component	
GC/MS analysis of 12 samples (9 tissue, 3 sediment), @ $500/sample	6.0
uvf screening of 9 sediment samples, @$75/sample	0.7
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$22.6

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

1999

Prepared:

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Agency: NOAA

FORM 3B Contractual & Commodities

4/15/98

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

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

1999

Project Number:
Project Title:
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared: 9 of 13

4/15/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$35.4
Travel		$6.8
Contractual		$0.8
Commodities		$1.3
Equipment		$0.0
Subtotal	$0.0	$44.3
Indirect		$10.9
Project Total	$0.0	$55.2
Full-time Equivalents (FTE)		7.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

See attached form 4B's for detail
UAF: University of Alaska, Fairbanks RWO.

FY 99

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Name: University of Alaska, Fairbanks (UAF) /Agency: DOI-BRD

FORM 4A
Non-Trustee
SUMMARY

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Dr. Dan Mann	Geomorphologist	4.0	5.4		21.6
	benefits					1.6
	Vacant	Technician	3.0	3.0		9.0
	benefits					3.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	7.0	8.4	0.0	
					Personnel Total	$35.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Fairbanks-Anchorage, RT	0.2	2	6	0.2	1.6
	(includes travel to EVOS 10th Anniversary Symposium)					0.0
	Fairbanks - Homer, RT	0.4	4	8	0.1	2.4
	Fairbanks - Kodiak, RT	0.5	4	8	0.1	2.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$6.8

FY 99

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
Duplication	0.1
Excess baggage/freight	0.5
Film processing	0.2
Contractual Total	$0.8

Commodities Costs:	Proposed
Description	FY 1999
Misc. field supplies (shovels, pry bars, boots, etc.)	1.3
Commodities Total	$1.3

FY 99

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Name: University of Alaska, Fairbanks (UAF)/ Agency: DOI-BRD

FORM 4B
Contractual & Commodities

Prepared: 12 of 13

4/15/98

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

Existing Equipment Usage: Description	Number of Units

FY 99

Project Number:
Project Title: Residual Oiling of Armored Beaches and Mussel Beds in the Gulf of Alaska
Name: University of Alaska, Fairbanks (UAF) / Agency: DOI-BRD

FORM 4B
Equipment
DETAIL

Prepared: 13 of 13

4/15/98

Effect of Disease on Pacific Herring Population Recovery in Prince William Sound

Project Number:	99462
Restoration Category:	Research and Monitoring
Proposer:	University of California, Davis
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	no
Duration:	3 years
Cost FY99:	$75,100
Cost FY00:	$78,500
Cost FY01:	$84,000
Cost FY02:	none
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring, commercial fishing, subsistence

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TRUSTEE COUNCIL

ABSTRACT

The Pacific herring population of Prince William Sound has not recovered from severe population decline in 1993. Viral hemorrhagic septicemia virus and the fungus *Ichthyophonus hoferi* were identified as the two main diseases during a multiyear research project that is in its final year (98162). Prevalence of *Ichthyophonus* decreased after 1995, but an unexpected increase in the prevalence of viral hemorrhagic septicemia virus in 1997 might delay recovery. To determine if disease continues to impair recovery, and to document recovery when it occurs, we propose to monitor prevalence of the two major diseases in Pacific herring in Prince William Sound twice annually, from October 1998 through April 2001.

INTRODUCTION

The population of Pacific herring (*Clupea pallasi*) in Prince William Sound (PWS), Alaska has not recovered since the estimated spawning biomass decreased precipitously from over 100,000 tons in 1992 to less than 20,000 tons in 1994 (Figure 1). Study of the population since 1993 has revealed that viral hemorrhagic septicemia virus (VHSV) and the fungus *Ichthyophonus hoferi* are the two major diseases in Pacific herring, and that VHSV probably contributed most to population decline in 1993 (Meyers et al. 1994; Marty et al. 1998). Prince William Sound Pacific herring fisheries were severely curtailed in 1993, and were never opened in 1994 or 1995. The population began to recover in 1996, and a small bait fishery was opened in November of 1996. All fisheries were opened in 1997, but an unexpected increase in prevalence of VHSV in spring samples (15% in 1997 vs. 0% in 1996) was associated with abnormal spawning activity.

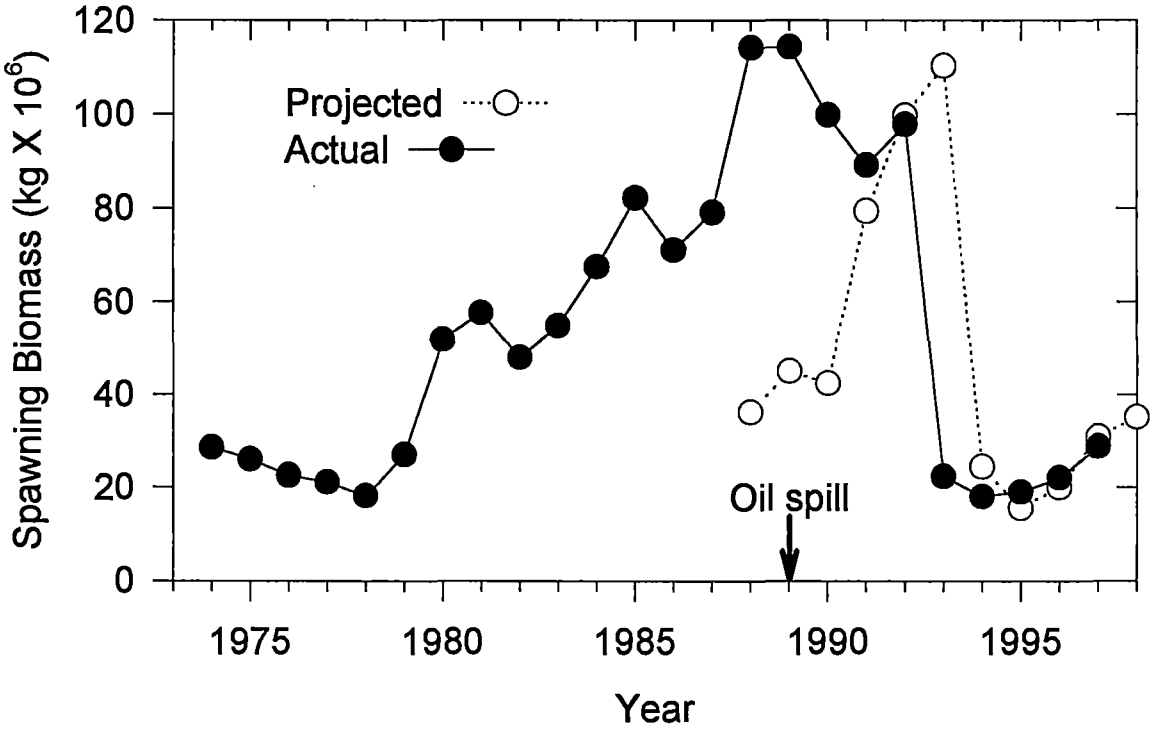

Figure 1. Biomass estimates of mature Pacific herring in Prince William Sound, Alaska. Unexploited spawning biomass is estimated using an age-structured assessment model.

After the major crash of 1993, the Pacific herring population continued to decline in 1994 and project 94320-S was initiated under emergency conditions to determine causes of herring morbidity (sickness), with particular emphasis on the role of VHSV. Beginning in 1995, a 4-year multidisciplinary project was initiated to explore the role of VHSV, *Ichthyophonus hoferi*, and other parasites on population change (95320-S, 96162, 97162, and 98162). Study in 1995 and 1996 included examination of fish from a reference site, Sitka Sound, in which the herring fishery was strong and there was no history of a large oil spill.

It soon became obvious that the results from this study had broad significance beyond the two populations being studied. We were beginning to answer basic questions about how disease contributes to mortality of free-ranging, pelagic, schooling fish. To more fully answer these basic questions, a proposal was submitted to the National Science Foundation (Biological Oceanography) to continue disease research in PWS for three more years; the proposal was submitted on 2-15-98, with a goal of starting research 10-1-98. Although the NSF proposal has a good chance of being funded, competition for unsolicited proposals to NSF is very intense, and funds for new projects are very limited. Therefore, this proposal is being submitted to share costs with NSF to continue this research. This proposal asks the Trustee Council to fund fish necropsy, tissue sampling, and virus analysis, and NSF will pay for blood analysis, histopathology, and population modeling on the same samples. Both organizations benefit from high quality, multiyear research, but at a fraction of the cost of supporting the entire project. Specifically, the Trustee Council will have access to the same types of data generated from 1994-1998, with the addition of a modeling component to determine the role of disease in stock assessment. We propose to continue monitoring the health of the Pacific herring population in PWS through spring of 2001.

Preliminary surveys suggested that the 1994 year-class was the most likely to recruit at numbers large enough for population recovery by 1999. Unfortunately, the prevalence of VHSV increased to 15% among all Pacific herring sampled in spring 1997 (Figure 2), and 23% of the 71 fish that were from 1994 year-class had VHSV. The effect of the VHSV outbreak on population biomass does not appear to be as severe as in 1993, but the viral outbreak may limit the contribution of the 1994 year-class to population recovery. This project is most closely linked to other Pacific herring projects, and details are given in the dedicated section below.

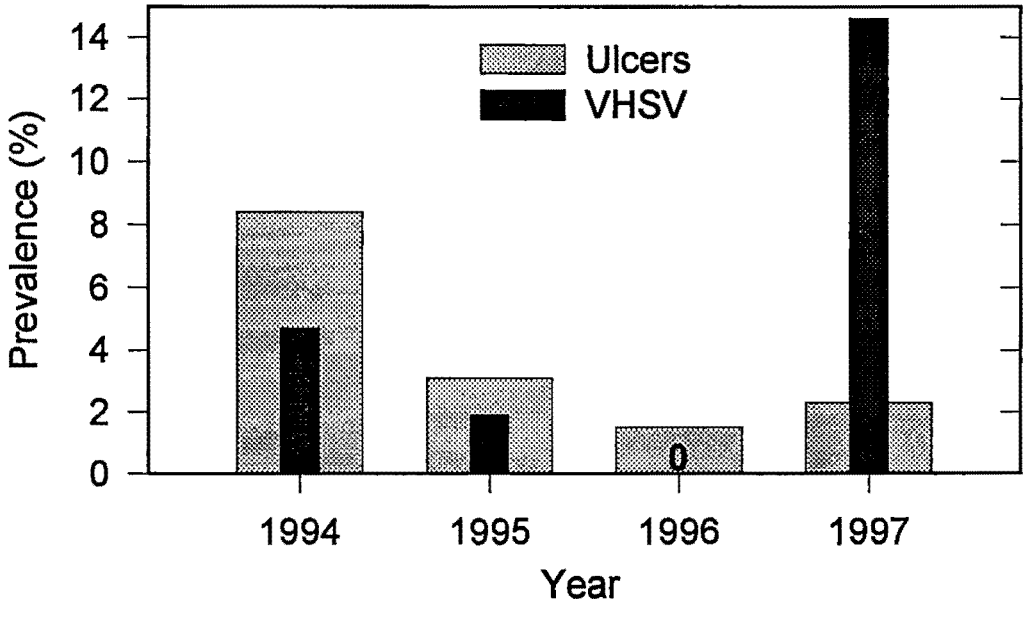

Figure 2. Prevalence of severe focal skin reddening (ulcers) and VHSV in adult Pacific herring sampled from Prince William Sound, Alaska.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring are an injured biological resource in Prince William Sound (PWS) classified as not recovering. Indeed, the spawning population in 1994 was lower than ever recorded in 20 years of reliable estimates. Because of small population size, commercial fishing for herring was severely curtailed in 1993, and closed entirely in 1994, 1995, resulting in lost services. Also, several thousand pounds of herring and herring spawn on kelp are harvested annually for subsistence purposes and form an important part of the local native culture of Chenega and Tatitlek. Decline in herring populations resulted in lost resources for subsistence use. Although all fisheries were re-established in November, 1996, the recovery objective has not yet been reached; i.e., "Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in PWS." Even if the 1994 year class proves to be the next highly successful year class, they will not fully recruit into the fishery until 1999, one year after current disease research (98162) in completed. Therefore, continued study is needed to determine if disease prevalence is limiting recovery and to document when recovery has occurred.

B. Rationale/Link to Restoration

This project should be done because it will provide information on what might be limiting population recovery and it will monitor when fish are healthy and recovery has occurred. Continued sampling fish twice a year is needed to determine the dynamics of disease in the population. During the five-year research project previously funded by the Trustee Council (98162), we established that VHSV and *Ichthyophonus hoferi* caused the most significant diseases. Prevalence of VHSV can be determined by virus isolation and prevalence of *Ichthyophonus hoferi* can now be estimated fairly closely by gross examination. Therefore, proposal for an additional three years of disease research eliminates blood analysis and histopathology from the design of previous study, at considerable savings to the overall project.

C. Location

Study will be done in Prince William Sound, Alaska. Information will benefit fisheries managers as they consider alternatives for managing Pacific herring fisheries. As the resource is enhanced, users throughout PWS could potentially benefit.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Dr. Marty has a solid record of local contact and dissemination of information, and continued collaboration with local users is proposed for FY 99. For example, Dr. Marty worked closely with the Cordova District Fishermen United (and Torie Baker) and ADFG to propose supplemental study of spawn-on-kelp pound fisheries in PWS in 1997 and 1998. This contact occurred through participation in conference calls, personal contact while in Anchorage and Cordova, and via e-mail. Area residents and subsistence users have shown interest in the unique

use of veterinary pathology in the field component of previous study, and information was distributed through participation in Jody Seitz' radio program and by submission of information on the spawn-on-kelp pound fishery to the Restoration Science Newsletter.

To aid in dissemination of information, project personnel are available by phone for interviews and will respond quickly to requests from the Restoration Office for general information and articles for newsletters. The project's principal investigator is based in California, but Dr. Kathy Burek of Alaska Veterinary Pathology Services (one of only two board-certified veterinary pathologists residing in Alaska) has been contracted as a necropsy pathologist in 1995 and 1996, and has indicated her interest to serve as the second pathologist in April 1999. Alaska residents will be hired by ADFG for sampling logistics and recording data, and ADFG will charter vessels from local residents for collecting and processing fish.

PROJECT DESIGN

A. Objectives

The restoration objective states that "Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in PWS." The population cannot be classified as healthy until individuals within that population are healthy. Increased prevalence of VHSV in spring 1997 samples was consistent with a population at risk. Field sampling to determine the ongoing disease status is a high priority of this project. Objectives include:

1. Determine the prevalence of major diseases in Pacific herring.

2. Determine the interaction of gender, age, and season on disease prevalence.

3. Determine if disease prevalence correlates with population trends.

B. Methods

Pacific herring will be randomly sampled from PWS in October (at the end of the feeding season, n = 100) and in April (near the time of spawning, n = 300). Each fish will be examined for abnormalities (e.g., *Ichthyophonus hoferi*), and tissues from each fish will be assayed for VHSV.

This proposal has two specific hypotheses to test:

1. Prevalence of external lesions, VHSV, or *Ichthyophonus hoferi* is different from previous years.
2. Gross lesions, VHSV, or *Ichthyophonus hoferi* are related season, age, or gender.

To test the hypothesis that reproductive stage affects the development of disease, sampling is needed during the spawning season (spring) and during the period of gonadal development and peak condition (fall). Nearly 80% of the PWS Pacific herring biomass schools in the waters on

the northern and western edge of Montague Island during October, and the fish remain in this area until after they spawn in April. All fish will be sampled from this region. During the summer, fish disperse throughout the Sound. The other 20% of the PWS Pacific herring biomass overwinters and spawns in the Northeast region of PWS; these fish have sampled for disease study on as part of the spawn-on-kelp investigations, and preliminary genetic evidence indicates that they may be a different population (J. Seeb, ADFG, unpublished data). To provide a minimum number of fish from which at least the dominant year class can be analyzed in detail, we propose sampling 300 fish in April. Fish are easier to capture in the spring, and the age distribution in the spring is most consistent with data used in the historical age-structured assessment model. With a sample size of 300, diseases with a prevalence as low as 1% can be detected with 95% confidence, and a 6% difference in sample prevalence (e.g., 10 vs. 16%) can be detected with a statistical power of 0.80 (Becker and Grieb 1987). To test hypotheses of age differences, the dominant year class--often >40% of the sampled population--will be compared with combined groups of smaller year classes. To detect seasonal differences, and minimize costs, 100 fish will be sampled in the fall. A sample size of 100 is sufficient to have 95% confidence that disease with a prevalence of 3% will be detected in at least one fish sampled (Becker and Grieb 1987).

Proposed study is designed to minimize bias associated with gear type, capture, and holding (Holst 1996). All fish will be sampled using commercial purse seines. In the event that large numbers of fish begin to spawn in areas too shallow for commercial seines, fish will be captured using cast nets. All necropsies will be completed < 4 hours after the seine is pursed around the fish.

To best characterize the condition of herring in Prince William Sound, herring will be subjected to complete necropsy using the following sampling schedule (as field conditions allow) during the three years of proposed study:

Dates	Reproductive Stage	Number of Fish
FY99: Oct./Nov., 1998 (2 nights)	peak condition/ gonadal development	100
mid-late April, 1999 (4 days)	spawning/post-spawning	300
	Total Fish, FY99:	400
FY00: Oct./Nov., 1999 (2 nights)	peak condition/ gonadal development	100
mid-late April, 2000 (4 days)	spawning/post-spawning	300
	Total Fish, FY00:	400
FY01: Oct./Nov., 2000 (2 nights)	peak condition/ gonadal development	100
mid-late April, 2001 (4 days)	spawning/post-spawning	300
	Total Fish, FY01:	400

Pacific herring will be sampled randomly by a commercial purse seine or cast net. Necropsies will be done on a vessel chartered by ADFG. To minimize chances for VHSV to spread from one fish to others during holding, fish will be held no longer than four hours before necropsy. Fish for necropsy will be anesthetized in tricaine methane sulfonate (Finquel®) and visually screened for external lesions (Marty et al. 1998), which are ranked as none (0), mild (1), moderate (2), or severe (3). Prevalence of *Ichthyophonus* will be estimated by gross examination of internal organs, especially the heart. Gross examination is not as sensitive as histopathology for diagnosis of *Ichthyophonus*, but in spring 1997 samples, Dr. Marty correctly diagnosed 67% of the *Ichthyophonus*-positive cases by gross examination alone. Unfortunately, inexperience with histological examination of *Ichthyophonus* makes gross examination less efficient. For example, in spring 1997 samples, the second pathologists correctly diagnosed only 20% of the *Ichthyophonus*-positive cases by gross examination alone. In future sampling events, a high priority will be placed on training the second pathologist to recognize gross features of mild *Ichthyophonus* infection.

Measurements on each fish include body weight, standard length, age (from scales), liver weight, and gonad weight. Otoliths are archived for later use if information on annual growth rates is desired. This study is designed to diagnose gross lesions and the two major diseases: VHSV and *Ichthyophonus hoferi*. Results will be compared with previous years of study. Several samples will be collected, but only selected samples will be analyzed:

a. Virus isolation - To assay fish for virus, anterior kidney, spleen, and any severe skin lesions will be put into individually labeled plastic bags and stored on ice (for each fish, one bag will hold kidney and spleen, and a separate bag will be used for skin lesions). Samples will be shipped by air to the ADFG fish pathology laboratory in Juneau (under the direction of Dr. Ted Meyers) for analysis every 48 to 72 hours. Isolation using EPC cell lines will be as previously described (Meyers et al. 1994). The application of polymerase chain reaction (PCR) techniques for primary diagnosis of VHSV is being explored (R.M. Kocan and J.R. Winton, personal communication); if these techniques prove more useful than virus isolation, PCR may be used in place of virus isolation for detection of VHSV.

b. Bacteriology - for each fish with severe gross lesions, a sterile loop is stabbed into the anterior kidney and then streaked on Trypticase Soy Agar (TSA) and Marine agar for bacterial isolation. Ulcers will be preserved for histopathology or virology, but they will not be cultured for bacteria (superficial bacteria can be diagnosed on histopathology).

Other samples will be collected and archived, but analysis will require funding through NSF (a proposal for this work was submitted to NSF on 2-17-98):

a. Histopathology (fix in 10% neutral buffered formalin) - gill, spleen, liver, gonad, heart, stomach, intestinal tract, exocrine pancreas, trunk kidney, skeletal muscle, skin, brain, and other gross lesions. Also, a touch prep of kidney from each fish is made on a glass slide.

b. Hematology - blood will be drawn from the caudal vein into a Lithium-heparinized syringe and stored on ice. Packed cell volume (PCV) is determined on site. A smear is made on a glass slide, dried, and archived. Plasma is separated by centrifugation (3,000 *g* for 7 min) and

frozen within 3 h of collection. Plasma will be archived at -80°C for at least two years or until funding for analysis is secured.

c. Immunology - plasma for IgM determination and a blood smear for leukocyte differential counts will be collected and archived.

In previous study, spring samples from PWS had several other parasites, but these did not seem to be significant on the population level. Gross lesions and other observations will be scored as in previous years. Although all lesions are described in a "comments" section, only the most common lesions are scored for statistical analysis: caudal fin fraying, caudal fin reddening, fin base reddening, focal skin reddening, diffuse skin reddening, iris reddening, branchial copepods, number of 0.5-mm-diameter white foci on gills, number of peritoneal Anisakidae, and gonadal fullness. Parasites requiring histopathology for diagnosis will not be scored unless NSF funds are secured.

The ADFG fisheries laboratory in Cordova, Alaska, will handle logistics for sampling fish for necropsy, collecting age and length data, preparing formalin and containers for tissue fixation, providing data recorders for one pathologist on site, and ship all samples. Results from virus isolation will be reported as a VHSV titer.

Quality control and quality assurance are part of all examinations. For necropsy examination, the senior pathologist (Dr. Marty) is on site at all times; when questionable or difficult lesions are encountered, the second pathologist can consult with Dr. Marty. In the event that Dr. Marty is unavailable for necropsy, five other pathologists have experience on the herring necropsy team, and services of these pathologists would be secured.

Statistical analysis in this study will focus on determining changes in disease prevalence over time. The association of selected categorical variables (e.g., VHSV status versus external lesion scores) will be evaluated using chi-square methods for categorical data analysis; comparisons will be considered valid only if individual expected cell frequencies are >1 and no more than 20% of the cells have expected cell frequency <5. Odds ratios will be calculated only for standard (2x2) two-way contingency tables. Significance of changes in disease prevalence will be tested using chi-square or Fisher's Exact test. For all analyses, comparisons will be considered significant when $P<0.05$ and highly significant when $P<0.01$.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal includes significant contributions from ADFG as the lead agency. The project is being run through ADFG because Dr. Marty has worked closely with ADFG on several Trustee Council-funded projects during this decade. ADFG has unique local knowledge on Pacific herring in PWS, and Greg Carpenter has the necessary experience and expertise to secure all necessary charters and ship hazardous materials from Cordova to Davis. Close collaboration with ADFG allows for seamless transfer of disease information to fishery managers, and rapid transfer of disease information to commercial and subsistence fishers. No other agencies are requesting funds for this section of the project, and no other agencies or universities will be contracted for this work. Note, however, that Dr. Richard Kocan, University of Washington, is submitting a

proposal to study disease in juvenile Pacific herring and determine if other forage fishes in PWS carry VHSV. Dr. Marty and Dr. Kocan worked closely on the initial multiyear herring disease project (98162 et al.), and they will continue to share information on these new projects. A letter of collaboration from Dr. Kocan is attached.

SCHEDULE

A. Measurable Project Tasks for FY99

DATES (results due on final date)	ACTIVITY
Fall Samples:	
Oct. 1 - Nov. 30, 1998:	Collect samples; Person in charge: Gary D. Marty, UC Davis
Nov. 1 - Dec. 31, 1998:	Scale analysis (age); Person in charge: Greg Carpenter, ADFG, Cordova, AK
Nov. 1, 1998 – Feb. 28, 1999:	Virology and bacteriology; Person in charge: Ted Meyers, ADFG, Juneau, AK
March 1- Aug. 1, 1999:	Statistical analysis; Person in charge: Gary D. Marty
March 23-27, 1999 (5 days):	Attend 10th anniversary symposium (Gary D. Marty)
Spring Samples	
April 1 - April 30, 1999:	Collect samples; Person in charge: Gary D. Marty
April - July 31, 1999:	Scale analysis (age); Person in charge: Greg Carpenter, ADFG, Cordova, AK
April - Sept. 30, 1999:	Virology and bacteriology; Person in charge: Ted Meyers, ADFG, Juneau, AK
Oct. 1999 - Feb. 1, 2000:	Statistical analysis; Person in charge: Gary D. Marty
Jan. 11, 1999 –April 15, 2000:	Annual report writing; Person in charge: Gary D. Marty
open:	Opportunities for public comment

B. Project Milestones and Endpoints

Review of Objectives:

1. Determine the prevalence of major diseases in Pacific herring.
2. Determine the interaction of gender, age, and season on disease prevalence.
3. Determine the effect of disease on population trends.

Objectives will be met when each year of results is reported in the annual report, but the most complete information will be available when the multi-year study is completed and the final

synthesis report is submitted April 15, 2002.

C. Completion Date

We anticipate that biannual sampling in PWS through the spring of 2001 (FY01) will be sufficient to document that all project objectives have been met. Prevalence of VHSV decreased from 1994 to 1996, but then increased in 1997. Prevalence of the second major pathogen, *Ichthyophonus*, was high in 1994 and 1995, and it has continued to decrease since 1996. If the prevalence of *Ichthyophonus* continues to decrease, and the prevalence of VHSV decreases, we should be able to document recovery by the year 2001.

PUBLICATIONS AND REPORTS

No publications are anticipated from this work in FY99. Because the study is primarily monitoring, and proposed for three years, publication will be most beneficial to the scientific community after all three years of data are collected and analyzed. Results from fall 1998 samples may be incorporated into manuscripts being prepared as part of the final report for the field component of project 98162, but funds needed for that work have already been appropriated.

PROFESSIONAL CONFERENCES - No funds are requested.

NORMAL AGENCY MANAGEMENT - Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Continuation of proposed disease research in PWS is critical for obtaining other funding. On Feb. 17, 1998, Dr. Marty submitted an unsolicited proposal to continue this research through the National Science Foundation's Division of Biological Oceanography. The three-year $522.3K proposal exactly matches the sampling schedule outlined in this proposal, and the proposal includes collaboration with ADFG (through John Wilcock) and the University of Alaska, Fairbanks (Dr. Terrance J. Quinn). The major difference is that the NSF proposal includes funds for complete analysis of all samples (e.g., histopathology and blood analysis) not included in this proposal but part of the first 5 years of disease research. Using Dr. Quinn's expertise, the NSF proposal includes a modeling component to mathematically determine the relation of disease and changes in population biomass. Trustee Council-funded studies of herring disease since 1994 were highlighted in the NSF proposal as a significant source of matching funds (about $2.1 million over the life of the project). NSF normally does not fund unsolicited proposals for more than $150K per year. If the Trustee Council funds this proposal, it would represent savings of $207.7K to NSF. At the same time, the Trustee Council would benefit from $522.3K worth of research for only $207.7K.

This project is designed to provide the same types of data that were generated during detailed disease study since 1994 (94320S, 95320S, 96162, 97162, and 98162). Each year of research produces some new findings, but with each year the significance of the project becomes greater than its individual parts. Indeed, the knowledge gained from the 5-year data set is already unprecedented among studies of disease in feral fish species. The addition of three more years of data on the most important diseases will only add to the significance of this work. Proposed study has two specific interactions: 1) fish captured at the same time as disease samples will be available for, but not replace, age-weight-length studies conducted under normal ADFG management or research studies; 2) Dr. Marty will continue to share information with Dr. Kocan as he proposes separate but related research on VHSV in PWS.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS - not applicable

PROPOSED PRINCIPAL INVESTIGATOR (Field Component)

Gary D. Marty
Department of Anatomy, Physiology, and Cell Biology
School of Veterinary Medicine
University of California
1 Shields Ave.
Davis, CA 95616
phone: 530-754-8062
FAX: 530-752-7690

PRINCIPAL INVESTIGATOR

Gary D. Marty, DVM, Ph.D., and Diplomate, American College of Veterinary Pathologists, will be responsible for design of pathology studies, on-site necropsy evaluation, and final report writing. Dr. Marty has the required fisheries background (BS and MS in fisheries biology) to integrate the many parts of this study, and he has performed these duties on a similar project since 1994.

OTHER KEY PERSONNEL (Field Component):

Greg Carpenter, BS, is in charge of chartering a commercial seiner for capturing fish and a laboratory vessel for fish necropsy. Mr. Carpenter is also in charge labeling sample vials, mixing 10% neutral buffered formalin, and for shipping hazardous materials (e.g., formalin) to UC Davis.

Ellen F. Freiberg, DVM, MPVM, performed the statistical analysis for a similar project since 1994, and she has 3 years of experience assisting with sampling and necropsies. She will continue in these roles, and she has also been trained as a pathologist for fish necropsies.

David E. Hinton, Ph.D., is professor and director of the Aquatic Toxicology Laboratory at the University of California, Davis. Dr. Hinton has extensive experience in fish toxicology and histopathology. He will be available for consultation at the University of California, Davis.

Theodore R. Meyers, Ph.D., is certified as a Fish Pathologist by the Fish Health Section of the American Fisheries Society. Dr. Meyers has been Principal Pathologist for the AK Dept. of Fish and Game since 1985. Dr. Meyers and the laboratories he supervises have been involved in the detection and diagnosis of VHSV in Alaskan fisheries since 1990, detecting the virus in cod and herring from PWS and in herring from other parts of Alaska. Dr. Meyers will oversee the diagnostic virology and bacteriology parts of this project.

LITERATURE CITED and RELEVANT PUBLICATIONS:

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30 March 1998

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FAX (206) 685-3275
e-mail kocan@fish.washington.edu

Dr. Gary Marty
VM:APC, Univ. of California
One Shields Avenue
Davis, CA 95616-8732

Dear Gary:

This is to confirm that I am willing to collaborate with you on your FY99 herring disease proposal in Prince William Sound. My proposal deals with juvenile herring from 0-year through 2-years-old and should mesh nicely with your adult herring studies. Ultimately, the fish I am studying will fall into the category of "adult" and it is important that their early life-history disease experiences be documented in order to accurately interpret their adult health status and potential susceptibility to diseases.

Our past collaboration was very successful and productive, and I look forward to continued collaboration in the future.

Sincerely,

Richard M. Kocan, Ph. D.
Aquatic Toxicology

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FFY 1998	Proposed FFY 1999						
Personnel	$0.0	$16.1						
Travel	$0.0	$0.0						
Contractual	$0.0	$44.5						
Commodities	$0.0	$9.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$69.6	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002			
General Administration	$0.0	$5.5						
Project Total	$0.0	$75.1	$78.5	$84.8	$0.0			
Full-time Equivalents (FTE)	0.0	0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

This project proposal includes two components:

1. University of California, Davis: Fish necrospsy
   a. Funds for writing the annual report in FY00 are included in the FY99 request.

2. Alaska Department of Fish and Game: Logistical and analytical support

FY99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Agency: ADFG

FORM 3A
AGENCY
PROJECT
DETAIL

4/14/98

Prepared: 4/2/98
Revised: 4/14/98, JRS

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
	G. Carpenter	Fishery Biologist II	16C	1.5	5.1		7.7
	Vacant	Fish & Wildlife Technician II	9A	0.5	3.2	2.6	4.2
	Vacant	Fish & Wildlife Technician II	9A	0.5	3.2	2.6	4.2
		Subtotal		2.5	11.5	5.2	
						Personnel Total	$16.1

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1996
				Travel Total	$0.0

FY99

Prepared: 4/2/98
Revised: 4/14/98, JRS

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:		Proposed
Description		FFY 1997
PWS Fall Sampling	Vessel Charter (R/V Montague, 3d @ 1100/d)	3.3
	Vessel Charter (seiner to locate fish, 3d @ 1200/d)	3.6
	Shipping	0.2
PWS Spring Sampling	Vessel Charter (R/V Montague, 6d @ 1100/d)	6.6
	Vessel Charter (seiner to locate fish, 6d @ 1200/d)	7.2
	Shipping	0.4
	Air Charter (2RT to Montague Is. @ 250/hr, 4 hr total)	1.0
Contract with the University of California, Davis		23.3
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$45.6

Commodities Costs:	Proposed
Description	FFY 1997
Misc. sampling supplies (tubes, jars, preservative, coolers, totes etc.) (approximately $500/sample event - 2 events)	1.0
Pathology Laboratory - Virology/Bacteriology Supplies (400 samples @ $20/sample)	8.0
Commodities Total	$9.0

FY99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Agency: ADFG

FORM 3B
Contractual & Commodities DETAIL
4/14/98

Prepared: 4/2/98
Revised: 4/14/98, JRS

New Equipment Purchases: Description		Number of Units	Unit Price	Proposed FFY 1997
Those purchases associated with replacement equipment should be indicated by placement of an R.			**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY99

Prepared: 4/2/98
Revised: 4/14/98, JRS

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Agency: ADFG

FORM 3B
Equipment
DETAIL

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$9.7
Travel		$5.6
Contractual		$2.3
Commodities		$2.2
Equipment		$0.0
Subtotal	$0.0	$19.8
Indirect		$3.5
Project Total	$0.0	$23.3
Full-time Equivalents (FTE)		0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$23.0	$26.5			

Dollar amounts are shown in thousands of dollars.

Comments: **Indirect Costs** include the standard overhead rates and applications for the Institute of Toxicology and Environmental Health (ITEH) at the University of California, Davis (18.9%).

Other funds - A 3-year $522.3K proposal was submitted to the National Science Foundation (NSF) on 2-15-98 (Dr. Gary D. Marty as principal investigator). The proposal to NSF includes all of this proposal except for travel to the 10th Anniversary meeting. The NSF proposal is more expensive because it includes complete blood analysis, histopathology, and population modeling not included in this proposal. This proposal can stand on its own, but it is designed to leverage NSF funds. If both proposals are funded, this proposal will not change, but Trustee Council funds will be used to decrease the cost of the NSF proposal. This will increase the chance of securing NSF funding because NSF will get all of the research described in the NSF proposal at a savings of $238K to NSF. The Trustee Council benefits by getting complete analysis of all samples collected, including population modeling, at no additional cost (otherwise, the Trustee Council would have to pay about $300K for this research over the life of the project).

Proposal includes funds (here, direct costs) for report writing (0.5 month time for G. Marty, $400 of the supply budget), community involvement (0.2 month time for G. Marty, $50 for long distance phone calls), and the 10th anniversary meeting (travel and per diem, $1175). The proposal does not include funds for NEPA compliance, review session attendance, publications, or professional conferences.

FY 99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/2/98
Revised: 4/14/98, JRS

4/14/98

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

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Marty, G.	Assistant Researcher III		1.5	5.4	0.0	8.1
Teh, C.	Laboratory Assistant III		0.5	3.1	0.0	1.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.0	8.5	0.0	
					Personnel Total	$9.7

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
airfare to Cordova for sample collection (1 fall, 3 spring)*		0.6	4	11	0.1	3.5
airfare to Anchorage for 10th Anniversary meeting		0.5	1	5	0.1	1.0
						0.0
*There are actually 22 days per diem rather than 11 on these trip,						0.0
but the field rate is $45/day which these formulas will not						0.0
accommodate. Thus the number of days were halved and the						0.0
rate doubled.						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4.5

FY 99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/2/98
Revised: 4/14/98, JRS

4/14/98

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

Contractual Costs:	Proposed
Description	FY 1999
150 fish necropsies @ $15/fish (professional services of consulting pathologist)	2.3
Contractual Total	$2.3

Commodities Costs:	Proposed
Description	FY 1999
Materials and supplies (for sampling supplies, report writing, long distance phone, film, computer disks)	1.6
statistical analysis	0.4
ITEH supplies	0.2
Commodities Total	$2.2

FY 99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/2/98
Revised: 4/14/98, JRS

4/14/98

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
none			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units
IEC clinical centrifuge equipped with rotors for on site plasma separation and packed cell volume determination	1
Revco -80° freezer for archiving plasma	1
YSI Model 55 hand-held dissolved oxygen meter for checking fish holding conditions before necropsy	1
For report writing and correspondence:	
Pentium 90 IBM-PC desktop computer with 64Mb RAM, Ethernet card, and internal 14,400 baud modem	1
486-100 IBM-PC color notebook computer with 16MB RAM and internal 14,400 baud modem	1
HP4L LaserJet printer	1
Codonics NP-1600 Color Photographic Network Printer, for publication grade printing of digital images	1

FY 99

Project Number: 99462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Equipment
DETAIL

Prepared: 4/2/98
Revised: 4/14/98, JRS

4/14/98

99463

Ecological Significance of Juvenile Herring Diseases and Their Effect on Subsequent Spawner Recruitment in Prince William Sound and SE Alaska

Project number:	99463
Restoration Category:	Research
Lead Agency:	Alaska Department of Fish and Game
Proposer:	University of Washington & USGS-BRD
Cooperating Agencies:	USGS-BRD, Seattle, WA
Duration:	FY '99 -> FY 2000
Cost FY 99:	$94,100
Cost FY 00:	$97,900
Geographic area:	Prince William Sound, AK
Injured resource:	Herring

RECEIVED
APR 14 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

ABSTRACT

Viral Hemorrhagic Septicemia Virus (VHSV) and *Ichthyophonus hoferi* both infect juvenile herring within a few months of hatching. Both organisms can cause direct heavy mortality or can weaken the fish so that they are more vulnerable to starvation at times of low food supply, and more susceptible to predation due of their weakened state. This study will examine morbidity and mortality in juvenile herring as population-limiting factors which affect spawner recruitment. Disease factors will be evaluated by culturing tissues, examining plasma antibodies, identifying pathogen nucleic acids by PCR and correlating changes over time with low food supply, heavy predatory activity and ultimately, recruitment. Geographically isolated populations will be compared to determine whether disease levels are constant throughout an area, or vary by location, thus resulting in different recruitment rates. Ultimately, estimates of juvenile mortality will be correlated with future recruitment predictions.

INTRODUCTION

This project is a logical extension of work conducted between 1995 and 1998, and is designed to determine whether VHS virus or *Ichthyophonus* are responsible for mortality in 0-year herring and sandlance. Previous studies (95320S, 96162, 97162, 98162) showed that both of these pathogens are capable of causing high levels of morbidity and mortality in herring and sandlance and that they infect fish by 4-6 months post-hatch. VHSV has been shown to be transmitted via water and that very few virus particles (eg. < 100 PFU) are necessary to initiate an infection or epizootic (Kocan et al. 1997). In Prince William Sound the prevalence rate of VHSV in spawning herring has fluctuated annually and seasonally since 1994, when surveys first began (Marty et al 1995, 1996, 1997). In 1997 and unexpected significant increase in the level of VHSV infection appeared for the first time in several years. Whether this increase will be associated with mortality in the spawning population, or will serve to spread the virus to the more vulnerable younger fish is still unknown. This project is designed to answer this very question.

Ichthyophonus has also been detected in wild 0-year fish at about 5-6% prevalence rate in Puget Sound, where the level increases yearly until it reaches 50% - 70% by the time the fish reach spawning age. In Atlantic herring, it has been reported that these levels are indicative of a pending epizootic with associated heavy mortality (Sinderman & Chenoweth 1993). No data is currently available on the prevalence rates of VHSV or *Ichthyophonus* in Prince William Sound 0-year fish, but preliminary studies carried out in conjunction with the SEA juvenile herring study has shown that 1 - 2 year-old herring are infected with *Ichthyophonus*, but at different levels depending on the geographical location of the schools (Kocan, annual rept. FY '96).

Because of the highly vulnerable nature of juvenile herring (and other forage fish) this study will examine the possibility that 0-year fish are affected by disease organisms to the extent that their losses are reflected in later spawning recruitment. 0-year fish will be captured from different geographical areas over several months during the summer, and examined for VHSV prevalence, antibody titer (resistance), tissue-associated *Ichthyophonus* and survival within different areas. Use of the Alaska SeaLife Center is anticipated as a base of operations and a holding facility for short-term studies on juvenile herring. Collaboration with the USGS NW Biological Science Center (Seattle) for virus assays and culture work has also been arranged (see attached letter of agreement). If the SEA juvenile herring project continues, or a similar project is activated, we would plan a collaborative study utilizing their expertise in finding, identifying and collecting juvenile herring and sandlance.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring *(Clupea pallasi)* are an injured biological resource in Prince William Sound classified as "not recovering" as of January 1998. Because of population crashes in 1993 and 1994, commercial herring fishing was closed through 1996, resulting in economic losses and lost services. Following the population declines in herring there have also been reported significant declines in marine birds and mammals which depend on herring as a forage food. Thus, the reduction in herring numbers in PWS has the potential for significant impacts throughout the ecosystem. Pacific herring are a major resource in Prince William Sound from both the

commercial and ecological perspectives. In addition, herring and herring spawn are harvested annually for subsistence purposes and form an important part of the local native culture of Chenega and Tatitlek. Herring fisheries in PWS in the past have had an average annual combined ex-vessel value of $8.3 M. In 1993, the ex-vessel value dropped to $2.0 M due to low abundance and the prevalence of small fish with low market value.

In 1993, over half of the ~130,000 tons of spawning Pacific herring expected to return to PWS failed to appear. Among those that did return, 15-42% behaved abnormally and had hemorrhages on the skin. Pathologists from ADF&G isolated VHSV from some PWS herring and from skin lesions of a Pacific cod (*Gadus macrocephalus*) caught nearby. At the same time, herring with similar skin lesions were found near Kodiak Island, although the fishery there met predicted expectations. In 1994 only 20,000 tons of herring returned to PWS and little or no spawning occurred. In 1994, 20% of spawning fish had moderate to severe external lesions. VHSV was isolated from 11/233 (5.7%), and 62/212 (29%) had *Ichthyophonus*. Samples have been taken annually in PWS as well as Sitka Sound to determine the role of VHSV in the etiology of the 1993 - 94 epizootics. It is still unclear whether the disease is chronically carried and transmitted at a low level or if the majority of the population becomes immune to VHSV by recovering from an infection. These questions can only be resolve by controlled field and laboratory studies.

In 1995 more *Ichthyophonus*. lesions (26%) were observed in PWS spawning fish than were found in Sitka Sound (SS) (6.7%). The organism was more prevalent in 7-yr-old fish than in younger year classes which were infected at historically endemic levels (15%). Because the route of infection for *Ichthyophonus* is not known conclusively, it is impossible to predict what might occur in the future. If the organism is transmitted directly from infected to uninfected fish, then proximity of fish in a school along with a high prevalence rate will enhance transmission. If however, fish are infected by ingesting contaminated prey (eg. intermediate host), then a switch in prey selection or prey abundance would trigger an epizootic of this organism. Until the route of infection is determined, we can only speculate on future epizootics.

B. Rationale - Link to Restoration

Following the *Exxon Valdez* oil spill (EVOS) in 1989 the Alaska Department of Fish and Game (ADF&G) conduced damage assessment studies on Pacific herring in Prince William Sound from 1989 through 1992. Field studies were designed to determine what, if any effect the spill had on the indigenous herring population. These studies included field sampling and evaluation of naturally spawned eggs, embryos, larvae, and adults. Laboratory studies were designed to determine whether Prudhoe Bay crude oil had any detrimental effect on developing herring and whether these effects were consistent with those observed in Prince William Sound following the EVOS. In 1992 the herring study group concluded that Prudhoe Bay crude oil did cause damage to herring at all levels from the population and whole animal to the genetic and biochemical level. The herring synthesis group also predicted in its final report to the Trustee Council that the most severely impacted age groups would be the 1988 and 1989 year classes which would return to spawn for the first time in 1992 and 1993. The group also predicted, based on its findings and the available scientific literature, that damage to the herring's immune system could result in severe disease outbreaks and possible neoplasia in subsequent years. Some of these predictions did indeed come true, the herring population in PWS has been depressed for the last 5 years and species, including man, dependent on herring have suffered because of the loss.

If the herring are to recover to historic levels, they must have strong recruitment in addition to long-term survival of the spawning population. When juvenile herring are lost to diseases, they are also lost as future spawners. Because 0-year and 1+ herring are difficult to sample, losses may occur that go undetected, and because these fish are constantly being stalked by predators, little evidence of mass mortalities would be evident. It is not uncommon for fishermen to state that "... the herring balls have moved out of the area", which may translate into: "The baitfish are dead!".

During FY 97-98 studies (Herring Disease; 97162-98162), we were able to demonstrate that juvenile herring are very susceptible to mortality caused by exposure to VHSV and *Ichthyophonus*, and that the same type of epizootics observed under laboratory conditions also occur in wild free-ranging fish. Whole populations of free-ranging herring and sandlance were found to be resistant to challenge infection by VHSV just 30 days after we observed that the same population was susceptible to infection. If free-ranging fish develop immunity in the wild similar to that observed under laboratory conditions, then it is very likely that resistant fish were exposed to the virus and underwent an epizootic, just as they do when brought into the laboratory. How many fish died as a result of this theorized epizootic in wild 0-year fish is unknown, and is the object of this proposal.

Summary of Major Hypotheses

- Disease-related mortality in juvenile herring and/or sandlance can significantly impact future abundance and recruitment.
- *Ichthyophonus* is endemic in free-ranging Pacific herring, but can cause significant morbidity & mortality under appropriate environmental conditions (eg. low food supply & heavy predation).
- Juvenile herring and/or sandlance can become infected with VHSV at low levels yet maintain a high survival rate, or can experience massive epizootics associated with high mortality .
- Juvenile herring/sandlance rearing in different geographic locations can have different disease histories and different survival rates depending on local conditions.

Integrated hypotheses: Juvenile herring / sandlance are most vulnerable to pathogens, suffering greater morbidity and mortality than mature fish. When juveniles become infected they can die outright, or are weakened and at a competitive disadvantage to their healthy cohorts. Diseased fish are more likely to starve when food supplies are low and more likely to be targeted by predators due to their erratic behavior and inability to escape. Because disease causes direct and indirect losses of juvenile herring, it could be a major factor in determining the recruitment strength at 3 - 4 years post-hatch.

C. Location

Field collections will be made in Prince William Sound, Alaska in conjunction with ongoing ADF&G or SEA activities and at the Alaska Sea Life Center. The ASLC has the necessary facilities for

short-term holding of herring for disease and natural immunity/physiology studies. Blood and tissue samples collected from experimental fish will be processed at the ASLC when possible, or will be transported to laboratories within Alaska or Washington where the necessary technology for processing the samples is available. Discussions with the director and staff of ASLC have indicated that the project would be appropriate for the Center and that the majority of the facilities are available for studying juvenile herring from May through September.

Facilities anticipated at the ASLC for 3-5 months would include: 1 office; 3 sea water holding tanks @ 100 to 200 g each; low temperature incubator; lab space and hood for cell culture; small craft for fish capture (eg. zodiac or equivalent); O_2 tanks for fish transfer; necropsy facility; 0.5 months technical help.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

An annual progress report will be presented at a Restoration Science Workshop, scheduled to be held in Anchorage each January. Principal investigators will be available on request to speak with the media and public while actively working in PWS and by phone during the remainder of the year. If requested, seminars and / or demonstrations will be arranged for community members at any time of the year - including at the time of the annual Workshop held in January. Activities at the ASLC would also be presented to the public as displays or seminars to groups when research staff are available on-site.

PROJECT DESIGN

A. Objectives

Objectives (FY 99 - 01):

- Determine changes in population abundance of juvenile herring / sandlance during their first two years post-hatch and correlate the changes with changes in disease prevalence.
- Track the prevalence of *Ichthyophonus* infection in geographically distinct juvenile herring populations and relate this to survival and recruitment.
- Monitor the immune status of wild juvenile herring during their first two years post-hatch to determine when and to what extent they have been exposed to VHSV.
- Correlate overall survival of 0-year and 1+ herring with 3-4 year-old recruitment into the spawning population.

B. Methods

1) General Methodology & Facilities (FY 99, 00, 01)

o Fish collections

Juvenile herring and sandlance will be collected in conjunction with the SEA program during annual summer surveys. Fish will be collected from multiple geographic sites and subsamples of 100 fish each will be taken for *Ichthyophonus* culture at the time of collection. It is expected that at least two samples from each site will be made each summer. These cultures will be returned to the Alaska Sea Life Center for grow-out and evaluation. Adult fish from various geographic areas will be sampled during normal AWL determinations in Cordova. Tissues from spawner AWL determination will be cultured and transported to ASLC for incubation and evaluation. As each age class recruits it will be compared with disease status and background obtained while they were juveniles.

0-year herring and sandlance will also be collected from "bait balls" in the vicinity of the Sea Life Center and transported to holding tanks at the Center where they will be evaluated for VHS transmission, survival, and development of resistance to reinfection. In parallel with these collections, juvenile herring will be collected as a part of the acoustical surveys being conducted by the Prince William Sound Science Center. VHS prevalence will be monitored by in vitro culture of tissues over time and from site-to-site, PCR evaluation of tissue for viral RNA, and the data ultimately compared with the recruitment size of each year class.

o Culture of *Ichthyophonus*

Spleen, liver, and heart tissue will be removed from fish within 12 h of capture, minced and placed in tissue culture flasks containing Leibovitz L-15 medium supplemented with 5% fetal bovine serum, gentamicin and penicillin/streptomycin. Each tube will receive tissue from two fish in order to save space, resources and time. The actual prevalence (p) can be calculated using the equation:

$$[\, p = 1\text{-sqrt } n/50]$$

where n equals the number of negative cultures and 50 is the number of tubes containing tissues from two fish. The cultures are incubated at 10-12°C and examined for the production of hyphae and endospores after 14 days. Justification for using in vitro culture can be found in section II of the FY97 annual report submitted to the Trustee Council in April, 1998.

o Food items and *Ichthyophonus* infection

Because there is a high probability that *Ichthyophonus* is transmitted to herring via infected prey items, such as copepods, an attempt will be made to correlate the predominant prey item from each collection area with changes in *Ichthyophonus* prevalence. Although it is recognized that *Ichthyophonus* is not very host specific in it's vertebrate fish host, it may be highly host-specific in an intermediate host. If this were true, then a change in prey abundance or a switch in preferred

prey by the herring could account for differences in *Ichthyophonus* prevalence seen in different herring populations within PWS (Marty 1996).

o VHSV in captive wild herring

Using a small skiff or Zodiac-type craft, herring and sandlance will be collected from "bait balls" over a period of 2 - 3 months in the vicinity of the ASLC. The fish will be transported to the Sea Life Center where they will be housed in flow-through seawater tanks and observed for the development of signs of VHS. A subsample of 60-100 fish will be taken at the time of capture, again after 7 - 8 days and after 30 days. Tissues from these fish will be assayed for VHSV by cell culture and PCR to demonstrate the development of the disease and recovery following the induced epizootic. Mortality will be recorded for each group and any reduction in mortality over time recorded. Condition factor of each group will be correlated with disease prevalence to determine if the health of each group is changing. As the fish age, they should become more resistant to the virus and their condition factor should improve, provided all other conditions are constant.

Once mortality has ceased, fish from each collection period will be challenged with a known lethal dose of VHS virus (usually after 30 days in captivity) to demonstrate their resistance to reinfection. Individuals that survived earlier epizootics (wild or captive) will be resistant to challenge infection while those that were not exposed will succumb to the challenge (Kocan 1996, 1997).

o Virological examination of fish

During this project fish will be examined for the presence of viral hemorrhagic septicemia virus (VHSV) by both conventional cell culture assay and by a novel reverse-transcriptase, polymerase chain reaction (PCR) assay. Kidney tissues will be removed from up to 60 individuals selected at random. These tissues will be processed in 5-fish pools using standard techniques for the isolation and identification of VHSV (Fish Health Section, 1994). The tissue pools will also be tested by PCR assay using a set of nested primers specific for nucleotide sequence within the nucleoprotein gene of VHSV(Winton & Batts, unpublished data).

o Serological examination of fish

Fish will be examined for the presence of specific serum (plasma) antibodies against VHSV by conventional virus neutralization assay. Blood samples will be obtained from up to 60 individuals selected at random, allowed to clot, and the serum collected. Dilutions of the serum will be reacted with equal volumes of a VHSV suspension and the mixtures titered using standard methods for detection of antiviral fish antibodies (Fish Health Section, 1994).

o Correlation with recruitment

Data collected on the disease history and health of juvenile herring from the various geographic locations will ultimately be correlated with recruitment into the spawning population from each area studied. If disease significantly affects the juvenile population of an area, it should be reflected in the recruitment size at year 3 and 4. Although it is recognized that other factors such as predation and nutrition may also play a role in survival, it is highly probable that predation will

be greatest on disease debilitated individuals, as poor nutrition will affect diseased individuals to a greater extent than healthy individuals.

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C. Cooperating Agencies, Contracts and Other Agency Assistance

No outside contracts except charters for fish collection are anticipated. Collaboration and assistance by personnel and facilities of the Alaska Sea Life Center and U.S. Geological Survey, Biological Resources Division (USGS-BRD) Seattle, WA will continue throughout the project period.

SCHEDULE

A. Measurable Project Tasks for FY 98

FY 99 thru FY '01

Oct. '98 to May '99:	o Develop protocols and set up rearing facilities at ASLC
March '99:	o Attend 10th anniversary of EVOS (Anchorage, AK)
April '99:	o Submit final report for FY'95-FY'98
	o Continue manuscript preparation for publication
June '99 - Aug. '99:	o Collect fish, sample tissues, plasma, etc.
	o Begin laboratory monitoring of herring at ASLC
	o Begin data analysis of juvenile herring disease status
May '99 to Sept. '99:	o Begin analysis of antibodies, virus and *Ichthyophonus* cultures
	o Compare neutralization antibodies over time from same location
Oct. '99:	o Complete data analysis of summer's field/lab collections
Dec. '99 to April '00:	o Write up and analyze data for annual report and Workshop
January 2001:	o Present FY 98-99 findings at Workshop in Anchorage

B. Project Milestones and Endpoints (FY 99-01)

1. Determine collection sites, methods of capture and holding protocol for herring/sandlance collections (Oct. 1998 to April 1999)

2. Collect tissues and plasma from juvenile herring and sandlance for VHS and Ichthyophonus culture (May 1999 to September 1999)

3. Collect and transport juvenile herring to ASLC for captive epizootic studies. (June 1999-Aug. 1999)

4. Collate data collected from summer '99 fish samples (June to Sept. 1999)

5. Assay plasma and tissue samples for VHS antibody and virus RNA (Oct. 1999 - March 2000)

6. Prepare manuscripts for publication in refereed journals from FY 96 thru FY 98 and write annual report for project (October 1998 to April 1999)

C. Completion Date

Report preparation (FY 99 -> 01)

Annual report for FY-98	-	April. '99
Annual report for FY-99	-	April. '00
Final report for FY-'99 -'00	-	April. '01

PUBLICATIONS AND REPORTS

Annual Report to Trustees for FY 97; January, 1998

Final Report to Trustees for FY 95-98; March, 1999

Kocan, RM, JE Hose, ED Brown & TT Baker (1996). Herring embryo (*Clupea pallasi*) sensitivity to Prudhoe Bay petroleum hydrocarbons: Laboratory evaluation and in situ exposure at oiled and unoiled sites in Prince William Sound. Can. J. Fish. & Aquat. Sci. 53: 2366-2375.

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Kocan, R., Hershberger, P., Mehl, T., Elder, N., Bradley, M., Wildermouth, D., Stick, K. (in press) Pathogenicity of Ichthyophonus hoferi for laboratory-reared Pacific herring (*Clupea harengus*) and its prevalence in wild Puget Sound herring. Can. J. Fish. Aquat. Sci.

PROFESSIONAL CONFERENCES

SEATAC Annual Conference; San Francisco, CA. November 1997

Pathogens and Diseases of Fish in Aquatic Ecosystems; Portland, OR June 1997
Two posters: Ichthyophonus and VHSV in herring

EVOS Annual Workshop; January 1998
Data from FY97

Puget Sound Research 1998
Seattle Conference Center, Seattle, WA March 12-13, 1998
Poster on herring diseases of the north Pacific

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Alaska Dept. of Fish and Game will contribute to this project by supplying assistance in capturing spawning fish during normal pre-spawn surveys, as well as transportation of fish to Cordova and the airport. The (USGS-BRD) will contribute Dr. Winton's and Nancy Elder's salaries as well as space and equipment at the Seattle Laboratory and at Marrowstone Island Field Station, Nordland, WA. It is anticipated that most of the serology and PCR work would be done by Dr. Winton's group, while the Ichthyophonus culture, induced epizootics and challenge infections would be carried out at the ASLC.

Statistical consultation (project design / data analyses) will be obtained through the UW Center for Quantitative Science. Computer services (data entry, data analysis, word processing) will be provided by SOF and USGS. Histological processing of tissue samples will be carried out in part by Dr. Ted Meyers (ADF&G, Juneau, AK) as well as histopathological evaluation of tissues from experimental infections. Cell culture, virology and molecular biology facilities will be provided by USGS-BRD, Seattle, WA and U of W. Filtered seawater facilities for herring studies are available at the Alaska Sea Life Center (Seward, AK) and at the Marrowstone Island Field Station (Nordland, WA).

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

N/A

PERSONNEL

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Over the past 12 years Dr. Kocan has had extensive experience with petroleum induced toxicity in aquatic organisms and since 1990 has been actively involved in the *Exxon Valdez* oil spill studies in Prince William Sound and has served as a peer reviewer for salmonids, rockfish, shellfish and herring during the Damage Assessment and Restoration phases of the program, as well as an expert witness for the State of Alaska and NOAA. From 1990 to 1993 he worked with the Alaska Department of Fish & Game in Cordova as a subcontractor on Herring Sublethal Effects (project #11), studying embryo-larval damage in Prince William Sound. He also worked on oil related problems in Puget Sound associated with near-shore damage and evaluation of oil originating from several shore-based oil operations. These include the Cherry Point shoreline where Texaco, BP Petroleum, ARCO and Intalco Aluminum Co. are located, as well as Fidalgo Bay, where Texaco has a transfer dock and refinery. These studies were originated by the State of Washington and the Lummi and Klallam Indian Tribes and were funded by both the State and the various industries. Since 1995 Dr. Kocan has been PI on a Restoration Project (#s 95162-98162) dealing with disease factors affecting herring populations in PWS and Puget Sound. He has successfully reared herring from egg to 2-years-old and used these fish in disease studies requiring pathogen-free fish.

In 1985, prior to working on oil related problems in the Pacific North West, Dr. Kocan spent several months studying with Drs. Westernhagen and Rosenthal at the Biologische Anstalt Helgoland in Germany. There he worked on cod, sole, flounder, herring and turbot embryos and larvae which had been exposed to petroleum contaminated seasurface microlayer in the Baltic and North Seas.

Over the years Dr. Kocan has developed techniques for "on site" exposure of fish embryos in contaminated marine waters, laboratory cultivation of herring from egg to adult as well as laboratory evaluation of sediments for toxicity to marine vertebrates and invertebrates. He has access to flowing seawater research facilities at the University of Washington, the USGS field station on Marrowstone Island, Washington and has discussed the use of the new Alaska Sea Life Center with the director.

James R. Winton, Ph.D
Dr. James Winton received a Ph.D. in Microbiology from Oregon State University in 1981 where he studied fish diseases under the direction of Dr. John Fryer. After graduation, he remained on the faculty and directed the fish health research activities at the Hatfield Marine Science Center in Newport, Oregon. During that period, he had faculty appointments in the Departments of Microbiology, General Science, and Fisheries and Wildlife. While at the Marine Science Center,

he did research on fish diseases, helped establish a diagnostic and certification service for private aquaculturists, and participated in international programs. His research interests include infectious diseases of fish, poikilothermic cell and tissue culture, and virus diseases of fish and shellfish.

In 1986 Dr. Winton moved to the US Fish and Wildlife Service, National Fisheries Research Center (USGS-BRD) in Seattle where he serves as the leader of a fish health research team consisting of more than 20 researchers, technicians, graduate students and visiting scientists working on infectious diseases of Pacific salmon and trout. The Center is now part of the Department of Interior, National Biological Survey. As an affiliate professor at the University of Washington, he helps direct the research of graduate students working at the Center and provides lectures on fish viruses. In the past six years, he has taught the virology portion of two week Fish Disease Course at the Hatfield Marine Science Center and part of the Fish Health Long Course at the National Fisheries Center at Leetown, W. Va. Dr. Winton served as co-editor of the Fish Health Section Newsletter from 1984-1989 and is currently the subject editor for fish pathology for the Journal of Applied Ichthyology and an editorial advisor for Diseases of Aquatic Organisms. He is a Certified Fish Pathologist and a member of numerous scientific and honorary societies. He also serves on the International Committee on Taxonomy of Viruses, the American Type Culture Collection Advisory Committee, and the Fish Disease Commission of the Office of International Epizootics in Paris, France.

During the last 5 years, Dr. Winton has worked extensively with VHSV including his role in identifying the first isolates of VHSV from North America. Since that initial discovery, workers in his laboratory have characterized the North American isolates serologically and biochemically, developed DNA probes for detecting and differentiating isolates of VHSV, and conducted challenge experiments of eight species of salmonid fish showing the North American strain of the virus was different than the European type. Recently, he has assisted in the characterization of the isolates of VHSV from cod and herring in Alaska and has worked closely with Dr. Ted Meyers and the fish pathology staff of ADF&G with whom he shares authorship on several relevant papers. He is an author on more than 70 scientific publications, those dealing with VHSV are listed below.

OTHER KEY PERSONNEL

Dr. Paul Hershberger, Research Associate.
Ph.D. University of Washington School of Fisheries. Experience with toxic marine algae, herring diseases, field operations, statistical analyses and on-site Prince William Sound experience with pound fishery (2 seasons).

Relevant Publications

Batts, W.N., C.K. Arakawa, J. Bernard, and **J.R. Winton.** 1993. Isolates of viral hemorrhagic septicemia virus from North America and Europe can be detected and distinguished by DNA probes. Diseases of Aquatic Organisms 17: 67-71.

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Winton, J.R., W.N. Batts, R. Deering, R. Brunson, K. Hopper, T. Nishizawa and C. Stehr. 1991. Characteristics of the first North American isolates of viral hemorrhagic septicemia virus. pp. 43-50. *In*: Proceedings of the Second International Symposium on Viruses of Lower Vertebrates, July 29-31, 1991, Corvallis, Oregon.

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DAVIS, CALIFORNIA 95616-8732

March 31, 1998

Dr. Richard Kocan
School of Fisheries
Box 355100
University of Washington
Seattle, WA 98195

Dear Dick,

This is to confirm that I am willing to collaborate with you on your FY99 herring disease proposal in Prince William Sound, Alaska. My proposal continues monitoring of viral hemorrhagic septicemia virus (VHSV) and *Ichthyophonus hoferi* in adult Pacific herring, with the goal to determine if disease is impairing recovery and to document when recovery has occurred. Your studies on VHSV in juvenile Pacific herring will provide critical information for interpreting the significance of disease prevalence as the juveniles become adults.

My research has greatly benefitted from our past collaboration, and I look forward to continued collaboration in the future.

Sincerely,

Gary D. Marty, DVM, Ph.D.
Diplomate, American College of Veterinary Pathologists
Research Pathologist

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$87.9
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$87.9
General Administration		$6.2
Project Total	$0.0	$94.1
Full-time Equivalents (FTE)		0.9
Other Resources	$12.0	$15.0

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	97.9	FY 2000	FY 2001		
Dollar amounts are shown in thousands of dollars.					
$14.0					

Comments: Indirect costs include the standard overhead rates and applications for the University of Washington (26%)

UW recommended 4% annual increase calculated for out-years.

USGS-BRD, Marrowstone Island Field Station provides computer stations, phones, FAX and specimen archives. On-site facilities and equipement are being supplied to the project by USGS (equivalent value of $12K for office/equip.).

USGS-BRD lab technician time donated @ 50% over 12 months; equivalent to $15K + benefits.

UW Fisheries provides computing and communications equipment, photography, and libraries (~$14K).

FY 99

Prepared: 3/25/98
Revised: 4/13/98, JRS

Project Number: 99463
Project Title: Juvenile Herring Diseases
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Budget Category:		Proposed FFY 1999						
Personnel		$51.2						
Travel		$6.6						
Contractual		$5.1						
Commodities		$6.9						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$69.8		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Indirect		$18.1						
Project Total		$87.9		91.4	$0.0	$0.0		
Full-time Equivalents (FTE)		0.9						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$12.0	$15.0	$14.0					

Comments: Indirect costs include the standard overhead rates and applications for the University of Washington (26%)

UW recommended 4% annual increase calculated for out-years.

USGS-BRD, Marrowstone Island Field Station provides computer stations, phones, FAX and specimen archives. On-site facilities and are being supplied to the project by USGS (equivalent value of $12K for office/equip.).

USGS-BRD lab technician time donated @ 50% over 12 months; equivalent to $15K + benefits.

UW Fisheries provides computing and communications equipment, photography, and libraries (~$14K).

FY 99

Project Number: 99463
Project Title: Juvenile Herring Diseases
Name: University of Washington

FORM 4A
Non-Trustee
DETAIL

Prepared: 3/25/98
Revised: 4/13/98, JRS

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

Personnel Costs: University of Washington School of Fisheries			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FFY 1998
Kocan, RM	PI, project manager; design experiments, analyze data; write reports; publish data		5.0	7.0	0	35.0
						0.0
						0.0
						0.0
Paul Hershberger (post doc)	Post Doctoral Fellow; collect field data, manage lab studies; analyze data		6.0	2.7	0	16.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		11.0	9.7	0	
					Personnel Total	$51.2

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FFY 1998
Seattle <-> Seward		0.8	2	90		1.6
Seattle <-> Cordova		0.8	2	10	0.1	2.6
						0.0
Seward Housing for 3 mos. @ $800/mo.						2.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$6.6

FY 99

Project Number: 99463
Project Title: Juvenile Herring Diseases
Name: University of Washington

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 3/25/98
Revised: 4/13/98, JRS

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

Contractual Costs:	Proposed
Description	FFY 1998
* Long distance; FAX; photograph; postage; graphics	1.5
charters; 4 @ $300 /day	1.2
Alaska SeaLife Center technicia @ 0.5 months (80 hr) @ $30/hr	2.4
Contractual Total	$5.1

Commodities Costs:	Proposed
Description	FFY 1998
cell culture media	
lab plastic ware	6.9
bovine serum	
fish food; krill, artemia, etc	
film	
Commodities Total	$6.9

FY 99

Prepared: 3/25/98
Revised: 4/13/98, JRS

Project Number: 99463
Project Title: Juvenile Herring Diseases
Name: University of Washington

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1998
			0.0
none	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
Power Mac 7600 (SOF; U.W)	1
Power Mac 7600 (Marrowstone Island Field Station)	1
Publication Office - U.W. SOF computers/printers	1
Seawater sterilization system: filtered and sterilized @ 400gpm (Marrowstone Island)	
Tissue culture hood; Marrowstone Island Field Station	

FY 99

Project Number: 99463
Project Title: Juvenile Herring Diseases
Name: University of Washington

FORM 4B
Equipment
DETAIL

Prepared: 3/25/98
Revised: 4/13/98, JRS

99464

Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology

Project Number:	99464
Restoration Category:	Research
Proposer:	The Regents of the University of California
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
Duration:	1st year, 4-year project
Cost FY99:	$51,900
Cost FY00:	$53,500
Cost FY01:	$53,500
Cost FY02:	$42,800
Geographic Area:	Prince William Sound, Seward
Injured Resource/Service:	Harbor Seal

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ABSTRACT

This project will characterize the morphological and physiological factors that limit the diving behavior and foraging efficiency of harbor seal pups. The size, body composition, oxygen stores and metabolic rates of healthy wild pups captured within Prince William Sound will be measured, and compared to values determined for animals that enter the Alaska SeaLife Center in need of rehabilitation. These comparisons will allow us to determine when and why harbor seal pups are most vulnerable to ecological disturbances, and to identify factors which have a high probability of impacting successful recruitment. Data collected in this study will be augmented by that collected in Prince William Sound in FY 98, and in California as part of a separate project.

INTRODUCTION

Understanding how neonatal mammals acquire the tools necessary to become competent predators is crucial to our understanding of how physiological processes influence behavioral strategies and ultimately animal survival. Within the Prince William Sound ecosystem these questions gain an added import, as the population of harbor seals continues to decline (Frost and Lowry 1994, Lewis et al. 1996, Frost et al. 1997). Research into the causes of this decline has recently focused on differences in animal body condition and health status, and on the foraging efficiency and success of the juveniles (Restoration projects \001, \064, and \341). These, and other, restoration projects have revealed patterns of change suggestive of a reduction in Prince William Sound's carrying capacity (Alverson 1992, Hoover-Miller 1994, Fadely 1997, Niebauer 1998). Shifts in prey availability are likely to most impact the health, condition, and survivorship of juveniles because of their smaller size, immature physiological status, and lower foraging efficiencies (Thorson and Le Boeuf 1994, Corpe 1996, Burns 1997, Horning and Trillmich 1997, Merrick and Loughlin 1997, Zenteno-Savin 1997). Indeed, current data suggest that young harbor seals are vulnerable to reductions in prey availability and body condition in a variety of ways, several of which may act synergistically to reduce their chance of survival. For example, many juvenile seals spend a greater proportion of their time foraging than adults, in part because their foraging efficiency is less than that of older animals (Burns 1997, Horning and Trillmich 1997). As a result, young animals must expend more energy, and potentially utilize more of their fat reserves, while at the same time exposing themselves to greater predation risk (Kooyman et al. 1983, Castellini et al. 1992, 1994, Ponganis et al. 1993, Thorson and Le Boeuf 1994, Horning and Trillmich 1997). For these reasons, it is imperative that we gain a better understanding of those factors, both physiological and morphological, that influence the energetic expenditure and diving behavior of harbor seal pups.

While harbor seals (*Phoca vitulina richardsi*) are one of the most precocial of phocid seals, and are able to swim and dive at birth, this skill carries with it both advantages and disadvantages (Boulva and McLaren 1979, Corpe 1996). In particular, swimming and diving is more energetically expensive than resting on the beach, and therefore, in order for young harbor seals to thrive while spending time in the water, they must quickly gain the ability to regulate their in water metabolic rates (Elsner et al. 1977, Thompson et al. 1987, Worthy and Lavigne 1987, Markussen et al. 1992, Castellini et al. 1992, 1994, Hansen and Lavigne 1997). In addition, the early development of the physiological mechanisms associated with diving, such as heart rate control, metabolic and blood flow regulation, and body oxygen stores, is essential because physiological maturity permits weaned pups to remain submerged for longer periods of time, increasing their foraging efficiency (Cherepanova et al. 1993, Thorson and Le Boeuf 1994, Castellini et al. 1994, Burns and Castellini 1996, Horning and Trillmich 1997). As lower at-sea metabolic costs, and higher foraging efficiencies would likely result in higher growth rates, better condition at weaning, and ultimately, higher survivorship, young seals that develop rapidly would therefore have a distinct advantage over those that could not.

As the rate at which weaned harbor seal pups develop both morphologically and physiologically is probably closely tied to their ability to manage their energy stores and to forage efficiently, it is important that the links between the two be better understood. For example, the dependence of young pups on their perinatal fat reserves for thermoregulation puts them at increased risk of starvation, should prey availability decline, or disturbance rates increase. If provisioning rates decline (either during the nursing period or once weaned) and fat reserves become compromised, then seals will lose more heat to the water and may need to expend greater amounts of energy to

maintain body temperature. At the same time mass specific metabolic rate will increase, which, in turn, will require more reserves to be utilized (Thompson et al. 1987, Markussen et al. 1992, Hansen and Lavigne 1997). Thus pups that are initially slightly compromised in condition, may rapidly lose mass through increased heat loss and energetic expenditure, at the exact time when they need to spend more time in the water foraging to recoup lost energy reserves.

Animals that are unable to rapidly replenish fat reserves will likely continue to decline in condition, and either die or require rehabilitation. As it is important to characterize the minimum physiological and morphological status required for survival in order to place wild measurements within the appropriate context, research on 'non-survivors' (pups brought to the Alaska SeaLife Center in Seward) is essential to this projects success. At the ASLC, we will be able to conduct research on the physiological and morphological condition of pups that would not have survived in the wild, and obtain essential benchmark data against which to judge the health and status of wild animals. Captive animals at the ASLC will also provide important comparative data from animals of known health and condition.

While previous and ongoing restoration projects have addressed seasonal and regional variations in harbor seal condition and foraging behavior, little attention has been given to those factors which may limit the foraging efficiency and success of the most vulnerable segment of the population, the juveniles. By studying the morphological and physiological status of harbor seal pups and then integrating this research with ongoing studies of juvenile health and diving behavior (Restoration Projects \341 and \064, as well as research by Alaska Department of Fish and Game (ADFG) and University of Alaska Fairbanks (UAF) at Tugidak Island) this project will attempt to determine how condition is related to energetic expenditures, foraging success, and ultimately survival.

NEED FOR THE PROJECT

A. Statement of Problem

Within Prince William Sound, the harbor seal population has been in decline since approximately 1984, and current population levels are less than 40% of that counted prior to the *Exxon Valdez* oil spill. The spill aggravated the decline by directly causing the mortality of approximately 36% of the harbor seal population in the oiled areas (Frost and Lowry 1994, Frost et al. 1995). Since the start of the restoration effort, the populations have continued to decline at approximately 6% per year (Frost et al. 1997), and the current population size is estimated to be 28% reduced from 1990 levels. Conversely, harbor seals populations have remained stable or have slightly increased in southeast Alaska (Lewis et al. 1996, Fadely 1997). The cause of the ongoing decline and lack of recovery within the harbor seal population of Prince William Sound has yet to be identified, and the population has remained classified as an injured resource.

It is for these reasons that the Restoration Program has established a strong field component that has designed and tested hypotheses about the health, condition, and foraging behavior of harbor seal adults and sub-adults within Prince William Sound. Unfortunately, previous projects have yet to reveal why populations have continued to decline (Frost and Lowry 1994, Fadely 1997, Frost et al. 1997). However, attention has focused on possible changes in food availability and ecosystem carrying capacity, and also on the youngest age class within the population, the pups. This attention is deserved, for juvenile survivorship is significantly lower than that of older

animals, and juvenile recruitment rates have limited population recoveries of several apex predators (Eberhardt and Siniff 1977, Eberhardt 1985, Clutton-Brock 1988, Sinclair 1988, York 1994). Indeed, in many pinniped species, juveniles have survivorship rates that are less than half those of adults (Eberhardt and Siniff 1977, Siniff 1980, York 1994, Hastings 1996). Research on several pinnipeds has suggested the following mechanism for this lowered survivorship: because of their small size and immature physiological status, juvenile marine mammals have relatively high metabolic rates, smaller oxygen stores, and lower energy reserves, which in turn work to severely limit the diving capacity and foraging efficiency of young animals. These physiological and morphological constraints limit the amount of time that juveniles can spend at depth and make it more difficult for juveniles to acquire sufficient food to grow rapidly in the first year post-weaning. In most species for which there is sufficient data (harbor seals, Weddell seals, Galapagos Fur seals, Steller sea lions, and northern elephant seals) yearlings are of approximately the same mass as weaned pups, but with a much lower body fat reserves (Testa 1987, Thorson and Le Boeuf 1994, Merrick and Loughlin 1997, Frost et al. 1997, Horning and Trillmich 1997). All these findings suggest that weaned pups and juveniles are more vulnerable to changes in food availability than adults, and are most likely to be adversely impacted by increased disturbance rates.

While this theoretical framework has been shown to be true for juvenile Weddell seals, Galapagos fur seals, Steller sea lions and Northern elephant seals (Thorson and Le Boeuf 1994, Corpe 1996, Burns 1997, Merrick and Loughlin 1997, Horning and Trillmich 1997), there is little existing data on how physiological limitations might impact juvenile harbor seal foraging behavior. Extant data indicates that, once weaned, harbor seal pups can not dive for as long or as deep as adults, have a lower foraging efficiency, and yet spend more time in the water than older age classes (Davis et al. 1985, Corpe 1996). Preliminary data collected in California by this researcher suggests that this reduced diving efficiency of harbor seal pups is a result of high metabolic rates, both in air and in water, and an inability to regulate the physiological mechanisms related to diving. Furthermore, there is evidence that young pups do not have the blubber reserves necessary to thermoregulate effectively, or the muscular oxygen stores to remain submerged for long (Worthy and Lavigne 1987, Markussen et al. 1992, Hansen et al. 1995, Frost et al. 1997, Kanatous et al. Subm.). While these findings suggest the mechanisms by which morphological and physiological factors might limit the diving efficiency of young harbor seals, without further directed research, how these factors impact juvenile behavior and survivorship can not be definitively characterized.

In light of the continued decline of harbor seals within Prince William Sound, it is imperative that these links be made. This is especially true, given the preliminary results of Restoration Project \064. That study has found that, relative to harbor seals from other (non-Alaskan) populations, harbor seal pups in Prince William Sound are large at weaning, but that they still show a reduced dive capacity in comparison to older age classes (Frost et al. 1997, pers. comm). In combination with the fact that yearling seals are generally of similar size but with smaller fat reserves than weaned pups, these finding suggest that adult females are able to adequately provision their pups during the lactation period, but that pups, once weaned and obliged to forage on their own, have a more difficult time finding sufficient food resources to grow quickly. Given that pup diving ability is less than that of adults and yearlings (Restoration Project \064, Frost, pers. comm), it is possible that juveniles growth rates are limited by their ability to efficiently find and capture prey, even in areas where adults are foraging very successfully (Thorson and Le Boeuf 1994, Le Boeuf et al. 1996, Burns et al. 1997, Horning and Trillmich 1997). While differences in foraging success between age classes are likely due to physiological and

morphological constraints imposed by age and size, these limits need to be characterized in order to assess whether juvenile survivorship and recruitment are impacted by these natural constraints, or if other factors may be limiting population recovery.

This project proposes to assess the role of age, physiology, and morphology on those factors known to influence diving capacity (metabolic rate, oxygen stores, and metabolic control), and to do so both for healthy pups in the wild, healthy animals in captivity, and for pups that are undergoing rehabilitation at the ASLC. It is important to characterize the physiological and morphological status of wild harbor seal pups so that we can understand how these factors influence their energetic requirements and foraging behaviors. Morphological and physiological status will be determined for all captured pups, and links with diving behavior will be made through collaboration with Restoration Project \064. However, in order to best understand how these factors influence survival, it is essential to identify the minimum body condition necessary for survival in the wild. This will be done by working with young harbor seals that are brought to the ASLC in need of rehabilitation. At the ASLC, we will measure the body composition, metabolic rate, oxygen stores, and heart rate regulatory ability of both rehabilitated and captive animals, and monitor changes in these parameters as the animals grow during the rehabilitation process. Work with rescued animals will provide data from animals over a wide range of size and condition, while work with the resident seals will provide comparative data from older animals known to be in good condition.

By studying the physiological and morphological status of harbor seal pups from the declining population within Prince William Sound, and that of animals at the ASLC that would not have survived otherwise, this project will shed light on those factors which limit diving and foraging behavior and probably influence survival. In particular, it will address questions relevant to the hypothesis that the post-weaning survival of pups is closely tied to their physiological and morphological development, and the resultant limitations on foraging efficiency. It will delineate the differences in diving ability of adults and juveniles, and may indicate ways in which changes in the ecosystem structure might impact juvenile health and condition more significantly than has been seen for older animals (Kooyman et al. 1983, Castellini et al. 1992, Thorson and Le Boeuf 1994, Burns and Castellini 1996, Horning and Trillmich 1997). Alternatively, by delineating juvenile dive capacities, this work may indicate that limitations in foraging behavior are not of sufficient scope to cause large reductions in juvenile survivorship, and that population declines may be more closely linked to factors such as predation and other causes of mortality. Therefore, in combination with data gathered during Restoration Projects \001, \064 and \341, this research will advance our understanding of how physiological limitations imposed by age and body size effect behavioral strategies and energetic use rates. Ultimately, this research may offer insight into those factors that influence juvenile survival and recruitment.

B. Rationale/Link to Restoration

Understanding the links between diving physiology, behavior, and survivorship has been a focus of marine mammal research for many years. Studies on many species have produced a clear understanding of those physiological factors which most influence diving ability (for review see Butler & Jones 1997). For all marine mammals, the ability to remain submerged for long periods of time is largely dependent on two parameters: the amount of oxygen that can be carried to depth, and the rate at which it is used. Absolute limitations on dive depth and duration are contingent, therefore, on the ability of to maximize oxygen stores and minimize use rates. Large oxygen stores exist in the blood and muscle, while use rates are mediated through regulation of

heart rate, metabolic rate, heat flow, and selective vasoconstriction (Kooyman et al. 1981, Qvist et al. 1986, Castellini 1991, Butler and Jones 1997). For adult pinnipeds, physiological limitations on maximal oxygen stores and minimal use rates proscribe the boundaries of behavior. However these limitations are generally thought to have little impact on routine activity patterns, because absolute capacity is much larger than that needed to forage successfully (Kooyman et al. 1981, Castellini 1991, Butler and Jones 1997).

However, the impact that physiological limitations have on juvenile diving behavior has recently been shown to be much greater (Kooyman et al. 1983, Thorson and Le Boeuf 1994, Burns and Castellini 1996, Burns 1997, Horning and Trillmich 1997). Indeed, juvenile pinnipeds can not dive for as long or as deep as adults, and have much lower foraging efficiencies. In part, this is because the physiological factors that limit dive duration are highly correlated with animal age and size. Younger, less mature individuals have smaller oxygen stores (in blood and muscle), and higher metabolic rates. Moreover, young individuals are not able to regulate heart rate, vasoconstriction, or heat flow as well as adults (Cherepanova et al. 1993, Castellini et al. 1994, Burns and Castellini 1996). Finally, because metabolic rate scales as $mass^{0.75}$, while oxygen stores scale as $mass^{1.0}$, immature animals are further disadvantaged by their smaller mass (Kodama et al. 1977, Schmitz and Lavigne 1984, Schmidt-Nielsen 1990, Rea and Costa 1992, Thorson and Le Boeuf 1994, Butler and Jones 1997). In combination, these physiological and morphological limitations make diving more energetically expensive for young animals and therefore delineate a much smaller range of possible dive behaviors.

As a result of their smaller size and immature physiological status, juvenile pinnipeds must either select prey that are easier to capture than those of adults (either due to the prey location or behavior), or forage on similar prey species as adults by 'pushing' their physiological limits (Hindell et al. 1992, Le Boeuf et al. 1996, Burns subm.). Most often they do this by spending more time in the water, expending more effort foraging, and diving closer to their anaerobic threshold (Burns subm.). As all these behavioral options have potential drawbacks, it is advantageous for weaned pups to quickly acquire both the physiological and behavioral skills of adults. Because they spend a large amount of time in the water prior to weaning, grow relatively slowly during the lactation period, and are weaned with a relatively small blubber reserve, this is especially true for young harbor seals (Kovacs and Lavigne 1987, Muelbert and Bowen 1993). The early development of physiological skills offers several advantages: physiologically mature pups would use less energy while in the water, and be able to acquire efficient diving and foraging skills more rapidly. In addition, lower at-sea costs would likely result in higher growth rates, and better condition at weaning. Finally, rapid development of diving physiology and body fat reserves would be of benefit once foraging independently (Burns 1997). However, even if young harbor seal pups are able to rapidly mature physiologically, their diving behavior will probably remain constrained, relative to that of adults, for quite some time.

While harbor seal pups are clearly able to survive early entry into the water, there do seem to be consequences of such precocial behavior. Harbor seals pups generally show the slowest growth rates of all the phocid pups, and rarely double their birth mass during lactation (Kovacs and Lavigne 1986, Muelbert and Bowen 1993). In addition, while most phocid pups are weaned with lipid reserves approaching 50% of their total mass, weaned harbor seal pups are often less than 35% fat (Ortiz et al. 1978, Kovacs and Lavigne 1986, Bowen et al. 1992, Muelbert and Bowen 1993, Oftedal et al. 1993). While a large lean mass implies large muscle oxygen stores, small lipid reserves also indicate the inability to withstand long fasts or food reductions post-weaning. All of these factors indicate that any reduction in food availability or energetic content will have

the largest impact on the youngest harbor seals, not only because they are not able to dive as deep or remain submerged for as long as adults, but also because they forage on a more limited prey base, have smaller energy reserves, and higher metabolic rates (Ashwell-Erickson and Elsner 1981, Worthy and Lavigne 1983, Davis et al. 1985, Rea and Costa 1992, Lydersen and Hammill 1993, Frost et al. 1997). Lowered energy return rates, for whatever reason, are therefore more likely to adversely impact juvenile seals than adults. Similarly, it is possible that the juvenile age classes may be impacted by changes in the ecosystem structure, even if adult animals are not.

Such may be the case within Prince William Sound. Pups handled as part of Restoration Project \064, were significantly larger and fatter at weaning than pups from other populations outside of Alaska (Frost, Iverson, pers. comm). The rapid growth and large size of pups from Prince William Sound indicates that adult females are able to forage successfully throughout the lactation period, and transfer large amounts of energy to their pups. However, the apparent foraging success of adults does not guarantee that newly weaned pups will also be successful. Indeed, for juveniles of many species, the transition to independent foraging is the period of highest mortality (Eberhardt and Siniff 1977, Testa 1987, Hastings 1996). This is likely to be true for juvenile harbor seals, which are probably limited in their foraging capacity for the reasons previously discussed. In addition, while larger size and fat reserves should be initially beneficial to weaned pups, there is as yet no evidence that larger than average pups have higher post-weaning survivorship rates than others, and there is some evidence to the contrary (Reiter et al. 1978, Testa 1987, Hastings 1996). Changes in both food abundance, availability, and/or community structure have been suggested by ecosystem studies in Prince William Sound, and while there is no strong evidence for changes in adult condition, it would be premature to assume that juvenile harbor seals do not experience foraging difficulties post-weaning (Alverson 1992, Fadely 1997, Frost et al. 1997, Niebauer 1998).

While this research will not address questions of prey abundance or availability, it will reveal the magnitude of the behavioral limitations imposed upon harbor seal pups as a result of their smaller size and immature physiological processes. As such, it will test the hypothesis that juveniles face foraging constraints not experienced by adults. It will also provide information against which to assess hypotheses regarding increased mortality rates due to other factors. For example, if data suggest that juveniles do not face significant reductions in foraging efficiency, then relating lower recruitment rates to foraging behavior becomes problematic, and other hypotheses gain strength. The degree to which foraging behavior may impact juvenile survivorship will also be tested through the planned work on metabolic rates. In combination with research carried out as part of Restoration Projects \064 and \341, the minimum energetic requirements measured in this research will allow us to estimate the amount of prey required for survival and growth, and the number of prey required per dive (Doidge and Croxall 1985, Boyd et al. 1994, Burns 1997). These will be the first such estimates made for wild harbor seal pups within the Prince William Sound ecosystem, and as such will provide baseline data against which to assess the hypothesis that food limitations are partially responsible for the ongoing population decline. Data obtained from wild pups will be compared to those previously determined for captive harbor seals from the Bering Sea population, the Central Californian coast, and populations along the Atlantic coast (Ashwell-Erickson and Elsner 1981, Hansen et al. 1995, Rosen and Renouf 1997, Burns, unpubl. data).

Finally, now that the ASLC is open, it is possible to characterize the minimum physiological and morphological status that individual seals can reach and still survive. It is important to do this,

because unless this lower survival limit is known, it is impossible to evaluate the status of 'healthy' wild individuals. Only with knowledge of the minimum status required for survival, can wild measurements be placed in the appropriate context. In addition, by working with pups undergoing rehabilitation, it will be possible to assess longitudinal changes in physiological and morphological parameters as would not be possible with single samples taken from animals in the wild. By doing so, this research will determine the links between age, morphological status, metabolic rates and diving physiology for animals over a much wider range of condition than are typically seen in the wild. Finally, it is also possible to work at the ASLC with the eight resident harbor seals. These animals are of known health and condition, and will be used as controls for both the wild and rehabilitated measurements.

This research, by combining work on wild and captive harbor seal pups, will critically test hypotheses about the rate of physiological and morphological development seen in harbor seal pups. It will examine how physiology and morphology impact diving and foraging behaviors of young harbor seals, and assess the minimum conditions necessary for survival. Ultimately, this project may shed light on how these factors impact juvenile harbor seal survival.

C. Location

This research will be conducted at two main sites: Prince William Sound, and at the Alaska Sea Life Center in Seward. The work in Prince William Sound with healthy wild pups will be carried out in collaboration with Alaska Department of Fish and Game (Restoration Project \064). Extensive sharing of data and resources has already been planned, and preliminary data will be collected during the 1998 summer season, as part of a separately funded collaboration with ADFG. This proposal requests funds for additional seasons of research in Prince William Sound.

Work on captive and rehabilitated animals at ASLC will be coordinated with restoration project \341. Data on pup metabolic rates will be shared with \341, and used in their models of energetic efficiency and dietary requirements. Work carried out on captive pups at ASLC will complement data currently being collected on rehabilitated pups at The Marine Mammal Center in Sausalito, California, as part of a separate project currently being carried out by the PI (Burns).

Finally, there exists the potential to work with wild harbor seal pups at Tugidak Island in cooperation with ongoing projects supported by ADFG and UAF. This work would take place during years 2 and 3 of this project (FY00, FY01) and both complement and augment data collected in Prince William Sound. By comparison, data from animals at Tugidak Island may help researchers identify whether harbor seal pups from Prince William Sound are physiologically or morphologically distinct from other pups within Alaska. Such comparisons will provide essential data for assessing whether the ongoing decline in Prince William Sound is linked to changes in ecosystem structure and food availability which are have lowered juvenile foraging success, or whether factors, such as reduced body condition, mortality due to predation, or other factors are relatively more important in Prince William Sound. While measurements made as part of this project are unlikely to directly reveal whether juveniles are food limited, through comparisons to other populations showing different patterns of growth (stable at Tugidak, growing in California), this work may help determine the extent to which juveniles could be so impacted.

As such, this project's findings will directly benefit several current Restoration Projects (especially \064 and \341). It will shed light on how diving and foraging behavior is constrained

by physiological and morphological factors, and indicate minimum requirements for food intake. In addition, work on animal metabolic rates will provide insight into the amount of food required by the population, and perhaps suggest methods by which changes in the ecosystem structure may be directly influencing the juvenile harbor seals. Alternatively, should this project's findings suggest that harbor seal pups are competent divers at a very young age, and that their foraging efficiency is not significantly limited as a result of their smaller size or physiological status, this work would support hypotheses which attribute the ongoing population decline to factors other than food availability.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The fieldwork on harbor seals supported by the Restoration Council has had integral collaboration with the Native communities as part of the ongoing BIOSAMPLING Program (Restoration Project \244). This project intends to continue this collaboration, and work with the BIOSAMPLING Program in order to obtain muscle tissues from harbor seals within Prince William Sound. This will allow a larger number of muscle samples to be analyzed for myoglobin content, so that age related changes could be better characterized. While we recognize that nursing and weaned pups are generally not represented in the BIOSAMPLING Program dataset, through cooperation with the BIOSAMPLING Program, we should be able to obtain samples from age classes not caught during the summer cruises in Prince William Sound. Currently, discussions are underway with Monica Reidel, Executive Director of the Alaska Native Harbor Seal Commission, about how best to collaborate with the BIOSAMPLING Program, and how best to return information to the local Native communities.

PROJECT DESIGN

A. Objectives

This research will address the physiological limitations and the resulting ecological consequences faced by harbor seal pups. It will do so by simultaneously testing the following four hypotheses. The test of these hypotheses will allow us to determine when and why harbor seal pups are most vulnerable to ecological disturbances:

The specific objectives of this study are to:

1. Characterize the development of physiological processes related to diving in young harbor seals. Are harbor seals physiologically more mature at a younger age than are other phocid pups, as predicted by their early entry into the water?

2. Characterize the morphological development of young harbor seals. Determine how pup body size and composition influences their metabolic rate and heat flow both on land and in water.

3. Compare the above physiological and morphological parameters as measured in healthy wild pups to those determined from stranded pups that, barring rescue, would not have survived in the wild. This will provide estimates of the minimum conditions necessary for survival in the wild.

4. Identify those physiological and morphological elements that influence juvenile diving behavior and foraging efficiency, and therefore have a high probability of impacting the successful recruitment of harbor seal pups into the population.

B. Methods

This project will take place during the 1999 – 2001 pupping seasons, and will be carried out on both wild pups from Prince William Sound and on stranded animals that are brought to the ASLC. Most work will take place between April and August, with some additional research carried out through the fall months. The physiological and morphological status of all pups will be determined using methods developed during the course of Restoration Project \001, or as part of a current research project (Burns, PI) on the physiological condition of young harbor seals in California. The particular methods to be used are detailed within the pertinent sections below, and include assessing body composition, muscle mass, blood volume and oxygen stores, metabolic rate, heat flux, and heart rate control of pups and yearlings. Except for pup metabolic rates (which are currently being used with pups in California) all aspects of this study are being tested this season in Prince William Sound, through the cooperation of \064. Additional collaborative research with ADFG on pups at Tugidak Island (Dr. Robert Small) is currently under discussion. If possible data from pups at Tugidak Island will be used to both supplement and contrast that collected in Prince William Sound.

Animal Capture and Handling:

Animals in the Wild: Work on wild harbor seals pups born in Prince William Sound will take place during summer 1998 (preliminary data collection, separately funded by this researcher) and then each summer for the duration of the project (1999-2001). Additional research on wild pups may also take place at Tugidak Island during the summers of 2000 and 2001.

Seals will be approached by boat and caught by seine net as they flush into the water, or captured by hand while on land. These techniques are currently in use throughout the harbor seal range, and are the accepted methods for catching animals (Jeffries et al. 1989, Frost et al. 1994). Animals captured are assumed to be a random sub-sample of the population as a whole. Sample sizes are planned to be 20 pups per year. Measurements will also be taken from 10 yearlings and 10 adults each year in order to obtain comparative values for older, more mature individuals.

Pup age at capture will be estimated through visual examination of the umbilical stub, tooth buds, claw tips, and by size comparison with animals of known age (Boulva and McLaren 1979, K. Frost, pers. exp.). All pups will be flipper tagged. Upon capture, animals will be physically restrained for non-invasive procedures, but sedated (0.25 mg/kg Diazepam given i.v.) for all invasive procedures. Lidocaine-HCL (2%) will be given at the site of all muscle biopsies (Walker and Bowen 1993, Kanatous et al. Subm.).

Captive harbor seal pups: The ability to work with pups that have been brought to ASLC for rehabilitation provides the opportunity for collecting data from animals that would not have survived otherwise. As such, these values will provide essential data on the minimum conditions necessary for survival, important benchmark data against which to judge the health and status of wild animals. However, because the number and arrival dates of pups can not be predicted, we plan to work opportunistically with the animals that do arrive. We expect that most pups will enter ASLC between June 1st and August 1st, and have planned two visits during this period, both

before and after the work with wild pups. While sample sizes can not be predicted, it is important to realize that any and all data collected from these animals is extremely valuable. Within the constraints of the animal's veterinary care, all handling procedures will be similar to those used with healthy wild pups.

Values obtained from pups undergoing rehabilitation will also be compared to those obtained from the eight resident harbor seals at the ASLC. These animals are of known age and healthy condition. In addition, they exist on diets of known amount and nutrient quality. These animals will therefore provide controls for all measurements from both wild and rehabilitated pups, and also provide comparative data from animals of older age.

Physiological Status:
Animals in the wild: The morphological and physiological development of young harbor seals will be characterized by determining animal mass (kg), size (length and girth), and body condition (composition, blubber depth, blubber quality) in cross-sectional samples taken from animals captured at the end of the pupping period. Developmental changes will be assessed by comparing values from young animals to those of adults determined as part of Restoration Project \001.

Mass will be determined with an accuracy of 0.25 kg using a electronic load cell, and animal size will be assessed by taking measurements of standard and curvilinear length, as well as a series of girth rings along the body (accuracy ± 2.0 cm) (Fadely 1997, Rosen and Renouf 1997). Blubber depths will be determined ultrasonically at each girth ring along the dorsal and lateral positions. The energetic reserves within the blubber layer will be assessed by bomb calorimetry of a blubber biopsy collected dorsally, just anterior to the hip (Fadely 1997, Rosen and Renouf 1997). These measurements are identical to those taken as part of Restoration Project \001, and will therefore be directly comparable to previously collected data from older animals. Finally, the total body fat (proximate composition) of the animal will be determined using deuterium (D_2O) injection (1.0 g/kg) by Dr. Iverson as part of Restoration Project \064, and will be shared with this project.

The maturation of total body oxygen stores will be determined by collecting blood samples from each animal, and measuring the hematocrit and hemoglobin concentration. Hematocrit will be maximized under the experimental conditions, as animals will be manually restrained for the initial blood sample (Castellini et al. 1996). Total blood volume will be determined using the Evan's blue dilution technique, which entails injecting the animal with approximately 2 mg Evans blue plasma dye, and then collecting a series of samples at fixed time intervals (Costa et al. In Press). In combination with hematocrit and hemoglobin data, this will allow us to model the blood oxygen stores.

Muscular oxygen stores will be determined by collecting a muscle biopsy sample (via muscle biopsy canula) from two muscles: the latissimus dorsi (a swimming muscle) and the pectoralis (a non-swimming muscle). This procedure has been successfully used on harbor seals and other marine mammals to determine myoglobin content, mitochondrial density and muscular fiber types (Reynafarje 1963, Reed et al. 1994, Kanatous et al. Subm.). Total muscular oxygen stores will be estimated by multiplying the average myoglobin concentration by the total muscle mass (determined by deuterium dilution). Whole body oxygen stores will be calculated as the sum of blood, muscle, and lung stores (Ponganis et al. 1993). Pup values will be compared to those

previously determined for older harbor seals. Muscle biopsies will be collected from all pups except those outfitted with satellite tags by Restoration project \064.

Animals in captivity: Upon arrival at ASLC, pups will be aged (by umbilical stump, tooth buds, claw tips, size, and appearance), weighed (± 0.25 kg), bled (via the extradural vein), have a series of length and girth measurements taken (± 2 cm), have their fat layer determined via ultrasound, and body composition determined by deuterium dilution. Body oxygen stores will also be determined in the manner described above. All measurements will be done using the same methods as in the wild. These measurements will be taken opportunistically on all pups that come into the center. Similar measurements will be taken from the eight resident harbor seals, so that comparative values from known age, healthy captives can be determined.

In addition to providing important information about the minimum condition necessary for survival, work on young pups at the ASLC will provide data on the physiological development of pups as they increase in age. Wild pups will only be handled once, but captive animals (both rehabilitated and resident) can be handled repeatedly as they get older, and in this way, longitudinal data can be gathered.

Heat Flux and Thermoregulation:

Because measures of blubber quality and quantity are not sufficient to model heat flux and thermoregulatory abilities, heat flow probes will be used to determine the thermal conductance of both wild and captive harbor seal pups (Elsner et al. 1977, Worthy and Lavigne 1987, Noren 1997, Rosen and Renouf 1997). This will give direct measures of the insulative quality of blubber, which, in combination with information on body composition and blubber depth, will indicate the thermoregulatory capabilities of young pups with different body conditions. Data recently collected from captive pups indicates that young animals with small blubber reserves are unable to maintain core temperature in air without shivering (Burns, unpubl. data). As pups are rehabilitated at the ASLC, blubber reserves will increase in size, and by following changes in heat flux and metabolic rate (see below) as blubber depth increases, we will be able to model the impact of body condition on thermoregulatory costs.

Metabolic and Heart Rate Regulation:

Animals in the wild: The resting metabolic and heart rate patterns of captured wild pups will be determined by outfitting selected individuals with heart-rate electrodes and recording EKG patterns while animals rest within cages on board the research vessel. It is our experience that when comfortably housed and left alone, young harbor seals remain calm, or sleep. This will allow us to record beat frequency, and to determine if, and how, young pups are able to regulate heart rate while both breathing and in apnea. As the ability to regulate heart rate during apnea has been shown to be related to the ability to regulate diving heart rates, this work with pups on land will help shed light on diving capacities (Castellini et al. 1994, Burns and Castellini 1996).

At the same time as EKG patterns are monitored, we will also determine the amount of energy used by the pups. This will be done by having the animals rest in small metabolic cages, while their oxygen consumption is monitored. This will be done for animals both in a dry cage, and one filled with water. Harbor seals will be allowed to acclimatize to the system (30 minutes dry, 15 minutes wet), following which time their metabolic rate will be determined (1 hour dry, 30 minutes wet). Oxygen consumption will be determined as follows: ambient air will be pulled through the metabolic chamber with a low-noise vacuum pump. A subsample of the outflow air will be conditioned and analyzed for oxygen content. The analog output from the analyzer will

be sent to a computer, and the oxygen concentration in the chamber determined every 5 seconds (Rea and Costa 1992, Castellini et al. 1992, Hansen et al. 1995). Preliminary data from harbor seal pups in California indicate that although young pups are able to regulate heart rate at a very early age, they have a higher than predicted metabolic rates both in air and in water (Burns, unpubl. data).

Pups at the ASLC: Metabolic and heart rate patterns will similarly be determined for pups that are undergoing rehabilitation at the ASLC. Through comparison with the data collected from wild animals, we will be able to model the influences of animal size, age, and body composition on these important parameters. Again, the ability to work at the ASLC provides two unique opportunities. We will be able to determine the metabolic rate for pups of very poor condition, and we will be able to model changes in metabolic rate as individual pups get older and change in condition. Comparative data will also be obtained from all resident captive animals. This data will be used both by this project and by Restoration Project \341.

Diving Behavior:
Changes in the diving ability of wild harbor seal pups will be determined as part of Restoration Project \064. Data collected as part of this project will be used to model the aerobic dive capacity of pups, and to assess the range of behaviors available to foraging juveniles. Then, in order to better understand how physiological and morphological limitations influence the actual diving behavior and foraging efficiency of pups, these theoretical models will be combined with diving data (as per Burns and Castellini 1996), and the links collaboratively studied.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Currently, field research is being planned in cooperation with Alaska Department of Fish and Game, which is providing logistical support for the work in Prince William Sound through Restoration Project \064. Planned collaborations include the study of how physiology impacts monitored diving behavior, and of how monitored foraging behavior and locations might be linked to energetic intake and use rates.

In 1998 preliminary data for this project will be collected in Prince William Sound through collaboration with ADFG and UAF. This work is being funded by an extant fellowship provided to Dr. Burns by the University of California Office of the President.

Collaborative work on wild harbor seal pups at Tugidak Island is also currently being discussed with ADFG biologists and UAF researchers. If approved, work at Tugidak would take place during years 2 and 3.

Research on captive, and stranded harbor seals will proceed with the cooperation of the ASLC. This work will be organized through the science support staff at the ASLC. In collaboration with Restoration Project \341, we plan to model the energetic requirements of young pups, and the energetic efficiency of animals feeding on different prey items. Interactions with other agencies on the aspects of this project designed to take place at ASLC are not known at this time, but will be coordinated through the ASLC. Marine Mammal Protection Act permits, as well as internal UCSC and ASLC Institutional Animal Care and Use Committee applications will need to be procured before the work can begin.

SCHEDULE

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

Data will be collected during the short period of the year when young animals are available. Fieldwork on healthy wild harbor seal pups will take place during the summer months (June – August). Work with rescued pups at the ASLC may occur at any given time of the year, but will most likely take place during the summer months which surround the pupping period (June – August). Data processing, analysis, and manuscript preparation will proceed during the remainder of the year.

Prior to the FY 99 pupping period, data collected from pups in Prince William Sound during the 1998 season (as part of a separately funded pilot project carried out in cooperation with ADFG and UAF) will be analyzed so that the FY 99 season's work can be targeted appropriately.

October – April:	Acquire equipment, test protocols, analyze data collected in Prince William Sound in FY 98, as part of a separately funded preliminary project. Prepare first annual report.
May – June:	Initial work with animals at ASLC for comparison to both healthy and rehabilitated young-of-the-year.
June – July:	Collection of field data from healthy wild harbor seal pups in Prince William Sound.
July – August:	Collection of same data from stranded and rehabilitated harbor seals at ASLC for comparison to wild animals.
August – September:	Laboratory analysis of all collected samples.

B. Project Milestones and Endpoints

Major milestones will occur in each of the three years of this project, but the five objectives listed above will be carried out in FY 99, FY00 and FY 01. FY 02 will be devoted to the completion of data analysis and manuscript writing, so that by the end of the project all results have been submitted to peer reviewed journals.

FY 99:	Set up of all protocols for both wild and captive animals. Second year of full data collection from wild pups in Prince William Sound (first year separately funded in 1998) and from stranded and rehabilitated harbor seals at ASLC.
FY 00:	Second year of full data collection from rehabilitated pups at ASLC. Preliminary comparisons of data collected from wild and captive animals. Identification of data gaps from both wild and captive work. Work on wild pups in Prince William Sound (year 3) and/or Tugidak Island.
FY 01:	Third year of full data collection from stranded and rehabilitated animals at ASLC. Possible collection of data from wild pups at Tugidak Island and Prince William Sound. Targeted data collection to complete any gaps.
FY 02:	Wrap up of protocols, close out of project, final reports and manuscript preparation and submission

C. Completion Date

This project will finish on September 30, 2002

PUBLICATIONS AND REPORTS

Since this is a new project, there are no current relevant publications. I do not anticipate any full refereed articles in FY 99 to result from FY 99 funding. However, preliminary data to be collected in Prince William Sound this summer (1998), as well as data currently being collected in California will facilitate rapid publication of project results. By FY 00, I should be at the stage of publishing short papers on how metabolic rate changes with age and how it and heat flux are related to animal condition and health status. In addition, initial papers on how body oxygen stores develop with age should be in preparation by FY 00. By FY 01, planned collaborative papers (with EVOS project /064 and /341) on how physiological development impacts juvenile diving behavior, and on the energetic requirements and intakes should be in review.

PROFESSIONAL CONFERENCES

In November 1999, and November 2001 the PI requests funds to attend the Society of Marine Mammal Biology meetings to present initial findings (1999) and final results (2001), and to discuss results with other researchers. In 1999, I anticipate presenting a paper on our preliminary findings from pups handled in FY 98 and FY 99. FY 98 research is being funded and supported by non-Trustee Council Sources. The 1999 meeting is in Hawaii, while the venue for the 2001 meeting has yet to be determined. I anticipate presenting the final results of this study in a talk at the 2001 meeting.

Funds are also requested for the PI to attend the annual EVOS workshop each year.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is planned to coordinate with several Trustee Council funded projects, as well as with planned work at the ASLC. Research on wild pups in Prince William Sound is being supported and coordinated with ADFG biologists Kathy Frost and Lloyd Lowry, as part of Restoration Project \064. By characterizing the physiological and morphological parameters that influence juvenile metabolic costs and limit diving capacities, this research will directly compliment their efforts to understand the health, trophic interactions, and diving behavior of juvenile harbor seals. We will share the research platform and coordinate all sample collection and data management. Preliminary data will be collected from pups in Prince William Sound during this summer (1998). This initial research will provide the groundwork for field research in FY 99 and beyond. Funding for the 1998 summer data collection comes from a postdoctoral fellowship currently held by Dr. Burns, and is achieved at no cost to the Trustee Council. During the 1998 season, this researcher will also gather data on animal health for Restoration Project \341, following protocols designed as part of Restoration Project \001.

In addition, efforts are currently underway to obtain similar data from wild pups at Tugidak Island, in cooperation with Dr. Robert Small, Alaska Department of Fish and Game and Dr.

Michael Castellini, University of Alaska Fairbanks. This collaboration would take place through use of a shared field site, as well as shared sample collections and data management. No additional costs will be incurred should this collaboration occur.

Work on captive harbor seals is being coordinated through the ASLC. Research on metabolic rates will directly compliment planned dietary assimilation efficiency trials (Restoration project \341) by providing information on the amount of energy required by the animals.

Finally, the research outlined in this proposal directly compliments a currently funded project "The development of diving physiology and behavior in a precocial phocid: the harbor seal" which is ongoing in California. All methods presented in this proposal have been successfully trialed in both wild and captive pups from the Californian coast population. A direct comparison should therefore be possible between parameters measured in a growing (Californian) and declining (PWS) population. This comparison may help highlight reasons for the continued population decline in Prince William Sound. Additional funding for the Californian research is being sought through an already submitted National Science Foundation grant and the Californian Department of Fish and Game "Effects of Oil on Wildlife" grants. Should either of these projects receive funding, equipment and supply costs to this project will be reduced.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Jennifer Moss Burns, Ph.D., specializes in understanding the development of young marine mammals, from both a behavioral and physiological perspective. Her research has focused on understanding how young seals are able to compete with older animals, given their smaller size and immature physiological status. She is a University of California President's Postdoctoral Fellow at the University of California Santa Cruz, and is currently studying many of the same questions put forth in this proposal in the growing harbor seal populations along the California coast. Dr. Burns received her Ph.D. from the University of Alaska Fairbanks, while working under Dr. Castellini. She has worked in Alaska with harbor seals for the past several years.

Publications by Dr. Burns since 1990, relevant to this research proposal include:

Burns, J.M. Subm. The development of diving behavior in juvenile Weddell seals: pushing physiological limits in order to survive. Canadian Journal of Zoology.

Burns, J.M., J.W. Testa, and M.A. Castellini. Accepted. Diving behavior and movement patterns of weaned Weddell seal pups. Polar Biology.

Burns, J.M., and M.A. Castellini. In Press. Dive data from satellite tags and time depth recorders: a comparison in Weddell seal pups. Marine Mammal Biology.

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OTHER KEY PERSONNEL

One undergraduate student (TBA) will assist with laboratory analyses and data entry, as part of their senior thesis research project at University of California Santa Cruz. This student will be trained during FY98 and assist with similar data collection and analysis as part of the current study in California: "The development of diving physiology and behavior in a precocial phocid: the harbor seal". Senior thesis students work as volunteers within campus laboratories.

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$48.5
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$48.5
General Administration		$3.4
Project Total	$0.0	$51.9
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$53.5	$53.5	$42.8		

Dollar amounts are shown in thousands of dollars.

Comments:
* The indirect rate is 24.4%, as determined for off-campus research.
* 2% of the project costs in FY99 are for workshop attendance ($1.0).
* The costs of preparing the FY 99 report are included in the FY 2000 budget.
* In FY 99, only 1.5 month of salary support (1.0 FTE) is requested, as Dr . Burns is 100% salary supported with a fellowship until 8/15/98.
* In FY 2000, 2001, and 2002, budget costs are designed to cover 6 months salary (1.0 FTE) support for the PI .
* Travel Costs cover those necessary for the PI to attend the Restoration workshop, and for the PI to travel to Prince William Sound once, and to the ASLC twice (for two weeks each time).
* Per diem costs in Prince William Sound will be covered by ADFG.
* All major, necessary equipment will be purchased in the first year.

FY 99

Prepared: 4/10/98

Project Number: 99464
Project Title: Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology.
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$4.8
Travel		$5.0
Contractual		$2.0
Commodities		$9.9
Equipment		$21.5
Subtotal	$0.0	$43.2
Indirect		$5.30
Project Total	$0.0	$48.5
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS			
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
	$50.0	$50.0	$40.0

Dollar amounts are shown in thousands of dollars.

Comments:
* The indirect rate is 24.4%, as determined for off-campus research.
* 2% of the project costs in FY99 are for workshop attendance ($1.0).
* The costs of preparing the FY 99 report are included in the FY 2000 budget.
* In FY 99, only 1.5 month of salary support (1.0 FTE) is requested, as Dr . Burns is 100% salary supported with a fellowship until 8/15/98.
* In FY 2000, 2001, and 2002, budget costs are designed to cover 6 months salary (1.0 FTE) support for the PI .
* Travel Costs cover those necessary for the PI to attend the Restoration workshop, and for the PI to travel to Prince William Sound once, and to the ASLC twice (for two weeks each time).
* Per diem costs in Prince William Sound will be covered by ADFG.
* All major, necessary equipment will be purchased in the first year.

FY 99

Prepared: 4/10/98

Project Number: 99464
Project Title: Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology.
Name: The Regents of the University of California

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Jennifer M. Burns	Principal Investigator		1.5	3.2	0.0	4.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.5	3.2	0.0	
					Personnel Total	$4.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
RT Travel to Anchorage for Annual Restoration Workshop		0.5	1	5	0.1	1.0
Travel to Seward: June 5-20th		0.5	1	15	0.1	2.0
RT Travel Seward to Prince William Sound (June 20-July 5)*		0.5	1	2	0.1	0.5
Stay in Seward: July 5 - 20th				15	0.1	1.5
						0.0
*Per Diem covered by ADFG when in Prince William Sound 6/21-7/4						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$5.0

FY 99

Prepared: 4/10/98

Project Number: 99464
Project Title: Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology.
Name: The Regents of the University of California

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
Communications: Phone and Fax	0.5
Printing and Copying Charges	0.5
Mailing and shipping services	0.5
Equipment maintenance	0.5
Contractual Total	$2.0

Commodities Costs:	Proposed
Description	FY 1999
Disposable supplies for sample collection (needles, syringes, vacutainers, vials)	2.5
Disposable supplies for sample processing and analysis (vials, chemicals, solvents)	1.5
Supplies for metabolic chamber and oxygen analyzer (tubing, dryerite, baralyme, nitrogen)	0.8
Supplies for EKG data collection and analysis (electrodes, wires, computer disks, chart paper)	1.0
Deuterium for body compositional analysis at ASLC	1.0
Metabolic Chambers for PWS and ASLC	0.6
Drugs, Reagents, Evan's Blue	1.0
Analystical costs: body composition	1.5
Commodities Total	$9.9

FY 99

Prepared: 4/10/98

Project Number: 99464
Project Title: Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology.
Name: The Regents of the University of California

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Sable Systems Oxygen Analysis	1	17.0	17.0
EKG and Respiration Amplifier and A/D converter	1	4.5	4.5
			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**	$21.5

Existing Equipment Usage: Description	Number of Units
Clinical Centrifuge	1
Scale	1
Hematocrit Centrifuge	1
Portable Ultrasound Unit	1
Nitrogen Dewar	2
Bomb Calorimeter	1
Spectrophotometer	1
Ultracentrifuge	1

FY 99

Prepared: 4/10/98

Project Number: 99464
Project Title: Physiological Condition of Juvenile Harbor Seals: Impacts of Age and Morphology.
Name: The Regents of the University of California

FORM 4B
Equipment
DETAIL

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Title: Recovery Status of Barrow's Goldeneyes

Project Number:	99466
Restoration Category:	Research
Proposer:	Dan Esler Alaska Biological Science Center USGS-Biological Resources Division 1011 E. Tudor Rd. Anchorage, Alaska 99503
Lead Trustee Agency:	DOI
Cooperating Agencies:	
Alaska SeaLife Center:	No
Project Duration:	1st year, 2-year project
Cost FY 99:	$12,200
Cost FY 00:	$14,200
Geographic Area:	Prince William Sound
Injured Resource/Service:	Barrow's goldeneye; subsistence; intertidal communities.

ABSTRACT

Although Barrow's goldeneyes are not on the list of resources injured by the *Exxon Valdez* oil spill, some recently collected evidence suggests that goldeneyes may have been injured and populations may not be fully recovered. Due to these concerns, this proposal is designed to critically assess the status of recovery of Barrow's goldeneye populations from the oil spill through assemblage and analysis of all existent, relevant data. This will be accomplished through analyses of data collected for other objectives within the Nearshore Vertebrate Predator (NVP) project and compilation of existing information from NVP and other sources. This work will lead to definition of recovery status, identification of any data gaps limiting our understanding of recovery status or impediments to recovery, and, if warranted, proposal of directed research to fill those gaps during FY2000 and beyond.

INTRODUCTION

Barrow's goldeneyes (*Bucephala islandica*) occur in nearshore habitats of Prince William Sound (PWS), the environment that received about 40% of the oil spilled after the *Exxon Valdez* ran aground (Galt et al. 1991). PWS is almost exclusively a wintering area for Barrow's goldeneyes. Estimates of sound-wide goldeneye numbers (which include a small proportion of common goldeneyes [*B. clangula*]) during 1996 were approximately 36,000 in winter and 400 in summer (Agler and Kendall 1997). Although concerns about nearshore recovery and restoration have resulted in a suite of studies sponsored by the Exxon Valdez Oil Spill Trustee Council (EVOSTC), assessments of Barrow's goldeneye recovery status and constraints to recovery have not been conducted.

Barrow's goldeneyes may be particularly susceptible to injury and constraints to recovery from the oil spill. Because of their close affiliation with intertidal habitats, which still contain oil in some areas (e.g., in Sleepy Bay, based on clean up efforts in summer 1997), Barrow's goldeneyes may continue to be exposed. Further, winter diets of Barrow's goldeneyes consist almost entirely of mussels (*Mytilus trossulus*; Koehl et al. 1982, Vermeer 1982), which have been demonstrated to contain hydrocarbon residues as recently as 1995 (Babcock et al. 1997). In fact, a growing body of evidence suggests that Barrow's goldeneyes suffered, and may continue to suffer, from effects of the oil spill (see Statement of Problem below). Also, Barrow's goldeneyes, like other sea ducks, are long-lived with relatively low annual productivity. Population dynamics of species with these life history characteristics have relatively low rates of potential population growth (Goudie et al. 1994, Schmutz et al. 1997). Thus, recovery of Barrow's goldeneye populations (if injured by the oil spill) would be expected to take many years, even in the absence of long-term, chronic effects.

This species warrants concern not only for population recovery, but also because Barrow's goldeneyes are an important subsistence resource for local residents. For example, in Chenega goldeneyes were harvested by over 25% of households and constituted the majority of harvested waterfowl (Scott et al. 1996). PWS residents have expressed concern over recovery of populations of harvested waterfowl species, including Barrow's goldeneyes (Dan Rosenberg, ADFG, pers. comm.).

Despite proclivity and some evidence for oil spill injury to Barrow's goldeneyes, this species is not on the list of injured resources developed by the EVOSTC. Some recently available data (see Statement of Problem below) suggest that Barrow's goldeneyes warrant consideration for listing as an injured species, and research addressing their recovery may be an appropriate restoration objective. This proposal addresses the need to fully evaluate recovery status of the species via analysis and compilation of existing data.

This project will capitalize on data collected during NVP studies on the primary study sites of northern Knight Island (oiled) and Montague Island (unoiled). These data were collected during efforts addressing sea otter (*Enhydra lutris*) and harlequin duck (*Histrionicus histrionicus*)

recovery. However, they also can be used to critically assess Barrow's goldeneye recovery. This project does not propose work that is already funded under NVP, but rather proposes to either (1) reanalyze data used to assess sea otter or harlequin duck recovery to address questions specific to goldeneyes or (2) analyze data specific to Barrow's goldeneyes that were collected as an aside when conducting NVP field studies. Data collected during NVP that will be used to assess goldeneye recovery include: mussel size class and abundance (collected to assess sea otter recovery), goldeneye abundance and distribution (collected during harlequin duck surveys), goldeneye body condition and diet (from birds collected for NVP copredator studies), and cytochrome P4501A induction of goldeneyes (from collected birds).

Other data that will be assessed with regard to Barrow's goldeneye recovery status include survey data from USFWS, Migratory Bird Management, mussel contaminant level data from NOAA, Auke Bay Lab, and immediate post-spill data collected during ADFG harlequin duck studies. All analyzed and compiled data will be incorporated into the NVP recovery assessment framework as described in Methods.

Based on results from analyses and compilation of available data, the proposed work will lead to conclusions regarding the status of recovery and will generate recommendations for specific research to fill any remaining data gaps. If necessary, additional research would be recommended following the logic and organization of the NVP project, which addressed potential demographic, trophic, and health constraints to recovery of nearshore vertebrate predators, and the nearshore environment generally. Along with addressing questions specific to Barrow's goldeneye recovery, the work conducted under this proposal, as well as any additional research, will serve as another window into recovery of the nearshore system (Holland-Bartels 1995).

NEED FOR THE PROJECT

A. Statement of Problem

Several pieces of evidence suggest that Barrow's goldeneyes suffered injury from the oil spill and that recovery has not occurred. Sound-wide population surveys have found differences in population trends between oiled and unoiled areas (Agler and Kendall 1997), as of March 1996. Further, comparisons of pre- and post-spill data suggest population reductions in oiled versus unoiled areas at several geographic scales of analysis (David Irons, USFWS, pers. comm.). Also, levels of P4501A expression in goldeneyes were significantly higher on oiled Knight Island than unoiled Montague Island (Esler, unpubl. data). These data, along with the life history characteristics that indicate susceptibility of Barrow's goldeneyes to oil spill effects, strongly suggest that a more complete evaluation of the status of recovery, and potential impediments to recovery, is an important restoration objective.

B. Rationale/Link to Restoration

Barrow's goldeneye restoration requires assessment of recovery status and definition of impediments to recovery (demographic, trophic, or health/oil exposure). This proposed work represents a comprehensive approach to understanding the factors that affect population dynamics and definition of critical bottlenecks to recovery. Without an understanding of the underlying processes that dictate population change, we can not prescribe specific activities to enhance recovery.

C. Location

Data to be compiled will come from throughout Prince William Sound. NVP data that will be used to assess Barrow's goldeneye recovery were collected on northern Knight Island (Bay of Isles and Herring Bay) and Montague Island. There is no field component for proposed work.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All efforts will be made throughout the restoration process to participate in and provide public involvement in the implementation of this project. Project staff will be available to present information to local communities or prepare articles or photographs for Trustee Council publications.

PROJECT DESIGN

A. Objectives

1. Analyze data collected during NVP studies and report on results regarding:

    a. Foraging ecology of Barrow's goldeneyes, including body composition, diet composition, and mussel size class selection.

    b. Factors influencing distribution and abundance of Barrow's goldeneyes, including mussel abundance, habitat characteristics, and oiling history.

2. Summarize data from other sources relevant to assessment of Barrow's goldeneye recovery status and impediments to recovery.

3. Generate conclusions regarding recovery status, identify impediments to recovery (if any), and recommend research needed to fill in data gaps to fully evaluate recovery status or impediments to recovery (if necessary).

B. Methods

Following the NVP framework, the proposed work will ask the questions: "Is there evidence for lack of recovery or continued injury from the oil spill?" and "If so, is recovery limited by trophic. demographic, or health constraints?".

Trophic Interactions

Data collected during NVP studies will prove valuable for understanding potential limiting effects of prey availability. Mussel availability and abundance data for NVP study sites will be used to assess food limitation. Lower biomass of mussels (in size classes consumed by goldeneyes) per goldeneye on the oiled study area would be consistent with a hypothesis of potential food limitation of recovery.

Waterfowl body mass and condition have been shown to be related to both contaminant exposure (see below) and food availability. Further, body mass and condition have been shown to affect subsequent survival (Conroy et al. 1989, Longcore et al. 1991, Bergan and Smith 1993) and productivity (Esler and Grand 1994). Lab analyses of lipid and protein levels were conducted for each Barrow's goldeneye collected for NVP copredator studies. Under this proposal, these data will be analyzed to assess variation in body condition related to sex, age, and oiling history (i.e., study area). Poorer body condition in oiled areas than unoiled areas, in conjunction with lower food availability, would be consistent with a hypothesis of food limitation of recovery.

Demography

Data regarding goldeneye distribution and abundance were collected during NVP harlequin duck surveys. These data will be analyzed to assess variation in goldeneye density related to mussel abundance, habitat characteristics, and oiling history. This will assess recovery status by determining whether densities of goldeneyes on oiled study areas are comparable to those on unoiled areas after accounting for intrinsic differences in habitat and food.

Migratory Bird Management, USFWS, has conducted surveys throughout Prince William Sound following the spill. This project proposes interpretation of data through the most recent (March 1998) survey, in light of other data regarding Barrow's goldeneye population health.

Indices to Health/Oil Exposure

Oil exposure of collected Barrow's goldeneyes was evaluated by measurements of cytochrome P4501A, an enzyme that is a specific indicator of exposure to aromatic hydrocarbons. For many nearshore predators, including Barrow's goldeneyes, elevated cytochrome P4501A was expressed in oiled sites, raising concern of continued exposure to *Exxon Valdez* oil. These data will be interpreted in light of other results.

Because Barrow's goldeneye diets consist almost exclusively of mussels during winter, mussel hydrocarbon contamination data from NOAA, Auke Bay Lab, will be reviewed to determine whether foraging represents a potential pathway of continued oil exposure.

Waterfowl body mass has been demonstrated to be related to contaminants (Hohman et al. 1990). Body mass and condition data will be interpreted in light of measures of oil exposure. Lowered body mass, in conjunction with differences in P450 induction, would be consistent with a hypothesis of health related constraints to recovery.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal relies on data collected by a number of researchers funded by the EVOSTC, including the proposed principal investigator, Chuck O'Clair (NOAA), Malin Babcock (NOAA), David Irons (USFWS), and Dan Rosenberg (ADFG).

SCHEDULE

A. Measurable Project Tasks for FY 99

Throughout: Analyze and summarize data regarding Barrow's goldeneye recovery status and impediments to recovery.

April: Prepare preliminary findings and recommendations and submit proposal for directed research in FY2000 and beyond, if necessary.

B. Project Milestones and Endpoints

FY2000

April: Submit final report.

C. Completion Date

All project objectives will be met during FY2000.

PUBLICATIONS AND REPORTS

A final report of activities will be submitted to the Restoration Office before 15 April 2000. The report will consist of 3 documents:

1. A report on status and constraints to recovery of Barrow's goldeneyes based on all available

data.

2. A draft manuscript regarding foraging ecology of Barrow's goldeneyes, including diet and body composition variation within and between oiled and unoiled study areas.

3. A draft manuscript addressing factors related to density of Barrow's goldeneyes, including habitat variables, mussel biomass, and oiling history.

PROFESSIONAL CONFERENCES

None in FY 99.

NORMAL AGENCY MANAGEMENT

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

As described above, this research relies on incorporation of data from other Trustee sponsored research. The major objectives of this work require interaction with other investigators and integration of all available data that are relevant to the question of Barrow's goldeneye recovery status. Also, this proposal relies on data collected during NVP studies by the principal investigator.

PROPOSED PRINCIPAL INVESTIGATOR

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PERSONNEL QUALIFICATIONS

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

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FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$10.6						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$10.6		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration		$1.6						
Project Total	$0.0	$12.2		$14.2				
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99466
Project Title: Recovery Status of Barrow's Goldeneyes
Agency: DOI-BRD

FORM 3A
TRUSTEE
AGENCY
SUMMARY

red:April 15, 1998

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

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Name	Position Description					
D. Esler	Wildlife Research Biologist	GS12/01	2.0	5.3		10.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.0	5.3	0.0	
					Personnel Total	$10.6

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Description					
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY 99

Project Number:
Project Title: Recovery Status of Barrow's Goldeneyes
Agency: DOI-BRD

FORM 3B
Personnel
& Travel
DETAIL

[redacted]red: April 15, 1998

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

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number:
Project Title: Recovery Status of Barrow's Goldeneyes
Agency: DOI-BRD

FORM 3B
Contractual & Commodities DETAIL

ared: April 15, 1998

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

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

Existing Equipment Usage:		Number	Inventory
	Description	of Units	Agency

FY 99

Project Number:
Project Title: Recovery Status of Barrow's Goldeneyes
Agency: DOI-BRD

FORM 3B
Equipment
DETAIL

ared: April 15, 1998

4/1 4 of 4

99467

Assessment of the interannual variability of pelagic production in Prince William Sound. Submitted under the BAA

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number: 99467-BAA

Restoration category: Research

Proposer: Prince William Sound Science Center

Lead Trustee Agency: NOAA
Cooperating Agencies:

Alaska SeaLife Center:

Duration: 1st year of 2

Cost FY99: $254.8K
Cost FY00: $250.0K

Geographic Area: Prince William Sound, Cook Inlet

Injured Resource/Service: Pacific herring and pink salmon

ABSTRACT

Residents of Prince William Sound (PWS) have repeatedly voiced the complaint that pink salmon, herring and other pelagic resources in the spill-area suffered long-term impacts from the oil spill. The Sound Ecosystem Assessment program has developed the first generation of models to predict pink salmon population changes as a result of natural causes so that they can be separated from anthropogenic causes, such as oil spills. The two models developed are a physical-biological model (circulation and plankton) and a nekton model. We propose to initiate a measurement program that will systematically measure weather conditions, physical conditions (water temperature, salinity. etc.) and plankton for input to the physical-biological model, and will measure macrozooplankton and pelagic nekton as input to the nekton model. These data will be collected with remote sensors and on a vessel of opportunity to make the model-based monitoring very cost-effective. These data are essential for the development of second generation models that can be used by management to now-cast population changes of key resources in PWS.

INTRODUCTION

In 1989, the National Science Foundation GLOBEC program defined the limitations of predicting animal population change in marine ecosystems. They stated that past failures of ecosystem models to improve prediction were not based upon mechanistic understanding of the physical-biological environment and the data used were often sparse, discrete measurements that were confounded by temporal and spatial variation. They proposed an observational oceanographic program be developed which used new quasi-continuous sampling technologies to synoptically measure the physics and biology that cause change in specific animal populations. This would be used to test hypotheses and build a first generation of numerical models that improve prediction.

Since 1994, the Sound Ecosystem Assessment (SEA) program has implemented a large-scale observational oceanographic program that uses new measurement technologies to test specific hypotheses (river-lake and prey-switching). The goal was to develop a new generation of models to predict pink salmon and herring population changes in Prince William Sound (PWS). The numerical models include a two-part physical-biological model (circulation and plankton) and a nekton model that is specific to the early life history of the pink salmon or herring. The absence of the cumulative physical-biological affect on the survival of age 0 fish has been considered the primary weakness of past predictive tools. Since weather, the dominant source of variability in physical-biological mechanisms that affect survival, cannot be reliably predicted for more than a week in advance, the cumulative affect of climatic conditions needs to be determined by regular monitoring and fed into the numerical models for now-casting purposes. With forecasting being subject to unpredictable weather events in the future, the best improvements in prediction will come from monitoring selected physical-biological variables through critical life history stages of these animals. With these types of models, we will improve our now-cast capability to account for mortality during early life history phases (for pink salmon fry as much as 90% of total mortality occurs in the first 90 days), ultimately increasing the accuracy of forecasting survival to adult stages.

The SEA program has developed a first-generation circulation model of Prince William Sound, a plankton model to simulate primary and secondary production of the Sound, and a species-specific nekton model for pink salmon (a herring over-wintering model is still a year or more away). In addition, we have developed software tools and alpha-beta tested hardware that will allow the development of a cost-effective monitoring program to collect the data needed to initialize and verify the models.

This proposal requests funding to implement a pilot monitoring program to begin providing the data needed for now-casting and verification.

We propose to equip a SERVES vessel with a towed sensor array, and conduct systematic surveys of the eastern and western corridors of Prince William Sound. The sensor package will consist of a towed vehicle equipped with a CTD, fluorometer, high and low frequency acoustic sensors, and a video plankton recorder. The acquisition and transfer operations for near-real time input for the models will be developed.

We propose to acquire:

- weather measurements from an array of weather stations (USFS, FAA, USCG, and Science Center) and instrument buoys (NOAA and CFOS) in the Sound;

and measure from a towed vehicle;

- water temperature, salinity and depth with a CTD,
- chlorophyll with a fluorometer,
- macrozooplankton prey densities (calanoid copepods) with high frequency acoustics,
- macrozooplankton species and size with a video plankton recorder (VPR), and
- dominant nekton predators (walleye pollock) with a low-frequency, digital echosounder.

Pink salmon, herring and pollock are valued resources and the physical-biological measurements are important to many other valuable resources in the Sound. Residents of Cordova, Valdez, Kodiak, Chenega Bay, Tatitlek, the village of Eyak and more have been contacted for traditional ecological knowledge of these resources and requested that we find out more about them.

During the SEA work (1994-present), we extensively surveyed the pelagic habitat of Prince William Sound because users had previously expressed concern about pink salmon survival. We noted that the *Neocalanus spp.* and walleye pollock were the dominant prey and predator species, respectively, along the out-migration route of the pink salmon fry. The SEA surveys were designed to test the river-lake and prey switching hypotheses and develop quasi-continuous measurement systems to improve accuracy of plankton and nekton population data. With the first-generation of models developed, it is time to develop a cost-effective, monitoring program to provide the input data to initialize the model simulations and the output data to verify the simulation results. This proposal, a pilot model-based monitoring effort, is the logical extension of SEA research, and a crucial step toward implementing research findings for improved management. The implementation of surveys on vessels of opportunity is a cost-effective step for development of a monitoring program, as well as long term implementation of monitoring critical resources in PWS.

NEED FOR THE PROJECT

A. Statement of the problem

In 1989, when the GLOBEC program defined the limitations of predicting animal population change in marine ecosystems, the EXXON VALDEZ oil spill occurred. Armed with the only tools available, state and federal agencies, and industry, began a massive, expensive and controversial damage assessment program. In 1994, the EVOS Trustee Council made a commitment to invest some resources into improving prediction in accordance with the GLOBEC program design. This was the beginning of the SEA program.

One of the original questions sought by the SEA program was to explain why the pink salmon abundance fluctuated dramatically after the oil spill. Pink salmon suffered a major decline in

interpretation of past damage assessments, present status and future risks. Such predictive capability is the foundation for good-decision making relative to the design of restoration activities that promote the conservation and sustainable use of the stock. Conservation and sustainable use of the pink salmon stock is key to restoring lost resources and services to the communities of Prince William Sound.

In 1989, when the GLOBEC program defined the limitations of predicting animal population change in marine ecosystems, the EXXON VALDEZ oil spill occurred. Armed with the only tools available, the state and federal agencies, and industry, began a massive, expensive and controversial damage assessment program. In 1994, the EVOS Trustee Council made a commitment to invest some resources into improving prediction in accord with the GLOBEC program design. This was the SEA program.

After four years of intensive field and modeling efforts, the SEA program has developed the first-generation of predictive tools. Peer reviewers at the start of this program estimated that this effort would require 8-10 years of development time so the program is far ahead of schedule. The eroding funding base has forced early closure on many aspects of this program so best professional judgment has been used extensively to guide the more rapid development.

The predictive tools are numerical models that require monitoring data to continually now-cast populations status. They require a monitoring program to implement. For the new tools to be useful to management they need to be verified and the monitoring program needs to be cost-effective. With the SEA program in its forth and last year of field investigations, it is time to propose the development of a cost-effective monitoring program to feed the modeling efforts. This proposal plans to initiation a pilot monitoring program in 1998, the year following the final field season of SEA, that will be used to collect the data needed to initialize model simulations and allow for the development of the second-generation of verified numerical models.

B. Rationale/Link to Restoration

This project provides the preliminary monitoring that is necessary before a fully operational model-based monitoring plan can be implemented in PWS to assess the status of the pink salmon and herring populations for guiding restoration and management activities. Successful restoration of pink salmon would promote the recovery of the commercial fishery and related services and may also assist recovery of harbor seals, Steller sea lions, killer whales and other foragers such as salmon shark, halibut, eagles, lingcod, bears and more. The ultimate goal of the model-based monitoring is to increase the capability to predict natural changes that are occurring with the pink salmon population. This capability is a prerequisite to the assessment of anthropogenic impacts such as caused by oil, assessment of restoration, and are of value to management and the industry for predicting run size. In terms of its role in science, this is the first case history test of the GLOBEC design for predicting marine animal population changes by using the physical-biological model as a foundation for the cause and effect of natural events. Success in this arena could result in significant changes to the science and management of marine resources. Ultimately, the relevance of this research will be measured in its contribution to sustaining human use of healthy marine populations.

Basically, we are looking at a two year pilot program to complete the transition from the research program to a fully operational model-based monitoring program. Initially, the physical and nekton monitoring will be the first sampling protocols that are standardized. Subsequently, the zooplankton monitoring will be implemented. This is due to the introduction of new plankton video recording system (VPR) to provide species composition and size information for the models. Concurrent with the monitoring will be the now-casting efforts that will refine the physical-biological and nekton models.

C. Location

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

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

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

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

PROJECT DESIGN

A. Objectives

Develop, evaluate and refine a cost-effective model-based monitoring program for now-casting pink salmon survival using the physical-biological and nekton models developed by the SEA program.

B. Methods

Integrate optical technology (VPR) developed by the GLOBEC program with digital acoustic technologies tested by the SEA program into a multi-sensor package that allows for cost-effective measurement of model input variables. Implement, analyze and review survey data and model simulations to develop the most cost-effective program to now-cast and forecast pink salmon population changes.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

No funds are allocated for charter of a vessel which will be provided by SERVES as a vessel of opportunity. SERVES vessels have been used in the past by Science Center programs at a savings of $4000/da in charter costs to the EVOS Trustee Council. We plan 60 survey days in 1998 and 1999 for a savings of $240,000. We plan to challenge the Oil Spill Recovery Institute to provide a 50% match of EVOS funds for this effort, which $120,000 will be for an multi-processor computing system for running 4d model simulations.

SCHEDULE

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

Oct. 1 - Dec. 31:	Examination of models and databases for survey design; design and begin fabrication of VPR system, design and begin assembling multi-processor computing system for running model simulations, obtain NEPA categorical exclusion; implement surveying;
January 1998:	Attend EVOS workshop in Anchorage
Jan 1 - Mar 31:	Continue surveys; alpha test VPR system; alpha test multi-processor computing system
Apr 1 - Jun 30:	Continue surveys; beta testing of VPR, beta testing of multi-processor computer system, community visits
Jul 1 - Sep 30:	Continued surveys; evaluate and refine survey design, include VPR sampling for second year implementation

B. Project Milestones and Endpoints

FY99 Identify and establish physical-biological-nekton survey and develop VPR sampling system

FY00 Implement VPR sampling protocol and integrate into monitoring plan

C. Completion Date

End of FY00 (September 2000).

PUBLICATIONS AND REPORTS

An annual report will be prepared to meet the Council's requirements for work done in 1999. No peer-reviewed articles are anticipated from the first year's work, although they will be prepared if results warrant. However, in the second year we will prepare manuscripts presenting results of the first two years of work for publication in professional journals.

PROFESSIONAL CONFERENCES

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

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

PRINCIPAL INVESTIGATORS

Gary Thomas, Ph.D., Remote sensing specialist
Vince Patrick, Ph.D., Numerical modeler
Jia Wang, Ph.D., Numerical modeler
Kenric Osgood, Ph.D., Biological Oceanographer (zooplankton)
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574
tel: (907) 424-5800
fax: (907) 424-5820
e-mail: loon-, patrick-, or osgood@grizzly.pwssc.gen.ak.us

Responsibilities: Dr. Thomas will be responsible for project administration and acoustic sampling. He has been working as a PI on the SEA program for the past three years.

Dr. Patrick will be responsible for running and refinement of the Nekton model. He has been working as a PI on the SEA program for the past three years in the spill impacted area.

Dr. Wang will be responsible for running and refinement of the Circulation model component of the physical-biological model. He has been working as a postdoctoral research associate at the University of Miami on subcontract to the PWS Science Center to develop the PWS circulation model for the past three years.

Dr. Osgood will be responsible for developing and implementing the VPR system. He recently completed a postdoctoral research position at Scripps Institute of Oceanography and is a specialist in remote sampling of marine zooplankton. He has been working at the PWS Science Center for the past six months on the SEA observational oceanography project.

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

KEY PERSONNEL

Project biologist/field manager (staff):	Primary responsibility for field scheduling and logistics, equipment and data management, assists with analyses and report writing.
Field assistants (staff):	Assists with all aspects of field work and sampling.

LITERATURE CITED

(1) Thomas, G.L. 1992. Successes and Failures of Fisheries Acoustics: An International, National, and Regional Perspectives. Fish. Res. 14 (2-3): 95-105.

(2) Thomas, G.L., Jay Kirsch, Jenny Allen and Vince Patrick. 1996. Development of a multi-species ecosystem model for managing the fisheries resources in the Greater Prince William Sound. 2nd World Fisheries Congress. In Press.
(3) Thomas, G.L., E. Backus, H.H. Christensen, and J. Weigand. 1991. The Prince William Sound/Copper River Delta/Gulf of Alaska Ecosystem. Dobbin and Assoc., Alexandria, VA., 15 pages.
(4) Wells, P.G., J. N. Butler, and J. S. Hughes, editors. 1995. Exxon Valdez Oil Spill: Fate and effects in Alaskan Waters. American Society for Testing and Materials, Philadelphia.

CURRICULUM VITAE

G.L. Thomas, Ph.D.
P.O. Box 1331
Cordova, Alaska 99574
(907) 424-3117, -5800 (work), -5820 (fax)

Education

B.A., 1970, California Western University, San Diego, CA.
M.S., 1973, California State University, San Diego, CA.
Ph.D., 1978, University of Washington, Seattle, WA.

Professional Experience

1990 to present - Prince William Sound Science Center (President)
1992 to present - Oil Spill Recovery Institute (Acting Director)
1996 to present - University of Miami, RSMAS (Professor, affliate)
1992 to 1994 - University of Alaska (Associate Professor, affiliate)
1973 to 1990 - University of Washington (Pre-doctoral Res. Associate- Res. Assistant Professor)
1971 to 1973 - Scripps Institute of Oceanography (Research Associate)

Academic Honors

1974 - Tacoma Sportsmen's Scholarship
1976 - Ellis Memorial Scholarship
1986 - Outstanding Service Award, North Pacific International Chapter of the American Fisheries Society
1990 - Outstanding Service Award Region 1, U.S. Fish and Wildlife Service

Professional Memberships

American Fisheries Society (life member)
American Institute of Fisheries Research Biologists
American Association for the Advancement of Science

Personal

Married 27 years: Mariola, housewife and volunteer
Children: Melanie, Jeremy, Emily and Heather

Selected Publications

Thomas, G.L., Jay Kirsch, Jenny Allen and Vince Patrick. 1997. Development of a multi-species ecosystem model for managing the fisheries resources in the Greater Prince William Sound. 2nd World Fisheries Congress. In Press.

Thomas, G.L. and Ole Mathisen (Guest Editors). 1993. Special Issue: Biological interactions between enhanced and wild salmon in Alaska. Fisheries Research. 18(1-2):1-159 and 18(1-2):1-17.

Thomas, G.L. (Guest Editor) 1992. Special Issue: Successes and Failures of Fisheries Acoustics: An International, National, and Regional Perspectives. Fish. Res. 14 (2-3):91-250 and 14:95-105.

Crittenden, Robert, and G.L. Thomas. 1992. The importance of statistical analysis to determining the accuracy and precision of acoustical estimates of fish abundance. Fisheries Research. 14:197-208.

Thomas, G.L., Steven Thiesfeld, Scott Bonar, Gilbert B. Pauley and Robert N. Crittenden. 1990. Estimation of submergent plant biovolume using acoustic range information. Canadian Journal of Fisheries and Aquatic Sciences. 47(4):805-812.

Thorne, R.E. and G.L. Thomas. 1990. Acoustic measurement of gas bubble release by Pacific herring. Canadian Journal of Fisheries and Aquatic Sciences. 47(10):1920-1928.

Beauchamp, David A., Donald J. Stewart, and G.L. Thomas. 1989. Corroboration of a bioenergetics model for sockeye salmon. Can. Journal of Fish. and Aquatic Sciences. 118(6):587-607

Thorne, R.E. and G.L. Thomas. 1988. Hydroacoustic observations of fish abundance and behavior around reefs and structures. Proceedings of PACON 1988, Marine Techn. Soc., Washington, D.C.

Crittenden, R.N., G.L. Thomas, D.A. Marino, and R.E. Thorne. 1988. A weighted duration-in-beam estimator for the volume sampled by a quantitative echo sounder. Canadian Journal of Fisheries and Aquatic Sciences. 45(7):1249-1256.

Thomas, G.L. and F.L. Felleman. 1988. Acoustic measurement of the fish assemblage beneath killer whale pods in the Greater Puget Sound. Rit Fiskideildar 11:276-284.

Thomas, G.L. and Darrell R. Jackson. 1987. Acoustic measurement of fish schools using array phase information. Canadian Journal of Fisheries and Aquatic Sciences. 44(9):1544-1550.

Thorne, R. L. and G. L. Thomas. 1984. Recent applications of hydroacoustics to assessment of limnetic fish abundance and behavior. Journal of North American Lake Management. 3:305-313.

Thomas, G. L. and R. L. Johnson. 1980. Density-dependence and vulnerability of fish to entrapment by offshore-sited cooling water intakes. OCEANS 1980. IEEE. 6:71-76.

Thomas, G. L. 1979. The application of hydroacoustic techniques to determine the spatial distribution and density of fishes in the nearshore area in the vicinity of thermal generating stations. OCEANS 1979. IEEE. 5:61-63.

Hunter, J. R. and G. L. Thomas. 1973. The effect of prey density and distribution on the searching and feeding behavior of larval anchovy, Engraulis mordax, Giard. In: J.H.S. Blaxter (Ed.). The Early Life History of Fish, pp. 559-574.

E. Vincent Patrick, Ph.D.

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

EDUCATION

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

PROFESSIONAL EXPERIENCE

Academic

Research Associate, Institute for Systems Research, University of Maryland 1993-present
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1992-1993
Research Associate, Advanced Visualization Lab, University of Maryland 1991-1992
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1988-1991

Non-profit

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

Industry

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

Government

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

SELECTED PUBLICATIONS

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

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

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

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

Thomas, G.L., Patrick, E.V., Kirsch, J. and Allen, J.R. (1996) Development of an ecosystem

model for managing the fisheries resources of Prince William Sound. Presented at Second World Fisheries Congress, Brisbane Australia, August 1996.

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

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

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

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

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

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BIRTH: 20 July 1961, St. Paul, Minnesota

CITIZENSHIP: U.S.A.

DEGREES: Ph.D. University of Washington, Seattle, 1993
Biological Oceanography

M.S. University of North Carolina at Chapel Hill, 1986
Marine Sciences (Physical Oceanography)

B.S. University of Maine at Orono, 1983
Biology, Mathematics Minor

POSITIONS HELD:

1996-Present, Research Associate, Prince William Sound Science Center, Cordova, AK.

1993-1996, Post-Graduate Researcher Marine Life Research Group, Scripps Institution of Oceanography, La Jolla, California.

1988-1993, Research/Teaching Assistant, School of Oceanography, University of Washington, Seattle.

1986-1988, Research Assistant, Curriculum in Marine Sciences, University of North Carolina, Chapel Hill.

1983-1986, Research/Teaching Assistant, Curriculum in Marine Sciences, University of North Carolina, Chapel Hill.

Summer 1982, Work/Learn Intern, Smithsonian Environmental Research Center, Edgewater, Maryland.

1979-1981, Laboratory and Field Assistant, Entomology Department, University of Maine, Orono.

PROFESSIONAL SOCIETIES:

American Society of Limnology and Oceanography,
American Geophysical Union, Oceanography Society.

PUBLICATIONS:

Osgood, K. E., and D. M. Checkley, Jr. 1997. Seasonal variations in a deep aggregation of *Calanus pacificus* in the Santa Barbara Basin. Mar. Ecol. Prog. Ser. 148: 59-69.

Osgood, K. E., and D. M. Checkley, Jr. 1997. Observations of a deep aggregation of *Calanus pacificus* in the Santa Barbara Basin. Limnol. Oceanogr. 42: 997-1001.

Osgood, K. E., and B. W. Frost. 1996. Effects of advection on the seasonal abundance patterns of three species of planktonic calanoid copepods in Dabob Bay, Washington. Cont. Shelf Res. 16: 1225-1243.

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FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$254.8
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$254.8
General Administration		$17.6
Project Total	$0.0	$272.4
Full-time Equivalents (FTE)		14.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$250.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99467-BAA
Project Title: Assessment of the interannual variability in pelagic production in PWS
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$113.5
Travel		$9.8
Contractual		$51.0
Commodities		$7.0
Equipment		$22.5
Subtotal	$0.0	$203.8
Indirect		$51.0
Project Total	$0.0	$254.8
Full-time Equivalents (FTE)		14.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$250.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number:
Project Title:Assessment of the interannual variability in pelagic production in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
G.L. Thomas	co-Principal Investigator		2.0	13.6		27.2
Vince Patrick	co-Principal Investigator		3.0	9.1		27.3
Kenric Osgood	co-Principal Investigator		3.0	6.2		18.6
Jay Kirsch	electrical engineer		4.0	7.0		28.0
Jenny Allen	visualization engineer		2.0	6.2		12.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		14.0	42.1	0.0	
					Personnel Total	$113.5

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

FY 99

Prepared:

Project Number:
Project Title: Assessment of the interannual variability in pelagic production in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
vessel charter, purse seiner for 5 days @1500/day	7.5
Jia Wang subcontract, UAF	30.0
fabrication services: towfins	3.0
fabrication services: electronic cables	2.0
network support and software lisc.	6.0
maintenance	2.5
Contractual Total	$51.0

Commodities Costs:	Proposed
Description	FY 1999
field supplies	1.0
office supplies	0.5
video and acoustic storage	0.5
software upgrades	2.5
hardware replacement	2.5
Commodities Total	$7.0

FY 99

Prepared:

Project Number:
Project Title: Assessment of the interannual variability in pelagic production in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
100 m acoustic cable for digital sounder	2	2.0	4.0
underwater video camera/plankton	1	12.5	12.5
pentium 2 - 300 mgHz, PC for transmitter/receive control and field processing	1	7.0	6.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.	**New Equipment Total**		$22.5

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

FY 99

Prepared:

Project Number:
Project Title: Assessment of the interannual variability in pelagic production in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

99468

FEATS: FUNDAMENTAL ESTIMATIONS OF ACOUSTIC TARGET STRENGTH

RECEIVED
APR 15 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Submitted Under the Broad Agency Announcement.

Project Number:	99468-BAA
Restoration Category:	Research
Proposer:	Prince William Sound Science Center
Sponsoring Agency:	NOAA
Duration:	21 months (4/99-7/00)
Cost FY 99:	$199.5 K
Cost FY 00:	TBD
Geographic Area:	Prince William Sound
Injured Resources/Service:	Pacific herring

ABSTRACT

To scale acoustic survey data from relative units (dB) to absolute units (kg/m^3), knowledge of the individual fish's target strength (TS) is required. The purpose of this research project is to conduct experiments to measure the TS of several dominant fish species in Prince William Sound (PWS). This year concentrates on the development of experimental apparatus, experimental logistics and the application of these to measuring Pacific herring TS. If desired, a second year of research may be added which will apply these procedures to other species: walleye pollock, capelin and sandlance. TS to length regressions will be calculated and applied to past surveys in PWS to obtain more accurate density and biomass estimates, and will serve future acoustic survey efforts of these species in coastal Alaska.

INTRODUCTION

Acoustical estimates of fish abundance are used for stock assessment and fisheries management, and for ecological and life history studies (Thorne 1983a; Thorne 1983b; Thomas 1992; MacLennan and Simmonds 1991; Gunderson 1993; Misund 1997). Acoustic surveys estimating Pacific herring fishing stocks have been conducted from Alaska to California, (Thorne 1977a; Thorne 1977b; Trumble et al. 1982; Thorne et al. 1983; Thorne and Thomas 1990) and have been conducted in Prince William Sound since 1993. Acoustic surveys are used to determine densities and distributions of the zooplankton and ichthyofauna in both the Sound Ecosystem Assessment (SEA) and the Alaska Predator Ecosystem Experiment (APEX) programs.

To convert acoustic survey data into population estimates it is essential to have precise and accurate estimates of fish target strength. Experiments with live active animals are more likely to produce results relevant to acoustic surveys (MacLennan and Simmonds 1993). Two approaches to measure live fish target strength are by directly ensonifying single or numbers of live fish in a cage (Edwards and Armstrong 1983) or by *in-situ* measurement of the target strength of wild fish with dual-beam or split beam techniques (Traynor and Ehrenberg 1981). In both cases, mean dorsal aspect TS is required. We propose measurements of PWS herring by these two methods. This proposal describes experiments to estimate target strength on live, caged and wild herring *in-situ*. The experiments were designed to investigate the nature of target strength and the way in which it varies with fish length and weight, numbers, depth and frequency, while monitoring orientation (fish tilt) with video.

Previous surveys provided relative estimates of fish density for both SEA and APEX. Relative densities may have good precision if the survey is replicated, but the accuracy of the density estimates is affected by the chosen TS to length regression. In addition, relative density estimates from different surveys can only be compared to one another if similar sampling protocols are used (Kjelson and Johnson 1978; Pennington 1985). Absolute density estimates, the actual number of organisms per unit area, are required to calculate population dynamic statistics such as reproductive rate, energy flow, and nutrient cycling (Kjelson 1977; Krebs 1989). Rose and several other reviewers have clearly stated that trying to estimate absolute density is impossible without determining the proper target strengths for the acoustic data. Therefore, absolute densities are required to describe food web interactions, density-dependent growth and mortality, and health of these fish populations, all of which are critical to the ecosystem models being developed by SEA and to harvest management.

Absolute density of scatterers in number of targets per m^3 can be determined by the equation:

$$D = \frac{\overline{v^2}}{k\bar{\sigma}}$$

Where...

$\bar{\sigma} \doteq 10^{TS/10}$	*average backscattering cross section, arithmetic equivalent of target strength per fish*
k	*electro-acoustic calibration coefficient*
v	*sonar output voltage at echo integrator*

This can be re-written in terms of absolute biomass density in kg/m^3 by multiplying the numerical density by average fish weight in kg, and separating the terms.

$$\bar{B} = \bar{D}\,\bar{w} \qquad \bar{B} = \left(\frac{\overline{v^2}}{k}\right)\left(\frac{\overline{w}}{\sigma}\right)$$

Where...

$\left(\frac{\overline{w}}{\sigma}\right) \doteq 10^{-TS_w/10}$ *arithmetic equivalent of target strength per weight*

Ideally, one would measure target strength (TS) in the field (*in-situ*), then determine the average backscattering cross section σ. However, for dense schools (typical of herring, young-of-year pollock, capelin, and sandlance), target coincidence makes *in-situ* TS measurement difficult, as multiple targets can be measured as one. See figure 1.

NEED FOR THE PROJECT

A. Statement of Problem

Many physical and biological variables affect target strength including: size of the fish; depth of the fish; tilt angle distribution of the fish; frequency of the transducer; physiology and morphology of the fish (Thorne 1983b; Foote 1987; Rose and Leggett 1988; Thorne and Thomas 1990; MacLennan and Simmonds 1991; Misund et al. 1995; Misund 1997).

TS typically increases with surface area of the fish, which is square to the length. Thorne

(1983) predicts that weight divided by backscattering cross-section linearly increases with length. Most length to TS relationships follow the formula TS = 20Log_{10}(FL) + b, where b is species dependent. For Atlantic herring b has been determined to be -72.1 (Foote, 1987), -73.2 (Halldorsson and Reynisson, 1983), -69.9 (Rudstam et al, 1988), and -73.2 (Misund and Ovredal, 1988).

Boyle's law predicts that the volume of a sphere will decrease with depth, so that in a fish, the bladder volume is inversely proportional to pressure (Mukai and Iida, 1996). Since backscattering cross-section is linearly related to surface area of the scatterer, this predicts that $\Delta TS = (-20/3)\ \text{Log}_{10}(1+\text{depth}/10)$ (Fig 3). Deviation from this theory may occur because the swimbladder is not a perfect sphere, there may be some time for the swimbladder to adapt to the new pressure, and fish may control the swimbladder size for buoyancy control. See figure 4.

The dependence of TS on fish tilt is non-linear, and is due to the non-spherical shape of the swimbladder and the fish. See figure 5. The maximum TS is not necessarily at level orientation, and mean tilt is usually not level (Huse and Ona 1996) either. TS regressions and models should include tilt effects, as fish behavior (diving, swimming, etc.) could change the TS and therefore the acoustic density estimations.

Classical scattering physics predicts a slight decrease of TS (Figure 6) with transducer frequency (Love, 1977). However, this does not include resonance effects, which could be important in that typical wavelengths of scientific sonar systems are close to typically swimbladder sizes.

Ona (1990) observed that swimbladder volume of cod was reduced to about 60% of its original volume when they were ready to spawn, due to compression by the gonads. If the swimbladder were spherical, this would yield a surface area reduction of 29%, resulting in a theoretical TS reduction of 1.5 dB.

The egg sack in Pacific herring is adjacent to the swimbladder, but the actual compression of the swim bladder is unknown. Also, herring are physostomes (open swimbladder) while cod are physoclists (closed swimbladder), so the compression amount with depth should differ. Since herring surveys are done year round, TS measures in both summer (regular gonads) and late winter (pre-spawning with ripe gonads) are required.

B. Rationale/Link to Restoration

In their acoustic surveys of Pacific herring, SEA, APEX and the Alaska Department of Fish and Game (ADF&G) presently use a length dependent scaling constant to convert the reflected acoustic energy into a biomass density estimate TS re: W = -5.982 * Log_{10}(FL) - 24.234 (where FL is the mean fork length (cm) of the fish caught in the area (Thorne 1977b; Thorne 1983a; Thorne 1983b; Thorne and Thomas 1990). However, this regression is based on only a few data points from trawl catches.

This equation differs from the more standard regression equation (TS= 20 logFL -71.9 dB) calculated for Atlantic herring *Clupea harengus* (Foote 1987; MacLennan and Simmonds 1991) as it derives the target strength as a proportion of biomass. The use of Foote's equation instead of Thorne's would increase the density estimates of these fish species by a factor of two (Fig. 2). Atlantic herring differ physiologically from Pacific herring in characteristics including meristic counts, length at age, maximum length, egg size and fecundity, growth rate, age at maturity and longevity (Blaxter and Hunter, 1982). Atlantic herring also differ in behavior such as spawning place and season, and typical depth distributions. Because of these differences, it is necessary to generate a separate TS to length regression for Pacific herring.

C. Location

Samples will be collected from Prince William Sound, and the experimentation will be conducted in Cordova. Data analysis will be performed mostly in Cordova, with some assistance from researchers in Fairbanks.

COMMUNITY INVOLVEMENT

Local fishing vessels will be chartered, which will facilitate the finding and catching of live fish. Results from acoustic surveys have been and will continue to be presented to the public in Cordova.

PROJECT DESIGN

A. Objectives

In year one, we will conduct two cage experiments, one tethered experiment and conduct analysis of *in-situ* measurements from acoustic-purse seine surveys of herring in Prince William Sound. The cage apparatus will be used to measure the TS of three sizes of Pacific herring at the depths they are commonly found during night and daytime periods. The cage apparatus also will be used to evaluate the effect frequency (38, 70, and 120 kHz) on the TS of three sizes of herring at their nighttime depth. The tethering apparatus will be used to measure TS versus fish aspect by changing the head-down or tail-up tilt of the fish. The aspect measurements will be made at the nighttime and daytime depths of herring. Analysis of *in-situ* measurements of TS herring on surveys in Prince William Sound will be made to evaluate the effects of density on coincidence.

The caged and tethered measurements will be made in the fall-winter of 1998 in protected areas of Prince William Sound, Alaska when all sizes of fish are available, the water is unstratified and underwater visibility is at its seasonal high. The *in-situ* measurements will be made with dual-beam procedures and include retrospective analysis of surveys conducted

between 1993 and 1998. This proposal includes a description of the methods of capture, transport and handling of fish, and the experimental apparatus and procedures used to determine the target strength. The TS equations developed in this research will be applied to past and future acoustic surveys in Alaska.

If funded for a second year, we will apply these methods to one or more of the following species: walleye pollock, sand lance and capelin.

B. Methods

The project has been broken into three experiments: 1) measurements of caged fish, which maintain the most natural environment for the fish, 2) measurements of tethered fish, which allow for control of the fish's orientation, and 3) *in-situ* measurements, which uses previously collected survey data.

An apparatus will be fabricated that is capable of mounting a transducer, a standard target, a cage or a tethered fish, and a video camera or a bistatic receiving transducer. Figure 7 is a preliminary design of a support structure, adapted from Iida, Mukai, and Hwang (1997). This apparatus will also be usable for calibration, density ground-truthing, and forward scatter experiments.

The targets of interest will be acoustically sampled using a 101-120 kHz BioSonics dual-beam transducer, a DT-70 kHz BioSonics single-beam transducer, and a DT-38 kHz single beam transducer. The acoustic signal will be processed using target discriminator software (BioSonics ESP 281 or DT Visanal), which outputs TS estimates which will be analyzed. After sufficient acoustic data have been collected, the fish will be measured for fork length, weight, age, and sexual maturity.

Three field experiments are planned: a short trial experiment to refine apparatus design and procedures, a fall experiment, and a spring experiment. Each experiment will be conducted in a deep, protected area of PWS and continue for several days. Nets for catching and holding samples may be borrowed from ADF&G Cordova, including a large anchovy net (250.0 x 34.0 m and 20.0 m, 25.0 mm stretch mesh) and, for shallow water sampling, a small salmon fry seine (50.0 x 8.0 m, 3.0 mm).

I. Field experiments

First, we will make TS measurements for individual, caged but free-swimming herring from three natural size-at-age groups (100 mm age 1 fish, 150 mm age 2 fish, and 200+ age 3+ fish) at a series of daytime and nighttime depth ranges. Second, we will make TS measurements for individual, caged but free-swimming herring from three size groups at their nighttime depth ranges with three common acoustic frequencies (38, 70 and 120 kHz). We will use low-light video for monitoring orientation to relate to target strength. Third, we will make measurements of individual, tethered fish at a series of depth ranges to evaluate the

effects of fish tilt on TS.

Caged fish TS measurements

The experimental technique is modified from Edwards and Armstrong (1983). Modifications to these designs will be made to include new, more acoustically transparent but stronger material. The fish will be contained in an experimental cage, which will be surrounded by a guard cage. Care will be taken to ensure that all measurements are made outside of the transducer near field and that the beam fully ensonifies the cage. The guard cage will be hung from a transducer platform, which will be suspended from an anchored vessel moored in a protected bay. The electronics will be housed on the vessel. Holding tanks and a boom and winch with 150 meters capacity will be used to raise and lower the target strength apparatus.

Detailed descriptions of the electronic systems are found in Thomas et al. (1997). A standard target will be used as a reference target. After each experiment the fish will be weighed and measured, since handling prior to the experiment induces stress. TS will be regressed to both length and weight.

Two experiments will be conducted with the cage: (1) evaluation of depth and fish size on target strength, (2) evaluation of transducer frequency and fish size on target strength.

Experiment 1: We will make measurements of individual, free-swimming herring in a cage to evaluate the effects of depth (day and nighttime depths) and fish size (length and weight) on target strength, while monitoring the fish orientation. The measurement of three size groups that correspond to age 1, 2 and 3+ fish by five depths, replicated three times, which will require 9 days of 24 hour observation. This time includes acclimation time for the fish to adapt to a new depth. A digital 120 kHz echosounder housed in a stainless steel casing rated for 1000 m will be used for these experiments.

Experiment 2: We will make measurements of individual, free-swimming herring in a cage to evaluate the effects of length and weight (relative to natural size/age groups) and transducer frequency on target strength, while monitoring the fish orientation. The measurement of three size groups (age 1, 2 and 3+ fish) by three frequencies (38, 70, and 120 kHz) will be made at one depth (20 m), replicated 3 times, which will require 18 days of 24 hour observation.

Tethered fish experiments

The experimental technique is modified from Mukai and Iida (1996). Modifications to these designs will be made to include new, more acoustically transparent but stronger material. Care will be taken to ensure that all measurements will be made outside of the transducer near field. The fish will be contained in an experimental cage, which will be surrounded by a guard cage. The guard cage will be hung from a transducer platform, which will be suspended from an anchored vessel moored in a protected bay. The electronics will be housed on the vessel. Holding tanks and a boom and winch with 150 meters capacity will be

used to raise and lower the target strength apparatus.

Detailed descriptions of the electronic systems are found in Thomas et al. (1997). A standard target will be used as a reference target. After each experiment the fish will be weighed and measured, since handling prior to the experiment induces stress. TS will be regressed to both length and weight.

One experiment will be conducted with the tether: the evaluation of depth and tilt on target strength. We will make measurements of individual, anaesthetized herring fixed in place in a frame to evaluate the effects of depth (day and nighttime depths) and fish size (length and weight) on target strength, while monitoring the fish orientation. The measurement of target strength at day and nighttime depths, replicated 10 times each for three sizes of fish, will require 6 days of observation. A digital 120 kHz echosounder housed in a stainless steel casing rated for 1000 m will be used for these experiments.

Behavioral monitoring

The fish will be continuously monitored with a low light closed circuit TV system that was equipped with a video tape recorder. TV monitors will be used to observe the condition of the fish during the experiments.

By mounting the video on the bottom of the cage, the behavior of the fish can be monitored during experiments, and unusual behavior (e.g. death, presence of predators) can be eliminated from the records. Edwards and Armstrong (1983) found that it was possible to determine if the fish were swimming with tilt angles close to +/- 90 degrees. The recording tail to head distance to video tape, followed by image processing, can determine fish tilt within the experimental cage.

Fish Capture and Transport

Only fish in prime condition will be used in these experiments. All herring will be captured with a commercial purse seiner. The fish will be segregated by size and stored in floating net enclosures for the duration of the experiment, and will be replenished when necessary. Live tanks with aeration systems will be used on deck to hold fish during experiments. Condition and mortality will be recorded for all experimental fish.

Environmental Conditions

Throughout the experiments the temperature and salinity will be measured by depth with a CTD, so that accurate absorption coefficients and sound speeds can be applied to the acoustic signals.

II. *In-situ* experiments

Since 1995 the SEA project has conducted surveys for juvenile herring, where *in-situ* dual-beam target strength data was collected along with echo-square integration data. This phase of the project is the simplest to implement as the data already exist (no additional field time or equipment is required); however, the data are the most problematic in that coincident targets can yield overestimates of TS, and catches often have multiple age-classes and species.

We will first identify net sets with single-species single-age catch, then determine the acoustic transects from previous surveys that temporally and spatially overlap these net sets. From this acoustic data, we will identify any valid single targets (via a target-tracking algorithm and off-axis angle distributions). The TS from the acoustics will then be regressed with lengths and weights from the catch. These TS data will also be compared with TS measurements from the caged experiments.

A relationship between the ability to detect a valid single target and the volume backscatter may also be established, which may indicate a density threshold at which target coincidence becomes a problem.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

ADF&G will assist with some field logistics.

SCHEDULE

A. Measurable Project Tasks

FY 99:

Apr 99	In-situ data aligned
May 99	Preliminary results available
Jun 99	Apparatus designed
Jul 99	Apparatus constructed
Aug 99	Apparatus tested
Sep 99	Field experiments (non-spawning)

FY 00:

Dec 99	Results available
Mar 00	Field experiments (pre-spawning), TBD
Apr 00	Annual report due
Jul 00	Results available

B. Project Milestones and Endpoints

Target strength equations for the dorsal aspect of Pacific herring by frequency, size and depth. These will be used to transform future acoustic survey information to density and biomass and correct past estimates if this is needed. TS equations will be developed from these data for length and weight per dB. The first preliminary length to target strength regression will be available one month after the first experiment.

C. Completion

The work will be completed and a final report written by April 2000.

PUBLICATIONS AND REPORTS

The result of this research will be a series of target strength regressions specifically for key species in Prince William Sound, Alaska, and an understanding of changes in TS due to physics, behavior, and physiology. With these equations it will be possible to convert the relative density estimates of previous surveys to accurate absolute densities with minimal interaction. It will then be possible to incorporate these data into the ecosystem models presently being developed for Prince William Sound. Furthermore, these equations will greatly improve acoustic estimates of biomass, thereby aiding in the management of fisheries resources.

PROFESSIONAL CONFERENCES

Results of the FEATS project will be presented at one professional meeting, a seminar at University of Alaska Fairbanks, and the EVOSTC restoration workshop in March 1999.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The FEATS project FEATS will cooperate with other EVOSTC-sponsored programs. Results of these experiments will be given to SEA and APEX fisheries researchers.

ENVIRONMENTAL COMPLIANCE

The FEATS project will operate under strict environmental compliance.

PROPOSED PRINCIPAL INVESTIGATORS

Jay Kirsch and Gary Thomas
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PRINCIPAL INVESTIGATOR QUALIFICATIONS

Qualifications of the principal investigators are attached.

OTHER KEY PERSONNEL

Kevin Stokesbury, UAF
John Wilcock, ADF&G

LITERATURE

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Thorne, R. E. 1977a. Acoustic assessment of hake and herring stocks in Puget Sound, Washington, and southeastern Alaska. In Hydroacoustics in fisheries research. by A. R. M. (ed). ICES Rapports et Procesverbaux. pp. 265-278.

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Thorne, R. E. 1983a. Assessment of population abundance by hydroacoustics. Biol. Oceanog. 2: 253-262.

Thorne, R. E. 1983b. Hydroacoustics. In Fisheries techniques. by L. A. Nielsen and D. L. Johnson. Am. Fish. Soc. Bethesda, MD. pp. 239-259.

Thorne, R. E. and G. L. Thomas. 1990. Acoustic observations of gas bubble release by Pacific herring (Clupea harengus pallasi). Can. J. Fish. Aquat. Sci. 47: 19 20-1928.

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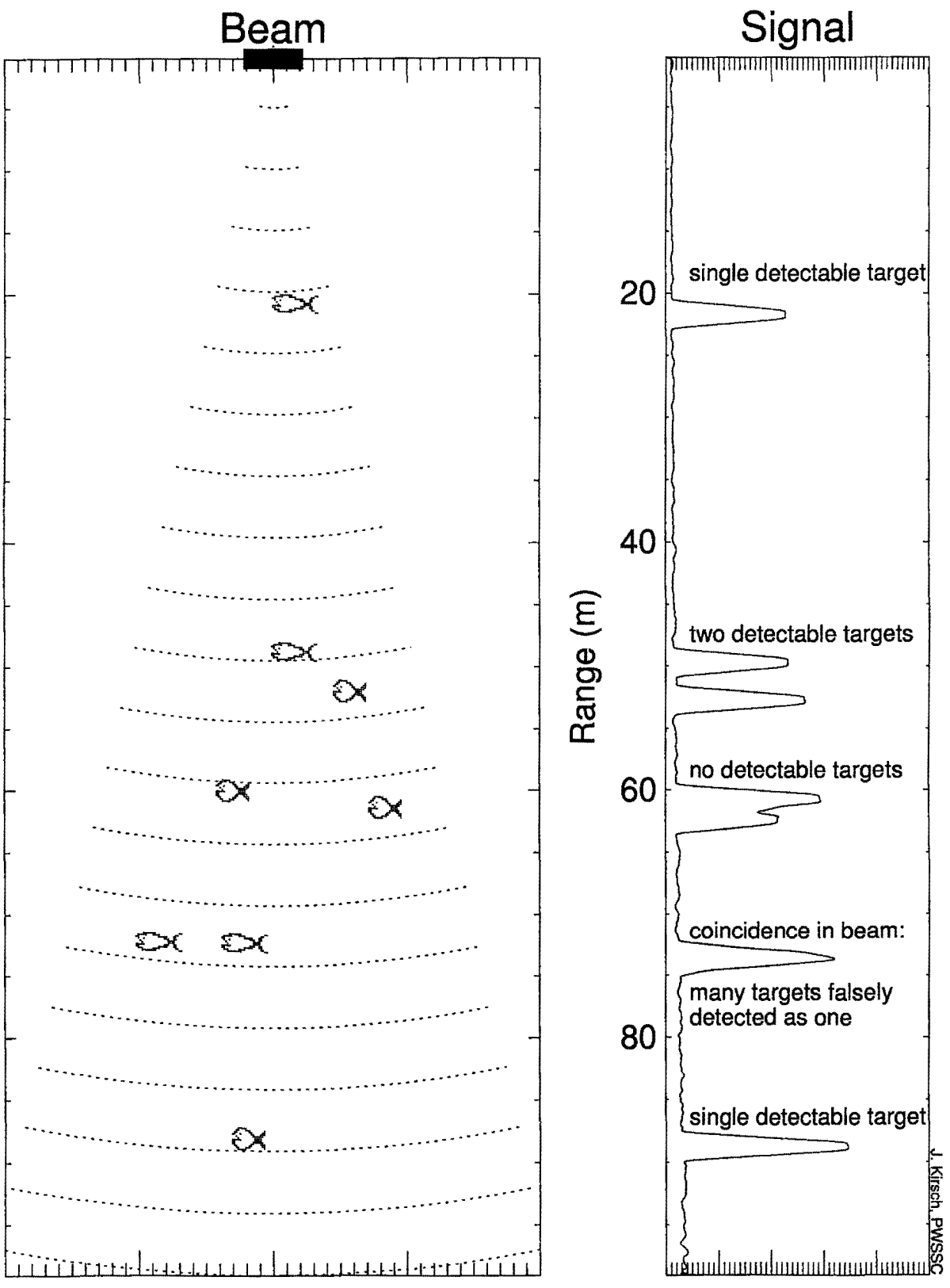

Figure 1. Effects of target overlap

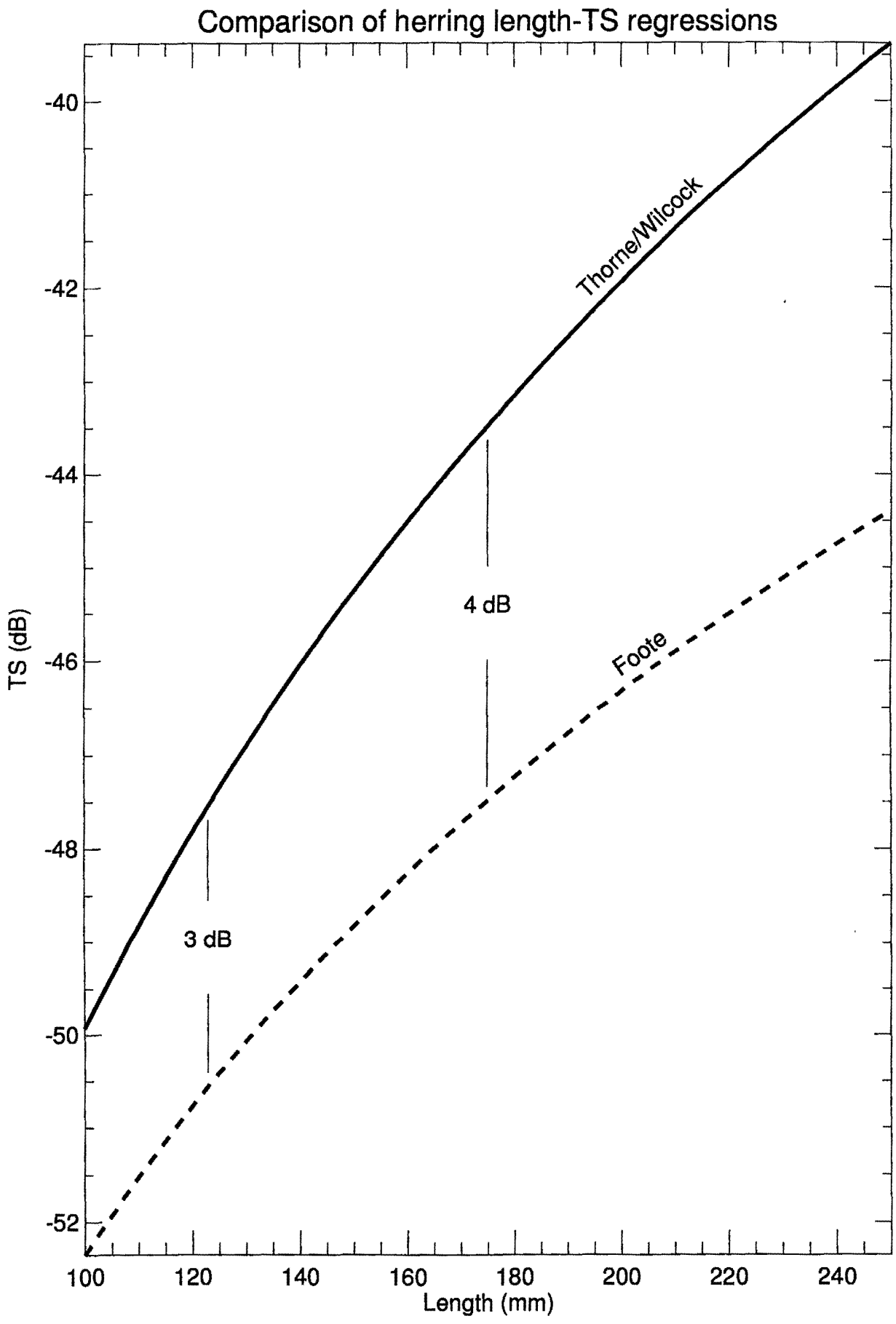

Figure 2. TS models compared: Thorne vs. Foote

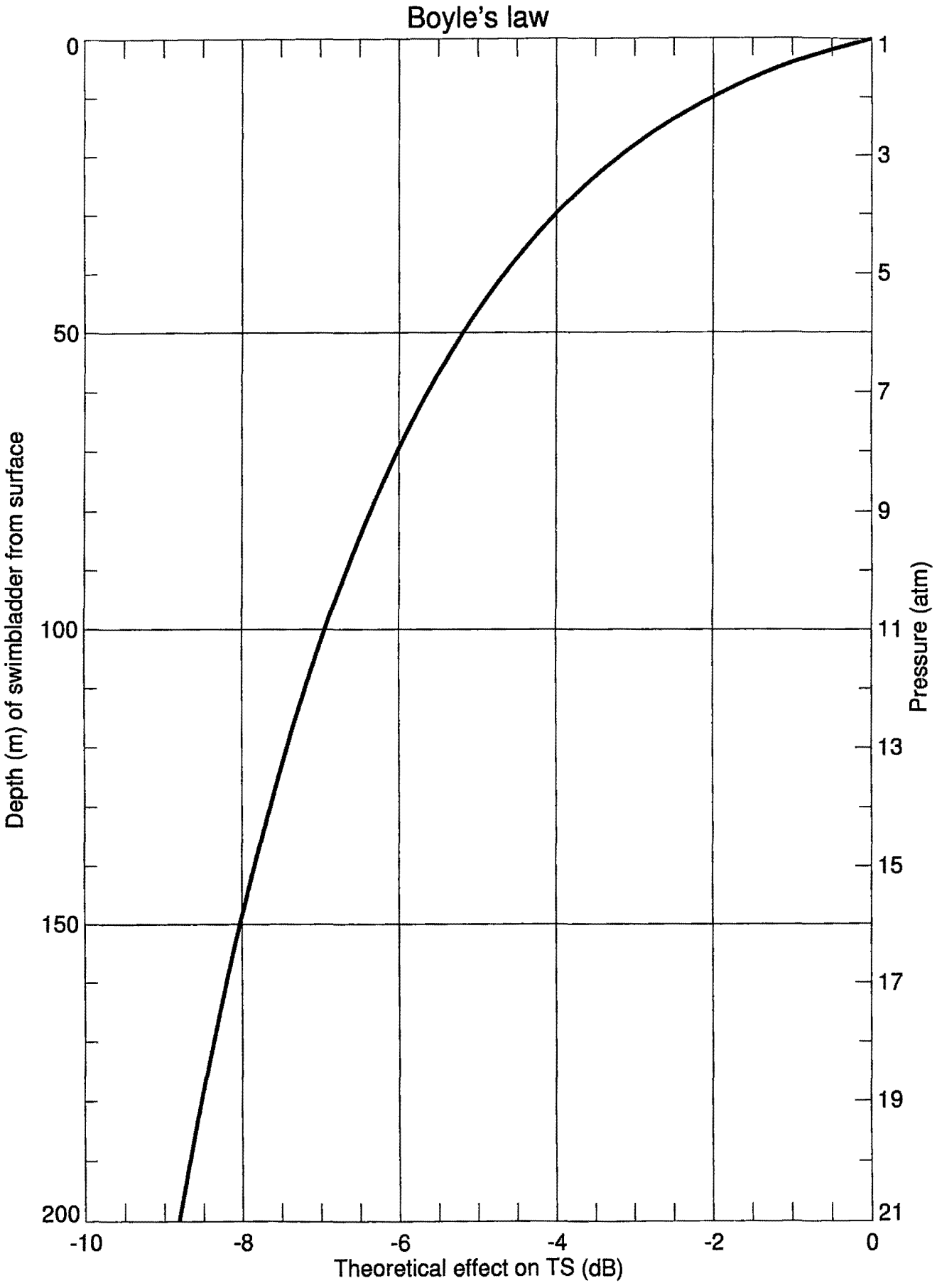

Figure 3. Effect of depth on TS

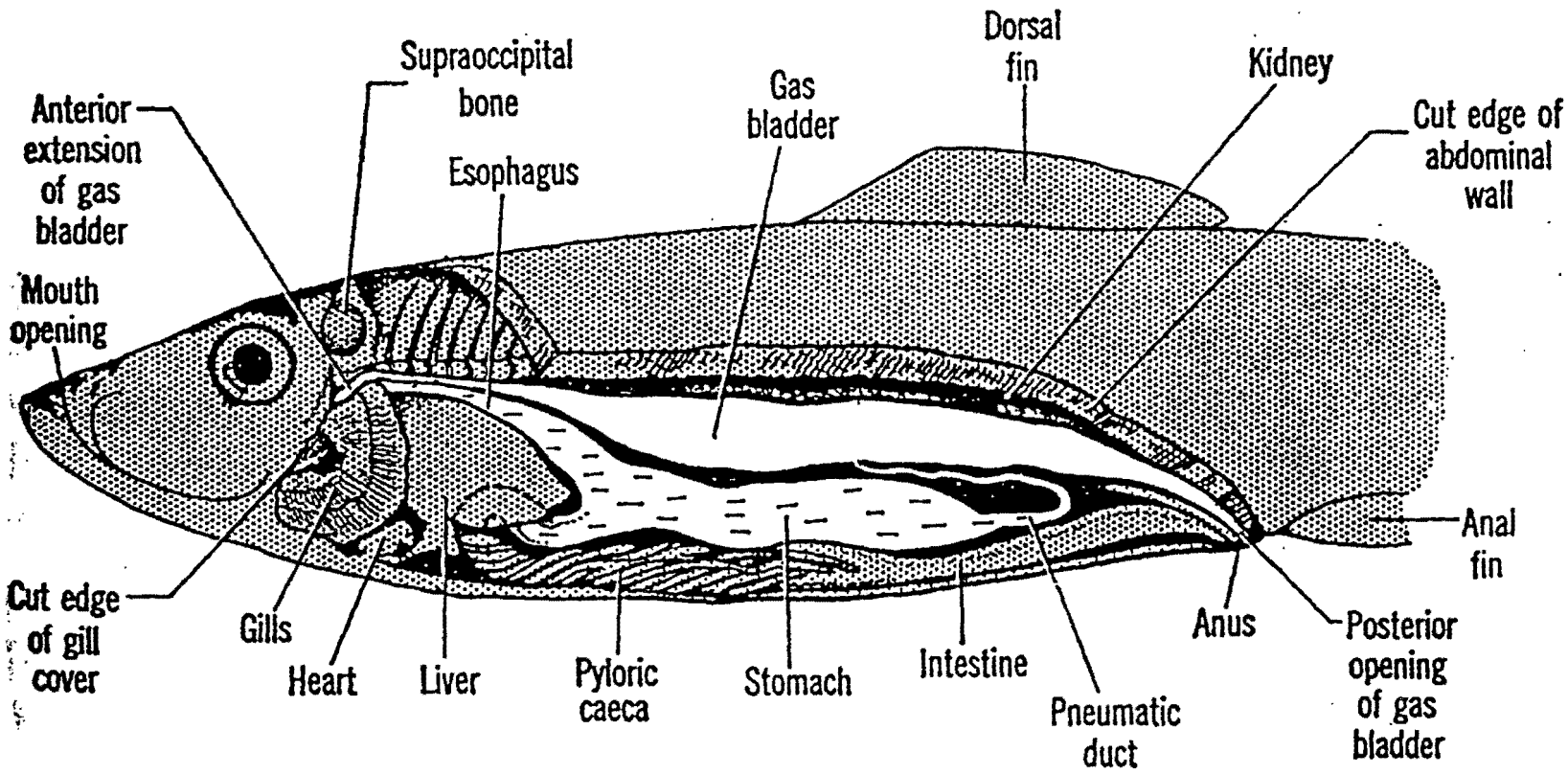

Figure 4. Herring anatomy, including swimbladder

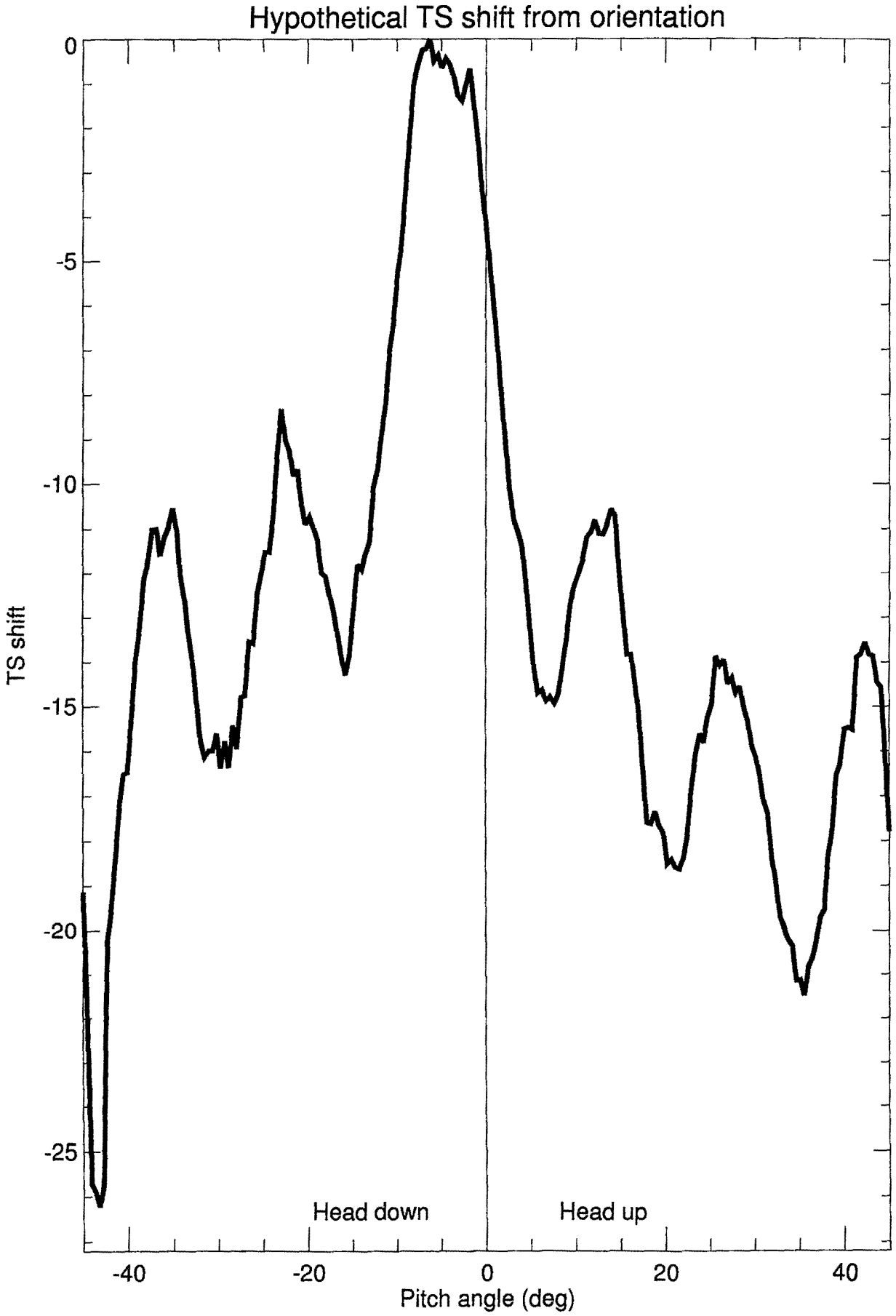

Figure 5. Effects of orientation on TS

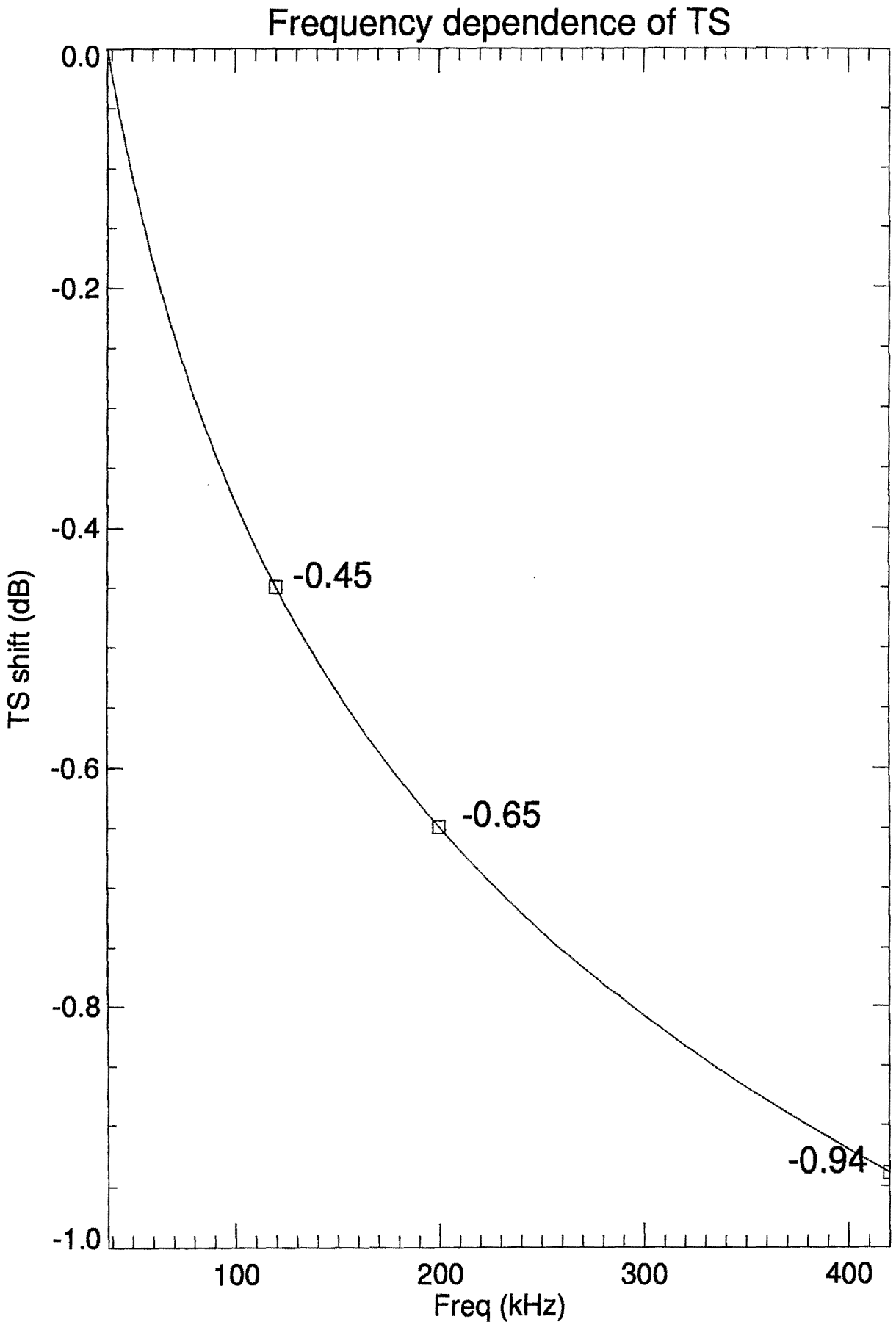

Figure 6. Simplified frequency response

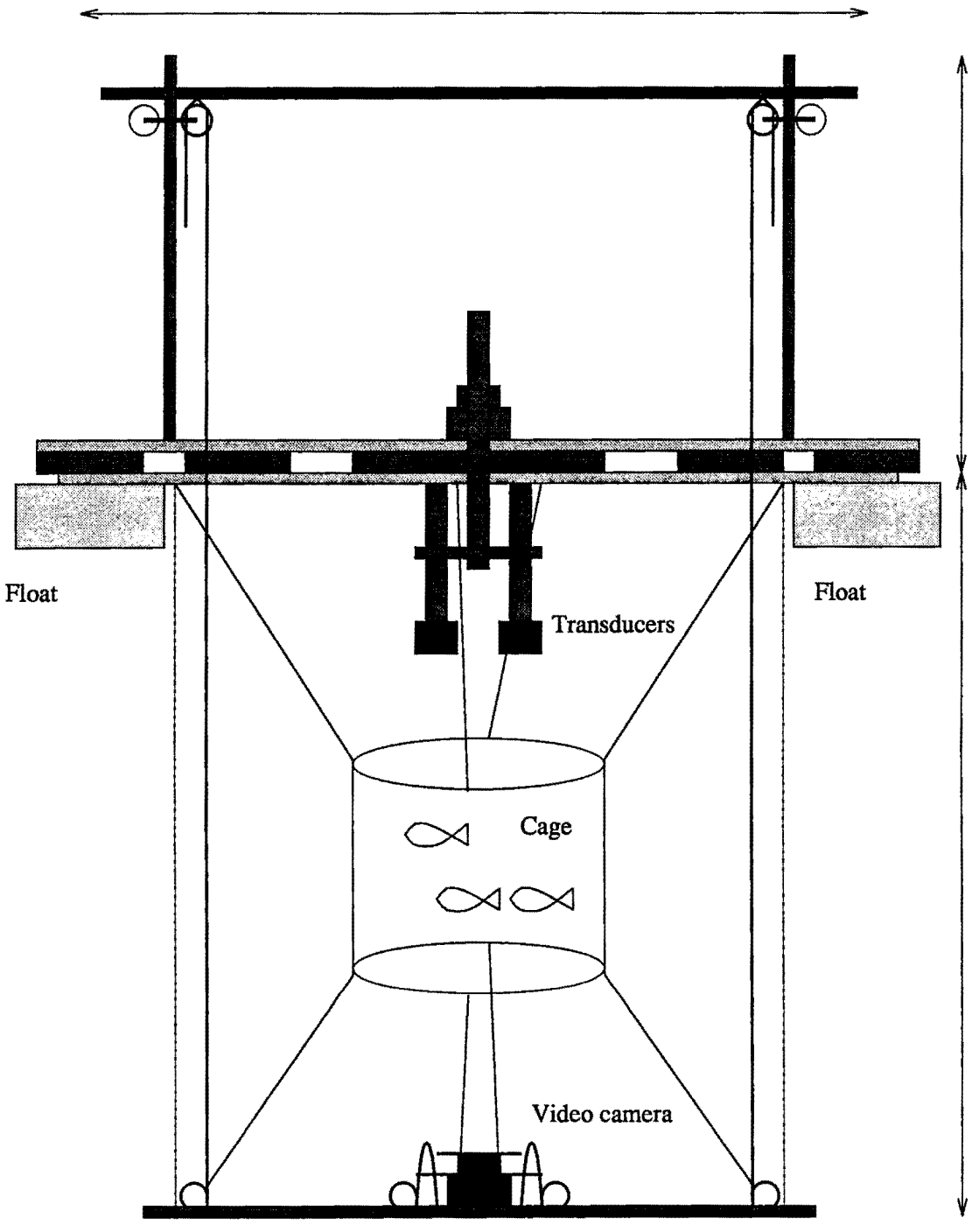

Figure 7. Preliminary design of fish support apparatus

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$199.5
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$199.5
General Administration		$14.0
Project Total	$0.0	$213.5
Full-time Equivalents (FTE)		8.0
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99468-BAA
Project Title: Project Title: Target Strength Studies in PWS
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$67.4
Travel		$8.2
Contractual		$58.5
Commodities		$5.0
Equipment		$20.5
Subtotal	$0.0	$159.6
Indirect		$39.9
Project Total	$0.0	$199.5
Full-time Equivalents (FTE)		8.0
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number:
Project Title: Target Strength Studies in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	G.L. Thomas	co-Principal Investigator	1.5	13.6		20.4
	J. Kirsch	co-Principal Investigator	5.0	7.0		35.0
	V. Patrick	co-Principal Investigator	1.5	8.0		12.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	8.0	28.6	0.0	
					Personnel Total	$67.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	EVOS Annual meeting	0.2	2	10	0.2	2.4
	CDV-Fairbanks	0.4	3	6	0.2	2.4
	CDV-San Diego (OS/AFS meeting)	1.0	2	14	0.1	3.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$8.2

FY 99

Prepared:

Project Number:
Project Title: Target Strength Studies in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
vessel charter, purse seiner for 5 days @1500/day	7.5
vessel charter, acoustic vessel for 40 days @ 800/day	32.0
Kevin Stokesbury (subcontract to UAF)	14.0
fabrication services: cage and tether apparatus	3.0
fabrication services: net pens and mesh cages	2.0
Contractual Total	$58.5

Commodities Costs:	Proposed
Description	FY 1999
field supplies	1.0
office supplies	0.5
video and acoustic storage	0.5
holding tanks	3.0
Commodities Total	$5.0

FY 99

Prepared:

Project Number:
Project Title: Target Strength Studies in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
150 m acoustic cable for digital sounder	1	15.0	15.0
underwater video camera	1	2.5	2.5
rotator for tethering apparatus	1	3.0	3.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.	**New Equipment Total**		$20.5

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

FY 99

Project Number:
Project Title: Target Strength Studies in PWS
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

Prepared:

JAMES M. KIRSCH

P.O. Box 943
Cordova, AK 99574
907-424-5800/5260
kirsch@grizzly.pwssc.gen.ak.us

OBJECTIVE: To apply my knowledge and experience in instrumentation and software engineering toward studying natural aquatic resources.

WORK EXPERIENCE:

ELECTRICAL ENGINEER 4/94 - present
Prince William Sound Science Center Cordova, AK
Developed and coded algorithms and graphical user interfaces for large-scale bioacoustic data reduction, visualization, species classification, and abundance estimation. Led research project, resulting in protocols for sonar operation, standardized processing techniques, and a fully-trained staff. Operated sonar in the field and processed/analyzed bioacoustic data, leading to assessments of the abundance/distribution of herring, pollock, and sockeye salmon. Beta-tested new digital sonars and assessed their feasibility of measuring absolute zooplankton abundance. Trained and supervised biologists and technicians in sonar operation and computer use.

FACULTY RESEARCH ASSISTANT 12/91 - 4/94
Chesapeake Biological Laboratory Solomons, MD
Create software to process bioacoustical, geographical and physical data. Generate algorithms for interpolation and visualization. Operate sonar and plan scientific cruises. Investigate new hardware/software technologies.

SOFTWARE SYSTEMS ENGINEER 9/90 - 12/91
General Electric Westover, NY
Generate test databases, software, and documentation for aircraft flight control computers. Assist senior engineers in the development of autopilot actuator systems.

SOUND ENGINEER 8/87-7/91
Music Department SUNY Binghamton
Operate professional audio equipment. Record live concerts/studio sessions, mix down multi-track tapes, configure microphones and speakers for optimum fidelity. Responsible for equipment and training of technicians.

Computer skills: IDL, C, MATLAB, DSP Assembler, UNIX System Administration

Publications:

Brandt, S.B., and J. Kirsch. 1993. Spatially-explicit models of striped bass growth in the mid-Chesapeake Bay. *Transactions of the American Fisheries Society* 122 : 845-869.

Thomas, G.L., E.V. Patrick, J. Kirsch, and J.R. Allen. 1997. Development of an ecosystem model for managing the fisheries resources of Prince William Sound. Pp. 606-613. D.C. Smith, A. Grant, and J.P. Beumer [eds.], Developing and sustaining world fisheries resources. CSIRO. Collingwood, Australia.

Presentations:

November 1992. Multifrequency Acoustic Visualization And Information Retrieval (MAVAIR) System. 124th meeting of the Acoustical Society of America, New Orleans, LA.

September 1995. Techniques for conversion of acoustic backscatter information into species specific biomass densities. Arctic Division, American Association for the Advancement of Science, Fairbanks, AK.

December 1996. Prediction of ping-to-ping cross talk in fisheries sonar. Third joint meeting of Acoustical Society of America and Acoustical Society of Japan, Honolulu, HI.

August 1997. The use of digital sonar systems for practical fisheries acoustics surveys. American Fisheries Society, Monterey, CA.

September 1997. Acoustic assessment of zooplankton in Prince William Sound in Spring 1996. Arctic Division, American Association for the Advancement of Science, Valdez, AK.

EDUCATION:

State University of New York at Binghamton, T.J. Watson School
B.S. in Electrical Engineering, 1991
New York State Licensed Intern Engineer

State University of New York at Buffalo, 8/88-5/89

Concentrations: Signal Processing, Acoustics, Communications, MIDI

Design Projects:

Electro-acoustical Notch Filter, Spring 1991
TMS320-based DSP Microcomputer, Fall 1990

WORKSHOP: Bioacoustical Oceanography Workshop, August 1993.
Friday Harbor Laboratories, at University of Washington.
Five weeks of lectures, seminars, field work, laboratory experiments, and computer work, emphasizing underwater sound, physics, mathematics, and biology.

ORGANIZATIONS: Acoustical Society of America, 1991-present
National Ski Patrol, 1996-present
Institute for Electrical and Electronics Engineers, 1998-present

INTERESTS: Skiing, Music, Hiking

REFERENCES: Available upon request.

CURRICULUM VITAE

G.L. Thomas, Ph.D.
P.O. Box 1331
Cordova, Alaska 99574
(907) 424-3117, -5800 (work), -5820 (fax)

Education

B.A., 1970, California Western University, San Diego, CA.
M.S., 1973, California State University, San Diego, CA.
Ph.D., 1978, University of Washington, Seattle, WA.

Professional Experience

1990 to present - Prince William Sound Science Center (President)
1992 to present - Oil Spill Recovery Institute (Acting Director)
1996 to present - University of Miami, RSMAS (Professor, affliate)
1992 to 1994 - University of Alaska (Associate Professor, affiliate)
1973 to 1990 - University of Washington (Pre-doctoral Res. Associate- Res. Assistant Professor)
1971 to 1973 - Scripps Institute of Oceanography (Research Associate)

Academic Honors

1974 - Tacoma Sportsmen's Scholarship
1976 - Ellis Memorial Scholarship
1986 - Outstanding Service Award, North Pacific International Chapter of the American Fisheries Society
1990 - Outstanding Service Award
Region 1, U.S. Fish and Wildlife Service

Professional Memberships

American Fisheries Society (life member)
American Institute of Fisheries Research Biologists
American Association for the Advancement of Science

Personal

Married 27 years: Mariola, housewife and volunteer
Children: Melanie, Jeremy, Emily and Heather

Selected Publications

Thomas, G.L., Jay Kirsch, Jenny Allen and Vince Patrick. 1997. Development of a multi-species ecosystem model for managing the fisheries resources in the Greater Prince William Sound. 2nd World Fisheries Congress. In Press.

Thomas, G.L. and Ole Mathisen (Guest Editors). 1993. Special Issue: Biological interactions between enhanced and wild salmon in Alaska. Fisheries Research. 18(1-2):1-159 and 18(1-2):1-17.

Thomas, G.L. (Guest Editor) 1992. Special Issue: Successes and Failures of Fisheries Acoustics: An International, National, and Regional Perspectives. Fish. Res. 14 (2-3):91-250 and 14:95-105.

Crittenden, Robert, and G.L. Thomas. 1992. The importance of statistical analysis to determining the accuracy and precision of acoustical estimates of fish abundance. Fisheries Research. 14:197-208.

Thomas, G.L., Steven Thiesfeld, Scott Bonar, Gilbert B. Pauley and Robert N. Crittenden. 1990. Estimation of submergent plant biovolume using acoustic range information. Canadian Journal of Fisheries and Aquatic Sciences. 47(4):805-812.

Thorne, R.E. and G.L. Thomas. 1990. Acoustic measurement of gas bubble release by Pacific herring. Canadian Journal of Fisheries and Aquatic Sciences. 47(10):1920-1928.

Beauchamp, David A., Donald J. Stewart, and G.L. Thomas. 1989. Corroboration of a bioenergetics model for sockeye salmon. Can. Journal of Fish. and Aquatic Sciences. 118(6):587-607

Thorne, R.E. and G.L. Thomas. 1988. Hydroacoustic observations of fish abundance and behavior around reefs and structures. Proceedings of PACON 1988, Marine Techn. Soc., Washington, D.C.

Crittenden, R.N., G.L. Thomas, D.A. Marino, and R.E. Thorne. 1988. A weighted duration-in-beam estimator for the volume sampled by a quantitative echo sounder. Canadian Journal of Fisheries and Aquatic Sciences. 45(7):1249-1256.

Thomas, G.L. and F.L. Felleman. 1988. Acoustic measurement of the fish assemblage beneath killer whale pods in the Greater Puget Sound. Rit Fiskideildar 11:276-284.

Thomas, G.L. and Darrell R. Jackson. 1987. Acoustic measurement of fish schools using array phase information. Canadian Journal of Fisheries and Aquatic Sciences. 44(9):1544-1550.

Thorne, R. L. and G. L. Thomas. 1984. Recent applications of hydroacoustics to assessment of limnetic fish abundance and behavior. Journal of North American Lake Management. 3:305-313.

Thomas, G. L. and R. L. Johnson. 1980. Density-dependence and vulnerability of fish to entrapment by offshore-sited cooling water intakes. OCEANS 1980. IEEE. 6:71-76.

Thomas, G. L. 1979. The application of hydroacoustic techniques to determine the spatial distribution and density of fishes in the nearshore area in the vicinity of thermal generating stations. OCEANS 1979. IEEE. 5:61-63.

Hunter, J. R. and G. L. Thomas. 1973. The effect of prey density and distribution on the searching and feeding behavior of larval anchovy, Engraulis mordax, Giard. In: J.H.S. Blaxter (Ed.). The Early Life History of Fish, pp. 559-574.

BIOGRAPHICAL SKETCH

E[redacted]incent Patrick, Ph.D.

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

EDUCATION

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

PROFESSIONAL EXPERIENCE

Academic

Research Associate, Institute for Systems Research, University of Maryland 1993-present
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1992-1993
Research Associate, Advanced Visualization Lab, University of Maryland 1991-1992
Asst. Research Scientist, Chesapeake Biological Laboratory, Univ. of Maryland, 1988-1991

Non-profit

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

I[redacted]stry

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

Government

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

SELECTED PUBLICATIONS

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

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

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

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

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

A[redacted]n, J.R., Kulkarni, R. and Patrick, E.V. (1995) Visualizing data and processes for a marine ecosystem. P[redacted]nted at the 46th Arctic Division Science Conference, American Association for the Advancement of Science,

Fairbanks, AK, September 1995.

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

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

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

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

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

Jennifer R. Allen

Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574 USA
907-424-5800 jrallen@grizzly.pwssc.gen.ak.us

EDUCATION

1983	Bachelor of Veterinary Science (First Class Honors) University of Sydney, Australia *[this degree is equivalent to the D.V.M. in the U.S..]*
1985	Residency in Equine Medicine and Surgery, Washington State University, Pullman, WA, USA. Specialized in digital imaging technologies.

EMPLOYMENT

1994-present Technical Project Manager and Information Systems Specialist, Prince William Sound Science Center, Cordova AK
Responsibilities include intranet development; web-based coordination and communications; design and implementation of systems for near-realtime data and output delivery for the SEA multidisciplinary collaborative modelling programs.

1989-93 Research Assistant and Teaching Assistant
Program in Statistics, Washington State University, Pullman WA

1985-89 Research Associate
College of Veterinary Medicine, Washington State University

1984-85 Resident in Equine Medicine and Surgery
College of Veterinary Medicine, Washington State University

SELECTED PUBLICATIONS

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

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

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

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

Thomas, G.L., Patrick, E.V., Kirsch, J. and Allen, J.R. (1996) Development of an

ecosystem model for managing the fisheries resources of Prince William Sound. Presented at Second World Fisheries Congress, Brisbane Australia, August 1996.

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

Thomas, G.L., Kirsch, J., Allen, J.R. and Willette, M. (1995) Temporal and spatial dynamics of the walleye pollock, *Theagra chalcogramma*, population along the outmigratory route of pink salmon fry, s, in Prince William Sound, Alaska. Presented at the 46th Arctic Division Science Conference, American Association for the Advancement of Science, Fairbanks, AK, September 1995.