19.07.05 (8 of 8)

Sockeye Salmon Stocking Feasibility at Chucks Lake.

Project number:	~~98356C~~ 98356
Restoration Category:	General Restoration
Proposer:	USFS
Lead Trustee Agency:	USFS
Cooperating Agencies:	ADF&G
Duration:	1st year, 7-year project
Cost FY 1997:	$41,000
Cost FY 1998:	TBD
Cost FY 1999 and beyond:	TBD
Geographic Area:	Prince William Sound
Injured Resource:	Subsistence/Sockeye Salmon

ABSTRACT

This project is intended to benefit subsistence users of northern PWS by establishing a sustainable sockeye salmon run within close proximity to the Village of Tatitlek. Chucks and Larae Lakes are two connected clear water lakes that total approximately 123 acres and are within 20 boating miles and 12 air miles of the Village of Tatitlek, to the west and across Valdez Arm. This system is currently not accessible to anadromous fish due to a 10 meter and 2.5 meter barrier falls at the lakes outlet stream near the intertidal zone with Heather Bay. There are two phases to this project: Phase 1, the feasibility phase will determine the ability of the Chucks and Larae Lakes system to support a sustainable population of sockeye salmon and at what level initial stocking should occur. Phase 2 of the project would be to initiate a sockeye salmon stocking program at the lake, if found to be feasible, and provide access to the system for returning fish to establish a self sustainable run of sockeye salmon, available for subsistence and sport harvest.

INTRODUCTION

Subsistence resources and services were injured throughout Prince William Sound as a result of the *Exxon Valdez* Oil Spill. This project proposal continues an investigation of the potential to improve subsistence opportunities through the establishment of a sustainable run of sockeye salmon (*Oncorhynchus nerka*) in the Chucks Lake system at Heather Bay, in Northern Prince William Sound (PWS). The Chucks and Larae lakes system total approximately 123 acres of potential sockeye rearing habitat that is currently not accessible to anadromous fish. These lakes could provide an opportunity to establish a replacement fishery to benefit subsistence users in Prince William Sound. Establishing a sockeye salmon population in these lake would also provide additional benefits to sport fisheries.

This project proposal is related to three projects previously funded in 1996 by the Trustee Council, projects; 97256a (Columbia Lake) , 97256b (Solf Lake) and project 97222 (Anderson Creek Fish Pass) were to assess the feasibility of a stocking programs and enhancements at these locations. Solf Lake on Knight Island was found to be a good candidate for stocking and enhancement work and is currently funded by the Trustees. Anderson Creek was dropped from further investigation when high levels of contaminants were discovered. And Columbia Lake was not recommended for stocking (due to low productivity) at this time and further investigations into this project have also been discontinued.

The Tatitlek IRA and EVOS Trustee Councils were informed of the 1996 findings at Columbia Lake in EVOS report # 97256c, Sockeye Salmon Stocking and Feasibility Study for Columbia Lake. Additional conversations with the Tatitlek Community Facilitator, Gary Kompkoff at the 1997 EVOS Restoration Workshop expressed interest in other project opportunities that would benefit the subsistence users in and around Tatitlek. Chuck's Lake and it's potential as a sockeye salmon enhancement project was discussed and additional information forwarded to the Tatitlek IRA Council for review and endorsement since these lakes are located on their lands.

Preliminary results and recommendations from the Chucks Lake feasibility project will be available in December 1998 for the Trustee Council to determine continued funding of the project. If the results are favorable and enhancement work proves feasible stocking could begin as soon as the year 2000. Because limited limnological data is available for Chucks Lake this proposal includes data collection which is required under ADF&G's management plan. The results of which will be used in determining the feasibility of the project.

Chucks and Larae Lakes were recognized for their potential for enhancement in a 1975 report by the Forest Service of Upper PWS (Howse, 1975) where a preliminary feasibility and engineering study revealed three possible options to overcome the migratory barriers. Recent attempts to locate these records have not yet proven successful. A more recent investigation completed in 1985 on contract with ADF&G No. 85-0159 (ADF&G,1985) identified physical and morphometric characteristics of this system. These data include zooplankton biomass, temperature and bathymetric profiles, dissolved oxygen, and water chemistry, as well as an inventory of resident fish populations.

NEED FOR THE PROJECT

A. Statement of Problem

Subsistence use of resources in the oil spill area declined following the spill. Although restoration studies have shown that harvest levels have since returned to prespill levels in most oil spill communities, Chenega Bay and Tatitlek are exceptions (Seitz and Fall, 1995; Seitz and Miraglia, 1995). These communities showed reduced harvest levels in 1993/94 and an increased reliance on salmon harvests (Seitz and Fall, 1995; Seitz and Miraglia, 1995). In addition, the *Exxon Valdez* Restoration Office's Invitation to submit proposals for FY97 stated that subsistence users are traveling greater distances and invest more time in subsistence harvesting than they did prior to the spill. Chucks Lake provides an opportunity to establish a replacement fishery that is easily accessible for subsistence users from Tatitlek and northern Prince William Sound.

This project determines the feasibility of stocking Chucks Lake with sockeye salmon and installing needed enhancements to establish a sustainable replacement fishery for subsistence users. Although very little (one sample) of limnological data exists for Chucks Lake, there is reason to expect that the lake has developed the planktonic base needed to support a sockeye population. This project if funded in phase 1 would provide information needed to analyze the ability of the system to support a sockeye salmon population and at what levels stocking should occur.

B. Rationale/Link to Restoration

Chucks and Larae Lakes are located in Heather Bay in Northern Prince William Sound. The lake system is on land that has been overselected by Tatitlek for conveyance under ANCSA. The two lakes total approximately 123 acres and have the potential to support a population of sockeye salmon for subsistence use. Estimated total production is 5,000 to 10,00 fish/annually based on comparison with similar systems. Phase 2 of this project would be to stock Chucks Lake and provide for anadromous access and monitor the effect on the lake. Should the results be favorable, the newly established population would be easily accessible to Tatitlek residents who already travel past Chucks Lake to Billy's Hole to harvest sockeye salmon for subsistence use.

C. Location

Chucks and Larae Lake are located on the eastern shore of Heather Bay in northern PWS. The lake is unnamed on USGS maps; however, this lake is described in the Anadromous Waters Catalog (ADF&G, 1992) as Chucks Lake, ADF&G 222-10-202A and Larae Lake, ADF&G 222-10-202B.

The lake is easily accessible from Valdez and Tatitlek; and may also benefit subsistence users from Chenega, Cordova and Whittier. This project may also provide incidental benefit to sport fishers in the area.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

This project is designed specifically to benefit subsistence users of northern PWS; therefore, community involvement is an important component for the success of the project. The feasibility phase of this project (FY98 and 99) will determine the ability of Chucks Lake to support a resident population of sockeye salmon. Phase 2 of the project would be to stock the lake with sockeye salmon and make necessary improvements. Contacts with the Tatitlek community liaison will be maintained throughout the feasibility phase of this project to discuss the results of the limnological investigation and explain what the potential adult sockeye production might be. Assuming favorable results, and that the Trustee Council chooses to finance the stocking and improvements at the lake, additional community involvement could be incorporated into monitoring the success of the stocking program and installation and maintenance of any improvements.

PROJECT DESIGN

A. Objectives

Phase 1. The overall objective of this project is to determine the feasibility of stocking Chucks Lake with sockeye salmon and what improvements would be required. There are four components of this objective:

1. Determine if Chucks Lake can sustain a population of sockeye salmon;
2. Determine appropriate stocking levels that can be sustained by Chucks Lake.
3. Coordinate with PWSAC and Main Bay hatchery to establish an appropriate brood stock and the necessary logistics to begin a stocking program.
4. Identify needed improvements and provide preliminary cost estimates.

Phase 2. This is the actual stocking stage of the project and is dependant upon the outcome of Phase 1. The objective of this phase of the project is to stock Chucks Lake with sockeye salmon and to make necessary improvements to the outlet so that a self sustaining population of sockeye salmon can be established.

B. Methods

Limnological Sampling: Quantitative and qualitative data for zooplankton populations (biomass, body-sizes, species composition etc.), algal biomass (chlorophyll a), temperature and light profiles, dissolved oxygen and water quality would be collected to estimate the potential productivity of the lake. Procedures for the collection of these samples are detailed in Koenings et. al. (1987). Samples would be collected from a minimum of two permanent collection sites every three to four weeks during May through September to assess seasonal variation. Laboratory analysis of the samples will follow procedures in Koenings et al (1987) and ADF&G standards for water chemistry analysis. Most laboratory analyses will be processed in September and October after the last samples have been collected.

Fisheries and Macroinvertebrate Initial Sampling (1996): Sampling in 1998 will focus on determining what fish species may already be present in Chucks Lake. Until initial sampling occurs it is unknown if additional sampling would be required to establish population sizes of the fish currently utilizing the lake. Qualitative data on the existing fish and macroinvertebrate populations will be collected using a variety of methods. The intent is to determine the presence or absence of a particular species. Age classes, the strength of the different classes, and the condition factor for each particular species will be determined provided representative samples can be collected. Semi-quantitative estimates of relative fish abundance can also be made using catch per unit effort at the time of the survey. Macroinvertebrate sampling will focus on the lakes and streams benthic communities and will assess the overall diversity by the presence or absence of various taxa. This initial sampling will also serve to establish baseline protocol for any future surveys to assess Chucks Lake.

The initial sampling techniques for fish species will include using fyke nets, variable mesh gill nets and baited minnow traps to collect fish at different depths throughout the lake and associated streams. Fyke nets will be used to sample for existing sockeye salmon populations at least 12 sites will be sampled in near shore and pelagic regions. Fyke nets may also be used to sample near the outlet if currents are not too strong. Baited minnow traps and larger tyvex traps will be used to sample for fish in the streams Pelagic regions of the lake will be sampled in a random pattern using a floating fyke net at three to seven meter depths. Variable mesh gillnets will also be used to trap for larger adult Dolly Varden char that are more difficult to capture in other traps. These gillnets will be set perpendicular to shore to sample varying depths.

Fish Population Size: If the initial trapping results yield high catches of resident fish, it would be important to estimate the population. The total number of fish in Chucks Lake will be estimated through a hydroacoustic survey. Age and size information will be obtained from the initial trapping and tow netting data. Species composition will be estimated from tow-net samples taken in conjunction with the hydroacoustic survey. Standard ADF&G procedures will be followed for the survey and analysis of results (Kyle, 1990).

Habitat surveys: Surveys will be conducted on Chucks Lakes associated tributaries streams to determine the availability of spawning and rearing habitats. Stream surveys will follow a modified Hankin and Reeves (1988) procedure which provides quantitative measurements of habitat types. Stream reaches are divided into habitat types based on flow patterns and channel bed shape (pools, riffles, glides etc). Physical parameters of the habitat types would be measured or estimated and descriptions of substrates and available cover will be recorded. Water residence times will be determined using flow estimates made from the watershed based on procedures described in the Forest Service Water Resources Atlas (Blanchet, 1983). Direct stream flow measurements may be collected if the outlet stream can be sampled using gurley meters. Lake surveys will be focused on developing a shoreline map, identifying potential spawning areas and on available cover for rearing habitat.

Engineering Survey: A preliminary ground survey of the barrier falls and proposed enhancement sites will be completed in 1998. Should the project prove feasible a more detailed survey and cost estimate will be required and will be outlined in subsequent proposals.

Stocking Program: Appropriate stocking levels will be determined in coordination with ADF&G using the data collected in 1998. If the decision is made to stock Chucks Lake, fry will be short-term reared at the Main Bay Hatchery and transported to the lake for release in June or July. 2000 is the earliest release date possible, the actual release time will be dependent upon space availability at Main Bay and/or ice cover and other conditions at the lake. Zooplankton will be sampled, using techniques described above, during each year of the stocking program to evaluate the affect of the stocking program on the plankton population.

Monitoring: Smolt will be collected by fyke net or weir to estimate the total out migration. Fish will be sampled to determine age, length and weight characteristics. Coded wire tags or thermal marking would be used to monitor the population. Returning adults will be enumerated at a weir on the outlet stream. Scales will also be collected and the age structure of the returning fish will be analyzed.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Personnel from the ADF&G Limnology Lab in Soldotna will conduct the limnological data collection, and the bathymetric mapping. ADF&G will also complete the water chemistry and plankton analysis laboratory work. USFS will conduct the habitat surveys, determine available spawning and rearing habitats, and evaluate the resident fish populations. Coordination will occur with PWSAC to make any necessary adjustments at the Main Bay Hatchery to accommodate additional incubation and short-term rearing. Coordination will also occur with PWSAC to perform any necessary fish culture work and to transport the fry to the lake.

SCHEDULE

A. Measurable Project Tasks for FY98 & FY99.

January 22-25:	Attend Annual Restoration Workshop
January 25:	Start NEPA scoping process.
Feb. 1 - April 15:	Prepare for field season.
May 15 - Sept 15:	Limnological data collection.
June/July:	Resident fish population data collection. Stream habitat and macro surveys. Preliminary engineering survey.
September:	Analysis of FY98 field data.
October:	Complete laboratory analysis of water chemistry and plankton data.
Nov. 1:	Evaluate FY98 results and prepare an updated proposal for Trustee Council with recommendations.

Dec. 1 - Jan. 22:	Determine appropriate broodstock and coordinate with Regional Planning Team. Begin NEPA.
.April 15:	Submit annual report and DPD.

B. Project Milestones and Endpoints

Phase 1. The overall objective of this stage of the project is to determine the feasibility of stocking Chucks Lake with sockeye salmon and installing improvements. This objective will be completed when the limnological sampling are completed and analyzed (early FY99). However, results from sampling in 1998 will be used to provide preliminary findings and should be available in time for the Trustee Council meeting in December. Coordination with PWSAC and Main Bay hatchery to determine an appropriate brood stock can be based on the preliminary results from FY98.

Phase 2. This is the actual stocking phase and fishway design and installation phase of the project. Should the results of Phase 1 be favorable stocking could begin in FY00. The following is a tentative schedule and measurable endpoints that apply to this phase of the project.

Jan. - March; FY99:	Apply for necessary permits and hatchery space; complete NEPA process. Coordinate with RPT and PWSAC.
June/July; FY99:	Collect eggs for brood stock.
June/July: FY00	Design and install fish way.
FY00 - 2003:	Release hatchery-reared fry
	Monitor zooplankton population
	Monitor smolt out-migration (FY2001 - FY2003)
	Submit annual reports

C. Completion Date

The project completion date will be at the end of FY2003.

PUBLICATIONS AND REPORTS

Annual reports will be prepared during each year of the project and preliminary reports on the feasibility assessment will be provided to the Trustee Council in late November 1999.

NORMAL AGENCY MANAGEMENT

Current budgets and Forest Service priorities would not provide the opportunity to conduct this project under our normal agency management in the near future. This project will produce the greatest benefit to subsistence users if the adult fish can be harvested in the foreseeable future. This project is on Tatitlek land which is not managed by the Forest Service. The Forest Service has experience in the design and installation of fish passes in Alaska, but would not generally work on land not managed by the agency.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Coordination with ADF&G biologists in Cordova, with the Regional Planning Team, and with PWSAC will begin in FY97 to address the mixed-stock fisheries and genetics issues that will influence the feasibility of this project. We will attend the summer or fall 1997 Regional Planning Team meeting to facilitate the necessary coordination. Once the initial results are available from FY98, the potential size of the stocking program and potential brood stocks can be identified. This information will be necessary to assess the potential effects of this project on local wild stocks and on the commercial fisheries in the area.

The limnological data collection at Columbia Lake will be coordinated with the collection of samples from Solf Lake (97256b). This will reduce the frequency and costs of airplane charters.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This is a new project proposal.

PROPOSED PRINCIPAL INVESTIGATOR

The principal investigator of this project will be the Fisheries Biologist at the Glacier Ranger District of the Chugach National Forest. This position is currently vacant and expected to be filled in FY97. Daniel Gillikin (Fisheries Biological Technician; Glacier Ranger District) is the interim biologist and will coordinate this project for the USFS. until a permanent principal investigator is assigned. Dan will also provide technical support and field coordination of the seasonal employees assisting in data collection and construction for the project.

ADF&G is the cooperating agency on the project. Pat Shields, Fishery Biologist I, will be the principal investigator for the limnological and bathymetry work. Marsha Spafard, Fish and Game Technician III and Denise Cialek, Fish and Game Technician III, will assist in the data collection and laboratory analysis of the limnological data.

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Patrick Shields
Limnology Laboratory (ADF&G)
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Soldotna, AK 99669
262-9368
262-4709 (FAX)

PRINCIPAL INVESTIGATOR

Dan Gillikin, U.S. Forest Service Glacier Ranger District Chugach National Forest. Currently holds the position of Fisheries Technician and acting Fisheries Biologist on the Glacier District. He has eight years of experience as a fisheries technician with Private and Federal Agencies in Washington and Alaska. He is currently the acting Fisheries Biologist for the Glacier District and manages the Districts Fisheries Program. He would work with the project manager and conduct project implementation, environmental compliance, agency coordination, budget management and reporting.

OTHER KEY PERSONNEL

Cliff Fox, U.S. Forest Service Glacier Ranger District Chugach National Forest. Currently holds the position of Resource Staff Officer on the Glacier District. Has 20 years experience in natural resource management with State and Federal Agencies in California, Idaho and Alaska. Has 25 years experience in project planning, implementation, and monitoring. Has multi-resource experience holding positions in fisheries, wildlife, timber, minerals, recreation, fire, real-estate, cultural resources, Forest Planning and environmental coordination. Presently oversees the District's fisheries, wildlife. timber, ecology, minerals and air quality programs. Would be responsible for project oversight during implementation, environmental compliance, agency coordination, budget management and reporting.

Cliff Fox
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LITERATURE CITED

ADF&G. 1985. Field Data Summary For Copper River And Prince William Sound Lake Investigations, 1985. ADF&G Contract No. 85-0159. Technical Report, 13 p.

ADF&G. 1992. An atlas to the catalog of waters important for spawning, rearing or migration of anadromous fishes, Southcentral Region, Resource Management Region II. Alaska Dept. of Fish & Game. Anchorage.

Blanchet, D. 1983. Chugach National Forest Environmental Atlas. USDA Forest Service, Alaska Region. Report number 124.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci., Vol. 45: 834-844.

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Kyle, G.B. 1990. Summary of acoustically derived population estimates and distributions of juvenile salmon (Oncorhynchus nerka) in 17 lakes of Southcentral Alaska, 1982-1987. Alaska Department of Fish and Game. FRED Division Report Series 104:47 p.

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Seitz, J. and R.Miraglia. 1995. Chenega Bay. In: Fall, J.A and C.J. Utermohle, (eds). *An investigation of the sociocultural consequences of outer Continental Shelf development in Alaska; II. Prince William Sound.* MMS 95-011; Technical Report No. 160.

Wetzel, R.G. and G.E. Likens. 1979. Limnological Analyses. W.B. Saunders Company, Philadelphia, PA. 357 p.

PERSONAL COMMUNICATIONS

Kyle, G.B., Limnologist, Alaska Department of Fish and Game. Div. of Comm. Fish. Mgmt. and Dev. Soldotna. 4-25-95; 4-2-96.

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998	PROPOSED FY 1998 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
Personnel	$0.0	$27.5						
Travel	$0.0	$0.0						
Contractual	$0.0	$4.5						
Commodities	$0.0	$4.5						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$36.5		Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
General Administration	$0.0	$4.5						
Project Total	$0.0	$41.0		$0.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)	0.0	0.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0	$0.0	

Comments: New project proposal. Feasibility study to determine if sockeye salmon can be stocked at Chuck's Lake. The lake is located in Heather Bay near Columbia Glacier. The project will be similiar to the Slof Lake Stocking project and be 5 to 6 years.

1998

Project Number: ~~98258C~~ 98356
Project Title: Chuck's Lake Stocking
Lead Agency: US Forest Service

FORM 2A
MULTI-TRUSTEE
AGENCY SUMMARY

Prepared: 4/4/97, K.Holbrook9

4/15/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$23.5
Travel		$0.0
Contractual		$2.0
Commodities		$4.5
Equipment		$0.0
Subtotal	$0.0	$30.0
General Administration		$3.7
Project Total	$0.0	$33.7
Full-time Equivalents (FTE)		0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	

Dollar amounts are shown in thousands of dollars.

Comments: New project proposal.

1998

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: US Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared

4/15/97

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
Vacant	Fish Biologist	GS-9	0.5	5 2		2.6
D.Gillikin	Crew Leader	GS-9	2.0	4.3		8.6
Vacant	Bio Tech	GS-7	2.0	4.0		8.0
Vacant	Bio Tech	GS-5	0.5	3.4		1.7
Vacant	Engineer	GS-11	0.5	5.2		2.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		5.5	22.1	0.0	
					Personnel Total	$23.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

1998

Prepared:

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: US Forest Service

FORM 3B
Personnel
& Travel
DETAIL

4/15/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Contractual Costs:		Proposed
Description		FY 1998
Air charter contract	250/hr for 8 hours	2.0
When a non-trustee organization is used, the form 4A is required.	Contractual Total	$2.0

Commodities Costs:		Proposed
Description		FY 1998
Boat fuel		2.0
Train tickets	4 vehicle tickets and 8 passenger tickets	1.0
supplies		0.5
camp food		0.5
camp supplies		0.5
	Commodities Total	$4.5

1998

Prepared:

4 of 9

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: US Forest Service

FORM 3B
Contractual & Commodities DETAIL

4/15/97

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1998

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: US Forest Service

FORM 3B
Equipment
DETAIL

Prepared:

4/15/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$4.0
Travel		$0.0
Contractual		$2.5
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$6.5
General Administration		$0.8
Project Total	$0.0	$7.3
Full-time Equivalents (FTE)		0.1

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments: This provides for collection and analysis of 10 zooplankton samples collected at Chucks Lake. Samples will be collected at five different times throughout 1998 field season.

1998

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 6 of 9

5/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:						
Name	Position Description	GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1998
Pat Shields	FB2		0.5	4.9		2.5
Lab Tech	Lab Tech		0.5	3.0		1.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	7.9	0.0	
					Personnel Total	$4.0

Travel Costs:					
Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1998
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

1998

Prepared:

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: ADF&G

FORM 3B
Personnel
& Travel
DETAIL

4/15/97

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

Contractual Costs:	Proposed FY 1998
Description	
Air charter 250/hr for 10 hours	2.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$2.5

Commodities Costs:	Proposed FY 1998
Description	
Commodities Total	$0.0

1998

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: ADF&G

FORM 3B
Contractual & Commodities DETAIL

Prepared: 8 c

4/15/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1998

Project Number: 98256C
Project Title: Chuck's Lake Stocking
Agency: ADF&G

FORM 3B
Equipment
DETAIL

Prepared:

4/15/97

Project Title: Ancient Salmonid fish bone and bivalve shells: indicators of oceanographic conditions and stock abundances, "Submitted under the BAA"

Project Number:	98357-BAA
Restoration Category:	Research
Proposers:	David Love, Dr. Timothy Heaton, University of South Dakota; Steve Ignell, NOAA-NMFS Auke Bay Laboratory; Dr. Linda Yarborough, USFS-Anchorage Ranger District
Lead Trustee Agency:	NOAA
Cooperating Agencies:	USFS
Alaska Sealife Center:	Not Applicable
Duration:	1st year, 3-year project
Cost FY 98:	$74,520
Cost FY 99:	$75,000
Cost FY 00:	$17,000
Geographic Area:	Field work completed, samples already available from sites in Prince William Sound. Laboratory work to be conducted in Juneau, Alaska.
Injured Resource/Service:	Herring, Salmon, Avian predators, Archeological resources.

ABSTRACT

We propose to acquire paleoecological data from four Prince William Sound (PWS) archeological midden sites to characterize natural variation in the climate, ocean conditions, and species life-histories in PWS. An increased understanding of naturally occurring environmental cycles in fish and mollusk stocks is needed to better evaluate restoration and management actions taken in recent years since the oil spill. The research plan includes: 1) radiocarbon dating of stratigraphic units from each midden, 2) measuring annual growth increments of intact molluscan shells; 3) stable isotope analyses of molluscan shells to determine seasonal and annual temperature patterns; and 4) reconstruction of fish size and growth rates from preserved fish remains. Results of these analyses will be used to reconstruct historic climate patterns in PWS, relate changes in those patterns to changes in fish and molluscan growth, and relate the historical variations in climate and species abundances to changes in growth and abundance of species impacted by the oil spill.

INTRODUCTION

Many of the causal factors at play in observed changes in population structure and abundance of Prince William Sound (PWS) herring and salmon immediately following the Exxon Valdez Oil Spill (EVOS) have yet to be completely elucidated. Part of this stems from difficulties in separating natural-caused changes in fish abundances from anthropogenic-caused changes, the former of which often includes a low frequency component with periodicities ranging from 10 to 20 years. These interdecadal variations correspond to large-scale changes in climate and the ocean that often appear as an abrupt shift in climate patterns, ocean conditions, or fish abundances and growth.

These low frequency variations and abrupt shifts often comprise a significant portion of the total variability in yearly fish abundances and suggest the need for long-term studies relating salmonid population response to natural events. Retrospective analyses of existing long-term data sets are an important tool for identifying the nature and extent of past variability in climatological, oceanographic, and biological systems. Although most fish abundance or growth data only extend back several decades, paleoenvironmental data occur at the millennial scale and can be readily obtained through sediment coring or excavation of stratified paleontological remains.

We propose to analyze paleoecological data acquired from various archeological sites discovered in PWS during the EVOS cleanup. Our research plan includes: 1) radiocarbon dating of selected layers in each site; 2) measuring annual growth increments of intact molluscan valves; 3) stable isotope analyses of molluscan shells to determine seasonal and annual temperature patterns; and 4) reconstruction of fish size and growth rates from preserved fish remains. Results of these analyses will be used to reconstruct historic climate patterns in PWS, relate changes in those patterns to changes in fish and molluscan growth, and relate the historical variations in climate and species abundances to changes in growth and abundance of species impacted by the oil spill.

NEED FOR THE PROJECT

A. Statement of Problem

Recently reported 20-year trends in chum salmon (*Oncorhynchus keta*) stocks indicate decreased mean length and increased mean age at maturity (Helle and Hoffman, 1995). Changes in oceanographic conditions and/or increased population densities have been suggested as causes but have not been proven. Recent studies have identified the linkage between large-scale physical forcing and major shifts in species abundances and growth rates (Beamish and Bouillon 1993; Hare and Francis 1995). The last major shift occurred in 1976 resulting in an intensification of the Aleutian Low pressure system, increased coastal sea surface temperatures, shallowing of the winter mixed layer depth in the Gulf of Alaska (GOA), and increased vigor in cyclonic circulation of the North Pacific Gyre. Concurrent with these changes in the physical environment, Alaskan salmon populations increased to record levels, summer zooplankton abundance doubled in the GOA, catches of Japanese, Californian, and Peruvian sardines increased, and Washington/Oregon salmon populations declined to record lows.

Twenty years have passed since the last identified "regime" shift in the North Pacific Ocean, suggesting that another change has already occurred or is immanent. If a major shift in oceanographic conditions occurred in PWS prior to and/or immediately after the EVOS, effects of restoration and management actions taken in recent years since the oil spill will be confounded by the environmental changes.

What is the long-term natural relationship of fish growth and abundance (inferred from changes in maximum body size) as it relates to climatic variability? Is it possible to extract a record of the paleo-oceanographic conditions encountered by past fish populations and locked in their bony structures? Early marine growth of chum salmon during their first and last year at sea have been shown to be correlated to sea surface temperatures (SST) as well as other oceanographic parameters (Helle, 1979). Extracting this information from ancient fish bone and shell deposits may be possible and may provide a long term record of growth in salmonids as it relates to oceanographic conditions (ie-SST). Salmonid bony structures are well preserved in PWS archeological middens C^{14} dated at least as old as 4,000 years before present.

B. Rationale/Link to Restoration

Analysis of these stratified layers of fish bones and bivalve shells will provide insight into environmental factors that affect natural production and growth of marine organisms including recovering stocks of salmon, herring, and piscivorous birds and mammals. One of the new maxims of fisheries science is the we cannot use the word "rebuilding" (or restoration) for fish stocks until we separate natural cycles from anthropogenic caused cycles (Dr. R. Beamish (Canadian Department of Fisheries and Oceans, personal communication). The proposed project is intended to improve our understanding of naturally occurring environmental cycles in fish and mollusk stocks thereby providing a better basis for evaluating restoration and management actions taken in recent years since the oil spill.

C. Location

Samples to be analyzed for FY98 have already been collected from four archeological midden sites in PWS by the USFS, Chugach National Forest. Laboratory research will be conducted at the Auke Bay Laboratory in Juneau, Alaska. Knowledge gained from the results of this research will benefit the sustainable management of the fisheries of PWS and may aid in the recovery of non-commercial species.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Research findings and project information will be provided to the communities of PWS during the annual EVOS Restoration Workshop in January of 1998 and via the Trustee Council annual report. Peer review and scientific assessments will also be possible at this time.

PROJECT DESIGN

A. Objectives

The overall objective of this project is to analyze paleoecological data acquired from four geographically unique PWS archeological midden sites to characterize natural variation in the climate, ocean conditions, and species life-histories in Prince William Sound and relate changes in ocean conditions with changes in mollusk and salmonid growth.

1. Radiocarbon date (C^{14}) selected stratigraphic units from each midden to construct an occupational chronology of the site and to identify the age of mollusk and fish bone samples used in the analyses.

2. Measure annual growth increments from whole valves preserved in the middens. Develop a separate growth model for each layer containing sufficient numbers of intact shells. Only those mollusk species found throughout the various stratigraphic units of the midden will be used in the growth analyses.

3. Utilize radioisotope ratios (O^{18} abundance; Sr/ Ca, Mg/Ca ratios) extracted from bone and shell deposits in selected stratigraphic units selected to infer changes in oceanographic temperatures and climatically produced changes in rainfall and/or freshwater discharge.

4. Using known age extant coho, pink and chum salmon, develop morphometric index relating vertebral and fin ray dimensions or sections to maximum size (or possibly size at earlier age). If possible, an accurate, non-destructive method will be developed to be used with ancient fish bone.

5. Speciate salmon bones (vertebrae, fin rays, etc), and determine maximum size at time of capture (and possibly size at earlier age) from morphometric index developed in (4). Compute average size at age by species for each layer containing sufficient numbers of intact bones.

6. Compare changes in environmental conditions (results of radioisotope analyses) with changes in mollusk and salmon growth determinations.

B. Methods

The overall hypothesis is: historic changes in climate (temperature) are correlated with historic changes in mollusk shell growth increments and salmon size at age.

Mollusk growth will be estimated by measuring growth increments preserved in the shell. A sub-sample of shells will be thin-sectioned to cross-reference growth annuli on shell margins with cross-sectional deposition. Cross-sectioning will involve use of small band saw and sander used for preparing otolith sections. Acetate peels of sectioned shells will be made as permanent record for mollusk growth using techniques developed by Auke Bay Lab personnel. Electronic images using digitizing video will be made of acetate peels for later measurement and analysis using Optimus electronic measurement software. A separate growth model will be developed for

each stratigraphic unit with sufficient numbers shells. Species used will depend upon the number of specimens found throughout the midden layers.

Mollusk shells will be micro-sampled at approximately a monthly resolution to monitor seasonal variations in oxygen and carbon isotope ratios. Such resolution may require milling of ~20 micron increments from the shell edges and will be contracted to Dr. Scott Carpenter of the University of Texas at Dallas. Approximately 20 analyses per bivalve specimen will be conducted thereby producing a two to three year record of seasonal variations. Two measures will be assessed: 1) amplitude of seasonal variations and 2) absolute d18O and d13C values. These measures may be supplemented (if necessary) with other stable isotope ratios such as Mg/Ca and Sr/Ca to help interpret the results. Data from various shell horizons shall be compared and interpreted with respect to historic changes in climate. In addition, similar measurements on contemporary bivalve specimens from PWS shall be used to groundtruth midden data which will be critical in assessing these proxies for paleo-climate.

Morphometric measures of known age coho, pink and chum salmon will be made prior to disarticulation via Dytisid beetles. Vertebrae and fin rays will then be measured and sectioned to determine bone deposition and growth rates during first year and to develop an index to maximum size (size at capture). Measurements of bone height, weight depth and annuli distances will be made with digital calipers (0.1 mm) and data will be downloaded onto electronic spreadsheet. Digitized images of bone for electronic dimensional analysis will be accomplished using Optimus video measurement software. Otoliths will be sectioned and aged to cross reference annuli deposition and growth rate using standard techniques. A mathematical relationship relating size to bone dimensions will be developed to produce a growth model. Cross-sectioned fin rays may be the best candidate for use in determining growth from annuli in teleosts (Hill, Cailliet, and Radtke 1989)

Salmon bones will be identified as to taxa based on comparative analysis of the collections of Dr. Rebecca Wigen and Susan Crockford at the University of British Columbia at Victoria, B. C. and Dr. Tim Heaton, University of South Dakota. Linda Yarborough of the USFS, Chugach National Forest will also provide exerptise in fish bone identification. Using the growth model developed above, growth rates during the first year and maximum size a capture will be determined. C^{14} dating for a select number of shells from different strata will be used to determine age of the strata sampled. $^{87}Sr/^{86}Sr$ isotopic composition of hydroxyapatite from the ancient bones, which differs in composition from bone of extant species may be utilized to double-check the marine origins of a few of the preserved bones (Koch, et al., 1992)

C. Cooperating Agencies, Contracts and Other Agency Assistance

NOAA-NMFS, Auke Bay Laboratory oceanographer Steve Ignell will provide direction in analyzing and interpreting mollusk shell growth and first-year growth in preserved fish bone as it relates to natural variations in climate, ocean conditions and species life-histories. Assistance in analysis of growth and inferred oceanographic conditions will also be required. Auke Bay Laboratory will provide laboratory space and office space, equipment necessary for the analysis, computer software and hardware.

USFS, Anchorage Ranger District archeologist Linda Yarborough will provide insight into the archeological context of midden samples taken, peer review of resultant annual reports and manuscripts, sort midden samples to separate fish bone from other organic material, and provide comparative specimens for identification with University of Victoria and University of South Dakota collections. USFS will also provide expertise and initial training to the PI in taxonomic identification of fish bone sampled.

Tom Stafford(University of Colorado at Boulder) will be contracted to do radiocarbon (C^{14}) dating of selected samples of strata, mollusk shell and fish bone. Although more expensive, repetitive radiocarbon dates received from Dr Stafford's UC-Boulder lab appear to be more accurate and more precise than other radiocarbon labs (Dr. Tim Heaton, personal communication).

Dr. Scott Carpenter, University of Texas at Dallas will provide stable isotope analysis. Results provided previously have been timely and cost effective.

SCHEDULE

A. Measurable Project Tasks for FY 98 (October 1, 1997-September 30, 1998)
Year 1 Project tasks

October 1-January 1:	Measure mollusk growth, Develop molluscan growth model, Submit C^{14} and stable isotope samples, Prepare for Restoration Workshop
January 15-24(3 of these days):	Attend Annual Restoration Workshop
January 25-30:	Visit Univ. of Victoria to get training in ancient fish bone species identification
February 1-March 1:	Identify ancient fish bone to species, Obtain known-age extant Salmonids for disarticulation
March 1-April 10:	Identify to species and estimate growth of bone from disarticulated, extant fish bone, C^{14} and Stable isotope analysis contracts due April 10.
April 15:	Submit annual report (FY 97 findings)
April 20-May 31: from	Apply developed technique/model to ancient fish bone PWS, Develop oceanographic relationship model, Analyze and summarize results

B. Project Milestones and Endpoints

Year 1-Preliminary study(8 months)

Complete the following for 1 of the 4 midden sites: 1) mollusk age and growth analysis, stable isotope measures, and C^{14} dating of associated strata. 2) Identification to species of the Salmonid fish bone present in the sampled sites. 3) Preliminary development of species-specific morphometric size-at-age and fish growth model from known-age bones of extant species.

Application of developed model to the ancient bones. 4) Preliminary interpretation and analysis of mollusk and fish bone parameters as related to inferred oceanographic events of the past.

Year 2-Complete analysis on remaining midden sites (8 months)

Complete analysis described for Year 1 on remaining 3 midden sites. Improve size-at-age and growth model developed during preliminary studies.

Year 3-Overall data analysis and manuscript preparation(3 months)

Analyze and summarize results from previous work completed in Years 1 and 2. Resultant manuscript will be submitted for publication to an appropriate peer-reviewed journal.

C. Completion Date

All of the projects objectives will have been met January 1, 2000 during the third year of the project. Final manuscript should be finished at this time.

PROPOSED PRINCIPAL INVESTIGATOR

David Love
doctoral candidate, Univ. of S. Dakota
P.O. Box 210745
Auke Bay, AK 99821
Phone: (907) 790-2770
E-mail: JFDCL@acad1.alaska.edu

PRINCIPAL INVESTIGATOR

David Love, a University of South Dakota (USD) doctoral candidate will be the principal investigator of this project under the guidance of Dr. Timothy Heaton, Director of Earth Sciences at the University of South Dakota. David obtained his undergraduate degree in fish biology from Colorado State University in 1986 and his masters degree in fish pathology in 1992 from the University of Alaska- Fairbanks, Juneau campus. David has published on fish and crab pathological studies, assisted in hydrocarbon toxicological research at Auke Bay Laboratory, and currently teaches introductory biology at the University of Alaska-Southeast as an Adjunct Faculty member. During the past 4 summers David has assisted in the paleontological research of the cave systems of southern Southeast Alaska, has co-authored one report on the excavation of the ancient bear bones from Bumper cave on Prince of Wales(POW) island and has experience excavated large quantities of ancient fish bone potentially dating as early as 40,000 years BP. A preliminary synopsis of the fish taxa of the POW area paleontological sites indicates that at least 20 taxa existed there (Dr. Timothy Heaton, University of South Dakota, personal communication). In addition to identification to species, bones from both areas may hold information about past climates and ecologies. With the guidance of Dr. Timothy Heaton, Steven Ignell, and Linda Yarborough, David hopes to begin to bring some of that information back to the present.

OTHER KEY PERSONNEL

Dr. Timothy Heaton studied under Stephen J. Gould at Harvard University, receiving his Ph. D. in 1988. Tim has been excavating and studying vertebrate fossils from caves on Prince of Wales Island for six years and is the only Quaternary vertebrate paleontologist with experience in southern Alaska. Fish remains from otter scat have represented both the greatest volume of bone recovered and the greatest species diversity in his research. He and his collaborators at University of Victoria, B.C. have the only adequate comparative collection for identifying fragmentary fish remains from coastal waters of the Pacific Northwest. Research in the POW area is still ongoing, and the PWS fish and mollusk project would go hand in hand with this research.

Steven Ignell is an oceanographer and mathematical statistician, currently employed by NOAA, Auke Bay Laboratory (ABL), interested in describing the causal oceanographic conditions that effect North Pacific fisheries. Steve has an ongoing interest in the oceanography of the northeastern Pacific, having undertaken several studies used in restricting high seas drift gill net fisheries. Currently the team leader for coastal studies of the ABL Ocean Carrying Capacity program, Steve oversees several paleo-oceanography projects using both sediment cores and ancient mollusk shell from culturally deposited middens.

USFS, Chugach National Forest archeologist Linda Yarborough was active in identifying, describing and proposing mitigation for EVOS-impacted archeological sites. Linda's input will be essential in interpreting the bone and shell samples excavated from the middens, completing specimen preparation for archiving and identifying the fish bone sampled.

LITERATURE CITED

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Hare, S. R. and R. C. Francis. 1995. Climate change and salmon production in the Northeast Pacific. In R. J. Beamish (ed.), Symposium on Climate Change and Northern Fish Populations. Can. Spec. Pub. Fish. Aquat. Sci. 121:359-372.

Helle, J.H. 1979. Influence of marine environment on the age and size at maturity, growth, and abundance of chum salmon, *Onchorynchus keta* (Walbaum), from Olsen Creek, Prince William Sound, Alaska. Ph. D. thesis. Oregon State University, Corvalis. Oreg. University Microfilms Int. No. 7927127.

Helle, J.H., and M.S. Hoffman. 1995. Size decline and older age at maturity of two chum salmon stocks in western North America, 1972-92, p. 245-260. In R.J. Beamish (ed.) Climate Change and northern fish populations. Can. Spec. Publ. Fish Aquatic. Sci. 121.

Hill, K.T., G.M. Cailliet and R.L. Radtke. 1989. A comparative analysis of growth zones in four calcified structures of Pacific blue marlin, *Makaira nigricans*. Fish. Bull., Vol. 87, No. 4, pp. 829-843.

Koch, P. L., A.N. Halliday, L.M. Walter, R.F. Stearley, T.J. Huston and G.R. Smith. 1992. Sr isotope composition of hydroxyapatite from recent and fossil salmon: the record of lifetime migration and diagenesis. Earth and Planetary Science Letters, 108:277-287.

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$1,400.0
Travel		$0.0
Contractual		$71,469.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$72,869.0
General Administration		$1,651.9
Project Total	$0.0	$74,520.9
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS				
	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
	$75,000.0	$17,000.0		

Dollar amounts are shown in thousands of dollars.

Comments: This project will acquire paleocological data from PWS archeological midden sites to characterize natural variation in climate, ocean conditions, and species life histories.

1998

Project Number: 98357-BAA
Project Title: Midden Oceanographic Study
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/15/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1998
Name	Position Description					
S. Ignell	Oceanographer	GS 12/5	0.2	7000.0		1,400.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.2	7000.0	0.0	
					Personnel Total	$1,400.0

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1998
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

1998

)ared:

Project Number:
Project Title: Midden Oceanographic Study
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:		Proposed
Description		FY 1998
4A Linkage		71,469.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$71,469.0

Commodities Costs:		Proposed
Description		FY 1998
	Commodities Total	$0.0

1998

Project Number:
Project Title: Midden Oceanographic Study
Agency: NOAA

FORM 3B
Contractual &
Commodities
DETAIL

Prepared: 4/15/97

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1998

Project Number:
Project Title: Midden Oceanographic Study
Agency: NOAA

FORM 3B
Equipment
DETAIL

ared:

4/15/97

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$39,960.0
Travel		$6,509.0
Contractual		$25,000.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$71,469.0
Indirect		
Project Total	$0.0	$71,469.0
Full-time Equivalents (FTE)		8.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$72,000.0	$15,000.0			

Dollar amounts are shown in thousands of dollars.

Comments: This project will acquire paleocological data from PWS archeological midden sites to characterize natural variation in climate, ocean conditions, and species life histories.

1998

Prepared:

Project Number:
Project Title: Midden Oceanographic Study
Name: University of South Dakota

FORM 4A
Non-Trustee
SUMMARY

4/15/97

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 1998
	D. Love	PI	8.0	4995.0		39,960.0
	T. Heaton	paleontologist	0.0			0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	8.0	4995.0	0.0	
					Personnel Total	$39,960.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1998
	Juneau to Victoria, BC	600.0	1	5	225.0	1,725.0
	Rapid City, SD to Victoria, BC	746.0	1	5	225.0	1,871.0
	Juneau to Anchorage	444.0	1	5	225.0	1,569.0
	Juneau to Anchorage (Restoration Workshop)	444.0	1	4	225.0	1,344.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$6,509.0

1998

ared:

Project Number:
Project Title: Midden Oceanographic Study
Name: University of South Dakota

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1998
Radiocarbon Dating (Carbon 14) contract (UC Boulder)	10,000.0
Stable Isotope Analyses contract (University of Texas)	15,000.0
Contractual Total	$25,000.0

Commodities Costs:	Proposed
Description	FY 1998
Commodities Total	$0.0

1998

Project Number:
Project Title: Midden Oceanographic Study
Name: University of South Dakota

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/15/97

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	
Description	of Units	

1998

8 of 8

ared:

Project Number:
Project Title: Midden Oceanographic Study
Name: University of South Dakota

FORM 4B
Equipment
DETAIL

4/15/97

TREE-RINGS IN THE *EXXON VALDEZ* SPILL AREA: ECOSYSTEM IMPLICATIONS FOR INJURED RESOURCES

Project Number: 98358

Restoration Category: Research

Proposer: University of Alaska Fairbanks

Lead Trustee Agency:
Cooperating Agencies:

Alaska Sea Life Center:

Duration: 1st year, 2-year project

Cost FY 98: $138.6

Cost FY 99: $105.0

Cost FY 00: $-0-

Cost FY 01: $-0-

Cost FY 02: $-0-

Geographic Area: Prince William Sound, Kenai Peninsula, Kodiak Is. southwest Cook Inlet

Injured Resource/Service: All

ABSTRACT

A new project is proposed to apply conventional ring-width and unconventional isotope and x-ray density techniques of tree-ring analysis to develop a long-term (at least 250-year) record of the climate of the spill area in relation to some of the key injured resources. Preliminary data indicate that tree-rings correlate well with temperature and Alaska salmon catch. Tree-ring techniques should help determine the likelihood of sustaining a given population of injured resources. This project would help overcome the lack of pre-spill monitoring data. The project is needed because not enough tree-ring sites have been sampled, not all the techniques have been used in the spill area, and correlation of tree-rings with injured resources has not been investigated.

INTRODUCTION

The *Exxon Valdez* oil spill occurred along the northwest Gulf of Alaska coast (Fig. 1) in one of the most intact and dynamic interactive land-air-sea systems of high productivity in the world. The spill event involved the release of toxic material, primarily represented by the unweathered volatile components of crude oil, and its subsequent spread 470 miles to the southwest over the next two months (Fig. 1). The spill also resulted in the mobilization and placement of cleanup crews in some of the highest quality coastal wilderness in the world. The primary productivity of the marine ecosystem of the spill area ranks high in worldwide terms but varies dramatically on an annual basis and over a multi-decade scale of time as natural changes work through the ecosystem. Several aspects of the spill-affected ecosystem contribute to its exceptional productivity of species that have been determined to be injured resources, but also suggest factors that make the system that produces them vulnerable to injury or natural fluctuation.

The abundant food resources of the area and its largely intact and uninhabited upland, shoreline, and nearshore habitats provide for a notable number and diversity of large marine animals. The freshwater streams of the spill area have experienced extremely low levels of industrial pollution, aside from effects of the spill. Aquatic habitat quality is excellent and contributes to one of the most productive fisheries in the world. Many of the birds and mammals in the ecosystem of the spill area seek out small, predator-free islands or rocky headlands for resting, breeding, or other special needs. The spill area contains some of the most significant marine mammal habitat in the world, and is one of the most northerly migratory bird overwintering areas in North America. Many birds use the spill area for breeding or as a seasonally important staging habitat during migration.

Most of these resources were injured by the spill, but they are also prone to large natural population fluctuations especially because of their sensitivity to changes in the productivity state of the overall system. As a result, the task of setting numerical recovery goals for injured resources is difficult because it must take into consideration the naturally varying condition of the system and ideally use a long-term time perspective. This time perspective would necessarily extend well before modern systematic environmental observations and measurements began.

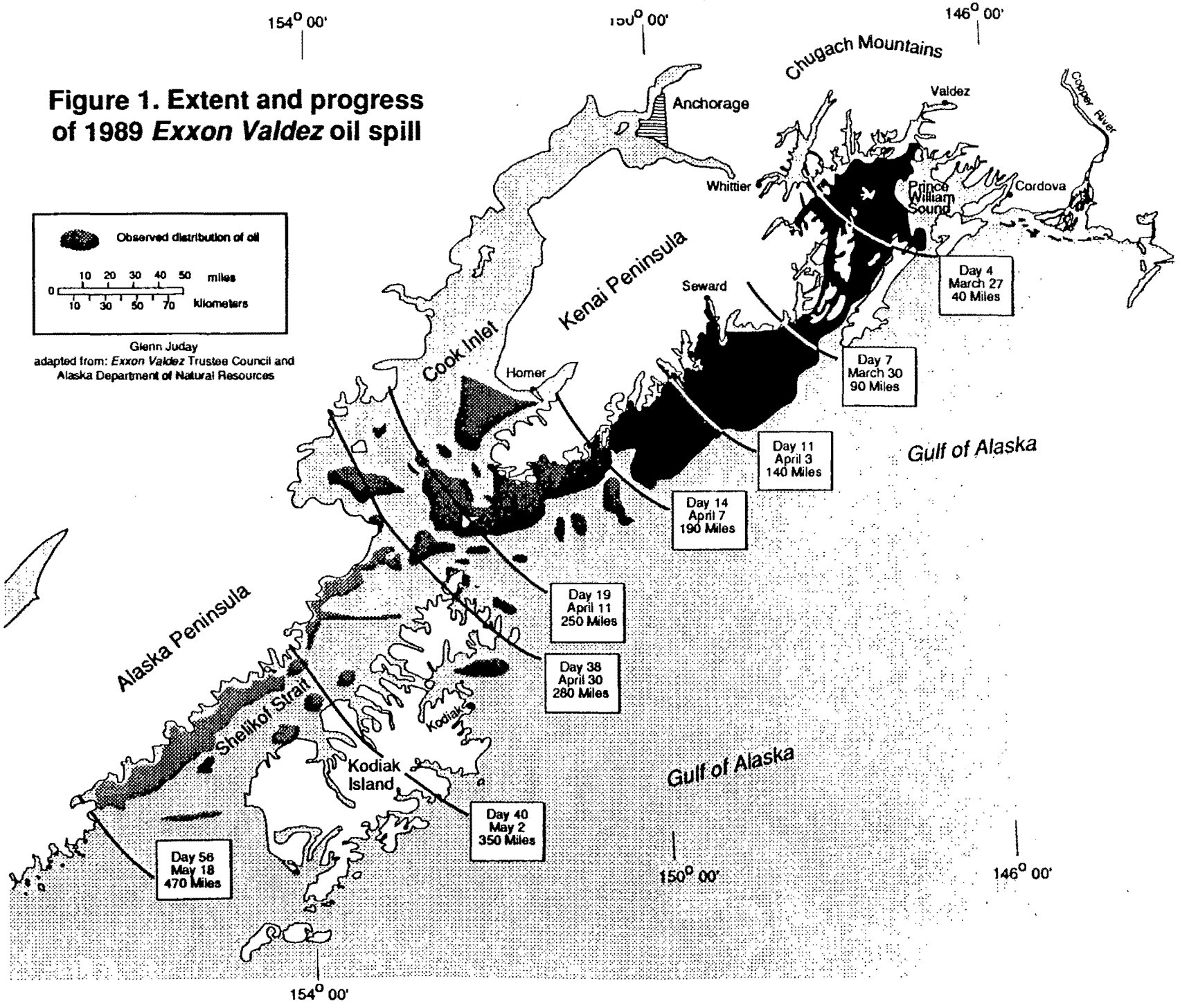
This proposal seeks support for a new project to apply conventional ring-width and unconventional isotope and x-ray density techniques of tree-ring analysis to develop a "signature" of the climate of the spill area in relation to some of the key injured resources for which monitoring data are available. Of particular interest are the intervals just before and after the 1976-77 climatic regime shift in the spill area. The tree-ring techniques should be able to provide a 200- to 350-year "window" on the past climate, so that the relative frequency of such regime shifts can be determined and the likelihood of sustaining a given population level of injured resources (recovered or not recovered) can be better determined. During the course of this project an effort will be made to apply time series produced from the results of other projects. If the potential is indicated and the need demonstrated, a follow-on cooperative project to integrate and synthesize all the time series would be proposed.

NEED FOR THE PROJECT

A. Statement of the problem

The information developed by this project would help resolve the problem of the lack of pre-spill monitoring data, one of the major recognized limitations of restoration studies undertaken to date. Tree-rings contain a wealth of information about the conditions affecting the growth and

Figure 1. Extent and progress of 1989 *Exxon Valdez* oil spill



health of trees (Fritts 1976). Most people are familiar with ring width measurements. But new technology allows other measurements of tree-ring, such as x-ray densitometry (Hughs et al. 1984, Thetford et al. 1991, Jacoby and D'Arrigo 1995) and stable isotope analysis (Francey and Farquhar 1982, Leavitt and Danzer 1992, Scheu et al. 1996) that are only now being explored to determine the information they contain.

A climatic control over the productivity level of key injured resources of the spill area is indicated from the preliminary tree-ring work of Wiles et al. (in press) and Juday (unpublished) (Fig. 2). Figure 2 represents the smoothed raw ring-width mean of 101 hybrid white/Sitka spruce trees sampled from the older forest communities of Fort Richardson adjacent to Anchorage (Fig. 3) compared to smoothed Alaska salmon catch from the Gulf of Alaska (Alaska Department of Fish and Game, public data). The major movements of the ring-width record correspond fairly well to most of the major increases or declines of salmon catch. The temperature sensitivity of the Fort Richardson tree-ring record has been established (Juday and Marler 1996). Wiles et al. (in press) find a similar correlation using a sample of 8 high-elevation tree-ring series from the Kenai Peninsula that primarily demonstrate sensitivity to spring and early summer temperature over a 2-year period.

While these preliminary results indicate potential for the tree-ring technique, (1) systematic investigation of the climatic sensitivity of tree-rings in the full range of sensitive sites has not been carried out, (2) the full range of techniques, including x-ray density and stable isotope analysis, have not been performed in the spill area, and (3) the ecosystem factors that tree-ring data correlate with and explain in the spill area have not been fully investigated.

Land temperature reconstructions derived from tree-rings in the spill area are strongly correlated with adjacent sea surface temperatures (Wiles et al. 1996). Forests in the spill-affected area belong to 2 major forest types, the coastal Sitka spruce-western hemlock forest, and the transition (coastal/boreal) forest of hybrid white/Sitka spruce (Fig 4., Viereck and Little 1972). Trees in the coastal type are relatively insensitive to all but the extremes of precipitation, whereas the transition forest at Fort Richardson displays a statistically significant relationship to precipitation one, two, and three years prior to ring formation (Juday and Marler 1996). High elevation coastal forest trees are sensitive to spring-summer temperature (Wiles et al. in press) but other sensitivities are unknown. Sampling across the geographic range of forests in the spill area potentially will identify additional factors of climatic sensitivity, confirm trends, and provide more precision than is available from the limited sampling to date.

Conventional ring-width techniques show real promise in climatic/environmental investigations of the past in the spill area, but ring-width growth trends in the trees inherently are responding to a multi-year battery of environmental factors. Unconventional tree-ring analysis, specifically x-ray density and carbon 13 stable isotope analysis have the potential to achieve annual resolution (Barber et al. 1997). Buckley et al. (1992) made a first attempt to model temperature changes along coastal western North America with tree-ring maximum latewood density, primarily using the summer half-year. Building on that work Wiles et al. (1996, in press) tree-ring expanded coverage into the spill area and obtained correlation of maximum latewood density with temperature for the summer half-year (April-September) at selected localities in western Prince William Sound and central Kenai Peninsula. We propose to expand the coverage across the spill area, add isotope techniques (Gray and Thompson 1976, DeNiro 1981), and relate the tree-ring signals to the overall productivity of the north Gulf of Alaska ecosystem that sustains the injured resources.

B. Rationale/Link to Restoration

Figure 2. Relationship of mean radial growth of Lutz spruce (n = 101) at Ft. Richardson to total catch of salmon in Alaska

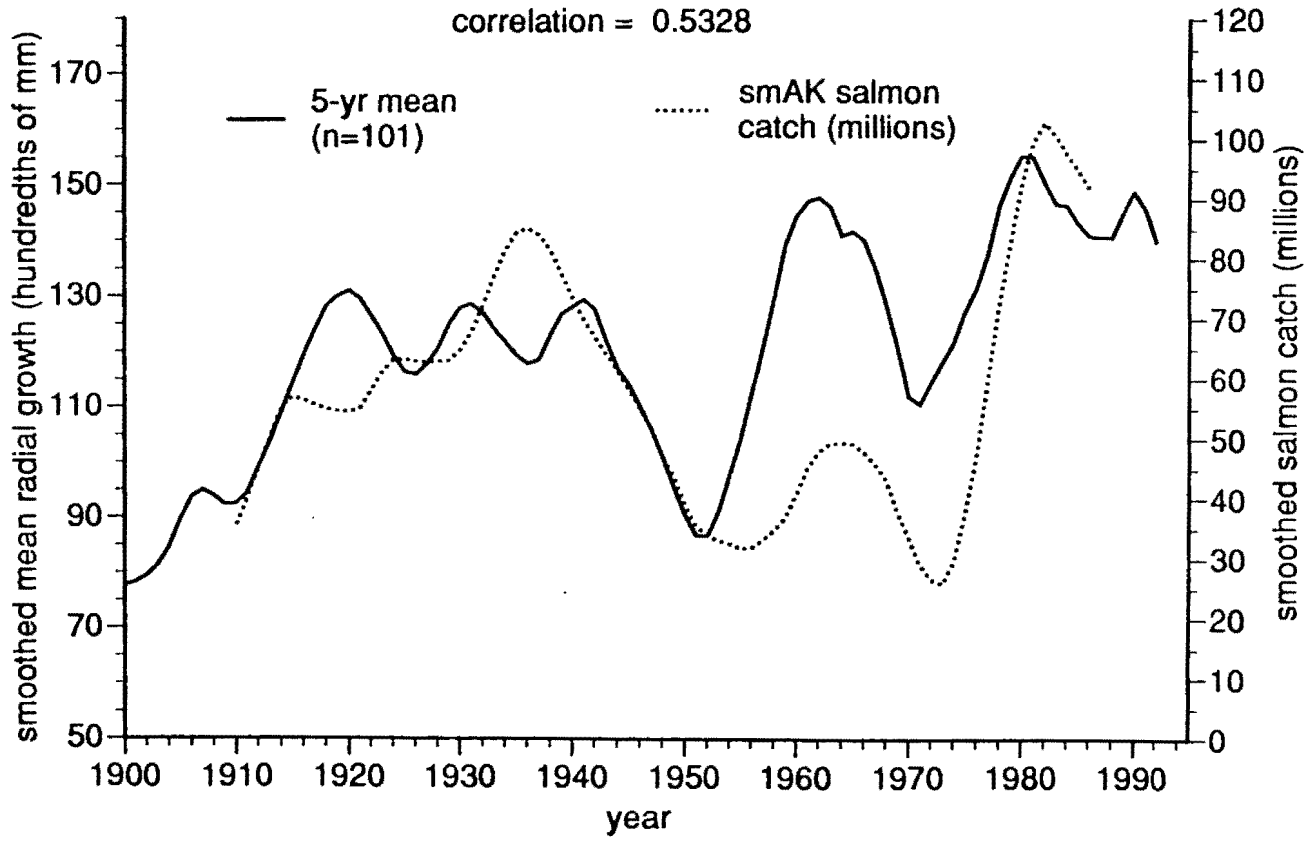


Figure 3. Location of Ft. Richardson

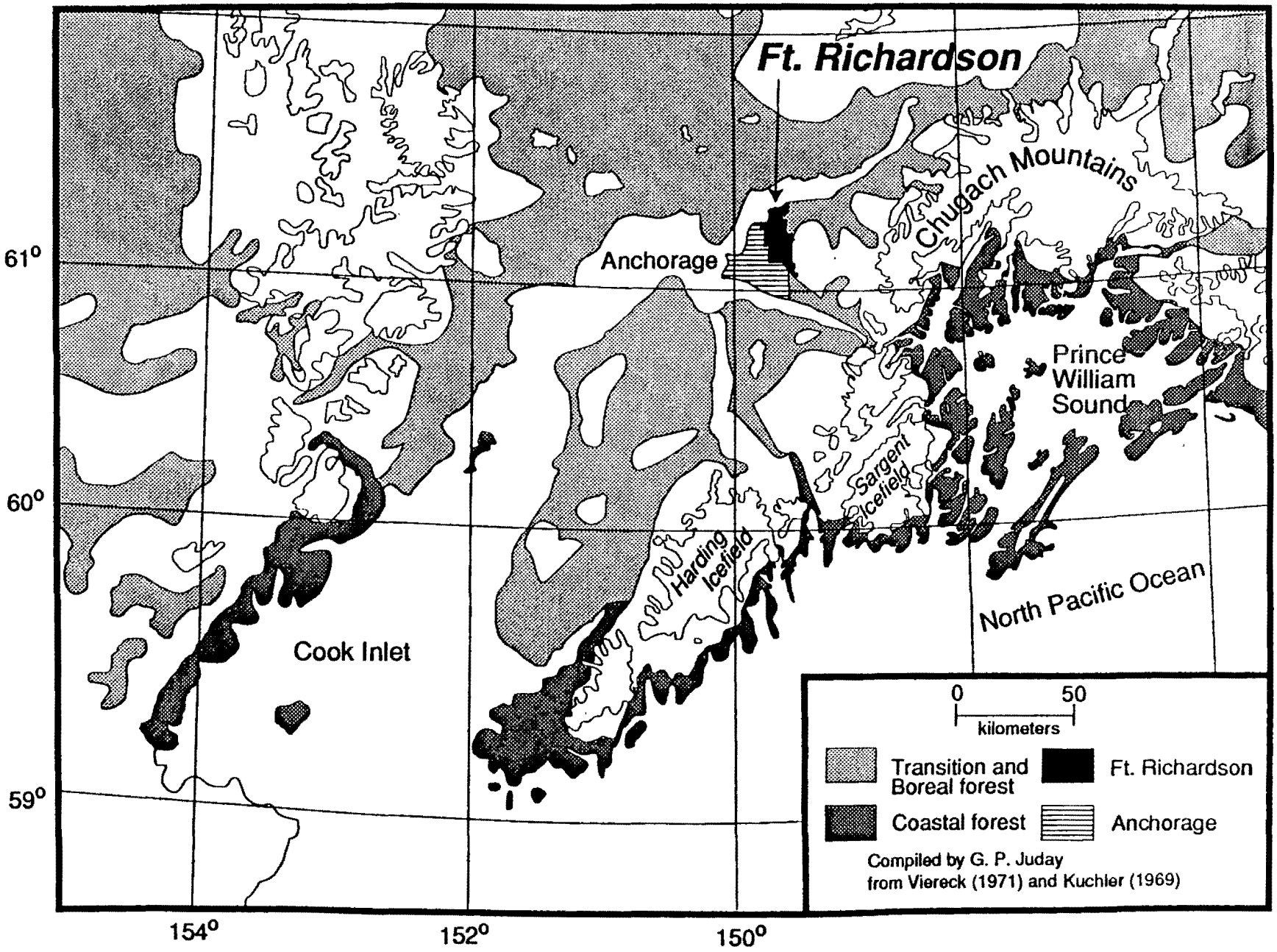
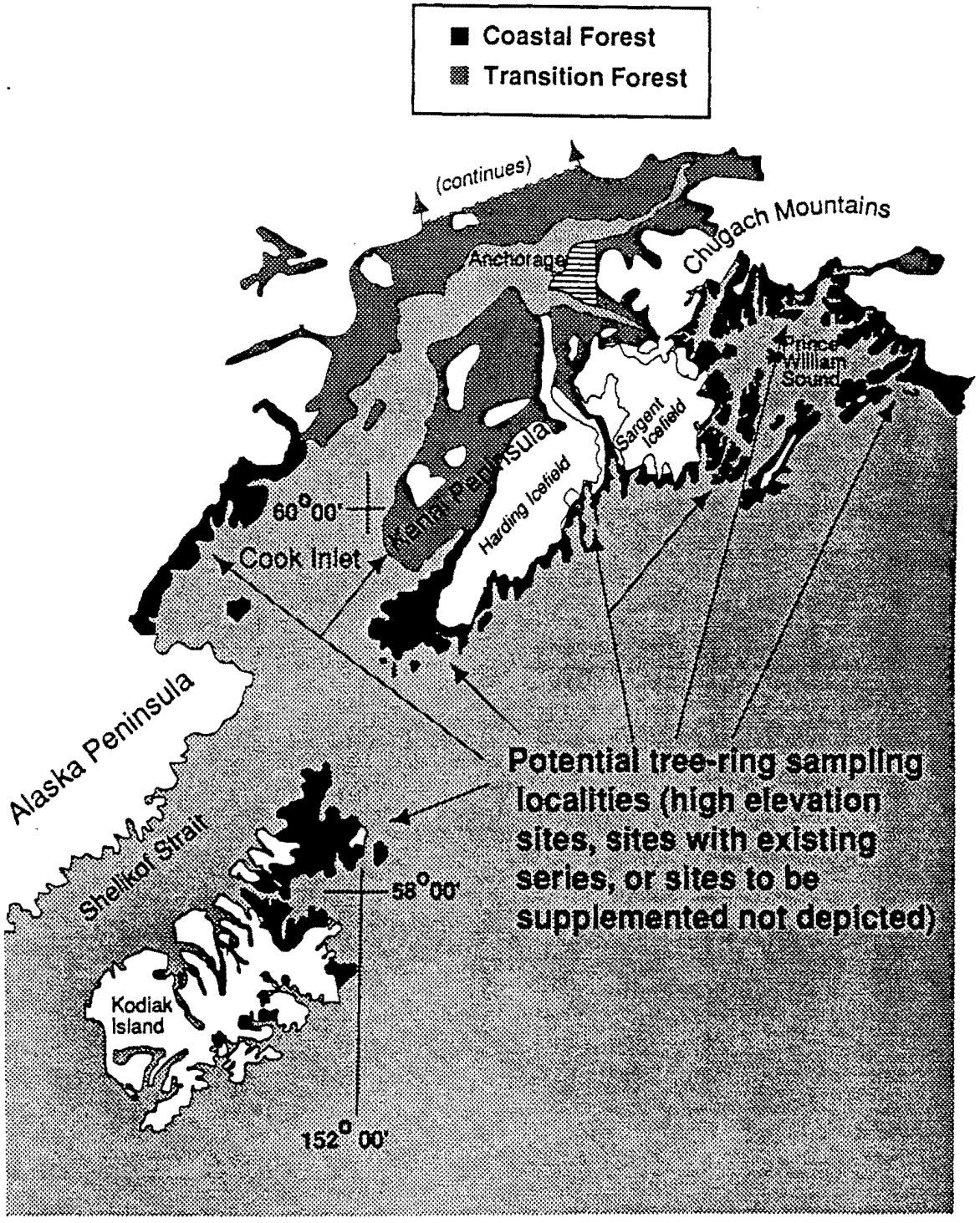


Figure 4. Forest distribution and potential sampling localities in southcentral Alaska



Compiled by G. P. Juday 1994
from Viereck (1971) and Kuchler (1969)

Injured resources, especially the higher level predators, are part of a large, complex, interacting system of climate, land and ocean primary production, and food web relations. Because the marine ecosystem relatively quickly removed or degraded large amounts of the spilled oil, direct cleanup is largely done. The best opportunities for restoration involve developing an understanding of key processes in the interconnected system, and then strategically intervening at sensitive points with actions that reduce or prevent further stress to the overall system.

With an appropriate long-term time perspective indexed to the productivity state of the spill-affected ecosystem, management decisions can better achieve the recovery of injured resources. For example, to establish realistic quantitative recovery goals for injured resources, the appropriate baseline of comparison is not necessarily the pre-spill number but the current carrying capacity of the system. Once this is established, even if only with coarse resolution at first, appropriate recovery actions such as adjusting the future level of take of harvested resources can be better determined. A long-term time perspective will also allow all stakeholders in injured resources to better assess the relative risk of sustaining future population levels. Finally, a long-term time perspective can be expected to indicate the factors of the environment that consistently control the productivity state of the system, which represents a form of "backcasting" for validation of modeling efforts.

The spill area has experienced recent large-scale mortality of dominant and commercially valuable hybrid and white spruce (Werner 1996), one the largest insect-caused episodes of tree mortality in North America. The death of trees on this scale has the potential to affect the recovery of some injured resources. This project has the potential to contribute to a resolution of the causes and recovery potential of the forests affected by this mortality in the spill area. Insects are often the proximate cause of tree death in these large outbreaks, but the insects have always been present at low background population levels and some environmental factor has triggered a rapid population buildup by releasing them from some major control of their numbers (Hard 1985). Specific climatic factors that allow insect buildups are nearly always involved. Often the triggering factor is a reduction in the host tree's ability to resist the outbreak, usually because of the occurrence of climatic stress conditions (Werner and Holsten 1983). Indicators of tree stress can be derived from the tree-ring sampling series collected for this project.

C. Location

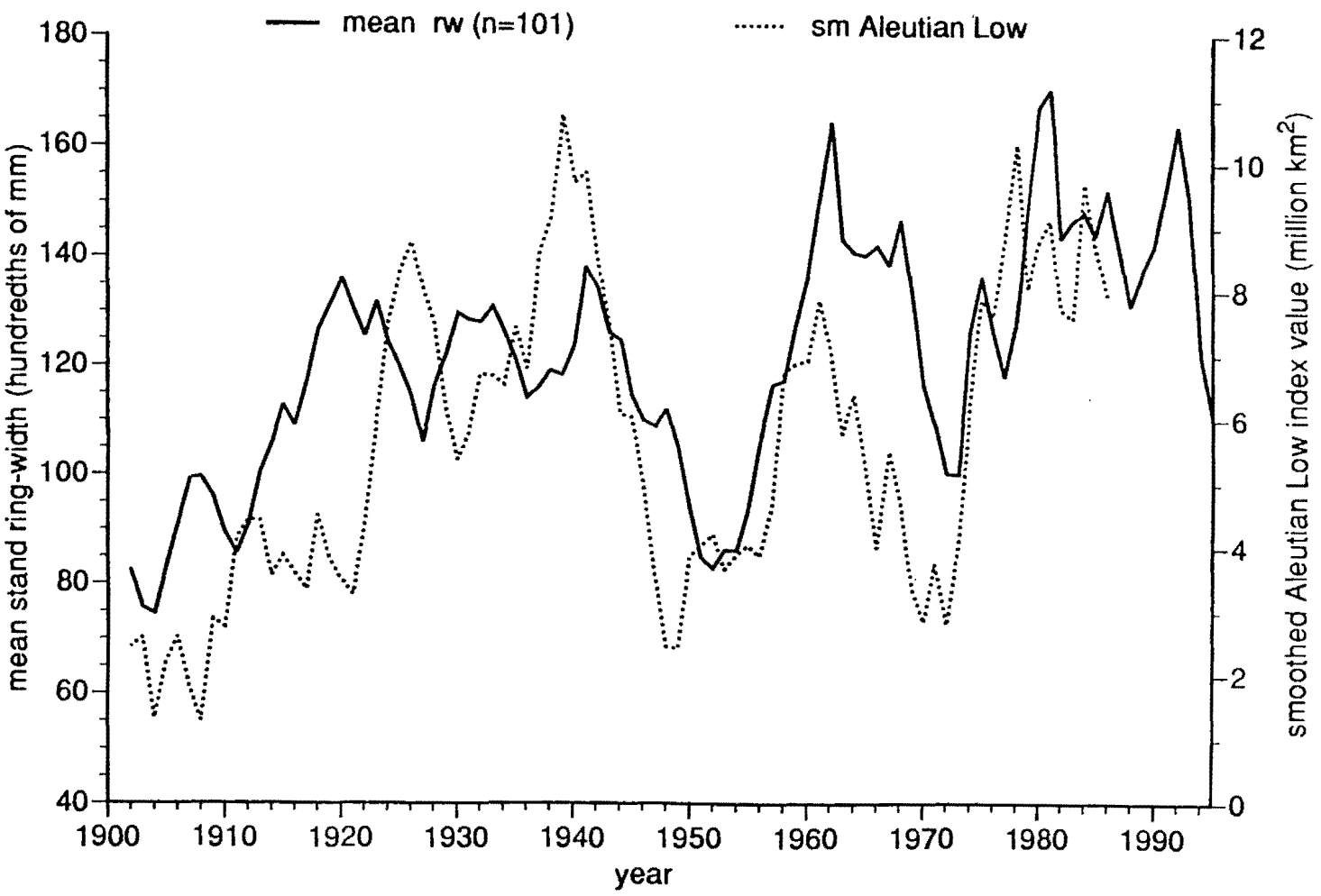
Climatic data will be examined from Kodiak, Anchorage, and Seward, with additional long-term perspective provided by the Sitka and Yakutat station data. The Aleutian low record (Beamish and Bouillon 1993) will be examined (Fig. 5), as well as the long-term, large-area scientific survey trawl surveys in the spill area (Anderson et al. 1996). Tree-ring samples will be collected from conventional high-elevation growth sensitive sites, from low elevation sites on the coastal front, and from inland transition forest sites. Suitable sites will be sought on the southwest Cook Inlet coast, the Kenai Peninsula, a location on Prince William Sound, and near western tree limit on Kodiak or Afognak Islands.

PROJECT DESIGN

A. Objectives

1. Identify new tree-ring sampling sites around Prince William Sound and the north Gulf of Alaska coast crucial to the elucidation of long-term climatic parameters.

Figure 5. Relationship of mean radial growth of hybrid white/Sitka spruce (n = 101) at Ft. Richardson to Aleutian low index



2. Identify the climatic and ecosystem state information contained in ring-width measurements already collected by other researchers and determine other proxy data that might be available in these records. This will involve a collaboration with G. Wiles et al. (1996).

3. Extend tree-ring sampling coverage in the spill area to non-sampled or under-sampled areas in order to determine regional variation in tree-ring climatic signals.

   a. Sample low elevation trees to examine whether a useful climatic signal can be extracted from trees on such sites.

   b. Sample sites potentially sensitive to precipitation and other non-temperature factors that could reflect the productivity state of the spill area ecosystem.

4. Explore different isotopes, specifically carbon 13, oxygen 18, and deuterium, in tree-rings to determine their correlation to climatic and ecosystem state information.

5. Examine the annual resolution potential of tree-ring isotope techniques.

6. Identify the climatic and ecosystem state information contained in ring-width measurements from newly collected tree-rings.

7. Determine the correlation of x-ray density measurements of tree-rings on an annual basis with climate and ecosystem conditions of the spill area.

8. Build a minimum 250-year tree-ring chronology that has the maximum correlation to the productivity level of key injured resources of the spill area ecosystem.

9. Prepare a final report.

10. Submit papers for publication.

B. Methods

Hypotheses

(1) Tree-rings in the forests of southcentral Alaska contain an interpretable record of climatic variability that represents climatic conditions in the spill area over the last 250 years. (2) Multiple tree-ring analysis techniques will capture different climatic signals as well as common, mutually confirming features, including some with annual resolution. (3) Certain features of tree-rings in the spill area correlate with and can serve as a proxy indicator of the overall abundance of certain injured resources. (4) The climatic regime shift seen in the Pacific in the mid-1970's, going from colder to warmer winter conditions (Miller et al. 1994) is unprecedented over the past few centuries and as long as it persists the new climatic regime represents a significant population limitation for certain injured resources.

Data collection phase

We will use available existing tree-ring chronologies in the spill area, especially the central Kenai Peninsula (Wiles et al. in press) and Fort Richardson series (Juday and Marler 1996). We will develop a sampling strategy for new tree-ring collection sites that incorporates (1) an environmental classification grid, (2) a regional or geographic coverage factor, and (3) identification of growth-sensitive site types. Sampling localities will include the Kodiak Island archipelago, outer Kenai Peninsula coast and the Prince William Sound region. A sampling goal will be twenty trees with usable cores from each site for statistically sound ring-width and density

analyses; fewer usable cores per site will be accepted when coverage is critical. Four extra cores will be taken from six of the most representative trees for each site for isotope analysis.

Sample preparation phase

Trees to be used for ring-width analysis will be mounted, sanded, and measured at either the University of Alaska Tree-Ring Laboratory or the Lamont-Doherty Earth Observatory (LEDO) Tree-Ring Laboratory. Tree-ring density measurements will be performed at LEDO. The samples for isotope analysis will sanded and prepped. This involves slicing the rings year-by-year (4 radii each from 4 trees), grinding the wood (1 g sample), extracting the cellulose (Leavitt and Danzer 1992), weighing out a standard measurement amount, and submitting to the UAF isotope laboratory (D. Schell). An additional step to replace exchangeable hydrogen with nitrate (nitration) is necessary so that only non-exchangeable hydrogen originating in the cellulose when it formed is measured for the deuterium analysis (Epstein et al. 1976, DeNiro 1981).

Analysis phase

Ring-widths will be processed into master chronologies using the ARSTAN method, employing conservative straight line or negative exponential curve fits for standardization (Cook 1985, Cook and Kairiukstis 1990). Ring-width series will be subject to common interval analysis to determine the maximum useable coherent signal at each locality. We will compare master chronologies to monthly records (potentially across multiple years) of the climate stations similar to the approach used by Wiles et al. (in press). If both data arrays (various ring properties vs. climate) exhibit normal distribution we will apply Pearson correlation to determine the maximum sensitivity to climatic factors, otherwise a Spearman rank correlation approach will be used. We will combine the selected climate factors into a normalized index. We will also perform principal components analysis (PCA) and multiple regression.

The comparison with climate factors will be repeated for density and isotope measurements, but with a focus on useable single-year relationships. We will plot isotope and density values by year and analyze the results by statistical comparisons of climate factors and the various tree-ring measurements. Ring-width chronologies will be compared to density and isotope records. All tree-ring measurements will be compared to the Aleutian low index (Beamish and Bouillon 1993), long-term trawl surveys in the spill area (Anderson et al. 1996), and other time series made available from other EVOS projects.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

A subcontract will be established with the Tree-Ring Lab at Lamont-Doherty Earth Observatory (LDEO) of Columbia University. The Lamont Lab is one of the two main "full service" tree-ring labs in the U.S. LDEO has a specialized tree-ring x-ray density machine and the staff that supervise its operation. The LDEO Tree-Ring Lab includes in-depth statistical expertise in specialized areas of time series analysis unique to the field which could benefit other EVOS projects. Staff of LDEO Tree-Ring Lab are familiar with Alaska and have conducted research there for many years. They have conducted other investigations involving the Pacific climate system and can bring those insights to the proposed research.

Results of long-term time series will be shared with P. Anderson (Kodiak) to examine overlapping time frames and the power of tree-ring features to index trends or changes in injured resources. This could lead to a working group or a follow-on project that would set goals to compile, integrate, and synthesize long-term time series in the EVOS project. The facilities of the National Center for Ecosystem Analysis and Synthesis in Santa Barbara, CA might be arranged for this purpose.

Cooperation with USDA Forest Service, Chugach National Forest ecology program will be developed. Recent timber sales will be identified in order to collect basal tree disks from stumps for detailed tree-ring analysis. An attempt will be made to identify sampling activity of mutual benefit.

SCHEDULE

A. Measurable Project Tasks for FY 98

Oct 1-Dec.31:	Determine research sites around spill region
January 15-24:	Attend Annual Restoration Workshop
Feb 1-May 1:	Arrange logistics (travel to sites, equipment, etc.)
	Collaborate with researchers on data already collected in study area.
May -September:	Field trips to collect tree core samples
September:	Begin lab work and tree-ring analysis

B. Project Milestone and Endpoints

1. Identify new tree-ring sampling sites around Prince William Sound and the north Gulf of Alaska coast crucial to the elucidation of long-term climatic parameters. Determination of new sites will take place in the fall of 1997.

2. Identify the climatic and ecosystem state information contained in ring-width measurements already collected by other researchers and determine other proxy data that might be available in the record. This will involve a collaboration with G. Wiles et al. (1996), and will take place from February - May 1998.

3. Extend tree-ring sampling coverage in the spill area to non-sampled or under-sampled areas in order to determine regional variation in tree-ring climatic signals. Sampling will take place between May and September of 1998.

    a. Sample low elevation trees to examine whether a useful climatic signal can be extracted from trees on such sites.

    b. Sample sites potentially sensitive to precipitation and other non-temperature factors that could reflect the productivity state of the spill area ecosystem.

4. Explore different isotopes, specifically carbon 13, oxygen 18, and deuterium, in tree-rings to determine their correlation to climatic and ecosystem state information. Finish by December 1998.

5. Examine the annual resolution potential of tree-ring isotope techniques. By May 1999.

6. Identify the climatic and ecosystem state information contained in ring-width measurements from newly collected tree-rings. May 1999 (may lead to proposal for synthesis meeting with other EVOS projects).

7. Determine the correlation of x-ray density measurements of tree-rings on an annual basis with climate and ecosystem conditions of the spill area. May 1999.

8. Build a minimum 250-year tree-ring chronology with the maximum correlation to the productivity level of key injured resources of the spill area ecosystem. August 1999.

9. Final Report. September 1999.

10. Publications (see below)

C. Completion Date

This project will be completed by September 1999.

PUBLICATIONS AND REPORTS

The positive response of high elevation treeline trees on the Kenai Peninsula to warm early summer temperatures is established, and an indication that salmon catch correlates with long-term temperature trends is established.

Wiles, G.C., R.D. D'Arrigo, and G.C. Jacoby. (in press). Gulf of Alaska atmosphere-ocean variability over recent centuries inferred from coastal tree-ring records. Climate Change.

Tree-rings from the Fort Richardson area have proved useful in calibrating and correcting satellite remote sensing data that otherwise erroneously indicate that the earth's vegetation has become more productive as recent warming has taken place.

Malmstrom, Carolyn M.; Thompson, Matthew V.; Juday Glenn Patrick; Randerson, James T; Field Christopher B. (submitted) Interannual Variation in Global-Scale Net Primary Production: Testing Model Estimates. Global Biogeochemical Cycles.

Jacoby, G. C., D'Arrigo, R. D. and Juday, G. P. (in press). Climate change and effects of tree growth as evidenced by tree-ring data from Alaska, in Proceedings of 7th Conference of the International Boreal Forest Research Association, August 19-23, 1996 St. Petersburg, Russia, All-Russian Research and Information Center for Forest Resources, Moscow.

Juday, G.P. (in preparation - invited submission). Evidence of stress effects from warming in the Alaska boreal forest. Journal of Forestry (December 1997).

Juday, Glenn P. and Scott A. Marler. 1997. Tree-ring evidence of climatic warming stress in Alaska: variation and stand history context. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

PROFESSIONAL CONFERENCES

Ecological Society of America Annual Meeting, Baltimore, Maryland, August 1998.
G. Juday, V. Barber, G. Jacoby, R. D'Arrigo, and G. Wiles will submit a paper on climatic sensitivity of previously collected tree-ring samples in the spill area and the correlation of tree-rings with population indices of injured resources.

PROPOSED PRINCIPAL INVESTIGATOR

Name Glenn Patrick Juday

Affiliation University of Alaska Fairbanks, Forest Sciences Department
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Phone number (907) 474-6717
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E-mail address gjuday@gis.lter.alaska.edu

G.P. Juday is Associate Professor of Forest Ecology in the Forest Sciences Department and Director of the Tree-Ring Laboratory at the University of Alaska Fairbanks. He is Past President of the Natural Areas Association, is currently Chair-Elect of the Society of American Foresters Forest Ecology Working Group, and has been a Co-Investigator in the NSF-supported Bonanza Creek Long-Term Ecological Research Site in interior Alaska for 5 years. He has worked in Alaska for 20 years, including developing the Research Natural Area component of the Chugach National Forest Plan. In 1993 he was consultant to the *Exxon Valdez* Trustee Council in developing approaches to the Restoration Science Plan and in preparing an overview document on Ecosystems of the Spill Area. He will provide overall project direction and supervision. He is Co-Major Advisor to V.A. Barber. He will collect tree cores and disks from stumps. He will cross-match tree-ring series, analyze data, present results at conferences, and publish scientific articles. He will take the lead in determining the potential for a follow-on synthesis project comparing tree-ring results to other long-term time series produced by EVOS investigations.

CO- INVESTIGATORS

Name Gordon C. Jacoby
Affiliation Tree-Ring Lab, Lamont-Doherty Earth Observatory of Columbia University
Mailing Address Palisades, NY 10964
Phone number (914) 365-8517
FAX number (914) 365-8152
E-mail address druidgw@lamont.columbia.edu

G.C. Jacoby is Senior Research Scientist at the Tree-Ring Laboratory of Lamont-Doherty Earth Observatory, which he founded He has more than 20 years experience in dendrochronology, including a specialization in northern forests and Alaska tree-ring problems. He will contribute archived tree-ring collections, advise on sampling localities and specimens, and collect tree cores. He will contribute analysis of ring-width series and advise on appropriate analysis techniques. He will present results to scientific meetings and be a co-author of scientific publications.

Name Roseanne D. D'Arrigo
Affiliation Tree-Ring Lab, Lamont-Doherty Earth Observatory of Columbia University
Mailing Address Palisades, NY 10964
Phone number (914) 365-8517
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E-mail address druidrd@ldgo.columbia.edu

R.D. D'Arrigo is Associate Research Scientist at the Tree-Ring Laboratory of Lamont-Doherty Earth Observatory. She has published extensively in the area of northern dendroclimatology and maritime climatic influences on tree-ring records. She will be involved in the identification of sampling localities and collect tree cores. She will analyze tree-rings and be involved in identifying potential climatic signals in tree-ring series. She will present results to scientific meetings and be a co-author of scientific publications.

Name Valerie A. Barber
Affiliation Institute of Marine Sciences and Forest Sciences Department, University of Alaska

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V.A. Barber is a Ph.D. student in the interdisciplinary program at the University of Alaska Fairbanks. During the course of FY 98 she will be supported as a graduate student and following completion of the degree, as a Research Associate. She will be principally responsible for x-ray density measurements and preparation of samples for isotope analysis. She will visit sampling sites and be involved in tree-ring collection and statistical analysis. She will be involved in data analysis, presentation of results at meetings, and will be a co-author of scientific publications.

OTHER KEY PERSONNEL

Technicians at the University of Alaska Fairbanks and Lamont-Doherty Tree-Ring Laboratories will prepare and measure tree-rings, perform calculations, archive and format data.

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Biographical summary

Name: Glenn Patrick Juday

Academic Rank, History Associate Professor of Forest Ecology (12-month appointment, tenured)

Professional and Research Experience

July, 1992-- (present)	Associate Professor of Forest Ecology (tenured) University of Alaska - Fairbanks, School of Agriculture and Land Resource Management, Forest Science Department. Director, UAF Tree-Ring Laboratory.
July, 1987-- June, 1992	Assistant Professor of Forest Ecology (tenure track position), University of Alaska - Fairbanks, School of Agriculture and Land Resource Management, Forest Science Division. Alaska Ecological Reserves Coordinator.
October, 1981- June, 1987	Visiting Associate Professor of Plant Ecology, (non-tenure track) University of Alaska - Fairbanks, School of Agriculture and Land Resource Management. Alaska Ecological Reserves Coordinator.
September, 1977- September, 1981	Alaska Ecological Reserves Coordinator, employed first through Federal-State Land Use Planning Commission for Alaska then University of Alaska, Arctic Environmental Information and Data Center, and USDA Forest Service (GS 13); based at Institute of Northern Forestry, Fairbanks, Alaska.

Education: B.S. summa cum laude, Phi Beta Kappa, 1972, Forest Management, Purdue University.

Ph.D., 1976, Plant Ecology, Oregon State University
Dissertation topic: The Location, Composition and Structure of Old-Growth Forests of the Oregon Coast Range.

Post-Doctoral Fellowship in Environmental Affairs, 1976-1977, (Rockefeller Foundation) Oregon State University, Executive Chair Oregon Natural Area Preserves Advisory Commission.

Field of Specialization and Areas of Interest

Tree ring studies, Biodiversity and forest management, Structure of old-growth forest ecosystems, Definition and identification of elements of natural diversity, Natural area management, Analysis of landscape-level processes responsible for natural diversity, Forest development and ecosystem life history, especially following fire and climate change, Long-term environmental monitoring

National Consulting and professional activity, honors, recognition

Chair-Elect, Society of American Foresters Forest Ecology Working Group 1997-98. Responsible for SAF Annual Convention Program, Technical Sessions, policy advice to National SAF.

Consultant to World Wildlife Fund, Climate Change Program. 1997. Washington, D.C. Scientific advisor on results of tree-ring research; news conference with HRH Prince Phillip, Anchorage, Alaska, March 1997.

Award of Special Appreciation from Chief, USDA Forest Service "In recognition of contribution to the Alaska Research Natural Area Program including identification of RNAs and establishment of important monitoring plots within RNAs." 1994

Paid consultant to *Exxon Valdez* Trustee Council and Restoration Program, Anchorage, Alaska, Jan. 1994 - present. Contributor to Guiding Principles document for restoration program of *Exxon Valdez* Oil Spill and author of Introduction to Ecosystems document.

Science Advisor, Wolfgang Bayer Productions, 1990-91 for "Glaciers, Rivers of Ice" © 1994, 60-minute science TV program on Discovery Channel..

President and Past-president, Natural Areas Association, 1985 - 1989 (International 3,000 member professional organization working to identify, study, protect, and manage natural areas and significant features of natural diversity).

Consultant to The Nature Conservancy National Headquarters, Science Programs Office, during special assignment, Jan. - March 1988. Conducted overview of federal natural area protection funding trends and history, need for application of results from conservation biology in natural area protection strategies.

Award of Special Appreciation, Alaska Division of Forestry, for "efforts leading to establishment of the Tanana Valley State Forest." 1983.

Principal author, Research Natural Area element of Tongass National Forest Plan Update, 1988-1991, and Chugach National Forest Plan 1981.

Certificate of Meritorious Service for service as Chairman of the Oregon Natural Area Preserves Advisory Committee 1973-1977. From Governor of Oregon and Oregon State Land Board. 1977.

Rockefeller Foundation Environmental Affairs Post-doctoral Fellowship - Executive Chairman, Oregon Natural Area Preserves Advisory Committee. Oregon State Land Board and Geography Department, Oregon State University. 1976-77.

Other Professional Leadership and service

Numerous lectures to national, regional, and community organizations. Testified on national forestry research needs and priorities before U.S. Congress 5 times.

Professional self-improvement

International Exchange, sponsored by Swedish Royal Academy of Sciences October 1992
Invited Speaker and Visiting Scientist, Forest Vegetation Ecology Department, Swedish National Agricultural University, Umea, Sweden

Sabbatical leave, September 1987 - April 1988
Holcomb Research Institute, Butler University, Indianapolis Indiana
Science Programs Office, The Nature Conservancy, Arlington, Virginia
Channel Islands National Park, Ventura California

Major Grants and Contracts

Co-Principal Investigator (one of 9; Dr. Keith Van Cleve, Principal Investigator) in project "Successional Processes in Taiga Forests of Interior Alaska: A Long-Term Ecological Research (LTER) Program for Study of Controls of Subarctic Forest Development." ($305,472 over the 6-year term of the $ 3,907,500 grant from the National Science Foundation)

Principal Investigator, "A study of recent climatic stress on white spruce from global warming through stable isotope analysis: confirming and clarifying effects for forest policy." Alaska Natural Resources Fund 1997, $11,400.

Coordinator, Rosie Creek Fire Research Project (1983-91, Alaska Legislature, $489,325).

PI and Coordinator of the Alaska Ecological Reserves Program. (1982-92, USDA Forest Service, Alaska DNR and Fish and Game, USDI Bureau of Land Management, $370,000).

Coordinator, Columbia Glacier Succession Study. (1985, USDA Forest Service, $22,000).

Co-coordinator, EPA Cold Climate Research Priorities Study. (1982, EPA - Battelle Northwest, $150,000)

Publications Summary

12 journal articles, 4 articles completed and in review, 8 published papers in proceedings, 7 Experiment Station publications, 27 contract and other publications, 46 published abstracts, 21 major reports on Alaska and Oregon Research Natural Areas, 16 editorials, 2 book reviews, 5 news and analysis articles.

Publications In Progress

Malmstrom, Carolyn M.; Thompson, Matthew V.; Juday Glenn Patrick; Randerson, James T; Field Christopher B. (submitted) Interannual Variation in Global-Scale Net Primary Production: Testing Model Estimates. Global Biogeochemical Cycles.

Rees, Daniel C., and Glenn Patrick Juday. (submitted) Plant species diversity and forest structure on logged and burned sites in central Alaska. [Ecological Monographs].

Juday, Glenn Patrick. (completed). Structure of Older White Spruce Forests in Interior Alaska Research Natural Areas. [Intended submission - Ecoscience].

Ott, Robert A., and Glenn Patrick Juday. (completed). Dynamics of canopy gaps and their influence on understory light, species richness and cover, and tree regeneration in the forests of southeast Alaska. [Intended submission - Ecology].

Ott, Robert A., and Glenn Patrick Juday. (completed). Interpretation of wind and treefall patterns at the site-and landscape-level in the forests of southeast Alaska: importance, techniques, and application. [Intended submission - Canadian Journal of Forest Research].

Juday, G.P. (in preparation - invited submission). Evidence of stress effects from warming in the Alaska boreal forest. Journal of Forestry (December 1997).

Juday, Glenn Patrick. (in prep). Growth Response of Upland White Spruce in Bonanza Creek LTER in central Alaska Consistent with Climatic Warming.

Juday, Glenn Patrick. (in prep.). Age structure and development of an old-growth white spruce forest in the Bonanza Creek LTER. [Intended submission - Canadian Journal of Forest Research].

Nationally peer-reviewed Articles

Jacoby, G. C., D'Arrigo, R. D. and Juday, G. P. 1997, Climate change and effects of tree growth as evidenced by tree-ring data from Alaska, in Proceedings of 7th Conference of the International Boreal Forest Research Association, August 19-23, 1996 St. Petersburg, Russia, All-Russian Research and Information Center for Forest Resources, Moscow (in press).

Landolt, J.C.; Stephenson, S.L.; Laursen, G.A.; Densmore, R.; Juday, G. (in press) Recent collections of Alaskan cellular slime moulds: a review. Mycologia.

Juday, Glenn Patrick. 1996 (on-line version issued Jan. 1996). Boreal Forests (Taiga) In: The Biosphere and Concepts of Ecology. Volume 14 Encyclopedia Britannica, 15th edition. pp. 1210-1216. [hardcopy version in printed and bound volume to be published in 1997]

Juday, Glenn Patrick. 1992. Alaska Research Natural Areas: 3. Serpentine Slide. USDA Forest Service General Technical Report PNW-GTR-271. Portland, Oregon. Pacific Northwest Research Station. 66 p.

Juday, Glenn Patrick. 1991. Interview with Michael V. Finley, Superintendent, Yosemite National Park. Natural Areas Journal 11(2): 79-86.

Juday, Glenn Patrick. 1990. Interview with Jerry Franklin, Bloedel Professor of Forestry, University of Washington, and Chief Plant Ecologist, USDA Forest Service. Natural Areas Journal 10(4): 163-172.

Juday, Glenn Patrick. 1990. Interview with Dr. Robert E. Jenkins, Vice President for Science Programs, The Nature Conservancy. Natural Areas Journal 10(2): 55-60.

Juday, Glenn Patrick. 1989. Interview with Orie L. Loucks, Professor of Zoology, Miami University, and Member of the Board of Governors of The Nature Conservancy. Natural Areas Journal 9(4): 207-210.

Alaback, Paul B.; Juday, Glenn Patrick. 1989. Structure and Composition of Low Elevation Old-Growth Forests In Research Natural Areas of Southeast Alaska. Natural Areas Journal 9(1): 27-39.

Juday, Glenn Patrick. 1989. Alaska Research Natural Areas: 2. Limestone Jags. USDA Forest Service General Technical Report PNW-GTR-237. Portland, Oregon. Pacific Northwest Research Station. 58 p.

Juday, Glenn Patrick. 1988. Alaska Research Natural Areas: 1. Mount Prindle. USDA Forest Service General Technical Report PNW-GTR-224. Portland, Oregon. Pacific Northwest Research Station. 34 p.

Other Refereed Publications

Juday, Glenn Patrick. 1993. Baked Alaska? Scientist examines temperature trends. Agroborealis 25(2): 10-14.

Juday, Glenn Patrick, and Nora Foster. 1990. A Preliminary Look at Effects of the Exxon Valdez Oil Spill on Green Island Research Natural Area. Agroborealis 22(1): 10-17.

Published Papers Presented to Conferences

Stephenson, Steven L., Laursen, Gary A., Landolt, John C., Juday, Glenn P., Bernard, Ernest C. 1994. The Columbia Glacier ecosystem in southern Alaska. Proceedings of the West Virginia Academy of Science 66:39. Morgantown, WV

Stephenson, Steven L., Dubey, Tara, Laursen, Gary A., Juday, Glenn P. 1994. Aquatic fungi in streams of the Granite Cove Research Natural Area in southern Alaska. Proceedings of the West Virginia Academy of Science 66:10. Morgantown, WV

Juday, Glenn Patrick. 1987. The emergence of the natural areas profession in the west. pp 42-45 In 1986 Montana Natural Areas Conference Proceedings. The Nature Conservancy, Big Sky Field Office, Helena, MT. 159 p.

Juday, Glenn Patrick, and John C. Zasada. 1985. The Structure and Development of an Old-Growth White Spruce (Picea glauca (Moench) Voss) Forest on an Interior Alaska Floodplain Site, Willow Island. pp 227-234. in Meehan, W.R., T.R. Merrell, Jr., and T.A. Hanley (Eds) Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a symposium held in Juneau, Alaska, 12-15 April 1982. American. Institute of. Fish. Research. Biologists. 425p.

Juday, Glenn Patrick. 1984. Temperature Trends in the Alaska Climate Record. Proceedings of the Conference on the Potential Effects of Carbon Dioxide-Induced Climatic Changes in Alaska. Ag. Exp. Sta. Misc Publication 83-1. Univ. of Alaska. pp 76 - 88.

McBeath, Jenifer H., Editor, Juday, Glenn P., Weller, Gunter, Associate Editors, and Mayo Murray, Technical Editor. 1984. The Potential Effects of Carbon Dioxide-Induced Climatic Changes in Alaska, The Proceedings of a Conference. Ag. Exp. Sta. Misc Publication 83-1. Univ. of Alaska. 208 pp.

McBeath, Jenifer H., Weller, Gunter, Juday, Glenn P., and Osterkamp, Thomas E., and Richard A. Neve'. 1984. The Potential Effects of Carbon Dioxide-Induced Climatic Changes in Alaska: Conclusions and Recommendations. Proceedings of the Conference on the Potential Effects of Carbon Dioxide-Induced Climatic Changes in Alaska. Ag. Exp. Sta. Misc Publication 83-1. Univ. of Alaska. pp 193 - 196.

Juday, Glenn Patrick. 1983. The Alaska Ecological Reserves Program: Approaches, Successes, and Problems. Transactions of the 48th North American Wildlife and Natural Resources Conference, Kansas City, MO. Wildlife Management Institute. pp 531-540.

<u>Contract Reports and Other Publications</u>

LaGory, K.; Juday G.P.; Paton, P.W.C.; Ott, R.A.; Wildman, A.M.; Sarles, J.K. 1996. Biodiversity Survey of Clear Air Station, Alaska (Final). Environmental Assessment Division, Argonne National Laboratory. December 1996. 38 pp. plus Appendices.

Marketing Alaska Forest Products Sector Team. 1995. Marketing Alaska Forest Products Sector Report. Report to the Alaska Department of Commerce and Economic Development, Juneau Alaska, October 10, 1995.

Juday, Glenn Patrick; Viereck, L.A.; Oswood, M.A.; Adams, P.A.; Bryant, J. 1995. 1995. Report of biodiversity research at Bonanza Creek/Caribou-Poker Creeks LTER. Report to the national LTER Coordinating Committee , Biodiversity workshop. 20-22 October 1995, St. Paul and Cedar Creek, MN. 9 p.

Juday, Glenn Patrick. 1994. Ecosystems and the *Exxon Valdez* Oil Spill Area. A report to the *Exxon Valdez* Oil Spill Trustee Council. 17 p. plus 21 illustrations.

Juday, Glenn Patrick. 1994. USDA Forest Service Alaska Region Research Natural Area Reference Stand Monitoring Data Base. Report to USDA Forest Service. Four volumes. (Data posted in the Forestry Sciences Laboratory On-line Computer Data Archive, Corvallis, Oregon).

Juday, Glenn Patrick. 1993. Establishment Report for Columbia Glacier - Granite Cove Research Natural Area, Chugach National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 55 pp. plus 4 maps (final).

Juday, Glenn Patrick. 1993. Establishment Report for Copper Sands Research Natural Area, Chugach National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 18 pp. plus 12 maps (final draft).

Juday, Glenn Patrick. 1993. Establishment Report for Schwan Glacier Terminus Research Natural

Area, Chugach National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 19 pp. plus 8 maps (final draft).

Juday, Glenn Patrick. 1992. White spruce forest structure and regeneration following wildfire. Field Trip Guide to Bonanza Creek LTER for the National Agricultural Research and Extension Users Advisory Board, August 18, 1992. 12 p.

Juday, Glenn Patrick. 1992. Forest Development/Forest Structure Research Projects for the Bonanza Creek Experimental Forest Long Term Ecological Research (LTER) Program 1992-1998. Report to the USDA Forest Service, Pacific Northwest Research Station (Contract PNW 90-71, Supplement Amendment 1). 18 p. plus 6 figures.

Juday, Glenn Patrick. 1992. Development and Migration of Copper Sands Research Natural Area 1950 - 1992. Report to the USDA Forest Service, Pacific Northwest Research Station (Contract PNW 90-71, Supplement Amendment 1). 16 p. plus 10 figures.

Juday, Glenn Patrick, and Paul Alaback. 1992. Structure of permanent forest reference plots at Red River Research Natural Area 1978-1991 and Marten River Proposed RNA 1991. Report to the USDA Forest Service, Pacific Northwest Research Station (Contract PNW 90-71, Supplement Amendment 1). 9 p. plus 56 figures.

Juday, Glenn Patrick. 1992. Columbia Glacier Field Trip Guide. 43rd Arctic Science Conference, September 12, 1992, Valdez, Alaska. 42 p.

Juday, Glenn Patrick. 1991. Ten Years of Successional Change on the Hugh Miller Inlet Plots, Glacier Bay National Park. Contract Report to Alaska Region, National Park Service, # CA-9700-0-9011. 35 p. plus 18 numbered figs., 5 appendices.

Juday, G.; Yarie, J.; and Van Cleve, K., Adams, P., Viereck, L., Dyrness, C.T. 1990. Bonanza Creek Experimental Forest LTER Field Trip Guide. International Conference on the Role of the Polar Regions in Global Change, June 15, 1990. University of Alaska Fairbanks and Institute of Northern Forestry, USDA Forest Service. Fairbanks, AK. 26p.

Juday, G., Alden, J., and Densmore, R. 1990. Rosie Creek Fire Field Trip Guide. Alaska Society of American Foresters State Convention, June 3, 1990. Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. 20p.

Juday, Glenn Patrick, and Foster, Nora. 1989. A preliminary report on the effects of the Exxon Valdez oil spill on Green Island Research Natural Area. Report to the National Oceanic and Atmospheric Administration, National Ocean Pollution Program, Washington, D.C. 38 p. plus illustrations.

Juday, G.P., Alaback, P., and Orme, M. 1988. Research Natural Area Proposals for the Tongass Forest Plan Revision. Report of the Research Natural Area Steering Committee, Results of Research Natural Area Workshops. May 24-25 and July 21, 1988. USDA Forest Service Alaska Region. 79 pp. plus 4 Appendices.

Juday, Glenn Patrick, and Peter Crimp. 1986. Research Areas - Section VI, C, of Part II (Forestry), pp 2-67 - 2-70, in Tanana Valley State Forest - Forest Management Plan Resource Analysis. Alaska Department of Natural Resources, Juneau. 226 numbered pages + i-x preface.

Juday, Glenn Patrick, and C. Theodore Dyrness, Eds. 1985. Early Results of the Rosie Creek Fire Research Project - 1984. Agriculture and Forestry Experiment Station, School of Agriculture and Land Resources Management, University of Alaska-Fairbanks. Miscellaneous Publication 85-2. 46 p.

Juday, Glenn Patrick. 1983. Research Natural Areas/Ecological Reserves. Appendix A in Alaska Regional Guide. USDA Forest Service, Alaska Region Report No. 126a. pp A-1 - A-23.

Underwood, Larry S., and Glenn Patrick Juday. 1979. An Ecological Reserves Report 38. Federal-State Land Use Planning Commission for Alaska. Anchorage. 36p.

Chilcote, William W., Juday, Glenn P., Fonda, Richard W., Sawyer, John O., and Alfred M. Wiedemann. 1976. A Survey of the Potential Natural Landmarks, Biotic Themes, of the North Pacific Border Region. USDI National Park Service. Washington, D.C. 727p.

Juday, G. P. (principal investigator). Knudson, D. and Gerlach, F. (eds.). 1973. Big Walnut Creek-Eel River--Evaluation of Suitability for the Indiana Natural Stream System. Ag. Exp. Sta. Bull. 11, Purdue University. West Lafayette, Indiana.

Juday, G. P. (principal investigator). Knudson, D. and Gerlach, F. (eds.). 1973. Elkhart River--Evaluation of Suitability for the Indiana Natural Stream System. Ag. Exp. Sta. Bull. 4, Purdue University. West Lafayette, Indiana.

Juday, G. P. (principal investigator). Knudson, D. and Gerlach, F. (eds.). 1973. Little Calumet River--Evaluation of Suitability for the Indiana Natural Stream System. Ag. Exp. Sta. Bull. 9, Purdue University. West Lafayette, Indiana.

Juday, G. P. (principal investigator). Knudson, D. and Gerlach, F. (eds.). 1973. Whitewater River--Evaluation of Suitability for the Indiana Natural Stream System. Ag. Exp. Sta. Bull. 10, Purdue University. West Lafayette, Indiana.

Published Abstracts

Jacoby, Gordon C., Rosanne D. D'Arrigo, and Glenn Juday. 1997. Indicators of recent environmental change in Alaska. (Abstract accepted) Eighth International Global Warming Conference and Exposition. Washington, D.C.

Rupp, S., G.P Juday, J. Zasada, L.A. Viereck, P.A. Adams. 1997. Observations and implications from a 40 year record of white spruce cone and seed production in interior Alaska. (Abstract accepted) 1997 Annual Meeting, International Boreal Forest Research Association. 5-8 August 1997, Duluth, MN.

Adams, Phyllis C., and Glenn P. Juday. 1997 Growth rate responses of white spruce to river discharge patterns on a boreal forest floodplain. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

Barber, Valerie A., Glenn P. Juday, and Bruce P. Finney. 1997. Stable isotope and wood density evidence of upland white spruce growth in Bonanza Creek LTER in central Alaska consistent with increased climatic stress. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

Rees, Daniel C. and Glenn P. Juday. 1997. Differences in plant species diversity and forest structure following natural fire versus historical logging in the boreal forest of Alaska. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

Juday, Glenn P. and Scott A. Marler. 1997. Tree-ring evidence of climatic warming stress in Alaska: variation and stand history context. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

Ott, Robert A., Timothy E. Garvey, and Glenn P. Juday. 1997. Wind flows and distribution of large-scale blowdowns on a landscape in the Tongass National Forest: implications for management. (Abstract accepted) 1997 Annual Meeting, Ecological Society of America. 11-14 August 1997, Albuquerque, NM.

Barber, Valerie; Juday, Glenn Patrick; and Bruce P. Finney. 1996. Climate reconstructions and changes in Alaskan boreal forests as determined by tree rings. (Program - Abstract on line) 47th Arctic Division Science Conference, AAAS. 19-21 September 1996, Girdwood, Alaska. p. 11.

Burke, Toby, and Glenn Patrick Juday. 1996. Bryophyte and lichen flora of the Alaska boreal forest including species potentially sensitive to forest management. (Program - Abstract on line) 47th Arctic Division Science Conference, AAAS. 19-21 September 1996, Girdwood, Alaska. p. 17.

Juday ,Glenn Patrick, and Daniel C. Rees. 1996. Differences in biodiversity of logged vs. Burned sites in interior Alaska. (Program - Abstract on line) 47th Arctic Division Science Conference, AAAS. 19-21 September 1996, Girdwood, Alaska. p. 17.

Juday ,Glenn Patrick, and Scott A. Marler. 1996. Tree-ring evidence of climatic warming in south-central Alaska; coincident with recent tree mortality. (Program - Abstract on line) 47th Arctic Division Science Conference, AAAS. 19-21 September 1996, Girdwood, Alaska. p. 11.

Juday, Glenn Patrick, and R. Barry. 1996. Growth response of upland white spruce in Bonanza Creek LTER in central Alaska indicates unprecedented stress consistent with climatic warming. (Abstract) 1996 Annual Combined Meeting, Ecological Society of America. 10-14 August 1996, Providence, RI. p. 222

Juday, Glenn Patrick. 1995. Lessons from forest biodiversity studies for boreal forest management in Alaska. (Abstract) 46th Arctic Division Science Conference, AAAS. 19-22 September 1995, Fairbanks, Alaska. p. 220.

Juday, Glenn Patrick. 1995. Forest landscape diversity at Clear Air Station. (Abstract) 46th Arctic Division Science Conference, AAAS. 19-22 September 1995, Fairbanks, Alaska. p. 175.

Juday, Glenn Patrick. 1995. Radial growth Response of white spruce to climate at Bonanza Creek LTER. (Abstract) 46th Arctic Division Science Conference, AAAS. 19-22 September 1995, Fairbanks, Alaska. p. 175.

Ott, Robert A., Garvey, Tim, Fincher, Jim, and Glenn P. Juday. 1995. Comparison of natural and anthropogenic disturbance regimes in temperate rainforests of southeast Alaska: considerations for ecosystem management. (Abstract) 46th Arctic Division Science Conference, AAAS. 19-22 September 1995, Fairbanks, Alaska. p. 183.

Juday, Glenn Patrick. 1993. Natural Diversity in Alaska and the Role of Special Protected Areas in Its Conservation. Abstracts, Alaska Biodiversity Conference. Alaska Natural Heritage Program. Anchorage, Alaska. March 24-26, 1992. p. 14.

Juday, Glenn Patrick. 1992. Biodiversity and natural area conservation in the boreal forest. Abstracts, 19th Annual Natural Areas Conference, Bloomington, Indiana. October 27-30. p. 68 (supplement).

Juday, Glenn Patrick. 1992. Factors Controlling Forest Succession Following Drastic Retreat of Tidewater Glaciers: Lessons from Columbia Glacier and Glacier Bay. 43rd Arctic Science Conference Program and Proceedings. Valdez, Alaska. September 8-12, 1992. p. 87.

Juday, Glenn Patrick. 1992. Photographing Changes in Columbia Glacier: 1899-1992. 43rd Arctic Science Conference Program and Proceedings. Valdez, Alaska. September 8-12, 1992. p. 175.

Juday, Glenn Patrick, and Nora Foster. 1990. The Exxon Valdez oilspill: early effects of acute stress on natural diversity in a pristine environment. Proceedings of the 17th Annual Natural Areas Conference and Yosemite Centennial. National Park Service. Concord, CA. October 14-19, 1990.

Juday, Glenn Patrick. 1990. Monitoring for Global Change in Alaska Research Natural Areas. Abstracts, International Conference on the Role of the Polar Regions in Global Change. Center for Global Change and Arctic System Research, University of Alaska Fairbanks. Fairbanks, Alaska. June 11-15, 1990. p. 14.

Juday, Glenn Patrick. 1989. Effects of the Exxon Valdez Oil Spill on the Beaches of Green Island Research Natural Area. IN: 40th Arctic Science Conference Proceedings, American Association for the Advancement of Science, Arctic Division. September 14-16. University

of Alaska Fairbanks. Fairbanks, AK. p 15.

Juday, Glenn Patrick. 1989. Structural Features of Older Hardwood Stands of the Bonanza Creek LTER. IN: 40th Arctic Science Conference Proceedings, American Association for the Advancement of Science, Arctic Division. September 14-16. University of Alaska Fairbanks. Fairbanks, AK. p 25.

Juday, Glenn Patrick. 1989. 10 Years of Successional Change on the Hugh Miller Inlet Plots at Glacier Bay National Park. IN: 40th Arctic Science Conference Proceedings, American Association for the Advancement of Science, Arctic Division. September 14-16. University of Alaska Fairbanks. Fairbanks, AK. p 25.

Juday, Glenn Patrick, and Paul Alaback. 1988. Selection of Research Natural Areas on the Tongass National Forest. Abstracts, 39th Arctic Science Conference, October 7-10, 1988. American Association for the Advancement of Science, Arctic Division, Fairbanks, Alaska. p. 225.

Juday, Glenn Patrick, and Alan Batten. 1988. Uncommon plants as a selection criterion for Research Natural Areas on the Tongass National Forest. Abstracts, 39th Arctic Science Conference, October 7-10, 1988. American Association for the Advancement of Science, Arctic Division, Fairbanks, Alaska. p. 226.

Juday, Glenn Patrick. 1986. Environment and Change on the Pete Dahl Slough Research Natural Area. p. 16-17 IN: Proceedings of the Eleventh Copper River Delta Conference, April 10 & 11, 1986, Cordova, Alaska. USDA Forest Service, Chugach National Forest, R10-MB-7.

Juday, Glenn Patrick. 1986. Using Geologic Diversity in the Alaska Ecological Reserves Program. IN: Abstracts 13th Annual Natural Areas Conference. Jefferson City, Missouri. p 3.

Juday Glenn Patrick, Alan Batten, and Anthony McGuire. 1985. The South-Facing Volkmar Bluff Meadows: Composition and Setting. Abstracts, 1985 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Fairbanks, Alaska. p 170.

Juday Glenn Patrick. 1985. Environmental Features of Proposed BLM Research Natural Areas on the Seward Peninsula. Abstracts, 1985 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Fairbanks, Alaska. p 181.

Juday Glenn Patrick. 1985. Planning for Research Natural Areas on the Tanana Valley State Forest. Abstracts, 1985 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Fairbanks, Alaska. p 224.

Juday Glenn Patrick. 1985. Environment of the Proposed Pete Dahl Slough Research Natural Area, Copper River Delta. Abstracts, 1985 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Fairbanks, Alaska. p 226.

Juday Glenn Patrick. 1984. The Interpretation of Forest Structure at 3 Proposed Research Natural Areas Across Central Alaska. Abstracts, 1984 American Association for the Advancement

of Science, Arctic Division, Annual Meeting, Anchorage, Alaska. p 233.

Juday Glenn Patrick. 1984. Forest Succession and Plant Communities Near the West Terminus of Columbia Glacier. Abstracts, 1984 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Anchorage, Alaska. p 235.

Juday Glenn Patrick. 1984. The Integration of Post-Fire Research in the Rosie Creek Burn. Abstracts, 1984 American Association for the Advancement of Science, Arctic Division, Annual Meeting, Anchorage, Alaska. p 237.

Juday Glenn Patrick. 1984. Some Structural Features of Old-Growth Forests of Northwestern North America. Program and Abstracts, 1984 American Association for the Advancement of Science Annual Meeting, New York, New York. p 147.

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Juday, Glenn Patrick. 1983. Research Natural Area (RNA) Selection for BLM in the White Mountains National Recreation Area (NRA) and Steese National Conservation Area (NCA). Program and Abstracts, Northwest Scientific Association. 56th Annual Meeting, Olympia Wash. p 22.

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Juday, Glenn Patrick Paul B. Alaback. 1979. Pacific Silver Fir in Southeast Alaska. Proceedings, 30th Alaska Science Conference, American Association for the Advancement of Science, Alaska Division. September 1979. p 23.

Juday, Glenn Patrick and Larry S. Underwood. 1979. Establishing an Ecological Reserves Program for Alaska. Proceedings, 30th Alaska Science Conference, American Association for the Advancement of Science, Alaska Division. September 1979. p 176.

Juday, Glenn Patrick. 1977. The Location, Characteristics and Fate of Important Natural Areas of the Upland Coastal Zone. Invited Symposium Paper, 50th Annual Meeting, Northwest Scientific Association, March 1977.

Juday, Glenn Patrick. 1976. Composition and Structure of Old-Growth Forests of the Valley-Margin Zone of Western Oregon. Paper presented to Northwest Scientific Association, Spring, 1976.

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Editorials -Letters from the President, Natural Areas Journal

Volume 9 (1989)
- Number (1) Natural Area Science
- Number (2) Natural Areas and Global Change
- Number (3) The Exxon Valdez Oil Spill in Prince William Sound
- Number (4) The Natural Areas Profession in 1989

Volume 8 (1988)
- Number (1) Where is the Natural Areas Association Going?
- Number (2) Natural Area Politics
- Number (3) Specialization in the Natural Areas Profession
- Number (4) The Yellowstone Fires and Natural Area Professionals

Volume 7 (1987)
- Number (1) The Other Side of Habitat Fragmentation
- Number (2) Diversity and Rarity
- Number (3) Restoring Natural Areas in the Human-Dominated Landscape
- Number (4) The Canadian Council on Ecological Areas

Volume 6 (1986)
- Number (1) untitled
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- Number (3) Stages in the Development of Natural Area Programs
- Number (4) The Habit of Giving

News and Analysis Articles

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(no byline) The Spring 1987 Meeting of the Natural Areas Association Board of Directors. Natural Areas Journal. 7(3). pg. 91.

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Major Reports on Natural Areas

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Juday, Glenn Patrick. 1990. A Report on Ecological Characteristics of Alternative Research Natural Areas of the Ketchikan Area, Tongass National Forest. 40 pp.

Juday, Glenn Patrick. 1990. Establishment Record for Columbia Glacier - Granite Cove Research Natural Area, Chugach National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 55 pp. plus 4 maps (draft).

Juday, Glenn Patrick, Foster, Nora, and Paul Alaback. 1990. Establishment Record for Green Island Research Natural Area, Chugach National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 77 pp. plus 15 maps and graphs (draft).

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Juday, Glenn Patrick. 1984. Windy Cove Proposed Research Natural Area:. Report for BLM Seward Peninsula Area, Fairbanks District, BLM. 23 pp.

Juday, Glenn Patrick. 1984. Camp Haven Gap Proposed Research Natural Area:. Report for BLM Seward Peninsula Area, Fairbanks District, BLM. 17 pp.

Juday, Glenn Patrick. 1984. Clear Creek Hot Springs Proposed Research Natural Area:. Report for BLM Seward Peninsula Area, Fairbanks District, BLM. 9 pp.

Juday, Glenn Patrick. 1983. Ray Mountains Proposed Research Natural Areas: Ishtalitna Creek Hot Springs, McQuesten Creek, and Spooky Valley. Report for BLM Central Yukon Planning Area (Record of Decision), Fairbanks District, BLM. 19 p.

Juday, Glenn Patrick. 1983. Chitanana Dunes Proposed Research Natural Areas: Redlands Lake and Arms Lake. Report for BLM Central Yukon Planning Area (Record of Decision), Fairbanks District, BLM. 19 p.

Juday, Glenn Patrick. 1983. Todatonten Pingos Proposed Research Natural Areas: Lake Todatonten Pingos and South Todatonten Summit. Report for BLM Central Yukon Planning Area, Fairbanks District (Record of Decision), BLM. 10 p.

Juday, Glenn Patrick. 1983. Box River Treeline Proposed Research Natural Area. Report for BLM Central Yukon Planning Area, Fairbanks District (Record of Decision), BLM. 13 p.

Juday, Glenn P. 1982. Limestone Jags Proposed Research Natural Area. Report for White Mountains National Recreation Area Plan, Fairbanks District (Record of Decision), BLM. 15 p.

Juday, Glenn Patrick. 1982. Serpentine Slide Proposed Research Natural Area. Report for White

Mountains National Recreation Area Plan, Fairbanks District (Record of Decision), BLM. 15 p.

Juday, Glenn Patrick. 1982. Mount Prindle Proposed Research Natural Area. Report for White Mountains National Recreation Area - Steese National Conservation Area Plan, Fairbanks District (Record of Decision), BLM. 9 p.

Juday, Glenn P. 1982. Big Windy Hot Springs Proposed Research Natural Area. Report for Steese National Conservation Area Plan, Fairbanks District (Record of Decision), BLM. 13 p.

Juday, Glenn Patrick. 1981. Proposed Research Natural Areas in the Chugach National Forest. Report for the Chugach National Forest Plan. 10 p.

Juday, Glenn Patrick. 1980. Establishment Report for Red River Research Natural Area, Tongass National Forest. Report to USDA Forest Service, according to format of Forest Service Manual section 4063. 46 p. plus 8 maps and graphs.

Juday, G. P. 1975. Preserve Analysis Report--MacDonald Forest, Division of State Lands. Salem, Oregon. 31 p.

Juday, G. P. 1974. Preserve Analysis Report--Cape Lookout, Division of State Lands. Salem, Oregon. 42 p

Juday, G. P. 1974. Old-Growth, Climax, and Mature Forests of Western Oregon Suitable for Spotted Owl Habitat in 1973 (three maps), Oregon Wildlife Commission, Portland, Oregon.

Offices and Memberships:

- Chair-elect, Society of American Foresters, Forest Ecology Working Group, 1997-1998
- Past President, the Natural Areas Association, 1990.
- President, the Natural Areas Association, 1985 - 1989.
- Member, Board of Directors, the Natural Areas Association, 1983 - 1985.
- Member and Chairman, Oregon Natural Area Preserves Advisory Committee to the State Land Board (Governor, Secretary of State, State Treasurer), 1973-1977.
- Member, Natural Areas Committee, Society of American Foresters, 1981-1982.
- Phi Beta Kappa. Inducted 1972.
- Member, National Directorate, U.S. Man and the Biosphere (MAB) Project 6 Arctic Lands. 1984 - 1988.
- Member and Chairman, U.S. - Canada Biosphere Reserve Selection Panel, Sitkan Province of North America. 1981 - 1984. Man and the Biosphere Programme (UNESCO).
- Member and consultant (since 1974) to The Nature Conservancy (sabbatical leave project with Science Programs, in residence at TNC Headquarters, Arlington, VA, January-April 1988)

Ecological Society of America
American Association for the Advancement of Science

Natural Areas Association
Society for Conservation Biology
Society of American Foresters
Indiana Academy of Science
Northwest Scientific Association
Xi Sigma Pi (Forestry Honorary)

Biographical Data for Valerie Barber

P.O. Box 84442
Fairbanks, AK 99708
email: barber@ims.alaska.edu
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1978 BS Biological Oceanography
Florida Institute of Technology
Melbourne, FL

1995 MS Chemical Oceanography
Thesis Title: Comparison of Chamber and 222Rn based Methane and Carbon Dioxide Fluxes in Boreal Forest Soils

Techniques used

- Gas Chromatograph - flame ionization and thermal conductivity
- Alpha scintillation counter
- soil properties

Presently working on Ph.D. Interdisciplinary program

- modeling water and energy budgets for lakes
- climate reconstruction
- isotope analysis
- sediment analysis
  - magnetic susceptibility
  - loss on ignition
  - isotope
  - grain size
  - smear slides
- water analysis
  - hardness
  - alkalinity
  - isotope 18O
- tree-ring analysis and climate reconstruction
  - isotopes
  - ring width
  - density

Computer Experience

- Macintosh and PC
- some UNIX
- Graphing, word processing, spreadsheets, databases, slide making
- Programming FORTRAN, Basic, Pascal, Arc Macro programming
- Global Information System (GIS)

Past experience

1997-Teaching Assistant Shipboard Techniques and Bioacoustics
1997-Teachers Aid K-12 educators Global Change class
1990-present Graduate Assistant
1993- Teaching Assistant Oceanography

1989-Research technician Ecosystems- Marine Biological Laboratory
Lakes and river project
water analysis
fish catch and release (tag, weigh, and measure)

1986-1990 Math and Computer Teacher
Cape Cod Academy

1985-1986 Manager Alp-Hof Lodge

1981-1985 Research Assistant, Biological Oceanography, Woods Hole Oceanographic Institute
Field experience- 4 2-3 week cruises on the North Atlantic
Collecting zooplankton with MOCNESS system
chlorophyll analysis
Programming
Report writing

Professional Meetings
Spring AGU Montreal May 1992
AAAS Valdez Sept. 1992
Geological Society- Cordilleran section May 1995
PALE Feb. 94, 95, 96
AAAS Girdwood Sept. 1996

Alaska Women in Science
Workshop for Girlscouts- 1993, 1996

FACILITIES, EQUIPMENT AND OTHER RESOURCES

The Tree-Ring Laboratory (TRL) at Lamont-Doherty Earth Observatory (LDEO) in January of 1996 moved into a newly renovated building central to the Lamont campus. The TRL has equipment and facilities for field sampling, processing and analysis of tree core samples, sections, and other wood material. There is climate controlled storage and a woodshop for sample preparation. Microscope stations are set up for sample examination. There are several computerized measuring machines and image analysis systems. The measuring machines, based on our own design, have a precision of +/- 0.001 mm. There is a complete x-ray densitometer system comprising microtome and saw for sample preparation, x-ray machine and darkroom for producing film images, and a Dendro 2003 workstation for efficient image scanning. There are other computers and peripherals for processing large data sets and generating long plots for intercomparisons. We have a library of software developed for processing of tree-ring data. In another Lamont department there is a Laser Ablation/Plasma-Coupled Mass Spectrometer for chemical analysis of wood. Other resources are the libraries and support services of the Lamont-Doherty Earth Observatory.

BIOGRAPHICAL SKETCH

Gordon C. Jacoby
Senior Research Scientist
Tree-Ring Laboratory
Lamont-Doherty Earth Observatory
of Columbia University
Palisades, New York 10964
(914) 365 8616 FAX (914) 365 8152
E-mail: druid@ldeo.columbia.edu

Born:	14 August 1934, Fitchburg, Massachusetts
Military:	U. S. Marines, 1953-1956, Tank Driver
Education:	Ph.D. in Hydrogeology, Columbia University, 1971
Professional Experience:	Senior Research Scientist, Lamont-Doherty Geological Observatory of Columbia University (LDGO), 1987 - present Research Scientist, LDGO, 1984-1987 Research Associate, LDGO, 1975-1984 Research Hydrogeologist, Institute of Geophysics and Planetary Physics University of California at Los Angeles, 1971-1975 Visiting Professor, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire, winter term, 1973
Tree-Ring Experience:	Founded and have been chief scientist at the Tree-Ring Laboratory at Lamont-Doherty Geological Observatory since 1975
Scientific Organizations, Journals	International Union of Forestry Research Organizations Leader of Tree-Ring Analysis Group 1988-1990 National Research Council Member of Committee on Opportunities in Hydrological Sciences 1989-1990 American Association for the Advancement of Science American Geophysical Union; Comm. on Environ. Global Change Tree-Ring Society Geology: Editorial Board; Jan. 1995-
Meetings:	International Meeting on Stable Isotopes in Tree-Ring Research 22-25 May 1979, New Paltz, New York Convener and Editor of proceedings volume International Symposium on Ecological Aspects of Tree-Ring Analysis 17-21 August 1987, Tarrytown, New York Chairman of Organizing Committee and Compiler of proceedings volume

Gordon C. Jacoby: Five Related & Five Significant Publications

Five Related

Jacoby, G.C., R.D. D'Arrigo and Ts. Davaajamts, Mongolian tree rings and 20th century warming, **Science**, 273, 771-773, 1996.

Jacoby, G.C., G.C. Wiles and R.D.D'Arrigo, Alaskan dendroclimatic variations for the past 300 years along a north-south transect, In Tree Rings, Environment and Humanity, J.S. Dean, D.M. Meko and T.W. Swetnam, eds. **Radiocarbon**, 235-248, 1996.

Jacoby, G.C. and R.D. D'Arrigo, Comment on "Comparison of proxy records of climate change and solar forcing" by T.J. Crowley and K. Kim, **Gephys. Res. Lett.**, 23, 2197-2198, 1996.

Jacoby, G.C. and R.D. D'Arrigo, Tree-ring width and density evidence of climatic and potential forest change in Alaska, **Global Biogeochemical Cycles**, 9, 2, 227-234, 1995.

D'Arrigo, R. D., Jacoby, G. C. and Free, R. M. 1992. Tree-ring width and maximum latewood density at the North American tree line: parameters of climatic change. **Can. Jour. of For. Res.** 22, 9, 1290-96.

Five Significant

Jacoby, G. C. and D'Arrigo, R. D. 1992. Global change and thermal history as recorded by northern North American tree-ring data, **Proceedings of the International Conference on the Role of the Polar Regions in Global Change**, University of Alaska, Fairbanks,v. I, 599-605.

Jacoby, G. C., G. Carver and W. S. Wagner, 1995. Trees and herbs killed by an earthquake ~300 yr ago at Humboldt Bay, California, **Geology**, 23, 77-80.

D'Arrigo, R. D. and Jacoby, G. C. 1993. Secular trends in high northern latitude temperature reconstructions based on tree rings. **Climatic Change** 25, 163-177.

Jacoby, G. C. and D'Arrigo, R. 1989. Reconstructed Northern Hemisphere Annual Temperature since 1671 based on high-latitude tree-ring data from North America. **Climate Change** 14: 39-59.

Jacoby, G. C. and D'Arrigo, R. D. 1992. Spatial patterns of tree growth anomalies from the North American boreal treeline in the early 1800's, including the year 1816, In **The Year without a Summer ?: World Climate in 1816**, Harington, C. R., ed. Natl. Museum of Science, Ottawa, Canada, 225-265.

Collaborators: Brian Atwater, Raymond Bradley, Boyd Benson, Malcolm Hughes, Harvey Kelsey, Jonathan Overpeck, David Rind, Lonnie Thompson, David Yamaguchi

Graduate Students: Gregory Wiles, Scott Putnam, 4 grad students, 2 postdoctoral

Thesis Advisor: Arthur N. Strahler

Current and Pending Support
4/7/97

GORDON JACOBY

A Supporting Agency	B Project Title	C Award Amount	D Period Covered By Award	E Man-Months Acad. Sum. Ca'.	F Location
A. Current Support					
USGS USGS 1434-HQ-97-GR-03040	TREE-RING DATING OF COSEISMIC COASTAL SUBSIDENCE IN THE PACIFIC NORTHWEST REGION.	81,515	2/1/97 - 1/31/98	2	LDEO
USGS USGS 1434-HQ-97-GR-03017	RENEWAL OF USGS 1434-94-G-2451: TREE-RING DATING OF COSEISMIC COASTAL SUBSIDENCE IN THE PACIFIC NORTHWEST REGION.	50,000	1/1/97 - 12/31/97	2	LDEO
*BERMUDA BIO BBSR #RPI 96-020	TREE-RING INDICES OF HIGH-FREQUENCY ATLANTIC SECTOR CLIMATE VARIABILITY. (D'ARRIGO, R. COOK, E.)	31,073	9/1/96 - 8/31/97	1	LDEO
NSF ATM 96-31750	CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (D'ARRIGO, R.)	46,500	9/1/96 - 8/31/97	1	LDEO
NOAA NA56GP0235	DEVELOPMENT AND ANALYSIS OF CLIMATICALLY-SENSITIVE TREE-RING CHRONOLOGIES FROM DATA-SPARSE SITES ALONG THE NORTH PACIFIC RIM. *All Salary Expended (D'ARRIGO, R. WILES, G.)	101,927	4/1/95 - 3/31/98	1.5	LDEO
NOAA NA56GP0217	DEVELOPMENT OF TREE-RING CHRONOLOGIES FROM INDONESIAN AND THAILAND FOR DENDROCLIMATIC STUDIES. *All Salary Expended (D'ARRIGO, R.)	144,656	4/1/95 - 3/31/97	1/yr.	LDEO
NSF ATM 94-06732	DERIVATION AND ANALYSIS OF CLIMATIC INFORMATION FROM TREE RINGS. *All Salary Expended (COOK, E. D'ARRIGO, R.)	829,800	7/15/94 - 6/30/97	4/yr.	LDEO
B. Pending Support					
NSF	2ND INCREMENT ATM 96-31750: CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (D'ARRIGO, R.)	150,000	9/1/97 - 8/31/98	2	LDEO

A Supporting Agency	B Project Title	C Award Amount	D Period Covered By Award	E Man-Months Acad. Sum. Cal.	F Location
NSF	SUPPLEMENT ATM 96-31750: CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (D'ARRIGO, R.)	4,800	6/1/97 - 5/31/98	N/C	LDEO
NSF #8323	LONG-TERM HIGH RESOLUTION PALEOCLIMATE IN THE WRANGELL MOUNTAIN RANGE IN ALASKA. (WILES, G.)	447,476	7/1/97 - 6/30/00	3/3/3	LDEO
NSF #8309	TREE RINGS, PALEOCLIMATE, AND SOLAR FORCING: STUDIES IN NORTHERN SIBERIA.	459,494	7/1/97 - 6/30/00	3/yr.	LDEO
NSF #8290	DEVELOPMENT OF TREE-RING CHRONOLOGIES FROM INDONESIA AND THAILAND FOR DENDROCLIMATIC STUDIES. (D'ARRIGO, R.)	174,842	7/1/97 - 6/30/99	.5/.5	LDEO
NOAA #7805	RENEWAL OF NA36GP0230: MODELING SEASONAL TO DECADAL-SCALE CLIMATE VARIABILITY FOR THE NORTH ATLANTIC SECTOR BASED ON DENDROCLIMATIC EVIDENCE FROM SURROUNDING LAND AREAS. (D'ARRIGO, R., COOK, E.)	187,581	4/1/97 - 3/31/00	1/yr.	LDEO

C. Outstanding Increments

NSF ATM 96-31750	YEAR 3, & 4. CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (D'ARRIGO, R.)	300,000	9/1/98 - 8/31/00	2/2	LDEO

D. Proposals Planned to be Submitted in Near Future:

NONE

E. Transfer of Support:

NONE

F. Other Agencies to Which Proposal Has Been/Will be Submitted:

NONE

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Education

Ph.D. in Geological Sciences,
Columbia University, 1989.
Thesis Advisor: Gordon C.Jacoby
M. Philosophy in Geological Sciences, Columbia University, 1986.
M.A.; B.S. in Biological Sciences/Botany,
S.U.N.Y. Binghamton, 1981.

Professional Experience

Associate Research Scientist, Lamont-Doherty Earth Observatory, 1991-present.
Instructor, Barnard College/Columbia University/CERC, spring 1995-present.
Course taught: Forests and Environmental Change
Associate Editor, Canadian Journal of Forest Research, 1993-present.
Member of Affirmative Action Committee, Columbia University, fall 1993-present
Post-Doctoral Research Scientist, Lamont-Doherty Earth Observatory, 1989-1991.
Research Technician, Tree-Ring Laboratory at Lamont-Doherty Earth Observatory of Columbia University, Palisades, N.Y., Spring 1983-Fall, 1983.
Research Technician and Environmental Educator, The New York Botanical Garden, Bronx, N.Y. 1981-83.
Senior Teaching Assistant, S.U.N.Y. Binghamton, General Botany/Cell Biology, 1978-80

Scientific Organizations

American Geophysical Union, American Association for the Advancement of Science, NY Academy of Sciences.
Sigma Xi

Awards

Heezen Prize, 1988, Lamont-Doherty Earth Observatory

Field Investigations

Canada, Alaska, Indonesia, Madagascar, New Zealand, Japan, Mongolia

Recent Collaborators

Robert Allan Glen Juday Brian Luckman
William Schuster Michael Barbetti

D'Arrigo, R. D. and G. C. Jacoby. Northern North American tree-ring evidence for regional temperature changes after major volcanic events (**submitted, Climatic Change**).

D'Arrigo, R. D. et al. Progress in dendroclimatic investigations in Thailand (**to be submitted. IAWA Bulletin**).

Book Chapters

D'Arrigo, R.D. and Jacoby, G.C. 1992. Dendroclimatic evidence from northern North America. In: **Climate since AD 1500**. R.S.Bradley and P.D. Jones (eds). Routledge, London. pp. 296-311.

D'Arrigo, R.D. and G.C.Jacoby. 1992. A tree-ring reconstruction of New Mexico winter precipitation and its relation to El Niño/Southern Oscillation events. In: V.Markgraf and H.Diaz, eds. **El Niño: Historical and Paleoclimatic Aspects of the Southern Oscillation**. Cambridge University Press pp.243-257.

Jacoby, G.C. and D'Arrigo, R.D. 1992. Spatial patterns of tree growth anomalies from the North American boreal treeline in the early 1800's, including the year 1816, in **The Year without a Summer?**: World Climate in 1816, Harington, C.R., Ed. Natl. Museum of Science, Ottawa, Canada, 225-265.

Jacoby, G.C. and R.D.D'Arrigo. 1995. Indicators of Climatic and Biospheric Change: Evidence from Tree Rings.pp. 108-118. In Proceedings, G.M. Woodwell and F.T.Mackenzie. **Biotic Feedbacks in the Global Climate System. Will the Warming Feed the Warming?** Oxford Univ. Press, NY.

Cook, E.R., B.M.Buckley and R.D.D'Arrigo. Decadal-scale oscillatory modes in a millenia-long temperature reconstruction from Tasmania. Paper presented at the **National Academy of Sciences Workshop on the Natural Variability of the Climate System on 10-100 Year Time Scales**, Irvine, CA. Sept. 21-24, 1992. **(in press)**.

Cook, E.R., B.M.Buckley and R.D.D'Arrigo. 1996. Inter-decadal climate variability in the Southern Hemisphere; evidence from Tasmanian tree rings over the past three millenia. **Proceedings of the NATO Advanced Research Workshop, Climate Variations and Forcing Mechanisms of the Last 2,000 Years.** Il Ciocco, Lucca, Italy, October 3-7, 1994, in Jones, P.D., Bradley, R.S. and J. Jouzel (eds). NATO ISI Series 141: 109-124.

D'Arrigo, R.D. and G.C. Jacoby. 1996. **Past Changes in Climate and Tree Growth in the Western Americas.** In Lawford, G., P.B.Alaback and E. Fuentes (eds.). High-Latitude Rainforests and Associated Ecosystems of the West Coast of the Americas. Climate, Hydrology, Ecology and Conservation. Springer-Verlag, New York. Proceedings Volume, AMIGO Conference, Sept. 21-26, Vancouver Island, 1992. pp. 75-88.

Jacoby, G.C., R.D. D'Arrigo and B.H. Luckman. 1996. Millenial and near-millenial dendroclimatic studies in northern North America. **Proceedings of the NATO Advanced Research Workshop, Climate Variations and Forcing Mechanisms of the Last 2,000 Years.** Il Ciocco, Lucca, Italy, October 3-7, 1994, in Jones, P.D., Bradley, R.S. and J. Jouzel (eds). NATO ISI Series 141: 67-84.

Selected Proceedings Papers/ Presentations

Buckley, B.M., R.D.D'Arrigo and G.C.Jacoby, 1991. Tree-rings as indicators of air-sea interactions in the northeast Pacific Sector. **Proceedings. Eighth Annual Pacific Climate (PACLIM) Workshop**, March 10-13, 1991 pp. 35-45.

Jacoby, G.C. and R.D. D'Arrigo.1992. Indicators of Climatic and Biospheric Change: Evidence from Tree-Rings.In: **Senate Hearing on Global Change Research: Indicators of Global Warming and Solar Variability**, before the Commission on Commerce, Science and Transportation, U.S.Senate, 122nd Congress, Second Session, U.S.Govt. Printing Office. Feb. 27, 1992.

Jacoby, G.C. and R.D.D'Arrigo. 1992. Global change and thermal history as recorded by northern North American tree-ring data. **Proceedings of International Conference on the Role of Polar Regions in Global Change**, Univ. of Alaska, Fairbanks.pp. 599-602.

Buckley, B., B.Barbetti, M.Watanasak, G.Jacoby and R. D'Arrigo. 1993. Southeast Asian tree-rings as proxy indices of monsoonal variability. Conference on: **High-Resolution Records of Past Climate from Monsoon Asia**. Taipei, Taiwan, April 21-23, 1993.

Burney, D.A., L.P.Burney, J.G. Rafamantanantsoa, R.D.D'Arrigo and G.C.Jacoby. 1993. Laminated sediment cores, tree-ring records, and laminated speleothems from Madagascar. **EOS Trans., AGU** Spring Meeting, May 24-28, 1993, Baltimore, MD.

Cook, E.R. and R. D. D'Arrigo.1993. Bureau of Meteorology Research Centre (BMRC) Research Report No. 36. **Climate Change and the El Niño-Southern Oscillation.** Proceedings of a Workshop, Melbourne, Australia 31 May-4 June 1993.

Cook, E.R., B.M.Buckley and R.D.D'Arrigo. 1993. Oscillatory modes of climate fluctuation since 300 B.C. in the Tasmanian sector of the Southern Hemisphere as reconstructed from tree rings. Proceedings, **Fourth International Conference of Southern Hemisphere Meteorology and Oceanography**, 29 March-2 April 1993, Hob. Tasmania.

D'Arrigo, R.D., G.C.Jacoby and G.Wiles. 1993. High-resolution tree-ring records from coastal Alaska and British Columbia: associations with northeast Pacific climate. SAM, NOAA **PICES North Pacific Marine Science Organization**, Seattle, WA October, 1993.

Calkin, P.E., Wiles, G.C., Jacoby, G.C., and D'Arrigo, R.D., 1994, Initial comparisons of glacial and tree-ring paleoclimate data: Northeastern Pacific: **Geological Society of America** Abstracts with Program, v.26 (7), p.A-176.

D'Arrigo, R.D., G.C.Jacoby and E.R.Cook. 1994. Western North Atlantic sea surface temperature reconstructions based on Labrador tree-ring data. Abstract, **24th Arctic Workshop**, INSTAAR, March, 1994.

Wiles, G., R.D.D'Arrigo and G.C.Jacoby. 1994. Northeastern Pacific temperature changes: high-resolution records from coastal trees. Abstract, **Annual PACLIM Workshop** and Proceedings Paper, April 1994.

Cook, E.R., B.M.Buckley and R.D.D'Arrigo. 1995. Inter-decadal climate variability in the Southern Hemisphere: evidence from Tasmanian tree rings over the past three millenia. In: C.M.Isaacs and V.L.Tharp (editors). 1995. Proceedings of the **Eleventh Annual Pacific Climate (PACLIM) Workshop**, April 19-22, 1994. Interagency Ecological Program, Techn. Rept. 40, Calif. Dept. Water Resources.

D'Arrigo, R.D., E.R.Cook , B.M.Buckley and F.J.Krusic. 1995. Tree-ring records from subantarctic forests in New Zealand. Invited paper, **IGBP-PAGES/PEP-II**

Nagoya Symposium on Paleoclimate and Environmental Variability in Austral-Asian Transect. Nov. 28-Dec. 1, 1995.

Jacoby, G.C. and R. D'Arrigo. 1995. Tree-ring evidence for regional cooling following major volcanic events. **IUGG Meeting**, Boulder, CO, July, 1995.

Jacoby, G. C. and R. D'Arrigo, 1995. **National Academy of Sciences Colloquium on Carbon Dioxide and Climate Change**. November 1995, Irvine, California.

Wiles, G.C., R.D.D'Arrigo and G.C.Jacoby. 1995. Modeling northeast Pacific ocean-atmosphere parameters using coastal tree-ring records. Abst., **25th Arctic Workshop**, Universite Laval, Quebec City, March 16-18, 1995.

Wiles, G.C., D'Arrigo, R.D., and Jacoby, G.C., 1995, Modeling north Pacific temperature and pressure changes from coastal tree-ring chronologies, in C.M. Isaacs and V.L. Tharp, **Proceedings of the Eleventh Annual Pacific Climate Workshop**, p. 67-78.

D'Arrigo, R. D. and Gordon C. Jacoby. 1996. Northern North American tree-ring evidence for regional temperature changes following major volcanic events. Proceedings volume. **Conference on Climate Variations and Biodiversity Change during the last Millenium**. Jan 8-9, 1996. Ottawa, Canada.

Jacoby, G. C., R. D. D'Arrigo and G. P. Juday. 1996. Climate change and effects on tree growth as evidenced by tree-ring data from Alaska. **IBFRO** (International Boreal Forest Research Association) meeting, St. Petersburg, Russia, August 1996.

Free, M., Robock, A., R. D'Arrigo and G. Jacoby. 1996. Solar, volcanic and anthropogenic effects on climate from 1400 to the present. Abstract, **American Geophysical Union**, Fall 1996 meeting.

D'Arrigo, R., G. Jacoby, A. Robock and M. Free. 1996. Comparison of modeled temperatures based on solar, volcanic and trace gas forcings with a hemispheric tree-ring temperature reconstruction. Abstract, **American Geophysical Union**, Fall 1996 meeting.

Jacoby, G. C. and R. D. D'Arrigo. 1996. Presentation, **Inter-American Institute Workshop**, Jasper, Canada, October 1996.

D'Arrigo, R. D. and E. R. Cook. Tree-ring indicators of hurricane parameters. Presentation, **Risk Prediction Initiative, Bermuda Research Station**, Principal Investigators Meeting, May 1997.

Jacoby, G.C., R. D'Arrigo and G. Juday. Indicators of recent environmental change in Alaska. Abstract, **Eighth International Global Warming Conference and Exposition**, Columbia University, May 1997.

D'Arrigo, R. D. 1997. Progress on dendroclimatic studies in Indonesia and Thailand. **IUFRO Meeting**, July 7, 1997, Pullman, Washington.

Current and Pending Support
4/9/97

ROSANNE D'ARRIGO

A Supporting Agency	B Project Title	C Award Amount	D Period Covered By Award	E Man-Months Acad Sum. Cal.	F Location
A. Current Support					
NSF ATM 97-07538	SOUTHEAST ASIAN DENDROCHRONOLOGY: A PAGES WORKSHOP AND THE FIRST SOUTHEAST ASIAN DENDROECOLOGICAL FIELDWEEK.	30,290	3/1/97 - 2/28/00	N/C	LDEO
NSF ATM 96-16975	TREE-RING DATA FROM SUBANTARCTIC FORESTS: INDICES OF SOUTHERN HEMISPHERE ATMOSPHERE-OCEAN CLIMATE VARIABILITY. (COOK, E.)	81,322	2/1/97 - 1/31/98	2	LDEO
*BERMUDA BIO BBSR #RPI 96-020	TREE-RING INDICES OF HIGH-FREQUENCY ATLANTIC SECTOR CLIMATE VARIABILITY. (COOK, E. JACOBY,G.)	31,073	9/1/96 - 8/31/97	1	LDEO
NSF ATM 93-21750	CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (JACOBY, G.)	46,500	9/1/96 - 8/31/97	1	LDEO
NSF ATM 96-27318	RENEWAL OF EAR 93-10093: DEVELOPING AN ABSOLUTELY-DATED HOLOCENE TREE-RING CHRONOLOGY FROM SUBFOSSIL HUON PINE IN TASMANIA FOR PALEOCLIMATIC AND ISOTOPE STUDIES. (COOK, E.)	252,360	7/1/96 - 6/30/99	1/yr.	LDEO
NOAA NA56GP0235	DEVELOPMENT AND ANALYSIS OF CLIMATICALLY-SENSITIVE TREE-RING CHRONOLOGIES FROM DATA-SPARSE SITES ALONG THE NORTH PACIFIC RIM. (JACOBY, G , WILES, G.)	101,927	4/1/95 - 3/31/98	1/yr.	LDEO
NOAA NA56GP0217	DEVELOPMENT OF TREE-RING CHRONOLOGIES FROM INDONESIAN AND THAILAND FOR DENDROCLIMATIC STUDIES. (JACOBY, G.)	144,686	4/1/95 - 3/31/97	2/yr.	LDEO
NSF ATM 94-16662	TREE-RING DATA FROM SUBANTARCTIC FORESTS: INDICES OF SOUTHERN HEMISPHERE ATMOSPHERE-OCEAN CLIMATE VARIABILITY. (COOK, E.)	180,000	2/15/95 - 7/31/97	5	LDEO

A Supporting Agency	B Project Title	C Award Amount	D Period Covered By Award	E Man-Months Acad Sum. Cal.	F Location
NSF ATM 94-06732	DERIVATION AND ANALYSIS OF CLIMATIC INFORMATION FROM TREE-RINGS. (JACOBY, G., COOK, E.)	829,800	7/15/94 - 6/30/97	4/yr.	LDEO

B. Pending Support

NSF	2ND INCREMENT ATM 96-31750: CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (JACOBY, G.)	150,000	9/1/97 - 8/31/98	3	LDEO
NSF	SUPPLEMENT ATM 96-31750: CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (JACOBY, G.)	4,600	6/1/97 - 5/31/98	N/C	LDEO
NSF #8290	DEVELOPMENT OF TREE-RING CHRONOLOGIES FROM INDONESIA AND THAILAND FOR DENDROCLIMATIC STUDIES. (JACOBY, G.)	174,842	7/1/97 - 6/30/99	2.5/3	LDEO
NOAA #7805	RENEWAL OF NA36GP0230: MODELING SEASONAL TO DECADAL-SCALE CLIMATE VARIABILITY FOR THE NORTH ATLANTIC SECTOR BASED ON DENDROCLIMATIC EVIDENCE FROM SURROUNDING LAND AREAS. (COOK, E., JACOBY, G.)	187,581	4/1/97 - 3/31/99	3/yr.	LDEO

C. Outstanding Increments

NSF ATM 96-16975	YEAR 2 & 3: TREE-RING DATA FROM SUBANTARCTIC FORESTS: INDICES OF SOUTHERN HEMISPHERE ATMOSPHERE-OCEAN CLIMATE VARIABILITY. (COOK, E.)	154,439	2/1/98 - 1/31/00	3/3	LDEO
NSF ATM 96-31750	YEAR 3 & 4 CLIMATE CHANGE IN MONGOLIA AND ITS ROLE IN GLOBAL ENVIRONMENTAL CHANGE. (JACOBY, G.)	300,000	9/1/98 - 8/31/00	3/3	LDEO

D. Proposals Planned to be Submitted in Near Future:

NONE

E. Transfer of Support:

NONE

F. Other Agencies to Which Proposal Has Been/Will be Submitted:

NONE

1998 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET
October 1, 1997 - tember 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$53.1
Travel		$16.4
Contractual		$41.0
Commodities		$2.0
Equipment		$0.0
Subtotal	$0.0	$112.5
Indirect		$26.1
Project Total	$0.0	$138.6
Full-time Equivalents (FTE)		17.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$105.0	$0.0	$0.0	$0.0	

Dollar amounts are shown in thousands of dollars.

Comments: Indirect = 25% of Personnel, Travel, Commodities, and Air Charter portion of Contractual (= .25 X 1.025= 25.6)
plus 5% of subcontract to LDEO (0.05 X 10.0 = .5)

1998

Prepared: 04/12/97

Project Number:
Project Title: Tree-Rings:Ecosystem Implications for Injured Resources
Name: University of Alaska Fairbanks, Ag. & Forestry Exp. Station

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs: Name		Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1998
G.	Juday	Principal Investigator		2.0	10.268		20.5
V.	Barber	Graduate student		8.0	1.224		9.8
V.	Barber	Research Associate (Ph.D.)		4.0	2.510		10.0
R.	Solomon	Research Technician		3.0	4.254		12.8
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		17.0	18.3	0.0	
						Personnel Total	$53.1

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1998
(All travel for UAF + LDEO personnel indicated)					0.0
Fairbanks-New York and New York-Anchorage (sampling, analysis)	0.850	6	30	0.1	8.1
Fairbanks-Anchorage (sampling, EVOS Workshop)	0.200	5	6	0.1	1.6
Anchorage-Kodiak (sampling)	0.400	5	12	0.1	3.2
Anchorage-Valdez (sampling)	0.225	5	6	0.1	1.7
mileage (2000 mi @ $0.25) (sampling)	0.500	1	5	0.1	1.0
Field per diem (sampling)			15	0.050	0.8
					0.0
(2 work trips to New York to be combined with attendance at					0.0
Ecological Society Mtg. @ Baltimore for G. Juday and V. Barber, extra					0.0
cost = $600 ea. for registration, travel, lodging)					0.0
					0.0
				Travel Total	$16.4

1998

Prepared: 04/12/97

Project Number:
Project Title: Tree-Rings:Ecosystem Implications for Injured Resources
Name: University of Alaska Fairbanks, Ag. & Forestry Exp. Station

FORM 4B
Personnel
& Travel
DETAIL

1998 EXXON VALDEZ TRUSTI)UNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1998
1 Subcontract to Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Tree-Ring Laboratory G. Jacoby and R. D'Arrigo (Co-PIs at LDEO), Research tech. @LDEO (includes supplies, Columbia University indirect cost on subcontract)	35.0
2 Air charter	6.0
Contractual Total	$41.0

Commodities Costs:	Proposed
Description	FY 1998
1 Tree-ring sampling commodities (replacement increment corers, wood core mounting sticks, extraction chemicals filter paper, glassware, sandpaper belts, blades, sample vials, waterproof notebooks, replacement field gear	2.0
Commodities Total	$2.0

1998

Prepared: 04/12/97

Project Number:
Project Title: Tree-Rings:Ecosystem Implications for Injured Resources
Name: University of Alaska Fairbanks, Ag. & Forestry Exp. Station

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
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	

1998

Prepared: 04/12/97

Project Number:
Project Title: Tree-Rings:Ecosystem Implications for Injured Resources
Name: University of Alaska Fairbanks, Ag. & Forestry Exp. Station

FORM 4B
Equipment
DETAIL

Status and Evaluation of Factors Limiting Recovery of the Black Oystercatcher

Project Number:	98359
Restoration Category:	Research and Monitoring
Proposer:	Richard B. Lanctot, Ph.D., Research Wildlife Biologist U.S. Geological Survey, Biological Resources Division (USGS-BRD) 1011 East Tudor Road, Anchorage, Alaska 99503 phone: 907-786-3609, fax: 907-786-3636 e-mail: richard_lanctot@nbs.gov
Lead Trustee Agency:	USGS-BRD
Cooperating Agencies:	DOI-FWS, DOI-NPS
Alaska SeaLife Center:	
Duration:	1st year, 4-year project
Cost FY 98:	$94,200
Cost FY 99:	$121,800
Cost FY 00:	$122,600
Cost FY 01:	$46,200
Geographic Areas:	Prince William Sound, Glacier Bay, Kodiak Island
Injured Resource/Service:	Black Oystercatcher (Haematopus bachmani), Nearshore Ecosystem

ABSTRACT

Black oystercatcher populations were damaged both directly and indirectly from the *Exxon Valdez* oil spill and their recovery status is unknown. This proposal presents a plan of action for improved monitoring of the black oystercatcher and an investigation into several factors (e.g., demography, oil toxicity, food, population sub-structuring) that may be limiting recovery. The species' unique role as an apex predator in the nearshore environment demands an ecosystem approach to our study that will reveal interactions among predator and prey.

INTRODUCTION

The black oystercatcher occurs along the Pacific Coast of North America from Alaska to Baja California. The species is one of the few vertebrates completely dependent on the intertidal zone for its food and nesting. Because the nearshore ecosystem served as a repository for much of the oil spilled by the T/V *Exxon Valdez*, the black oystercatcher was especially vulnerable to short- and long-term effects of the oil spill. Indeed, 20% of the black oystercatcher population inhabiting the spill zone suffered direct mortality as a result of the oil spill (280 of 1,400 individuals, Andres 1994a). Indirect effects from oiling, such as aborted nesting, lower hatching and fledging success, ingestion of oil by adults and chicks, and slower growth rates have also been recorded (Sharp and Cody 1993, Andres 1994a, in press). Oystercatchers may also be susceptible to oiling in the winter as most feeding and roosting areas occur in protected bays and inlets where oil contamination may be more long-term (Babcock et al. 1996). Population monitoring programs conducted after the oil spill indicate oystercatchers in oiled areas have not recovered (Klosiewski and Laing 1994, Agler and Kendall 1997), although the accuracy of such counts are debateable (see below).

In this study, we propose conducting systematic surveys of known breeding and wintering sites to more accurately determine the recovery status of the population. We propose evaluating four factors (demography, oil exposure, food limitations, and population structure) that may be limiting recovery (Table 1). In designing this study, we closely followed the outline of the Nearshore Vertebrate Predator Proposal (NVPP 1994, project 95025). We have co-ordinated with several principal investigators within the Nearshore Vertebrate Predator project to share data on food competition and availability, oil exposure to mussel beds, and location of breeding and wintering birds.

Although this study focuses on one species, in many ways it provides a window to the health of the nearshore ecosystem by studying one of the system's apex predators. Oystercatchers potentially compete with sea otters (*Enhydra lutris*), river otters (*Lutra canadensis*) and sea ducks for macrofaunal invertebrates (NVPP 1994), and are known to influence and be influenced by the structure of the nearshore vertebrate and invertebrate communities (e.g., Hayn and Denny 1989, Falxa 1992). The oystercatchers role as an apex predator means changes in its population directly or indirectly influence the invertebrates they prey upon, the invertebrates and vertebrates with which they compete, and the larger vertebrates that prey upon them. In our study, we will attempt to document these interactions, as we endeavour to establish workable restoration objectives.

NEED FOR THE PROJECT

A. Statement of the Problem

Comparisons of the number of black oystercatchers sighted in oiled and unoiled areas of Prince William Sound between 1989 and 1996 indicate oystercatchers have not recovered from the effects of the EVOS (Agler and Kendall 1997). These surveys, however, provide only rough estimates of bird numbers because boat transects miss known breeding and wintering sites (Andres, pers. comm.). Surveys which specifically target areas inhabited by oystercatchers are needed to determine the current status of black oystercatchers in Prince William Sound.

EVOS funded investigations of the black oystercatcher in the late 1980s and early 1990s indicate population recovery may be constrained by several factors, including demographics, continued exposure to oil, limited food availability, or genetic factors unrelated to food or oil. Simultaneous investigations into each of these factors is needed to document the potential limitations each plays in population recovery and to identify appropriate restoration actions.

B. Rationale/Link to Restoration

What is the status of the black oystercatcher?

According to the EVOS Restoration Plan (EVOSTC 1994), the "black oystercatcher will have recovered when Prince William Sound populations attain prespill levels and when reproductive success of nests and growth rates of chicks raised in oiled areas are comparable to those in unoiled areas."

Marine boat surveys indicate that black oystercatchers have not met the first criterion of attaining prespill population levels (Agler and Kendall 1997). Unfortunately, these surveys provide a poor index to oystercatcher numbers because boat transects fail to sample many known breeding and wintering locations. Shoreline censuses designed specifically for oystercatchers are needed to accurately assess the status of this species. Such species specific surveys were last conducted in 1993 (Andres 1994a, 1996) and consisted of visiting known breeding locations (i.e., nesting sites) in oiled and unoiled portions of western Prince William Sound. The black oystercatcher's habit of reusing old nest sites (Andres and Falxa 1995) makes this the most reliable method of monitoring breeding oystercatcher numbers. Although a single survey might be suitable for generating a point estimate of the number of breeding pairs, repeated surveys within and across years are needed to determine recovery status (i.e., population trends) and to evaluate other recovery criteria and constraints (see below).

The second recovery criterion is based on the reproductive success of birds found in oiled and unoiled areas. Nests have hatched and young have fledged at similar rates at oiled and unoiled areas in recent years (Sharp and Cody 1993, Andres, in press). However, these comparisons are confounded by unequal numbers of predators in oiled and unoiled areas. For example, nests located on unoiled Montague Island are exposed to substantially higher numbers of predators, such as the common raven (*Corvus corax*) and river otter, than nests located on oiled Green Island (Andres 1996). Thus the increased risk of predation to unoiled nests and young may bias comparisons. Given the small number of nests (usually < 15) associated with oiled and unoiled areas, it is difficult to control for the effects of predation statistically. Accordingly, we propose to increase the overall survey area to include additional unoiled islands in Prince William Sound where predator numbers are lower. This will also increase the number of monitored nests providing more accurate demographic data. Repeated surveys throughout the breeding season will ensure all breeding attempts are recorded (e.g., failed breeders, renesters) and that hatching success of less studied pairs is documented.

The third recovery criterion is based on growth rates of chicks between oiled and unoiled areas. Throughout 1991-93, chicks in oiled areas grew slower than chicks in unoiled areas (Andres 1994a, 1996). In addition, analyses of fecal samples collected in 1992-93 indicated that some chicks were being exposed to oil through contaminated food brought to them by adults (Andres

1996). Exposure to hydrocarbons may result in reduced juvenile survival and ultimately lower recruitment of adults into the breeding population. One way to evaluate this possibility is to relocate oystercatchers banded as juveniles in the early 1990s. Occasional sightings of banded oystercatchers in recent years indicate a number of these birds have survived and may have entered the breeding population (Andres, pers. comm.). A low recruitment rate of birds banded as juveniles in oiled areas, relative to those banded in unoiled areas, would suggest a long-term negative effect from oil exposure. Additionally, birds captured during the winter months can be aged to provide an estimate of the proportion of hatching year, second year, and after second year birds. These age class proportions provide a direct measure of chick survival that can be compared among wintering areas in oiled and unoiled areas of Prince William Sound and between the Sound and other locations in the Pacific Rim.

Are black oystercatchers recovering as quickly as possible?

Demographic constraints?

Black oystercatcher recovery may be constrained by low intrinsic reproductive capacity. Oystercatchers have a low birth rate (1-3 young) and a delayed maturation period (adults begin breeding at 5 years of age; Andres and Falxa 1995). This reproductive lag means the effects of low chick production during the initial spill years may not be seen until much later, when young would normally enter the breeding population. Sharp and Cody (1993) estimated 635 and 293 chicks were not produced in 1989 and 1990, respectively, because adults failed to breed due to oiling of breeding territories and disturbances associated with clean-up activities. Fortunately, surveys proposed for 1998 - 2000 will provide some information on juvenile recruitment into the breeding population. Chicks banded in 1991 by Andres should have begun entering the breeding population in 1996 (three years after the last intensive survey on the species) and birds banded in 1993 will begin entering the breeding population in 1998 (the first year of this study). If the majority of the 1989-90 cohorts are missing, the number of breeding pairs residing in oiled islands may be expected to decrease because maturing adults are unavailable to occupy vacant territories.

Very little demographic data are available for black oystercatchers in Prince William Sound. Information on breeding and wintering site fidelity, adult survival and movement patterns is badly needed. Such basic information is crucial for understanding the extent of past and ongoing injury and to determine limitations to recovery and restoration strategies. For example, knowing whether one pair returns year-after-year to breed on the same nesting territory will help interpret changes in survey counts. Similarly, estimates of adult annual survival will provide a clearer picture of the population dynamics of the species and hence what limits population growth. Following individual pairs through time will generate information on inter-annual variation in breeding effort and nesting success that confound traditional point estimates of reproductive success. We propose an intensive breeding and wintering banding program that will allow these parameters to be measured for the first time.

Continued Oil Exposure?

Black oystercatchers may be especially susceptible to continued oil exposure because of their complete dependence on the intertidal area for food and nesting (Andres 1996). This area served as the deposition site for much of the *T/V Exxon Valdez* oil (ADEC 1992, Morris and Loughlin

1994). Prey items preferred by black oystercatchers, such as mussels (Andres and Falxa 1995), have been found to have chronically high levels of hydrocarbons in oiled areas (Babcock et al. 1994, Babcock et al. 1996). Fecal samples from chicks also revealed exposure to oil through contaminated prey items (Andres 1996). Because black oystercatchers limit their activities to discrete foraging and nesting territories, the potential for oil exposure can be calculated by superimposing oystercatcher territories on oil distribution maps. Most other apex predators travel over large areas, making the level of oil exposure difficult to measure. The potential for oil exposure is further heightened if pairs are found to reuse nesting territories across years. Birds that feed in oiled areas may then be repeatedly exposed to oil. Repeated exposure to oil is thought to be responsible for the significantly higher levels of P450 in river otters occupying oiled sites relative to unoiled sites (T. Bowyer, pers. comm.). Information such as this, collected on an individual pair basis, may help explain variation in breeding effort, reproductive success, and chick growth rate and survival.

Wintering birds may also be extremely susceptible to oil because of their dependence on protected bays and inlets. Mussel beds within these areas may retain high levels of hydrocarbons because of the lack of natural wave action (Babcock et al. 1996). If birds tend to winter in the same spot across years (as documented in California and to limited extent in Prince William Sound; Falxa 1992, Andres, pers. comm.), they may be continually exposed to oil through ingestion of mussels. The level of current and past oiling in wintering (Morris and Loughlin 1994, M.Babcock and Andres, unpubl. data), can then be related to an individual's subsequent survival and reproductive success.

Food Availability?

Prey type, density, and size class distribution of various invertebrates, such as limpets, chitons, and mussels, may be influenced by several factors. Many invertebrates were killed or contaminated by oil from the T/V *Exxon Valdex* (Highsmith et al. 1993). Additionally, predation by oystercatchers and other predators (e.g., sea otters, sea ducks) are known to influence the abundance and average size of invertebrates. For example, oystercatcher predation influences the distribution, abundance, and size structure of local limpet populations, resulting in a loss of medium to large (>10 mm) limpets (Frank 1982, Marsh 1986, Andres, unpubl. data) The relationship between oystercatcher predation and mussel populations is less clear, although medium sized (28-40 mm) mussels appear to be preferred (Andres 1996). Together, limpets and mussels are the most important prey items of oystercatchers in Alaska, comprising 35% and 44% of the diet, respectively (Andres and Falxa 1995).

Based on these predator-prey relationships, we will address the hypothesis that food availability may be limiting recovery of the black oystercatcher by examining abundance and size distribution of major prey items in oiled and unoiled areas. If food is limiting recovery of oystercatchers in oiled areas, we would predict fewer prey to be found at oiled sites relative to unoiled sites. Similarly, we would predict a smaller relative proportion of the preferred prey size class in the oiled area if food is limiting recovery. The discreteness of oystercatcher foraging territories and the ease with which they can be monitored allows detailed measurements of prey availability to be made. In addition to our measurements, we will also use data collected on mussels by C. O'Clair (pers. comm.) to investigate mussel abundance and size distributions. The latter will be limited to instances where known oystercatcher territories overlap with mussel sample sites.

The interpretation of the abundance and size distributions of prey items is potentially confounded by prey growth and recruitment, as well as predation by other invertebrates and vertebrates (see Fig. 8, NVPP 1994). For example, sea ducks and sea otters can compete with oystercatchers for the same prey (or prey size). To examine this factor, we will record the presence of other predators feeding in known oystercatcher territories in oiled and unoiled areas. Territories with high numbers of competitors (>1 standard deviation above the mean number) will not be used in our analyses. We also hope to evaluate the effect of prey growth on size distribution data by incorporating results of a research study being proposed by C. O'Clair (pers. comm.).

Population Structuring?

Recovery of black oystercatchers in oiled areas may be constrained because the presence of distinct breeding populations inhibit emigration of individuals from outside. Such a scenario means population recovery is limited by the rate of local reproductive success and ultimately recruitment. We believe it is likely that such reproductively isolated populations may exist given the high adult breeding site fidelity and limited juvenile dispersal (Groves 1982, Falxa 1992) and the small population size of the black oystercatcher within Prince William Sound (≈1,000 Agler, pers. comm.).

Wintering oystercatchers have also been reported to use traditional feeding and roosting areas throughout their range (Andres and Falxa 1995), and banded individuals have been resighted at the same wintering areas for three or more years in California (Falxa 1992). Unfortunately, there is little information on where individuals from Prince William Sound go in winter; aerial surveys indicate that 75% or more of the birds that breed in Prince William Sound migrate to other areas (Andres 1994b). Large flocks of birds recorded at Glacier Bay (up to 600 birds) and Kodiak Island (up to 350 birds; Andres and Falxa 1995) suggest these are the most likely destinations for fall migrating individuals. It is unknown, however, how birds segregate between wintering areas. For example, do birds that breed in eastern Prince William Sound migrate to Glacier Bay while birds in western Prince William Sound migrate to Kodiak? It is also unknown where the birds that remain in Prince William Sound breed in the summer. Elucidating these migration patterns may help to understand why black oystercatchers in oiled areas have not recovered. It may be that birds breeding in oiled areas remain in Prince William Sound during the winter where they continue to be exposed to oil. Such a scenario seems likely on heavily oiled Green Island. Breeding birds on this island may prefer to winter at Gibbon Anchorage, a traditional wintering site on the northern side of Green. Given the persistently high level of oiling in the substrates and mussels on nearby Applegate Rock (Babcock et al. 1996), it seems likely these birds are exposed to oil in the winter as well.

The presence of a highly structured population within Prince William Sound would suggest specific populations have been (and may continue to be) affected by oil while others have not (and never were). Recovery of the affected populations then becomes limited to reproductive recruitment within a population as opposed to emigration from non-impacted populations. Knowledge of population structure is also critical for interpreting counts of black oystercatchers made during surveys within Prince William Sound. A comparison of counts made on heavily oiled Green Island and adjacent unoiled islands from 1989 to 1993 illustrate this point (Andres 1994a). During this time period, oystercatcher numbers increased on Green Island but remained stable or decreased on neighboring islands. An optimistic interpretation of these data is that the

Green Island birds had recovered from the effects of the oil spill. Alternative explanations, however, might include 1) reoccupation by oystercatchers displaced by oil spill disturbances, 2) occupation of vacated territories by previously non-breeding adults, and 3) recruitment of immature adults into the breeding population. These explanations would reflect movement of individuals from within the remaining population rather than a recovering population. We propose using both direct (mark-and-recapture) and indirect (biparentally and maternally inherited genetic markers) measures to estimate population structure, movements and relatedness among breeding and wintering areas.

C. Location

Many of our stated objectives proposed require comparisons between oiled and unoiled areas. For this study, we chose two oiled sites located at Green Island and Northern Knight Island, and two unoiled study sites at Montague and southwestern Knight islands. Special emphasis will be placed on following oystercatchers in Herring Bay and the Bay of Isles on Knight Island; and Stockdale Harbor, Port Chalmers and Mooselips Bay of Montague Island. These locations have been used extensively by researchers of the Nearshore Vertebrate Predator project (#96025), allowing maximum overlap in information sharing and logistics. Green Island and Southwestern Knight Island were chosen especially because breeding pair increases and decreases, respectively, were recorded between 1991 and 1993 (Andres 1994a). Such changes suggest movement of birds may be occurring between these two locations and as such provide important areas to study population differentiation. In addition, surveys will be conducted in other regions of the Sound, including Latouche, Elrington, Evans, Bainbridge and Chenega islands, so that the potential confounding effects of predator numbers may be investigated.

Several wintering sites in and outside of Prince William Sound will be visited to band birds and collect blood samples, as well as to search for birds banded in other locations and in the same location in prior years. Wintering sites within Prince William Sound will include Gibbon Anchorage on Green Island, Port Chalmers and Rocky Bay on northeastern Montague Island, and Constantine Harbor on Hinchinbrook Island. Hanning Bay, on southern Montague Island and Latouche Island will also be surveyed for wintering flocks. Wintering sites outside the Prince William Sound will include Chiniak Bay on Kodiak Island (R. MacIntosh, D. Zwiefelhofer, pers. comm.) and the Beardslee Islands in the Glacier Bay National Park (H. Lentfer, pers. comm.). Our research at Glacier Bay National Park and Preserve and Kodiak National Wildlife Refuge will help identify key wintering sites in the area so that maps outlining oystercatcher distribution and abundance may be constructed.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Every effort will be made to encourage public involvement in this study. Local knowledge of breeding and wintering areas of black oystercatchers will be solicited from land owners, commercial operators and interested private parties within each of the proposed study areas. Hunters, fishers, commercial tour providers and lodges will be solicited to report sightings of banded oystercatchers. Licensed/permitted wildlife tour companies that routinely operate in Kenai Fjords and Glacier Bay National Parks, and Kodiak National Wildlife Refuge will be solicited for information on oystercatcher distribution and band resightings. Information on

oystercatcher locations will also be requested from subsistence mussel collectors who routinely travel throughout the Sound. Posters advertising the presence of banded black oystercatchers will be erected in communities near the proposed study areas to ask for the assistance of local people and visitors in locating banded birds. We will specifically target the large number of sea kayakers that visit Glacier Bay during the summer months. Information learned during the study will be relayed back to local people via direct correspondence (e.g., all banded bird reports will be answered individually), local newspaper information, and posters.

PROJECT DESIGN

A. Objectives

Fiscal Year 1998

1. Conduct surveys that specifically monitor breeding and wintering black oystercatchers in Prince William Sound.

2. Capture, band, and collect blood samples from black oystercatchers in Prince William Sound.

3. Conduct preliminary genetic analyses on black oystercatcher blood samples to identify suitable markers for study.

Overall Project Objectives

1. Determine the status of recovery of black oystercatcher populations in Prince William Sound.

2. Determine if recovery of the black oystercatcher is constrained by continued oil toxicity.

3. Determine if recovery of the black oystercatcher is constrained by food availability.

4. Determine if recovery of the black oystercatcher is constrained by demographic factors.

5. Assess spatial segregation and population differentiation of breeding and wintering black oystercatcher populations in western Prince William Sound, Glacier Bay and Kodiak Island using direct and indirect techniques.

6. Determine appropriate restoration actions, based on answers to objectives 1-5.

B. Methods

Capture, banding and resighting effort

Intensive efforts will be made to capture 20-30 breeding adults and their chicks on each of our oiled and unoiled study areas. Adults will be captured when returning to their nests with snap or

walk-in traps. Snap traps have been successfully used to capture nesting black oystercatchers in British Columbia (S. Hazlitt, R. Campbell, pers. comm.) and walk-in traps have been used successfully for American oystercatchers (*Haematopus palliatus*) in Virginia (E. Nol, pers. comm.). Brood-rearing oystercatchers typically attack Common Ravens (*Corvus corax*) and gulls (*Larus* sp.) approaching their young (Andres, pers. comm.). This aggressive behavior is also exhibited towards humans and allows adults to be captured with mist nests. This technique has proven successful in capturing adults of other similarly aggressive shorebirds (Lanctot et al. 1995). Chicks will be captured in the nest site when possible, or opportunistically at a later age when found on beaches. Wintering birds will be captured with cannon nets and mist nets at locations where flocks aggregate. This work will be done in collaboration with researchers conducting other winter work when possible (e.g., capturing wintering harlequin ducks, *Histrionicus histrionicus*; T. Bowman, pers. comm. or conducting winter surveys on Kodiak Island, D. Zwiefelhofer, pers. comm.). Cannon nets have been successfully used to capture Eurasian oystercatchers (*Haematopus ostralegus*; Ens 1992) and mist nets have been used to capture non-breeding black oystercatchers in British Columbia (R. Campbell, pers. comm.).

All adults and chicks will be weighed and measured (tarsus, culmen, bill depth and length, and wing lengths), and the color of each bird's bill and iris will be recorded. Adults will be sexed based on within-pair differences in size of bill, wing, and tarsus (females are larger), and verified with behavioral observations of pairs (e.g., copulation position). Individuals will be categorized into three age classes based on bill and iris color, including hatching year, second year, and after second year. Blood will also be collected from adults and chicks to allow for genetic (see below) and health assays (if deemed necessary in the future). Adults and chicks will be banded with a U. S. Fish and Wildlife Service metal band and a unique combination of color bands on their tibio-tarsus. Each bird will have a green flag placed on its right leg to denote that it was banded in the United States as required by the Pan American Shorebird Banding program. A unique band color will be placed above the green flag at each study site to enhance our ability to detect movement of birds between areas (e.g., Glacier Bay birds will have an orange band above the green flag). Coordination with other researchers studying black oystercatchers will ensure duplicate band combinations are not used (e.g., B. Andres, R. Butler, R. Campbell, pers. comm.).

Population Monitoring and Demography

Breeding Surveys

Two-person crews will search shorelines by boat or on foot to determine the presence of breeding oystercatchers. Searches will be conducted throughout the oiled and unoiled areas during four time periods between mid-May and mid-August to ensure all breeding attempts are recorded (e.g., failed breeders, renesters) and to document breeding success of less studied pairs. Standardized survey methods (see Andres, 1994a, 1996) will be used so that population comparisons can be made across years. All breeding territories found in previous years will be checked in 1998-2000, allowing comparisons to be made of the total number of birds seen in each year. The black oystercatcher's habit of alarm calling and flying towards intruding humans should maximize our detection of breeding pairs across years. Additional islands within the Sound will be surveyed during this study so that the confounding effect of uneven predation on nests within oiled and unoiled areas can be minimized (i.e., a large sample of nests from a large area will swamp out uneven predator numbers). These periodic summer visits, combined with an intensive banding program, will provide information on breeding pair numbers, breeding site

fidelity, nesting effort, hatching success, juvenile recruitment, and over-winter survival (see below).

Winter Surveys

Visits will be made to wintering sites during fall (November) and winter (March) in 1997 -2000. Surveys of Glacier Bay National Park and Kodiak Island will be delayed until the second year of the study. By then we might be able to resight individuals banded on the breeding grounds in Prince William Sound. Shorelines will be searched by two-person crews in boats to document the distribution and total number of birds. All birds will be approached and checked for bands and extensive efforts will be made to capture birds when aggregations are found (see above). Emphasis will be placed on visiting areas where birds have been recorded historically (H. Lentfer, R. MacIntosh, D. Zwiefelhofer, pers. comm.). This information will be used to prepare maps showing population distribution and densities for Glacier Bay National Park and portions of Kodiak Island.

Annual Survival and Migration Pattern Analyses

Estimates of annual survival and migration patterns rely on resightings of banded birds. To maximize sightings, all oystercatchers detected during breeding and winter shoreline surveys will be approached and checked for the presence of bands. Reading tarsus bands on black oystercatchers is particularly easy because of the species' habit of flying towards humans (especially nesting adults) and landing on nearby intertidal rocks. We will also coordinate and encourage other Trustee agency and local-area cooperators to read tarsus bands on black oystercatchers (see Community Involvement).

Resightings of individually marked oystercatchers on their breeding territories in subsequent years will be used to determine annual survival estimates. Probabilities of survival and reobservation will be calculated using Jolly-Seber capture-recapture procedures (Leberton et al. 1992). Variations in survival and reobservation among years for each banded cohort will be examined with likelihood ratio tests between survival models. These models take into account birds that were not resighted but were actually still alive (but failed to return to the same site), and thus represent a more robust estimate of annual survival than that based simply on resightings of banded adults. This technique requires that at least three years of data be collected to account for resighting probabilities (i.e., banding year plus two resighting years; D. Ward, pers. comm.). Similar estimates of annual survival have been conducted on other shorebirds such as Snowy Plovers (*Charadrius alexandrinus*, Paton 1994) and Semipalmated Sandpipers (*Calidris pusilla*, Sandercock and Gratto-Trevor, in press).

Banded birds detected in wintering areas within and outside Prince William Sound will be traced to their respective breeding sites so an approximate picture of winter segregation of breeding birds can be constructed. We propose visiting wintering areas within and outside Prince William Sound for three and two different winters, respectively. Repeated visits to the same area will provide baseline information on individual winter site fidelity and migration patterns of adults between breeding and wintering sites. This information will also be helpful for interpreting population structuring data obtained from our genetic analyses (see below).

Foraging Behavior

Within oiled and unoiled areas, a sample of 10 breeding pairs each will be followed to determine feeding territory locations and to monitor food availability. Priority will be placed on studying pairs that forage in areas previously sampled for mussel abundance and oil (Nearshore Vertebrate Predator project # 96025). In addition, at each feeding site, three variable-length transects will be placed parallel to the shoreline within the intertidal area during low tide (approximately in the location adults are seen to feed). Along each transect five 0.25 m^2 quadrats will be placed at random distances along the line. The species composition and abundance of the dominant invertebrates (see Andres and Falxa 1995) eaten by black oystercatchers will be recorded. Further, limpets and mussels will be quantified into age class distributions. Comparisons of prey abundance and size class distribution will then be made between pairs in oiled and unoiled areas using a unpaired t-test and log-likelihood G test, respectively.

Exposure to Oil

The possibility of oystercatchers being exposed to oil will be evaluated by superimposing breeding territories and winter feeding and roosting sites on maps illustrating oil distribution (Morris and Loughlin 1994, M. Babcock and Andres, unpubl. data). We do not plan on conducting oil exposure or health assays on oystercatchers at this time because bioindicator analyses of two other apex predators (sea otters and harlequin ducks), that share similar habitats and food preferences, indicated no differences between oiled and unoiled sites (J. Bodkin, D. Esler, pers. comm.). Because bioindicator analyses found evidence of continued oiling in river otters (T. Bowyer, pers. comm.), we will collect the necessary samples from captured birds so that future analyses are possible. Demographic data (e.g., adult site fidelity, nesting success) collected on birds breeding or wintering in oiled locations will be compared to similar data collected on birds found in unoiled locations using one-way analysis of variance.

Population Genetics

The Approach

We propose using genetic markers to first, estimate the level of population structure within Prince William Sound, and second, to document the segregation of breeding birds on wintering areas. In this situation, a fine level of population structure might mean Green and Knight island birds are from different sub-populations (i.e., rarely interbreed) and thus subjected to different environmental perturbations. In contrast a course level of population structure might mean that all oystercatchers from within Prince William Sound are from the same sub-population. This genetic information will provide a clearer picture of which birds were (and may continue to be) exposed to oil both during the summer and winter, and identify how population recovery is affected by demography (i.e., emigration vs. local recruitment).

Virtually every genetic technique relies on some type of marker that identifies individuals in a unique way. For example, an individual may have a particular combination of two alleles for a single loci (microsatellite) or multiple alleles for multiple loci (multiple-locus minisatellite fingerprinting). The average similarity in these markers between individuals within and among populations provides an index of gene flow. Groups of individuals that share a high proportion of alleles are thought to be more closely related than groups of individuals that share a low

proportion of alleles. In this way, we can compare individuals sampled from within the same area and across different areas to see whether each breeding population is truly distinct or is an artificial separation based simply on geography but not supported by reproductive isolation.

The level of gene flow occurring between two populations may be measured by comparing markers generated from nuclear and mitochondrial DNA (mtDNA). Nuclear and mtDNA assays have been used extensively for estimating genetic distance between populations (Kuhnlein et al. 1989), for understanding parentage and breeding structure (Burke and Bruford 1987, Westneat 1990, Haig et al. 1993), and tracing dispersal patterns (Rabenold et al. 1990). Nuclear DNA is inherited through both the father and mother, while mtDNA is inherited through only the mother (Avise and Vrijenhoek 1987). This fact allows the effect of gender-biased gene flow (via sex-biased dispersal and natal philopatry) on genetic relatedness of individuals to be determined. For example, if females but not males are faithful to particular breeding locations across years, then analyses based on mtDNA will show low levels of average similarity values among breeding locations (i.e., strong matrilineal population structure, see Avise 1994). In contrast, if males (and/or females) move widely among breeding areas, nuclear DNA analyses will show high levels of average similarity values among breeding populations. Thus, the use of both mitochondrial and nuclear DNA analyses identifies more accurately the level, direction, and cause of gene flow occurring between two populations. Such information is critical because it may imply a considerable demographic independence among populations. In a situation where females exhibit high breeding site and natal philopatry, recruitment is contingent only upon reproductive success of the local females (i.e., emigration of females from other populations does not occur). Consequently, a population that is compromised or extirpated by human or natural causes (e.g., bird populations within oiled regions of Prince William Sound) will be unlikely to recover or re-establish in the short term (Avise 1995).

Sample Collection

Birds will be captured at a minimum of four breeding and three wintering sites within Prince William Sound, and at one to two wintering sites in Glacier Bay and Kodiak Island, respectively (Table 2). This sampling scheme will provide an excellent assessment of population differentiation locally (e.g., multiple breeding sites within Prince William Sound) and regionally (i.e., between Kodiak, Prince William Sound and Glacier Bay), as well as allow us to potentially identify the breeding origin of birds sampled in wintering locations.

Blood (200-300 µl) will be collected from 20-40 captured adults or chicks at each site by standard brachial or jugular venipuncture techniques to allow genetic assays (Hoysak and Weatherhead 1991, Lanctot 1994). Blood will be placed in 1.5 ml eppendorf tubes with 1 ml of non-refrigerated Longmire's buffer and labelled with the bird's U.S. Fish and Wildlife Service band number. DNA will be extracted using standard Proteinase K, phenol-chloroform techniques (Sambrook et al. 1989) and resuspended in TE (10 mM Tris-HCL, pH 8.0, 1 mM EDTA).

Nuclear DNA Analysis

Microsatellites developed for Eurasian Oystercatchers (provided by R. van Treuren, pers. comm.) will be surveyed for variation using an initial sample of 10 individuals selected from across the study sites. Extracted DNA will be resuspended in TE, and after determining concentration with

a fluorimetry, made into working stocks of 50 ng/100 µl of solution. Up to four microsatellite loci which show sufficient levels of variation will be used to characterize all individuals. PCR conditions for each primer pair will be optimized, visualized on 1.5% agarose gel using ethidium bromide staining, and later scanned for variation using gamma-^{32}P ATP end-labelled primers. Details for these procedures can be found in Mullis et al. (1994) and Ellegren (1992). We propose using the number of alleles per locus (A) and expected heterozygousity to estimate the level of microsatellite variation for each population. Chi-square analyses with pooling (Hartl and Clark 1988) will be used to test for deviations from Hardy Weinberg expectations. Estimates of the variance in allele frequency across populations will be determined using θ (see Weir and Cockerman 1984) and tested for significance by jack-knifing across samples (Weir 1990). Nei's (1972) estimate of genetic distance among populations, estimates of population allele frequencies and heterozygosity will be calculated using the BIOSYS-1 program (Swofford and Selanger 1981). The degree of gene flow among populations will be estimated using methods described by Slatkin (1985) based on the proportion of private alleles and the magnitude of θ among populations. We will also calculate a second measure of population differentiation (Rst) as described by Slatkin (1995).

Should the microsatellite loci fail to provide adequate levels of variation, we will use hypervariable multilocus minisatellite analyses (DNA fingerprinting). Mulitlocus minisatellites have been shown to be directly comparable to single-locus microsatellite data (Scribner et al. 1994). For this technique, 5 µg of DNA from each individual will be run on 1.0% agarose gels and transferred to nylon membranes using standard techniques (Sambrook et al. 1991; Bruford et al. 1992). Membranes will be hybridized with either polycore repeat 33.6 or one of four single-locus minisatellites cloned from ruff and used as multilocus probes for other shorebird species in our lab (provided by T. Burke, pers. comm.). Allele sizes for each locus will be determined empirically, and similarities among and within populations will be estimated based on fragment similarities (*S*, Lynch 1990, 1991). Kruskal-Wallis ANOVA, followed by Mann-Whitney U tests, will be used to determine if band sharing differed significantly within and between breeding and wintering populations. Wright's (1951) index of population subdivision, F_{st}, will be used to measure the fraction of genetic diversity attributable to population differentiation using Lynch's (1991) formula. An estimate of genetic distance (Nei 1972) and level of heterozygousity (Stephens et al. 1992) will also be determined. These techniques have been used successfully on other avian species at the Alaska Science Center's Molecular Ecology Lab.

Mitochondrial DNA analyses

We propose quantifying mtDNA variation within and among black oystercatcher populations using restriction-fragment length polymorphisms (Avise 1986). An initial assessment of mtDNA variation will be made by testing 10 individuals chosen from the entire geographic range of the study to 20 restriction endonuclease enzymes. Two polymorphic loci will be selected and all individuals will be analyzed for restriction site variation. Seven micrograms of DNA from each individual will be digested overnight in each of the variable restriction enzymes. Five microliters of the enzyme reaction mixture will be used to test for complete digestion, and the remainder will be run on large (20 x 30 cm) 0.8% agarose gels with Tris-Borate tank and gel buffers. Gels will be run for approximately 1800-2000 volt hours and stained with ethidium bromide (0.5 ug/ml) so that all fragments greater than 0.5 km in size will remain on the gels. DNA will be transferred to nylon membranes using standard capillary blotting techniques (Sambrook et al. 1991, Bruford et al. 1992) and fixed by UV irradiation for 3 minutes. Membranes will be hybridized with CsCl-

purified mtDNA labelled with ^{32}P using standard oligo-labeling protocols, washed under high stringency conditions and exposed to x-ray film to reveal individual haplotypes (Sambrook et al. 1989, Bruford et al. 1992). Haplotypic diversity will be used to estimate levels of genetic variation within each population. Estimates of population differentiation will be determined using the Phi_{st} statistic (Excoffier et al. 1992) and estimates of maternal gene flow will follow procedures described in Slatkin and Barton (1989).

An alternative approach to investigating mtDNA, should the restriction-fragment length polymorphisms procedures provide poor data, will be to sequence a portion of the Cytochrome b region of the mtDNA molecule. Here, the Cytochrome b region will be amplified in a sample of 10 females using mitochondria-specific PCR primers (provided by A. Baker, pers. comm.). Amplified products will be sequenced and checked for variation. Given sufficient variation, we will sequence all females sampled in the study and use the occurrences of unique haplotypes to estimate within and across population variation. To test whether the frequency of these haplotypes varies significantly across populations we will use log-likelihood G tests.

Comparison of Genetic Analyses and Band Resightings

Our proposal provides a direct (band resightings) and indirect (genetic) measure of population structuring in black oystercatchers. While these two techniques independently provide an estimate of population differentiation and gene flow, together they can help interpret historic patterns of gene flow. For example, if the banding data indicates a high level of population differentiation and the genetic data does not, it is likely that the oystercatcher population has only recently diverged and insufficient time has elapsed to allow genetic differences to evolve. In contrast, if the genetic data indicates a high level of population differentiation and the banding data does not, it is likely that reproductive barriers isolated oystercatcher populations have only recently broken down.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Cooperation in the form of logistical support and field personnel will be provided by DOI -NPS (Glacier Bay) and DOI - FWS (Migratory Bird Management, Anchorage, and Kodiak National Wildlife Refuge). Coastal logistics will be supplied by either government research vessels or contracted to private companies when government vessels are unavailable. Laboratory facilities and expertise for conducting mitochrondrial DNA and nuclear DNA analyses will be provided by the USGS-BRD (Scribner).

SCHEDULE

A. Measurable Project Tasks for FY 98

October 1 - 31, 1997:	Arrange logistics and field personnel for winter research.
November 1-15, 1997:	Winter surveys and capturing adults in Prince William Sound.
November 16 - February 29, 1998:	Arrange logistics and begin genetic analysis.
January 15-24, 1998:	*Reporting of project findings at Restoration Workshop.*
March 1- 15, 1998:	Winter surveys and capturing adults in Prince William

	Sound
March 16 - May 10, 1998:	Compilation and analyses of data, arrange logistics; and continue genetic analyses.
May 10 - August 20, 1998:	Breeding surveys in Prince William Sound (4x), capture adults and chicks, measurements of food availability.
Aug. 18 - September 30, 1998:	Compilation and analyses of data; continue genetic analyses from breeding and winter populations, logistics for future winter work.

B. Project Milestones and Endpoints

Project Objective Deadlines

1. Determine the status of recovery of black oystercatcher populations in Prince William Sound.

The first survey of wintering birds in Prince William Sound will be conducted in November of 1997 and presented at the Restoration Workshop in January 1998. A comparison of nest site occupancy between 1993 and 1998 will be presented at the Restoration Workshop in January 1999 and included in annual progress report. The above information on wintering and breeding birds will be available each year and presented at annual Restoration Workshops and progress reports. This survey data when combined across years will provide the first accurate information on oystercatcher population trends. Overall answer to objective will be included in final report on April 15, 2001.

2. Determine if recovery of the black oystercatcher is constrained by continued oil toxicity.

Feeding and roosting sites of wintering oystercatchers found in November 1997 will be superimposed on oil distribution maps allowing oil exposure estimates for wintering birds to be made. This estimate will be presented at the Restoration Workshop in January 1998. Demographic data collected on oystercatchers breeding or wintering in oiled locations will be compared annually to similar data collected on birds found in unoiled locations. Yearly results will be presented at Restoration Workshops and included in annual progress reports. Overall answer to the objective will be included in final report on April 15, 2001.

3. Determine if recovery of the black oystercatcher is constrained by food availability.

Statistical analyses comparing food availability on oystercatcher territories located in oiled and unoiled regions will be conducted after each summer's research and presented at annual Restoration Workshops and included in progress reports. This information will be collated across years to look for consistent patterns in our results. Overall answer to objective will be included in final report on April 15, 2001.

4. Determine if recovery of the black oystercatcher is constrained by demographic factors.

The first information on juvenile recruitment will be presented at the annual Restoration Workshop in 1999. At each Restoration Workshop and in each annual progress report, we will present information on return rates, breeding and wintering site fidelity, and nest success for

oiled and unoiled areas. This type of information will be combined across years to provide an estimate of adult survival, and interannual variation in site fidelity and nest success. Overall answer to objective will be included in final report on April 15, 2001.

5. Assess spatial segregation and population differentiation of breeding and wintering black oystercatcher populations in western Prince William Sound, Glacier Bay and Kodiak Island using direct and indirect techniques.

Initial nuclear and mtDNA genetic assays will be conducted in November and December of 1997 and presented at the Restoration Workshop in January 1998. Additional genetic assays will be conducted after each field season throughout the duration of the project. Preliminary genetic results will be included in each annual progress report. Final genetic results will be included in the final report on April 15, 2001. Observations of banded birds will be collated throughout the life of the project and summarized for final report.

6. Determine appropriate restoration actions, based on answers to objectives 1-5.

To be included in final report on April 15, 2001.

Project Schedule for Remaining Years of Study

November/December 1998:	Winter surveys and capturing adults in Prince William Sound and Glacier Bay National Park.
January 1999:	Analyse data; continue genetic analyses, write annual report on FY 98 work.
January 1999:	*Reporting of project findings at Restoration Workshop.*
February/March 1999:	Winter surveys and capturing adults in Prince William Sound and Kodiak Island.
April 15, 1999:	*Submission of 1998 Annual Progress Report.*
May - August 1999:	Breeding surveys, capturing adults and young, and measurements of food availability in Prince William Sound as indicated above.
November/December 1999:	Winter surveys and capturing adults in Prince William Sound and Glacier Bay National Park.
January 2000:	*Reporting of project findings at Restoration Workshop.*
February/March 2000:	Winter surveys and capturing adults in Prince William Sound and Kodiak Island.
April 15, 2000:	*Submission of 1999 Annual Progress Report.*
May - August 2000:	Breeding surveys, capturing adults and young, and measurements of food availability in Prince William Sound as indicated above.
August 2000 - April 2001:	Summarize and analyze data to write annual report on FY99 work: genetic work completed.
January 2001:	*Reporting of project findings at Restoration Workshop.*
April 15, 2001:	*Submission of Final Report.*

Note: In December 2000, a full review of the 1998 and 1999 data will be used to assess

the status of black oystercatcher recovery and to allow changes in the study design. If the species meets all recovery objectives as designated in the Exxon Valdez Restoration Plan (EVOSTC 1994), the project would move into the final data analysis and close out.

C. Completion Dates

April 15, 2001:	Final report submitted to Chief Scientist. (unless project close out initiated one year earlier)

PUBLICATIONS AND REPORTS

No publications from this research are planned for fiscal year 1998 due to the preliminary nature of this study. We do plan on publishing papers in subsequent years and if possible, hope to substitute portions of the annual or final reports with publications in peer-reviewed journals. An annual report will be submitted April 15, 1998.

PROFESSIONAL CONFERENCES

We have no plans to attend professional conferences in fiscal year 1998 due to the preliminary nature of this study. Request for funds to attend conferences in fiscal year 1999 and 2000 are included in our budget.

NORMAL AGENCY MANAGEMENT

Research on shorebirds at the USGS-BRD has traditionally been restricted to studies on potentially endangered or threatened species (e.g., bristle-thighed curlew studies), or on shorebird communities in areas of critical importance (major staging areas) or proposed for development (e.g., Cook Inlet). In virtually all cases, funding for these projects has been from congressional add-ons (non-base funding), private foundations or other DOI agencies. Funding to conduct single-species studies is difficult, if not impossible, to collect unless the species shows signs of becoming threatened or endangered. Black oystercatchers are not currently threatened and there is no statute or regulation that requires their study. Consequently, we do not have, or foresee, funds being available to conduct research on black oystercatchers in the near future.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

To reduce costs this project will use supplies, housing, vehicles and/or government vessels at DOI-NPS (Glacier Bay National Park), DOI-FWS (Kodiak National Wildlife Refuge and Migratory Birds Management) and USGS-BRD (Alaska Science Center) to conduct field research (Appendix 1). In addition, salaries for most personnel (except Lanctot) will be provided by each person's respective agency. USGS-BRD is also providing salaries for three seasonal biotechnicians during each year of the study. Coordination through subject-specific workshops (e.g. Intertidal) and the annual EVOS Restoration Workshop will facilitate further exchange of information and identification of additional opportunities for project collaborations.

This project has been designed to overlap extensively with the Nearshore Vertebrate Predator Project (#96025). We have chosen the same oiled and unoiled study areas so that information on food competition and availability (J. Bodkin, C. O'Clair), oil levels in mussel beds (M. Babcock), and location of breeding and winter birds (M. Bishop, D. Esler) can be shared. Research platforms and field equipment will be shared when possible. Winter research will be coordinated with personnel studying harlequins to maximize field equipment use (D. Esler, T. Bowman). Information on oystercatcher locations has also been requested from B. Agler (EVOS project #96159).

Research on black oystercatcher was conducted from 1989-93 by the DOI-FWS via EVOS funding (Projects Bird Study 12, R-17, 103C, 93035). Brad Andres, one of the principal investigators of these projects, will continue to advise this project by providing historic information and continuity to the current study. Information from the past and current project will be exchanged to promote the greatest understanding of the species.

The Alaska Science Center, USGS-BRD, has an extensive shorebird research program dating back to 1976. Studies have focused on both breeding and post-breeding shorebirds, mostly in littoral and coastal regions of Alaska. The extensive experience of the USGS-BRD's shorebird leader (Robert Gill) will be invaluable to conducting the black oystercatcher study. The Alaska Science Center, through a collaboration with Kim Scribner, will also provide the Molecular Ecology Laboratory and expertise needed to conduct the genetic analyses in this study.

ENVIRONMENTAL COMPLIANCE

We anticipate this project to be categorically excluded from complying with the National Environmental Policy Act. The project has met approval of the Alaska Science Center's Animal Care and Welfare Committee to ensure compliance with the provisions of the Animal Welfare Act. Special Use Permits will be requested from appropriate state or private organizations to work in Prince William Sound, Kodiak National Wildlife Refuge and Glacier Bay National Park. Appropriate environmental impact statements will be written where necessary. The majority of field work is non-intrusive and relies primarily on observations. The proposed capture and sample collection techniques have been used routinely on shorebirds and are considered very safe (Oring et al. 1988, Lanctot 1994). Applications for special use permits will be submitted to Glacier Bay National Park to capture, band, and bleed birds. Tarsus leg band application will follow the guidelines of the U.S. Fish and Wildlife Service, Migratory Bird Banding Lab, Laurel, Maryland. Coastal vessel operations will adhere to U.S. Coast Guard requirements.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Dr. Richard Lanctot -- Research Wildlife Biologist at the Alaska Science Center, USGS-BRD His background includes nine years experience studying shorebird breeding biology, including studies on buff-breasted sandpipers, spotted sandpipers, western sandpipers, semipalmated sandpipers, piping plovers, and bristle-thighed curlews. Four of those years were spent investigating the impacts of oil development on shorebirds at Prudhoe Bay. He also has three years experience conducting genetic analyses in the Alaska Science Center's Molecular Ecology Laboratory using all of the techniques proposed in this study. Publications include papers on the breeding biology of a variety of shorebird species, and methodological papers on censusing and sampling blood from avian species.

OTHER KEY PERSONNEL

Project administration and coordination, and study design will be conducted by USGS-BRD project leader (Lanctot). Genetic analyses will be supervised by the Molecular Ecology Laboratory leader (Scribner) and performed by the project leader (Lanctot). Andres will provide historic information on locations of wintering and breeding birds, field techniques and data interpretation. Field work will be co-ordinated and performed by the project leader (Lanctot) and assisted by collaborators living at or familiar with Glacier Bay National Park (Lentfer, Yerxa), Kodiak National Wildlife Refuge (Zwiefelhofer) and Prince William Sound (Andres, Gill). In this way, local area technical expertise will be used to ensure safe and efficient implementation of the field portion of the project.

Dr. Brad Andres -- Studied the effects of the EVOS on black oystercatchers breeding in PWS, Alaska, from 1991-93, and has authored several damage assessment and restoration reports. He is currently coordinating migratory landbird and shorebird programs and conducting field projects within Region 7 of the DOI-FWS. Prior to working on black oystercatchers, he studied the impacts of oil development on migrating shorebirds on the North Slope of Alaska. Publications include papers on natural history, habitat requirements and management of shorebirds.

Mr. Robert E. Gill, Jr. -- Supervisory shorebird biologist with the Alaska Science Center, USGS-BRD. He has studied shorebird breeding and migration ecology in most parts of Alaska for over 20 years. His extensive publication record includes papers on conservation strategies, migration patterns, and breeding ecology of shorebirds.

Mr. Hank Lentfer / Mr. Rusty Yerxa – Biological technicians at Glacier Bay National Park and Preserve. Mr. Lentfer studied black oystercatchers breeding in Glacier Bay National Park in 1989-1990. Both people have extensive field and boating experience working in the waters of Glacier Bay.

Dr. Kim T. Scribner – Research Geneticist, Molecular Ecology Laboratory, Alaska Science Center, USGS-BRD. He has over 17 years of research experience on a variety of avian, mammalian and amphibian taxa, and has published extensively in the fields of population genetics and conservation biology. He is currently conducting genetic

analyses on the endangered spectacled eiders, harlequin duck (EVOS Project No. 96161), white-fronted geese, and a variety of salmon species.

Mr. Dennis Zwiefelhofer – Wildlife Biologist/Marine Vessel Operator at Kodiak National Wildlife Refuge. He has over 18 years experience in avian biology; surveying and studies of seabirds, seaducks, waterfowl and raptors. He was responsible for Kodiak area post EVOS seabird surveys and bird collection (morgue) facility, and was a member of the EVOS initial response SCAT teams. USCG licensed vessel operator.

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Table 1. Injury and evidence for recovery of the black oystercatcher from the *Exxon Valdez* Oil Spill, 1989: demographic, oil exposure, trophic, and genetic factors.

Demographic

• Nine direct adult mortalities documented; oiled chicks found in 1989 (Sharp and Cody 1993).

• Andres (1994a) estimated roughly 20% (280 individuals) of the Prince William Sound population died as a result of the EVOS.

• Winter and summer populations of oystercatchers were lower than expected in the oiled area of Prince William Sound when comparing pre- (1972-73) and post-spill (1989-91) data. A similar finding was found when comparing summer populations between 1984 to 1989-91 (Klosiewski and Laing 1994).

• Total number of breeding pairs increased on Green Island, remained the same on Montague Island, and decreased on Knight Island, from 1989 to 1993 (Andres 1997).

• Oystercatchers increased at a similar rate in the oiled zone than the unoiled zones of Prince William Sound during winter and spring surveys from 1989 to 1995. This suggests that the population in the oiled region is not recovering (Agler and Kendall 1997).

Oil Exposure

• Hatching success increased on the heavily oiled Green Island between 1989 and 1991 (Andres 1997).

• Brood loss was greater for pairs nesting in oiled areas in 1989, but did not differ between oiled and unoiled areas in 1991 (Andres 1997).

• Weight gain of chicks raised at oiled sites was slower than for chicks raised at unoiled sites in 1991-93 (Andres 1994a, 1996).

Table 1. (continued)

Trophic
• Mussels died at a higher rate and had higher levels of petroleum hydrocarbons on oiled Green Island than on unoiled Montague Island in 1989 (Sharp and Cody 1993, Andres 1994a). Persistent *Exxon Valdez* crude oil in dense mussel beds may pose a chronic oil exposure problem to breeding and wintering oystercatchers (Babcock et al. 1994, 1996; Andres 1996).
• Black oystercatchers tend to take medium-sized reproductively mature mussels (Andres and Falxa 1995, Andres 1996). This preference may affect the recovery of mussel populations and indirectly affect the recovery of other nearshore vertebrate predators that also rely on mussels for food (NVPP 1994).
Genetic Structure
• The small population size of the black oystercatcher in Prince William Sound (ca. 1,000 Agler, pers. comm.) combined with high breeding and wintering site fidelity, and limited juvenile dispersal, may isolate breeding populations and result in inbreeding depression (Lacy 1987).
• No genetic information is available on the species at present.

Table 2. Proposed 1997-2000 black oystercatcher blood sample collection by location

	1997	1998	1999	2000	Total
Prince William Sound					
Breeding sites/Oiled area					
Green Island	0	20	10	10	40
Northern Knight Island	0	20	10	10	40
Breeding sites/unoiled area					
Montague Island	0	20	10	10	40
Southwestern Knight	0	20	10	10	40
Winter sites					
Green Island	20	10	10	0	40
NE Montague Island	20	10	10	0	40
Hinchinbrook Island	20	10	10	0	40
Outside Prince William Sound					
Wintering sites					
Glacier Bay National Park	0	20	20	0	40
Kodiak Island	0	20	20	0	40
Total	60	150	110	40	360

APPENDIX 1. DETAILED FY 1998 BUDGET

Personnel		
Research Wildlife Biologist (GS-11-1) - 12 months	**	$51,600
Biotechnician (GS-5) - 2 pay periods		$1,800
Subtotal		**$53,400**
Travel		
ANC/Whittier/ANC (9 RT @ $100)		$900
Rail to Whittier, 25' boat - 1 RT		$750
Per diem in field (454 people days x $3)		$1,360
Subtotal		**$3,010**
Contractual		
Airplane charter for winter survey in Prince William Sound ($350/hr x 10 hrs)		$3,500
Equipment Maintenance		$3,000
Freight		$500
Genetic Analyses (210 samples @ $30)		$6,300
Subtotal		**$13,300**
Commodities		
Food (454 person days @ $10)		$4,540
Rite-in-Rain books, data sheets		$200
Skiff Boat fuel (16 gal/day @ $2/gal, 125 days)		$4,000
Big Boat fuel (1 gal/mile @ $2/gal, 20 miles/day x 85 days)		$3,400
Blood Sampling supplies		$200
Banding supplies		$300
Boat safety supplies		$500
Film supplies, developing		$200
First Aid Kit (2 @ $100)		$200
Rain gear (4 people @ $150)		$600
Waders/hip boots (4 @ $100)		$400
Computer software		$1,000
Miscellaneous supplies		$700
Subtotal		**$16,240**
New Equipment	***	$0
Grand Subtotal		**$85,950**
General Administration		
(15% of personnel)		**$8,010**
(7% of contractual)		**$930**
Grand Total		**$94,890**

FY 1998 Budget (continued)

Equipment Provided by Trustee Agencies

DOI-FWS, Migratory Bird Management for studies in Prince William Sound
- 25' Boston Whaler Fully outfitted
- Inflatable boats and outboard motors
- Camp gear (weatherport, tents, sleeping bags, cook kits, etc.)
- Float coats, survival suits, and basic survival gear
- Hand held VHF radios (2)
- Propane freezer and stove
- Generator (recharging radios)
- Mist nets

USGS-BRD
- Camp gear (tents, sleeping bags, cook kits, etc.)
- Banding supplies (mist nets, banding poles, etc.)
- Spotting scopes, binoculars
- Laptop computer - 486 minimum
- Molecular Ecology lab personnel expertise and lab space, including use of equipment and miscellaneous supplies
- Office supplies, copying, telephone, fax, postage

** We feel the entire salary of the research biologist (Lanctot) is justified given that he will lead all field work, conduct the genetic analyses, administer the entire project, manage the data, and write the majority of the papers for the project. His time will be spent entirely on this project. Salary support for three GS-5 biotechnicians (approximately $22,000) will be provided by USGS-BRD.

*** We anticipate the need for some commodities and equipment from the *Exxon Valdez* Oil Spill office.

1998 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998	PROPOSED FY 1998 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
							$94,213.0	
Personnel	$0.0	$53,400.0						
Travel	$0.0	$3,012.0						
Contractual	$0.0	$13,300.0						
Commodities	$0.0	$16,200.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$85,912.0		Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
General Administration	$0.0	$8,301.0						
Project Total	$0.0	$94,213.0		$121,800.0	$122,600.0	$46,200.0	$0.0	
Full-time Equivalents (FTE)	0.0	1.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$22,000.0		$22,000.0	$22,000.0	$0.0	$0.0	

Comments: The Alaska Science Center, USGS-BRD, is responsible for coordinating all aspects of this project. Responsibilities include field logistics, collection of field data and blood samples, genetic assays and data analyses, report writing, and publication of results. Other trustee agencies include the DOI-FWS and DOI-NPS. We are collaborating with Migratory Bird Management, Anchorage, to conduct studies in Prince William Sound, and Kodiak National Wildlife Refuge for field work on Kodiak Island. Glacier Bay National Park and Preserve will assist us in conducting field work at Glacier Bay. Field work at Kodiak Island and Glacier Bay will not begin until FY1999 and continue for an additional year. These trustee agencies will provide personnel and expertise to conduct field work, provide logistical support for conducting the field work, and help in the preparation of reports.

Majority of increase in funding requests in FY 1999 and 2000 are to cover costs associated with conducting winter research at Glacier Bay National Park and Preserve, and Kodiak Island (e.g., boat rental, field supplies). Roughly three-fourths of the costs in FY2001 are to cover personnel costs of the principal investigator.

1998

Prepared: 13-Apr-97

Project Number: 98357
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Lead Agency: USGS-BRD

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

1998 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$51,600.0
Travel		$2,822.0
Contractual		$11,300.0
Commodities		$15,900.0
Equipment		$0.0
Subtotal	$0.0	$81,622.0
General Administration		$7,978.5
Project Total	$0.0	$89,600.5
Full-time Equivalents (FTE)		1.0
Other Resources		$22,000.0

LONG RANGE FUNDING REQUIREMENTS

Dollar amounts are shown in thousands of dollars.

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$117,200.0	$118,000.0	$46,200.0		
	$22,000.0	$22,000.0	$0.0		

Comments: Accounting, personnel hiring, purchasing, secretarial assistance, computer equipment, and other office supplies will be provided by USGS-BRD.

$12,900 of total costs are for report writing, NEPA compliance, community involvement and workshop attendance.

An additional $22,000 will be provided by USGS-BRD to pay for season biotechnicians.

Field work, genetic analyses, program administration, data analyses and report writing will be conducted by principal investigator - R. Lanctot of the USGS-BRD.

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: USGS-BRD

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 1998
R. Lanctot	Principal Investigator - lead field work during summer and winter, conducts genetic assays, administers project, analyzes data and writes reports.	GS/11/1	12.0	4300.0		51,600.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.0	4300.0	0.0	
					Personnel Total	$51,600.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
ANC/Whittier/ANC - to conduct field research	100.0	8	424	3.0	2,072.0
(4 people x 2 trips per person)					0.0
Boat transportation to Whittier from Anchorage by rail	750.0	1	0	0.0	750.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2,822.0

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: USGS-BRD

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed
Description	FY 1998
Airplane charter for winter survey in Prince William Sound ($350/hr x 10 hours)	3,500.0
Equipment maintenance - binocular and scope repair and cleaning, field gear repair and cleaning	1,000.0
Freight - shipment of field gear to Prince William Sound	500.0
Genetic assays (210 samples @ $30/sample)	6,300.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$11,300.0

Commodities Costs:	Proposed
Description	FY 1998
Food (424 person days @ $10/day)	4,200.0
Rite-in-rain books, data sheet preparation	200.0
Skiff boat fuel (16 gal/day @ $2/gal, 125 days)	4,000.0
Big boat fuel (1 gal/mile @ $2/gal, 20 miles/day, 85 days)	3,400.0
Blood sampling supplies	200.0
Banding supplies	300.0
Boat safety supplies	500.0
Film supplies, developing	200.0
First Aid Kits	200.0
Rain gear, waders, hip boots for 4 people	1,000.0
Computer software	1,000.0
Miscellaneous supplies	700.0
Commodities Total	$15,900.0

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: USGS-BRD

FORM 3B
Contractual & Commodities DETAIL

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
No items needed at present.			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
Tents and sleeping bags for 4 people	4	USGS-BRD
Banding supplies	1	USGS-BRD
Spotting scopes	1	USGS-BRD
Binoculars	1	USGS-BRD
Computer and printer	1	USGS-BRD
Molecular Ecology Lab equipment and miscellaneous supplies	1	USGS-BRD
Office supplies, copying, telephone, fax, postage	1	USGS-BRD

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: USGS-BRD

FORM 3B
Equipment
DETAIL

1998 EXXON VALDEZ TRUS1 :OUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$1,800.0
Travel		$190.0
Contractual		$2,000.0
Commodities		$300.0
Equipment		$0.0
Subtotal	$0.0	$4,290.0
General Administration		$322.5
Project Total	$0.0	$4,612.5
Full-time Equivalents (FTE)		0.1
Other Resources		

[redacted]

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$4,600.0	$4,600.0	$0.0		

[redacted]

Dollar amounts are shown in thousands of dollars.

Comments: Comments: Office supplies, computer equipment, and scretarial assitance will be provided through the Migratory Bird Management Branch, Anchorage.

Damage assessment work on black oystercatchers was funded in 1991-93 as Project numbers R-17, 103C, 93035.

No money is requested for report writing, NEPA compliance and community involvement.

Program management will be conducted through the USGS-BRD lead agency.

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: DOI-FWS

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 1998
Vacant	readies and sends supplies to field	GS/5/1	1.0	1800.0		1,800.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	1800.0	0.0	
					Personnel Total	$1,800.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
ANC/Whittier/ANC - one trip for Brad Andres to go to field	100.0	1	30	3.0	190.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$190.0

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: DOI-USFWS

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed FY 1998
Description	
Equipment maintenance - weatherport, camp supplies outboard motors, boats	2,000.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$2,000.0

Commodities Costs:	Proposed FY 1998
Description	
Food in camp (30 days at $10/day)	300.0
Commodities Total	$300.0

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: DOI-USFWS

FORM 3B
Contractual & Commodities
DETAIL

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
No items needed at this time.			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
25' Boston Whaler fully outfitted	1	DOI-FWS
Inflatable boats and outboards	1	DOI-FWS
Camp gear (weatherport, cook kits, etc.)	1	DOI-FWS
Float coats/survival suits and basic survival gear	4	DOI-FWS
Hand held VHF radios	2	DOI-FWS
Propane freezer and stove	1	DOI-FWS
Generator	1	DOI-FWS
Banding supplies (mist nets, bands, scales, rulers, etc.)	1	DOI-FWS

1998

Prepared: 13-Apr-97

Project Number:
Project Title: Status and evaluation of factors limiting recovery of the black oystercatchers.
Agency: DOI-USFWS

FORM 3B
Equipment
DETAIL

98363

Project Title: Ecosystem Analysis at the Watershed Scale on PGC Lands on the Kenai Peninsula.

Project Number:	98 363
Restoration Category:	General Restoration.
Proposer:	Port Graham Corporation
Lead Trustee Agency:	ADF&G
Cooperating Agencies:	National Park Service, F&WS, & DNR
Alaska SeaLife Center:	No
Duration:	FY98 to FY99
Cost FY 98:	$177.0.
Cost FY 99	$110.0.
Cost FY 00	$60.0.
Geographic Area:	The watersheds or portions of the watershed that are on Port Graham Corporation lands on the eastern and southern coasts of the Kenai Peninsula—specifically Port Graham, Chugach Bay, Windy Bay, Rocky Bay, Chugach Island, Yalik Bay, Nuka Bay, Two Arm Bay, Harris Bay and Aialik Bay.
Injured Resource/Service:	Sea Otter, Harbor Seal, Stellar Seal Lion, Marbeled Murrelet, Black Oystercatcher, Sockeye Salmon, Pink Salmon, Pacific Herring, Alutiqq People. Subsistence.

ABSTRACT

Conduct an Ecosystem Analysis at the Watershed Scale for all watersheds on Port Graham Corp lands. These includes all watersheds from the Ailalik Peninsula near Seward down the coast to the Port Graham Drainage in Kachemak Bay. Characterize all human, aquatic, riparian and terrestrial features, conditions, processes and interactions within these watersheds. Analysis will enhance the ability of all the land managers to estimate, direct, indirect and cumulative effects of PGC management activities and guide the general type, location and sequence of appropriate management activities within each watershed. Restoration of habitat and possible enhancement projects to encourage the increase of the populations of all the damaged resources included in this area including the human resources.

The objective is to encourage the restoration of all damaged resources in the area prior to the *Exxon Valdez* Oil Spill and to enhance subsistence resources to replace lost resources.

INTRODUCTION

This inventory and analysis will be designed to provide proper management direction in order to protect all the damaged and declining resources within this area of the oil spill. Cumulative impacts of management decisions will be assessed prior to implementation in the study area. On site inspections, inventory of damaged resources will be accomplished by professional biologists and scientists. Restoration of habitat and possible enhancement projects to encourage the increase the populations of all the damaged resources included in this area including the human resources.

The objective is to encourage the restoration of all damaged resources in the area prior to the *Exxon Valdez* Oil Spill and to enhance subsistence resources to replace lost resources.

NEED FOR THE PROJECT

A. Statement of Problem

Oil Spill Damage to watersheds on the Eastern Kenai Peninsula. The loss of traditional subsistence resources and services has been extensively documented in this area. Some subsistence resources may never recover to their pre-oil spill levels. There is a need to substitute and increase the subsistence resources for the residents of LCI
Lack of knowledge of the extent, range and quality of the watersheds in this region. Assessment of damage to resources. Restore and enhance resources to pre-spill levels. The traditional subsistence resources of the Alutiqq people have been severely impaired or have been permanently damaged. Other species damaged or impacted by the oil spill which would benefit from this project include the marbeled murrelet, the black oyster catcher, the river otter and the harlequin duck. Subsistence will be deemed to be recovered when the local residents have restored confidence of the abundance and safety of this important resource and service This project seeks to replace lost or damaged resources by replacing or enhancing the habitat

The protection and enhancement projects will increase the level of subsistence resources that come from the uplands on adjoining streams, lakes and marine shoreline ecosystems.

B. Rationale/Link to Restoration

Inventory, evaluate and enhance for protection of resources to increase subsistence resource for Port Graham residents and others for compensation of loss caused by the *EXXON Valdez Oil Spill.* It will compensate and substitute for the damaged and lost resources available to subsistence users in the LCI. The protection and enhancement of these watersheds will not only aid the subsistence users but also the impacted commercial, recreation and sport users of these watersheds.

The policy of the Trustee Council, as stated in the Restoration Plan, is that projects designed to restore or enhance an injured resource: 1) must have a sufficient relationship to the injured resource 2) must benefit the same user group that was injured 3) should be compatible with the character and public uses of the area. This project meets all three portions of the Trustee Council's policy toward restoring or enhancing an injured resource.

C. Location: Lower Cook Inlet and Kenai Fjords

All watersheds from the Port Graham drainage on Kachemak Bay, Chugach Bay, Windy Bay, Rocky Bay, Chugach Island, Yalik Bay, Nuka Bay, Two Arm Bay, Harris Bay and Aialik Bay.

COMMUNITY INVOLVEMENT

This project will encompass direct involvement of the residents of Port Graham and Nanwalek. Also, Seldovia elders and residents will be utilized for information. This analysis will be accomplished through the joint efforts of Port Graham Corp, ADF&G, State-DNR, USFWS and the National Park Service. Through the training of Alutiqq people for the field and office work, the depth of understanding of the watershed resources will be evaluated through the eyes and experience of the people who have lived on these lands and waters for millennia. Project will help the government managers develop an awareness and sensitivity of the Alutiqq peoples needs for protection and enhancement of these irreplaceable resources.

Port Graham, Nanwalek and Seldovia residents will be consulted as to their local knowledge of these areas. Local hire for field work will be used extensively.. Study area is remote, extensive use of locals boats and housing will be required. Seminars with these communities will be conducted to assess possible enhancement and/or restoration projects. Subsistence use will be inventoried and assessed for pre and post spill utilization.

PROJECT DESIGN

1. Inventory, assess and develop protection and enhancement projects on the watershed scale including all riparian areas, wetlands floodplains and beach facies on the eastern Kenai Peninsula coast.

2. Prepare protection and enhancement projects which will be directed to improving the subsistence resources as a substitution and compensation for the lost and damaged subsistence resources for the residents of Port Graham.

3. Develop project plans to enhance or protect the subsistence resources in these areas.

B. Methods

Research FY 98: Consult with professional wildlife biologists, hydrologists and land managers in ADF&G (Fish & Habitat) and the National Park Service (NPS). Acquire Maps, aerial photos, satellite imagery ADF&G records and reports. Research other agency files for relevant data. Contract with professional consultants. Finalize project plan, recruit and train Alutiqq people for office and fieldwork. Prepare inventory assessment forms, maps and photos and methods for inventory and assessment. Meetings with subsistence and other users for use of watersheds, etc. Coordinate with Port Graham, Nanwalek Village Councils and Cook Inlet Keeper.

Field: Organize crew, map and evaluate streams from headwaters to coast. Hire professional biologist to map wetlands analyze physical and chemical characteristics. Inventory past and current resources. There are approximately 26 major watersheds that are within the proposed study area. These are important drainages for subsistence resources. Develop watershed database with a GIS system. Develop draft management

options for protection and enhancement projects for all resources and evaluate field proposals on-site.

Year 2: Continue Year One Activities. Continue year one. Meet with agency specialists and scientists and develop draft parameters. Review long-term plans of PGC. Develop plans and proposed activities that will not adversely affect these watersheds, but will protect and enhance these ecosystems.

Post Field: **Report on findings, Evaluate, Protection, Enhancements.**

Post Field: Report on findings, Evaluate, Protection, Enhancements. Prepare watershed guidelines and develop monitoring system.

C. Cooperating Agencies, Contracts and Other Agency Assistance

ADF&G will be the lead trustee agency. ADF&G will then contract through KPB-EDD who will then contract with the Port Graham Corp. for the entire project. Cooperation will be needed with the EPA for any NEPA compliance necessary and KPB for Coastal Zone Management AMSA Compliance. EA's will be prepared under ADF&G direction. Contracts with heavy equipment or boats, if necessary will be through the Port Graham Corp. Technical assistance from the Alaska Dept. of Fish and Game will be required and sought for all phases of this project. Additional technical assistance will be provided by Dr. Peter Armato of Seward, the lead watershed and coastal ecologist for the National Park Service in southcentral Alaska .

A. Measurable Project Tasks for FY 98

October 1, 1997 to December 1997:	Assemble maps & photo data. Coordinate project with ADF&G.
January 1998 to May 1998:	Develop final plan. Hire personnel, develop maps, photos &data. Consult with users. Consult with users.
May 1998:	Train field crews.
June 1998 to September 1998:	Conduct surveys in Port Graham, Kachemak Bay, Rocky & Windy Bay, Chugach Bay & Chugach Island. Begin surveys in Nuka & Ailalik Bay.
October 1998 to May 1999:	Annual report project. Prepare field construction plan for additional enhancement projects for FY 1999.

B. Project Milestones and Endpoints

October 1997 to September 1998:	Start inventory and assessment. Complete 50-60% of watersheds.
October 1998 to September 1999:	Complete inventory of all wetlands and lakes. revisit important wetlands for development, protection and enhancement projects.
October 1999 to March 2000:	Develop project plans for enhancement and protection projects for EVOS funding.
April 2000 to September 2000:	Complete surveys. Prepare draft survey reports and prepare final reports and data.

C. Completion Date

January 2000 to September 2000: Complete report and review and develop protection and enhancement projects. Complete plans and request for restoration funding.

Annual Reports: Annual Reports will be prepared. The survey reports, database and accompanying maps will be made available to ADF&G and NPS where appropriate. A final report will be prepared on the management options phase of this project. EA's will be prepared as needed.

PROFESSIONAL CONFERENCES

The project results will be presented at the appropriate EVOS conferences and technical sessions and other conferences.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be coordinated with all ADF&G and PGC/EVOS Projects, including the salmon stream assessment project currently underway.

PROPOSED PRINCIPAL INVESTIGATOR

This project will be organized and managed by the following agencies and entities:

Trustee Agency: **Alaska Dept. of Fish & Game**

Contractor:
Port Graham Corporation
Patrick Norman-President
Walter Meganack, Jr.-Project Manager
P.O. Box 6689
Port Graham, Alaska 99663

PERSONNEL

John L. Hall & Arvid J. Hall of Taiga Resource Consultants will be the technical advisors and managers who will assist Walter Meganack, Jr.

Dr. Peter Armato, National Park Service Watershed and Coastal Ecologist.

The professional watershed consultant will be contracted with after the approval of this project and consultation with ADF&G.

LITERATURE CITED:

**Carpenter, Dickson, et al. 1995,
Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment Final Report. Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for wild Pink and Chum Salmon.
Alaska Department of Fish and Game.**

**Martin, 1996. Fish Habitat and Channel Conditions for Streams on Forested Lands of Coastal Alaska: An Assessment of Cumulative Effects.
Pentec Environmental.**

**Regional Interagency Executive Committee 1995,
Ecosystem Analysis at the Watershed Scale: Federal guide for Watershed Analysis, Version 2.2. U.S. Government Printing Office.**

Stanek, 1985. Patterns of Wild Resource Use in English Bay and Port Graham, Alaska. Alaska Department of Fish and Game.

Sundet & Kuwada, 1994. Stream Habitat Assessment Project: Prince William Sound and Lower Kenai Peninsula, Project No. R-51. Exxon Valdez Trustee Council Restoration and Habitat Protection Planning. Alaska Department of Fish and Game.

Budget Category	Authorized FFY 1997	Proposed FFY 1998
Personnel		$114.7.
Travel		$12.9.
Contractual		$8.5.
Commodities		$3.0.
Equipment		$5.0.
Subtotal	$.0.	$144.1.
Indirect (5%)	$.0.	$7.2.
Subtotal	$.0.	$151.3.
GA (17%)	$.0.	$25.7.
Total	$.0.	$177.0.
Other Funds		

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003	
$110.0	$60.0	$.0	$.0	$.0	$.0

Dollar amounts are shown in thousands

Comments:

GA will cover %7 for ADF&G and %10 KPB-EDD. PGC will receive %5 for indirect costs of administration.

1998 April

Project Number: 98.363
Project Title: Ecosystem Analysis at the Watershed Scale
Trustee: ADF&G

Form 4A
Non-Trustee
DETAIL

Personnel Costs			Months Budgeted	Monthly Costs	Overtime	Proposed FFY 1998
Name	**Position Decription**					
Professional Watershed Scientist	Professional Watershed Scientist		1.5	12.8	0.25	$19.5.
Walter Meganack, Jr, Pat Norman	Project Management		2	10	0.5	$20.5.
John Hall	Land & Resource Consultants		3.5	9.3	0.5	$33.1.
Arvid Hall	Land & Resource Consultants		3.5	8	0.5	$28.5.
	Technical Assistant		1.5	2.5	0.5	$4.3.
Peter Armato-NPS			1	6.5	0	$6.5.
			0	0	0	$0.0.
			0	0	0	$0.0.
			0	0	0	$0.0.
	Admininstrative Support		2	1.2	0	$2.4.
	Subtotal		15	50.3	2.25	
					Personnel Total	$114.7.

Travel Costs	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FFY 1998
Description					
RT PG-Homer	$60	10	38	$50	$2.5.
RT Seattle-Anchorage	$400	4	20	$100	$3.6.
RT PG-Anchorage	$180	1	46	$100	$4.8.
NPS-Scientist Per Diem			20	$100	$2.0.
					$0.0.
					$0.0.
Subtotal		15	124	300	
				Travel Total	$12.9.

1998 April

Project Number: 98_____
Project Title: Ecosystem Analysis at the Watershed Scale
Trustee: ADF&G

Form 4B Personnel & Travel DETAIL

EVOS BDGT #3 WS-98 Equip

New Equipment Purchases:	Number of Units	Unit Price	Proposed FFY 1998
Description:			
Field Equipment	1	$5.0.	$5.0.
			$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 the placement of an R.		New Equipment Total:	$5.0.

Existing Equipment Usage:		Number of Units	Proposed FFY 1998
Description			
None			
	0	0	
			0

1998 April

Project Number: 98_____
Project Title: Ecosystem Analysis at the Watershed Scale
Trustee: ADF&G

Form 4B Equipment DETAIL

EVOS BDGT #4 WS-98 Ctrct&C

Contractual Costs:	Proposed FFY 1998
Description:	
Satellite Imagery, Aerial Photos, Ortho-rectified Map Base, GIS Products, Maps & Existing Reports	$8.5.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
Contractual Total	$0.0.
	$8.5.

Commodities Cost	Proposed FFY 1998
Description	
Office Supplies	$1.5.
Postage	$1.5.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
	$0.0.
Commodities Total	$3.0.

1998 April

Project Number: 98_____
Project Title: Ecosytem Analysis at the Watershed Scale
Trustee: ADF&G

Form 4B Contractual &Commodities DETAIL

Effects of food stress on survival and reproductive performance of seabirds

Project Number:	98264
Restoration Category:	Research (new)
Proposed By:	US Geological Survey (PI/John Piatt)
Cooperating Agencies:	University of Washington, Alaska SeaLife Center
Duration:	4 years
Cost FY 98:	$88,100
Cost FY 99:	$115,200
Cost FY 00:	$119,600
Cost FY 01:	$65,000
Cost FY 02:	$0
Geographic area:	Cook Inlet, Gulf of Alaska
Injured resource:	Common Murre, Black-Legged Kittiwake, Pigeon Guillemot

Abstract

Traditional field methods of assessing effects of food stress on the survival and reproductive performance of seabirds may give equivocal results. Here we propose to apply an additional tool - the rise in blood levels of stress hormones such as corticosterone in response to a standardized stressor: capture, handling and restraint. This well known response (found throughout vertebrates from fish to mammals) provides a strong assessment of whether or not a free-living population is chronically stressed or, if baseline levels of corticosterone appear normal, the stress-induced increase in corticosterone indicates potential for stress. Thus the "field endocrinology" approach provides additional information of current stress status and the potential for stress. To apply these techniques we will investigate seabirds breeding in Lower Cook Inlet and also use captive birds for controlled experiments at the ***Alaska SeaLife Center***. The hormone assay techniques and collection methods in the field are well established in the cooperators' laboratories. Furthermore, pilot studies conducted in 1996 indicate that these methods are applicable to Alaskan seabirds and that their endocrine responses to stress are similar to other vertebrates studied to date. The preliminary studies have already validated the techniques and they are ready for application to the proposed investigations here. This study utilizes a unique opportunity of a concurrent field and captive study of the behavioral and physiological consequences of stress in seabirds. Moreover, it will provide the basis for management of seabird populations in the areas affected by the *Exxon Valdez* oil spill.

INTRODUCTION

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

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

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

Piatt 1990, Shea & Ricklefs 1985, Shea & Ricklefs 1996, Kitaysky et al. in preparation). For example, if feeding conditions are poor, adults should increase foraging to raise young. This parental strategy results in relatively low variation in bird reproductive success, but large variation in post-breeding survival of parent seabirds. In both scenarios, a trade-off between reproduction and survival must be balanced to maintain their populations.

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

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

NEED FOR THE PROJECT

A. Statement of the Problem

Immediate and potential long-term effects of food-related stress on foraging and reproductive behavior in seabirds are incompletely known. Recent declines of seabird populations in the Gulf

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

B. Rationale

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

The Alaska SeaLife Center provides a unique opportunity to carry out long-term physiological and behavioral experiments where the physiology of a bird and variation in the environment can be easily manipulated. These experiments, if carried out in parallel to the already initiated experimental work at the seabird colonies in Lower Cook Inlet, will enhance our understanding of the effects of oil pollution on seabird populations and the potential for seabird recovery programs in the polluted areas. Measurements of corticosteroid levels in blood of young and adult birds, and experimental manipulations of this hormone will facilitate our understanding of the crucial relationships among stress physiology, behavior and population dynamics. An additional component will assess the recovery of populations from stress - especially in relation to a role of stress hormones. This is a novel approach, indicated in stress physiology literature (e.g. Wingfield and Romero 1997), but yet to be applied to recovery programs.

C. Summary of Major Hypotheses and Objectives

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

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

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

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

corticosterone in stressed chicks cause an increase in parental effort in chick-provisioning which results in the elevated post-breeding mortality of parents.

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

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

D. Completion Date

The study will be completed in December of 2001, after three reproductive seasons at the colonies in Lower Cook Inlet, three years of captive trials on post-fledging foraging efficiency and recovery from stress at Alaska SeaLife Center, laboratory analyses and sufficient time for analyses of results and preparation of manuscripts for publication.

COMMUNITY INVOLVEMENT

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

FY 98 BUDGET
(see attached detailed Excel spreadsheet)

Personnel	$37,000
Travel	$11,600
Contractual Services	$12,000
Commodities	$5,000
Equipment	$8,500
Lab. supplies	$14,000
Gen. Administration	$0
TOTAL PROJECT COST	$88,100

Project Design

A. Background

Decreases in the availability of food can account for the increased mortality of seabird chicks in nests. Nevertheless, a high tolerance of juvenile seabirds to intermittent or low rates of food provisioning by their parents can buffer against an immediate loss in reproductive success. Juvenile seabirds possess an ability to retard growth processes in response to the dietary restrictions and might fledge successfully despite severe food shortages during their development (Øyan & Anker-Nilssen 1996). Controlled experiments have shown that food-related growth retardation can account for the lower body mass and smaller body size of the young at fledging when compared to the young raised on *ad libitum* nutritional regimes (Kitaysky 1996). However, low body mass of young seabirds at fledging is not a reliable predictor of post-fledging survival (Lloyd 1979, Hedrgren 1981, Harris & Rothery1985). Potential deleterious effects of retardation in morphological development (other than effects of low body mass at fledging) on post-fledging survival and reproductive performances of food-stressed individuals have never been studied in seabirds. Chronical stress in mammals affects hippocampal regions of the brain (Sapolsky et al. 1986) which can result in less efficient learning of new behavioral methods, e.g. foraging techniques, by stressed young. Long-term effects of food-related stress during early development in Zebra finches (*Poephila guttata*) include reduced body size and possibly lower reproductive success during the adult stage of their life (Boag 1987, Boag & Grant 1981, Zink 1983). Thus, there is a possibility that food-stress in young seabirds results in: (1) increased post-fledging mortality due to a low ability of the retarded young to learn foraging techniques and/or a reduction in their foraging efficiency; (2) low reproductive performances during the adult stage of their life (e.g., delayed maturity and low reproductive success).

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

Studies of the effects of food shortages on parental behavior of seabirds have shown that the duration of the chick-rearing period may be extended if food conditions are poor (e.g., Harris & Rothery 1985, Ydenberg 1989). Changes in food availability, for instance food shortages that follow *El-Nino* events in tropics, did not affect growth of young seabirds suggesting that parents were able to compensate for a decrease in food availability by adjusting their efforts in chick-

provisioning for the changed feeding conditions or pursuing brood reduction strategy (Shea & Ricklefs 1996). An increase in the duration of parental care and a possibility of additional investment of parent seabirds in reproduction during food shortages might lead to an increase in post-breeding mortality. For example, results of field experiments indicated that parent Atlantic puffins that were experimentally exposed to a prolonged chick-rearing period were in poor physiological condition at the end of breeding season compared to control birds (Erikstad et al. 1997). This raises a possibility that seabirds which reproduce during seasons of food shortages would suffer a greater post-breeding mortality compared to the birds that reproduce under conditions that are favorable for reproduction.

Results of pilot studies showed that parent Black-legged Kittiwakes and Common Murres respond to a standardized stressor such as capture, handling and restraint, by increasing plasma levels of corticosterone. These results indicated that the hormonal response of adult seabirds can be used to assess susceptibility to stress as might be expected during food shortages. For instance, adult Black-legged Kittiwakes that reared their young under poor feeding conditions at Chisik Island showed a significantly weaker corticosterone response to the handling procedure compared to the parent kittiwakes that reared their young under favorable feeding conditions at Gull Island (Fig. 3). On the other hand, chick-rearing under favorable foraging conditions does not alter the physiological condition of parent Black-legged Kittiwakes. In particular, exposure to the standardized stressor did not indicate a significant difference in the hormonal response of birds raising young with those with experimentally removed chicks (Fig. 4). This raises a possibility that not chick-rearing *per se*, but an additional effort in foraging for the young during food shortages can alter the physiological conditions of parent Black-legged Kittiwakes and result in decreased post-breeding survival of adults. Moreover, the pattern and extent of a corticosterone increase following application of the standardized stressor allows us to assess changes in physiology of a parent in relation to its normal effort in reproduction as opposed to changes associated with stress.

In contrast to Black-legged Kittiwakes and Common Murres, parent Tufted and Horned Puffins breeding at Chisik and the Barren Islands did not respond to the standardized stressor by increasing in corticosterone levels (Fig. 5). In addition, baselines of corticosterone were also significantly higher in puffins compared to those in other examined species of seabirds (Fig. 6). This may indicate chronic severe stress in puffins at Chisik Island and the Barren Islands, where foraging conditions were poor during the sampling period [Piatt et. al, unpublished data]). Alternatively, these results may be indicative of species-specific profiles of corticosterone levels in these closely-related species of seabirds. If this is the case, adult Horned and Tufted puffins may be more susceptible to an additional stress compared to other species of seabirds in the study area.

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

B. Objectives

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

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

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

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

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

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

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

C. Methods

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

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

To assess whether seabirds from different populations are chronically stressed or not, we will determine baseline levels of corticosterone in relation to the reproductive stages, pre-incubation, incubation and chick-rearing. Adult birds will be captured at the breeding colonies by using a noose pole. We will collect a blood sample (approximately 100-150 μL) from the brachial vein

of the wing immediately after capture. To determine potential for stress in different populations we will measure circulating levels of corticosterone in response to a standardized stressor, capture, handling and restraint. For that, additional samples of blood (15-30 μL) will be collected from the same birds over a period of 1 h after capture (at 5, 10, 30 and 60 min intervals). To collect blood samples from chicks we will use similar methods as for adult birds, except that the first sample will be smaller (30-50 μL).

The results of our pilot study indicate that a sample size of N>7 (per each group of birds) was sufficient to detect significant inter- and intra-specific differences in baseline concentrations of corticosterone in adult birds (Figures 1,4,6). Therefore, approximately 7-10 adult birds and chicks will be sampled at each colony at every stage of the reproductive period (total 25-30 birds of each species per colony/year). After sampling, adult birds will be released at the colony and chicks returned to their nests. Previous field and captive studies indicate that taking of blood does not affect the physiological condition or behavior of birds (J. Wingfield, personal observations). In 1996, Black-legged Kittiwakes released after bleeding at Gull Island were sighted at the nests within 1-10 min period. Similarly, bleeding of captive seabird chicks does not appear to affect their behavior or development (A. Kitaysky and M. Romano, personal observations).

2. Field manipulations with stress levels of corticosterone.

To test whether corticosterone affects begging of chicks and provisioning of food by parent seabirds we will experimentally manipulate the concentration of this hormone in plasma of birds at Gull Island. We plan to use two experimental treatments (30-35 nests each) where either the chicks or their parents will be given subcutaneous implants of corticosterone (sealed plastic tubes filled with the crystallized hormone, for details see Wingfield & Silverin 1986) during the first week after hatching. The control birds will be given empty implants. The following parameters will be measured to record a change in the behavior of birds due to the hormonal treatment: chick-feeding rate (assessed as #feedings/day per parent) and nest attendance by the parents (in minutes per day). Recording of behavior will be accomplished with a high-speed video-camera established at the colony. Blood samples will be taken on weekly basis from all young and parent birds to monitor concentrations of corticosterone in plasma of manipulated and unmanipulated birds. The experiment will be repeated during breeding season of 1998 and 1999 by using different groups of Black-legged Kittiwakes and Common Murres.

All experimental birds will be individually marked with a unique combination of color bands and standard aluminum USFWS rings. Individual markings will allow us to identify the birds during the experiments and to monitor their survival after breeding and future reproductive performances during the following breeding seasons. Both Black-legged Kittiwakes and Common Murres have strong nest site and mate fidelity and their breeding performance and survival are relatively easy to monitor over period of several years (Coulson & Thomas 1983). Golet and co-authors (Golet et al., in preparation) showed that the difference in post-breeding survival between Black-legged Kittiwakes raising their young with those with experimentally removed chick was possible to detect with sample sizes of about 100 nests per treatment. As

indicated by the pilot studies, chick-rearing per se does not cause stress to a parent under favorable environmental conditions. However, poor foraging conditions as an additional stressor would impair parents' physiological condition. Thus we expect a considerable difference in survival due to the manipulations with stress levels of corticosterone. We anticipate that sample size of 30 nests (60 birds per experimental treatment) would allow us to make a conclusive suggestion on the relationships among survival, reproduction and stress in Black-legged Kittiwakes and Common Murres in Lower Cook Inlet. This component of the study will complement, and be coordinated with, a larger study of adult survival at Gull and Chisik Islands (Van Pelt and Piatt, FY 98 proposal submitted to EVOS trustees).

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

To test whether the food/pollution-related stress affects post-fledging learning abilities and foraging efficiency of young seabirds, in 1998 we will raise Black-legged Kittiwakes and Common Murre chicks on three different nutritional regimes in captivity. For the experimental treatments (15 chicks per each treatment) we will use the methods described by Romano and co-authors (Romano et al., unpublished) where either quantity and quality of the chick diets will be altered or a supply of mineral oil will be given to chicks with food. In particular, one group of young will be raised on reduced quantities of the high quality food (sandlance, *Ammodytes hexapterus*, and capelin, *Mallotus villosus*, or herring, *Clupea harengus*). Chicks from the second experimental treatment will be raised on sufficient amounts of food of poor quality (juvenile pollock, *Theragra chalcograma*). Birds from the third experimental treatment in addition to the *ad libitum* feeding by the food of high quality will be given small quantities of oil. Chicks from the control group will be raised on the food of high quality (sandlance and capeline) given *ad libitum*.

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

During foraging efficiency trials, we will use a long (across the whole tank), narrow (50-60 cm width), and shallow watertank (40-50 cm depth) for surface-feeding kittiwakes, and deep tank (100-150 cm depth) for the pursuit-diving foraging alcids, were food items will be placed. Food availability, as determined by prey density and abundance, will be regulated by the number of food items placed in the container and the current speed at which the food items will pass through the tank. Prior to foraging efficiency trials, experimental birds will be denied food

during eight hours (by closing the removable wall between a cliff and a tank). Then fasting birds will be allowed to access the food placed in the container at the surface of the tank and their foraging efficiency will be determined for each bird individually. Foraging performance of each bird will be tested individually. The number of foraging attacks and the foraging success (number of the captured prey items) will be recorded to quantify the foraging efficiency of the birds under different conditions of the food availability. Foraging efficiency of the birds will be determined under three different foraging conditions: low (low density of food and high current velocity), intermediate (medium density of food and current speed), and high (high density of food and low current velocity) availability of food. To avoid an "observer effect", the foraging behavior of birds will be recorded as a series of short-term duration (15-20 minutes) trials recorded on a high-speed video-camera established in the aviary. To monitor body and physiological conditions of the captive birds we will measure their body mass and collect blood samples during the post-fledging period of their life (at weekly interval). To assess the recovery rate of juveniles from the stress, we will repeat the foraging efficiency trials as the birds age.

Age of sexual maturation of the food-stressed birds will be examined in the facilities of Alaska SeaLife Center. Usually, Black-legged Kittiwakes become sexually mature at age of 3-4 years. Most alcids reach sexual maturity probably at the same age (e.g., Golovkin et al. 1989). Kittiwakes and alcids readily breed in captivity at different SeaLife Centers if were raised there from the chicks. Therefore, we expect that the captive birds will start to breed at the Alaska SeaLife Center facilities as soon as they have reached sexual maturity. If this is not the case, the morphological development of gonads will indicate onset of maturity in captive birds. As known for many species of birds that do not breed in captivity, the processes of gonadal development still occur and can be used to determine the onset of the sexual maturity. To monitor the development of sex gonads we will measure them by using the laparotomy technique (Wingfield & Farner 1976). In addition to the observation of morphological development of gonads, periodical sampling of blood from the captive birds will be used to monitor concentrations of gonadotropic hormones in the peripheral system of the captive animals (Wingfield & Farner 1980). Thus, onset of maturation can be detected at age 2 in some birds.

4. Captive trials on recovery from stress.

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

5. Laboratory analyses.

In parallel to the field and captive research we will conduct the laboratory analyses of blood samples taken from the birds during the experimental manipulations. All blood samples will be

taken from the brachial vein of the wing, blood plasma will be separated from blood cells and then frozen at -10 C. All plasma samples will be transported to the laboratory at the University of Washington and processed according to the radio-immuno assay techniques (see Wingfield et al. 1992 for the details).

D. Contracts and Other Agency Assistance

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

D. Location

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

SCHEDULE

A. Project Tasks for FY 98

January-April:	preparation for field work, hiring personnel
May-June:	blood sampling during pre-incubation stage, setting study plots for the experimental work
July:	blood sampling during incubation stage, study plot monitoring
August:	blood sampling during chick-rearing stage, colony work: implanting birds with the hormonal implants, monitoring parental feeding rates and
chick	survival
July-September:	chick-rearing in captivity at Kacitsina Bay lab
September-October:	transfer captive birds to the SeaLife Center at Seward, start captive trials on foraging efficiency of juveniles
October-April 99:	laboratory analyses of blood samples, data analysis

February 1999:	Annual Report on FY 98 results
March-April 99:	preparation for FY 99 research
May 1999:	begin field work for 1999

B. Project Milestones and Endpoints

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

If the objectives are achieved, it should be possible by year 2001 to evaluate current status and potential for stress at the colonies in Lower Cook Inlet. Moreover, it will reveal how effects of stress on reproduction and survival are expressed in seabird populations. This will provide the basis for management of seabird populations in the areas affected by the oil spill.

C. Project reports

February 15, 1999:	Annual report on work accomplished in summer-fall period of 1998, and preliminary results.
February 15, 2000:	Interim report on work accomplished in summer-fall period of 1998-1999, extensive analyses of results and preliminary conclusions.
February 15, 2001:	Annual report on work accomplished in summer-fall period of 2000, and preliminary results.
February 15, 2002:	Draft Final report on work accomplished and results obtained, 1998-2001.

We also plan to publish interim and final results of this study in conference proceedings and scientific journals.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

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

Environmental Compliance

All experimental manipulations will be performed in accordance with Animal Research Use protocols issued at the University of Washington. Permits for bird collection for the captive experiments are required from the U.S. Fish and Wildlife Service and the State of Alaska.

Personnel

Principal Investigator - John F. Piatt (US Geological Survey, Anchorage). Including financial and logistic support for colony work in Lower Cook Inlet.

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

Cooperator - John Wingfield (University of Washington, Seattle). Financial and logistic support for laboratory analyses in his lab at UW.

Research assistants:

-Biotech (6 month, vacant)

signed: _____

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date prepared: 4/15/97

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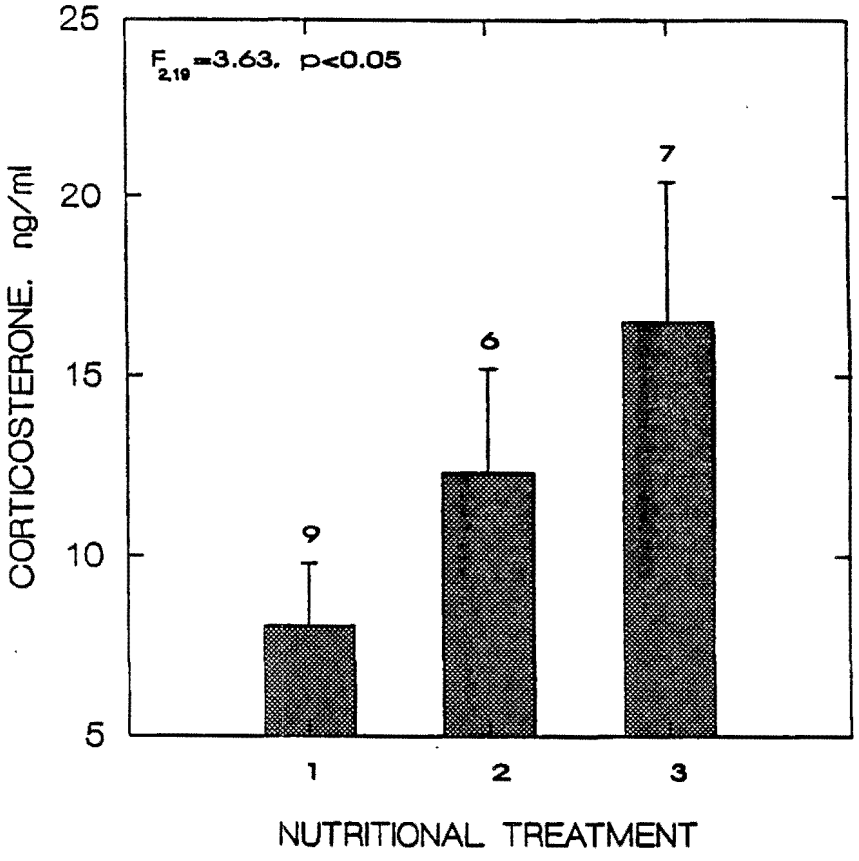

Fig. 1. Baseline levels of corticosterone in plasma of Black-legged Kittiwakes raised on restricted amounts of high-quality food (sandlance, treatment 2), sufficient amounts of poor-quality food (juvenile pollock, treatment 3) and control chicks raised sufficient amounts of high-quality food (sandlance, treatment 1).

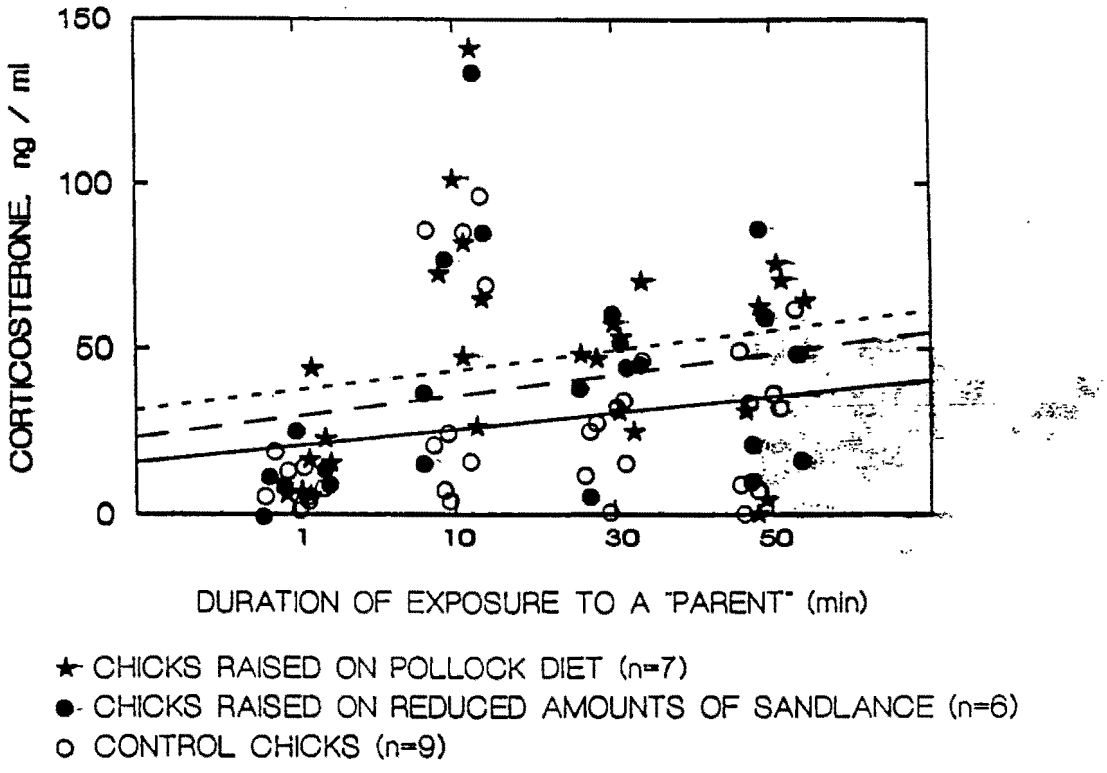

Fig. 2. Corticosterone responses of the hand-fed chicks to presence of a "parent" (in this case - presence of investigator). Repeated-measures ANOVA indicates that, over time, chicks raised on poor-quality diet (pollock, fine-dotted line) , and on reduced amounts of high-quality food (sandlance, dotted line) had significantly stronger ($F_{2,19}=4.117$, $p=0.003$) hormonal responses to the presence of parents compared to control chicks (solid line). Higher corticosterone responses of the food-stressed chicks are probably related to an increase in their begging behavior.

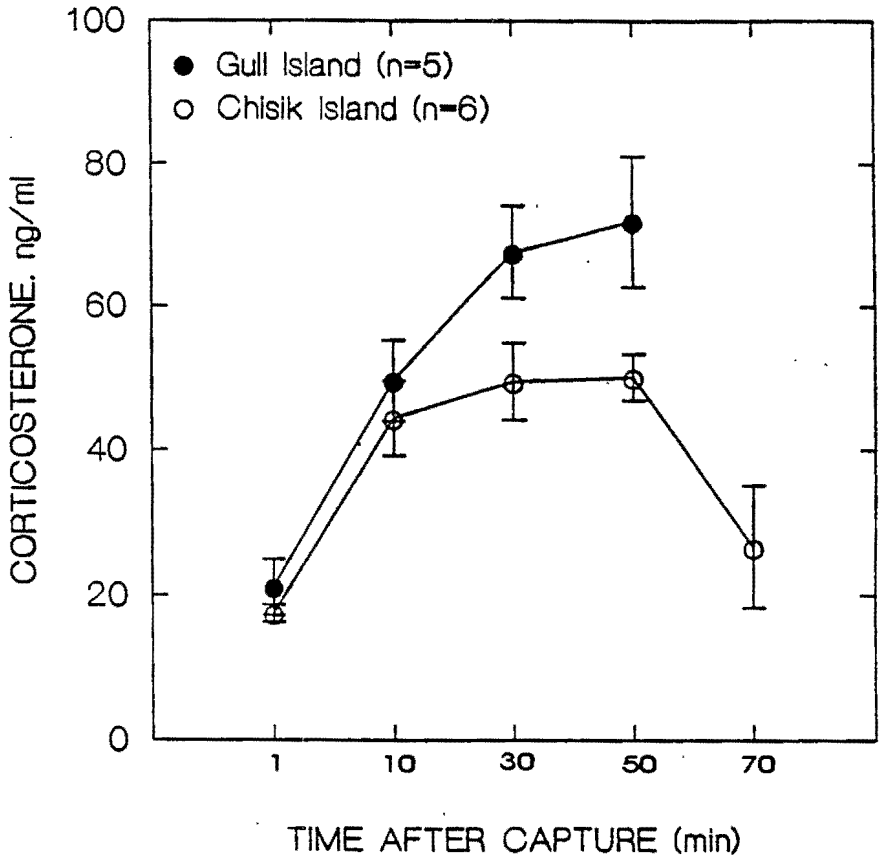

Fig. 3. Corticosterone responses of Black-legged Kittiwakes to a standardized stressor: capture, handling and restraint. T-tests showed that adults that reared young under poor feeding conditions at Chisik Island had a significantly weaker ($p<0.001$) responses (at 30 and 50 minutes after capture) compared to those that reared their chicks under favorable feeding conditio at Gull Island.

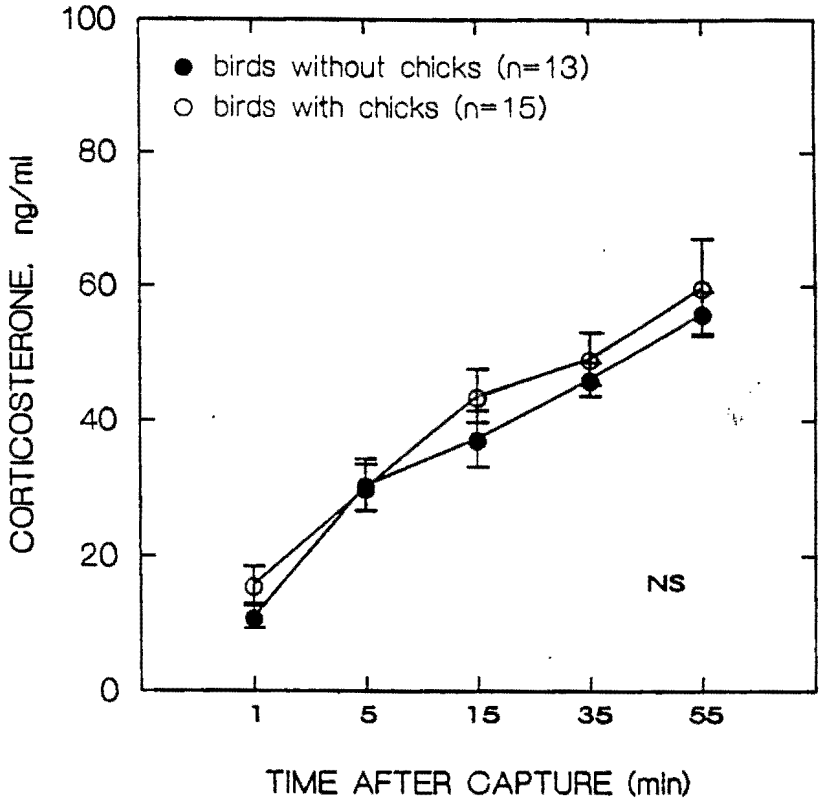

Fig. 4. Corticosterone responses of Black-legged Kittiwakes to a standardized stressor: capture, handling and restraint. Repeated measures ANOVA indicates that, under favorable feeding conditions, there is no significant differences in the hormonal responses to the stressor between parents that reared their young with those with experimentally removed chicks (Wingfield et al., unpublished data).

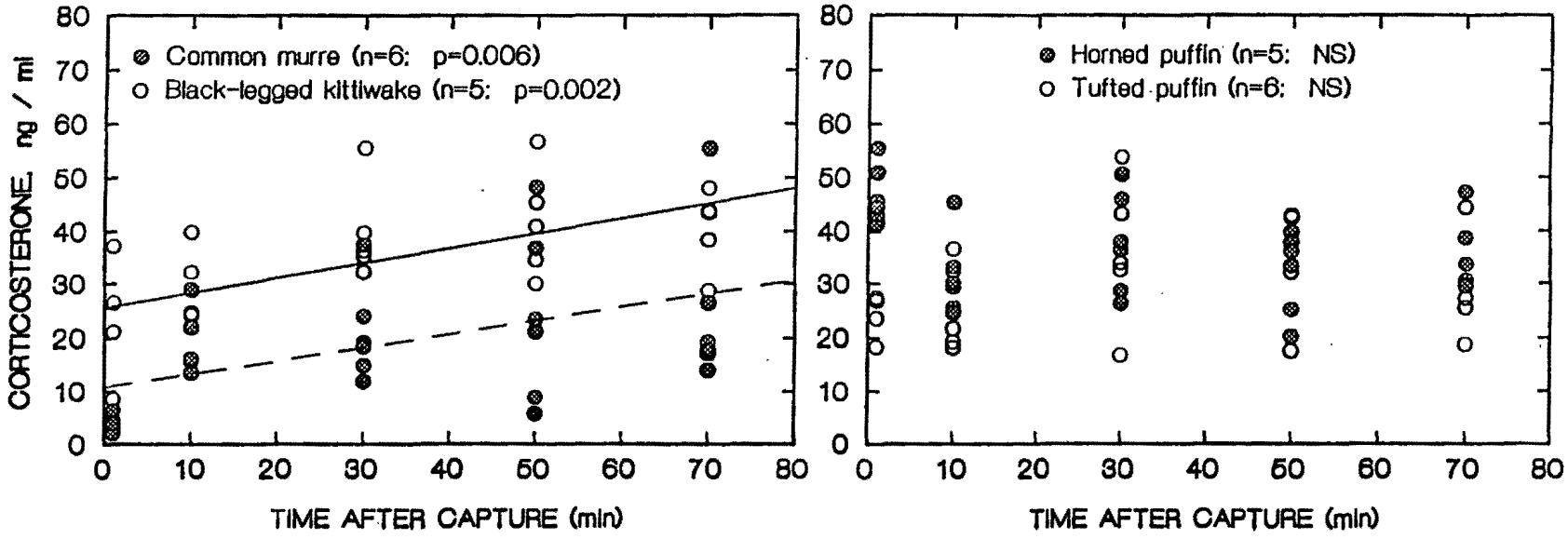

Fig. 5. In contrast to Black-legged Kittiwakes and Common Murres (sampled at Gull Island), parent Tufted and Horned Puffins (sampled at Chisik Island and the Barren Islands) did not respond to the standardized stressor by increasing corticosterone levels in plasma.

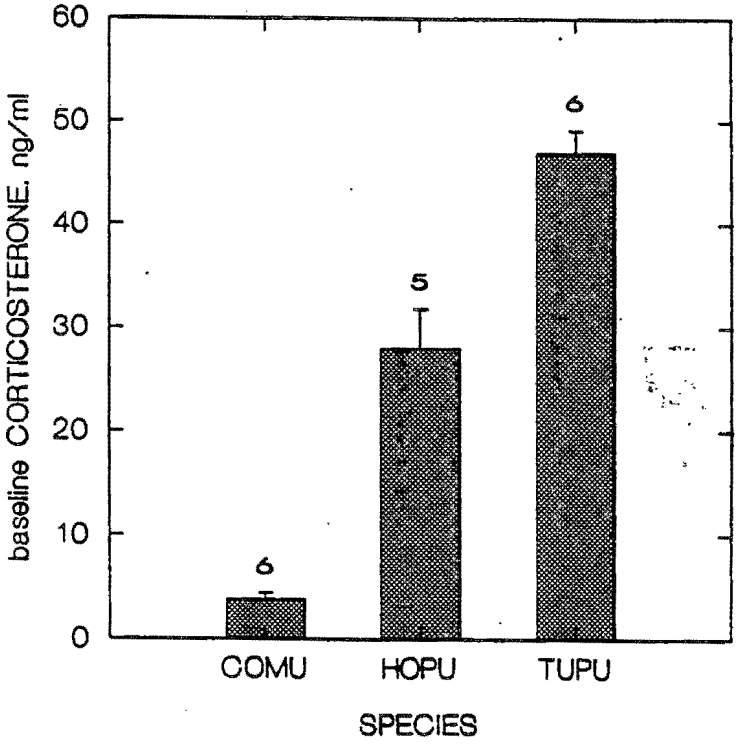

Fig. 6. Baseline levels of corticosterone are significantly higher (at $p<0.001$) in parent Horned and Tufted Puffins compared to those in other alcid species, the Common Murre.

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$9,910.0
Travel		$11,600.0
Contractual		$37,000.0
Commodities		$5,000.0
Equipment		$22,500.0
Subtotal	$0.0	$86,010.0
General Administration		$2,239.0
Project Total	$0.0	$88,249.0
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	

Dollar amounts are shown in thousands of dollars.

Comments:

1998

Project Number: 98 364
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 1 of 4

4/17/97

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
Vacant	Biotech	GS-5	5.0	1982.0		9,910.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		5.0	1982.0	0.0	
					Personnel Total	$9,910.0

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

1998

Prepared:

Project Number: 98_____
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3B
Personnel
& Travel
DETAIL

4/17/97

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

Contractual Costs:	Proposed
Description	FY 1998
University of Washington Research Work Order	37,000.0
Post-doc Salary - 25K	
Benefits and fees - 12K	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$37,000.0

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

1998

Prepared:

Project Number: 98_____
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3B
Contractual & Commodities DETAIL

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1998
Centrifuge			2,000.0
Laptop Computer			3,000.0
Mobile freezer			1,500.0
Misc Scientific field supplies			2,000.0
Laboratory supplies for Radio-immunoassay			14,000.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$22,500.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
All boat, lodging, field laboratory, and logistic support provided by APEX project 98163M (Cook Inlet Seabirds)		

1998

Prepared:

Project Number: 98_____
Project Title: Effects of food stress on survival and reproductive performance of seabirds
Agency: U.S. Geological Survey

FORM 3B
Equipment
DETAIL

4/17/97

Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers

Project Number:	98370
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
Duration:	1st year, 3-year project
Cost FY 98:	$84,324
Cost FY 99:	$90,000
Cost FY 00:	$90,000
Geographic Area:	Prince William Sound/Gulf of Alaska
Injured Resource/Service:	Harbor seals

ABSTRACT

Specific amino acids from food proteins will be compared in seals and to identify essential amino acids useful as habitat or prey markers. Specific amino acids labeled with ^{15}N and ^{13}C will be used to follow transamination and carbon relocation during metabolic processes in the seals. Year 1 will be used to establish laboratory and animal handling protocols and to analyze the amino acid composition and isotope ratios from prey species and existing marine mammal blood samples obtained from wild-caught seals and seals held at existing facilities. Years 2 and 3 will employ captive harbor seals at the Alaska SeaLife Center and will expand the compounds studied to include fatty acid composition and the isotope ratios in specific fatty acids.

INTRODUCTION

Stable isotopes have become an essential tool in the study of living organisms and their physiology. The hazards of handling radioisotopes and severe protocol requirements when using live organisms have resulted in a steadily increasing shift to the use of stable isotopes as tracers for both human and animal subjects. Some usage, such as the detection of *Helicobacter pylori* infections in ulcer patients, is now routine and bringing stable isotope analysis to many hospitals as a standard method. In contrast to the employment of natural abundance techniques in the marine environment, most physiology experiments employ compounds enriched with ^{13}C or ^{15}N to enhance detectability and to follow the transfers to different metabolites within the organism. Improved lower limits of detectability and smaller sample size requirements now allow the use of stable isotopes where only radioisotopes would have worked in the past.

This proposal describes experiments to be used at the Alaska SeaLife Center (ASLC) and at the University of Alaska Fairbanks (UAF) to provide calibration and more detailed information on stable isotope transfers and fractionation in marine mammals (and perhaps sea birds in the future) to enable better interpretation of natural abundance data being acquired in Prince William Sound and the adjacent Gulf of Alaska. Coordination with other investigators performing feeding experiments and dietary studies at ASLC will lead to a thorough integration of efforts and optimization of the use of animal subjects in years 2 and 3 of the study. Year 1 will consist of protocol development and refinement of analytical techniques. The succeeding years will consist of experiments on harbor seals at ASLC.

Over the past two decades, isotope ratio analysis has emerged as a powerful tool in ecosystem research, both on the process scale and as a validation technique for large-scale ecosystem models (Michener and Schell, 1994). In relevant applications to this study, Schell et al. (1989) described a geographic gradient in isotope ratios in biota across the Alaskan Beaufort Sea and the Bering–Chukchi seas and showed that this gradient could be applied to describing bowhead whale natural history. The isotopic gradient arises from the primary producers in the ecosystem and is passed up food chains to label consumers up to the top predators. Within each biome, there is reasonable fidelity to the $\delta^{13}C$ observed in the primary producers and a predictable increase in the $\delta^{15}N$ with each known increase in trophic level. However, among individuals of each taxa analyzed there are often large ranges in values, especially in the carbon isotope ratios.

A fundamental assumption in the employment of isotope ratios as natural tracers is that the amount of isotopic fractionation in the process of metabolizing food is known as the incorporation of assimilated components into the consumer. For marine mammals, these data are scarce and most of the ongoing work is based on the findings derived from terrestrial bird and mammal studies. The accurate interpretation of isotope ratio data on food webs and marine mammals depends completely on a knowledge of fractionation effects arising from dietary sufficiency and composition. To date, we do not have this knowledge. This project is aimed at the very specific goal of acquiring accurate isotope fractionation data on harbor seals through controlled feeding and laboratory experiments.

NEED FOR THE PROJECT

A. Statement of Problem

Harbor seals were undergoing an unexplained decline in numbers before the oil spill and the decline was further accelerated by the disaster. Since that time the population has not recovered and is still at a low level, although now perhaps finally stabilized. No definitive cause and effect relationships have been found for the decline or failure to recover. It is becoming increasingly evident, however, that changes in the marine environment in the past two decades have altered the carrying capacity downward in the northern Gulf of Alaska and the effects are being passed up the food chains. Carbon isotope ratios in biota of the northern Pacific Ocean appear to have been declining for nearly twenty years (Schell, 1997) and imply that a major decrease in productivity has occurred. Interpretation of the isotope ratios from wild seals and birds requires that the isotopic fractionation that occurs during metabolism is known, including the effects of optimal and suboptimal diets. There are almost no data regarding marine mammals on this subject and none on harbor seals. This study will undertake to follow both the "whole animal" carbon and nitrogen isotopic fractionation and the determination of specific effects on individual amino acids and other metabolites in harbor seals.

B. Rationale/Link to Restoration

Natural abundance isotope ratios have been used as a tracer in several EVOS-sponsored studies in Prince William Sound and adjacent waters. In conjunction with fatty acid analysis, it has been demonstrated that harbor seals feed at a variety of trophic levels and can shift between benthic and pelagic prey in habitats that are relatively close together. It has also been shown that a distinct carbon and nitrogen isotope ratio gradient exists between Prince William Sound and the open waters of the Gulf of Alaska, providing a natural marker of advected water and biota into the sound. Since climatic effects can alter both the carrying capacity and composition of the biota in Prince William Sound, it is advantageous to identify natural tracers that can aid in distinguishing between physiological effects and those potentially arising from oil spill impacts. Such impacts may be very indirect through alteration of food chains or through sublethal effects on marine mammals.

Carbon isotope ratios serve as conservative tracers of energy supply between trophic levels (phytoplankton to zooplankton to fishes to top consumers). Seals, cetaceans, birds, etc., acquire the isotope ratios in proportion to the amount of food derived from each differing source. This, in turn, is reflected in the composition of body tissues and in keratinous tissues (claws, feathers, baleen, whiskers) as a temporal record when multiple sources of food are consumed over time and space. This allows the discerning of important habitats and food resources in animals that seasonally migrate or undergo periods of hyper- and hypotrophy. Little is known, however, of the internal fractionation of isotopes that occurs in mammals during fasting and/or extended periods of suboptimal diets.

Nitrogen isotope ratios reflect both the food sources and the trophic status of that animal. As nitrogen in food is consumed and assimilated by a consumer, the heavy isotope is enriched by

approximately 3‰, with accompanying loss of the lighter isotope through excretion. The enrichment occurs with each trophic step and thus allows the construction of conceptual models and food webs and the assignment of relative trophic status to species for which dietary data are sparse. Hobson and Welch (1992) used isotope ratios to describe the trophic relationships of birds and mammals to the available prey species in the Canadian Arctic. Further extension to benthos by Dunton et al. (1989) and to fishes (Vinette, 1992) has confirmed that the isotopic trends are evident across the entire food web. During fasting or starvation, nitrogen isotopes may be fractionated during transamination reactions leading to overall shifts in the average isotope ratios of the whole animal. Detailed interpretation of data from samples taken from wild seals requires that these effects be known.

C. Location

The research effort will be conducted at the Alaska SeaLife Center and the University of Alaska Fairbanks. The instrumental analyses such as chromatography and mass spectrometry will initially be undertaken at UAF with the dietary studies and sampling at ASLC. In years 2 and 3 more of the effort will be shifted to ASLC as detailed dietary experiments are conducted.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Much of the research will be conducted at the Alaska SeaLife Center and the Principal Investigator anticipates both community interaction and explanation of the research approach and usefulness at that site.

PROJECT DESIGN

A. Objectives

The major null hypotheses to be tested in 1997–98 and succeeding years are as follows:

1. The isotope ratios of harbor seals accurately reflect diet under all conditions. Increased fractionation does not occur during periods of fasting or suboptimal feeding and does not affect either carbon or nitrogen isotope ratios in the seal.

2. There are no essential amino acids in seals and their prey that can act as conservative markers of specific habitats or food sources.

The objectives of this study are divided into three elements:

1. Year 1 will consist of developing methods and protocols for the isolation of metabolites from harbor seal blood and tissue samples to be employed during the following controlled diet studies. The Institute of Marine Science has purchased a new GC-IRMS (gas chromatograph–isotope ratio mass spectrometer) that will be used to determine isotope ratios

in the individual amino acids isolated from serum samples. These amino acids will be separated by high performance liquid chromatography using semi-preparative columns and inorganic buffers. Testing for essential amino acids in harbor seals will be initiated using blood samples acquired from seals now held at the Mystic Marinelife Aquarium in Mystic, Connecticut. These animals are being used in vibrissae growth rate studies and blood samples can also be collected. By feeding ^{15}N and ^{13}C labeled glycine to the seals prior to blood sample collection, it will be evident if the label has been transaminated to all amino acids and to what extent.

2. The second component will be a study of the effects of suboptimal versus optimal diet on the fractionation of carbon and nitrogen isotopes in harbor seals. Diets of known amount and composition (isotopic and energetic) will be fed to the seals at ASLC and blood protein amino acids will be monitored for composition and isotope ratios. This research will be closely coordinated with studies of controlled diet/assimilation efficiencies in harbor seals by Dr. M. Castellini so that minimal animal handling and sampling will be necessary.

3. The third component will be to determine source prey for isotopically distinct amino acids or other metabolites. The identification of specific amino acids that carry a conservative signal to top consumers (birds, cetaceans, fissipeds) would yield an extraordinarily valuable tool to follow food web transfers or to identify specific habitat importance. This will be accomplished by the analysis of proteins and fatty acids in prey species from locations around the study areas. Many samples are already archived and available to the Principal Investigator and others will be collected as required following initial appraisal for useful components.

B. Methods

Isotopic Analysis of Blood Protein Amino Acids

The proteins in blood serum samples from harbor seals will be separated from inorganic components via ion retardation columns and the isolated protein hydrolyzed to free amino acids. Multiple procedures to optimize amino preservation will be employed, such as acid and basic hydrolysis and through the use of proteolytic enzymes. Once isolated the free amino acids will be separated by HPLC (high pressure liquid chromatography) and the aliquots with individual amino acids will be taken to dryness. These samples will then be run on an elemental analyzer coupled to the isotope ratio mass spectrometer. The nitrogen and carbon dioxide liberated in the elemental analyzer will be separated by gas chromatography and run individually in the IRMS. By either oral dosing or intravenously dosing a seal with ^{13}C or ^{15}N-labeled glycine, the appearance of the label will be noted over time in the amino acid spectrum. Those amino acids remaining free of the label will be identified as probable essential amino acids derived solely from diet. Mobilization and isotopic fractionation of these amino acids will be tested further in dietary studies.

Isotope Fractionation During Fasting and Suboptimal Diets

Many marine mammals undergo periods of fasting or suboptimal diets such as during molt or reproduction. Nothing is known regarding the effects of these periods on the fractionation of

either carbon or nitrogen isotopes in harbor seal tissues. The amino acid threonine, for example, has been shown to become very isotopically depleted in ^{15}N during starvation, with lesser effects on glycine and serine (Hare et al., 1991). In coordination with studies of dietary effects on blood hormones or other work requiring harbor seal blood samples at ASLC, we will analyze aliquots as described above for shifts in the isotope ratios. Mobilization of amino acids during fasting can be tested via isotope dilution of labeled amino acids given intravenously at the start of the fast. These experiments will be conducted in the second year of the experiment and will be carefully planned to minimize animal handling and for maximum synergy with other researchers. All procedures will be approved by the ASLC scientific committee and conducted as required by the IACUC (Institutional Animal Care and Use Committee) of the University of Alaska and ASLC.

Sources of Essential Amino Acids in the Diets of Harbor Seals
The identification of specific metabolites, especially fatty acids and amino acids, in the tissues of harbor seals will be followed by a survey of potential prey species to identify probable sources. Fatty acids will be isolated and run from the gas chromatograph directly into the microcombustion unit of the preparatory system and then into the mass spectrometer. This will yield both a fatty acid spectrum and the isotope ratios for each component. The combination of chemical markers may provide a powerful tool for the identification of specific prey or habitat usage. The APEX program currently supported by EVOS will be a source of samples as will other opportunistic cruises in the spill and control areas. Herring, sand lance, pollock and capelin will be special targets, given their importance in the food chains of Prince William Sound.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

M. Castellini is concurrently submitting a proposal for related work on blood hormones at the Alaska SeaLife Center. This project will be closely coordinated with his work to optimize sampling and mutual assistance.

SCHEDULE

A. Measurable Project Tasks for FY 98 (October 1, 1997 – September 30, 1998)

October - July:	Establish methodology and protocols for the isolation and identification of amino acids from blood proteins
July - December:	Using blood samples from Mystic Marinelife seals, isolate and establish normal ranges of isotope ratios for amino acids; begin feeding experiments

B. Project Milestones and Endpoints

The milestones in this project are a blend of definitive goals and a continuing research process that will extend to the end of the funding period.

FY 98

October - February:	Establishment of laboratory protocols, amino acid analysis for mass spectrometry
March - April :	Continue analyses on archived blood samples
April - December:	Data synthesis, reporting of preliminary findings

The following are specific goals beyond FY 98:

FY 99

November - August:	Isolate amino acids from prey species and establish isotope ratios in essential amino acids; prepare Annual Report, Renewal Proposal
January - August:	Conduct feeding experiments, prepare draft manuscripts

FY 99 - FY 00

September - September:	Complete experiments; synthesize data and identify gaps; prepare manuscripts and submit Final Report.

C. Completion Date

Completion of the sampling and analytical aspects of this project are anticipated in 2000.

PUBLICATIONS AND REPORTS

Results of this project will be made available via the following:

Annual Reports: These reports will detail progress and preliminary findings and notable achievements. These are anticipated for the ends of FY 98 and FY 99.

Final Report: A Final Report will be provided. Technical results in this report will be shared with EVOS collaborators and assistance provided as opportune during the experiments. Preliminary exchange of findings will be conducted with EVOS investigators and the scientific community via professional meetings and informal communications.

Peer-reviewed publications: Over the course of this study peer-reviewed publications will be generated for the open literature based on the scientific findings. These publications will be generated by the PI and graduate students as first author publications when the primary focus is on the findings produced by the isotopic techniques or as second author publications when the isotope work is a minor part of the scientific results.

Papers at scientific society meetings: We request support for travel to appropriate scientific meetings for dissemination of results and interaction with colleagues. It is anticipated that the Society for Marine Mammalogy and/or the American Society for Limnology and Oceanography meetings will be attended by the PI and a graduate student. The Marine Mammal Meeting in

January 1998 is in Monaco and the added costs over a domestic meeting will be obtained from other sources.

Public lectures: Interaction with the public will arise through formal and informal presentation of results as part of ongoing public participation in the work at ASLC. Synthesis meetings designed to explain the findings of ecosystem studies will be presented at meetings coordinated by ASLC or EVOS and open to the public. Informal presentation of results will occur through interaction with interested members of the public, press and scientific community. Classroom instruction will also involve integration of findings into the presentation of educational material.

PROFESSIONAL CONFERENCES

The results of this project will be communicated at appropriate meetings. The biennial meeting of the Society for Marine Mammalogy or the American Society for Limnology and Oceanography is typical for this type of presentation, as are specific workshops and meetings emphasizing application of isotope techniques to biological problems.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Resources and Services – This study focuses on harbor seals, sea birds and the cetaceans of Prince William Sound. Although the major effort is concerned with harbor seals, other marine mammal tissues will be analyzed if available to provide context and comparable data. Sea lions held at ASLC will also be sampled if conditions allow. The projects anticipated under the direction of Dr. Michael Castellini will be especially closely coordinated through mutual interests and animal handling requirements.

PROPOSED PRINCIPAL INVESTIGATOR

Donald M. Schell
Institute of Marine Science
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, AK 99775-7220
Phone: (907) 474-7115
Fax: (907) 474-7204
E-mail: schell@ims.alaska.edu

PRINCIPAL INVESTIGATOR

D. M. Schell has been involved in stable isotope studies for over 25 years. His research has included natural abundance tracer studies and enrichment experiments. His work on bowhead whales and geographic gradients in stable isotope ratios has been published and subjected to rigorous reviews. The findings have been upheld and have provided insight into bowhead whale natural history unattainable by other techniques.

Dr. Schell oversees the Stable Isotope Ratio Mass Spectrometry Facility at the University of Alaska Fairbanks. This consists of three working instruments which are dedicated to specific elements as demand requires. A Europa automated continuous flow system will be used for most samples but back-up analytical capability is available. A new automated machine has recently been funded by the National Science Foundation and ordered for delivery in July 1997. This machine will increase the sample analysis capability and provide greater sensitivity for small samples.

As PI, Schell will oversee the Quality Assurance/Quality Control aspects of this project. Protocols for sampling have been established and working standards are cross-calibrated with other nationally recognized laboratories.

OTHER KEY PERSONNEL

Machine operations are the responsibility of Norma Haubenstock, technician. She is well trained and has more than nine years experience with mass spectrometers. Additional funds are budgeted for an assistant to prepare samples, load and operate the automated system and to aid in data processing and archiving for all users. A Ph.D. student will also be included in the project.

LITERATURE CITED

Dunton, K.H., S.M. Saupe, A.N. Golikov, D.M. Schell and S.V. Schonberg. 1989. Trophic relationships and isotopic gradients among arctic and subarctic marine fauna. Mar. Ecol. Prog. Ser. 56:89–97.

Hare, P.E. M.L. Fogel, T.W. Stafford, A.D. Mitchell and T.C. Hoering. 1991. The isotopic composition of carbon and nitrogen in the individual amino acids isolated from modern and fossil proteins. J. Archaeological Science 18:277–292.

Hobson, K.A. and H. Welch. 1992. Determination of trophic relationships within a high arctic marine food web using $\delta^{13}C$ and $\delta^{15}N$ analysis. Mar. Ecol. Prog. Ser. 84:9–18.

Michener, R.H. and D.M. Schell. 1994. The use of stable isotopes in tracing marine aquatic food webs. In: R. Michener and K. Ljatha (eds.). *Stable Isotopes in Ecology and Environmental Research*, p. 138–157. Blackwell Scientific, Cambridge.

Schell, D.M. 1997. Whale baleen provides a multi-year record of primary productivity in the Bering Sea. (Abstract) Amer. Soc. Limnol. Oceanogr. Santa Fe. NM, 10–14 Feb., p. 296.

Schell, D.M., S.M. Saupe and N. Haubenstock. 1989. Bowhead whale (*Balaena mysticetus*) growth and feeding as estimated by techniques. Mar. Biol. 103: 433–443.

Vinette, K.A. 1992. Carbon and nitrogen isotope ratios in bowhead whales and their zooplankton prey as indicators of feeding strategy and environmental change. M.S. Thesis, University of Alaska Fairbanks. 147 Pp.

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	Estimated FY 2003	Estimated FY 2004
Personnel		$51.5						
Travel		$5.9						
Contractual		$4.0						
Commodities		$6.1						
Equipment		$0.0						
Subtotal		$67.5						
Indirect		$16.9						
Project Total		$84.3	$90.0	$90.0				
Full-time Equivalents (FTE)		1.5						
	Dollar amounts are shown in thousands of dollars.							
Other Funds								

Comments:

Indirect costs are 25% Total Direct Cost, the rate negotiated by the EVOS Trustee Council with the University of Alaska.
2 Semesters of Tuition are included in Ph.D. Student Wages.

FY 98

Prepared: 04/14/97

Project Number: 98370
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: University of Alaska Fairbanks

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 1998
	D. Schell	Professor – P.I.	1.0	11.7		11.7
	N. Haubenstock	Technician – Mass Spectrometry	2.0	4.9		9.8
	Vacant	Graduate Student (Ph.D.)	12.0	1.7		19.9
	Vacant	Technician	3.0	3.4		10.1
		Subtotal	18.0	21.7	0.0	
					Personnel Total	$51.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1998
	Fairbanks to Mystic, Connecticut	1000	1	5	120	1.6
	Fairbanks to Seward	300	6	25	100	4.3
					Travel Total	$5.9

FY 98

Prepared: 04/14/97

Project Number:
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1998
Communications	0.7
Instrument Service – HPLC, GC-IRMS	3.0
Shipping, expediting samples, equipment	0.3
Contractual Total	$4.0

Commodities Costs:	Proposed
Description	FY 1998
Mass spectrometry-helium, high purity oxygen, liquid nitrogen	3.5
Chemicals, GC columns, glassware, expendables	2.2
Project supplies (computer, printer supplies)	0.4
Commodities Total	$6.1

FY 98

Project Number:
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 04/14/97

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

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1998
Description			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY 98

Prepared: 04/14/97

Project Number:
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

UNIVERSITY OF ALASKA BUDGET INFORMATION

The University of Alaska accounting system accumulates data according to an established system of accounts codes. This differs from the level or category of detail required on this proposal. Per the new Cost Accounting Standards Board (CASB) guidelines, costs are to be listed in a proposal only to the level of detail at which the subsequent expenditures may be tracked. Therefore, please note that supplies itemized on the budget form may be tracked to UA accounting system categories such as the following examples: 1) project supplies; 2) professional, technical and scientific supplies; 3) field camp supplies; and 4) hazardous materials. Service listings are also broad, but include specific categories such as duplicating, postage, toll charges, and software licensing. A complete list of University of Alaska Accounts Codes is available upon request.

Effects of Restoration Projects along the Kenai River on Juvenile Salmon Habitat

FY98 Detailed Project Description

Project Number:	98-USGSWRD 98380
Restoration Category:	Monitoring
Proposer:	US Geological Survey, Water Resources Division
Lead Agency:	U.S. Geological Survey, Water Resources Division
Cooperating Agencies:	Alaska Department of Fish and Game, Alaska Pacific University, University of Alaska
Duration:	Year 1 of 3
Cost FY 98:	$142.3K
Cost FY 99:	$125K
Cost FY 00:	$50K
Geographic Area:	Kenai River Watershed
Injured Resource/Service:	This project will quantify the improvement to juvenile salmon habitat resulting from EVOS funded streamside restoration projects along the Kenai River.

ABSTRACT:

Following the Exxon Valdez Oil Spill (EVOS), fishing was diverted from Prince William Sound to the Kenai River in south-central Alaska (fig. 1). The salmon habitat along the river was affected by this increased fishing pressure. Considerable investment has been made by the EVOS Trustee Council to restore and protect this salmon habitat along the river. These restoration projects use bio-degradable or natural materials and are designed according to the local hydraulic conditions. The projects should protect the bank from erosion and provide juvenile salmon with valuable habitat. However, without quantifying the improvement to the habitat or a positive response in the fishery, a valid restoration of the injured resource cannot be determined.

INTRODUCTION:

Through the year 2002, approximately $2.1 million of EVOS settlement funds are recommended to be spent on the Kenai River to restore habitat and enhance the recreational fishing that was injured by the oil spill (EVOS Trustee Council, 1996, 1997). The Alaska Department of Fish and Game (ADF&G) has permitting authority over stream activities that affect anadromous fish habitat. For example, their habitat biologists approve or disapprove projects by reviewing plans and specifications of projects proposed for installation below the ordinary high-water line of the Kenai River. The ADF&G allows construction projects only when it has been shown that the project's effects on aquatic habitat have been considered.

The newest restoration projects are designed to provide salmon with navigable water velocities, adequate water depths, and abundant protective cover. In addition to providing these physical features, these projects trap fine sediment. Commonly, near shore water velocities are slowed along these new restoration projects because additional flow resistance is created by extending live willow sprouts into the water or by installing root wads or rocks along the bank. Adequate water depths are provided near the projects by creating vertical or undercut banks out of biodegradable or natural materials. Protective cover is commonly provided by planting live vegetation that overhangs the bank, creating irregularly shaped banks, or placing root wads and boulders in the water.

These restoration design features provide juvenile salmon with suitable physical habitat but may also alter the biological and chemical characteristics of the site. For example, the lower velocities provided by increasing the shoreline roughness may be navigable by juvenile salmon but may adversely affect flood properties, such as water depth, near the site. In addition, trapping fine sediment may promote growth of new vegetation, but also may provide a mechanism to concentrate potential toxins that adhere to fine sediment at the restored site. These trapped fine sediments may change stream substrate and subsequently affect the community composition of benthic macroinvertebrates at the site, negatively influencing the available food sources for juvenile salmon.

Recently installed EVOS funded bank-restoration projects have yet not been adequately documented to determine whether juvenile salmon habitat has been significantly improved. This proposed study will quantify attributes of juvenile salmon habitat at restored (treated) sites, compared to natural (untreated) sites along the river. Additionally, this proposed study will assess numbers and species composition of juvenile salmon near restoration projects to evaluate any positive response in the fishery resulting from the restoration projects. This proposed study will be closely coordinated with the ongoing restoration efforts of the funded EVOS 180 project through Gary Liepitz, the ADF&G habitat biologist at the Kenai River Center in Soldotna. Additional coordination with another proposed EVOS study led by ADF&G, "Salmon carcasses and juvenile chinook salmon production in the Kenai River ecosystem," is anticipated if that study is funded.

NEED FOR THE PROJECT

A. Statement of Problem

A detailed inventory of streamside construction and restoration projects along the Kenai River has been completed by ADF&G (Liepitz, 1994). Restoration projects installed since 1993 have not been evaluated for their contribution to juvenile salmon habitat. All restoration project designs have been approved by a fishery habitat biologist, but there has been no documentation of whether they are providing adequate habitat, meeting their design expectations, or benefiting juvenile salmon. Detecting the response of fish to habitat alterations is a difficult problem because of spatial and temporal scales in the ecosystem (Minns and others, 1996). Yet each restoration project occupies a unique setting along the river and will alter the ambient hydraulic characteristics of the river differently (Dorava, 1995). Thus each restoration project must be evaluated individually.

To evaluate the success of new restoration projects, several questions must be addressed: Have changes in habitat occurred? If so, are the changes affecting a response in the juvenile salmon population? What is the response? Is the integrity of the restoration project being maintained? For example, is the bank being protected? Is the restoration project remaining intact and properly functional? Are flood hazards increased and if so, does the increased flood risk outweigh the benefits for the fishery?

B. Rational/Link to Restoration

This project will monitor the performance of EVOS funded restoration projects to determine if they are providing suitable habitat for juvenile salmon and if they are protecting the banks from erosion. The proposed monitoring should be done in conjunction with site restoration to quantify improvements in habitat at specific sites and to adjust restoration designs as required to improve habitat.

C. Location

One or two new restoration projects in each of five reaches of the Kenai River (Liepitz, 1994) will be selected for detailed evaluation. If possible, sites will be selected that are scheduled for restoration during 1998 and 1999, so that measurement of habitat characteristics can be made prior to and after restoration of the site.

PROJECT DESIGN:

A. Objectives:

1) Compare measurements of habitat attributes of juvenile salmon near at five to ten recently installed bio-engineering projects along the Kenai River with measurements of habitat attributes along nearby undisturbed natural banks.

2) Measure juvenile salmon physical, chemical and biological habitat attributes near five to ten sites that are subjected to damage seasonally by bank anglers.

3) Count juvenile salmon numbers and determine species composition near the bio-engineered restoration projects and compare with those found near disturbed and undisturbed natural banks.

4) Assess size and condition differences in the juvenile salmon collected at each type of site sampled.

5) Evaluate the effects of bio-engineered restoration projects on stream hydraulic characteristics during flood conditions.

B. Methods:

Measuring Habitat Attributes:

Detailed habitat suitability comparisons will be made using Habitat Evaluation Procedures (HEP) (Stiehl, 1994) to determine the relative value of habitat attributes provided near each type of treatment site investigated. The habitat attributes to be measured include stream velocity and flow direction, suspended-sediment concentration, streambed composition and chemistry, streamside and in-stream cover, and benthic macroinvertebrate numbers. A team of two individuals will complete the habitat attribute measurements to reduce observer variability in classifying the habitat (Roper and Scarnecchia, 1995)

Stream velocity at each site will be averaged from measurements made at 6 locations (fig. 2). The 6 measurements within each 30-m-long sampling site will be made as 3 pairs of measurements spaced about 15 m apart horizontally along the site's bank. Each pair of measurements will include a measurement made at approximately 1 and 2 m streamward from the bank. The velocity measurements will be made with a hand-held acoustic doppler velocity meter. This meter documents 3-dimensional water movement below it by identifying what speed and which direction the water is flowing. The habitat value of water velocity will be evaluated as a mean value for each treatment site. The mean velocity value can be determined by averaging the values recorded by the velocity meter over the depth of water at each measuring point. Flow direction at each velocity measuring point and at the surface near each treatment site will be noted to evaluate alteration of the streamflow into or away from the bank by the type of treatment at the site.

Suspended-sediment concentration and bed-material movement will be measured at a single location near the downstream end of each treatment site prior to other in-stream measurements (fig. 2). A streambed material sample will be collected from a point near the center of the treatment site to determine size characteristics of the material (fig. 2). The streambed material sample will also be analyzed to determine the concentrations of selected toxins such as trace metals and gasoline range organics. The chemical analysis of the sediments will include determination of the concentrations of lead, zinc, cadmium, chromium, mercury, and arsenic, as well as benzene and toluene.

Three benthic macroinvertebrate samples will be collected from each treatment site (fig. 2) with a modified Surber sampler, using methods described by Cuffney and others, (1993). The samples will be combined into one composite sample for each treatment site, then preserved and transported to the aquatic entomology laboratory at the Environment and Natural Resources Institute at the University of Alaska Anchorage for sorting, counting, and identification to the lowest practical taxonomic level. Bio-assessment metrics, such as the percent dominant taxa and community similarity coefficients (Gore, 1985), will be computed for each treatment site for inter-site comparisons.

Measurements of velocity and sediment movement have been scheduled for periods when the river is flowing at or near the mean annual flow (June 1-15) and again near annual peak discharge (July 20-August 10). When the flow in the river is approaching the mean annual minimum (April 15-30), streamside restoration projects are usually out of the water or are higher than the natural, low-flow water surface. During these low-flow conditions, macroinvertebrate samples will be collected and each treatment site will be closely examined for damage from the previous high-water season.

Assessing Juvenile Salmon:

Initial assessments of juvenile salmon habitat near each type of site will be done with an underwater camera. The camera will be carefully placed into the stream about 2 m from the bank and will document the number of juvenile salmon as well as other fish present in the stream margin of each treatment site. Recording the numbers and types of fish present at each treatment site and the natural behavior of the fish will provide valuable insight about the suitability of the habitat at each site.

Additional assessments of juvenile salmon will be completed when samples are collected three times during this investigation from each treatment site using customized minnow traps and fine meshed blocking nets. Blocking nets pinned to the river bottom and a hand-held seine will be used to route juvenile salmon into the waiting trap (fig. 2). The catch efficiency of this experimental capture method will be determined for different environmental conditions prior to this investigation by conducting several capture tests using marked juvenile salmon. After this capture testing, juvenile salmon will be collected at each treatment site from a 2-m-wide segment of the river margin approximately 30 m long. The abundance and species composition of juvenile salmon collected will be compared among treatment sites. This sampling will be done pseudo-synoptically (each site will be sampled at nearly the same time, with the same method and same amount of sampling effort).

Initially, a subset of the collected juvenile salmon will have the contents of their stomach sampled by flushing with a small syringe. The stomach contents will then be compared to the macroinvertebrate data. This will determine if the juvenile fish are feeding on macroinvertebrates from the site itself or on some that drift into the site. Additionally, a subset of collected juvenile salmon from each site will be uniquely tagged with a hot or cold brand so they can be identified during re-sampling. Using the combination of synoptic sampling and tagging, objective 3, and 4 will be obtained. Furthermore, some information regarding the amount of time juvenile salmon spend near each type of treatment site may be obtained if sufficient numbers are recaptured.

The number of different fish species collected at each sampling site will be determined. Based on previous sampling studies along the Kenai River (Bendock and Bingham, 1988; Berger and others, 1982; Estes and Kunts, 1986), we anticipate there will be a predominance of juvenile chinook salmon. The size and weight of each juvenile salmon collected will be measured. These measurements will be used to assess physiological differences in juvenile salmon collected near all treatment sites, such as a condition factor K, which is equal to a constant multiplied by the fish's weight/length cubed (Laird and Needham, 1988). Comparisons of the numbers of juvenile salmon, species, size, and weight will be made among those collected near all treatment sites. This population information will help determine where juvenile salmon prefer to reside and if a physiological consequence is associated with this preference.

Analyzing Data:

A multivariate analyses of covariance (MANACOVA) (Hoaglin and others, 1983, 1985) will be used to test if habitat (velocity, depth, cover, substrate size, substrate chemistry, and macroinvertebrates) affects the abundance of juvenile salmon. The influence of each habitat attribute on juvenile salmon abundance will be tested to evaluate the effects of restoration projects on juvenile salmon populations.

Identifying and defining possible links between habitat alterations and response in juvenile salmon will require examining changes in juvenile salmon populations and physiology, and determining the likely causes. For example, if the juvenile salmon found near restoration projects are more numerous and much larger than those found in disturbed or undisturbed sites, does this result from differences in physical conditions such as water velocity? Are the salmon expending less energy residing at these projects or is forage better at the restoration project? Does sediment chemistry play a significant role in the quality of habitat?

Evaluating Flood Properties:

A step-backwater hydraulic model will be used to evaluate potential water-surface elevation changes resulting from installation of a bio-engineered restoration project along the banks of the Kenai River. Alterations to bank restoration designs will be evaluated with this numeric model to assess their effects on flood-stage-water-surface-elevations. This evaluation will help satisfy objective 5.

C. Cooperating Agencies, Contracts, and Other Agency Assistance:

The project will be coordinated by the principal investigator, Joseph Dorava, research hydrologist with the U.S. Geological Survey. He will be assisted by Gary Liepitz, habitat biologist with the ADF&G and Paul McLarnon, fisheries biologist graduate student in Environmental Sciences at Alaska Pacific University (APU). This team will work under the supervision of Gordon Nelson, U.S. Geological Survey District Chief, and Lance Trasky, Regional Supervisor for the Habitat Division of ADF&G. The team will receive additional advisement from Jim Reynolds, University of Alaska Fairbanks (UAF) and Roman Dial from APU. All appropriate technical staff of the USGS, ADF&G, and APU will assist as necessary to meet the commitments outlined in this proposal.

SCHEDULE:

A. Measurable Project Tasks for FY98

This project is expected to occur during the period October 1, 1997 to September 1, 2000. Field investigations are expected to occur in 1998 and 1999 and the report writing and publication will be complete by September 30, 2000. During FY98 the following schedule of tasks will be completed:

Oct. 1, 1997 - April 1:	Purchase sampling gear, design sampling strategy
April 1-May 1:	Select sampling sites, collect macroinvertebrate sample
May 1-June1:	First juvenile salmon sampling trip begin measuring habitat
June 1-July 15:	Second juvenile salmon sampling trip continue measuring habitat
July 15-Aug. 15:	Third juvenile salmon sampling trip complete measurements of habitat
Aug. 15-Oct.1, 1998:	Begin writing annual project report

B. Project Milestones and Endpoints

1. Measure habitat attributes at each site and complete habitat evaluations by September 30, 1999.
2. Complete juvenile salmon sampling September 30, 1999. Complete evaluation of these data by April 15, 1999.
3. Complete evaluation of the performance of the restoration projects during flood conditions by September 30, 1999.

C. Completion Date

All project objectives will be met and all project reports completed by September 30, 2000.

PUBLICATIONS AND REPORTS:

A U.S. Geological Survey Water-Resources Investigations Report (WRIR) describing the effects of bio-engineered restoration projects on juvenile salmon habitat will be prepared after data collection and analysis.

Paul McLarnon will write a Masters Thesis for APU describing the population and physiologic differences between juvenile salmon collected at the sampling sites. Paul plans to graduate in May 2000.

Other topical reports may be published by the investigators as peer reviewed journal articles when appropriate.

PROFESSIONAL CONFERENCES:

The principal investigator has proposed to convene a special session at the American Geophysical Union's Fall Meeting in San Francisco California in December of 1999. The proposed session title is "Linking Hydrology and Aquatic Habitat." A paper describing the initial assessment of the effects of restoration projects along the Kenai River on juvenile salmon habitat is planned.

NORMAL AGENCY MANAGEMENT:

Although involved in numerous water quality and aquatic habitat investigations, the U.S. Geological Survey (USGS), the lead agency proposing this project, is not normally funded to evaluate the effects of restoration projects on juvenile salmon and their habitat. Because the USGS does not directly manage or regulate the activities along the Kenai River, no conflict of interest can exist. Additionally, because the USGS is a professional government research agency, no bias exists in our interpretation of project data.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT:

This investigation will be coordinated with an assessment of the water quality of freshwater streams entering Cook Inlet which the USGS began in October, 1996. The Cook Inlet project is part of the USGS National Water Quality Assessment Program (NAWQA) and is funded at about $1 million per year during the next 5 years. The NAWQA program will contribute considerable support to this EVOS project through administrative assistance and project supervision as well as providing a data base for storage and dissemination of EVOS project data. Additional coordination with the ADF&G Habitat Division and Sport Fish Division is planned for site selection and habitat assessments. Another proposed EVOS project led by ADF&G "Salmon carcasses and juvenile chinook salmon production in the Kenai River ecosystem", if funded, will be coordinated closely with this project. The proposed ADF&G project's principal investigator, Dana Schmidt, has already begun integration of the two projects with USGS. Some of the sampling design for each project overlaps, including the proposed macroinvertebrate and juvenile salmon collection. Coordination of these two proposed EVOS projects has been anticipated and will result in considerable cost and data sharing.

PROPOSED PRINCIPAL INVESTIGATOR:

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March 1997

CONDENSED AUTOBIOGRAPHY:

NAME: Joseph Mark Dorava

LOCATION: Alaska District, Western Region

DISCIPLINE: Surface Water

PROJECT SHORT TITLES: (1) Assessment of Stream Erosion along the Kenai River
(2) Hydrologic Processes and Hazards at Alaska Volcanoes

PROJECT CHIEF: (1) same (2) Christopher F. Waythomas

GRADE AND DATE OF LAST PROMOTION: GS-12; October 1996

DATE AND LOCATION OF ENTRANCE WITH WRD: January 1987, Madison, Wis.

EDUCATION:

University of Alaska, Anchorage, M.Sc., 1993
(Environmental Quality Engineering)

University of Wisconsin, Madison, B.S., 1988
(Civil and Environmental Engineering)

North Central Technical Institute, Wausau, Wis., A.A., 1979
(Architectural Residential Design)

AWARDS AND HONORS:

National Performance Review Hammer Award
October, 1996
Star Award, September 1996
Cash Award, August 1992
Special Achievement Award, October 1990

PROFESSIONAL SOCIETIES:

American Geophysical Union
American Water Resources Association

PROFESSIONAL EXPERIENCE:

1995-present: Project chief in charge of an assessment of stream erosion along the Kenai River in south-central Alaska. The primary goal of the project is to assess the contribution to streambank loss induced by boat wakes. One graduate student and two undergraduate students are assisting with the project. The Alaska Department of Fish and Game, our primary cooperator, also provides a habitat biologist to review the project and to help evaluate the effects on salmon habitat from bank erosion.

1990-present: Hydraulic Engineer/Hydrologist participating in investigations of hydrologic hazards for the Alaska Volcano Observatory. My primary role has been to assess the hydrologic effects of volcanic activity on watersheds near the volcanoes and to evaluate the hydrologic hazards associated with volcanic activity.

1994-1995: Project chief in charge of the Alaska District's research efforts assessing alterations to juvenile chinook salmon habitat in the Kenai River for the Alaska Department of Fish and Game. The project investigated the effects of streamside structures on river hydraulics and the subsequent effects on aquatic habitat. Final work for this study was completed in October 1995 and Water-Resources Investigations Report 95-4226 "Hydraulic characteristics near streamside structures along the Kenai River, Alaska" was published in 1995.

1993-1995: Project chief in charge of the Alaska District's effort in researching, compiling, and writing reports describing the environmental and hydrogeologic conditions at 66 sites for the Federal Aviation Administration (FAA). I was promoted to this position after obtaining my Master's Degree in Environmental Quality Engineering. During coordination of this project, I established cost-effective contracts with the local Federal Library for literature research, and with the local university for work-study student help. Additionally, I coordinated three graduate-student papers for the project, advised two students working on their Masters' Theses, and published 45 Open-File Reports on time and within budget.

1988-90: Hydraulic/Civil Engineer working for the Anchorage Subdistrict Office collecting data, and processing and preparing the data for publication in the annual water-data report. During this time, I helped to develop a system for the automated collection of weather records to assist hydrologists with estimating streamflow during periods of ice effect.

1987-88: Hydrologic Trainee/Technician working in the Wisconsin District Office assisting in investigations of flood frequency and magnitude for several communities participating in the State Flood Insurance Program. My role included conducting field surveys, modeling flood flows, delineating flood plains, writing technical reports, and participating in public discussions of the study results.

SIGNIFICANT ACHIEVEMENTS SINCE LAST PROMOTION

Since my promotion to GS-12 in October 1996, I have achieved several significant research goals. I have completed an assessment of the recovery of the benthic macroinvertebrate community in the Drift River following the 1989-90 eruption of Redoubt Volcano. This study was completed with assistance from one of my professors from the University of Alaska and represents the only known assessment of biological community recovery from volcanic activity in Alaska. The manuscript describing this work has been approved by the USGS and has been submitted to the Journal of Environmental Management for publication consideration. Significant implications for the multi-million dollar Cook Inlet salmon fishery result from frequent, violent, eruptions of active volcanoes in the Cook Inlet region. Results from this study have elucidated the potential effects of volcanic activity on benthic macroinvertebrates, aquatic habitat, and economically important salmon fisheries. This is especially important in Alaska where the human population near volcanoes is sparse, but valuable natural resources are abundant.

Additionally, I have completed a study of the effects of boatwakes on streambank erosion along the Kenai River in southcentral Alaska. This study utilized a simple data-collection scheme where bank loss was measured with erosion pins, and concurrently boats were counted with float gages. This simple data-collection scheme was coupled with a more complex data analysis, in which the energy contribution from the tractive forces of the measured natural river currents was compared with the energy from measured boatwakes. The results of this study indicated that as much as 97 percent of the energy dissipated on the study site banks resulted from boatwakes. The study design and results have been continuously reviewed in the public arena because the Kenai River fisheries represent more than $78 million in annual income for the State of Alaska. In addition, the Governor has asked for a 1997 revision or update to the 10-year-old Management Plan for the Kenai River Special Management Area. The results of the boatwake study have been an integral part of that plan's mitigation strategy development. The boatwake study report has been submitted for Director's approval, and the results and study design have already generated national interest by USGS. Preliminary results of the study have been included in a national synthesis of habitat investigations by the USGS and project managers in the Idaho District have inquired about the study's application to their concerns about the effects of boatwakes on aquatic habitat.

I have also assisted with the development of a model for assessing volcano hazards in the Cook Inlet region of Alaska. This model was completed during the previous two years and uses Redoubt Volcano as an example of the type of hazards that result at volcanoes in southcentral Alaska. This model has been approved by the staff of the Alaska Volcano Observatory and once approved by the Director, it will become the standard by which the hazard assessments of numerous other active volcanoes of the region are completed.

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ADDITIONAL SCIENTIFIC CONTRIBUTIONS

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Assessment of the potential volume of water generated by melting ice and snow on Spurr Volcano during future eruptions of Crater Peak: Geological Society of America Annual Meeting, October 1994, Seattle, Wash.

Alterations to juvenile chinook salmon habitat at selected streamside construction projects along the Kenai River, Alaska: American Water Resources Association, Alaska Chapter Annual Meeting, April 1995, Juneau, Alaska.

Hydrologic hazards at recently active volcanoes in the Cook Inlet Region, Alaska: presented a poster at the summer symposium Water Resources and Environmental Hazards in the Pacific Rim, American Water Resources Association International Symposium Honolulu, Hawaii, June 25-28, 1995.

Outburst flood from Kidazgeni Glacier, Spurr Volcano, Alaska: American Geophysical Union, Fall Meeting, California, December 1995

Salmon habitat alterations resulting from recent flooding along the Kenai River, Alaska: American Water Resources Association Alaska Chapter, Proceedings of 1996 Annual Conference, April 18-19, 1996, Anchorage, Alaska.

OTHER COMMITTEE ASSIGNMENTS:

Kenai River Watershed Interagency Coordination Committee, member since 1994.

Technical working group of the Kenai River Special Management Area since 1996

Elected to Director of the Southcentral Alaska Section of the Alaska Chapter of the American Water Resources Association, Coordinated monthly section meetings since 1994

Elected to chair the Awards Committee of the Alaska Chapter of the American Water Resources Association, since 1996

Graduate student committee for Gayle Moore and Paul McGuarnin, Alaska Pacific University

OTHER TALKS AND SEMINARS:

Brown-Bag speaker at National Training Center, Denver: Talk involved the showing of a video of the August 18, 1992, eruption of Crater Peak, January 1993.

Brown-Bag speaker for USGS seminar series in Anchorage: Talk described the hydrologic hazards associated with eruptions of Crater Peak, April 1994.

Invited Brown-Bag speaker for USGS BRD seminar series in Anchorage: Talk about preliminary boatwake investigation results, December 1996

Invited guest speaker at the Alaska Department of Fish and Game office in Soldotna for a meeting of division heads to address issues concerning salmon habitat effects of the 100-year flood that occurred in September 1995 along the Kenai River in southcentral Alaska.

Guest speaker at a panel presentation for the Kenai Visitors and Cultural Center in Kenai, Alaska, November 14, 1995. Spoke about the effects of flooding on salmon habitat and specifically about the role of streamside structures during the 100-year flood of September 1995.

Addressed the Governor's Advisory Board for the Kenai River Special Management Area to describe the boatwake study design and to describe study results November 1996 and January 1997.

SIGNIFICANT PAPERS

Paper 1. Dorava, J.M. and Milner, A. M., in review at journal, Effects of recent volcanic eruptions on aquatic habitat in the Drift River, Alaska: Implications at other Cook Inlet region volcanoes, Journal of Environmental Management

This manuscript describes the recovery of the benthic macroinvertebrate community in the Drift River following the 1989-90 eruptions of Redoubt Volcano. Additionally it describes the implication of volcanic activity on the economically important fisheries in the Cook Inlet region. No other work of this nature has been done in Alaska and this manuscript should make an important contribution to understanding the effects of volcanic activity on the biological communities near Alaska's numerous active volcanoes.

Paper 2. Dorava J.M., and Liepitz, G.S., 1996, Balancing the three R's (Regulation, Research, and Restoration) on the Kenai River, Alaska: U.S. Geological Survey Fact Sheet FS-160-96

This fact sheet describes the connection between hydrology and aquatic habitat along the Kenai River. It provides ground work for defining the interactions between natural and anthropogenic forces as well as political entities. Providing a framework of knowledge to begin working from was an important consideration in producing this fact sheet. It has been distributed widely and was placed directly into Senator Ted Stevens' hand by the Alaska District Chief in July 1996.

Paper 3. Dorava, J.M., 1995, Hydraulic characteristics near streamside structures along the Kenai River, Alaska: U.S. Geological Survey Water-Resources Investigations Report 95-4226, 41 p.

This paper describes the ambient hydraulic conditions in the river near specific streamside structures and then evaluates the effects of the structure on these conditions by measuring hydraulic properties, such as depth, velocity, and flow direction around the structure. The implications for salmon habitat are explained in terms of acceptable conditions for juvenile chinook salmon. The Alaska Department of Fish and Game is distributing the report to approximately 300 owners of structures that produce unacceptable hydraulic characteristics in the river along with an offer to help fund removal of the structure and restoration of the streambank. The results of this study continue to be important to the permitting process for work along anadromous fish rivers. Numerous professional consultations have been requested from this work as well as solicitation of my expert testimony concerning the hydraulic characteristics near non-permitted construction projects.

SCIENTIFIC LEADERSHIP

A letter from the Alaska Department of Fish and Game, Habitat and Restoration Division's Regional Supervisor, Lance Trasky documents a request for my expert testimony regarding the hydraulic characteristics in the Kenai River near a sheet-pile bulk head. This request reflects the importance of the hydraulics study which I completed in 1995. This letter is followed by an authorization permitting me to provide factual testimony written by George F. Hargrove Jr., Management Officer, Western Region, USGS.

I provided professional guidance and advice to several graduate and undergraduate students from local universities. This included two graduate students who have finished Master's Degrees, two graduate students still finishing their Master's programs, and 10-15 undergraduate students who work on projects in the District Office that also fulfill graduation requirements at the university. During the past year, one graduate student received a scholarship from the American Water Resources Association for work completed on the Kenai River, and an undergraduate student won a statewide and a national paper competition with a manuscript describing work he completed evaluating riverbank position changes over time using GIS techniques. I believe my role as a mentor for these students assisted them in obtaining these recognitions. The Alaska Pacific University, where these two students attended classes, is currently considering giving me an appointment as an associate research professor to formalize my continuing relationship with their students. In addition to the research advisement I provide to university students, I am developing a curriculum in hydrology that will provide the students, mostly with environmental science majors, with a better understanding of water-resources issues. Many of them have certainly already expressed an interest and my experience with them indicates a need for such a course.

I have been closely involved in the Governor's Advisory Board which is writing revisions to the Management Plan for the Kenai River Special Management Area. The studies I have done on the river and my understanding of hydrology and aquatic habitat have made considerable contributions to the new plan. I have designed a long-term water-quality monitoring program, a modification to the boatwake study to assess the effects of specific mitigation strategies such as no-wake zones or limits on boat size, and an assessment of juvenile salmon responses to restoration projects. Each of these potential projects has been included in the draft management plan revisions as specific recommendations. Additionally, I have made numerous presentations at public meetings to explain the effects of boatwakes on streambank erosion along the Kenai River so that the river residents understand the study results and its implications.

I have helped to organize a week-long symposium about the Cook Inlet watershed which will be held in Anchorage in October 1997. This symposium will complement the Cook Inlet NAWQA program and provide many contacts and much useful information to the new study unit chief.

I have been working closely with Bob Black and Mark Munn of the Washington District Office designing a study addressing the effects of the Exxon Valdez Oil Spill on cutthroat trout in Prince William Sound in southern Alaska. Prospects for this project being funded are very positive.

OTHER KEY PERSONNEL

Gary Liepitz, Habitat Biologist, ADF&G. Gary will evaluate hep analysis of selected study sites, and coordinate this investigation with other Kenai River projects.

Paul McLarnon APU. Paul will sample juvenile salmon, identify, and measure them. Paul's evaluation of these samples will contribute to his MS Thesis describing juvenile salmon physiology near restoration projects.

LITERATURE CITED

Bendock, T., and Bingham, A., 1988, Juvenile salmon seasonal abundance and habitat preference in selected reaches of the Kenai River, Alaska, 1987-1988: Juneau, AK, Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series 70, variously paged.

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Dorava, J.M., 1995, Hydraulic characteristics near streamside structures along the Kenai River, Alaska: U.S. Geological Survey Water Resources Investigations Report 95-4226, 41 p.

Estes, C.C., and Kuntz, K.J., 1986, Kenai River habitat study: Alaska Department of Fish and Game Federal Aid in Fish Restoration F-10-1 and Anadromous Fish Studies, v. 27, variously paged.

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Liepitz, G.S., 1994, An assessment of the cumulative impacts of development and human uses on fish habitat in the Kenai River:, Alaska Department of Fish and Game, Habitat and Restoration Division Technical Report 94-6, 59 p.

Minns, C.K., Kelso, J.R., and Randall, R.G., 1996, Detecting the response of fish to habitat alterations in freshwater ecosystems: Canadian Journal of Fisheries and Aquatic Science 53 (Suupliment 1) pp 403-414

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Stiehl, R.B., 1994, Habitat Evaluation Procedures Workbook, National Biological Survey, Fort Collins Colorado, variously paged

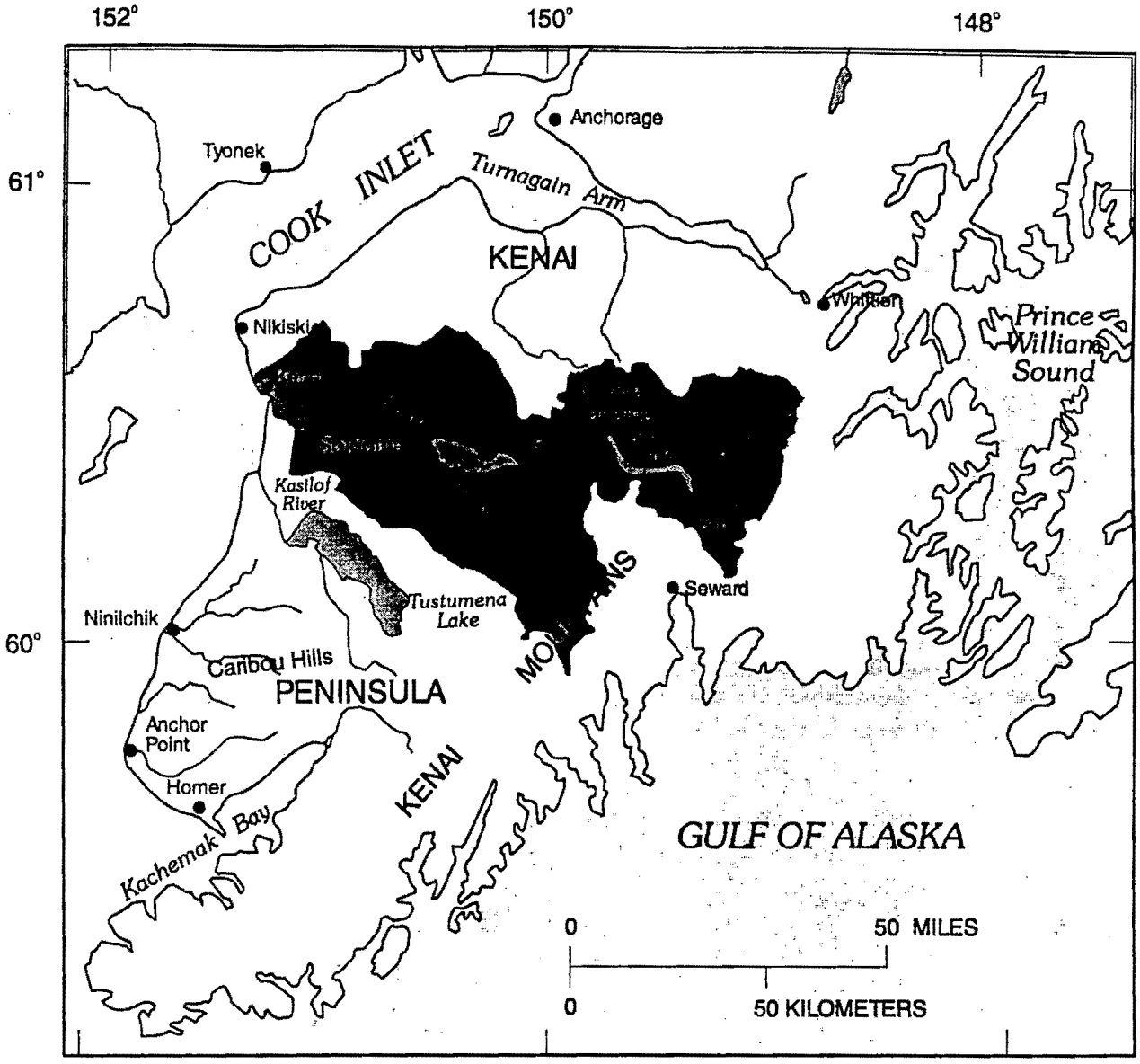

Figure 1 Kenai River watershed in southcentral Alaska

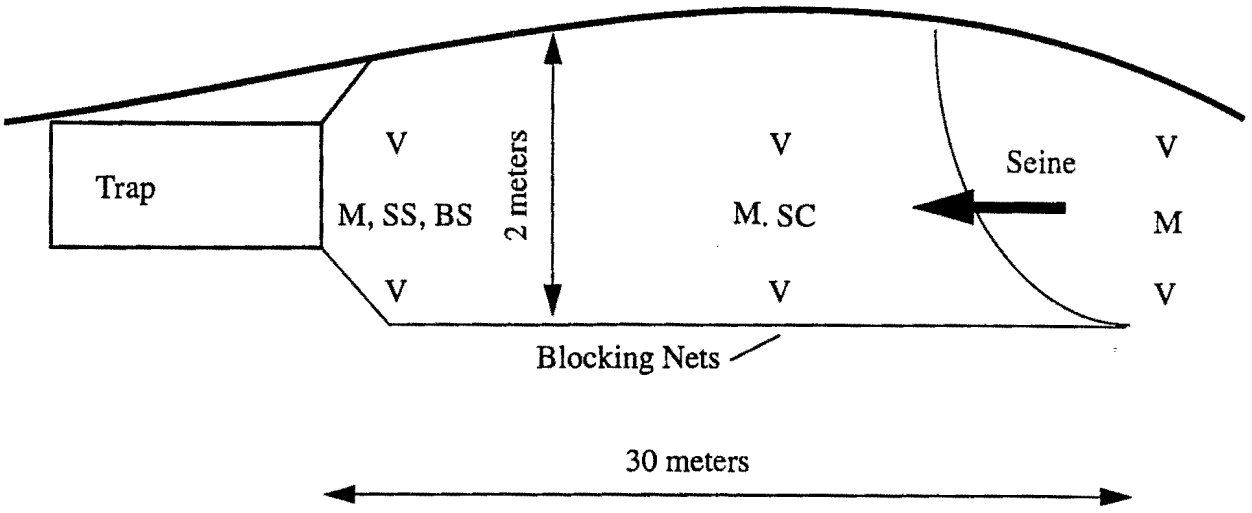

Figure 2-- Schematic of juvenile salmon trap blocking net design
and data collection plan at each treatment site; V= Velocity, M = Macroinvertebrate,
SS = Suspended Sediment. BS = Bed Sediment, SC = Sediment Chemistry

1998 EXXON VALDEZ TRUST__ _OUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$42.2
Travel		$16.6
Contractual		$45.0
Commodities		$5.0
Equipment		$24.0
Subtotal	$0.0	$132.8
General Administration		$9.5
Project Total	$0.0	$142.3
Full-time Equivalents (FTE)		0.7
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$125.0	$50.0		

Dollar amounts are shown in thousands of dollars.

Comments:
Thsi project budget reflects a cost savings by cooperating with the ADF&G in both site selection, and data analysis.
Specifically the EVOS project 98-239 will share five study sites for macroivertebrate analysis with this project. Additional cocordination with the Kenai River Center during site selection will likely safe additional expenses if other hep work can be shared.

1998

Prepared:

Project Number: ~~98-USGS1~~ 98380
Project Title: Effects of restoration projects along the Kenai River on juvenile salmon habitat
Agency: U.S.Geological Survey

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/13/97

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
Joseph M. Dorava	Research Hydrologist	GS/12	5.5	5.8		31.9
Larry Myers	Hydrologic technician	GS/7	2.0	3.5		7.0
Linda Harriss	Reports Ilustartor	GS/9	0.5	2.5		1.3
Liska Snyder	Reports Editor	GS/11	0.5	4.0		2.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.5	15.8	0.0	
					Personnel Total	$42.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Anchorage/Kenai	0.2	8	40	0.2	9.6
Anchorage/SanFrancisco	0.8	1	6	0.2	2.0
Anchorage/Fairbanks	0.5	2	10	0.1	2.0
Rental Vehicles			30	0.1	3.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$16.6

1998

Project Number: 98-USGS1
Project Title: Effects of restoration projects along the Kenai River on juvenile salmon habitat
Agency: U.S.Geological Survey

FORM 3B
Personnel
& Travel
DETAIL

Prepared:

4/13/97

1998 EXXON VALDEZ TRUSTE UNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1998
Alaska Pacific University Graduate Student	40.5
Report Printing Page charges	1.0
University fo Alaska Environment and Natural Resources Insittute (Macroinvertebrates)	3.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$45.0

Commodities Costs:	Proposed
Description	FY 1998
Chart Paper	1.5
Stakes/Posts	1.0
Fish Nets and traps	2.5
Commodities Total	$5.0

1998

Prepared:

Project Number: 98-USGS1
Project Title: Effects of restoration projects along the Kenai River on juvenile salmon habitat
Agency: U.S.Geological Survey

FORM 3B
Contractual & Commodities DETAIL

4/13/97

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1998
Hand Help doppler current meter	2	14.0	14.0
Seine 30m	2	3.0	6.0
Fish-Eye underwtaer Camera	1	4.0	4.0
			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**		$24.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

1998

Project Number: 98-USGS1
Project Title: Effects of restoration projects along the Kenai River on juvenile salmon habitat
Agency: U.S.Geological Survey

FORM 3B
Equipment
DETAIL

Prepared:

4/13/97

Monitoring of Oiled Mussel Beds in Prince William Sound

Project Number:	~~98090~~ 98390
Restoration Category:	Monitoring
Proposer:	Patricia Harris, Christine Brodersen NMFS, Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice NOAA Program Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agency:	----
Alaska Sea Life Center:	----
Duration:	One year, plus closeout
Cost FY 98:	163K
Cost FY 99:	58K
Geographic Area:	Oil spill impacted areas of Prince William Sound
Injured Resource/Service:	mussels, intertidal communities, subsistence use

ABSTRACT

Oiled mussel beds on soft substrates were the sites of the highest oil concentrations in sediment and in tissues (mussels) in the years following the oil spill. This proposal is to monitor the progress of natural restoration of 13 oiled mussel beds last sampled in 1995, and on 12 cleaned (restored) mussel beds last sampled in 1996. Documentation of recovery (or non-recovery) is of interest to subsistence villagers in Prince William Sound, and to the Nearshore Vertebrate Predator project. Of the 50 oiled mussel beds in PWS that have been documented by this project since 1991, 13 remained oiled in 1995, the last year that most were sampled. We will re-sample these beds to determine the degree of continued contamination in sediments and the overlying mussels, along with two un-oiled control beds. In addition, 12 mussel beds were restored (cleaned) in 1994 by removing contaminated sediment and replacing the sediment with clean sediment. Sediments in these cleaned beds remained clean through May 1995, but 1996 samples indicate some recontamination of sediments; no samples will be collected in 1997. Further monitoring in 1998 is needed to evaluate the long term effectiveness of natural cleaning and restoration in both sets of oiled mussel beds.

INTRODUCTION

Many blue mussel (*Mytilus trossulus*) beds impacted by the *Exxon Valdez* oil spill (EVOS) were not cleaned by the EVOS Interagency Shoreline Cleanup Committee because mussels are an important food source and a physically stabilizing element in intertidal areas. It was hoped that natural processes would clean the beds in reasonable time. However substantial amounts of *Exxon Valdez* oil (EVO) still remained in mussels and sediments underlying mussel beds in 1991 (Babcock et al. 1994). In 1992, the Auke Bay Laboratory and National Park Service (Restoration Project R103) documented 50 mussel beds in PWS and nine on the Kenai and Alaska Peninsulas with underlying sediment concentrations greater than 1700 μg/g total petroleum hydrocarbons (TPH); 25 of the beds in PWS had concentrations in excess of 10,000 μg/g TPH. The highest oil concentrations found in animals or sediments in 1991 and 1992 by any researchers in the *Exxon Valdez* spill area were in mussel beds and underlying sediments in PWS. Persistent high concentrations of hydrocarbons in mussels were identified as a possible source of impacts in several consumer species (NVP) and could also impact human subsistence users.

In 1995, hydrocarbon (HC) concentrations in mussels and underlying sediments were declining, but at variable rates. Environmental differences between sites as well as differences in the distribution and amount of subsurface oil affect the rate of decrease. In beds still contaminated in 1995, dates of return to pre-spill concentrations in sediments, estimated by regression analysis of 1992-1995 data, ranged from 1996 to 2003. (Pre-spill concentrations are defined as less than 100 ug/g TPH wet weight in sediments and less than 0.05 µg/g total polyaromatic hydrocarbons (TPAH) dry weight in mussels. Thirteen mussel beds remained oiled in 1995; TPH in sediments ranged from 200 to 20,000 µg/g and TPAH in mussels ranged up to 4.5 µg/g. Three of the 13 beds were visited in the spring of 1997 and were still visibly oiled. No chemical sampling has occurred at these 13 beds since 1995; in FY 98 they will not have been sampled for 3 years.

In addition to monitoring natural recovery of the oiled beds, two attempts have been made to actively speed the natural process. The earliest attempts in 1992 and 1993 were minimally intrusive, and were not effective. Hydrocarbon concentrations in 5 manipulated beds, as well as in many survey beds, remained high in 1993 (Babcock et al.1996).

In 1994, the scale of restoration was increased and we cleaned 12 mussel beds (project 94090). We manually removed oiled mussels, replaced oiled sediments underlying the mussels with clean sediments, and replaced mussels onto the clean sediments. HC levels in the clean underlying sediments remained low from late summer 1994 through early summer 1995, and TPAH in mussels were greatly reduced by 1995. However, in 1996 TPH concentrations in underlying sediments ranged from 340 to 9000 µg/g, indicating recontamination from oil below and adjacent to 6 of the 12 beds. Mussel densities showed overall decline in most beds from the fall of 1994 to summer 1995, but this was also the case in many of the control beds. Therefore further sampling is needed to learn whether HC concentrations in mussels have returned to safe levels for consumers, whether mussel densities in restored beds have stabilized, and if the implemented restoration techniques were effective and feasible for future restoration work.

Chemical monitoring decreased over time after the spill through the year 1995; declining concentrations were measured during this time period. No chemical monitoring has occurred

during 1996 and 1997. This proposal will measure the hydrocarbon loads at the worst sites in 1998, nine years after the spill, providing a status check on oiled sites where natural recovery was slow, and on oiled sites that were actively cleaned (restored) in 1994.

NEED FOR THE PROJECT

A. Statement of Problem

Mussels remain an important food source in PWS intertidal communities, and mussel beds provide habitat for other invertebrate species. Monitoring of HCs in the beds until pre-spill levels are reached is especially important until the full recovery of mussel predators (e.g. harlequin ducks, sea otters, and black oystercatchers) has been documented.

Subsistence users need to know whether mussels and other species trophically linked to the beds are oil free. We do not know which oiled mussel beds have returned to pre-spill levels since their last sampling in 1995 and which are a continuing source of contamination. The patterns of decline in concentrations from 1991 to 1996 and observations of visible oiling in some mussel beds in early 1997 indicate pre-spill concentration levels have not yet been reached in many places. Indications of some sediment recontamination in half of the beds restored in 1994 necessitate further monitoring of these beds.

B. Rationale/ Link to Restoration

Investigators with all studies of species linked to mussels through their habitat or food webs need to know whether mussel beds continue to be a source of oil hydrocarbons. Subsistence harvesters need to know if mussel beds are clean or not. Monitoring the gradual return to pre-spill conditions of mussel beds, which are the worst remaining known source of EVO contamination, is basic to all other EVOS studies.

The restoration technique used in 1994 on the mussel beds needs this assessment to evaluate its long term effectiveness. Oiled beaches remain a problem for PWS residents, stimulating this and other chemical restoration activities. It is important to understand the effectiveness and logistics required for all chemical restoration activities.

C. Location

The mussel beds to be evaluated are in the oil-impacted areas of PWS (Knight Island, Disk Island, Eleanor Island, Chenega Island, Latouche Island, Squirrel Island, and Applegate Island) and two unimpacted areas, Olsen Bay and a portion of Knight Island. Residents of Chenega Bay use the beaches near several of the oiled mussel beds.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The results will be reported in non-technical terms to the Chenega Bay Village Council in writing, and if the Council so requests, at a public meeting in Chenega Bay as well. Students from the Youth Area Watch Program, especially those from Chenega Bay will be invited to participate in sampling.

PROJECT DESIGN

A. Objectives

1. Measure the hydrocarbon levels in mussels and underlying sediments and mussel densities in mussel beds that were still contaminated with EVO in 1995.

2. Measure hydrocarbon levels in mussels and underlying sediments, and mussel densities, in beds that were restored in 1994 to evaluate degree and pattern of recontamination and to assess mussel bed health.

B. Methods

Our working hypotheses are 1) that sediment and tissue hydrocarbon levels in oiled PWS mussel beds have returned to negligible levels and 2) that the beds cleaned in 1994 have remained clean and intact.

Objective 1

Site Selection:
The 13 oiled mussel beds selected for sampling still contained > 0.05 µg/g TPAH in mussel tissues and/or > 200 µg/g TPH in underlying sediments in 1995. KN004 was not sampled in 1995, but was selected because TPAH in mussels was .6 µg/g in 1994. Olsen Bay and Barnes Cove, two unoiled control beds monitored since 1991, will be sampled as well.

Survey Mussels Beds Proposed for Sampling in 1998:

Beach Segment*	Geographic Name	Notes
AE005A-2	Applegate Island	
DI067A-6	Disk Island	sampling 2 sediment depths
EL013A	Eleanor Island	sampling of 2 zones, 2 sediment depths
EL015A-3	Eleanor Island	
EV036A	Evans Island	
KN004	Bay of Isles	
KN119B	Herring Bay	
KN133A	Herring Bay	sampling of 3 zones, 2 sediment depths
KN136A	Bay of Isles	sampling 2 sediment depths
KN505A	Herring Point	

KN575A	Barnes Cove	unoiled control
LA015E-2	Latouche Island	sampling 2 sediment depths
LA018A	Latouche Island	
MA002C	Foul Bay	
OLSEN	Olsen Bay	unoiled control

* nomenclature follows the interagency Shoreline Cleanup Assessment Team (SCAT) shoreline assessment segment designations. Where we sampled multiple oiled mussel beds within one segment, they are designated with a number following the segment number.

Sampling:

Mussel and sediment sampling will follow methods developed by this project in previous years (Babcock et al. 1996). In most of the above beds, a transect, generally 30 m long and parallel to the water line (as topography allows), will be established through the middle of a mussel bed. Triplicate pooled samples of 20-25 mussels each will be collected approximately every 3 m along the transect and within 1 m above and below the transect and placed in three HC-free jars. Three pooled subsamples of sediment (0-2 cm deep) under the collected mussels will be collected by scooping sediment from each exposed location with a HC-free stainless steel spoon into each of three HC-free glass jars. A sample of sediments 4-6 cm below the surface will be taken in 5 beds where samples at that depth have been collected since 1992 to see if initial patterns of oiling related to depth still persist (see table above). All samples will be immediately cooled, and frozen within 6 h. Mussel densities will be estimated by counting mussels in 2 of the 4 frames within a 0.25 m x 0.25 m sampling quadrat at least 8 subsites along the transect; densities will be expressed as mussels/m^2.

Two beds, KN133A and EL013B, had zones of significantly different concentrations of oil in 1992 (Harris et al., 1996). These beds will be re-sampled by the zones observed in 1992 (rather than by transect) to see if the initial within-bed oiling pattern persists as concentrations have declined. In each zone, three pooled replicate samples of sediments at depths 0-2 cm, 3 pooled replicate sediment samples at depths 4-6 cm, and three replicate samples of mussels will be collected.

Chemical Analysis

Sediment samples will be analyzed by ultraviolet fluorescence as adapted from Krahn et al.(1991) and used successfully at Auke Bay Laboratory since 1992. Data are reported as µg total hydrocarbons /g wet weight of sediment (TPH). Sediment samples with high concentrations of TPH and all mussel samples will be analyzed by gas chromatography/mass spectroscopy (GC/MS) for quantitative measurements of HC analytes (Larsen et al., 1992); data are reported as µg total polyaromatic hydrocarbons(- perylene)/ g dry weight of mussel or sediment (TPAH).

Data Analysis

Hydrocarbon data will be tested for normality and log transformed if necessary to carry out ANOVA to examine differences between sites (1998 data) and sampling times at each site (using 1992-1998 data) Assuming triplicate sampling as proposed, statistical power will be 80% (alpha =0.05) to detect a change or difference of 60% at two sites or two sampling times at the same station (Kinnetic Laboratories, 1993)

Objective 2

Site Selection

Sites to be sampled include those cleaned in 1994 and adjacent uncleaned beds that represent natural restoration.

Restored Mussel Beds Proposed for sampling in 1998

Beach Segment	Geographic Name	Notes
CH10B-2A	Chenega Island	originally sampled as 2 beds, now as 1 with 3 zones
CH10B-2B	Chenega Island	
CH10B-2C	Chenega Island	
CH10B-2D	Chenega Island	uncleaned control
DI067A-1	Disk Island	
DI067A-2AL	Disk Island	
DI067A-2AR	Disk Island	
DI067A-2B	Disk Island	
DI067A-2C	Disk Island	uncleaned control
EL011B-B	Eleanor Island	
EL011B-C	Eleanor Island	
EL011B-D	Eleanor Island	uncleaned control
KN113B	Herring Bay	
SQ001D	Squirrel Island	

Sampling

Within each of these beds, triplicate pooled samples of mussels and of sediments will be collected at 8 random spots, rather than along a transect In 1992, intensive sampling indicated 3 distinct zones of oiling at CH10B-2A (Harris et al. 1996). These zones were obscured when the bed was cleaned, at least to a depth of 12 cm; but the recontamination pattern shown in 1996 samples indicates the re-formation of zones. Therefore, at CH10B-2A the initial zones will be re-sampled, so that triplicate pooled samples will be collected from each zone. At all cleaned beds and at uncleaned controls, sediments will be sampled at 3 depths: surface (0-2 cm), deep (4-6 cm), and below replaced sediment depth (>12 cm) to enable us to determine whether oil below the replaced layer is recontaminating replaced sediments.

The actual sampling, sample handing, chemical analysis, and data analysis will follow the procedures discussed under objective 1.

Summary of Sampling

	Objective 1	Objective 2	
Sample Type	# Survey Samples	# Restoration Samples	Totals
UV Sediment	78	144	222
GC/MS Sediment	12	8	20
GC/MS Tissue	54	48	102

C. Cooperating Agencies, Contracts, and Other Agency Assistance

No other agencies are involved, and the only contracts involved will be contract labor for sample processing for chemical analyses if Auke Bay Laboratory employees are not available when the work is done.

SCHEDULE

A. Measurable Project Tasks for FY 98 (October 1, 1997 - September 30, 1998)

March - May (2 months)	Arrange logistics
May - June (10 flying days)	Collect samples from PWS sites
June - October	Hydrocarbon analyses

B. Project Milestones and Endpoints

Data analysis and reporting for samples collected in summer of 1998 will be completed in winter 1999, with the submission of an Annual Report in April of 1999. A DPD will be submitted for FY 1999 for completion of hydrocarbon analysis, data analysis, preparation for the 1999 Symposium, and preparation of an annual report and a manuscript.

C. Completion Date

If our working hypotheses are shown true (significant amounts of oil are *not* found in PWS mussel beds), our objectives will have been met in April of 1999. If the hypotheses have been shown false, and significant amounts of oil *are* found, another round of sampling will be proposed for a future year, probably 2001.

PUBLICATIONS AND REPORTS

FY98: none
FY99: Symposium presentation, final report and manuscript.

PROFESSIONAL CONFERENCES

FY98: none
FY99: EVOS Symposium

NORMAL AGENCY MANAGEMENT

Although NOAA NMFS has statutory stewardship for all living marine resources, NOAA is conducting this project only because the oil spill occurred and marine resources were injured. NOAA NMFS will, however, make a significant contribution (as stated in the proposed budget) to the operation of this project.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Logistics of sampling will be tied as closely as practical to the sampling efforts of the Pristane Monitoring project (98195) and the sampling associated with the hydrocarbon monitoring of the Chenega Cleanup project (98291). The potential for overlap is great since the same personnel will be involved. Data and results will be shared with other projects, especially those involving mussel predators (Nearshore Vertebrate Predators 98028, Alaska Predator Ecosystem Experiment (98163), and Differentiation/Interchange of Harlequins (98161). Students from the Youth Area Watch (98210) will be invited to participate in sampling.

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PRINCIPAL INVESTIGATORS

Patricia M. Harris

Education: New York University
University of Alaska Fairbanks; B.S. Biological Science 1966
Graduate work at U of A Fairbanks, U of A Southeast, University of British Columbia

Relevant Experience:
1989-1992: Co-principal investigator of NRDA study Subtidal 3, was responsible for field logistics and sample collection and assisted in data analysis and report preparation; also assisted other NRDA projects in field collections.

1992 -1997: Participated in study design, field work, proposal preparation, data analysis, and report preparation for mussel bed monitoring and restoration (R103-97090).

1994-1997: Participated in logistical planning, sampling, community involvement coordination, sample tracking, chemical and data analysis, proposal and report preparation for the pilot pristane project (1994, 1995) and 96195, and 97195.

1996: Participated in mussel population surveys in PWS with Nearshore Vertebrate Predator Project (96025)

Relevant publications: Co-author of annual and final reports for NRDA study Subtidal 3 and several publications pertaining to distribution of Exxon Valdez oil in mussels and underlying sediments. Several public presentations of oil-related scientific research.

Responsibilities: Study design, coordinate sample collection logistics, collect hydrocarbon samples, analyze data, prepare proposals and reports.

Christine C. Brodersen

Education: University of Washington; B.S. Zoology 1971
Graduate work at U of A Southeast

Relevant Experience:
1974 - present: Fisheries Research Biologist at Auke Bay Fisheries Laboratory, including:

1974 - mid-1980s: Conducted laboratory research on the toxicity of Alaskan crude oils to Alaskan marine species, especially larval stages.

1989 - 1991: Conducted training classes in the handling of hydrocarbon-analysis samples for personnel in agencies doing EVOS field work; coordinated legal chain-of-custody procedures for Auke Bay Laboratory EVOS work.

1989 - present: Participated in proposals, data analysis and reporting for mussel bed monitoring and restoration work (R103 - 96090) and conducted associated laboratory experiments on measures of potentially oil-related stress in mussels.

1994 - 1996; Conducted laboratory experiments on trophic transfer of pristane that helped establish the theories behind the PWS pristane project (96195).

1996: Participated in extensive mussel population surveys in PWS with Nearshore Vertebrate Predator study.

Relevant publications & presentations:
More than a dozen papers, reports and presentations on the effects of Alaskan oil, tanker ballast water, and the EVOS.

Responsibilities: Analyze data, prepare proposals, track samples, and collect hydrocarbon samples.

Stanley D. Rice

Education: BA, (1966) MA (1968) in Biology Chico State University
Ph.D. Comparative Physiology , Kent State University

Relevant Experience:
Employed at the Auke Bay Laboratory since 1971 as a research physiologist and task leader, Dr. Rice has been Habitat Program Manager since 1986. Since 1971 he has researched oil effects and has published more than 80 papers related to oil and was the lead editor for the proceedings of *Exxon Valdez* Symposium published in 1996. His studies have ranged from field to lab tests, from behavioral to biochemical studies, and from salmonids to invertebrates. Dr. Rice has managed cooperative projects since 1974, including the Auke Bay Laboratory's 10 Exxon Valdez damage assessment studies, the establishment of chemistry lab and hydrocarbon analytical techniques, and establishment and management of an hydrocarbon database. Dr. Rice has provided principal investigators and managers in NOAA and other agencies with reviews and critical input into agency decisions. He has interacted closely with other agencies on logistics coordination, critiquing study design, and interpreting observations. His responsibilities to this project will be overall management, and participation in study design and report preparation.

LITERATURE CITED

Babcock, M. M., P, M. Rounds, C. C. Brodersen and S. D. Rice. 1994. 1991 and 1992 recovery monitoring and restoration of intertidal oiled mussel (*Mytilus trossulus*) beds in Prince William Sound Impacted by the *Exxon Valdez* oil spill. U. S. DOC, NOAA Processed Report. NMFS AFSC 94-02, 483 p.

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Harris, P.M., S.D. Rice, M.M. Babcock and C.C. Brodersen. 1996. Within-bed distribution of Exxon Valdez crude oil in Prince William Sound blue mussels and underlying sediments. In: Proceedings of the 1993 *Exxon Valdez* Oil Spill Symposium, Pp. 298-308. Am. Fish. Soc. Bethesda, MD.

Kinnetic Laboratories Incorporated. 1993. Prince William Sound RCAC long-term monitoring program power analysis report. 35pp.

Krahn M. M., G. M. Ylitalo, J. Joss, and S-L. Chan. 1991. Rapid, semiquantitative screening of sediments for aromatic compounds using sonic extraction and HPLC/fluorescence analysis. Mar. Environ. Res. 31:175-196.

Larsen, M., L. Holland, D. Fremgen, J. Lunasin, M. Wells, and J. Short. 1992. Standard operating procedures for the analysis of petroleum hydrocarbons in seawater, marine sediments, and marine faunal tissue at the Auke Bay Laboratory. Internal document. U.S. Dep. Commer., Natl. Mar. Fish. Serv., Alaska Fish. Sci. Cent., Auke Bay Lab., 11305 Glacier Hwy., Juneau, AK 99801-8626.

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$94.9
Travel		$12.4
Contractual		$27.5
Commodities		$9.4
Equipment		$0.0
Subtotal	$0.0	$144.2
General Administration		$16.2
Project Total	$10.0	$160.4
Full-time Equivalents (FTE)		1.7
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$58.0				

Dollar amounts are shown in thousands of dollars.

Comments:

NOAA's contribution: chem lab equipment, salaries : S.D. Rice 1 mo. @ 9.9/mo, J.W. Short 1 mo @6.8/mo

Total contribution: 16.7K

1998

Prepared: 1 of 4

Project Number: ~~98090~~ 98390
Project Title: Mussel Bed Monitoring
Agency: NMFS, Auke Bay Laboratory

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/11/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
Harris	Zoologist	GS-9/6	7.0	4.2		29.4
Brodersen	Fisheries Research Biologist	GS-11/7	3.0	5.3		15.9
						0.0
Chem Lab personnel for analyses:						0.0
Holland		GS-11/6	1.6	5.3		8.5
Larsen		GS-11/6	3.0	5.3		15.9
Lunasin		GS-9-5	6.0	4.2		25.2
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		20.6	24.3	0.0	
					Personnel Total	$94.9

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
2 trips for 2 perosons to Cordova	0.4	4	9	0.2	3.4
					0.0
aircraft charter, @$1K/day	1.0	9			9.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$12.4

1998

Prepared:

Project Number: 98090
Project Title: Mussel Bed Monitoring
Agency: NMFS, Auke Bay Laboratory

FORM 3B
Personnel
& Travel
DETAIL

4/11/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1998
TAG contract labor in chem lab for analyses, and field work 5.5 months	27.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$27.5

Commodities Costs:	Proposed
Description	FY 1998
HC-clean sample jars	0.8
Chem Lab supplies for analyses (solvents , glassware)	8.6
Commodities Total	$9.4

1998

Prepared:

Project Number: 98090
Project Title: Mussel Bed Monitoring
Agency: NMFS, Auke Bay Laboratory

FORM 3B
Contractual & Commodities DETAIL

4/11/97

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
computer, printer	4	NOAA
GC/MS	1	NOAA
HPLC	1	NOAA
GPS	1	NOAA
UVF radio	1	NOAA

1998

Project Number: 98090
Project Title: Mussel Bed Monitoring
Agency: NMFS, Auke Bay Laboratory

FORM 3B
Equipment
DETAIL

Prepared: 4 of 4

4/11/97

Project Title: Harlequin Duck Population Dynamics-Patterns and Processes

Project Number:	98426
Restoration Category:	Research
Proposers:	Dan Rosenberg Alaska Dept. of Fish and Game 333 Raspberry Road Anchorage, Alaska 99503
	Dan Esler Alaska Science Center USGS-Biological Resources Division 1011 E. Tudor Rd. Anchorage, Alaska 99503
Lead Trustee Agency:	ADFG
Cooperating Agencies:	DOI
Alaska SeaLife Center:	Yes
Project Duration:	1st year, 5-year project
Cost FY 98:	$257,000
Cost FY 99:	$456,000
Cost FY 00:	$451,500
Cost FY 01:	$384,000
Cost FY 02:	$327,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Harlequin duck; intertidal community.

ABSTRACT

This program is designed to document patterns of harlequin duck (*Histrionicus histrionicus*) population structure and numerical fluctuation in oiled and unoiled parts of Prince William Sound and determine the processes underlying population dynamics. Core data collection includes yearly assessment of population numbers, population structure, and annual survival rates. In addition, we propose a series of specific research objectives designed to fill in data gaps necessary to build a comprehensive population dynamics model of Prince William Sound harlequin ducks. Ultimately, we intend to understand the relationships between oiling history, individual variation, demographic parameters, and population dynamics.

INTRODUCTION

This project proposes to compare annual variation in harlequin duck demographics between oiled and unoiled areas of Prince William Sound and identify the critical underlying processes that affect population dynamics. Central to this project is derivation of a comprehensive population dynamics model that (1) incorporates demographic parameters, (2) identifies critical periods of the annual cycle that may be limiting recovery from the *Exxon Valdez* oil spill (EVOS), and (3) predicts population trends and recovery times. The population model will be modified from efforts by Canadian Wildlife Service biologists (Goudie et al. 1994) and, like most waterfowl population models, will emphasize females, under the assumption that males are non-limiting based on the male-biased sex ratio.

Critical data necessary to build population models for oiled and unoiled areas of Prince William Sound include: adult survival, subadult survival, production (fledged ducklings per female), recruitment (fledging to subadult survival), and dispersal (immigration/emigration)(Fig. 1). Previous and ongoing Trustee funded research (projects -427, -161, and -025) will provide some of the data necessary for modeling. Other parameters will be estimated under specific research objectives described in this proposal. Finally, proposed population surveys will test population trends and demographics predicted by the model.

The proposed research will be an iterative process, resulting in collection of critical data for population modeling over the life of the project (see schedule below). It is designed to build upon previous and ongoing studies and results of the first few years of this proposed five year project. For FY98, we propose the following:

1) Radiomarking subadult females for studies of winter survival and movement;

2) Monitoring annual survival through band recoveries during wing molt;

3) Conducting surveys of population numbers and structure in March; and

4) Establishing a captive research flock of harlequin ducks for age determination studies.

Radiomarking subadult females and monitoring annual survival

Adult survival during winter, when much of the annual mortality likely occurs, is being described by the Nearshore Vertebrate Predator (NVP) project (/025). One aspect of the research in this proposal is to measure subadult female survival in oiled and unoiled areas; population sensitivity to subadult survival is second only to sensitivity to adult survival (Goudie et al. 1994). The NVP harlequin studies also provide a base of marked individuals for mark-recapture estimates of annual survival rates, as birds have been captured and banded since 1995. Over the life of this

proposed project, we can accurately describe annual survival rates from band recoveries (Fig. 2) and contrast those with winter survival rates for adults from NVP and subadults (this project) to partition seasonal survival.

March Demographic Surveys

The U.S. Fish and Wildlife Service (FWS) has been monitoring marine bird abundance in PWS intermittently since 1972. Since 1989, FWS surveys have been designed to first assess damages following the *Exxon Valdez* oil spill and then monitor abundance to assess recovery of injured species. These surveys gather information on abundance and distribution only, they have not gathered information on population structure, information necessary for the development and testing of a population model. As part of the *Exxon Valdez* oil spill restoration project 98427 CLO, harlequin duck recovery monitoring (separate proposal), we will attempt to compare the FWS survey (Agler et al. 1995) with project -427 surveys using similar analytical methods.

Recruitment is a particularly difficult parameter to estimate. Population monitoring will allow estimation of recruitment via age structure variation. Standard methods for population monitoring have been derived as part of the Trustee sponsored harlequin duck monitoring program (-427) and March data were collected in 1997. The proportion of young birds in a population is a function of immigration of young, survival of young, and production of young. With estimates for production and dispersal/movements (see below), along with a measure of age class structure, we can solve for recruitment. This approach requires accurate determination of age class during surveys. We propose to establish a captive research flock to be used to correlate plumage characteristics with age (see below).

Winter is a period of maximum and stable populations. March surveys will also provide information on breeding propensity, changes in population size, and age and sex composition. Results will be compared with 1995 and 1996 results and prior years when applicable. Monitoring will also provide baseline data against which to evaluate possible impacts on populations caused by future contaminants or environmental perturbations.

Captive Research Flock

Despite recent efforts, problems in age determination of harlequin ducks remain. The present study will test the reliability of several methods currently used for sex and age determination in this species. Current and past EVOS harlequin duck projects (-427) relied on plumage characteristics to age male ducks. Known age birds have not been available to test the accuracy of this method. By comparing plumage changes in known-age captive birds with wild birds, we hope to be able to verify the results of past monitoring studies and improve confidence in future survey results.

Subadult males resemble adult males during the wing molt, when capture is easiest. At this time, plumage characteristics can not be used to age either sex. Instead cloacal characteristics are used to determine age. However, sufficient numbers of known age harlequin ducks have not been available to test the accuracy of this method. With known age captive birds, we can compare the rate of regression of the bursa of fabricus with age and winter plumage patterns to develop a key to accurately age males in winter and spring and age wild females caught in trapping operations.

Captive birds will also be used to study wing molt chronology; feather loss and regrowth rates; will be available for toxicological studies; and will be used to develop methods for captive breeding programs. Past toxicological studies designed to determine effects of naturally weathered crude oil used mallards, a potentially poor surrogate, to simulate effects on harlequin ducks (Stubblefied et al. 1995).

Other Model Parameters

Rates of immigration and emigration will be estimated on two scales. First, we will rely on the data generated from the Trustee sponsored harlequin duck DNA project (/161) to assess broad scale segregation of wintering groups throughout the North Pacific and infer movement patterns from estimates of gene flow. More specific data regarding movements by adult females are being generated from the radio telemetry portion of the harlequin duck component of the NVP project. Also, movements data will be collected as part of the subadult survival aspect of this proposed work. Finally, continuing the annual mark and recapture of birds will allow determination of molt site fidelity. These data will be used to calculate probabilities of movements, by age class, between oiled and unoiled areas and the subsequent effects on population size and structure.

Another important component of a comprehensive population model is accurate production figures. Production is composed of several parameters: breeding propensity, clutch size, nesting success, and duckling survival. These can be difficult and expensive data to gather. However, the minimum data needed for population modeling are the number of ducklings fledged per hen. Unfortunately, basic reproductive ecology data are lacking for harlequin duck populations wintering in PWS, with the exception of individuals that remain in PWS to breed (Crowley 1996). The necessary first step in assessing reproductive ecology is determination of breeding distribution. Potential breeding sites range as far north as the Brooks Range, as far west as the Seward Peninsula, and east into the Yukon Territory. We propose using telemetry (conventional or satellite) to describe breeding areas and measure productivity beginning with a pilot project in FY98 and continuing in FY 99 and FY 00. Use of conventional radio telemetry will be first tested and integrated into the project component as a technique for establishing a captive flock. A broad scale assessment of breeding distribution of harlequin ducks wintering in Prince William Sound is proposed for FY 99 and FY 00.

A critical part of this proposal involves understanding the processes that affect individuals, the relationship between individual variation and demography, and finally the role of demography in

population change via population modeling. Incorporated in this approach is measurement of individual variation, e.g., in physiology, and the relationship of individual variation to oiling history of the area that birds are captured. Also, we intend to address the question of the importance of individual variation (whether related to oiling history or not) on demographic parameters. For example, does body condition during molt affect winter survival? Does female body mass in spring affect production? The hierarchical approach described in the proposal will allow an understanding of the patterns of harlequin duck population dynamics and also the underlying processes that lead to the observed patterns.

NEED FOR THE PROJECT

A. Statement of Problem

Harlequin ducks occur year-round in intertidal zones of PWS (Isleib and Kessel 1973). Approximately 1,000 harlequin ducks died as a direct result of oil exposure following the Exxon Valdez oil spill (ECI 1991). Postspill studies conducted in 1991-1993 indicated an initial decline in molting birds, a lack of productivity, and fewer breeding pairs present in spring in oiled areas, although no conclusive evidence had been found of histological or physiological effects from oil (Patten 1995, Patten et al. 1995).

Surveys conducted in 1994, 1995 and 1996 continued to find no brood production in the spill area (Rosenberg 1995, Rosenberg et al. 1996). These surveys did not detect continued declines in west side molting densities as did Patten (1995) and Patten et al. (1995) but they did detect differences in population structure and breeding propensity between eastern and western PWS. Fewer paired birds, more unpaired females, a higher proportion of females remaining within the study area in spring, and a greater percentage of flightless females during the late July survey predicts less movement to breeding areas by WPWS females. Higher male:female ratios in the oiled area suggested lower female survival rates. Lower female survival rates in oiled areas has been confirmed by the Nearshore Vertebrate Predators Project 96025 (Dan Esler, USGS-BRD, pers. comm.). Nearly seven years after the *Exxon Valdez* oil spill harlequin ducks had not recovered (Exxon Valdez Oil Spill Trustee Council 1996).

More recently, the authors of this proposal and other harlequin duck biologists working in PWS have suggested that lack of evidence of reproduction in western PWS is not necessarily evidence of lack of recovery, given that pre-spill reproduction there was likely low and the majority of the birds wintering in PWS, both east and west, leave PWS to breed. However, concern about harlequin duck population recovery from the oil spill is still warranted. Differences in population structure and adult female winter survival between eastern and western PWS may be a result of the *Exxon Valdez* oil spill. We do not know where PWS harlequin ducks breed and subsequently we know few specifics about productivity outside of PWS.

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

Data gaps exist in our understanding of the effects of the oil spill on harlequin duck population dynamics. Sea duck populations, in general, are composed of long-lived birds that have delayed sexual maturity, low annual production rates, and "boom and bust" years. Consequently, sea duck population dynamics are quite sensitive to adult female survival rates, size of the breeding component, and variable breeding propensity (% of adults breeding annually). Under the best conditions, recovery from population perturbations may take years. We intend to address the data gaps by identifying the processes that affect harlequin duck populations, assessing differences in the processes between oiled and unoiled areas, and predicting recovery times.

B. Rationale/Link to Restoration

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

Population modeling is a powerful tool for describing population fluctuation and for identifying critical periods of the annual cycle (e.g., Lebreton and Clobert 1991, Schmutz et al. 1997). We will use linked matrix models (Caswell 1989), building on published harlequin duck models (Goudie et al. 1994), to incorporate spatial structuring in this exercise, to allow spatial variation, movements, and comparisons between oiled and unoiled areas.

Understanding various population parameters on the breeding, wintering, and molting sites are all necessary to complete our understanding of population dynamics and its implications to recovery. A complete understanding of population dynamics, with implication to oil spill restoration,

requires quantification of variation among individuals that is related to oiling history, the effects of individual variation on demographic parameters, and finally the sensitivity of populations to variation in demographic parameters. Once these links are made, we will have a clearer sense of the limits to recovery and the time frame to complete recovery

C. Location

Subadult female winter survival studies (capture, marking, and tracking) and March surveys (population demographics) will be conducted in Prince William Sound. Specific study sites will be those used in previous and ongoing Trustee-sponsored research and monitoring programs to capitalize on previously collected data and populations of marked individuals. Capturing breeding females, locating nests, and collecting eggs for the captive flock will occur in the Talkeetna Mountains and Nelchina and Copper river basins. The captive flock will be housed at the Alaska SeaLife Center (ASLC).

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

As in previous and ongoing harlequin duck research, this program will rely on involvement of Prince William Sound residents The project will continue to inform and coordinate our activities with Martha Vlasoff, community coordinator. We will continue to solicit local knowledge through local facilitators and from local residents when applicable. All efforts will be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project. Project staff will be available to present information to local communities or prepare articles or photographs for Trustee Council publications. Boat and air charter contracts, telemetry observers, other services will be contracted from local sources when possible.

Traditional ecological knowledge has been solicited in the forum provided during Annual Workshops and is currently an ongoing part of project -427, Harlequin Duck Recovery Monitoring.

PROJECT DESIGN

A. Objectives

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

2. Describe plumage variation and bursa regression with age to improve interpretation of population monitoring and survival estimates.

3. Estimate critical demographic parameters, including: subadult survival, immigration and emigration, recruitment, breeding distribution, and production.

4. Quantify the relationships between oiling history, individual variation in physiology, health, or phenology, and demographic parameters.

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

6. Establish a captive flock to be used for present and future research and public education.

B. Methods

Survival Estimates-Capture

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

Captured harlequin ducks will be removed from the trap, separated by gender, placed in holding pens, and transported by boat to the main vessel for processing. Birds will be banded with USFWS aluminum bands and with individually coded plastic tarsus bands. Sex will be identified based on plumage characteristics and age will be determined by bursal probing. Adults do not have a bursa; SY birds will be distinguished from third year subadults by the depth of the bursa (SY bursa > 2 cm; TY bursa < 1 cm).

Mark and recapture data will be analyzed to estimate annual survival rates (Lebreton et al. 1992) by age and sex cohort and by area.

Subadult Female Winter Survival.

Winter survival rates of subadult female harlequin ducks will be assessed using radio telemetry. A total of 100 birds will be radioed, with approximately 50 each in oiled and unoiled study sites. We will use implantable radio transmitters with external antennas. Radios will be programed to transmit for at least 210 days and will weigh approximately 15g, which is $\leq$ 3% of the body

weight of the smallest molting female harlequin duck. Transmitters will be equipped with motion sensitive mortality switches; pulse rate will change from 45 to 90 beats per minute when a mortality is indicated.

Transmitters will be implanted in the body cavity with an external antenna protruding from the lower back (Korschgen et al. 1996). Implanted transmitters have been successfully used in waterfowl studies (e.g., Olsen et al. 1992, Haramis et al. 1993) and are less disruptive than backpack transmitters (Peitz et al. 1993, Rotella et al. 1993), especially for diving ducks (Korschgen et al. 1984). Surgeries will be conducted by certified veterinarians experienced in avian implant surgeries, following procedures outlined in Alaska Science Center, National Biological Service standard protocol.

Radio telemetry flights will be conducted weekly through winter. Flights will detect each marked individual and note status and general location. For birds indicated as dead, more exact locations will be determined to facilitate carcass recovery by boat or float plane as soon as possible. Data will be entered and analyzed using a Kaplan-Meier staggered entry design (Pollock et al. 1989a, 1989b, Bunck et al. 1985).

Body condition of all radioed birds will be estimated using condition indices derived as part of the NVP project which are built on morphological measures, body mass, and measures of total body electrical conductivity (TOBEC; Walsberg 1988, Roby 1991). Diagonal tarsus length and culmen length will be measured to the nearest 0.1 mm using digital calipers. Using a wing board, we will measure, to the nearest mm, wing length from the wrist notch to the end of ninth and tenth primaries, length of the ninth and tenth primaries from their intersection with the wing, and wing stub, the distance from the wrist notch to the end of the wing flesh. The status of the wing, i.e., whether it is a molting wing, old wing, or fully formed new wing, will be recorded to ensure that only molting birds are used in analyses. Body mass will be measured on an electronic balance to the nearest gram.

TOBEC measurements will be conducted following manufacturers instructions. Before conducting TOBEC readings, the TOBEC machine must be turned on for a warm-up period of at least 50 minutes. Also, reference scans of a standard phantom must fall within the acceptable range of values before scans will begin. The reference phantom will be scanned occasionally during bird scans to ensure that the machine was functioning correctly. Each bird will be passed through the TOBEC analyzer six times to ensure an accurate reading. Birds will be restrained with a velcro strap to ensure a common position for all birds during analysis.

March Population Demographic Surveys

Surveys will be conducted in representative portions of oiled areas in western PWS, unoiled areas in eastern PWS, and on Montague Island. Survey routes and methods used for spring surveys in 1995 and 1996 and March 1997 will be repeated (Rosenberg et al., 1996) as will winter survey

routes conducted by NVP project 025. However, repeat surveys will not be conducted and surveys in oiled and unoiled areas will not be conducted simultaneously because population flux is expected to be minimal. Surveys will be conducted from approximately March 12 through March 20. All harlequin ducks will be recorded along each survey route. Observations will be recorded as pairs or by sex, and males will be divided into three age groups using predetermined criteria (Rosenberg, 1995).

Surveys will be conducted from open skiffs up to 20 feet long. Each skiff will have two observers (including the driver). Surveys will be conducted from within 30 meters of shore along predetermined routes. A pace and course will be chosen that will assure complete coverage of the survey area and maximize the opportunity to see ducks. All transects will be mapped and all observations will be recorded by date and location and mapped by flock. Habitat associations, time, and weather will be noted.

Population composition and annual changes in density will be compared to test whether harlequin duck populations are exhibiting similar growth trends or the oiled (injured) population is exhibiting a different direction or rate of change. Hypothesis testing will be similar to Rosenberg and Petrula (1997), (EVOS Restor. Ann. Rept. Proj. 97427-in prep.) for applicable survey types. A generalized logit model (Agresti, 1990) will be used to test differences in population structure for oiled versus unoiled survey sites for winter and spring. Density changes will be tested by regression and population structure will be tested with logistic regression (Agresti, 1990).

Power Analysis.

In 1997 we will analyze population trends to determine whether the rate of change in duck numbers is the same for EPWS and WPWS (Rosenberg and Petrula, 1997. EVOS Restor. Ann. Rept. Proj. 97427 - in prep.). For illustrative purposes, we compared similar surveys conducted in 1991, 1993, and 1995 for 25 locations in EPWS (Rosenberg et al. 1996). Linear regression was used to estimate the rate of change in duck populations for each survey location. The average of the 25 slopes was then used to estimate the overall rate of change for EPWS. Because comparable coverage (>2 years data) was not available for WPWS, we assumed that the slope estimates would have the same variability as in EPWS. The power of the test to determine whether the rate of change in duck populations is the same between EPWS and WPWS was then calculated for different levels of variation in slope between EPWS and WPWS and is presented below and in Figure 3. We now have comparable coverage (3 years data) for WPWS (1994-1996). Similar methods will be used in this proposal.

Captive Flock

The captive flock of harlequin ducks will be established from eggs collected in the wild. The collection of eggs, however, requires the detection of nest sites which for harlequin ducks can be problematic because of their low densities and remote locations. Radio-tagged females enabled

Crowley (1966) to locate harlequin nests on coastal streams in Prince William Sound. We plan to radio-tag harlequin ducks on streams in the Talkeetna Mountains and Nelchina and Copper river basins. Harlequin ducks will be captured with mist nets suspended across streams. A net located upstream and one downstream of resting birds will be set prior to flushing birds from their loafing spot. A monitor will be stationed at each net to avoid injury and prevent escape of captured birds. Breeding pairs will be targeted during our trapping efforts. On sections of streams suspected to be frequently used by harlequin ducks, nets will be erected prior to spotting birds and monitored during periods of peak harlequin activity (early A.M. or late P.M). We will try to concentrate our trapping efforts to the pre-laying (late April, early May) and late incubation periods (early-mid July) so as to limit the probability of nest abandonment by females.

When a duck is captured we will record its weight, culmen and tarsus measurements, apply a U.S.F.W.S. metal leg band, and remove a blood sample to be archived at ADF&G headquarters in Anchorage. A 10 gram radio transmitter (ATS, Inc.) will be secured to the back of the bird between the wings using an arrowhead style attachment and super glue. This method of attachment has proven effective and non-detrimental to spectacled eiders captured on the Yukon Delta (P. .Flint pers. com, U.S.G.S. -BRD). Battery life for the transmitter is expected to last approximately 100 days. Transmitters are not expected to fall out until after batteries have expired. Ducks will be immediately released at the point of capture. Radioed hens will be tracked from the ground to locate nests. Once located, eggs will be candled to determine initiation and expected hatch dates, and 1 or 2 eggs will be collected from each clutch, removed from the field, and incubated at an appropriate facility until hatch. Eggs will be divided between two incubators to minimize chances of incubator failure. Ducklings will be raised and maintained at the ASLC in Seward, Alaska according to University of Alaska, Fairbanks and the ASLC protocol established for the care and handling of animals (Dr. Mike Castellini, pers. comm.). An effort will be made to revisit nests after the expected hatch date to determine its fate. We will also evaluate the feasibility of monitoring radioed females with ducklings. Counts of ducklings at specific intervals can provide an estimate of duckling survival to fledging.

To determine molting areas of radio-tagged birds captured on breeding streams, we will begin aerial tracking flights from fixed-wing aircraft for radioed males in July when most post-breeding males have returned to the coast. Searches for radio-tagged females on the coast will begin after the hen can no longer be located on the breeding stream, or in early September.

Prior to collecting eggs, ADF&G personnel will meet with ASLC personnel to design specific care and handling procedures for harlequin ducks. ADF&G personnel are currently in contact with aviculturists in the Pacific Northwest, who have had experience raising harlequin ducks in captivity. Aviculturists will be consulted throughout this process.

ADF&G personnel will make weekly trips to the ASLC to monitor general health of captive birds, record plumage patterns, growth rates, bursa measurements, and diet.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Alaska Department of Fish and Game personnel, led by Dan Rosenberg, will be responsible for March surveys of population numbers and structure; establishment and monitoring of the captive bird flock; and monitoring radioed ducks to identify breeding distribution and productivity.

USGS personnel, led by Dan Esler, will be responsible for annual capture of molting birds, assessment of subadult survival, capture and marking of birds for assessment of breeding distribution, and derivation of population models.

ASLC will be responsible for the daily maintenance and care and handling of the captive flock.

Responsibility for assessing productivity will be determined once we have data that will direct how the reproductive ecology portion of this proposal needs to be conducted.

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

SCHEDULE

A. Measurable Project Tasks for FY 98

March:	Population surveys.
April-June:	Egg collection for captive flock.
July-September:	Molt capture for survival estimation and radio implantation. Monitor birds radioed on breeding areas. Monitor captive flock.

B. Project Milestones and Endpoints

FY99

Throughout:	Monitor captive flock.
October-March:	Monitor radioed subadult females.
March:	Population surveys.
March:	Capture birds for defining breeding areas.
April:	Submit annual report.
May-June:	Monitor birds for defining breeding areas, capture birds for defining breeding areas, augment captive flock.

August-September	Molt capture for survival estimation and radio implantation; assess productivity via telemetry portion of captive flock creation.

FY00

Throughout:	Monitor captive flock.
October-March:	Monitor radioed subadult females.
March:	Population surveys.
March:	Capture birds for defining breeding areas.
April:	Submit annual report.
May-June:	Monitor birds for defining breeding areas, augment captive flock if necessary.
August-September	Molt capture for survival estimation.

FY01

Throughout:	Monitor captive flock.
March:	Population surveys.
April:	Submit annual report.
May-August:	Reproductive ecology studies.
August-September	Molt capture for survival estimation.

FY02

April:	Submit annual report.
May-August:	Reproductive ecology studies.

C. Completion Date

All project objectives will be met following FY02.

PUBLICATIONS AND REPORTS

An annual report of FY98 activities will be submitted to the Restoration Office before 15 April 1999. Because FY98 is the first year of this project, journal publications will not be generated until later years.

PROFESSIONAL CONFERENCES

None in FY 98.

NORMAL AGENCY MANAGEMENT

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

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

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

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL QUALIFICATIONS

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

Mr. Rosenberg has conducted harlequin duck population (age and sex structure) and production surveys in Prince William Sound since 1994 as the Principle Investigator of a Trustee sponsored restoration project. He has conducted extensive waterfowl population monitoring and habitat assessment surveys on the Copper River delta, Stikine River delta, Kenai wetlands, upper Cook Inlet, Aleutian Islands, and Kodiak Island. As project leader, Mr. Rosenberg has assessed impacts to waterfowl and wildlife populations from hydroelectric development, urban expansion, habitat alterations, chemical pollutants, timber harvest, and surface mining.

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 8 years. Since 1995 he has served as project leader for harlequin duck studies as part of the Trustee sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A & M University in 1988 and is currently enrolled as a doctoral candidate at Oregon State University. He has 10 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird management.

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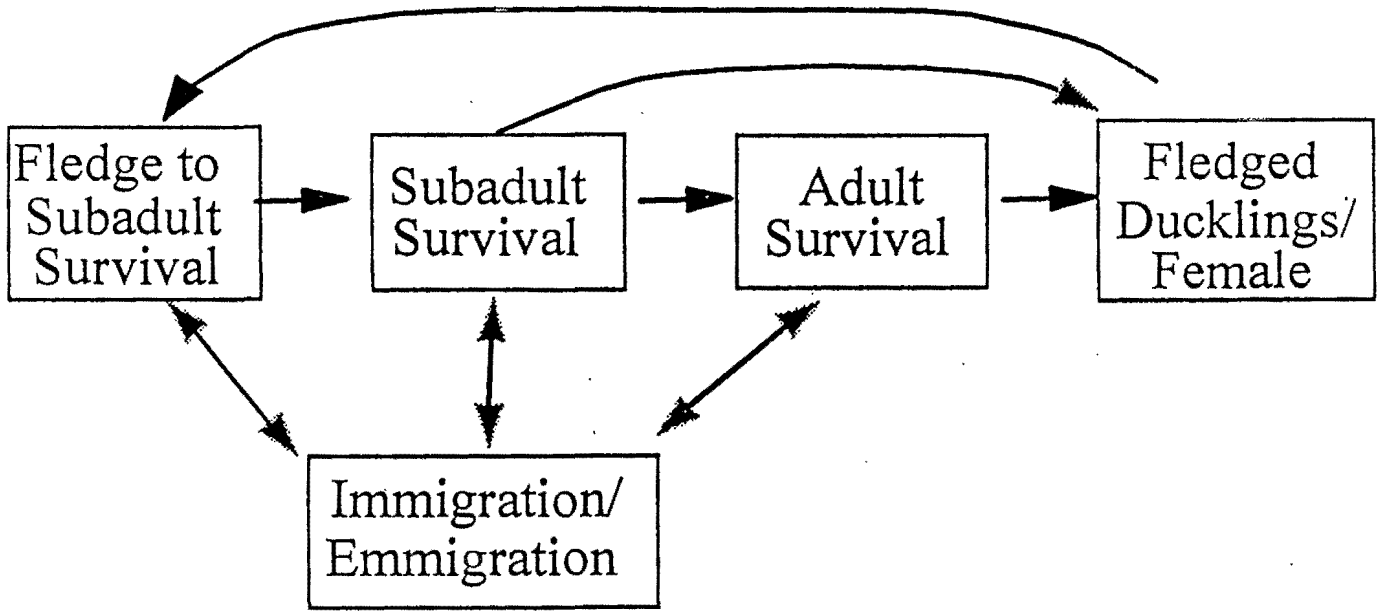

Figure 1. Harlequin duck population model schematic.

Power to Detect Overall Survival Difference of 0.15

Survival of oiled group = 0.70
Survival of unoiled group = 0.85
Number banded/year/treatment group = 50
Alpha = 0.10

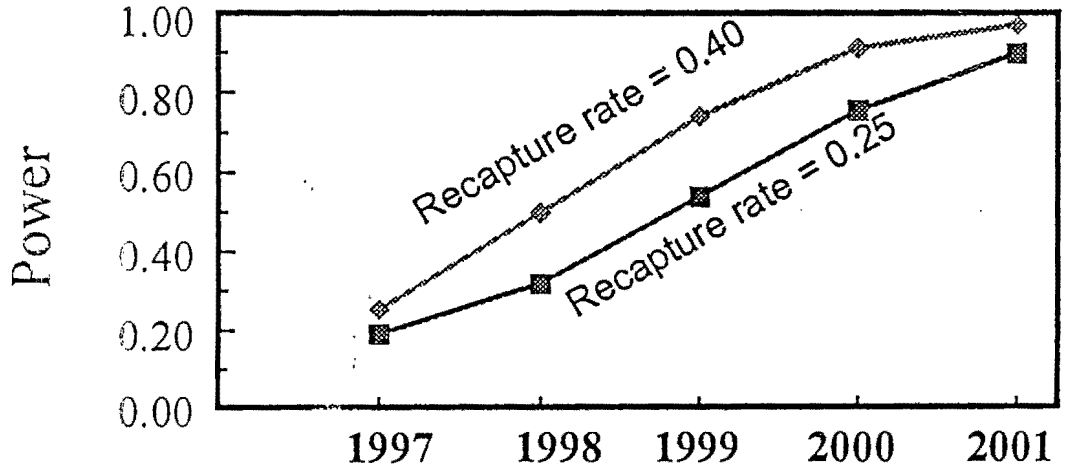

Figure 2. Power analysis to detect survival differences between banded harlequin ducks in oiled and unoiled areas of Prince William Sound.

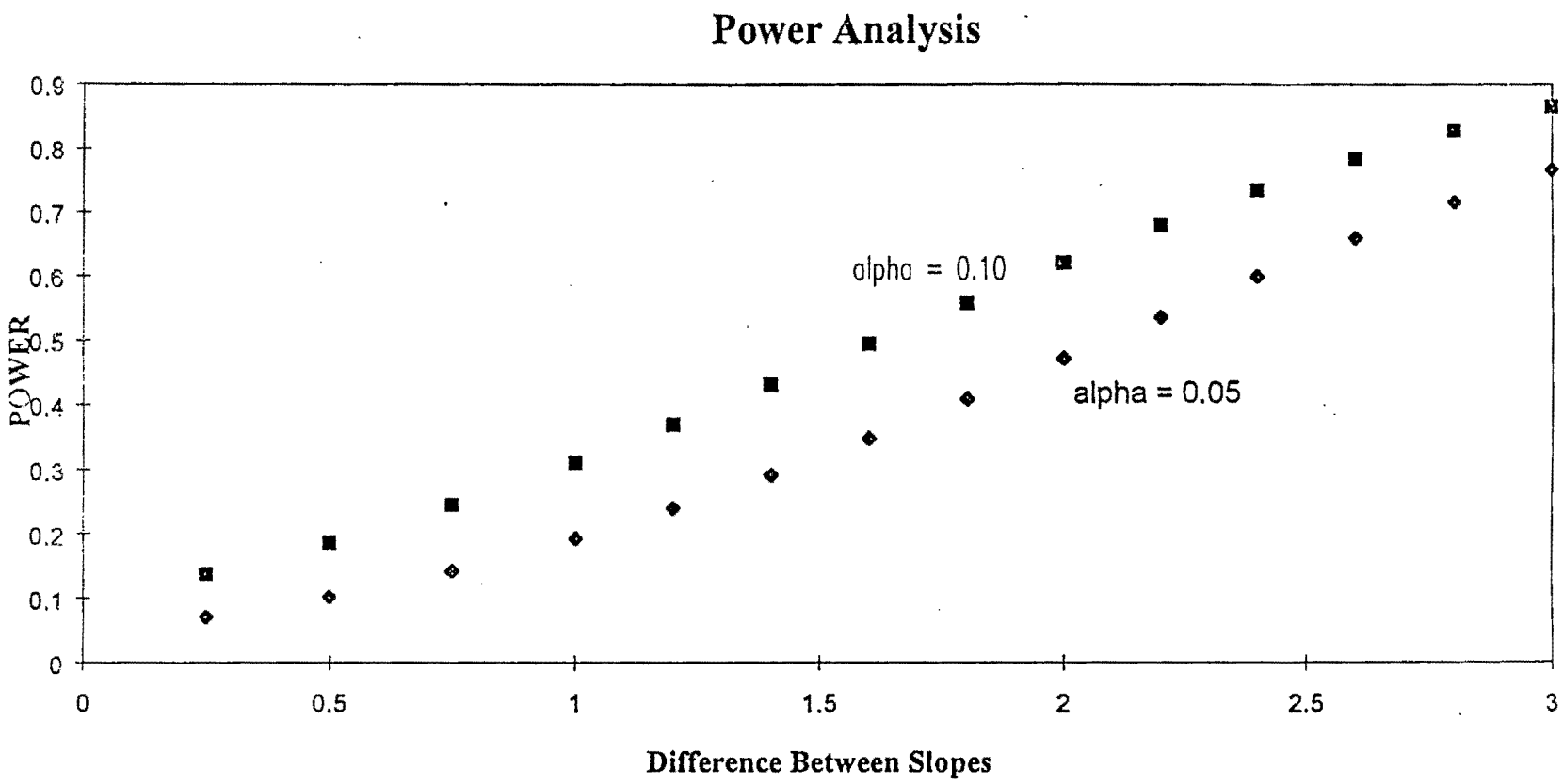

Figure 3. Power of the test to determine if the rate of change in eastern Prince William Sound and western Prince William Sound harlequin duck populations is the same. To be modified (see text).

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

Budget Category:	Authorized FY 1997	Proposed FY 1998	PROPOSED FY 1998 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$137.3			$120.3	
Personnel	$0.0	$94.5						
Travel	$0.0	$13.5						
Contractual	$0.0	$80.6						
Commodities	$0.0	$45.4						
Equipment	$0.0	$3.2	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$237.2		Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
General Administration	$0.0	$19.8						
Project Total	$0.0	$257.0		$456.2	$451.5	$384.0	$327.0	
Full-time Equivalents (FTE)	0.0	2.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0	$0.0	

Comments: This is a cooperative proposal between the Alaska Department of Fish and Game and the Department of Interior, USGS-BRD. No money is allocated for NEPA compliance. Only salary money is allocated for attendance at Anchorage workshops.

1998

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Lead Agency: ADFG

FORM 2A
MULTI-TRUSTEE
AGENCY SUMMARY

Prepared: April 97

4/14/97

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$71.2
Travel		$9.1
Contractual		$30.6
Commodities		$9.9
Equipment		$3.2
Subtotal	$0.0	$124.0
General Administration		$12.8
Project Total	$0.0	$136.8
Full-time Equivalents (FTE)		1.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$154.0	$160.0	$167.0	$176.0

Dollar amounts are shown in thousands of dollars.

Comments: A portion of this project includes work at the Alaska SeaLife Center. We were unable to obtain information on how costs for the care and maintenance of animals housed at the SeaLife Center would be administered. Therefore, we have not included cost estimates for the care and maintenance of harlequin ducks at the SeaLife Center. These will need to be added as appropriate.

1998

Prepared: April 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/14/97

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
D. Rosenberg	WBIII, Principle Investigator	18J	2.0	6.2		12.4
D. Crowley	WBI, Field Biologist	14D	1.0	4.3	1.5	5.8
Mike Petrula	WBI, Field Biol., data analyst, report prep.	14C	4.0	4.1	2.0	18.4
2	F&G Tech III, FieldTechnicians	11F	5.0	3.7	4.0	22.5
E. Becker	Biometrician II	19K	1.0	6.9		6.9
C. Barnhill	Cartographer II	16K	1.0	5.2		5.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		14.0	30.4	7.5	
					Personnel Total	$71.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Portage-Whittier Alaska Railroad vehicle and boat (trailer) 21-43'	0.4	4	8	0.1	2.4
Portage-Whittier Alaska Railroad vehicle	0.1	4			0.4
Portage-Whittier Alaska Railroad psng. and equipment	0.1	2			0.2
Anchorage-Cordova by air	0.3	2	2	0.1	0.8
Personal Vehicle Mileage, Anchorage-Glenallen/Talkeetna	0.2	6	30	0.1	4.2
Airport parking, taxi fare,					0.1
Travel/per diem Seward - AK SeaLife Center	0.1	10	10	0.1	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$9.1

1998

Prepared: April 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

4/14/97

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

Contractual Costs:	Proposed
Description	FY 1998
Warehouse for equipment storage and maintenance - 6 months @ $775/mo	5.0
Air Charter for field support & radio tracking 20 hrs. @ $250/hr	3.0
Helicopter Charter for field support - 8 hrs. @ $500/hr	4.0
Boat and outboard motor repair	3.0
Vehicle leasing - 6 mos. @ 200/month	1.2
Trailer and boat moorage fees- Whittier and Valdez	0.2
Photo processing	0.2
Vessel support for winter surveys 14 days @1000/day	14.0
When a non-trustee organization is used, the form 4A is required. Contractual Total	$30.6

Commodities Costs:	Proposed
Description	FY 1998
Boat Fuel 250 galllons @ $1.50/gal	0.4
Boat Supplies- replacement parts, props, fuel lines, fuel filters, water filters, battery, absorbent rags, oil, emergency provisions	1.0
Field Survey Supplies- rite-in-rain notebooks/paper, nautical charts, batteries,	0.3
Computer software for analysis, graphing, mapping	0.8
Camp Food-4 people for 20 days @ 18/day/person	1.5
Camp materials and supplies	0.8
Harlequin duck leg bands 500@ $1/band	0.5
Mist nets and trapping equipment	1.0
Radio Transmitters 20@145 each	2.9
Incubators for duck eggs - 2@ $250 each	0.5
Pet carriers -2@ $60 each	0.2
Commodities Total	$9.9

1998

Prepared: 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: ADFG

FORM 3B
Contractual & Commodities DETAIL
4/14/97

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
Canon 12x36 Image stabilizing binoculars - Canon USA price quote	2	1.6	3.2
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		New Equipment Total	$3.2

Existing Equipment Usage: Description	Number of Units	Inventory Agency
20 ft. Caribe rigid hull inflatable	1	ADFG
17 ft. Boston Whaler	1	ADFG
10x40 binoculars	4	ADFG
Spotting Scopes	2	ADFG
Achilles 8 ft inflatable dinghy	2	ADFG
Remington Shotguns	2	ADFG
Honda generators	3	ADFG
Survival Suits	2	ADFG
Outboard Motors/various hp	6	ADFG
Magellan GPS	3	ADFG
Radio Tracking Receivers	2	ADFG
Marine VHF radios	4	ADFG

1998

Prepared: April 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: DOI-BRD

FORM 3B
Equipment
DETAIL

4/14/97

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$23.3
Travel		$4.4
Contractual		$50.0
Commodities		$35.5
Equipment		$0.0
Subtotal	$0.0	$113.2
General Administration		$7.0
Project Total	$0.0	$120.2
Full-time Equivalents (FTE)		0.8
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
Project Total	$302.2	$291.5	$217.0	$151.0

Dollar amounts are shown in thousands of dollars.

Comments:

1998

Prepared: 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: DOI-BRD

FORM 3A
TRUSTEE
AGENCY
SUMMARY
4/14/97

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

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1998
Biological Technicians	Field Assistants	GS-5	7.0	1.9		13.3
Veterinarian	Surgical Implants	GS-13	1.0	6.0		6.0
Anesthetist	administer anesthetics		1.0	4.0		4.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		9.0	11.9	0.0	
					Personnel Total	$23.3

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Field personnel Anchorage/Cordova	0.3	4	20	0.1	3.2
Field personnel/equipment/vehicles Portage/Whittier Alaska Railroad	0.1	8			0.8
Vehicle and Boat (trailer) 21-43' Portage/Whittier Alaska Railroad	0.4	1			0.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.4

1998

Prepared: April 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: DOI-BRD

FORM 3B
Personnel
& Travel
DETAIL

4/14/97

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

Contractual Costs:	Proposed
Description	FY 1998
Boat Charter 30 days @ $1,500./day	45.0
Aircraft Charter 20hrs. @ $225./hr.	4.5
Radio telemetry observer (personal services contract) 20hrs. @ $25./hr	0.5
When a non-trustee organization is used, the form 4A is required. Contractual Total	$50.0

Commodities Costs:	Proposed
Description	FY 1998
Veterinary surgical supplies for radio implants	7.0
Radio transmitters 100 @ $200 ea.	20.0
Kayak rental 8@ $310 ea.	2.5
Trap maintenance - misc. equipment and supplies	1.5
Personnel training	1.0
Boat fuel 1,000 gal. @ $1.50/gal	1.5
Boat maintenance	2.0
Commodities Total	$35.5

1998

Prepared: 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: DOI-BRD

FORM 3B
Contractual & Commodities DETAIL
4/14/97

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
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
TOBEC machine	1	DOI
Binoculars	4	DOI
Marine VHF radios	6	DOI
Telemetry receivers	2	DOI

1998

Prepared: April 97

Project Number: 98426
Project Title: Harlequin duck population dynamics-patterns and processes
Agency: DOI-BRD

FORM 3B
Equipment
DETAIL

4/14/97

Project Title: Harlequin Duck Recovery Monitoring - Close-Out

Project Number:	98427 CLO
Restoration Category:	Monitoring
Proposers:	Dan Rosenberg Alaska Dept. of Fish and Game 333 Raspberry Road Anchorage, Alaska 99503
Lead Trustee Agency:	ADFG
Cooperating Agencies:	
Alaska SeaLife Center:	No
Project Duration:	Two years
Cost FY 98:	$86,300.
Cost FY 99:	$1,000.
Cost FY 00:	$0
Cost FY 01:	$0
Cost FY 02:	$0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Harlequin ducks

ABSTRACT

This project will complete the harlequin duck recovery monitoring project /427. A final report and manuscripts will be prepared, reporting on the findings of this 4 year project.

INTRODUCTION

Harlequin ducks (*Histrionicus histrionicus*) occur year-round in intertidal zones of PWS (Isleib and Kessel 1973). Approximately 1,000 harlequin ducks died as a direct result of oil exposure following the Exxon Valdez oil spill (ECI 1991). Oil spill studies of harlequin ducks in western Prince William Sound (PWS) from 1990-93 found consistently low numbers of birds during the breeding season, a lack of breeding activity on suitable streams in 1991 and 1992, negligible production of broods through 1993, and an apparent decline in post-breeding molting birds (Patten 1995, Patten et al. 1995). Nearly five years after the Exxon Valdez oil spill there was no sign of recovery (Exxon Valdez Oil Spill Trustee Council 1993).

Two main hypotheses were presented to explain lack of reproduction and population declines: (1) ingested oil is continuing to cause either mortality and/or sublethal impairment of reproduction; and/or (2) initial mortality caused significant losses to the local western PWS breeding component and subsequent low production. Postspill studies indicated an initial decline in molting birds, a lack of productivity, and fewer breeding pairs present in spring in oiled areas, although no conclusive evidence has been found of histological or physiological effects from oil.

In response to this lack of recovery, project /427, Harlequin Duck Recovery Monitoring was begun in 1994 with a pilot project to develop age criteria and survey methods to compare the population structure, numbers, and distribution during spring in oiled and unoiled areas of PWS. Studies were expanded in late-spring 1994 to compare molting populations and measure production (brood surveys). Age and sex criteria and a survey design were developed and complete spring and fall surveys were conducted in 1995, 1996, and 1997. A winter survey was added in 1997. Annual Reports were prepared for each years survey results (Rosenberg 1995, Rosenberg et al. 1996, Rosenberg and Petrula 1997).

This project will prepare a final report and manuscripts for publication in peer reviewed journals. Because the FY97 field season ends close to the end of the fiscal year, money is also allocated for equipment maintenance and storage.

NEED FOR THE PROJECT

A. Statement of Problem

Prior to 1994, EVOS projects gathered abundance and distribution data mostly on total harlequin ducks, with little information on sex and age composition, or proportions of paired birds. The focus of these projects was extensive survey coverage and oil exposure studies. Sea duck populations, in general, are composed of long-lived birds that have delayed sexual maturity, low annual production rates, and "boom and bust" years. Consequently, sea duck population dynamics are quite sensitive to adult female survival rates, size of the breeding component, and variable breeding propensity (% of adults breeding annually). Data on sex and age composition are very useful in examining these aspects of a population.

The consistently low numbers of birds during the breeding season, a lack of breeding activity on suitable streams in 1991 and 1992, negligible production of broods through 1993, and an apparent decline in post-breeding molting birds all led to concern for harlequin duck populations and the need to monitor the population structure and productivity of this species and assess its recovery.

B. Rationale/Link to Restoration

These surveys assessed recovery of harlequin duck populations and sought to identify factors inhibiting or contributing to recovery and restoration. Monitoring provided information on population structure and growth. Focus on these population parameters is necessary to determine the status and recovery potential of harlequin ducks; determine if recovery objectives are being met; and suggest factors limiting recovery. The monitoring effort also allowed us to modify recovery objectives as new information became available. This provided a more reliable basis for restoration planning and was consistent with an adaptive management approach that allowed more efficient allocation of efforts and enrichment of knowledge over time.

This report will consider a variety of population parameters and assess whether the lack of production in western Prince William Sound; lower breeding propensity; higher female mortality; and the suspected high degree of site fidelity to nesting and molting areas has interfered with population recovery in oiled areas. A continued decline in harlequin duck populations in western Prince William Sound may lead to a significant reduction or loss of this resource from the area and beyond. It is important to know if populations are continuing to decline, and if so, understand the factors responsible for limiting recovery. Populations may continue to decline due to a lack of recruitment, greater mortality, oil toxicity, or a combination of factors.

C. Location

This report will include survey results from oiled portions of western PWS and unoiled portions of eastern PWS (Rosenberg 1995, Rosenberg et al. 1996, Rosenberg and Petrula 1997). No new field work will be conducted.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

This report will include information gathered on Traditional Ecological Knowledge of harlequin ducks in PWS. Project personnel will adhere to the EVOS Restoration Office protocols for including indigenous knowledge in the restoration process. The project will inform and coordinate our community involvement activities, including the collection of indigenous knowledge with Dr. Henry Huntington, TEK specialist EVOS Restoration Office; Martha Vlasoff, community coordinator; and the Subsistence Division of the Alaska Department of Fish and Game.

No funding has been requested for travel to local communities to present information on TEK of the findings of this study.

PROJECT DESIGN

A. Objectives

FY 98:

1) Analyze data from FY97 field season;

2) Incorporate data in current Geographical Information System developed for these studies;

3) Prepare final report including all information gathered from 1994-1997.

4) Prepare 2-3 manuscripts for publication in peer reviewed journals.

B. Methods

Statistical analysis will follow methods in previous annual reports (Rosenberg 1995, Rosenberg et al. 1996, Rosenberg and Petrula 1997).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Unpublished data will be shared with USGS-BRD, project \025 Nearshore Vertebrate Predator project. No contracts will be solicited for this report.

SCHEDULE

A. Measurable Project Tasks for FY 98

October-December:	Maintain and store field equipment. Data entry and analysis. GIS and map preparation. Begin final report and manuscript preparation.
January-March:	Attend EVOS Restoration Workshop. Continue data analysis and report preparation.
April 15:	Submit final report and manuscripts.

B. Project Milestones and Endpoints

FY99

October-March: Publish manuscripts.

C. Completion Date

All project objectives will be met following FY99.

PUBLICATIONS AND REPORTS

A final report of FY94-FY97 activities will be submitted to the Restoration Office before April 15, 1998. Manuscripts for peer reviewed journals will be submitted for publication prior to November 1, 1998.

PROFESSIONAL CONFERENCES

A paper will be presented to the Harlequin Duck Working Group biennial meeting to be held in March 1998. Location to be announced.

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

Results will be compared and integrated with other EVOS Trustee sponsored research, including projects /025 Nearshore Vertebrate Predator Project, /161 Harlequin duck genetics, /159 Prince William Sound Marine Bird Surveys, and /052B Traditional Ecological Knowledge. Information from this project will support proposed project 98426 Harlequin Duck Population Dynamics-Patterns and Processes. Results from Crowley (1966) , EVOS Restoration project R71, will be incorporated into manuscripts.

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL QUALIFICATIONS

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

Mr. Rosenberg has conducted harlequin duck population (age and sex structure) and production surveys in Prince William Sound since 1994 as the Principle Investigator of a Trustee sponsored restoration project. He has conducted extensive waterfowl population monitoring and habitat assessment surveys on the Copper River delta, Stikine River delta, Kenai wetlands, upper Cook Inlet, Aleutian Islands, and Kodiak Island. As project leader, Mr. Rosenberg has assessed impacts to waterfowl and wildlife populations from hydroelectric development, urban expansion, habitat alterations, chemical pollutants, timber harvest, and surface mining.

OTHER KEY PERSONNEL

Mike Petrula, Wildlife Biologist, ADFG. Data analysis, report and manuscript preparation.

LITERATURE CITED

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Restoration Proj. 93-033. Draft Rept. (in prep.). Alaska Dept. Fish and Game, Anchorage, AK.

Rosenberg, D. H. 1995. Experimental harlequin duck breeding survey in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 94427), Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage, Alaska. 30 pp.

Rosenberg, D.H., M.J. Petrula, and D.W. Crowley, 1996. Distribution, Abundance, and Structure of Harlequin Duck Populations in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 95427), Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage, Alaska.

Rosenberg, D.H., and M.J. Petrula. 1997 (in prep.). Distribution, Abundance, and Structure of Harlequin Duck Populations in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 95427), Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage, Alaska.

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel	$165.1	$65.4
Travel	$9.4	$1.6
Contractual	$33.5	$7.0
Commodities	$16.5	$2.0
Equipment	$0.9	$0.0
Subtotal	$225.4	$76.0
General Administration	$27.1	$10.3
Project Total	$252.5	$86.3
Full-time Equivalents (FTE)	2.8	1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$1.0	$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments: Close Out for Project 98427 Harlequin Duck Recovery Monitoring. No field work is proposed for this project in FY98. No money is allocated for NEPA compliance. Only salary money is allocated for attendance at Anchorage workshops. Page costs for publication in peer reviewed journals is not included because manuscripts may not appear in print in FY98. Page costs for publication are included in FY99. Project includes costs to repair, maintain, and store boats and field gear following the FY97 field season which ends in mid-September, 1997.

1998

Prepared: April 97

Project Number: 98427 CLO
Project Title: Harlequin Duck Recovery Monitoring
Agency: ADFG

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 1998
D. Rosenberg	WBIII, Principle Investigator	18F	4.5	6.2		27.9
Mike Petrula	WBI, Data analysis, report prep., graphics	14C	4.5	4.1		18.5
Dave Crowley	WBI, Manuscript preparation	14D	1.0	4.3		4.3
E. Becker	Biometrician II	19L	1.0	6.9		6.9
C. Barnhill	Cartographer II	16L	1.5	5.2		7.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.5	26.7	0.0	
					Personnel Total	$65.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Harlequin Duck Working Group Meet. Loc.and date TBA 1/	8.0	1	6	0.1	1.2
Rental Car-Harlequin Duck Working Group			6		0.3
Airport parking, taxi fare, EVOS Workshop parking.					0.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.6

1/ The Harlequin Duck Working Group Meeting is an international Workshop that meets every other year. The 1998 meeting is expected to be held in Vancouver, BC or in the State of Maine.

1998

Prepared: April 97

Project Number: 98427 CLO
Project Title: Harlequin Duck Recovery Monitoring
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

4/14/97

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

Contractual Costs:	Proposed
Description	FY 1998
Warehouse for equipment storage and maintenance - 6 months @ $775/mo	4.7
Boat and outboard motor repair and maintenance	2.0
Photo processing, Workshop presentation productions	0.3
When a non-trustee organization is used, the form 4A is required. Contractual Total	$7.0

Commodities Costs:	Proposed
Description	FY 1998
Computer software for analysis, graphing, mapping	1.0
Equipment Maintenance	1.0
Commodities Total	$2.0

1998

Prepared:April 97

Project Number: 98427 CLO
Project Title: Harlequin Duck Recovery Monitoring
Agency: ADFG

FORM 3B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
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

1998

Prepared: April 97

Project Number: 98427 CLO
Project Title: Harlequin Duck Recovery Monitoring
Agency: ADFG

FORM 3B
Equipment
DETAIL

4/14/97