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

Project Number:	02552-BAA
Restoration Category:	Research
Proposer:	Prince William Sound Science Center
Sponsoring Agency:	NOAA
Duration:	Three years
Cost FY 02:	$ 102,500
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink salmon, Pacific herring

ABSTRACT

One of the least understood physical processes that influence the biological components of PWS is the exchange between the northern Gulf of Alaska (GOA) and Prince William Sound (PWS). The main objective of this proposal is to document the interannual variability in water mass exchange between PWS and the adjacent northern GOA at Hinchinbrook Entrance, and to identify mechanisms governing this exchange. Support is requested for continued deployment of an upward looking ADCP mooring in Hinchinbrook Entrance to create time series of velocities spanning three years. The mooring will be equipped with a CTD to create a time series of deep temperature (T) and salinity (S). To identify the dominant factors that govern PWS/GOA exchange, the mooring velocity and deep T/S time series will be combined with meteorological and physical data collected under other research programs in progress in PWSand the GOA.

INTRODUCTION

The Sound Ecosystem Assessment (SEA), funded by the EVOS Trustee Council from 1994 to 1999, was aimed at understanding physical and biological factors affecting pink salmon and Pacific herring survival on an ecosystem level. As part of the SEA study, an upward-looking acoustic Doppler current profiler (ADCP) mooring was deployed in Hinchinbrook Entrance from June through September 1995 and from September 1996 through May 1997. Time series of horizontal and vertical velocities were created for these two periods. The data were low-pass filtered (40 hour) to remove the tidal component.

At Hinchinbrook Entrance, the summer and early fall months of 1995 (June through September) were characterized by outflow above about 150m and inflow below (Vaughan et al., 1999). Easterly offshore winds caused surface Ekman layer inflow, accompanied by deeper outflow. Except for the Ekman inflow, which reached speeds greater than 80 cm/sec, the magnitude of the flow seldom exceeded 20 cm/sec. In late September, at the very end of the 1995 time series, the pattern seemed to reverse to one of inflow above about 150m and outflow below.

The fall and early winter months (September 1996 through January 1997) at Hinchinbrook Entrance were characterized by inflow above 150m and weak outflow below. The magnitude of the inflow often exceeded 60cm/sec. The change to the opposite baroclinic structure in September could be a regular seasonal event, or indicate different conditions in 1995 and 1996. Late winter and spring months (January through May 1997) were characterized by more barotropic inflows and outflows (Vaughan et al., 1998). Speeds during this time were the weakest observed, typically less than 20cm/sec. The mechanisms responsible for the observed variability have not been identified. Offshore wind forcing or flows through the deep trench southeast of Montague Island may influence the vertical structure at Hinchinbrook Entrance.

Along channel transports through Hinchinbrook Entrance were calculated from the 1995 and 1996-1997 time series for layers above and below 150m, and compared to transports from 1978 (Niebauer et al., 1994). Trends in the monthly mean transports were similar above and below 150m for both time periods. In the upper layer, maximum inflows occurred in October and December, although the magnitudes in 1978 (0.3 Sv) were slightly greater than in 1996 (0.2 Sv). Above 150m, weaker outflows occurred in summer 1995 and in summer 1978. Below 150m, weak inflow occurred in summer 1995 and in summer 1978.

In December 1999, the ADCP mooring was redeployed in Hinchinbrook Entrance under EVOS project 00552. The mooring was retrieved in July 2000, but the ADCP failed to record any data. The problem (a bad chip in the ADCP deck box) was identified and corrected, and the mooring was redeployed in September 2000. A series of in-water tests were performed prior to deployment to insure the instrument was functioning properly.

The mooring is scheduled for retrieval in May 2001, and for redeployment in September 2001. This proposal is for continued support of the Hinchinbrook mooring deployment.

This project will interface with other projects underway in PWS. GLOBEC Northeast Pacific (NEP) monitoring surveys in the northern GOA are scheduled to continue in FY00 through FY04. Process studies in the northern GOA are scheduled for FY01 and FY03. A GLOBEC survey line of particular interest is the trench on the southeastern side of Montague Island, which runs from the western side of Middleton Island to Hinchinbrook Entrance, and is almost certainly the conduit of any dense water entering PWS.

Anther project underway in PWS is the development of a near real-time nowcast/forecast (N/F) system, co-sponsored by the Oil Spill Recovery Institute (OSRI), the Alyeska Ship Escort and Response Vessel System (SERVS), and the PWS Region Citizens Advisory Council (PWS RCAC). The main objective of this project is to develop a prototype N/F circulation model that will be capable of calculating current velocity vector fields, particle trajectories, and the evolution of passive drifter concentrations. Current data are collected using a downward looking ADCP towed from one of the Alyeska SERVS vessels. East-west and north-south transects through central PWS, and repeated transects at Hinchinbrook Entrance (to eliminate the tidal contribution), were conducted in 1999 and 2000. Funding has been secured to continue measurements in 2001.

NEED FOR THE PROJECT

A. Statement of the Problem

Mechanisms governing exchange between the northern GOA and PWS are not well understood. It is not clear quantitatively what controls the amount of throughflow at Hinchinbrook Entrance, or how the throughflow affects the circulation in PWS. In particular, it is not known what causes the baroclinic structure in summer and early fall, the apparent reversal of this structure in September, and the transition to a barotropic structure in winter. The Hinchinbrook Entrance velocity data collected during the SEA program revealed significant spatial (horizontal and vertical) and seasonal variability of the throughflow. Documenting the interannual variability of the currents at Hinchinbrook Entrance and identifying the mechanisms that govern the exchange will require a time series of velocity at all depths that spans several years.

B. Rationale/Link to Restoration

Juvenile fish in PWS rely on zooplankton as their food source. Exchange at Hinchinbrook Entrance could either seed PWS with zooplankton or flush zooplankton out, thereby regulating the amount of available food and possibly the number of copepods diapausing in PWS in winter. Exchange at Hinchinbrook Entrance may influence the central Sound circulation, and possibly the transport of juvenile fish from one nearshore region to another.

C. Location

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

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Bids will be solicited from the private sector for oceanographic charters in FY01. This project will contribute information to local newsletters and newspaper articles. Results will be published in peer reviewed scientific journals. Results will be posted on a PWSSC web page, and will be accessible to the public.

PROJECT DESIGN

A. Objectives

The main objective of this proposal is to document the interannual variability in water mass exchange between PWS and the northern GOA at Hinchinbrook Entrance, and to identify mechanisms governing this exchange. Funding is requested for continued deployment of an upward looking ADCP mooring in Hinchinbrook Entrance in FY02. In addition to the ADCP velocity time series, time series of deep temperature (T) and salinity (S) will be collected by a CTD mounted on the mooring.

B. Methods

An upward-looking ADCP mooring (RDI 150 kHz broadband) will be deployed in the fall of each year (e.g., September) and retrieved in the spring or summer (e.g., May). The approximate mooring location will be latitude 60 17.0', longitude 146 51.0', which is in the deepest part of Hinchinbrook Entrance at the northern end of the Montague Island trench. As configured, the ADCP will measure horizontal and vertical velocities from a few meters above the transducer faces to within roughly 45m of the surface in 8m bin depths. To maximize deployment time while still capturing the tidal cycle, the sampling interval will be 2 hours.

The data will be processed using standard RDI software and analyzed using software developed under SEA. The horizontal velocities will be translated into along-channel and cross-channel components, and 40 hour low-pass filtered to remove the tidal components. Transports will be calculated from the along-channel low-pass filtered velocities above and below 150m (as well as other depth intervals) and compared to previous years' values. Power spectra for each component will also be calculated at several depths and compared to previous years.

In addition to the velocity data, T/S data will be collected by a SeaBird 16 CTD mounted on the mooring. The instrument has been equipped with a new pressure housing enabling it to function at the mooring depth. The data will be processed using standard SeaBird software. Density will be calculated from T and S.

The velocity and T/S data will be stored on the PWSSC network computers. Analyzed data products will be available via a PWSSC web site. Raw data will be available to other EVOS investigators after publication.

With a 2 hour sampling interval, continuous data collection is limited by battery power to approximately 9 months. The second deployment took place in September 2000. In FY01, retrieval is scheduled for May 2001, and redeployment for September 2001. In FY02, the final retrieval is scheduled for May 2002.

It is unfortunate that this collection strategy does not include measurements in the summer months. Previous summer observations at Hinchinbrook Entrance have revealed many interesting features. September and May were chosen for several reasons. With a maximum 9 month deployment time, a single mooring will miss 3 months of the year. Since severe weather often precludes shipboard work in the late fall through early spring, the summer months were chosen to miss. In the summer, the mooring time series will be supplemented by velocity measurements using a towed shipboard instrument as described below. Conditions in both September and May are usually mild enough to allow mooring work. Also, this time period covers the late fall and early winter when volume transports at Hinchinbrook Entrance are maximum. Efforts are underway to secure funding for a second mooring, so that year-round measurements will be possible.

Target cruise dates for years 2001 and 2002 are:

May 2001	(retrieval)
September 2001	(deployment)
May 2002	(retrieval)

FY01 included two mooring cruises (May 2001 and September 2001). FY02 will include one mooring cruise (May 2002) unless continued funding makes additional deployments possible. A vessel with a crane, A-frame, or other equipment suitable for mooring deployments will be required.

To identify the dominant factors that govern PWS/GOA exchange, the mooring velocity and deep T/S time series will be combined with additional data types collected under other programs. The time series obtained from the mooring will be supplemented by the velocity transects made with a downward-looking towed ADCP (funded under the OSRI N/F project). The repeated transects will capture the spatial variability of the Hinchinbrook Entrance flow patterns. T/S measurements on the SERVS cruises will be obtained using expendable CTDs (XCTDs). Conditions in the GOA, particularly in the trench southeast of Montague Island, will be documented by the GLOBEC group at the Institute of Marine Science (IMS) at the University of Alaska Fairbanks (UAF).

Meteorological data are available from the NOAA NDBC stations, particularly the Seal Rocks and Mid-Sound buoys, and from the FAA station located on Middleton Island. The numerical circulation model developed by the OSRI N/F modeling group at the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science (RSMAS) will be used in conjunction with the observations to identify mechanisms governing PWS/GOA exchange.

The mooring velocity time series coupled with the repeated ADCP transects over multiple years will show whether the baroclinic inflow/outflow structure that dominated the flow in summer 1995 and in fall through early winter 1996 (including the apparent September reversal and the 150m separation depth), as well as the transition from a baroclinic to barotropic structure in January 1997, is typical or anomalous. The mooring velocity time series coupled with time series of wind from the meteorological buoys will allow further investigation of surface Ekman layer inflow.

The T/S time series will signal the movement of any new deep water mass into or out of PWS. T/S observations from the GLOBEC cruises should reveal the source of deep water flowing into PWS, or the southern extent of deep water flowing out of PWS. Time series of GOA wind speed and direction (from the Middleton Island station) should indicate if large scale atmospheric forcing in the Gulf is responsible for the inflow/outflow patterns and transitions at Hinchinbrook Entrance, and for the variability in transports above and below 150m.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Cooperating agencies will be OSRI, PWS RCAC, and Alyeska SERVS.

SCHEDULE

A. Measurable Project Tasks

FY01:

April 15, 2001:	FY00 Annual Report due
May 2001:	Mooring retrieval
September 2001:	Mooring deployment

FY02:

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

FY03:

April 15, 2003: FY02 Final Report due

B. Project Milestones and Endpoints

Milestones of each year will be the successful deployment and retrieval of the mooring. The endpoint of each fiscal year will be marked by the Annual Report due date (April 15 of 2001, 2002 and 2003).

C. Completion Date

All project objectives will be completed in FY02 except for submission of the final report. The completion data of this project is September 30, 2003.

PUBLICATIONS AND REPORTS

The following manuscripts are in review and are expected to be published in FY01:

Physical Variability in Prince William Sound during the SEA Study (1994 - 1998), Fisheries Oceanography, March 2001. (This manuscript was previously entitled Physical Processes Influencing the Pelagic Ecosystem of Prince William Sound).

Seasonal Hydrography and Tidal Currents of Bays and Fjords in Prince William Sound, Alaska, March 2001.

PROFESSIONAL CONFERENCES

Travel is requested to attend the EVOS Workshop in Anchorage. Travel is also requested to present results at the American Geophysical Union (AGU) Ocean Sciences Meeting in February 2002.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be coordinated with the efforts Dr. T. Weingartner and Dr. D. Musgrave, both of IMS/UAF (GLOBEC), and with Dr. C. Mooers and Dr. I. Bang, both with UM/RSMAS (OSRI N/F). This project will cooperate with other EVOS sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

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

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

Professional Experience (since 1986):
1986 - 1993: Research Assistant, University of Miami, RSMAS, MPO, Miami, Florida
1993 - 1995: Postdoctoral Associate, University of Miami, Cooperative Institute for Marine and Atmospheric Studies, a cooperative institute between RSMAS and NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, Robert L. Molinari, supervisor
Sept. 1995 - present: Physical Oceanographer, Prince William Sound Science Center, Cordova, Alaska

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

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

Vaughan, S. L., C. N. K. Mooers, and S. M. Gay III, 2001: Physical Variability in Prince William Sound during the SEA Study (1994-1998). J. Fish. Oceanogr. (submitted).

Gay III, S. M. and S. L. Vaughan, 2001: Seasonal Hydrography and Tidal Currents of Bays and Fjords in Prince William Sound, Alaska. J. Fish. Oceanogr. (submitted).

OTHER KEY PERSONNEL

Shelton M. Gay: cruise staging, instrument calibration and maintenance,

data acquisition and analysis, contribute to journal publications.

LITERATURE CITED

Niebauer, H.J., T.C. Royer, and T.J. Weingartner, 1994: Circulation of Prince William Sound, Alaska. J. Geophys. Res., 99, C7, pp 14,113-14,126.

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

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

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$0.0						
Travel		$0.0						
Contractual		$95.8						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$95.8						
General Administration		$6.7						
Project Total	$0.0	$102.5						
Full-time Equivalents (FTE)		0.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared:

Project Number: 02552-BAA
Project Title: Exchange between PWS and the Gulf of Alaska
Agency: NOAA

Budget Category:	Authorized FY 2001	Proposed FY 2002

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel		$55.1						
Travel		$6.1						
Contractual		$11.8						
Commodities		$2.2						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$75.2						
Indirect (27.43%)		$20.6						
Project Total	$0.0	$95.8						
Full-time Equivalents (FTE)		0.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared:

Project Number: 552
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

Personnel Costs:				Months	Monthly		
	Name	Position Description		Budgeted	Costs	Overtime	
	Shari Vaughan	Physical Oceanographer (PI)		3.8	8300.0		
	Shelton Gay	Physical Oceanographer		3.8	6200.0		

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

		Subtotal		7.6	14500.0	0.0
						Personnel Total

Travel Costs:		Ticket	Round	Total	Daily	
	Description	Price	Trips	Days	Per Diem	
	EVOS Workshop - Anchorage - January 2002	220.0	1	3	145.0	
	1 r/t Cordova-Fairbanks	460.0	1	3	145.0	
	1 r/t Cordova-Miami	960.0	1		0.0	
	1 r/t Miami-Cordova	960.0	1	4	145.0	
	AGU Ocean Sciences Mtg. - Honolulu - Feb. 11-15, 2002	980.0	1	6	171.0	
					Travel Total	

FY02

Prepared:

Project Number: 552
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

Contractual Costs:	
Description	
Vessel Charter (1cruise, 2 days each @ $3000 per day) Equipment calibration/repair Network costs and maintenance ($100/computer-month) Professional servies - mooring technician ($2000 per cruise)	3 of 5

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

Phone, fax, copying Mail, freight, shipping	
Contractual Total	
Commodities Costs:	
Description	
Office supplies Computer supplies Marine supplies	
Commodities Total	

FY02

Prepared:

Project Number: 552
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

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

Existing Equipment Usage:	Number of Units	
Description		

FY02

Prepared:

Project Number: 552
Project Title: Exchange between PWS and the Gulf of Alaska
Name: Prince William Sound Science Center