Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem

Project Number:	02340
Restoration Category:	Monitoring
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	no
Duration:	1 year
Cost FY 02:	$19,309
Geographic Area:	Resurrection Bay/Gulf of Alaska shelf
Injured Resource/Service:	All organisms and services

ABSTRACT

This proposal seeks funds to complete the final report for project number 01340, "Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem". The fourth year of measurements will be completed in September 2001 (or December 2001 if the GAK 1 mooring is to be continued under the GEM program). After completion of the data collection phase of the project we will prepare a final report and a manuscript for publication focussing on freshwater variations on the Gulf of Alaska shelf. This manuscript will synthesize the data collected as part of the EVOS program as well as some of the retrospective efforts included in previous annual reports.

INTRODUCTION

This proposal seeks support to complete analysis on the four years of GAK 1 hydrographic and mooring measurements that have been supported by EVOS since November 1997. These data have maintained the 30-year (1970 – present) time series of conductivity-temperature versus depth (CTD) data collected at hydrographic station GAK1 on the northern Gulf of Alaska shelf. EVOS support for this program began in November 1997 with monthly cruises to station GAK1. These are presently scheduled to continue through September 2001. The monthly data are being supplemented with hourly (or shorter) measurements of temperature and conductivity at six depths using instruments moored at station GAK1. Weingartner (1999, 2000, and 2001) gives a more complete description and analysis of the data collected thus far. However, the principal findings to date are:

1. The anomalous summer 1997 warming (amounting to 1-2^{o}C above normal) was confined to the upper 40 m of the ocean. That warming was mainly a result of anomalously clear skies and low winds during the summer of 1997.
2. The abnormally large El Niño-related winter 1998 warming (~2^{o}C) occurred throughout the entire 250 m depth of the shelf. The return to near normal temperatures beginning last May and continuing through the present is being documented.
3. The abnormally large El Niño-related winter 1998 freshening (amounting to a vertically averaged salinity decrease of 0.15 psu) over the upper 200 m of the shelf. Freshening ceased in May and, below 200 m, was replaced with the saltiest waters ever observed at this location. These high salinity waters are enriched in nutrients and potentially available to phytoplankton in the surface layers.
4. A return to near normal temperatures in the summer after May 1998.
5. The integral time scales for temperature and salinity at GAK1 are about 1 month, which implies that the monthly values (which comprise the historical data set) are not severely aliased.
6. Within-month temperature and salinity variance computed from the moored instruments is no greater than the interannual variability based on the monthly data from the historical record.
7. Variations in freshwater forcing and the baroclinic transport of freshwater are large on seasonal, interannual, and interdecadal time scales. On average freshwater transport increases fivefold between spring and fall. Alaska Coastal Current freshwater transport in spring 1998 (during the 1997-98 El Niño) was twice that of spring 1999.
8. A first order description of seasonal variations in freshwater transport of the Alaska Coastal Current shows that these variations are accounted for by the annual cycles of: 1) coastal discharge and 2) the Ekman onshore transport of relatively fresh surface waters. Their sum accounts for the annual cycle of the baroclinic component of the freshwater transport within the Alaska Coastal Current. This transport primarily occurs within the upper 150m of the water column and within 35 km of the coast.
9. The Alaska Coastal Current could significantly influence the marine ecosystem on the southeast Bering Sea. Our preliminary estimate is that the Alaska Coastal Current contributes about 25% of the Bering Sea freshwater supply. Therefore, improved understanding of

environmental variability of the Gulf of Alaska ecosystem could improve our understanding of changes in the Bering Sea ecosystem.

10. Time series of coastal discharge estimates based on Royer's (1982) method, measured discharge, the leading EOF of precipitable water over the Northeast Pacific Ocean, and coastal salinity data all suggest a decrease in freshwater discharge into the northern Gulf of Alaska from the late 1950s through the mid-1970s. Discharge increased from the mid-70s through the early-80s; coincident with the regime shift of the 1970s and with the Pacific Decadal Oscillation (PDO) (Mantua, 1997; Overland et al., 1999). These findings add to other suggestions of a freshening across the North Pacific Ocean basin since the 1970s (Wong et al., 1999).
11. Monthly anomalies in the PDO index are coherent with Royer's monthly discharge anomalies at periods of 2 - 4 years suggesting a possible relationship to El Niño events.
12. Monthly sea level anomalies at Seward Alaska are significantly correlated with monthly anomalies of vertically integrated (0-200m) salinity and the 0/200db dynamic height. Hence sea level could serve as a proxy for shelf salinity variations here and perhaps elsewhere in the Gulf of Alaska. The Gulf of Alaska watershed and coastal ocean are severely undersampled with respect to precipitation, river discharge, and salinity. Long-term time series of these are lacking and even the future maintenance of existing discharge and weather stations is uncertain. There is a need to develop proxy variables that can be used to reliably estimate runoff and coastal salinity. A goal of this EVOS program is to determine if sea level can serve as a proxy for ocean salinity variations.
13. There is a promising correlation emerging between GAK 1 dynamic height (0/200 db) and the freshwater and mass transport as computed from the cross-shore density field in the Alaska Coastal Current. This suggests that the GAK 1 data could be used as an index for these variations.
14. We continued our investigations into the reasons for the anomalously low-salinity shelf water observed during the winter of 1998 and suggest that this was a consequence of several factors. First, there was above average seasonal (fall and winter) coastal discharge from Alaska. Second, there was also above average discharge from the Pacific Northwest as represented by the discharges from the Fraser River in British Columbia and the Columbia River in Oregon in the preceding summer and early fall. Third, there was anomalously strong seasonal coastal downwelling around the coastal Gulf of Alaska. These factors enhanced one another in several ways. The high runoff diluted inner shelf waters and strengthened the cross-shelf density gradients. These gradients, in conjunction with the strong cyclonic wind stress, enhanced the alongshore extent and strength of the coastal current. The anomalously strong downwelling would also have enhanced trapping of freshwater against the coast and augmented coastal freshening by increasing the onshore transport of low-salinity surface waters. Furthermore, our results suggest that the simultaneous occurrence of all of these anomalies is unusual because 1997-98 was the only year since 1970 in which all of these anomalies coincided.

We propose to complete one remaining objective and then to combine our results into a final report and a manuscript for publication in the peer-reviewed literature.

NEED FOR THE PROJECT

A. Statement of Problem

The GAK1 monthly time series illustrates some of the very large interannual and interdecadal variability of the high latitude North Pacific. The higher sampling rate (hourly) provided by the moored time series, allows detection and quantification of shorter period variations indicative of significant transitions that might be aliased by the monthly sampling. The results are enhancing interpretations of historical data and place the magnitude of previous anomalies in a better statistical framework. Moreover, the time series could serve as a proxy for transport in the Alaska Coastal Current. Variability in the marine environment, as reflected in ocean temperatures and salinities, and, if possible, shelf circulation, need to be quantified to understand the structure of, and changes in, the northern Gulf of Alaska marine ecosystem. The data will also support ongoing efforts to assess the recovery of marine species and services affected by the oil spill. Indeed, several EVOS-supported investigators underscored the need to understand natural climate variability and its influence on the recovery of species injured by the oil spill (Purcell et al., 1999; Piatt and Irons, 1999; Duffy, 1999; Anderson et al., 1999).

B. Rationale/Link to Restoration

The results from this proposal will provide published information to current and future investigators working in the Gulf of Alaska and adjacent waters needing information on environmental variability. This information will assist in:

1. Understanding thermohaline variability on time scales ranging from the tidal to the interdecadal.

2. Interpreting historical data sets for use in retrospective studies.

3. Configuring a cost-effective, long-term monitoring program.

4. Designing process studies necessary to develop ecosystem models for this shelf.

C. Location

The work will be completed at the University of Alaska's Institute of Marine Science in Fairbanks, AK. The results will combined with the existing historical data that are on the Institute of Marine Science webpage: http://www.ims.alaska.edu:8000/gak1/gak.dat. We will put the manuscript on the webpage as a pdf file to make it accessible to the broadest possible community.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

We do not see any overt connection to traditional ecological knowledge. However, the most expedient way to share these data with both the public and scientific communities is via the internet. Such a link will allow easy access to the data for those working at the community level and with traditional ecological knowledge.

PROJECT DESIGN

A. Objectives

There were two objectives at the heart of this program. The first was to continue the 30-year time series at station GAK1 through a combination of monthly CTD measurements and through yearlong deployments of a mooring containing temperature and conductivity (T/C) recorders. The second was to contribute to the design of a cost-effective monitoring program for the Gulf of Alaska shelf. Our sampling schemes, in conjunction with the GLOBEC data set, complement one another by providing high vertical resolution at monthly time scales and high temporal resolution but at a lower vertical resolution. Our generic goal of ecosystem monitoring is a long-term undertaking requiring multiple and multi-disciplinary efforts, however, our effort constitutes one essential step toward that goal.

B. Methods

Funds are requested to prepare a final report (manuscript for publication in the peer-reviewed literature). Many of our analyses are completed except for working up the final year of data (being collected now) and a remaining objective. That objective is to compare simple atmospheric pressure patterns or indices with long term precipitation and/or stream flow measurements from around the gulf. Pressure patterns over the Northern Hemisphere have been reconstructed back to 1900. However, there is only one virtually continuous streamflow record for the northern Gulf of Alaska since ~1920 and continuous precipitation records date to 1930. Thus quantifying decadal scale variability is hampered by the lack of precipitation and discharge records. If proxies for these variables can be established then a surrogate discharge time series for the gulf can be reconstructed for the past 100 years. I anticipate that pressure patterns favoring northward atmospheric transport into the Gulf of Alaska might be highly correlated with regional runoff and precipitation. If such an index results then it would serve as a proxy for discharge variability dating to the early 1900s. Note that we are not trying to duplicate other indices (such as the PDO) which characterize hemispheric scales but rather to construct a more local (e.g., Gulf of Alaska) index that would be a better predictor of regional precipitation variations. I will use~40 years of monthly atmospheric precipitable water and atmospheric pressure indices obtained from the NCEP/NCAR reanalyzed meteorological fields interpolated onto a 2.5^{o} grid between 65^{o}-35^{o}N and 160^{o}-120^{o}W. The purpose is to construct statistical relationships between atmospheric pressure indices and precipitable water and stream discharge. (Precipitable water data are available from: http://www.cdc.noaa.gov./cdc/data.nmc.reanalysis.html#surface) and streamflow data are obtainable from the USGS website: http://2o-nwisw.er.usgs.gov/nwis-w/AK/. I have used some of these data in a different analysis (Weingartner, 2000). We will also use Royer's Gulf of Alaska discharge time series in this analysis.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – March 30, 2003)

September 2001: Recover GAK 1 mooring and complete monthly CTD surveys.

November–December 2001:	Perform above if companion proposal to continue these measurements as a bridge to GEM is funded.
December - March:	Complete post-calibrations and data processing.
March – July 2002:	Prepare report and manuscript (depending upon final calibration schedule).

B. Project Milestones and Endpoints

The data collected as part of this project will be available to a broad community of users and posted on our website as well as published in the peer-reviewed literature.

C. Completion Date

This project will be completed by March or July 2003.

PUBLICATIONS AND REPORTS

We intend to submit a manuscript to the Journal of Geophysical Research (or comparable journal) at the completion of this project.

PROFESSIONAL CONFERENCES

We have presented some of the previous findings listed in the Introduction at national conferences in conjunction with GLOBEC work. We have also presented posters at the annual EVOS workshop as well as the Ocean Sciences meeting (January 2000, San Antonio) and the Eastern Pacific Ocean Conference (EPOC; September 2000, Sidney, British Columbia). In each case we have melded the GAK 1 results with GLOBEC results where appropriate and have acknowledged the support of EVOS as well as NSF and NOAA. I anticipate doing the same in the future. No funds are sought from EVOS for travel and attendance at national meetings, as I will use GLOBEC funds to cover these costs.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have discussed aspects of the GAK1 historical data with several investigators supported by the Trustee Council. Many have expressed interest in these data and know how to access it. Other scientists are aware of these data through papers and meetings, (e.g., the American Geophysical Union which serves primarily the U.S. oceanographic community and the North Pacific Marine Science Organization [PICES] composed of marine scientists from around the Pacific Rim) and, of course, at GLOBEC meetings. Though we have discussed how we would make these data available, we welcome advice from the Trustee Council on additional ways to share these data with other investigators and/or the public.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

None

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Thomas J. Weingartner

EDUCATION

Ph.D. Physical Oceanography, 1990, North Carolina State University
M.S. Physical Oceanography, 1980, University of Alaska
B.S. Biology, 1974, Cornell University

MEMBERSHIPS

American Geophysical Union; American Meteorological Society

PUBLIC SERVICE

Member, Science Steering Committee, NSF - Arctic System Science-Ocean Atmosphere Ice Interaction (OAII) component
Member, Science Steering Committee, NSF - ARCSS-OAII Shelf-Basin Initiative
Member, Science Steering Committee, NSF - ARCSS-Human Dimensions of the Arctic component
Member, UNOLS - Fleet Improvement Committee

PROFESSIONAL EXPERIENCE

Assistant Professor; Institute of Marine Science, School of Fisheries and Ocean Sciences, U. of Alaska Fairbanks, Alaska; 11/93 - present
Research Associate; Institute of Marine Science, School of Fisheries and Ocean Sciences, U. of Alaska Fairbanks, Alaska; 9/91 - 10/93
Postdoctoral Student; Institute of Marine Science, School of Fisheries and Ocean Sciences, U. of Alaska Fairbanks, Alaska; 7/88 - 8/91
Graduate Research Assistant; Department of Marine, Earth and Atmospheric Sciences, North Carolina State U.; Raleigh, North Carolina; and Department of Marine Science, U. of South Florida; St. Petersburg, Florida; 8/84 - 10/88

PROFESSIONAL INTERESTS

Physical oceanography of the Arctic and North Pacific Ocean and the adjacent shelves, biophysical linkages in oceanography; public education.

PUBLICATIONS

Weingartner, T. J., S. Danielson, Y. Sasaki, V. Pavlov, and M. Kulakov. The Siberian Coastal Current: a wind and buoyancy-forced arctic coastal current. *J. Geophys. Res.,* ***104***: 29697 – 29713, 1999.

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Roach, A. T., K. Aagaard, C. H. Pease, S. A. Salo, T. Weingartner, V. Pavlov, and M. Kulakov. 1995. Direct measurements of transport and water properties through Bering Strait. *J. Geophys. Res.,* 100:18443-18458.

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Niebauer, H. J., Royer, T. C., and T. J. Weingartner. 1994. Circulation of Prince William Sound, Alaska. *J. Geophys. Res.*. 99:14113-14126

Coyle, K. O., G. L. Hunt, M. B. Decker, and T. Weingartner. 1992. The role of tidal currents in concentrating euphausiids taken by seabirds foraging over a shoal near St. George Island, Bering Sea. *Mar. Ecol. Progr. Ser*. 83:1-14.

Musgrave, D. L., T. J. Weingartner, and T. C. Royer. 1992. Circulation and hydrography in the northwest Gulf of Alaska. Deep-Sea Res. 39:1499-1519.

Weingartner, T. J. and R. H. Weisberg. 1991. A description of the annual cycle in sea surface temperature and upper ocean heat in the equatorial Atlantic. *J. Phys. Oceanogr*. 21:83-96.

Weingartner, T. J. and R. H. Weisberg. 1991. On the annual cycle of equatorial upwelling in the central Atlantic Ocean. *J. Phys. Oceanogr*. 21:68-82.

Royer, T. C., J. Vermisch, T. J. Weingartner, H. J. Niebauer, and R. D. Muench. 1990. Ocean circulation influence on the *Exxon Valdez* oil spill. *The Oceanography Society* 3:3-10.

Weisberg, R. H. and T. J. Weingartner. 1988. Instability waves in the equatorial Atlantic Ocean. *J. Phys. Oceanogr*. 18: 1641-1657.

Weisberg, R. H. and T. J. Weingartner. 1986. On the baroclinic response of the zonal pressure gradient in the equatorial Atlantic Ocean. *J. Geophys. Res*. 91:11717-11725.

Manuscripts in preparation:

Weingartner, T. J., T. Royer, S. Danielson and S. Okkonen. Freshwater transport and variability within the Alaska Coastal Current, Gulf of Alaska.

Weingartner, T. J., K. Aagaard, D. J. Cavalieri, and Y. Sasaki. Winter baroclinic processes on the northeast Chukchi Sea shelf.

Weingartner, T. J., K. Aagaard, and Y. Sasaki. Circulation in Barrow Canyon and implications on shelf-basin exchange.

OTHER KEY PERSONNEL

Mr. Seth Danielson is the computer programmer who will assist in data processing, analyses, and maintenance of the web page. Both are employees of the Institute of Marine Science.

LITERATURE CITED

Anderson, P. J., J. F. Piatt, J. E. Blackburn, W. R. Bechtol, T. Gotthardt. 1999. Long-term changes in Gulf of Alaska marine forage species 1953-1998, p. 137 abstract only, Legacy of an Oil Spill- 10 Years after *Exxon Valdez,* Anchorage, AK, March 23-26.

Duffy, D. C. 1999. And an oil spill ran through it: lessons from the APEX study of the effects of the *Exxon Valdez* Spill on Alaskan Seabirds and Fish, p. 143 abstract only, Legacy of an Oil Spill- 10 Years after *Exxon Valdez*, Anchorage, AK, March 23-26.

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Weingartner, T. 2000. Toward long-term oceanographic monitoring of the Gulf of Alaska ecosystem, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 98340), Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, Alaska.

Weingartner, T. 1999. Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 98340) Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, Alaska.

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2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$0.0						
Travel		$0.0						
Contractual		$19.3						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$19.3	Estimated FY 2003					
General Administration		$1.4						
Project Total		$20.7						
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared:

Project Number: 02340
Project Title:Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Agency: Alaska Department of Fish and Game

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$12.4						
Travel		$0.5						
Contractual		$2.5						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$15.4	Estimated FY 2003					
Indirect		$3.9						
Project Total		$19.3	$14.5					
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

The indirect rate is 25% TDC as negotiated by the Exxon Valdez Oil Spill Trustee Council with the University of Alaska.

FY02

Prepared:

Project Number: 02340
Project Title:Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: Thomas J. Weingartner

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		
	Name	Position Description	Budgeted	Costs	Overtime	
	Weingartner, T.	PI/Associate Professor	1.0	6.8		
	Danielson, S.	Analyst Programmer	1.0	5.6		
		Subtotal	2.0	12.4	0.0	
					Personnel Total	

Travel Costs:		Ticket	Round	Total	Daily	
	Description	Price	Trips	Days	Per Diem	
	Fairbanks to Anchorage	258.0	1	2	121.0	
					Travel Total	

FY02

Prepared:

Project Number: 02340
Project Title:Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: Thomas J. Weingartner

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	
Description	
Page charges	
Contractual Total	
Commodities Costs:	
Description	
Commodities Total	

FY02

Prepared:

Project Number: 02340
Project Title:Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: Thomas J. Weingartner

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

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: 02340
Project Title:Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: Thomas J. Weingartner