Project Title: Mapping the Physics and Physical Processes of Marine Habitats: The First Step in a Spatially Nested Monitoring Program

Project Number:	02556
Restoration Category:	Research and Monitoring
Proposer:	Kachemak Bay Research Reserve
Lead Trustee Agency:	ADFG
Duration:	1st year, 1 year project
Cost FY02:	$50,000
Geographic Area:	Kachemak Bay/Lower Cook Inlet
Injured Resource/Service:	Subtidal and intertidal communities, sediments, mussels, clams, archeological resources

ABSTRACT

Groups, individuals, and programs as diverse as natural resource agencies, local governments, researchers, conservation advocates in Cook Inlet and Kachemak Bay, and the EVOS/GEM can benefit from a comprehensive, high resolution database of shoreline and nearshore habitats, and from information on the physical changes seen through time. At present, no such detailed database or monitoring program exists within the Gulf of Alaska. We propose to use a method adopted along the U.S. west coast to gathering such habitat information in a cost-effective yet detailed manner. The method relies on a nested hierarchical nearshore classification based on the physics of the environment to select replicate shore sites for monitoring algal and invertebrate diversity.

INTRODUCTION

The overall purpose of our proposal is to develop a statistically rigorous monitoring program in Kachemak Bay and lower Cook Inlet to address the needs of resource managers, researchers, conservation groups, local governments, and oil spill prevention/restoration organizations. This proposal seeks funding to build a spatially comprehensive database of the geomorphology and physical attributes of subtidal and intertidal habitats for the greater Kachemak Bay/Lower Cook Inlet area. We regard this as the foundation for developing a monitoring program to detect changes in nearshore communities resulting from shifts in watershed and marine processes. The NOAA Environmental Sensitivity Index (ESI) maps, developed for oil spill response planning, do not contain the data necessary for resolving small spatial scale features of the shoreline needed in ecological studies where biophysical linkages often occur at scales of less than one meter.

This project is linked to FY02 EVOS proposal #02565. While this project can be conducted independently, the cumulative value of these projects being undertaken simultaneously is great.

NEED FOR THE PROJECT

A Statement of Problem

The ecology of the nearshore benthos (from intertidal to 10 m depth) has been studied in detail at many coastal locations in the U.S. However, the processes that couple the intertidal regions with those in the nearshore ocean are poorly understood. For example, it is not apparent if production in some intertidal communities is regulated by the delivery of nutrients from the coastal ocean or by drainage from nearby rivers and estuaries (Menge et al., 1997). Such “edge” communities at the transition between one regime and another have rarely been studied as an integrated system. However, it is clear that there is strong physical and biological coupling between the nearshore and the intertidal (Schoch and Dethier, 1996). Prediction of how these communities will change over time or space is still a significant challenge. Map data of dominant habitats and species, as well as statistics about abundance, are important to our understanding of how these systems interact and function and have many applications in resource management as well as basic research. Such understanding is especially critical as we try to make predictions about impacts of large-scale environmental phenomena, from coastal eutrophication, to oil spills, to shifts in weather patterns and wind driven processes (ENSO and global climate change).

The planet is experiencing an unprecedented loss and impoverishment of its biological wealth as measured by species extinctions and degradation of its ecological systems (Schoch, 1998). Benthic organisms within the marine nearshore ecosystem are sensitive to environmental gradients and may serve as indicators of changes occurring in the coastal ocean. These benthic communities often include organisms with life spans ranging from days to seasons or years, and they frequently occur in large numbers, thus providing an attractive baseline for statistical analyses. For these reasons, and logistical accessibility, detecting change in nearshore biological communities is a key component of experimental ecological research and applied monitoring programs. But quantifying the distribution, abundance, and diversity of nearshore organisms

over large spatial scales is problematic for scientists and resource managers. Monitoring biological communities for a response to natural or anthropogenic perturbations encounters two fundamental problems. The first is the large temporal and spatial variability of organism abundances in natural ecosystems, which masks our ability to statistically separate an actual change caused by a perturbation from natural cycles. Second, extrapolating or generalizing the results of localized studies to broad areas is fraught with problems; yet biological sampling is too labor-intensive to attempt everywhere (Underwood & Petraitis 1993). One solution in the marine realm involves systematic quantification and minimization of physical gradients among sample sites.

B. Rationale/Link to Restoration

A method developed in Alaska by the principal investigator partitions complex shorelines into physically homogeneous segments. Groups of physically similar segments can then be aggregated into groups of replicates that allow more rigorous monitoring of the marine environment. This method has been successfully applied to shorelines in Kenai Fjords, Lake Clark (Schoch and Chen, 1995; Schoch, 1996), Katmai (Schoch 1994), and Glacier Bay National Parks: http://www.nps.gov/glba/learn/preserve/projects/coastal/. The database is now in use by the Olympic Coast National Marine Sanctuary (Schoch 1999) for the basis of a marine reserve network design, resource agencies in Puget Sound (Schoch and Dethier, 1998) for ecological modeling, and by the Partnership for Interdisciplinary Studies of the Coastal Ocean (PISCO: www.piscoweb.org) along the western U.S. (Schoch et al., 2000a, 2000b) for monitoring and comparing biodiversity at nested spatial scales. Monitoring across replicates increases the statistical power of ecological data by minimizing the variability of the biological community caused by physical forces. This method is proposed for implementation in Kachemak Bay as a first step in monitoring the changes in marine and estuarine physical and biological diversity. The method can be applied anywhere as the foundation for a statistically sound, scientifically defensible monitoring program.

With respect to the link to restoration effort, this project is proposed under the strategy "Ecosystem Synthesis/GEM Transition." This project is best linked to New Projects: Innovative Tools and Strategies for Improving Monitoring." ADFG encourages the Trustees to fund this project this year because it will answer key resource questions and lay the foundation for the development of an intertidal component of the GEM program. Moreover, the proposed research and monitoring effort will help leverage NOAA funds to establish and maintain a long-term oceanographic monitoring program in the Kachemak Bay/Lower Cook Inlet area.

Kachemak Bay is a NOAA National Estuarine Research Reserve (NERR). The NERR system has 26 sites throughout the United States that are dedicated to research and education of the marine/terrestrial interface of estuarine ecosystems. These reserves are a partnership between individual states and NOAA, so that each reserve is allocated approximately 70% of their funding for basic operations from the federal government. The remaining 30% of the funding must come from non-federal sources.

The NERR site in Kachemak Bay, called the Kachemak Bay Research Reserve (KBRR), is well

situated to begin studies on coastal ecosystem dynamics. Kachemak Bay is located at the interface between land and ocean waters and thus near the juncture of major oceanographic and land-based processes. The interaction of these forces is the major focus of the research being conducted by KBRR. The KBRR is developing models to understand the variability of factors driving primary productivity in the bay and specifically, the linkages and interactions of water delivered from the offshore ocean and surrounding watersheds. Watershed influences on the intertidal and other habitats in the Bay range from freshwater input, transport of nutrients, sediments and contaminants to topographic influences on winds and precipitation amounts and rates. Changes in watershed vegetation cover due to urbanization, spruce bark beetle infestation, logging and forest fires will alter transport dynamics and nutrient cycling, and thus the habitat quality and structure of biological communities in the intertidal and other habitats. Oceanographic processes, working from the other end of the ocean-bay-shore continuum, influence nutrient transport, life history dispersal mechanisms of plants, invertebrates and fishes, sediments and contaminants. The NERR system has a research mandate to develop a national time series of water chemistry from which natural variability and long-term changes can be measured over different spatial scales. As part of this system, the KBRR has a program to continuously measure seasonal oceanographic water characteristics including nutrients, phytoplankton, temperature and salinity at two stations in the Bay (Homer and Seldovia) as part of the national System Wide Monitoring Program (SWMP). These sensor arrays measure water temperature, conductance, salinity, pH, turbidity, dissolved oxygen, depth, PAR, and fluorescence on a continuous basis.

If successful, this proposal (along with proposals #02565 and #02569) will provide the KBRR with the required matching funds to receive additional support from NOAA to: (1) maintain and operate the exisiting monitoring program (e.g., pay for staff time to operate and maintain the oceanographic sensors); (2) expand the instrument array by adding two additional stations in Halibut Cove and Bear Cove; and (3) operate and maintain the more comprehensive monitoring program. Without these funds, the KBRR will mostly likely not be able to meet the required 30% non-federal match requirement and will have to decline the NERR operation funds that would be used to develop and run this monitoring program.

C. Location

This project will take place in Kachemak Bay: the north shore from Anchor Point to the Fox River, then the south shore from Fox River to Nanwalek. The project will benefit all the resource management agencies in the Bay, oil spill advisory councils, conservation agencies, and local governments (see attached letters of support). The communities include City of Homer and greater Homer area, Anchor Point, Seldovia, Port Graham, Nanweluk, and small unorganized communities on the south shore or Kachemak Bay (Halibut Cove, Jakalof Bay, Bear Cove). The benefits of this project will have broader application if these tools, technologies, and monitoring approaches are applied to other areas affected by the spill.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The KBRR is an integrated research and education program. A goal of KBRR education

program is to provide for community involvement and conduct educational programs that will interpret and instruct the public on research projects conducted in the region. While this project does not have an explicit community involvement/data gathering component in this FY02 proposal, the KBRR will interpret research results by the following means:

- The KBRR web page;
- The KBRR interactive research and education programs;
- Conferences, workshops, and presentations on our programs to the community and schools;
- Display information on research projects at KBRR facilities and/or with partner organizations such as the Pratt Museum
- The results of this project, the GIS database, may have application with developing school monitoring programs.

The Olympic Coast National Marine Sanctuary is already employing a similar database developed by Dr. Schoch as an integral component for their teacher education program. The Sanctuary educators on the West Coast wish to link Olympic Coast Washington teachers and students with teachers, communities and students in Kachemak Bay, Alaska, with hopes to also link with other west coast Sanctuaries in California using this same model and protocol. This proposed research project will play an important role in laying the foundation for future public education and citizen monitoring efforts.

PROJECT DESIGN

A. Objectives

The objective of this proposal is to augment the long-term NOAA programs in ocean physics and chemistry in Kachemak Bay by adding an ecological component to address issues identified in the GEM Science Plan and by National Academy of Sciences reviewers. We propose to use subtidal and intertidal monitoring protocols developed by PISCO in Washington, Oregon, and California in Kachemak Bay. To that end, we envision being the ecological endpoint to a series of monitoring sites that now stretch from Mexico to Canada. By establishing water column, subtidal, and intertidal monitoring programs, using standardized protocols of the NERRS and PISCO, we will be able to make meaningful comparisons of data across multiple spatial scales to address issues of change locally and globally. The first step in the monitoring program is to inventory and map the benthic habitats in Kachemak Bay. In terms of identifying characteristic habitat types, rare habitats, and habitat diversity, these data will be required in order to determine the best locations for monitoring sites and to establish an ecological context to the habitats chosen for monitoring. Monitoring marine habitats relies largely on understanding where the larval sources are in relation to the populations and communities being monitored. Other issues

include how and where larvae move at different times of the year, what habitats are used by which organisms at what periods of their life cycles, etc. The sources and movements of larvae in the Bay are not the focus of this proposal, but it is necessary for reviewers to understand that these components of the ecosystem are not being overlooked.

We propose to map the nearshore habitats in Kachemak Bay and quantify the *physical attributes* that force spatial variation in diversity of fish, invertebrate, and algal populations among the various habitat types in the Bay.

B. Methods

The approach for minimizing biological variability (thus increasing statistical power to detect change) is to adopt a highly stratified sampling design based on the physics of the nearshore environment. We will use the protocols developed by PISCO to segment complex biogeochemical shoreline gradients using a combination of qualitative and quantitative partitioning criteria. Previous studies have often failed to develop quantitative links between specific intertidal assemblages and physical attributes of habitats, thus making it impossible to "scale up" in either time or space from limited *in situ* sampling (Menge et al., 1997). The proposed shoreline partitioning model addresses the needs of coastal ecologists seeking to make comparisons among spatially independent beach sites. This model relies on quantification of physical features known to have direct and indirect ecological responses, and uses these as criteria for partitioning complex shorelines into a spatially nested series of homogeneous segments. For example, at small spatial scales the quantified geophysical parameters include sediment grain size, wave energy, substrate dynamics, and sediment chemistry. At large spatial scales water chemistry attributes such as salinity, chlorophyll and nutrient concentrations are used. These nested segments can be used to study between-segment and within-segment variability, which in turn will support studies of the biotic and abiotic processes that control variability. This segment approach allows large areas of shoreline to be classified based on relatively limited *in situ* sampling. The results of previous research by the principal investigator in Alaska (Lake Clark, Kenai Fjords, Katmai and Glacier Bay National Parks) have shown this to be a robust approach, despite the enormous complexity of these regions (Schoch & Dethier 1996). An additional use of this database has recently been developed through an Olympic Coast National Marine Sanctuary initiative to establish a marine reserve network on the outer Washington coast.

The proposed study site will include all of Kachemak Bay and the smaller fjords and inlets along the more remote south shore. Homogeneous alongshore segments (10-100 meters in length) will be delineated and the physical component of the habitat characterized by up to ten geophysical parameters within each of three intertidal zones. These partitions include three intertidal polygons nested within each alongshore segment. Alongshore segments are grouped within oceanic cells to control for variations in salinity, temperature, nutrients and wave energy. These physical data provide the foundation to support comparisons and experimental studies of epibiota and infaunal abundances.

Methods Summary

1. At no cost to the project, use the existing and expanded system of ocean sensors at Homer and Seldovia, measuring salinity, temperature, D.O., pH, PAR, fluorescence and turbidity to identify the spatial and temporal variability of ocean and estuarine water along and across the axis the Bay;

2. At no cost to the project, partner with the Cook Inlet Regional Citizens Advisory Council to obtain low altitude oblique aerial videography of the coastal zone in Kachemak Bay, at extreme low tides, for large scale (100-1,000 m) partitioning of the shoreline based on shore geomorphology, geophysical and biological characteristics of the nearshore, and characteristics of the upland watershed (Howes et al. 1994, Zacharias et al 1999);

3. Use *existing* NOAA high altitude vertical aerial photography and field measurements to map and partition the shoreline into geophysically homogeneous segments (10-100 m), quantifying the geophysical attributes known to force biological community structure in the nearshore marine system;

4. Build a GIS database of physical habitat features for intertidal and subtidal lands in Kachemak Bay and analyze the statistical distribution of characteristic habitat types.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Not applicable: all funds requested in this proposal will be used by ADFG/KBRR staff.

SCHEDULE

A Measurable Project Tasks

We intend to begin the fieldwork as soon as we are notified of a successful proposal. We anticipate 3 months of full-time field data collection, 2 months of data entry and analysis, and another 4 months of data analysis and GIS database development.

December 31, 2001:	complete fieldwork and begin data entry
February 28, 2002	complete data entry and begin GIS development
May 31, 2002	complete draft GIS database before summer field season
September 30, 2002	complete draft report
April 1, 2003	submit final report

B. Project Milestones and Endpoints

The project milestones are to complete a map the nearshore habitats in Kachemak Bay and quantify the physical attributes that force spatial variation in diversity of fish, invertebrate, and algal populations among characteristic habitat types in the Bay, will be met by the end of the funding period.

C. Completion Date

The work will be completed at the end of the funding cycle. The final report will be prepared by April 1, 2003. No funding is requested to complete this report.

PUBLICATIONS AND REPORTS

The product of this work is regarded as the foundation for further monitoring of the biological components of the ecosystem. The research and scientific value of this data is relevant to the monitoring of the biological components of the system; however, the management value will be realized immediately. As such, we do not expect to publish this data in a scientific journal until the biological data has also been collected and analyzed.

PROFESSIONAL CONFERENCES

The principal investigator is professionally obligated to present the results of Kachemak Bay research projects at the annual NERRS Research Conference (travel funded by NOAA), and the annual PISCO Conference (travel funded by PISCO). The PI seeks funding to attend the 2002 American Geophysical Union (AGU)/American Society of Limnology and Oceanography (ASLO) Conference.

NORMAL AGENCY MANAGEMENT

This project is <u>not</u> required by statute or regulation regardless of whether or not the spill had occurred. The proposed work has not been conducted by either ADFG or KBRR in the past without funds from the Trustees Council.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We are coordinating this project with ADFG Commercial and Sport Fish Division projects in Kachemak Bay focusing on clam bed research, with the Cook Inlet RCAC to map beaches for oil spill response planning, with The Nature Conservancy to map important conservation areas, and with the City of Homer to map high use beaches for potential land use zoning (see attached letters of support).

The work proposed here will support the biological component of the study described in the accompanying Proposal (#02565): Bottom-up or Top Down: What Forces the Variability of Subtidal and Intertidal Fishes, Invertebrates and Algal Communities in Kachemak Bay?

Furthermore, we are building on the NOAA System Wide Monitoring Program by using the oceanographic time series data being collected in the Bay to identify and monitor the variability

of major estuarine spatial and temporal divisions. The data collected will become a part of the PISCO database archived at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, CA.

We are partnering with the Cook Inlet Regional Citizens Advisory Council to map the shores of Kachemak Bay and parts of western Cook Inlet using an innovative technique of aerial mapping developed in British Columbia and Washington.

In summary, the KBRR has put forth a substantial effort to obtain funds from non-Council sources. KBRR proposals for EVOS Trustee funds will make it possible to secure additional NOAA funds to maintain and expand the Reserve system-wide monitoring program, which will be great benefit to the GEM program.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Dr. Schoch is the Science Coordinator for the Kachemak Bay Research Reserve in Homer, Alaska (a NOAA National Estuarine Research Reserve). He has a dual Ph.D. in Biological Oceanography and Geological Oceanography from the College of Oceanic and Atmospheric Sciences at Oregon State University (1999) and continues to work with his post-doc advisors (Lubchenco and Menge) as a Senior Fellow for the Partnership for Interdisciplinary Studies of the Coastal Ocean (PISCO) studying marine ecosystem dynamics. His research interests are in the physical and biological linkages between marine nearshore and continental shelf ecosystems, specifically how physical processes such as currents, wave energy, sediment dynamics, and nutrient fluxes structure intertidal and subtidal communities. His current research projects include studying larval distributions and forces affecting recruitment, monitoring the variability of primary productivity as a function of ocean climate, and investigating kelp bed community dynamics. He serves as the science advisor for the Olympic Coast National Marine Sanctuary Advisory Council, and is the chair of their Research Advisory Committee. He also serves as the technical advisor to the Sanctuary Marine Conservation Working Group, consulting on the design and development of a marine reserve network on the outer coast of Washington. He also consults to the Washington Department of Natural Resources on intertidal habitat modeling in Puget Sound and Georgia Straits.

OTHER KEY PERSONNEL

The grant, if funded, will provide support for a Research Analyst, and a Research Assistant to assist with data entry and analysis. The NERRS Graduate Research Fellowship Program will provide 2 graduate students to assist Dr. Schoch with the fieldwork at no cost to the project.

LITERATURE CITED

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FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$43.0						
Travel		$2.0						
Contractual		$6.0						
Commodities		$4.3						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$55.3	Estimated					
General Administration		$6.9	FY 2003					
Project Total	$0.0	$62.2	$20.0					
Full-time Equivalents (FTE)		0.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: The KBRR went through a substantial effort to obtain funds and establish partnerships with other organizations to support the proposed research and monitoring effort. These efforts include:

NOAA/KBRR Support: The proposed EVOS projects (including proposals #02565 and #02569) will meet the required non-federal match for approximately $274K in NOAA operations funds. Federal funds will be used to operate and expand the Reserve monitoring program. These NOAA funds will support, in part, two research staff, the purchase of ocean sensors and a CTD, Reserve research and support facilities and equipment. Without this match, the KBRR will need to decline all or part of these funds, and likely will not be able to implement and maintain the long-term monitoring program.

Cook Inlet RCAC - The Cook Inlet RCAC will provide $30,000 for an aerial video survey of the bay to map geomorphogical processes

NERRS Graduate Research Fellows - KBRR is funding 2 graduate students ($34,000) who will assist with

FY02

Prepared: 4/12/01

Project Number: 02556
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FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		
Name	Position Description	Step	Budgeted	Costs	Overtime	
Steve Baird	GIS Specialist (Research Analyst II)	18A	3.0	4.0		
(Hire in Progress)	Research Assistant (FB-I)	14A	4.0	4.0		
Dr. G. Carl Schoch	PI	18A	3.0	5.0		
	Subtotal		10.0	13.0	0.0	
					Personnel Total	

Travel Costs:	Ticket	Round	Total	Daily	
Description	Price	Trips	Days	Per Diem	
Dr. G. Carl Schoch to attend GEM program development and planning worl	0.2	2	8	0.2	
				Travel Total	

FY02

Prepared: 4/12/01

Project Number: 02556
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Agency: ADFG

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:			
Description			
Fuel for Skiff			
When a non-trustee organization is used, the form 4A is required.		**Contractual Total**	
Commodities Costs:			
Description			
Misc Supplies and Operating Expenses for Boat			
Software upgrades	1	2.0	
Surveyors rod	1	0.3	
Surveyors level	1	0.4	
Surveyors tape	1	0.1	
		Commodities Total	

FY02

Prepared: 4/12/01

Project Number: 02556
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Agency: ADFG

FY 02 *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		
Research Skiff	1	
KBRR headquarters and research facilities	2	
KBRR Computers	3	

FY02

Prepared: 4/12/01

Project Number: 02556
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