Oceanographic monitoring in Cook Inlet – Doroff (ADFG KBRR) and Holderied (NOAA KBL, 15120114-G)

FY15 PROJECT PROPOSAL SUMMARY PAGE
Continuing, Multi-Year Projects

Project Title: Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species

Project Period: February 1, 2015 – January 31, 2016

Primary Investigator(s): Angela Doroff (Research Coordinator, Kachemak Bay National Estuarine Research Reserve), Kris Holderied (Director, NOAA Kasitsna Bay Laboratory)

Study Location: Kachemak Bay and Lower Cook Inlet, Alaska

Project Website: See project information on www.gulfwatchalaska.org

Abstract: This project is designed to assist in the evaluation of recovery and restoration of injured resources in the foot print of the *Exxon Valdez* oil spill (EVOS), by characterizing oceanic conditions in Cook Inlet and determining, in coordination with oceanographic monitoring at other sites under the Gulf Watch Alaska program, connections between marine conditions and plankton communities in near-shore and Gulf of Alaska waters. Mapping currents and water mass movements contributes to our understanding of patterns in the abundance and diversity of marine plankton, invertebrates, fish, birds, and mammals in coastal south-central Alaska. In this study, we are mapping the waters in lower Cook Inlet and Kachemak Bay to understand seasonal patterns, effects of freshwater runoff, intrusions of the Alaska Coastal Current, and complex frontal structures, and then relate these observations to distributions of injured resources. Characterizing seasonal patterns in physical oceanography will also help us understand the connectivity of water movement and potential plankton transport pathways between Kachemak Bay, lower Cook Inlet and the adjacent Gulf of Alaska shelf. By determining the local species of phytoplankton and zooplankton and understanding their seasonal distribution we will begin to understand lower trophic patterns that support upper trophic level marine species. This continuing project proposal does not change significantly from our original proposal for year 4. Information from this project is also being used to inform local mariculture operations, understand depletions of hard shell clams and other invertebrate species, develop NOAA Cook Inlet ocean circulation model applications, and support monitoring and research programs for harmful algal blooms and ocean acidification.

Estimated Budget:

EVOSTC Funding Requested* (*must include 9% GA)*:

FY12	FY13	FY14	FY15	FY16	TOTAL
$191.9K	$177.4K	$166.5K	$133.7K	$117.7K	$787.2K

Non-EVOSTC Funds to be used:

FY12	FY13	FY14	FY15	FY16	TOTAL
$257K	$155K	$155K	$155K	$155K	$944.0

**this reflects the combined budget summaries for the Kachemak Bay Research Reserve and NOAA Kasitsna Bay Laboratory which are trustee agencies. See individual budgets submitted separately for this project.*

Date: September 2, 2014

I. EXECUTIVE SUMMARY

This project is designed to assist in the evaluation of recovery and restoration of injured resources in the foot print of the *Exxon Valdez* oil spill (EVOS), by characterizing oceanic conditions in Cook Inlet and determining, in coordination with oceanographic monitoring at other sites under the Gulf Watch Alaska program, connections between marine conditions and plankton communities in near-shore and Gulf of Alaska waters. It is important to know if oceanic conditions and changes in the Gulf of Alaska are synchronous with near-shore trends, and monitoring at multiple sites (in coordination with other Gulf Watch Alaska monitoring projects) will help discern such relationships. We are particularly interested in how near-shore conditions reflect the significant inter-annual variability in the North Pacific Ocean which is driven partially by variations in major climate patterns such as ENSO and the Pacific Decadal Oscillation. In addition we are investigating linkages between marine conditions in Cook Inlet/Kachemak Bay and Prince William Sound. Both are large estuaries that are connected by the Alaska Coastal Current, influenced by freshwater input (precipitation and snowpack and glacier melt), and experience upwelling of waters from the adjacent shelf. Cook Inlet has stronger tidal currents and associated complex oceanographic fronts that are linked to bathymetry and freshwater runoff. In this study, we also leverage use of data from past oceanographic monitoring in Cook Inlet (Okkenon et al. 2009) and Kachemak Bay (Murphy and Iken 2013) to extend the time series used for analysis. Mapping currents and water mass movements of a region is essential for understanding patterns in the abundance and diversity of marine plankton, invertebrates, fish, birds, and mammals in coastal Alaska. By characterizing phytoplankton and zooplankton communities and understanding their seasonal distribution, we will quantify seasonal patterns lower trophic species that support upper trophic level marine organisms. In coordination with the Seward Line (PI: Hopcroft) and Continuous Plankton Recorder (PI: Batten) projects we will assess estuary-shelf linkages and potential plankton transport pathways between Kachemak Bay, lower Cook Inlet and the adjacent Gulf of Alaska shelf. The project combines intensive oceanographic monitoring in Kachemak Bay, with seasonal, quarterly monitoring in lower Cook Inlet. Kachemak Bay monitoring includes: 1) continuous data from existing Kachemak Bay Research Reserve (KBRR) water quality monitoring stations (YSI sondes measuring temperature, salinity, dissolved oxygen, turbidity, pH) at the Homer and Seldovia harbors; 2) an additional shoreline water quality station to be deployed and maintained during ice-free months in Bear

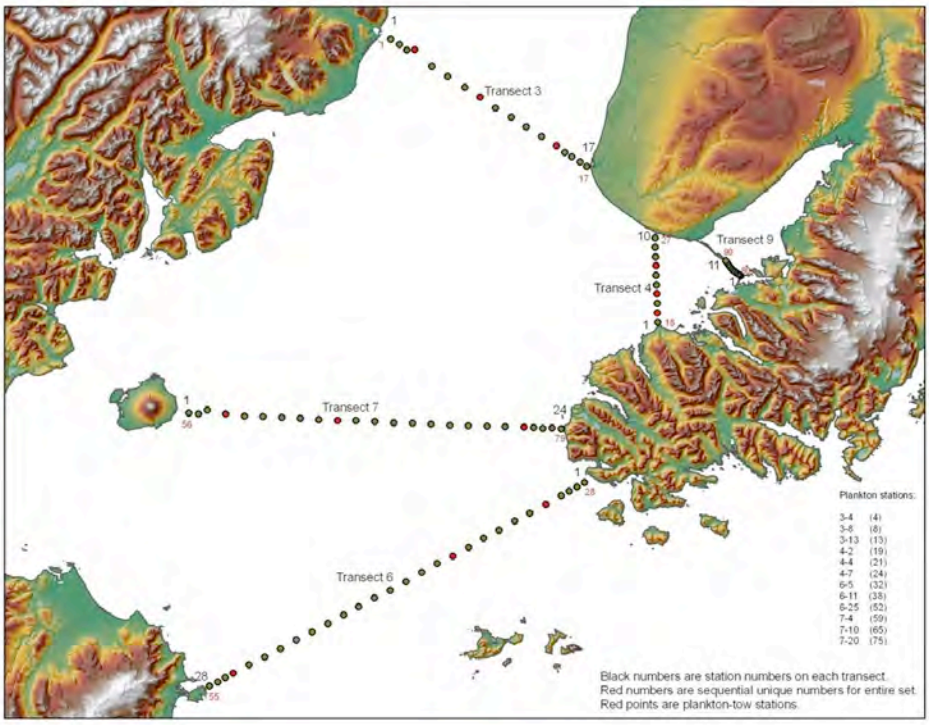

Figure 1. Cook Inlet sampling Transects

Cove (near head of Kachemak Bay); and 3) monthly small-boat conductivity-temperature-depth (CTD) profiler and plankton sampling conducted on a mid-bay transect (at Homer Spit). The seasonal surveys include CTD and plankton sampling along the five transects shown in Figure 1. Note that the Continuous Plankton Recorder (PI: Batten) vessel track intersects three of our Cook Inlet transects.
Highlights from field work to date include the quantification of rapid changes in oceanographic conditions and plankton across persistent, tidal current and bathymetry-linked fronts and convergence zones in lower Cook Inlet, with implications for the development of biological hotspots.

We have also identified consistently strong stratification for more of the year than originally anticipated, except in tidal rip areas, which indicates the importance of buoyancy flux in this region. Information from this project is also being used to inform local mariculture operations, understand local depletions of hard shell clam and other invertebrate species, develop NOAA Cook Inlet ocean circulation model applications, and support monitoring and research programs for harmful algal blooms and ocean acidification.

II. COORDINATION AND COLLABORATION

A. Within a EVOTC-Funded Program

The lower Cook Inlet oceanographic and plankton monitoring project was designed to complement concurrent monitoring conducted in other projects of the Environmental Drivers component of the EVOSTC-funded Gulf Watch Alaska program. These projects include "The Seward Line: marine ecosystem monitoring in the northern Gulf of Alaska" (PI: Hopcroft), "Long-term Monitoring of Oceanographic Conditions in the Alaska Coastal Current from Hydrographic Station GAK 1" (PI: Weingartner), "Long-term monitoring of oceanographic conditions in Prince William Sound" (PI: Campbell), and "Long-term Monitoring of zooplankton populations on the Alaskan Shelf and Gulf of Alaska using Continuous Plankton Recorders" (PI: Batten). Collectively, the Gulf Watch Alaska oceanographic sampling provides comparisons between conditions within two large estuaries, Cook Inlet (PIs: Doroff and Holderied) and Prince William Sound (PI: Campbell) and between the estuaries and the adjacent shelf (PIs: Weingartner, Hopcroft and Batten). Campbell is also providing identification for the Cook Inlet zooplankton samples, which enhances data consistency across the integrated program. The Environmental Drivers component group has also met in person and by phone to improve coordination of zooplankton sampling methods, to enhance cross-program data analysis and assess the need for future modifications in sampling design.
To support other Gulf Watch Alaska biological monitoring efforts, this project is providing oceanographic time series for the Kachemak Bay benthic component project "Long-term monitoring of Ecological Communities in Kachemak Bay: a comparison and control for Prince William Sound" (PIs: Konar and Iken) and berths on our lower Cook Inlet cruises for U.S. Fish and Wildlife Service seabird and marine mammal observers who are part of the pelagic monitoring component (PI: Kuletz).

B. With Other EVOSTC-funded Projects

This study does not leverage other EVOSTC funded projects outside of Gulf Watch Alaska, although oceanographic data sampling and analysis is being coordinated with the EVOSTC-funded Herring Research and Monitoring Program (PI: Pegau).

C. With Trustee or Management Agencies

The Kachemak Bay Research Reserve (KBRR) provides resources for continuous monitoring of water quality and meteorological data and this proposed project leverages and supplements the System-wide Monitoring Program (SWMP) of NOAA's National Estuarine Research Reserve system at KBRR and use of a CTD and plankton nets. NOAA Kasitsna Bay Laboratory (KBL) is providing in-kind contributions of staff time and use of a CTD. The combined in-kind contributions from KBRR and KBL are $155K/year. Thus

far, this research and monitoring program have provided the following linkages to related projects in the study area:

a. KBRR and KBL are using oceanographic data from this project to help validate a Cook Inlet ocean circulation model developed by NOAA's National Ocean Service, which has been used for a tidal energy assessment of the Inlet and will be part of a NOAA operational Cook Inlet marine forecast system. KBRR and the University of Alaska Fairbanks (UAF) are using time series of oceanographic data (temperature and salinity) from long-term monitoring studies (inclusive of but not limited to this project) and drifter buoy data in an external model validation effort. KBL is providing CTD data to the model developer (NOS Coast Survey Development Laboratory) for development and validation efforts.
b. This study improved the time series and geographic scope of ongoing phytoplankton monitoring for harmful algal species conducted by KBRR and KBL. The phytoplankton species that causes paralytic shellfish poisoning, *Alexandrium fundyense,* were found at all Kachemak Bay sampling locations throughout the summer, although at relatively low concentrations. *A. fundyense* concentrations were found to be significantly correlated with both water temperature and salinity conditions.
c. The NOAA KBL has a joint project with the Alaska Ocean Observing System (AOOS) and UAF to quantify variability in water chemistry associated with ocean acidification in Kachemak Bay and lower Cook Inlet. The project leverages ship time from this project to periodically collect water samples at CTD stations for carbonate chemistry analysis. Coastal water chemistry changes with freshwater input from glacial watersheds and snowmelt, upwelling of ocean waters and phytoplankton blooms and understanding this variability is needed to assess how much ocean acidification may threaten nearshore species and habitats. FY14 funding ($25K) was provided to KBL by NOAA's Integrated Ocean Observing System (IOOS).
d. Through a partnership with the U.S. Fish and Wildlife Service, we are enhancing the Gulf Watch Alaska program to provide a platform for marine bird and mammal surveys that will improve understanding of relationships between marine conditions, primary productivity, and seabirds and marine mammals. We will continue to provide ship berths to USFWS observers and in year 4 USFWS will also be able to leverage funding from a separate Cook Inlet project with the Bureau of Ocean Energy Management (BOEM) to support the seabird and marine mammal observing effort.
e. NOAA KBL and BOEM have also initiated a collaboration to update information on marine conditions and ecological linkages in Cook Inlet, to support BOEM's environmental analysis for potential oil and gas lease sales in the region. BOEM is providing an initial $75K to conduct seasonal Cook Inlet surveys and oceanographic data analysis to support their environmental analysis needs for potential oil and gas lease sales in the region. The BOEM funding will allow us to maintain quarterly Cook Inlet cruises, for which there was not sufficient funding available under our original EVOSTC proposal.

III. PROJECT DESIGN – PLAN FOR FY15

A. Objectives for FY15 (year 4)

There are no significant changes from the original proposal to this project. Due to cost savings by KBRR we are able to obtain charter vessel support for three seasonal Cook Inlet surveys, rather than the two in our original proposal. As mentioned in Section II, we also plan to collaborate with BOEM to conduct a fourth survey during year 4 and maintain the quarterly frequency for the seasonal surveys without additional EVOSTC funds. Also, based on results of phytoplankton sampling from this project to date, we propose to conduct a limited amount of additional nutrient sampling, at no additional cost, to evaluate the benefits of additional nutrient information (objective 4b).

The objectives for year 4 include:

1. Improve understanding of marine conditions and water mass movement in Kachemak Bay
    a. Conduct monthly CTD sampling surveys along a mid-Kachemak bay transect and continuous sampling at KBRR water quality stations.
    b. Install a seasonal YSI data sonde in Bear Cove during the ice-free period to monitor trends in salinity, temperature, and nutrients at the head of the Bay in proximity to oyster farms and native clam beds.
    c. Analyze water mass characteristics, spatial, seasonal and annual changes in the depth and persistence of freshwater lens and stratification in Kachemak Bay.
2. Determine linkages, and temporal variability in those links, between Kachemak Bay/lower Cook Inlet and the adjacent Gulf of Alaska shelf.
    a. Conduct three oceanographic surveys in lower Cook Inlet and coordinate with BOEM for support of additional fourth survey.
    b. Analyze CTD data for spatial, seasonal and annual variability and trends, as well as linkages to oceanographic data from the GAK1 mooring and Seward line.
3. Examine the short-term variability and track long-term trends in oceanographic and water quality parameters
4. Improve understanding of temporal and spatial variability in plankton communities and linkages to marine conditions.
    a. Sample at a subset of stations along each CTD transect for marine plankton. Zooplankton samples will continue to be analyzed by PI Campbell as part of the PWS oceanographic monitoring project. Phytoplankton will continue to be analyzed by KBL staff.
    b. Compare zooplankton between Kachemak Bay and lower Cook Inlet and with CPR sampling results for temporal patterns in species composition.
    c. Evaluate the feasibility on collecting nutrient data on a subset of plankton monitoring stations at depth and surface waters in lower Cook Inlet and outer Kachemak Bay.

B. Changes to Project Design

No changes to project personnel or overall project cost from our original proposal. As described in Section II, we are leveraging cost savings and collaboration with BOEM to maintain a quarterly frequency of Cook Inlet sampling without additional EVOSTC funding. Within the proposed project budget, we will collect a limited number of additional water samples at selected CTD stations for nutrient analyses, to evaluate the benefit of obtaining nutrient data at higher temporal and spatial resolution for understanding seasonal variability in plankton abundance and community composition.

IV. SCHEDULE

A. Project Milestones for FY 15

1. Objective 1-3.

a. Quarterly CTD/marine plankton surveys will be conducted in Cook Inlet (Figure 1. One survey will be conducted with BOEM support.

b. Monthly CTD/marine plankton surveys will be conducted in Kachemak Bay.

c. Continuous water quality station monitoring data will be collected at 5 stations during ice-free months and 3 stations during winter months. Kachemak Bay sub-bay temperatures will be monitored year-round with Hobo tidbit sensors deployed by KBRR.

d. Quality-controlled and processed CTD data will provided to the Gulf Watch Alaska Ocean Workspace no later than one year after data collection. Water quality station

monitoring data is available through the NERR Centralized Data Management Office (http://cdmo.baruch.sc.edu/)

2. Objective 3.

a. Using data collected in Objective 1, we will calculate temperature and salinity patterns and anomalies (for continuous data) in lower Cook Inlet and Kachemak Bay.

3. Objective 4. For samples collected during our field cruises, phytoplankton samples will be analyzed within three months by KBL and zooplankton samples preserved and shipped quarterly to the Prince William Sound Science Center for analysis. The species composition, timing, and where applicable, relative abundance of marine plankton will be determined for the study area. When complete, these trends will be related to other Gulf Watch Alaska studies.

B. Measurable Project Tasks for FY 15

All year:	*Monthly CTD/plankton survey in Kachemak Bay*
	Continuous water temperature monitoring in Kachemak Bay sub-bays
FY 15, 1st quarter (February 1, 2015 - April 31, 2015)	
February:	*Project funding available*
	1st Quarterly CTD/plankton survey in lower Cook Inlet
	Continuous water quality monitoring at 3 stations
March:	*Continuous water quality monitoring at 3 stations*
April:	*2nd Quarterly CTD/plankton survey in Cook Inlet*
	Continuous water quality monitoring at 5 stations
FY 15, 2nd quarter (May 1, 2015-July 30, 2015)	
May :	*Continuous water quality monitoring at 5 stations*
June :	*Continuous water quality monitoring at 5 stations*
July:	*3rd Quarterly CTD/plankton survey in lower Cook Inlet*
	Continuous water quality monitoring at 5 stations
FY 15, 3rd quarter (August 1, 2015 – October 31, 2015)	
August:	*Continuous water quality monitoring at 5 stations*
	Work plan input to science coordinator
September:	*Continuous water quality monitoring at 5 stations*
October:	*4rd Quarterly CTD/plankton survey in lower Cook Inlet*
	Continuous water quality monitoring 5 stations
FY 15, 4th quarter (November 1, 2015- January 31, 2016)	
November:	*Continuous water quality monitoring 3 stations*
	Attend annual PI meeting
December:	*Continuous water quality monitoring 3 stations*
January:	*Annual report input to science coordinator*
	Present at Alaska Marine Science Symposium
	Continuous water quality monitoring 3 stations

V. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes to original personnel.

VI. BUDGET

A. Budget Forms (Attached)

There are no proposed changes from the original proposal (please see attached budget sheets for the Kachemak Bay Research Reserve and the NOAA Kasitsna Bay Laboratory).

B. Changes from Original Proposal

No changes from the original proposal other than we are leveraging cost savings and collaboration with BOEM to maintain a quarterly frequency of Cook Inlet sampling without additional EVOSTC funding and we will conduct a pilot expansion of nutrient sampling at no additional cost.

C. Sources of Additional Funding

During year one of this study, we supported work being conducted for this EVOSTC project with an additional $102K of funding for new water quality monitoring equipment which enabled the purchase of equipment for continuous monitoring of Chlorophyll a at each of the water quality monitoring sites in Kachemak Bay. The chlorophyll data will be available to this project through year five. Annual in-kind contributions to this project total $155K from the following sources: $120K Kachemak Bay Research Reserve's System-wide Monitoring Program for water quality and weather; $10K CTD (2 CTDs are utilized on the project (one each from KBRR and the NOAA KBL); $25K in in-kind salary for KBL staff. To date, the combined in kind contributions from KBRR and KBL to date for this project have been $567K. In year 4 KBL plans to leverage a portion of $75K from BOEM funding for another Cook Inlet collaboration project to maintain quarterly Cook Inlet sampling (see descriptions in Section II.C above).

VII. Highlights of Work to Date

- The Kachemak Bay Research Reserve and NOAA Kasitsna Bay Laboratory are using oceanographic data from this Gulf Watch Alaska project to help validate a Cook Inlet ocean circulation model developed by NOAA's National Ocean Service, which has been used for a tidal energy assessment of the Inlet and will be part of a NOAA operational Cook Inlet marine forecast system. KBRR and the University of Alaska Fairbanks (UAF) are using time series of oceanographic data (temperature and salinity) from long-term monitoring studies (inclusive of but not limited to this project) and drifter buoy data in an external model validation effort. KBL is providing CTD data to the model developer (NOS Coast Survey Development Laboratory) for development and validation efforts.
- This Gulf Watch Alaska study improved the time series and geographic scope of ongoing monitoring of phytoplankton for harmful algal species conducted by the NOAA Kasitsna Bay Laboratory and Kachemak Bay Research Reserve. The phytoplankton species that causes paralytic shellfish poisoning, *Alexandrium fundyense,* were found at all Kachemak Bay sampling locations throughout the summer, although at relatively low concentrations. *A. fundyense* concentrations were found to be significantly correlated with both water temperature and salinity conditions. Phytoplankton sampling throughout the year allowed us to quickly identify and disseminate information on two water discoloration events that occurred in Kachemak Bay during 2013: a red water event caused by the ciliate *Mesodinium rubrum* that occurred in June and a brown water event caused by the dinoflagellate *Karenia mikimotoi* that occurred in September, the first described bloom of *K. mikimotoi* in Alaskan waters.
- The project leveraged partnerships with the Alaska Ocean Observing System and University of Alaska Fairbanks to collect water samples to quantify variability in water chemistry associated with ocean acidification.
- Through a partnership with the U.S. Fish and Wildlife Service, we are enhancing the Gulf Watch Alaska program to provide marine bird and mammal surveys that will improve understanding of relationships between marine conditions, primary productivity, and seabirds and marine mammals.