

FY16 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, 2016 – January 31, 2017

Primary Investigator(s): Angela Doroff (University of Alaska Anchorage, Kachemak Bay National Estuarine Research Reserve) and Kris Holderied (NOAA Kasitsna Bay Laboratory)

Study Location: Kachemak Bay, lower Cook Inlet

Project Website: <http://www.gulfwatchalaska.org/>

Abstract*: This project is a component of the integrated Long-term Monitoring of Marine Conditions and Injured Resources and Services. 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). 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 will help discern such relationships. Mapping currents and water mass movements of a region contributes to our understanding of patterns in the abundance and diversity of marine plankton, invertebrates, fish, birds, and mammals in coastal Alaska. We are mapping the waters in lower Cook Inlet and Kachemak Bay to understand the intrusions of the Alaska Coastal Current and to identify spatial and temporal changes in this region and relate these observations to injured resources. Developing an understanding of the structure of the physical oceanography will help us understand the connectivity of water movement and potential plankton transport between lower Cook Inlet and Kachemak Bay. By determining the local species of phytoplankton and zooplankton and understanding their seasonal distribution we will begin to understand the biological patterns associated with upper trophic levels of the nearshore marine system. Information from this project will also be useful to local mariculture operations, subsistence harvesters of hard shell clams and other invertebrates, NOAA Regional Ocean Circulation Model applications, and monitoring programs for harmful algal blooms.

Estimated Budget:

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

FY12	FY13	FY14	FY15	FY16	TOTAL
\$191.9	\$177.4	\$166.5	\$133.7	\$108.8	\$778.2

Non-EVOSTC Funds to be used:

FY12	FY13	FY14	FY15	FY16	TOTAL
\$282.0	\$180.0	\$180.0	\$255.0	\$255.0	\$1,152.0

* *Funds expressed in \$1000 increments*

Date: September 1, 2015

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 are assessing 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 that is deployed and maintained during ice-free months in Bear 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 (from 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.

Figure 1: Cook Inlet seasonal sampling transects and water quality monitoring stations

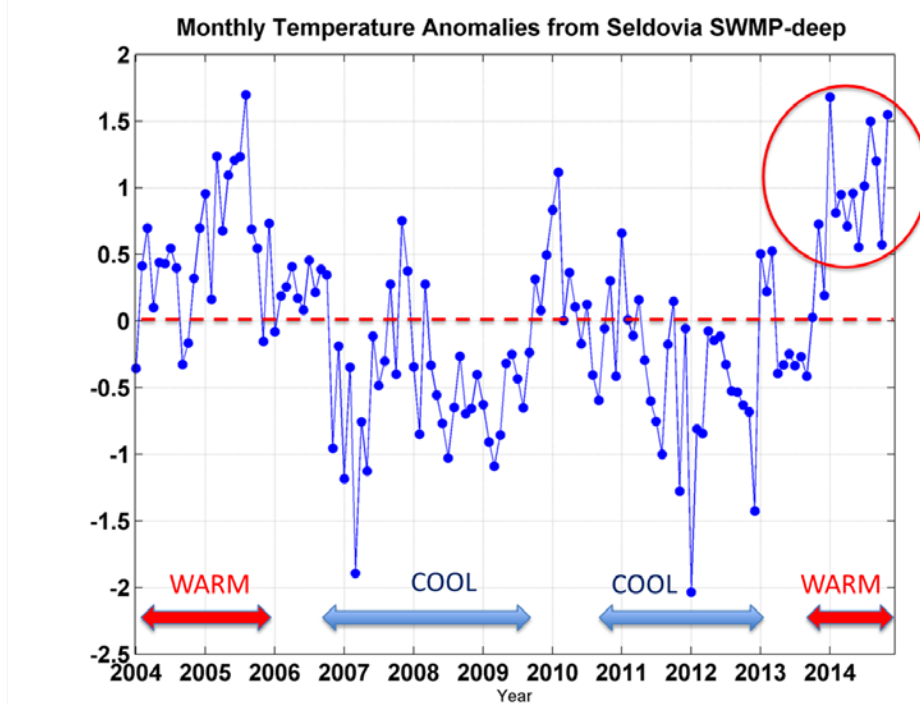


Information from this project is also being used to inform local mariculture operations, understand local depletions of hard shell clam and other invertebrate species, develop NOAA Cook Inlet ocean circulation model applications, and support monitoring and research programs for harmful algal blooms and ocean acidification.

In the first four project years, we have observed both anomalously cold and anomalous water temperature conditions, with a transition from colder to warmer conditions observed in late fall 2013. Warmer water temperatures, approximately 1-2 degrees Celsius above 2004-2014 monthly average temperatures,

persisted through 2014 and to present in 2015, consistent with anomalously warm northeast Pacific Ocean temperatures. Figure 2 shows a time series of water temperature anomalies at the Seldovia water quality monitoring station, indicating periods of warm and cool temperatures. In the past 12 months Cook Inlet monitoring results were presented in an article in the program science synthesis report, in a talk at the Alaska Marine Science Symposium (January 2015) and in a talk at the Pacific Anomalies Workshop at Scripps (May 2015).

Figure 2. 2004-2014 monthly water temperature anomalies (degrees C) calculated from observations at the near-bottom sonde and the KBRR SWMP station at Seldovia harbor. Anomalies are relative to average monthly temperatures calculated from 2004-2014 record. 2014 temperatures are noted with red circle, with every month warmer than average.



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).

In the past 12 months we worked with other PIs in the Environmental Drivers component (Batten, Campbell, Hopcroft, Weingartner) to write and revise the introduction for the Environmental Drivers section of the science synthesis report (Chapter 2) and Holderied co-authored (with Weingartner) an article entitled “Linking Variability in Oceanographic Patterns Between Nearshore and Shelf Waters Across the Gulf of Alaska”.

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

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 KBL is providing in-kind contributions of staff time and use of a CTD. The combined in-kind contributions from KBRR and KBL are expected to be \$155K for project year 5, with additional funds leveraged from other organizations (see below). 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. The model is projected to be operational by 2017 and development will have benefited from the data generated in this EVOSTC project.
- b. This study is improving the time series and geographic scope of ongoing monitoring of phytoplankton for harmful algal species conducted by KBRR and KBL, in support of NOAA mission goals to detect and improve response to harmful algal blooms. The phytoplankton species that causes paralytic shellfish poisoning, *Alexandrium fundyense*, has been found at times at all Kachemak Bay sampling locations throughout the summer, although at relatively low concentrations to date. *A. fundyense* concentrations were found to be significantly correlated with both water temperature and salinity conditions and these relationships are being used to develop a new web-based PSP risk assessment tool. In project year 4, Kachemak Bay experienced bloom conditions for *Pseudo-nitzschia*, the phytoplankton species can produce domoic acid toxins (see project highlights), although toxin levels have been low to date.
- c. 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. FY15 funding (\$25K) was provided to KBL by NOAA's Integrated Ocean Observing System (IOOS) and \$25K is also in the AOOS FY16 plan (subject to availability of funding).

- d. We continue to collaborate with the U.S. Fish and Wildlife Service to provide ship berths for USFWS observers to conduct marine bird and mammal surveys that will improve understanding of relationships between marine conditions, primary productivity, and seabirds and marine mammals. For project years 4 and 5, USFWS received funding from the Bureau of Ocean Energy Management (BOEM) to support the seabird and marine mammal observing effort.
- e. NOAA KBL and BOEM also initiated a two-year collaboration in 2014 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 has provided \$150K 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 is allowing 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 FY16

A. Objectives for FY16

There are no significant changes from the original proposal to this project, except that we are leveraging additional funding to maintain quarterly seasonal oceanographic surveys in lower Cook Inlet. The objectives for project year 5 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 at Seldovia and Homer harbors.
 - 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 and spatial, seasonal and annual changes in the strength, depth and persistence of stratified conditions in Kachemak Bay/Cook Inlet.
2. Continue to assess linkages between Kachemak Bay/lower Cook Inlet and waters of the adjacent Gulf of Alaska shelf and Alaska Coastal Current
 - a. Leveraging funding from BOEM, conduct four seasonal oceanographic surveys in lower Cook Inlet (see Figure 1 for sampling locations).
 - b. Analyze CTD data for spatial, seasonal and annual variability and trends, as well as linkages to oceanographic conditions measured by other Gulf Watch Alaska investigators in Prince William Sound, at the GAK1 mooring and along Seward Line.
3. Examine the short-term variability and track long-term trends in oceanographic and water quality parameters from water quality station observations. Assess persistence of warm water conditions associated with the Pacific Ocean warm anomaly and linkages to conditions in Prince William Sound and the northern Gulf of Alaska shelf.
4. Improve understanding of temporal and spatial variability in plankton communities and linkages to marine conditions.
 - a. Sample zooplankton and phytoplankton at a subset of stations along each oceanographic transect (see Figure 1 for locations). Zooplankton samples will continue to be analyzed by Rob Campbell as part of the Prince William Sound oceanographic monitoring project. Phytoplankton will continue to be analyzed by KBL staff.

- b. Continue comparison of temporal and spatial patterns in zooplankton distributions between lower Cook Inlet observations and continuous plankton recorder observations (Batten project).
- c. Use results of summer 2015 nutrient field sampling project (separate NOAA funded KBL project) to guide 2016 nutrient sampling at a subset of plankton monitoring stations in lower Cook Inlet and Kachemak Bay.

B. Changes to Project Design

No changes to original project personnel or proposed year 5 project budget. We are leveraging funding from other sources (BOEM and NOAA) to complete four seasonal surveys in year 5 and to conduct sampling and analysis for nutrients to better understand temporal variability in marine nutrient supply and the effect on primary production in Cook Inlet and Kachemak Bay. This will also parallel similar efforts in Prince William Sound (Campbell project).

IV. SCHEDULE

A. Project Milestones for FY 16 (project year 5)

1. Objective 1-3.

- a. Quarterly CTD/marine plankton surveys will be conducted in lower Cook Inlet (see Figure 1), leveraging BOEM funding.
- b. Monthly CTD/marine plankton surveys will be conducted in Kachemak Bay.
- c. Continuous water quality station monitoring data will be collected at 5 KBRR 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 by KBL and zooplankton samples preserved and shipped 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 also be related to other Gulf Watch Alaska studies, including the Prince William Sound (Campbell) and Gulf of Alaska shelf oceanographic projects (Hopcroft, Weingartner, Batten), the Kachemak Bay nearshore monitoring project (Konar and Iken) and the pelagic seabird monitoring project (Kuletz).

B. Measurable Project Tasks for FY 16

All year: *Monthly CTD/plankton survey in Kachemak Bay*
Continuous water temperature monitoring in Kachemak Bay sub-bays

FY 16, 1st quarter (February 1, 2016 - April 31, 2016)

February: *Project funding available*
1st Quarterly CTD/plankton survey in lower Cook Inlet

Continuous water quality monitoring at 3 SWMP stations (2 at Seldovia, 1 at Homer)

March: Continuous water quality monitoring at 3 SWMP stations

April: 2nd Quarterly CTD/plankton survey in Cook Inlet

Continuous water quality monitoring at 5 SWMP stations (2 at Seldovia, 2 at Homer, 1 at Bear Cove)

FY 16, 2nd quarter (May 1, 2016-July 30, 2016)

May : Continuous water quality monitoring at 5 SWMP stations

June : Continuous water quality monitoring at 5 SWMP stations

July: 3rd Quarterly CTD/plankton survey in lower Cook Inlet

Continuous water quality monitoring at 5 SWMP stations

FY 16, 3rd quarter (August 1, 2016 – October 31, 2016)

August: Continuous water quality monitoring at 5 SWMP stations

September: Continuous water quality monitoring at 5 SWMP stations

October: 4th Quarterly CTD/plankton survey in lower Cook Inlet

Continuous water quality monitoring 5 SWMP stations

Draft 5-year report/special issue input to science coordinator

FY 16, 4th quarter (November 1, 2016- January 31, 2017)

November: Continuous water quality monitoring 3 SWMP stations

Attend annual PI meeting

December: Continuous water quality monitoring 3 SWMP stations

January: Annual and 5-year report input to science coordinator

Present at Alaska Marine Science Symposium

Continuous water quality monitoring 3 SWMP stations

V. PROJECT PERSONNEL – CHANGES AND UPDATES

There are no changes to the project personnel. On 1 July 2015, the Kachemak Bay Research Reserve transitioned from the Alaska Department of Fish and Game to the University of Alaska Anchorage (UAA) and Doroff is now a UAA employee.

VI. BUDGET

A. Budget Forms (Attached)

There is no change from our original proposal for the amount of funding requested for project year 5, though there are minor (<10%) changes in allocation of funds between budget categories. Please see budget workbook provided for the Kachemak Bay Research Reserve and the NOAA Kasitsna Bay Laboratory. The transition of KBRR from ADFG to UAA may affect the KBRR overhead amount for the project (still to be determined in the transition process), but it will not increase the total funding for KBRR or the project.

B. Changes from Original Proposal

The only changes from the original proposal are that 1) we are leveraging KBRR project cost savings and a KBL collaboration with BOEM to maintain a quarterly frequency of Cook Inlet sampling without additional EVOSTC funding and 2) we will conduct nutrient sampling at no additional cost. Pending a decision on the amount of UAA project overhead, we may add additional vessel charter time to the project.

C. Sources of Additional Funding

During year one of this study, we supported work being conducted for this EVOTC grant 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; these data will be available to this project through year five. Additional in-kind contributions to this project for year 5 total \$180K from the following sources: \$120K for KBRR's System-wide Monitoring Program for water quality and weather observations; \$10K CTD (2 CTDs are utilized on the project, one each from KBRR and the NOAA KBL); and \$25K in salaries for KBL staff. Funding from other sources that will support the project include: \$75K from BOEM for collaboration with KBL, and \$25K from the NOAA Integrated Ocean Observing System program/AOOS for collaboration with KBL. For project years 1-5, the combined in kind contributions from KBRR and KBL and additional funding from other sources will total \$1,152K.