EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY18 CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Component Project

18120114-J—Long-term Monitoring of Oceanographic Conditions in Cook Inlet/Kachemak Bay, Alaska

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

August 23, 2017

Project Abstract

The Cook Inlet/Kachemak Bay monitoring project provides year-round, high temporal resolution oceanographic and plankton data to assess the effects of seasonal and inter-annual oceanographic variability on nearshore and pelagic species injured by the Exxon Valdez Oil Spill. We continue a 6-year time-series of shipboard oceanography surveys along the estuarine gradient from Kachemak Bay into southeast Cook Inlet, as well as a 16-year time series of continuous nearshore water quality station observations in Kachemak Bay. Shipboard surveys are conducted on repeated transects monthly in Kachemak Bay, seasonally in southeast Cook Inlet and annually across the Cook Inlet entrance. Shipboard sampling includes conductivity-temperature-depth casts (including fluorescence, turbidity, and dissolved oxygen), phytoplankton, and zooplankton. The project provides oceanographic data to support Gulf Watch Alaska (GWA) nearshore component monitoring in Kachemak Bay and important environmental driver information downstream of other GWA components. By sampling across Prince William Sound, Cook Inlet and the northern Gulf of Alaska shelf, in connection with other GWA Environmental Drivers component projects, we strengthen the ability of the GWA program to evaluate local (within estuary) and remote (shelf, North Pacific) climate forcing effects on nearshore ecosystems. Recent results show that during 2014-2016: 1) water temperatures were warmer than average throughout the water column and fresher below the pycnocline - consistent with the upper 100m of the water column at GAK1, but different from the lower water column, with warm water possibly contributing to sea star declines observed by the nearshore sampling team; 2) increased blooms of Alexandrium phytoplankton species caused paralytic shellfish poisoning events in Kachemak Bay which may have contributed to marine mammal and seabird mortalities; and 3) abundances of warm water zooplankton species increased relative to 2012-2013. We are not proposing any major changes to this project in FY18.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$169,700	$174,400	$183,400	$135,700	$133,300	$796,500

Non-EVOSTC Funds to be used, please include source and amount per source: See Section 6C for details

FY17	FY18	FY19	FY20	FY21	TOTAL
$205,000	$213,000	$215,000	$217,000	$194,000	$1,044,000

1. EXECUTIVE SUMMARY

The Cook Inlet/Kachemak Bay Environmental Drivers monitoring project conducts year-round, high temporal resolution oceanographic and plankton sampling to assess the effects of seasonal and inter-annual oceanographic variability on nearshore and pelagic species injured by the Exxon Valdez Oil Spill. In FY18 we continue a 6-year time-series of shipboard oceanography surveys along the estuarine gradient from Kachemak Bay into southeast Cook Inlet, as well as a 16-year time series of continuous nearshore water quality station observations in Kachemak Bay. Our overall project goal is to continue and enhance time-series of oceanographic data in lower Cook Inlet and Kachemak Bay to help understand variations in nearshore and pelagic food webs.

Data on variability and change in both nearshore and shelf water column conditions are required to evaluate several hypotheses that have been put forward to explain climate-driven changes in Gulf of Alaska biological production (summarized in Mundy and Spies 2005). These include the match-mismatch hypothesis (Mackas et al. 2007, Anderson and Piatt 1999), pelagic-benthic split hypothesis (Eslinger et al. 2001), and optimum stability window hypothesis (Gargett 1997). The Gulf Watch Alaska (GWA) Environmental Drivers componentprovide the long-term, high quality, time-series data needed for these regional evaluations of ecosystem dynamics, as well as for distinguishing between natural and anthropogenic changes in species populations (e.g., oil spills, fishing, aquaculture, nutrient runoff, climate change). The Cook Inlet Kachemak Bay oceanographic monitoring project provides critical information to the GWA program's regional assessment on nearshore and estuarine oceanographic patterns, as well as estuary-to-shelf oceanographic gradients and nutrient exchange.

Important fish, shellfish, seabird, shorebird and marine mammal species forage in Cook Inlet and Kachemak Bay for some or all of their life history; long-term data on environmental conditions and plankton are required to understand how climate variability and change can affect upper trophic species through bottom-up ecosystem processes. Water temperature, stratification, fresh water runoff, the strength and position of the Alaska Coastal Current, and nutrient conditions change with regional climate variation (e.g. El Niño/La Niña, Pacific Decadal Oscillation, 2014-2016 Pacific Warm Anomaly), and can have significant impacts on marine species in the region (e.g., Speckman et al. 2005). However, we still lack an adequate understanding of how nearshore and pelagic food webs respond to these climate-driven variations in physical processes, particularly for inshore regions (Mundy and Spies, 2005). Data collected in this project helps the GWA program build the capacity to understand the physical and biological processes that are factors in structuring marine food webs.

The Cook Inlet/Kachemak Bay oceanography monitoring project provides year-round, seasonally resolved oceanographic and plankton data to the GWA program. This project supports the GWA Nearshore component intertidal monitoring project, as well as ongoing pelagic seabird and marine mammal monitoring efforts in Kachemak Bay. Shipboard surveys are conducted on repeated transects monthly in Kachemak Bay, seasonally in southeast Cook Inlet and annually across the Cook Inlet entrance. Sampling at shipboard survey stations includes: 1) conductivity-temperature vs depth (CTD) profiler casts to collect temperature, salinity, pressure, fluorescence, turbidity, and dissolved oxygen data; 2) surface phytoplankton tows; and 3) vertical zooplankton tows. Continuous oceanographic (temperature, salinity, pressure, dissolved oxygen, turbidity and chlorophyll) and monthly nutrient and chlorophyll data are collected year-round at Kachemak Bay National Estuarine Research Reserve water quality stations in the Seldovia and Homer harbors, and during ice-free months (March to November) at a Bear Cove mooring. The sampling provides data with sufficient temporal resolution to detect seasonal shifts in oceanographic patterns and community composition changes and sufficient spatial

resolution to characterize along- and cross-estuary gradients. Continued sampling in FY18 will test the hypotheses that plankton communities change in response to marine conditions, including to the recent persistent Pacific Ocean warming (DiLorenzo and Mantua 2016) and to an expected return to average ocean temperature conditions. The higher frequency of plankton sampling in Cook Inlet, Prince William Sound (Campbell project), in Resurrection Bay (Hopcroft project) and with the Continuous Plankton Recorder (Batten project) will allow the GWA Environmental Drivers group to compare lower trophic level responses to forcing at local and regional scales across the northern Gulf of Alaska study region.

The funding requested for the Cook Inlet/Kachemak Bay project leverages in-kind contributions of staff time, vessel use and equipment from the NOAA Kasitsna Bay Laboratory and Kachemak Bay NERR, along with additional funding from the Alaska Ocean Observing System. We are not proposing any major changes to this project for FY18.

For FY17-21, the sampling design (Figure 1) was modified from the FY12-16 design (Figure 2) to provide more detailed information on estuary-shelf gradients, to aid in determining how oceanographic conditions affect plankton abundance and community structure. This information will better support region-wide assessment of the impact of climate variability on the northern Gulf of Alaska marine ecosystem. Data analyses from the FY2012-2016 cross-bay and cross-inlet surveys are continuing, along with comparisons to data from other Environmental Drivers projects.

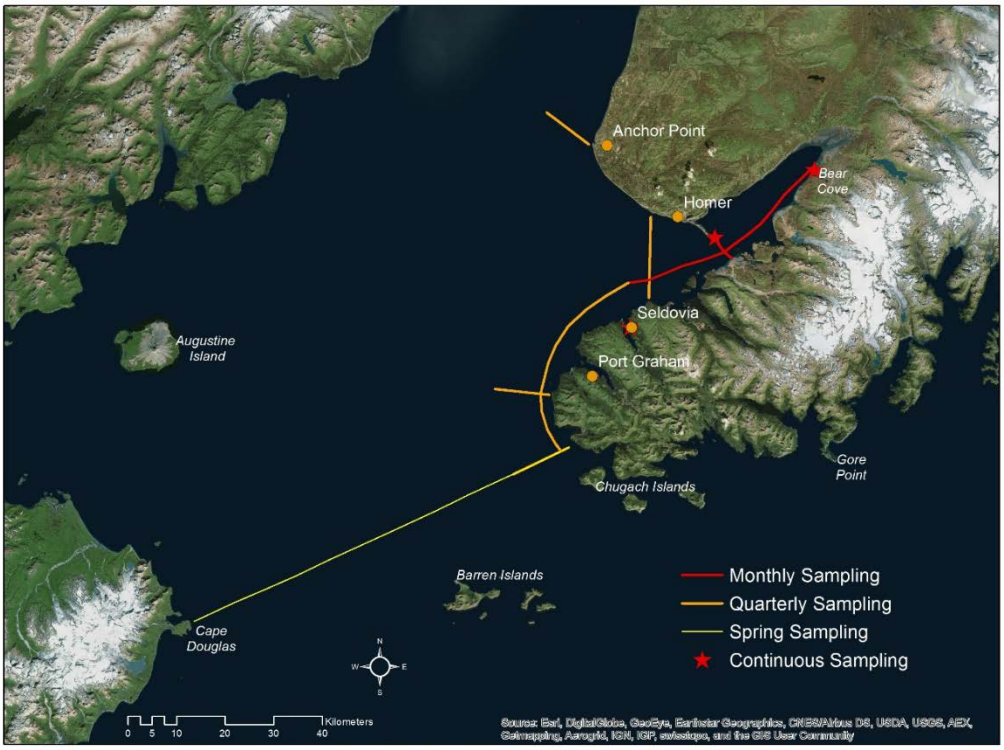


Figure 1. Map of the lower Cook Inlet/ Kachemak Bay study area with FY17-21 sampling locations and frequency. Red stars depict continuous sampling SWMP locations at Seldovia, Homer and Bear Cove.

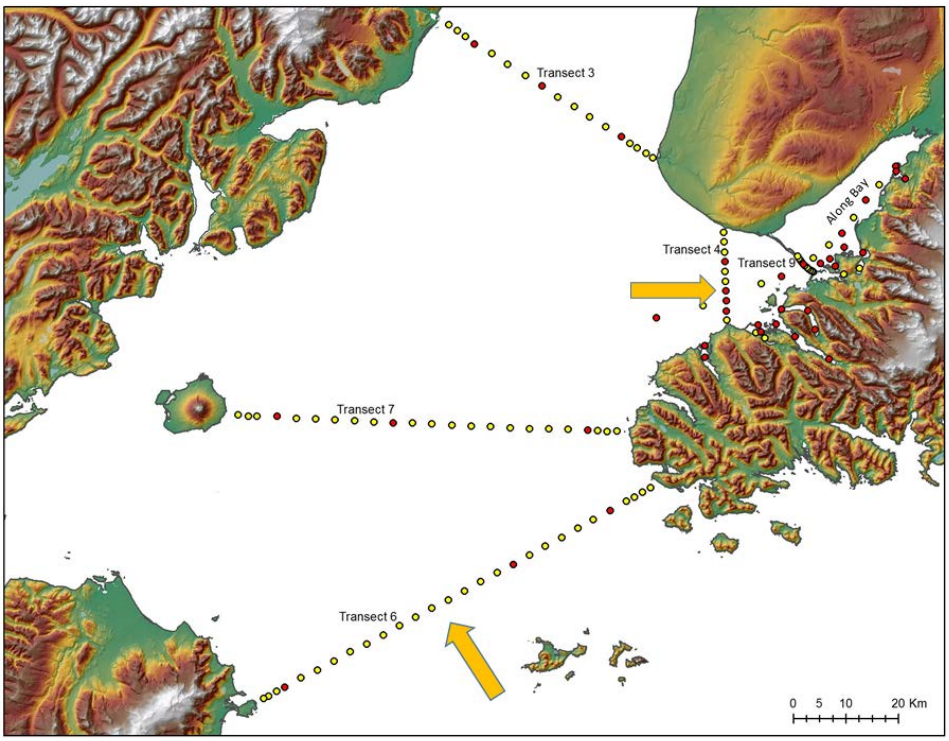


Figure 2. Study area map with FY12-16 sampling locations, including CTD station sites. Yellow arrows indicate direction of view for contour plots of oceanographic data in Figures 5 and 6.

In FY17 (year 6 of GWA program) we continued analyses of data from the first five years of the project to assess seasonal, interannual and spatial patterns. Selected results include the following:

1. Continuous water quality station data from Kachemak Bay show that surface and deep waters at the Seldovia harbor site are warming at the same rate, but deep water is warming faster than surface waters at the Homer harbor site (Figure 3). The warming observations are consistent with the timing of the Pacific warm water anomaly, but the transition to warmer conditions was observed earlier in Kachemak Bay waters (late fall 2013) than at the GAK 1 mooring (summer 2014). Warmest summer water temperatures in the bay were consistently observed at the Bear Cove mooring near the head of Kachemak Bay.

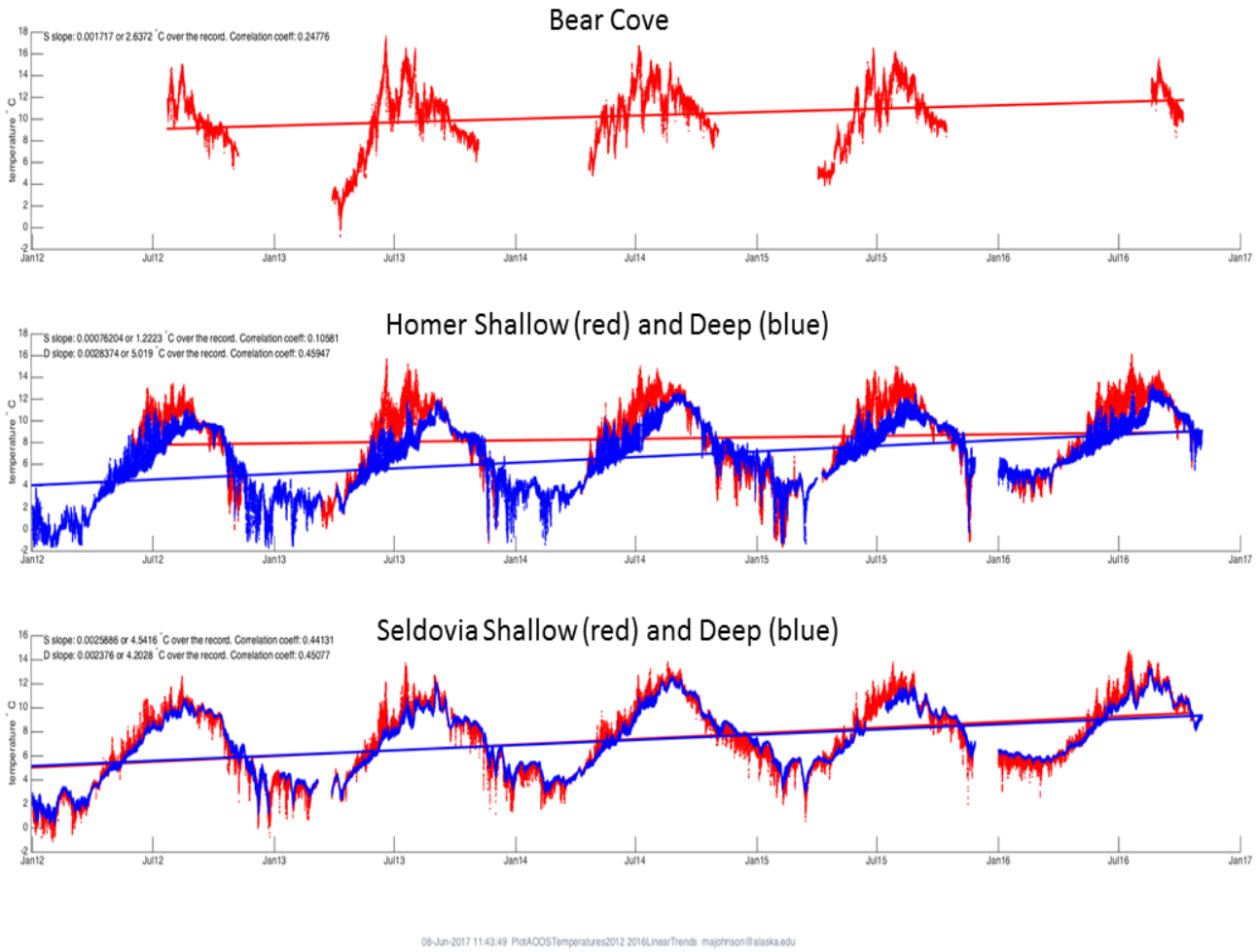


Figure 3. Daily averaged near-surface sea temperature (°C) from three locations in Kachemak Bay, Alaska for 2012-2016, with linear trend lines. Seldovia and Homer Harbor sites have two sensors, with one located 1 m below the surface (red) and one located 1 m above the sea floor (blue). Bear Cove has one surface sensor.

2. The Gulf of Alaska experienced a transition from anomalously cold water temperatures in 2012 to persistent warm temperature anomalies in 2014-2016, as part of the Pacific Warm Anomaly ("Blob") and El Nino climate events. Warmer than average water temperatures were observed throughout the water column in Kachemak Bay starting in late 2013 and persisting through 2016 (Figure 4, top), with the strongest monthly average temperature anomalies observed in winter 2015-2016 (Figure 4, red circle), as contrasted to cool winter temperatures in winter 2012-2013 (Figure 4, blue circle). Surface salinities did not change consistently in this same period (Figure 4, bottom) and may be more influenced by precipitation events and snowpack, rather than the warm anomaly. However, in deeper waters below the seasonal pycnocline, freshening was observed in 2014-2016 (Figure 4, purple circle), which is consistent with the freshening of Alaska Coastal Current waters observed in the upper water column at the GAK 1 mooring, but contrasts with increasing salinity observed below 100 m at GAK1.

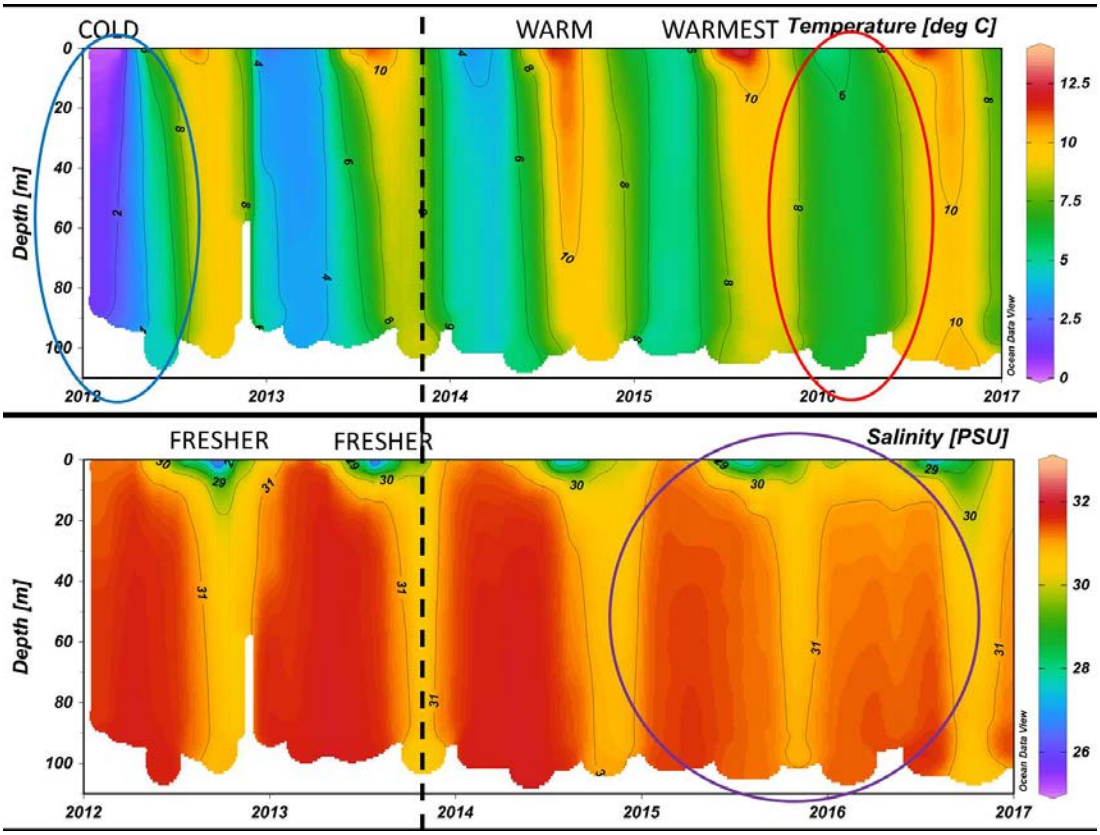
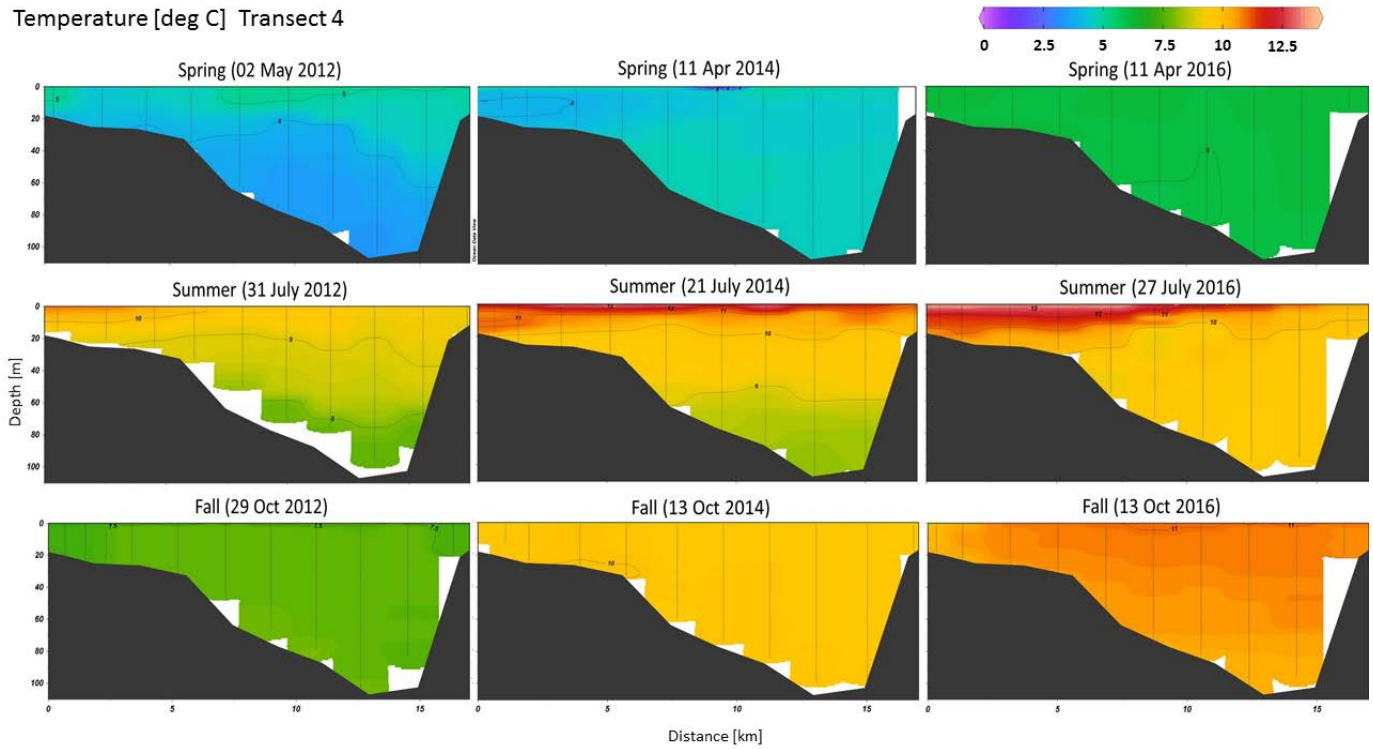


Figure 4. Time series of vertical profiles of water column temperature (top, degrees C) and salinity (bottom, PSU) from 2012-2016 collected from monthly CTD casts at a mid-Kachemak Bay station. The dashed black line marks the transition to warmer conditions in late 2013, with warmer than average temperatures observed throughout the water column in 2014-2016. See text for explanation of circled features.

3. Anomalously warm waters were also observed throughout the water column at outer Kachemak Bay and all lower Cook Inlet sampling locations in 2014-2016. Examples of these patterns are shown for the transect across outer Kachemak Bay (Figure 5) and across the Cook Inlet entrance (Figure 6). Outer Kachemak Bay waters warmed from 2014-2016 in all seasons and waters below the seasonal pycnocline freshened in 2016 relative to 2012, but stratification increased in summer 2016 due to low surface salinities from freshwater input (Figure 5b). The entrance to Cook Inlet exhibited a similar warming trend (Figure 6a), but there was less of a difference in salinities below the seasonal pycnocline.

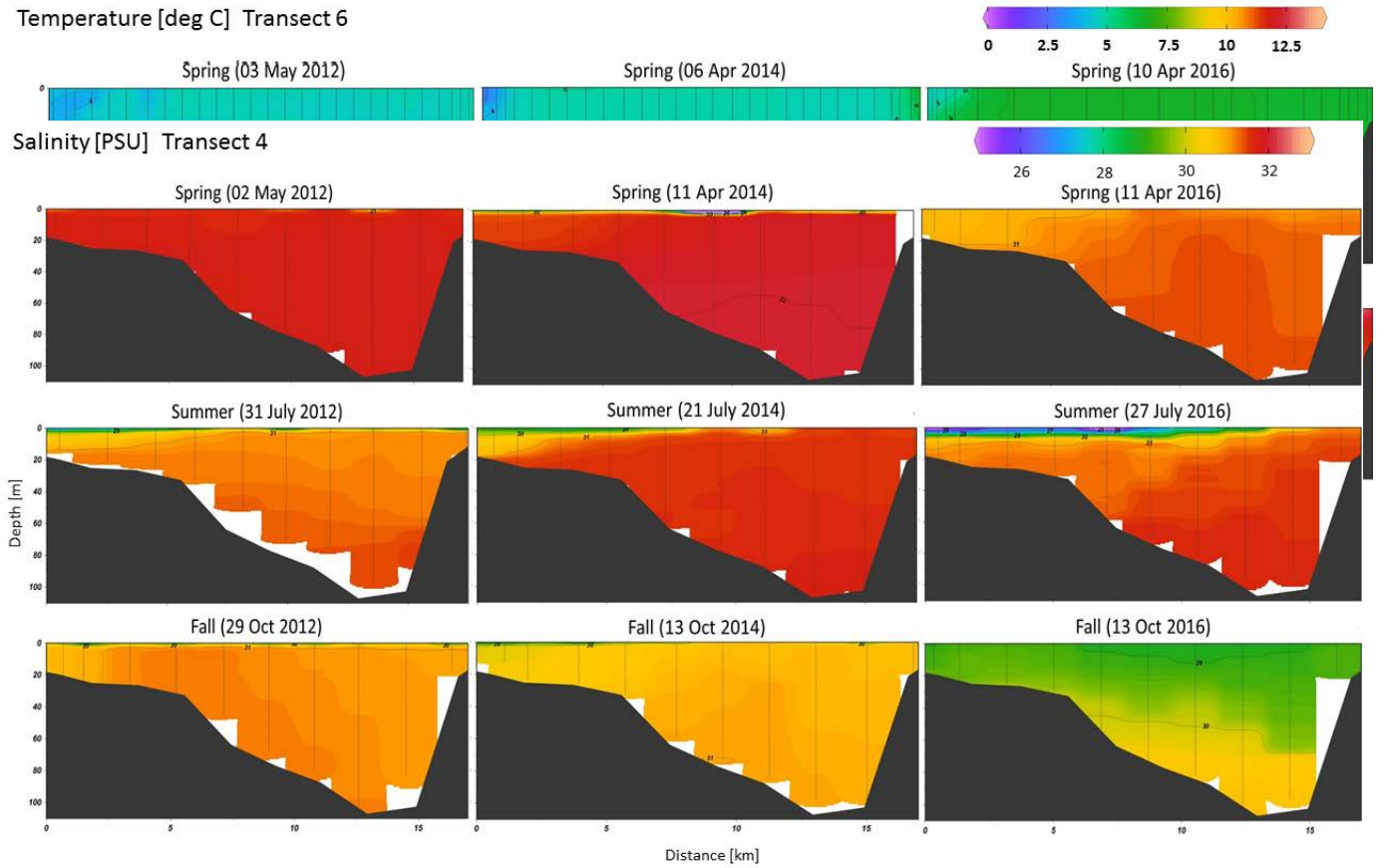
a)



b)

Figure 5. Seasonal variability for water column temperature (top) and salinity (bottom) for cross-estuary transect in outer Kachemak Bay (Transect 4, view looking into bay) in 2012, 2014, and 2016. Temperatures increased in all seasons from 2012 to 2016 and waters also freshened below the seasonal pycnocline during that time period.

a)



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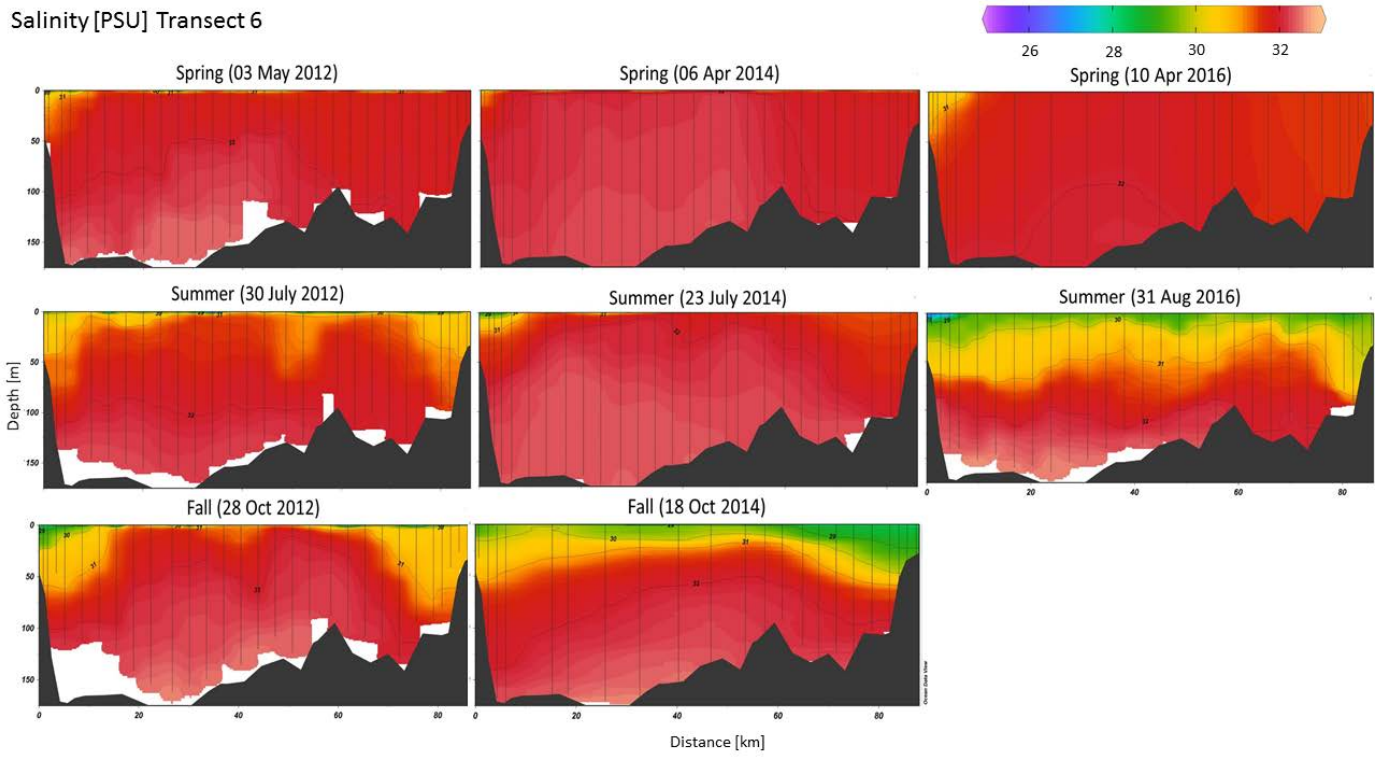


Figure 6. Seasonal variability for water column temperature (top) and salinity (bottom) across the Cook Inlet entrance (Transect 6, view looking into Cook Inlet) in 2012, 2014, and 2016. Temperatures increased in all seasons from 2012 to 2016. Surface freshening was strongest in the late summer/early fall.

4. We analyzed the 2012-2015 zooplankton and phytoplankton data to assess seasonal and spatial patterns in species composition and abundance. Six zooplankton taxa were the most abundant over time, and are predominantly copeopods: *Pseudocalanus* spp., *Acartia longerimis,* barnacle nauplii, *Neocalanus plumchrus,* egg, and *Parasagitta elegans.* Pseudocalanus were common throughout all areas, Acartia and barnacle nauplii were more abundant inside Cook Inlet and Kachemak Bay, whereas Neocalanus were more abundant in the entrance to Cook Inlet (Figure 7). Zooplankton abundance was highest in the spring, with a few exceptions where abundances were highest in summer (Figure 7). Similarly, six phytoplankton taxa were most abundant over time: *Chaetoceros* spp., *Thalassiosira* spp., *Leptocylindrus* spp., *Pseudo nitzschia, Skeletonema* spp., and *Cerataulina* spp. This system is largely dominated by diatom blooms with *Chaetoceros spp.* and *Thalassiosira spp.* dominating the spring and summer samples from all transects (Figure 8). Phytoplankton abundances were highest in the spring and summer, dropping to very low or undetectable abundances in the fall and winter. Total phytoplankton cell abundances were highest within Kachemak Bay, and the lowest cell abundances were observed at the Cook Inlet stations on the northern and western sides of the study area. The diatom *Pseudo-nitzschia*, which has been implicated in harmful algal blooms along the west coast of the continental US and Canada, has been seen in high abundances in our fall samples from Kachemak Bay and the entrance to Cook Inlet when the numbers of *Chaetoceros* and *Thalassiosira* begin to decline (Figure 8).

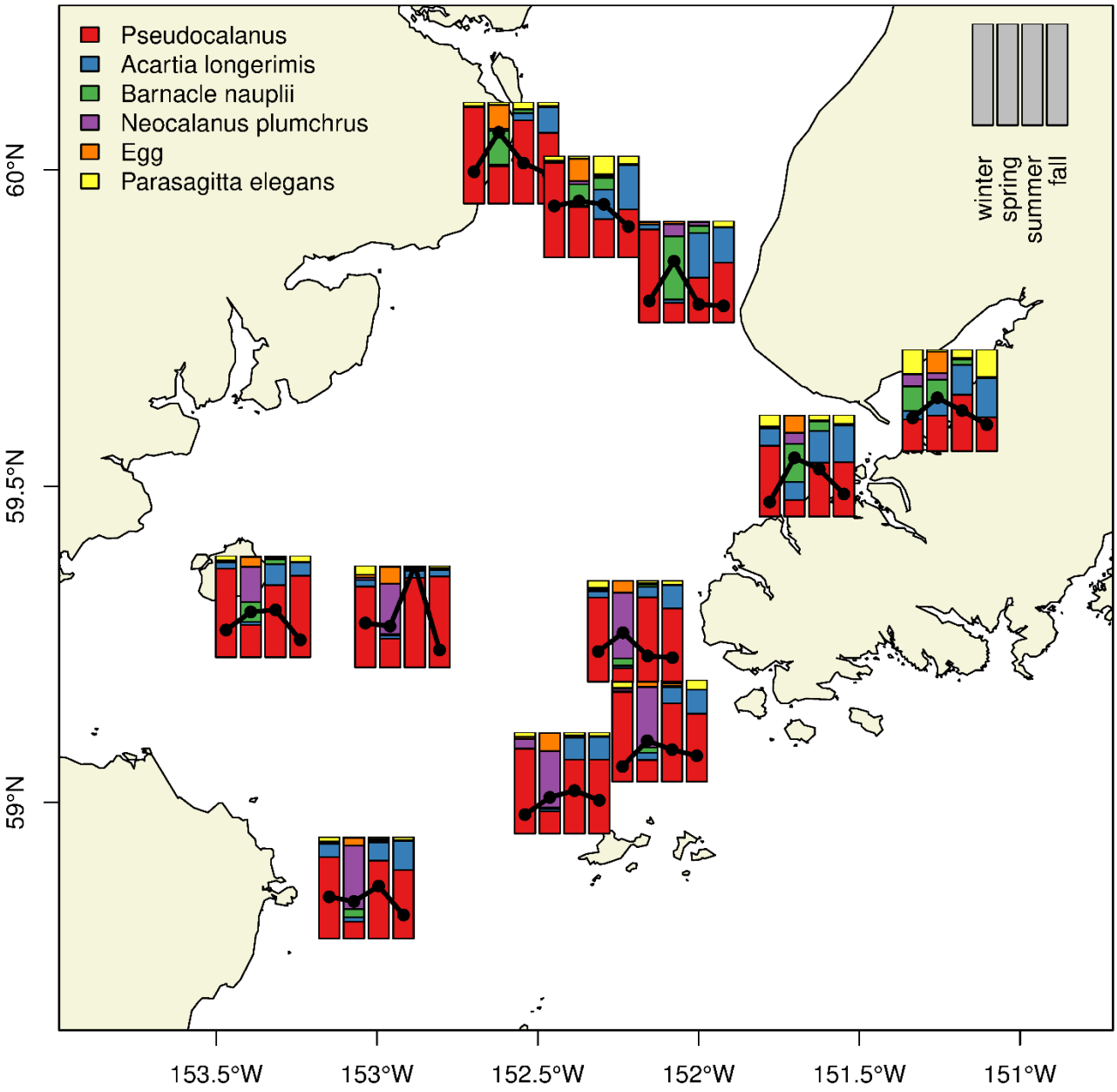


Figure 7. Seasonal variation of relative species composition (bars) and abundance (black line) for the six most abundant zooplankton taxa across the study area for 2012-2015. Bars depict seasonal data combined from all years and the black line represents total abundance for the six taxa.

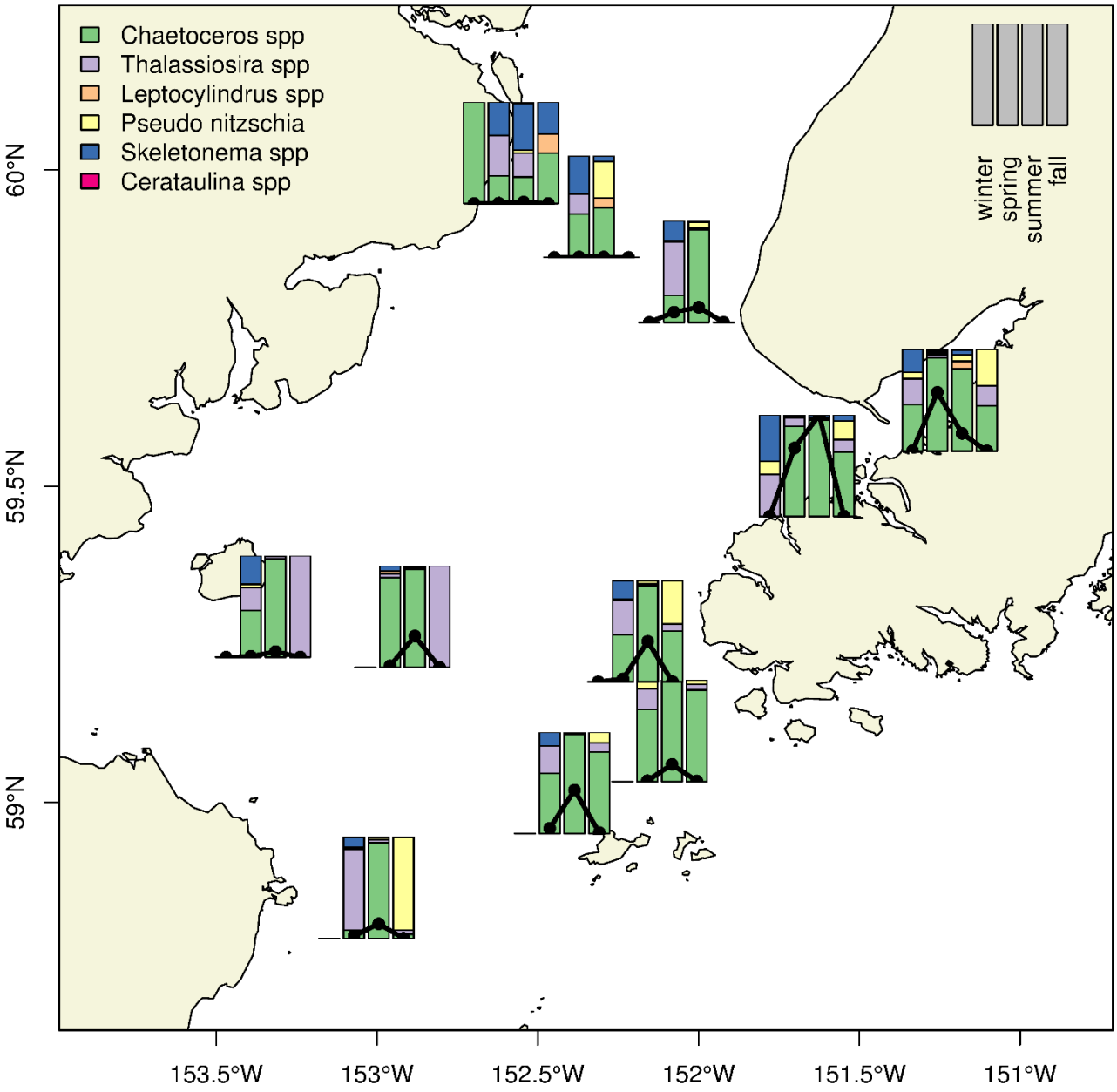


Figure 8. Seasonal variation of relative species composition (bars) and abundance (black line) for the six most abundant phytoplankton taxa across the study area for 2012-2015 Bars depict seasonal data combined from all years and the black line represents total abundance for the six taxa.

5. The toxic phytoplankton *(Alexandrium spp.)* that causes paralytic shellfish poisoning (PSP) was present in lower Cook Inlet and Kachemak Bay during each year of sampling, however maximum cell concentrations increased with warming water conditions in 2014-2016 (Figure 9). Detailed monitoring in Kachemak Bay has enabled us to link warming water temperatures, increases in Alexandrium cell concentrations and increases in PSP toxins in shellfish tissues (Figure 10). PSP events had not been observed in Kachemak Bay for over a decade, but occurred in 2015, 2016 and 2017. PSP toxins may have contributed to seabird (common murre) and sea otter mortality events seen in Kachemak Bay and the northern Gulf of Alaska in 2015-2016.

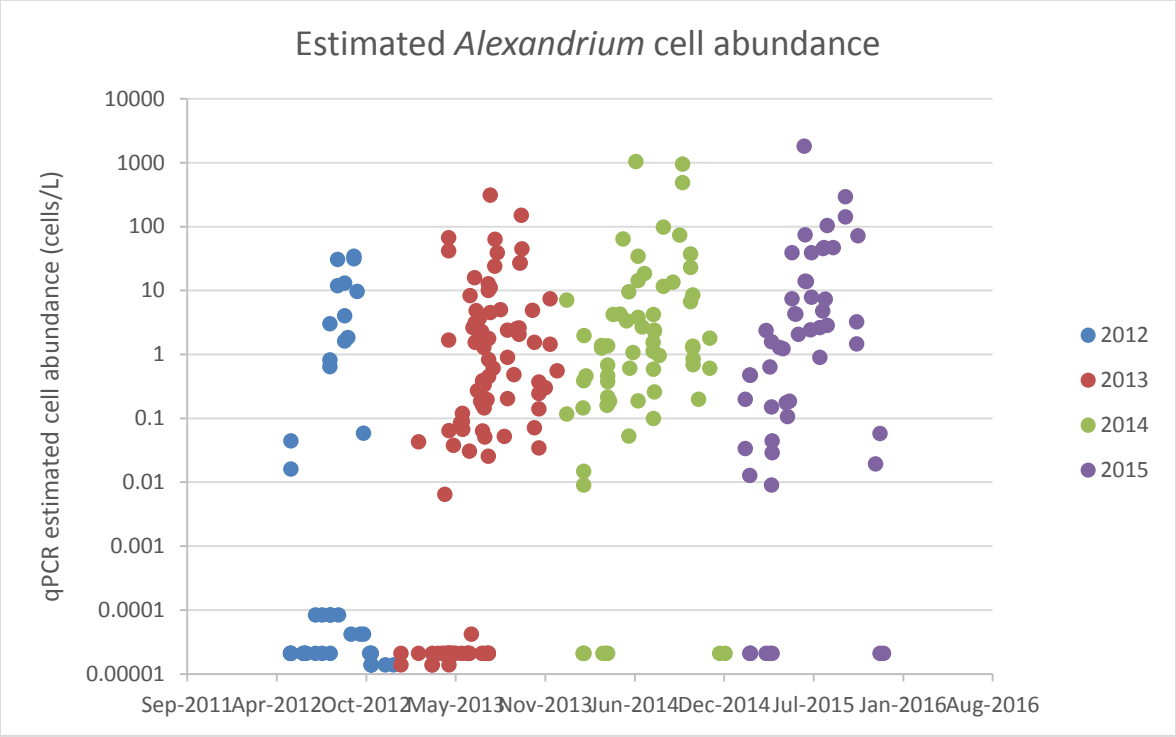
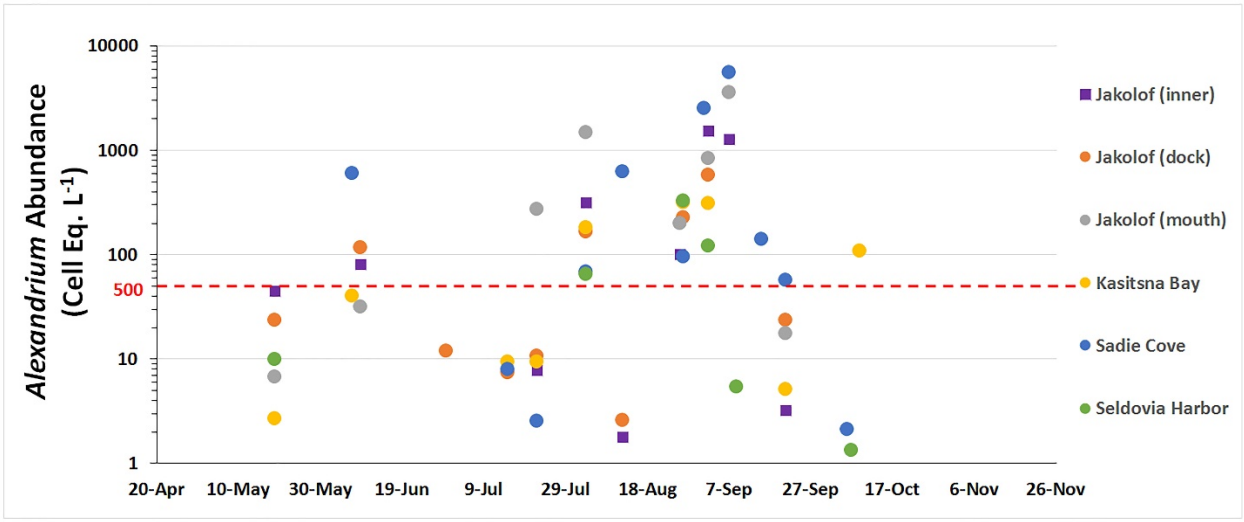


Figure 9. *Alexandrium* cell abundance estimated from quantitative polymerase chain reaction (qPCR) analyses for all phytoplankton samples collected in lower Cook Inlet and Kachemak Bay, 2012-2015. Note logarithmic scale for cell abundance on the y-axis. Paralytic shellfish poisoning toxins were observed in shellfish tissues as phytoplankton cell concentrations rose above 100-500 cells/liter.



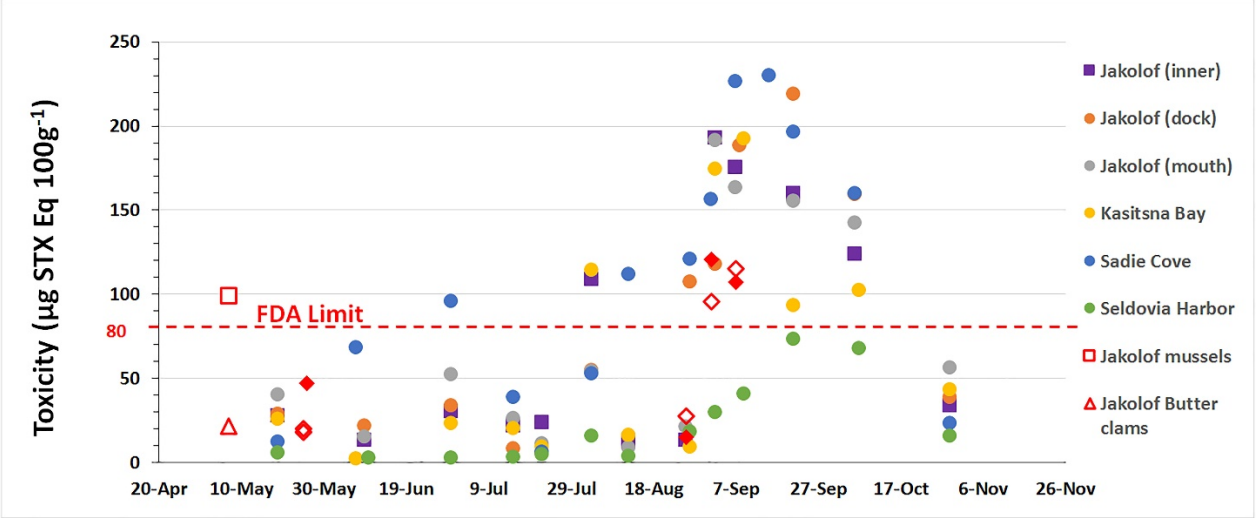


Figure 10. *Alexandrium* cell abundance (top) and shellfish tissue toxicity in clam, mussel and oyster samples from several sites in Kachemak Bay from May-October 2016. Cell abundance was estimated using qPCR. Cell concentrations above approximately 500 cells/liter (red dashed line on top graph) corresponded to toxicity levels above the FDA toxicity limit for safe shellfish consumption (red dashed line on bottom graph).

2. COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

1) Environmental Drivers component: We continue to coordinate on oceanographic and zooplankton sampling protocols and synthesis of monitoring results with other Environmental Drivers component PIs through teleconferences, joint field work, and PI meetings. We are collaborating with Rob Campbell at the Prince William Sound Science Center on zooplankton sample analyses. The project provides year-round,

seasonally resolved oceanographic and plankton data and detailed information on along- and across-estuary gradients to the GWA program.

2) Nearshore component: The Cook Inlet/Kachemak Bay project provides information on seasonal and inter-annual patterns in water temperature, stratification, freshwater content and nutrients to the GWA Nearshore component PIs to assess drivers of intertidal ecosystem changes at their Kachemak Bay sites. In FY18 we will continue a collaboration with Nearshore component PIs to assess oceanographic variability across the GWA study area.

3) Pelagic component: We coordinate with GWA Pelagic component (Kathy Kuletz, USFWS Migratory Bird Management office) to opportunistically host a seabird/marine mammal observer on our shipboard surveys, with the goal of improving understanding the relationships between marine conditions, primary productivity, and seabird and marine mammal populations.

Herring Research and Monitoring

We coordinate informally with Scott Pegau (HRM program lead) and Rob Campbell (PWS oceanography project under GWA program) to compare PWS and Cook Inlet oceanographic patterns and changes in plankton, herring and other forage fish populations.

Data Management

We work closely with the AOOS/Axiom data management team and provide data and metadata to the Research Workspace and AOOS Gulf of Alaska Data Portal within required timeframes. In FY18 we will continue a collaboration with Axiom and AOOS to improve an online tool for paralytic shellfish poisoning risk assessment that is based on real-time water temperature observations.

B. With Other EVOSTC-funded Projects

We will coordinate with other EVOSTC-funded projects as appropriate by providing data and collaborating on science syntheses and publications.

C. With Trustee or Management Agencies

1) NOAA: We collaborate with researchers at the NOS/NCCOS Beaufort Laboratory (North Carolina) to use the project oceanography and phytoplankton sampling data to identify environmental triggers for increases in the phytoplankton species (*Alexandrium* spp.) that cause paralytic shellfish poisoning events. In FY18 we will also investigate the potential for sand lance to provide a vector for PSP toxins to seabirds and whales. We collaborate with NMFS on the NOAA Kachemak Bay Habitat Focus Area program, which includes projects for clam restoration and PSP risk assessment.

2) State of Alaska agencies – ADFG and ADEC: We provide real-time and historical trends for water temperature data to shellfish managers with the Alaska Department of Fish and Game (Commercial and Sportfish Divisions) in Homer and Kenai, and with the Alaska Department of Environmental Conservation in Anchorage. We use project data to help inform management for shellfish harvest, mariculture operations, harmful algal bloom event response and marine invasive species monitoring.

3) U.S. Fish and Wildlife Service: We collaborate with Kathy Kuletz of the USFWS Migratory Bird Management office to opportunistically host shipboard seabird/marine mammal observers on our shipboard surveys. We coordinate with the USFWS Marine Mammals Office on sea otter stranding and sampling programs and project data is provided to USFWS (Alaska Maritime National Wildlife Refuge) and

NOAA (NMFS Protected Resources) to help understand potential ecosystem causes of seabird, sea otter and whale mortality events.

4) North Pacific Research Board: Holderied is participating in the NPRB-funded FY16-18 synthesis effort for the Gulf of Alaska Integrated Ecosystem Research Program with researchers from NOAA, USFWS, ADFG and other organizations. Project data is being used to help understand how linkages between nearshore and shelf waters affect forage fish distributions and groundfish recruitment.

3. PROJECT DESIGN – PLAN FOR FY18

A. Objectives for FY18

Objective 1: Determine the thermohaline structure of Kachemak Bay and the southeastern Cook Inlet entrance at seasonal and longer time scales.

Objective 2: Determine long-term trends and variability from daily to inter-annual time scales in Kachemak Bay oceanography.

Objective 3: Determine seasonal patterns of phytoplankton and zooplankton species abundance and community composition within Kachemak Bay and southeastern Cook Inlet.

Objective 4: Assess inter-annual changes in oceanographic structure and phytoplankton/zooplankton species composition across the Cook Inlet entrance.

Objective 5: Assess seasonal patterns in oceanography, macronutrients, and plankton between Kachemak Bay, southeastern Cook Inlet and the adjacent shelf (collaboration with Seward Line and CPR projects).

Objective 6: Determine temporal patterns and linkages in oceanographic conditions and plankton communities between Kachemak Bay/lower Cook Inlet, the Gulf of Alaska shelf and Prince William Sound, in collaboration with other Environmental Drivers component projects.

Objective 7: Provide environmental forcing data for correlation with biological data sets in the nearshore benthic project component and pelagic components of GWA.

Objective 8: Provide ADF&G, NOAA and USFWS resource managers with assessment of oceanographic trends and seasonal conditions.

B. Changes to Project Design

There are no changes proposed to the project design.

4. SCHEDULE

A. Project Milestones for FY18

Objective 1: Complete shipboard surveys with CTD sampling along repeated transects within Kachemak Bay (monthly) and southeastern Cook Inlet (quarterly in February, April, July and October).

Objective 2: Complete monthly shipboard CTD surveys within Kachemak Bay, and quarterly seasonal surveys in southeastern Cook Inlet. Collect oceanographic data continuously (at 15 minutes sampling interval) with YSI XO series sondes within Kachemak Bay at three stations, with data collection year-round at the Homer and Seldovia harbor sites and during ice-free months (~March-November) at the Bear Cove site.

Objective 3: Complete monthly plankton surveys in Kachemak Bay and quarterly plankton surveys in southeastern Cook Inlet. A 0.333 micron mesh bongo net is used to sample zooplankton vertically from 50 m depth to the surface, and a 20 micron mesh hand net is used for surface phytoplankton sampling.

Objective 4: Complete annual spring CTD and zooplankton/phytoplankton surveys across the Cook Inlet entrance. Complete an analysis of interannual changes in oceanography and plankton community composition to support the GWA year 3 science synthesis workshop.

Objective 5: In collaboration with Seward Line (Hopcroft) and CPR (Batten) projects, complete an analysis of seasonal patterns in oceanography and plankton in Kachemak Bay, lower Cook Inlet and the adjacent Gulf of Alaska shelf to support the GWA year 3 science synthesis workshop.

Objective 6: In collaboration with other Environmental Drivers component projects, complete an initial analysis of temporal patterns in oceanographic conditions across Kachemak Bay/lower Cook Inlet, the Gulf of Alaska shelf and Prince William Sound, in collaboration with other Environmental Drivers component projects. The analysis will support the GWA year 3 science synthesis workshop.

Objective 7: Deliver quality assured/quality controlled data to the GWA Research Workspace and provide data visualization products to GWA Nearshore and Pelagic component PIs.

Objective 8: Publish quality assured/quality controlled data on the GWA Gulf of Alaska Data Portal and provide ADF&G (Commercial Fisheries and Sport Fish Division in Homer AK), NOAA/NMFS and USFWS resource managers with data visualization products on oceanographic trends and seasonal changes.

B. Measurable Project Tasks for FY18

Tasks include repeated monthly, quarterly and annual oceanographic surveys, listed below by quarter. Data delivery and publication on the Gulf of Alaska Data Portal will be completed no later than one year after collection.

FY 2018 (Year 7)

FY 18, 1st quarter	(February 1, 2018 - April 30, 2018)
February:	Project funding approved by Trustee Council; monthly survey Kachemak Bay; Seasonal survey of transects in Kachemak Bay and southeastern Cook Inlet.
March 1:	Submit annual report
March:	Monthly survey Kachemak Bay; Deploy seasonal Bear Cove water quality mooring.

April:	Monthly survey Kachemak Bay; Seasonal survey of all transects in Kachemak Bay, southeastern Cook Inlet; Annual survey of Cook Inlet entrance.
FY 18, 2nd quarter	(May 1, 2018 - July 31, 2018)
May:	Monthly survey Kachemak Bay
June:	Monthly survey Kachemak Bay
July:	Monthly survey Kachemak Bay; Seasonal survey of transects in Kachemak Bay and southeastern Cook Inlet
FY 18, 3rd quarter	(August 1, 2018 - October 31, 2018)
August:	Monthly survey Kachemak Bay
August 23:	Submit FY19 Annual Work Plan
September:	Monthly survey Kachemak Bay
October:	Monthly survey Kachemak Bay; Seasonal survey of transects in Kachemak Bay and southeastern Cook Inlet.
FY 18, 4th quarter	(November 1, 2018 - January 31, 2019)
November:	Monthly survey Kachemak Bay; Annual GWA PI Meeting; Remove Bear Cove mooring
December:	Monthly survey Kachemak Bay; Submit analyses/manuscript for Year 3 science synthesis
January:	Monthly survey Kachemak Bay; Alaska Marine Science Symposium & PI meeting

5. PROJECT PERSONNEL – CHANGES AND UPDATES

We are requesting approval from EVOSTC to transition the Kachemak Bay National Estuarine Research Reserve project PI from Angie Doroff to Jessica Shepherd. Shepherd is the KBNERR manager and has been involved with the project and GWA program throughout the first six years of the program. Doroff will continue to provide her expertise to the project as a collaborator. A copy of Shepherd's CV is attached.

6. BUDGET

A. Budget Forms (See GWA FY18 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Proposal

No budget changes for FY18 from our original proposal.

C. Sources of Additional Funding

1. KBNERR System-wide monitoring program: this long-term monitoring program provides the continuous measures in Kachemak Bay for temp/conductivity, DO, pressure (depth), pH, turbidity and fluorescence (a measure of phytoplankton biomass); nutrients (Nitrite + Nitrate, Ammonium, Orthophosphate, and Silicate) are analyzed at the Virginia Institute of Marine Science (VIMS) Lab. Chlorophyll-a and Phaeophytin pigments are analyzed using standard methods at the KBNERR from water samples collected at five sites throughout the ice-free periods in the Bay. The Reserve also provides real-time and archival meteorological data from two sites for this program which include measures of: air temperature, relative humidity, barometric pressure, wind speed, wind direction, and total solar radiation, precipitation, and PAR. Collectively, these data provide a longer term perspective for our point-sample oceanographic data. This monitoring contributes $120K/year.

2. KBNERR/ADF&G community-based monitoring for harmful species: this project contributes an extensive volunteer network for monitoring phytoplankton in the event of a harmful algal bloom in Kachemak Bay.

This project has supplemented our monitoring with surface temperature measurements at all mariculture sites located in sub-bays of Kachemak Bay since 2006.

3. NOAA Kasitsna Bay Laboratory and AOOS: NOAA KBL and AOOS have an ongoing collaboration to assess oceanography, ocean acidification and harmful algal bloom conditions in Kachemak Bay, and to develop risk assessment tools for paralytic shellfish poisoning. AOOS plans to provide $25K in FY18 to support these efforts.

7. RECENT PUBLICATIONS AND PRODUCTS

Publications

Doroff, A. and K. Holderied. 2017. Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 16120114-G), Kachemak Bay National Estuarine Research Reserve, University of Alaska, Anchorage, and National Oceanic and Atmospheric Administration, National Ocean Service, Kasitsna Bay Laboratory, Homer, AK.

Holderied, K. and T. Weingartner. 2016. Linking Variability in Oceanographic Patterns Between Nearshore and Shelf Waters Across the Gulf of Alaska. IN Quantifying temporal and spatial variability across the northern Gulf of Alaska to understand mechanisms of change. Gulf Watch Alaska program science synthesis report. Exxon Valdez Oil Spill Trustee Council.

Konar B., K. Iken, and A. Doroff. 2017. Long-term monitoring: nearshore benthic ecosystems in Kachemak Bay. Five-year Project Report: Restoration Project 16120114-L Final Report. 120pgs.

Doroff, A., M. Johnson, and G. Gibson. 2017. Ocean Circulation Mapping to Aid Monitoring Programs for Harmful Algal Blooms and Marine Invasive Transport in South-central, Alaska. State Wildlife Grant, Alaska Dept. of Fish and Game. Annual Report. 41pgs.

Published Datasets

Holderied, K. and A. Doroff. 2017. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Water Quality, Meteorological, and Nutrient Data collected by the National Estuarine Research Reserve System's System-wide Monitoring Program (NERRS SWMP), 2012-2016, Gulf Watch Alaska Environmental Drivers Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1c.

Holderied, K. and A. Doroff. 2017. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, CTD Data, 2012-2016, Gulf Watch Alaska Environmental Drivers Component *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1d.

Holderied, K. and A. Doroff. 2017. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Zooplankton Data, 2012-2015, Gulf Watch Alaska Environmental Drivers Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k12.

Presentations

Doroff, A., J. Trammell, S. Abrahamson, M. Geist, M. Aisu, R. Painter, J. Shepherd, S. Baird, and J. Hetrick. 2017. Advancing shellfish sustainability in the Kachemak Bay Habitat Focus Area. Alaska Marine Science Symposium 2017: Poster presentation.

Doroff, A., M. Johnson, G. Gibson, and C. Bursch. 2017. Exploring short-term variation in ocean circulation patterns to better understand hydrographic factors relevant to harmful algal blooms in Kachemak Bay, Alaska. Alaska Marine Science Symposium, January 2017, Anchorage AK. Poster presentation.

Holderied, K., K. Powell, D. Hondolero, J. Schloemer and A. Doroff. 2017. Interannual oceanographic variability and the estuarine response to the Pacific warm anomaly in Kachemak Bay Alaska. Alaska Marine Science Symposium, January 2017, Anchorage, AK. Oral presentation.

Holderied, K., D. Hondolero, S. Kibler, M. Vandersee, S. Buckelew, A. Doroff and J. Schloemer. 2017. Using coastal Alaska response to the 2014-2016 Pacific warm anomaly to improve risk assessment for paralytic shellfish poisoning. Oral presentation.

Hondolero, D., S. Kibler, K. Holderied, and W. Litaker. 2017. Paralytic shellfish toxins in Kachemak Bay, Alaska: Environmental factors affecting *Alexandrium* growth. Alaska Marine Science Symposium, January 2017, Anchorage, AK. Poster presentation.

Schloemer, J., A. Doroff, S. Baird, and C. Bursch. 2017. Exploring primary productivity processes during 2012-2016 through continuous time-series data on water quality in Kachemak Bay. Alaska Marine Science Symposium, January 2017, Anchorage, AK. Poster presentation.

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DiLorenzo, E., and Mantua, N. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change, published online: 11 July 2016 DOI:10.1038/ nclimate3082.

Eslinger D., R.T. Cooney, C.P. McRoy, A. Ward, and T. Kline. 2001. Plankton dynamics: observed and modeled responses to physical conditions in Prince William Sound, Alaska. Fish. Oceanogr. 10(Suppl. 1):81-96.

Gargett, A. E. 1997. The optimal stability "window": a mechanism underlying decadal fluctuations in North Pacific salmon stocks? Fisheries Oceanography 6(2):109–117.

Mackas, D. L., S. Batten, and M. Trudel. 2007. Effects on zooplankton of a warmer ocean: Recent evidence from the Northeast Pacific. Progress in Oceanography 75(2):223–252.

Mantua N, Hare SR, Zhang Y, Wallace JM, Francis RC (1997) A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bull Am Met Soc 78:1069 – 1079.

Mundy, P.R. and R. Spies. 2005. Introduction (Chapter 1, p 1-14), IN: The Gulf of Alaska: Biology and Oceanography, edited by P.R. Mundy, Alaska Sea Grant College Program, University of Alaska Fairbanks, 214 p.

Speckman, S. G., J. F. Piatt, C. V. Minte-Vera, and J. K. Parrish. 2005. Parallel structure among environmental gradients and three trophic levels in a subarctic estuary. Progress in Oceanography, 66:25–65.

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Education

M.A. | PRESENT | UNIVERSITY OF ALASKA, ANCHORAGE

- Major: Creative Writing - Nonfiction

M.A. | DEC. 2003 | UNIVERSITY OF ALASKA, FAIRBANKS

- Major: Northern Studies – conservation science
- Minor: Resource Management

B.S. | DEC. 1987 | UNIVERSITY OF COLORADO, BOULDER

- Major: Environmental Biology
- Minor: Literary Journalism

Experience

RESERVE MANAGER | KACHEMAK BAY RESEARCH RESERVE | JUNE 2014 - PRESENT

Oversight of 12 Reserve staff plus interns and volunteers; provide workload prioritization; and maintain schedules for task delivery. Research, write, and submit federal, state, and private grants and provide grant and budget oversight, performance updates, and annual reporting. Track a 1.9M annual budget and maintain cost-effective oversight of expenditures.

EDUCATION COORDINATOR | KACHEMAK BAY RESEARCH RESERVE | MAY 2009 - PRESENT

Partner with state and federal agencies (i.e. NPS, ADF&G, USFWS, NOAA), school districts, universities (UAA, UAF), and other public and private agencies to develop and deliver educational programs that further the Reserve education mission and meet the needs of state educators for hands-on, standards-based lessons in science and technology. Develop and present educational K-12 and public programs throughout the year to ensure optimum delivery of engaging marine science programs for all ages. Coordinate with area Researchers to integrate current marine research into educational programs. Insure scientific quality of program development and delivery.

EDUCATION MANAGER | ALASKA SEALIFE CENTER | NOVEMBER 2006 – MAY 2009

Leadership of four full-time and numerous seasonal education staff to ensure optimum delivery of engaging marine science programs for all ages; researched, wrote, and submitted federal, state, and private grants (i.e. NSF, NOAA, DEC, NPS, OSRI) on topics including marine ecosystems, climate change, and salmon science; principle investigator for six grants totaling $910,000; managed a FY 2009 operating budget of $310,000 including $150,000 in program-generated dollars; provided grant and budget oversight, performance updates, and annual reporting for the Education Department; represented ASLC at national and state meetings, conferences and committees.

Responsible for adult education including teacher workshops , Elderhostel, and lecture series; teacher-of-record for teachers attending teacher workshops while earning credit through University of Alaska, Anchorage; researched and wrote a marine ecosystems curriculum for delivery to high school students; developed and implemented a semester-long Remotely Operated Vehicles technology class for middle and high school students; determined curriculum effectiveness through pre- and post-assessments of lessons.

SCIENCE WRITER | UNIVERSITY OF ALASKA, FAIRBANKS | SEPT 2004 – OCT 2006

Development of science and math curricula for Alaskan and Hawaiian middle and high school students on diverse subjects including the aurora, the solar system, volcanoes, plate tectonics, global warming, climatology, and tsunamis; interviewed University of Alaska Scientists to verify and expand upon curriculum material; presented complex scientific, technical, and mathematical information (both orally and in writing) in a manner appropriate for a variety of audiences, including teachers, students and the public; wrote and edited dozens of lesson plans that incorporated multi-media products, and internet based science websites; aligned all lessons to national, state, and school district content and performance standards; worked cooperatively with teachers in Alaska's bush communities to develop effective strategies for teaching physics and Earth science to Native students in a rural setting; incorporated culturally relevant material, and cultural sensitivity into lessons; designed and implemented assessment strategies to determine long-range effectiveness of educational outreach programs.

Publications, Presentations, Workshops, Programs:

2016	Teachers on the Estuary Workshop – teacher on record
2014 – 2017	Week-long Master Naturalist Training
2013 – 2017	NSF's Experimental Program to Stimulate Completive Research
2012 – 2013	Citizen Scientist coastal habitat mapping field-component
2012	Citizen Science Teacher Workshop – teacher on record
2011 – 2015	EVOS Alaska Gulf Watch – monitoring project outreach
2011 - 2012	Homer Outdoor Education Market Analysis/Needs Assessment
2011	Assessing Threats of Marine Invasive Species and Harmful Algal Blooms: Planning, Monitoring, and Research for the Kachemak Bay Research Reserve
2007 – 2017	Ocean and Science Learning Center/NPS research outreach
2005 – 2006	Volcanos Alive! Interactive multimedia science education
2004 - 2006	Aurora Alive! Interactive multimedia science education