EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY20 (YEAR 9) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Component Project

20120114-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 16, 2019

Project Abstract

The Cook Inlet/Kachemak Bay monitoring project provides year-round, high temporal resolution oceanographic and plankton community data to assess the effects of seasonal and inter-annual oceanographic variability on nearshore and pelagic species affected by the *Exxon Valdez* Oil Spill. We continue an 8-year time-series of year-round, monthly shipboard oceanography surveys along the estuarine gradient from Kachemak Bay into southeast Cook Inlet, as well as an 18-year time series of continuous nearshore water quality station observations in Kachemak Bay. Shipboard sampling includes conductivity-temperature-vs-depth casts, and phytoplankton and zooplankton net tows. Outputs from the project include seasonally resolved patterns and interannual shifts in oceanography, plankton abundance and community composition, and occurrences of harmful algal species. The project provides oceanographic and plankton data to support the GWA Nearshore Component in Kachemak Bay and provides year-round information on estuary-shelf oceanographic gradients to help evaluate the effects of local (within estuary) and remote (shelf, North Pacific) climate forcing on nearshore and pelagic ecosystems. Results show that: 1) water temperatures in 2018 were close to long-term averages through summer, then warmed above average in early fall and remained anomalously warm through July 2019 (up to 2 degrees C above average); 2) Kachemak Bay zooplankton community composition in summer 2017 returned to patterns observed in 2012-2015; and 3) abundances of the phytoplankton species that cause paralytic shellfish poisoning were surprisingly low in September 2018, despite warm conditions, but increases in these toxic species and in shellfish toxicity were observed in July 2019. No proposed project changes for FY20.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$169,700	$174,400	$183,400	$135,700	$133,200	$796,300

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	$182,800	$186,000	$1,001,800

1. PROJECT EXECUTIVE SUMMARY

Overview

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 FY20, we propose to continue an 8-year time-series of shipboard oceanography and plankton surveys along the estuarine gradient from Kachemak Bay into southeast Cook Inlet, as well as an 18-year time series of continuous nearshore oceanography observations in Kachemak Bay (Fig. 1). Our overall project goal is to continue to enhance time-series of oceanographic and plankton data in lower Cook Inlet and Kachemak Bay to help understand what drives variations in nearshore and pelagic food webs.

The Cook Inlet/Kachemak Bay oceanography monitoring project provides seasonally resolved oceanographic and plankton data to the Gulf Watch Alaska (GWA) program, with critical information on nearshore patterns and estuary to shelf oceanographic gradients for the Environmental Drivers component. Project data support the GWA Nearshore component intertidal monitoring project in Kachemak Bay, as well as harmful algal bloom (HAB), forage fish, seabird and marine mammal monitoring efforts funded under other programs in Kachemak Bay and lower Cook Inlet. Important fish, shellfish, seabird, shorebird and marine mammal species forage in Cook Inlet and Kachemak Bay and long-term oceanographic and lower trophic data are required to understand how climate variability can affect upper trophic species through bottom-up ecosystem processes. 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). Examples 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 GWA program provides 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., climate variations, nutrient supply, HABs, oil spills, fishing, aquaculture).

Shipboard surveys are conducted monthly in Kachemak Bay and Cook Inlet and include: 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 water quality stations in the Seldovia and Homer harbors, and during ice-free months (normally March to November) at a Bear Cove mooring (Fig. 1). The sampling provides data with sufficient temporal resolution to detect seasonal shifts in oceanographic patterns and plankton community composition, and at sufficient spatial resolution to characterize along- and cross-estuary oceanography gradients and spatial distributions of plankton communities.

Continued sampling in FY20 will investigate whether the observed warming in 2019 persists and if plankton community response is similar to what was observed during the 2014-2016 marine heat wave. We will also analyze the effects of the prolonged dry conditions in summer 2019 on freshwater inputs (leveraging data from a new University of Alaska Fairbanks (UAF) project funded by the National Science Foundation (NSF) in Kachemak Bay), oceanographic conditions, and plankton communities. In FY20 we plan to expand on synthesis efforts with other investigators from the Environmental Drivers and Nearshore components, as well as with US Geological Survey (USGS) researchers working in Cook Inlet/Kachemak Bay, to assess plankton community responses to climate variations across the northern Gulf of Alaska during 2012-2019, and investigate how those changes are affecting toxic algae, forage species composition, seabird reproductive success and marine mammal distributions in Kachemak Bay and Cook Inlet.

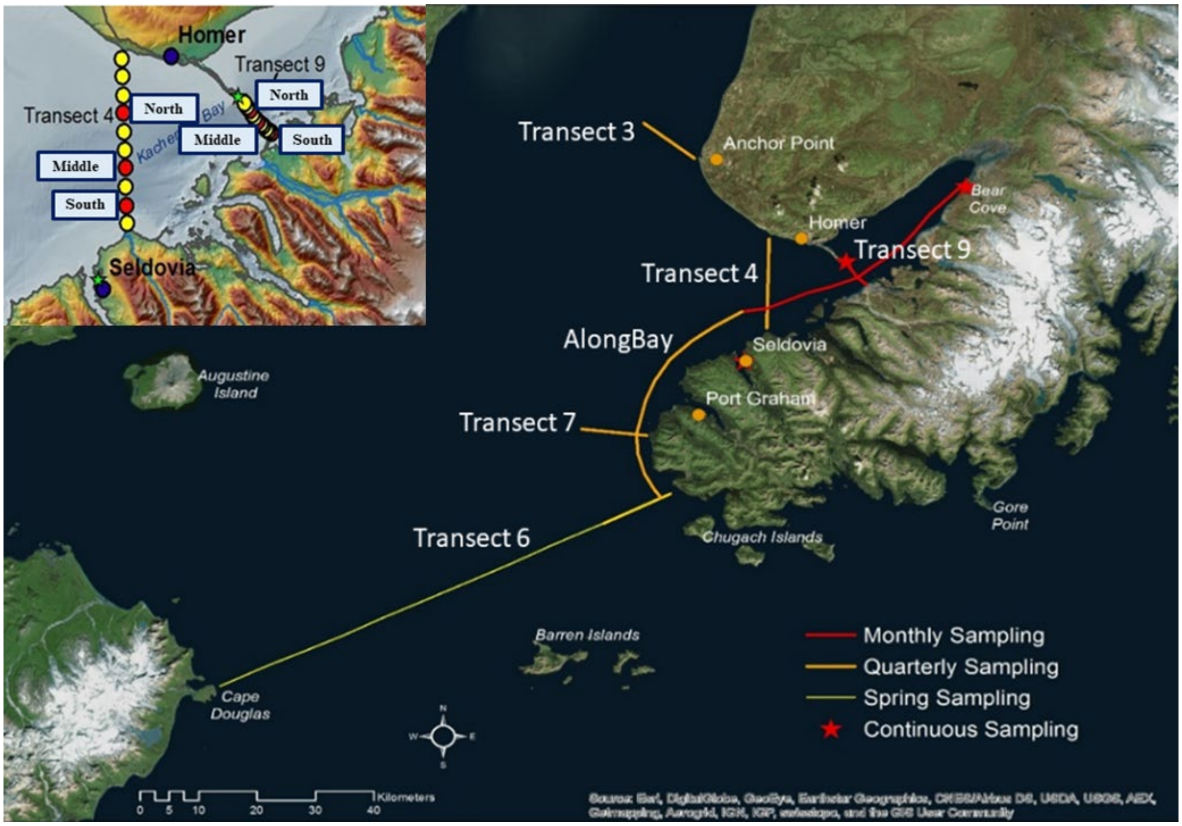

Figure 1. Map of the lower Cook Inlet/ Kachemak Bay study area with FY17-21 sampling transect locations and sampling frequency. Red stars depict continuous water quality monitoring station locations at Seldovia, Homer and Bear Cove. Inset map shows location of cross-bay sampling stations in Kachemak Bay (red dots indicate locations of plankton sampling). See 2018 annual report for map with individual station locations.

Selected Results

In FY19 (year 8 of GWA program), we continued data analyses to assess seasonal, interannual and spatial patterns and plankton response to environmental drivers. Selected results include the following:

1. *Continuous water quality* - station data from Kachemak Bay show that water temperatures were warmer and fresher in summer 2019 than in summer 2018, with temperatures exceeding 15°C at the Homer harbor station and 17°C in Bear Cove at the head of the bay (Fig. 2). It is noteworthy that the low observed salinity values in July and August 2019 at Homer and Bear Cove sites likely indicate substantial freshwater input to the bay from glacier melt, since the region received almost no precipitation from June to early August 2019. Bear Cove salinities are the lowest observed during the GWA study period. The differences in both temperature and salinity conditions between the Seldovia (cooler, saltier) and Homer/Bear Cove (warmer, fresher) stations were also more pronounced in summer 2019 than in either 2017 or 2018, which may be associated with increased water column stratification in the inner bay. Minimum 2018-2019 winter temperatures were colder at Homer

(<2°C) than in Seldovia (~4°C), which is similar to differences observed in previous years, though warmer than the previous winter (Fig. 2). In 2017 and most of 2018, water temperatures in Kachemak Bay cooled relative to the anomalously warm conditions observed during the 2014-2016 Pacific marine heat wave, but waters warmed above average again beginning in fall 2018 and extending into 2019, with anomalies of up to 2°C above 18-year monthly means (Fig. 3).

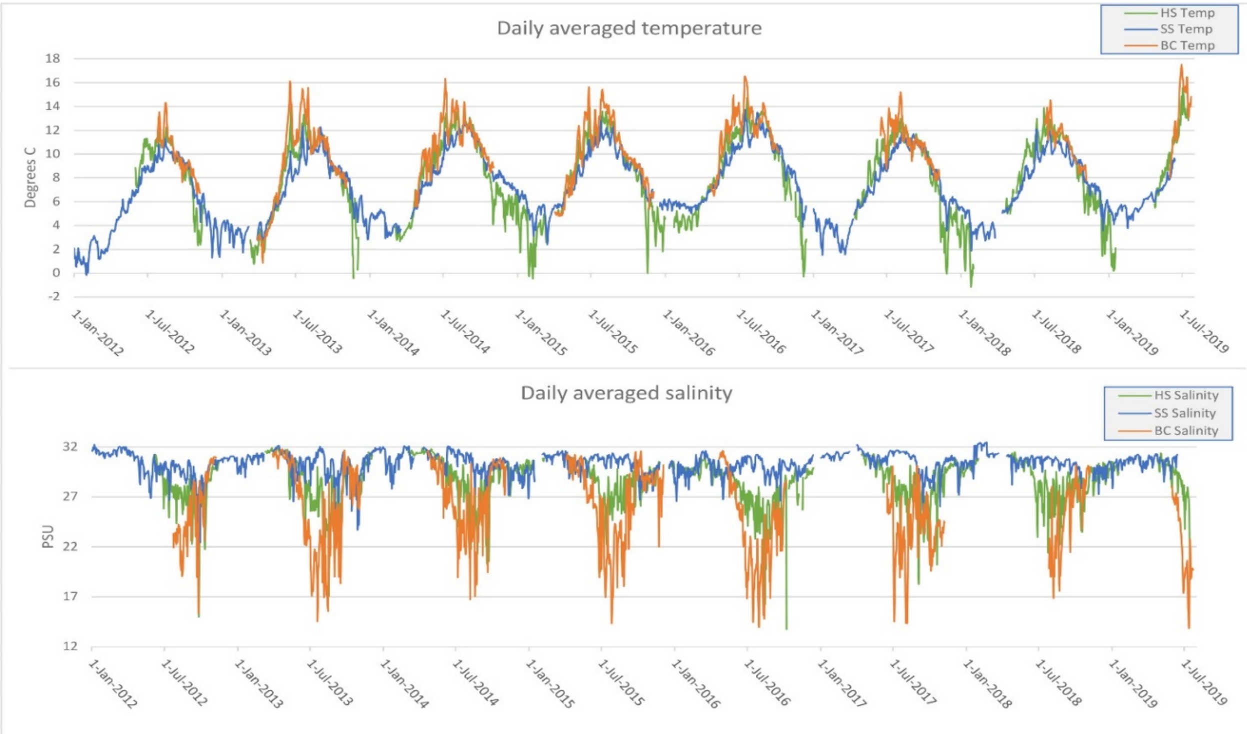

Figure 2. Daily averaged near-surface sea temperature (top) and salinity (bottom) three water quality stations in Kachemak Bay, Alaska for the Jan 2012 to mid-July 2019 portion of an 18-year time series. Seldovia harbor (blue) conditions in the outer bay reflect more open ocean conditions, with a smaller range of seasonal temperatures and higher salinities. Homer harbor (green) and Bear Cove (orange) observations reflect the greater influence of freshwater input in the inner bay, with a larger seasonal temperature range and lower salinities.

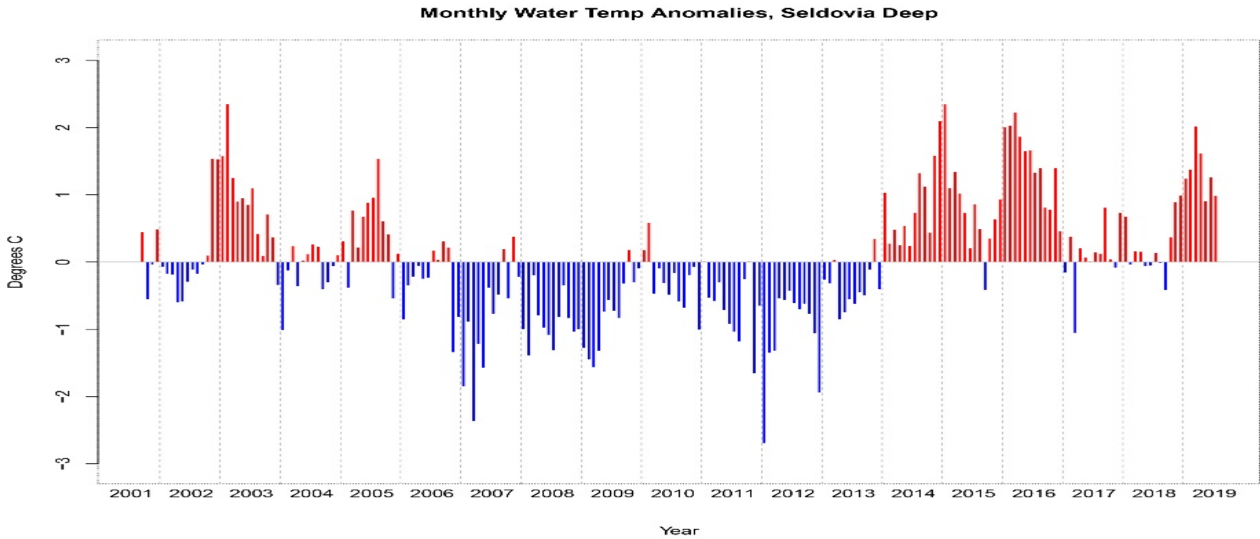

Figure 3. Monthly average water temperature anomalies (red bars-warm, blue bars-cool) calculated from continuous data from the near-bottom sensor at the Seldovia harbor Kachemak Bay National Estuarine Research Reserve water quality monitoring station from May 2001 to July 2019 (against the 2002-2018 monthly means).

2. *Shipboard oceanographic observations* - showed that water column temperature patterns are similar to those observed at the water quality stations, with warmer temperatures observed through the water column in November/December 2018 (> 7°C) relative to the same period in 2017. Fig. 4 provides example temperature (top) and salinity (bottom) time series for the entire study period from one CTD station located in the middle of Kachemak Bay (along the cross-bay transect). In late 2018, the deeper waters in Kachemak Bay also remained fresher than what was observed during the fall to winter transition in 2017. Water column temperatures have remained consistently warmer in 2019 than conditions observed in 2018 (not shown).

For the FY17-21 GWA program, we conduct monthly along-estuary sampling to resolve spatial and seasonal changes in the estuary-shelf oceanographic gradients. Fig. 5 compares temperature (Fig. 5a) and salinity (Fig. 5b) time series from selected monthly along-bay surveys in 2017 and 2018. For FY20 we plan to use the 2017-2019 detailed time series of along-estuary oceanographic patterns to assess seasonal linkages between the bay and waters of the adjacent shelf, including comparisons with oceanographic observations made at the GAK 1 mooring and along the Seward Line. We also plan to use ocean circulation model outputs from the new National Oceanic and Atmospheric Administration (NOAA) Cook Inlet Operational Forecast System to assess water transports. As an example, September differences in temperature (Fig. 5a) and salinity (Fig. 5b) conditions below the pycnocline between 2017 (warmer, fresher) and 2018 (cooler, saltier) may reflect differences in Alaska Coastal Current waters which come into the bay or changes in the shelf-estuary exchange. We also plan to assess how differences in along-estuary, surface salinity patterns vary with local changes in precipitation, snowpack and glacier melt, such as shown in the change in the surface freshwater lens along Kachemak Bay in September 2018 (a dry month) relative to 2017. For this analysis we will also leverage freshwater data collected since May 2019 at seven streams on the south side of Kachemak Bay by University of Alaska Anchorage researchers under a new 5-year, NSF-funded project to investigate the effects of glacial watershed coverage on freshwater inputs to the estuary and on nearshore ecosystems.

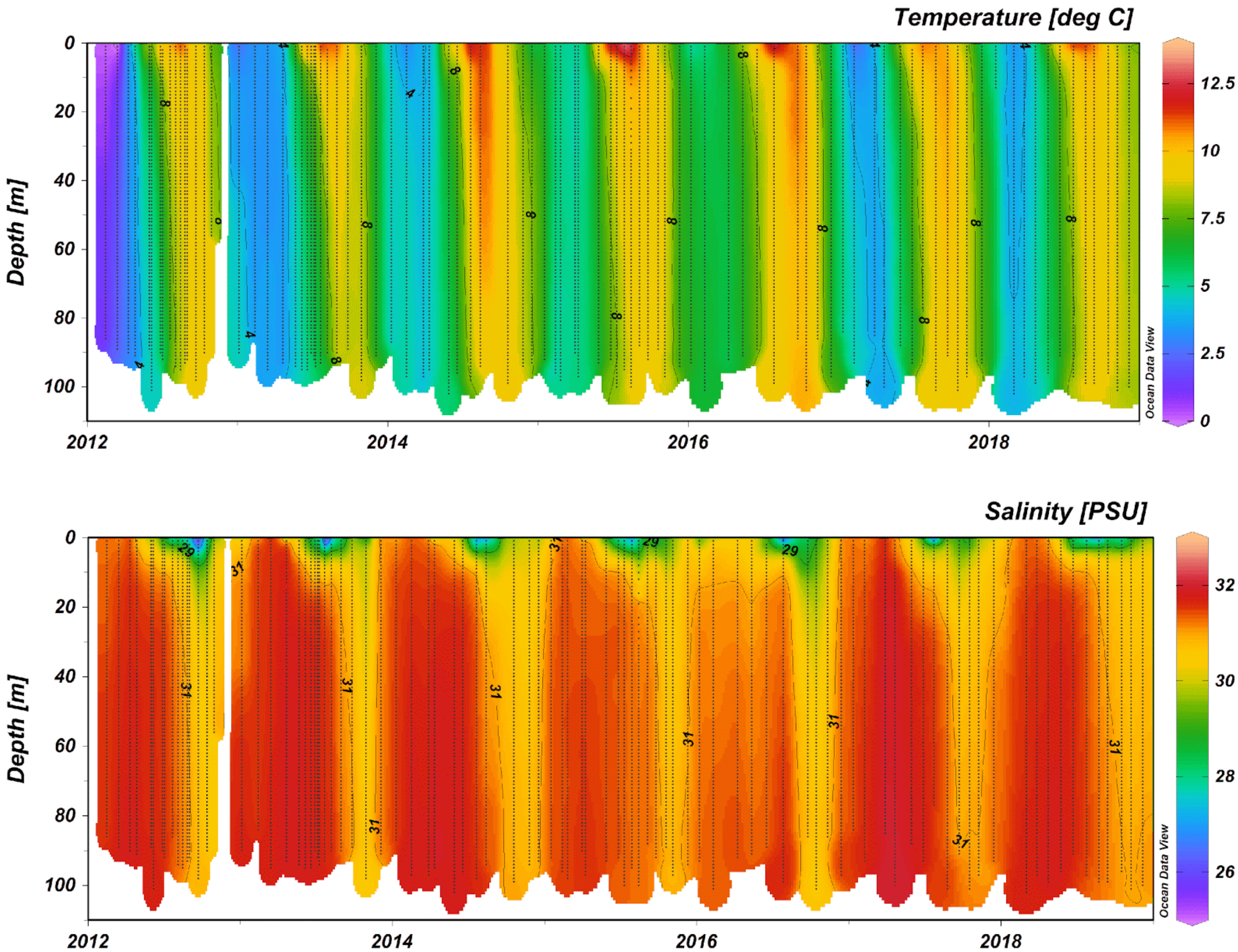

Figure 4. Time series of vertical profiles of water column temperature (top, °C) and salinity (bottom, practical salinity units (PSU)) from 2012-2018 collected from monthly CTD casts at a mid-Kachemak Bay station.

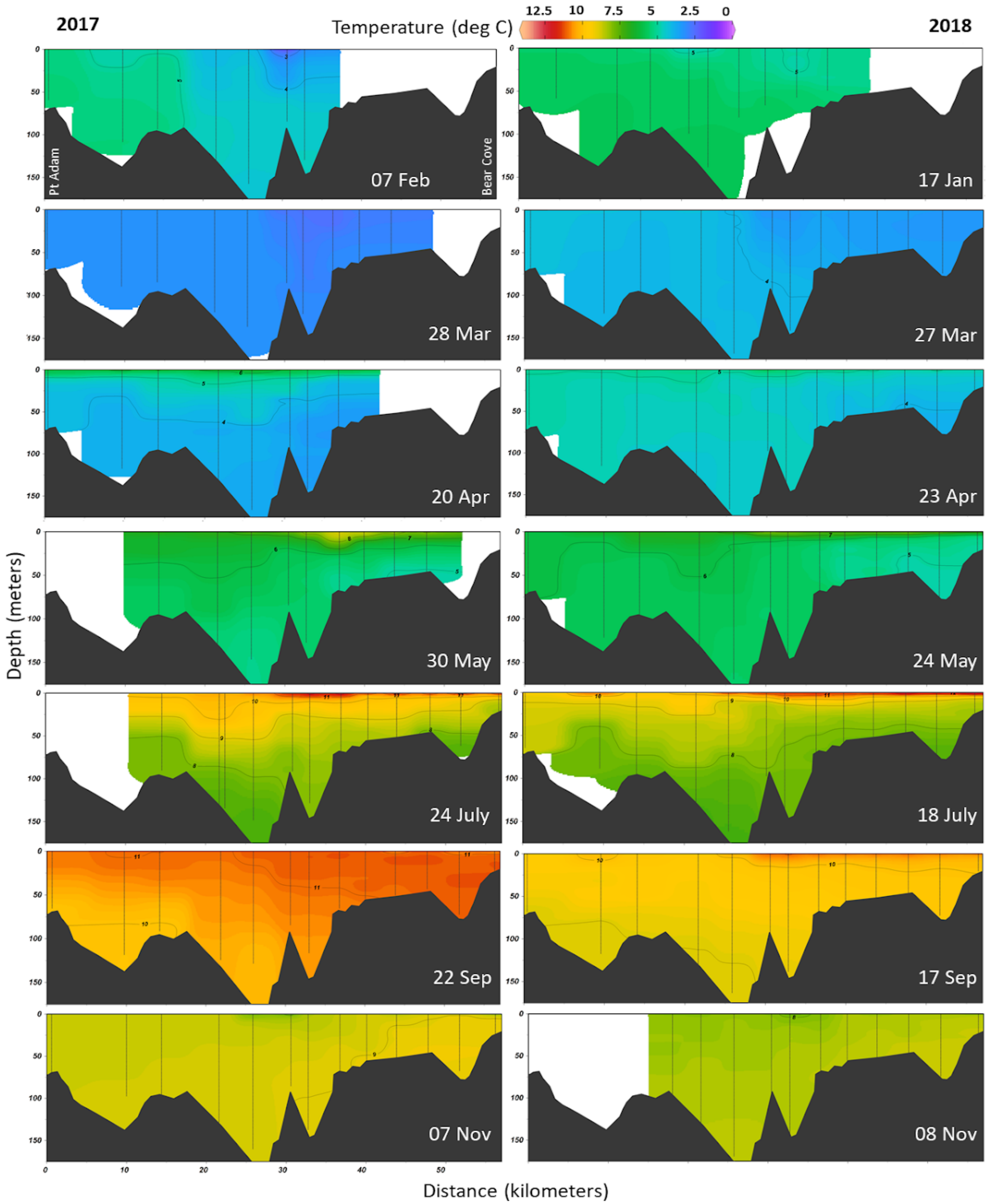

Figure 5a. Comparison of selected 2017 (left column) and 2018 (right column) contours of seasonal variation in temperature from CTD profiler data on the along-Kachemak Bay transect. Sections run from Point Adam (left) in southeast Cook Inlet to Bear Cove (right) at the head of Kachemak Bay. Vertical lines indicate sampling locations. Note that not all sampled months are shown.

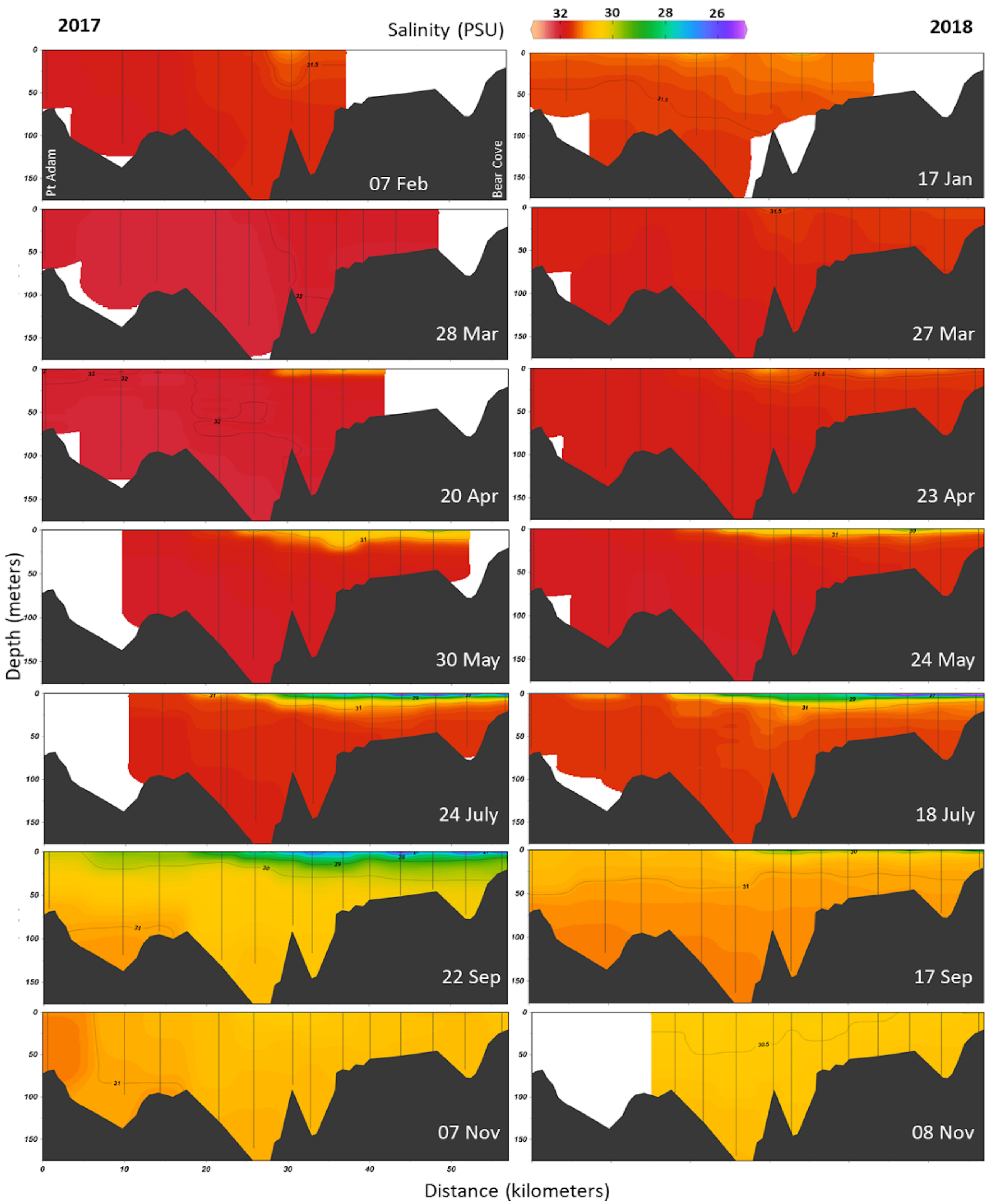

Figure 5b. Same as Figure 5a, but for seasonal contours of salinity from CTD profiler data on the Along-Bay transect in 2017 (left column) and 2018 (right column). Vertical lines indicate sampling locations. Note that not all sampled months are shown.

3. *Zooplankton monitoring* - data analysis has been completed for 2017 data, in collaboration with Rob Campbell and Caitlin McKinstry at the Prince William Sound Science Center (PWSSC). Fig. 6 shows a time series of relative species abundance for the eight most abundant species from 2012 to 2017 for the mid-Kachemak Bay sampling station. In 2017, *Aglantha digitale* and barnacle nauplii were a higher proportion of the zooplankton community in winter and early spring months than in previous years and, compared to 2016, *Limacina helicina* and *Pseudocalanus* spp became relatively more abundant again, similar what to was observed in 2012-2015. In FY19, as part of zooplankton data analyses, we have been working with Rob Campbell to calculate zooplankton abundance anomalies similar to those calculated from GWA zooplankton monitoring data in Prince William Sound (PWS). The patterns obtained from combining all zooplankton data in the study area (Fig. 7) indicate some increase in the abundance of warm water species in 2016, as was observed in PWS, but the shift is not as clear in the aggregate as it is for individual species at different locations. The differences may also reflect relatively cool conditions in Kachemak Bay waters, relative to PWS and the adjacent shelf (Holderied and Weingartner, 2016). We plan to incorporate 2018 zooplankton monitoring data, a seasonal breakdown of zooplankton community composition, and spatial variability between Kachemak Bay and Cook Inlet into these analyses this fall and in FY20.

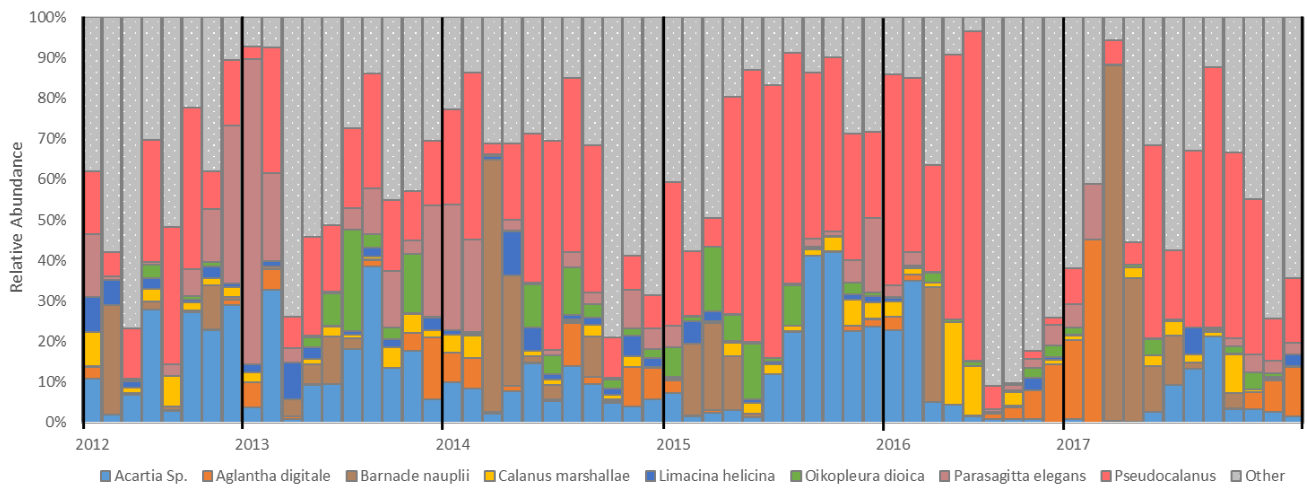

Figure 6. Proportion of zooplankton species contributing most to community abundance in Kachemak Bay from 2012-2017. Samples were collected at the mid-bay station. Species not identified as one of the top eight contributors were combined in the “other” category.

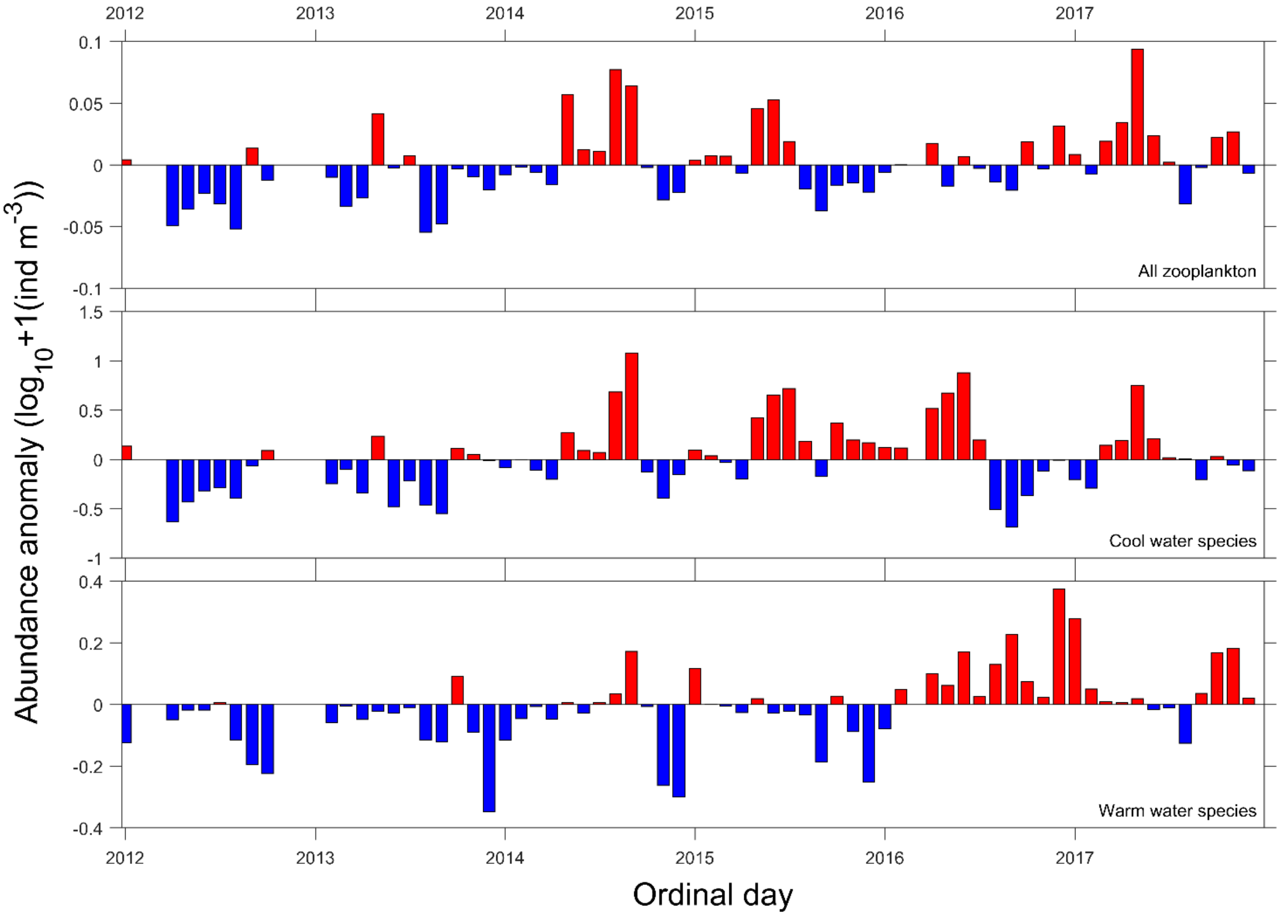

Figure 7. Abundance anomalies of all zooplankton (top panel), warm water copepod species (middle panel) and cool water copepod species (bottom) panel from all Kachemak Bay and Cook Inlet stations, 2012–2017. Observations were $\log_{10}$+1 transformed, averaged by month, and subtracted from the monthly average to produce an anomaly (without detrending). Note that scaling on the y-axis varies among panels. Warm water and cool water species were those identified as indicative by Fisher et al. (2015) and Peterson et al. (2017). Warm water species include *Calanus pacificus*, *Clausocalanus* spp., *Corycaeus anglicus*, *Ctenocalanus vanus*, *Mesocalanus tenuicornis*, and *Paracalanus parvus*. Cool water species are *Calanus marshallae*, *Pseudocalanus* spp., *Acartia longiremis*, and *Oithona similis*. Graphic courtesy of Rob Campbell (PWSSC).

4. *Phytoplankton monitoring* - a surprising finding in 2018 was significantly lower peak phytoplankton abundances than observed in previous years, with lower abundances found consistently in shipboard surveys, intensive sampling at Kasitsna Bay Laboratory dock, and in daily averaged chlorophyll probe data from the KBNERR water quality stations (see 2018 annual report for details). In 2019 we have seen a return to higher abundances of all phytoplankton species, both in the spring bloom with *Chaetoceros* spp. and with *Pseudo-nitzschia* spp. blooms occurring from May-July (Fig. 8).

Leveraging other NOAA/National Centers for Coastal Ocean Science (NCCOS) and Kachemak Bay National Estuarine Research Reserve (KBNERR) efforts, we are monitoring harmful algal species in the project area by quantifying the abundance of *Alexandrium* and *Pseudo-nitzchia* spp. from water samples, as well as collecting shellfish samples from sites around Kachemak Bay and testing the tissues for paralytic shellfish poisoning (PSP) toxins. The toxic phytoplankton (*Alexandrium* spp.) that causes PSP was present in Cook Inlet and Kachemak Bay during each year of the project, with maximum cell concentrations increasing with warm water conditions in

2014-2016 and decreasing with cooler conditions in 2017 through summer 2018 (Fig. 9). Although an increase in *Alexandrium* spp. has been observed in phytoplankton samples from July and early August 2019, shellfish toxicity levels have remained below 35µg of toxin per 100g of tissue (Fig. 10). Despite persistent *Pseudo-nitzschia* blooms in May-July 2019, only low levels of domoic acid have been observed in tested shellfish tissues, which is consistent with results from previous years.

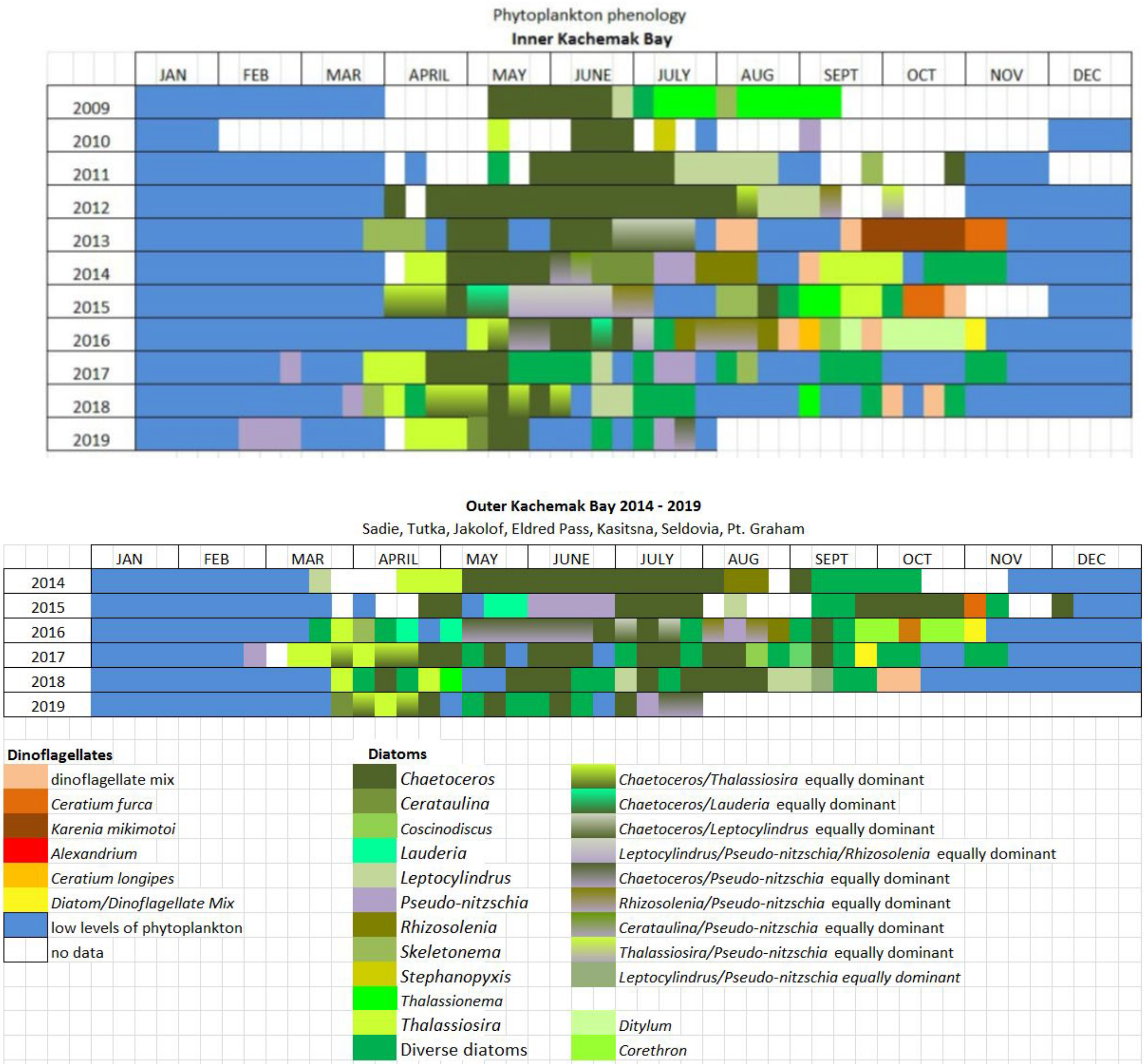

Figure 8. Seasonal and interannual changes in relative abundances of phytoplankton in Kachemak Bay for 2009-July 2019. Data are from samples collected by the Kachemak Bay National Estuarine Research Reserve phytoplankton monitoring network and National Oceanic and Atmospheric Administration Kasitsna Bay Laboratory researchers at locations in the inner bay (top) and outer bay (bottom).

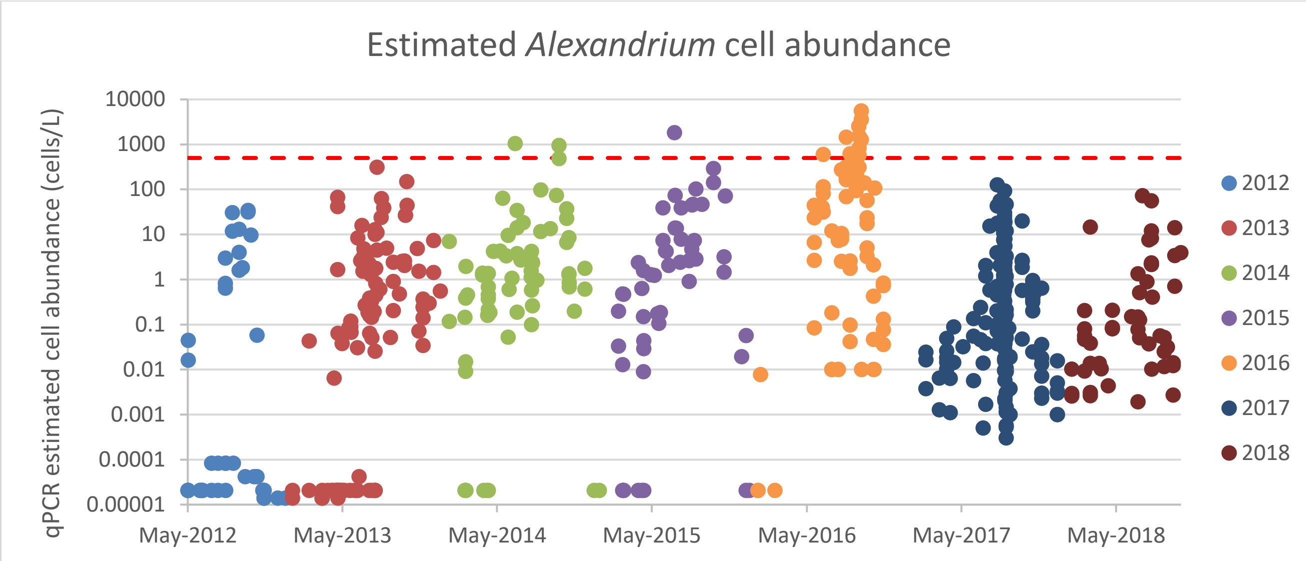

Figure 9. *Alexandrium* cell abundance estimated from quantitative polymerase chain reaction (qPCR) analyses for all phytoplankton samples collected in lower Cook Inlet and Kachemak Bay, 2012-2018. Note logarithmic scale for cell abundance on the y-axis. Paralytic shellfish poisoning toxins are likely to be detected in shellfish tissues for cell abundances above a limit of 500 cells/liter (dashed line on figure).

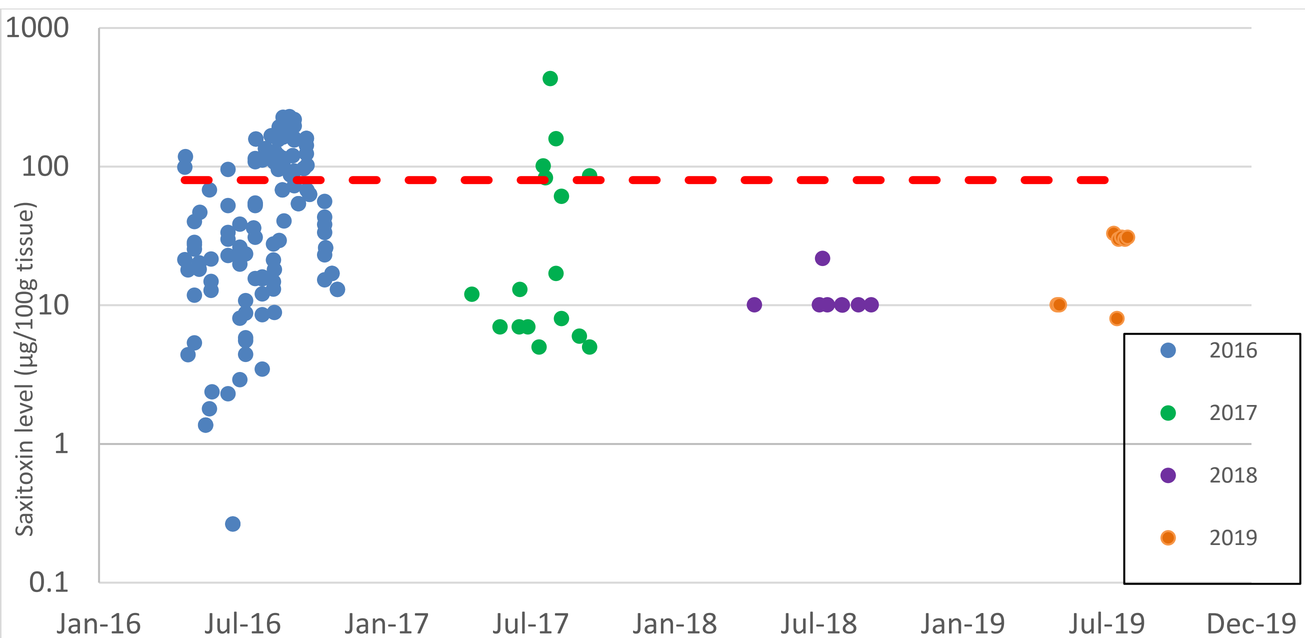

Figure 10. Shellfish tissue toxicity for saxitoxin (paralytic shellfish poisoning [PSP] toxin) from 2016-2019 for samples taken around Kachemak Bay. Note logarithmic scale for the y-axis. Cautionary regulatory limit for PSP toxin (80 µg toxin/100g tissue) for human shellfish consumption is shown as a red dashed line.

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 1. This table breaks down project deliverables and their status into milestones and tasks by fiscal year and quarter, beginning February 1, 2017. Yellow highlight indicates proposed fiscal year workplan. C = completed, X = not completed or planned. Fiscal year quarters: 1 = Feb 1 – April 30; 2 = May 1 – July 31; 3 = Aug. 1 – Oct. 31; 4 = Nov. 1 – Jan. 31.

	FY17				FY18				FY19				FY20				FY21			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Field Sampling																				
Monthly Surveys	C	C	C	C	C	C	C	C	C	C	X	X	X	X	X	X	X	X	X	X
Spring Surveys (all)	C				C*				C				X				X			
Summer Surveys		C				C				C				X				X		
Fall Surveys			C				C				X				X				X	
Winter Surveys	C				C				C				X				X			
SWMP Water quality	C	C	C	C	C	C	C	C	C	C	X	X	X	X	X	X	X	X	X	X
SWMP Nutrients	C	C	C	C	C	C	C	C	C	C	X	X	X	X	X	X	X	X	X	X
SWMP Meteorological	C	C	C	C	C	C	C	C	C	C	X	X	X	X	X	X	X	X	X	X
Milestone 2: Data Delivery	C			C	C			C	C			X	X			X	X			X
Milestone 3: Reporting																				
Annual Reports	C				C				C				X				X			
Annual PI meeting				C				C				X				X				X
Annual Work Plan			C				C				C				X				X	

In addition to the primary project deliverables in Table 1, during the past year we led or contributed to three presentations and participated in three outreach events (see Section 7). Four ecosystem indicators (zooplankton community, temperature, salinity, and HAB anomalies) are being newly developed for the Annual Ecosystem Status Report to the North Pacific Fisheries Management Council and zooplankton data have been compiled for the Suryan et al. GWA synthesis manuscript. We anticipate completing FY19 and FY20 milestones and tasks as planned.

B. Explanation for not completing any planned milestones and tasks

*Due to bad weather during window of boat availability during spring 2018, we were not able to complete the entire entrance line survey in spring 2018. We sampled the southeast side of the entrance with our small boat and completed an extra, extended along-bay transect to characterize spring bloom.

All other sampling, milestones, and tasks for 2018 and first two quarters of 2019 were completed in accordance with our proposal and with sampling protocols available on the GWA Research Workspace.

C. Justification for new milestones/tasks

No new milestones or tasks are proposed for FY20.

3. PROJECT 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 principal investigators (PIs) through teleconferences, joint field work, and PI meetings. We are collaborating with Rob Campbell (PWS oceanography, project 20120114-G) on zooplankton sample processing and data analyses, including zooplankton community anomaly indices (see Fig. 7 above). The project provides year-round, seasonally resolved oceanographic and plankton data and detailed information on along- and across-estuary gradients to the GWA program. Monthly sampling provides year-round oceanographic context for the April to November sampling of the Continuous Plankton Recorder (project 20120114-D) in lower Cook Inlet and the adjacent shelf, as well as for comparison with seasonal oceanographic sampling in PWS (project 20120114-G) and continuous sampling at the GAK-1 mooring (project 20120114-I). We are collaborating with Science Coordinator Rob Suryan (project 20120114-A) and other Environmental Drivers PIs on analyses of oceanographic and zooplankton patterns for FY19 GWA synthesis manuscripts and contributions to the Gulf of Alaska Ecosystem Status Reports for the North Pacific Fishery Management Council.

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 help them assess drivers of intertidal ecosystem changes at Kachemak Bay sites. In FY20 we plan to continue a collaboration assessing nearshore oceanographic variability across the GWA study area, to include new assessments of changing freshwater inputs.

3) Pelagic Component: We provide opportunities to GWA Pelagic component (Kathy Kuletz, US Fish and Wildlife Service [USFWS] project 20120114-M) to host a seabird/marine mammal observer on our shipboard surveys.

Herring Research and Monitoring

We coordinate informally with Scott Pegau (Herring Research and Monitoring program lead) to compare long-term changes in oceanographic patterns across the northern Gulf of Alaska, particularly in nearshore areas.

Data Management

We work closely with the Alaska Ocean Observing System (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 FY19 we worked with Axiom, AOOS, and the Alaska Harmful Algal Bloom Network to improve an online tool for PSP risk assessment that is based on real-time water temperature observations and we plan to expand the spatial extent of these tools to more of the GWA region in FY20.

B. With Other EVOSTC-funded Projects

This project will coordinate with other *Exxon Valdez* Oil Spill Trustee Council (EVOSTC)-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications.

C. With Trustee or Management Agencies

1) NOAA: We collaborate with researchers at the National Ocean Service 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 PSP events. We collaborate with NOAA National Marine Fisheries Service (NMFS) on the NOAA Kachemak Bay Habitat Focus Area, including clam restoration and PSP risk assessment efforts. We provide information on oceanographic conditions and HABs to NMFS Protected Resources staff for whale and sea lion mortalities in Cook Inlet.

2) State of Alaska agencies – Alaska Department of Fish and Game (ADFG) and the Alaska Department of Environmental Conservation (ADEC): We provide real-time and historical trends for water temperature data to shellfish managers with the ADFG (Commercial and Sportfish Divisions, Homer and Kenai) and ADEC (Food Safety and Sanitation Program, Anchorage). We are coordinating with staff from ADEC, ADFG and the Alaska Department of Health and Social Services (Epidemiology Division, Anchorage), as well as with other partners across the state as part of the Alaska HAB Network. Project data help inform management for shellfish management, mariculture operations, harmful algal bloom event response, and marine invasive species monitoring.

3) USFWS: We provide opportunities to Kathy Kuletz of the USFWS Migratory Bird Management office to opportunistically host 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 marine mammal researchers to help understand potential causes of seabird and sea otter mortality events.

4) North Pacific Research Board (NPRB): In FY20 we will continue collaborating with researchers from Oregon State University, PWSSC, and NCCOS on an NPRB-funded, Gulf of Alaska HAB project started in FY19. The project is assessing potential transfers of PSP toxins through the marine food web by monitoring abundances of toxic phytoplankton species and PSP toxin levels in zooplankton, forage fish, salmon, and halibut.

4. PROJECT DESIGN

A. Overall Project Objectives

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 continuous plankton recorder 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 PWS, 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 ADFG, ADEC, NOAA, and USFWS resource managers with assessment of oceanographic trends and seasonal conditions.

B. Changes to Project Design and Objectives

There are no changes proposed to the project design or objectives.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

There are no proposed changes for the project PIs (Holderied and Baird) in FY20. Ben Weitzman (NOAA Kasitsna Bay Laboratory) and Chris Guo (KBNERR) are joining the project team and will provide field sampling and data analysis support. Kim Schuster (previous NOAA contractor) has moved to a position with ADFG this year. Ben Weitzman previously worked in the Nearshore component of the GWA program and will also be assisting with our cross-program data synthesis efforts. With existing project funds, we will hire NOAA Kasitsna Bay Laboratory contract staff to assist with data analysis and oceanographic field work.

6. PROJECT BUDGET

A. Budget Forms (See GWA FY20 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Project Proposal

There is no proposed change to the total budget amount for the project or major budget changes for FY20 from our original proposal. As was done in our FY19 workplan, we propose to move a small amount of funds (~$11K) from the KBNERR to NOAA Kasitsna Bay Laboratory budgets in FY20 to cover additional small boat field work and data analysis efforts by Kasitsna Bay Laboratory contract staff. Due to changes in project personnel in FY19 and NOAA contracting issues (associated in part with the federal government shutdown), we expect that we will not be able to expense all prior-year EVOSTC funds that were obligated to a contract task order for labor services before the task order expires. We plan to de-obligate the funds from the existing contract and we request approval to re-obligate those funds to a new NOAA contract task order. Despite changes in contract personnel, in FY19 we were able to accomplish all field sampling and data analysis support tasks for the project by leveraging additional in-kind KBNERR and NOAA Kasitsna Bay Laboratory staff time. By re-obligating prior year funds, we will be able to expand our data analysis efforts in project year 9 beyond what was originally proposed, without needing additional funding from EVOSTC. Specifically, this will allow us to do more cross-disciplinary data syntheses in Cook Inlet and cross-GWA region data syntheses of oceanographic and plankton data, in collaboration with Rob Suryan and other GWA investigators.

C. Sources of Additional Project Funding

1. KBNERR System-wide monitoring program: This long-term monitoring program provides continuous water quality data in Kachemak Bay for temperature, conductivity, dissolved oxygen, pressure (depth), pH, turbidity and chlorophyll fluorescence (measure of phytoplankton biomass). Water samples are

collected monthly at five sites for nutrients (nitrite + nitrate, ammonium, orthophosphate, and silicate) and chlorophyll. Nutrients are analyzed at the Virginia Institute of Marine Science Lab. Chlorophyll-a and Phaeophytin pigments are analyzed at KBNERR. KBNERR also provides real-time and archival meteorological data (air temperature, relative humidity, barometric pressure, wind speed, wind direction, total solar radiation, precipitation, and photosynthetically available radiation) from two sites to this project. Collectively, these data provide a longer term and continuous context for comparison to data from oceanographic surveys in this project. KBNERR monitoring efforts include approximately $91K in leverage from the NOAA operations grant for KBNERR to cover personnel wages and benefits, travel, analysis contracts, supplies and overhead.

2. NOAA National Ocean Service/ NCCOS/Kasitsna Bay Laboratory and Beaufort Laboratory: NCCOS contributes in-kind federal staff time to the project for field sampling, boat operations, data analysis, project management, and report writing, as well as in-kind contributions of oceanographic equipment and small boat support. We also leverage separate NCCOS HAB research efforts, including monitoring and laboratory analysis for toxic phytoplankton species and toxins. For project leveraging, we estimate contributions of $65K/year for direct, in kind NCCOS federal staff support to the project, including from Kris Holderied (PI, field work, data analysis, reports), Dominic Hondolero (field work, data analysis, reports) and Mike Geagel (boat support) with NCCOS Kasitsna Bay Laboratory, and Steve Kibler (HAB field work, data analysis) and Mark Vandersea (laboratory and data analysis for toxic algae) with NCCOS Beaufort Laboratory. Ben Weitzman will be contributing staff time to the project as new NOAA federal staff at Kasitsna Bay Laboratory, but his time is not included in the FY20 estimate for leveraged funds. We are also not including an estimate for in-kind use of Kasitsna Bay Laboratory equipment and small boats.

3. NOAA Kasitsna Bay Laboratory and AOOS: NOAA KBL and AOOS have an ongoing collaboration to assess oceanography, ocean acidification and HAB conditions in Kachemak Bay, and to develop risk assessment tools for paralytic shellfish poisoning. AOOS plans to provide $25K in FY20 to support these efforts, subject to availability of federal funds.

7. FY17-19 PROJECT PUBLICATIONS AND PRODUCTS

<u>*Publications*</u>

Bentz, S., M. Johnson, G. Gibson, S. Baird, and J. Schloemer. 2018. 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. 45pp.

Doroff, A., and K. Holderied. 2018. 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 Long-term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120114-G), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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. 41pp.

Holderied, K., and S. Baird. 2019. Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120114-J.

Holderied, K., and J. Shepherd. 2018. Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species. FY17 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-J.

Vandersea, M.W., S.R. Kibler, P.A. Tester, K. Holderied, D.E. Hondolero, K. Powell, S. Baird, A. Doroff, D. Dugan, R.W. Litaker. 2018. Environmental factors influencing the distribution and abundance of *Alexandrium catenella* in Kachemak Bay and lower Cook Inlet, Alaska. *Harmful Algae*, 77:81-92. https://doi.org/10.1016/j.hal.2018.06.008

Vandersea, M.W., S.R. Kibler, S.B. Van Sant, P.A. Tester, K. Sullivan, G. Eckert, C. Cammarata, K. Reece, G. Scott, A. Place, K. Holderied, D. Hondolero, and R.W. Litaker. 2017. qPCR assays for *Alexandrium fundyense* and *A. ostenfeldii* (Dinophyceae) identified from Alaskan waters and a review of species-specific *Alexandrium* molecular assays. *Phycologia* 56:303-320.

Walsh, J.R., R. Thoman, U.S. Bhatt, P.A. Bieniek, B. Brettschneider, M. Brubaker, S. Danielson, R. Lader, F. Fetterer, K. Holderied, K. Iken, A. Mahoney, M. McCammon, and J. Partain. 2018. The high latitude marine heat wave of 2016 and its impacts on Alaska [in "Explaining Extreme Events of 2016 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.* 99 (1). S39-43. doi:10.1175/BAMS-D-17-0105.1

Published and updated datasets

DataONE Published Datasets

Doroff, A., Holderied, K. 2018. 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/rw1k21f.

Holderied, K., Powell, K., Doroff, A. 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., Doroff, A. 2018. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Zooplankton 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/rw1k21g.

Gulf of Alaska Data Portal

Holderied, K. Baird, S., Schloemer, J., Schuster, K. 2019. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Meteorological and Nutrient Data, 2017, Gulf Watch Alaska Environmental Drivers Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.

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Research Workspace

Holderied, K. Baird, S., Schloemer, J., Schuster, K. 2019. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Meteorological and Nutrient Data, 2018, Gulf Watch Alaska Environmental Drivers Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.

Holderied, K. Baird, S., Schloemer, J., Schuster, K. 2019. Oceanographic Monitoring in Cook Inlet and Kachemak Bay, Water Quality Data, 2018, Gulf Watch Alaska Environmental Drivers Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.

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Presentations

Holderied, K. 2018. Alaska Coastal Science and Management Examples. **Oral presentation** at Joint Polar Satellite System Arctic Summit, Anchorage, AK. May 2018.

Holderied, K. and E. Ammann. 2017. Improving shellfish restoration and habitat assessment in coastal Alaska: Kachemak Bay Habitat Focus Area. **Oral presentation** at Coastal and Estuarine Research Federation conference. Providence, RI. Nov 2017.

Holderied, K., D. Hondolero, S. Kibler, M. Vandersea, A. Doroff, J. Schloemer, and S. Buckelew. 2017. Using coastal Alaska marine responses to the 2014-2016 Pacific Warm Anomaly to improve risk assessment for climate-driven increases in paralytic shellfish poisoning events. **Oral presentation** at Climate Predictions Applications Science Workshop. Anchorage AK. May 2017.

Holderied, K., K. Powell, S. Baird, and J. Schloemer. 2018. Variability in estuarine salinity and stratification in Kachemak Bay, Alaska from 2012-2017. **Poster presentation** at Alaska Marine Science Symposium, Anchorage AK. Jan 2018.

Holderied, K., K. Powell, J. Schloemer, S. Baird, and D. Hondolero. 2018. Heating up and cooling off in Kachemak Bay Alaska – what does it mean for the marine ecosystem? **Oral presentation** at the Kachemak Bay Science Conference, Homer, AK. Mar 2018.

Holderied, K., K. Powell, J. Schloemer, and D. Hondolero. 2018. Variability in nearshore and estuarine oceanography in the northern Gulf of Alaska: 2004-2017. **Poster presentation** at 2018 Ocean Sciences Meeting, Portland, OR. Feb 2018.

Holderied, K., J. Schloemer, K. Powell Schuster, S. Baird, and D. Hondolero. 2019. Seasonal and spatial variability in ocean acidification conditions in Kachemak Bay and Cook Inlet Alaska. **Poster presentation** at Alaska Marine Science Symposium, Anchorage AK. Jan 2019.

Hondolero, D, Vandersea, M, Holderied, K, Kibler, S, Powell, K, Baird, S, Doroff, A, Litaker, W. 2018. Environmental factors affecting toxic phytoplankton plankton in Kachemak Bay. **Oral presentation** at the Kachemak Bay Science Conference, Homer, AK. Mar 2018.

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Powell Schuster, K., K. Holderied, J. Schloemer, and D. Hondolero. 2019. Variability of zooplankton abundance and community structure in Kachemak Bay and lower Cook Inlet Alaska: 2012-2017. **Poster presentation** at Alaska Marine Science Symposium, Anchorage AK. Jan 2019.

Renner, M., K. Holderied, K. Powell, D. Hondolero, J. Schloemer, A. Doroff, and K. Kuletz. 2018. Ecosystem variability in Lower Cook Inlet across trophic levels, space, seasons, and climate regimes. **Oral presentation** at Alaska Marine Science Symposium, Anchorage, AK. Jan 2018.

Schloemer, J., S. Baird, S. Bentz, M. Johnson, and R. Masui. 2019. Using circulation mapping and long-term water quality data to aid community monitoring programs in Kachemak Bay, Alaska. **Poster presentation** at Alaska Marine Science Symposium, Anchorage AK. Jan 2019.

Vandersea, M., P. Tester, K. Holderied, D. Hondolero, S. Kibler, K. Powell, S. Baird, A. Doroff and W. Litaker. 2018. Distribution and abundance of Alexandrium catenella in Kachemak Bay and Lower Cook Inlet, Alaska. **Poster presentation** at Alaska Marine Science Symposium, Anchorage, AK. Jan 2018.

Outreach

Aderhold, D., S. Buckelew, M. Groner, K. Holderied, K. Iken, B. Konar, H. Coletti, and B. Weitzman. 2018. GWA and HRM information exchange event with community in Port Graham, AK, May 2018.

Holderied, K. 2017. What's up with the Blob? Public evening talk. Alaska Islands and Ocean Visitor Center. Homer AK. Feb 2017.

Holderied, K. 2017. Solving Alaska Ocean Mysteries – connections matter. Keynote address. Northwest Aquatic and Marine Educators Annual Conference. Homer AK. Aug 2017.

Holderied, K. 2019. Kachemak Bay Oceanography. Alaska Department of Fish and Game Razor Clam Summit. Homer AK. Apr 2019.

Holderied, K., Hondolero, D., Konar, K., Weitzman, B., Kloecker, K. 2019. GWA evening science talks for community in Seldovia AK. May 2019.

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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.

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August 12, 2019

To: EVOS Trustee Council

Subject: Letter of AOOS Matching Support for the Gulf Watch Alaska (GWA) Nearshore Component: Oceanographic Conditions in Lower Cook Inlet and Kachemak Bay

Dear EVOS Trustee Council Members,

I am writing in response to your requirement (FY20 Workplan Section 6C) for documentation of in-kind contributions that comprise the Alaska Ocean Observing System (AOOS) cost-share for the GWA Program Environmental Drivers Component: *Oceanographic Conditions in Lower Cook Inlet and Kachemak Bay* (PI Kris Holderied). The need for routine oceanographic observations in Cook Inlet and Kachemak Bay has been identified as a high priority in regional workshops and stakeholder meetings sponsored over the past decade by AOOS and other regional federal, state and local organizations. AOOS has been supporting monitoring activities in Kachemak Bay and Lower Cook Inlet consistently during the EVOSTC funded efforts there. AOOS plans to continue its support through the five-year NOAA Grant #NA16NOS0120027award ending in year 2021.

AOOS support during this 5-year program is as follows:

- June 1 - May 31, 2017 $25,000
- June 1 - May 31, 2018 $25,000
- June 1 - May 31, 2019 $25,000

In-kind support for June 1 – May 31, 2020 is currently planned at $25,000, contingent on annual federal funding levels, which are expected to remain level through 2021. AOOS expects to have sufficient funds to continue meeting our matching fund obligations to this project. That said, Federal budgets are authorized on an annual basis and the date of our funding and amount of funds we receive varies from year to year.

Please notify me of any additional questions or needed clarifications relative to the AOOS contributions.

Sincerely,

Molly McCammon
Executive Director
AOOS