EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY21 (YEAR 10) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Component Project

21120114-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 14, 2020

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 a 9-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 harmful algal species. The project provides oceanographic and plankton data to support the Gulf Watch Alaska 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 remained anomalously warm through December 2019 (up to 2°C above average), but cooled rapidly in January 2020 with colder air; 2) zooplankton community species composition and phenology changed during the marine heatwave, but not overall abundance; and 3) harmful phytoplankton species continue to be detected and project data are being used to assess environmental drivers of harmful algal blooms as well as toxin transfer in the marine food web. Due to COVID-19 restrictions, we were unable to complete some small boat surveys in FY20 (Feb-July). Nutrient samples were not collected and water quality sondes were not switched out from March - June at Seldovia, and April - May at Homer.

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**	**$192,000**	**$1,007,800**

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 FY21 we propose to continue a 9-year time-series of shipboard oceanography and plankton surveys along the estuarine gradient from Kachemak Bay into southeast Cook Inlet, as well as a 19-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. Project data also complement environmental driver data collected in other regions, from Prince William Sound to the Gulf of Alaska offshore from Seward. 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 (Anderson and Piatt 1999, Mackas et al. 2007), 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 (Fig. 1). 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 mooring in Bear Cove as part of the Kachemak Bay National Estuarine Research Reserve's (KBNERR's) system-wide monitoring program (SWMP) (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 FY21 will investigate whether the observed warming in 2019 returns following the cooling of early 2020 and if plankton community response is similar to what was observed during the 2014-2016 marine heatwave. 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 FY21 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.

Kachemak Bay monthly shipboard oceanographic and plankton surveys in April and May 2020 and the April 2020 Cook Inlet entrance sampling were not conducted due to COVID-19-related restrictions on small boat fieldwork. A limited (CTD only) survey was conducted in early June and a complete quarterly CTD and plankton survey was conducted in July 2020, with reduced field crew and new COVID-19 protocols. Also due to COVID-19 restrictions on field work and local travel, the instruments recording continuous data for KBNERR's long-term water quality monitoring program (normally swapped monthly) were not serviced from March through May or June (depending on the station). While these instruments continued to collect data, the longer sensor deployments may affect data quality, which will be evaluated during the data QA/QC process.

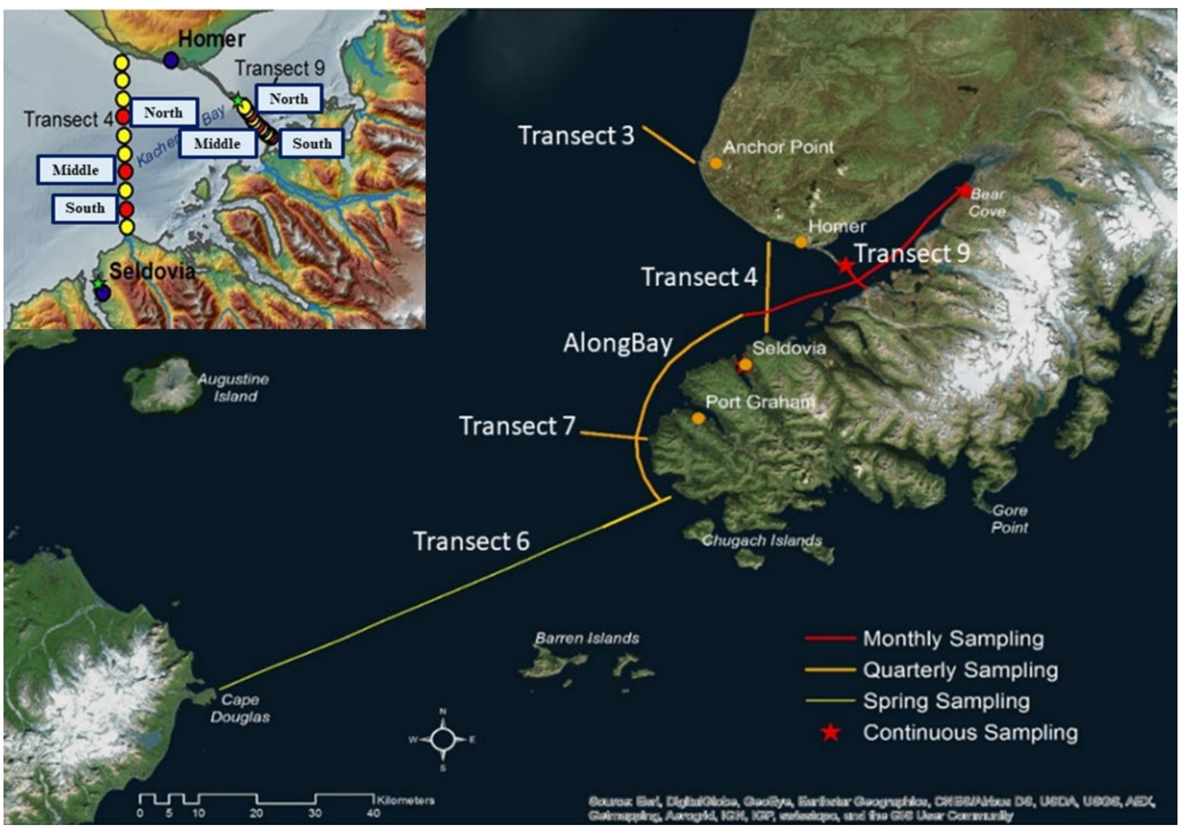

Figure 1. Map of the lower Cook Inlet/ Kachemak Bay study area with FY17-21 sampling transect locations and sampling frequency. Red stars depict continuous water quality monitoring station locations at Seldovia, Homer and Bear Cove. Inset map shows location of cross-bay sampling stations in Kachemak Bay (red dots indicate locations of plankton sampling). See FY19 annual report for map with individual station locations.

Selected Results

In FY20 (year 9 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 monitoring*

Water quality station data from Kachemak Bay show that water temperatures were warmer and fresher throughout 2019 than in the previous two years, with temperature anomalies up to 2°C above the long-term average (Fig. 2). Temperature anomalies were as warm or warmer than those observed during the 2014-2016 Pacific marine heatwave (Fig. 2). These temperatures may have been partially driven by 18 consecutive months of warm air temperature anomalies through December 2019. However, air temperature anomalies from January through March 2020 showed colder than normal air temperatures, with January 2020 being the 2nd most anomalously cold month in our 17-year data record for the Homer Spit station. Water temperatures in Kachemak Bay returned to near average or slightly cool from January through May 2020 (Fig. 2).

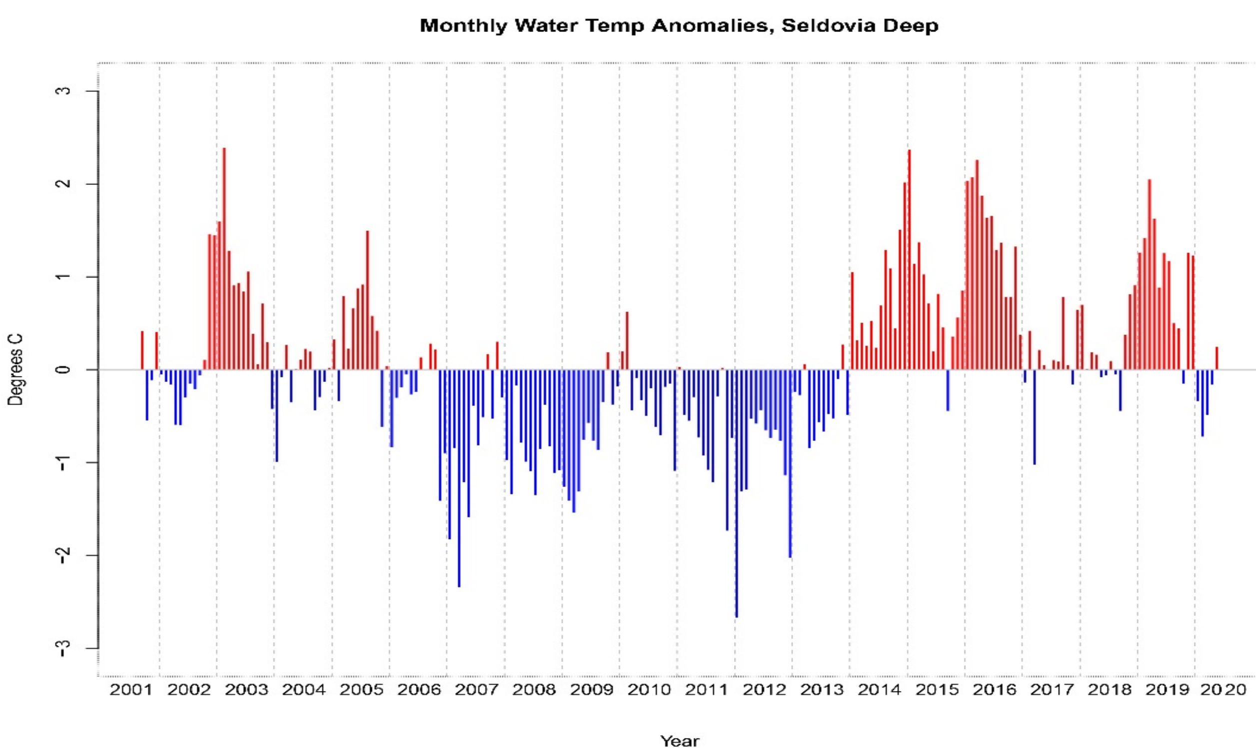

Figure 2. Monthly average water temperature anomalies (red bars-warm, blue bars-cool) calculated from continuous data from the near-bottom sensor at the Seldovia harbor Kachemak Bay National Estuarine Research Reserve water quality monitoring station from May 2001 to May 2020 (against the 2002-2018 monthly means).

2. *Shipboard oceanographic observations*

Results from small boat surveys show that water column temperature patterns in 2019 were similar to temporal shifts observed at the water quality stations, with warmer temperatures observed throughout the water column in both winter and summer, relative to 2017 and most of 2018. Fig. 3 provides an example of a temperature (top) and salinity (bottom) time series for the entire study period from one CTD station on the cross-bay transect in the middle of Kachemak Bay. Winter water column temperatures were as warm as those observed during the 2014-2016 marine heatwave and 2019 summer temperatures were warmer throughout the water column than seen during any previous project year, reflecting the hot, dry summer weather. Somewhat surprisingly, given the moderate drought conditions experienced from June to August 2019, the salinity time series (Fig. 3, bottom) showed little difference in timing and intensity of seasonal summer freshening of near-surface waters. Along with similar temporal patterns in salinity observed at the Homer SWMP station (see FY19 annual report), the water column observations indicate that the lack of rain may have been balanced by increased inputs of glacial meltwater associated with the persistent sunny weather and warm summer air temperatures (results presented in January 2020 Alaska Marine Science Symposium talk by Holderied). The CTD observations also show rapid cooling throughout the water column in January 2020, in response to the anomalously cold air temperatures, with the coldest temperatures observed since early 2012.

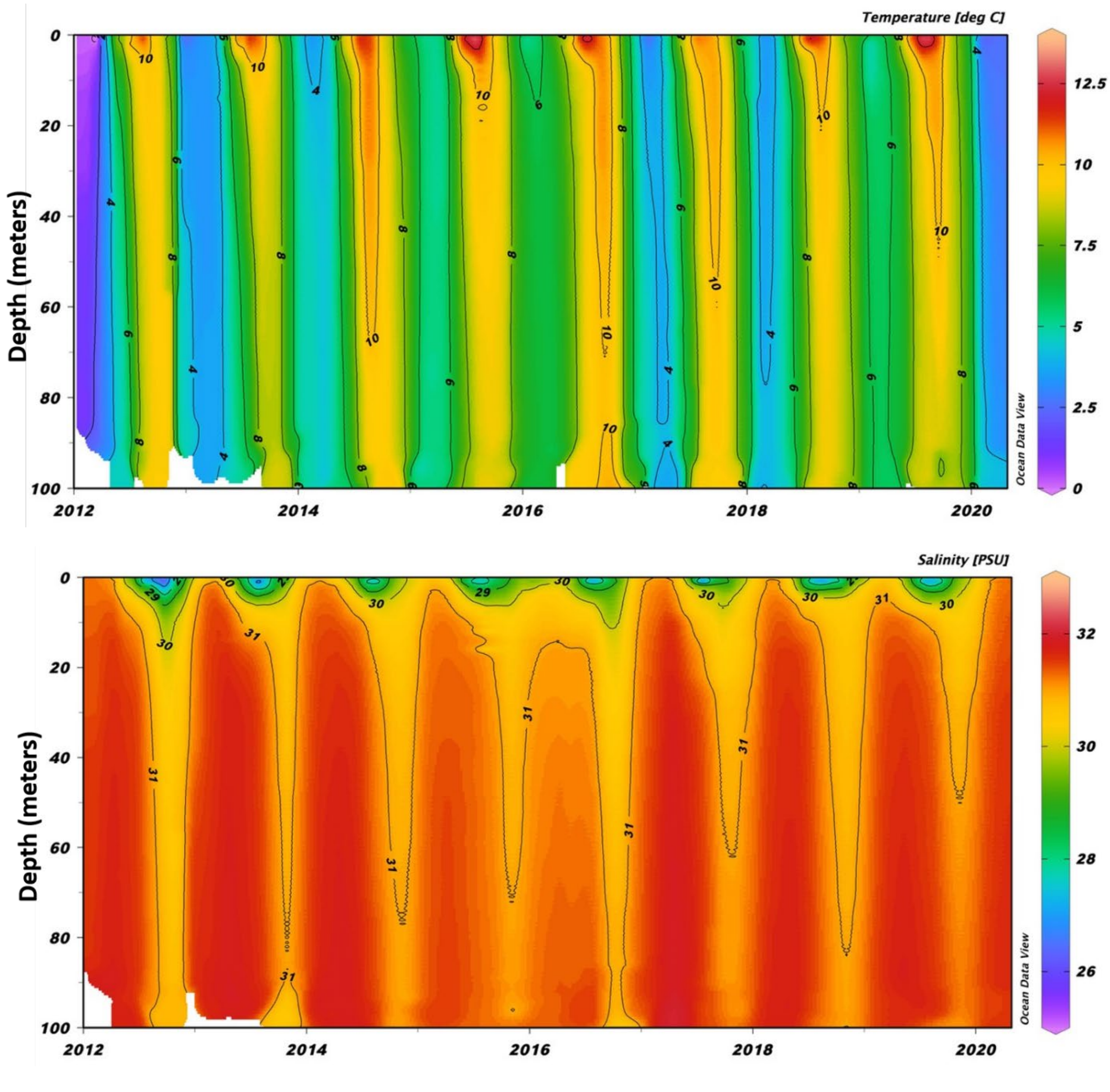

Figure 3. Time series of vertical profiles of water column temperature (top, °C) and salinity (bottom, practical salinity units, PSU) from 2012 to March 2020, collected from monthly CTD casts at a mid-Kachemak Bay station. Note cold temperatures throughout water column in February/March 2020.

Due to prolonged cold and stormy weather and marine icing conditions, small boat sampling of the Cook Inlet stations (along Transects 3, 6, and 7) outside Kachemak Bay was not completed in February 2020, but we were able to sample all oceanographic and plankton stations in Kachemak Bay (on Transects 9, 4, and along-bay transect). After not being able to conduct ship surveys in April and May 2020 due to COVID-19 restrictions, we resumed CTD sampling in June and CTD and plankton sampling in July. In July 2020 we were also able to conduct additional oceanographic sampling along our inner Kachemak Bay CTD stations at the same time when intensive stream measurements were being made and drifter buoys were deployed to track freshwater plume dispersion in the bay. The sampling is part of a National Science Foundation-funded Established Program to Stimulate Competitive Research (EPSCOR) Fire and Ice project to investigate the effects of glacial watershed coverage on freshwater inputs to the estuary and on nearshore ecosystems (PIs Dr. Brenda Konar, University of Alaska Fairbanks [UAF], and Dr. Lee Ann Munk, University of Alaska Anchorage [UAA]). Both GWA and EPSCOR researchers plan to conduct monthly sampling Kachemak Bay in August and September, which will produce combined summer observations of oceanography, plankton, freshwater inputs, and nearshore fish populations for both 2019 and 2020. For FY21 we plan to expand analyses of oceanographic patterns across the GWA study region done in FY20, as part of GWA synthesis efforts, to examine seasonal linkages between the bay and waters of the adjacent shelf (using GAK-1 mooring, Seward Line, Continuous Plankton Recorder, and Kachemak Bay nearshore data), as well as comparing with estuary conditions in Prince William Sound. We also plan to build on the 2020 GWA science synthesis efforts and conduct additional cross-component data analyses in Kachemak Bay, using GWA oceanographic and nearshore data, to assess in more detail how changing marine conditions affect spatial and temporal variability in rocky intertidal ecosystems.

3. *Zooplankton monitoring*

Zooplankton sample identification and data processing has been completed for the 2018 Kachemak Bay and Cook Inlet samples, in collaboration with Rob Campbell and Caitlin McKinstry at the Prince William Sound Science Center (PWSSC), and analysis of 2019 samples is ongoing. Results from analyses of the effect of the marine heatwave on zooplankton community structure were presented by McKinstry in a poster at the Ocean Sciences Meeting in February 2020 and we are collaborating with Campbell and McKinstry on a manuscript to assess spatial and temporal variability in zooplankton community composition in Kachemak Bay and lower Cook Inlet. 2018 zooplankton data were incorporated into a time series of zooplankton abundance anomalies calculated by combining all zooplankton samples in the study area (Fig. 4), with results indicating that warm water copepod species increased during the heatwave year of 2016, but also in the latter part of 2017, under more average oceanographic conditions. Warm water copepod species declined and cool water species increased in 2018, which had near normal marine for most of the year (Figs. 2 and 3). In addition to these changes in zooplankton community composition, there were temporal shifts in seasonal transitions in zooplankton communities during warmer years (see FY19 annual report for details). Temporal patterns in overall zooplankton abundance did not show a clear relationship with the marine heatwave or warmer years through 2018 (Fig. 4), and it will be interesting to see how zooplankton abundance and community structure changed during the anomalously warm spring and summer of 2019.

The 2012-2018 zooplankton data have also been used to analyze seasonal progression in zooplankton community composition in detail. Fig. 5 shows example results with a non-metric multidimensional scaling (nMDS) analysis plot for 2012-2018 data from monthly sampling on the mid-Kachemak Bay transect. Incorporation of 2018 data did not significantly change the seasonal breakdown obtained from analyzing data only through 2017 (results in the FY19 annual report).

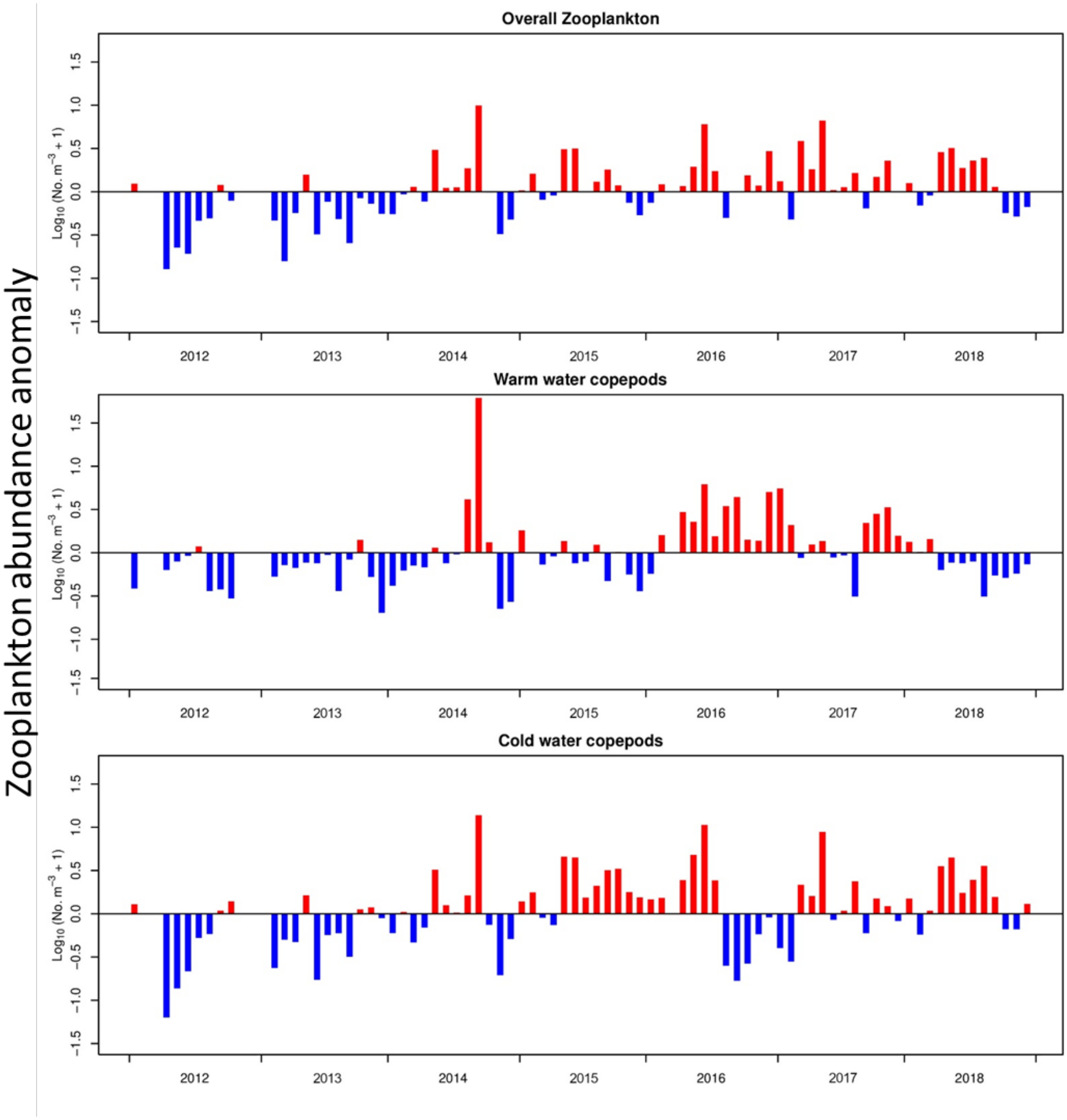

Figure 4. Abundance anomalies of all zooplankton (top panel), warm water copepod species (middle panel) and cool water copepod species (bottom) panel from all Kachemak Bay and Cook Inlet stations, 2012–2018. Observations were log10+1 transformed, averaged by month, and subtracted from the monthly average to produce an anomaly (without detrending). 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 Caitlin McKinstry (Prince William Sound Science Center).

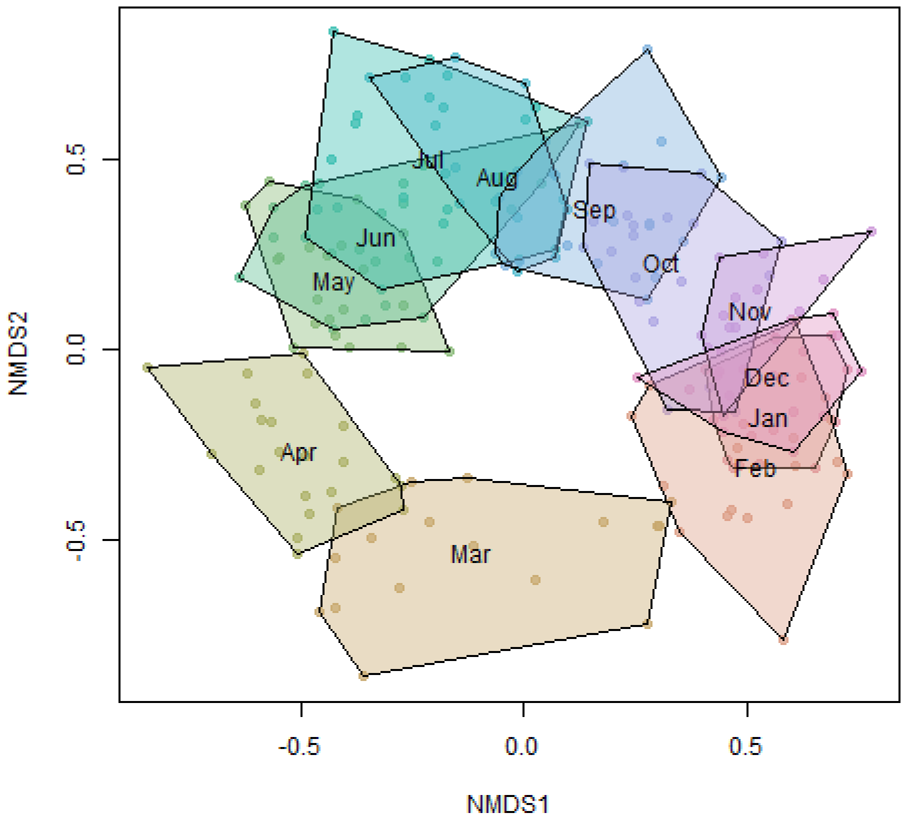

Figure 5. Non-metric multidimensional scaling (nMDS) plot using zooplankton community composition analysis from 2012-2018 net tow samples collected monthly along the mid-bay transect across Kachemak Bay (Transect 9). Samples are colored and connected by month to show seasonal progression in community structure.

Results of indicator species analyses (ISAs) illustrate how zooplankton communities vary temporally and spatially in the study area, including between the more estuarine communities in Kachemak Bay and more pelagic mix of plankton species in Cook Inlet (Fig. 6). Cook Inlet and Kachemak Bay zooplankton community composition displayed a seasonal progression from *Neocalanus* spp. and ichthyoplankton in early spring, switching to a meroplanktonic larval group in late spring, and then to a fall gelatinous plankton and warm water copepod community (Fig. 6c). In 2016, during the core of the marine heatwave, the timing of community transitions shifted, with the late spring group emerging earlier in the year and the fall group persisting into winter months.

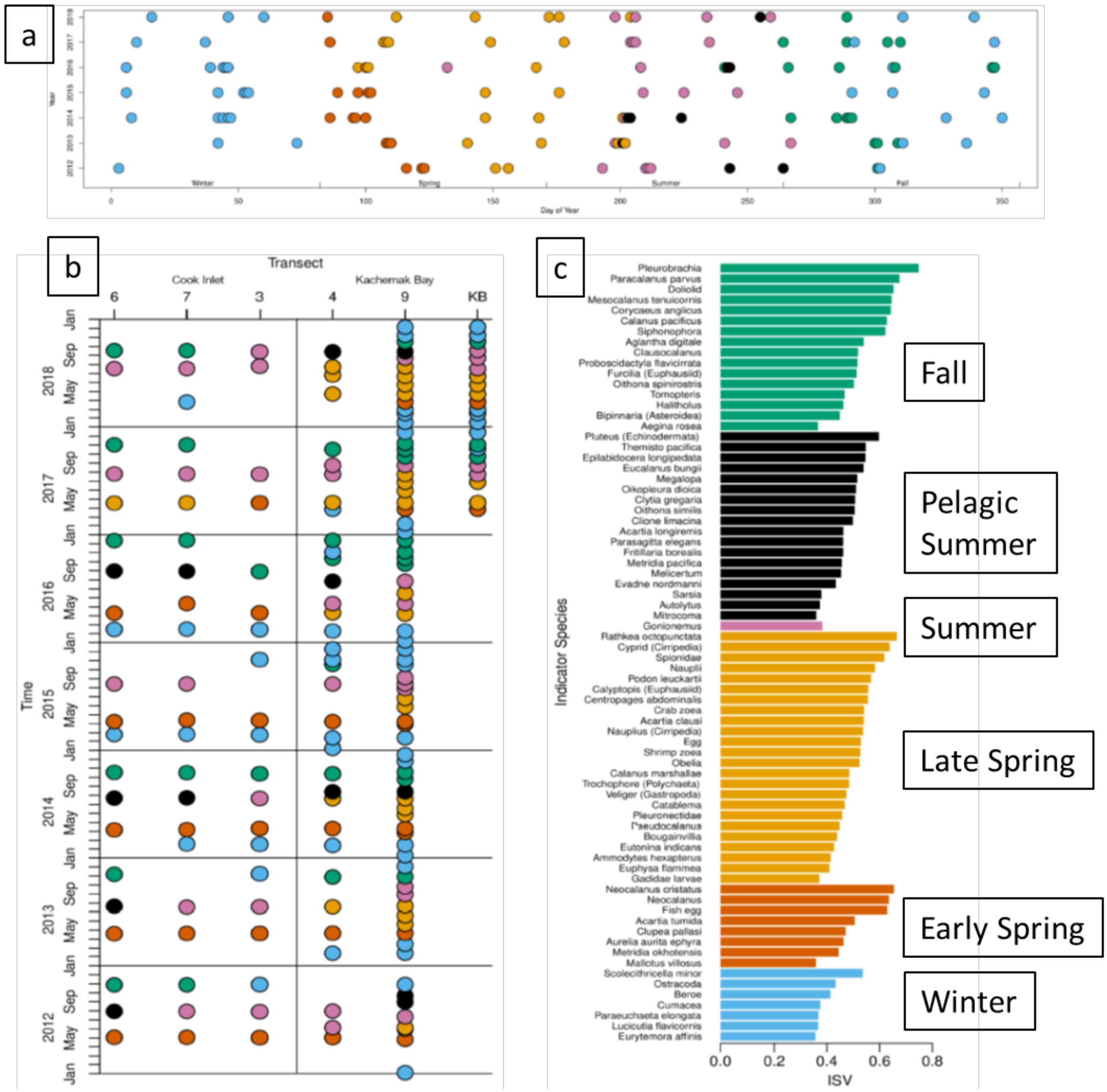

Figure 6. Kachemak Bay and Cook Inlet seasonal zooplankton community transition analysis (2012-2018). Colors correspond to indicator species analysis (ISA) groups for each sampling tow produced by hierarchical clustering analysis and non-metric multidimensional scaling analysis. a. ISA groups plotted by year (vertical axis) and day of year to show seasonal transition of communities. b. Splat plot of time and ISA groups averaged over each transect (n = 196). c. Indicator species values (ISVs) that defined each group produced by hierarchical clustering analysis. Of the 88 species/categories included in the analysis, the 74 most significant ($p < 0.05$) are presented.

4. *Phytoplankton monitoring*

Our monitoring efforts in 2020 have shown no abnormal phytoplankton blooms through the end of July 2020. We had a typical early diatom bloom in April/May that has since subsided, and we are currently seeing a proportional rise in dinoflagellate species at the end of July. We closely monitor the samples for toxic phytoplankton (*Alexandrium* spp.) that can produce the saxitoxins which causes paralytic shellfish poisoning (PSP). The PSP threat to coastal Alaska communities was sadly evidenced by a PSP-related death this summer in Unalaska. Potentially harmful species are present in samples from Kachemak Bay throughout the year (Fig. 7) but are most common and more abundant in warmer months (Vandersea et al. 2018). *Alexandrium* species have been 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, decreasing with cooler conditions in 2017 and 2018, and remaining lower than expected in warmer conditions in 2019 (Fig. 8). Shellfish toxicity levels remained below regulatory limits for human consumption so far 2020 (Fig. 9), though a July butter clam sample tested just below the threshold. Despite sporadic *Pseudo-nitzschia* blooms in the spring and late fall, only low levels of domoic acid have been observed in tested shellfish tissues in 2019 and 2020, which is consistent with results from previous years (results not shown).

In addition to shellfish toxin testing, we are also leveraging GWA sampling efforts to examine the prevalence of saxitoxins from *Alexandrium* the food web by collecting additional zooplankton and phytoplankton samples during our regular monitoring efforts and analyzing them to determine toxin concentrations (North Pacific Research Board [NPRB] project #1801, Prevalence of paralytic shellfish toxins the marine food web of southcentral and southwest Alaska). As part of this food web project, we are also collecting forage fish and predator fish samples for toxin testing. Samples for this project are being collected in Kachemak Bay, Prince William Sound, and the Alaska Peninsula/Aleutian Islands. The forage fish samples are analyzed whole and the predator fish samples are sub-sampled by muscle tissue, digestive organs, liver, kidney, and stomach content. Our results from 2019 show that saxitoxins were present in both forage fishes and predator fishes. Dolly Varden (*Salvelinus malma*), Pacific sand lance (*Ammodytes hexapterus*), and Pacific herring (*Clupea pallasii*) samples were collected that were above the regulatory limit for safe consumption (Fig. 10). Sand lance and herring are of particular concern because they were commonly found in the stomachs of predator fish. Predator fish samples were collected for Pacific halibut (*Hippoglossus stenolepis*), pink salmon (*Oncorhynchus gorbuscha*), sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), and king salmon (*Oncorhynchus tshawytscha*). The halibut samples we collected were all below the regulatory limit for all tissues. The salmon samples showed higher levels of toxin differing among species and tissue types, with the highest levels in king salmon kidneys and red salmon livers, which had samples that exceeded the regulatory limit for safe consumption of 80 micrograms of toxin per 100 grams of tissue (Fig. 10). Although the high numbers in the kidney and liver are concerning, the samples from muscle tissues have so far showed levels of toxin below the regulatory limits, possibly indicating that the fishes are able to metabolize and excrete the toxins without accumulating them in muscle tissues which are more typically consumed. However, the relatively low abundances of *Alexandrium* observed in water samples in 2019 may be confounding our efforts to conduct toxin testing in both forage and predator fishes. We plan to continue sampling for food web toxin transfers to the extent possible with COVID-19 restrictions through the rest of 2020, with additional sampling planned in 2021 under the NPRB project.

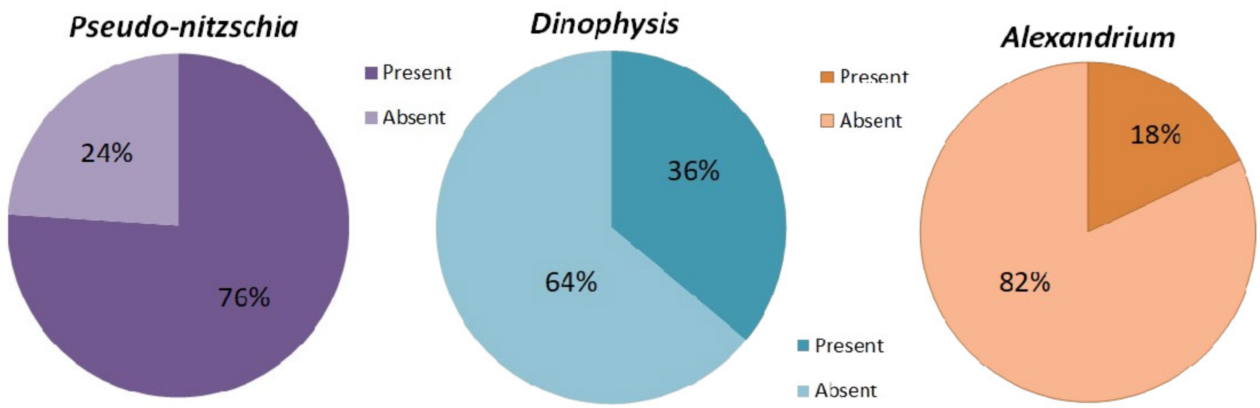

Figure 7. Percentage of samples with three potentially harmful phytoplankton species from Kachemak Bay National Estuarine Research Reserv Harmful Algal Bloom monitoring program. Note that, while *Pseudo-nitzschia* cells and blooms are common, domoic acid levels have remained consistently low in tested shellfish tissue, indicating that *Pseudo-nitzschia* are not currently producing high amounts of domoic acid toxin in Kachemak Bay. Conversely, *Alexandrium* cells are less commonly found, but are associated with elevated saxitoxin levels in shellfish and fish tissues.

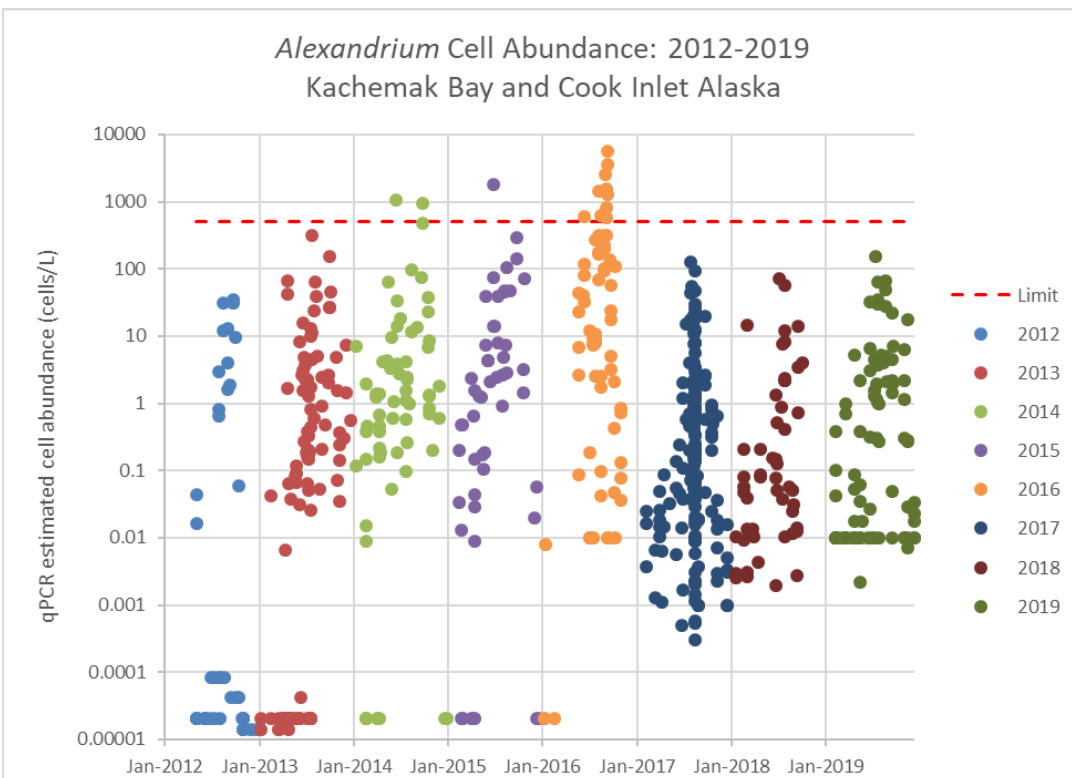

Figure 8. *Alexandrium* cell abundance estimated from quantitative polymerase chain reaction (qPCR) analyses for all phytoplankton samples collected in lower Cook Inlet and Kachemak Bay, 2012-2020. Note logarithmic scale for cell abundance on the y-axis. Paralytic shellfish poisoning toxins are likely to be detected in shellfish tissues for cell abundances above a limit of 500 cells/liter (dashed red line on figure).

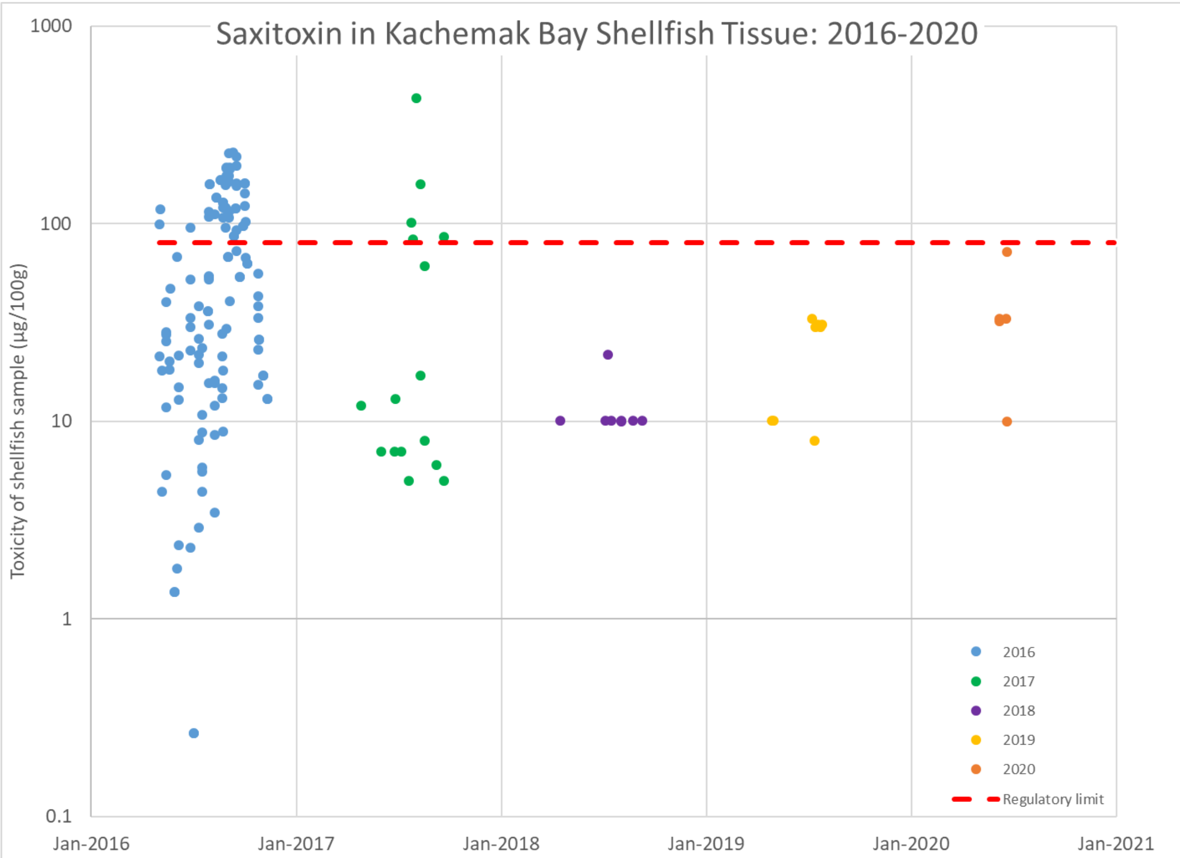

Figure 9. Shellfish tissue sample toxicity for saxitoxin (paralytic shellfish poisoning [PSP] toxin) from 2016-2020 for samples taken around Kachemak Bay. Note logarithmic scale for the y-axis. Cautionary regulatory limit for PSP toxin for human shellfish consumption (80 µg toxin/100g tissue) is shown as a red dashed line.

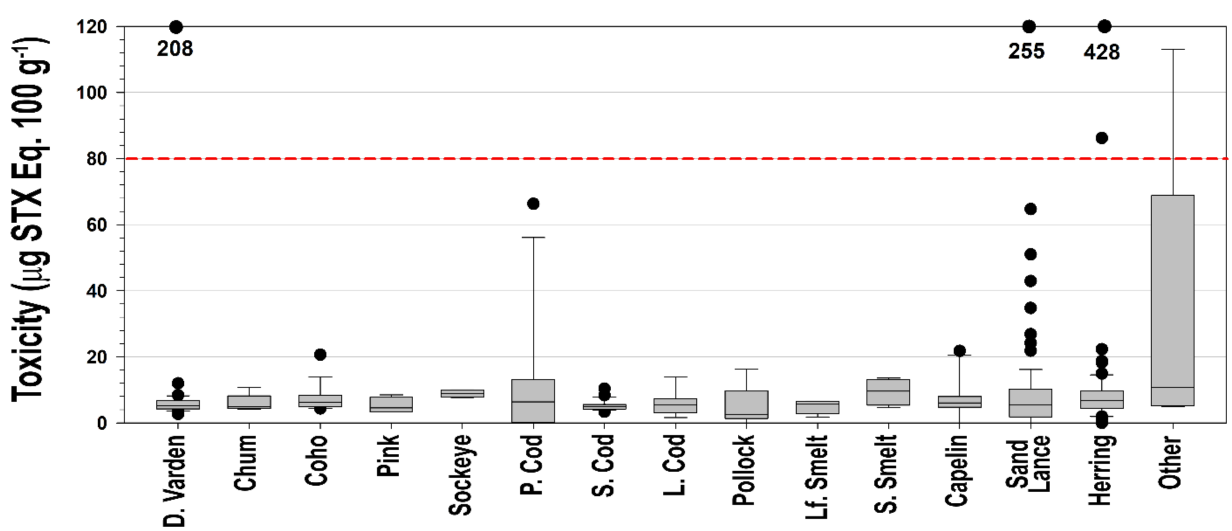

Figure 10. Fish tissue sample toxicity for predator and forage fish samples from Kachemak Bay and lower Cook Inlet. Results are shown in micrograms (µg) of toxin per 100 grams of tissue. The red dashed line shows the regulatory limit for human consumption.

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 task progress by fiscal year and quarter, beginning February 1, 2017. Additional milestones and/or tasks have been added in red. C = completed, X = planned or not completed, V = cancelled due to COVID-19, P = partially completed, due to constraints of COVID-19. 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	C	C	P	P	X	X	X	X	X	X
Spring Surveys (all)	C				C				C				P				X			
Summer Surveys		C				C				C				P				X		
Fall Surveys			C				C				C				X				X	
Winter Surveys	C				C				C				C				X			
SWMP Water quality	C	C	C	C	C	C	C	C	C	C	C	C	P	P	X	X	X	X	X	X
SWMP Nutrients	C	C	C	C	C	C	C	C	C	C	C	C	P	P	X	X	X	X	X	X
SWMP Meteorological	C	C	C	C	C	C	C	C	C	C	C	C	P	P	X	X	X	X	X	X
Milestone 2: Data Delivery	C			C	C			C	C			C	C			X	X			X
Milestone 3: Reporting																				
Annual Reports	C				C				C				C				X			
Annual PI meeting				C				C				C				X				X
Annual Work Plan			C				C				C				C				X	

In addition to the primary project deliverables in Table 1, during the past year we led or contributed to a published peer-review science article, the GWA program synthesis report and three of the GWA program synthesis manuscripts (program-wide, Environmental Drivers and Nearshore). We also gave two oral science presentations, one public talk and two training lectures using project data and results (see Section 7). Four new ecosystem indicators (zooplankton community, temperature, salinity, and harmful algal blooms) are being developed for the annual Ecosystem Status Report to the North Pacific Fisheries Management Council. We anticipate completing remaining FY20 and FY21 milestones and tasks as planned, unless limited by COVID-19 fieldwork restrictions.

B. Explanation for not completing any planned milestones and tasks

Due to prolonged cold and stormy weather and marine icing conditions, small boat sampling could not be conducted at Cook Inlet stations outside Kachemak Bay (along Transects 3, 6, and 7) in February 2020 (Quarter 1), however we were able to sample all oceanographic and plankton stations in Kachemak Bay that month (on Transects 9, 4, and the along-bay transect).

We were unable to complete some small boat surveys in FY20 (Quarters 1 and 2) due to COVID-19 restrictions on field work (no ship-based surveys April and May 2020 and CTD-only survey in June 2020).

SWMP nutrient samples were not collected and water quality sondes were not switched out from March through June at Seldovia, and April through May at Homer due to COVID-19 restrictions. SWMP water quality and meteorological instruments continued to collect data, and any data quality impacts from the longer than normal deployments (2 months at Homer sites, 3 months at Seldovia sites) will be examined during the QA/QC process.

C. Justification for new milestones/tasks

No new milestones or tasks are proposed for FY21.

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 (Prince William Sound oceanography, project 20120114-G) on zooplankton sample processing and data analyses, including on joint science presentations and a manuscript. 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 Prince William Sound (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 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, and freshwater content and nutrients to the GWA Nearshore component PIs to help them assess drivers of intertidal ecosystem changes at Kachemak Bay sites. In FY21 we plan to expand assessment of the effects of nearshore oceanographic and meteorological variability on rocky intertidal ecosystems.

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 and Martin Renner may assist in making those observations on small boat 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 FY20 we worked with Axiom, AOOS, and the Alaska HAB 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 FY21.

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) National Oceanic and Atmospheric Administration (NOAA): We collaborate with researchers at the National Ocean Service National Centers for Coastal Ocean Science (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 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) NPRB: In FY21 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 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 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. However, data collection was impacted by COVID-19 related restrictions on fieldwork (see above for details). We have minimized the impacts as much as possible with new shipboard sampling protocols, but COVID-19 status may affect future sampling in the rest of FY20 and FY21.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

There are no proposed changes for the project PIs (Holderied and Baird) in FY21. Ben Weitzman (NOAA Kasitsna Bay Laboratory) and Chris Guo (KBNERR) joined the project team in FY20 and will provide field sampling, data analysis and report writing support. Ben Weitzman previously worked in the Nearshore component of the GWA program, led the nearshore component synthesis manuscript in FY20, and will continue to assist with cross-GWA program data synthesis efforts. Martin Renner started working under contract with NOAA Kasitsna Bay Laboratory in FY20 to assist with data analysis, data synthesis, and field sampling.

6. PROJECT BUDGET

A. Budget Forms (See GWA FY20 Budget Workbook)

Please see project budget forms compiled for the program.

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$47.2	$49.3	$44.5	$41.4	$40.1	$222.4	$0.0
Travel	$7.9	$7.6	$10.5	$8.6	$8.1	$42.7	$0.0
Contractual	$74.8	$76.8	$88.1	$51.7	$52.2	$343.6	$0.0
Commodities	$11.0	$11.5	$11.5	$10.0	$9.9	$53.9	$0.0
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Indirect Costs (*will vary by proposer*)	$14.8	$14.8	$13.6	$12.8	$12.0	$68.1	$0.0
SUBTOTAL	$155.7	$160.0	$168.2	$124.5	$122.2	$730.6	$0.0
General Administration (9% of	$14.0	$14.4	$15.1	$11.2	$11.0	$65.8	N/A
PROJECT TOTAL	$169.7	$174.4	$183.4	$135.7	$133.2	$796.3	
Other Resources (Cost Share	$205.0	$213.0	$215.0	$182.8	$192.0	$1,007.8	

B. Changes from Original Project Proposal

There are no proposed changes to the total budget amount for the project or major budget changes for FY21 from our original proposal. We propose to move a small amount of funds ($3K difference from approved FY20 workplan) from the KBNERR budget to the NOAA Kasitsna Bay Laboratory budget in FY21 to cover additional small boat field work and data analysis efforts by Kasitsna Bay Laboratory contract staff. As planned in FY20 (and approved in our FY20 workplan), due to changes in project personnel and expiration of a labor services contract, we deobligated EVOSTC funds that were obligated to the labor services contract task order and plan to re-obligate the funds to a new NOAA contract task order at the beginning of Federal FY21. By re-obligating prior year funds, we will be able to expand our data analysis efforts in both project years 9 and 10 beyond what was originally proposed, without needing additional funding from EVOSTC. Specifically, this will allow us to conduct additional cross-disciplinary data syntheses in Cook Inlet and cross-GWA region data syntheses of oceanographic and plankton data, in collaboration with Rob Suryan, other GWA investigators and other state and federal agency researchers.

C. Sources of Additional Project Funding

1. KBNERR SWMP: 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 $92K 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 $75K/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), Ben Weitzman (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. We are not including an estimate for in-kind use of Kasitsna Bay Laboratory equipment and small boats.

3. NOAA Kasitsna Bay Laboratory and AOOS: NOAA Kasitsna Bay Laboratory and AOOS have an ongoing collaboration to assess oceanography, ocean acidification and HAB conditions in Kachemak Bay, to develop risk assessment tools for paralytic shellfish poisoning and to help validate the NOAA Cook Inlet Operational Forecast System. AOOS has included $25K in FY21 funding plans to support these efforts, subject to availability of federal funds (see attached documentation).

7. FY17-20 PROJECT PUBLICATIONS AND PRODUCTS

Publications

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.

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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.

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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"]. Bulletin of the American Meteorological Society 99:S39-43. doi:10.1175/BAMS-D-17-0105.1

Published and updated datasets

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Doroff, A., and K. Holderied. 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.

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Gulf of Alaska Data Portal

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Holderied, K., S. Baird, J. Schloemer, and K. Schuster. 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.

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

Presentations

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

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. November.

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.

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. January.

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. March.

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. February.

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. January.

Holderied, K. 2019. Gulf Watch Alaska: Ecosystem Monitoring (and data for you?) in the northern Gulf of Alaska. **Oral presentation**. NMFS/Alaska Fisheries Science Center Groundfish Seminar Series. October.

Holderied, K., S. Baird, J. Schloemer, and D. Hondolero. 2020. Impact of the warm, dry 2019 summer of nearshore waters in Kachemak Bay Alaska – rain vs. glacial melt? **Oral presentation** at Alaska Marine Science Symposium, Anchorage, AK. January.

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. March.

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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. January.

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. January.

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. January.

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.

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

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

Holderied, K. 2019. Kachemak Bay Oceanography. Alaska Department of Fish and Game Razor Clam Summit (Alaska, Oregon and Washington state shellfish managers). Homer, AK. April.

Holderied, K., D. Hondolero, K. Konar, B. Weitzman, and K. Kloecker. 2019. Gulf Watch Alaska evening science talks for community. Seldovia, AK. May.

Holderied, K., S. Baird, B. Konar and K. Iken. 2019. Homer AK. Kachemak Bay Ecosystem Monitoring. Gulf Watch Alaska program public evening science talk. October.

Holderied, K., and S. Baird. 2020. Presentations of Gulf Watch Alaska Kachemak Bay/Cook Inlet Oceanography and KBNERR SWMP programs. Kachemak Bay Virtual Master Naturalist Training. Homer AK. June.

NOAA. 2018. Science and Stewardship: Keys to Restoring Kachemak Bay (video). NOAA National Marine Fisheries Service. https://coastalscience.noaa.gov/news/kachemak-bay-hfa-video/.

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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 75:223-252.

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.

Peterson, W.T., J.L. Fisher, P.T. Strub, X. Du, C. Risien, J. Peterson, and C.T. Shaw. 2017. The pelagic ecosystem in the Northern California Current off Oregon during the 2014–2016 warm anomalies within the context of the past 20 years. Journal of Geophysical Research, Oceans 122:7267-7290. doi: 10.1002/2017JC012952

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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