ATTACHMENT B. Annual Project Report Form (Revised 11.21.19)

1. Project Number:

20120114-J

2. Project Title:

Long-term Monitoring of Oceanographic Conditions in Cook Inlet/Kachemak Bay

3. Principal Investigator(s) Names:

Kris Holderied, National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science/Kasitsna Bay Laboratory

Steve Baird, Kachemak Bay National Estuarine Research Reserve, Alaska Center for Conservation Science, University of Alaska

James Schloemer, Kachemak Bay National Estuarine Research Reserve, Alaska Center for Conservation Science, University of Alaska

Dominic Hondolero, National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science/Kasitsna Bay Laboratory

Benjamin Weitzman, National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science/Kasitsna Bay Laboratory

Martin Renner, National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science/Kasitsna Bay Laboratory

Chris Guo, Kachemak Bay National Estuarine Research Reserve, Alaska Center for Conservation Science, University of Alaska

4. Time Period Covered by the Report:

February 1, 2020-January 31, 2021

5. Date of Report:

March 2021

6. Project Website (if applicable):

www.gulfwatchalaska.org

https://aoos.org/alaska-ocean-acidification-network/

https://aoos.org/alaska-hab-network/

7. Summary of Work Performed:

The overall project goal is to continue and enhance time-series of oceanographic data from shipboard surveys and shore-based stations in lower Cook Inlet and Kachemak Bay that characterize seasonal, inter-annual, and spatial variability and trends in marine conditions. The project is part of the Environmental Drivers component of the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) Gulf Watch Alaska (GWA) program and provides oceanographic and plankton data to help assess the impacts of changing environmental conditions on nearshore and coastal pelagic species injured by the spill. Project data provide a detailed, year-round oceanographic context for the GWA Nearshore project in Kachemak Bay, as well as other ongoing state and federal agency programs in the region. Kachemak Bay and Cook Inlet oceanographic and plankton data are also being synthesized with data from other GWA Environmental Drivers projects in Prince William Sound (PWS), the outer Kenai Peninsula, and the Gulf of Alaska to understand coastal responses to climate variability in the northern Gulf of Alaska.

During 2020, under the lower Cook Inlet/Kachemak Bay oceanographic monitoring project, we collected year-round oceanographic, zooplankton, and phytoplankton data, conducted additional multivariate analysis on plankton data, developed an oceanographic synthesis manuscript for submission to a peer-reviewed journal with other GWA investigators (Danielson et al. in prep.), delivered quality-controlled data to the Research Workspace before program deadlines, conducted data analyses with project time series data from 2012-2020 and presented results at conferences and workshops, including the Alaska Marine Science Symposium.

Specific project objectives include the following, with a brief status of progress towards the objectives made in 2020. More detailed sampling updates and results are provided below.

1. Determine the thermohaline structure of Kachemak Bay and the southeastern Cook Inlet entrance at seasonal and longer time scales. *Status: Completed planned year-round sampling, with gaps due to COVID-19 restrictions*.
2. Determine long-term trends and variability from daily to interannual time scales in Kachemak Bay oceanography. *Status: Conducted data analysis and incorporated in GWA synthesis documents*.
3. Determine seasonal patterns of phytoplankton and zooplankton species abundance and community composition within Kachemak Bay and southeastern Cook Inlet. *Status: Completed planned year-round sampling, with gaps due to COVID-19 restrictions.*
4. Assess interannual changes in oceanographic structure and phytoplankton/zooplankton species composition across the Cook Inlet entrance. *Status: Completed spring 2020 sampling at entrance*.
5. Assess seasonal patterns in oceanography and plankton between Kachemak Bay, southeastern Cook Inlet and the adjacent shelf (collaboration with Seward Line [project 20120114-L]

project). *Status: Completed manuscript for submission to Deep Sea Research II (Danielson et al. in prep.).*

6. Determine temporal patterns and linkages in oceanographic conditions and plankton communities between lower Cook Inlet and Kachemak Bay and the Gulf of Alaska continental shelf (GAK1 [project 20120114-I], Seward Line [project 20120114-L], and CPR [project 20120114-D] projects) and Prince William Sound (PWS) (PWS oceanography [20120114-G] and Seward Line [project 19120114-L] projects). *Status: Manuscript in progress on zooplankton community patterns with PWS oceanography project researchers (McKinstry and Campbell).*
7. Provide environmental forcing data for correlation with biological data sets in the nearshore benthic project component and pelagic components of GWA. *Status: Kachemak Bay project data incorporated in GWA nearshore synthesis manuscript (Weitzman et al. in press)*.
8. Provide Alaska Department of Fish and Game (ADF&G), National Oceanographic and Atmospheric Administration (NOAA), and U.S. Fish and Wildlife Service (USFWS) resource managers with assessment of oceanographic trends and seasonal conditions. *Status: Kachemak Bay project data used for NOAA harmful algal bloom (HAB) studies and paralytic shellfish poisoning risk assessment and provided to ADF&G for shellfish research planning.*

Sample collection dates and locations for 2017-2020 are summarized in Table 1. Shipboard sampling completed in 2020 included oceanographic and plankton surveys monthly in Kachemak Bay along mid-bay (Transect 9) and along-bay lines, with additional quarterly surveys in outer Kachemak Bay (Transect 4) and in southeast Cook Inlet near Anchor Point (Transect 3), Flat Island (Transect 7), and Point Adam (Transect 6), similar to previous years (see Fig. 1 for station locations). Due to COVID-19 federal and state health mandates and restrictions, sampling was halted in March 2020. Sampling resumed in a reduced capacity in June 2020 (i.e., conductivity-temperature-depth [CTD] and phytoplankton only) then returned to full collection in July. Sampling was reduced again in November 2020 due to inclement weather which continued into December; however, a reduced sampling was completed in December (i.e., CTD only). Oceanographic data were collected vertically from surface to near-bottom at stations (shown as dots on Fig. 1), using CTD profilers. Zooplankton and phytoplankton sampling were also conducted at up to three stations along each Kachemak Bay transect and one station on the Cook Inlet transects (red dots in Fig. 1). In addition to shipboard surveys, continuous, year-round oceanographic data and monthly nutrient and chlorophyll data were obtained from Kachemak Bay National Estuarine Research Reserve (KBNERR) System Wide Monitoring Program (SWMP) water quality stations at the Seldovia and Homer harbors.

Warmer than average seawater temperatures were observed in both shipboard CTD and continuous water quality stations in 2020 throughout Kachemak Bay, particularly during summer, June-August. Despite elevated summer water temperatures, levels of toxic algae remained below regulatory limits for human shellfish consumption and phytoplankton abundances were at or below average levels in 2020. Additional analyses were conducted of zooplankton data to identify detailed, seasonal progression in zooplankton community composition and we are collaborating with PWS project

researchers on a synthesis manuscript to describe seasonal, interannual and spatial patterns in zooplankton communities across the northern Gulf of Alaska.

Field Sampling update

Field sampling activities for 2020 were impacted by COVID-19 restrictions put in place by NOAA and the University of Alaska Anchorage (UAA) beginning in March. We missed the April and May sampling, and only conducted partial sampling in June. We completed the remainder of the sampling in accordance with our proposal and with the detailed sampling protocols available on the Alaska Ocean Observing System (AOOS) Research Workspace with a few interruptions due to inclement weather (Table 1). We again conducted the fall southeast Cook Inlet quarterly sampling in September, to correlate sampling timing more closely with other GWA Environmental Drivers projects. In addition to meeting GWA project objectives, we leveraged phytoplankton and oceanographic data from shipboard surveys to help support NOAA HAB research on the environmental factors causing blooms of the phytoplankton species *Alexandrium* spp. (which produce saxitoxins and cause paralytic shellfish poisoning) as well as food web transfers of saxitoxins to fish, invertebrate, and zooplankton species. Some results from the HAB monitoring and research efforts are included in this report, as HABs can affect many parts of the marine food web, including *Exxon Valdez* Oil Spill-injured species. Shipboard surveys also continue to be leveraged to collect surface and near-bottom water samples for a KBNERR and NOAA Kasitsna Bay Laboratory ocean acidification monitoring project, conducted in collaboration with the Alutiiq Pride Shellfish Hatchery.

Table 1. Sampling frequency of Kachemak Bay and lower Cook Inlet transects during second five-year project period (2017-2020). Blue color denotes that samples were collected. AB stands for the Along-Bay transect.

		CTD						PHYTOPLANKTON						ZOOPLANKTON						OCEAN ACIDIFICATION WATER SAMPLES					
		Transect No.						Transect No.						Transect No.						Transect No.					
Year	**Month**	**AB**	**3**	**4**	**6**	**7**	**9**	**AB**	**3**	**4**	**6**	**7**	**9**	**AB**	**3**	**4**	**6**	**7**	**9**	**AB**	**3**	**4**	**6**	**7**	**9**
2017	January	■					■						■	■					■						■
2017	February	■					■						■						■						■
2017	March	■					■	■					■	■					■	■					■
2017	April	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■
2017	May	■					■						■						■	■					■
2017	June	■					■	■					■	■					■	■					■
2017	July	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2017	August	■					■						■						■						■
2017	September	■					■	■					■	■					■						■
2017	October	■		■			■	■		■			■	■		■			■			■			■
2017	November	■			■	■	■	■			■	■	■	■			■	■	■	■			■		■
2017	December	■					■						■						■						■
2018	January	■					■	■					■	■					■						■
2018	February	■					■	■					■	■					■						■
2018	March	■				■	■	■				■	■	■				■	■	■					■
2018	April	■		■			■	■		■			■	■		■			■	■		■			■
2018	May	■					■	■					■	■					■	■					■
2018	June	■	■	■			■	■	■	■			■	■	■	■			■	■		■			■
2018	July	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					■
2018	August	■					■	■					■	■					■	■					■
2018	September	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				■		
2018	October	■					■	■					■	■					■	■					■
2018	November	■					■	■					■	■					■	■					■
2018	December	■					■	■					■	■					■	■					
2019	January						■						■						■						
2019	February	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■		■
2019	March	■					■	■					■	■					■	■					■
2019	April	■					■	■					■	■					■	■					■
2019	May	■	■	■	■	■	■	■					■	■	■	■	■	■	■	■		■	■		■
2019	June	■					■	■					■	■					■	■					■
2019	July	■					■	■					■	■					■	■					■
2019	August	■					■	■					■	■					■	■					■
2019	September	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■		■
2019	October	■					■	■					■	■					■	■					■
2019	November	■					■	■					■	■					■	■					■
2019	December	■					■	■					■	■					■	■					■
2020	January																								
2020	February	■		■			■	■		■			■	■		■			■	■					■
2020	March	■					■	■					■	■					■	■					■
2020	April																								
2020	May																								
2020	June	■					■	■					■												
2020	July	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■		■
2020	August	■					■	■					■	■					■	■					■
2020	September	■		■	■	■	■	■			■	■		■		■	■	■	■	■			■		■
2020	October	■					■	■					■	■					■	■					■
2020	November																								
2020	December	■					■																		

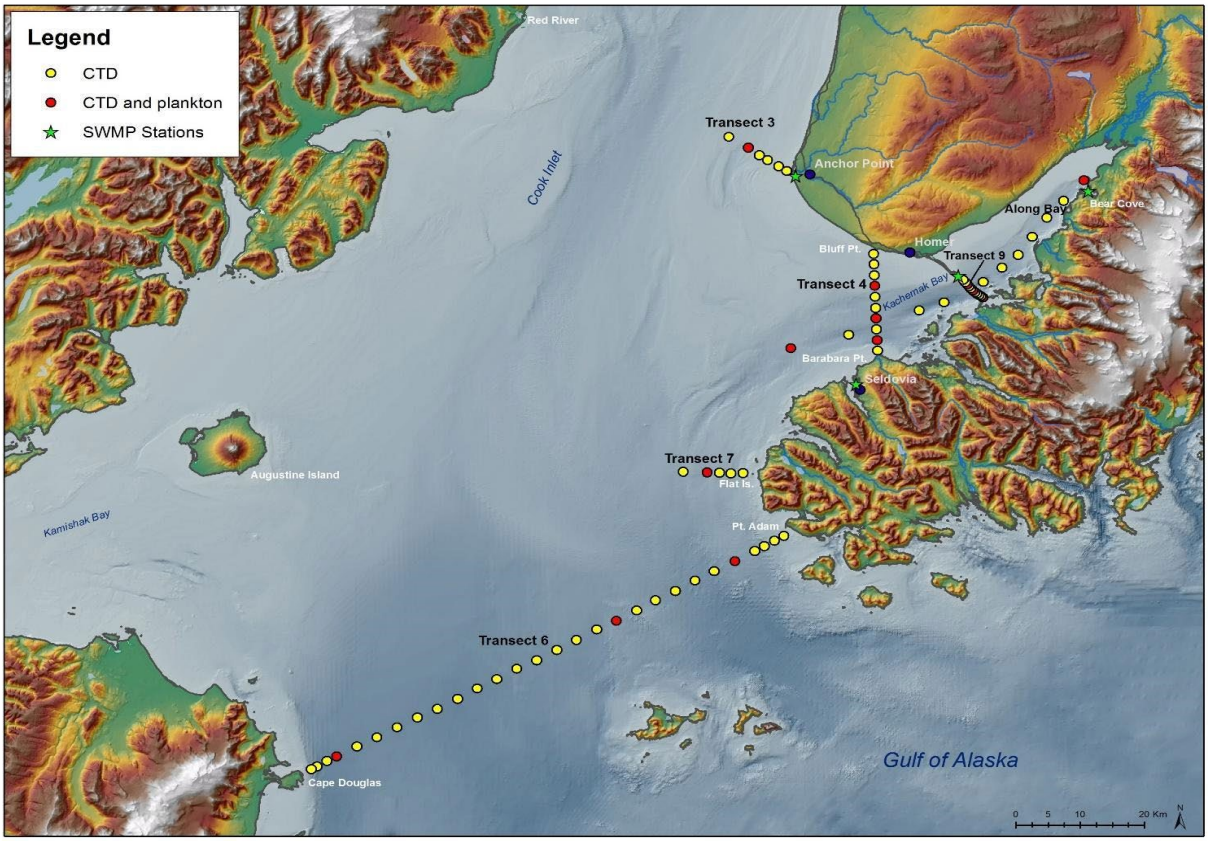

Figure 1. Sampling locations for the lower Cook Inlet and Kachemak Bay project in 2019. Stations shown for shipboard oceanography (all dots) and phytoplankton and zooplankton sampling (red dots). Kachemak Bay National Estuarine Research Reserve continuous sampling stations are marked with green stars. Due to COVID restrictions and equipment failure, KBNERR's Bear Cove continuous sampling station was not deployed in 2020.

Recent Results and Scientific Findings

Detailed results from 2020 monitoring and analyses of Kachemak Bay/Cook Inlet project data are described below, and address project objectives 1-6. In addition, we provided oceanographic data to other NOAA researchers for HAB research and to ADF&G Sportfish Division and Commercial Fisheries Division biologists for shellfish population research and management (objective 8).

Oceanography sampling results

The KBNERR SWMP water quality station data provide a longer-term (2001-2020) context for the GWA study period, as illustrated by temperature and salinity time series from the near-bottom sensor at the Seldovia Harbor station (Fig. 2). Since October 2018, Kachemak Bay water temperatures have been mostly warmer than the long-term average, with anomalies of up to 2˚C. These anomalies were very similar to the anomalies during the anomalously warm period from 2014-2016, while 2017 and most of 2018 were closer to the long-term average. Unusually cold air

temperatures in January 2020 (with a monthly air temperature anomaly 6˚C below the long-term average) resulted in cold water temperature anomalies of around -0.5˚C from January through April. Since May 2020 waters have again been slightly warmer than the long-term average. Kachemak Bay waters were also somewhat less saline than the long-term average, although not to the extent seen during 2014-2016. We have also been seeing occasional unusual intrusions of less saline water lasting from a day to four days since 2016 (Fig. 2). The mechanism behind these is currently not understood.

To illustrate oceanographic patterns throughout the water column and between years, Fig. 3 shows a time series of vertical temperature, salinity, and fluorescence profiles from February 2012 to October 2020 from monthly sampling at the middle CTD station along the mid-Kachemak Bay survey line (Transect 9, station 6). The winter of 2019-20 was noticeably colder than the previous 2018-19 winter, with temperatures reaching 4˚C, similar to the 2017-18 winter conditions that followed warm anomalies during 2014-2016. Temperatures then increased to abnormally warm during summer, which persisted longer than normal into the fall (Fig. 3, top panel). These warm fall waters reached 10˚C and stretched deeper (>80 m) than years prior (Fig. 3, top panel). Previous years have shown that warm summer temperatures are often associated with warmer winter temperatures. During the 2014-2016 pacific marine heatwave, increasingly warmer winter temperatures, near or above 5˚C, lessened seasonal recovery with two of three years having a subsequently higher peak temperature than the last. Similarly, the winter of 2018-2019 was conspicuously warmer than that of the two years prior, near or above 5˚C, and the following summer was one of the warmest on record. Previous years have also shown that cooler winters are associated with cooler summers. For example, temperatures during winters of 2012-2013 were the coldest (1-4˚C) to occur during this study, manifesting in either reduced surface and water column temperatures or a constrained period of summer warming. However, this pattern was not evident summer 2020 where, following a cool winter, water temperatures were among the warmest observed in the study period, matching record high temperatures (>12.5˚C) at surface, and establishing new record high temperatures (>10˚C) throughout most of the water column (Fig. 3). Salinity levels were abnormally low following a somewhat typical winter (Fig. 3, middle panel). A notable freshwater lens formed in the spring with near-surface levels below 26 practical salinity units (PSU), which is lower than levels from recent years. Reflecting the abnormal temperature trends, these fresh conditions persisted through fall and extended deep in the water column (Fig. 3, middle panel). Although air temperatures were similar to those of 2019, seasonal rainfall was greater, which combined with glacial and snowmelt is a suspect as the driver of our observations. For a biological perspective, we examined fluorescence concentrations from the same sampling periods as temperature and salinity (Fig. 3, bottom panel). These fluorescence results suggest that local production correlated with fall trends in temperature and salinity, in which increased fluorescence levels extended further into the fall and reached deeper in the water column than years prior (Fig. 3, bottom panel). We used our monthly along-bay CTD survey data to further investigate this unusual 2020 trend and to further illustrate water column response to seasonal temperatures, confirming that fall warm temperatures and decreased salinity levels were relatively deeper and more widespread compared to previous years (Fig. 4). It was

notable that deeper waters were unusually fresh through December 2019; however, the fresh conditions in December 2020 appear even stronger (i.e., reaching deeper) than in 2019 (Figs. 3 and 4). We also found that, despite the record-setting summer of 2019, a cold air mass moved in across much of the region and resulted in a drastic cooling of the water column through spring 2020. However, the seasonal cooling was temporary and did little to mitigate the following summer, where temperatures exceeded 10˚C throughout much of the water column. These data suggest that seasonal variability can strongly mitigate warming trends, but consistent cool temperatures may be necessary to temper the thermal mass of oceanic water bodies.

It is important to note that the extent and duration of measurements collected in 2020 is less than all previous seasons (Table 1) due to restrictions associated with COVID-19 and therefore, unusual patterns in these data may be an artifact of fewer observations made during the reporting period relative to previous years. These data will be extensively quality controlled in the months to come.

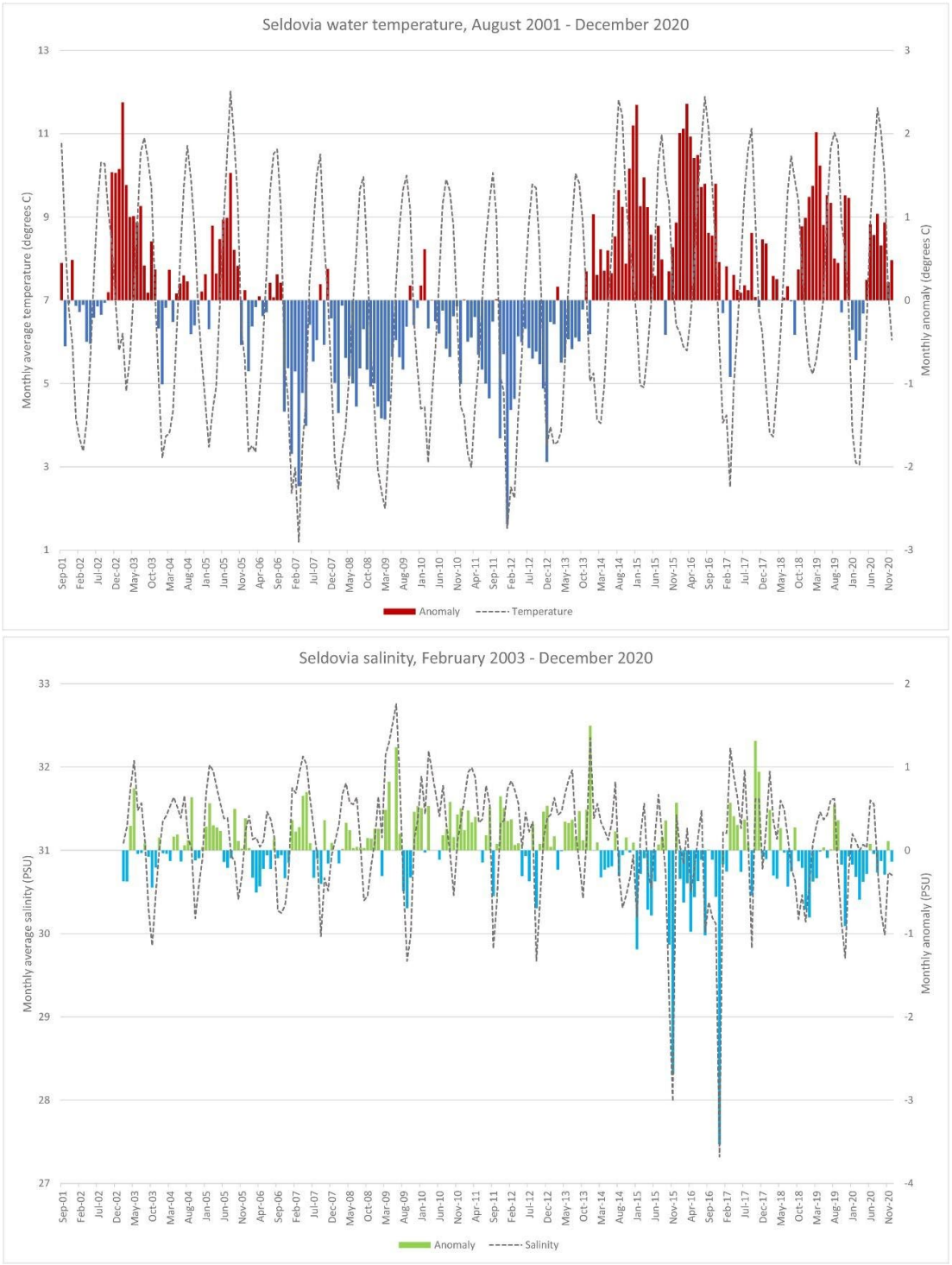

Figure 2. Time series of monthly average (dashed line) and monthly anomaly (bars) water temperatures (top) and salinities (bottom) at Kachemak Bay National Estuarine Research Reserve monitoring station in Seldovia during 2001-2020. These System Wide Monitoring Program station data are collected from a sensor package 1 meter above sea bottom. Red/green bars indicate positive (warm/salty) anomalies and blue/cyan bars indicate negative (cold/fresh) anomalies.

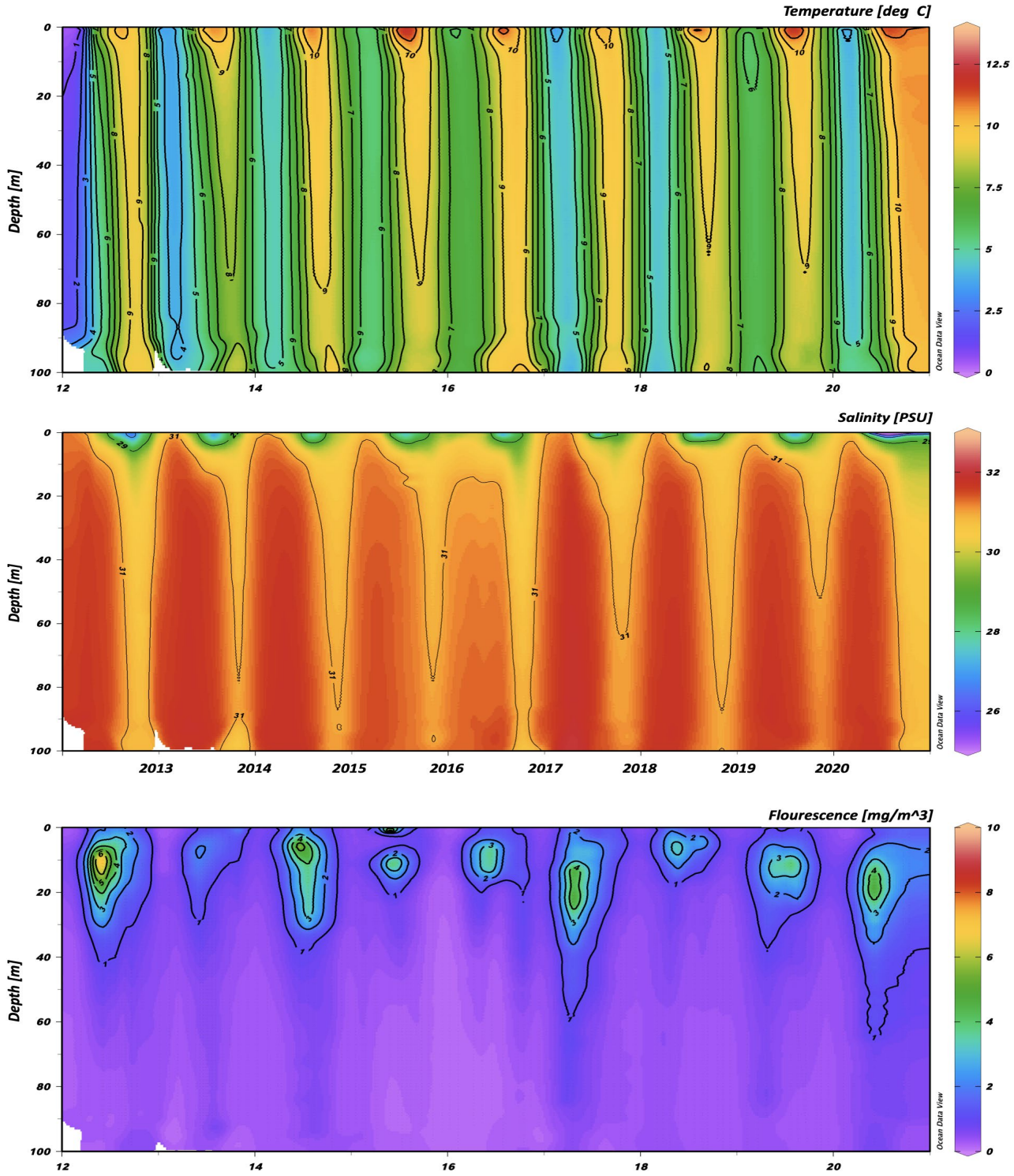

Figure 3. Time series of vertical profiles of water column temperature (top, degrees C), salinity (middle, practical salinity units [PSU]), and fluorescence (bottom, mg/m^3) from 2012-2020 collected from monthly conductivity and temperature at depth casts at a mid-Kachemak Bay station.

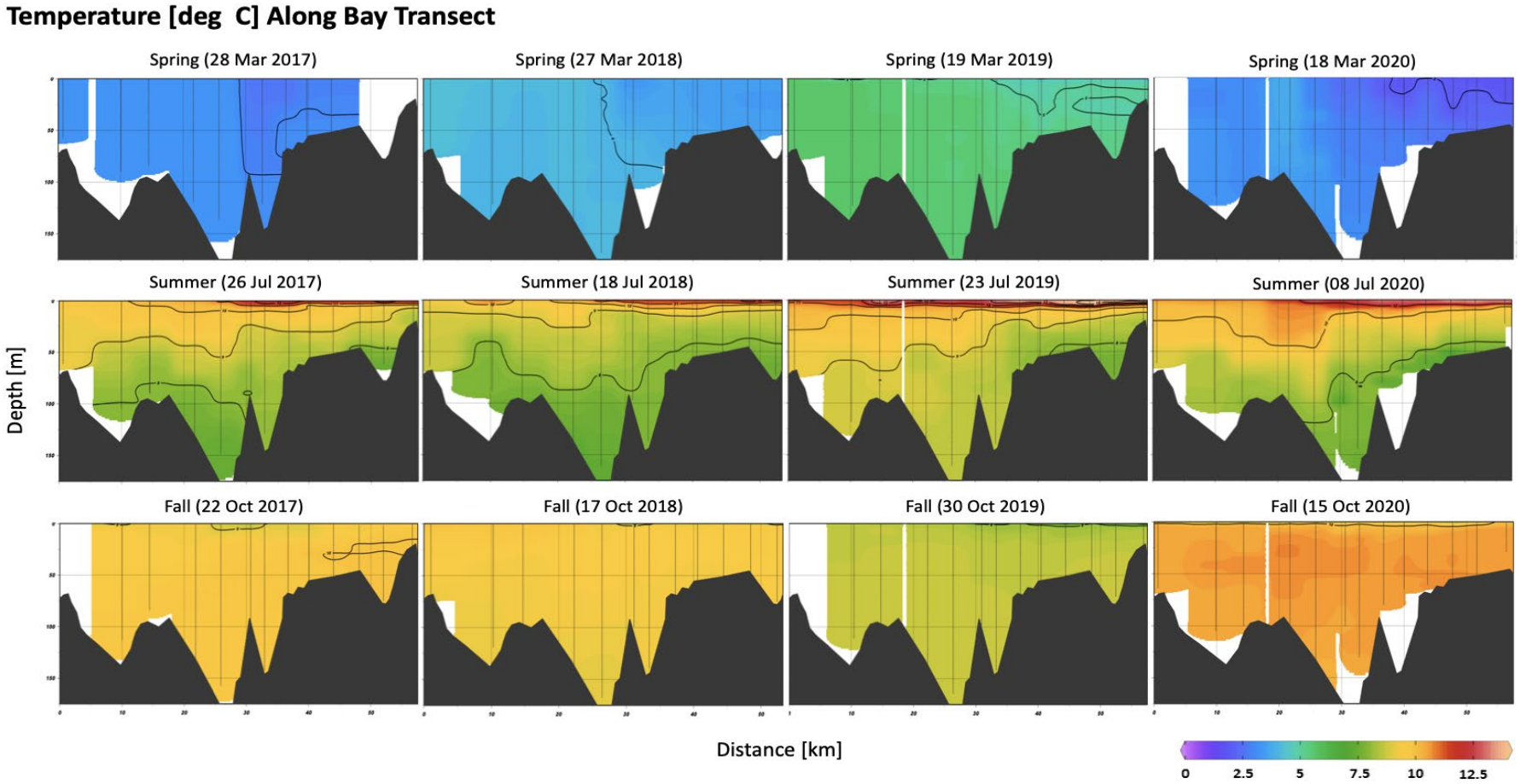

Figure 4. Comparison of seasonal seawater temperature contours from conductivity and temperature at depth profiler data on the Along-Bay transect from 2017-2020. Gridded plotting shows fall, summer, and spring (top-to-bottom) along the y-grid and 2017-2020 years along the x-grid (left-to-right). Plots show depth (m) and temperature (degrees C) on the y-axis and horizontal distance (km) on the x-axis. Distance runs from Point Adam (0 km) in southeast Cook Inlet to Bear Cove (58 km) at the head of Kachemak Bay, with bathymetry shown in black.

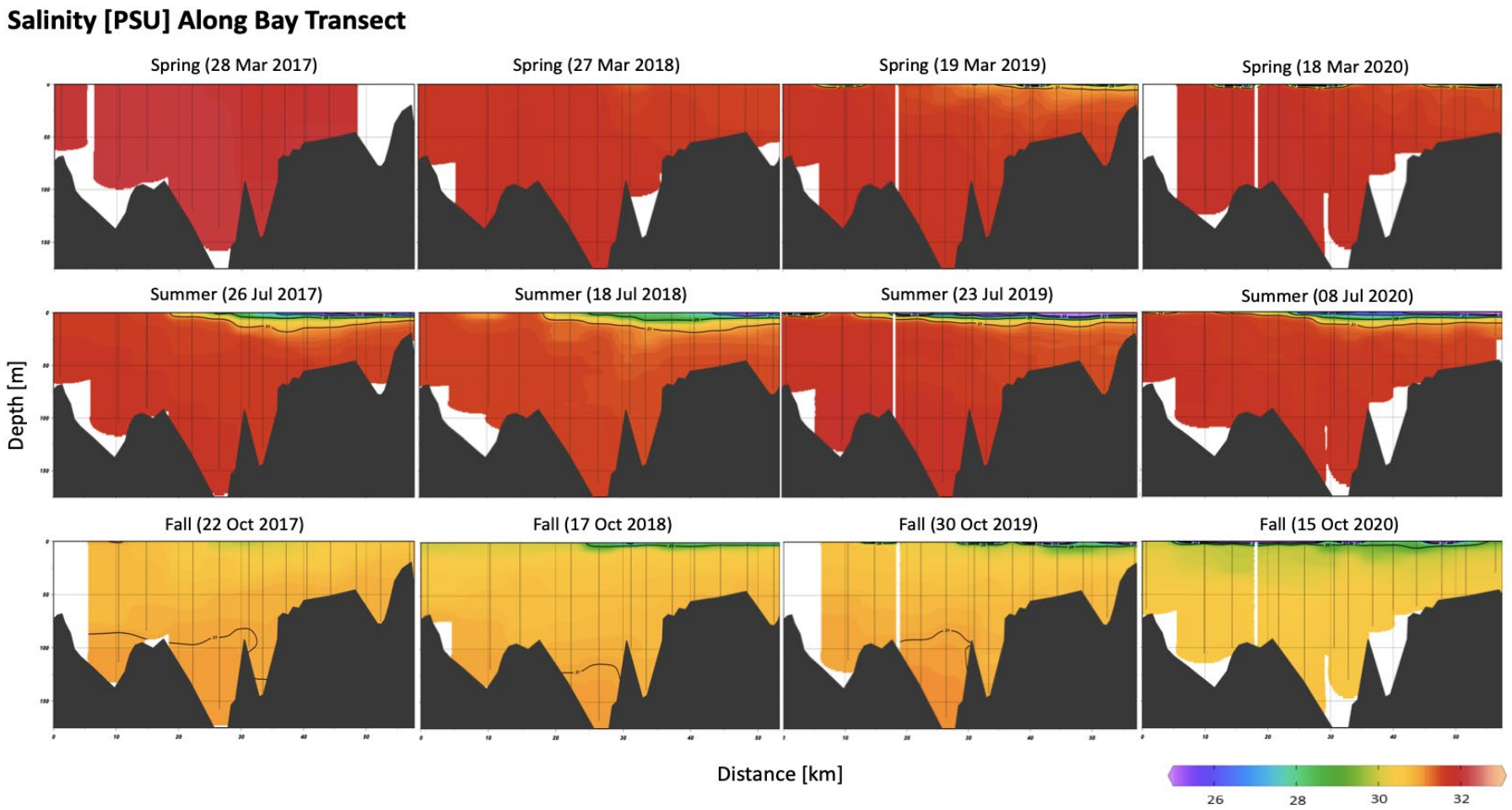

Figure 5. Comparison of seasonal salinity contours from conductivity and temperature at depth profiler data on the Along-Bay transect from 2017-2020. Gridded plotting shows fall, summer, and spring (top-to-bottom) along the y-grid and 2017-2020 years along the x-grid (left-to-right). Plots show depth (m) and salinity (PSU) on the y-axis and horizontal distance (km) on the x-axis. Distance runs from Point Adam (0 km) in southeast Cook Inlet to Bear Cove (58 km) at the head of Kachemak Bay, with bathymetry shown in black.

Phytoplankton Results

In 2020 we were able to conduct our sampling under stringent COVID-19 protocols. In total we collected 166 samples for visual counts and qPCR quantitative analysis for *Alexandrium* spp estimates. We are also continuing to leverage our environmental drivers project to collect samples for North Pacific Research Board project #1801, collecting 84 samples for phytoplankton and zooplankton saxitoxin analysis. This is a project to examine "prevalence of paralytic shellfish toxins in the marine food web of southcentral and southwestern Alaska." In addition to our shipboard sampling for phytoplankton and zooplankton toxins for this project, we also collected approximately 50 samples of tissues from predatory fishes for saxitoxin analysis from May-September 2020.

Unfortunately, due to COVID-19 facility restrictions the person conducting our visual counts of phytoplankton samples was unable to conduct the counts during the pandemic. She has submitted a request for isolated facilities, but as of February 2021 has not been granted access to the lab to conduct the visual counts of the 2020 samples. The qPCR and toxin analyses were also delayed due to COVID-19 restricting access to the facilities. The qPCR and toxin samples are being sent out in February 2021 but are not completed at this time.

Limited toxin sampling was conducted by the KBNERR plankton monitoring program. At no time during the sampling period of spring through fall did the saxitoxins in the sampled mussels exceed the regulatory limit for consumption (80 micrograms of toxin per 100 grams of tissue). The KBNERR phytoplankton monitoring program monitors three main species of concern. The species are *Alexandrium, Dinophysis,* and *Pseudo-nitzschia*. All three species were present in KBNERR samples from spring through the fall (Fig. 6), but not in high abundances, with the exception of one event where *Dinophysis* was observed in elevated abundance at one of their locations in late August 2020.

We are planning to change our method of quantifying phytoplankton abundance after 2021. To quantify productivity going forward, we will be using chlorophyll measurements following the same protocols as the KBNERR system wide monitoring program. For 2021, we will continue to collect samples for visual counts as well as collecting chlorophyll samples. After one year of sampling both we will compare the results and summarize our findings. We will continue to collect separate samples following the KBNERR phytoplankton monitoring program protocols which will be used to semi-quantitatively collect species data and allow us to continue monitoring for the presence of species of concern (such as *Alexandrium*), in addition to our continued qPCR sampling. The goal in switching quantification methods is to save time, as conducting visual counts is more time intensive than using chlorophyll as a proxy for productivity.

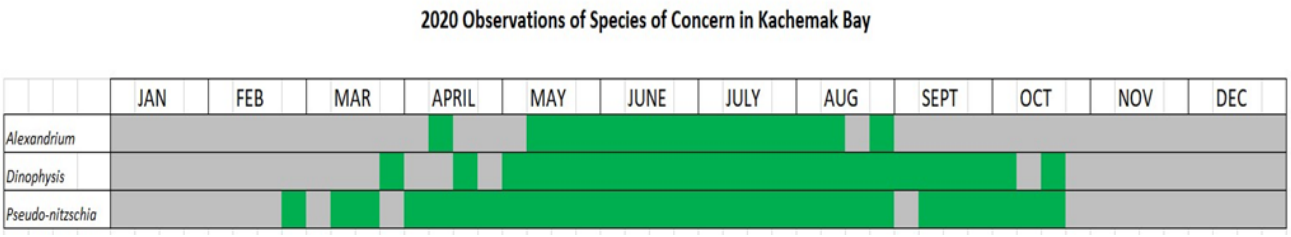

Figure 6. Chart showing the presence of species of concern from Kachemak Bay National Estuarine Research Reserve phytoplankton monitoring program (2020). The chart is shown in one-week increments, with green showing the presence of the species and grey indicating the absence of species.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

Environmental Drivers component: We continue to coordinate on oceanographic and zooplankton sampling protocols and synthesis of monitoring results with all GWA Environmental Drivers component investigators through teleconferences, joint field work, and GWA principal investigator (PI) meetings. We are collaborating with PI Rob Campbell (PWS oceanography project 20120114-G) at the Prince William Sound Science Center on zooplankton sample analyses. The project provides year-round, seasonally resolved oceanographic and plankton data and detailed information on along- and across-estuary gradients to the GWA program. We collaborated with Environmental Drivers PIs (Seth Danielson, GAK-1 project 20120114-I, Rob Campbell, PWS oceanography project 20120114-G, and Rob Suryan, GWA Science Coordinator, project 20120114-A to incorporate project data into synthesis manuscripts for submission to Deep Sea Research II in 2021 (Danielson et al. in prep.).

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 (project 20120114-H) to assess drivers of intertidal ecosystem changes at their Kachemak Bay sites and serve as a model system for other parts of the Gulf of Alaska. We also collaborated with nearshore PIs on two synthesis manuscripts, one to assess nearshore oceanographic variability (Danielson et al. 2019) and another to assess the effects of heatwaves on rocky intertidal communities (Weitzman et al. in press) across the GWA study area. Cook Inlet project scientists continue to collaborate closely with nearshore component colleagues by participating in Nearshore component sampling in Kachemak Bay. In 2020, Dominic Hondolero and Benjamin Weitzman resampled both GWA nearshore sites and Terry Klinger's long-term rocky intertidal community transects in Kachemak Bay. Collaboration among components and researchers in Kachemak Bay has led to plans for a synthesis manuscript that will establish the biophysical linkages between the environmental drivers and nearshore data streams being collected.

2. Across Programs

a. Herring Research and Monitoring

We coordinate informally with Scott Pegau (Herring Research and Monitoring program lead) to investigate long-term changes in oceanographic patterns at near-shore sites across the northern Gulf of Alaska.

b. Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the required timeframes. We are continuing a collaboration with Axiom, Alaska Ocean Observing System (AOOS) and the Alaska HAB Network to develop improved web-based tools for paralytic shellfish poisoning risk assessment that include the real-time water temperature observations from the KBNERR water quality stations.

B. Individual Projects

We currently have no collaborations with other EVOSTC-funded projects outside GWA and Herring Research and Monitoring programs.

C. With Trustee or Management Agencies

NOAA: We collaborate with researchers at the National Ocean Service/ National Centers for Coastal Ocean Science Beaufort (NC) and Charleston (SC) laboratories to use the project oceanography and phytoplankton sampling data to identify environmental triggers for increases in the phytoplankton species (*Alexandrium* spp.) that cause paralytic shellfish poisoning events. We collaborate with NOAA National Marine Fisheries Service on the NOAA Kachemak Bay Habitat Focus Area, including clam restoration and paralytic shellfish poisoning risk assessment efforts.

State of Alaska agencies: We provide real-time and historical trends for water temperature data to shellfish managers with the ADF&G (Commercial and Sportfish divisions in Homer) and with ADF&G Aquatic Farming, Alaska Department of Environmental Conservation, and Alaska Department of Health and Social Services through the Alaska HAB Network. Project data help inform management for shellfish harvest, mariculture operations, harmful algal bloom event response and marine invasive species monitoring.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Danielson, S., T. Hennon, D. Monson, R. Suryan, R. Campbell, S. Baird, K. Holderied, and T. Weingartner. *in prep*. A study of thermal variability in the Northern Gulf of Alaska across years of marine heatwaves and cold spells.

Suryan, R.M., M.L. Arimitsu, H.A. Coletti, R.R. Hopcroft, M.R. Lindeberg, S.J. Barbeaux, S.D. Batten, W.J. Burt, M.A. Bishop, J.L. Bodkin, R.E. Brenner, R.W. Campbell, D.A. Cushing, S.L. Danielson, M.W. Dorn, B. Drummond, D. Esler, T. Gelatt, D.H. Hanselman, S.A. Hatch, S. Haught, K. Holderied, K. Iken, D.B. Iron, A.B. Kettle, D.G.

Kimmel, B. Konar, K.J. Kuletz, B.J. Laurel, J.M. Maniscalco, C. Matkin, C.A.E. McKinstry, D.H. Monson, J.R. Moran, D. Olsen, W.A. Palsson, W.S. Pegau, J.F. Piatt, L.A. Rogers, N.A. Rojek, A. Schaefer, I.B. Spies, J.M. Straley, S.L. Strom, K.L. Sweeney, M. Szymkowiak, B.P. Weitzman, E.M. Yasumiishi, and S.G. Zador. In press. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports.

Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R. Suryan, T. Dean, D. Hondolero, and M. Lindeberg. 2021. Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. Frontiers in Marine Science 8:556820. doi: 10.3389/fmars.2021.556820

2. Reports

DeCino, K., and K. Holderied. 2020. State of the Bay report for Kachemak Bay, AK.

Danielson, S.L., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. 2020. Chapter 1 A study of marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells. In R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Holderied, K., and S. Baird. 2020. Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species. FY19 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 19120114-J. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.

Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Seeeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2020. Chapter 4 Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. In R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

3. Popular articles

No new contributions for this reporting period.

B. Dates and Locations of any Conference or Workshop Presentations where EVOSTC-funded Work was Presented

1. Conferences and Workshops

DeCino, K., and K. Holderied. 2021. Highlighting ecosystem status for Alaska coastal communities in Kachemak Bay, Alaska. Poster presentation at the Alaska Marine Science Symposium, Anchorage AK, January.

Holderied, K., M. Renner, A. Jzyk, D. Hondolero, and B. Weitzman. 2021. Speed dating through meroplankton? Linking ocean and nearshore ecosystems in Kachemak Bay Alaska. Poster presentation at the Alaska Marine Science Symposium, Anchorage AK, January.

Renner, M., K. Holderied, C. McKinstry, D. Hondolero, and R. Campbell. 2021. Is it spring yet? Seasonal clusters of phyto- and zooplankton communities in Kachemak Bay and Lower Cook Inlet. Poster presentation at the Alaska Marine Science Symposium, Anchorage AK, January.

2. Public presentations

No public presentations during this reporting period.

C. Data and/or Information Products Developed During the Reporting Period, if Applicable

A variety of data and information products have been developed for presentations listed above, for GWA program synthesis manuscripts, and for management agency use (NOAA offices, ADF&G, Alaska Department of Environmental Conservation). Data products include graphics of oceanographic time series plots, time series anomalies, and along-transect vs depth contour plots. Data and graphic products from this project were also used by two NOAA Hollings Undergraduate Scholar students, Andrew Scotti and Brianne Visaya, for Kachemak Bay ecosystem projects with Kris Holderied and Brenda Konar (GWA Nearshore project). Both students provided public science outreach talks on their results in Homer, Alaska in July 2019 and gave scientific presentations at NOAA offices in Silver Spring, MD in August 2019. In the Fall/winter semester of 2020, an undergraduate student intern, Alyssa Jyzk, assessed zooplankton community data from the Kachemak Bay shipboard surveys, leading to a focus on trends in meroplankton and a poster produced and presented virtually at the Alaska Marine Science Symposium in January 2021.

D. Data Sets and Associated Metadata that have been Uploaded to the Program's Data Portal

Quality-controlled CTD data sets through January 2021 have been uploaded to the AOOS Research Workspace (https://workspace.aoos.org/project/4673/folder/2538393/4_ctd-aggregated-files). The 2020 data will be published after final review is completed with the data management team.

Quality-controlled zooplankton data through December 2018 have been uploaded to the AOOS Ocean Workspace (https://researchworkspace.com/project/4673/folder/4743501/zooplankton-data). The 2018 data will be published after final review is completed with the data management team. 2019 data are being analyzed by Rob Campbell and Caitlin McKinstry at PWSSC and will be uploaded to the Research Workspace when the species identifications and data QA/QC are complete.

KBNERR SWMP water quality data from Bear Cove, Homer, and Seldovia water quality data sondes and associated metadata through 2019 have been uploaded to the Research Workspace

(https://researchworkspace.com/project/4673/folder/2693997/kbnerr-met,-nutrient,-water-quality-data_2017-2021). Data are also publicly available on the NOAA National Estuarine Research Reserve site: http://cdmo.baruch.sc.edu/. The 2020 data will be uploaded to Research Workspace when QA/QC is complete.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY21): The Science Panel appreciates the PI's response to the Science Director's question. As a follow up: Are higher charter costs associated with a higher daily rate for the NOAA vessel or more overhead?

PI Response (FY21): To clarify, the vessel charter funds are not for the NOAA Kasitsna Bay Lab small boat, as only boat fuel is funded by the GWA project for those boat operations. A larger private vessel is chartered for lower Cook Inlet surveys that cannot be accomplished with a small boat, including the cross-Inlet entrance survey in the spring and winter survey in southeast Cook Inlet. Private vessel daily rates are currently higher than previous years, which may be due to pandemic-related changes in vessel availability.

Science Panel Comment (FY21): Also, what are the budget implications of cancelled or reduced surveys? What are proposed plans for a surplus, if any?

PI Response (FY21): Based on our experience in conducting small boat operations under COVID-19 protocols in summer 2020, we anticipate accomplishing all our planned oceanographic field work in Kachemak Bay and Cook Inlet in FY21. In the event that boat operations are further restricted due to the pandemic, our contingency plan would be to request repurposing of funds for boat fuel (for NOAA Kasitsna Bay Lab small boat), vessel charter (contracted larger private vessel), and personnel time for field sampling, to support more personnel time (Kasitsna Bay Lab contractor and KBNERR staff) for data analyses and syntheses. If pandemic-related changes need to be made later in FY21, we may need to request roll over of some of the funds to FY22.

Science Panel Comment (FY20): The project is meeting goals on time. The Panel initially had concerns with this project being outside of the core area of interest but we are pleased to see the usefulness of these data and the insights produced with connections to the EVOSTC-funded programs as a whole. This project collaborates with and provides data to Trustee and non-Trustee agencies. The Science Panel wonders whether quarterly plankton sampling could provide important new data on herring larvae that could be useful for collaborations with HRM projects.

PI Response (FY20): We appreciate the comments of the science panel and Science Coordinator and are grateful that the ecosystem monitoring efforts supported by the EVOSTC in Kachemak Bay/Cook Inlet have also enabled additional collaborations with other funding agencies. We agree with the science panel that ichthyoplankton sampling to assess seasonal patterns in herring and other forage fish larvae would provide important data for both the Herring Research and Monitoring and GWA programs and we would be interested in further discussions with the GWA/Herring Research and Monitoring teams and science panel on how that might be incorporated into the program. The KBNERR conducted a pilot study in Kachemak Bay in 2018-2019 to assess seasonal changes in nearshore fish communities and their sampling included both larval and adult fish. We will be analyzing those data in conjunction with our zooplankton and oceanographic data to improve our

understanding of seasonal patterns in forage species and will work with other GWA and Herring Research and Monitoring investigators on those analyses. Kachemak Bay National Estuarine Research Reserve has also proposed a non-program project to the EVOSTC that would expand the pilot study efforts and provide seasonal information on larval, juvenile, and adult fish that fills a current gap in our understanding of food web responses to environmental changes. Additionally, US Geological Survey researchers (including GWA PIs Yumi Arimitsu and John Piatt) have conducted forage species sampling in Cook Inlet with hydroacoustics and trawls for the past four summers, under a Bureau of Ocean Energy Management-funded program.

In addition, the GWA program is collaborating with other ichthyoplankton sampling programs including the Recruitment Processes Alliance at the NOAA Alaska Fisheries Science Center. To date, this involves including some of the ichthyoplankton time series in one of Gulf Watch Alaska's synthesis manuscripts (Suryan et al.) and leveraging the GWA/Long-term Ecological Research oceanographic vessel platforms of opportunity to collect ichthyoplankton samples for the NOAA Recruitment Processes Alliance to analyze. We intend to work with researchers and data from across these projects this year and are excited about how that will help us better understand nearshore and pelagic ecosystem changes and linkages.

11. Budget:

Please see provided program workbook.

For KBNERR, field sampling, data analysis, and reporting tasks were performed by staff at a lower cost to the project, due to leveraging of other funding. Savings were also realized due to field work and travel cancellations in 2020 due to COVID-19 restrictions. This will allow us to complete additional data analyses and synthesis efforts in FY21. We do not expect to need any >10% change of funding between budget categories.

For NOAA, the Kasitsna Bay Lab actual cumulative budget varied slightly from planned amounts (<10% of total) due to reduced travel (~$10K less) and commodity (~$11K less) costs due to COVID-19 restrictions on travel and field work. Some funds were reallocated to the Kasitsna Bay Lab labor contract to assist with GWA data synthesis efforts and $7.6K is remaining to be spent on commodities. We anticipate expending remaining funds by the end of FY21.

***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	$160.4
Travel	$7.9	$7.6	$10.5	$8.6	$8.1	$42.7	$19.7
Contractual	$74.8	$76.8	$88.1	$51.7	$52.2	$343.6	$292.8
Commodities	$11.0	$11.5	$11.5	$10.0	$9.9	$53.9	$21.1
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	$43.4
SUBTOTAL	$155.7	$160.0	$168.2	$124.5	$122.2	$730.6	$537.3
General Administration (9% of subtotal)	$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 Funds)	$205.0	$213.0	$215.0	$182.8	$192.0	$1,007.8	

LITERATURE CITED

Danielson, S., T. Hennon, D. Monsoon, R. Suryan, R. Campbell, S. Baird, K. Holderied, and T. Weingartner. in prep. A study of thermal variability in the Northern Gulf of Alaska across years of marine heatwaves and cold spells.

McKinstry, C.A.E., and R.W. Campbell. 2018. Seasonal variation of zooplankton abundance and community structure in Prince William Sound, Alaska, 2009–2016. Deep Sea Research Part II: Topical Studies in Oceanography 147:69-78.

Weitzman, B., Konar, B., Iken, K., Coletti, H., Monson, D., Suryan, R., Dean, T., Hondolero, D., and Lindeberg, M. 2021. Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. Frontiers in Marine Science 8:556820. doi: 10.3389/fmars.2021.556820