ATTACHMENT B. Annual Project Report Form (Revised 11.21.19)

1. Project Number:

19120114-J

2. Project Title:

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

3. Principal Investigator(s) Names:

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4. Time Period Covered by the Report:

February 1, 2019-January 31, 2020

5. Date of Report:

March 2020

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 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 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 2019, under the lower Cook Inlet/Kachemak Bay oceanographic monitoring project, we collected year-round oceanographic, zooplankton, and phytoplankton data, completed taxonomic identification for zooplankton samples collected in 2018 (in collaboration with PWS oceanographic project researchers, project 19120114-G), conducted additional multivariate analysis on plankton data, developed an oceanographic synthesis manuscript with other GWA investigators, delivered quality-controlled data to the Research Workspace before program deadlines, conducted data analyses with project time series data from 2012-2018 and presented results at conferences and workshops, including in a talk at the Alaska Marine Science Symposium.

Specific project objectives include the following, with a brief status of progress towards the objectives made in 2019. 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*.
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.*
4. Assess interannual changes in oceanographic structure and phytoplankton/zooplankton species composition across the Cook Inlet entrance. *Status: Completed spring 2019 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 19120114-L] and Continuous Plankton Recorder [CPR, project 19120114-D] projects). *Status: Completed GWA synthesis manuscripts, one with Environmental Drivers component (Danielson et al. 2019) and one with the GWA Science Coordinator (Suryan et al. 2019)*.

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 19120114-I], Seward Line [project 19120114-L], and CPR [project 19120114-D] projects), and PWS (PWS oceanography [19120114-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. 2019).*
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 2017-2019 are summarized in Table 1. Shipboard sampling completed in 2019 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) (see Fig. 1 for station locations). Oceanographic data were collected vertically from surface to near-bottom at stations (shown as dots on Fig. 1), using conductivity-temperature-depth (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, as well as in ice-free months from a mooring near the head of Kachemak Bay in Bear Cove (shown by green stars in Fig. 1).

In 2019, oceanographic observations from shipboard CTD and continuous water quality stations in Kachemak Bay showed mostly above average water temperatures, especially during June-August. Phytoplankton abundances returned to more average levels, as compared to lower than normal abundances seen in 2020, and levels of toxic algae remained below regulatory limits for human shellfish consumption. 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 manuscript to describe seasonal, interannual and spatial patterns in the zooplankton community.

Field Sampling update

Field sampling activities for 2019 were completed in accordance with our proposal and with the detailed sampling protocols available on the Alaska Ocean Observing System (AOOS) Research

Workspace. We maintained monthly shipboard oceanographic and plankton sampling in Kachemak Bay and quarterly sampling in outer Kachemak Bay and southeast Cook Inlet, 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. January 2019 Kachemak Bay sampling was not completed due to ice blocking access to the Homer small boat harbor for over three weeks, but we conducted a survey in the first week of February after the ice cleared. 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 (2017-2019). Blue color denotes that samples were collected. AB stands for the Along-Bay transect.

		CTD						**PHYTOPLANKTON**						**ZOOPLANKTON**						**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	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■
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2017	June	■					■	■					■	■					■	■					■
2017	July	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2017	August	■					■						■						■						■
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2017	November	■			■	■	■	■			■	■	■	■			■	■	■	■			■		■
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2018	November	■					■	■					■	■					■	■					■
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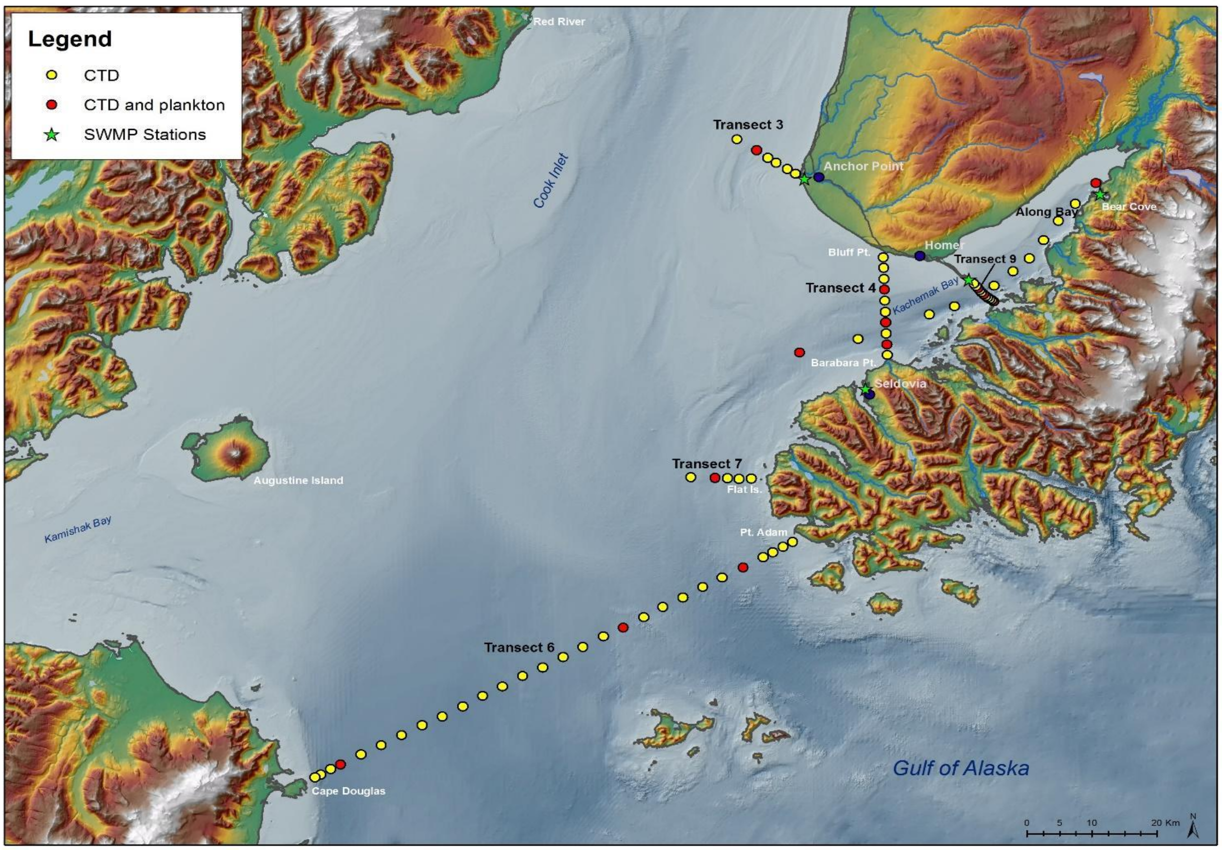


Figure 1. Sampling locations for the lower Cook Inlet and Kachemak Bay project in 2019. Stations shown for shipboard oceanography (all dots) and phytoplankton and zooplankton sampling (red dots). Kachemak Bay National Estuarine Research Reserve continuous sampling stations are marked with green stars. No changes to sampling locations in 2019.

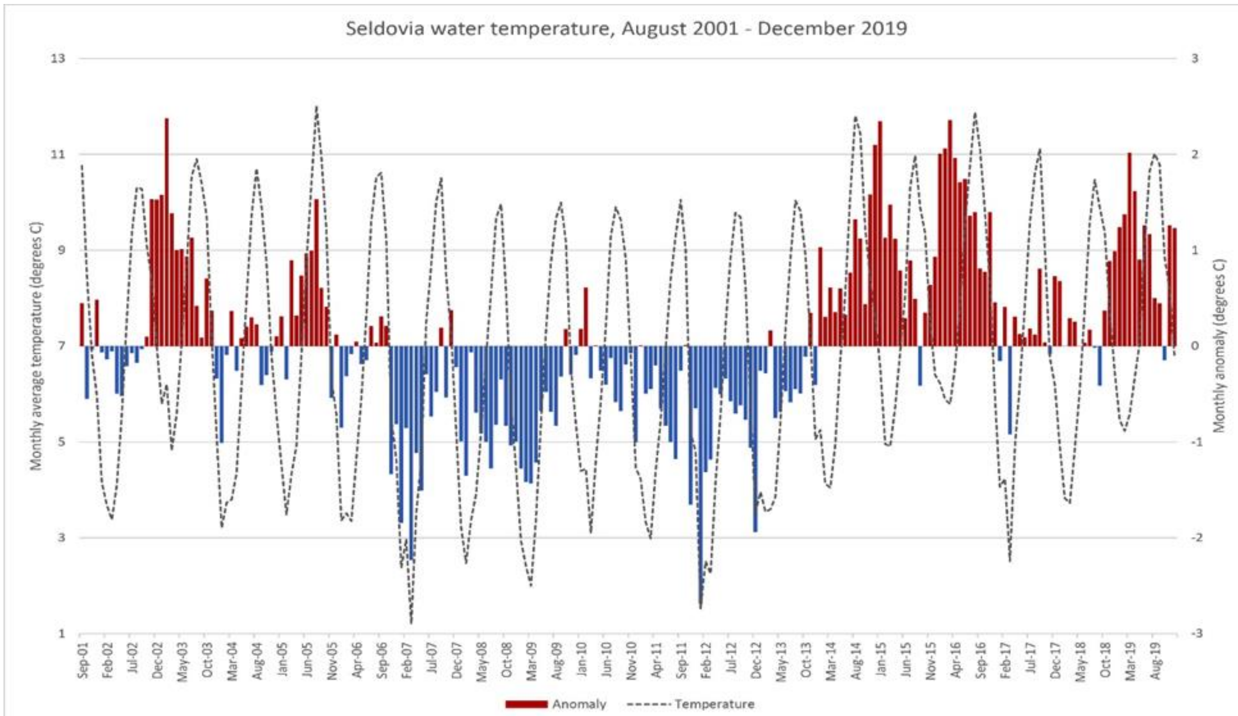
Recent Results and Scientific Findings

Detailed results from 2019 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 and collaborated with Rob Suryan (GWA science coordinator) and other Environmental Drivers and Nearshore component researchers on GWA synthesis manuscripts (objective 7) and have 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 (2001-2019) 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 warmer than the long-term average, with anomalies of up to 2˚C, and averaging near 1˚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. Kachemak Bay waters were also somewhat less saline than the long-term average, although not to the extent seen during 2014-2016. The periods of lower salinity in 2014-2016 and since October 2018 can also be seen in the salinity time series shown in Fig. 3. 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. 4 shows a time series of vertical temperature (top) and salinity (bottom) profiles from February 2012 to December 2019 from monthly sampling at the middle CTD station along the mid-Kachemak Bay survey line (Transect 9, station 6). The winter of 2018-2019 was noticeably warmer than the previous two winters, with temperatures staying near or above 5˚C, similar to the anomalously warm winter conditions in 2014-2015, though not as warm as 2015-2016. Reflecting the warm, dry summer weather, summer 2019 water temperatures were among the warmest observed in the study period, including during the 2014-2016 marine heat wave, with hottest (>12.5˚C) surface temperatures persisting longer than normal and waters above 10˚C reaching as deep as 80 m (Fig. 4). Warm temperatures persisted through the end of December, when very cold air moved in across the state. Somewhat surprisingly, given the moderate drought conditions experienced from June to August, the monthly surface salinities remained similar to what was observed in previous years, which is similar to what was observed at the Homer SWMP station. This lack of increased salinity in the water column, despite several months of drought conditions, indicates that the lack of rain was balanced by increased inputs of glacial meltwater associated with the persistent sunny weather and warm summer air temperatures. We used our monthly along-bay CTD survey data to further investigate the estuary response to the 2019 summer drought conditions, finding that the near-surface lens of fresher water has same spatial extent as and was as fresh or fresher than during the same months in 2017 and 2018 (Fig. 5). It was also interesting to note that deeper waters remained relatively fresh into December, which is unusual. It will be interesting to see how fast the water column responds to the anomalously cold weather in January 2020.



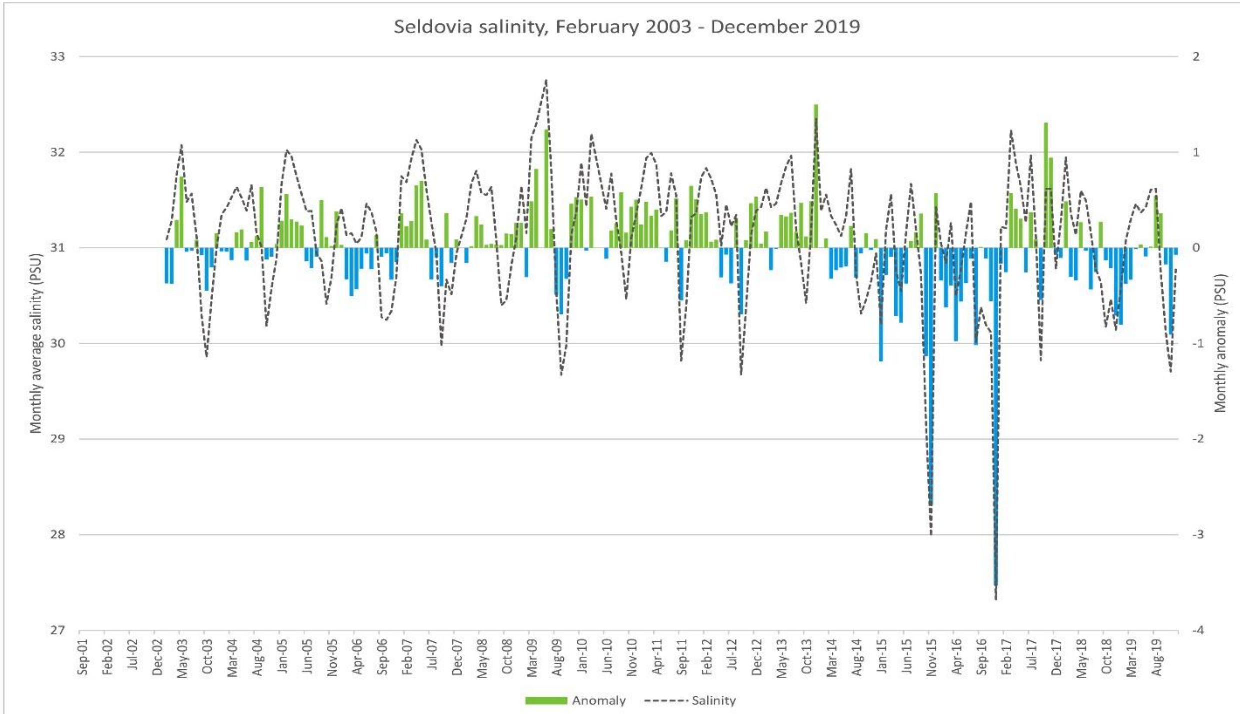


Figure 2. Time series of monthly average (dashed line) and monthly anomaly (bars) water temperatures (top) and salinities (bottom) at Kachemak Bay National Estuarine Research Reserve monitoring station in Seldovia during 2001-2019. These System Wide Monitoring Program station data are collected from 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.

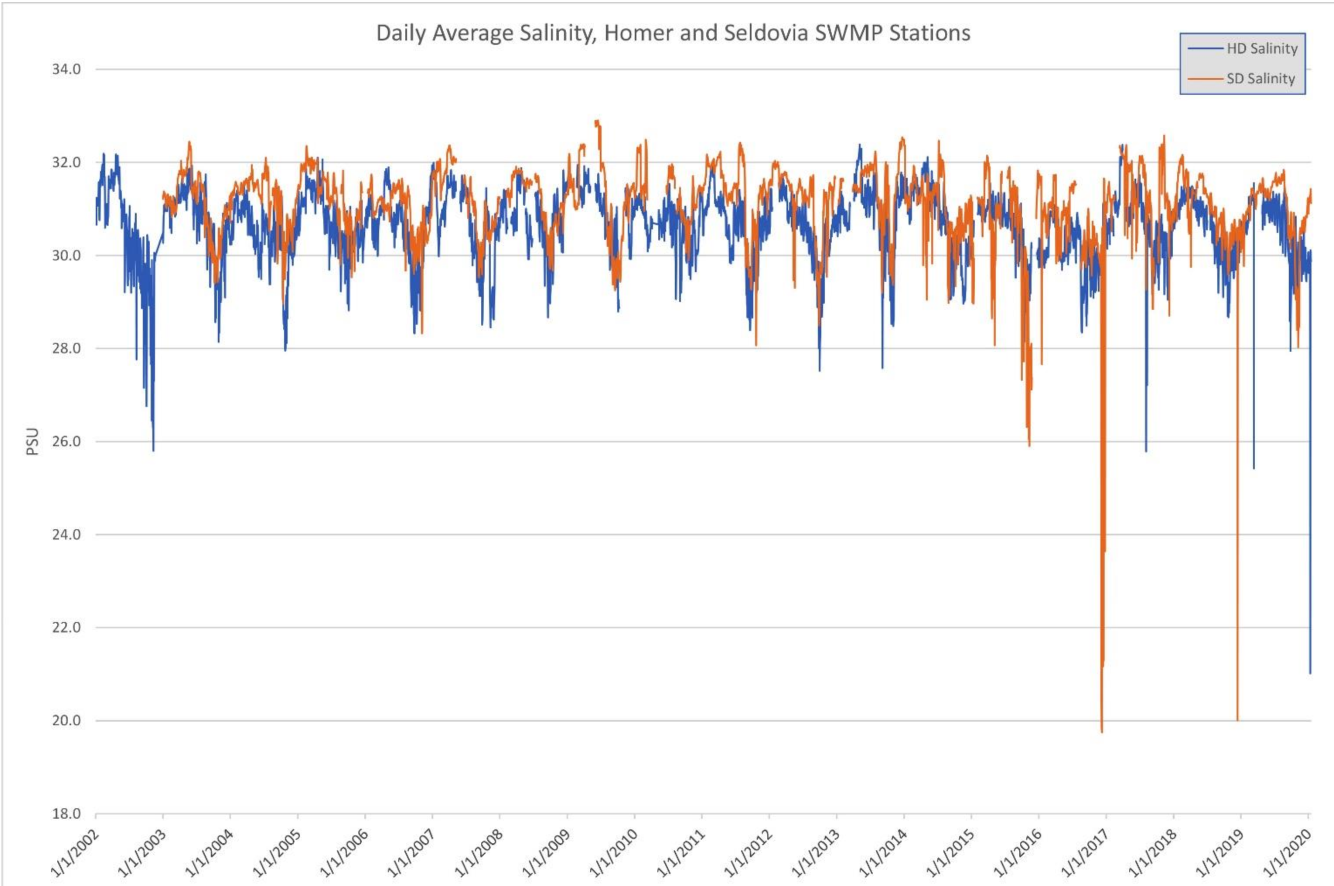


Figure 3. Time series of salinity measurements from the Homer (blue) and Seldovia (orange) System Wide Monitoring Program sites, both at an average depth of 8 meters, one meter from the bottom.

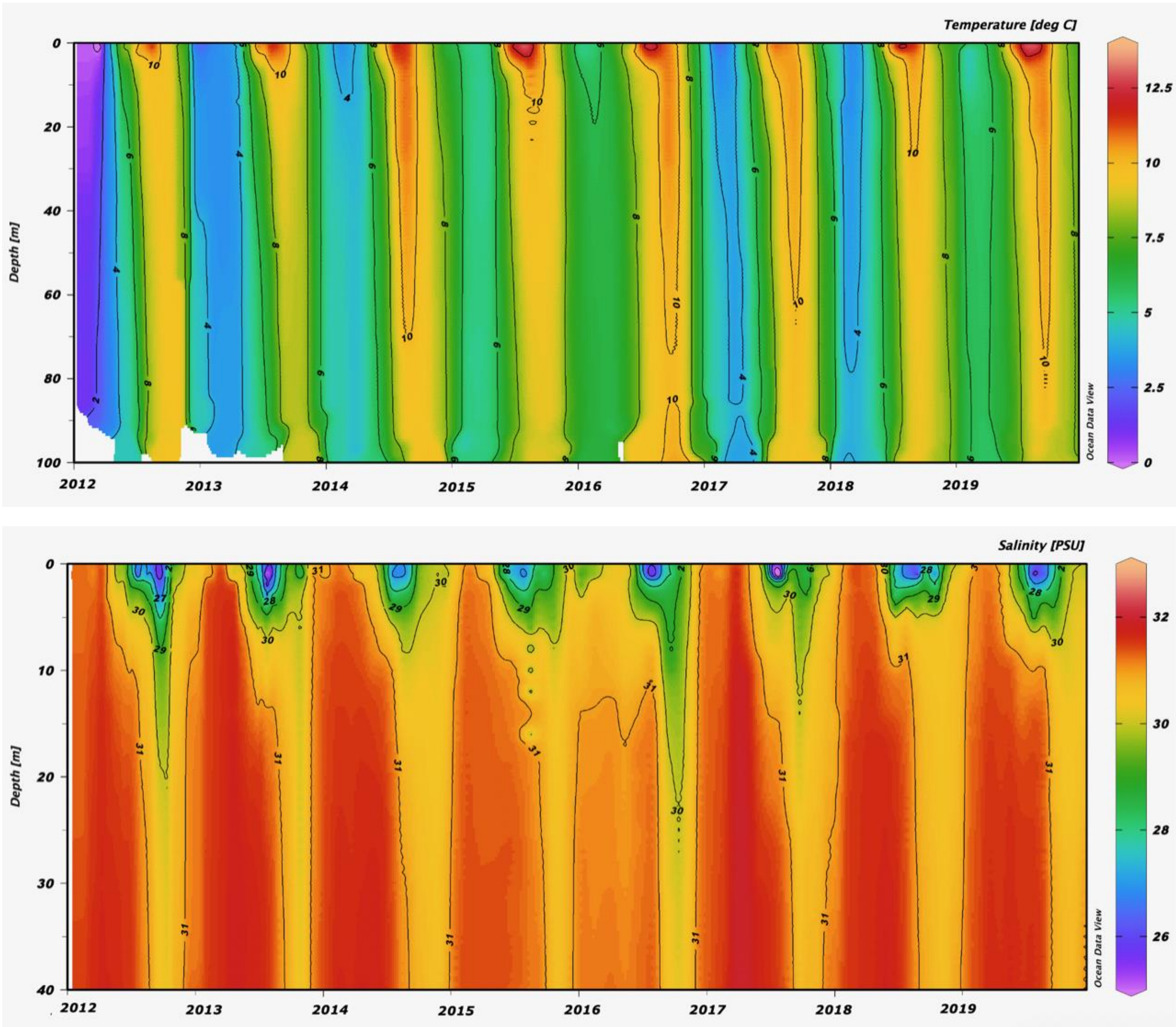


Figure 4. Time series of vertical profiles of water column temperature (top, degrees C) and salinity (bottom, practical salinity units [PSU]) from 2012-2019 collected from monthly conductivity and temperature at depth casts at a mid-Kachemak Bay station. Note that the temperature plot covers the entire water column (~100 m), while the salinity plot only extends to 40 m depth, in order to show the near-surface intensified patterns in more detail.

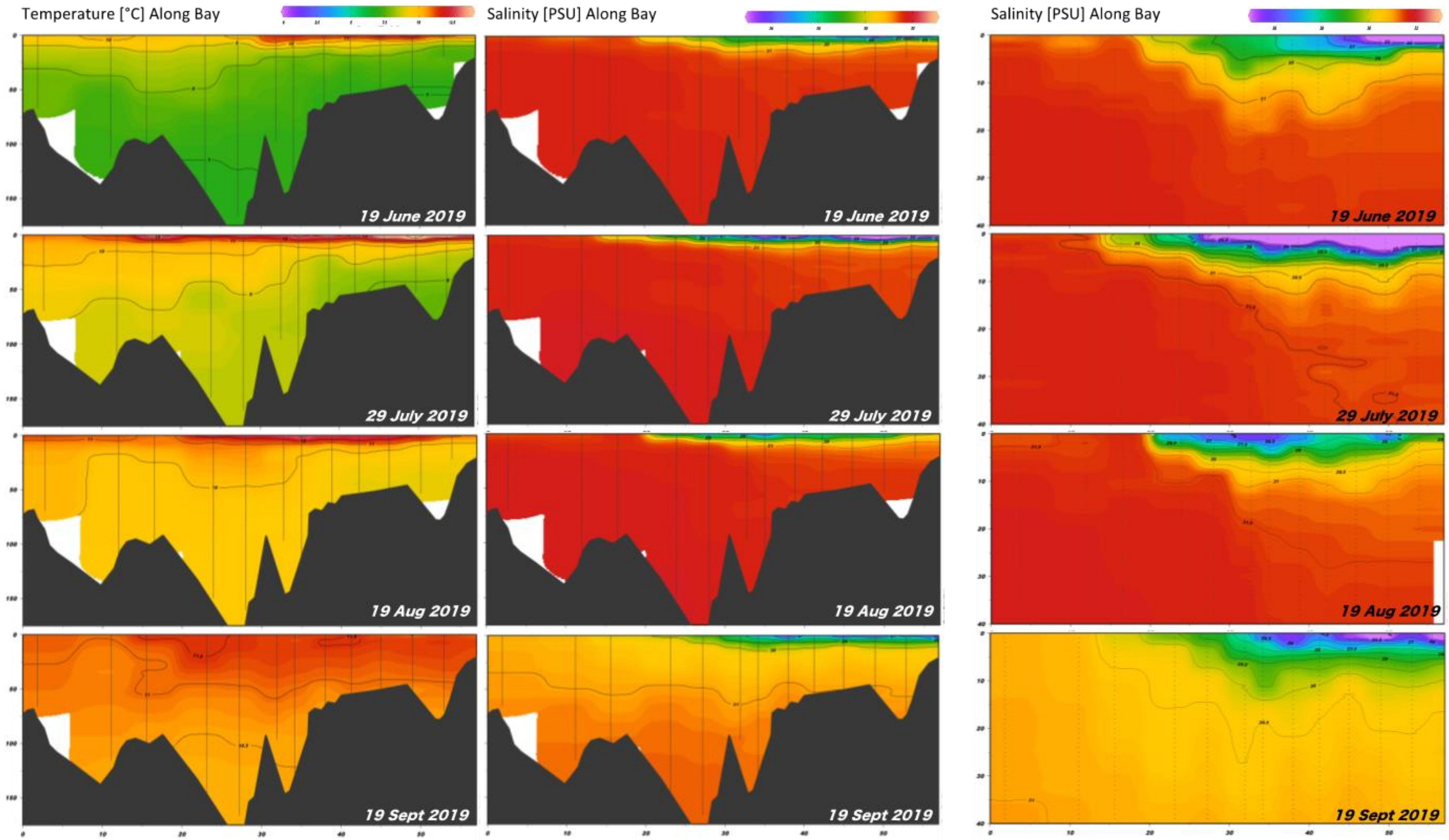


Figure 5. Comparison of summer temperature (left column) and salinity (middle and right columns) contours from conductivity and temperature at depth profiler data on the Along-Bay transect. Depth is on the y-axis and horizontal distance is on the x-axis. Sections run from Point Adam (left) in southeast Cook Inlet to Bear Cove (right) at the head of Kachemak Bay, with bottom depths shown in black. Right column shows upper 40 meters of the water column salinity, for more near-surface detail.

Phytoplankton Results

In 2018 the average monthly phytoplankton cell abundance was much lower than previous observations; a pattern that persisted through the usual summer bloom timeframe (Fig. 6). Our observations were corroborated by the Kachemak Bay Research Reserves citizen monitoring program. In 2019 we saw average monthly cell abundances return to numbers that were more similar to the years prior to 2018 (Fig. 6). We did not observe any unusual species in our sampling this year, even with our unusually sunny and dry weather, which persisted from May through September.

We continue to monitor the presence of *Alexandrium catanella*, the phytoplankton that causes paralytic shellfish poisoning, using the molecular qPCR method. The most recent results from 2019 showed results similar to 2017 and 2018, in spite of the high temperatures and drought conditions from May through September 2019 (Fig. 7). We think it is possible that the lack of rainfall runoff was buffered by an increase in meltwater from the glaciers due to the warmer temperatures. The results will be incorporated into improved HAB risk assessment tools, such as the Kachemak Bay HAB Information System (www.aoos.org/k-bay-hab/), in collaboration with other NOAA offices, Alaska Department of Environmental Conservation, ADF&G, and Alaska Department of Health and Social Services.

We continue to leverage our environmental drivers project to examine HABs in Kachemak Bay. As part of North Pacific Research Board (NPRB) project #1801, Prevalence of paralytic shellfish toxins in the marine food web of southcentral and southwestern Alaska, we are examining the toxicity of plankton, forage fishes, and predatory fishes in Kachemak Bay and neighboring regions.

On our regular monitoring trips for GWA we collect phytoplankton and zooplankton samples for toxin testing that complement our beach seining and port sampling efforts. We did not see high abundances of *Alexandrium* in 2019 and subsequently, toxin levels were also low in our phytoplankton samples and were similar to abundances in Prince William Sound (Fig. 8). For Kodiak, we have not yet analyzed the samples for cell abundance, however the toxicity of phytoplankton samples went above the Food and Drug Administration (FDA) regulated limit for consumption (80 micrograms of toxin per 100 grams of tissue) (Fig. 8). Looking at the forage fish data for the three regions we found that toxicity levels in forage fish were low, with only a few samples exceeding the FDA limit for safe consumption. The samples that exceeded the limit were Dolly Varden, Pacific sand lance, and Pacific herring (Fig. 9).

We also conduct port sampling to examine toxins in predatory fishes: pink salmon, sockeye salmon, coho salmon, and Chinook salmon. For these samples we looked at the separate toxicity of several organs and tissues in each fish: muscle tissue, digestive tract, stomach contents, liver, kidney, and roe from female fish. Our 2019 sampling found that toxicities were low except for the kidneys of Chinook salmon, which showed elevated levels of toxins (Fig. 10). However, the low levels of toxin in the phytoplankton and zooplankton were likely reflected in the low levels of toxin in predator tissues. The NPRB project has one more year of sampling and we will be monitoring results to see if patterns of toxins in forage fish and predator fish will be similar to those in phytoplankton and zooplankton again.

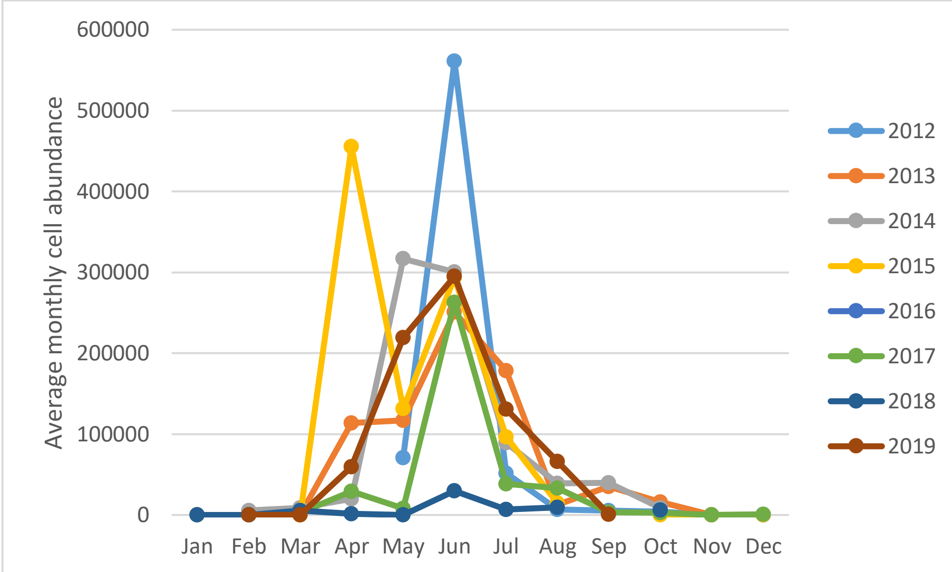


Figure 6. Average phytoplankton cell abundance by month for each year, 2012-2019 from samples collected at the Kasitsna Bay Laboratory dock from May 2012 through September 2019. No sampling data for 2016.

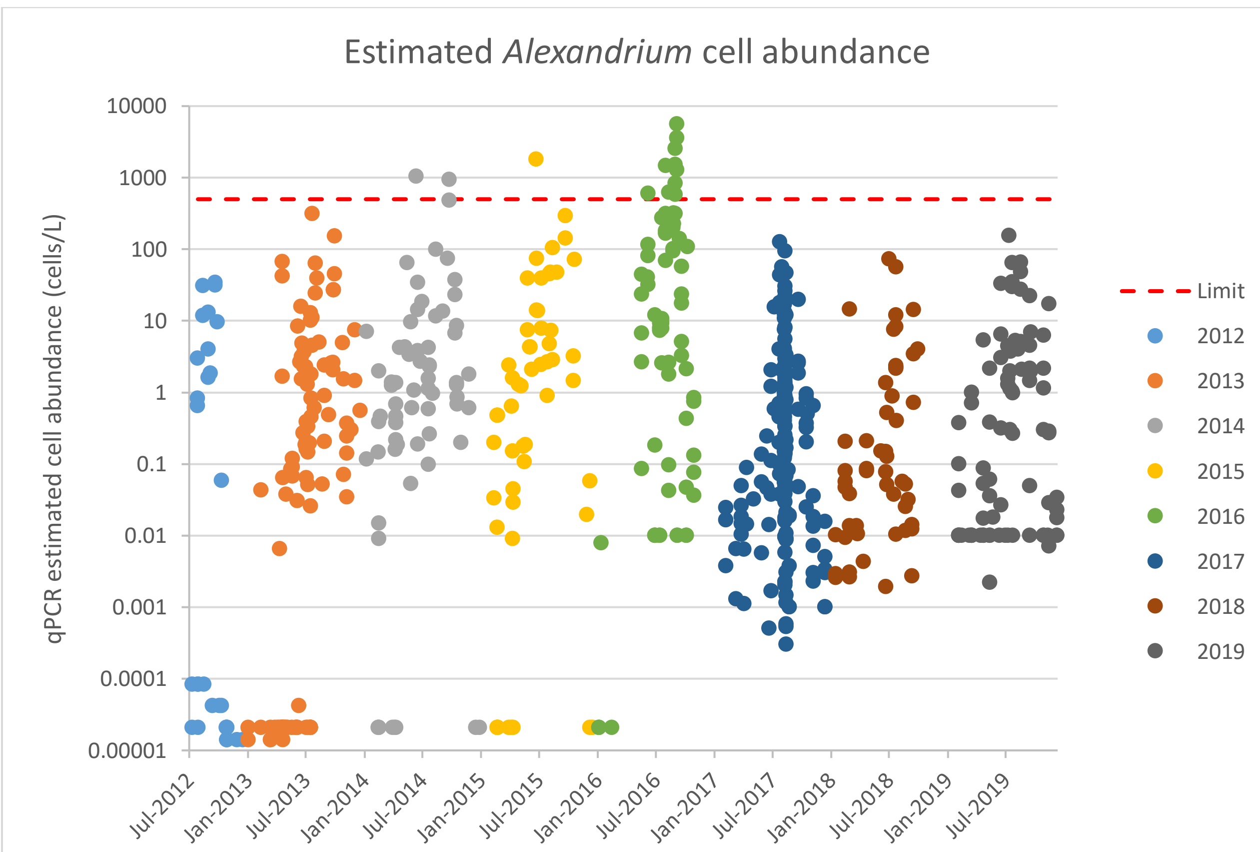


Figure 7. Time series of estimated Alexandrium *spp. abundances from Kachemak Bay and lower Cook Inlet samples from qPCR analysis for 2012-2016. Results are shown on a logarithmic scale. The level for expecting shellfish toxicity at 500 cells per liter is shown as a dashed red line.*

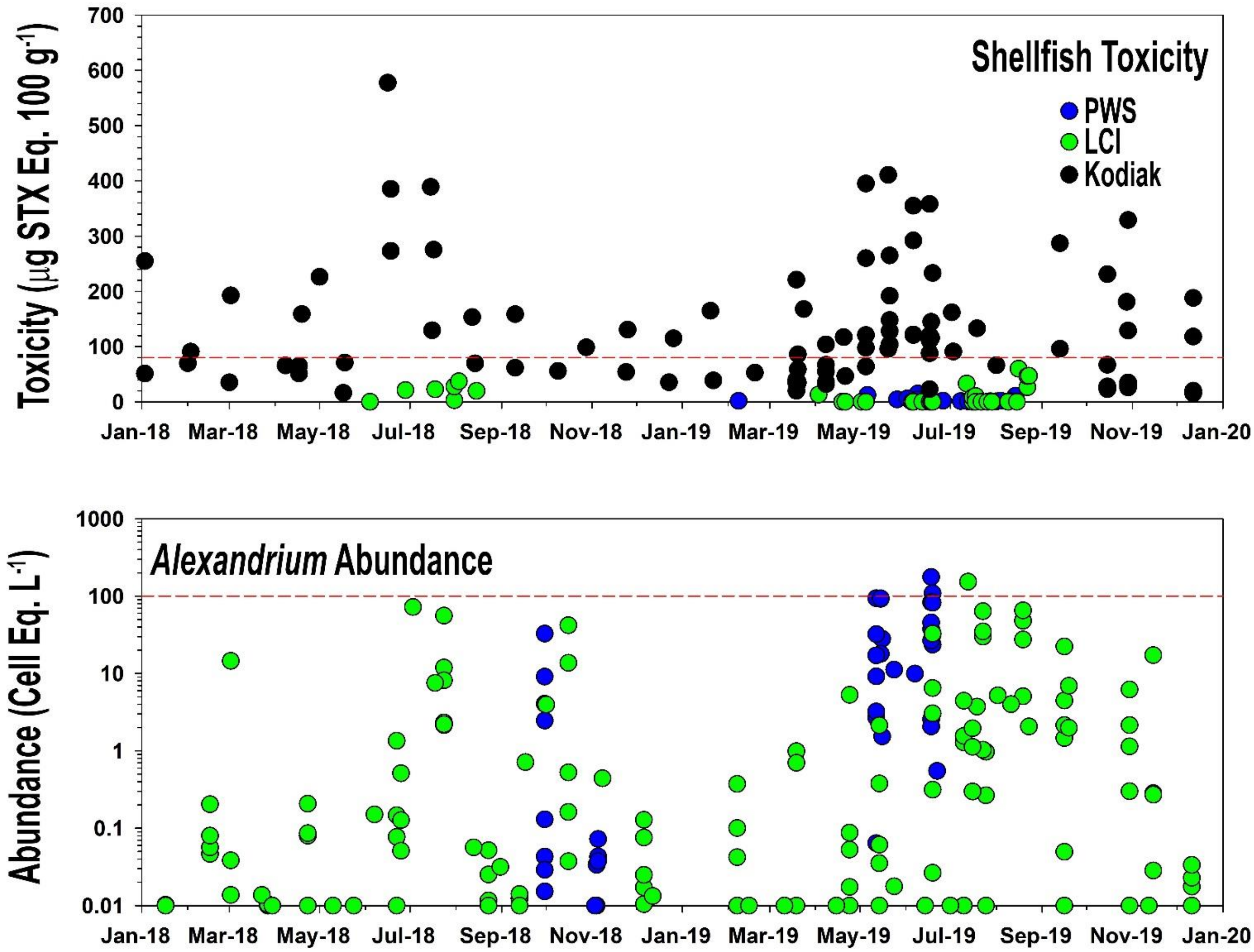


Figure 8. Plots of Alexandrium *toxicity from water samples collected in Prince William Sound (PWS), Lower Cook Inlet (LCI), and Kodiak and* Alexandrium *abundances from LCI and PWS. Toxicity is shown in micrograms of toxin per 100 grams of tissue and the red dashed line indicates the FDA limit for safe consumption. Abundance is shown on a logarithmic scale and the red dashed line shows the estimated abundance at which we could see unsafe levels of toxin. Cell abundance analyses of the Kodiak samples have not been completed.*

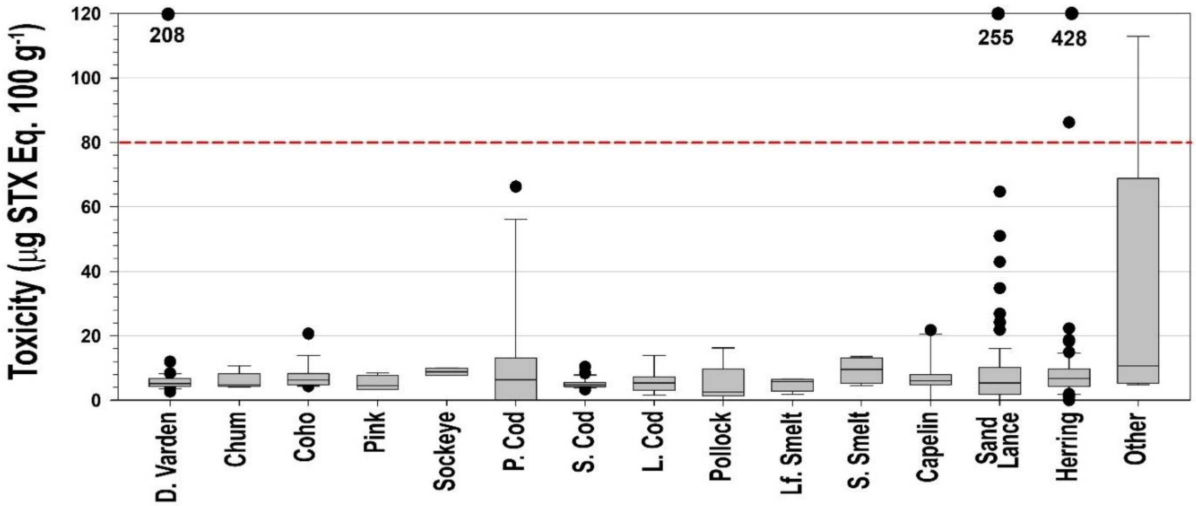


Figure 9. Plot showing the toxicity of forage fishes during 2019 including samples taken from Lower Cook Inlet (LCI), Prince William Sound (PWS), Kodiak, and the Aleutian Islands. Toxicity is shown in micrograms of toxin per 100 grams of tissue. The red dashed line indicates the Food and Drug Administration limit for safe consumption.

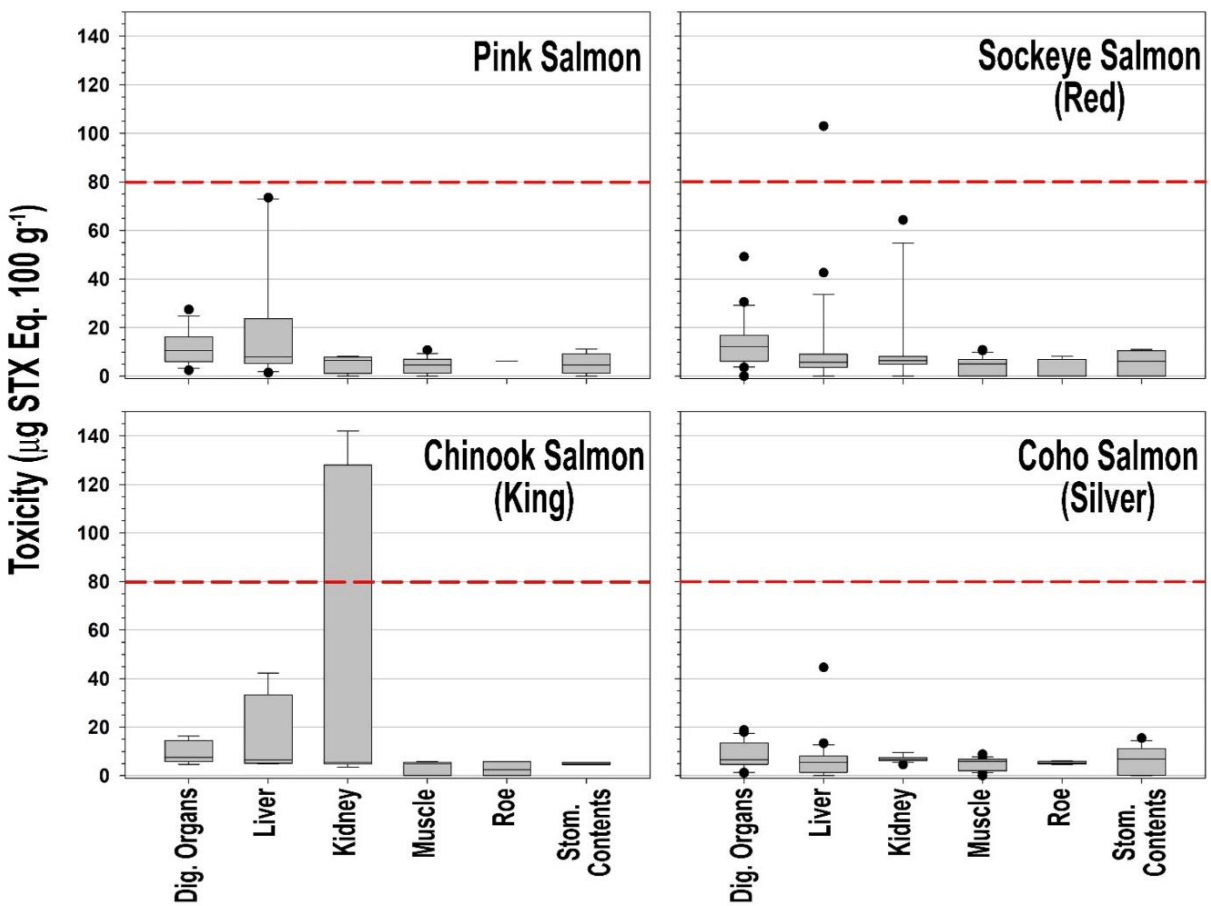


Figure 10. Plots showing distribution of Saxitoxins in different species of Pacific salmon during 2019. Toxicity is shown in micrograms of toxin per 100 grams of tissue for different organs within the individual fishes. The red dashed line shows the FDA recommended limit for safe consumption.

Zooplankton Results

In 2019 we conducted additional analyses on the 2012-2017 zooplankton data (462 samples and 236 taxa) to investigate seasonal patterns in more detail and, in collaboration with Rob Campbell and Caitlin McKinstry at Prince William Sound Science Center (PWSSC), completed species identification and conducted preliminary data analysis on the 2018 zooplankton data. To examine seasonal patterns across multiple years with the 2012-2017 data, we calculated three non-metric Multi-Dimensional Scaling (nMDS) axes to characterize the zooplankton community structure in space and time. We calculated these axes once and then investigated spatial, seasonal and interannual patterns. Results from seasonal analyses are presented here. With a focus on seasonal patterns, we refrained from recalculating these axes for subsets of stations (shown in previous GWA reports) in order to preserve what had been learned about these axes in preceding analyses. Zooplankton samples from Transect 9 (mid-Kachemak Bay line) presented a special opportunity, with monthly samples collected for all six years. Plotting the first two major nMDS axes of all Transect 9 samples, including relative abundance, shows a detailed seasonal progression in the zooplankton community composition (Fig. 11). We then used the data to derive data-driven seasonal categories. We used hierarchical clustering on Manhattan distances to group monthly mean zooplankton samples (Fig. 12). This analysis finds the pair of months with the shortest distance, groups this pair by averaging, then re-applies the algorithm until all samples are included. The branch lengths were used to optimize the number of clusters and four clusters emerged, which biologically correspond to winter dormant stage, spring bloom, summer stable-state, and fall bloom/decline. The most distinct cluster was spring (March-April), separated by a long branch from all other seasonal clusters, but more connected to winter (November to February) than summer (May to August) or fall (September-October). The distance from summer to fall was comparatively short, suggesting that zooplankton community composition in Kachemak Bay varies most in three seasonal stages (winter, spring, summer-fall). Applying these seasons to all zooplankton data in Kachemak Bay and lower Cook Inlet and plotting their position on the two first nMDS axes, we find winter and summer split clearly along the first nMDS axis, and spring and fall, equally well separated, on the second nMDS axis (Fig. 13). Because the scales have not been recalculated, direct comparisons can be made between the nMDS plots for all locations (Fig. 13) and for Transect 9-only (Fig. 11).

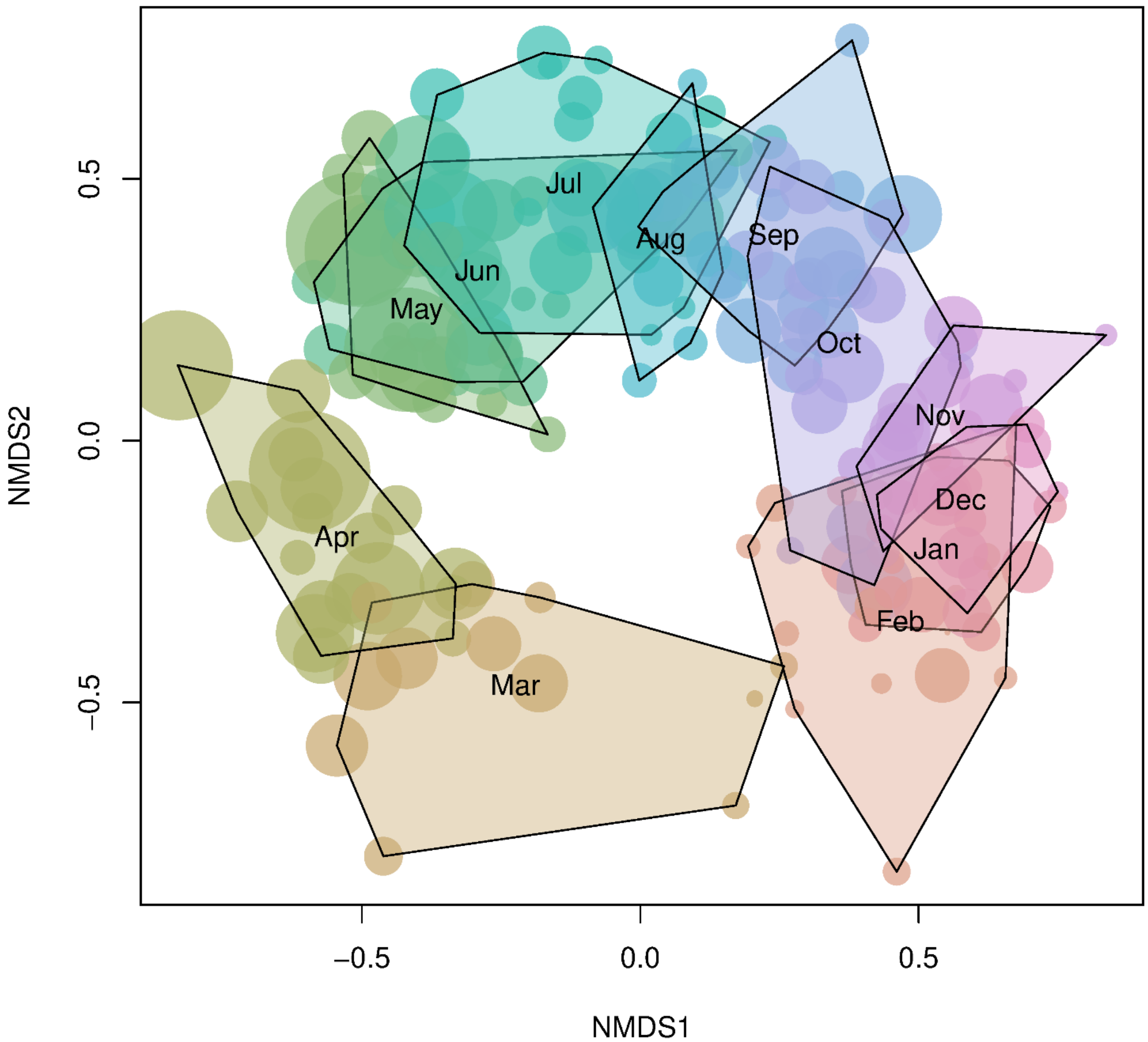


Figure 11. Non-metric multidimensional scaling (nMDS) plot using zooplankton community composition analysis from 2012-2017 data collected along mid-Kachemak Bay transect (Transect 9). Samples are colored and connected by month, with relative abundances indicated by dot size.

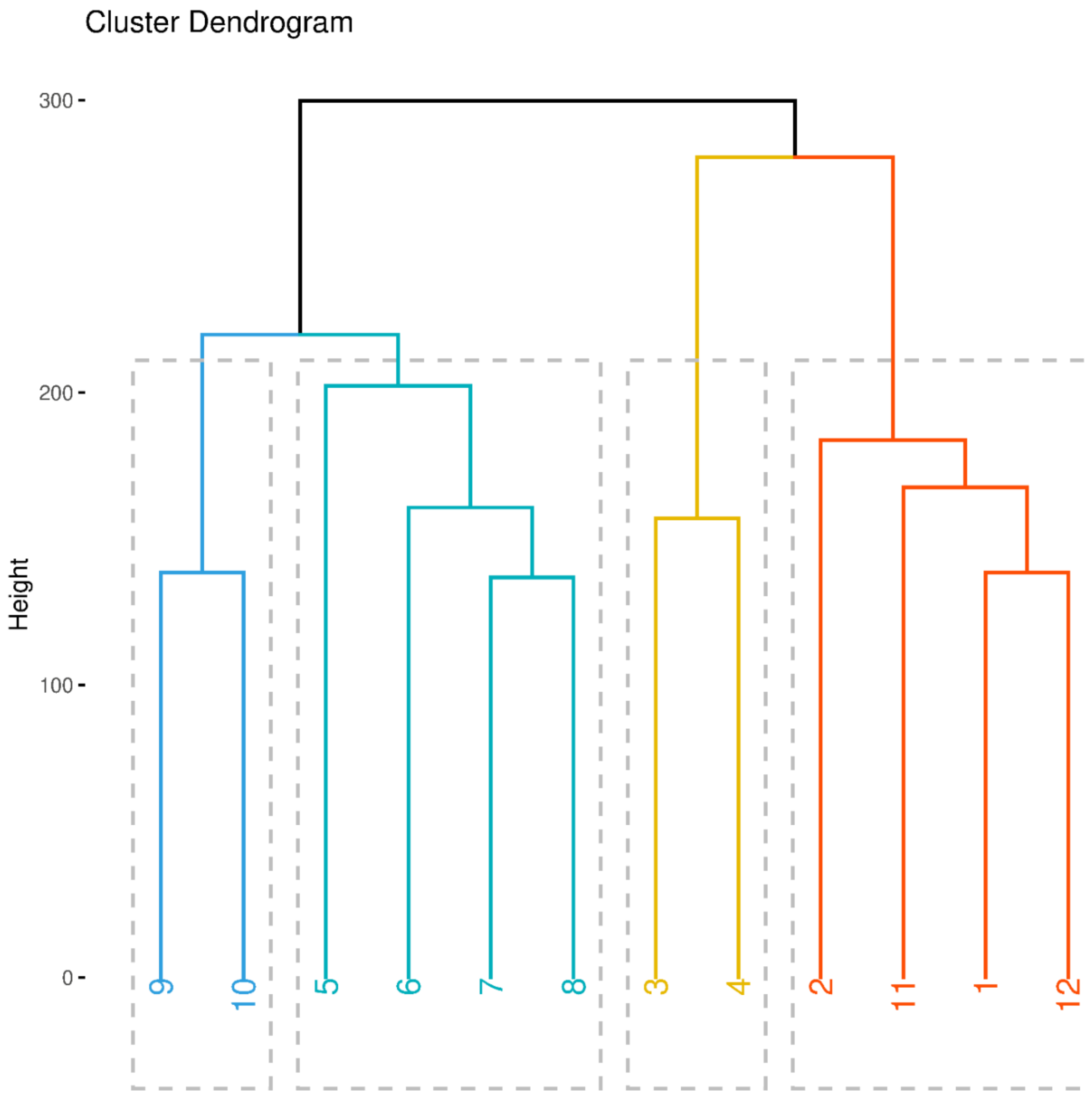


Figure 12. Cluster Dendrogram from hierarchical clustering of zooplankton community composition on Manhattan distances. Numbers are months, with fall (9-10), summer (5-8), spring (3-4) and winter (11-12, 1-2).

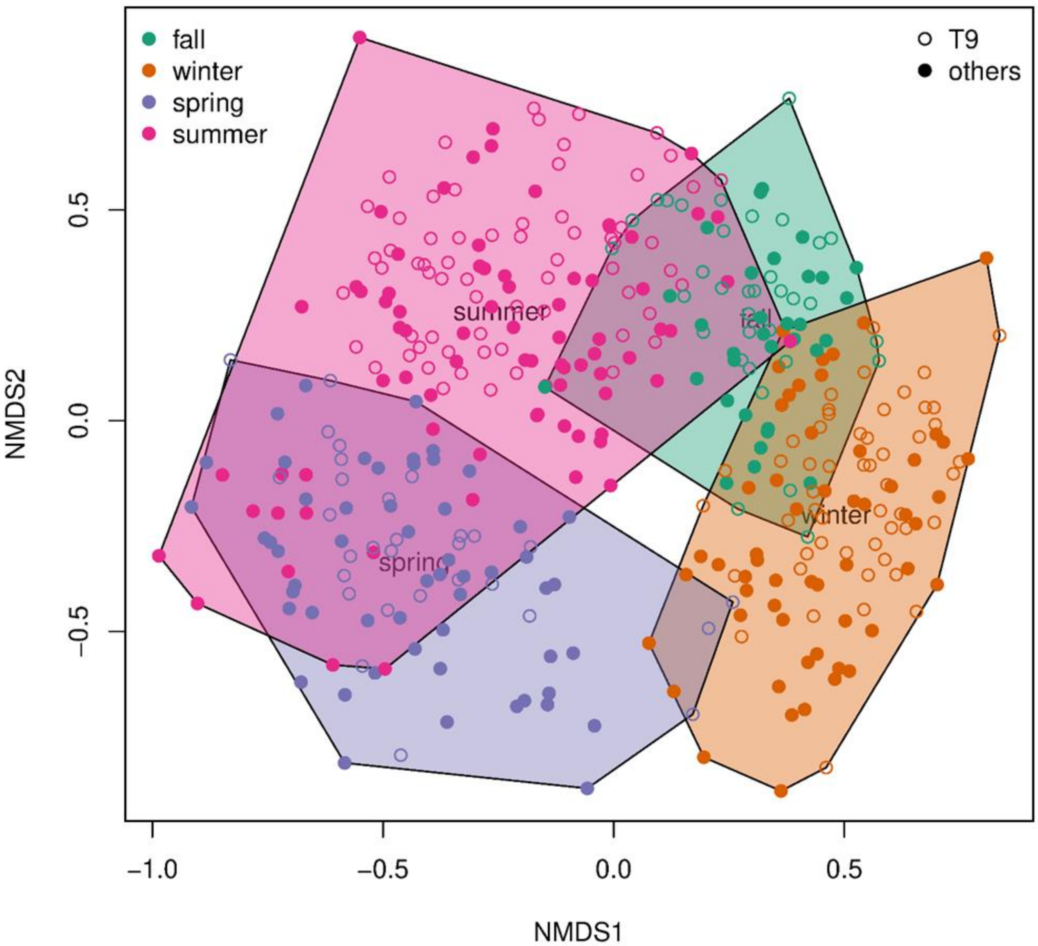


Figure 13. Non-metric multidimensional scaling (nMDS) plot using zooplankton community composition analysis from 2012-2017 data collected in Kachemak Bay and lower Cook Inlet. Samples are colored and connected by season, with data from mid-Kachemak Bay (Transect 9) stations shown as open dots and other stations shown as solid dots.

In order to make our study more comparable to the other zooplankton studies within GWA, we continue to collaborate on analyses with GWA partners at PWSSC (project 19120114-G). Initial analyses of all zooplankton data through 2018 have been conducted (based on methods in McKinstry and Campbell 2018), with results presented by Caitlin McKinstry at the Ocean Sciences Meeting in February 2020. Time series of zooplankton abundance, warm and cold copepod species, krill, gelatinous zooplankton, and large copepods are shown in Fig. 14. Overall zooplankton community abundance levels are relatively consistent between years, though there are differences in seasonal patterns, such as higher spring and lower summer abundances seen in 2016. In 2018 the abundance of warm copepods was lower than it had been in 2016 and 2017, which may reflect closer to average ocean temperatures. Fig. 15 further illustrates seasonal patterns in abundance for the zooplankton community as a whole and for groups of copepods species, fit with a generalized additive model (GAM).

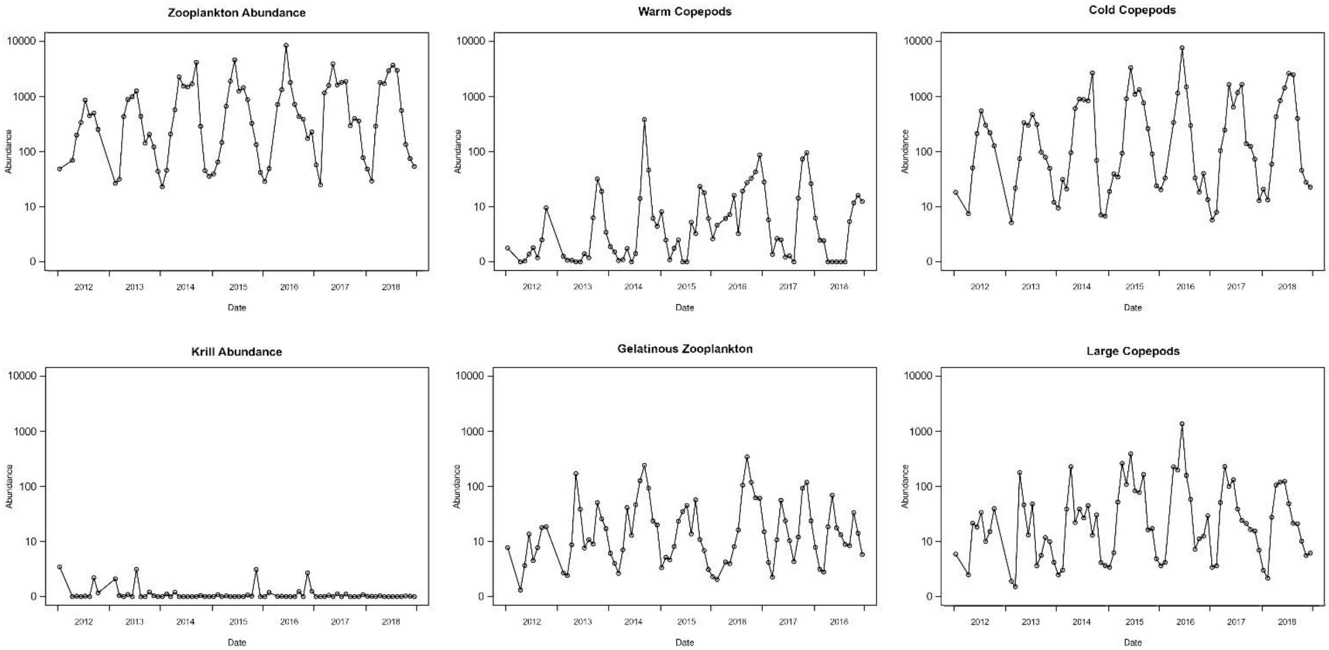


Figure 14. Log10(n+1) monthly means timeline. Note that standard deviation is not included, and variance should be expected. Zooplankton abundance includes all species and categories observed. Warm water copepods include Calanus pacificus, Clausocalanus spp., Ctenocalanus vanus, Corycaeus anglicus, Mesocalanus tenuicornis, *and* Paracalanus parvus. *Cold water copepods include* Acartia longiremis, Calanus marshallae, Pseudocalanus *spp., and* Oithona similis. *Krill include all euphausiids observed in zooplankton samples (*Euphausia pacifica, Thysanoessa gregaria, T. inermis, T. inspinata, T. longipes, T. raschii, T. spinifera*). All cnidarians, ctenophores, and pelagic tunicates are included in the Gelatinous Zooplankton category (too many to list). Large copepods include* C. marshallae, Epilabidocera longipedata, Eucalanus bungii, Metridia okhotensis, Metridia pacifica, Neocalanus *spp. (*plumchrus *and* flemingeri*), and* N. cristatus.

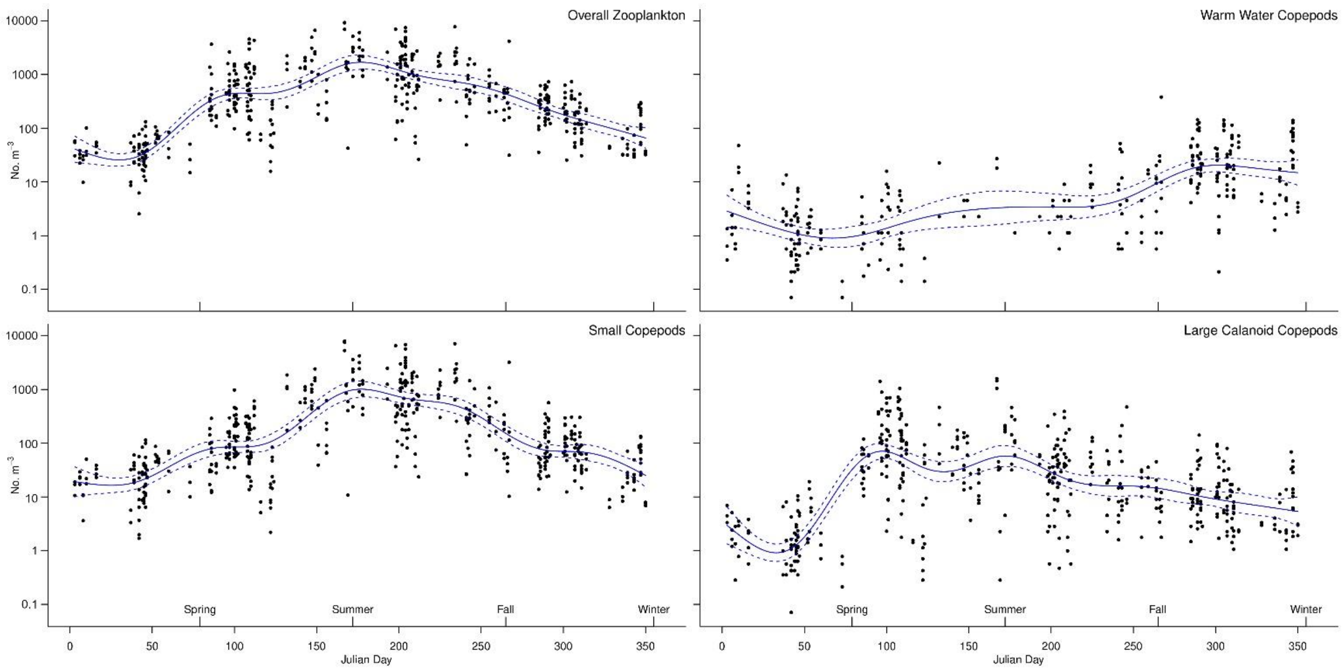


Figure 15. Log10(n+1) zooplankton abundance data with a generalized additive model fitted line (solid blue line) and 95% confidence intervals (dotted blue line). Categories are as described in Fig. 14 above.

Using Ward's agglomerative method, a hierarchical cluster analysis (HCA) produced distinct groups based on species assemblages. These groups were used in the Indicator Species Analysis (ISA) to examine which species were indicative of each group (Fig. 16). We are working with McKinstry and Campbell on a manuscript that describes seasonal and interannual variability in zooplankton communities in Kachemak Bay and lower Cook Inlet, based on 2012-2018 project data, and expect to submit the manuscript for review and publication in 2020.

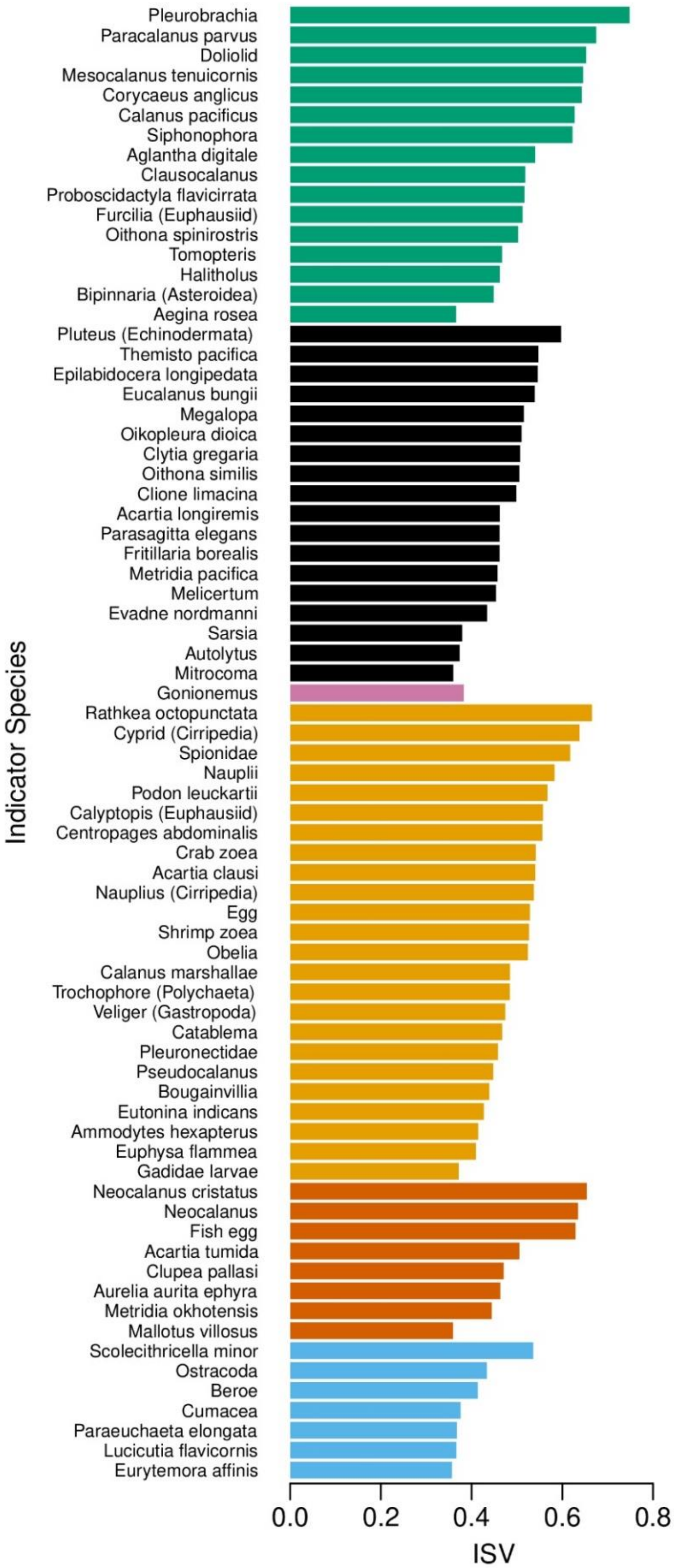


Figure 16. Indicator species values (ISVs) based on groups produced by the hierarchical clustering analysis of mean transect clustering (cophenetic correlation coefficient: 0.514) to form the indicator species analysis groups using zooplankton species and categories present in more than 7.5% of tows (n = 88 species). Of the 88 species and categories included in the analysis, the 74 most significant ($p < 0.05$) are presented here.

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 (Prince William Sound oceanography project 19120114-G) at the PWSSC 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 (Sonia Batten, CPR project 19120114-D, Seth Danielson, Rob Campbell, Prince William Sound oceanography project 19120114-G, GAK1 project 19120114-I, and Russ Hopcroft, Seward Line project 1912-114-L) and Rob Suryan (GWA Science Coordinator, project 19120114-A) to incorporate project data into synthesis manuscripts in 2019.

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 19120114-H) to assess drivers of intertidal ecosystem changes at their Kachemak Bay sites. We also collaborated with Dan Monson on the synthesis manuscript to assess nearshore oceanographic variability across the GWA study area, to develop a synthesis manuscript in 2019. A Cook Inlet project scientist (Dominic Hondolero) also assisted with Nearshore component sampling in Kachemak Bay in May 2019.

Pelagic component: We provide opportunities to GWA Pelagic component PI Kathy Kuletz (project 19120114-M and project 19120114-L) to host a seabird/marine mammal observer on any of our shipboard surveys. However, U.S. Fish and Wildlife Service (USFWS) was not able to provide observers for most of 2019.

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, AOOS and the Alaska Harmful Algal Bloom 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.

USFWS: We offer opportunities to host USFWS seabird/marine mammal observers on our shipboard surveys. In 2019 the NOAA Kasitsna Bay Laboratory hosted USFWS Marine Mammals office researchers for a summer-long sea otter tagging and tracking project. Twenty otters were tagged and tracked into the early fall and we are coordinating with USFWS researchers to combine tracking data, our GWA project oceanography data and nearshore prey and habitat information (from GWA Nearshore project and other NOAA, KBNERR, and University of Alaska Fairbanks research projects) to improve understanding of sea otter distributions, habitat associations and foraging. We also coordinate with the USFWS Marine Mammals Office on sea otter stranding and sampling programs. Project data is provided to USFWS (Alaska Maritime National Wildlife Refuge) and NOAA (National Marine Fisheries Service Protected Resources Division) to help investigate potential causes of seabird, sea otter, and whale mortality events.

NPRB: In 2019 we continued an NPRB-funded study, in collaboration with Xiuning Du (Oregon State University), R. Campbell (PWSSC), and Steve Kibler (NOAA/National Centers for Coastal Ocean Science Beaufort Lab), to investigate the potential for forage fish to provide a vector for paralytic shellfish poisoning toxins to seabirds and whales.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Vandersea, M., P. Tester, K. Holderied, D. Hondolero, S. Kibler, K. Powell, S. Baird, A. Doroff, D. Dugan, A. Meredith, M. Tomlinson and R. Litaker. 2019. An extraordinary Karenia mikimotoi "beer tide" in Kachemak Bay Alaska. Harmful Algae. https://doi:10.1016/j.hal.2019.101706

2. Reports

Danielson, S.L., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. 2019. 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, AK.

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. *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. Sweeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2019. 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, AK.

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

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

Holderied, K. 2019. Kachemak Bay Oceanography. Oral presentation for Alaska Department of Fish and Game Alaska/West Coast Razor Clam Summit. Alaska Islands and Ocean Visitor Center. Homer, Alaska, April.

2. Public presentations

Holderied, K. 2019. Kachemak Bay Research and Monitoring. Oral presentation for Cook Inlet Regional Citizens Advisory Council (CIRCAC) Environmental Monitoring Committee. Homer, Alaska, August.

Holderied, K., S. Baird, B. Konar and K. Iken. 2019. Kachemak Bay Ecosystem Monitoring. Public evening talk at Kachemak Bay Campus, Kenai Peninsula College, University of Alaska Anchorage. Homer, Alaska, October. (Outreach during annual GWA PI meeting)

Holderied, K. 2019. Gulf Watch Alaska: Ecosystem Monitoring (and data for you?) in the northern Gulf of Alaska. Public seminar for NOAA National Marine Fisheries Service/Alaska Fisheries Science Center Groundfish Seminar series. Seattle, WA, October.

Holderied, K. 2019. Harmful Algal Blooms in Alaska. Oral presentation for Alaska Ocean Observing System Board of Directors. Anchorage, Alaska, December.

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.

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

1. Quality-controlled CTD data sets through January 2020 have been uploaded to the AOOS Research Workspace (https://workspace.aoos.org/project/4673/folder/2538393/4_ctd-aggregated-files). The 2019 data will be published after final review is completed with the data management team.

2. Quality-controlled zooplankton data through December 2018 have been uploaded to the AOOS Ocean Workspace (https://workspace.aoos.org/project/4673/folder/2538393/4_ctd-aggregated-files). 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.

3. Quality-controlled phytoplankton data and associated metadata through 2018 have been uploaded to the AOOS Research Workspace. The 2018 data will be published after final review is completed with the data management team. The 2019 data are being analyzed and will be uploaded to the Research Workspace when the species identifications and data QA/QC are complete.

4. KBNERR SWMP water quality data from Bear Cove, Homer, and Seldovia water quality data sondes and associated metadata through 2018 have been uploaded to the Research Workspace (https://workspace.aoos.org/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 2019 data will be uploaded to Research Workspace when QA/QC is complete.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY19): *The Science Panel is pleased to see the multivariate analyses of community composition relating changes in temperature and chlorophyll and would like to see these type of analyses in other projects. In regard to the FY17 annual proposal, we would like clarification on how the Kachemak Bay phytoplankton samples in 2016 were processed improperly and what will be done to prevent this from happening again in the future. We note the Increase in tunicates; what species are they? Are they pyrosomes as reported from SE AK and along the US west coast?*

PI Response (FY19): We appreciate the Science Panel's comment on our multivariate analyses for zooplankton community composition and worked with other Environmental Drivers component PIs (especially Rob Campbell) on more of these analyses in FY19 and are continuing those collaborations in FY20. In FY16, the phytoplankton samples from all our EVOSTC-funded shipboard sampling stations were processed normally. However, some of the samples from intensive phytoplankton sampling at the Kasitsna Bay Lab dock (part of other NOAA programs) were processed with a different Lugol's preservative concentration that did not work effectively and has not been used since. While the dock sampling is not part of our EVOSTC-funded work, we do use those data to provide a better temporal context for our monthly shipboard sampling. Regarding tunicates, we have not detected pyrosomes in our zooplankton samples; we also have not detected an increasing trend in the tunicate larvaceans that appear through the 2016 results included in our last annual report.

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. This will allow us to complete additional data analyses and synthesis efforts in FY20, as requested and approved in FY20 workplan. We do not expect to need any >10% change of funding between budget categories.

For NOAA, we were delayed in fully obligating FY19 (project year 8) funds by 31 January 2020, for travel, contracts and commodities. Travel spending issue is due primarily to timing of allocation of funds across federal fiscal years, and spending is on track to execute at the proposed levels. Obligations for contracts are behind schedule primarily due to labor and vessel charter contracting delays, but we anticipate no impact to field work schedules and will be able to complete additional data analyses and synthesis in 2020 with funding in labor contract (as requested and approved in FY20 workplan). Obligations for supplies were reduced because we were able to leverage other funding sources, which will enable us to sustain same level of field supplies for GWA project in FY20 and FY21 as first three years. We do not expect to need any >10% change of funding between budget categories.

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	$97.2
Travel	$7.9	$7.6	$10.5	$8.6	$9.1	$43.7	$19.0
Contractual	$74.8	$76.8	$88.1	$51.7	$50.4	$341.8	$212.5
Commodities	$11.0	$11.5	$11.5	$10.0	$10.0	$54.0	$16.9
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	$12.6	$68.7	$27.3
SUBTOTAL	$155.7	$160.0	$168.2	$124.5	$122.2	$730.6	$372.9
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	$186.0	$1,001.8	

LITERATURE CITED

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.