**ATTACHMENT C** ***EVOSTC Annual Project Report Form***

Form Rev. 10.3.14

**1. Program Number:** *See*, Reporting Policy at III (C) (1).

14120114-G

**2. Project Title:** *See*, Reporting Policy at III (C) (2).

Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species

**3. Principal Investigator(s) Names:** *See*, Reporting Policy at III (C) (3).

**Angela Doroff** (Kachemak Bay National Estuarine Research Reserve, Alaska Center for Conservation Science, University of Alaska) and **Kris Holderied** (National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science/Kasitsna Bay Laboratory)

**4. Time Period Covered by the Report:** *See*, Reporting Policy at III (C) (4).

February 1, 2015-January 31, 2016

**5. Date of Report:** *See*, Reporting Policy at III (C) (5).

March 1, 2016

**6. Project Website (if applicable):** *See*, Reporting Policy at III (C) (6).

www.gulfwatchalaska.org

**7. Summary of Work Performed:** *See*, Reporting Policy at III (C) (7).

*Introduction (see annual work plans for more details on methods)*:

In project year 4 the Kachemak Bay National Estuarine Research Reserve (KBNERR) and National Oceanographic and Atmospheric Administration (NOAA) Kasitsna Bay Laboratory (KBL) continued to conduct oceanographic surveys in lower Cook Inlet (Transects 3, 6, and 7) and Kachemak Bay (Transects 4 and 9) along with shore-based oceanographic data collection (see Figure 1 for locations). We survey the outer Kachemak Bay (Transect 4) and lower Cook Inlet transects quarterly with a chartered vessel and the mid-Kachemak Bay transect (Transect 9) monthly from NOAA Kasitsna Bay Laboratory small boats. Given the limits of charter vessel time funded for this project and challenging weather conditions in lower Cook Inlet, we prioritize data collection along the northern (Transect 3 – to monitor freshwater input from the upper inlet) and southern (Transect 6 – to monitor connections with the shelf) Cook Inlet transects, with sampling also conducted on the middle line (Transect 7) when conditions allow. Oceanographic data are collected at vertical stations with conductivity-temperature-depth (CTD) profilers (shown as dots on Figure 1), using Seabird Electronics 19plus CTD profilers. Plankton sampling is conducted at three of the stations along each transect. Vertical zooplankton tows are conducted with 333 µm bongo nets and surface water is filtered through 20 µm nets for phytoplankton sampling. Oceanographic and plankton sampling, including instrument calibration, data collection, sample processing, quality control, and quality assurance, are conducted in accordance with the project sampling protocols (available on the Ocean Workspace). To provide more temporal resolution, continuous oceanographic measurements are made year-round at System Wide Monitoring Program (SWMP) water quality stations at the Seldovia and Homer harbors as well as in ice-free months from a buoy in Bear Cove (Figure 1). Nutrient and chlorophyll measurements are made monthly at the SWMP stations, with concurrent testing of a chlorophyll probe for a continuous measurement capability.

In year 4 we continued to coordinate on oceanographic and zooplankton sampling protocols and on the region-wide Pacific warm anomaly with other principal investigators (PIs) in the Environmental Drivers component group, as well as with fishery, marine mammal, and seabird researchers and managers at the NOAA, Alaska Department of Fish and Game (ADFG), U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey. As one result of the PI group discussions on improving sampling protocols, in our Cook Inlet project we concurrently sampled zooplankton with two different net sizes (150 µm in addition to 333 µm) at select stations to compare the results between net sizes. The results are being incorporated in planning for the next 5 year phase of the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) long-term monitoring program. We also worked with PIs across the program on the final Gulf Watch Alaska (GWA) program science synthesis report, contributing to the program overview chapter (Holderied) and the Environmental Drivers component chapter (Doroff and Holderied), and authoring a paper on regional variability in oceanography across the northern Gulf of Alaska (Holderied).

*Field Sampling: Oceanographic and Plankton Surveys*

In 2015, oceanographic surveys were successfully conducted monthly along Transect 9 in Kachemak Bay, with marine plankton sampling also completed in all months except January 2015 (due to poor weather conditions and scheduling conflicts). We conducted seasonal surveys in Kachemak Bay and Cook Inlet in February and April 2015 and a summer survey on the east side of Cook Inlet and Kachemak Bay in August 2015. We leveraged additional funding obtained by KBL (Holderied) from the Bureau of Ocean Energy Management (BOEM) to add a third seasonal Cook Inlet survey to the two funded by EVOSTC for project year 4. We planned to conduct the extra survey in October 2015, but were significantly delayed by issues with the vessel contract and then with nearly continuously stormy weather in lower Cook Inlet (affecting Transects 6 and 7 the most) from November 2015 to January 2016. We did complete a fall survey of Kachemak Bay and mid-Cook Inlet (Transect 3) in November 2015. Within our study area there are 88 oceanographic stations; 68 in lower Cook Inlet and 20 in Kachemak Bay. In year 4, we conducted CTD profiler sampling at 366 stations, with a subset of those stations also sampled for zooplankton (n=66 samples) and phytoplankton (n=68 samples). In addition, we continued to leverage collaborations with other organizations (NOAA National Centers for Coastal and Ocean Science [NCCOS], Aleutian Islands Pribilof Association, Inc.) and other funding from the Alaska Ocean Observing System (AOOS) to collect water samples for ocean acidification analyses and collect plankton and shellfish samples to assess threats from toxic phytoplankton (for species causing paralytic and amnesiac shellfish poisoning). Kachemak Bay experienced the first paralytic shellfish poisoning event in over 10 years in September 2015, which temporarily closed oyster farm harvests and was likely associated with persistently warm water temperatures that were up to 2$^{o}$C above the average for that time of year. The routine sample collection dates and locations to date for this project are summarized in Table 1.

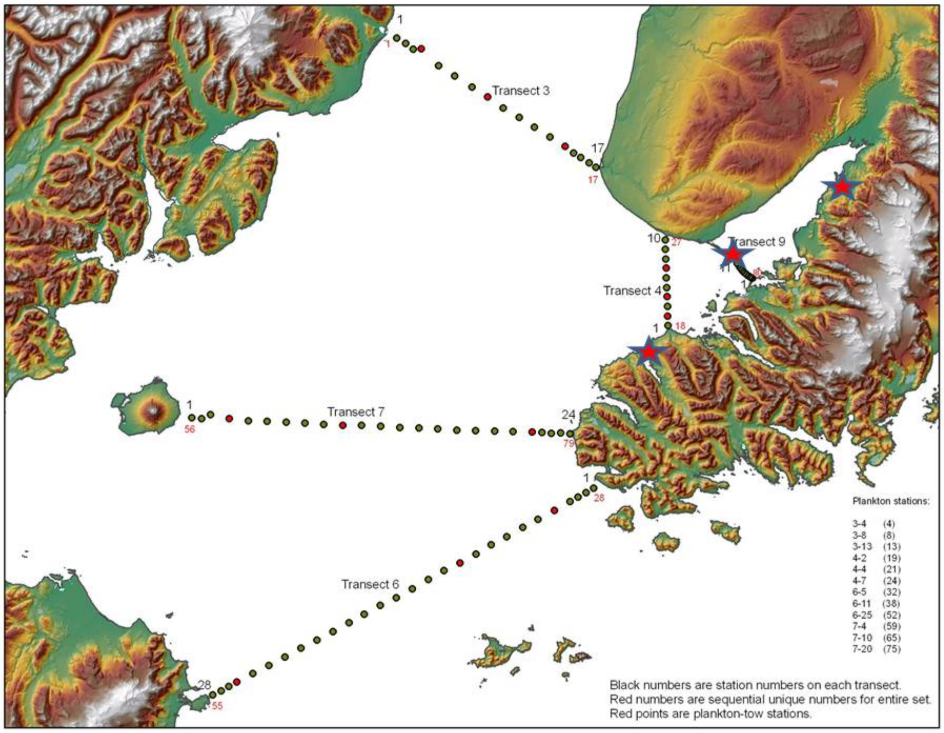



Figure1. Lower Cook Inlet and Kachemak Bay transects and sampling station locations for oceanographic sampling by CTD (all stations marked with dots) and phytoplankton and zooplankton sampling (red dots). Transects 3, 4, 6, and 7 are sampled quarterly (with assistance from BOEM funding for years 4 and 5) and Transect 9 is sampled monthly. Stars indicate the location of water quality and nutrient monitoring stations in Kachemak Bay at the Homer and Seldovia harbors and seasonally in Bear Cove.

Table 1: Sampling frequency at Lower Cook Inlet* and Kachemak Bay* transects during years 2012-2015;
*Environmental Drivers Gulf Watch Alaska Program*

| | | **CTD** | | | | | **Zooplankton** | | | | | **Phytoplankton** | | | | | **Water Samples** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transect No. | | | | | Transect No. | | | | | Transect No. | | | | | Transect No. | | | | |
| Month | Year | 3 | 4 | 6 | 7 | 9 | 3 | 4 | 6 | 7 | 9 | 3 | 4 | 6 | 7 | 9 | 3 | 4 | 6 | 7 | 9 |
| February | 2012 | | | | | 10 | | | | | | | | | | | | | | | |
| March | 2012 | | | | | 10 | | | | | | | | | | | | | | | |
| April | 2012 | | | | | 20 | | | | | 4 | | | | | 2 | | | | | 4 |
| May | 2012 | 16 | 30 | 27 | 18 | 20 | 3 | 3 | 3 | 3 | 6 | 3 | 1 | 3 | 3 | 11 | 3 | 3 | 3 | 3 | 6 |
| June | 2012 | | 20 | | | 33 | | | | | 6 | | 5 | | | 6 | | 7 | | | 6 |
| July | 2012 | 16 | 10 | 28 | 12 | 31 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 |
| August | 2012 | | 10 | | | 41 | | | | | 3 | | 3 | | | | | | | | 3 |
| Septembe | 2012 | | | | | 57 | | | | | | | | | | 9 | | | | | 3 |
| October | 2012 | 16 | 10 | 28 | 17 | 20 | 1 | | 3 | 3 | 3 | 1 | | 3 | 3 | 6 | 1 | | 3 | 3 | 3 |
| | **∑ =** | **48** | **80** | **83** | **47** | **242** | **7** | **6** | **9** | **8** | **25** | **7** | **12** | **9** | **8** | **37** | **7** | **13** | **9** | **8** | **28** |
| January | 2013 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| February | 2013 | | 10 | | | 11 | | 3 | | | 3 | | 3 | | | 3 | | 2 | | | |
| March | 2013 | | | | | 10 | | | | | 3 | | | | | 2 | | | | | 2 |
| April | 2013 | 16 | 10 | 23 | 24 | 10 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 4 | 3 | 1 |
| May | 2013 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | 3 |
| July | 2013 | 16 | 10 | 28 | 23 | 10 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | | 4 | 4 | |
| August | 2013 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| Septembe | 2013 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| October | 2013 | | 10 | | | 10 | | 4 | | | 3 | | 7 | | | 9 | | | | | 2 |
| Novembe | 2013 | 16 | | 20 | | 1 | 3 | | 3 | | | 3 | | 3 | | | | | | | |
| Decembe | 2013 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| | **∑ =** | **48** | **40** | **71** | **47** | **102** | **9** | **13** | **9** | **6** | **30** | **9** | **16** | **9** | **6** | **34** | **2** | **3** | **8** | **7** | **8** |
| January | 2014 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| February | 2014 | 16 | 10 | | 12 | 10 | 3 | 3 | | 3 | 3 | 3 | 3 | | 3 | 4 | | | | | |
| March | 2014 | | | | | 10 | | | | | 5 | | | | | 3 | | | | | |
| April | 2014 | 16 | 10 | 28 | 23 | 10 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | | | | |
| May | 2014 | | | | | 11 | | | | | 3 | | | | | 3 | | | | | 1 |
| June | 2014 | | | | | 11 | | | | | 3 | | | | | 3 | | | | | |
| July | 2014 | 17 | 10 | 28 | 22 | 12 | 3 | 4 | 7 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 6 | | 1 |
| August | 2014 | | 10 | | | 10 | | 3 | | | 2 | | 3 | | | 3 | | | | | |
| Septembe | 2014 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| October | 2014 | 16 | 10 | 22 | 22 | 10 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 4 | 2 | 2 |
| Novembe | 2014 | | | | | 10 | | | | | 3 | | | | | 2 | | | | | |
| Decembe | 2014 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| | **∑ =** | **65** | **50** | **78** | **79** | **124** | **12** | **16** | **13** | **15** | **37** | **12** | **15** | **9** | **12** | **36** | **4** | **4** | **10** | **2** | **4** |
| January | 2015 | | | | | 10 | | | | | | | | | | | | | | | |
| February | 2015 | 15 | 11 | 28 | 17 | 12 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | | 1 | | |
| March | 2015 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| April | 2015 | 16 | 10 | 10 | 17 | 10 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | | | | 1 | |
| May | 2015 | | | | | 10 | | | | | 3 | | | | | 3 | | | | | |
| June | 2015 | | | | | 10 | | | | | 3 | | | | | 2 | | | | | |
| July | 2015 | | | | | 12 | | | | | 3 | | | | | 3 | | | | | |
| Septembe | 2015 | | 10 | | | 20 | | | | | 3 | | 2 | | | 5 | | | | | |
| October | 2015 | | 10 | | | 10 | | 3 | | | 3 | | 3 | | | 3 | | 3 | | | 3 |
| Novembe | 2015 | 17 | 11 | | | 11 | 3 | 4 | | | 3 | 3 | 4 | | | 3 | 3 | 4 | | | 4 |
| Decembe | 2015 | | 10 | | | 10 | | 3 | | | 3 | | 3 | | | 3 | | | | | |
| | **∑ =** | **48** | **62** | **38** | **34** | **125** | **9** | **16** | **5** | **6** | **30** | **9** | **18** | **5** | **5** | **31** | **4** | **7** | **1** | **1** | **7** |

** Lower Cook Inlet - Transects 3, 6, and 7; Kachemak Bay - Transects 4 and 9*

*Oceanographic Monitoring:*

Oceanographic profile data from CTD casts were processed with standard SeaBird Electronics algorithms, exported to Excel spreadsheets, entered in an Access database and visualized in graphs of salinity, temperature, density profiles, along-transect contour maps and anomaly time series plots (used in publications and presentations listed in Section 8 of this report). Raw (hex format) and processed (.csv and netcdf format) data files were provided to the Ocean Workspace with updated metadata.

*Water Quality Monitoring*

Continuous data collection and reporting continued throughout year 4 for the KBNERR SWMP stations for meteorological, water quality, and monthly nutrient samples; all data are being quality controlled and archived through the National Estuarine Research Reserve program's Central Data Management Office, with near real-time access to provisional water quality station data in Seldovia and Homer. A YSI moored buoy system was used to deploy an additional oceanographic data sonde in Bear Cove from April to November 2015. During ice-free months in Kachemak Bay, all three surface data sondes also monitor chlorophyll-a. The Bear Cove mooring data were telemetered to provide researchers and local oyster farmers real-time access to the water quality data. Near real-time data access was also provided through the AOOS Data Portal.

*Zooplankton Sampling*

During this reporting period, 66 zooplankton samples were collected (Table 1), preserved, and are being analyzed at the Prince William Sound Science Center (PWSSC) in collaboration with Rob Campbell and his GWA Environmental Drivers oceanography project in Prince William Sound. Sample analyses are complete through November 2014 and all remaining year 4 samples are at PWSSC for analysis.

*Phytoplankton Sampling*

In year 4, we collected and processed 68 phytoplankton samples from filtered surface water samples that were collected, preserved, and analyzed during our sampling efforts in lower Cook Inlet and Kachemak Bay. Phytoplankton samples were collected during all monthly and quarterly shipboard surveys, at the same stations where zooplankton sampling was conducted. Phytoplankton samples were visually identified and enumerated using a light microscope and volumetric Palmer counting cells at NOAA Kasitsna Bay Laboratory. A subset of the samples was also analyzed at the NOAA NCCOS laboratory in Beaufort, North Carolina, by using the more sensitive molecular technique of quantitative polymerase chain reaction assay (qPCR).

*Recent Results and Scientific Findings*

*Oceanography sampling results:* Kachemak Bay and lower Cook Inlet waters were much warmer than average in 2015, continuing the pattern that started in late 2013 and persisted through all of 2014 and 2015, reflecting the large-scale Pacific warm anomaly. Warmest anomalies were observed in the winter of 2014-2015, with observations of over 2.5$^{o}$C above the monthly average from 2001-2015 at the Seldovia SWMP station and similar changes seen throughout the study area (Figure 2). The last time the Seldovia water temperatures were this much warmer than the average of this period was in 2003. The temperature patterns in Cook Inlet and Kachemak Bay continue to be coherent with observed patterns on the shelf (Weingartner/Danielson and Hopcroft projects at GAK1 and Seward Line) and in Prince William Sound (Campbell project) at time scales of longer than a couple months. This is consistent with the results from our analysis of oceanographic variability across the northern Gulf of Alaska region (see Holderied and Weingartner article in the GWA science synthesis document, entitled "Linking Variability in Oceanographic Patterns Between Nearshore and Shelf Waters Across the Gulf of Alaska"). In addition to the persistent warm temperatures, we also observed a persistent freshening of waters at the Seldovia station for most of 2014 and 2015 (Figure 3), which is also consistent with observations at the GAK 1 mooring. Figure 4 shows a comparison of the annual cycles of photosynthetically available radiation (PAR) and chlorophyll along Kachemak Bay, between the Bear Cove station at the head of the bay and the Seldovia station in the outer bay. There are significant differences in the timing, duration and intensity of the phytoplankton bloom between the two stations, which has implications for helping to understand observed differences in toxic algae concentrations between sub-bays in Kachemak Bay, as well as potential differences in food web processes.

While warm temperatures persisted from 2014 to 2015, the biological response was much more dramatic in 2015, with extensive seabird and sea otter mortalities, and the first paralytic shellfish poisoning event and oyster farm closures in Kachemak Bay in over a decade (September 2015). However, in anecdotal observations of what may be a more positive response, feeder king salmon were much more abundant in the bay in both 2014 and 2015 and, in 2015 very large and perhaps unprecedented numbers (>50) of actively feeding humpback whales were observed in the bay all summer and into November. Significant numbers of herring (likely age 0 based on size, but also older year classes) also appear to have returned to Kachemak Bay in significant numbers in the summer of 2015, based on numerous sightings of schools reported by fishermen, water taxi operators and local researchers and in limited salmon diet observations reported by fisherman. Given the changes observed this past year and the significance of a potential herring return to the bay (which had large herring fisheries in the 1920s and 1930s), we are exploring options with ADFG, researchers in the GWA pelagic component and Herring Research and Monitoring (HRM) researchers to start some direct or indirect (fish diet) forage species sampling in the bay.

*Zooplankton sampling results:* We analyzed zooplankton samples from 15 stations throughout the study area during all seasons 2012-2014. We utilized only most frequently observed taxa (present in > 5% of samples) in multivariate analyses of these data. Abundance data were transformed [log(n + 1)] to stabilize variance (Keister and Peterson 2003). Using Ward's agglomerative method, a hierarchical cluster analysis (HCA) produced distinct groups based on species assemblage. These groups were used in the Indicator Species Analysis (ISA; Dufrene and Legendre 1997) to examine which species were indicative of each group. The Indicator Species Value (ISV) varied based on how consistently present taxa were in their group (0 [absent] to 1 [present in all group samples]). A total of 212 zooplankton samples were analyzed from lower Cook Inlet, outer Kachemak Bay, and inner Kachemak Bay (n = 66, n = 64, n = 85 for 2012, 2013, and 2014, respectively). Figure 5 is a composite histogram of the most frequently encountered species in all sample periods and locations combined. We developed a hierarchical cluster analysis grouping with all data during all time periods and the associated ISVs for each species in each group (see Figures 6 and 7). We show only the first five species with statistically significant ($p < 0.05$) presence in the groups. Finally, a visual comparison of meroplankton abundances in 2012, 2013 and 2014 is shown in Figure 8. In Kachemak Bay, meroplankton were present during all months sampled and were more abundant during summer and fall months.

<u>*Phytoplankton sampling results:*</u> This project has improved the time series and geographic scope for existing phytoplankton monitoring for harmful algal species conducted by KBL and KBNERR. The phytoplankton species that cause paralytic shellfish poisoning, *Alexandrium fundyense*, were found at all Kachemak Bay sampling locations throughout the summer, although at relatively low concentrations. *A. fundyense* concentrations were found to be significantly correlated with both water temperature and salinity conditions. In 2015, we also saw a bloom of *Pseudo-nitzschia sp.* that occurred much earlier than usual. This bloom occurred in May shortly after the normal *Chaetoceros spp.* bloom (Figure 9). The *Pseudo-nitzschia* bloom persisted through most of the summer and our toxin testing of plankton and shellfish samples indicated that domoic acid toxins were present, but only in relatively low amounts, in contrast to the high domoic acid toxin levels that were observed along the coasts of California and Oregon last summer. We are collaborating with other NOAA colleagues to help understand what drives those differences. In addition to the *Pseudo-nitzschia* bloom, we observed a late summer bloom of *A. fundyese* that resulted in the first paralytic shellfish poisoning event in Kachemak Bay in over ten years, with temporary closure of portions of the Kachemak Bay commercial oyster shellfishery in September 2015. Shellfish samples taken from several sub-bays in Kachemak Bay indicated that the saxitoxin that causes paralytic shellfish poisoning was present above the regulatory limit of 80 μm per 100 g tissue sample.

<u>*Results figures*</u>:

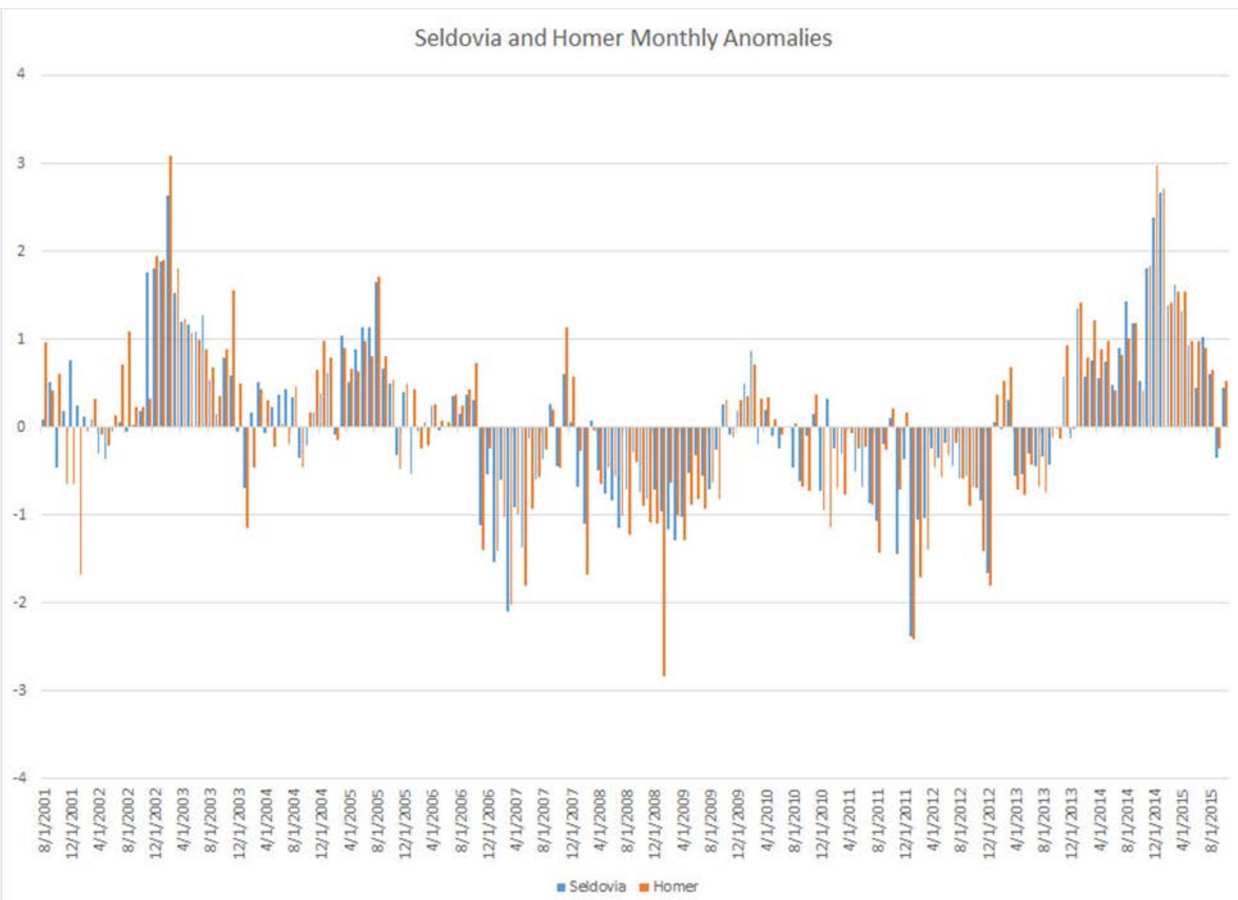



Figure 2. Monthly temperature anomalies based on water temperatures recorded 1m above the benthos at KBNERR long-term water quality monitoring sites in Homer and Seldovia harbors from Aug 2001- Aug2015. The anomaly is calculated as the difference between the monthly average value and the monthly mean value for the time period.

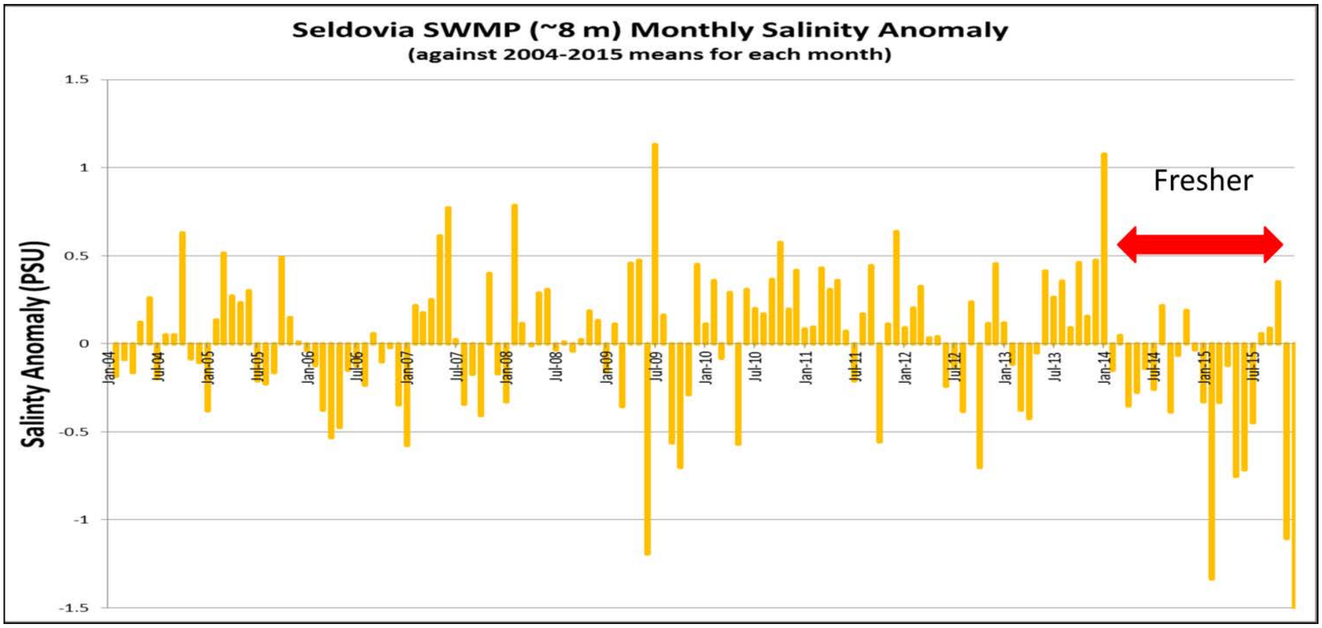



Figure 3. Monthly salinity anomalies calculated from continuous salinity data recorded 1m above the bottom (~8m depth) at the KBNERR long-term water quality monitoring site in Seldovia harbor. The anomaly is calculated as the difference between the monthly average and the 2004-2015 mean for that month. Note that the time period is shorter than the temperature anomalies shown in Figure 2 due to some early data quality issues. The 2014—2015 warm period was also consistently fresher than average.

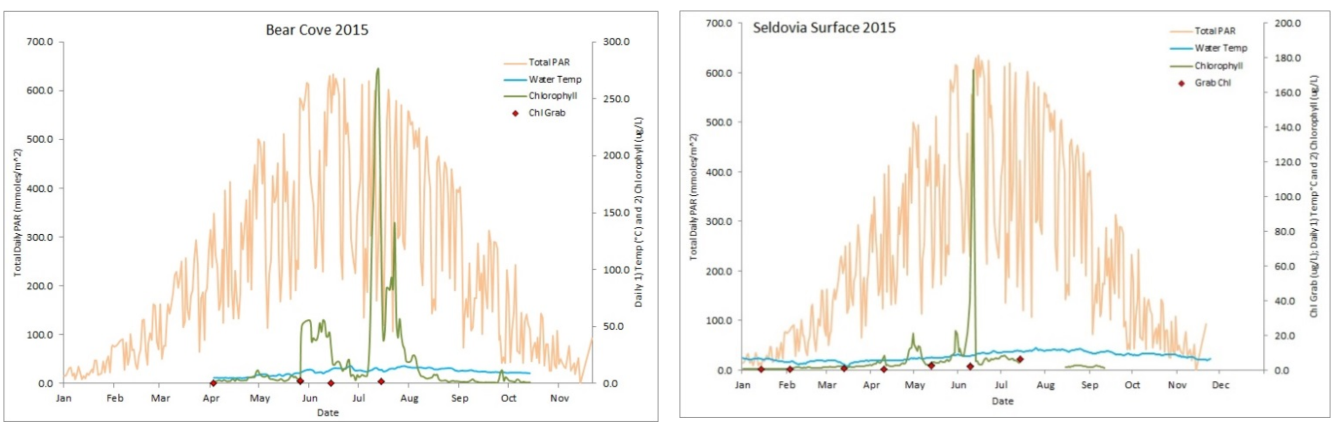



Figure 4. Monthly water temperature (blue) and Chlorophyll (probe [green] and water grab sample [red diamond]) from Bear Cove (1m below the water surface at the head of Kachemak Bay) and Seldovia Harbor (1m below the water surface at the mouth of Kachemak Bay) plotted with the total photosynthetically active radiation data (red) in the KBNERR long-term monitoring sites from Jan-Dec 2015.

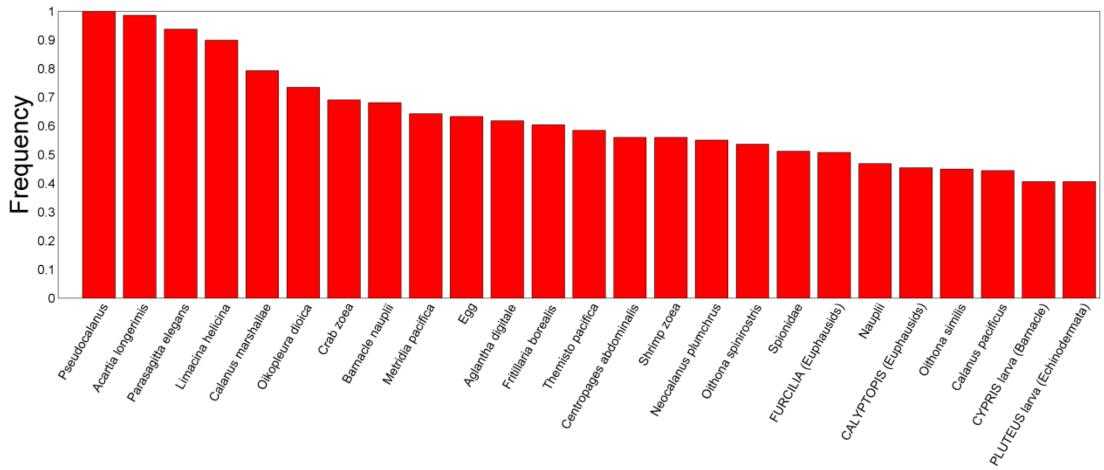



Figure 5. The most frequently (0 = absent; 1 = observed in all samples) observed zooplankton at all sampling locations for Kachemak Bay and lower Cook Inlet, Alaska during 2012-2014.

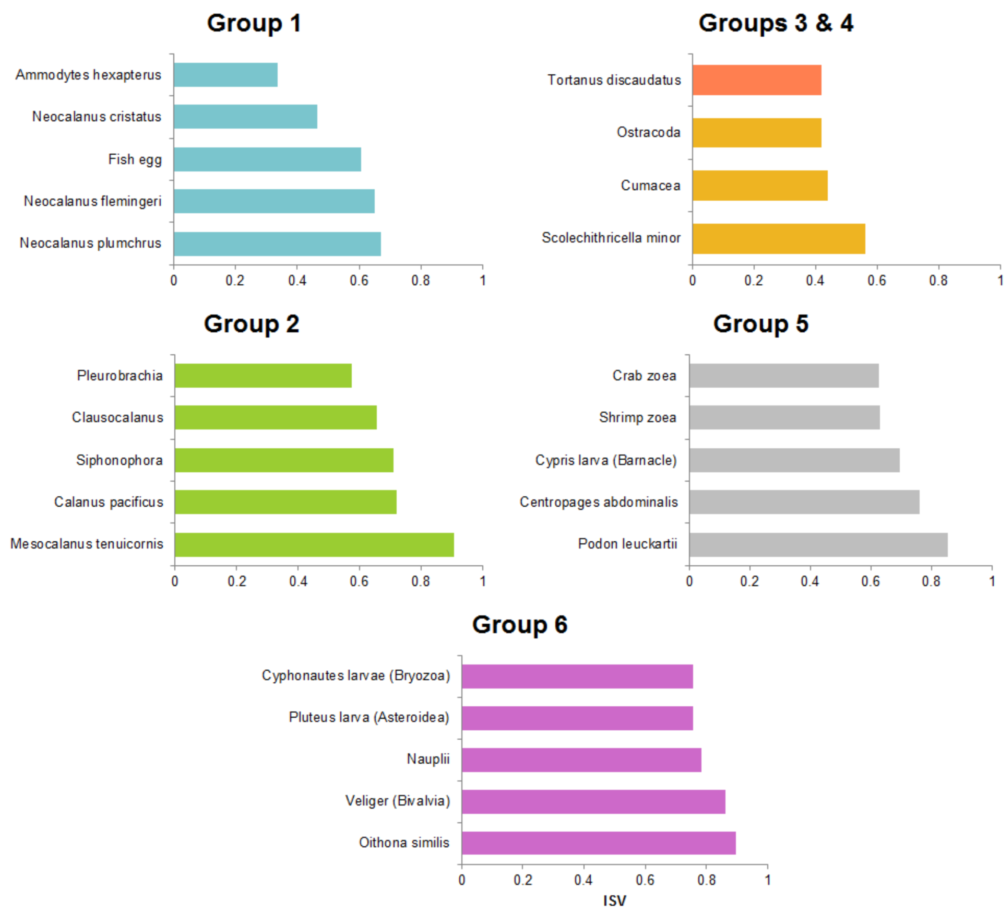



Figure 6. There were six groups identified in the hierarchical cluster analysis; we show the five significant ($p < 0.05$) indicator species within each grouping. The Indicator Species Value (ISV) on the X axis varies based on how consistently present taxa were in their group (0 = absent; 1 = present in all group samples). Group 4 contained only one species (*Tortanus discaudatus*) and was included with the Group 3 graph for brevity.

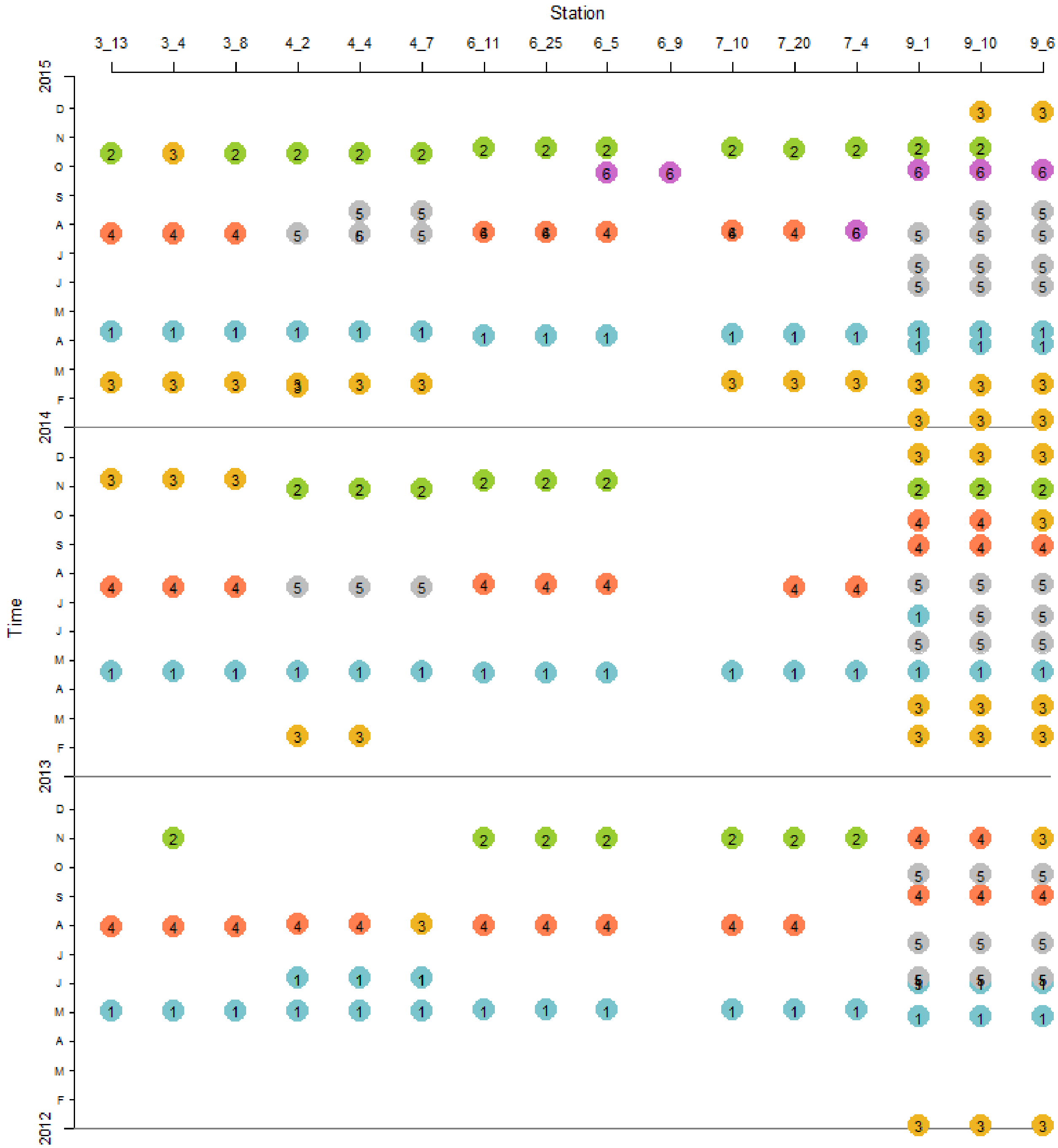
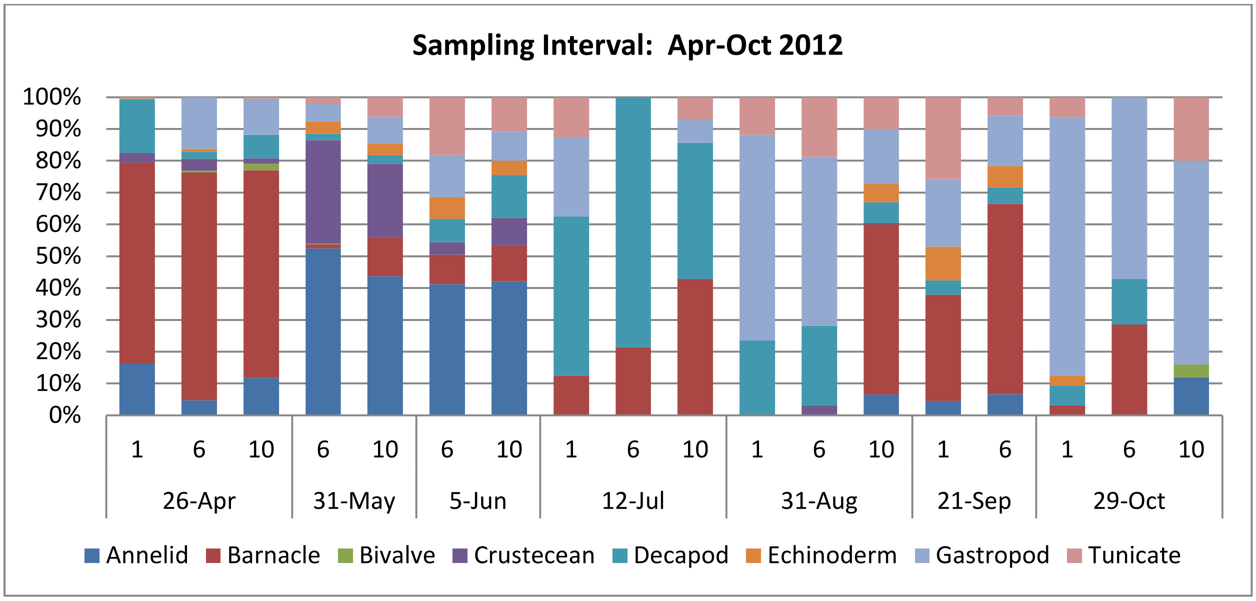
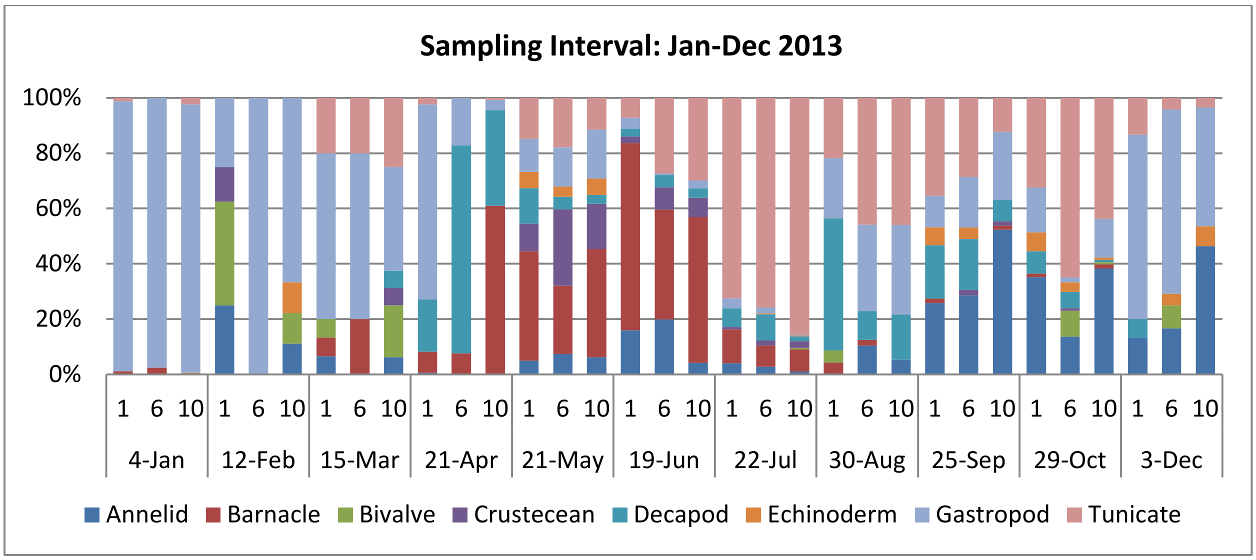



Figure 7. Plot of indicator species contained in zooplankton tows for each station (Transect #_station) by location, month, and year collected. Transects 4 and 9 are located in Kachemak Bay all others in lower Cook Inlet. Colored dots and numbers indicate the hierarchical cluster group (see Figure 6) to which each sample belongs.

Figure 8 (see NEXT PAGE). In Kachemak Bay, meroplankton were present during all months sampled and were more abundant during summer and fall months (see Figure 7). These three histograms show the percent occurrence of broad classifications by station by sampling date during 2012-2014 along Transect 9.


Sampling Interval: Apr-Oct 2012
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 6 10 6 10 6 10 1 6 10 1 6 10 1 6 1 6 10
26-Apr
31-May
5-Jun
12-Jul
31-Aug
21-Sep
29-Oct
Annelid Barnacle Bivalve Crustecean Decapod Echinoderm Gastropod Tunicate


Sampling Interval: Jan-Dec 2013
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80%
60%
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20%
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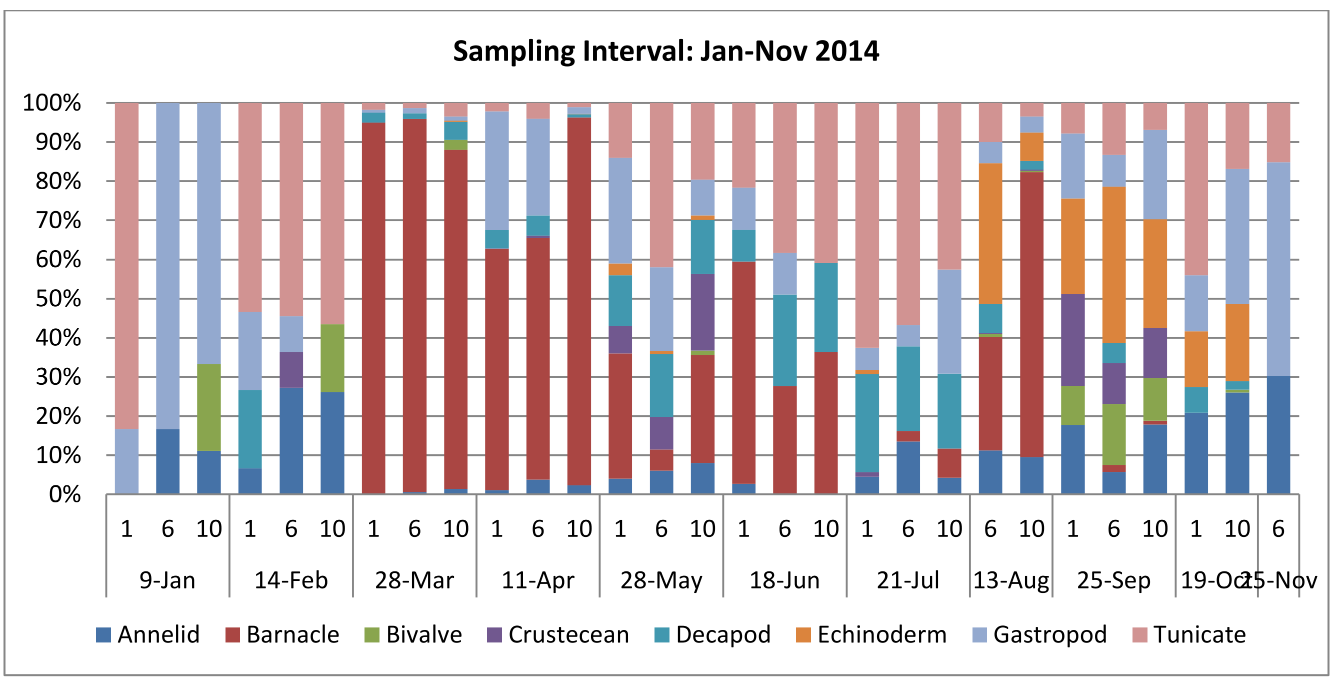
Annelid Barnacle Bivalve Crustecean Decapod Echinoderm Gastropod Tunicate


Sampling Interval: Jan-Nov 2014
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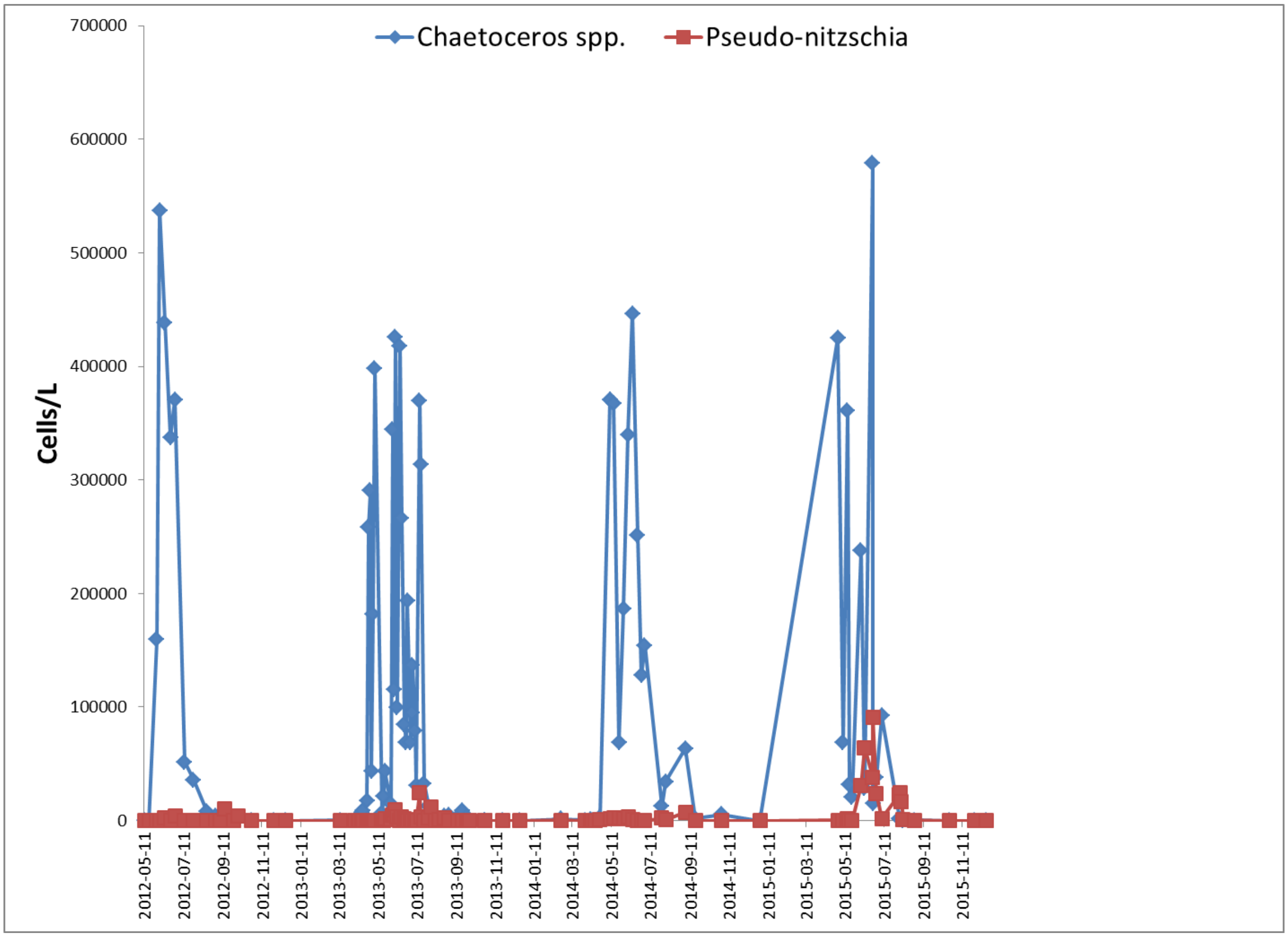


Figure 9. Graph showing the time series of cell concentrations of *Chaetoceros spp*. and *Pseudo-nitzschia spp.* from January 2012 through December 2015 observed from routine phytoplankton sampling conducted at the NOAA KBL dock. Note the increase in *Pseudo-nitzschia* concentrations during the 2015 bloom.

*Deliverables and Milestones:*

| Deliverable/Milestone | Status |
|---|---|
| Monthly Kachemak Bay CTD & plankton surveys | Completed. Note, only CTD data collected in Jan 2015 due to weather and personnel schedule conflict. |
| Two seasonal lower Cook Inlet/Kachemak Bay CTD & plankton surveys | Completed. February (all), April (T3, T4, T9, partial T6 & T7). Additional seasonal surveys in August (T4, T9, partial T6 & T7) and November (T3, T4, T9). |
| Annual PI Meeting and AMSS PI meeting | Completed. Doroff and Holderied attended November 2015 PI meeting and attended PI meeting at the Alaska Marine Science Symposium in January 2016. |
| Present work at Alaska Marine Science Symposium | Completed January 2016. |

**8. Coordination/Collaboration:** *See,* Reporting Policy at III (C) (8).

**a) Collaborations with the Gulf Watch Alaska and Herring Research and Monitoring programs**.

1) *Environmental Drivers component*: We continued to coordinate on oceanographic and zooplankton sampling protocols and monitoring results with other Environmental Drivers component PIs (Weingartner, Hopcroft, Batten, Campbell) through teleconferences and in breakout discussions at the annual PI meeting. Zooplankton data from this project and the PWSSC are being jointly analyzed and presented by Doroff, Campbell, and McKinstry; this ensures the maximum comparability between the nearshore regions. Holderied also participated with other environmental drivers PIs in the Pacific Warm Anomaly workshops at Scripps in May 2015 and at the University of Washington in January 2016, presenting monitoring results from this project.

2) *Pelagic component*: We continued to coordinate with Kathy Kuletz of the USFWS Migratory Bird Management office to host a seabird/marine mammal observer on our quarterly Cook Inlet surveys, with the goal of improving understanding of relationships between marine conditions, primary productivity, and seabird and marine mammal populations. Starting in federal FY15, USFWS is also leveraging funding from a separate Cook Inlet project with the BOEM to support the seabird and marine mammal observing effort.

3) *Herring Research and Monitoring Program*: We continue to have informal discussions on oceanographic patterns and relationships between marine conditions and plankton, herring, and forage fish populations with the HRM program lead (Scott Pegau), to compare conditions between Prince William Sound and Cook Inlet. We are particularly interested in understanding the causes behind the large increase in whales, and apparently herring, in Kachemak Bay in 2015 and are working with the GWA pelagic component PIs, HRM program PIs and ADFG to explore how we might cost-effectively sample forage fish species presence in Kachemak Bay.

**b) Collaborations with other Trustee Council-funded projects not part of integrated programs.**

N/A

**c) Collaborations with Trustee or Management Agencies**

1) *NOAA/National Ocean Service/National Centers for Coastal Ocean Science.* We continue to collaborate with researchers at our National Ocean Service NCCOS Beaufort Laboratory in North Carolina to use the oceanography and phytoplankton sampling data to identify environmental triggers for increases in the phytoplankton species (*Alexandrium* spp.) that cause paralytic shellfish poisoning events. We are partnering with AOOS/Axiom to develop a web-based paralytic shellfish poisoning risk management tool, based initially on real-time temperature data collected at the Seldovia SWMP station. Holderied presented the initial version of this tool in November 2015 at the Coastal and Estuarine Research Federation conference in Portland, Oregon.

2) *NOAA Kasitsna Bay Laboratory and BOEM*:

NOAA KBL and BOEM initiated a collaboration in FY2014 to update information on marine conditions and ecological linkages in Cook Inlet, to support BOEM's environmental analysis needs for potential oil and gas lease sales in the region. BOEM is providing $150K to KBL to conduct seasonal Cook Inlet surveys and develop oceanographic data analysis to support BOEM's environmental analysis needs for potential oil and gas lease sales in the region. The BOEM funding will allow us to conduct additional

Cook Inlet cruises in Year 5, for which there was not sufficient funding available under our original EVOSTC proposal.

**9. Information and Data Transfer:** *See,* Reporting Policy at III (C) (9).

### a) Publications


Hoem Neher, T., B. Ballachey, K. Hoffman, K. Holderied, R. Hopcroft, M. Lindeberg, M. McCammon, and T.Weingartner, editors. 2016. Quantifying temporal and spatial variability across the northern Gulf of Alaska to understand mechanisms of change. Gulf Watch Alaska program science synthesis report for the Exxon Valdez Oil Spill Trustee Council.

Batten, S., R. Campbell, A. Doroff, K. Holderied, R. Hopcroft and T. Weingartner. 2016. Chapter 2: Environmental Drivers: Regional Variability in Oceanographic Patterns across the Gulf of Alaska. In Quantifying temporal and spatial variability across the northern Gulf of Alaska to understand mechanisms of change. Gulf Watch Alaska program science synthesis report. Exxon Valdez Oil Spill Trustee Council.

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


### b) Conference/workshop presentations and attendance

Doroff, AM, R. Campbell, C. McKinstry. 2016. Zooplankton assemblages in lower Cook Inlet and Kachemak Bay 2012-2014. Poster presentation at Alaska Marine Science Symposium, Anchorage AK. Jan 2016.

Holderied, K. 2015. How connected are Kachemak Bay and the Gulf of Alaska? And why it matters. Oral presentation at the Kachemak Bay Science Conference, Homer AK. Mar 2015.

Holderied, K., R. Hopcroft, T. Weingartner, S. Batten, R. Campbell, S. Danielson, and A. Doroff. 2014-2015 Oceanographic Anomalies in the Gulf of Alaska  Oral presentation at Pacific Anomalies Workshop I, NOAA Integrated Ocean Observing System, La Jolla, CA. May 2015.

Holderied, K., D. Hondolero, S. Kibler, W. Litaker, and A. Doroff. 2015. A web-based, paralytic shellfish poisoning risk assessment tool for Kachemak Bay Alaska. Poster presentation at the Coastal and Estuarine Research Federation Conference, Portland, OR. Nov 2015.

Holderied, K., A. Doroff and D. Hondolero. 2015. Seasonal variability in oceanography and ocean acidification in Kachemak Bay and lower Cook Inlet, Alaska. Poster presentation at the American Fisheries Society, Alaska chapter meeting, Homer AK. Nov 2015.

Holderied, K. and D. Hondolero. 2016. Oceanographic and ecosystem response to the 2013-2015 Pacific Warm Anomaly in Kachemak Bay Alaska. Poster presentation at the Pacific Anomalies Workshop II, NOAA Integrated Ocean Observing System, Seattle, WA. Jan 2016.

Holderied, K., A. Doroff, and D. Hondolero. 2016. From cool to hot: 2012-2015 transition in Kachemak Bay and Cook Inlet Alaska waters. Poster presentation at the Alaska Marine Science Symposium, Anchorage AK. Jan 2016.

Hondolero, D. 2015. Kachemak Bay phytoplankton and harmful algal bloom patterns. Oral presentation at the Kachemak Bay National Estuarine Research Reserve Harmful Algal Bloom Workshop, Homer AK. February 2015

Hondolero, D. 2015. Monitoring Phytoplankton in Kachemak Bay and lower Cook Inlet. Oral presentation at the Kachemak Bay Science Conference, Homer AK. Mar 2015.

Hondolero, D., S. Kibler, M. Vandersea, W. Litaker, and K. Holderied. 2015. Effects of Stratification and Nutrient Limitation on Phytoplankton Blooms in Kachemak Bay. Oral presentation at the American Fisheries Society, Alaska chapter meeting, Homer AK. Nov 2015.

Hondolero, D. and K. Holderied. 2016. Monitoring Phytoplankton in Kachemak Bay, Alaska. Poster presentation at Alaska Marine Science Symposium, Anchorage AK. Jan 2016.

**c) Data/information products**

Numerous data and information products have been developed for the GWA science synthesis report, the EVOSTC joint science workshop, and the public presentations listed above. Data products include graphics of oceanographic time series plots, time series anomalies, comparisons of temperatures between different regions (e.g., GAK1, Seldovia, and Cordova), and along-transect vs depth contour plots. Data and graphic products from this project have been made available to and used by three 2015 summer interns working with Holderied from Middlebury College, Mt Holyoke College and the University of Massachusetts Amherst, as well as by University of Alaska Anchorage (UAA) Kachemak Bay Campus Semester on the Bay undergraduate student interns working with Holderied and Doroff in fall 2015. All the student interns provided public science outreach talks on their results and the summer interns developed outreach materials for public, free-learning “Discovery Labs” hosted by KBNERR.

**d) Data sets uploaded to the data portal**

- CTD data sets and associated metadata from 2012, 2013, and 2014 have been uploaded to the AOOS Ocean Workspace, with 2012 and 2013 data published to the Gulf Watch Alaska Data Portal. The 2014 data will be published after final review is completed with the GWA science coordinator.
- Zooplankton data and associated metadata that has been analyzed through 2014 have been uploaded to the AOOS Ocean Workspace. Metadata have been generated and data will be uploaded to the Gulf Watch Alaska Data Portal.
- KBNERR SWMP water quality data from Bear Cove, Homer, and Seldovia water quality data sondes and associated metadata through 2015 have been uploaded to the Ocean Workspace and are published on the Gulf Watch Alaska Data Portal. Data are also publicly available through 2015 on the NOAA National Estuarine Research Reserve site: http://cdmo.baruch.sc.edu/

**10. Response to EVOSTC Review, Recommendations and Comments:** *See*, Reporting Policy at III (C) (10).

N/A for this project.

**11. Budget:** *See,* Reporting Policy at III (C) (11).

See attached budget sheets for Doroff (ADFG/UAA/KBNERR) and Holderied (NOAA/KBL) in the consolidated GWA budget spreadsheet.

KBNERR Budget Narrative: In Project Year 1, KBNERR leveraged our long-term monitoring grant to obtain $102K for new water quality monitoring equipment to have Chl_a probes at each of the water quality monitoring sites in Kachmak Bay. In kind annual contributions are as follows: $120K KBNERR SWMP; $5K KBRR CTD use. On 13 July 2015, KBNERR transferred fiscal agents from ADFG Division of Sport Fish to UAA, Alaska Center for Conservation Science. At the close of State fiscal year (30 June 2015), the budget for this project was held pending final building transfers and project audits. UAA allowed spending against the project for salary and required PI meetings; however, the budget was not fully transferred until 28 January 2016. The funding was transferred to UAA by a reimbursable services agreement and incurred an additional 25% overhead. Since then, we've had good support for securing two necessary ship charters in February and April for next project year; we will conduct necessary equipment calibrations and maintenance, and will be able to meet project deliverables by extending these funds through the end of the State fiscal year (30 June 2016).

KBL Budget Narrative: See NOAA budget report in the program budget spreadsheet.