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 Research Reserve) and Kris Holderied (NOAA/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, 2014-January 31, 2015

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

March 1 2015

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):

Our project conducts 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. We survey the outer Kachemak Bay 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 is 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 Kachemak Bay Research Reserve (KBRR) 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 these stations, with concurrent testing of a chlorophyll probe for a continuous measurement capability. We

continued to coordinate on oceanographic and zooplankton sampling protocols with other principal investigators (PIs) through Environmental Drivers component group meetings. Following up on the sampling protocol discussions, we concurrently sampled zooplankton with two different net sizes (150 µm in addition to 333 µm) at some stations this year. We participated in the group effort to write the Environmental Drivers component chapter and wrote a research summary article for the Gulf Watch Alaska (GWA) program science synthesis report.

Field Sampling: Oceanographic and Plankton Surveys

Oceanographic and plankton sampling was successfully conducted monthly in Kachemak Bay and quarterly in lower Cook Inlet this year, with CTD profiler sampling at total of 391 stations. Zooplankton and phytoplankton were sampled at 84 stations, with a total of 93 zooplankton tows (two nets used at some stations) and 84 surface phytoplankton samples. The photo in Figure 2 shows an example of a zooplankton sample from October 2014. All planned transects were surveyed, with the exception that adverse winter conditions (see photo in Figure 3) prevented sampling along part of Transect 7 and all of Transect 6 in Cook Inlet in February 2014 and only CTD data was collected along Transect 9 in January 2015. We leveraged funding from the NOAA Integrated Ocean Observing Program/Alaska Ocean Observing System (AOOS) to conduct additional along-bay surveys in Kachemak Bay in March and May 2014, as well as an intensive small boat CTD survey during August 2014, to better assess tidal and spatial variability of marine conditions in the bay. The sample collection dates and locations to date for this project are summarized in Table 1.

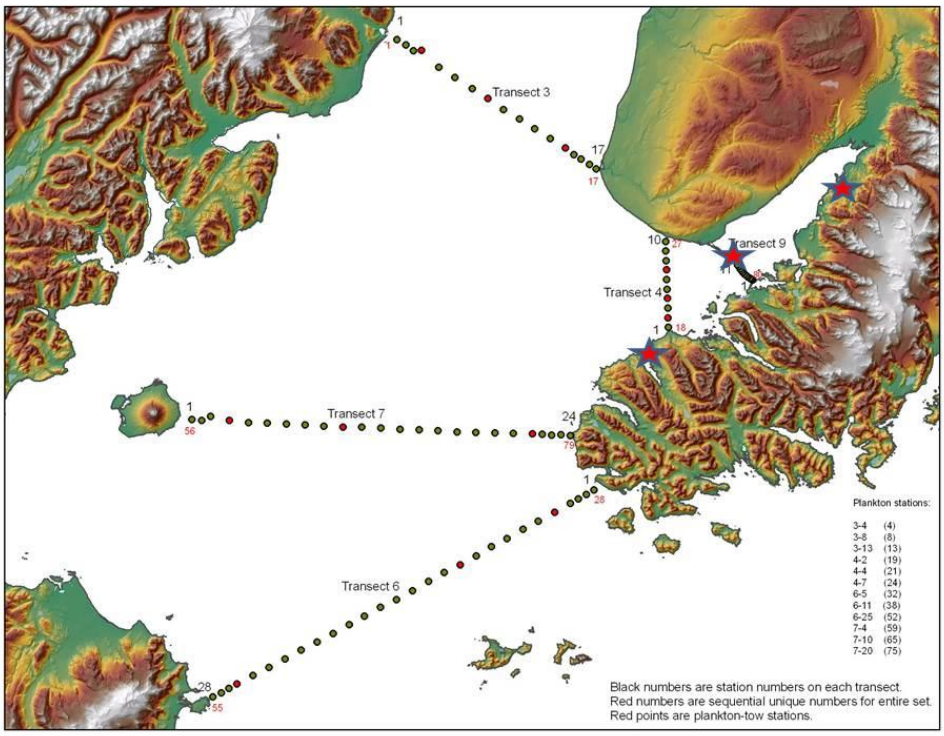

Figure1. Lower Cook Inlet and Kachemak Bay transects and sampling station locations for oceanographic sampling by CTD (all stations marked with dots) and phytoplankton and zooplankton sampling (red dots). Transects 3, 4, 6, and 7 are sampled quarterly and Transect 9 is sampled monthly. Stars indicate 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. Data and samples collected during 2012-2015 in Lower Cook Inlet (Transects 3, 6 and 7) and in Kachemak Bay (Transects 4 and 9) for the Environmetnal Drivers Gulf Watch Alaska Program.																				
			CTD				ZOOPLANKTON					PHYTOPLANKTON					OCEAN ACIDIFICATION				
			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
April	2012					10					4					2					
May	2012	16	10	27	18	21	3	3	3	3	6	3	1	3	3	12	1	1	1	3	
June	2012					20					6					6					1
July	2012	16	10	28	12	11	3	3	3	2	3	3	3	3	2	3	2	2	3	2	
August	2012					10					3										
October	2012	15	10	28	17	10	1		3	3	3	1		3	3	3		1	5	4	
	Σ=	47	30	83	47	82	7	6	9	8	25	7	4	9	8	26	3	4	9	9	1
January	2013					10					3					3					
February	2013		10			11					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					
September	2013					10					3					3					
October	2013		10			10		4			3		7			9					2
November	2013	16		20			3		3			3		3							
December	2013					10					3					3					
	Σ=	48	40	71	47	101	9	10	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					9					5					3					
April	2014	16	10	28	23	10	3	3	3	3	3	3	3	3	3	3					
May	2014					9					3					3					1
June	2014					11					3					3					
July	2014	17	10	27	22	12	3	4	7	6	3	3	3	3	3	3	2	2	6		1
August	2014		10			19		3			5		3			6					
October	2014	16	10	22	22	10	3	3	3	3	3	3	3	3	3	3	2	2	4	2	2
November	2014					10					3					2					
December	2014					10					3					3					
January	2015					10					0					0					
	Σ=	65	50	77	79	130	12	16	13	15	37	12	15	9	12	36	4	4	10	2	4

Table 1. Lower Cook Inlet and Kachemak Bay transects and sampling station frequency for CTD, phytoplankton, zooplankton, and water samples for ocean acidification sampling for project years 2012-2014.

Figure 2. Angela Doroff with zooplankton sample taken during October 2014 Cook Inlet survey.

Figure 3. Brad Garasky waits for next CTD station during February 2014 Cook Inlet oceanographic survey.

Oceanographic survey monitoring:

Oceanographic profile data 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). We are leveraging the CTD data collected as part of this study and the KBRR SMWP station data to validate hindcasts of the newly developed National Ocean Service (NOS) Coast Survey Development Laboratory ocean circulation model of Cook Inlet and Kachemak Bay. The validation effort is being conducted by KBRR and University of Alaska Fairbanks with additional grant funding. The figures below provide two examples of initial observation-model comparisons for 2012 surveys along Transect 3 in central Cook Inlet (Figure 4) and along Transect 4 in outer Kachemak Bay (Figure 5).

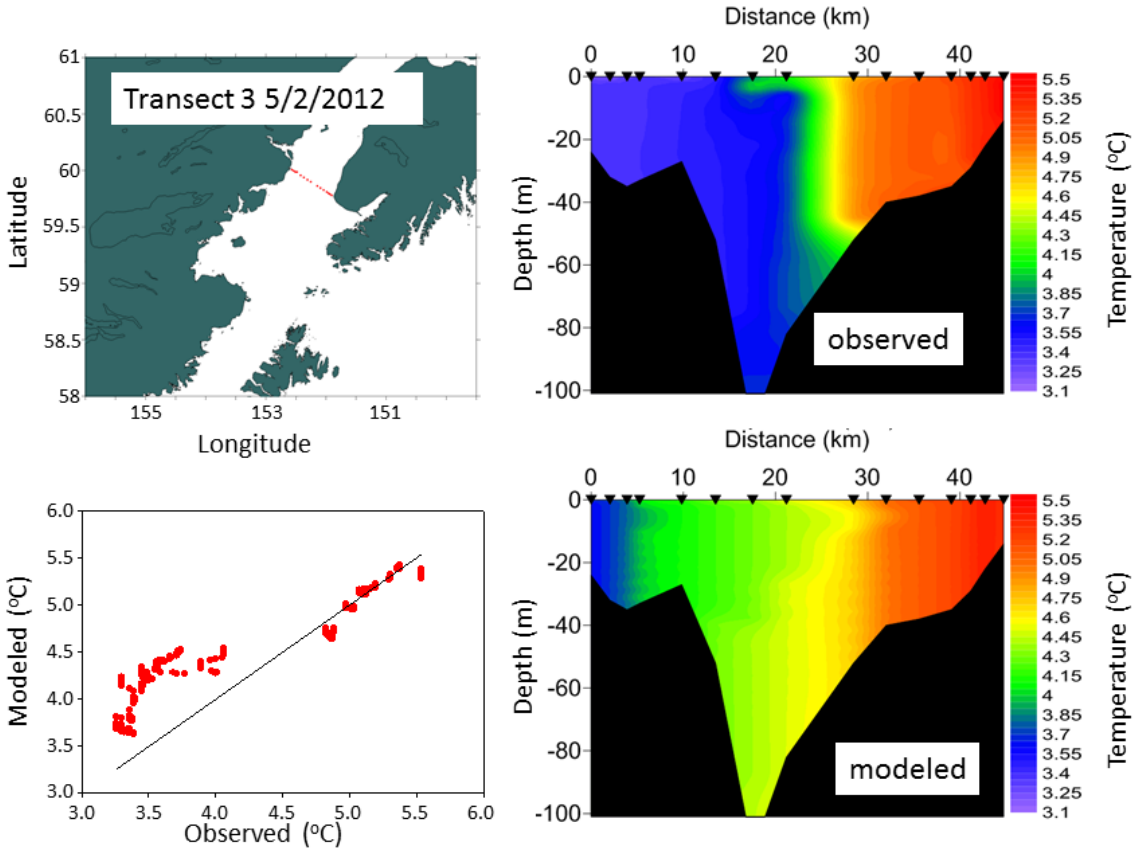

Figure 4. Comparison of observed and modeled water temperatures along Transect 3 in central Cook Inlet in May 2012. Map shows transect location. Contour plots on right show observed (top) and modeled (bottom) temperatures from surface to bottom and east (left) to west (right) across the transect. Note observational evidence of vertical mixing and strong horizontal temperature gradients during this survey. Scatter plot at lower left compares model and observed data at the same locations.

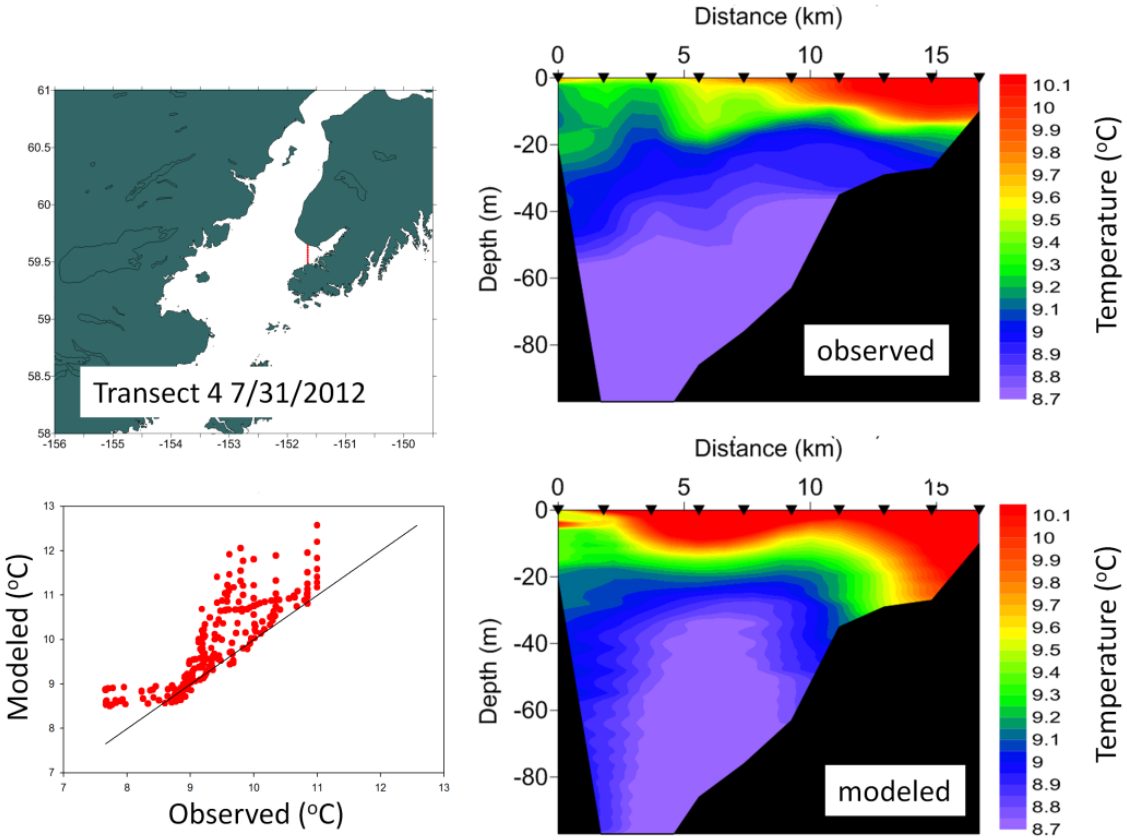

Figure 5. Comparison of observed and modeled water temperatures along Transect 4 in outer Kachemak Bay in July 2012. Map shows transect location. Contour plots on right show observed (top) and modeled (bottom) temperatures from surface to bottom and south (left) to north (right) across the transect. Note observational evidence of vertical temperature stratification during this survey. Scatter plot at lower left compares model and observed data at the same locations.

Water Quality Monitoring

Continuous data collection and reporting continued throughout year 3 for the KBRR SWMP stations for meteorological, water quality, and monthly nutrient samples; all data are being quality controlled and archived through the NERR'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 late March to November 2014. 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 provided through the AOOS data portal.

Zooplankton Sampling

During this reporting period, 93 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 oceanography monitoring project in the Sound. Sample analyses are complete through February 2014 and all remaining year 3 samples have been delivered to PWSSC. For 2013, Figure 6

provides a seasonal comparison of zooplankton species presence and relative abundance. Our next steps with the data are to 1) complete sample analysis for 2014, 2) stratify the zooplankton samples by day and night time periods, 3) coordinate sample analyses across studies sites with other Gulf Watch Alaska projects, 4) analyze supplementary samples collected using a 150 micron mesh size net to assess potential capture of early life stages of small and large copepods, 5) evaluate zooplankton sampling relative to the water stratification identified in the CTD at each collection site, and 6) evaluate the sampling location along the transect for the zooplankton samples with respect to potential convergence zones based on bathymetry.

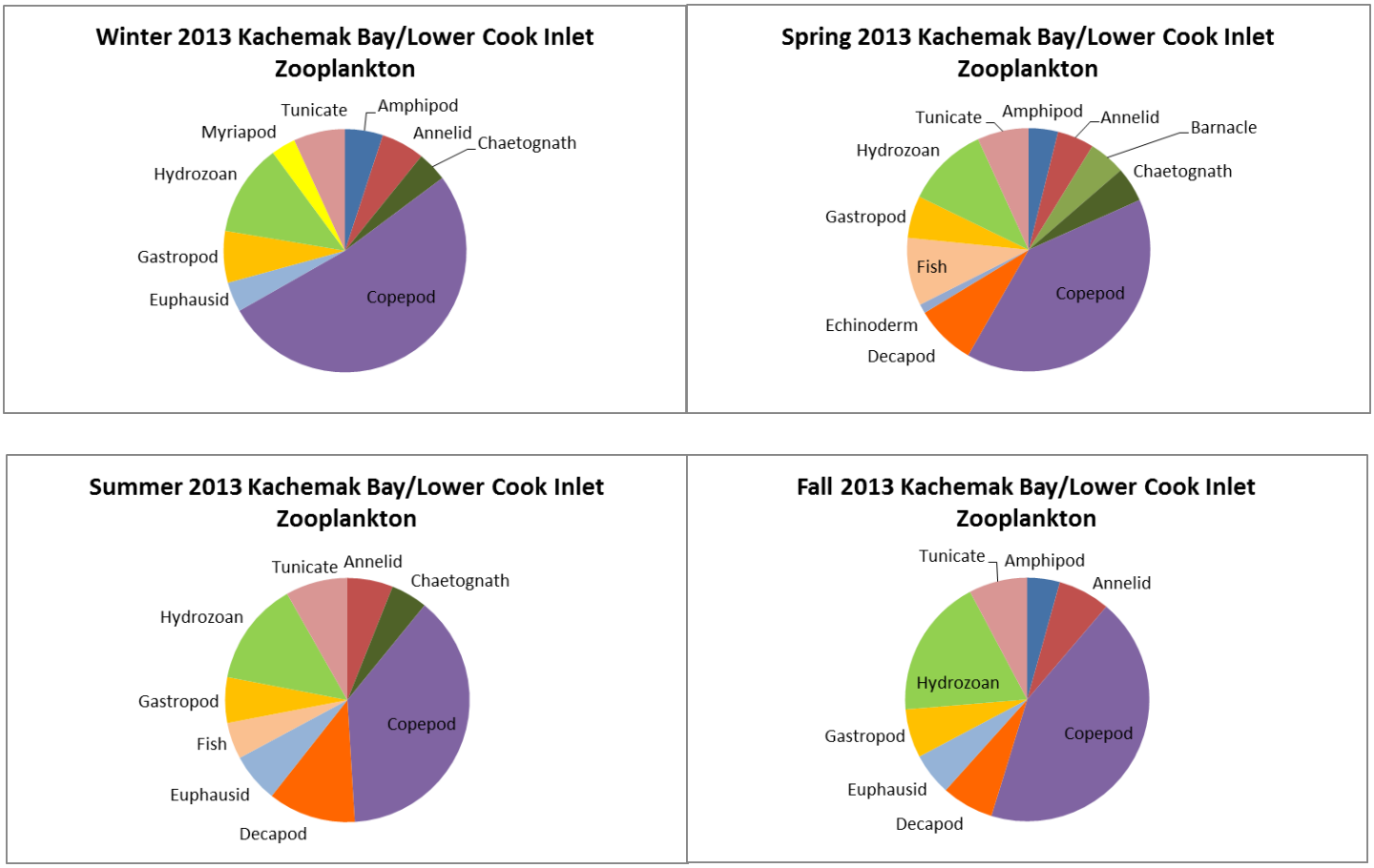

Figure 6. Seasonal zooplankton species presence and relative abundance in 2013 from Kachemak Bay and Cook Inlet surveys.

Phytoplankton Sampling

In year 3, we collected and processed 84 phytoplankton samples from filtered surface water samples 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/NOS/National Centers for Coastal Ocean Science (NCCOS) laboratory in Beaufort NC, using the more sensitive molecular technique of quantitative polymerase chain reaction assay (qPCR).

This project has improved the time series and geographic scope for existing phytoplankton monitoring for harmful algal species conducted by KBL and KBRR. 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.

Recent Results and Scientific Findings

The anomalously warm 2014 weather conditions in the Gulf of Alaska were reflected in warm water temperatures at the KBRR water quality station at Seldovia, with July temperatures above 12 degrees C and a monthly average temperature of nearly 12 C (Figure 7). Water temperatures have not been observed to be this warm since the summer of 2005. Monthly averaged water temperatures were warmer than the 2004-2014 average for all months in 2014, with anomalies of greater than 1.5 C in January, August and November 2014 (Figure 8). We are partnering with NOAA and UAF to validate a Cook Inlet ocean circulation model and oceanographic and plankton data are being used in NOAA studies to understand triggers of paralytic shellfish poisoning events. We conducted an initial comparison of estuary conditions within Cook Inlet and Kachemak Bay with marine conditions on the adjacent Gulf of Alaska shelf at the GAK1 mooring (Weingartner project). Results are provided in an article authored by Holderied and Weingartner in the GWA science synthesis document submitted to EVOSTC in December 2014, entitled "Linking Variability in Oceanographic Patterns Between Nearshore and Shelf Waters Across the Gulf of Alaska". One interesting result was that the water temperature time series at the Seldovia water quality station and in near-surface waters at GAK 1 are coherent for time periods greater than three months, but independent at shorter time scales (see synthesis report for details). The similarity of inner shelf and estuary temperature series at low frequencies has potential implications for a more synchronous response of the Gulf of Alaska marine system to inter-annual and basin-scale climate forcing, while spatial variability in ocean conditions at shorter periods could drive spatial heterogeneity in primary and secondary production, as well as in forage fish populations. Spatial variability also has implications for determining ongoing monitoring needs for ocean conditions within the region.

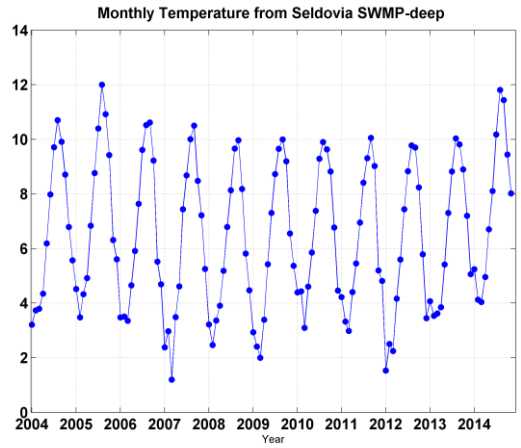

Figure 7. Monthly averaged temperature calculated from near bottom sonde at the Seldovia SWMP station from Jan 2004-Oct 2014.

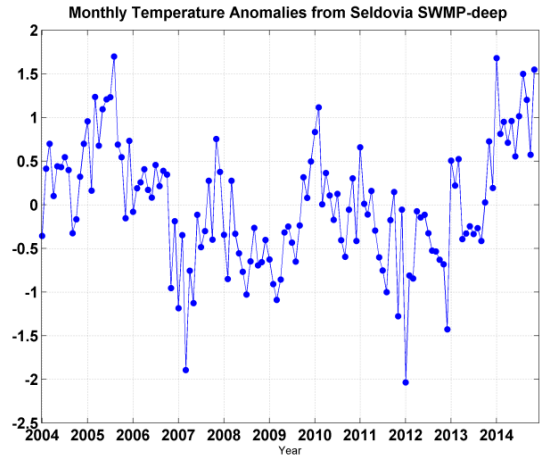

Figure 8. Monthly temperature anomalies calculated from near bottom sonde at the Seldovia SWMP station compared to Jan 2004-Oct 2014 monthly average.

Deliverable/Milestone	Status
Monthly Kachemak Bay CTD & plankton surveys	Completed. Only CTD data collected in Jan 2015.
Quarterly lower Cook Inlet/Kachemak Bay CTD & plankton surveys	Completed. February (T3,T4,T7 (partial)), April, July, Oct-Nov 2014
Annual PI Meeting and AMSS PI meeting	Completed. Holderied attended November 2014 PI meeting. Doroff and Holderied attended PI meeting at AMSS in January 2015.
Present work at Alaska Marine Science Symposium	Completed January 2015

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. Following up on the sampling protocol discussions, we concurrently sampled zooplankton with two different net sizes (150 µm in addition to 333 µm) at some stations this year and will discuss those results with the group when the analyses are complete. We participated in the group effort to write the Environmental Drivers component chapter and Holderied and Weingartner wrote a research summary article for the Gulf Watch Alaska (GWA) program science synthesis report.

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 Bureau of Ocean Energy Management (BOEM) to support the seabird and marine mammal observing effort.

Survey Year	On Transect	Off Transect	Total
2012	64	16	80
2013	64	70	134
2014	49	43	92

Table 2. Summary of sea otter sightings on and off transect during 2012-2014 in Kachemak Bay and lower Cook Inlet concurrent with oceanographic sampling events.

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.

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 NOS/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.

2) *NOAA/National Ocean Service/Office of Coast Survey and University of Alaska Fairbanks*. Oceanographic data from this project and historical sampling in Cook Inlet are contributing to the validation of the ROMS ocean circulation model developed for Cook Inlet by the NOS/Coast Survey Development Laboratory. NOS provided the model code to UAF (G. Gibson) and KBRR and UAF are collaborating on a two year project to use circulation information to improve monitoring for paralytic shellfish poisoning events, entitled "Synthesis of Oceanographic Data to Aid Monitoring Programs for Harmful Algal Blooms in Kachemak Bay, Alaska".

3) *NOAA/NOS Kasitsna Bay Laboratory, Alaska Ocean Observing System (AOOS) and UAF*.

We continued to collaborate in year 3 with AOOS and UAF to quantify variability in water chemistry associated with ocean acidification in Kachemak Bay and lower Cook Inlet. We leveraged charter ship time from the EVOSTC project to periodically collect water samples at CTD stations for carbonate chemistry analysis at UAF. Coastal water chemistry changes with freshwater input from glacial watersheds and snowmelt, upwelling of ocean waters and phytoplankton blooms and understanding this variability is needed to assess how much ocean acidification may threaten nearshore species and habitats. FY14 funding ($25K) was provided to KBL by NOAA's Integrated Ocean Observing System (IOOS).

4) *NOAA Kasitsna Bay Laboratory and BOEM*:

NOAA KBL and BOEM have also initiated a collaboration to update information on marine conditions and ecological linkages in Cook Inlet, to support BOEM's environmental analysis for potential oil and gas lease sales in the region. BOEM is providing an initial $75K to conduct seasonal Cook Inlet surveys and oceanographic data analysis to support their environmental analysis needs for potential oil and gas lease sales in the region. The BOEM funding will allow us to maintain quarterly Cook Inlet cruises in Year 4, 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. In review. Quantifying temporal and spatial variability across the northern Gulf of Alaska to understand mechanisms of change. Gulf Watch Alaska program science synthesis report. Submitted to the Exxon Valdez Oil Spill Trustee Council, December 1, 2014.

Batten, S., R. Campbell, A. Doroff, K. Holderied, R. Hopcroft and T. Weingartner. In review. 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. Submitted to the Exxon Valdez Oil Spill Trustee Council, December 1, 2014.

Holderied, K. and T. Weingartner. In review. 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. Submitted to the Exxon Valdez Oil Spill Trustee Council, December 1, 2014.

b) Conference/workshop presentations and attendance

Kibler, S and D. Hondolero. 2014. "Harmful Algal Blooms: Better Tools for Detection and Quantification". Public talks in Seldovia, AK and Homer AK. August 2014.

Holderied,K. 2014. Oral presentation on Gulf Watch Alaska program, Cook Inlet oceanography and plankton monitoring and implications for developing decision support tools for paralytic shellfish poisoning events. NOAA Ecological Forecasting Webinar in Anchorage, AK. September 2014.

Holderied, K.,M. McCammon, K. Hoffman, T. Neher, T. Weingartner, R. Hopcroft, M. Lindeberg and B. Ballachey. 2015. "Gulf Watch Alaska: Monitoring the Pulse of the Gulf of Alaska's Changing Ecosystems". Oral presentation at Alaska Marine Science Symposium, Anchorage AK. Jan 2015.

Hondolero D. and K. Holderied. 2015. "Monitoring Phytoplankton in Kachemak Bay, Alaska". Poster presentation at Alaska Marine Science Symposium, Anchorage AK. Jan 2015.

c) Data/information products

No formal data products have been developed beyond those produced for the publications and presentations listed above. However for the synthesis report discussions and AMSS and EVOSTC joint science workshop, numerous graphics have been produced of oceanographic time series plots, time series anomalies, comparisons of temperatures between different regions (e.g. GAK1 and Seldovia), and along-transect vs depth contour plots (e.g. Figures 7 and 8 in this report).

d) Data sets uploaded to the data portal

- CTD data sets and associated metadata from 2012, 2013 and part of 2014 have been uploaded to the AOOS Ocean Workspace. 2012 data has been published on the Gulf Watch Alaska data

portal, and we are currently working with Axiom to revise CTD data formats for the data portal and streamline provision of data in both csv and netCDF file formats for all our data.

- Zooplankton data and associated metadata that has been analyzed through 2013 have been posted on the AOOS Ocean Workspace but have not yet been uploaded to the data portal.
  SWMP water quality data from Bear Cove, Homer and Seldovia water quality data sondes and associated metadata through 2013 have been uploaded to the Ocean Workspace and are published on the Gulf Watch Alaska data portal. Data are also publicly available through 2014 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/KBRR) and Holderied (NOAA/KBL) in the consolidated GWA budget spreadsheet.

KBRR Budget Narrative: In Year 1 of the project, KBRR leveraged our LTM 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 KBRR SWMP; $5K KBRR CTD use. Overall, the KBRR portion of the grant was 30% underspent at the close of project year 3; outstanding contracts for ship charter time are the primary reason. Budget Line items over 10% are as follows: Personnel (0.01) underspent; Travel (1.46) underspent; PI was unable to attend the Nov 2014 PI meetings in project years 2 & 3 due to schedule conflicts; Contractual (1.60) underspent; funds will be applied to ship charter time Feb, Apr, Oct in project year 4; Equipment (0.64) underspent in project year 3 (we did not yet calibrate the CTD or replace probes on the YSI sonde and will be incurring those costs early in project year 4 of the study). Application of carry over funding to ship charter time will allow quarterly sampling (up to 4 surveys in year 4 and 2 surveys in year 5) without requesting additional EVOSTC funding. Underspending to date is largely due to additional grant funds ($102K) in project year 1that have resulted in carry over funding.

NOAA/KBL Budget Narrative: In-kind contributions from KBL include CTD equipment ($5.0K/year, $15K total for years 1-3), KBL laboratory staff salary ($25K/year, $75K total for years 1-3). Additional leveraged funding includes $25K funding from AOOS for Kachemak Bay oceanographic monitoring ($75K total for years 1-3) and $75K funding received from BOEM in FY15 to sustain Cook Inlet oceanographic monitoring. Spending on this project has been significantly delayed due to our ability to leverage other funding for some boat operations, which will enable us to sustain seasonal monitoring longer into years 4 and 5 of the project than had been planned in our original proposal. In addition, planned purchases of new oceanography sensors were delayed due to better than expected equipment endurance and purchase of a field computer was not completed due to a change in IT acquisition policies (the computer has been provided in-kind by NOAA). Overall the project is underspent by $52.5K ($25.7 in commodities, $12.7K in equipment, $7.5K in contracts and $3.9K in travel). We proposed in our Year 4 work plan to use some savings from prior year commodity purchases and travel (limited by federal travel restrictions) to establish contracts for nutrient, carbonate chemistry and data analysis contracts in FY15. We also expect to apply computer purchase savings to acquire new oceanographic equipment in FY15.