ATTACHMENT C EVOSTC Annual Project Report Form

Form Rev. 9.14.17

1. Program Number:

17120114-H

2. Project Title:

Nearshore Ecosystems in the Gulf of Alaska

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4. Time Period Covered by the Report:

February 1, 2017-January 31, 2018 (Year 6)

5. Date of Report:

March 2018

6. Project Website (if applicable):

www.gulfwatchalaska.org

7. Summary of Work Performed:

Overview

Nearshore monitoring in the Gulf of Alaska (GOA) provides ongoing evaluation of the status and trends of more than 200 species, including many of those injured by the 1989 *Exxon Valdez* oil spill. The nearshore monitoring design includes spatial, temporal, and ecological features that strengthen inferences regarding drivers of change.

In 2017 we sampled in Kachemak Bay (KBAY), Katmai National Park and Preserve (KATM), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS) following previously established methods. Metrics included monitoring the abundance and distribution of marine invertebrates, macroalgae, sea grasses, birds, mammals, and physical parameters such as temperature. In addition to taxon-specific metrics, monitoring included recognized important ecological processes such as predator-prey dynamics and measures of nearshore ecosystem productivity. We are not proposing any major changes to this project for FY18 except to add black oystercatcher and marine bird and mammal sampling to Kachemak Bay. This will be an in-kind contribution from the Department of the Interior agencies within the nearshore component (Table 1).

Table 1. Nearshore component metrics measured by location and year, 2017-2021. Completed activities for 2017 are bolded while planned activities in future years (2018 – 2021) are not.

Location and Metric	**2017**	**2018**	**2019**	**2020**	**2021**
Western PWS, intertidal invertebrates and algae	**X**	x	x	x	x
Western PWS, intertidal kelps and sea grass	**X**	x	x	x	x
Western PWS, black oystercatchers	**X**	x	x	x	x
Western PWS, contaminants/water quality		x			
Western PWS, sea otter carcass recovery	**X**	x	x	x	x
Western PWS, sea otter spraint observations	**X**	x	x	x	x
Western PWS, sea otter foraging observations	**X**	x	x	x	x
Western PWS, water / air temperature	**X**	x	x	x	x
Kachemak Bay, intertidal invertebrates and algae	**X**	x	x	x	x
Kachemak Bay, intertidal kelps and sea grass	**X**	x	x	x	x
Kachemak Bay, black oystercatchers		x	x	x	x
Kachemak Bay, contaminants/water quality		x			
Kachemak Bay, sea otter spraint observations	**X**	x	x	x	x
Kachemak Bay, sea otter foraging observations		x	x	x	x
Kachemak Bay, water / air temperature	**X**	x	x	x	x
Katmai NP, intertidal invertebrates and algae	**X**	x	x	x	x
Katmai NP, intertidal kelps and sea grass	**X**	x	x	x	x
Katmai NP, black oystercatchers	**X**	x	x	x	x
Katmai NP, contaminants/water quality		x			
Katmai NP, sea otter spraint observations	**X**	x	x	x	x
Katmai NP, sea otter carcass recovery	**X**	x	x	x	x
Katmai NP, sea otter foraging observations	**X**	x	x	x	x
Katmai NP, water / air temperature	**X**	x	x	x	x
Kenai NP, intertidal invertebrates and algae	**X**	x	x	x	x
Kenai NP, intertidal kelps and sea grass	**X**	x	x	x	x
Kenai NP, black oystercatchers	**X**	x	x	x	x
Kenai NP, contaminants/water quality		x			
Kenai NP, sea otter carcass recovery	**X**	x	x	x	x
Kenai NP, sea otter carcass recovery	**X**	x	x	x	x
Kenai NP, sea otter foraging observations	**X**	x	x	x	x
Kenai NP, water / air temperature	**X**	x	x	x	x
PWS, sea otter aerial survey			x		
Kenai NP, sea otter aerial survey		x			x
Katmai NP, sea otter aerial survey	**X**			x	
Kachemak Bay, sea otter aerial survey*	**X**				
PWS Nearshore marine bird survey**		x		x	
Katmai nearshore marine bird survey	**X**	x	x	x	x
Kenai nearshore marine bird survey	**X**	x	x	x	x

*Funded by USFWS in 2017

**Under Pelagic component Restoration Project 16120114-K

2017 Highlights

Below we present results from several aspects of our nearshore studies, as examples of the variety of findings that are emerging from this long-term program, both expected and unanticipated. These include: (1) nearshore water temperature anomalies through 2017, (2) sea star declines and potential recovery across the GOA, (3) clam biomass estimates across the GOA, (4) variation in selected mussel metrics across the GOA, and (5) sea otter abundance and density estimates across all four regions in the GOA. In addition to the metrics listed above, we present two examples of further data exploration that have been conducted in Kachemak Bay. Additional data syntheses and analyses have been presented in a variety of reports, journal articles, posters, presentations, and outreach events, listed in section 9 of this report.

2017 Data Summaries

Water Temperatures

Intertidal water temperature anomalies confirm that The Blob washed ashore in May of 2014 across the northern Gulf of Alaska with temperature sensors showing a similar magnitude of warming in all blocks (Fig. 1). In Prince William Sound (PWS), data are available from sensors at annual monitoring sites in WPWS, as well as additional sites in the eastern and northern PWS from 2013 – 2017. Within the Sound, some sites were warmer/cooler than the overall mean PWS temperatures, with eastern PWS sites generally warmer and the Whale Bay site in WPWS the coldest. Also, three sites within northern PWS showed less indication of a warming trend associated with The Blob, which may relate to greater glacial input in the northern Sound.

Intertidal water temperatures also appeared to track pelagic water temperature fairly closely. Using 2013 water temperatures in PWS (Fig. 2) as an example, daily mean water temperatures from all intertidal sensors was highly correlated with daily mean water temperatures recorded from the mid-Sound National Oceanographic and Atmospheric Administration (NOAA) buoy (buoy 46060) including during a mid-summer cooling event in that year. However, the range of water temperature readings from intertidal sensors was much greater than the range of water temperatures recorded at the buoy.

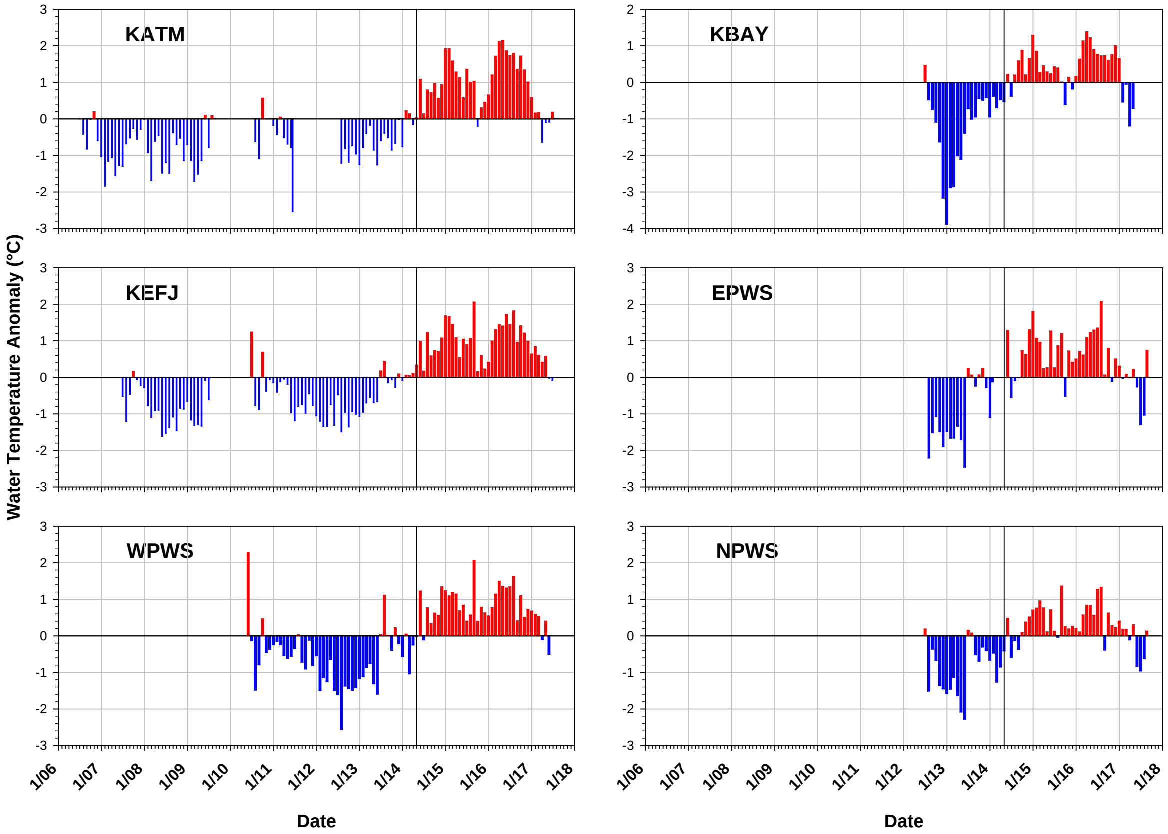

Figure 1. Monthly water temperature anomalies at intertidal sites in the Gulf of Alaska show concordance in timing and magnitude of warming beginning in May 2014.

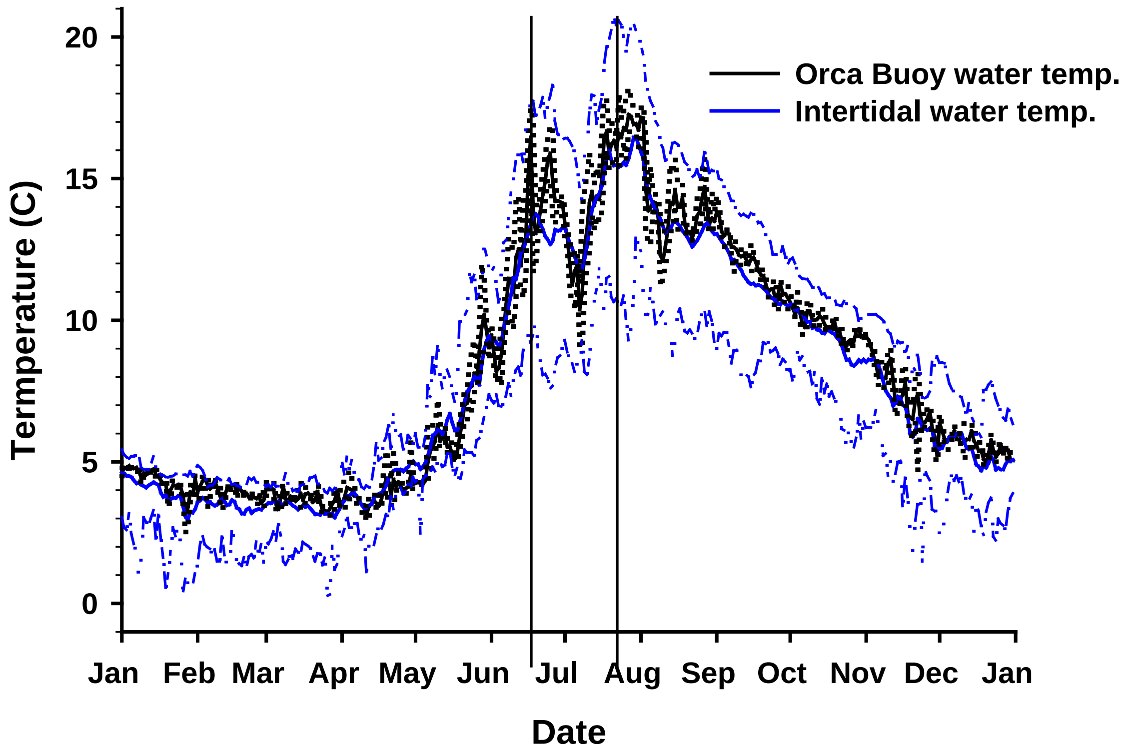

Figure 2. Daily mean (max/min) water temperatures from intertidal sensors (blue) compared to the mid-Sound National Oceanic Atmospheric Administration (NOAA) buoy 46060 in Prince William Sound (black) during 2013. Means = solid lines, range = dashed line. Mid-summer cooling event highlighted by vertical lines.

Sea Stars

Gulf Watch Alaska (GWA) has been monitoring intertidal sea stars in the four blocks (KBAY, KEFJ, KATM, and WPWS) in the northern GOA to determine spatial and temporal trends in sea star populations. In 2014, sea star wasting expanded north from California and reached the GOA, where numerous sea stars were found exhibiting symptoms of this disease in KBAY and PWS. This is the first time a disease has been recognized as impacting sea star populations in Alaska waters. It is also the longest it has lasted in the general North Pacific.

The sea star data were examined for spatial and temporal trends in abundance and diversity, and to determine if effects of sea star wasting could be detected. Analyses demonstrated high spatial and temporal variability in sea star densities in all surveyed blocks. In addition to high temporal variability in abundance, diversity and dominance of individual species varied greatly among blocks (Fig. 3). The dominant sea star in KEFJ has been *Pisaster ochraceus*, followed by *Pycnopodia helianthoides* and *Dermasterias imbricata*. WPWS has been dominated by *Pycnopodia* and *Dermasterias*. KBAY has had one dominant sea star, *Evasterias troschelii*. KATM is primarily dominated by *Evasterias*, followed by *Pisaster* and *Pycnopodia*.

A decline in sea star numbers, most likely attributable to sea star wasting, has been seen across all blocks in recent years. In 2017, recruitment was evident in WPWS and KEFJ, but not in KBAY or KATM (Fig. 4). Continued monitoring of sea stars and their associated communities will also provide insights into the impacts that sea star wasting is having over time.

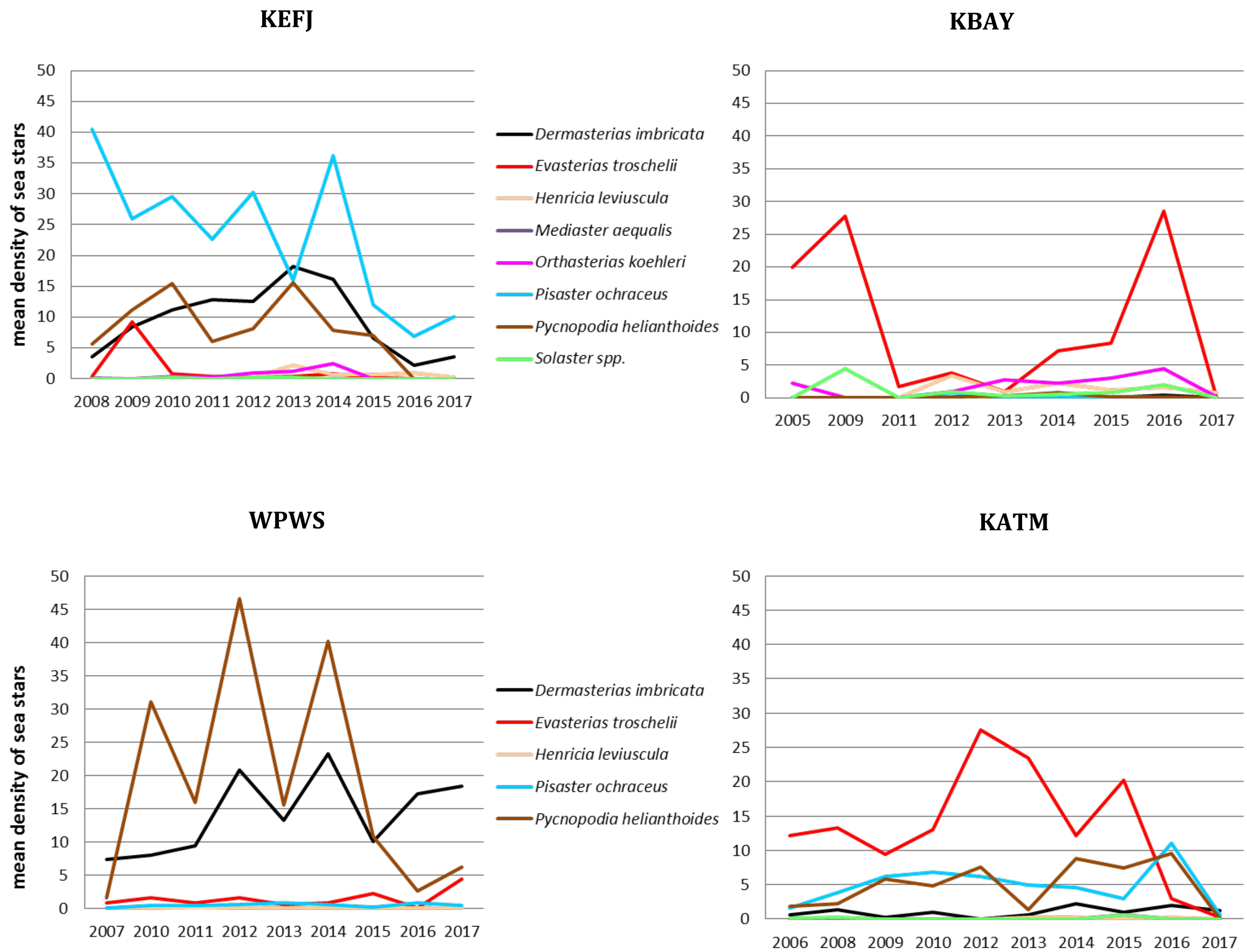

Figure 3. Mean abundance (per 4 x 50 m swath) of sea stars present in each region across the years that the region was sampled.

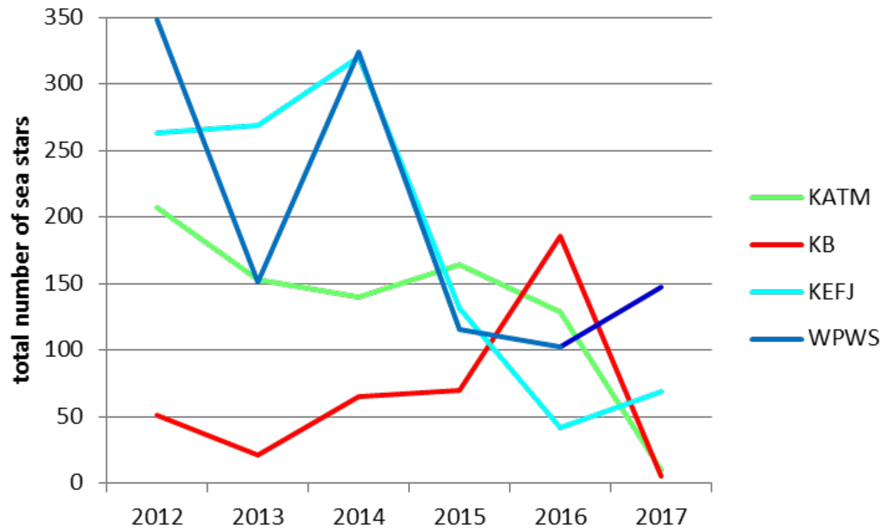

Figure 4. Total number (per 4 x 50 m swath) of sea stars present in each region from 2012-2017.

Clams

2017 marked one decade of biannual monitoring efforts on mixed-sediment beaches across the GOA. Using size and abundance data for all bivalves observed between 2007 and 2017, we estimated clam biomass among the four sampling blocks (KATM, KBAY, KEFJ, and WPWS). Sampling events were skipped at WPWS in 2009 and KATM in 2011 due to programmatic decisions. KEFJ was sampled consistently six times. KBAY was not included in the bivalve monitoring component until 2013. We chose to present changes in mean biomass among blocks, through time, as an integrator of changes in both size and abundance. We specifically examined changes in total biomass of all clams (Fig. 5a), mean biomass of *Macoma spp.* (Fig. 5b), mean biomass of *Saxidomus gigantea* (Fig. 5c), and mean biomass of *Leukoma staminea* (Fig. 5d). *Saxidomus*, a large bodied suspension feeder, is the largest contributor of biomass, where they occurs. *Macoma*, a guild of small bodied deposit feeders, usually comprise the numerically dominant taxa. *Leukoma*, also a large bodied suspension feeder, was examined to assess status following a population crash in the early 2000s.

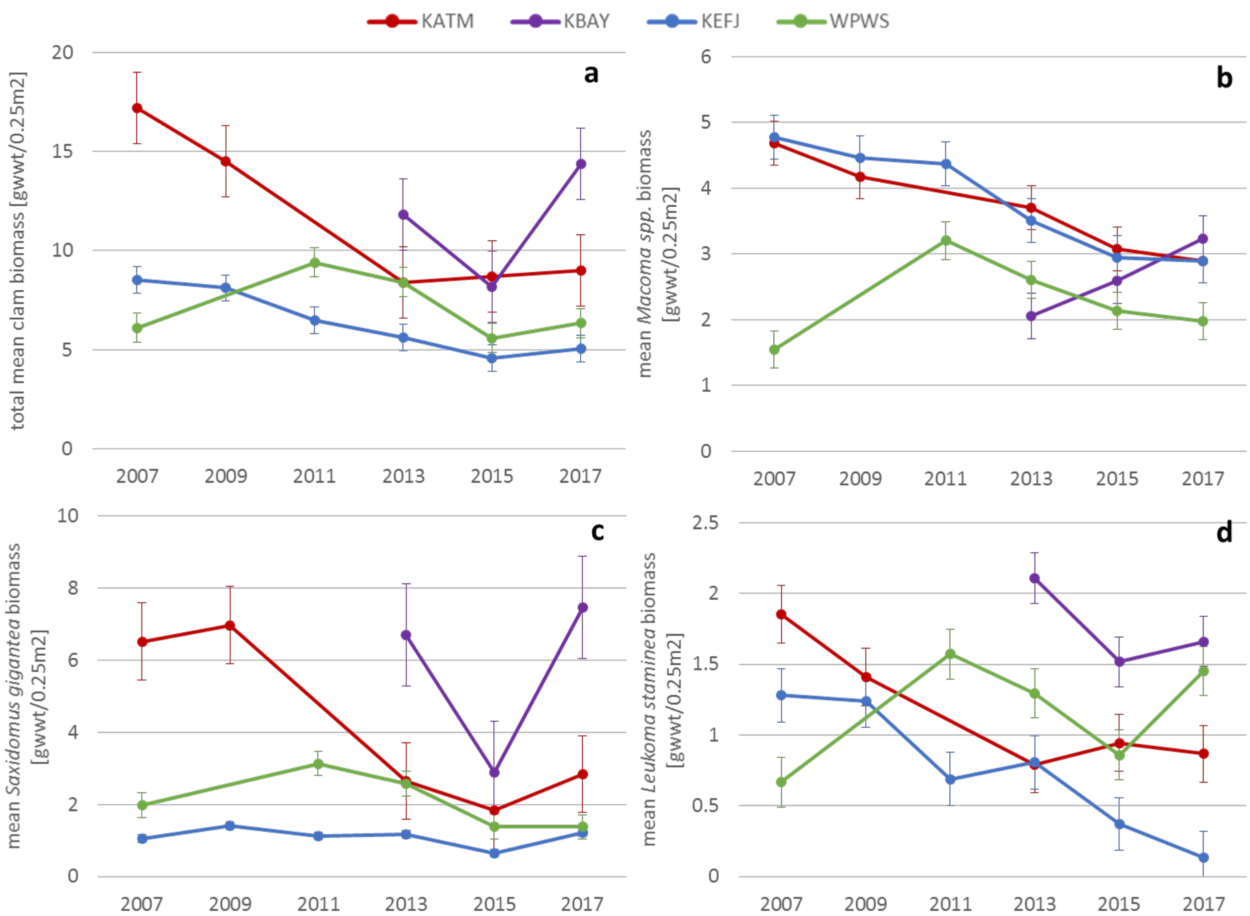

Figure 5. Mean biomass of (a) all clams, (b) *Macoma spp.*, (c) *Saxidomus gigantea*, and (d) *Leukoma staminea*, from 2007-2017. Units of biomass are in grams of wet edible tissue weight per quarter square meter [gwwt/0.25m^2]. Error bars represent standard error.

In 2017, clam biomass was greatest in KBAY, followed by KATM, WPWS, and KEFJ; however, these 4 blocks have varied greatly through time (Fig. 5a). KATM, which had the highest historic values, declined precipitously between 2009 and 2013, likely due to reduced biomass of *Saxidomus (*Fig. 5c). Consistent declines in biomass at KEFJ are likely due to declining biomass of *Leukoma* and the numerically-dominant, but small-bodied, *Macoma spp.*, which in KEFJ exceed the biomass of *Saxidomus* (Fig. 5b&c). WPWS exhibited some variation, but overall biomass trends were relatively stable. The KBAY block was not initiated until 2013 and over 3 sampling events has revealed a relatively high degree of variability, largely due to fluctuations in *Saxidomus* biomass. Historic data indicate that KBAY may have also experienced a similar decline in large-bodied clam biomass, similar to KATM. *Leukoma* biomass was generally found to decrease through time, except in WPWS, where biomass was variable and increasing between 2015 and 2017. Clams constitute an important benthic resource for consumers such as sea otters, sea stars, sea ducks, bears, and humans. Differences among blocks in the clam community structure and composition will have implications for consumers as the prey base changes through time. Mixed-sediment beaches will be revisited in 2019.

Mussels

We estimate the abundance of mussels at 21 mussel sites across the four sampling blocks (KATM, KEFJ, WPWS, and KBAY) through collections of mussels in quadrats. From these counts we calculate densities of all mussels, small mussels (those ≤ 5 mm representing recruits for each year) and large mussels (those ≥ 20 mm). Measurement of mussels > 1 mm provide estimates of mussel sizes by site and by block.

Densities of all mussels vary by block (Fig. 6), with KEFJ averaging densities of 25,000/m^2, KATM and KBAY averaging about 9,000/m^2, and WPWS about 3,000/m^2. We see high annual variation in all mussel densities, with maximum densities in all blocks except WPWS occurring in 2014, and a trend toward declining densities of all mussels through 2017.

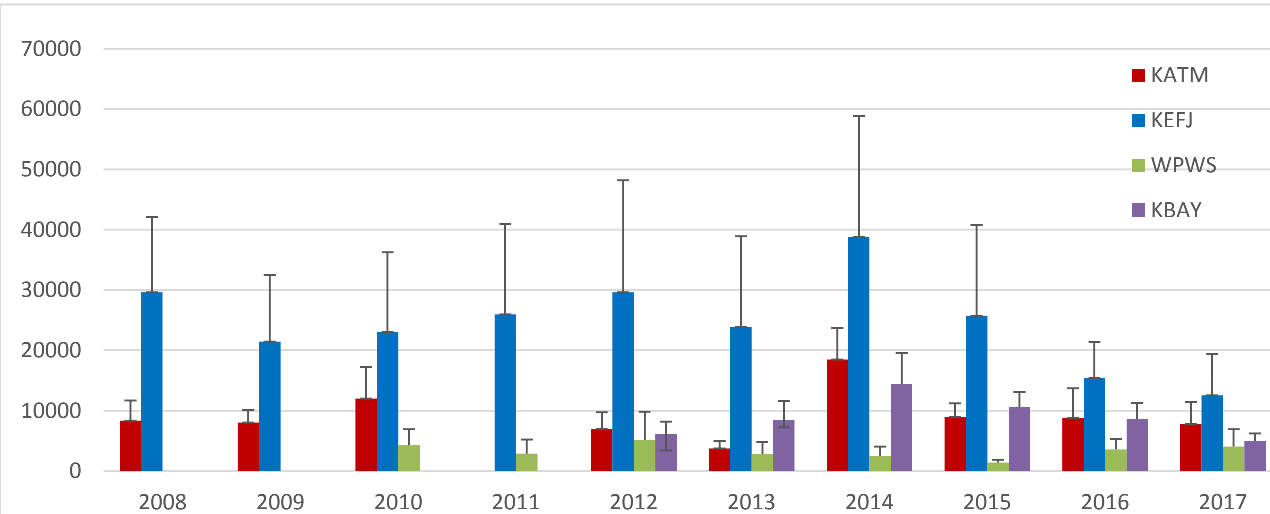

Figure 6. Density of all mussels (#/m^2) sampled at mussel sites. Error bars indicate 1SE.

In 2012, we began estimating the density of small mussels, those ≤ 5 mm, presumed to reflect mussels that had recruited into the sampled population over the prior year. Small mussel densities across the GOA average about 4,000/m^2, generally comprise about 27% of the total mussel density, and are rarely absent (only absent in 4 of 72 site x year combinations). In 2014, similar to the trend in all mussel densities, we observed the greatest densities of small mussels except in WPWS.

Densities of large mussels (≧ 20mm) exhibit spatial patterns similar to densities of all mussels, with KEFJ exhibiting the highest values, averaging about 3,000/m^2 (12% of total density, i.e., density of all mussels), KATM and KBAY averaging about 1,000/m^2 (11% of total density), and WPWS averaging about 350/m^2 (12% of total density) (Fig. 7). The similar proportion of large mussels to all mussels at the block level (~12%) is suggestive of consistent processes structuring the upper end of the distribution of mussel sizes across the GOA. We also see a marked increase in the density of large mussels at KEFJ in 2017, possibly reflecting high survival of small mussels that were evident in KEFJ in 2014 and 2015.

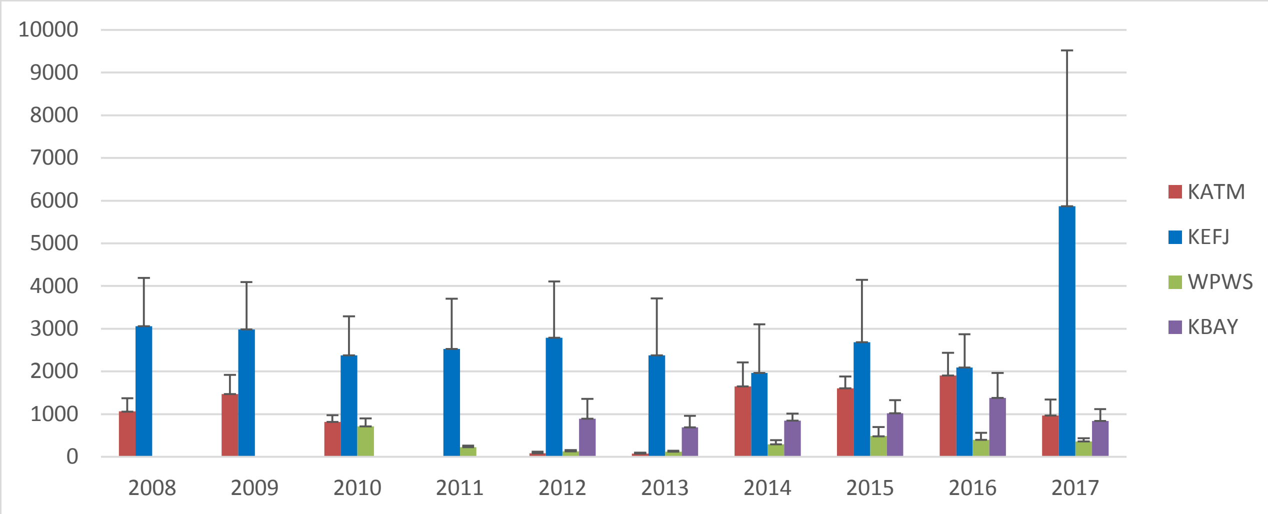

Figure 7. Density of large (≥ 20 mm) mussels (#/m[2]) sampled at mussel sites. Error bars indicate 1SE.

Sea Otters

An aerial survey method developed specifically for estimating sea otter abundance was used to sample each survey area. Based on aerial surveys in 2012 and 2015, sea otter abundance in KATM appears to have stabilized following more than a decade of population growth. In KEFJ, 3 surveys between 2002 and 2010 suggest a stable sea otter population. Sea otter abundance in WPWS increased at 3% per year from 2007-2013 but declined in 2017, although not significantly. Abundance estimates for KBAY have increased since 2002, with an apparent stabilization in abundance estimates between 2012 and 2017 (Fig. 8).

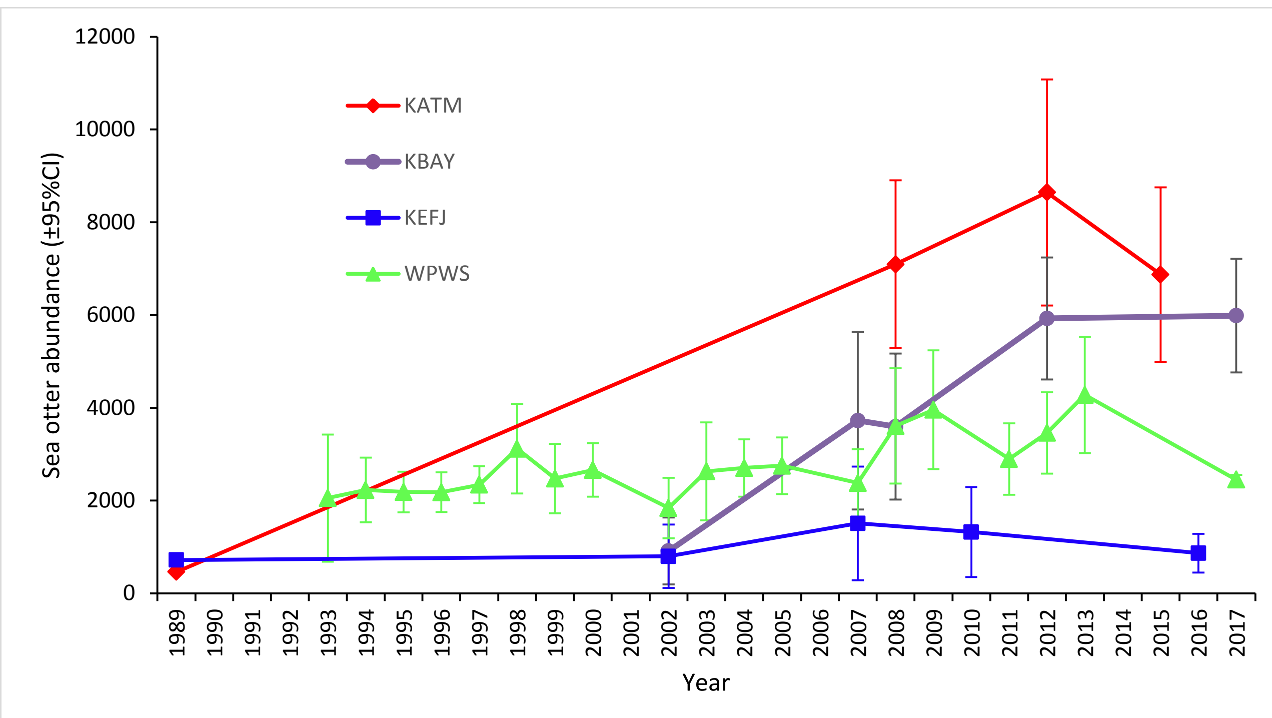

Figure 8. Sea otter abundance in the four sampling blocks. Error bars indicate 95% CI.

Density estimates show similar patterns with relatively low densities in KEFJ and WPWS and higher densities in KATM and KBAY (Fig. 9). This is likely due to the amount of available sea otter habitat in the regions. KBAY and KATM are shallow with abundant mixed-sediment habitats that likely support high densities of clams (see Fig. 5a above), a preferred prey of sea otters.

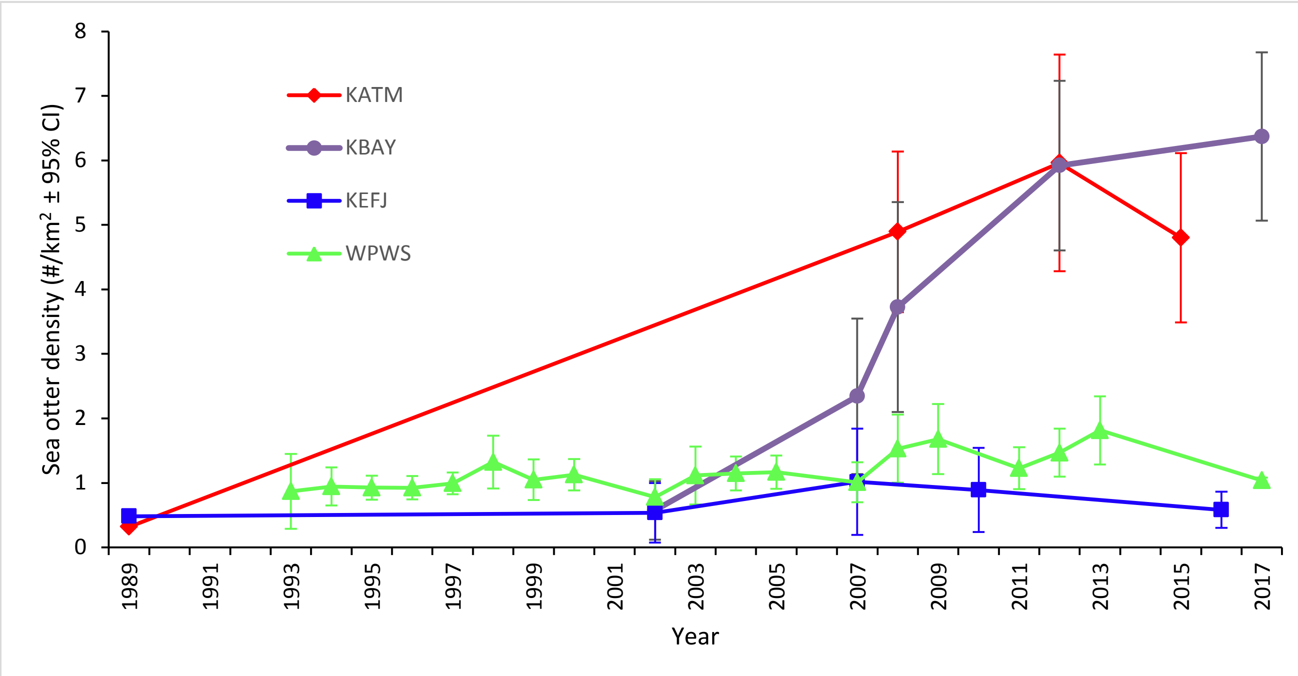

Figure 9. Sea otter density in the four sampling blocks. Error bars indicate 95% CI.

2017 Data Exploration

The following examples of data exploration provide insight into possible processes driving populations in the nearshore. We plan to conduct further data exploration, using these methods, in all nearshore sampling blocks across the GOA.

Linking temperature to community composition

Despite the overall warming water temperatures experienced within the GOA overall, including Kachemak Bay, air temperatures during the 2016-2017 winter period were much colder than in previous years. Cold air temperatures affect nearshore communities especially during low tide periods in the winter. Consequently, we detected significant changes to the rocky intertidal communities at mean tide level (MTL) and the mean lower low water (MLLW) tidal elevations in spring 2017, which we believe may be attributed to the cold/freezing temperatures during the preceding winter.

Several temperature metrics (see Table 2) were assessed from temperature sensors (30 min interval measurements) deployed year-round at the MLLW level at three rocky intertidal sites in KBAY. Temperature was assessed and averaged across all three sites as (1) the average winter temperature (January – March), i.e., temperature readings taken at high tide during water cover. In addition, we assessed (2) average exposure temperature from minimum temperature spikes during negative tides (those that fall below MLLW), (3) the absolute lowest recorded temperature at negative tides per year, (4) total time at below-zero Celsius (freezing) temperatures (i.e., number of negative temperature readings * 30 min logging intervals / 60, to result in time in hours), and (5) the total number of negative tides per winter. Significantly lower average water temperatures, average exposure temperatures and total exposure time to sub-zero temperatures were recorded in winter 2017.

Table 2: Annual temperature metrics at the MLLW level averaged over three rocky intertidal sites in KBAY. Bold values are significantly different from previous years. Lowest temperature record is a single value per year and was not included in any statistical analysis.

Year	Avg water temp (°C)	Avg exposure temp (°C)	Lowest temp record (°C)	Total time < 0°C exposure (h)	# negative tides
2014	4.637	0.571	-6.507	90.3	59
2015	5.763	1.517	-5.885	81.3	57
2016	5.989	2.962	-0.923	4.5	54
2017	**4.090**	**-1.980**	-7.912	**232.0**	58

Biological metrics evaluated in the rocky intertidal communities were the percent cover of fleshy algae (all algal species not including coralline crust), barnacles, and open (bare) substrate, all derived from visual quadrat assessments. Results are presented as anomalies, as the deviation from the 4-year mean. All community metrics in 2017 had vastly different anomalies than previous years, with similar patterns in the MTL and MLLW strata (Fig. 10). Fleshy algal cover was significantly lower than in previous years while barnacle cover and open substrate were significantly higher. In general, the analysis of fleshy algae does not include *Fucus distichus*, a species tolerant to freezing events due to antifreeze components at the cellular level. *F. distichus* is also primarily found higher in the intertidal, outside of the study area examined here.

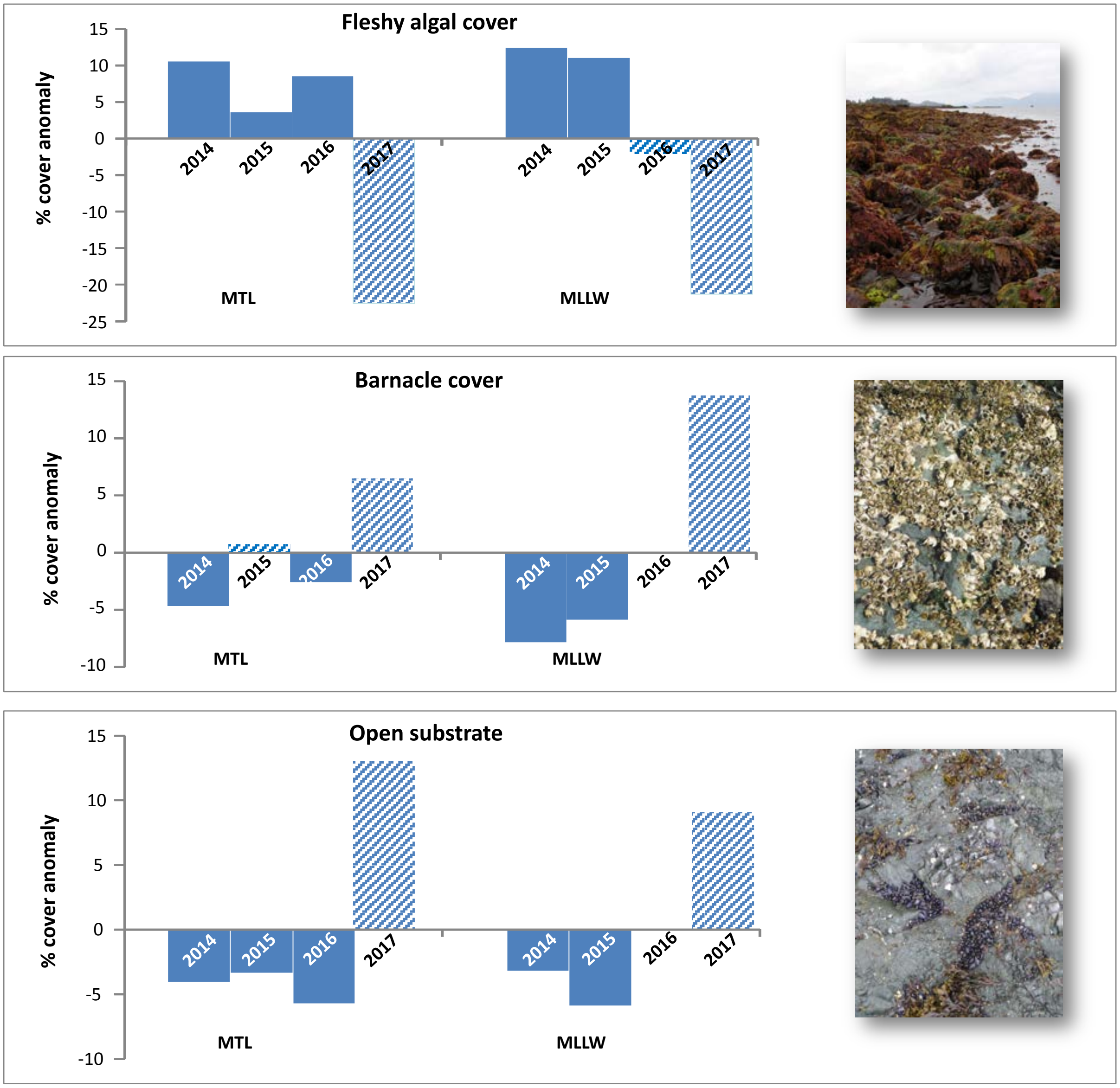

Figure 10. Mean anomaly in percent cover of three community metrics at MLT and MLLW rocky intertidal communities in KBAY over four years. Lower than average fleshy algal cover (negative anomalies), and higher than average barnacle and open (bare) substrate cover (positive anomalies), are highlighted by light, shaded bars.

The observations reported here suggest that local weather events may have great effects on survival and community structure despite the observed larger-scale and longer-term trend of climate and ocean warming. The strong 2017 community effects may be related to the drastic cold air temperatures, while few community responses were seen during the preceding years of continuously warming winter water temperatures from 2014-2016 (see Table 2 and Fig. 10). It is possible that organisms such as fleshy algae are better able to acclimate to the slowly warming trends than to sudden freezing events. In contrast to fleshy algae, barnacles are highly resistant to freezing and able to survive in these conditions. Continued observations of the nearshore rocky intertidal communities alongside key environmental variables (e.g., temperature) will give insight into the longevity of the ecological consequences of such local stressors.

Mussel growth and mortality

Size-frequency distribution measurements of mussels from six rocky intertidal sites in KBAY were used to infer population characteristics in terms of demographics, growth and mortality. Finite normal mixture models were fit to the length frequency data to resolve age cohorts within the populations (by site) based on existing growth curves for the species from Prince William Sound. Site-specific mortality rates were calculated from decay of age cohorts.

Size-frequency data indicate that each site received new mussel settlement each year (2012-2017). Growth curves from integrated mixture models indicate few mussels persist past 6 yrs of age (> 20-30mm) in KBAY with the exception of two sites (Elephant and Cohen Islands) where individuals may approach 10 yrs of age (40-50 mm, Fig 12). Strong site-specific differences in growth and mortality were evident. Sites that were characterized by low slopes and sandy substrate among rocks tended to have fast growth but also high mortality (~70%), whereas sites with rock walls tended to have slower growth but also lower mortality (~20-30%) (Fig. 11). Aside site specific patterns, we also observed regional patterns as mussel growth in KBAY seems to be slower than in Prince William Sound. Understanding these local and regional patterns is important as mussels are a crucial link between primary production and upper trophic levels in the nearshore environment.

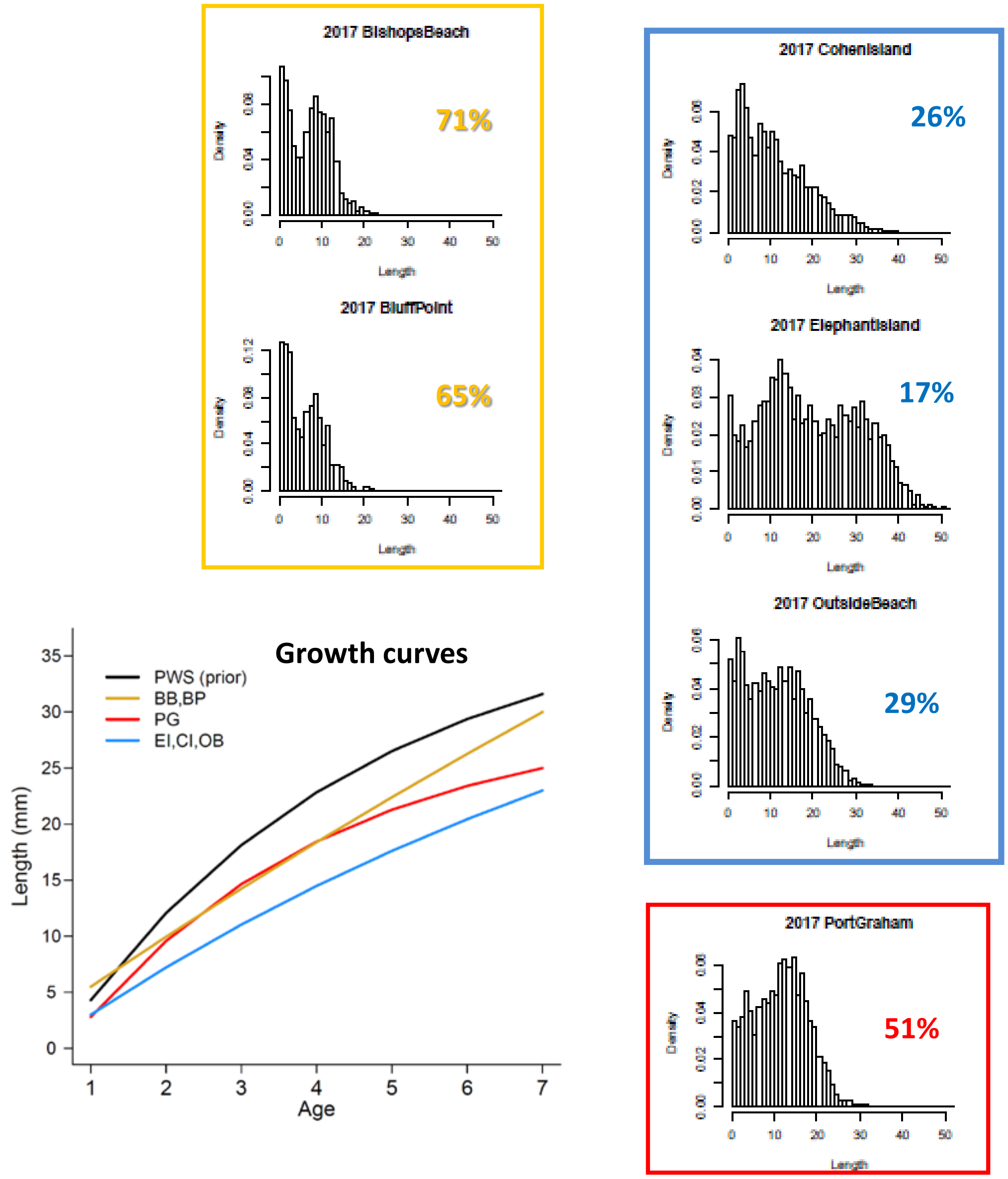

Figure 11. Growth curves (van Bertalanffy) for *Mytilus trossulus* based on an existing growth model for Prince William Sound (black) informed by site-specific population parameters. Mortality rates are listed as colored numbers next to example size-frequency histograms per site for 2017.

8.	Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

2017 was the first year the nearshore component of GWA merged into a single project. Prior to that, both nearshore projects (numbered 16120114-R and 16120114-L during the first five years of the GWA program) collaborated extensively to ensure that data collected across the GOA were comparable within the GWA program and, when possible, to provide another window into the causative factors and spatial extent of changes in nearshore systems.

The nearshore component has begun to work closely with the environmental drivers component (projects 17120114-G, I, J, and L) of GWA to examine trends in water temperature over space and time. A poster titled, "Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; The Blob washes ashore", was presented at the 2018 Alaska Marine Science Symposium.

Efforts were made during the annual GWA PI meeting in November 2017 for cross-component bird data integration and synthesis (projects 17120114-C, E, H, L, M, and O). All parties had data summaries to discuss and determine how we may look at trends over time, changes in distribution, and integration with data from other components, including environmental drivers. Next steps include incorporating our published marine bird survey data (https://alaska.usgs.gov/products/data.php?dataid=170) into the North Pacific Pelagic Seabird Database (NPPSD). Incorporation of our data into NPPSD, along with all Gulf Watch Alaska and other marine bird survey data will allow for larger scale analyses of marine bird trends throughout the Gulf of Alaska over time.

An educational collaboration continues to exist within the GWA nearshore project. Two University of Alaska field courses taught by GWA nearshore PIs (B. Konar and K. Iken) at the Kasitsna Bay Lab, contribute to the nearshore data collection. Students get valuable experience and training from participation in this project, and the project benefits from the involvement of students. In addition, the KBAY portion of this project provides summer funding for one graduate student who can dedicate more time to assist in the sampling and sample processing. Additional graduate student funding is being sought to enable University of Alaska students to take on questions arising from the nearshore monitoring.

2. Across Programs

a. Herring Research and Monitoring

We have not collaborated with the Herring Research and Monitoring group to date.

b. Data Management

We have begun to work with Axiom to create data visualization tools in Jupyter notebooks within the Alaska Ocean Observing System workspace. Data associated with our mussel bed monitoring has been provided to Axiom. We anticipate a final product during the winter of 2018 that can serve as an example to build additional visualizations.

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 timeframes required.

c. Lingering Oil

Data collected by the nearshore component of GWA are relevant for understanding ecosystem recovery with respect to the Lingering Oil program (e.g., sea otter abundance, energy recovery rate, and age-at-death data have all been used to evaluate population recovery).

B. Projects not Within a Trustee Council-funded program

None to report.

C. With Trustee or Management Agencies

Ongoing Collaborations

In 2013, building on GWA findings indicating that sea otters in KEFJ consume mussels at much higher frequencies than at other areas, we initiated a study of annual patterns in mussel energetics and sea otter foraging at KEFJ, funded by the National Park Service (NPS) and U.S. Geological Survey (USGS). That study is to be completed in 2018. Initial results indicate that mussel energy density varies seasonally, likely corresponding to spawning condition. Further, we found that mussel consumption by otters varied slightly seasonally in association with varying mussel energy density, but overall mussel consumption was high in KEFJ across seasons.

Our GWA nearshore data from KATM contributed to USGS and North Pacific Research Board (NPRB) studies of the status of the southwest Alaska stock of sea otters, which is listed as threatened under the Marine Mammal Protection Act. These data are shared with the U.S. Fish and Wildlife Service, Marine Mammals Management, who is responsible for sea otter management.

Nearshore component PIs (Coletti, Iken, Konar, and Lindeberg) have been working on nearshore community assessment and long-term monitoring recommendations for the Bureau of Ocean Energy Management (BOEM). The BOEM Proposed Final Outer Continental Shelf (OCS) Oil & Gas Leasing Program 2012-2017 includes proposed Lease Sale 244 in the Cook Inlet Planning Area in 2017. An OCS Cook Inlet Lease Sale National Environmental Policy Act (NEPA) analysis has not been undertaken since 2003. Updated information was needed to support an analysis associated with the planned lease sale. The overall objective of this study was to provide data on habitats and sensitive species to support environmental analyses for NEPA documents, potential future Exploration Plans, and Development and Production Plans. The goal was to utilize existing protocols already developed thorough GWA when possible to ensure data comparability. The project will be ongoing through 2019 and all data are being provided to the AOOS data portal.

Funded through the Coastal Marine Institute (CMI), a partnership between BOEM and the University of Alaska Fairbanks (UAF), GWA Nearshore PIs (Iken and Konar) are working with a graduate student on analyzing food web structure in western Cook Inlet (above-mentioned BOEM project) and at GWA sites in Kachemak Bay. This adds valuable information about the energetic links among the species that are analyzed for their abundance and distribution through GWA.

Nearshore GWA PIs (Ballachey, Bodkin, Coletti, and Esler) are working with NPS on the 'Changing Tides' Project (https://www.nps.gov/katm/learn/changing-tides.htm). This study examines the linkages between terrestrial and marine ecosystems and is funded by the National Park Foundation. Field work was initiated in July 2015 with in-kind support from our KATM vessel charter. National Parks in Southwest Alaska are facing a myriad of management concerns that were previously unknown for these remote coasts, including increasing visitation, expanded commercial and industrial development, and environmental changes due to natural and anthropogenic forces. These are concerns because of their potential to impair biological resources in coastal systems. The project has three key components: (1) brown bear fitness and use of marine resources, (2) health of bivalves (clams and mussels), and (3) an integrated outreach program. We (GWA nearshore component) assisted with the collection of a variety of bivalve species from the coast of Katmai National Park and Preserve. Bivalve specimens were collected and kept live in small aquarium-like containers, and condition and performance metrics were assessed in the laboratory by Alaska SeaLife Center collaborators Tuula Hollmen and Katrina Counihan. Other specimens were collected for genetic transcription diagnostics (gene expression) to measure the physiologic responses of individuals to stressors, in collaboration with Liz Bowen and Keith Miles of USGS. This project will increase our understanding of how various stressors may affect both marine intertidal invertebrates and bear populations. The project will be on-going through 2019.

In collaboration with Dr. Suresh Sethi (Cornell University), Nearshore GWA PIs (Konar, Iken Bodkin, and Coletti) examined mussel size-frequency data as a tool to link physical and biological site characteristics to fundamental demographic processes in mussel populations. A poster titled, "Regional and local drivers combine to structure mussel growth and mortality", was presented at the 2018 Alaska Marine Science Symposium. Preliminary results are provided in section 7 of this report.

Proposed Collaborations
Nearshore GWA PIs (Esler and Coletti), in collaboration with NPS and UAF, have submitted proposals to NPS and the NRPB aimed at documenting variation in nearshore physical oceanography in relation to tidewater glacial input, and quantify biological responses to that variation across trophic levels in Kenai Fjords National Park. This work will allow prediction of changes in nearshore ecosystems in the face of ongoing glacier mass loss and retreat from the marine environment. This proposed work relies heavily on GWA nearshore monitoring data and will build on our understanding of nearshore marine processes.

In collaboration with researchers at University of Alaska Anchorage (UAA) and University of Alaska Southeast (UAS), nearshore GWA PIs (Konar and Iken) have a proposal pending with the National Science Foundation to examine how the timing, duration, and character of the freshwater flux from precipitation vs glacial melt influences nearshore biological communities. This work will examine an array of sites from southeast Alaska to Kachemak Bay.

In-kind support from GWA and NPS was provided to the Pacific Nearshore Project (https://pubs.usgs.gov/fs/2010/3099/) that investigated methods to asses overall health of nearshore ecosystems across the north Pacific. In particular, samples were collected during GWA trips to KATM and WPWS to examine the sources of primary productivity to two fish species that differed in their feeding mode (kelp greenling/nearshore benthic vs. black rockfish/pelagic). Stable isotope analyses showed that both benthic foraging and pelagic foraging fish species derive their energy from a combination of macro- (kelps) and micro-algae (phytoplankton) sources. Initial stable isotope analyses from across the GOA of a variety of nearshore invertebrates supports the concept that kelps are a primary contributor of carbon to nearshore ecosystems in the GOA. Further work was completed, with support from GWA, examining the role of local and basin-wide ocean conditions on growth rates of benthic foraging and pelagic foraging fish species.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

Bodkin, J.L., H.A. Coletti, B.E. Ballachey, D. Monson, D. Esler, and T.A. Dean. 2017. Spatial and temporal variation in Pacific blue mussel, *Mytilus trossulus*, abundance in the northern Gulf of Alaska, 2006-2015. Deep Sea Research Part II: https://doi.org/10.1016/j.dsr2.2017.04.008

Bowen, L., A.K. Miles, B.E. Ballachey, S. Waters, J.L. Bodkin, M. Lindeberg, and D. Esler. 2017. Gene transcription patterns in response to low level petroleum contaminants in *Mytilus trossulus* from field sites and harbors in southcentral Alaska. Deep Sea Research Part II: https://doi.org/10.1016/j.dsr2.2017.08.007

Coletti, H., D. Esler, B. Ballachey, J. Bodkin, G. Esslinger, K. Kloecker, D. Monson, B. Robinson, B. Weitzman, T. Dean, and M. Lindeberg. 2018. Gulf Watch Alaska: Nearshore Benthic Systems in the Gulf of Alaska. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-R), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Esler, D., B. E. Ballachey, C. O. Matkin, D. Cushing, R. Kaler, J. Bodkin, D. Monson, G. G. Esslinger, and K. Kloecker. 2017. Timelines and mechanisms of wildlife population recovery following the *Exxon Valdez* oil spill. Deep Sea Research Part II: https://doi.org/10.1016/j.dsr2.2017.04.007

Konar, B. and K. Iken. 2017. The use of unmanned aerial vehicle imagery in intertidal monitoring. Deep Sea Research Part II: https://doi.org/10.1016/j.dsr2.2017.04.010

Konar B., K. Iken, and A. Doroff. 2018. Long-term monitoring: nearshore benthic ecosystems in Kachemak Bay. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-L), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Weitzman, B. P., J. L. Bodkin, K. A. Kloecker and H. A. Coletti. 2017. SOP for monitoring intertidal bivalves on mixed-sediment beaches — version 2.0: Southwest Alaska Inventory and Monitoring Network. Natural Resource Report NPS/SWAN/NRR—2017/1443. National Park Service, Fort Collins, Colorado.

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

Bodkin, J.L., B.E. Ballachey, G.E. Esslinger, B.P. Weitzman, A.M. Burdin, L. Nichol and H.A. Coletti. 2017. A century of sea otter science and conservation in National Parks. X Sea Otter Conservation Workshop, 17-19 March 2017, Seattle Aquarium. Seattle WA. **Oral Presentation**.

Bodkin, J., H. Coletti, B. Ballachey, D. Monson, T. Dean, D. Esler, G. Esslinger, K. Iken, K. Kloecker, B. Konar, M. Lindeberg, and B. Weitzman. Detecting and inferring cause of change in Alaska nearshore marine ecosystem: An approach using sea otters as a component of the nearshore benthic food web. **Oral Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Coletti, H., D. Esler, B. Ballachey, J. Bodkin, T. Dean, G. Esslinger, K. Iken, K. Kloecker, B. Konar, M. Lindeberg, D. Monson, B. Robinson, and B. Weitzman. 2018. A decade's worth of data: Key metrics from a large-scale, trophic web based long term monitoring program in the northern Gulf of Alaska. **Poster Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Esler, D. 2017. Sea ducks as indicators of nearshore marine conditions. 6th International Sea Duck Conference, San Francisco. **Oral Presentation**.

Esler, D. 2017. Sea Duck Traits: Their Influence on Oil Spill Vulnerability and Restoration Potential. 6th International Sea Duck Conference, San Francisco. **Oral Presentation**.

Esslinger, G.G., H.A. Coletti, J.L. Bodkin, D.H. Monson, B.E. Ballachey, T.A. Dean, and D. Esler. 2017. Contrasting demography and behavior among sea otter populations in the northern Gulf of Alaska. Alaska Chapter of The Wildlife Society Annual Meeting, Fairbanks. **Oral Presentation**.

Esslinger, G.G., H.A. Coletti, J.L. Bodkin, D.H. Monson, B.E. Ballachey, T.A. Dean, and D. Esler. 2017. Trends and equilibrium density vary among sea otter populations in the northern Gulf of Alaska. Sea Otter Conservation Workshop, Seattle. **Oral Presentation**.

Iken, K. and B. Konar. 2018. Freezing in a warming climate? Poster Presentation the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Kloecker, K.A., D. H. Monson, B. Robinson, H. A. Coletti, B. E. Ballachey, and D. Esler. 2017. Correlates between sea otter diet and prey energetics in a mussel-specialist population. Sea Otter Conservation Workshop, Seattle. **Oral Presentation**.

Konar, B., K. Iken, H. Coletti, T. Dean, D. Esler, K. Kloecker, M. Lindeberg, B. Pister, and B. Weitzman. 2018. Trends in intertidal sea star abundance and diversity across the Gulf of Alaska: effects of sea star wasting. **Poster Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Martyn, P., D. Monson, H Coletti, A Miller and D Esler. Using Small Unmanned Aircraft Systems (sUAS) to map intertidal topography in Katmai National Park and Preserve, Alaska. **Poster Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Monson, D.H., B.P. Weitzman, K.A. Kloecker, D. Esler, L.A. Sztukowsi, S.A. Sethi, H.A. Coletti, and T. Hollmen. 2017. Understanding Trophic Relationships of Sea Otters and Their Effects on Demographic Attributes. Sea Otter Conservation Workshop, Seattle. **Oral Presentation**.

Monson, D., K. Holderied, R. Campbell, S. Danielson, R. Hopcroft, B. Ballachey, J. Bodkin, H. Coletti, T. Dean, K. Iken, K. Kloecker, B. Konar, M. Lindeberg, B. Robinson, B. Weitzman, and R. Suryan. 2018. Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; "The Blob" washes ashore. Poster Presentation the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018. **Poster Presentation.**

Piatt, J., T. Jones, K. Kuletz, H. Renner, J. Parish, R. Corcoran, S. Schoen, B. Bodenstein, R. Kaler, M. Garcia-Reyes, H. Coletti, M. Arimitsu, R. Duerr, K. Lindquist, J. Lindsey, and W.

Sydeman. Unprecedented Scale of Seabird Mortality in the NE Pacific During the 2015-2016 Marine Heatwave. **Oral Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Sethi, S., K. Iken, B. Konar, and H. Coletti. 2018. Regional and local drivers combine to structure mussel growth and mortality. **Poster Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Siegert, D., K. Iken, B. Konar, S. Saupe, and M. Lindeberg. 2018. Nearshore food web structure in two contrasting regions of Cook Inlet. **Poster Presentation** the Alaska Marine Science Symposium, Anchorage Alaska. January 21-25 2018.

Weitzman, B. 2017. Unhappy as a clam? **Article**. Delta Sound Connections. http://pwssc.org/wp-content/uploads/2017/06/DSC-2017-web2.pdf.

YouTube Video highlighting the common murre die-off. 2017. Cooperative efforts between NPS, USFWS, USGS and GWA. https://www.youtube.com/watch?v=Nhji4H5u65M

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

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Nearshore Component: Black oystercatcher nest density and chick diets from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2016 Data. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7WH2N5Q.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Nearshore Component: Monitoring Site Locations from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.5066/F78S4N3R.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Nearshore Component: Intertidal Mussel Site Data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2008-2015. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.5066/F7FN1498.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Nearshore Component: Intertidal Mussel Site Data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2016. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.5066/F7WS8RD4.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Intertidal Rocky Shore Limpet Size Data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7513WCB.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Intertidal Rocky Shore Nucella and Katharina counts from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7513WCB.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Intertidal Rocky Shore Invertebrate and Algae from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7513WCB.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Intertidal Rocky Shore Seastar counts from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7513WCB.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Marine Bird and Mammal Survey Data from Katmai National Park and Preserve and Kenai Fjords National Park, 2006-2015. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://dx.doi.org/10.5066/F7416V6H.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Benthic Component: Marine Water Quality, Water Temperature from Prince William Sound, Katmai National Park & Preserve, and Kenai Fjords National Park, 2006-2014. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7WH2N3T.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska, Benthic Monitoring Component: Sea otter Carcass Collection from Prince William Sound, Katmai National Park & Preserve, and Kenai Fjords National Park. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7WH2N3T.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska, Benthic Monitoring Component: Sea otter foraging observations from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2013. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7H993CZ.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Sea Otter Aerial Surveys in Katmai National Park and

Preserve 2008 and Kenai Fjords National Park 2007. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace.

Coletti, H. J. Bodkin, B. Ballachy, D. Monson, D. Esler, M. Lindeberg, T. Dean, B. Weitzman, K. Kloeker, G. Esslinger. 2017. Gulf Watch Alaska Nearshore Component: Black oystercatcher nest density and chick diets from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2016 Data. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. http://dx.doi.org/10.5066/F7CJ8BN7.

Iken, K. and B. Konar, 2017, Long-term Monitoring of Ecological Communities in Kachemak Bay, 2012-2016, Gulf Watch Alaska Nearshore Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.24431/rw1k1o.

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

Below is a list of the required data to be posted to the workspace and status. All posted data have appropriate metadata and have also been uploaded to the Research Workspace.

-Black oystercatcher for the KATM, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2591589/bloy

-HOBO temperature data for the KATM, KBAY, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2617326/hobo

-Marine bird and mammal survey data for the KATM and KEFJ regions: https://workspace.aoos.org/project/4650/folder/2591593/mbm

-Mussel site data for the KATM, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2765217/mussel

-Rocky intertidal community data (including percent cover, sea star counts, invertebrate counts and substrate) for the KATM, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2591591/rocky

-Sea otter forage data for the KATM, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2591590/seot

-Mixed-sediment (soft) data for the KATM, KBAY, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2591592/soft

-Sea otter spraint data for the KATM, KEFJ and WPWS regions: https://workspace.aoos.org/project/4650/folder/2769975/spraint

For the KBAY region specifically, the following final data sets with appropriate metadata have been uploaded as csv files to the Research Workspace:

-Mussel size-frequency distribution for six sites in 2017: KB2017_Mytilus_SFD.cvs: https://workspace.aoos.org/project/4653/folder/2762861/mussel-data

-Rocky intertidal community data: KB2017_percentcover_RockyIntertidal_data.csv: https://workspace.aoos.org/project/4653/folder/2762860/rocky-intertidal-community-data

-Rocky intertidal swath data: KB2017_rockyintertidal_swath_counts.csv: https://workspace.aoos.org/project/4653/folder/2762911/rocky-intertidal-swath-data

-Rocky intertidal substrate data: KB2017_substrate_percentcover.csv: https://workspace.aoos.org/project/4653/folder/2762910/rocky-intertidal-substrate-data

-Seagrass shoot count data: KB2017_Zostera_shootdensity.csv: https://workspace.aoos.org/project/4653/folder/2762912/seagrass-data

The following datasets are pending but will be posted to the AOOS workspace by March 1, 2018.

-Sea otter aerial survey data for WPWS

-Sea otter carcass data for KATM, KEFJ and WPWS

-Eelgrass percent cover data for KATM, KEFJ and WPWS

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comments and Responses on Revised FY17-21 Proposal, September 2016

In September 2016, the Science Panel commented: The Panel wished to draw attention of the PIs to similar recent declines in mussels in the Gulf of Maine in the Atlantic. No action is required by the PIs, but they might find parallel research on a similar problem interesting. A paper by Sorte et al. in Global Change Biology would be once place to look: Sorte, C. J. B., Davidson, V. E., Franklin, M. C., Benes, K. M., Doellman, M. M., Etter, R. J., Hannigan, R. E., Lubchenco, J. and Menge, B. A. (2016), Long-term declines in an intertidal foundation species parallel shifts in community composition. Glob Change Biol. doi:10.1111/gcb.13425

PI Response: Thank you for the reference.

Science Panel Comments and Responses on FY18 Work Plans, September 2017

In September 2017, the Science Panel commented: The Panel appreciates the amount of data being collected on multiple nearshore sites. There is not a clear integration with oceanographic studies, but there is enough substance to make this a meaningful, stand- alone nearshore ecosystem project. The Panel is very pleased with their productivity and integration of students into the studies.

The Panel would like to see more of the synoptic surveys, what they are finding or not finding temporally and on a spatial scale. A question from the Panel for the PIs to ponder: Have egg-eating seabirds/waterfowl changed their distribution in regards to location in time and space to herring spawning?

PI Response: The nearshore component greatly appreciates the Science Panel's support of our progress towards an integrated nearshore program. There have been recent discussions to use oceanographic data, initially temperature, across all components to examine linkages between offshore and nearshore systems. We anticipate that analyses of temperature data will be our first step in integrating other oceanographic processes to pelagic and coastal systems for the GWA program.

Several PIs in the nearshore program did publish a paper in Ecosphere (http://onlinelibrary.wiley.com/doi/10.1002/ecs2.1489/full) that examined temporal trends in sea otter abundance, energy recovery rates, and demographics at varying spatial scales. However, based on the design of the nearshore component, an exercise examining trends across space and time could be done for a variety of species. We are meeting as a component prior to the PI meeting in November to examine data trends to date and develop product ideas for the next 1-3 years within the nearshore component. Specific to the Science Panel's question about changing seabird/waterfowl distribution, we have set aside time for cross-component bird data integration and synthesis discussions at the PI meeting in November. All parties will have data summaries to discuss and determine how we may be able to look at trends over time, and changes in distribution, and integration with data from other components, including environmental drivers.

11. Budget:

Please see provided program workbook.

The University of Alaska Fairbanks portion of the budget is underspent because of salaries and services not yet rendered. An unscheduled family trip by one PI resulted in the stable isotope analysis getting behind schedule and the inability for the PI to attend the November 2017 PI meeting. We anticipate services and salary to be fully spent in subsequent years.