EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY21 (YEAR 10) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Nearshore Component Project

21120114-H—Nearshore ecosystems in the Gulf of Alaska

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Date Proposal Submitted

August 14, 2020

Project Abstract

Nearshore monitoring in the Gulf of Alaska (GOA) provides ongoing evaluation of status and trends of more than 200 species, including many of those injured by the 1989 *Exxon Valdez* oil spill. The monitoring design includes spatial, temporal and ecological features that support inference regarding drivers of change. Continued monitoring will lead to a better understanding of variation in the nearshore ecosystem across the GOA and a more thorough evaluation of the status of spill-injured resources. This information has been used in a number of management contexts and will be critical for anticipating and responding to ongoing and future perturbations in the region, as well as providing for global contrasts. In FY21, we propose to continue sampling 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. Monitoring metrics include marine invertebrates, macroalgae, birds, mammals, and physical parameters such as temperature. In addition to taxon-specific metrics, monitoring includes recognized important ecological relations such as predator-prey dynamics, measures of nearshore ecosystem productivity, and contamination. In FY20, due to the COVID-19 global pandemic, normal field operations were significantly reduced. Minimal sampling was conducted in KEFJ and WPWS, while none was completed in KATM. Most intertidal work was completed in KBAY, but upper trophic level surveys were significantly reduced there. We anticipate normal proposed field operations for FY21. Due to the reduction in field costs in FY20, we are proposing to use some of those funds to support a graduate student at UAF to examine variation in carbon sourcing to nearshore consumers across all four nearshore component regions, using samples collected in recent years, which will contribute to interpretation of monitoring data.

EVOSTC Funding Requested* *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$401,900	$452,700	$411,400	$426,100	$426,200	$2,118,600

Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)

FY17	FY18	FY19	FY20	FY21	TOTAL
$410,000	$410,000	$410,000	$389,600	$513,200	$2,132,800

1. PROJECT EXECUTIVE SUMMARY

Nearshore marine ecosystems face significant challenges at global and regional scales, with threats arising from both the adjacent lands and oceans. An example of such threats was the 1989 grounding of the T/V *Exxon Valdez* in Prince William Sound (PWS). An important lesson arising from this event, as well as similar events around the world, was that understanding the structure and function of the ecosystem and the processes that drive it are essential when responding to and managing present and anticipated threats.

The nearshore is broadly recognized as highly susceptible and sensitive to natural and human disturbances on a variety of temporal and spatial scales (reviewed in Valiela 2006, Bennett et al. 2006, Dean and Bodkin 2006, Dean et al. 2014). For example, changes in nearshore systems have been attributed to such diverse causes as global climate change (e.g., Barry et al. 1995, Sagarin et al. 1999, Hawkins et al. 2008, Hoegh-Guldberg and Bruno 2010, Doney et al. 2012), earthquakes (e.g., Baxter 1971, Noda et al. 2015), oil spills (e.g., Peterson 2001, Peterson et al. 2003, Bodkin et al. 2014), human disturbance and removals (e.g., Schiel and Taylor 1999, Crain et al. 2009, Fenberg and Roy 2012), disease (e.g., Menge et al. 2016, 2019; Burt et al. 2018), and influences of invasive species (e.g., Jamieson et al. 1998, O'Connor 2014). Nearshore systems are especially good indicators of change because organisms in the nearshore are relatively sedentary, accessible, and manipulable (e.g., Dayton 1971, Sousa 1979, Peterson 1993, Lewis 1996). In contrast to other marine habitats, there is a comparatively thorough understanding of mechanistic links between species and their environment (e.g., Connell 1972, Paine 1974, 1977; Estes et al. 1998; Menge and Menge 2013; Menge et al. 2015) that facilitates understanding causes for change. Many of the organisms in the nearshore are sessile or have relatively limited home ranges, providing a geographic link to sources of change. Nearshore habitats likely will have meaningful changes in the future, and we will be able to detect relatively localized sources of change, assess human induced vs. naturally induced changes, and provide suggestions for management of human impacts.

The Nearshore Component of the Gulf Watch Alaska (GWA) long-term monitoring project investigates and monitors the nearshore environment of the greater *Exxon Valdez* oil spill (EVOS) area, with focus on selected elements of the nearshore food web (Fig. 1). Our overarching goal is to understand drivers of variation in the Gulf of Alaska (GOA) nearshore ecosystem. The foundational questions of the Nearshore Project include: (1) What are the spatial and temporal scales over which change in nearshore ecosystems is observed? (2) Are observed changes related to broad-scale environmental variation, local perturbations, or underlying ecological processes? (3) Does the magnitude and timing of changes in nearshore ecosystems correspond to those measured in pelagic ecosystems? The design features of the nearshore monitoring project include rigorous site selection procedures that allow statistical inference over various spatial scales (e.g., GOA and regions within the GOA) as well as the capacity to evaluate potential impacts from more localized sources, especially those resulting from human activities, including lingering effects of EVOS (Fig. 2). In addition to detecting change at various spatial scales, design features incorporate both static (e.g., substrate, exposure, and bathymetry) and dynamic (e.g., variation in oceanographic conditions, productivity, and predation) drivers as potential mechanisms responsible for change. More than 200 species dependent on nearshore habitats, many with well-recognized ecological roles in the nearshore food web, are monitored annually within four regional blocks in the GOA. Evaluation of those species over time in relation to well-defined static and dynamic drivers will allow accurate and defensible measures of change and support management and policy needs addressing nearshore resources both within the GOA and globally.

Figure 1. Conceptual illustration of the nearshore food web with terrestrial and oceanic influences indicated. Sea otters, black oystercatchers, sea ducks, and sea stars act as the top-level consumers in a system where primary productivity originates mostly from the macroalgae and sea grass and moves through benthic invertebrates to the top-level consumers.

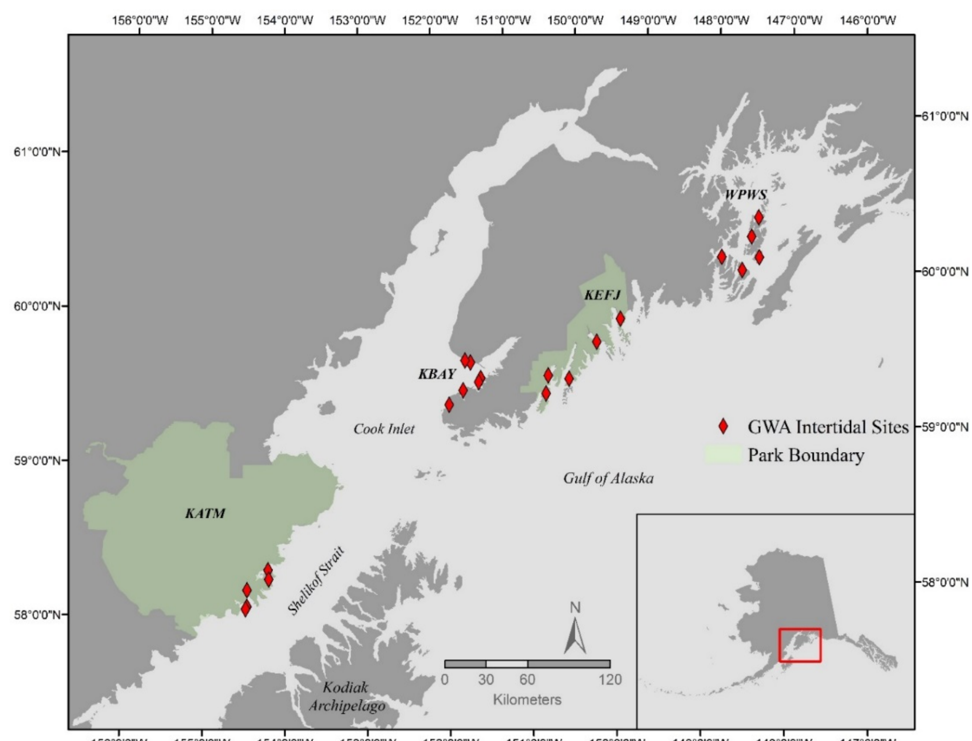

Figure 2. Map showing study sites within Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS). The red diamonds represent rocky intertidal sites that act as a central point to established monitoring sites or transects of several other marine nearshore metrics.

In following our scheduled monitoring plan for GWA and to promote consistent sampling across all regions, we added upper-trophic level sampling components to Kachemak Bay (KBAY) in 2018 and continued that in 2019. **However, in 2020, due to COVID-19, our scheduled field work was drastically reduced and, in some cases, cancelled.** All summer sampling and winter (March) marine bird and mammal surveys slated to be completed in KATM in 2020 were cancelled. WPWS spring beach walks used to collect sea otter carcasses for age-at-death estimates were cancelled. In KBAY, we were able to conduct most intertidal surveys (including sea star surveys and intertidal temperature logger retrieval and deployments), black oystercatcher surveys, and some sea otter observations. Intertidal temperature loggers were swapped out, photos taken, and sea star surveys completed at two sites in KEFJ and across all WPWS sites. We were also able to photo document all mussel sites in WPWS. Black oystercatcher surveys were conducted at 2 of 5 sites in KEFJ, 4 of 4 sites in WPWS, and 4 of 4 sites in KBAY.

Here we present some highlights of recent findings (see also FY19 Annual Report). These include: (1) trends submitted to the 2019 National Oceanic and Atmospheric Administration (NOAA) Ecosystems Status Report for the GOA; (2) black oystercatcher chick diet variation over space and time; (3) sea otter variation in diet over space and time; (4) an overview of contaminants work completed in partnership with NOAA's Mussel Watch Program and (5) an update to the black oystercatcher migration study that the GWA nearshore component has been conducting in partnership with Simon Fraser University.

1. *NOAA Ecosystems Status Report*

Intertidal Water Temperatures

Nearshore water temperature trends in all four intertidal zones from PWS to the Alaska Peninsula show warming beginning in 2014 (Fig. 3), corresponding to the large marine heatwave phenomenon ("the Blob") detected by more pelagic sensors (Danielson et al. 2019). Our data confirm that the physical manifestations of this large-scale oceanographic event were expressed in nearshore ecosystems. A science synthesis paper has been prepared in collaboration with the Environmental Drivers component of GWA evaluating coherence of water temperatures across the central GOA, including how Gulf-scale temperature trends measured in the pelagic realm manifest in nearshore waters (Danielson et al. 2019).

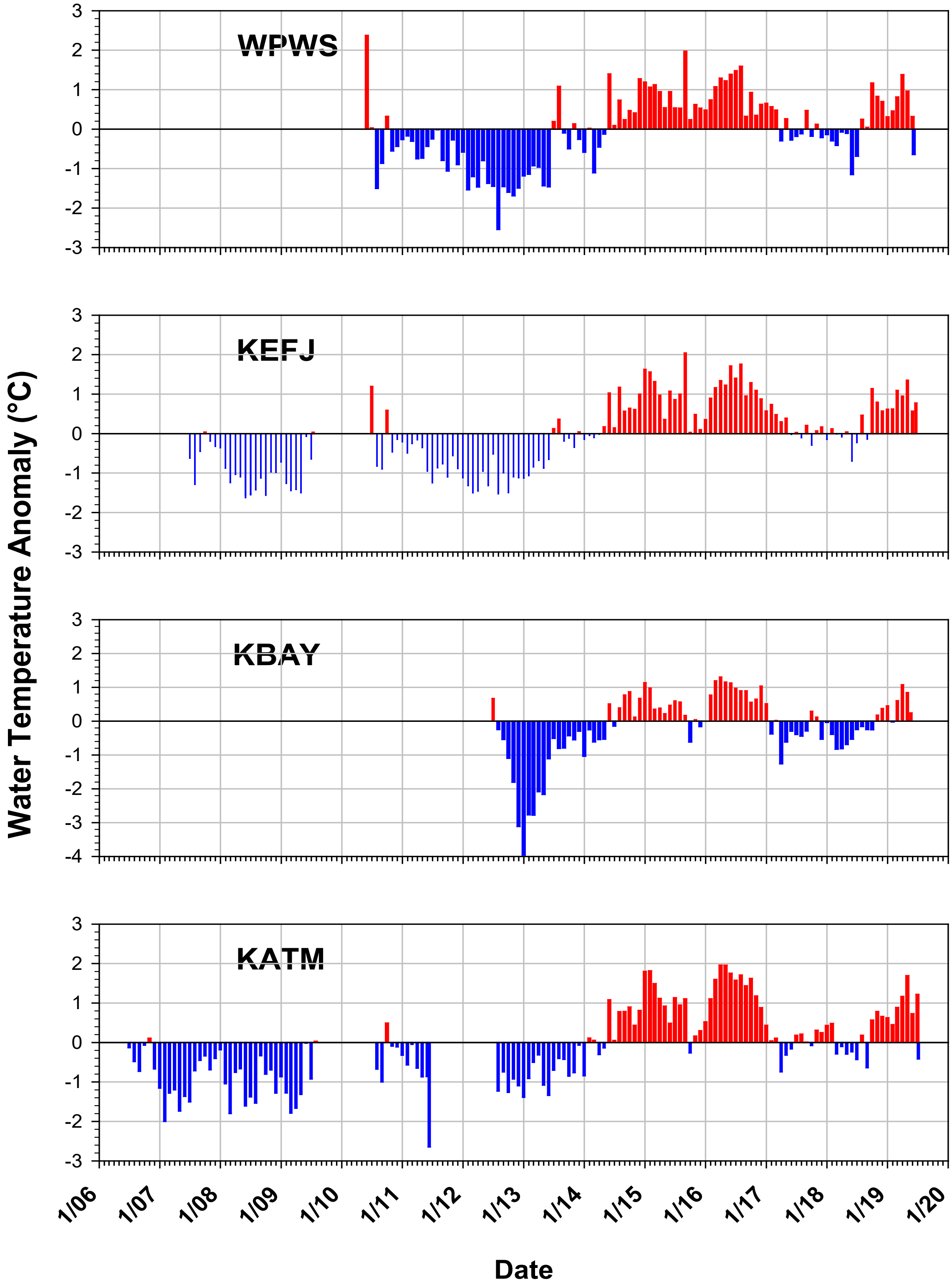

Figure 3. Intertidal temperature anomalies at the 0.5 m tide level four regions of the western Gulf of Alaska (west of 144°W), western Prince William Sound (WPWS; 2011-2019), Kenai Fjords National Park (KEFJ; 2008-2019), Kachemak Bay (KBAY; 2013-2019), and Katmai National Park and Preserve (KATM; 2006-2019).

Algal Cover

We used percent cover of the perennial intertidal, dominant alga rockweed (*Fucus distichus*) as a metric of trends in a primary producer (Fig. 4). Since the onset of the marine heatwave in 2014, we have quantified generally negative anomalies, although results in 2019 are trending back towards average conditions. *F. distichus* is known to cycle in abundance at local scales; the broad, consistent patterns in our data suggest that a large-scale phenomenon, presumably the marine heatwave, was acting on this metric at the scale of the northern Gulf of Alaska. Variation in *F. distichus* abundance is included as part of a science synthesis paper (Weitzman et al. 2019) evaluating intertidal community responses to the marine heatwave.

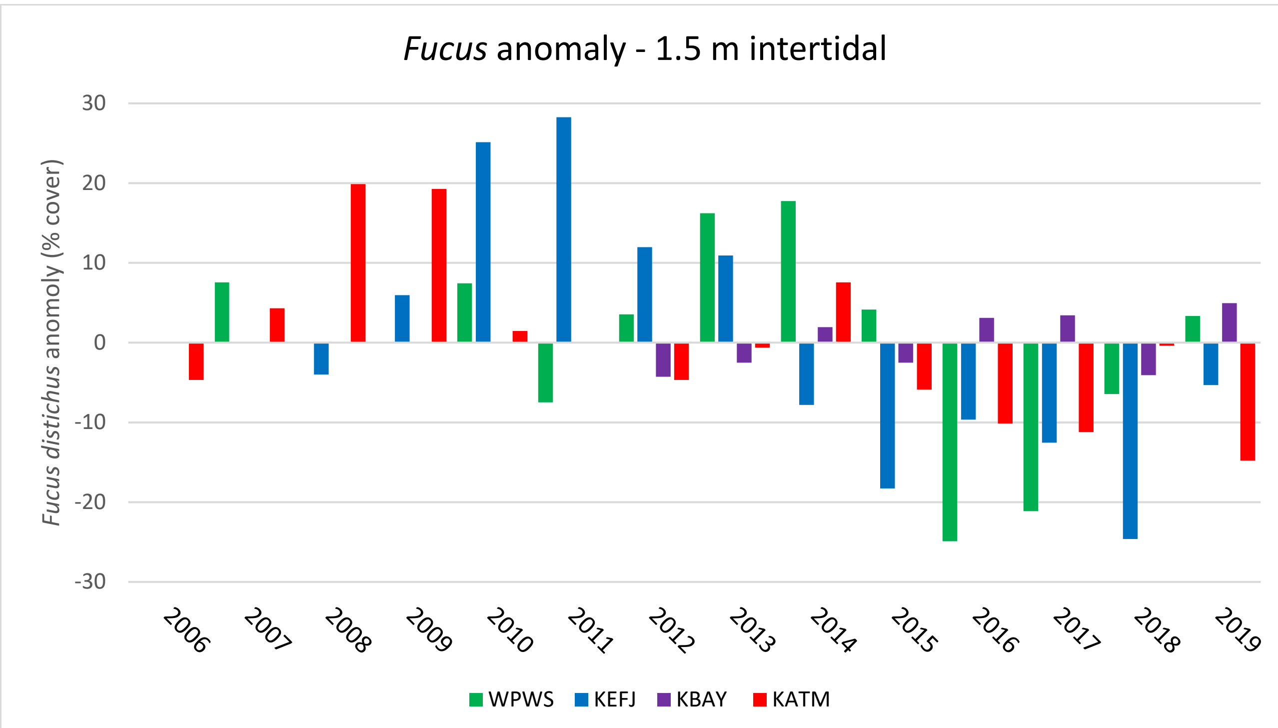

Figure 4. Percent cover anomalies for rockweed (*Fucus distichus*) in four regions of the western Gulf of Alaska, western Prince William Sound (WPWS; 2007, 2010-2019), Kenai Fjords National Park (KEFJ; 2008-2019), Kachemak Bay (KBAY; 2012-2019), and Katmai National Park and Preserve (KATM; 2006-2010, 2012-2019).

Mussel Density

We present trends in abundance of the mussel *Mytilus trossulus,* a ubiquitous invertebrate filter feeder, as a common nearshore prey species that transfers primary production to higher trophic levels, including various sea stars. Densities of large mussels (≥ 20 mm, Fig. 5) show a strong trend across all regions consistent with timing of the marine heatwave, but in this case switching from generally negative to positive anomalies – an opposite response compared to *F. distichus* and sea stars (Figs. 4 and 6). Variation in mussel abundance through 2017 was described in detail in a recent paper (Bodkin et al. 2018) and percent cover data up to the present are included as part of a science synthesis paper evaluating intertidal community responses to the marine heatwave (Weitzman et al. 2019).

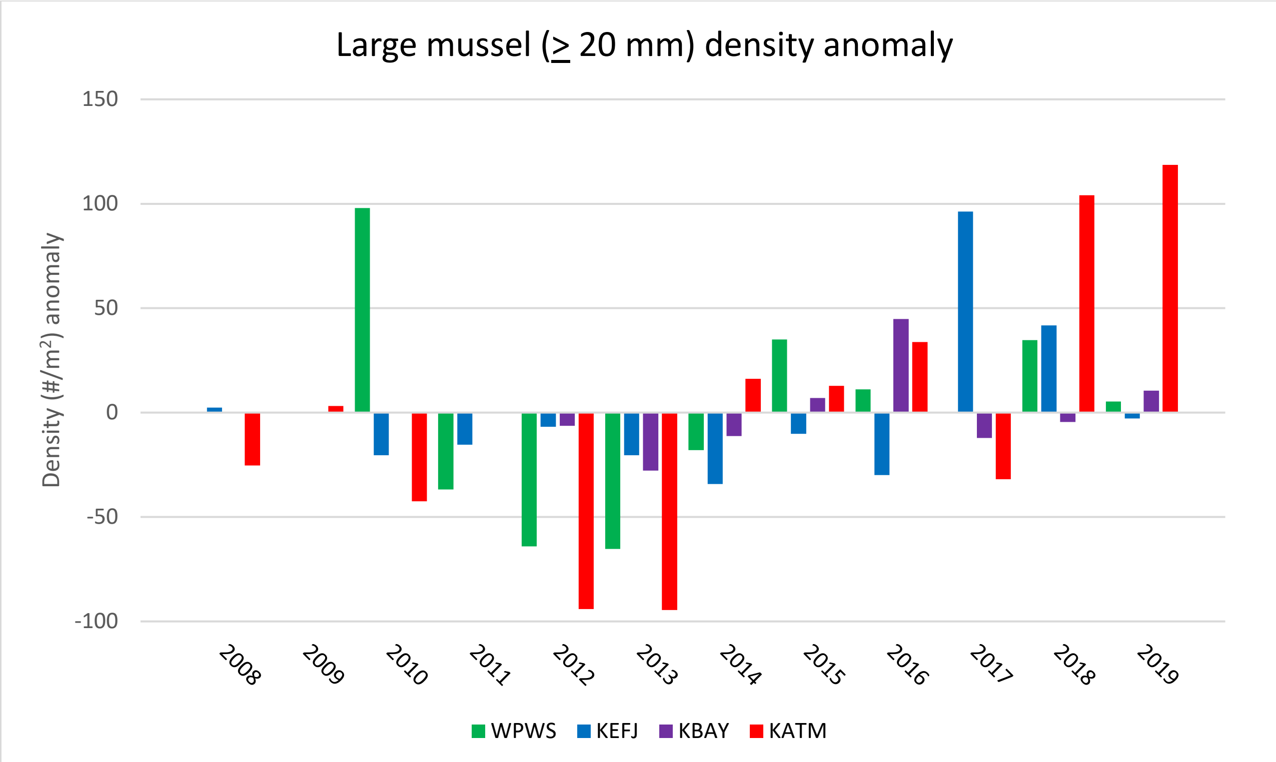

Figure 5. Density anomalies for large mussels (> 20 mm) in four study regions spanning the northern Gulf of Alaska, western Prince William Sound (WPWS; 2010-2019), Kenai Fjords National Park (KEFJ; 2008-2019), Kachemak Bay (KBAY; 2012-2019), and Katmai National park and Preserve (KATM; 2008-2010, 2012-2019).

Sea Star Abundance

As an important predator in structuring nearshore communities (including mussel populations), we present trends in sea star abundance. Sea star abundance varied greatly among regions through 2015 (Fig. 6). However, in 2016, abundance of all species combined began to decline due to the sea star wasting disease epidemic and remained strongly negative across all regions during the marine heatwave, with trends towards potential recovery evident in 2019. These findings are described in detail in a recent paper (Konar et al. 2019). In 2020, the sea stars thought to be unaffected by sea star wasting disease in the northern GOA (primarily *Henricia* and *Dermasterias*) continue to have low but stable abundances at many of our sites. The once more dominant sea stars (primarily *Pycnopodia, Evasterias*, and *Pisaster*) continue to be absent (or rare) from many of the GWA sites, although one site in PWS showed some recovery potential with many small *Pycnopodia*.

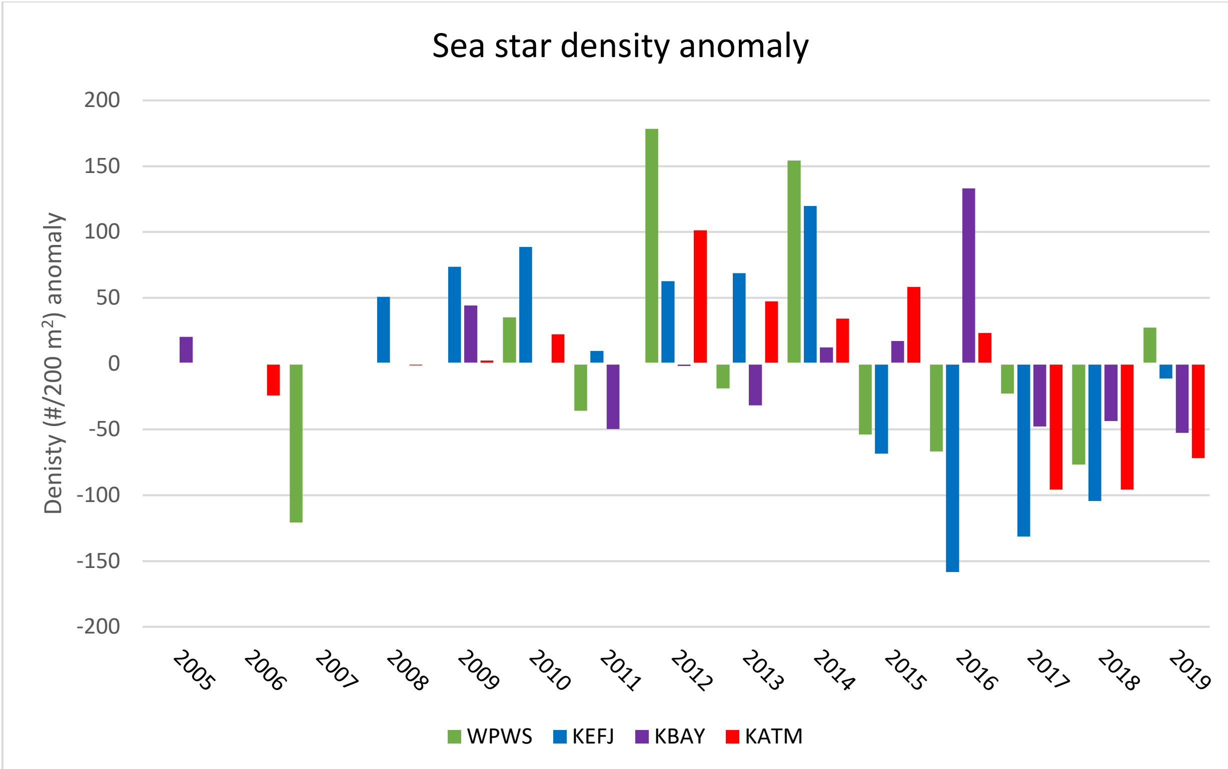

Figure 6. Density of sea stars (*Dermasterias imbricata*, *Evasterias troschelii*, *Pisaster ochraceus*, and *Pycnopodia helianthoides*) in four study areas spanning the northern Gulf of Alaska, western Prince William Sound (WPWS; 2007, 2010-2019), Kenai Fjords National Park (KEFJ; 2008-2019), Kachemak Bay (KBAY; 2005, 2009, 2011-2019), and Katmai National Park and Preserve (KATM; 2006, 2008-2010, 2012-2019).

Inter-specific Interactions and Interpretation of NOAA Ecosystem Status Metrics

The negative anomalies of rockweed and sea stars are coincident with warm water temperatures in nearshore areas, although very different mechanisms likely are driving observed patterns. *F. distichus* declines likely are due to direct effects of warming temperatures on survival or recruitment. The decline in sea star abundance likely was due to sea star wasting disease (Hewson et al. 2014), which was first detected in the study region in 2014 (Konar et al. 2019) and is likely exacerbated by higher-than-average water temperature (Bates et al. 2009, Eisenlord et al. 2016). Positive anomalies during 2015-2019 for large mussels are consistent with a response to reduced predation pressure precipitated by the decline of sea stars. Sea stars are known to have strong top-down effects on intertidal communities, including mussels specifically (Paine 1974), so this inter-specific interaction is a plausible explanation for observed patterns. Further, we speculate that other nearshore predators, including sea otters, sea ducks, and black oystercatchers, may benefit from increased abundance of large mussels when sea stars decline.

Intertidal and nearshore ecosystems provide valuable habitat for early life stages of commercially, ecologically and culturally important species in the GOA. These time series presented above illustrate various factors that contribute to change in the species composition of nearshore ecosystems, the abundance of dominant taxa and underlying processes. Trends in these indicators suggest that some nearshore biological responses to the recent heatwave appear to continue, in some cases into 2019, and could affect future recruitment and survival of species whose early life stages rely on nearshore habitat. With the warm water anomalies continuing in to 2019 (see Fig. 3), we also expect to see responses of nearshore-reliant species to shifts in prey availability across the Gulf of Alaska from changing ocean conditions.

2. Black Oystercatcher Spatio-Temporal Variation in Diet

Upper trophic-level predators can be useful indicators of ecosystem status (Estes 1996, Croll et al. 2005). In nearshore marine ecosystems, black oystercatcher chick diets, which are comprised of intertidal macroinvertebrates, may reflect prey community composition, which varies on both spatial and temporal scales. Because of their reliance on the nearshore and susceptibility to change that occurs there, black oystercatchers have been monitored by the Southwest Alaska National Park Service (NPS) Inventory and Monitoring and GWA Nearshore programs since 2006. We examined spatial and temporal patterns of variation in the diet of black oystercatcher chicks in the northern GOA.

We collected 23,171 prey items delivered by parents to chicks at 193 nests, representing 30 taxa identified to the genus or species level. Diet was dominated by three species of limpets (*Lottia pelta, L. persona, L. scutum*), that cumulatively made up 67 % of prey by number, followed by Pacific blue mussels (*Mytilus trossulus*; 22 %), and black katy chitons (*Katharina tunicata*; 5 %). Diet composition did not vary by year or among regions, which were three broad areas in the northern GOA (WPWS, KEFJ and KATM) (Fig. 7). However, diet did vary significantly among sites (bay-level areas within regions). Proportions of limpets and mussels in the diet at sites ranged from 56 ± 4.7 % (mean ± SE) to 88 ± 1.3 % and 2.5 ± 1.3 % to 32 ± 4.3 %, respectively. Overall, these findings suggest that while diet has been relatively consistent over time and among regions, local variation at the site level influences patterns of prey composition in black oystercatcher populations. Black oystercatcher surveys were implemented in KBAY in 2018, therefore with only two years of data from that region, results are not included here.

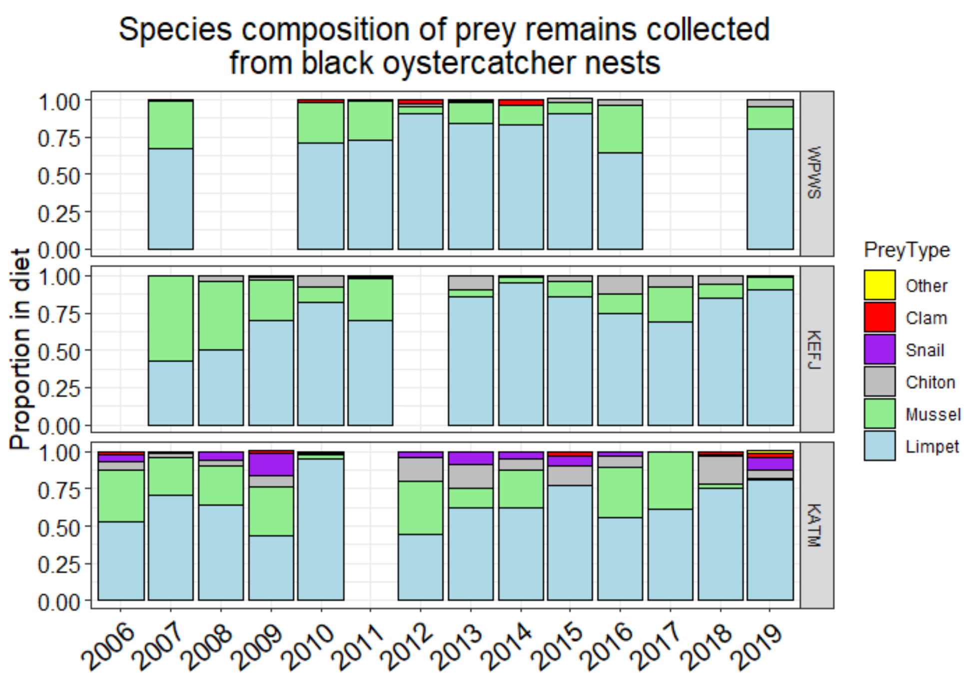

Figure 7. Composition of prey items delivered by Black Oystercatcher parents to chicks in three study areas spanning the northern Gulf of Alaska, 2006-2019.

3. Sea Otter Spatio-Temporal Variation in Diet

Sea otters can dramatically affect the structure and complexity of their nearshore ecological community. They cause well described top-down cascading effects on community structure by altering abundance of prey (e.g., sea urchins), which can in turn alter abundance of lower trophic levels (e.g., kelps) (Estes and Palmisano 1974, Estes and Duggins 1995, Konar and Estes 2003, Estes 2015). As a keystone species (Estes and Duggins 1995), sea otters have been monitored by the Southwest Alaska NPS Inventory and Monitoring and GWA Nearshore programs since 2006 (Dean et al. 2014). Sea otter metrics include 1) carcass recovery to evaluate mortality, 2) aerial surveys to estimate abundance, and 3) foraging behavior and spraint observations, which provide insight into the diet of sea otters. Here we present preliminary analysis of prey composition for foraging observations collected on sea otters across all four regions beginning in 2003 (WPWS) through 2018 (all regions). To provide context as to possible drivers of prey composition differences across space and time, the Nearshore component independently measures prey resources of the sea otter in the intertidal, including sampling of clams, mussels, and other invertebrates. Patterns in prey composition and clam density and biomass are presented here, and mussel abundance in Fig. 5.

In contrast to the black oystercatcher, variation by region is evident in the proportion of prey types in the diet of sea otters (Fig. 8). The sea otter diet at KEFJ continues to be dominated by mussels, while in contrast, KATM continues to be dominated by clams with a diversity of other prey. WPWS appears to have shifted recently from a diet primarily of clams to one higher in mussels in 2018. KBAY foraging observations were initiated in 2017 and suggest a relatively high proportion of mussel consumption. Coinciding with increases in mussel consumption, we have documented an increase in large (≥20 mm) mussels across the study areas (Coletti et al. 2019, see Figure 3 of this report). It should be noted that sea otter foraging data have been analyzed through 2018, 2019 is pending analysis.

Clam densities and biomass varied by regions over time, with KATM and KBAY tending to have higher clam densities and biomass than KEFJ or WPWS (Fig. 9). To account for the higher biomass but similar density, data suggest that clams at KBAY are larger relative to KATM and the other regions (all clams were measured at the time of collection; these data are being processed and will confirm any differences among regional sizes of clams). From 2017 to 2019 there was an increase in the density and biomass of clams at all regions, though especially so in KATM. A student project is relating annual clam recruitment in cores to the subsequent standing stock of clams at those same beaches. Preliminary results suggest that recruitment cores may predict adult standing stock (Zhang et al. 2020 poster presentation). By 2021, we will have 5 years of complementary quadrat and core data allowing us to evaluate potential relations between recruitment of juveniles and adult clam populations.

In summary, preliminary analysis of the diet and prey data streams indicates the abundance of clams measured in the intertidal may not necessarily correlate to the proportion of clams in the sea otters' diet. We do see some response in the otters' diet to increased mussel abundance consistent with recovery of mussel populations across the GOA after 2013. Clearly, a variety of factors can influence relations between predator and prey, including abundance, availability, quality and preference. The ability of nearshore monitoring data to inform resource management will continue to benefit from explicit design features incorporating these complex relations.

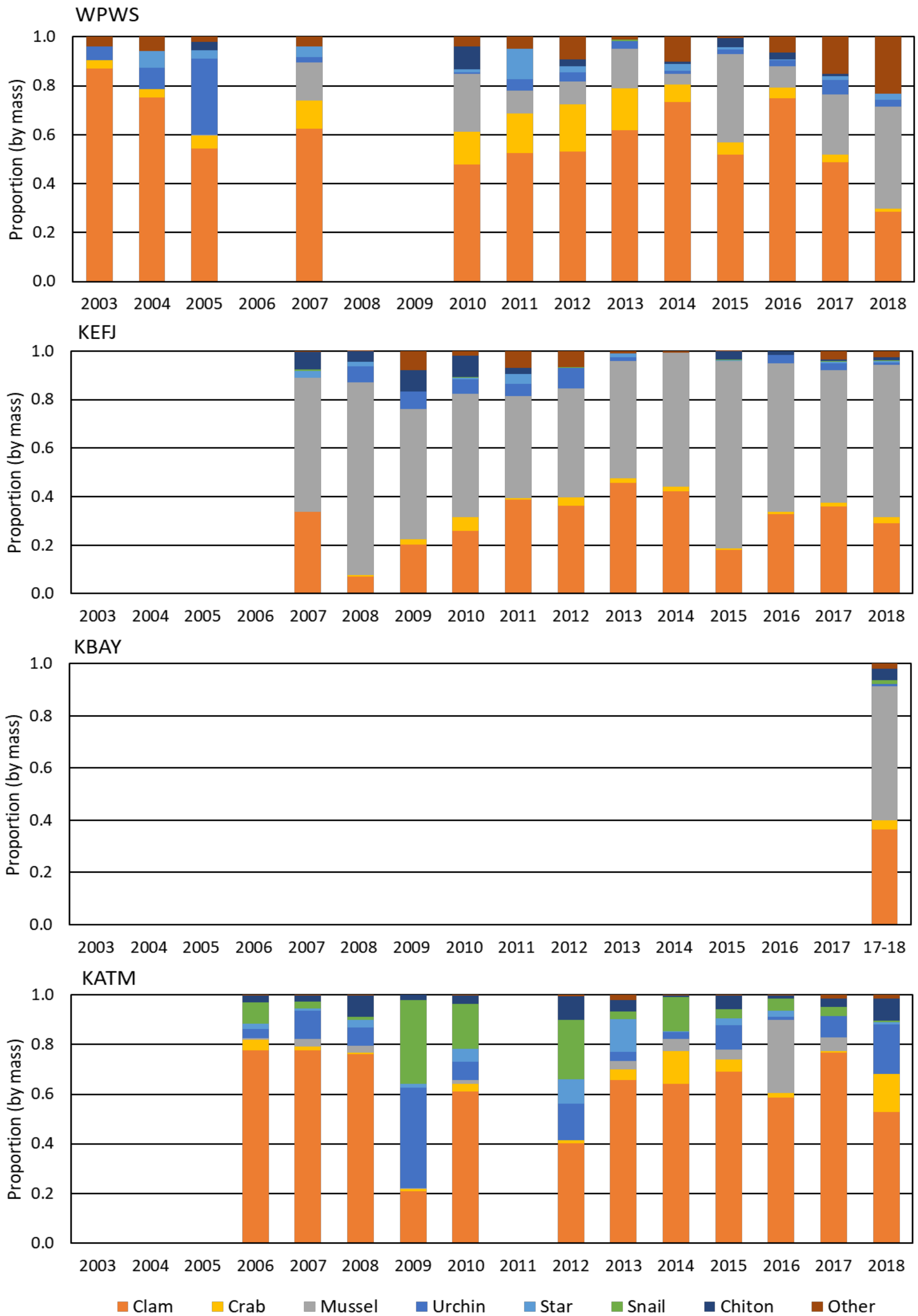

Figure 8. Sea otter prey proportions by region: western Prince William Sound (WPWS; 2003-2005, 2007, 2010-2018), Kenai Fjords National Park (KEFJ; 2007-2018), Kachemak Bay (KBAY; 2017-2018 – combined due to low sample size in 2017), and Katmai National Park and Preserve (KATM; 2006-2010, 2012-2018).

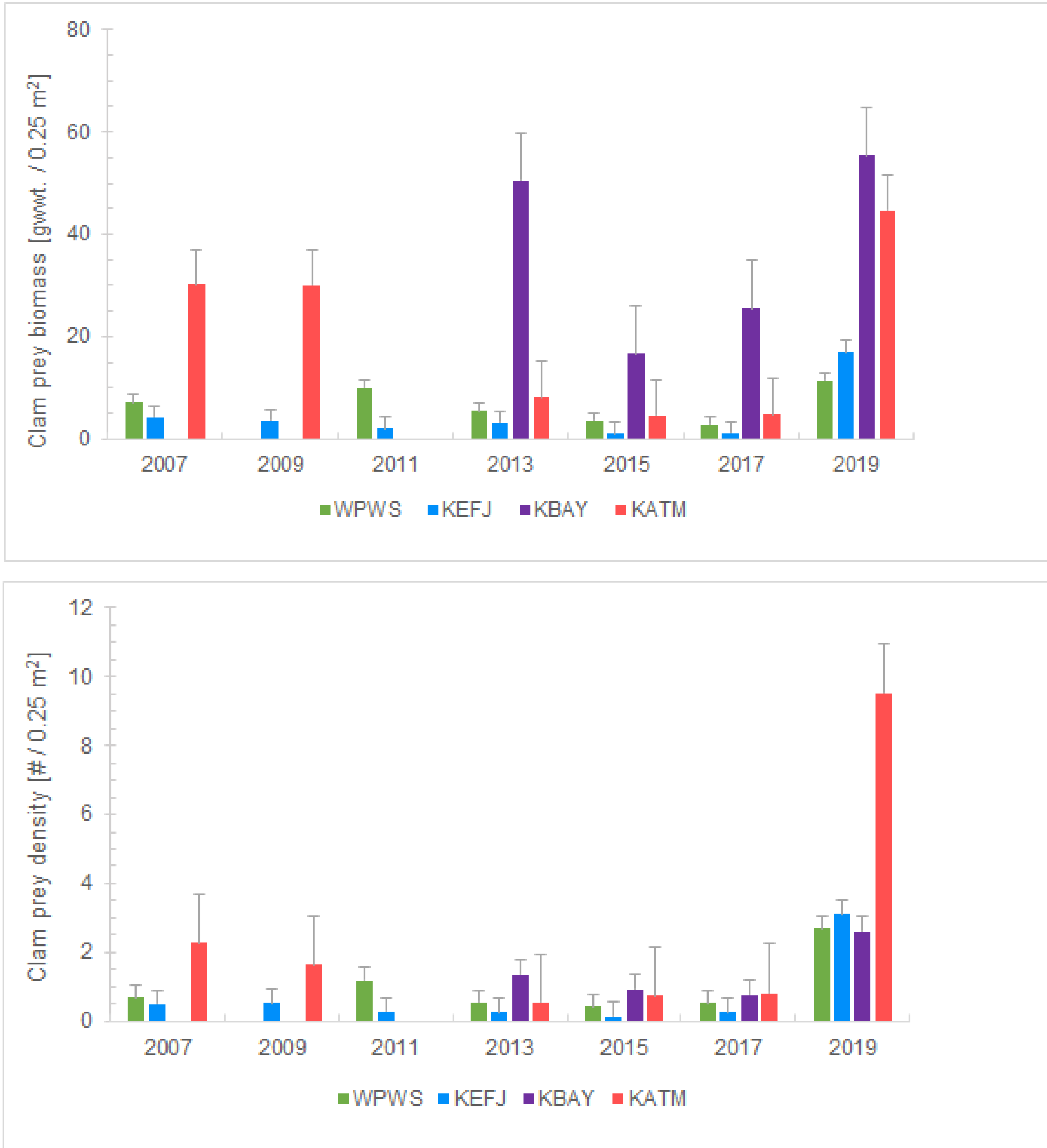

Figure 9. Mean ± 1 SE clam biomass (grams of wet weight per quarter m^2 of edible tissue; upper panel) and density (number of individuals per quarter m^2; lower panel) by region: western Prince William Sound (WPWS), Kenai Fjords National Park (KEFJ), Kachemak Bay (KBAY), and Katmai National Park and Preserve (KATM).

4. Contaminants in Mussel Tissue

In 2018, we collected mussels for analysis of a broad suite of contaminants across all four regions. This work is not conducted annually but rather is slated to occur every 8 years unless a contaminant-specific issue emerges. In 2019, we received results from the laboratory analysis conducted by NOAA; we note that these analyses were conducted following protocols for the Mussel Watch program, ensuring comparability to other times and places. In fact, results from these analyses are being combined with those from other locations in the northern GOA in a report to be published this year (Rider et al. 2020). Preliminary results indicate that there are no contaminants concerns at this time within our study areas consistent with findings from the lingering oil project 16120114-S that oil remains sequestered.

5. Black Oystercatcher Migration Study

The time series of marine bird and mammal survey data generated by the GWA nearshore component reveal important patterns within individual species. For example, black oystercatcher densities show different seasonal patterns in KATM and KEFJ. In KATM, black oystercatchers occur at similar densities during summer and winter, suggesting that either KATM breeders are non-migratory or that different individuals move into KATM post-breeding. In contrast, black oystercatchers in KEFJ occur regularly during the breeding season but are absent, or nearly so, during winter, indicating that breeders there migrate elsewhere post-breeding. These contrasting patterns have been useful for a tag-on project initiated in FY19 in collaboration with Simon Fraser University. This work is using geolocator and GPS tags to understand links between black oystercatcher breeding in all four nearshore regions (KBAY, KATM, KEFJ, and WPWS) and their subsequent wintering areas. This study will help determine why some individuals migrate and others are resident, as well as the individual and environmental factors that influence different strategies. Although the field work planned for FY20 was affected by COVID-19, we did conduct some activities. In WPWS, KEFJ, and KBAY we recaptured some of the individuals that were marked last summer and removed the attached instruments, which is necessary to download data and determine annual cycle movements. We also deployed new GPS tags on several black oystercatchers, which will add high-resolution data for addressing movements and migration strategies. This project will continue in FY21, with the intent of recapturing individuals marked in 2019 and 2020 and deploying additional instruments.

Goals for FY21

Our FY21 goals for the nearshore long-term monitoring program are to continue to document status of the nearshore system by continuing time series, some of which span more than five decades, and many that were initiated soon after the 1989 spill. This information will be synthesized with other components of GWA to identify potential causes of change, including those related to EVOS. We will continue to use existing and new information to address our overarching questions and to communicate findings to the public, resource managers, and communities across the GOA. We are not proposing any major changes to project field activities for FY21. However, residual funds from FY20 that will be carried over into FY21 (due to cancelled or scaled back field operations in FY20) and will be used to support a graduate student (MSc) at the University of Alaska Fairbanks (UAF) starting in January of 2021. The focus of the student's thesis will be to examine variation in the sources of carbon (phytoplankton vs. macroalgae) to nearshore lower and mid-level trophic consumers and how that variation may manifest itself in organismal responses (for example: growth rates). This information will provide important understanding of the drivers of annual changes that we detect during annual monitoring. Other in-kind funding will be provided to support the project and student from NPS and UAF. The redirection of GWA funds and additional in-kind funding are captured in the budget for FY21. Also, through support from GWA, US Geological Survey (USGS) hired a post doc in June 2020, Sarah Traiger. Sarah will play an important role in FY21, leading efforts to synthesize data collected throughout the GWA components, making the most out of the wealth of data that have been collected over the course of the program. An initial project will involve examining responses of lower trophic level species to loss of sea stars associated with the Pacific marine heatwave and sea star wasting disease. Additional synthesis projects will be developed as Sarah evaluates the available data and coordinates with GWA principal investigators (PIs) and partner agencies about important and interesting relationships that can be investigated.

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 1. This table breaks down project deliverables and their status into milestones and task progress by fiscal year and quarter, beginning February 1, 2017. Additional FY21 milestones and/or tasks have been added in red. C = completed, X = planned or not completed, V = cancelled due to COVID-19, P = partially completed, due to constraints of COVID-19. Fiscal year quarters: 1 = Feb 1 – April 30; 2 = May 1 – July 31; 3 = Aug. 1 – Oct. 31; 4 = Nov. 1 – Jan. 31.

	FY17				FY18				FY19				FY20				FY21			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Surveys																				
1. Collection of sea otter skulls for determination of age-at-death	C	C			C	C				C			V	V			X	X		
2. Annual collection of sea otter diet and energy recovery rate data		C				C				C				P				X		
3. Aerial surveys of sea otter abundance (alternating between KATM, KEFJ and WPWS)		C				C				C				V				X		
4. Sampling of intertidal invertebrates and algae		C				C				C				P				X		
5. Sampling of sea grasses and subtidal kelps		C				C				C				P				X		
6. Diet and productivity of BLOY		C				C				C				P				X		
7. Marine bird and mammal surveys (summer KBAY, KATM, KEFJ)		C				C				C				V				X		
8. Marine bird and mammal surveys (winter KATM or KEFJ, alternate years)	C				C				C					V			X	X		
Milestone 2: Analyses																				
9. Stable isotope analysis of selected nearshore species		C				C				C				P				X		

Milestone/Task	FY17				FY18				FY19				FY20				FY21			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
10. Contaminant analysis						C	C	C												
Milestone 3: Reporting																				
Published data sets available			C				C				C				X				X	
Annual Reports	C				C				C				C				X			
Annual PI meeting				C				C				C				X				X
FY Work Plan (DPD)			C				C				C				C					
New Milestone: Graduate student																				
Support MSc stable isotope project - UAF																		X	X	X

In addition to the primary project deliverables in Table 1, during the past year we led or contributed to 7 publications (3 led by nearshore component PIs), 11 reports, 16 presentations (10 oral, 6 poster), 9 outreach products plus several press releases and social media posts (see 2019 annual report). Nearshore ecosystem indicators were developed and contributed to the 2019 Annual Ecosystem Status Report to the North Pacific Fisheries Management Council. The Nearshore component has one PI as lead author for a GWA program level science synthesis publication (Weitzman et al.) and Nearshore component data are being provided for the Suryan et al., Danielson et al. and Arimitsu et al. synthesis manuscripts (see Section 7). We anticipate completing FY21 milestones and tasks as planned.

B. Explanation for not completing any planned milestones and tasks

Due to COVID-19, our scheduled field work was drastically reduced and, in many cases, cancelled (see Table 1 above). All summer sampling and winter (March) marine bird and mammal surveys slated to be completed in KATM in 2020 were cancelled. WPWS spring beach walks used to collect sea otter carcasses for age-at-death estimates were cancelled. In KBAY, we were able to conduct most intertidal surveys, black oystercatcher surveys, and some sea otter observations. At two sites in KEFJ and across all WPWS sites, intertidal temperature loggers were swapped out, site photos were taken, sea star surveys were completed, and black oystercatcher surveys were conducted. We were also able to photo document all mussel sites in WPWS.

C. Justification for new milestones/tasks

The need for additional manpower has been consistently discussed as a constraint in developing management-relevant products using GWA data. The addition of post-docs has partially addressed that need. Due to the reduced field effort resulting from restrictions due to COVID-19, we have realized some savings in FY20 allocated funds. We propose to apply some of that residual funding towards an MSc student at UAF, applying stable isotope analysis to samples collected during GWA visits to evaluate sources of carbon (e.g., phytoplankton versus kelp-derived) assimilated by nearshore consumers. This information will lend insights into underlying causes of variation that we observe during annual intertidal monitoring.

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

The Nearshore Component of GWA is a highly coordinated effort involving multiple PIs with expertise on various aspects of nearshore ecosystems; the overall design and coordination are critical for drawing inference about factors affecting the nearshore. Beginning in 2012 under GWA, there were two nearshore projects (16120114-R Nearshore Benthic Systems in the GOA and 16120114-L, Ecological Trends in Kachemak Bay). The two projects have worked closely over the past several years to ensure that data from all sites are comparable when possible, allowing the strongest possible inferences about the causative factors and spatial extent of changes in nearshore systems. For example, data sets were combined across projects for analyses, which were published in a peer reviewed journal (Konar et al. 2016). In 2017, the two nearshore projects were integrated into a single, coordinated project. This was intended to enhance collaboration across the GWA in the nearshore, which has been achieved, as evidenced by multiple collaborative papers that draw data across all nearshore regions.

An educational collaboration also exists within this project. There are two UAF field courses usually taught by PIs Konar and Iken at the Kasitsna Bay Lab that assist with data collection for this program. Although these courses were not run this year due to COVID-19, it is expected that these courses will resume in FY21. Students get valuable experience and training from participating in the project, and the project benefits from having these 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, sample processing, and outreach.

We have worked closely with the other GWA components (Environmental Drivers and Pelagic) over the previous years to identify data sets that can be shared. For example, Environmental Drivers data were used extensively in an analysis of mussel trends across the GOA, presented in the GWA Science Synthesis report (Monson et al. 2015), and these data are now also being used to inform mussel demographics in KBAY as part of a MSc thesis at UAF. For the current five years (2017-2021), we are exploring the spatial and temporal variation in productivity across the nearshore and linkages to physical oceanographic processes. It will be a priority to evaluate whether changes in nearshore systems correlate with oceanographic conditions or with synchronous changes in pelagic species and conditions, particularly in light of the broad-scale warm water anomaly recently experienced throughout the GOA. The geographic scale of our study (GOA-wide) will provide greater ability to discern both potential linkages across these diverse components, as well as among the study areas within the nearshore, allowing us to evaluate variability and relations among the nearshore resources. We will incorporate data on annual and seasonal patterns measured both in the Environmental Drivers and Pelagic components of the overall GWA study.

Two Pelagic Component projects of the overall GWA program of particular importance to the nearshore are surveys of nearshore marine birds in PWS, including summer (20120114-M) and fall-winter (20120114-E) marine bird population trend projects (for additional long-term data sets of marine birds, see Irons et al. 2000, Stocking et al. 2018). The nearshore project conducts comparable surveys in KEFJ and KATM, with surveys added to KBAY and in 2018. Contrasting the changes occurring in the pelagic and nearshore environments during the recent years when GOA waters have warmed by several degrees (https://alaskapacificblob.wordpress.com/2016/02/09/subsurface-warmth-persists/) may be particularly illuminating.

Lingering Oil

The Nearshore Component of GWA historically has been closely linked with the Lingering Oil component, given that lingering oil occurs in nearshore habitats and affects nearshore species. EVOSTC funded a lingering oil sampling project for FY20 and FY21 (21200014-P) that has been incorporated into the GWA program, though sampling planned for summer 2020 was delayed to 2021 because of COVID-19. Data collected by the Nearshore Component are relevant for understanding ecosystem recovery with respect to the Lingering Oil Program; for example, sea otter abundance, energy recovery rate, and age-at-death data have been used to evaluate population recovery to this point (Bodkin et al. 2014, Ballachey et al. 2014). Contaminant samples (mussels) collected during the 2018 field season were analyzed for a broad suite of compounds, including hydrocarbons. We look forward to potential lingering oil projects and collaborations in the future.

Herring Research and Monitoring

The nearshore component does not have any collaborations to date with the Herring Research and Monitoring program.

Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. With Other EVOSTC-funded Projects

This project will coordinate with other EVOS Trustee Council (EVOSTC)-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications.

C. With Trustee or Management Agencies

In addition to the logistical, administrative, and in-kind support that the NPS, USGS, NOAA, and UAF have provided to ensure the success of the GWA Nearshore Component, there are several additional projects with trustee and management agencies that the Nearshore Component of GWA has collaborated with. Below are several recent examples. We expect to continue these kinds of related projects.

NOAA Fisheries

Contributed nearshore indices will be used by NOAA Fisheries (Stephani Zador and Ellen Yasumiishi, Alaska Fisheries Science Center) in the annual stock assessments Ecosystems Considerations Chapter to the North Pacific Fisheries Management Council. The health of nearshore ecosystems informs managers on essential fish habitat and sensitive early life stages of federally managed fish species mandated through the Magnuson-Stevens Act.

NPS Changing Tides

Nearshore GWA PIs (Ballachey, Bodkin, and Coletti) are working with NPS on the 'Changing Tides' Project. 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 significantly degrade and potentially impair 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 KATM. Several specimens were 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. Others are being used to perform 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 at multiple spatial and temporal scales. Additional work examining the interaction between bears and marine mammals was added in 2016 (initiated by D. Monson). Previously, it was generally believed that bears likely utilize marine mammals via scavenging of beached carcasses. This component will shed light on the importance of marine mammals (primarily sea otters and harbor seals) as live prey taken on offshore islands along the Katmai coast.

BOEM Nearshore community assessments

Nearshore Component PIs (Coletti, Iken, Konar, and Lindeberg) have been working (2015-2019) on the development of recommendations to the Bureau of Ocean Energy Management (BOEM) for nearshore community assessment and long-term monitoring. The BOEM Proposed Final Outer Continental Shelf (OCS) Oil and Gas Leasing Program 2012-2017 included proposed Lease Sale 244 in the Cook Inlet Planning Area in 2017. Until this leasing program, an OCS Cook Inlet Lease Sale National Environmental Policy Act (NEPA) analysis had not been undertaken since 2003. Updated nearshore information was needed to support the environmental analyses 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. Throughout this process, a goal has been to utilize existing nearshore monitoring protocols already developed through GWA when possible to ensure data comparability across all regions. The project went through 2019 and, in addition to providing the data to BOEM, all data are being provided to the Alaska Ocean Observing System Gulf of Alaska Data Portal.

BOEM Cook Inlet Sea Otter Research

A new BOEM-funded effort to evaluate sea otter population status, distribution, habitat use, and foraging was set to begin in FY20. Due to COVID-19, most efforts will begin in FY21. This USGS-led project involves many partners, including NPS, UAF, Alaska Department of Fish and Game, and US Fish and Wildlife Service. There are clear linkages and synergies with GWA work in Kachemak Bay, as much of the GWA-funded work on sea otters will be informative to the BOEM-funded work and vice versa. Through collaboration with NPS and UAF, a sea floor habitat mapping aspect of this work will have direct implications for GWA interpretation of distributions of birds and mammals.

CMI Nearshore food webs in Cook Inlet

Funded through the Coastal Marine Institute (CMI), a partnership between BOEM and UAF, GWA PIs Iken and Konar are working with a 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. The student defended her thesis in summer 2020 and is currently working on preparing a manuscript for publication in a peer-reviewed journal (a planned GOA-wide DSR II special issue).

The Pacific nearshore project

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 (von Biela et al. 2016a). 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 (unpublished data). Further work was completed by von Biela et al. (2016b), 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. In 2018, we initiated a pilot study to build on the Pacific Nearshore Project by sampling fish and mussels across all four regions. Objectives are to 1) examine how variable relative contributions of macroalgae and phytoplankton to nearshore intertidal mussels and subtidal fishes are over space and time; 2) examine variation in the relative contributions of primary producers and determine if it is related to growth performance; and 3) assess annual growth rates of mussels and fish to determine if they are synchronous with other GWA environmental drivers or indicators of productivity in nearshore or pelagic ecosystems. This is the project for which we are now planning to use residual funding to support a UAF student to work on these samples and questions.

Nearshore ecosystem responses to glacial inputs

Nearshore GWA PIs (Esler, Coletti, Weitzman), in collaboration with NPS, are conducting research documenting variation in nearshore physical oceanography in relation to tidewater glacial input and quantifying 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 and University of Alaska Southeast, nearshore GWA PIs (Konar and Iken) lead an Established Program to Stimulate Competitive Research (EPSCoR) project funded by 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 examines an array of sites from southeast Alaska to Kachemak Bay. Specific links to the GWA program include the inclusion of mussel demographics from KBAY EPSCoR sites, an expansion of nearshore sensor data (photosynthetically active radiation, dissolved oxygen, and sedimentation in addition to the temperature and salinity data collected at GWA sites), complementary stable isotope data on mussels and various carbon sources, as well as sea star transects.

4. PROJECT DESIGN

A. Overall Project Objectives

The fundamental objective of this work is the continued long-term monitoring of a suite of nearshore species at multiple locations across the GOA, with an overall goal of understanding drivers of variation in the GOA nearshore ecosystem and understanding pathways to recovery of EVOS affected resources.

The specific objectives for the nearshore component are:

1. To determine status and detect patterns of change and variation in a suite of nearshore species and communities.
2. To identify temporal and spatial extent of observed changes and variation.
3. To identify potential causes of change or variation in biological communities.
4. To communicate results to the public and to resource managers to preserve nearshore resources.
5. To continue restoration monitoring in the nearshore in order to evaluate the current status of injured resources in oiled areas and identify factors potentially affecting present and future trends in population status.

B. Changes to Project Design and Objectives

No changes have been made to the project design or objectives. Although COVID-19 disrupted data collection for some of our metrics, the rationale and approach that serve as the foundation for the work are resilient to those gaps. Also, our efforts to collect as much data as safe and practical in FY20 will contribute to the long-term goal of detecting and understanding nearshore variation. Similarly, redirection of funding to support of a UAF MSc student will provide mechanistic understanding of observed variation, which will be of significant value for the life of the GWA program.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

We anticipate continued support from M. Lindeberg (NOAA), A. Miller (NPS), C. Miller (NPS), T. Shephard (NPS), J. Pearce (USGS) and other USGS and NPS scientific staff for data collection and sampling across all four regions. This team of scientists has an extensive background of research efforts in coastal marine areas of Alaska.

Ben Weitzman, a nearshore PI, transitioned from USGS to NOAA in August 2019. Ben will remain involved in GWA work in his new role. A new post-doc, Sarah Traiger, has been hired by USGS to take on some larger multi-trophic level and cross-GWA component synthesis.

6. PROJECT BUDGET

A. Budget Forms (See GWA FY20 Budget Workbook)

Please see project budget forms compiled for the program.

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$228.8	$229.1	$229.4	$250.7	$250.9	$1,188.9	$0.0
Travel	$17.4	$17.5	$17.6	$10.7	$10.8	$74.0	$0.0
Contractual	$83.1	$125.5	$83.1	$73.1	$73.1	$437.9	$0.0
Commodities	$23.9	$23.0	$23.0	$44.0	$44.0	$157.9	$0.0
Equipment	$5.0	$10.0	$14.0	$2.0	$2.0	$33.0	$0.0
Indirect Costs (*will vary by proposer*)	$10.5	$10.3	$10.3	$10.4	$10.5	$52.0	$0.0
SUBTOTAL	$368.7	$415.4	$377.4	$390.9	$391.3	$1,943.7	$0.0
General Administration (9% of	$33.2	$37.4	$34.0	$35.2	$35.2	$174.9	N/A
PROJECT TOTAL	$401.9	$452.7	$411.4	$426.1	$426.6	$2,118.6	
Other Resources (Cost Share	$410.0	$410.0	$410.0	$389.6	$389.6	$2,009.2	

B. Changes from Original Project Proposal

Few changes to the overall Nearshore component budget have been made. In previous fiscal years, a few items have been re-allocated within the project. For FY18 - FY21, the $6,000.00 allocated to USGS (Coletti and Esler) for stable isotope analyses have been moved to UAF (Konar and Iken). UAF has the capacity to manage and analyze the samples for the nearshore project as a whole. Salary support to collect sea otter foraging observations in KBAY has been moved from Konar and Iken to Coletti and Esler (FY18 5.7k, FY19 5.8k, FY20 6.0K and FY21 6.1k). This will ensure the continued integration of the nearshore project.

For FY20 and FY21 funds have been shifted among budget categories; for example, personnel costs have increased while contractual costs have decreased, reflecting the transition from contracted PIs to agency staff. Also, we requested and received EVOSTC approval for an additional $23,980 (including 9% GA) for FY20 and FY21. These funds will cover some of the costs of operating the R/V *Alaskan Gyre*, which have increased substantially and were unanticipated at the time of the original proposal.

In FY21 we propose redirecting funding that was unused for field operations in FY20 (due to COVID-19 restrictions) to UAF to support a MSc student to conduct a project evaluating stable isotope variation in nearshore food webs and associated effects on productivity of nearshore flora and fauna. These changes are reflected in the FY21 budget. We are making a 2-year commitment to a student, which goes beyond the currently funded GWA 5-year cycle, but we are confident we can acquire the necessary funds for FY22. We will be requesting the reallocation of some FY21 funds to support the student, which will be captured in the FY21 nearshore Work Plan. See table below.

Table 2. Proposed funding sources for a Master of Sciences Student at the University of Alaska Fairbanks to evaluate stable isotope variation in nearshore food webs and associated effects on productivity of nearshore flora and fauna.

Funding Source	FY21	FY22	Totals	Comments
UAF GWA	$12,000		$12,000	Reallocation of project funds
NPS GWA	$22,000	$20,000	$42,000	Year 2 existing NPS agreement using GWA FY21 funds
USGS GWA	$20,000		$20,000	Reallocation of project funds
NOAA GWA	$10,000		$10,000	Reallocation of project funds
NPS Base		$30,000	$30,000	Year 2 existing NPS agreement using NPS base funds
available funds:	**$64,000**	**$50,000**	**$114,000**	
student cost:	$63,386	$69,077	**$132,463**	
shortage	($614)	$19,077	$18,463	Will be GWA encumbered funds or agency base funding

C. Sources of Additional Project Funding

Annual in-kind contributions consist of staff time (USGS = $52K; NPS = $176k; NOAA = $10k), reduced vessel costs (USGS = $45K; NPS= $25K), winter bird surveys (NPS=$20K), use of equipment such as rigid-hull inflatable, inflatables/outboards, GPSs, spotting scopes, field laptops, sounding equipment (USGS = $40K; NPS = $40K), commodities (USGS = $5k; NPS = $5K), contractual services (UAF = $5K), and travel (NPS = $5.5K). NPS will also contribute an additional $30K to UAF to support the MSc student (see table above). Additionally, in cooperation with NPS ($60K from NPS base funds) and USGS ($20K), we are also purchasing a new rigid-hull inflatable to replace an old skiff used to support GWA work.

7. FY17-20 PROJECT PUBLICATIONS AND PRODUCTS

Publications

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Research Workspace

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Bowen, L., H.A. Coletti, B. Ballachey, T. Hollmen, S. Waters, and K. Counihan. 2018. Transcription as a Tool for Assessing Bivalve Responses to Changing Ocean Conditions. **Oral Presentation**. Ocean Sciences Meeting. February 11-16.

Coletti, H. A. Gulf Watch Alaska overview and updates. **Oral Presentation.** MARINe and BOEM joint meeting. September.

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**. Alaska Marine Science Symposium, Anchorage Alaska. January 21-25.

Coletti, H.A., G. Hilderbrand, D. Monson, J. Erlenbach, B. Ballachey, B. Pister and B. Mangipane. 2019. Where carnivores clash: Evidence of competition - Prey-shifting by brown bears during a period of sea otter recovery. **Oral Presentation.** Sea Otter Conservation Workshop 2019. March.

Coletti, H.A., P. Martyn, D.H. Monson, D. Esler and A.E. Miller.2018. Using Small Unmanned Aircraft Systems (sUAS) to map intertidal topography in Katmai National Park and Preserve, Alaska. **Poster Presentation**. Ocean Sciences Meeting. February 11-16.

Coletti, H.A., R. Suryan, D. Esler, R. Kaler, T. Hollmen, M. Arimitsu, J. Bodkin, T. Dean, K. Kloecker, K. Kuletz, J. Piatt, B. Robinson, and B. Weitzman. 2019. Birds of a feather flock together… or do they? Regional and temporal patterns of community composition and abundance in nearshore marine birds across the Gulf of Alaska. **Oral Presentation**. Alaska Bird Conference. March 2019.

Counihan, K., L. Bowen, B. Ballachey, H. Coletti, T. Hollmen, and B. Pister. 2019. Physiological and gene transcription assays in combinations: a new paradigm for marine intertidal assessment. **Oral Presentation**. Alaska Marine Science Symposium. January 28 – February 1.

Dorsaz, T., and B. Konar. 2019. Clam predation patterns as a way of understanding sea star wasting disease's impacts in Kachemak Bay. **Poster Presentation**. Alaska Marine Science Symposium. January 28 – February 1.

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

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

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. **Oral Presentation**. Alaska Chapter of The Wildlife Society Annual Meeting, Fairbanks.

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. **Oral Presentation**. Sea Otter Conservation Workshop, Seattle.

Griffin, K., and H. Coletti. Seabird colonies on the Katmai coast. **Poster Presentation.** Alaska Marine Science Symposium. January 27-30.

Hondolero, D., T. Bell, B. Weitzman, and K. Holderied. Kelp forest mapping in Kachemak Bay, Alaska using a drone. **Poster Presentation.** Alaska Marine Science Symposium. January 26-31.

Kurtz, D., D. Esler, T. Jones, B. Weitzman, and B. Robinson. 2019. Spatial and temporal patterns in nearshore physical oceanography in tidewater glacial fjords. **Poster Presentation.** Alaska Marine Science Symposium. January 28 – February 1.

Iken, K., and B. Konar. 2018. Nearshore Gulf Watch Alaska monitoring in Kachemak Bay. **Oral Presentation**. Kachemak Bay Science Conference, Homer, AK. March 8-9.

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

Iken, K., and B. Konar. 2018. Nearshore Gulf Watch Alaska monitoring in Kachemak Bay. **Poster Presentation**. Kachemak Bay Science Conference. March 7-10.

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. **Oral Presentation.** Sea Otter Conservation Workshop, Seattle.

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**. Alaska Marine Science Symposium, Anchorage Alaska. January 21-25.

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Kurtz, D., D. Esler, T. Jones, B. Weitzman, and B. Robinson. 2019. Spatial and temporal patterns in nearshore physical oceanography in tidewater glacial fjords. **Poster Presentation**. Alaska Marine Science Symposium. January 28 – February 1.

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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**. Alaska Marine Science Symposium, Anchorage Alaska. January 21-25.

Monson, D., R. Taylor, G. Hilderbrand, J. Erlenbach, and H. Coletti. 2019. Top-Level Carnivores Linked Across the Marine / Terrestrial Interface: Sea Otter Haulouts Offer a Unique Foraging Opportunity to Brown Bears. **Oral Presentation**. Alaska Marine Science Symposium. January 28 – February 1.

Parrish, J.K., H. Burgess, T. Jones, J. Lindsey, A. Lestenkof, B. Bodenstein, B. Mangipane, E. Labunski, E. Lujan, H. Coletti, H. Renner, J. Christensen, J. Piatt, K. Hilwig, K. Lewandowski, K. Plentnikoff, K. Lefebvre, K. Kuletz, K. Griffin, L. Divine, L. Wilson, M. Romano, M. Cady, M. Good, M. Brubaker, N. Graff, N. Stellrecht, P. Lestenkof, P. Fitzmorris, P. Melovidov, R. Kaler, R. Corcoran, S. Schoen, S. Backensto, S. Knowles, S. Thomas, T. Mullet, C. Wright, A. Will and T. Lewis. 2020. Unabated Mass Mortality of Marine Birds in the Northeast Pacific. **Oral Presentation.** Alaska Marine Science Symposium. January 27-30.

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

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

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**. Alaska Marine Science Symposium, Anchorage Alaska. January 21-25.

Siegert, D., K. Iken, S. Saupe, and M. Lindeberg. 2019. Comparison of intertidal food web structure between two regions of lower Cook Inlet. **Poster Presentation**. Alaska Marine Science Symposium. January 28 – February 1.

Siegert, D., K. Iken, S. Saupe, and M. Lindeberg. 2019. Comparing intertidal food web and community structure across two regions of lower Cook Inlet. **Oral Presentation**. CMI Annual Review, Anchorage, AK. February 1.

Siegert, D., K. Iken, S. Saupe, and M. Lindeberg. 2018. Nearshore food web structure in two contrasting regions of Cook Inlet. **Oral Presentation**. CMI Annual Review, Anchorage, AK. January 26.

Siegert, D., K. Iken, S. Saupe, and M. Lindeberg. 2018. Nearshore food web structure in two contrasting regions of Cook Inlet. **Poster Presentation**. Kachemak Bay Science Conference, Homer, AK. March 8-9.

Suryan, R.M., M.R. Lindeberg, M. Arimitsu, H. Coletti, R.R. Hopcroft, D. Aderhold and K. Hoffman. 2019. Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. Perspectives from Gulf Watch Alaska. **Oral Presentation**. Alaska Marine Science Symposium. January 27 – 30, 2020.

Weitzman, B. 2019. Can you dig it? Patterns of variability in clam assemblages across the Gulf of Alaska. **Oral presentation.** UAF College of Fisheries & Ocean Sciences Special Seminar, Fairbanks, AK. February 27.

Weitzman, B., D. Esler, H. Coletti, B. Konar, and K. Iken. 2018. Can you dig it? Patterns of variability in clam assemblages within mixed-sediment habitats across the Gulf of Alaska. **Oral Presentation**. Kachemak Bay Science Conference. March 7-10.

Williamson, E., B. Konar, K. Iken, and M.K. McCabe. 2020. Size frequency distribution of *Mytilus trossulus* in Kachemak Bay. **Poster Presentation**. Alaska Marine Science Symposium. January 27-30.

Zhang, B., B. Konar, B. Weitzman, H. Coletti, and D. Esler. 2020. Associating clam recruitment with adult standing stock in the Northern Gulf of Alaska. **Poster Presentation**. Alaska Marine Science Symposium. January 27-30.

Outreach

Aderhold, D., S. Buckelew, M. Groner, K. Holderied, K. Iken, B. Konar, H. Coletti, and B. Weitzman. 2018. GWA and HRM information exchange event in Port Graham, AK, May 15.

Aderhold, D., Holderied, K., Hondolero, D., Konar, B., Siegert, D., Weitzman, B., and Kloecker, K. 2019. Gulf Watch Alaska monitoring program overview: Drivers, HABs, Foods webs, nearshore changes, and sea otters. Gulf Watch Alaska Community Outreach Event. Seldovia Community Center, Seldovia, AK. May 17.

Backensto, S., and H. Coletti. 2019. Another Year of Seabird Die-Offs. High Latitude Highlights, the NPS Alaska Region Resource Newsletter. Fall Issue: pg 2- 3.

Ballachey, B. 2019. The Exxon Valdez Oil Spill: Perspectives & Lessons, 30 years later. University of Calgary Continuing Education class; Course BMC153 Environmental Site Assessment. Calgary, CA. March 2019.

Coletti, H., D. Esler, B. Robinson, and B. Weitzman. 2018. Ocean Alaska Science and Learning Center Teacher Workshop. Kenai Fjords National Park, AK, June.

Coletti, H., D. Esler, B. Robinson, and B. Weitzman. 2019. Ocean Alaska Science and Learning Center Teacher Workshop. Kenai Fjords National Park, AK, June.

Esler, D. 2019. Sea Ducks in Nearshore Marine Systems: Contrasting Responses to Oil Spill and Heat Wave Perturbations. Oral Presentation. Prince William Sound Regional Citizens' Advisory Council Science Night.

Grobelny, C., and J. Pfeiffenberger. 2020. Exploring the Fjords: A Hands-On Teacher Workshop. NPS OASLC YouTube video https://www.youtube.com/watch?v=N14pfHOoN0U&feature=youtu.be

Konar, B., and K. Iken. 2018. Wasting sea stars in the Gulf of Alaska. Delta Sound Connections 2018-2019. Prince William Sound Science Center.

Robinson, B., H. Coletti, D. Green, L. Ware, D. Esler. 2019. The black oystercatcher: Migration, movement and monitoring. Oral Presentation. Gulf Watch Alaska Community Outreach Event. Kachemak Bay Campus, Homer, AK. October 8.

Weitzman, B. 2019. Sea otter and clam population dynamics in Kachemak Bay. Kachemak Bay National Estuarine Research Reserve Lunch Lecture Series, Kachemak Bay Campus, Homer, AK. December 6.

Weitzman, B. 2019. Monitoring nearshore ecosystems in the Gulf of Alaska through sea otters. Fireweed Academy Community Outreach and Lecture Series, Homer, AK. December 13.

Weitzman, B. 2017. Unhappy as a clam? Delta Sound Connections. Prince William Sound Science Center. 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

National Park Service Press Release

Links to NPS press releases and press response related to NPS efforts to track seabird die offs are listed below. These press releases and articles link to the NPS die-off webpage, which in turn, summarizes statewide, including Gulf of Alaska, data. The Nearshore component of GWA provides data to these summaries.

https://www.nps.gov/orgs/1840/2019-alaska-seabird-die-off.htm

https://www.nps.gov/subjects/aknatureandscience/commonmurrewreck.htm

https://www.washingtonpost.com/climate-environment/2019/05/29/thousands-seabirds-starved-death-bering-sea-scientists-see-fingerprint-climate-change/

https://www.arctictoday.com/alaska-seabird-die-offs-now-in-their-fifth-year-are-a-red-flag-in-warming-climate/

https://www.alaskapublic.org/2019/10/11/as-seabird-die-offs-continue-unalaskans-train-to-track-local-mortalities/

https://www.nationalparkstraveler.org/2019/09/seabird-die-reported-bering-land-bridge-national-preserve

TV Coverage:

https://www.ktuu.com/content/news/Unangan-culture-impacted-by-mass-die-off-of-seabirds-in-the-Bering-Sea-510746261.html

https://www.ktva.com/story/41030559/researchers-investigate-annual-seabird-dieoffs-in-alaska

Impacts of climate disruption linked to seabird die-off

https://www.ktuu.com/video/?vid=510653162

Radio Coverage:

https://www.knba.org/post/it-s-starvation-biologists-alaska-see-fifth-year-significant-seabird-die-offs

International coverage/Australia that includes link to NPS website:

https://www.abc.net.au/news/2019-10-05/mutton-birds-delayed-migratory-vic-arrival-alarms-birdwatchers/11572220

https://www.abc.net.au/news/2019-10-25/mutton-bird-mystery-deepens-griffiths-island/11627720

National Park Service Social Media Outreach:

Web article on 1/28/2020: Marine Heatwave Linked to Seabird Die-off (Piatt et al. 2020)

Facebook post on 1/28/2020 linked to the Piatt et al. 2020 paper:

#ParkScience Ocean ecosystems are changing, driven largely by ocean heatwaves and, specifically, the massive heatwave of 2014-2016 known as The Blob. This paper focuses on the common murre die-off that killed as many as a million birds. Other ecosystem changes were found in conjunction with the marine heatwave that made sense in connection to the murre starvation. The base of the food chain, plankton, were impacted and had an impact on many other marine species. These changes, while especially pronounced in 2014-2016, continue with warming ocean waters today. #AMSS2020 [10,434 people reached, 425 engagements, 22 shares, 17 comments]

NPS Twitter post on 1/28/2020, link to the web article and tagged #AMS2020

Updates to NPS webpage: Seabird die-offs:
https://www.nps.gov/subjects/aknatureandscience/commonmurrewreck.htm

Facebook post on 12/17/2019 about black oystercatchers linked to Nearshore Vital Signs page on the NPS Southwest Alaska Network (SWAN) website. [26,249 people reached, 2,597 engagements, 34 shares, 4 comments]

Facebook post on 12/5/2019 about seabird die-offs [20,037 people reached, 1.433 engagements, 121 shares, and 23 comments]

Facebook post on 11/15/2019 about mussel monitoring, pointing to a web article on physiological and gene transcription assays [6,579 people reached, 126 engagements]

Facebook post on 9/10/2019 about seabird die-off, link to USFWS page with latest update [7,127 people reached, 165 engagements, 4 shares, 1 comment]

Facebook post on 9/9/2019 about seabird die-offs featuring an image from COASST and linking to our seabird die-off web page [13,543 people reached, 667 engagements, 35 shares, 6 comments (Fukishima comments addressed)]

Facebook post on 8/26/2019 about sea star wasting disease with links to your resource brief [24,593 people reached, 2,081 engagements, 76 shares, and 12 comments]

Facebook post on 8/132019 on marine mammal and seabird die-offs (more specifically addressing all the comments we get about Fukushima) [13,132 people reached, 761 engagements, 27 shares, and 15 comments]

Facebook post on 5/30/2019 on phytoplankton, warming oceans, with links to NPS web article on the Blob and a science magazine article on marine heatwaves [8,043 people reached, 232 engagements, 5 shares]

Facebook post on 4/22/2019 on the Winter Marine Bird and Mammal Survey [10,500 people reached, 377 engagements, 10 shares, and 4 comments]

Facebook post on 4/21/2019 on the Winter Marine Bird and Mammal Survey [12,227 people reached, 540 engagements, 7 shares, and 1 comment]

Facebook post on 4/20/2019 on the Winter Marine Bird and Mammal Survey [11,996 people reached, 414 engagements, 13 shares, and 1 comment]

Facebook post on 4/19/2019 on the Winter Marine Bird and Mammal Survey [12,919 people reached, 476 engagements, 10 shares]

Facebook post on 4/16/2019 on the Winter Marine Bird and Mammal Survey [14,498 people reached, 498 engagements, 47 shares, and 13 comments]

Facebook post on 3/24/2019 on anniversary of EVOS [9,056 people reached, 263 engagements, 20 shares, 1 comment]

Facebook post on 3/23/2019 about the EVOS [9,548 people reached, 186 engagements, 5 shares, 6 comments]

Facebook post on 3/22/2019 about the EVOS [10,434 people reached, 448 engagements, 17 shares, 2 comments]

Facebook post on 3/21/2019 about the EVOS [9,745 people reached, 343 engagements, 7 shares, 9 comments]

Facebook post on 3/20/2019 about the EVOS [9,227 people reached, 348 engagements, 28 shares, 5 comments]

Facebook post on 3/23/2019 about the EVOS and link to two of your papers on drivers of change in intertidal communities [9,420 people reached, 222 engagements, 13 shares, 1 comment]

Facebook post on 3/18/2019 about the EVOS, link to Gulf Watch Alaska [11,436 people reached, 562 engagements, 158 shares, 13 comments]

Facebook post on 3/17/2019 about the EVOS, link to Listening to the Sound [9,231 people reached, 395 engagements, 21 shares, 9 comments]

Facebook post on 2/22/2019 on sea otters, link to web article on future directions in sea otter research [12,262 people reached, 348 engagements, 14 shares, 3 comments]

Kenai Fjords National Park Facebook page:

Facebook post on 4/7/19 3rd in a series about the winter marine bird and mammal survey, with links to Marine Birds webpage, [3900 people reached, 220 engagements, 4 shares, 1 comment]

Facebook Post on 4/6/19 2nd in a series about the winter marine bird and mammal survey [3900 people reached, 287 engagements, 3 comments]

Facebook post on 4/5/19 1st in a series about the winter marine bird and mammal survey, [3560 people reached, 191 engagements, 1 share]

8. LITERATURE CITED

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