Exxon Valdez **Oil Spill Trustee Council**

Long-Term Research and Monitoring, Mariculture, Education and Outreach

Annual Project Reporting Form

Project Number: 23120114-H

Project Title: Nearshore Ecosystems in the Gulf of Alaska

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Reporting Period: February 1, 2022 – January 31, 2023

Submission Date: March 1, 2023

Project Website: https://gulfwatchalaska.org/

Please check all the boxes that apply to the current reporting period.

☒ **Project progress is on schedule.**

☐ **Project progress is delayed.**

☐ **Budget reallocation request.**

☒ **Personnel changes.**

Brian Robinson has moved on from the U. S. Geological Survey (USGS) and Gulf Watch Alaska Long-Term Research and Monitoring (GWA-LTRM); however, his contributions to the program and its success have been significant. For FY24 field operations, the nearshore component is in the process of hiring a seasonal employee to assist with data collection and logistics until a full-time replacement can be made.

1. Summary of Work Performed:

We conducted nearshore marine ecosystem monitoring in four regions within the spill-affected area of the northern Gulf of Alaska (GOA): Western Prince William Sound (WPWS), Kenai Fjords National Park (KEFJ), Kachemak Bay (KBAY), and Katmai National Park and Preserve (KATM). The nearshore monitoring program focuses on sampling numerous ecosystem components in the GOA that are both numerically and functionally important, including kelps (and other marine algae), seagrasses, marine intertidal invertebrates, marine birds, black oystercatchers, sea otters, and physical properties. Our nearshore monitoring has been carefully designed, with coordinated sampling of all metrics, to detect changes and provide insights into drivers of change observed at different spatial and temporal scales. Our objectives are as follows:

- Determine status and detect patterns of change in a suite of nearshore species and communities.
- Identify temporal and spatial extent of observed changes.
- Identify potential causes of change in biological communities, including those related to climate change.
- Communicate observations to the public and to resource managers to conserve and manage nearshore resources.
- Continue restoration efforts to evaluate the current status of spill-injured resources and identify factors potentially affecting present and future trends in population and ecosystem status.

The design features of the Nearshore Component include a rigorous site selection process that allows 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, and especially those resulting from human activities, including lingering effects of the *Exxon Valdez* oil spill (EVOS). In addition to detecting change at various spatial scales, design features incorporate both static (e.g., substrate, exposure, 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 change in those species over time in relation to well defined drivers supports accurate measures of change, provides defensible conclusions related to causes, and supports management and policy needs regarding nearshore resources.

In 2023, we completed all aspects of the nearshore monitoring component across all four regions. The status of all measured metrics was reported on recently (Coletti et al. 2023) through 2021. For the 2023 annual report, we are reporting on intertidal water temperature, and several intertidal indicators that represent key nearshore ecosystem processes, including primary production and prey abundance. We also summarize recent work completed by Robinson et al. (2023) examining changes over time of nearshore-reliant marine birds and their responses to the Pacific marine heatwave (PMH) and work accepted for publication by Corliss et al. describing variation in growth of nearshore consumers in relation to sources of primary production.

Nearshore water temperature

Nearshore water temperature across the GOA from Prince William Sound to the Alaska Peninsula showed a warming trend beginning in 2014 that persisted across all regions through 2016 and into 2017 in WPWS and KEFJ (Fig. 1). These results confirm that the 2014-2016 PMH in the GOA was expressed in intertidal zones, mirroring documented trends in the open ocean environments (Danielson et al. 2022). While intertidal temperatures returned to cooler conditions in 2017, a new heat spike in 2019 in all regions was recorded. After that, temperatures started to cool again, although with some indication of higher variability among the four regions than observed prior to the PMH. In 2023, at the time of collection (mid-summer), all four regions were much cooler than the long-term average.

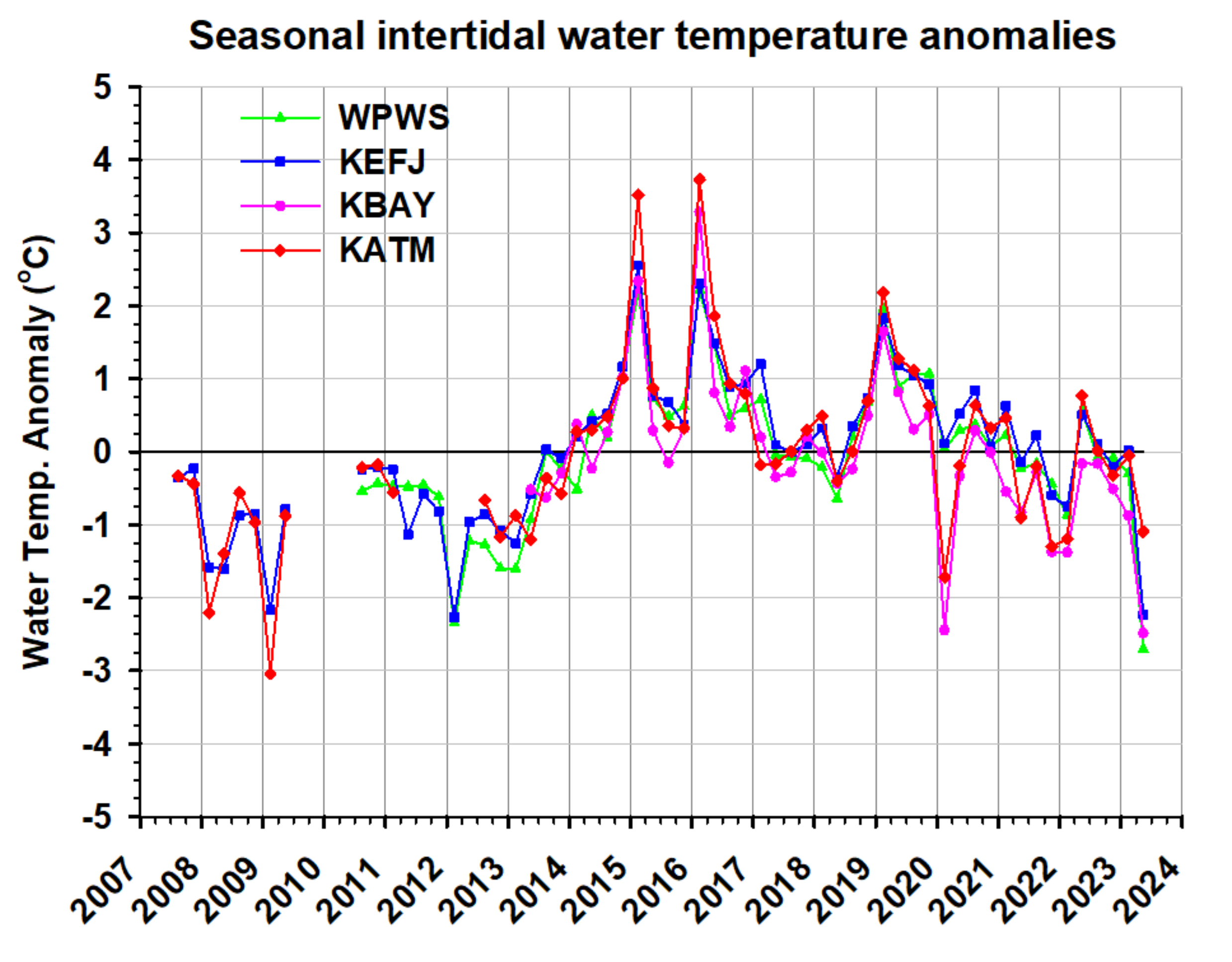

Figure 1. Seasonal intertidal water temperature anomalies at the 0.5 m tide level four regions of the western Gulf of Alaska (west of 144°W), Western Prince William Sound (WPWS; 2011-2023), Kenai Fjords National Park (KEFJ; 2008-2023), Kachemak Bay (KBAY; 2013-2023), and Katmai National Park adjacent to Shelikof Strait (KATM; 2006-2023). Long tick marks indicate the start of the calendar year (January) while short tick marks are quarterly divisions within the year (April, July, October).

Rocky intertidal community structure

We examined rocky intertidal community structure at 21 sites across our four regions, spanning 1,200 km of coastline. Sites were monitored annually at mid and low tidal strata. During and after the PMH (2015-2019), we found that macroalgal foundation species (e.g., kelps and perennial seaweeds) declined across the study regions, illustrated here by the decline in *Fucus distichus* at both the 0.5m and 1.5m tidal elevation (Figs. 2 and 3). The GOA-wide shift from a macroalgal dominated rocky intertidal to a filter-feeder dominated state concurrent with the changing environmental conditions associated with a marine heatwave event suggests the PMH had Gulf-wide impacts to the structure of rocky intertidal communities (Weitzman et al. 2021). Similarities in community structure increased across regions, leading to a greater homogenization of these communities and lower species diversity (Fig. 4). This was due to declines in macroalgal cover, driven mostly by a decline in the rockweed, *Fucus distichus*, and other fleshy red algae in 2015, followed by an increase in barnacle cover in 2016, and an increase in mussel (*Mytilus trossulus*) cover in 2017 (Figs. 2 and 3). In 2023, variability in community structure, increase in species diversity since 2017 at both tidal elevations (Fig. 4) and increases in macroalgae following the PMH may be an indication of the ecosystem returning to one dominated by local-scale conditions compared to the large-scale effect of the PMH.

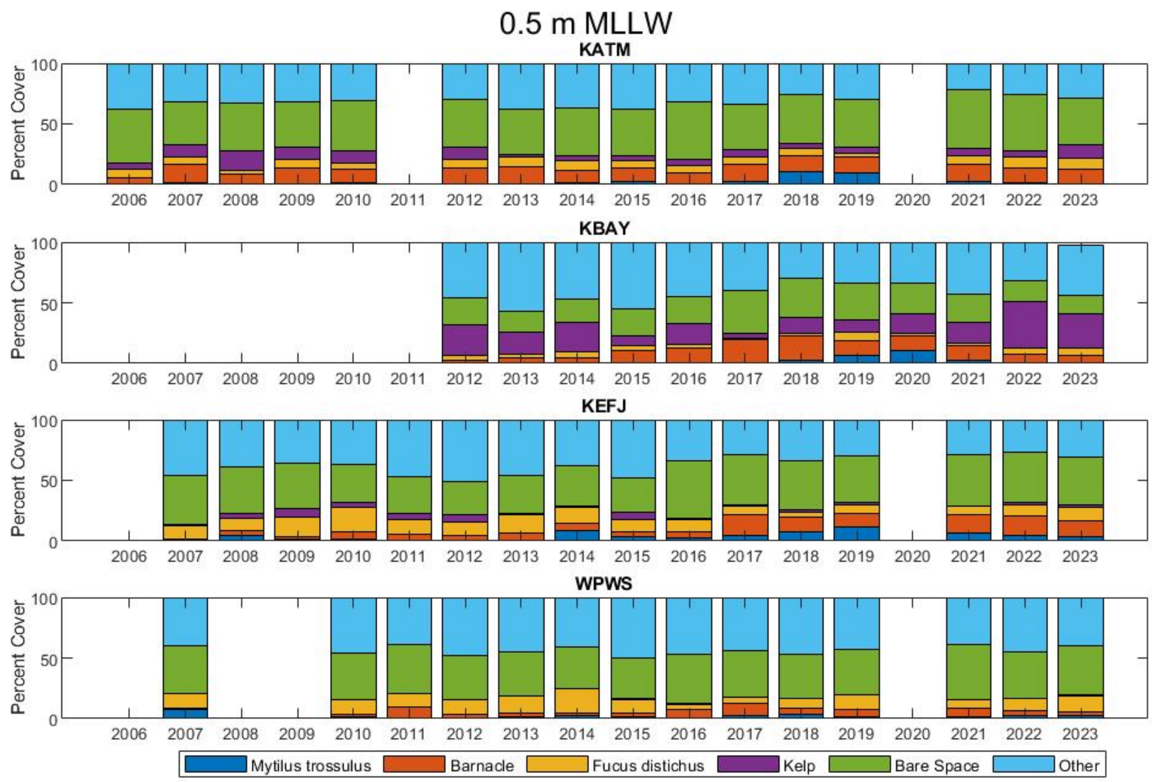

Figure 2. Percent cover of Mytilus trossulus, barnacles, Fucus distichus, kelps, and bare substrate at the 0.5 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS), 2006-2023. "Other" includes all other macroalgae and sessile invertebrates.

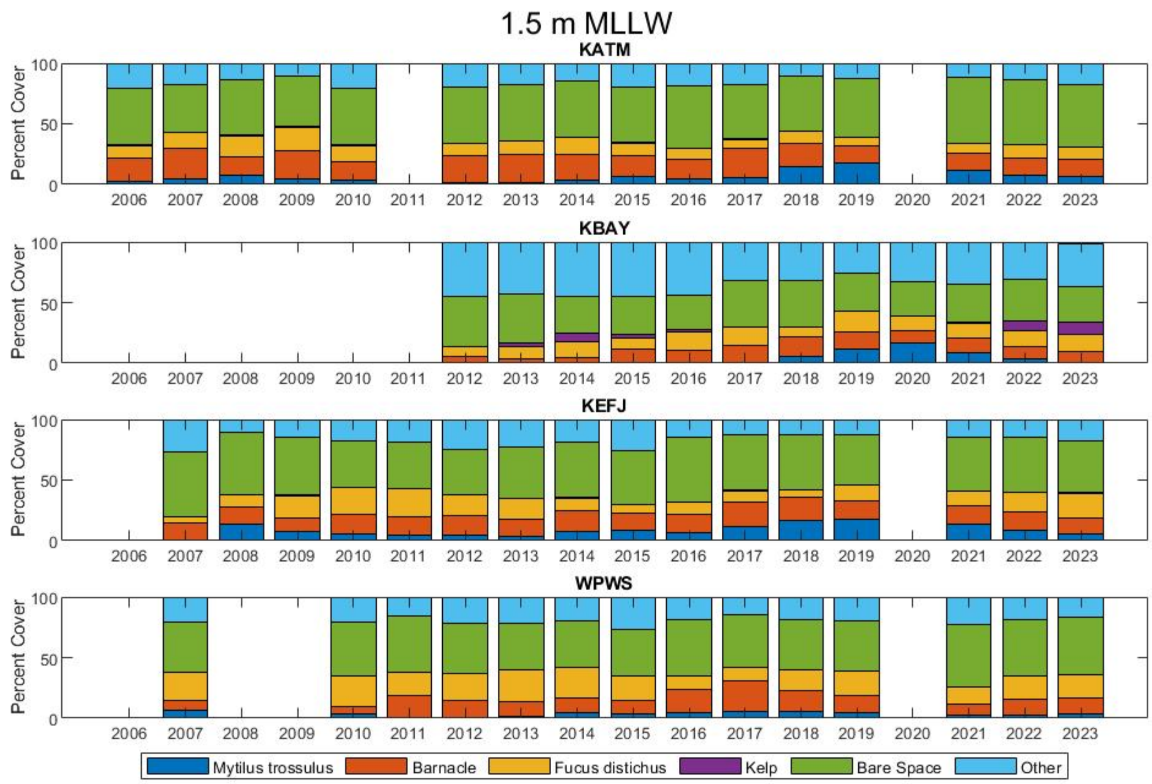

Figure 3. Percent cover of Mytilus trossulus, barnacles, Fucus distichus, kelps, and bare substrate at the 1.5 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS), 2006-2023. "Other" includes all other macroalgae and sessile invertebrates.

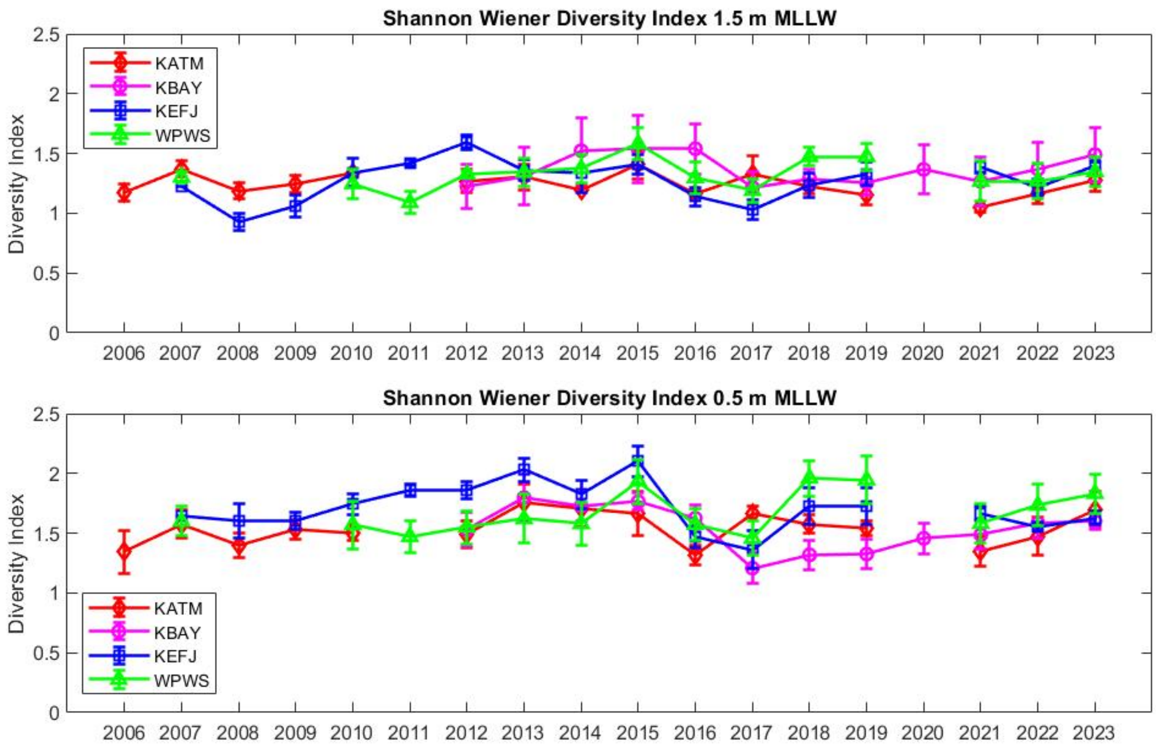

Figure 4. Shannon Wiener Diversity Index for all macroalgae and invertebrates at the 1.5 m and 0.5 m tidal elevation relative to mean lower low water (MLLW) across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS), 2006-2023. Error bars indicate ±1SE.

Specific mussel beds are sampled at each site within each region every year. Large mussel densities (≥ 20 mm) showed an overall positive trend across regions concurrent with timing of the PMH through 2019, although not consistent in timing across regions (Fig. 5). In 2021, it appeared that large mussel densities had returned to the long-term average across all regions. But, by 2022, negative trends in KATM and WPWS were evident with average values in KBAY and a positive trend in KEFJ. The 2023 data indicated that KATM was still experiencing a negative large mussel density trend, while average (WPWS) and positive trends were present in the other regions (KEFJ and KBAY). As oceanographic conditions return to cooler temperatures, variability in mussel abundance at these regional spatial scales supports our conclusion that, in the absence of broad-scale perturbations like the PMH, other variables, including local conditions are more important drivers of mussel abundance (Bodkin et al. 2017, Traiger et al. 2022, LaBarre et al. 2023).

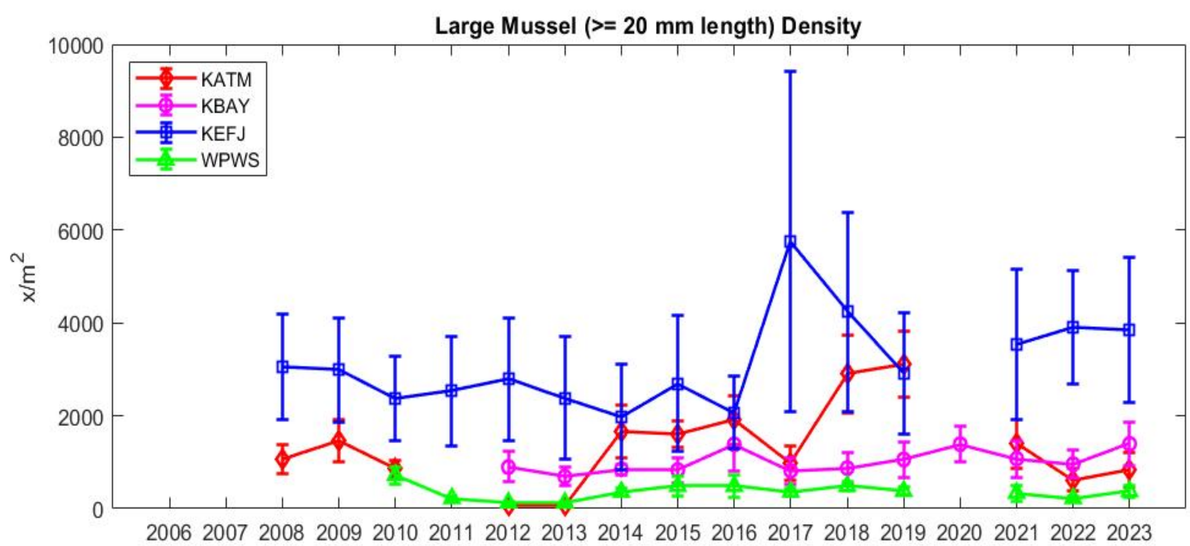

Figure 5. Large (≥ 20 mm) mussel (Mytilus trossulus) density across four regions at mussel sites through 2023. Sampling started in 2008 in Kenai Fjords National Park (KEFJ), Katmai National Park and Preserve (KATM), and Western Prince William Sound (WPWS). Kachemak Bay (KBAY) mussel bed sampling began in 2012. Error bars indicate ±1SE.

Infaunal bivalves are sampled in intertidal mixed sediment habitats every other year in all regions. *Macoma* spp., the most numerically dominant clam across regions, had slightly lower abundance in 2023 than in the previous year sampled at KATM and KEFJ (Fig. 6). Overall clam density and biomass was lower in 2023 than the long-term mean (Figs. 6 and 7). Clam biomass in KBAY has declined at each sampling since 2017.

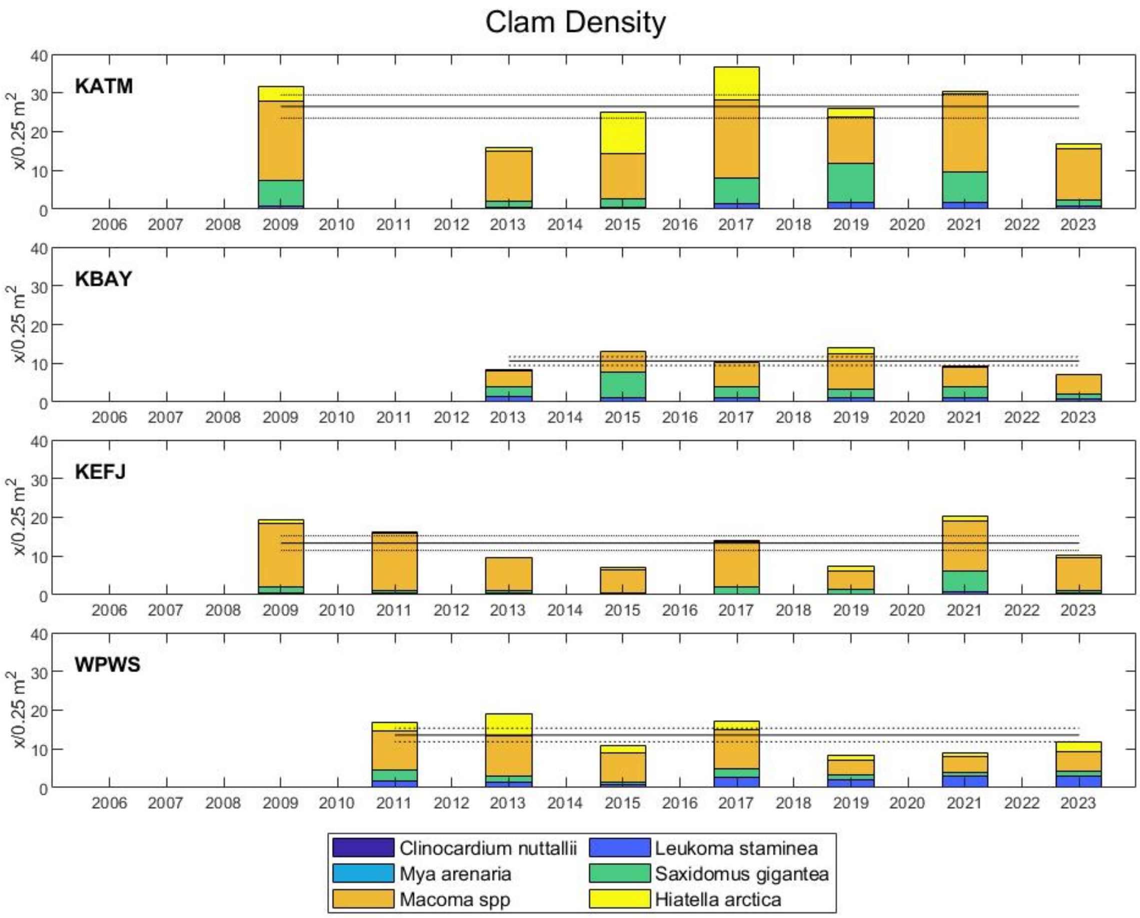

Figure 6. Clam density at the 0.0 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS). Sampling is done every other year and began in 2009 in KATM and KEFJ (KATM was not sampled in 2011), in 2011 in WPWS and 2023 in KBAY. Solid horizontal line shows long-term mean total clam density and dashed lines show ±1 standard error.

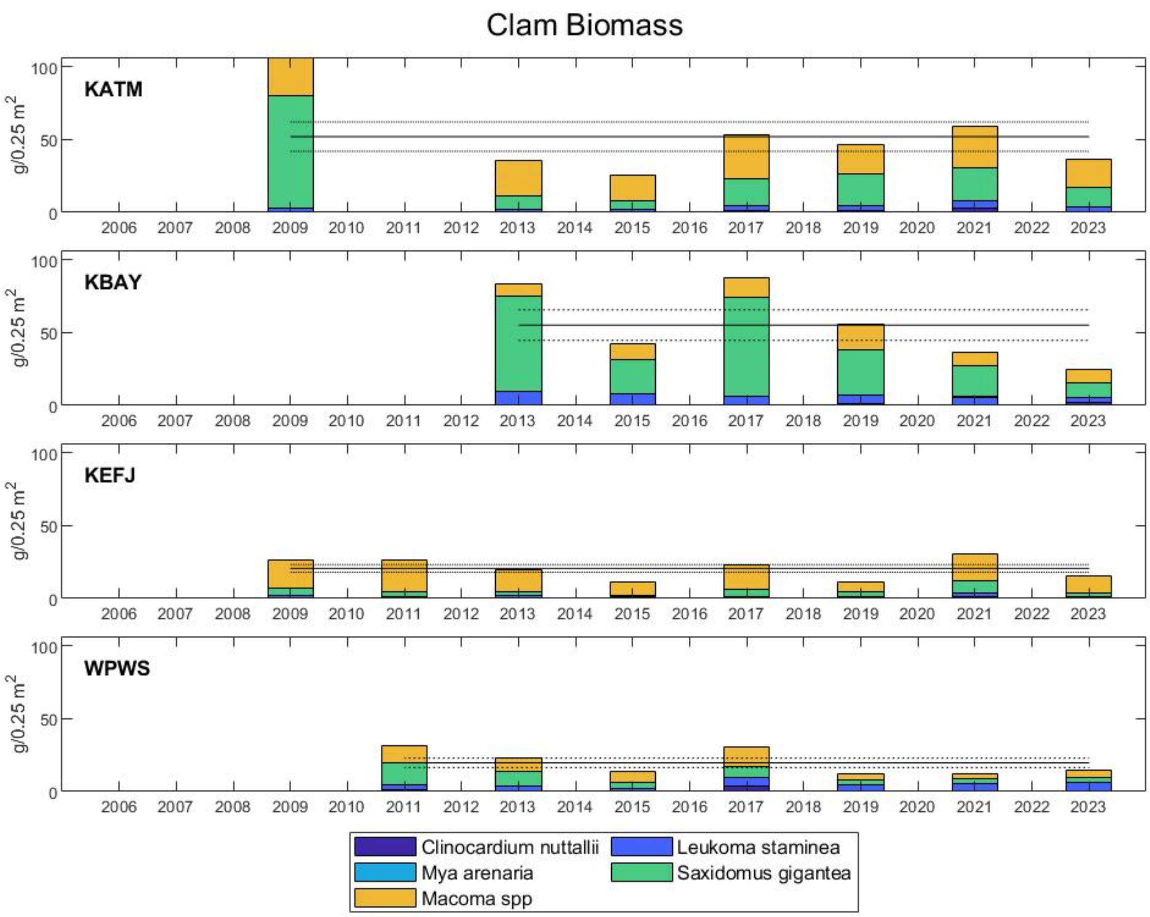

Figure 7. Clam biomass (grams of wet weight per 0.25 m^2) at the 0.0 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS). Sampling is done every other year and began in 2009 in KATM and KEFJ (KATM was not sampled in 2011), in 2011 in WPWS, and 2013 in KBAY. Solid horizontal line shows long-term mean total clam biomass and dashed lines show ±1 standard error.

Density and species composition of sea stars varied greatly among regions through 2015 but between 2015 and 2017, abundance declined across all regions (Fig. 8), likely due to sea star wasting (Konar et al. 2019), possibly exacerbated by the PMH (Harvell et al. 2019). In 2019 and 2020, there was some recruitment and recovery observed in WPWS and KEFJ. However, the sea star species thought to be least affected by sea star wasting in the northern GOA (primarily

Henricia spp. and *Dermasterias imbricata*) accounted for the positive trends through 2020. In 2023, density estimates within each region indicated that WPWS was approximately average compared to the long-term mean density (0.03 ± 0.04, mean ± se), while KATM density remained somewhat positive (higher density than average in KATM (0.13 ± 0.02, mean ± se)) and KEFJ density was strongly positive (significantly higher density than the long-term average in KEFJ (0.26 ± 0.04, mean ± se)). KBAY continues to have low abundance of sea stars at the intertidal sites, simultaneously lowering the long-term mean (0.13 ± 0.02, mean ± se). Preliminary analyses for 2023 also indicated that variability in sea star species composition among regions has increased. For example, *Pisaster* was the dominant species in KEFJ (72%) and KATM (76%). In WPWS, *Dermasterias* dominated the sea star composition at 34% followed by almost equal proportions of *Evasterias* (26%), *Pisaster* (19%) and *Pycnopodia* (20%). In KBAY, densities were still slightly lower than average; however, of the few stars observed in KBAY, *Orthasterias* was proportionally dominant at 64%. The variability in the sea star community (both by density and species composition) among regions may be an indication of the ecosystem returning to one dominated by local-scale conditions as opposed to driven by large-scale perturbations such as sea star wasting and the PMH.

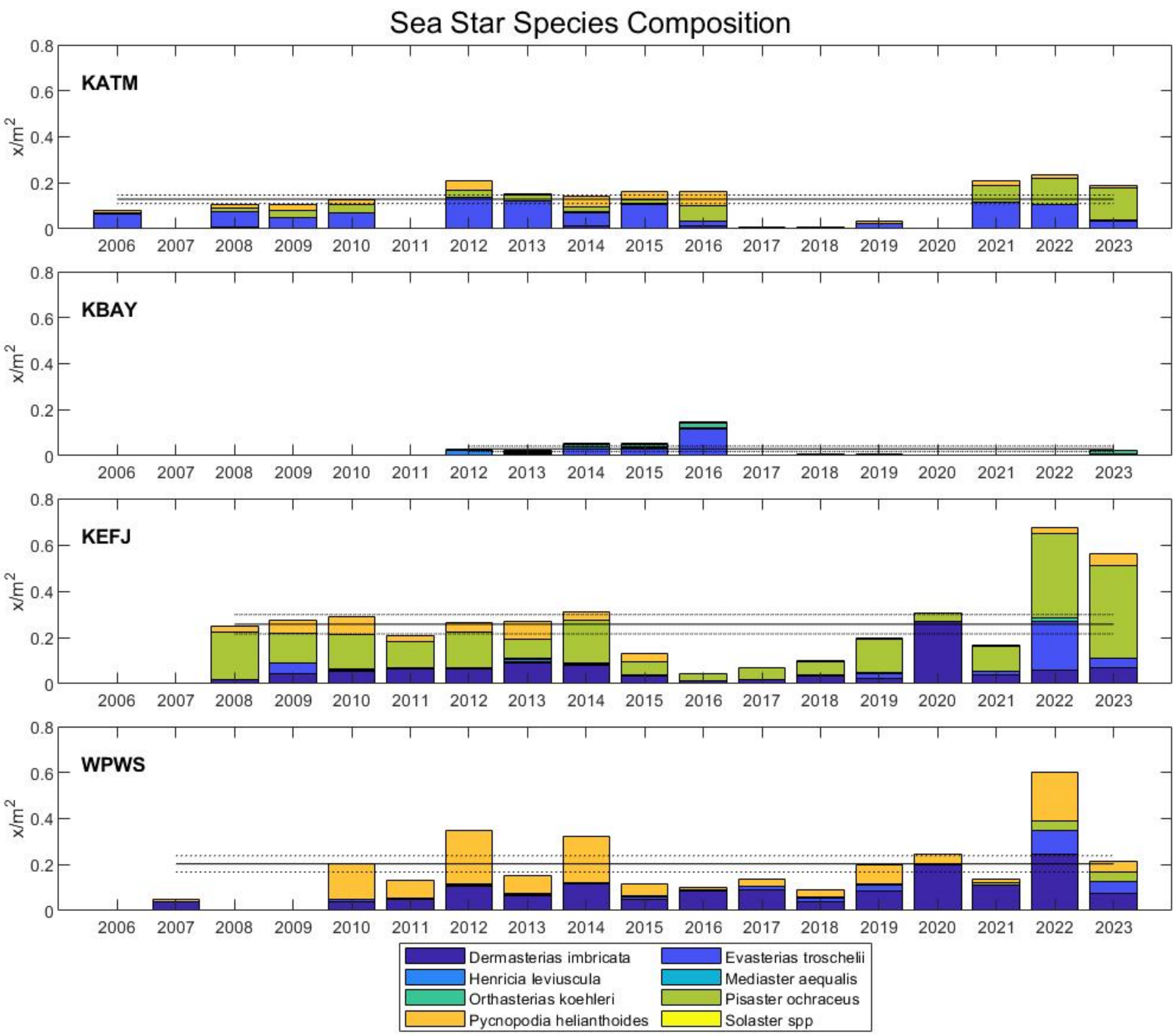

Figure 8. Sea star species composition and density across all four Gulf Watch Alaska regions through 2023: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and Western Prince William Sound (WPWS). Solid horizontal line shows long-term mean total clam biomass and dashed lines show ± 1 standard error.

Collectively, these indicators demonstrate that consistent, broad-scale responses in nearshore ecosystems occurred coincident with the PMH throughout much of the northern GOA, including areas both inside (WPWS, KBAY) and outside (KEFJ and KATM) of protected marine waters.

A comprehensive analysis of rocky intertidal community structure indicated a change of autotroph-macroalgal dominated communities to heterotroph-filter-feeder communities, ultimately resulting in homogenization of community structure across all four regions (Weitzman et al. 2021). During this same time period, we found that the loss of sea stars allowed for the increase in mussel density due to a decline in predation pressure. In addition, we note that the decline in Fucus observed across our study regions opened space in the intertidal for mussels to settle, further allowing for the increase in mussels across the Gulf. However, other factors such as predation pressure from nearshore vertebrates, shifts in primary productivity, and changes in environmental variables (salinity) may also influence mussel density (Traiger et al. 2022).

In addition to analyzing abundance, a Nearshore Component supported MSc student (Katie Corliss, University of Alaska Fairbanks (UAF), advisor Katrin Iken) used stable isotope analysis to assess the contribution of phytoplankton versus macroalgal derived carbon to three nearshore species, the black rockfish (*Sebastes melanops*), kelp greenling (*Hexagrammos decagrammus*), and the mussel. Results indicated that in the GOA, the three nearshore species derived a large majority of the carbon in their tissues from macroalgae (70-88%), compared to phytoplankton (Corliss et al. in revision). Corliss et al. also determined that the proportion of macroalgal carbon to mussels increased during the PMH, indicating that macroalgae may be an important pathway to support mussels during marine heatwaves. This work further supports the premise that macroalgae play a major role in providing the primary productivity that fuels the nearshore food web and may be especially critical as climate scenarios predict increased frequency of marine heatwaves (Gruber et al. 2021).

With these shifts in lower-trophic community structure, i.e., declines in sea stars and increases in mussels, we hypothesized that responses to the PMH by upper-trophic level species, such as sea ducks and sea otters, would likely occur. For example, we examined the response in relative abundance of marine bird benthivores, like sea ducks, to the change in prey availability documented by the Nearshore Component. In general, marine bird species reliant on benthic marine invertebrates fared better than their piscivorous counterparts foraging on the pelagic marine ecosystem, indicating the food availability for benthivores mediated negative responses to the PMH (Robinson et al. 2023). This was particularly evident for Barrows goldeneye (*Bucephala islandica*) and the black oystercatcher (*Haematopus bachmani*), both of which rely on mussels in their diet. Long-term trend data on sea otter (*Enhydra lutris*) abundance indicates that sea otter populations have increased within monitoring blocks over time and appear generally stable despite differences in total estimated abundance among blocks (Fig. 9) with no apparent response in overall abundance to the PMH. However, preliminary data analyses on sea otter diet indicate increases in mussel consumption in KATM concurrent with increases in mussel abundance (Fig. 10). This pattern may become more evident with additional analyses and incorporation of additional datasets.

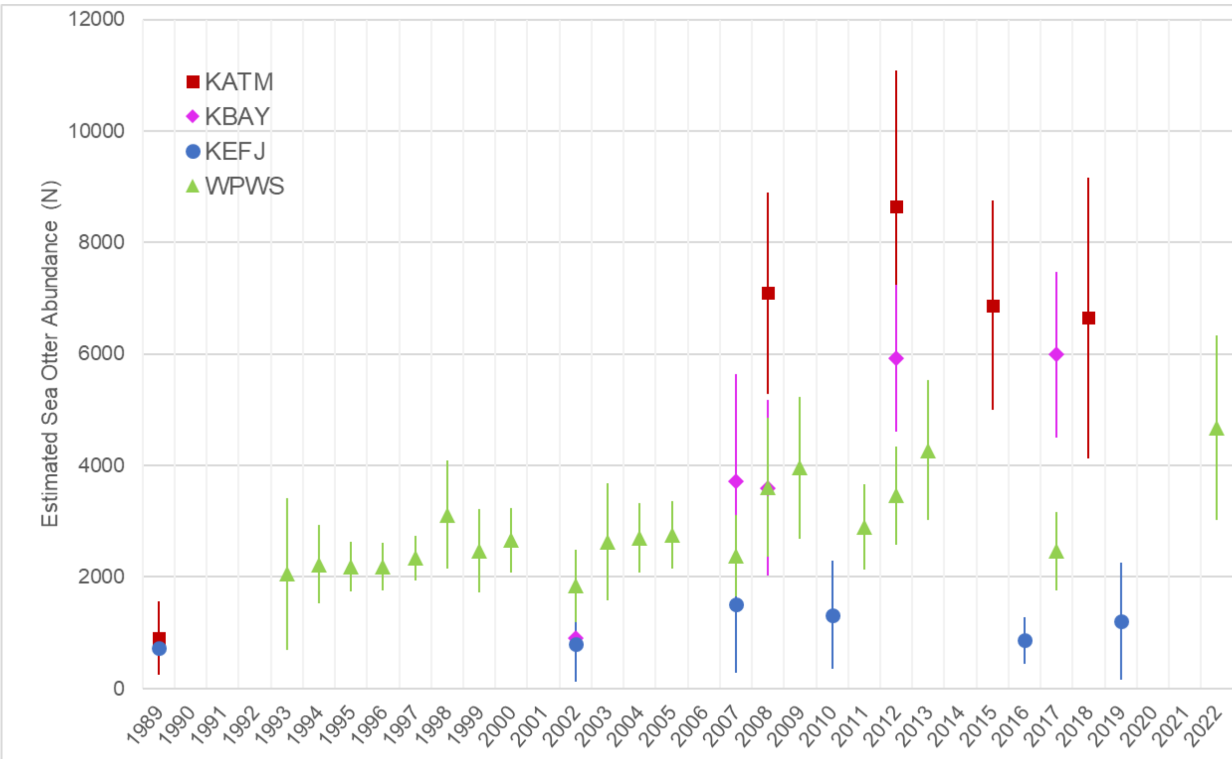

Figure 9. Mean estimated sea otter abundance (±95CI) by year for Katmai (KATM red), Kachemak Bay (KBAY purple), Kenai Fjords (KEFJ blue), and Western Prince William Sound (WPWS green).

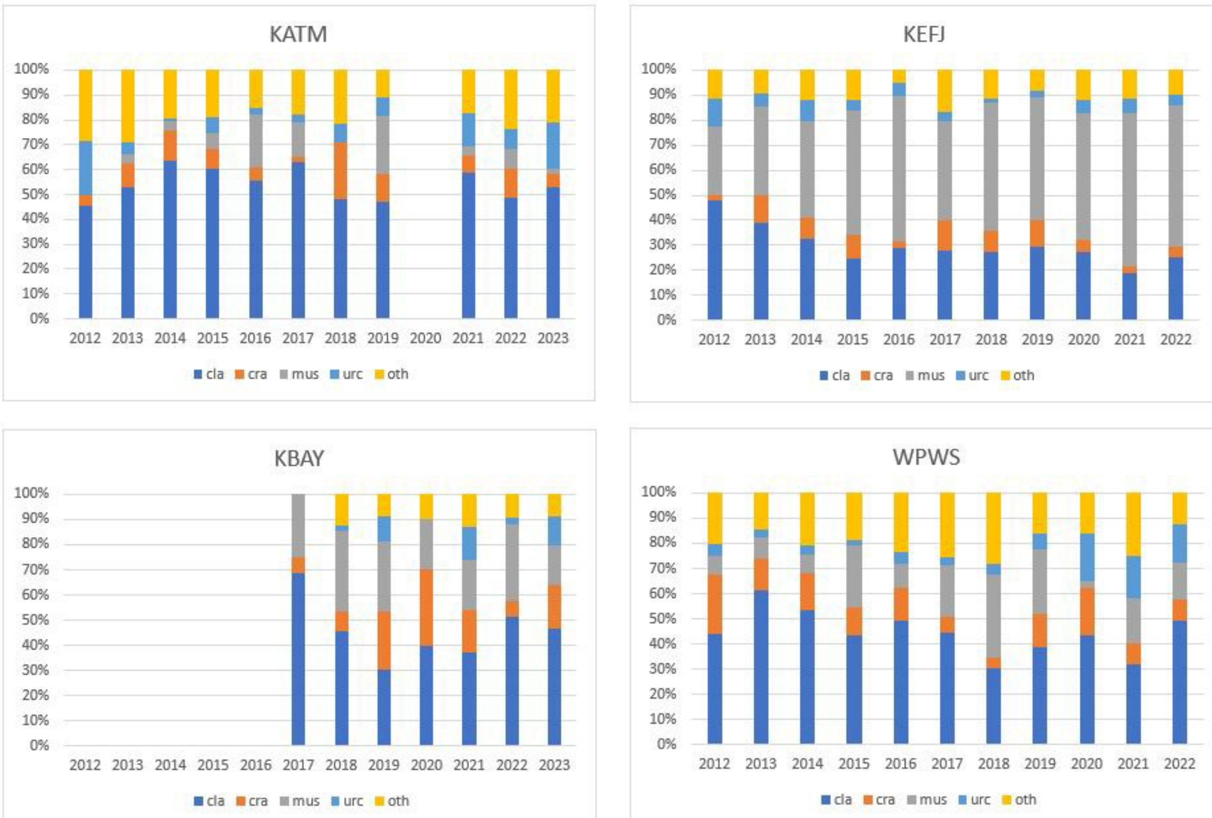

Figure 10. Prey composition of foraging bouts from Katmai National Park & Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and western Prince William Sound (WPWS) from 2012-2023. Proportions were calculated by summing the presence of each prey type for all foraging bouts observed each year. Prey types are clam (cla), crab (cra), mussel (mus), urchin (urc), and other (oth). A foraging bout consists of all dives by an individual sea otter (up to 20 dives or 1 hour of observation time) without breaks exceeding 10 minutes. Observers avoid collecting data from more than a single bout from the same sea otter. For this preliminary analysis, clams, rock jingles, and scallops are combined in the 'cla' category. The other category consists of fish, sea cucumbers, barnacles, sea stars, chitons, octopus, marine worms, marine snails, and rarely observed prey such as egg masses and sand dollars.

Intertidal and nearshore ecosystems provide valuable habitat for early life stages of various commercially important species in the GOA, including Dungeness crab (*Metacarcinus magister*), Pacific cod (*Gadus macrocephalus*), salmonids (*Oncorhynchus* spp.), and several species of rockfish (*Sebastes* spp.). Observations from 2023 indicate a possible return to more average conditions in nearshore habitats, which suggests that heatwave effects, both positive and negative, are dissipating. The divergence of community structure in rocky intertidal habitats at the regional level and reductions in large mussels that may be driven by the return of various sea star species supports our conclusion that, in the absence of broad-scale perturbations, other variables and local conditions are important drivers in the nearshore (Coletti et al. 2021). Marine heatwaves are expected to become more common and widespread as a consequence of climate change. From primary producers to top-level consumers, our studies offer insight as to the varying extent of species' responses to these wide-scale perturbation and the timescales over which effects are expressed. Further, we also hypothesize that in the long term, we may see responses of nearshore-reliant, upper trophic level species (such as sea otters and sea ducks) to shifts in prey availability from changing ocean conditions across the GOA.

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Rankin, C., D. Esler, B. Robinson, H. Coletti, and D. Green. 2023. Correlates of black oystercatcher strategies of partial migration. Oral presentation, Alaska Bird Conference, Anchorage, Alaska, December.

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Coletti, H. 2023. Varying responses to a marine heatwave. Science for Lunch with Alaska NPS. Anchorage, Alaska, February.

Kloecker, K., N. LaRoche, and H. Coletti. 2023. Nearshore marine ecosystems and sea otters. Romig Middle School STEM Day, Anchorage, Alaska, February.

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Traiger, S. 2023. "Kids2College", in person visit to Juneau Community Charter School organized by the Alaska Commission on Postsecondary Education, May.

Traiger, S. 2023. "Learning About Our Beaches" Teacher Workshop and presentation on intertidal ecology at the Dzantik'l Heeni Middle School, Juneau, Alaska, April.

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William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 3.0, September 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F7FN1498.

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Data sets and associated metadata:

Coletti, H., D. Esler, K. Iken, B. Konar, B. Ballachey, J. Bodkin, T. Dean, G. Esslinger, K. Kloecker, M. Lindeberg, D. Monson, B. Robinson, S. Traiger, and B. Weitzman. 2023. GWA nearshore component posted data. Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/7867a791-8b05-4a8c-8065-eb6e1b425f5f/project.

Nearshore Component Data are being archived with approved data repositories to ensure their availability in perpetuity. The locations of archived data files, and their associated metadata, are listed below.

Metric	DOI #
Intertidal Temperature	
KBAY, KATM, KEFJ, and WPWS Air and water T; 1 file for each year/block	https://doi.org/10.5066/F7WH2N3T
Rocky Intertidal	
KBAY2012-2015_Lottia_Count_Size.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2010-2023_Limpet_Count.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2023_Limpet_Size.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2023_Rocky_Intertidal_ Motile_Invert_Count.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2006-2023_Nucella_Katharina_Lirabuccinum_Count.csv	https://doi.org/10.5066/F7513WCB
KBAY2014-2023_Rocky_Intertidal_Substrate_Percent_Cover.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2014-2023_Rocky_Intertidal_SubstratePercentCover.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2023_Rocky_Intertidal_Percent_Cover.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2006-2023_Rocky_Intertidal_Cover.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2023_Rocky_Intertidal_Percent_Cover.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2023_Rocky_Intertidal_TopLayerPercentCover.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2023_Sea_Star_Anemone_Count.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2020-2023_Sea_Star_Size_Disease.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2023_Sea_Star_Count.csv	https://doi.org/10.5066/F7513WCB
Soft Sediment Bivalves	
KBAYKATMKEFJWPWS_2007-2023_Soft_Sediment_Bivalve_Site_Info.csv	https://doi.org/10.5066/F71834N0
KBAYKATMKEFJWPWS_2007-2023_Soft_Sediment_Bivalve_Size.csv	https://doi.org/10.5066/F71834N0
KBAYKATMKEFJWPWS_2007-2023_Soft_Sediment_Bivalve_Count.csv	https://doi.org/10.5066/F71834N0
Eelgrass	
KBAY2012-2023_Zostera_Shoot_Density.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJPWS_2008-2016_Zostera_Percent_Cover_Summary.csv	none
Mussels	
KBAY_2012-2023_Mytilus_Count_Size.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2008-2022_Mytilus_Site_Info.csv	https://doi.org/10.5066/F7FN1498
KATMKEFJWPWS_2008-2022_Mytilus_Core_Count.csv	https://doi.org/10.5066/F7FN1498

KATMKEFJWPWS_2014-2022_Mytilus_Core_Size_Frequency.csv	https://doi.org/10.5066/F7FN1498
KATMKEFJPWS_2008-2022_Mytilus_20mm_Size.csv	https://doi.org/10.5066/F7FN1498
KATMKEFJPWS_2008-2022_Mytilus_20mm_Count.csv	https://doi.org/10.5066/F7FN1498
Mussel Contaminants	
KBAYKATMKEFJPWS_2007-2018_Mussel_Contaminants.csv	https://doi.org/10.25923/dbyq-7z17
Marine Bird and Mammal Surveys	
KBAYKATMKEFJ_2006-2021_Summer_MBM_Densities_By_Transect.csv	https://doi.org/10.5066/F7416V6H
KBAYKATMKEFJ_2006-2021_Summer_MBM_Observations.csv	https://doi.org/10.5066/F7416V6H
KBAYKATMKEFJ_2006-2021_Summer_MBM_Transects.csv	https://doi.org/10.5066/F7416V6H
KATMKEFJ_2008-2021_Winter_MBM_Observations.csv	https://doi.org/10.5066/F7416V6H
KATMKEFJ_2008-2021_Winter_MBM_Densities_By_Transect.csv	https://doi.org/10.5066/F7416V6H
KATMKEFJ_2008-2021_Winter_MBM_Transects.csv	https://doi.org/10.5066/F7416V6H
Black Oystercatchers	
KBAYKATMKEFJWPWS_2006-2023Black_Oystercatcher_Transect_Summary.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2006-2023_Black_Oystercatcher_Nest_Details.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2017-2023_Black_Oystercatcher_Egg_Float_Stage.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2006-2023_Black_Oystercatcher_Chick_Diet.csv	https://doi.org/10.5066/F7WH2N5Q
Sea Otters	
KATMKEFJWPWS_2006-2021_Sea_Otter_Mortality.csv	https://doi.org/10.5066/F7H993CZ
KBAYKATMKEFJPWS_2012-2021_Sea_Otter_Foraging_Observations.csv	https://doi.org/10.5066/F7N29V4R
KBAYKATMKEFJWPWS_2006-2023_Sea_Otter_Spraint.csv	https://doi.org/10.5066/P9EDM6NL
Sea Otter Survey - Lower Cook Inlet including Kachemak Bay - 2017	https://doi.org/10.5066/P9Q4DA3T
Sea Otter Survey - Katmai - 2008-19	https://doi.org/10.5066/F7930SG7
Sea Otter Survey - Kenai Fjords - 2002-16	https://doi.org/10.5066/F7CJ8BN7
Sea Otter Survey - Northern and Eastern Prince William Sound - 2014	https://doi.org/10.5066/P9OG6SR5
Sea Otter Survey - Outer Kenai Peninsula including Kenai Fjords - 2019	https://doi.org/10.5066/P9TTJVBC
Sea Otter Survey - Western Prince William Sound - 2017	https://doi.org/10.5066/P9KNKOG1

Additional Products not listed above:

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About Sea Otters. Field Notes. Prince William Sound Science Center. Field Notes - Prince William Sound Science Center (pwssc.org)

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3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

The nearshore project works with Prince William Sound Science Center (PWSSC) on a regular basis. Principal investigators (PIs) Iken and Konar, University of Alaska Fairbanks (UAF), are subawardees on the National Oceanic and Atmospheric Administration (NOAA) grant for *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) funds administered by PWSSC. Nearshore team members also coordinate meetings, reporting, and other activities through PWSSC. PIs from the Nearshore component have given presentations on GWA-LTRM at teacher workshops hosted by the Alaska SeaLife Center.

EVOSTC Long-Term Research and Monitoring Projects

The nearshore project is a component of the GWA-LTRM program, which is funded by the EVOSTC. In addition to collaborations within the Nearshore component, PIs are collaborating with Environmental Drivers component PIs to develop a synthesis manuscript on the effects of meroplankton abundance on intertidal benthic abundance of mussels, barnacles, and sea stars in Prince William Sound and Kachemak Bay. Current and past Environmental Drivers PIs (Rob Campbell, PWSSC, and Kris Holderied, NOAA) are providing data and expertise. Preliminary work on Prince William Sound data was presented at the Alaska Marine Science Symposium in 2023 and a paper is currently in prep. The Nearshore component has also coordinated with the Pelagic component, particularly the killer whale project (23120114-M), on UAF PhD student Hannah Myers work on killer whale acoustics.

EVOSTC Mariculture Projects

Mariculture ReCon is a multiyear program funded by the EVOSTC with overlapping researchers and study regions with the Nearshore component of GWA-LTRM. Within Kachemak Bay, Mariculture ReCon and GWA-LTRM will share logistics and field crews.

Members of GWA-LTRM and U. S. Fish & Wildlife Service (H. Coletti, R. Kaler, K. Kloecker, B. Weitzman, P. Schuette, and A. Kirkham) participated in coordination and logistics planning with Mike Rehberg (Alaska Department of Fish and Game [ADF&G]) and Anne Schaefer (PWSSC) to ensure comparability with GWA-LTRM and to build collaborative engagement.

EVOSTC Education and Outreach Projects

The Nearshore component supports a "Floating teacher workshop" every summer during the sampling period in Kenai Fjords National Park. The program is supported by the National Park Service (NPS) Ocean Alaska Science and Learning Center and Alaska Geographic with the goal of bringing teachers and scientists together in the field. Teachers learn about field sampling methods and create appropriate curriculum.

PIs from the Nearshore component have given presentations on GWA-LTRM at teacher workshops hosted by the Alaska SeaLife Center. Similar to the Floating Teacher Workshops, the goal is for teachers to learn from scientists and others while building appropriate curriculum to take back to their classrooms.

PI Traiger worked with the CORaL Network and PWSSC staff to develop an outreach video based on a recent publication: Evidence of Increased Mussel Abundance Related to the Pacific Marine Heatwave and Sea Star Wasting (https://www.youtube.com/watch?v=AZex4dYvsHU).

PI Coletti worked with the PWSSC to develop a Field Note on sea otters.

Individual EVOSTC Projects

Nearshore PIs coordinate with the Data Management program to ensure data are reviewed for quality control and assurance and posted to the Gulf of Alaska Data Portal annually within required timeframes. The Nearshore component under GWA-LTRM does not currently coordinate with other individually funded EVOSTC projects.

Trustee or Management Agencies

In addition to the logistical, administrative, and in-kind support that the NPS, U. S. Geological Survey (USGS), NOAA, and UAF have provided to ensure success of the GWA-LTRM Nearshore component, there are several additional projects with Trustee and management agencies that the Nearshore component of GWA-LTRM has collaborated with. Below are several recent examples. We expect to continue these kinds of related projects in the future.

NOAA Fisheries

The Nearshore component (all PIs) contributed nearshore indices to NOAA Fisheries for the annual GOA Ecosystems Considerations Report 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 Nearshore ecosystem responses to glacial inputs

Nearshore GWA-LTRM PIs (Esler, Coletti, Robinson, and Weitzman), in collaboration with NPS, have initiated work 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 KEFJ. 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 work relies heavily on GWA-LTRM nearshore monitoring data and will build on our understanding of nearshore marine processes.

NPS

Nearshore GWA-LTRM PIs (Ballachey, Bodkin, Monson, Kloecker, and Coletti) are working with NPS and others to examine 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 GWA-LTRM 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. There are several components which include (but are not limited to): (1) brown bear fitness and use of marine resources, (2) status of bivalves (clams and mussels), (3) wolf use of marine resources, (4) sea otter diet and abundance and (5) an integrated outreach program. We (GWA-LTRM

Nearshore component) assisted with the collection of a variety of samples from the coast of KATM as well as support sea otter forage data collection in and outside KBAY. 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.

Bureau of Ocean Energy Management

GWA-LTRM PIs (Monson, Kloecker, both USGS ASC) work closely with a USGS, Alaska Science Center Nearshore Marine Ecosystems project funded by the Bureau of Ocean Energy Management that is conducting sea otter research in Cook Inlet. This Cook Inlet Sea Otter Research (CISOR) project focuses on quantifying sea otter abundance, distribution and habitat use in lower Cook Inlet (LCI). Specific CISOR activities that dovetail well with GWA-LTRM nearshore studies include seasonal aerial sea otter surveys in LCI, LCI benthic habitat surveys and sea otter foraging, and activity observation along the east side of LCI. All these activities intersect and overlap to various degrees at Kachemak Bay while also providing additional data outside the GWA-LTRM study areas that will aid in interpreting and contrasting GWA-LTRM data sets. CISOR PIs include Dan Monson, Kim Kloecker, and Nicole Laroche, who also participate in GWA-LTRM field work and data analysis.

U.S. Fish and Wildlife Service Marine Mammals Management

The Nearshore component (all PIs) contributed sea otter abundance data to U.S. Fish and Wildlife Service, Marine Mammals Management for incorporation into updated Stock Assessment Reports (SARs) for the Southcentral and Southeast Alaska stocks of northern sea otters. The updated SARs provide managers with minimum population estimates and suggested harvest management limits of sea otters, based on the population status and regional harvest patterns over the recent history.

Alaska Native and Local Communities

Nearshore PIs (several) will be working with Chugach Regional Resources Commission (CRRC). Nearshore PIs (Coletti and Weitzman) presented data specific to nearshore ecosystems, including changes to nearshore resources and predators, including sea otters, during their March 2023 subsistence gathering.

Nearshore PIs and U.S. Fish and Wildlife Service are collaborating with CRRC on research across the Chugach region to promote consistency and comparability of data collection by CRRC and available baseline information provided by GWA-LTRM. Should survey efforts be undertaken, CRRC and Nearshore PIs are coordinating to develop complementary survey designs that can all be incorporated into future Stock Assessment Reports.

PI Traiger was a mentor to two high school students during spring semester 2023 as part of the Sealaska Heritage Institute Mentorship Program.

4. Response to EVOSTC Review, Recommendations and Comments:

While there are no new EVOSTC reviews, recommendations, or comments for FY23, the Nearshore component is providing additional responses to comments from May 2021. Below are original Science Panel comments and updated PI responses. For previous responses to comments, please see the FY22 annual report for this project.

May 2021 EVOSTC Science Panel Comment: The PIs propose to extend ongoing monitoring of the nearshore food web across the Gulf of Alaska over the next 10 years to provide continued evaluation of the status and trends of more than 200 species, including most of those injured by the 1989 Exxon Valdez oil spill. Their goals are to determine 1) the current structure of the nearshore food web and the spatial and temporal scales over which changes occur, 2) whether changes are from broad-scale environmental variation or local perturbations and 3) whether the magnitude and timing of these changes correspond to those occurring in the pelagic ecosystem. The objectives and sampling protocol remain the same for this continuing proposal. Their six objectives are to 1) determine status and detect patterns of change in a suite of nearshore species and communities, 2) identify the temporal and spatial extent of these changes, 3) identify potential causes of change in biological communities, including those related to climate change, 4) evaluate the current status of injured resources in oiled areas and identify factors potentially affecting present and future trends in population status, 5) involve a graduate student to determine the impacts of environmental drivers on the performance of key taxa and trophic relationships and 6) communicate results to the public and resource managers to preserve nearshore resources.

We recognize the importance of the nearshore monitoring component and continuing the project as proposed. We appreciated the level of synthesis presented at the recent FY20 science workshop as well as the productivity of the group as presented in the proposal.

PI Response: Our integration and synthesis efforts continued in FY23 with multiple peer-reviewed papers, several reports and many presentations that encompassed our findings throughout the study area and across the nearshore ecosystem from intertidal resources to sea otters and brown bears.

May 2021 EVOSTC Science Panel Comment: Please clarify the number of new graduate students proposed. The timeline indicates that two grad students are being requested. However, objective 5 states that a grad student will be involved and the executive summary states that a grad student and postdoc will be involved; a postdoc is not included in the timeline or elsewhere in the proposal.

PI Response: *At this time, we have a recently graduated MSc student (Katie Corliss) who completed her thesis examining the role of macroalgal carbon to the nearshore food web using stable isotope analysis in the spring of 2023 (under K. Iken - UAF). Her thesis has been submitted to a peer reviewed journal and is currently in revision. We have a current MSc student (Max Hughes; under B. Konar – UAF) who will complete his work examining cascading effects of sea star wasting on rocky intertidal communities in the spring of 2024.*

5. Budget:

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5-YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$354,453	$367,215	$377,899	$264,718	$271,730	$1,636,014	$450,593
Travel	$14,837	$14,895	$14,955	$15,017	$15,080	$74,784	$53,776
Contractual	$170,600	$173,400	$191,065	$191,600	$189,600	$916,265	$170,877
Commodities	$26,000	$26,975	$27,999	$22,730	$21,000	$124,704	$61,846
Equipment	$25,937	$37,247	$38,417	$33,645	$34,935	$170,181	$34,255
Indirect Costs (varies by proposer)	$21,670	$22,897	$23,507	$24,137	$24,788	$116,999	$21,301
SUBTOTAL	$613,497	$642,629	$673,842	$551,847	$557,133	$3,038,947	$792,648
General Administration (9% of subtotal)	$55,215	$57,837	$60,646	$49,666	$50,142	$273,505	N/A
PROJECT TOTAL	$668,712	$700,465	$734,488	$601,513	$607,275	$3,312,453	
Other Resources (In-Kind Funds)	$572,400	$577,500	$567,700	$573,100	$578,700	$2,869,400	

Above is the combined budget for federal PIs (NPS and USGS) and UAF. The Nearshore Component was underspent in FY22 relative to the proposed budget for 2 reasons: (1) late arrival of funds from the EVOSTC required higher cost-share contributions from DOI agencies (e.g., contracted boat charters), and (2) funds carried over from FY17-21 were used to cover a significant proportion of FY22 costs within all Nearshore Component entities. Nearshore Component residual funds from FY17-21 (resulting from a reduction in field efforts during the COVID-19 global pandemic) were EVOSTC-approved for carry-over and expenditure during

FY22. Unspent funding from FY22 will continue to support staffing and field operations for nearshore monitoring activities for the duration of the program.