Exxon Valdez **Oil Spill Trustee Council**

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

Annual Project Reporting Form

Project Number: 22120114-H

Project Title: Nearshore ecosystems in the Gulf of Alaska

Principal Investigator(s):
Heather Coletti, National Park Service
Dan Esler, U.S. Geological Survey, Alaska Science Center
Katrin Iken, University of Alaska Fairbanks
Brenda Konar, University of Alaska Fairbanks
Brenda Ballachey, U.S. Geological Survey Emeritus, Alaska Science Center
James Bodkin, U.S. Geological Survey Emeritus, Alaska Science Center
George Esslinger, U.S. Geological Survey, Alaska Science Center
Kim Kloecker, U.S. Geological Survey, Alaska Science Center
Mandy Lindeberg, National Oceanic and Atmospheric Administration
Dan Monson, U.S. Geological Survey, Alaska Science Center
Brian Robinson, U.S. Geological Survey, Alaska Science Center
Sarah Traiger, U.S. Geological Survey, Alaska Science Center
Benjamin Weitzman, U. S. Fish and Wildlife Service, Marine Mammal Management

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

Submission Date (Due March 1 immediately following the reporting period): 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.**

---

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 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 these to the public and to resource managers to conserve 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 static and dynamic drivers allows accurate and defensible measures of change and supports management and policy needs addressing nearshore resources.

In 2022, 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. in review – EVOS 2017-2021 final report) through 2021. For the 2022 annual report, we are reporting on intertidal water temperature and several intertidal indicators that represent key nearshore ecosystem components of primary production and prey abundance. Upper-trophic level predator trends through 2022 are still being analyzed.

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 Pacific marine heatwave in the Gulf of Alaska was expressed in intertidal zones in addition to open ocean environments (Danielson et al. 2022). While temperatures had appeared to cool and return to normal across all regions later in 2017 and into 2018, warmer than average intertidal water temperatures were again experienced in 2019 across all four study regions, followed by a cooling during the early part of 2020, particularly in the western blocks of KBAY and KATM. Temperatures appeared to return to the long-term average across all regions early in 2021, followed by cooling across all regions into the summer months of 2021, which has persisted through the first half of 2022 in all regions, except KATM.

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 Pacific marine heatwave (PMH; 2015-2019), we found that macroalgal foundation species declined across the study regions, illustrated here by the decline in *Fucus distichus* at both the 0.5 m and 1.5 m tidal elevation. 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 (Figs. 2 and 3). 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 cover in 2017 (Figs. 2 and 3). In 2022, algal cover in KATM continues to be lower than average at the 1.5 m. The variability in community structure and increases in macroalgae following the PMH may be an indication of the ecosystem returning to one dominated by local-scale conditions as opposed to driven by large-scale perturbations.

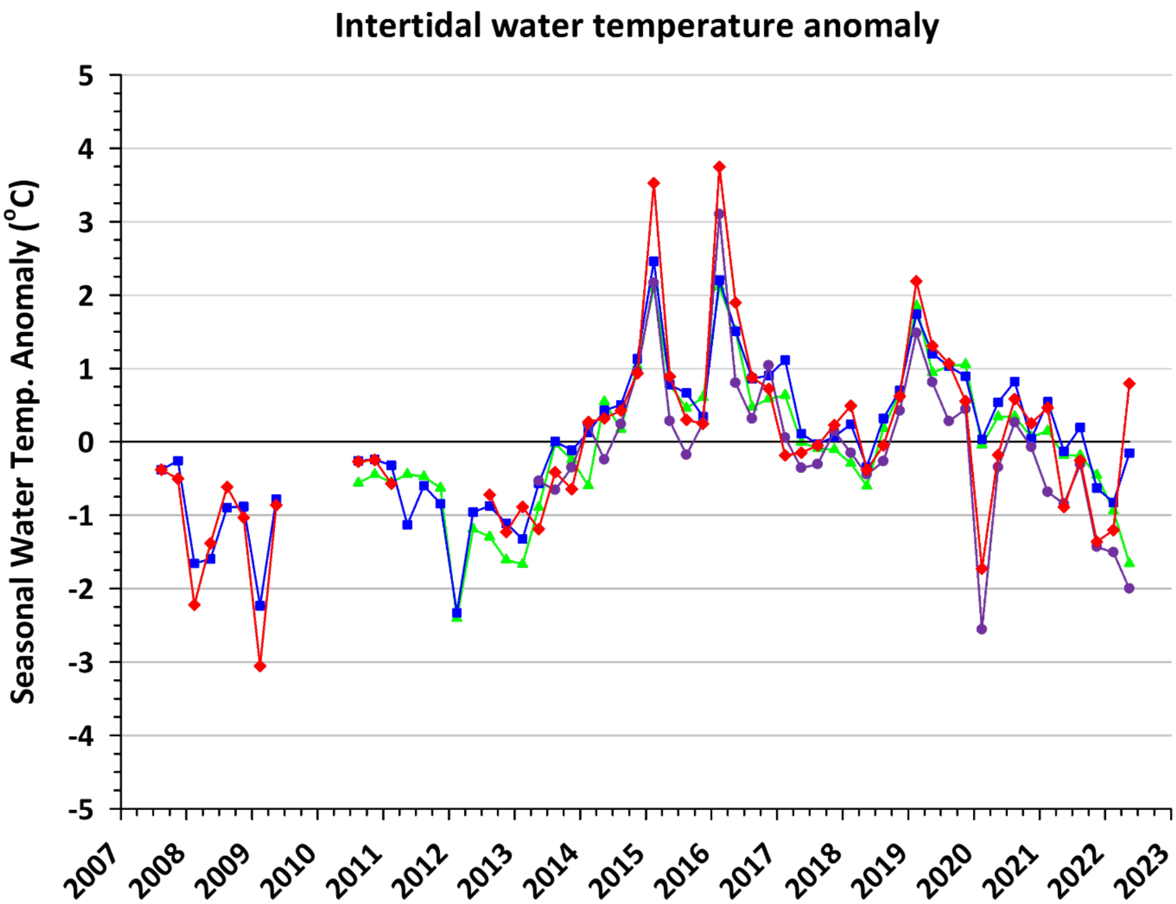

Figure 1. Seasonal intertidal water temperature anomalies at the 0.5 m tide level four regions of the western Gulf of Alaska (west of 144°W), western Prince William Sound (WPWS; 2011-2022), Kenai Fjords National Park (KEFJ; 2008-2022), Kachemak Bay (KBAY; 2013-2022), and Katmai National Park adjacent to Shelikof Strait (KATM; 2006-2022). Long tick marks indicate the start of the calendar year (January) while short tick marks are quarterly divisions within the year (April, July, October).

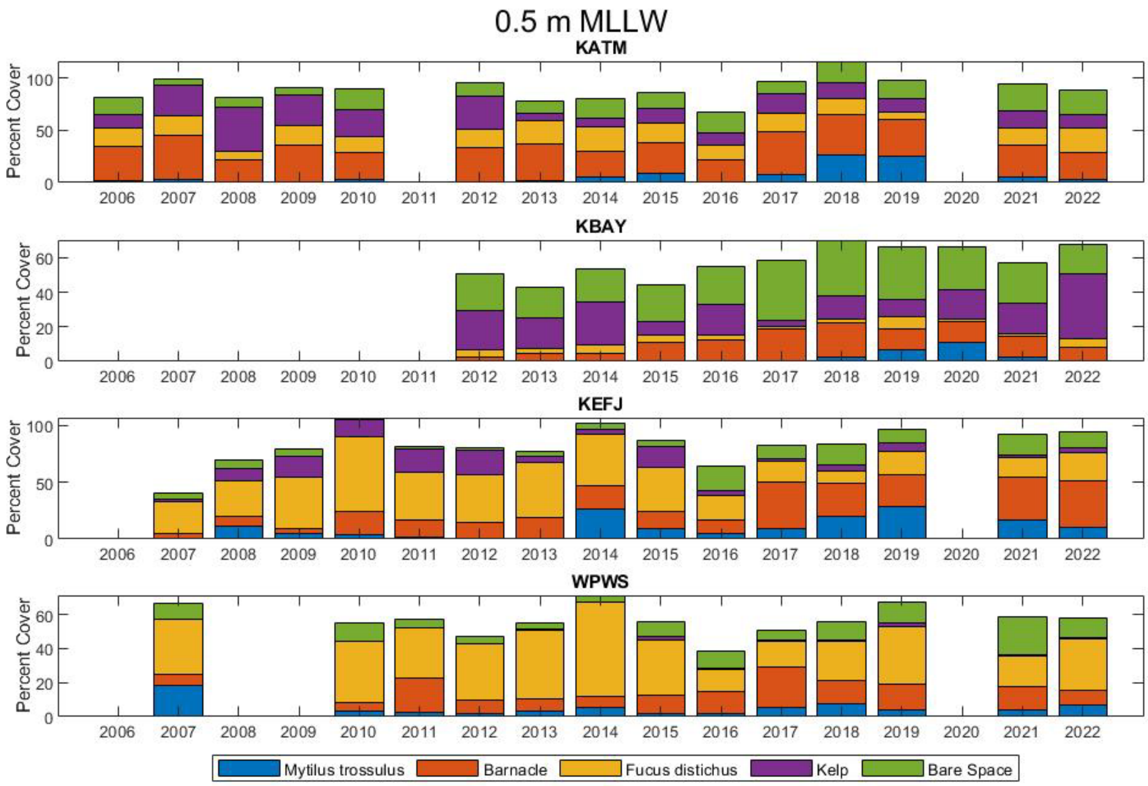

Figure 2. Percent cover of Mytilus trossulus, barnacles, Fucus distichus, kelps, and bare substrate at the 0.5 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and western Prince William Sound (WPWS), 2006-2022.

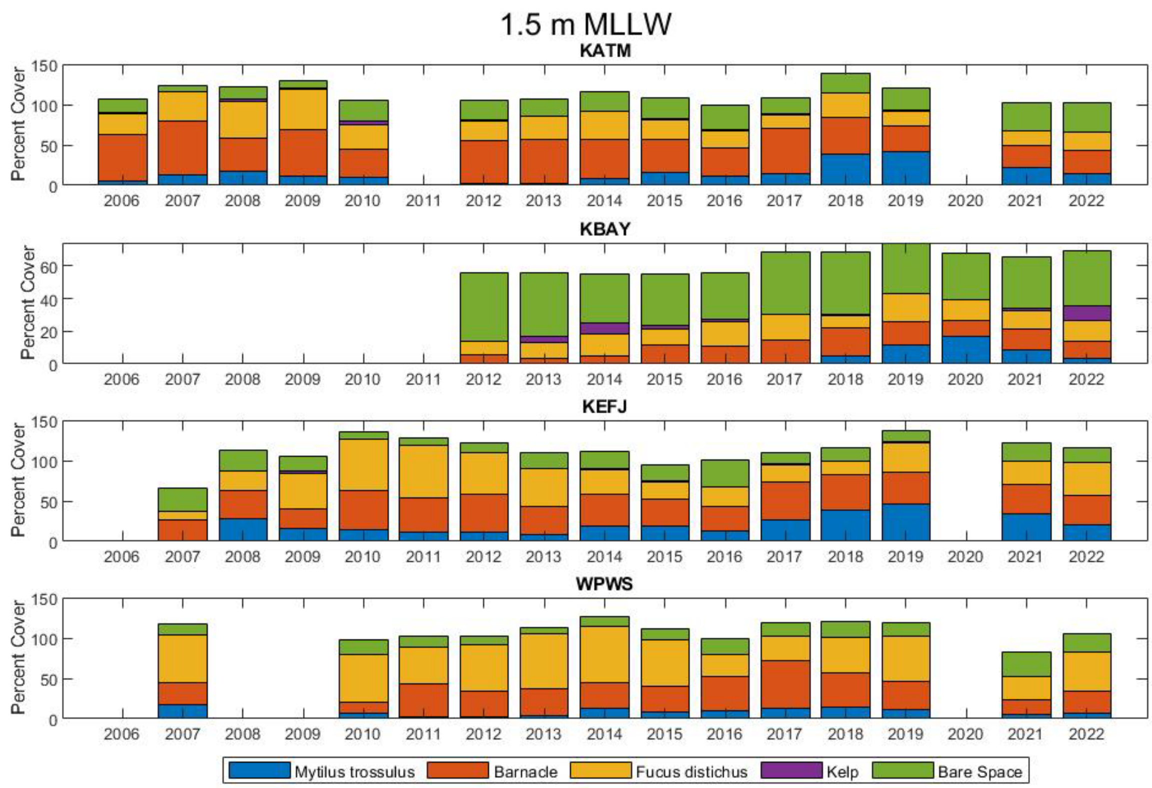

Figure 3. Percent cover of Mytilus trossulus, barnacles, Fucus distichus, kelps, and bare substrate at the 1.5 m tidal elevation across the four Gulf Watch Alaska regions: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and western Prince William Sound (WPWS), 2006-2022.

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 marine heatwave through 2019, although not consistent in timing across regions (Fig. 4). In 2021, it appears that large mussel density 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 positive values in KEFJ. 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, other variables and local conditions are important drivers of mussel abundance (Bodkin et al. 2018). Evaluation of drivers of mussel abundance, specifically variation in temperature and sea star abundance, was the subject of a recent Nearshore Component synthesis paper (Traiger et al. 2022).

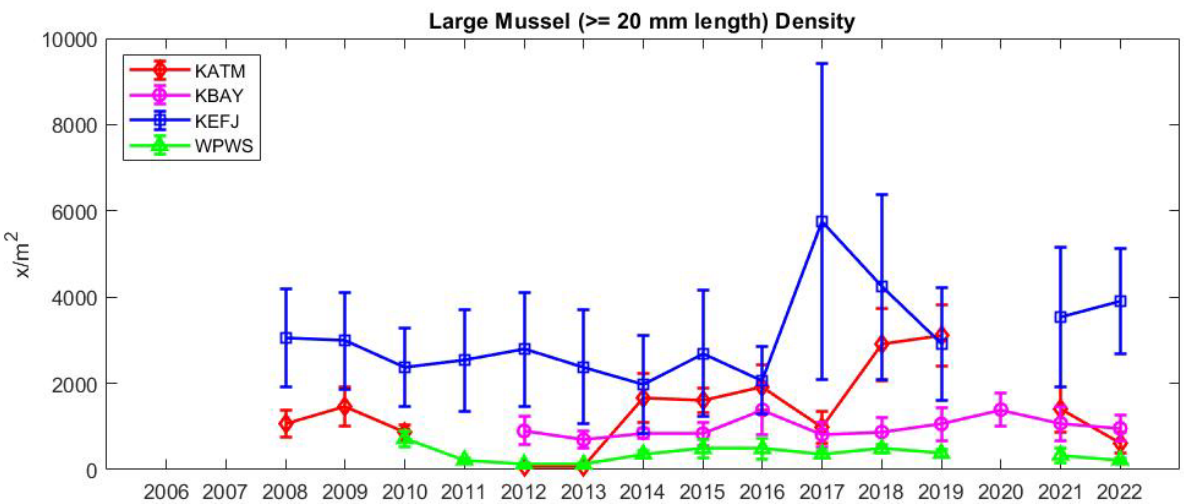

Figure 4. Large (>= 20 mm) mussel (Mytilus trossulus) density across four regions at mussel sites through 2022. Sampling started in 2008 in Kenai Fjords National Park (KEFJ), Katmai National Park and Preserve (KATM), and western Prince William Sound (WPWS). Kachemak Bay (KBAY) mussel bed sampling began in 2012. Error bars indicate ±1SE.

Sea star abundance, density, and diversity varied greatly among regions through 2015. Between 2015 and 2017, abundance declined and remained low across all regions through 2018, likely due to sea star wasting (Konar et al. 2019). In 2019, there was some recruitment and recovery in WPWS, which persisted through 2020. However, the sea star species thought to be least affected by sea star wasting in the northern GOA (primarily *Henricia* and *Dermasterias*) continued to be present and accounted for the positive anomalies. The positive trend in WPWS and KEFJ during 2020 surveys was driven by high numbers of *Dermasterias* (81% and 88% of observed sea stars, respectively). The previously dominant sea stars (primarily *Pycnopodia, Evasterias*, and *Pisaster*) continued to be absent (or rare) in many of the Nearshore Component monitoring regions, although one site in WPWS in 2020 showed some recovery potential with many small *Pycnopodia*. However, in 2021 all regions except KATM again were trending downward (Fig. 5). The star species documented in KATM that accounted for the positive trends were primarily *Evasterias* (53%), Pisaster (35%) and *Pycnopodia* (10%), indicating a potential recovery of sea stars along the KATM coast but not elsewhere across the Gulf. This may help explain the slightly negative trend in large mussel density observed in KATM in 2021 and 2022 (Fig. 4) but fails to explain this pattern elsewhere in the GOA. In 2022, KEFJ and WPWS showed strong positive anomalies dominated by *Pisaster* (54%) and *Evasterias* (31%) in KEFJ and *Dermasterias* (41%) and *Pycnopodia* (35%) in WPWS. The star species documented in KATM that accounted for the positive anomaly in 2022 were primarily *Evasterias* (45%) and *Pisaster* (48%). Sea star densities in KBAY have not yet recovered to 2016 and earlier values;

however, it was also one of the last regions to succumb to sea star wasting. 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.

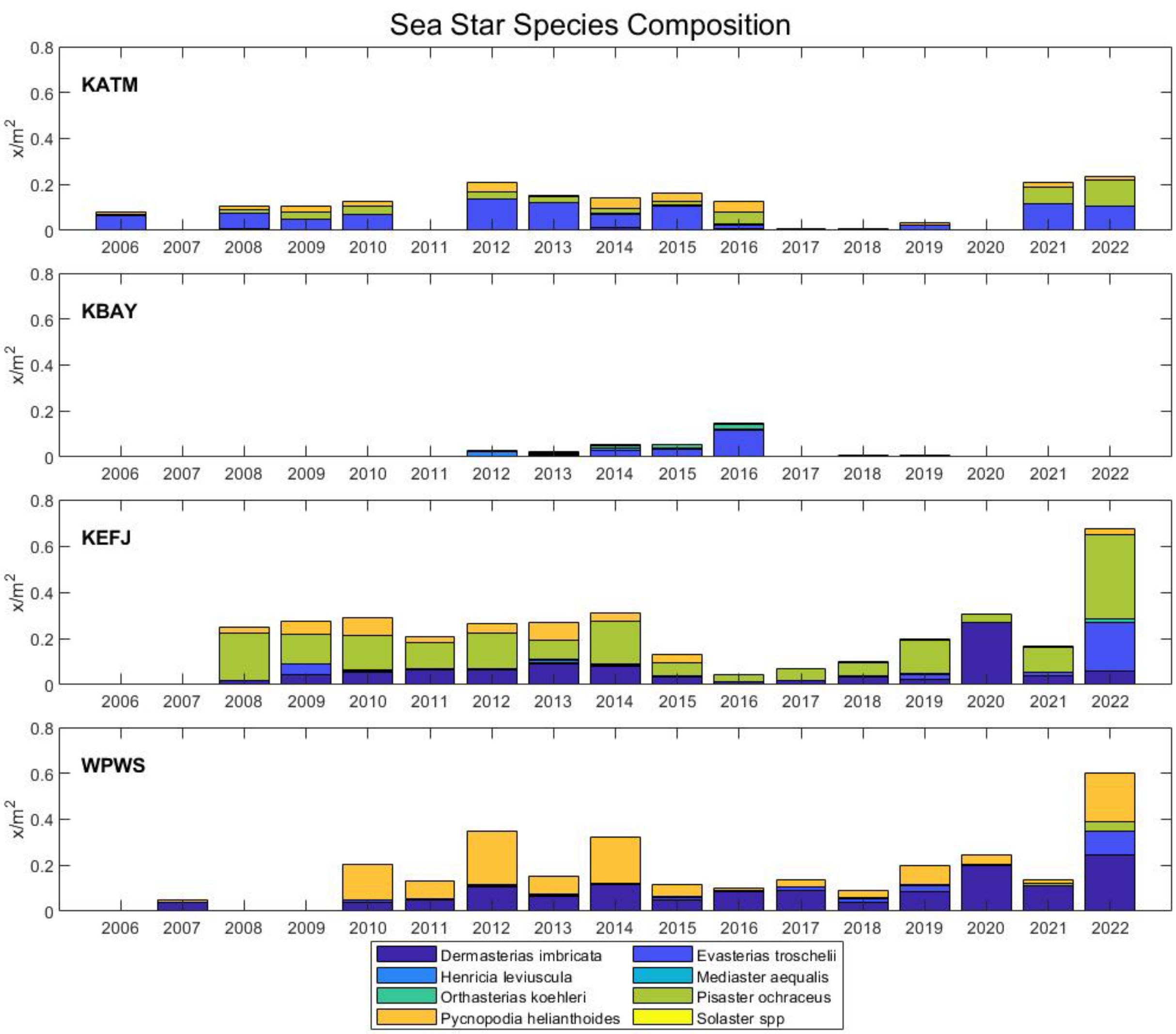

Figure 5. Sea star species composition and density across all four Gulf Watch Alaska regions through 2022: Katmai National Park and Preserve (KATM), Kachemak Bay (KBAY), Kenai Fjords National Park (KEFJ), and western Prince William Sound (WPWS).

Collectively, these indicators demonstrate that consistent, broad-scale perturbations of nearshore ecosystems occurred coincident with the Pacific marine heatwave throughout much of the northern Gulf of Alaska, including areas both inside (WPWS, KBAY) and outside (KEFJ, KATM) of protected marine waters. A comprehensive analysis of rocky intertidal community structure was completed, indicating a change of autotroph-macroalgal dominated communities to heterotroph-filter-feeder communities, ultimately resulting in a 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 up 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).

Intertidal and nearshore ecosystems provide valuable habitat for early life stages of various commercially important species in the Gulf of Alaska, including Dungeness crab, Pacific cod, salmonids and several species of rockfish. Observations from 2022 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 site 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. 2022). 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 Gulf of Alaska.

Bodkin, J. L., H. A. Coletti, B. E. Ballachey, D. H. Monson, D. Esler, and T. A. Dean. 2018. Variation in abundance of Pacific Blue Mussel (*Mytilus trossulus*) in the Northern Gulf of Alaska, 2006–2015. Deep Sea Research Part II: Topical Studies in Oceanography 147:87-97.

Coletti, H., J. Bodkin, T. Dean, K. Iken, B. Konar, D. Monson, D. Esler, M. Lindeberg, and R. Suryan. 2022. Intertidal Ecosystem Indicators in the Northern Gulf of Alaska in Zador, S. G., and E. M. Yasumiishi. 2022. Ecosystem Status Report 2021: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. https://apps-afsc.fisheries.noaa.gov/refm/docs/2021/GOAecosys.pdf

Coletti, H., D. Esler, B. Ballachey, J. Bodkin, G. Esslinger, K. Kloecker, D. Monson, B. Robinson, S. Traiger, K. Iken, B. Konar, T. Dean, M. Lindeberg, and B. Weitzman. 2023. In Review. Gulf Watch Alaska: Nearshore Ecosystems in the Gulf of Alaska. *Exxon Valdez* Oil Spill Restoration Project 2017-2021 Final Report (Restoration Project 21120114-H), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Danielson, S. L., T. D. Hennon, D. H. Monson, R. M. Suryan, R.W. Campbell, S. J. Baird, K. Holderied, and T. J. Weingartner. 2022. Temperature variations in the northern Gulf of Alaska across synoptic to century-long time scales. Deep Sea Research Part II: Topical Studies in Oceanography https://doi.org/10.1016/j.dsr2.2022.105155

Konar, B., T. J. Mitchell, K. Iken, H. Coletti, T. Dean, D. Esler, M. Lindeberg, B. Pister, and B. Weitzman. 2019. Wasting disease and environmental variables drive sea star assemblages in the northern Gulf of Alaska. Journal of Experimental Marine Biology and Ecology https://doi.org/10.1016/j.jembe.2019.151209

Traiger, S. B., J. L. Bodkin, H. A. Coletti, B. Ballachey, T. Dean, D. Esler, K. Iken, B. Konar, M. Lindeberg, D. Monson, B. Robinson, R. M. Suryan, and B. P. Weitzman. 2022. Evidence of increased mussel abundance related to the Pacific marine heatwave and sea star wasting. Marine Ecology https://doi.org/10.1111/maec.12715

Weitzman B., B. Konar, K. Iken, H. Coletti, D. Monson, R. Suryan, T. Dean, D. Hondolero, and M. Lindeberg. 2021. Changes in rocky intertidal community structure during a marine heatwave in the Northern Gulf of Alaska. Frontiers in Marine Science https://doi.org/10.3389/fmars.2021.556820

2. Products:

Peer-reviewed publications:

Bowen L., S. Knowles, K. Lefebvre, M. St. Martin, M. Murray, K. Kloecker, D. Monson, B. Weitzman, B. Ballachey, H. Coletti, S. Waters, and C. Cummings. 2022. Divergent gene expression profiles in Alaskan sea otters: an indicator of chronic domoic acid exposure? Oceans 3:401-418. https://doi.org/10.3390/oceans3030027

Coletti, H., G. Hilderbrand, J. Bodkin, B. Ballachey, J. Erlenbach, G. Esslinger, M. Hannam, K. Kloecker, B. Mangipane, A. Miller, D. Monson, B. Pister, K. Griffin, K. Bodkin, and T. Smith. 2022. Where land and sea meet: brown bears and sea otters. Frontiers in Young Minds https://doi.org/10.3389/frym.2022.715993

Danielson, S. L., T. D. Hennon, D. H. Monson, R. M. Suryan, R.W. Campbell, S. J. Baird, K. Holderied, and T. J. Weingartner. 2022. Temperature variations in the northern Gulf of Alaska across synoptic to century-long time scales. Deep Sea Research Part II: Topical Studies in Oceanography https://doi.org/10.1016/j.dsr2.2022.105155

Dawson, M. N., P. J. Duffin, M. Giakoumis, L. M. Schiebelhut, R. Beas-Luna, K. L. Bosley, R. Castilho, C. Ewers-Saucedo, K. A. Gavenus, A. Keller, B. Konar, J. L. Largier, J. Lorda, C. M. Miner, M. M. Moritsch, S. A. Navarrete, P. T. Raimondi, S. B. Traiger, M. Turner, and J. P. Wares. *In Review.* Almost a decade of death… and other dynamics: deepening perspectives on the diversity and distribution of sea stars and wasting. The Biological Bulletin.

Dowling, A., B. Konar, and K. Iken. *In press.* Influence of environmental conditions on *Mytilus trossulus* size frequency distributions in two glacially influenced estuaries. Estuaries and Coasts.

Monson, D., R. L. Taylor, G. V. Hilderbrand, J. A. Erlenbach, H. A. Coletti, K. A. Kloecker, G. G. Esslinger, and J. L. Bodkin. 2022. Brown bear–sea otter interactions along the Katmai coast: terrestrial and nearshore communities linked by predation. Journal of Mammalogy https://doi.org/10.1093/jmammal/gyac095

Siegert D., B. Konar, M. R. Lindeberg, S. Saupe, and K. Iken. 2022. Trophic structure of rocky intertidal communities in two contrasting high-latitude environments. Deep Sea Research Part II: Topical Studies in Oceanography https://doi.org/10.1016/j.dsr2.2022.105050

Traiger, S. B., J. L. Bodkin, H. A. Coletti, B. Ballachey, T. Dean, D. Esler, K. Iken, B. Konar, M. Lindeberg, D. Monson, B. Robinson, R. M. Suryan, and B. P. Weitzman. 2022. Evidence of increased mussel abundance related to the Pacific marine heatwave and sea star wasting. Marine Ecology https://doi.org/10.1111/maec.12715

Reports:

Coletti, H., D. Esler, B. Ballachey, J. Bodkin, G. Esslinger, K. Kloecker, D. Monson, B. Robinson, S. Traiger, K. Iken, B. Konar, T. Dean, M. Lindeberg, and B. Weitzman. 2023 In Review. Gulf Watch Alaska: Nearshore Ecosystems in the Gulf of Alaska. *Exxon Valdez* Oil Spill Restoration Project 2017-2021 Final Report (Restoration Project 21120114-H), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Coletti, H., D. Esler, B. Konar, K. Iken, B. Ballachey, J. Bodkin, T. Dean, G. Esslinger, K. Kloecker, M. Lindeberg, D. Monson, B. Robinson, S. Traiger and B. Weitzman. 2022. Gulf Watch Alaska: Nearshore Ecosystems in the Gulf of Alaska. *Exxon Valdez* Oil Spill

Restoration Project 2021 Annual Report (Restoration Project 17120114-H), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Coletti, H., J. Bodkin, T. Dean, K. Iken, B. Konar, D. Monson, D. Esler, M. Lindeberg, and R. Suryan. 2022. Intertidal Ecosystem Indicators in the Northern Gulf of Alaska in Zador, S. G., and E. M. Yasumiishi. 2022. Ecosystem Status Report 2022: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. https://apps-afsc.fisheries.noaa.gov/refm/docs/2022/GOAecosys.pdf

Esslinger, G. G., B. H. Robinson, D. H. Monson, R. L. Taylor, D. Esler, B. P. Weitzman, and J. Garlich-Miller. 2021. Abundance and distribution of sea otters (*Enhydra lutris*) in the Southcentral Alaska stock, 2014, 2017 and 2019. U.S. Geological Survey Open-File Report 2021–1122, 19p. https://doi.org/10.3133/ofr20211122.

Green, D., C. Rankin, L. Ware, D. Esler, B. Robinson, and H. Coletti. 2022. Movement ecology of Black Oystercatchers. in Alaska Shorebird Group. 2022. Annual summary compilation: new and ongoing studies or initiatives focused on Alaska shorebirds. Alaska Shorebird Group, Anchorage, AK.

Mearns, A., D. Janka, S. Pegau, R. Campbell, and B. Robinson. 2022. Three-decades of rocky intertidal photo series documenting interannual variability in western Prince William Sound. Proceedings of the Forty-Fourth Arctic and Marine Oil Spill Program Technical Seminar, Environment and Climate Change Canada, Ottawa, ON, Canada. pp. 230-242.

Robinson, B., D. Esler, and H. Coletti. 2022. Long-term monitoring of Black Oystercatchers in the Gulf of Alaska. in Alaska Shorebird Group. 2022. Annual summary compilation: new and ongoing studies or initiatives focused on Alaska shorebirds. Alaska Shorebird Group, Anchorage, AK.

Popular articles:

Coletti, H. 2022. How Alaskan Marine Ecosystems Responded to a Massive Heatwave. Park Science. Volume 36, Number 2, Winter 2022 (December 30, 2022). https://www.nps.gov/articles/000/how-alaskan-marine-ecosystems-responded-to-a-massive-heatwave.htm

Traiger, S. 2022. Will the sun (flower sea stars) come out tomorrow? Assessing recovery of the Sunflower sea star after wasting disease: In The State of Kachemak Bay 2021. National Centers for Coastal Ocean Science. coastalscience.noaa.gov

Conferences and workshops:

Corliss, K., K. Iken, V. von Biela, H. Coletti, D. Esler, D. Monson, J. Bodkin, and B. Robinson. 2023. Trophic pathways and their relationship to growth in nearshore consumers across the northern Gulf of Alaska. Oral presentation, Alaska Marine Science Symposium, January Anchorage, AK.

Hughes, M., K. Iken, S. Traiger, and B. Konar. 2023. The direct and cascading effects of sea star wasting on rocky intertidal communities. Poster presentation, Alaska Marine Science Symposium, January, Anchorage, AK.

Mearns, A., R. Campbell, D. Janka, S. Pegau, and B. Robinson. Volunteer-driven annual photography documents the range of natural variability of rocky intertidal communities in western Prince William Sound. Poster presentation, Alaska Marine Science Symposium. January 2023. Anchorage, AK.

Reynolds, E., and B. Konar. 2023. Sea otter interactions with mariculture. Poster presentation, Alaska Marine Science Symposium, January, Anchorage, AK.

Robinson, B., H. Coletti, B. Ballachey, J. Bodkin, G. Esslinger, and D. Esler. 2022. Spatial and temporal variation in nearshore marine bird communities in a warming Gulf of Alaska. Pacific Seabird Group, February.

Robinson, B., H. Coletti, and D. Esler. 2022. Turning up the heat: Investigating effects of the Pacific marine heatwave on Black Oystercatcher diets in the Gulf of Alaska. International Wader Study Group Annual Meeting, Szeged, Hungary, September.

Traiger, S., J. Bodkin, R. Campbell, H. Coletti, D. Esler, K. Holderied, C. McKinstry, D. Monson, M. Renner, B. Robinson, R. Suryan, and B. Weitzman. 2023. Does larval supply matter? Relating meroplankton variability with benthic invertebrate abundance in Prince William Sound. Alaska Marine Science Symposium, Anchorage, January.

Wright, S.K., D. Lowry, R. Gustafson, J. Hyde, M. Lindeberg, S. Lonhart, M. Neuman, D. Stevenson, N. Tolimieri, and S. Traiger. Sunflower Sea Star: Update on the Endangered Species Act Status Review. Alaska Marine Science Symposium. January 2023. Anchorage, Alaska

Public presentations:

Corliss, K. 2022. Otoliths and marine food webs. BEST Homeschool Presentation.

Traiger, S. 2022. Recent changes in the Gulf of Alaska nearshore ecosystem revealed by long-term monitoring. Seminar August 26th, USGS Central Midwest Science Center.

Weitzman, B. 2022. Sea Otters Across Alaska: Perspectives on Population Change through long-term monitoring and advancing methods. UAF College of Fisheries & Ocean Sciences Fall Seminar, November 11.

<u>*Data and/or information products developed during the reporting period:*</u>

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, and University of Alaska Fairbanks - College of Fisheries and Ocean Sciences, 2017, Black Oystercatcher Nest and Diet Data from Kachemak Bay, Katmai National Park and Preserve, Kenai Fjords National Park, and Prince William Sound, 2006-2022 (ver 2.0, September 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F7WH2N5Q.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2016. Intertidal mussel (Mytilus) data from Prince 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.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2022, Rocky intertidal data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 1.0, September 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F7513WCB.

U.S. Geological Survey Alaska Science Center, National Park Service Southwest Alaska Inventory and Monitoring Network, University of Alaska Fairbanks, 2022. Sea otter spraint data from Kachemak Bay, Katmai National Park and Preserve, Kenai Fjords National Park and Prince William Sound: U.S. Geological Survey data release, https://doi.org/10.5066/P9EDM6NL.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, and University of Alaska Fairbanks - College of Fisheries and Ocean Sciences, 2016, Intertidal temperature data from Kachemak Bay, Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 3.0, August 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F7WH2N3T.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, and University of Alaska Fairbanks, 2018, Intertidal soft-sediment bivalves from Prince William Sound, Kachemak Bay, Katmai National Park and

Preserve, and Kenai Fjords National Park (ver 2.0, September 2022): U.S. Geological Survey data release, https://doi.org/10.5066/F71834N0.

Data sets and associated metadata:

Nearshore Component data are organized and presented coherently on the publicly available Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/7867a791-8b05-4a8c-8065-eb6e1b425f5f/project

Also, 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_2010-2022_Limpet_Count.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2022_Limpet_Size.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2022_Rocky_Intertidal_ Motile_Invert_Count.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2006-2022_Nucella_Katharina_Lirabuccinum_Count.csv	https://doi.org/10.5066/F7513WCB
KBAY2014-2022_Rocky_Intertidal_Substrate_Percent_Cover.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2014-2022_Rocky_Intertidal_SubstratePercentCover.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2022_Rocky_Intertidal_Percent_Cover.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2006-2022_Rocky_Intertidal_Cover.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2022_Rocky_Intertidal_Percent_Cover.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2022_Rocky_Intertidal_TopLayerPercentCover.csv	https://doi.org/10.5066/F7513WCB
KBAY2012-2022_Sea_Star_Anemone_Count.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJWPWS_2020-2022_Sea_Star_Size_Disease.csv	https://doi.org/10.5066/F7513WCB
KATMKEFJWPWS_2006-2022_Sea_Star_Count.csv	https://doi.org/10.5066/F7513WCB
Soft Sediment Bivalves	
KBAYKATMKEFJWPWS_2007-2021_Soft_Sediment_Bivalve_Site_Info.csv	https://doi.org/10.5066/F71834N0
KBAYKATMKEFJWPWS_2007-2021_Soft_Sediment_Bivalve_Size.csv	https://doi.org/10.5066/F71834N0
KBAYKATMKEFJWPWS_2007-2021_Soft_Sediment_Bivalve_Count.csv	https://doi.org/10.5066/F71834N0

Metric	DOI #
Eelgrass	
KBAY2012-2022_Zostera_Shoot_Density.csv	https://doi.org/10.24431/rw1k1o
KATMKEFJPWS_2008-2016_Zostera_Percent_Cover_Summary.csv	none
Mussels	
KBAY_2012-2022_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_2006-2021_Black_Oystercatcher_Transect_Summary.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2006-2021_Black_Oystercatcher_Nest_Details.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2017-2021_Black_Oystercatcher_Egg_Float_Stage.csv	https://doi.org/10.5066/F7WH2N5Q
KBAYKATMKEFJWPWS_2006-2021_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_2006-2021_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

Metric	**DOI #**
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:

NOAA-NCCOS. 2022. Kachemak Bay Ecosystem Assessment Project. https://arcg.is/1Hza1r0

NPS. 2022. Brown bear – sea otter interactions. https://www.nps.gov/articles/000/bears-and-otters.htm

NPS. 2022. Mussel abundance increased after sea star disease. https://www.nps.gov/articles/000/mussel-abundance.htm

NPS. 2022. How sea otters may be impacted by harmful algal blooms. https://www.nps.gov/articles/000/domoic-acid-and-sea-otters.htm

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

There were no collaborative projects with the Alaska SeaLife Center. The Nearshore team collaborates with Prince William Sound Science Center (PWSSC) at a programmatic level because members of the Gulf Watch Alaska-Long-Term Research and Monitoring (GWA-LTRM) program management team work for PWSSC and PWSSC is the fiscal agent for the University of Alaska's grant through the National Oceanic and Atmospheric Administration. The GWA-LTRM Nearshore Component has expressed interest in supporting the mariculture ReCon project (see below) and working with CoRAL network, both of which include PWSSC principal investigators (PIs).

EVOSTC Long-Term Research and Monitoring Projects

GWA-LTRM Nearshore PIs are collaborating with GWA-LTRM Environmental Drivers 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. Environmental Driver PIs (Rob Campbell, Kris Holderied) are providing data and expertise. Preliminary work on Prince William Sound data was presented at Alaska Marine Science Symposium in 2023.

EVOSTC Mariculture Projects

Mariculture ReCon is a multiyear program funded by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) with overlapping researchers and study regions with GWA-LTRM. Within Kachemak Bay, Mariculture ReCon and GWA-LTRM will be able to 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) and Anne Schaefer (PWSSC) to ensure comparability with GWA-LTRM and build collaborative engagement.

EVOSTC Education and Outreach Projects

The Nearshore Component developed sea star surveys for the Juneau school district "Sea Week." These surveys were designed to be like the GWA-LTRM protocols but adapted to two different age ranges (K-6, 7-8). The Nearshore Component designed datasheets, field ID guides, and written protocols for teachers and students, and participated in a teacher workshop. This activity was used during several field trips to Juneau area beaches in 2022.

The Nearshore Component has participated in meetings with members of the CORaL network funded by EVOSTC to evaluate ways the programs can work together on outreach activities.

Individual EVOSTC Projects

The Nearshore Component works with the Data Management program to ensure data collected in the nearshore ecosystem are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes. Nearshore Component PIs will work with other individually funded EVOSTC projects if collaborative efforts make sense based on data collected. In addition, Nearshore Component PIs have worked with the following projects that collected data relevant to individually funded EVOSTC projects:

- Amy Dowling, an MSc student at the University of Alaska Fairbanks (UAF) under GWA-LTRM PI Brenda Konar, analyzed data from both GWA-LTRM and the National Science Foundation sponsored program Alaska EPSCoR to examine how environmental conditions influence blue mussel size frequencies in Kachemak Bay and Lynn Canal. This was work she completed for her MS, which she also just published (Dowling et al. *In Press*).
- Emily Reynolds, an MSc student at UAF under GWA-LTRM PI Brenda Konar, is examining sea otter interactions with oyster farms in Kachemak Bay. Emily is funded by Alaska Sea Grant but will share the data she is collecting with GWA-LTRM and may

also use some of the GWA sea otter foraging data to complement her analyses. The GWA-LTRM sea otter foraging sites represent the "control sites" with no mariculture farms.

Trustee or Management Agencies

In addition to the logistical, administrative, and in-kind support that the National Park Service (NPS), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (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 Gulf of Alaska 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, 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 proposed work relies heavily on GWA nearshore monitoring data and will build on our understanding of nearshore marine processes.

NPS

Nearshore GWA PIs (Ballachey, Bodkin, Monson, Kloecker, 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 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 Alaska Science Center) 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 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.

US Fish & Wildlife Service Marine Mammals Management

The Nearshore Component (all PIs) contributed sea otter abundance data to US Fish & Wildlife Service (USFWS), Marine Mammals Management for incorporation into updated Stock Assessment Reports (SAR) for the Southcentral and Southeast Alaska stocks of northern sea otters (*Enhydra lutris kenyoni*). 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.

Native and Local Communities

GWA-LTRM Nearshore Component PIs (several) will be working with Chugach Regional Resources Commission (CRRC) and presenting data specific to nearshore ecosystems, including changes to nearshore resources and predators, such as sea otters during their 2023 Subsistence meeting.

In addition, Nearshore Component PIs and USFWS are collaborating with CRRC on research across the Chugach region to ensure consistency and comparability of data collection by CRRC and baseline information, provided by GWA-LTRM. Should survey efforts be undertaken, CRRC and GWA-LTRM PIs are coordinating to develop complementary survey designs that can all be incorporated into future Stock Assessment Reports.

4. Response to EVOSTC Review, Recommendations and Comments:

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: The PIs thank the EVOSTC Science Panel for their continued support and recognition of the importance of the nearshore environment. As a single project with many PIs, we will continue to strive for integration and synthesis within and beyond the nearshore component. Our integration and synthesis efforts continued in FY22 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: We propose to have MS level grad students (one student at any given time) throughout the entirety of the project, which we estimate to be 4-5 MS students over the total of the proposal timeline. At this time, we have one MSc student (Katie Corliss) who will complete her thesis examining the role of macroalgal carbon to the nearshore foodweb using stable isotope analysis in the spring of 2023 (under K. Iken - UAF). We have another 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.

The postdoc position will be filled for the first three years of the project (FY22-24) to continue to support analysis and synthesis of nearshore data streams with the entire program. We added specific text in the proposal to objective 5 (see Section 4, Project Design, B. Procedural and Scientific Methods, pages 11-12) to clarify. We also modified the timeline (Section 7, Project Status of Scheduled Accomplishments, pages 26-27) to include the number of MS students anticipated (a minimum of 4, but potential for 5) and added the postdoc position from FY22 through FY24.

September 2021 EVOSTC Science Panel Comment: The goal of this continuing proposal is to extend ongoing monitoring of the nearshore food web across the Gulf of Alaska over the next 10 years for evaluating the status and trends of more than 200 nearshore species, including most of those injured by the 1989 *Exxon Valdez* oil spill. The objectives and sampling protocol remain the same. The PIs have been productive, and we recommend continued funding of this important component of the Long-term Research and Monitoring program.

PI Response: We thank the EVOSTC Science Panel for their recommendation.

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	$186,783
Travel	$14,837	$14,895	$14,955	$15,017	$15,080	$74,784	$18,020
Contractual	$170,600	$173,400	$191,065	$191,600	$189,600	$916,265	$95,611
Commodities	$26,000	$26,975	$27,999	$22,730	$21,000	$124,704	$22,363
Equipment	$25,937	$37,247	$38,417	$33,645	$34,935	$170,181	$6,313
Indirect Costs (varies by proposer)	$21,670	$22,897	$23,507	$24,137	$24,788	$116,999	$2,701
SUBTOTAL	$613,497	$642,629	$673,842	$551,847	$557,133	$3,038,947	$331,791
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	

COMMENTS:
This is the combined budget for the individual Coletti/Esler and Iken/Konar budgets that follow.

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.

FY22-26	**Project Number: 22120114-H** **Project Title: Nearshore** **PI(s): Coletti (NPS), Esler (USGS), & Iken & Konar (UAF)**	**SUMMARY TABLE**

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.