***Exxon Valdez* Oil Spill Trustee Council**

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

Annual Project Reporting Form

Project Number: 22120114-D

Project Title: Continuous Plankton Recorder monitoring of plankton populations on the Alaskan Shelf

Principal Investigator(s): Clare Ostle, Marine Biological Association, UK

Sonia Batten, North Pacific Marine Science Organization

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

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

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1. Summary of Work Performed:

Fortunately the continuous plankton recorder (CPR) sampling has not been impacted by the COVID-19 pandemic; since CPR sampling is semi-autonomous the ships have been comfortable in taking the equipment on board and deploying it. All 2022 tows were successfully completed as planned, we had to cut the sampling season short as the cargo vessel (the Matson Kodiak) had to go into dry dock in July. To account for this shorter sampling season, we started towing the CPR in the Gulf of Alaska earlier than normal (March), to achieve four full months of samples collected.

The CPR was deployed on four transects in 2022, monthly from March to June. All four transects were successful in their sampling. Location of the ship's transect continues to be consistent from month to month (Fig. 1). At the time of writing, provisional plankton data for March to June are available and the samples are undergoing quality control. Annual sea surface temperature in 2022 was warmer than average (over the period 2004 - 2022) in the Alaskan shelf region (Fig. 2).

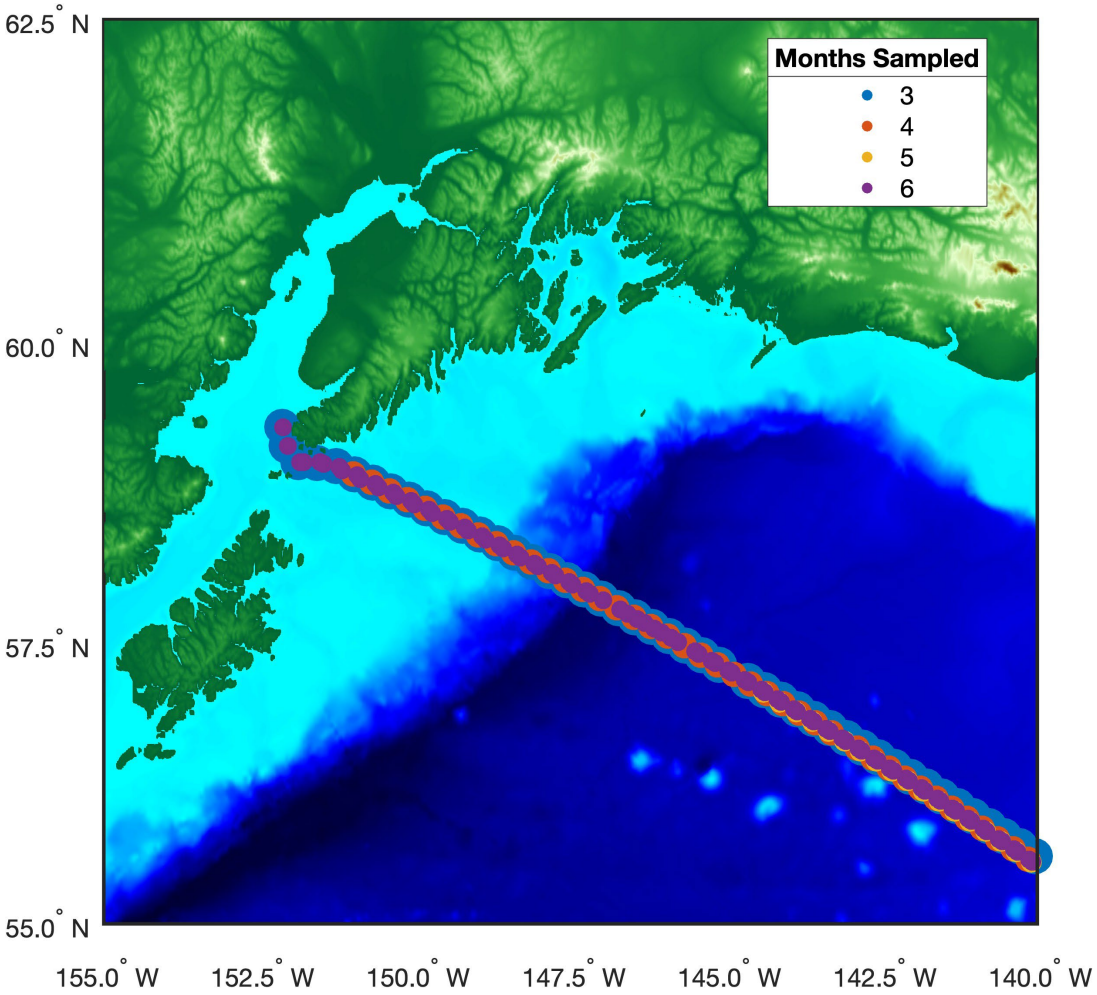

Figure 1. Location of monthly continuous plankton recorder transects in 2022. Sampling occurred from March to June, after which the cargo vessel went into dry dock.

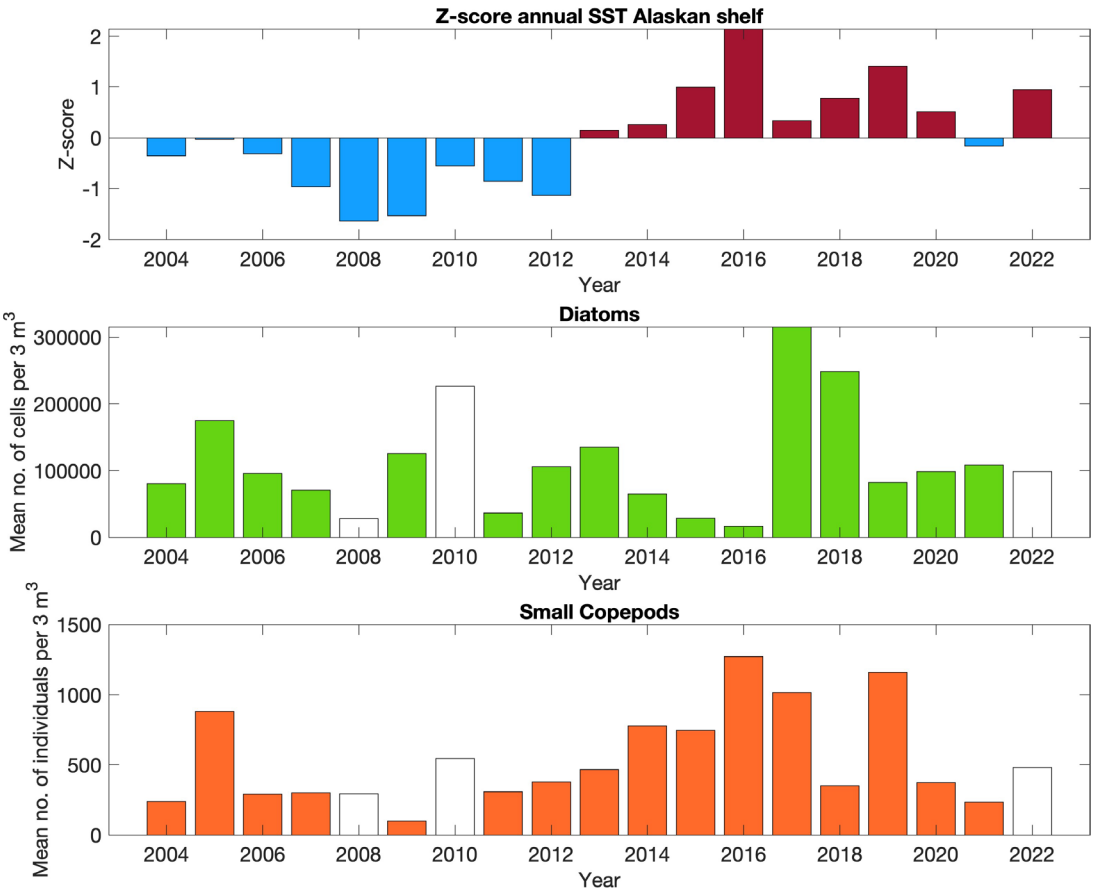

Figure 2. Annual standardised z-score sea surface temperature (SST) within the Alaskan Shelf region (Fig. 1) from 2004 to 2022. Where positive z-score values signify values above the mean (red) and negative values are below the mean (blue). Obtained from the International Comprehensive Ocean-Atmosphere Data Set. Mean annual diatom (green) and zooplankton (orange) abundance, unfilled years are when sampling was sub-optimal. 2022 data are preliminary.

Although only some of the data are available at this time these preliminary analyses suggest that in 2022 (and for all of the years after 2019, 2020-2022) the plankton have returned to levels that were more similar to those found during pre-heatwave conditions (Fig. 2).

Other evidence that supports this suggestion is shown in Fig. 3 and Fig. 4; Firstly, the mean size of copepods was not significantly different to average (warm years typically see a shift to smaller mean size).

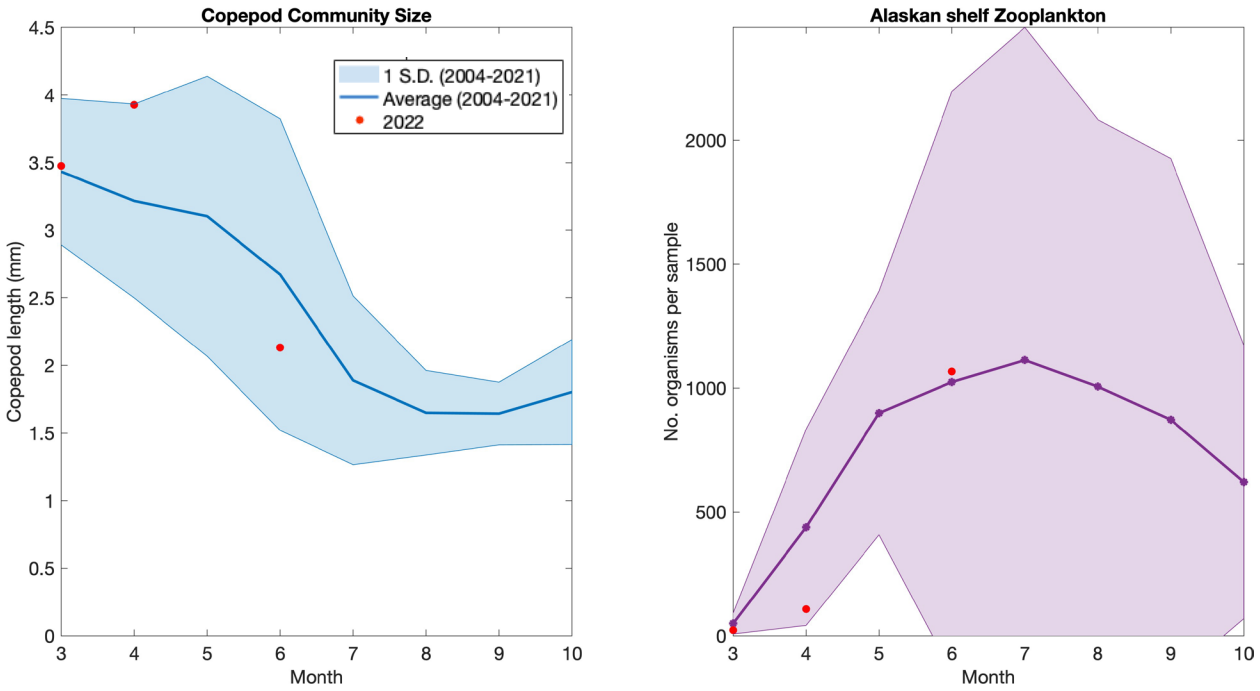

Figure 3. Left panel shows the seasonal mean monthly copepod length through 2004-2021 with red circles showing the 2022 values (larger than average in the spring, and slightly smaller in the summer, however not significantly) and right panel shows the seasonal mean number of zooplankton per sample.

Secondly, the abundance of a particular copepod species indicative of warmer conditions (*Calanus pacificus*) looks to be low in 2022 (and in the last 3 years (2020-2022) see Fig. 4).

In summary, these results suggest that the marine heatwave impacts appear to have ended. This is likely to have positive effects on ecosystem functioning.

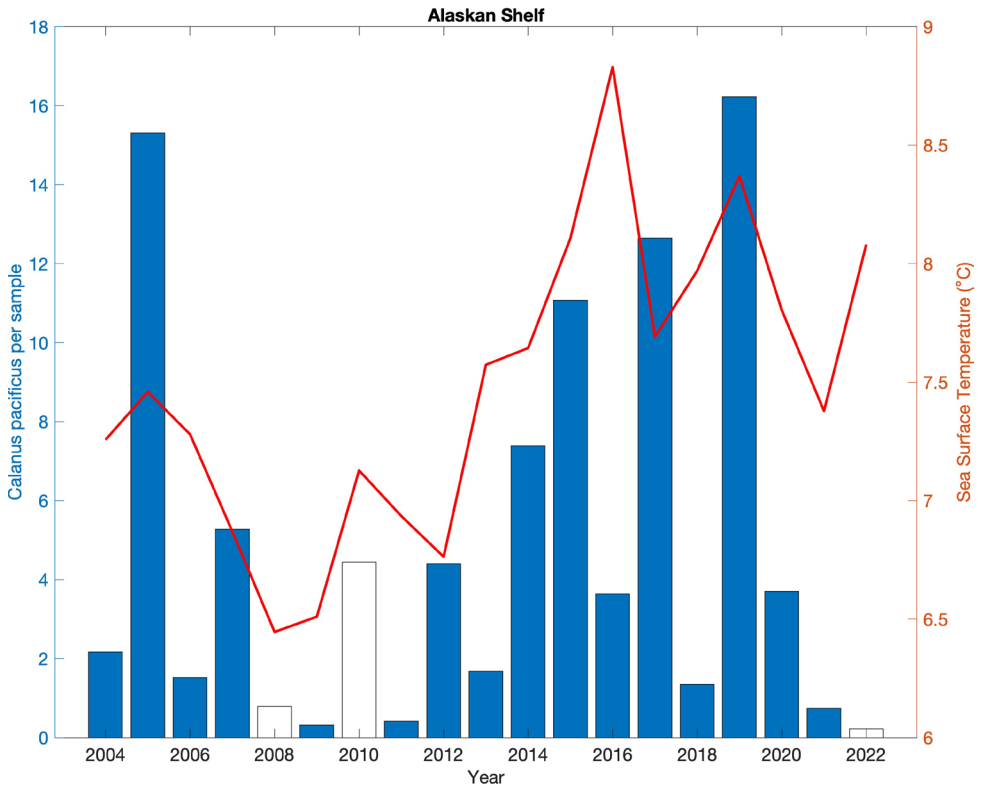

Figure 4. The mean annual abundance of the warm water indicator, Calanus pacificus*, (blue bars) together with annual sea surface temperature (red line). 2022 data are preliminary.*

2. Products:

Peer-reviewed publications:

Batten, S. D., C. Ostle, P. Hélaouët, and A. W. Walne. 2022. Responses of Gulf of Alaska plankton communities to a marine heat wave. Deep Sea Research Part II: Topical Studies in Oceanography 195:105002. https://doi.org/10.1016/j.dsr2.2021.105002

Li, K., J. C. Naviaux, S. S. Lingampelly, L. Wang, J. M. Monk, C. M. Taylor, C. Ostle, S. Batten, and R. K. Naviaux. 2023. Historical biomonitoring of pollution trends in the North Pacific using archived samples from the Continuous Plankton Recorder Survey.

Science of the Total Environment 865:161222. Elsevier B.V. https://doi.org/10.1016/j.scitotenv.2022.161222

Reports:

Ferriss, B. E., and S. Zador. 2022. Ecosystem Status Report 2022: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third Ave., Suite 400, Anchorage, AK 99501. https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2022-gulf-alaska

Fisheries and Oceans Canada. 2021. Canada's Oceans Now: Pacific Ecosystems 2021. Fisheries and Oceans Canada. https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2021/index-eng.html

Popular articles:

Powell, K., and C. Ostle. 2023. Where I work. Nature 613:406. https://doi.org/10.1038/d41586-023-00024-1

Ostle, C., and S. Batten. 2022. Plankton feeling the heat. Delta Sound Connections 2022-2-23. https://pwssc.org/wp-content/uploads/2022/06/DSC-2022-WEB.pdf.

Conferences and workshops:

Ostle, C., S. Batten, M. Brunetta, J. Fisher, M. Hennekes, D. Johns, F. Loro, H. Melling, J. Nelson, A. Sastri, R. Stern, and M. Wootton. 2022. Using the Continuous Plankton Recorder to detect and monitor the spread of Harmful Algal Blooms from the Pacific into the Arctic Ocean. Oral presentation. PICES meeting, Busan, South Korea.

Ostle, C., S. Batten, M. Brunetta, J. Fisher, M. Hennekes, D. Johns, F. Loro, H. Melling, J. Nelson, A. Sastri, R. Stern, and M. Wootton. 2022. Using the Continuous Plankton Recorder to detect and monitor the spread of Harmful Algal Blooms from the Pacific into the Arctic Ocean. Oral presentation. DBO Data Workshop, Victoria Canada.

Ostle, C., S. Batten, M. Brunetta, J. Fisher, M. Hennekes, D. Johns, F. Loro, H. Melling, J. Nelson, A. Sastri, R. Stern, and M. Wootton. 2023. Using the Continuous Plankton Recorder to detect and monitor the spread of Harmful Algal Blooms from the Pacific into the Arctic Ocean. Poster presentation. Alaska Marine Science Symposium, Anchorage, Alaska.

Ostle, C. 2023. Alaska HABs research: Current state and future directions. Participant. Alaska Marine Science Symposium workshop, Anchorage, Alaska.

Public presentations:

Ostle, C. 2022. Update on the North Pacific CPR survey. Presented to the North Pacific Marine Science Organization (PICES) Monitor Technical Committee annual meeting, September.

Batten, S., and C. Ostle. 2022. The North Pacific Continuous Plankton Recorder survey. Fisheries and Ocean Sciences Seminar, University of Alaska Fairbanks, spring.

Data and/or information products developed during the reporting period:

Data (2004 – 2021) were provided for the NOAA Gulf of Alaska 2022 Ecosystem Status Report: https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2022-gulf-alaska

The data have been included in the International Group for Marine Ecological Time Series (IGMETS) effort led by the Intergovernmental Oceanographic Commission of UNESCO (IOC), the International Ocean Carbon Coordination Project (IOCCP) and the Ocean Carbon and Biogeochemistry Program (OCB) which seeks to integrate a suite of in situ biogeochemical variables from time-series stations, together with satellite-derived information, to look at holistic changes within different ocean regions. The website http://igmets.net/ has a Time Series Explorer which allows the user to construct time series of available variables and investigate trends. North Pacific CPR data provide much of the plankton information for the region. The data are also stored in the Ocean Biodiversity Information System (OBIS): https://obis.org/dataset/e981eab6-f849-4891-8fac-495852829456.

Data sets and associated metadata:

All Data and metadata from 2021 surveys (plankton counts and physical data) have been uploaded to the Research Workspace and made available on the Gulf of Alaska data portal: https://gulf-of-alaska.portal.aoos.org/#metadata/87f56b09-2c7d-4373-944e-94de748b6d4b/project.

Additional Products not listed above:

No new contributions for this reporting period.

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

Funding has been provided to the North Pacific CPR Survey Consortium through the Alaska Sea Life Center (from the North Pacific Research Board) and the Prince William Sound Science Center (PWSSC; from Gulf Watch Alaska-Long-Term Research and Monitoring [GWA-LTRM]) for over a decade. We have thus already developed good working relationships with the administrators in these organizations. We have participated in the PWSSC outreach program by giving talks to elementary and high school students, and at a public lecture as part of the PWSSC science lecture series in Cordova. We have also contributed articles to Delta Sound Connections. Collaborations with PWSSC researchers on juvenile herring have resulted in published papers (Batten et al. 2016) and we are currently working on an additional collaborative manuscript.

EVOSTC Long-Term Research and Monitoring Projects

Environmental Drivers Component

This project provides a spatial link between the locally more intensive (but less seasonally resolved) sampling of lower trophic levels from the Seward line and Kachemak Bay within the Environmental Drivers Component. Although there are differences in sampling design in each place, necessitated by the different sampling conditions, there are techniques available to facilitate integration, as mentioned above. The CPR data can also provide information on seasonal timing changes which will help with interpretation. The time series in Prince William Sound offers a chance to compare variability across the wider region and examine the degree to which the outer shelf may influence the Sound. There is thus strong collaboration within the Environmental Drivers group.

Pelagic Monitoring Component

Productivity of the plankton populations directly influences the organisms monitored by the Pelagic Component and will be a necessary contribution to their studies. The recent collaborative paper, Arimitsu et al. (2021), describes some of these relationships with forage fish, and we expect such collaboration to continue, particularly as the time-series becomes long term and trends can become validated.

Nearshore Monitoring Component

Nearshore studies are perhaps harder to link directly, but many benthic invertebrates have a planktonic phase. We have already provided a subset of CPR data to other GWA-LTRM principal investigators summarizing the meroplankton to examine the long-term variability in larvae.

Lingering Oil Monitoring Component

As above, the coastal component of lingering oil is harder to link directly, but we do see some connections with planktonic larval stages and are hoping to explore this further.

Herring Research and Monitoring Component

We have actively collaborated with the Herring Research and Monitoring Component, and a publication has been produced (Batten et al. 2016). These time series will be updated during this project, and as they lengthen, we expect further insights, especially in light of the unusually warm conditions currently being experienced. We currently have a further collaborative publication with the Herring research and Monitoring group in preparation.

Synthesis and Modeling Component

Suryan et al. (2021) provides an example of the collaborative efforts of the group with a synthesis report in Scientific Reports on the ecosystem response to the marine heatwave in the Gulf of Alaska. Such collaborations will continue and results we become more significant as the time-series involved are continued and long-term trends can be described.

Data Management Project

The CPR data from the Gulf of Alaska region are provided as an annual data product to the data management team. This data are quality controlled and provided in a consistent format for ease of use and dissemination.

EVOSTC Mariculture Projects

As above, the plankton underpin many important food webs, particularly fisheries, and reflect the environmental conditions, it is therefore likely that our plankton time-series will be of significant use to mariculture projects within mariculture projects funded by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC), and we are open to such collaboration and sharing of data.

EVOSTC Education and Outreach Projects

We have a good track record with education and outreach and enjoy getting involved. Sonia Batten has presented at the Cordova elementary and secondary schools and given a public lecture in the area as well as a presentation as part of the PWSSC lecture series. We very much enjoy this aspect of the work and will look to continue to contribute.

Individual EVOSTC Projects

As plankton underpin many important food webs and reflect the environmental conditions, we envisage that our data will be of significant use to several of the other projects involved, and we are open to such collaboration.

Trustee or Management Agencies

CPR data are provided as an annual summary to the National Oceanic and Atmospheric Administration Ecosystem Considerations Report (CPR contributed since 2016), a synthesis report used by fisheries managers, and the Ecosystem and Socioeconomic Profiles (CPR contributed since 2020) to form individual stock-specific assessments (e.g., walleye pollock, Pacific cod, and sablefish in the Gulf of Alaska). This contribution will be continued. See https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands for previous reports.

Native and Local Communities

The GWA-LTRM program and this project are committed to involvement with local and Alaska Native communities. Our vision for this involvement will include active engagement with the Education and Outreach Focus Area (see above), program-directed engagement through the program management team (project 22120114), and project-level engagement.

In addition, this project will continue engaging with local communities as we have during the first 10 years of the program.

4. Response to EVOSTC Review, Recommendations and Comments:

May 2021 EVOSTC Science Panel Comment: We continue to appreciate the value of the CPR studies and its contribution to our understanding of PWS and GOA more broadly and see value in continuing this project as proposed. The project continued meeting its objectives during the pandemic.

PI Response: We would like to thank the science panel for their positive comments and support of the CPR work in the GOA; we very much enjoy working with the group and are excited about the potential for a further 10 years of fruitful collaborations.

May 2021 EVOSTC Science Panel Comment: We concluded that integration of all five of the LTRM Environmental Driver components (CPR, PWS, Cook Inlet/Kachemak Bay, GAK 1, Seward Line) should be pursued using existing and proposed resources to better demonstrate the

combined value of these efforts and as planning for the post-EVOSTC era when funding will no longer be available. We understand why administratively these enterprises are kept separate in the present proposal but urge each of them to consider ways in which the datasets can be integrated and used to present a more holistic picture of the region and the extent to which inshore areas are predictable (or not) from offshore areas (and vice versa). We defer to the program managers and project PIs to determine the best approach to tackle this synthesis; one suggestion is to recruit some of the postdoctoral fellows proposed under the broader LTRM heading to address this region-wide synthesis of oceanographic conditions using already existing data.

PI Response: Continued integration among all GWA projects, including Environmental Drivers, is a priority for the next 10 years of GWA-LTRM. For Environmental Drivers, the Danielson et al. (in review) paper provides examples of spatial and temporal scales of variability in near-surface ocean temperatures across the GOA from all sources within and various sources outside GWA. We will expand on these efforts on the physical environment by conducting similar analyses with sub-surface temperatures and salinity, which strongly link to nutrients. Additional integration steps will focus on similar analyses for phytoplankton and zooplankton, ultimately integrating the two approaches to propose mechanisms of change in species abundance and composition, onshore vs. offshore production, etc. Correct, the Environmental Drivers component will be using their three years of postdoc funding to support these efforts. Furthermore, Environmental Driver PIs will work with the GWA Synthesis and Modeling component over the next 10 years to highlight integrated analyses within work plans and annual reports.

Danielson, S. L., T. D. Hennon, D. H. Monson, R. M. Suryan, R. W. Campbell, S. J. Baird, K. Holderied, and T. J. Weingartner. in review. Marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells. Submitted to Deep-Sea Research II Special Issue.

September 2021 EVOSTC Science Panel Comment: We continue to appreciate the value of the CPR studies and its contribution to our understanding of PWS and GOA more broadly and see value in continuing this project as proposed. The project continued meeting its objectives during the pandemic.

PI response: We would like to thank the science panel for their positive comments and support of the CPR work in the GOA, we very much enjoy working with the group and are excited about the potential for further years of fruitful collaborations.

5. Budget:

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROJECT 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		$39,616	$40,607	$41,622	$42,663	$43,730	$208,238	$19,808
Travel		$1,316	$1,366	$1,399	$1,433	$1,467	$6,980	$658
Contractual		$9,304	$9,537	$9,775	$10,020	$10,270	$48,906	$4,652
Commodities		$5,837	$5,985	$6,134	$6,287	$6,445	$30,688	$2,919
Equipment		$0	$0	$0	$0	$0	$0	$0
Indirect Costs	Rate = 40%	$22,429	$22,998	$23,572	$24,161	$24,765	$117,925	$11,214
SUBTOTAL		$78,502	$80,492	$82,503	$84,564	$86,676	$412,737	$39,251
General Administration (9% of subtotal)		$7,065	$7,244	$7,425	$7,611	$7,801	$37,146	N/A
PROJECT TOTAL		$85,567	$87,736	$89,928	$92,175	$94,477	$449,884	
Other Resources (In-Kind Funds)		$128,351	$131,605	$134,892	$138,262	$141,715	$674,825	

COMMENTS:
The North Pacific CPR survey is supported by a Consortium managed by the North Pacific Marine Science Organisation, of which the EVOSTC is a member. Costs included here are estimated at 40% of the full costs of acquiring data along the north-south transect. The remining in-kind funds will come from the consortium which currently includes the NPRB, Canadian Dept Fisheries and Oceans and the Marine Biological Association.

Cumulative spending for FY22 appears low due to the delay in the release of project funding and because MBA invoices for the project quarterly and the most recent spending is available through November 2022.

FY22-26	Project Number: 22120114-D Project Title: CPR in the GOA PI(s): Ostle (MBA) & Batten (PICES)	NON-TRUSTEE AGENCY SUMMARY PAGE

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