Exxon Valdez **Oil Spill Trustee Council**

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

Annual Project Reporting Form

Project Number: 23120114-G

Project Title: Oceanographic Conditions in PWS

Principal Investigator(s): Robert W. Campbell, Prince William Sound Science Center

Reporting Period: February 1, 2023 – January 31, 2024

Submission Date: March 1, 2024

Project Website: https://gulfwatchalaska.org/

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

☒ **Project progress is on schedule.**

All project progress is on schedule except for issues with the profiling mooring (see below).

☒ **Project progress is delayed.**

The profiling mooring was not deployed in 2023 following a failure of the battery that powers the system and a long delay at the factory for calibration of some of the instruments. Following a budget reallocation, two new batteries have been purchased and the mooring is staged and ready for the 2024 deployment.

☐ **Budget reallocation request.**

☐ **Personnel changes.**

---

1. Summary of Work Performed:

Summary:

The planned oceanographic surveys of Prince William Sound (PWS) were conducted during the reporting period (Table 1). All conductivity and temperature at depth (CTD) data collected to date have been processed, and seasonally detrended anomalies of temperature at selected depths in central PWS are shown in Fig. 1. Temperatures in central PWS were mostly above average since from late 2013, as has been observed elsewhere in the Gulf of Alaska (see Seward Line [23120114-L] and GAK1 [23120114-I] projects), and late 2013 to 2016 has been labelled a basin

scale marine heatwave (Gentemann et al. 2017). Following a weak cooling trend into early 2018 and a brief period of negative anomalies, anomalies again trended warmer than average, which corresponded to basin-wide increases in sea surface temperature observed in 2019. Near-surface temperature anomalies in 2019 exceeded those observed during the 2013-2016 marine heatwave and appear to be the result of a similar mechanism: a persistent atmospheric ridge (Bond et al. 2015, Amaya et al. 2020). In 2013-2014 the ridge disrupted winter storm tracks and lead to reduced mixing of heat out of the surface layer during winter; in 2020 a similar ridge led to over a month of calm, sunny weather in July-August that led to enhanced solar heat flux to the surface layer and very high surface layer temperatures. Anomalies again trended towards much warmer than average in 2022 but switched to negative anomalies in 2023. The Gulf of Alaska experienced an unprecedented "triple-dip" La Niña (e.g., Shi et al. 2023) from 2020 to 2023 which eventually led to lower near-surface temperatures basin-wide. Temperatures in PWS tend to lag those in the Gulf of Alaska by approximately one year (Campbell 2018), which appears to have been the case in 2023.

Table 1. Status of project deliverables and milestones.

Deliverable/Milestone	Status
PWS Survey	Conducted March 3 – 6 2023
PWS Survey	Conducted 19-20 April 2023
PWS Survey	Conducted 20-21 May 2023
PWS Survey	Conducted 5-6 June 2023
PWS Survey	Conducted 15-16 October 2023
PWS Survey	Conducted 4-5 November 2023
CTD Data processed	Completed December 2023
Chlorophyll- samples processed	To be completed in Q1 2024
Plankton samples enumerated	Ongoing

Following a multiyear backlog created by staff changes and the coronavirus pandemic, analysis of zooplankton samples caught up this year, and all samples up to the end of 2022 have been analyzed (zooplankton samples are time consuming to process and take about a year to

complete). Analysis of the 2010 to 2021 samples shows a shift in zooplankton taxa in PWS during the marine heatwave years (Fig. 2). When copepod species are split into the "warm" and "cool" water species assemblages used by Peterson et al. (2017), it is apparent that although changes in overall zooplankton abundance have been relatively small (note the different axes scaling in the panels of Fig. 2), abundances of "warm" water copepod species increased, while that of the canonical "cool" water subarctic copepod species decreased during heat wave years. A shift back towards increased cool water species and decreased warm water species occurred in 2018 but may have switched again in late 2019 following the second heatwave; cool water species have become much less common recently. A lag of 1-2 years between the onset of warmer conditions (Fig. 1) and changes in the zooplankton composition (Fig. 2) is apparent. The lag can be attributable to both transport (i.e., the advection of taxa more common to the California Current to the north), and/or enhanced productivity of warm-preferring taxa in place. No studies showing changes in transport during the marine heatwave years have been published yet, and the canonical warm water species used here have been observed in the PWS region previously (e.g., Cooney and Coyle 1985), which supports the latter hypothesis. A detailed analysis of the changes in species composition is outlined in McKinstry and Campbell (2018).

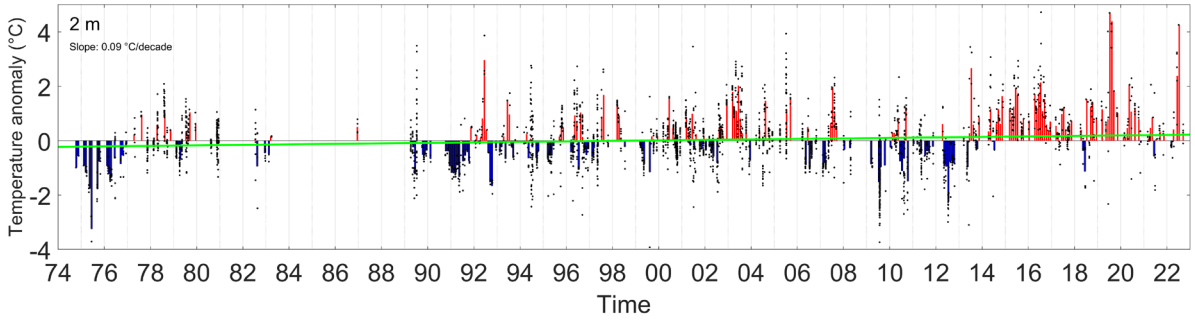

Figure 1. Biweekly near surface temperature anomalies in central Prince William Sound. Anomalies were calculated as the residual to a second order cosine curve fit to all years data (to remove seasonality [Campbell 2018]). Black points are observations, bars are biweekly averages, and the green line indicates the linear trend. Slope was significantly different from zero ($p<0.05$).

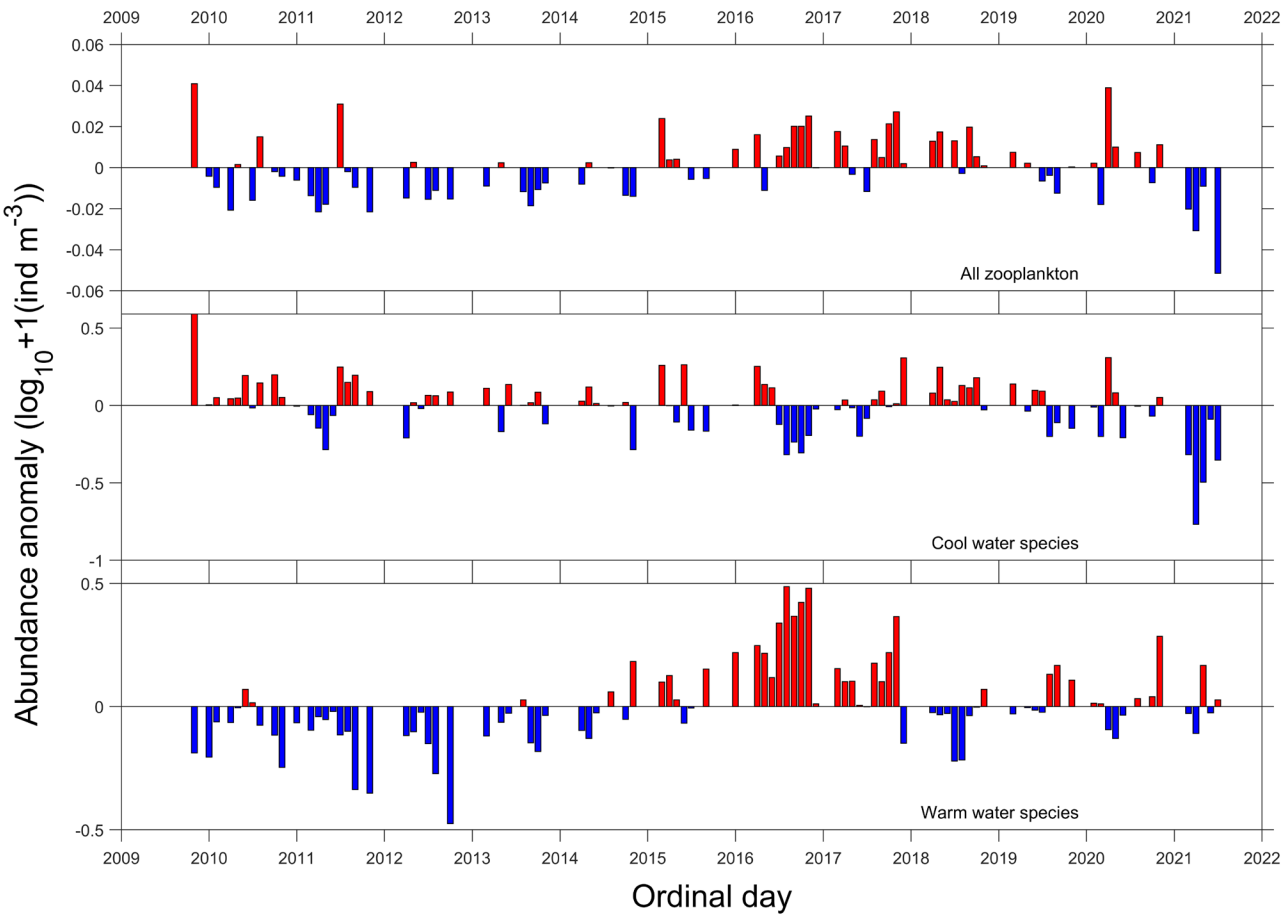

Figure 2: Time series of zooplankton anomalies in Prince William Sound, 2010-2021. Zooplankton were divided into "warm" and "cool" water copepod species per Peterson et al. (2017) and average anomalies calculated across groups per Fisher et al. (2015). Warm water species were Calanus pacificus, Clausocalanus sp., Corycaeus anglicus, Ctenocalanus vanus, Mesocalanus tenuicornis and Paracalanus parvus. Cool water species were Acartia longiremis, Calanus marshallae, Oithona similus, and Pseudocalanus sp. Abundances were log10+1 transformed prior to calculating anomalies. Note that the scaling of the ordinate varies among panels.

Profiler status:

The PWS Profiler was not deployed in 2023. The primary battery that powers the system failed following the 2022 deployment- communications with the battery controller stopped, most likely due to a failure of the controller. The controllers are no longer available and the battery is not repairable. That left only one of the original batteries purchased with the system in 2014, which is well beyond its service life (i.e., ~40% of original capacity) and only used for powering the profiler when servicing it on land. In addition, the nitrate sensor for the profiler (a Seabird SUNA) was returned for a factory service/calibration in 2022, but the service was extremely long, and the instrument was not returned until May 2023, well after the spring bloom had occurred. For those reasons, it was decided to not deploy the profiler in 2023, and to focus on readiness for 2024. Two new batteries have been purchased, and the profiler will be deployed in March 2024.

Literature cited:

Amaya, D. J., A. J. Miller, S-P. Xie, and Y. Kosaka. 2020. Physical drivers of the summer 2019 North Pacific marine heatwave. Nature Communication 11:1903. doi: 10.1038/s41467-020-15820-w.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific, Geophysical Research Letters 42:3414–3420. doi:10.1002/2015GL063306.

Campbell, R. W. 2018. Hydrographic trends in Prince William Sound, Alaska, 1960–2016. Deep Sea Research Part II 147:43-57. doi: 10.1016/j.dsr2.2017.08.014.

Campbell, R. W., P. L. Roberts, and J. Jaffe. 2020. The Prince William Sound Plankton Camera: A profiling in situ observatory of plankton and particulates. ICES Journal of Marine Science 77:1440-1455. doi:10.1093/icesjms/fsaa029.

Cooney, R. T., and K. O. Coyle. 1985. The occurrence of the subtropical copepod, *Mesocalanus tenuicornis*, in Columbia Bay, Prince William Sound, Alaska. Crustaceana 49:310-313.

Fisher, J. L., W. T. Peterson, and R. R. Rykaczewski. 2015. The impact of El Nino events on the pelagic food chain in the northern California Current. Global Change Biology 21:4401-4414. doi: 10.1111/gcb.13054.

Gentemann, C. L., M. R. Fewings, and M. Garcia-Reyes. 2017. Satellite sea surface temperatures along the west coast of the United States during the 2014–2016 northeast Pacific marine heat wave. Geophysical Research Letters 44:312-319. Doi: 10.1002/2016GL071039.

McKinstry, C. A. E., and R. W. Campbell. 2018. Seasonal variation of zooplankton abundance and community structure in Prince William Sound, Alaska, 2009–2016. Deep Sea Research Part II 147:69-78. doi: 10.1016/j.dsr2.2017.08.016.

Peterson, W. T., J. L. Fisher, P. T. Strub, X. Du, C. Risien, J. Peterson, and C. T. Shaw. 2017. The pelagic ecosystem in the Northern California Current off Oregon during the 2014–2016 warm anomalies within the context of the past 20 years. Journal of Geophysical Research Oceans 122:7267–7290. doi:10.1002/2017JC012952.

Shi, L., R. Ding., S. Hu, X. Li, and J. Li. 2023. Extratropical impacts on the 2020–2023 Triple-Dip La Niña event. Atmospheric Research 294:106937. doi: 10.1016/j.atmosres.2023.106937.

2. Products:

Peer-reviewed publications:

Michael, S.M., J. Crusius, A. W. Schroth, R. W. Campbell, and J. A. Resing. 2023. Glacial meltwater and sediment resuspension can be important sources of dissolved and total dissolvable aluminum and manganese to coastal ocean surface waters. Limnology and Oceanography doi: 10.1002/lno.12339

Reports:

Campbell, R. 2023. Temperature trends in Prince William Sound. Pages 195-196 *in* B. E. Ferriss editor. Ecosystem Status Report 2023: Gulf of Alaska Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, Anchorage, Alaska.

Campbell, R. W. 2023. Monitoring the Oceanographic Conditions of Prince William Sound. *Exxon Valdez* Oil Spill Long-term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 21120114-G), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Popular articles:

Campbell, R. W. 2023. Extreme close up! Counting plankton with cameras. Delta Sound Connections 2023-2024. https://pwssc.org/wp-content/uploads/2023/05/DSC-2023-FINAL-LR.pdf.

Conferences and workshops:

Campbell, R. W. 2024. Recent changes in the near-surface oceanography and productivity of Prince William Sound. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Ertz, R., C. Cunningham, and R. W. Campbell. 2024. High throughput digitization of salmon scale imagery. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Mearns, A., S. Pegau, D. Janka, R. W. Campbell, B. Robinson, and B. Lydon. 2024. Volunteer photos tracking oscillations in Prince William Sound rocky intertidal biota for 34 years. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Pretty, J., L. Sutton, and R. Campbell. 2024. Examining functional trait diversity of marine zooplankton communities in Prince William Sound. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Traiger, S., J. Bodkin, R. W. Campbell, H. Coletti, D. Esler, K. Holderied, K. Iken, B. Konar, C. McKinstry, D. Monson, J. Pretty, M. Renner, B. Robinson, R. Suryan, and B. Weitzman. 2024. Does larval supply matter? Meroplankton as drivers of intertidal invertebrate abundance. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaksa, January.

Public presentations:

Campbell, R. W. 2023. Effects of recent marine heat waves on the waters of PWS. *Oral presentation,* Chugach Regional Resources Commission Annual Subsistence Memorial Gathering, Anchorage, March.

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

No new contributions for this reporting period.

Data sets and associated metadata:

Campbell, R. 2023. Environmental drivers: Oceanographic conditions in Prince William Sound. Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/fc5b0956-ef7c-49df-b261-c8e2713887fc/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

Dr. Campbell is Chief Scientist of the PWS Science Center and works closely with PIs (Cypher, Schaefer, Rand) on several *Exxon Valdez* Oil Spill Trustee Council (EVOSTC)-funded projects.

EVOSTC Long-Term Research and Monitoring Projects

This project is part of the environmental drivers component of the Gulf Watch Alaska Long-Term Research and Monitoring program funded by the EVOSTC. The principal investigator (PI) works closely with other environmental drivers projects and across components with pelagic projects, particularly the forage fish project (23120114-C) to collect fish, and nearshore project (23120114-H).

EVOSTC Mariculture Projects

Dr. Campbell is a PI on the EVOSTC funded Mariculture ReCon project and is working with PIs Cypher, Shaefer, Rehberg and others on that project. We are sharing ship time and instruments among the projects. The data collected as part of this project will be used in that project as well.

EVOSTC Education and Outreach Projects

We engaged with the EVOSTC education and outreach projects with this group at the GWA-LTRM PI meetings in November 2022, January 2023, and November 2023 and we are looking forward to working with them to expand our capacity for bringing our science to new audiences.

Individual EVOSTC Projects

The forage fish project works with the Data Management program to ensure data collected are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes. We will work with other individually funded EVOSTC projects if collaborative efforts make sense based on data collected.

Trustee or Management Agencies

We generally endeavor to conduct a spring cruise around the time of herring spawning when the Alaska Department of Fish and Game is doing their surveys (contact: Jenni Morella, Alaska Department of Fish and Game, Cordova).

In addition, we contributed indicators to the National Oceanic and Atmospheric Administration's (NOAA's) Gulf of Alaska Ecosystem Status Report to the North Pacific Fisheries Management Council on temperature trends in PWS.

The in situ camera and machine vision system developed for the profiler is being spun off into novel applications. In 2020 funding was obtained under the NOAA Saltonstall Kennedy program to develop low-cost and low-power camera systems to be deployed in small clear water streams to count salmon passage. The camera systems will include an onboard micro supercomputer that will be trained to identify different species of salmon as they pass and detect if they are moving up- or down-stream. The systems will be designed to transmit their counts of species-specific fish passage in near real-time through a cellular or satellite data connection. We have produced working prototype cameras and have trained algorithms to successfully discriminate between pink and sockeye salmon. Development of the cameras will continue.

We have also found that the machine vision algorithms developed to identify the plankton images collected by the profiler show promise for aging salmon scales. A proposal to the North Pacific Research Board was funded in 2022 (project 2203, "Automation of sockeye scale age estimation"). We have digitized several thousand scales from the Copper River fishery and will compare ages estimated by five different human technicians to age estimates by deep neural network classifiers.

Native and Local Communities

We presented information on this work at the Chugach Regional Resources Commission Subsistence Memorial Gathering in March 2023.

4. Response to EVOSTC Review, Recommendations and Comments:

No comments for FY23.

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	$165,796	$139,941	$174,189	$178,544	$183,008	$841,478	$189,974
Travel	$1,994	$2,044	$2,095	$2,147	$2,201	$10,481	$9,875
Contractual	$50,350	$51,610	$52,899	$54,222	$55,578	$264,659	$66,700
Commodities	$11,000	$11,275	$11,557	$11,845	$12,142	$57,819	$22,548
Equipment	$0	$30,000	$0	$0	$0	$30,000	$25,998
Indirect Costs Rate = 0%	$0	$0	$0	$0	$0	$0	$0
Indirect Waived							
SUBTOTAL	$229,140	$234,870	$240,740	$246,758	$252,929	$1,204,437	$315,095
General Administration (9% of subtotal)	$20,623	$21,138	$21,667	$22,208	$22,764	$108,399	N/A
PROJECT TOTAL	$249,762	$256,008	$262,407	$268,967	$275,692	$1,312,836	
Other Resources (In-Kind Funds)	$225,000	$225,000	$225,000	$225,000	$225,000	$1,125,000	

During FY23, EVOSTC approved moving $30,000 from personnel to equipment to purchase new batteries for the profiler. The amended cells and lines are highlighted in yellow. This project remains underspent on personnel, partly due to the delay at the start of program, and because other projects nearing completion needed to be spent first. Spending on vessel charter was also reduced in 2023 because the profiling mooring was not deployed, spending will increase in both those categories in FY24.