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

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

Annual Project Reporting Form

Project Number: 25120114-G

Project Title: Oceanographic Conditions in PWS

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

Reporting Period: February 1, 2025 – January 31, 2026

Submission Date: March 16, 2026

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.**

The project requests a budget reallocation for equipment and unanticipated travel expenses. Please see the Budget section below.

☐ **Personnel changes.**

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1. Summary of Work Performed:

Summary

The planned oceanographic surveys of Prince William Sound (PWS) were conducted during the reporting period (Table 1), only a partial survey was conducted in September, following a catastrophic failure of one of the engines in the PWSSC research vessel New Wave. At the time the second engine (which had failed in 2024) was being rebuilt, and it was air freighted back to Alaska to minimize downtime. The second failed engine is being rebuilt as of the writing of this report and will be reinstalled in the vessel in the first quarter of 2026. Following a short early deployment, the PWS profiler developed power system problems that we were unable to remedy quickly. We are currently working with the Ocean Observatories Initiative group at Oregon State University to obtain some of their spare parts, uncertainty about the National Science Foundation funding underpinning that project has led to their ceasing all profiler deployments. Campbell has worked with Senator Murkowski's staff on a Congressional Directed Spending request (in federal fiscal years 2024, 2025 and 2026) for funds to develop a next generation profiler, the project was included in the Commerce Science Justice bill signed January 23, 2026, and will begin once an agreement has been set up with the National Oceanic and Atmospheric Administration (NOAA).

All conductivity and temperature at depth (CTD) data collected to date have been processed, and seasonally detrended anomalies of near-surface temperature and salinity, and average mixed layer depth are shown in Fig. 1 (top panel). Temperatures in central PWS were mostly above average since late 2013, as has been observed elsewhere in the Gulf of Alaska (see Seward Line [25120114-L] and GAK1 [25120114-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 led to reduced mixing of heat out of the surface layer during winter; in 2019 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 warmer than average in 2022 but has for the most part oscillated near the climatological average since then, with briefer warm and cold stanzas. This may have been in part due to the 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.

Near surface salinities have shown a long-term freshening trend in central PWS, likely due to increased freshwater inputs from enhanced precipitation and increasing meltwater attributable to the loss of ice mass. Although highly variable, the depth of the seasonal mixed layer appears to be on a long-term thinning trend, driven by that warming of near-surface waters and enhanced freshwater inputs (e.g., Janout et al. 2010, Campbell 2018). The thinning of the mixed layer has been considerable, averaging ~3.4m per decade. The extent of the change is particularly striking in the temperature anomalies from the profiler (Fig. 2), which show persistent negative anomalies at depth – deep waters tend to be colder, and thus the shoaling of the mixed layer manifests as a large negative anomaly.

Table 1. Status of project deliverables and milestones.

Deliverable/Milestone	Status
PWS/Mariculture survey	Conducted 7-9 March 2025
Profiler deployment	Conducted 28 March & 4 April 2025
PWS survey	Conducted 10-12 April 2025
PWS/Mariculture survey	Conducted 15-17 May 2025
PWS/Mariculture survey	Conducted 14-22 July 2025 (multiple sorties)
PWS survey	Conducted 9-13 September 2025 (partial)
PWS/Mariculture survey	Conducted Nov 2-14 (multiple sorties)
CTD Data processed	Completed December 2025
Chlorophyll- samples processed	Completed December 2025
Plankton samples enumerated	Ongoing

The reduction in mixed layer depth could be expected to impact overall productivity by limiting the total amount of nutrients available near surface annually. Nitrate and phosphate are typically completely drawn down in the surface mixed layer each year during the spring bloom (Eslinger et al. 2001); a thinner mixed layer should result in less overall nitrate, phosphate and silicate available in the photic zone. The longest time series of marine productivity in the region is the satellite ocean color record, from the SeaWIFs and MODIS missions. As an index of overall productivity satellite chlorophyll observations in central PWS were integrated annually for each year from 1998 to 2024 (Fig. 3). This is essentially the amount of near surface chlorophyll "seen" by the satellites each year. The satellite chlorophyll time series shows a declining trend over the last 27 years, with most of the lowest values observed in recent years. The recent marine heat waves likely impacted overall productivity (Suryan et al. 2021), and shoaling of the mixed layer may be playing a larger role in more recent years.

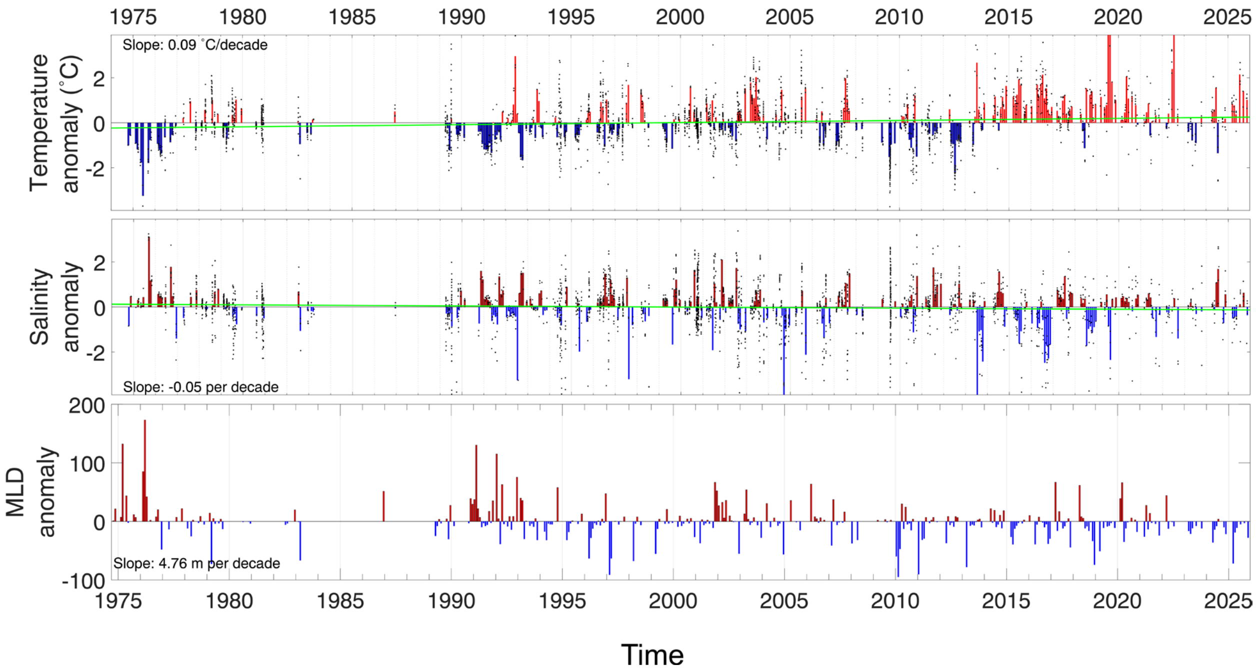

Figure 1. Top panel: Biweekly near surface temperature anomalies in central Prince William Sound. Anomalies were calculated as the residual to a second order cosine curve fit to all years data (to remove seasonality [Campbell 2018]). Black points are observations, bars are biweekly averages, and the green line indicates the linear trend. Middle panel: near surface salinity anomalies calculated with the same method. Bottom panel: Monthly mixed layer depth anomalies. Mixed layer depth was estimated as the depth of the maximum Brunt–Väisälä frequency.

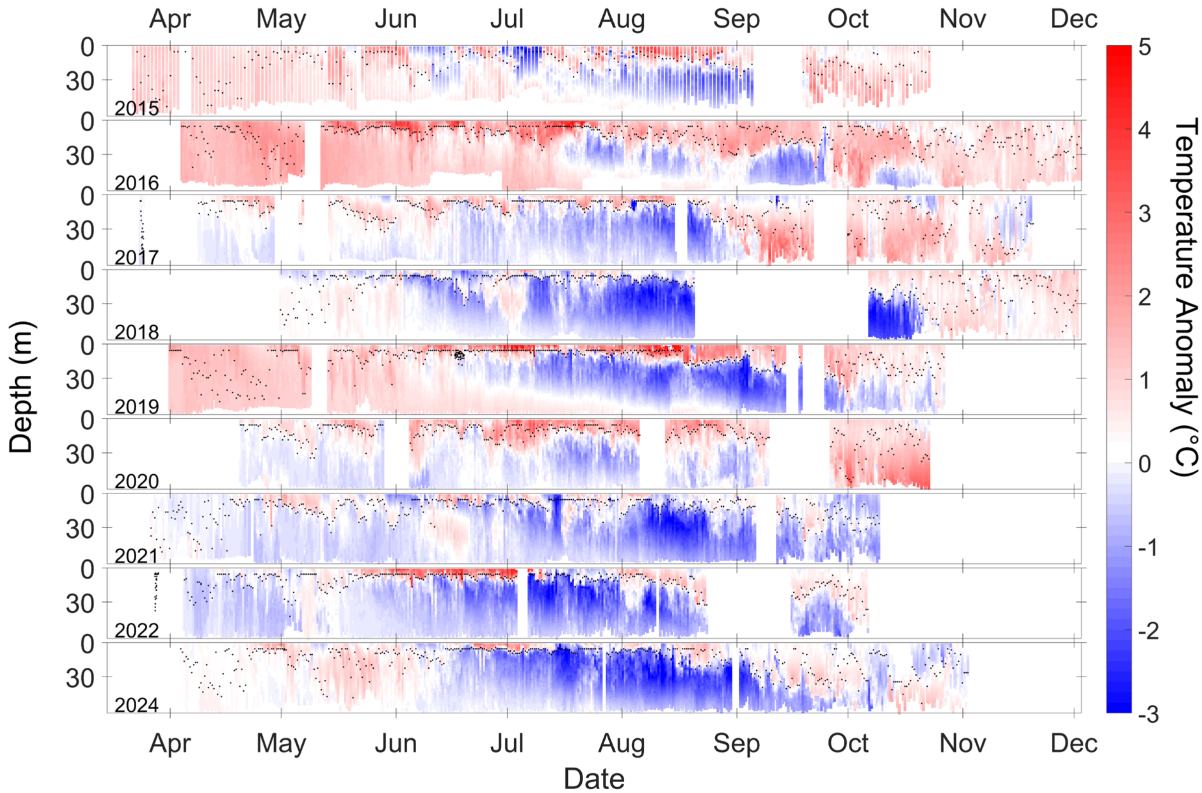

Figure 2. Time series of temperature anomalies from deployments of the Prince William Sound (PWS) Profiler, 2015-2024. Anomalies were calculated with the method of Campbell (2018), using an updated version of the entire climatology from central PWS. Black dots indicate the depth of the maximum Brunt–Väisälä frequency, as a metric of the mixed layer depth.

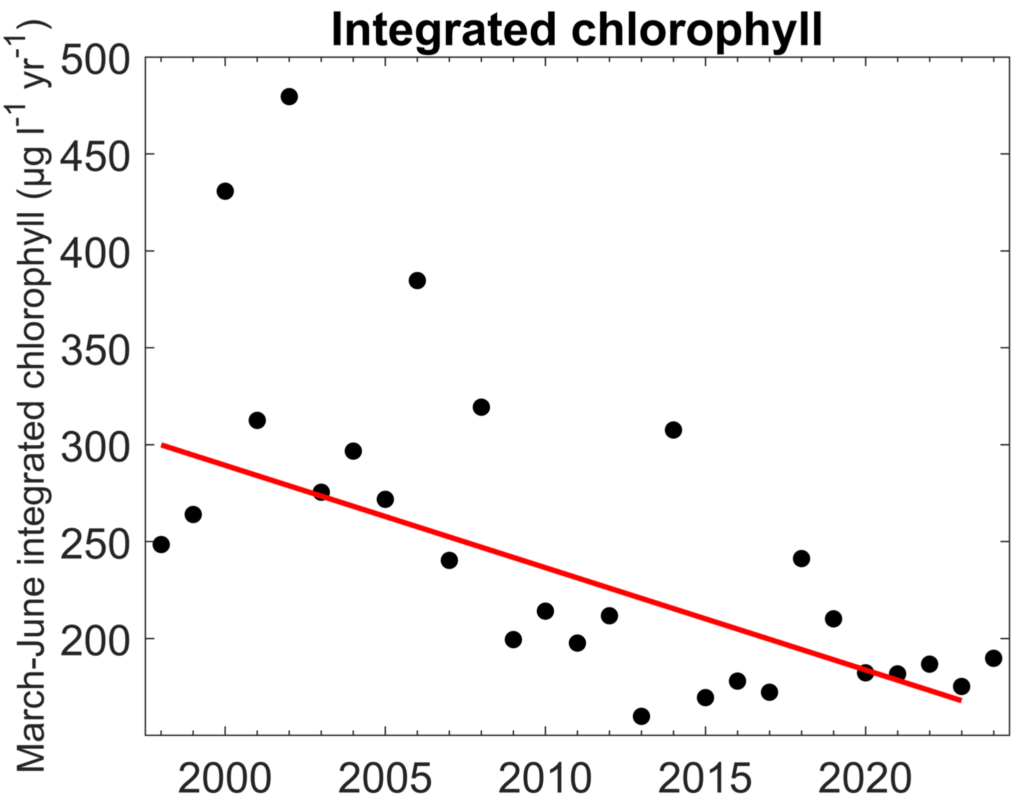

Figure 3. Annual spring-summer chlorophyll-a in central Prince William Sound (PWS), 1998-2025. Daily satellite chlorophyll-a observations from the seaWIFS and MODIS satellite missions (National Oceanographic and Atmospheric Administration Coastwatch datasets erdSW1chla1day and erdMWchla1day, respectively) were integrated across non-cloud-masked pixels between March 1 and June 30 using the trapezoid rule. The MODIS and seaWIFS time series were examined for an offset during the period when the missions overlapped, and seaWIFS values corrected to remove the offset. The polygon of pixels used in central PWS was selected to avoid coastlines and to avoid turbid Copper River water that can manifest as spurious chlorophyll values (pers. obs.).

All zooplankton samples up to the end of 2024 have been analyzed (zooplankton samples are time consuming to process and take about a year to complete). Analysis of the 2010 to 2024 samples shows a shift in zooplankton taxa in PWS during the marine heatwave years (Fig. 4). 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. 4), abundances of “warm” water copepod species increased, while that of the canonical “cool” water subarctic copepod species decreased during heatwave 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. Both warm and cool water species have become much less common recently, particularly the warm water taxa. A lag of 1-2 years between the onset of warmer conditions (Fig. 1) and changes in the zooplankton composition (Fig. 3) 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). Recently, overall zooplankton abundance anomalies have trended towards lower than average, particularly in 2022, this could be a manifestation of the aforementioned potential for lower trophic level productivity and will bear further observation.

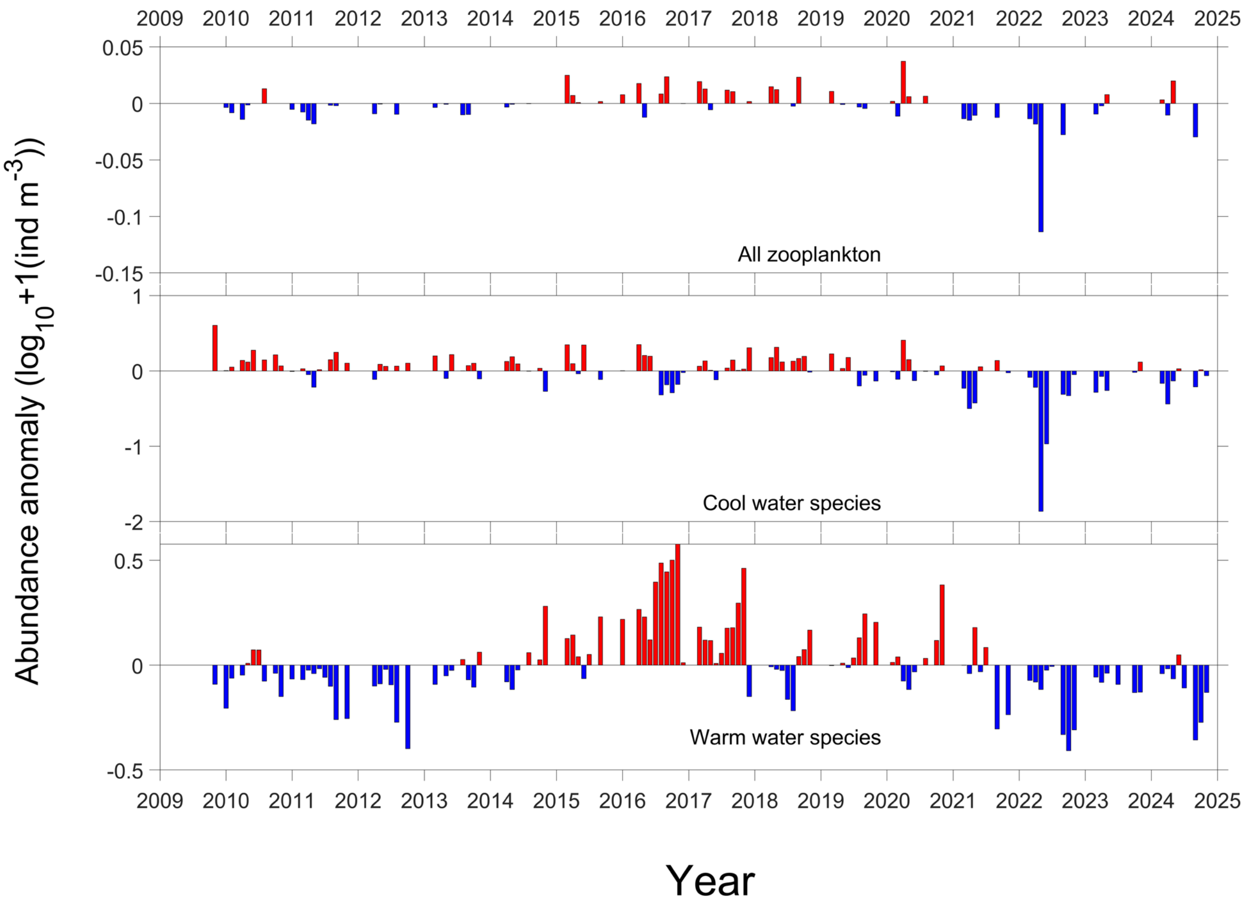

Figure 4. Time series of zooplankton anomalies in Prince William Sound, 2010-2023. Zooplankton were divided into "warm" and "cool" water copepod species per Peterson et al. (2017) and average anomalies calculated across groups per Fisher et al. (2015). Warm water species were Calanus pacificus, Clausocalanus 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.

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.

Eslinger, D. L., Cooney, R. T., Mcroy, C. P., Ward, A., Kline, T. C., Simpson, E. P., Wang, J. and J. R. Allen. 2001. Plankton dynamics: observed and modelled responses to physical conditions in Prince William Sound, Alaska. Fisheries Oceanography 10(Suppl. 1):81–96.

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.

Janout, M. A., T. J. Weingartener, T. C. Royer, and S. L. Danielson. 2010. On the nature of winter cooling and the recent temperature shift on the northern Gulf of Alaska shelf. Journal of Geophysical Research 115: C05023. doi:10.1029/2009JC005774.

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.

Suryan, R. M., M. L. Arimitsu, H. A. Coletti, R. R. Hopcroft, M. R. Lindeberg, S. J. Barbeaux, S. D. Batten, W. J. Burt, M. A. Bishop, J. L. Bodkin, R. E. Brenner, R. W. Campbell, D. A. Cushing, S. L. Danielson, M. W. Dorn, B. Drummond, D. Esler, T. Gelatt, D. H. Hanselman, S. A. Hatch, S. Haught, K. Holderied, K. Iken, D. B. Iron, A. B. Kettle, D. G. Kimmel, B. Konar, K. J. Kuletz, B. J. Laurel, J. M. Maniscalco, C. Matkin, C. A. E. McKinstry, D. H. Monson, J. R. Moran, D. Olsen, W. A. Palsson, W. S. Pegau, J. F. Piatt, L. A. Rogers, N. A. Rojek, A. Schaefer, I. B. Spies, J. M. Straley, S. L. Strom, K. L. Sweeney, M. Szymkowiak, B. P. Weitzman, E. M. Yasumiishi, and S. G. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports. https://doi.org/10.1038/s41598-021-83818-5.

2. Products:

Peer-reviewed publications:

None to report.

Popular articles:

Campbell, R. W. 2025. Counting plankton with cameras. Delta Sound Connections 2023-2024. https://pwssc.org/wp-content/uploads/2025/05/DSC-2025-FINAL_WEB.pdf

Conferences and workshops:

Campbell, R.W., and R. Ertz. 2026. Automating salmon scale aging with machine vision. Poster presentation at the Alaska Marine Science Symposium, Anchorage, Alaska, January. [spinoff of the neural network plankton identification programs developed under this project].

Pegau, W. S., A. Mearns, R. W. Campbell, V. Chu, M. Wheeler, and D. Janka. 2026. 36th year of repeated photo monitoring of rocky intertidal sites in western Prince William Sound. Poster presentation at the Alaska Marine Science Symposium, Anchorage, Alaska, January.

Public presentations:

None to report.

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

The neural network plankton identification programs developed under this project have been applied to aging salmon scales. This process was presented as a poster at the Alaska Marine Science Symposium (see Conferences and Workshops, above).

Data sets and associated metadata:

Campbell, R. 2025. 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:

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3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

Dr. Campbell is Chief Scientist of the PWS Science Center (PWSSC) and works closely with principal investigators (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 EVOSTC. The PI works closely with other environmental drivers projects and across components with pelagic projects, particularly the forage fish project (25120114-C) to collect fish, and nearshore project (25120114-H). Shifts in federal priorities left the forage fish project unable to conduct fieldwork in 2025, we were able to collect sand lance and herring and participate in some validations of aerial surveys for them, both as part of our regular sorties and some additional dedicated trips.

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, and the data collected is archived together in the Gulf of Alaska data portal (rather than maintaining two separate datasets). The data collected as part of this project will be used in that project as well.

EVOSTC Education and Outreach Projects

We engage with the Community Organized Restoration and Learning (CORaL) network regularly and took participants in the Community Coastal Experience out on the PWSSC research vessel during their visit to Cordova. Campbell attended the Collective Alaska Native Perspectives training in Cordova in February 2025.

Individual EVOSTC Projects

The PWS oceanography 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).

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 agers to that done by deep neural network classifiers.

Native and Local Communities

We consult regularly with the Dept. of Environment and Natural Resources at the Native Village of Eyak and visit their kelp farm regularly during Mariculture ReCon surveys. Campbell assisted them with a bull kelp study done from 2023 to 2025 with deployments of Acoustic Doppler Current Meters.

4. Response to EVOSTC Review, Recommendations and Comments:

No review, recommendations, or comments were provided in 2025. This project responded to comments in the FY24 annual report.

5. Budget:

The delay in the distribution of funds from the NOAA grant caused numerous problems for expenses related to this project.

This project requests a reallocation of contractual funds for equipment purchases and to account for unanticipated travel expenses. Contractual funds allocated to vessel charters are available to reallocate because some surveys were missed due to weather, breakdowns and occasional instrument failure. We request reallocating $7000 from contractual to equipment because we had an opportunity to purchase two more channels for our nutrient autoanalyzer, which allows us to run all four nutrients in single run, saving a great deal of retooling time. Travel has been overspent because of an unbudgeted change in the program. Prior to FY22, travel for PI meetings was covered by the PWSSC administrative budget, whereas in FY22-26 those costs have been assumed by the individual projects. That change was not included in the original budget, and we request $11,000 be reallocated from contractual to cover that discrepancy.

***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	$447,328
Travel	$1,994	$2,044	$2,095	$2,147	$13,201	$21,481	$20,952
Contractual	$50,350	$51,610	$52,899	$54,222	$37,578	$246,659	$162,182
Commodities	$11,000	$11,275	$11,557	$11,845	$12,142	$57,819	$53,565
Equipment	$0	$30,000	$0	$0	$7,000	$37,000	$36,272
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	$720,300
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	

COMMENTS:
PWSSC waives the indirect cost on this proposal due to its administration of the overall proposal.

This project requests a reallocation of funds for equipment purchases and to account for unanticipated travel expenses. We request reallocating $7000 from contractual to equipment because we had an opportunity to purchase two more channels for our nutrient autoanalyzer, which allows us to run all four nutrients in single run, saving a great deal of retooling time. Travel has been overspent because of an unbudgeted change in the program. Prior to FY22, travel for PI meetings was covered by the PWSSC administrative budget, whereas in FY22-26 those costs have been assumed by the individual projects. That change was not included in the original budget and we request $11000 be reallocated from contractual to cover that discrepancy.

FY22-26

Project Number: 25120114-G
Project Title: PWS Oceanographic
Primary Investigator: Campbell

NON-TRUSTEE AGENCY SUMMARY PAGE