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

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

Annual Project Reporting Form

Project Number: 23120114-I

Project Title: Oceanographic station GAK1 long term monitoring of the Alaska Coastal Current

Principal Investigator(s): Seth Danielson, University of Alaska Fairbanks

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.**

☐ **Project progress is delayed.**

☐ **Budget reallocation request.**

☐ **Personnel changes.**

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1. Summary of Work Performed:

We met all top priority objectives of the project with successful recovery and re-deployment of the 2023/2023 GAK1 mooring in May 2023. All dataloggers returned full-year time series of all parameters, and only a modest number of data were removed in the data QA/QC stage of processing due to low or questionable quality. Temperature, salinity, and density data for 2023 are shown in Fig. 1.

In this reporting period we have begun the re-analysis of the full GAK1 time series, beginning with the construction of an updated climatology for our two dynamic variables, temperature, and salinity. This effort is the first step in a half-century retrospective analysis of the GAK1 dataset, which will include efforts from Gulf Watch Alaska Long-Term Research and Monitoring program (GWA-LTRM) post-doc funding provided to Dr. Tyler Hennon of the University of Alaska Fairbanks (UAF).

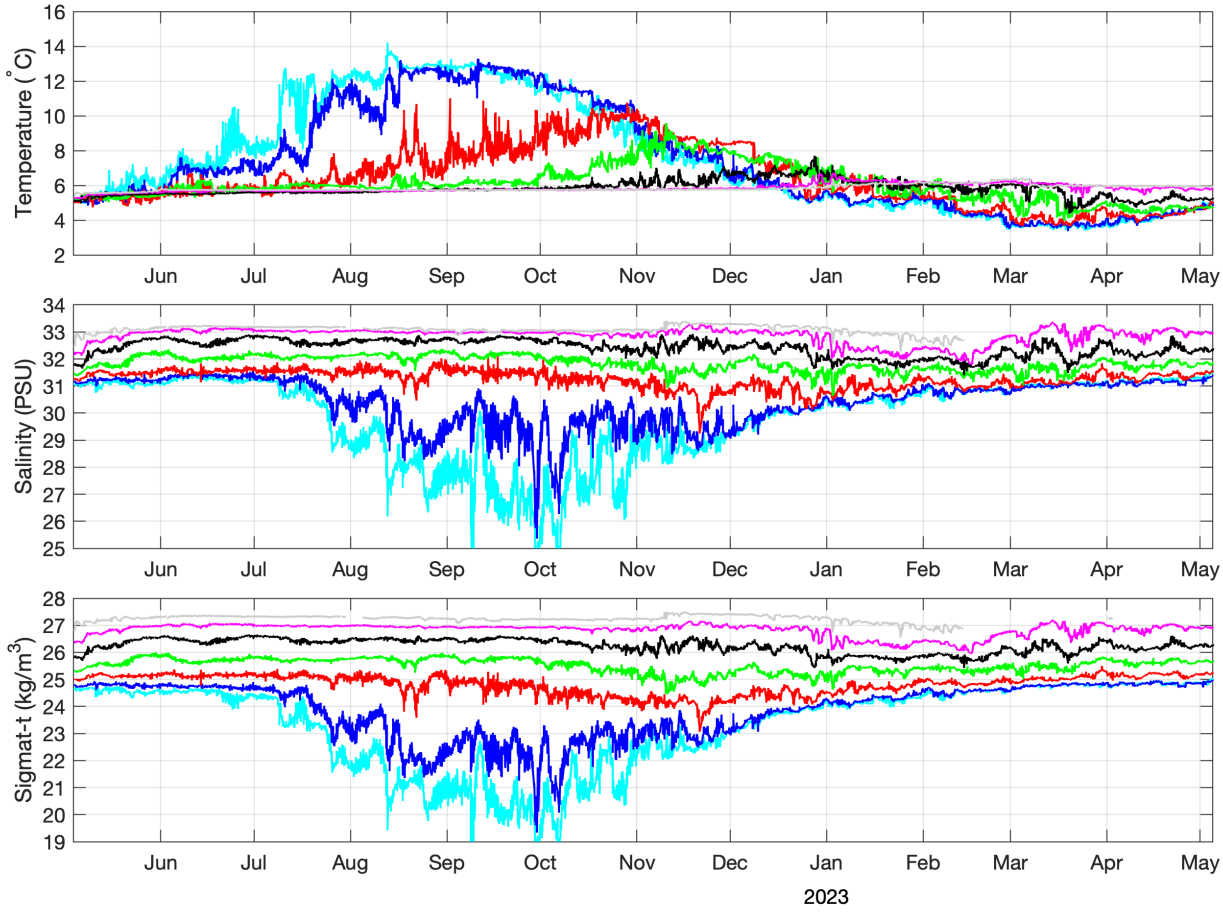

Figure 1. Data records from the 2021-2023 deployment of the GAK1 mooring, with temperature (top), salinity (middle), and density (bottom). Colors denote different instrument depths, with the 2023 sensors winding up near 19 m (cyan), 32 m (blue), 62 m (red), 102 m (green), 153 m (black), 204 m (magenta), and 254 m (gray).

In addition to the mooring, we collected nominally monthly hydrographic profiles at GAK1 from *R/V Nanuq*. Combining the mooring and conductivity, temperature, and depth (CTD) profile data into a single annual anomaly time series, we find that the near surface has been close to the 50-year average but slightly warm while the near-bottom is close to the average and slightly cool (Fig. 2). The most recent salinity readings (Fig. 3) also depict contrasting anomalies, and for this case, both reinforce the observed long-term trends.

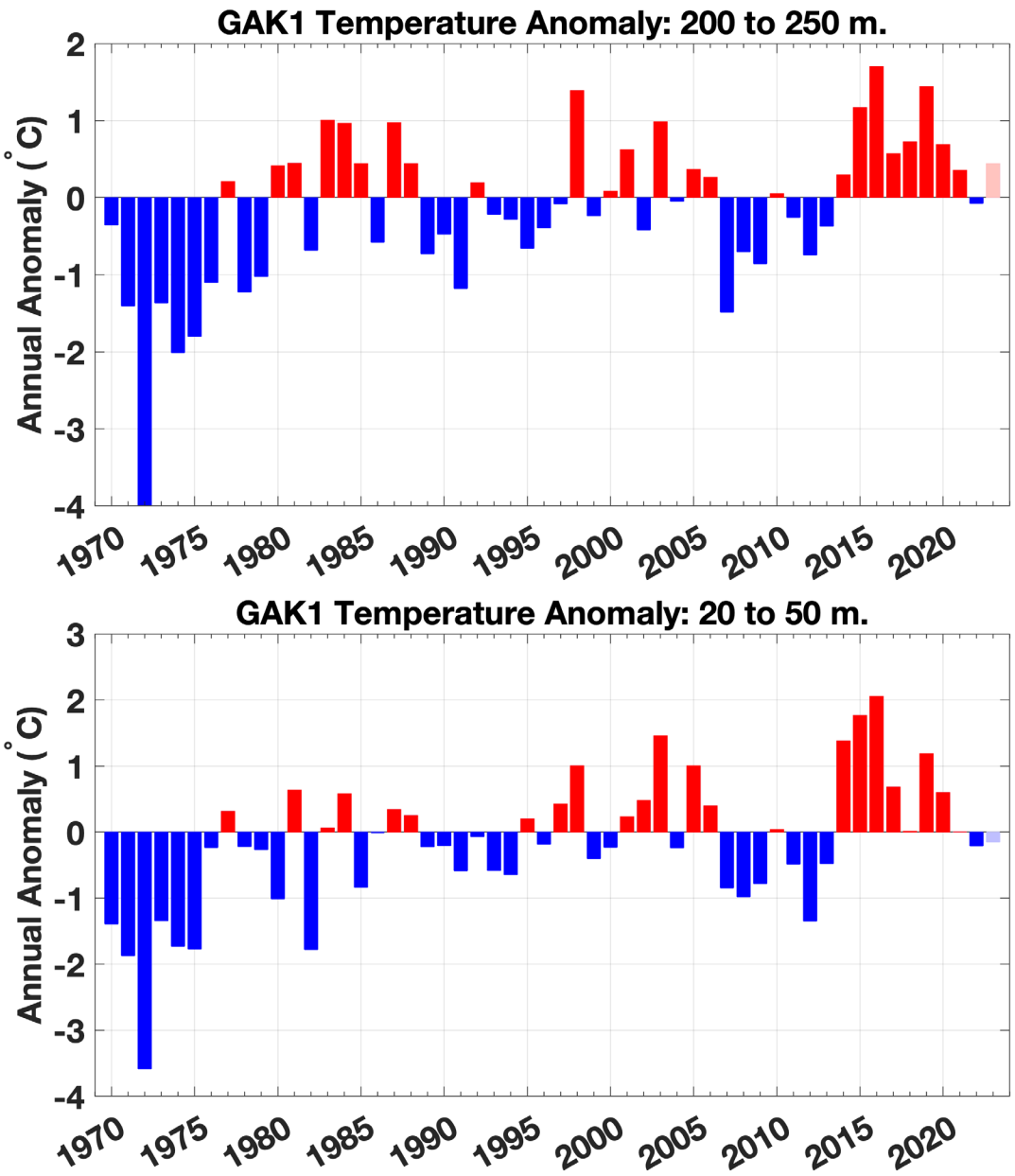

Figure 2. Upper water column (top) and lower water column (bottom) annual temperature anomalies through 2023 (final year is shaded light to indicate that the processed data record does not yet extent through December).

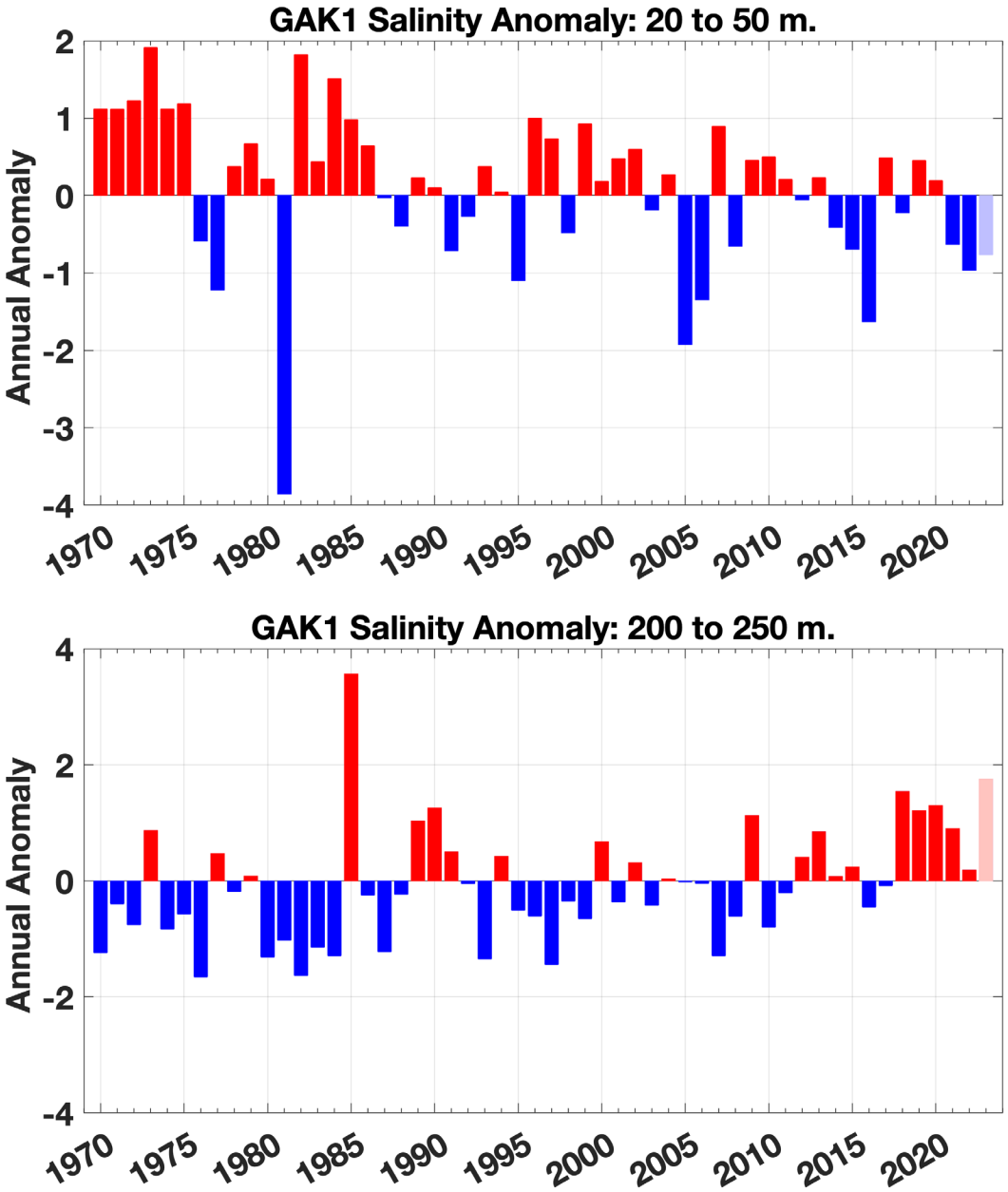

Figure 3. Upper water column (top) and lower water column (bottom) annual salinity anomalies through 2023 (final year is shaded light to indicate that the processed data record does not yet extent through December).

As we begin to undertake our 50-year retrospective analysis, the first step is constructing updated monthly mean climatologies from all our data. Our first attempt at this is shown in Fig. 4, which is based on a combined moored and ship-based dataset. The next steps will involve an error analysis to show how much error can be expected during months in which only a CTD or only mooring datasets are available for analysis. The climatology allows us to clearly observe the temporal lags and magnitudes of the seasonal cycles of heating, cooling, freshening, and near-bottom salinization.

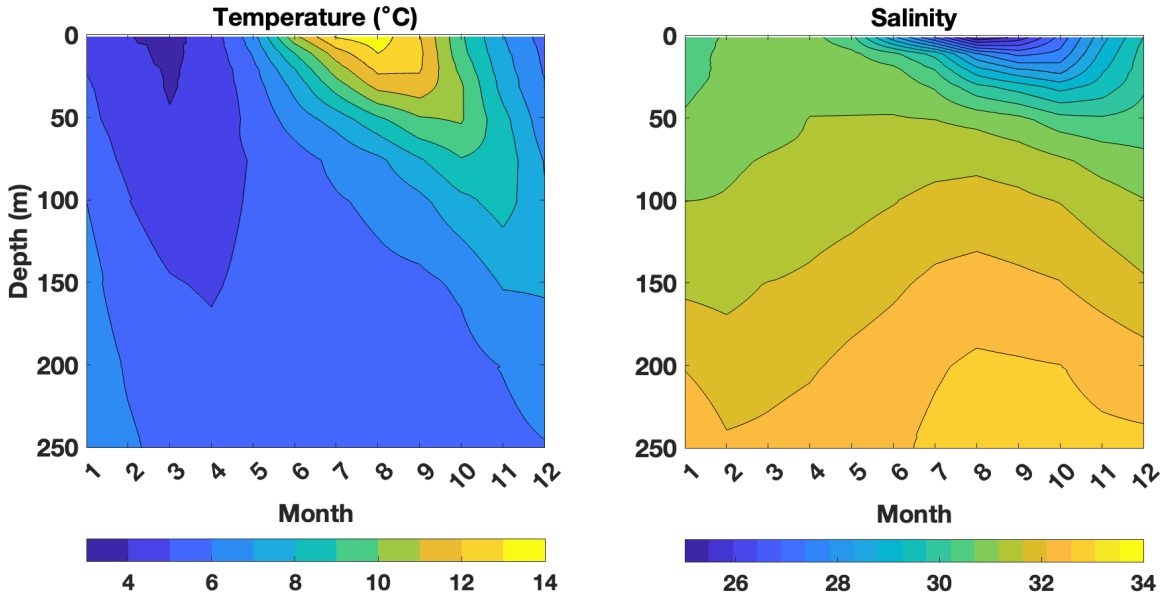

Figure 4. Monthly climatology of temperature (left) and salinity (right) from the best 53-year combined time series of the conductivity and temperature at depth profile and moored datalogger records.

2. Products:

Peer-reviewed publications (using data from GAK1):

Almeida, L. Z., B. J. Laurel, H. L. Thalmann, and J. A. Miller. 2024. Warmer, earlier, faster: Cumulative effects of Gulf of Alaska heatwaves on the early life history of Pacific

cod. Elementa: Science of the Anthropocene 12:00050. https://doi.org/10.1525/elementa.2023.00050.

Amaya, D. J., M. G. Jacox, M. A. Alexander, J. D. Scott, C. Deser, A. Capotondi, and A. S. Phillips. 2023. Bottom marine heatwaves along the continental shelves of North America. Nature Communications 14:1038.

Monacci, N. M., J. N. Cross, W. Evans, J. T. Mathis, and H. Wang. 2024. A decade of marine inorganic carbon chemistry observations in the northern Gulf of Alaska–Insights to an environment in transition. Earth System Science Data Discussions 16:647-665. https://doi.org/10.5194/essd-16-647-2024.

Nielsen, J. K., and C. A. Tribuzio. 2023. Development and parameterization of a data likelihood model for geolocation of a bentho-pelagic fish in the North Pacific Ocean. Ecological Modelling 478:110282.

Strom, S. L., K. J. Bright, and K. A. Fredrickson. 2024. Widespread ciliate and dinoflagellate mixotrophy may contribute to ecosystem resilience in a subarctic sea: the northern Gulf of Alaska. Aquatic Microbial Ecology 90:1-21.

Reports:

Danielson, S. L. 2023. Long-term monitoring of oceanographic Conditions in the Alaska Coastal Current from Hydrographic Station GAK-1. *Exxon Valdez* Oil Spill Long-term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 21120114-I), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Dorn, M. W., B. S. Fadely, O. A. Ormseth, L. A. Rogers, R. M. Suryan, M. Szymkowiak, R. P. Angliss, M. G. Dalton, B. E. Ferriss, K. K. Holsman, J. K. Jansen, E. A. Laman, B. J. Laurel, E. P. Lemagie, M. A. Litzow, J. M. London, D. W. McGowan, J. R. Moran, J. H. Moss, W. A. Palsson, J. L. Pirtle, P. H. Ressler, C. K. Seung, K. E. W. Shelden, and B. C. Williams. 2023. Gulf of Alaska Regional Action Plan to Implement the NOAA Fisheries Climate Science Strategy Through 2024. NOAA Technical Memorandum NMFS-AFSC-478. https://www.fisheries.noaa.gov/s3/2023-11/GoA-RAP-Final-TM-Oct-2023.pdf.

Ferriss, B. E. 2023. Ecosystem assessment. Pages 8-12 *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. https://apps-afsc.fisheries.noaa.gov/REFM/docs/2023/GOAecosys.pdf.

Hennon, T., and S. Danielson. 2023. Predicted ocean temperatures in the northern Gulf of Alaska. Pages 37-39 *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. https://apps-afsc.fisheries.noaa.gov/REFM/docs/2023/GOAecosys.pdf.

Shotwell, S. K., B. Ferriss, P. J. F. Hulson, B. Laurel, B. Matta, L. Rogers, A. Ableman, G. Adams, K. Aydin, S. Barbeaux, and M. Callahan. 2023. Appendix 2.1 Ecosystem and socioeconomic profile of the Pacific cod stock in the Gulf of Alaska-Report Card. https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOApcod_app1.pdf.

Conferences and workshops:

Danielson, S. 2023. Updates of GAK1 and Seward Line physical hydrography. NOAA Integrated Ecosystem Assessment Program spring Preview of Ecosystem and Economic Conditions (PEEC), Online presentation from Fairbanks, Alaska, 8-10 May 2023.

Danielson, S. 2023. Gulf of Alaska physical oceanography. Presentation to Research Experience for Undergraduates (REU) NGA LTER Summer 2023 Weekly Science Seminar. Fairbanks, Alaska, June.

Public presentations:

None to report.

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

The GAK-1 timeseries is served as a "Signature Data Set" on the NGA LTER program's website. This can be accessed at: https://nga.lternet.edu/data-overview/signature-datasets/

Data sets and associated metadata:

Danielson, S. 2023. Environmental drivers: Gulf of Alaska mooring (GAK1). Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/3c4ecb88-6436-4312-8281-ed584e020b0e/project.

Additional Products not listed above:

Updates to the UAF GAK1 home page are maintained at http://research.cfos.uaf.edu/gak1/.

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

The GAK1 project 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 (NOAA).

EVOSTC Long-Term Research and Monitoring Projects

GAK1 is part of the GWA-LTRM program within the Environmental Drivers component. Principal investigator (PI) Danielson coordinates closely with other Environmental Drivers projects, particularly Seward Line (23120114-L, PI Hopcroft) and ocean acidification (23220202, PI Hauri). PI Danielson also coordinates across components with Nearshore and Pelagic PIs on publications and synthesis products.

EVOSTC Mariculture Projects

None to report.

EVOSTC Education and Outreach Projects

Ms. Nicole Webster, a PhD student in PI Danielson's UAF oceanography lab, has been working closely with Katie Gavenus of Center for Alaskan Coastal Studies, joining CORaL Network visits to Prince William Sound communities and leading science exploration, especially in the realm of underwater soundscapes.

Individual EVOSTC Projects

The GAK1 project works with the Data Management program to ensure data collected by the project are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes.

Trustee or Management Agencies

The GAK1 project along with the National Park Service is contributing to the support of a new UAF-based summer oceanography field course, an intensive 11-day 3-credit course that introduces students to modern oceanographic field techniques. The students get to sample at GAK1, contributing to the 50-year time series. The GAK1 project supports one day of vessel charter time for the course, and benefits by having the August CTD profile conducted by the students.

The GAK1 project also contributes data and reporting to NOAA's Gulf of Alaska Ecosystem Status Report.

Native and Local Communities

Ms. Nicole Webster, a PhD student in PI Danielson's UAF oceanography lab, traveled to the Prince William Sound community of Tatitlek in February 2023 to provide outreach learning opportunities for K-12 students. Ms. Webster's academic focus is on underwater sound, and her activities included listening to an underwater hydrophone and discussing underwater soundscapes. A second planned community visit to Chenega Bay was cancelled due to Covid-19. Ms. Webster also joined the CORaL network's Community Coastal Experience (CCE) in Qutalleq / Seward in September 2023. The CCE group spent the morning at Qutekcak Native Tribe learning about the cultural history of Sugpiaq People in the area.

4. Response to EVOSTC Review, Recommendations and Comments:

We thank EVOSTC for continued support of the GAK1 project. The best measure of the far-reaching impact of this project is that the GAK1 dataset contributes to new peer-reviewed publications now at the rate of 4 or 5 per year (most of which do not even include the PI as a co-author) and the contributions to agency reports, such as NOAA's Ecosystem Status Report and the spring Preview of Ecosystem and Economic Conditions (PEEC) workshop.

The review recommends synthesis of the Environmental Driver components. The ED projects have funding for analyses by two post-doc level collaborators that will focus on physics and zooplankton, respectively. The physical oceanography analysis will be led by Dr. Tyler Hennon of UAF, and it will be an analysis of the salinity fields collected across the ED projects. This will be a complementary effort to the temperature-focused synthesis published in Danielson et al. (2022) during the last phase of funding. Dr. Hennon will focus on the contrasting trends in

salinity observed at the seafloor and near the surface, and attempt to diagnose their root causes. The near surface freshening is likely due to net glacial ablation associated with warming atmospheric temperatures; the cause of the near-bottom salinization is not presently clear.

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	$43,544	$44,921	$46,045	$85,132	$87,420	$307,062	$72,507
Travel	$6,528	$6,562	$6,599	$6,635	$6,673	$32,997	$3,213
Contractual	$7,200	$7,385	$7,573	$7,769	$7,968	$37,895	$26,327
Commodities	$3,150	$3,229	$3,310	$3,392	$3,478	$16,559	$20
Equipment & F&A Exempt	$49,552	$63,680	$60,473	$59,081	$61,202	$293,988	$8,073
Indirect Costs Rate = 25% (non-equipment)	$15,106	$15,524	$15,882	$25,732	$26,385	$98,628	$12,564
SUBTOTAL	$125,080	$141,301	$139,882	$187,741	$193,126	$787,129	$122,704
General Administration (9% of subtotal)	$11,257	$12,717	$12,589	$16,897	$17,381	$70,842	N/A
PROJECT TOTAL	$136,337	$154,018	$152,471	$204,638	$210,507	$857,971	
Other Resources (In-Kind Funds)						$0	

Project expenses are generally on track as proposed, other than being behind because of the lag in the NOAA grant. We will be placing a significant order for commodities this spring to stock up on mooring and CTD expendables that will carry us forward for a couple of years. We may decide to move the student (allocated for FY25 and FY26) forward to accelerate the timeline of that work. If we decide to make this change, we will request a formal re-budget of resources.