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

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

Annual Project Reporting Form

Project Number: 22120114-I

Project Title: Oceanographic station GAK-1 long term monitoring of the Alaska Coastal Current

Principal Investigator(s): Seth Danielson

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/ ; http://research.cfos.uaf.edu/gak1/

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 had a successful recovery and re-deployment of the 2021/2022 GAK-1 mooring in May 2022. 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 (note occasional data gaps in the Fig. 1 records).

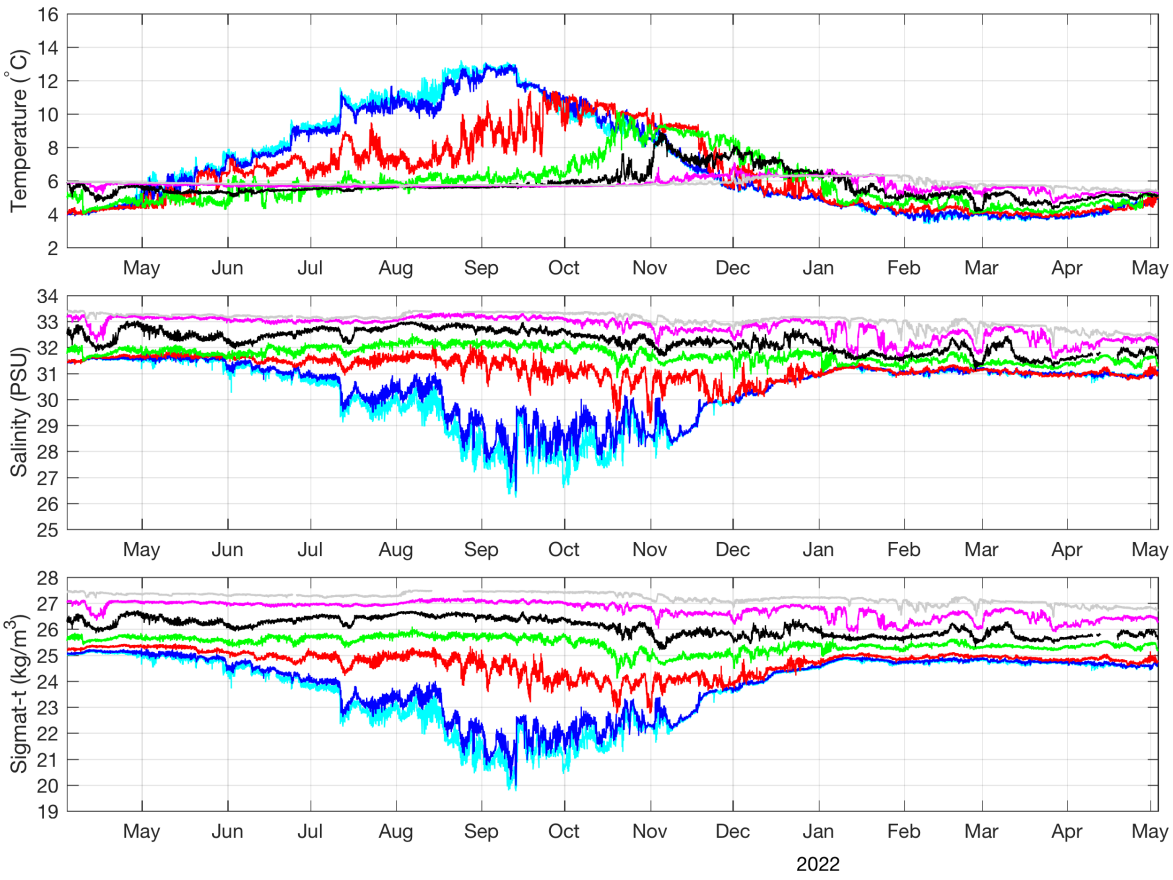

Figure 1. Data records from the 2021-2022 deployment of the GAK-1 mooring, with temperature (top), salinity (middle) and density (bottom). Colors denote different instrument depths, with the 2023 sensors winding up near 18 m (cyan), 24 m (blue), 56 m (red), 99 m (green), 147 m (black), 200 m (magenta) and 247 m (gray).

In addition to the mooring, we collected monthly hydrographic profiles at GAK-1 from *R/V Nanuq,* managing to get casts in all months except March. Combining the mooring and conductivity and temperature at depth (CTD) profile data into a single monthly anomaly time series, we find that the water column mean (0-250 m depth) average temperatures have recently cooled to below both the long-term average and the best fit trend line (Fig. 2). The most recent salinity readings are also below the long-term average; the long-term full water column salinity record has no temporal trend.

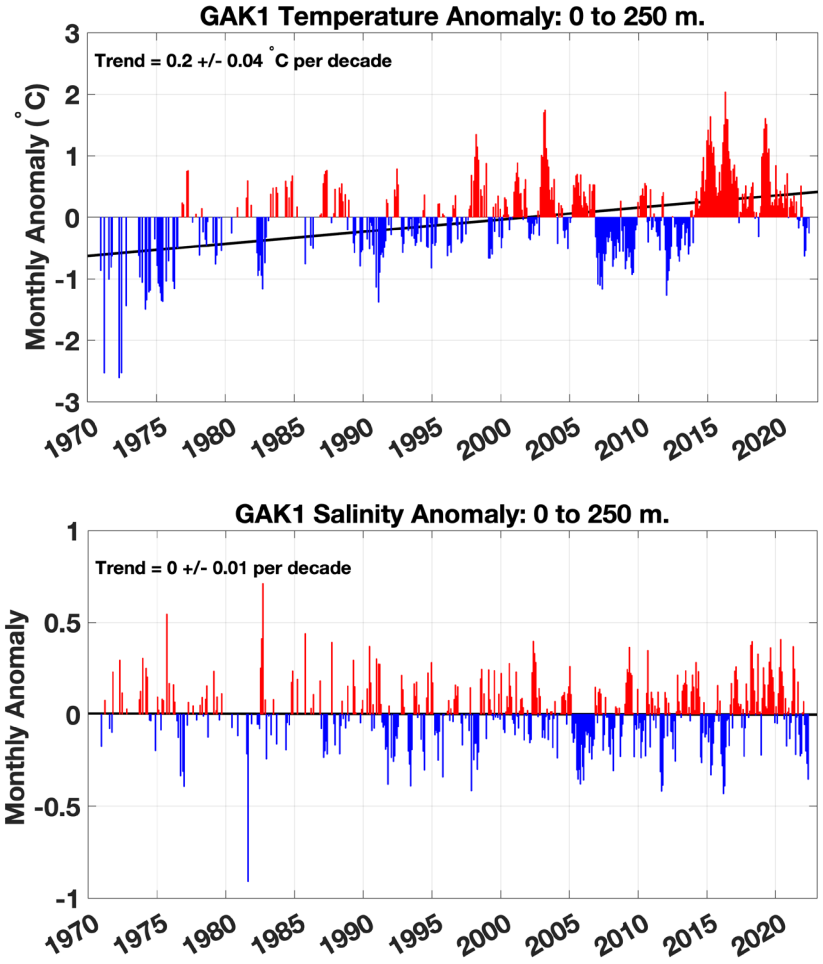

Figure 2. Full water column (0-250m depth) anomalies of temperature (top) and salinity (bottom) extending over 1970 to 2022. Dataset depicts the full combined mooring (1999 to present) and CTD profile (1970 to present) synthetic dataset. Note the presence of a statistically significant warming trend in temperature, while the integrated water column salinity record has no discernable trend.

New analyses of the GAK-1 record indicate that the nature of thermal and haline trends are seasonally dependent (see Danielson 2023). Although additional progress has not yet been made in diagnosing the causes of these signals, we anticipate that a focused study of seasonality in the coastal Gulf of Alaska will yield new insights into the physical and ecological functioning of this marine system.

Literature Cited

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.

2. Products:

Peer-reviewed publications:

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 203:105155.

Litzow, M. A., A. A. Abookire, J. T. Duffy-Anderson, B. J. Laurel, M. J. Malick, and L. A. Rogers. 2022. Predicting year class strength for climate-stressed gadid stocks in the Gulf of Alaska. Fisheries Research 249:106250.

Lindeberg, M. R., M. Baker, D. M. Dickson, D. G. Kimmel, O. A. Ormseth, and S. L. Strom. 2022. Long-term monitoring and integrated research–understanding ecosystem processes in the Gulf of Alaska. Deep Sea Research Part II: Topical Studies in Oceanography 203:105208.

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.

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.

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, Suite 400, Anchorage, Alaska 99501.

Popular articles:

Danielson, S., H. Statscewich, E. Farley, and J. Horne. 2022. Underwater glider makes first ever mid-winter voyage in the Gulf of Alaska. Delta Sound Connections 2022-2023. https://pwssc.org/wp-content/uploads/2022/06/DSC-2022-WEB.pdf

Conferences and workshops:

Danielson, S. L. 2022. GAK-1 updates. NOAA Integrated Ecosystem Assessment Program Spring Preview of Ecosystem and Economic Conditions (PEEC) Workshop, 23-25 May. Online.

Danielson, S. L. 2022. GAK-1 updates. Northern Gulf of Alaska Long-Term Ecological Research (NGA LTER) Principal Investigators Workshop, December, Fairbanks, AK.

Danielson, S. L. 2023. GAK1 as a Platform of Opportunity for Additional Sensors. Field Effort Coordination Planning Meeting, Alaska Ocean Observing System, Alaska Marine Science Symposium, 25 January, Anchorage, AK.

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 University of Alaska Fairbanks GAK-1 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

Principal Investigator (PI) Danielson 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 teamwork for PWSSC and PWSSC is the fiscal agent for the University of Alaska Fairbanks's (UAF's) grant through the National Oceanic and Atmospheric Administration.

EVOSTC Long-Term Research and Monitoring Projects

PI Danielson led a 2022 synthesis publication that focused on Gulf of Alaska temperature variations (Danielson et al. 2022). This publication included coauthors from other Gulf Watch Alaska projects including other Ecosystem Drivers PIs (Campbell, Holderied), from the Nearshore component (Monson), and the program management team (Suryan).

The GWA-LTRM Seward Line project was bolstered by the addition of the National Science Foundation Northern Gulf of Alaska Long Term Ecological Research (NGA LTER) to the Seward Line funding and science consortium. The NGA LTER program brought access to the global-class *R/V Sikuliaq* as a sampling program. For many years, the GAK-1 project has been able to leverage CTD profiles in May and September from the Seward Line cruises. With the addition of the NGA LTER program, GAK-1 now also benefits from a mid-summer (July) CTD profile and has been able to carry out the annual GAK-1 mooring deployments and recoveries from this platform in May.

In addition, the GAK-1 project collaborated with the Herring Research and Monitoring project that involved acoustic tagging of PWS herring. One peer-reviewed paper resulted from this work, which involved the deployment of an underwater glider equipped with a tag-detecting acoustic sensor. Collaboration included sharing of GAK-1 vessel time for glider recovery and a prior installation of a tag detector on the GAK-1 mooring.

EVOSTC Mariculture Projects

None to report.

EVOSTC Education and Outreach Projects

PI Danielson participated in the joint GWA-LTRM/CORaL Network meeting held in Anchorage in January 2023 at the Alaska Marine Science Symposium; this followed a separate meeting of Danielson and another UAF faculty member with the ASLC Chief Science and Education Officer Wei Ying Wong in November 2022. These informational and planning/coordination

meetings have helped set the stage for further future collaboration between the GAK-1 project and the CORaL network. We look forward providing our scientific expertise to new educational ventures.

Individual EVOSTC Projects

PI Danielson works with the Data Management program to ensure data collected at GAK-1 are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal withing required timeframes. GAK-1 data are publicly available and used widely; PI Danielson will work with individually funded EVOSTC projects if GAK-1 data would be valuable for those projects.

Trustee or Management Agencies

PI Danielson contributes GAK-1 indices to the National Oceanographic and Atmospheric Administration for the annual Gulf of Alaska ecosystems Considerations Report to the North Pacific Fisheries Management Council.

Native and Local Communities

Ms. Nicole Webster is a PhD student in PI Danielson's UAF oceanography lab. In February 2023 Ms. Webster traveled to the PWS community of Tatitlek to provide outreach learning opportunities for K-12 students in this community. 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.

4. Response to EVOSTC Review, Recommendations and Comments:

May 2021 EVOSTC Science Panel Comment: The PIs propose to continue monitoring the GAK-1 Oceanographic Station. The project monitors five important Alaska Coastal Current (ACC) ecosystem parameters from surface to depth including temperature, stratification, surface pressure, chlorophyll a fluorescence as an index of phytoplankton biomass, and along-shelf currents. The project has been productive over the years and the PIs have made the case that this knowledge enhances our understanding of the physical conditions in the Gulf of Alaska, including Prince William Sound. The objectives and sampling protocol will remain the same as in previous iterations of this proposal in order to maintain continuity of the dataset.

We concluded that integration of all five of the LTRM Environmental Driver oceanographic proposals (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 may 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.

May 2021 EVOSTC Science Panel Comment: We recognize the value of continuing this important work. In addition to comments on this specific proposal, in March we also offered a general comment to all five EVOS-funded oceanography projects asking for a plan to synthesize these into a comprehensive, integrated picture of oceanographic conditions across the northern Gulf of Alaska. The PIs for all five oceanographic projects provided the identical response to this request. We seek clarification specifically about how the PI of this project (22120114-D) has contributed to the present syntheses (Danielson et al. in review) and will contribute to these syntheses moving forward. The present generic response across all 5 proposals was not sufficient. What data would be used and how would they fit into the overall analysis and what will be the role of the PI in each case?

PI response: *Thank you all for your continuing support and affirmations of the importance of consistent, long-term sampling carried out by the GAK-1 project. PI Danielson led the now-*

published temperature synthesis (Danielson et al. 2022). He anticipates also taking a leading role in another Ecosystem Drivers synthesis paper, tentatively identified as addressing the role of salinity across the various Ecosystem Drivers component (although it is not fully clear exactly how the Continuous Plankton Recorder project would fit into such a physics-focused synthesis, without complementary profile data; use of Argo float data might be one solution). A pan-shelf salinity analysis would primarily focus on CTD data collected in Prince William Sound, Cook Inlet, and on the Northern Gulf of Alaska shelf at GAK-1, along the Seward Line and at other NGA LTER sampling sites. Danielson is also operating underwater gliders (autonomous ocean "drones") that are accumulating considerable new data in winter and spring, when few oceanographic vessels are taking samples. While the bulk of the salinity analyses would fall to the physical oceanographers, a second and more ecosystem-focused component of this synthesis should also look at biological co-variates relative to the CTD hydrography. Because salinity is the dominant factor in setting shelf stratification, it is likely that a synthetic analysis of the long GWA-LTRM time series could reveal some bottom-up signals that reflect the consequence of pycnocline control of nutrient supply to the euphotic zone. Such a biologically focused synthesis tack would rely heavily on each Ecosystem Driver PI to assess their data relative to water column structure.

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 203:105155.

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	$2,851
Travel		$6,528	$6,562	$6,599	$6,635	$6,673	$32,997	$0
Contractual		$7,200	$7,385	$7,573	$7,769	$7,968	$37,895	$153
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	$0
Indirect Costs (non-equipment)	Rate = 25%	$15,106	$15,524	$15,882	$25,732	$26,385	$98,628	$756
SUBTOTAL		$125,080	$141,301	$139,882	$187,741	$193,126	$787,129	$3,780
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	

COMMENTS:
Due to the spend-down of the prior year's grant and the annual timing of mooring operations, a number of encumbered but not-yet-expensed items are not reflected in the totals shown in Column J. These encumbered expenses include over $40k in equipment items on order, sensor calibrations that are presently being performed at the manufacturer's factory and upcoming vessel charters.

Indirect Costs: Facilities and Administrative (F&A) Costs are calculated at 25.0% of the Modified Total Direct Costs (MTDC), as per the proposal guidelines. MTDC includes Total Direct Costs minus tuition, scholarships, participant support costs, rental/lease costs, subaward amounts over $25,000, and equipment. A copy of the agreement is available at: http://www.alaska.edu/cost-analysis/negotiation-agreements/.

FY22-26	Project Number: 22120114-I Project Title: GAK-1 Mooring Primary Investigator: Danielson (UAF)	NON-TRUSTEE AGENCY SUMMARY PAGE

In explanation of the low apparent spending levels, in part the depicted spending reflects the prior phase no-cost extension, which lasted until January 2023. In anticipation of the grant transition, dating back to FY21 and before, we stretched our prior phase project funding as long as possible because of uncertainties about when the current phase funding would arrive at UAF in FY22. In addition, the present spending does not reflect a number of high-dollar encumbrances that include placed equipment orders, ongoing instrument calibrations and service at the mooring datalogger manufacturer, and encumbered vessel charters. Although encumbered, these items do not yet appear on the spent side of the balance sheet.