FY 22-31 *PROJECT* PROPOSAL
LONG-TERM RESEARCH AND MONITORING PROGRAM

Does this proposal contain confidential information? ☐Yes ☒No

Project Number and Title

Gulf Watch Alaska Long-Term Research and Monitoring Program: Environmental Drivers Component

22120114-I Oceanographic Station GAK-1 Long Term Monitoring of the Alaska Coastal Current

Primary Investigator(s) and Affiliation(s)

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Project Abstract (maximum 300 words)

This program continues a now half-century-long time series of temperature and salinity monitoring at oceanographic station GAK-1. The GAK-1 data set is the single longest regularly repeated water column hydrographic profile times series in all of Alaska's coastal waters. Sampling began in 1970 and consists of quasi-monthly vessel-based conductivity-temperature versus depth (CTD) casts. In 1998, the monthly measurements were augmented with a mooring eventually outfitted with up to seven temperature/conductivity dataloggers distributed between 20 m and 250 m depth and optical sensors near 20 m depth. The project monitors five important Alaska Coastal Current (ACC) ecosystem parameters that quantify and help us understand hourly to seasonal, interannual and multi-decadal variability in (1) temperature and salinity throughout the 250 m deep water column; (2) near surface stratification; (3) surface pressure fluctuations; (4) chlorophyll a fluorescence as an index of phytoplankton biomass; and (5) along-shelf transport in the ACC. All of these parameters are basic descriptors that characterize the workings of the inner shelf and the ACC, an important habitat and migratory corridor for organisms inhabiting the northern Gulf of Alaska (GOA), including Prince William Sound. We are aware of over 100 publications employing data collected at station GAK-1 and since 2010 the citation list has grown on average by nearly five publications per year. GAK-1 data is used within at least fifteen graduate student Masters theses and doctoral dissertations, many dozens of peer-reviewed papers, and both State of Alaska and federal management agency reports. The topics covered by these publications range from physical, chemical and biological oceanography to paleoclimate studies, fisheries research and management, and ecosystem-based management applications. The GAK-1 data set provides a consistent, curated, long-term baseline for assessing temporal change of environmental conditions in the GOA.

EVOSTC Funding Requested (must include 9% GA)

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$136,337	$154,018	$152,471	$204,638	$210,507	$857,971
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$250,360	$168,803	$137,100	$140,366	$144,093	$840,722
				FY22-31 Total	*$1,698,693*

**If the amount requested here does not match the amount on the budget form, the request on the budget form will considered to be correct.*

Non-EVOSTC Funds to be used:

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
n/a	n/a	n/a	n/a	n/a	n/a
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
n/a	n/a	n/a	n/a	n/a	n/a
				FY22-31 Total	n/a

The GAK-1 project receives most of its funding from EVOSTC. In-kind support is provided by the Seward Line project (EVOSTC/AOOS/NPRB/NSF funding) in the form of GAK-1 CTD profile sampling in May, July, and September, and occasionally as ship time associated with the annual mooring recovery/deployments.

1. EXECUTIVE SUMMARY

The goal of the GAK-1 project is to provide a long-term high-quality reference dataset (Figs. 1 and 2) for the coastal Northern Gulf of Alaska (NGA) that enables scientists, students, commercial and subsistence fishers, and resource managers to better understand climatic and ecological conditions, their changes, and ramifications of change. Understanding, anticipating, and responding to change requires a foundational frame of reference in the form of long-term in situ observations. Such datasets are the best means to guide our assessments and interpretations of system variability. Untangling the relations between climatic and other drivers of change (e.g., oil spills or fishing regulations) similarly requires long-term reference time series. Environmental time series data can provide information valuable to the management of fish and shellfish populations and fisheries (Anderson and Piatt 1999, Munro and Tide 2014).

There exist no other full water column temperature and salinity time series in the NGA with comparable data quality, temporal extent (i.e., 50 years), frequency of sampling and consistency of location. Because the GAK-1 data provide useful proxies for transport in the Alaska Coastal Current (ACC; Table 1), our measurements also provide information about along-shelf advection of heat, fresh water, and passively advected organisms and geochemical constituents (Weingartner et al. 2005). Hence, the GAK-1 dataset is the premier reference dataset for evaluating hypotheses that seek mechanistic descriptions of the regional ocean environment and ecosystem across a broad range of time scales. As shown by an ever-increasing number of publications that utilize the GAK-1 dataset, the value of this unique time series continues to grow and even accelerate with passing decades.

The GAK-1 dataset is collected under the fundamental hypothesis that oceanic conditions are important to the physical and biological functioning of the Prince William Sound and NGA ecosystems. The main purpose of the GAK-1 project is to document key metrics of the state of the marine system so that scientists, resource managers, and others can assess system state and changes, develop hypotheses, and test hypotheses. To that end, dozens of papers have examined this hypothesis from numerous perspectives (for a comprehensive listing, see the GAK-1 home page at http://research.cfos.uaf.edu/gak1/). As the chemical and biological datasets begin to catch up (via quality of resolution, duration, and frequency) to the physical measurements, we expect that the insights gleaned through interdisciplinary analyses will grow in kind.

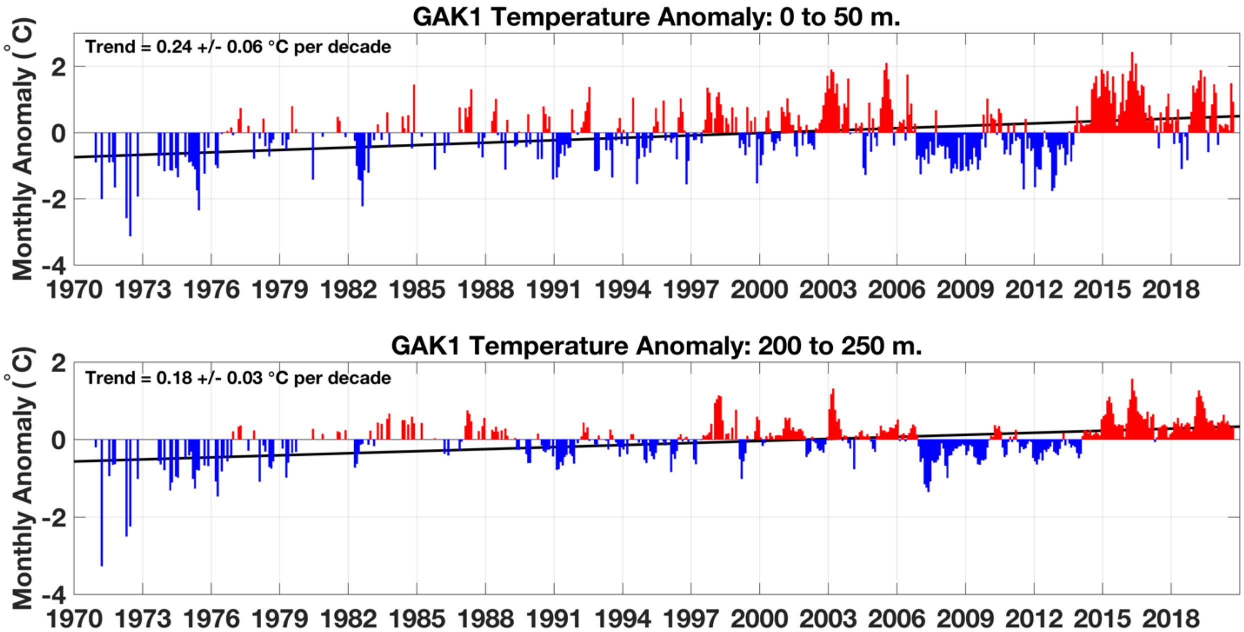

Figure 1. 1970 to 2020 depth-averaged temperature anomalies from the GAK-1 dataset across 0-50 m (top) and 200-250 m (bottom) depth intervals. The data exhibit a long-term trend in warming (least squares fit black line) along with signals associated with the cycles of the El Niño Southern Oscillation and other phenomena.

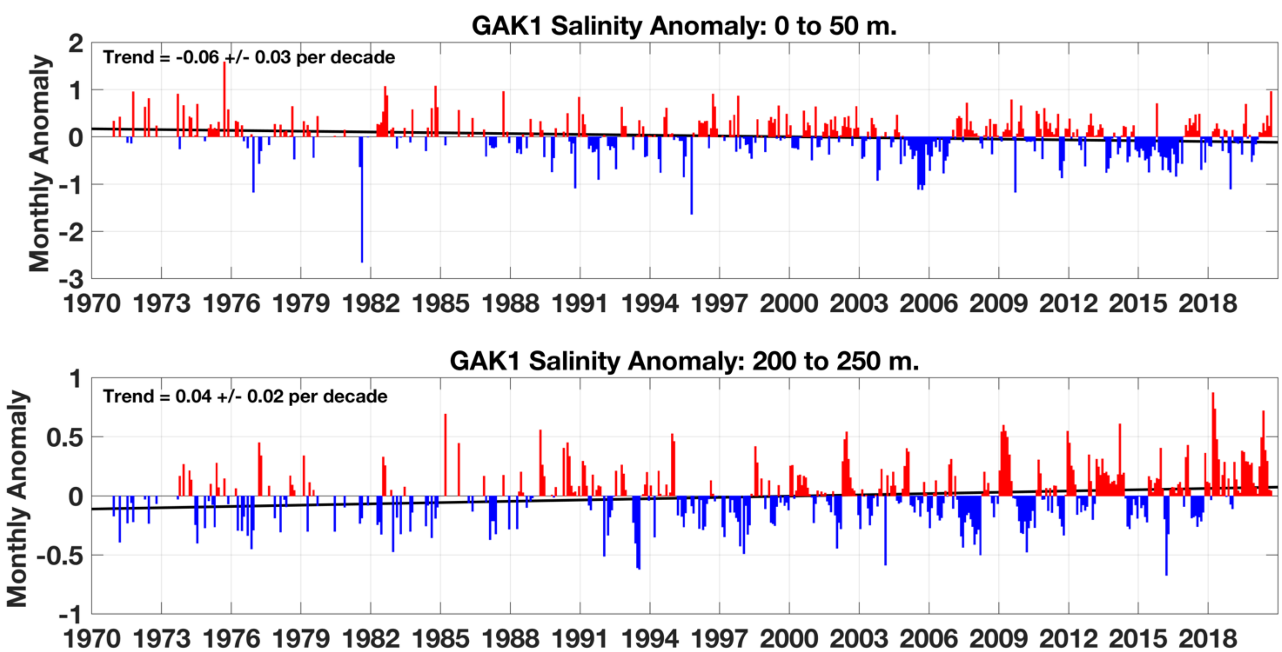

Figure 2. 1970 to 2020 depth-averaged salinity anomalies from the GAK-1 dataset across 0-50 m (top) and 200-250 m (bottom) depth intervals. The data exhibit a long-term freshening at the surface and salinization near the seafloor (least squares fit black lines).

Table 1. Relation between the along-shelf baroclinic transport and GAK-1 measurements of salinity and dynamic height integrated from the surface to 200 m depth (dynamic height is derived from the CTD temperature, salinity, and pressure data). From left to right, the columns show the observed parameters, months that the regression holds for, fraction of variance explained by the regression, regression slope, and the 95% confidence bound on the slope. Reproduced from Weingartner et al. (2005).

GAK-1 Parameter	Months	r^2	Slope	CI
30 m Salinity	Nov-May	0.47	0.69	+/- 0.28
50 m Salinity	Jun-Aug	0.72	0.85	+/- 0.43
0-200 m Dynamic Height	Jun-Aug	0.86	0.93	+/- 0.3

To date, the GAK-1 time series has helped show:

1. Large interannual differences associated with El Nino and La Nina events, including substantial differences in the spring bloom between these phenomena (Weingartner et al. 2002, Childers et al. 2005).
2. The intimate connection between coastal freshwater discharge and the depth-varying evolution of winter and spring temperatures over the shelf (Janout 2010, Janout et al. 2013).
3. Hydrographic data from station GAK-1 provides a reliable index of ACC transports of mass, heat, and freshwater (Weingartner et al. 2005).
4. That GAK-1 near-surface salinities are correlated with coastal freshwater discharge from around the Gulf of Alaska (GOA; Weingartner et al. 2005).
5. Variations in mixed-layer depth, which affects primary production (Sakar et al. 2005).
6. Long-term trends in salinity and temperature (Royer 2005, Royer and Grosch 2006, Weingartner et al. 2005, Janout et al. 2010, Kelley 2015, Danielson et al. *in review*).
7. The relationships between temperature and salinity variations and the Pacific Decadal Oscillation and the strength and position of the Aleutian Low (Royer 2005, Weingartner et al. 2005, Janout et al. 2010).
8. That the GAK-1 record can guide understanding the variability in iron concentrations, a limiting micro-nutrient required by many phytoplankton. Iron concentrations and surface salinity are correlated in certain seasons (Wu et al. 2009).
9. Between about 1000 and 1500 years before present the northern GOA likely experienced a cooler, more sluggish and higher salinity ACC, whereas between 600 and 1000 years before present a stronger Aleutian Low may have driven a stronger and fresher ACC (Hallmann et al. 2011)
10. Ocean acidification (carbonate) system variability can be described using multiple linear regression models to predict dissolved inorganic carbon and total alkalinity using observations of nitrate, temperature, salinity, and pressure (Evans et al. 2013).
11. A decoupling of near-surface and near-bottom waters through increased stratification (Kelley 2015) with implications for nutrient resupply to the euphotic zone and long-term changes in shelf productivity.
12. As shown and discussed by Mueter et al. (1994), Mueter (2004), Spies (2007), and Suryan et al. (2021) these factors affect and relate to many ecosystem processes on both the shelf and within Prince William Sound and Lower Cook Inlet/Kachemak Bay.

Measurements at GAK-1, at the mouth of Resurrection Bay, began in 1970. Initially the sampling was opportunistic, became more regular in the 1980s and 1990s, and fully systematic beginning in the late 1990s with *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) support of moorings and monthly conductivity and temperature versus depth (CTD) casts. Additionally, the National Science Foundation (NSF)/National Oceanic and Atmospheric Administration (NOAA) Global Ocean Ecosystem Dynamics (GLOBEC) program support of Seward Line sampling occupied station GAK-1 with multidisciplinary sampling up to 7 times per year from 1997 to 2004. Since then, data collection involves monthly CTD casts and hourly temperature and salinity measurements from a subsurface mooring (Fig. 3). GAK-1 is the only continuously sampled station over the NGA shelf that measures both salinity and temperature across the 250 m deep water column.

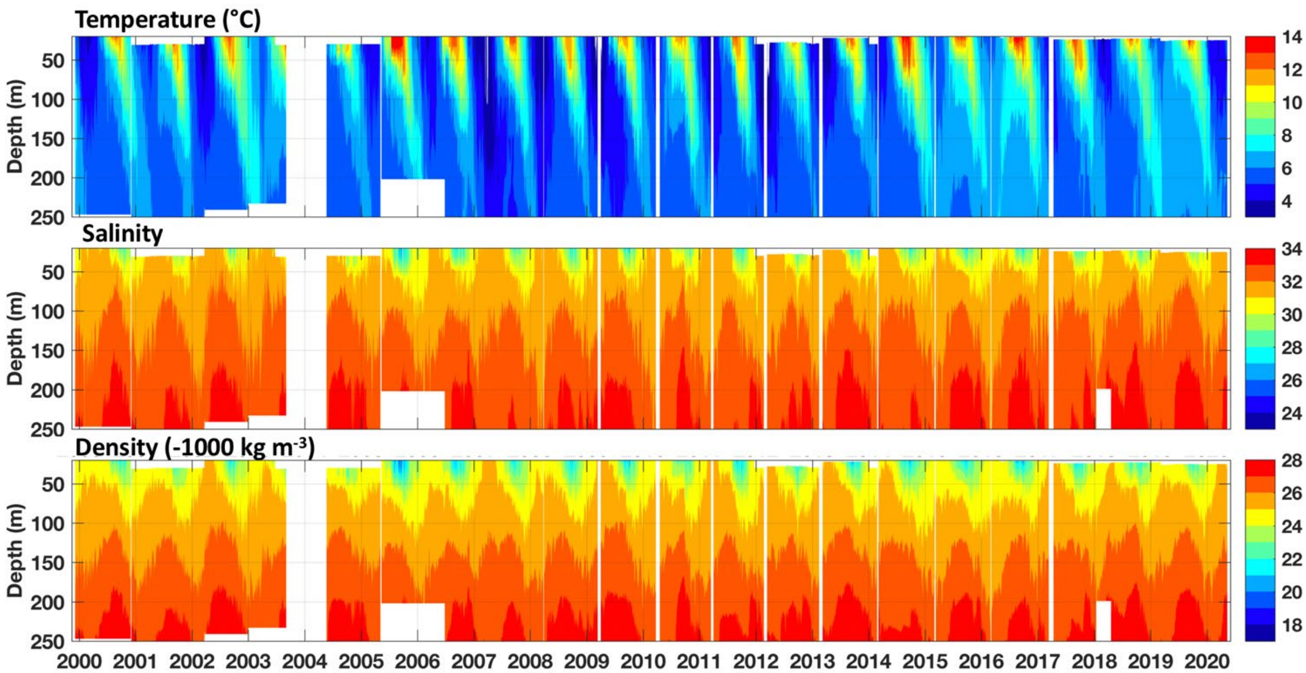

Figure 3. Time series over December 1999 to May 2000 of temperature (top), salinity (middle) and density (bottom) from the GAK-1 mooring. The large measurement gap in late 2003 and early 2004 occurred when the mooring was dragged off site, likely by a tug/barge catenary line.

In 1976, the GAK-1 data began to reveal the warming that eventually was recognized as the mid-1970s North Pacific regime shift associated with the Pacific Decadal Oscillation (Mantua et al. 1997), a far-reaching alteration in environmental conditions (both ecologically and economically) such that GOA fisheries were forced to retool from benthic shrimp to fin-fish gear and methods (Anderson and Piatt, 1999). Other significant events captured by the GAK-1 time series include major El Niño Southern Oscillation (ENSO) events in 1972–73, 1982–83, 1997–98, and 2014–16, and a North Pacific Marine Heatwave (MHW) that triggered massive seabird die-offs (Piatt et al. 2020) and other long-lasting impacts across the Gulf Watch Alaska (GWA) study area (Suryan et al. 2021). Each of these observed events was associated with now well-known modes of climate variability (e.g., Mantua et al. 1997, DiLorenzo et al. 2008) and each represents changing ocean conditions that can affect marine primary productivity, secondary productivity and upper trophic level success through bottom-up forcing. Disentangling the causes of natural or human-induced variation in the marine ecosystem is not always possible, but data records such as GAK-1 allow us to probe and assess correlative relations and direct mechanistic linkages.

2. RELEVANCE TO THE INVITATION

An overarching goal of the program is to inform management agencies and the public about changes in the spill-affected area. The GAK-1 project provides the single longest and most consistent sea surface-to-seafloor reference data set for assessing physical changes in the marine realm of the spill-affected area. The purpose of this proposal is to provide long-term monitoring data of the oceanography of ACC and the NGA shelf. The monitoring proposed herein quantifies the state and variability of the NGA's shelf environment. The ACC is the most prominent feature of the GOA shelf circulation. It is a narrow (~40 km), swift, year-round flow maintained by the integrated forcing of winds and coastal freshwater discharge (Weingartner et al. 2005). That forcing is variable and reflected in ACC properties. The current originates on the British Columbian shelf and leaves the Gulf for the Bering Sea through Unimak Pass (Aagaard et al. 2006). Substantial portions of the ACC circulate through Prince William Sound and feed lower Cook Inlet and Kachemak Bay before flowing southwestward through Shelikof Strait; another significant fraction bypasses Shelikof Strait to flow along the southeastern coast of Kodiak Island (Stabeno et al. 2016). As shown in Table 1, the GAK-1 measurements provide an empirically verified proxy for the along-shelf transport of the ACC. With this metric we are able to assess fluctuations in the advection of passively drifting organisms, fresh water, and heat in the coastal zone (Weingartner et al. 2005). The current controls water exchange and transmits its properties into the nearshore habitats of the fjords and bays between Prince William Sound and the Alaska Peninsula. ACC monitoring provides the broader-scale context for understanding variability in adjacent marine ecosystems and its effect on particular species (e.g., herring, salmon).

3. PROJECT HISTORY

The GAK-1 time series was initiated in 1970 by Dr. Thomas Royer, who maintained sampling until after the 1989 oil spill. Oversight of the project was transferred in the early 1990s to Dr. Thomas Weingartner, who led the program until his retirement in 2017. Principal Investigator (PI) Danielson has been involved with the GAK-1 project since 1997.

For the first 20 years, sampling was accomplished by ships-of-opportunity, primarily research vessels as they left or entered the port of Seward. Consequently, the time interval varied from several times per month to several times per year. Since September 1990 the sampling has been accomplished nominally monthly, usually as a single CTD (conductivity-temperature-depth) profile to within 10m of the bottom (263 m). Samples taken between September 1990 and 1996 were sponsored by NOAA's Office of Global Programs (Office of Ocean and Earth Sciences, Ocean Observing Division, Observing Networks Branch) and thereafter by EVOSTC (Project 21120114-I). Since 1997, sampling has been enhanced by regular multi-disciplinary occupations of the Seward Line, supported by NOAA and NSF through the GLOBEC program over 1997-2004 and since 2005 by the Alaska Ocean Observing System (AOOS), the North Pacific Research Board (NPRB), and the EVOSTC. The NSF's NGA Long Term Ecological Research (LTER) program resumed summer occupation of the Seward Line and GAK-1 beginning in 2018.

In 1998, a subsurface taut-wire mooring was added to the GAK-1 monitoring program in order to collect temporally high-resolution hydrographic data. Initially, sensors were located at only two depths but since late 1999 there have been dataloggers located at six or seven depths. The monthly CTD casts and the mooring provide cross-platform redundancy for each other so as to maintain time series integrity in the event of a loss of the mooring, instrumentation failure, or interruptions in the CTD sampling.

GAK-1 data have been used in at least fifteen graduate student master's theses and doctoral dissertations. We are aware of more than 100 publications employing data collected at station GAK-1 and since 2010 the citation list has grown by nearly five publications per year. These include peer-reviewed journal articles and State of Alaska and federal management agency reports. The topics covered by these publications range from physical, chemical, and biological oceanography to paleoclimate studies, fisheries research and management, and ecosystem-based management applications. A complete listing of publications using GAK-1 data is online at the GAK-1 homepage: http://research.cfos.uaf.edu/gak1/.

4. PROJECT DESIGN

A. Objectives and Hypotheses

The fundamental goal of this program is to provide high quality, long-term data to quantify and understand variations that occur over short (hours to days) to long (inter-annual to multi-decadal) period variability of the GOA shelf. This measurement provides the broader temporal and spatial perspective important to our ecosystem-level understanding and management of the NGA. Specifically, we will measure:

1. Temperature and salinity throughout the water column
2. Near-surface pressure fluctuations
3. Water column stratification
4. Chlorophyll a fluorescence as a measure of phytoplankton standing crop
5. Photosynthetically Available Radiation (PAR) as a measure of light availability

We propose no major changes to the GAK-1 project management, personnel, or field effort. In the previous funding cycle, we executed a near-seamless transition of program oversight from PI Weingartner to Danielson, and in this period, Danielson transitioned from University of Alaska Fairbanks (UAF) Research Faculty status to Tenure-track Faculty status. These personnel re-alignments have allowed us to budget for three years of graduate student support in the present proposal (FY25, FY26, and FY27). The student will be tasked with investigating the still-undetermined causes of the increasing near-bottom salinity observed at GAK-1 (Kelley 2015) and relating the observed changes in stratification to our observations of phytoplankton standing crop. In support of the student project, the present proposal adds an irradiance (PAR) sensor onto the mooring in order to better understand the relations between light limitation, stratification, and the spring bloom (chlorophyll a fluorescence) in the coastal realm. This addition will also complement the optical measurements being made at mid-shelf mooring station GEO, which is maintained by the NGA LTER program.

The GAK-1 dataset is collected under the guiding hypothesis that oceanic conditions are important to the physical and biological functioning of the Prince William Sound and GOA ecosystems. Process-oriented hypotheses that we propose to investigate during this upcoming funding cycle investigate mechanistic linkages that tie the physical environment to biological productivity and nutrient availability:

H1: Increasing levels of stratification in coastal waters are related to both increasing coastal freshwater discharges and alterations in shelf-basin communication.

H2: Spring bloom timing and magnitude in coastal waters is regulated by a combination of stratification and near-surface light levels.

B. Procedural and Scientific Methods

Following our previous approach, we propose nominally monthly CTD profile measurements and year-long, continuous measurements from a subsurface mooring with temperature and conductivity (T/C) data loggers placed at depths of 20, 30, 60, 100, 150, 200, and 250 m. The moored instruments and monthly CTD sampling schemes are purposely complementary and partially duplicative in order to maintain dataset integrity. The CTD provides high vertical resolution at monthly time scales and the mooring provides high temporal resolution, but at coarser vertical spacing. The monthly CTDs provide redundancy in the event the mooring is catastrophically lost or an instrument fails on the mooring, and the mooring provides redundancy to the CTDs in the event that weather, equipment issues, or other factors prohibit a CTD profile in a given month.

The monthly CTD casts are now collected using the UAF Seward Marine Center vessel the R/V *Nanuq* using a Seabird SBE-25 CTD on a conducting-wire winch. The SBE 25 has an accuracy ~0.01 or better for salinity (unitless, employing the Practical Salinity Scale) and 0.005°C for temperature. The GAK-1 monthly temperature and salinity are statistically significant predictors of monthly anomalies of the alongshelf baroclinic transport in the ACC (Table 1) so ACC transport anomalies are monitored using the GAK-1 data (Weingartner et al. 2005). The moored T/C recorders are SeaBird SBE-37 Microcats, manufactured by Seabird, Inc. Seabird performs pre- and post-deployment calibrations upon which we determine sensor drift (typically ~0.01°C yr^{-1} and ~0.03 yr^{-1} or better, respectively).

A fluorometer (Wetlabs, Inc.) and a PAR sensor are included just below 20 m depth to document the light environment and determine timing and duration of the spring, summer, and fall blooms. The fluorometer emits an illuminated beam of light (at 470 nm) that stimulates chlorophyll in the beam path. The absorbed light excites the chlorophyll molecules, which emit light (fluoresce) at a 695 nm. The emitted light is detected by the fluorometer and the intensity of the fluorescence is proportional to chlorophyll biomass. Note that fluorescence is only a relative measure of chlorophyll a concentration and the signal has dependencies on temperature, phytoplankton species composition, and health of the algae cells. Monthly CTD casts collect water for actual chlorophyll determination and flourometer calibration.

The mooring is recovered and re-deployed annually. Bio-fouling and glacial till sediment gradually degrades the signal quality of the fluorometer so we strive to deploy the mooring in March or early April (depending upon weather) in order to minimize fouling potential just prior to the spring bloom in April or May. Temperature and salinity data are sampled at 15-minute intervals and the optical sensors sample hourly. In order to help reduce the effects of biofouling over the course of the year, the chosen optical sensors are now equipped with "bio-wipers" that clean the sensor optical window prior to every measurement.

ALTERNATIVE METHODOLOGIES

Autonomous underwater vehicles (AUVs) could provide higher vertical resolution than the mooring sensors and higher temporal resolution than the ship based CTDs. AUVs have the ability to move along tracklines (e.g., along the Seward Line) or remain near one point and conduct repeat vertical profiles. They can operate for 1-4 months on a single battery charge (depending on battery type) and have the ability to fly themselves from and then back to northern Resurrection Bay at the start and end of a mission, respectively. AUVs can also incorporate additional biological and geochemical measurement parameters. However, the AUV spin-up equipment cost (~$200k) is significant and expensive batteries and additional technician time is needed to run the AUV. We determined that the proposed ship and mooring-based sampling methods still represent the most cost-effective balance for temporal and spatial resolution in the data collection. Danielson leads the Slocum glider AUV lab at UAF and anticipates some proof-of-concept missions that will fly near GAK-1 and along the Seward Line (support from AOOS). We will continue to monitor the potential cost-effectiveness and applicability of using AUVs in support of the GAK-1 project.

C. Data Analysis and Statistical Methods

CTD data represents the fundamental physical hydrographic measurements and data are fully comparable to all other high-quality CTD profile and time series data from around the globe, including profile data from the ARGOS program in the deep North Pacific. The chosen SeaBird Electronics instruments represent this manufacturer's industry leading CTD sensors that are well known for their accuracy, stability, and low sensor drift. With a sample rate of one month for the CTD profiles we adequately capture seasonal-scale hydrographic anomalies and with the 15-minute MicroCat sampling we resolve the fluctuations associated with storms, tides, shelf waves, and other high frequency motions.

The temperature and salinity data analyses are straightforward and will follow the same procedures that we have employed previously (e.g., Royer et al. 2005, Weingartner et al. 2005, Kelley et al. 2015, Danielson et al. *in review*). Our approach involves computation of standard statistical estimates for each month and depth and comparing these with historical data since an important thrust of this effort is to quantify seasonal to interannual and longer variability. To assess the statistical strength and significance of covariation, we compute the standard deviation (σ), root-mean-square-difference (RMSD), Spearman's cross-correlation (r) and p-value parameters. Statistical significance is ascribed for $p < 0.05$. Slope detrending is based on least-squares fits. The first zero crossing of the autocorrelation function provides a measure of the decorrelation time scale, which in turn guides our selection of the effective degrees of freedom (EDOF) for assessing statistical significance (Emery and Thomson 2001).

Working with the mooring and CTD profile data, monthly anomaly time series are computed by subtracting the climatological monthly mean from each monthly average at each depth level to create an anomaly that retains units of °C. Daily anomalies from the moorings are constructed in a parallel fashion but using a daily climatological mean rather than the monthly climatology. Some analyses require normalized anomalies, for which each individual monthly anomaly was divided by the standard deviation for the corresponding set of monthly means, resulting in a record having zero mean and unity variance.

Hypothesis H1 will require co-analysis of GAK-1 data along with Seward line hydrography, ARGOS float measurements from off of the shelf, reanalysis depictions of past atmospheric wind forcings, and potentially numerical model results. Danielson's lab runs a variety of ocean circulation models that encompass the GOA continental shelf (e.g., Danielson et al. 2020b, 2020c) and these model integrations are available for our investigations. Also in support of H1, we will continue to incorporate in our analyses of temperature and salinity variability an integrated discharge time series and air-sea heat fluxes. Heat flux calculations that show winter heat losses (from the ocean to the atmosphere) are more variable both interannually and at longer periods than summer heat gains. For example, winter heat loss has decreased by nearly 20% since the mid-1970s and this change was reflected in the warming at GAK-1 through 2005. Since that time winter heat loss has increased substantially and returned to values that occurred in the early 1970s. Winter heat loss, in conjunction, with runoff, affects the ocean temperature distribution through spring when many fish larvae are emerging to feed (Janout et al. 2010). On the other hand, summer heat gains appear to be relatively consistent from year to year because this is primarily a function of cloud cover. Royer et al. (2006) contend that summer surface temperatures over the shelf and in Prince William Sound are primarily a function of the stratification. They suggest that stronger stratification traps heat in the surface layer and elevates surface temperatures, whereas weaker stratification allows the heat to mix to greater depths. Within the ACC, stratification is primarily a function of the vertical salinity gradients that we measure at GAK-1.

In support of hypothesis H2, we will quantify spring and summer phytoplankton blooms in relation to changes in stratification, light, runoff, and winds. Stratification estimates will be made from the 3 uppermost instruments and the monthly CTD surveys. Correlation of 0 m depth CTD daily anomalies with daily anomalies of satellite-based measurements shows that the satellite dataset accounts for nearly 60% of the in situ daily variance ($r=0.77$, $p < 0.001$) (Danielson et al. *in review*). Hence, the 0-20 m near-surface temperature can be estimated with a linear interpolation between the top datalogger on the mooring and the surface. Unfortunately, there exist no comparable remote sensing estimates of sea surface salinity. The fluorescence data will provide an estimate of the number of blooms and bloom duration observed in spring and summer. This approach is necessarily limited because the start of the spring bloom may occur at depths shallower than the 20m fluorometer. Our fluorometer and PAR sensor dataloggers have “biowipers” that help prevent biofouling signal degradations. However, when present, biofouling likely develops after the spring bloom, so our qualitative descriptions should be valuable in describing year-to-year variability. GLOBEC-era measurements, as well as those by Eslinger et al. (2001) from Prince William Sound, indicate that the timing of the spring bloom varies considerably on an inter-annual basis, perhaps by as much as several weeks or more. Weingartner et al. (2002) show that the onset of the spring bloom on the GOA shelf is tied to the quantity and phasing of winter and early spring runoff because freshwater is the principal stratifying agent in the ACC in both seasons. For example, the spring bloom in the ACC was delayed until May in 2007 and 2008 because of the weak stratification; in contrast it occurred between early to mid-April during the GLOBEC years when winters were wetter and warmer, and stratification stronger and earlier.

The results of the investigations into both H1 and H2 can be further extended by incorporating nutrient chemistry data collected by the Seward Line project. The increasing stratification (Kelley, 2015) may alter nutrient availability. We can turn to the nutrient data collected along the Seward Line (including at GAK-1) in order see if any mechanistic linkages identified in our evaluation of H1 and H2 exert meaningful impact on the nutrient supply to the euphotic zone. Danielson is an NGA-LTER co-I and will work with the Seward Line project to move such analyses forward.

D. Description of Study Area

The fieldwork will be conducted at oceanographic station GAK-1 at the mouth of Resurrection Bay. GAK-1 is located at 59.850 °N, 149.467 °W, and is located on the inner edge of the ACC midway between Prince William Sound and Cook Inlet in approximately 265 m water depth. Spilled oil was advected by the ACC from Prince William Sound to Kodiak in 1989.

5. COORDINATION AND COLLABORATION

A. With the Alaska SeaLife Center or Prince William Sound Science Center

We provide the GAK-1 mooring as a platform on which additional sensors may be mounted. Collaboration with the PWSSC includes incorporation of a Vemco PIT fish tag detector on the GAK-1 mooring via coordination with PWSSC Herring Research and Monitoring (HRM) PI Mary Anne Bishop. In addition, Danielson's AUV lab upgraded a Slocum Glider to carry a Vemco RxLive detector and has recently been flying the glider in PWS in search of winter season herring habitat (see below for additional details).

Danielson regularly communicates with Alaska SeaLife Center (ASLC) PI Tuula Hollmen to discuss ongoing operations and potential collaborations surrounding a variety of in-progress and planned projects. Presently our only formal collaboration is for a NPRB-funded effort in which Danielson's lab is loaning T/C dataloggers to the ASLC project. Danielson serves on the Science Advisory Committee of the ASLC. In addition, Danielson participated in the development of a Virtual Field Trip titled "Mystery of The Blob" developed by ASLC in collaboration with the GWA program (https://gulfwatchalaska.org/resources/educational-resources/virtual-field-trips/).

B. Within the EVOSTC LTRM Program

Environmental Drivers Component

The Seward Line project occupies GAK-1 with a CTD cast in May, July and September. This support allows the GAK-1 project to reduce expenses by not having to budget or pay for vessel time during these three months. The GAK-1 project provides our CTD cruises as an opportunity for Seward Line scientists (PI Hopcroft) to collect phytoplankton, nutrient, and zooplankton samples from our monthly cruises.

The GAK-1 project collaborates with all environmental drivers projects in the form of data sharing and joint analyses, such as can be found in Batten et al. (2018) and Danielson et al. (2020b).

Pelagic Monitoring Component

We make the GAK-1 dataset available to any investigator who can utilize the 50-year hydrographic time series. Collaboration includes data sharing and collaborative analyses. For example, data from across all components were recently incorporated into a GWA effort to document impacts of the 2014-2016 marine heatwave, in which the GAK-1 record sets the environmental stage as Fig. 1 (Suryan et al. 2021).

Nearshore Monitoring Component

We make the GAK-1 dataset available to any investigator who can utilize the 50-year hydrographic time series. Collaboration includes data sharing and collaborative analyses; for example, we recently collaborated on an analysis of northern GOA temperatures that made extensive use of many intertidal data records collected by the nearshore component (Danielson et al. *in review*).

Lingering Oil Monitoring Component

We make the GAK-1 dataset available to any investigator who can utilize the 50-year hydrographic time series.

Herring Research and Monitoring component

The GAK-1 project makes physical and biological data available to the HRM component. In addition, PI Bishop of the HRM component inquired about the availability of GAK-1 as a platform for mounting an acoustic tag receiver for the purpose of detecting tagged herring. We installed this sensor on the GAK-1 mooring deployed in spring 2019, spring 2020, and will continue to do so for future deployments as needed. Danielson's oceanography lab also operates a fleet of Teledyne Webb UAV Slocum gliders. In 2020, we upgraded one glider to carry a Vemco RxLive receiver so that we could listen for tagged fish and get detections returned in near-real-time. This is work done in partnership with PWSSC PIs Drs. Mary Anne Bishop and Rob Campbell, and NOAA scientist Dr. John Eiler. The upgrades were implemented in summer/fall 2020 and the glider was deployed January 20, 2021 and recovered on February 23, 2021. The glider, upgrades, and piloting were supported by funding from the Integrated Ocean Observing System (IOOS) and its regional partner, AOOS. We plan to deploy the glider for a second month-long mission in winter 2021 and then attempt to fly the glider from Prince William Sound to Seward, pausing at the GAK-1 mooring for some continuous days of early spring hydrographic sampling. If this proof-of-concept test flight goes well, then we may consider future glider missions to GAK-1.

Synthesis and Modeling Component

We make the GAK-1 dataset available to any investigator who can utilize the 50-year hydrographic time series. In addition, Danielson generates a series of aggregated environmental indicator time series that may be useful to numerous analysis, synthesis and modeling activities. These include measures of stratification, mixed layer depth, coastal freshwater runoff, wind speed and direction, wind stress curl, atmospheric pressure, and sea surface height anomalies, and geostrophic velocity. The latter two are available only beyond the continental shelf in deep waters, but they both carry potential to affect oceanographic conditions in the spill-affected area. Danielson has presented summaries of these indices at the GWA annual PI meeting and will continue to promote their utility as diagnostic tools.

Data Management Project

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required. The Axiom data management team has used the GAK-1 data set as a model for demonstrating the power of Research Workspace browser-based Jupyter Notebooks as a data synthesis, analysis, and reporting tool.

C. With Other EVOSTC-funded Projects (not within the LTRM Focus Area)

Current EVOSTC-funded projects not within the Long-Term Research and Monitoring (LTRM) focus area have not intersected with this project so far. As the EVOSTC funds future projects outside the GWA LTRM program we will evaluate their applicability to our project and coordinate as appropriate. The GAK-1 project provides a long-term high-quality reference dataset for the coastal NGA that enables scientists, students, commercial and subsistence fishers and resource managers to better understand climatic and ecological conditions, their changes, and ramifications of change.

D. With Proposed EVOSTC Mariculture Focus Area Projects

We look forward to working with the EVOSTC's Mariculture Program and projects they embark on. We anticipate they will be interested in GWA LTRM datasets and we expect there will be opportunities for coordination and collaboration. The GAK-1 project provides a long-term high-quality reference dataset for the coastal NGA that enables scientists, students, commercial and subsistence fishers, and resource managers to better understand climatic and ecological conditions, their changes, and ramifications of change.

E. With Proposed EVOSTC Education and Outreach Focus Area Projects

The GWA LTRM program will develop an outreach plan that includes coordination and collaboration with the Trustee's Education and Outreach Program and projects. We look forward to participating in education and outreach opportunities where our project findings can contribute to a better understanding of the Gulf of Alaska ecosystem by the general public. The GAK-1 project provides a long-term high-quality reference dataset for the coastal NGA that enables scientists, students, commercial and subsistence fishers and resource managers to better understand climatic and ecological conditions, their changes, and ramifications of change.

F. With Trustee or Management Agencies

We contribute annual reports and indicator time series to NOAA's Gulf of Alaska Ecosystem Status Report to the North Pacific Fisheries Management Council (e.g., Ferriss and Zador 2020), https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2020-gulf-alaska. Analyses include examination of GAK-1 near-surface and near-seafloor salinity and temperature over the 1970-present period of record. As a dataset with a 50-year time series that is publicly available, GAK-1 data are used for a wide variety of research and management purposes (see publications listed at http://research.cfos.uaf.edu/gak1/).

We note that the GAK-1 effort has assisted many others with their research over the years both within EVOSTC-funded projects and external projects. For example, in 2001-02 it provided a test bed for prototype halibut tags (developed by U.S. Geological Survey-Biological Resources Division scientists), which were then used to study halibut migrations in the GOA and the Bering Sea. GAK-1 data were used by herring biologists to assess energetic costs of overwintering herring (Heintz, pers. comm), and it has been used studies of king crab (Bechtol 2009), spiny dogfish Tribuzio (2009), the community structure of rocky coasts (Ingolfsson 2005), rock sole (Fedewa et al. 2015) and salmon (Boldt and Haldorson 2002). We have had requests from Steve Moffit (Alaska Department of Fish and Game salmon biologist) to use these data as an aid in salmon forecasts (see Eggers et al. 2013, Munro and Tide 2014) and we are aware of several GOA fishermen who routinely access this data set. Many other similar examples can be found in the publication list at the GAK-1 website listed above.

We have assisted the National Park Service (NPS) in establishing a similar monthly sampling and data processing protocol in Glacier Bay National Park and Preserve through the Inventory and Monitoring program (http://science.nature.nps.gov/im/units/sean/default.aspx), which also serves their data online. The sampling in Glacier Bay therefore provides a complementary data set that is made upstream in terms of the general circulation of the GOA shelf. Collectively, the Glacier Bay, Prince William Sound, Cook Inlet, and GAK-1 data sets provide a broad-scale perspective of the GOA coastal environment. We are collaborating at no cost to this proposal with NPS scientists using CTD sampling and analysis protocols identical to those at GAK-1. Since southeast Alaska waters contribute to the ACC, the nearly 30-year Glacier Bay time series provides the opportunity to assess variability across Gulf and to understand how these regions co-vary and how the ACC evolves as if flows westward toward Prince William Sound. The GAK-1 project collaborates with the Ocean Acidification Research Lab (OARC) to help facilitate the GAK-OA buoy turnaround and provides the GAK-1 mooring as a platform for OARC sensors. The GAK-OA mooring is located close to GAK-1, in Sunny Cove and is funded by NOAA's Ocean Acidification Program.

The UAF-College of Fisheries and Ocean Sciences (CFOS) is spinning up an annual offering of a Subarctic Oceanography Field Techniques intensive August-mester field course. Half of the two-week course will be based out of the Seward Marine Center and we anticipate visiting GAK-1 as part of this course. We will offer the students opportunities to work with the GAK-1 data and learn how to program, service, and deploy the GAK-1 instrumentation. Because 80% of the graduates from the UAF-CFOS graduate program subsequently go on to jobs with state or federal agencies, this field course will provide first-hand experience with and knowledge of the GAK-1 time series to future agency employees.

G. With 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 project (2222LTRM-A&B), and project-level engagement. During the first year of the funding cycle (FY22), the GWA LTRM program will reach out to local communities and Alaska Native organizations in the spill affected area to ask what engagement they would like from us and develop an approach that invites involvement of PIs from each project, including this one. Our intent as a program is to provide effective and meaningful community involvement that complements the work of the Education and Outreach Focus Area and allows communities to engage directly with scientists based on local interests.

In addition, this project will continue engaging with local communities as we have done during the first 10 years of the program. In 2016 and again in 2018 PI Danielson wrote a letter of support of a subsequently funded proposal that is now providing science curricula and educational materials to the Chugach School District, which encompasses schools in the Prince William Sound communities of Chenega Bay, Tatitlik, and Whittier. The project funder is the NOAA Office of Education Environmental Literacy program and the project is titled “Environmental Literacy Through Alaskan Climate Stewards (ELACS): K-12 Alaskan Students, Teachers and Their Communities Creating Climate Resilience Action”. Danielson has met via Zoom with students in all three of these communities, described his own research program, helped them develop their own research plans, and has provided research-quality oceanographic sensor dataloggers to each school. These include three RBR SoloT thermistor dataloggers and one RBR Concerto CTD. The data they collect can be directly compared to the GAK-1 dataset, and it is our hope that some students will be inspired to do so as part of their investigations. Danielson continues to make himself available to these classrooms. Most recently, he showed them how to follow the recent Prince William Sound herring-detecting glider mission online and examine the glider data returns. We look forward to further building these relationships in the years to come.

6. DELIVERABLES

This project will compile and submit for archive annual updates of data and metadata from (1) the GAK-1 mooring datalogger records and (2) the GAK-1 monthly CTD profile data. In addition, we will semi-annually update the GAK-1 Internet home page (http://research.cfos.uaf.edu/gak1/), compile and provide annual project activity reports that include data analyses, and continue to produce peer-reviewed journal articles. Timing of two anticipated peer-reviewed articles is based on pending 50-year retrospective analysis (FY23) and the expected graduation of the M.S. student (FY27).

7. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

Project milestones and tasks by fiscal year and quarter, beginning February 1, 2022. Fiscal Year Quarters: 1= Feb. 1-April 30; 2= May 1-July 31; 3= Aug. 1-Oct. 31; 4= Nov. 1-Jan 31.

	FY22				FY23				FY24				FY25				FY26			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone: CTD Profiles																				
Monthly CTD profiles	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Milestone: Service Mooring																				
Annual mooring turnaround	C				X				X				X				X			
Milestone: Data QA/QC																				
Data processing		X		X		X		X		X		X		X		X		X		X
Reporting																				
Annual reports					X				X				X				X			
Deliverables																				
Peer reviewed paper					X															
Data posted online		X		X		X		X				X		X		X		X		X

	FY27				FY28				FY29				FY30				FY31			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone: CTD Profiles																				
Monthly CTD profiles	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Milestone: Service Mooring																				
Annual mooring turnaround	X				X				X				X				X			
Milestone: Data QA/QC																				
Data processing		X		X		X		X		X		X		X		X		X		X
Reporting																				
Annual reports	X				X				X				X				X			
Final report																				X
Deliverables																				
Peer reviewed paper				X																
Data posted online		X		X		X		X				X		X		X		X		X

8. BUDGET

A. Budget Forms (Attach)

Please see Gulf Watch Alaska Long-Term Research and Monitoring workbook.

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	
Travel		$6,528	$6,562	$6,599	$6,635	$6,673	$32,997	
Contractual		$7,200	$7,385	$7,573	$7,769	$7,968	$37,895	
Commodities		$3,150	$3,229	$3,310	$3,392	$3,478	$16,559	
Equipment & F&A Exempt		$49,552	$63,680	$60,473	$59,081	$61,202	$293,988	
Indirect Costs Rate =	25%	$15,106	$15,524	$15,882	$25,732	$26,385	$98,628	
(non-equipment)								
SUBTOTAL		$125,080	$141,301	$139,882	$187,741	$193,126	$787,129	
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	

Budget Category:		Proposed FY 27	Proposed FY 28	Proposed FY 29	Proposed FY 30	Proposed FY 31	5- YR TOTAL PROPOSED	ACTUAL CUMULATIVE	**TEN YEAR TOTAL**
Personnel		$89,773	$50,826	$52,094	$53,398	$55,013	$301,104		$608,166
Travel		$6,713	$6,753	$6,794	$6,835	$6,878	$33,973		$66,970
Contractual		$8,173	$8,384	$8,600	$8,823	$9,051	$43,031		$80,926
Commodities		$3,564	$3,654	$3,744	$3,838	$3,934	$18,734		$35,293
Equipment & F&A Exempt		$94,409	$67,844	$36,740	$37,659	$38,600	$275,252		$569,240
Indirect Costs Rate =	25%	$27,056	$17,404	$17,808	$18,224	$18,719	$99,211		$197,839
(non-equipment)									
SUBTOTAL		$229,688	$154,865	$125,780	$128,777	$132,195	$771,305		$1,558,434
General Administration (9% of subtotal)		$20,672	$13,938	$11,320	$11,590	$11,898	$69,417	N/A	$140,259
PROJECT TOTAL		$250,360	$168,803	$137,100	$140,366	$144,093	$840,722		**$1,698,693**
Other Resources (In-Kind Funds)							$0		**$0**

Estimated costs associated with the proposed project are detailed below. Costs are budgeted in accordance with Federal Regulations and UA Board of Regents policies. Unless otherwise stated, all rates are current and include annual increases where appropriate for subsequent project years.

Salaries:

174 hours (1.0 mo.) per year are requested for PI Danielson (at $56.78/hour) to oversee the project, author reports and papers, and lead analyses. 185.8 hours (1.07 mo.) per year in Years 1-9 and 190 hours (1.09 mo.) in Year 10 are requested for Peter Shipton (at $26.60/hour in FY22 and $27.38/hour in FY23+) to carry out the field work of the monthly CTD profiles and mooring turn-around. 280 hours (1.61 mos.) per year are requested for Elizabeth Dobbins (at $35.47/hour) to process and archive the data.

Support is also budgeted for one graduate student in Years 4-6 (696 hours in the academic year and 696 hours in the summer at $21.34/hour) to investigate the hypotheses described in the proposal.

Salaries are listed at the current FY21 rate and include a leave reserve of 20.6% for faculty, 24.1% for professionals, 23.2% for support (classified) staff, and 0.1% for students. Salaries include additional adjustments as part of the University of Alaska market compensation project, as well as an annual inflation increase of 2.5%. Should these increases not occur as planned, the project will be charged actual salary at the time of effort.

Benefits:

Staff benefits are applied according to UAF's FY21 provisional fringe benefit rates. Rates are 30.4% for faculty salaries, 42.5% for professionals, 54.1% for support (classified) staff, and 9.7% students (summers only for students). A copy of the rate agreement is available at http://www.alaska.edu/cost-analysis/negotiation-agreements/. Graduate student health care is included at the AY20-21 rate of $2,687 per student per year in Years 4-6 ($979 for fall semester, $972 for spring semester, and $736 for summer semester), with a 7.0% annual inflation increase.

Equipment:

$14,000/year in Year 1 and Year 6 is requested for EG&G Dual PORT Acoustic Release for mooring recovery. $5,000/year in Year 1 and Year 6 is requested for mooring line. $32,000/year ($8,000 ea.) in Year 2 and Year 7 is requested for Seabird 37SMP T/C/P Dataloggers for the mooring sensors. $28,000 ($14,000 ea.) in Year 3 is requested for Wetlabs ECO Triplett Optical Dataloggers for the chlorophyll a fluorescence and associated optical measurements. $12,000 ($6,000 ea.) in Year 6 is requested for Wetlabs ECO PAR Optical Dataloggers for light measurement.

Equipment Fabrication Salary:

174 hours (1.0 mo.) per year are requested for Peter Shipton (at $26.60/hour in FY22 and $27.38/hour in FY23) to design and build the mooring. 40 hours (0.23/mo.) of overtime per year is also requested for Peter Shipton (at $39.90/hour in FY22 and $41.07/hour in FY23) for GAK-1 field efforts that extend Shipton's participation beyond an 8-hour workday.

Shipton's salary includes a 23.2% leave reserve, 2.5% annual inflation increase, and additional adjustments as part of the UA market compensation project. Staff benefits are applied according to UAF's FY21 provisional fringe benefit rates. Rates are 54.1% for support (classified) staff. A copy of the rate agreement is available at http://www.alaska.edu/cost-analysis/negotiation-agreements/.

Travel:

One trip per year is requested for one individual to travel to Anchorage, AK (at $300/ticket for airfare) to attend the Gulf Watch PI meeting. One trip per year is requested for two individuals to travel to Seward, AK (at $300/ticket for airfare to Anchorage) to attend the GAK1 team meeting.

Per Diem (meals/incidentals/lodging) is $445/day for Seward and $299 for Anchorage per UA Board of Regents regulations for Alaska in-state travel. Car rental is budgeted at $75/day (daily rate including taxes and fees) for the trip to Seward (individuals will fly into Anchorage and drive to Seward). Ground transportation is budgeted at $100/trip for the PI meeting in Anchorage.

An inflation rate of 2.5% per year has been included for all transportation costs. All airfare cost data is based on Internet research. All Per Diem is in accordance with GSA/JTR Regulations.

Commodities (Materials & Supplies):

$5,042 ($450 in Year 1 with a 2.5% annual increase) is requested for program/project tools and field supplies such as personal protection equipment (PPE) like float coats and rubber gloves and other general project supplies. $13,445 ($1,200 in Year 1 with a 2.5% annual increase) is requested for instrument batteries for all of the mooring dataloggers. $16,806 ($1,500 in Year 1 with a 2.5% annual increase) is requested for mooring consumable supplies and hardware.

Contractual Services and Other Direct Costs:

Per UAF policy, non-resident tuition costs ($1,079 per credit for 9 credits per semester) are included in Years 4-6- for the graduate student as well as non-resident student fees at $900 per semester (academic year only). Student tuition and fees are listed at the AY20-21 rate with a 10% inflation increase per year.

$72,823 ($6,500 in Year 1 with 2.5% annual increase) is requested for instrument calibrations and refurbishments. $6,721 ($600 in Year 1 with a 2.5% annual increase) is requested for shipping of the recovered mooring instruments to the calibration facility. $1,382 ($100 in Year 1 with a 2.5% annual increase) is requested for satellite fees for the mooring recovery beacon.

$161,778 (eight 1-day trips/year at $1,805/day in Year 1 with 2.5% annual increase) is requested for Vessel charter for conducting the monthly GAK1 CTDs. $44,815 (one 2-day trip/year at $2,000/day in Year 1 with 2.5% annual increase) is requested for vessel charter for mooring deployment/recovery.

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/.

B. Sources of Additional Funding

Non-EVOSTC Funds to be used, please include source and amount per source:

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
n/a	n/a	n/a	n/a	n/a	n/a
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
n/a	n/a	n/a	n/a	n/a	n/a
				FY22-31 Total	n/a

The GAK-1 project receives most of its funding from EVOSTC. In-kind support is provided by the Seward Line project (EVOSTC/AOOS/NPRB/NSF funding) in the form of GAK-1 CTD profile sampling in May, July and September, and occasionally as ship time associated with the annual mooring recovery/deployments.

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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.

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10. PROJECT PERSONNEL: Curriculum Vitae

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Professional Preparation

Lehigh University; B.S. Electrical Engineering, 1990, with honors
University of Alaska Fairbanks; M.S. Oceanography, 1996
University of Alaska Fairbanks, Ph.D. Oceanography, 2012

Memberships

American Geophysical Union
The Oceanography Society

Appointments

Associate Professor of Oceanography, CFOS-UAF, Fairbanks, AK, 2018-present
Research Associate Professor of Oceanography, IMS-UAF, Fairbanks, AK, 2016-2018
Research Assistant Professor of Oceanography, IMS-UAF, Fairbanks, AK, 2013-2016
Technician, Research Analyst/Professional, Institute of Marine Science, UAF, Fairbanks, AK, 1997–2013
Driller, Polar Ice Coring Office, University of Nebraska, Lincoln, NB, 1996-1997
Research Assistant, Institute of Marine Science, UAF, Fairbanks, AK, 1994-1996
Driller, Polar Ice Coring Office, Institute of Marine Science, UAF, Fairbanks, AK, 1993-1994
Junior Engineer, Allen Organ Company, Macungie, PA, 1990-1992

Peer-Reviewed Publications (10 relevant)

Danielson, S.L., D.F. Hill, K.S. Hedstrom, J. Beamer and E. Curchitser, 2020. Coupled terrestrial hydrological and ocean circulation modeling across the Gulf of Alaska coastal interface. *J. Geophys. Res.-Oceans, https://doi.org/10.1029/2019JC015724*

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Batten, S.D., Raitsos, D.E., **S.L. Danielson**, Hopcroft, R., Coyle, K., McQuatters-Gollop, A., 2018. Interannual variability in lower trophic levels on the Alaskan Shelf. *Deep-Sea Res. II: Topical Studies in Oceanogr.* http://dx.doi.org/10.1016/j.dsr2.2017.04.023.

Walsh, J. E., R.L. Thoman, U.S. Bhatt, P.A. Bieniek, B. Brettschneider, M. Brubaker, **S. Danielson**, R. Lader, F. Fetterer, K. Holderied, K. Iken, A. Mahoney, M. McCammon, and J. Partain, 2018. The high latitude marine heat wave of 2016 and its impacts on Alaska [in “Explaining Extreme Events of 2016 from a Climate Perspective”]. *Bull. Amer. Meteor. Soc.*, 9 9 (1), S39–S43, doi:10.1175/BAMS-D-17-0105.1.

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Janout, M.A., T.J. Weingartner, T. C. Royer, **S.L. Danielson**, 2010. On the nature of winter cooling and the recent temperature shift on the northern Gulf of Alaska shelf, *J. Geophys. Res.*, 2009JC005774R, DOI: 10.1029/2009JC005774.

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Peer-Reviewed Publications (4 significant)

Huntington, H.P., **S.L. Danielson**, F.K. Wiese, M. Baker, P. Boveng, J.J. Citta, A. De Robertis, D.M. Dickson, E. Farley, J.C. George, K. Iken, D.G. Kimmel, K. Kuletz, C. Ladd, R. Levine, L. Quakenbush, P. Stabeno, K.M Stafford, D. Stockwell and C. Wilson, 2020. Evidence suggests potential transformation of the Pacific Arctic ecosystem is underway. *Nature Climate Change*, 10(4), pp.342-348

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Weingartner, T.J., **S.L. Danielson**, Y. Sasaki, V. Pavlov and M. Kulakov, 1999. The Siberian Coastal Current: A wind- and buoyancy-forced Arctic coastal current, *J. Geophys. Res*; V104; No. C12; 29,697-29,713.

Collaborators

N.B. A comprehensive listing of all 340 coauthors and project collaborators from the prior 48 months does not fit within available space. The below listing shows 50 top first-author non-UAF and non-GWA conflicts.

Aagaard, Knut, APL/UW; **Ashjian**, Carin, WHOI; **Baker,** Matthew, North Pacific Research Board**; Baumgartner**, Mark, WHOI, **Bower**, Michael, NPS; **Brown**, Kristina, DFO-IOS Canada; **Carmack**, Eddy,DFO-IOS Canada; **Cooper**, Lee, University of Maryland; **Curchitser**, Enrique, Rutgers; **Deary**, Alison, NOA, **Dickson,** Danielle, North Pacific Research Board, **Doney**, Scott, WHOI; **Drinkwater**, Kenneth, Institute of Marine Research; **Eisner**, Lisa, NOAA**; Grebmeier**, Jackie, University of Maryland; **Farley**, Ed, NOAA; **Hill**, David, OSU; **Horne,** John, University of Washington; **Huntington**, Henry, Huntington Consulting; **Jakobsson**, Martin, Stockholm University; **Janout**, Markus, Alfred Wegner Institute; **Janzen,** Carol, Alaska Ocean Observing System; **Jones,** Tahzay, National Park Service**; Juranek**, Laurie, OSU; **Kavanaugh,** Maria, OSU; **Kimmel,** Dave, NOAA PMEL; **Krause,** Jeffrey, DISL**; Ladd**, Carol, NOAA; **Lalande,** Catherine, Laval University; **Lomas,** Michael, Bigelow Labs**; Logerwell**, Elizabeth, NOAA**; Lu**, Kofan, JAMSTEC; **Mackinnon**, Jennifer, Scripps; **Marsh**, Jennifer, NOAA; **McCammon**, Molly, Alaska Ocean Observing System; **McKinstry**, Caitlin, PWSSC**; Mordy**, Calvin, NOAA; **Padman,** Laurie, ESR; **Pickart**, Robert, WHOI; **Pilskaln,** Cynthia, UMASS; **Rand**, Kimberly, NOAA**; Sousa**, Leandra, North Slope Borough; **Stabeno,** Phyllis, NOAA; **Stafford,** Katherine, University of Washington; **Stock**, Charlies, NOAA GFDL; **Timmermans**, Mary-Louise, Yale; **Vestfals**, Cathleen, OSU; **Williams,** William, DFO-IOS Canada; **Womble**, Jamie, National Park Service; **Wood,** Kevin, NOAA; **Woodgate**, Rebecca, Applied Physics Lab; **Zinkann**, Ann, NOAA.

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July 29, 2021

To: Mandy Lindeberg - NOAA, GWA-LTRM Program Lead
Katrina Hoffman - PWSSC, President and CEO
Shiway Wang, EVOSTC Executive Director

Re: Letter of Commitment

We are pleased to provide this letter of institutional commitment for the following University of Alaska Fairbanks projects proposed as part of the Gulf Watch Alaska Long-Term Research and Monitoring program:

- 22120114-I, Oceanographic Station GAK-1 Long Term Monitoring of the Alaska Coastal Current, principal investigator (PI) Seth Danielson, $1,558,434
- 22120114-H, Nearshore Ecosystems in the Gulf of Alaska, PIs Katrin Iken and Brenda Konar, $1,543,053
- 22120114-L, Seward Line, PIs Russell Hopcroft and Seth Danielson, $1,961,848
- 22220111-L, Ecological Interactions Between Pacific Herring and Pacific Salmon in Prince William Sound, PI Kristen Gorman, $426,792

This proposal was drafted by the PIs in response to the *Exxon Valdez* Oil Spill Trustee Council's (EVOSTC's) FY22-31 Invitation for Proposals and subsequent request for final submission on August 13, 2021. The costs listed above for each project are for the 10-year period from 2022 through 2031 and do not include EVOSTC general administration fees. UAF indirect costs have been included at the negotiated F&A rate for State of Alaska-sponsored, 25.0% of Modified Total Direct Costs.

These proposals represent a continued commitment of the successful long-term research and monitoring projects supported by the EVOSTC and various agencies and organizational investments.

Sincerely,

S. Bradley Moran

S. Bradley Moran, Dean
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