# Gulf of Alaska Research Seed Funding Opportunity

In late 2017 UAF was awarded funds by the MJ Murdock Charitable Trust to construct a moored Gulf of Alaska Ecosystem Observatory (GEO). Over 2018-2019 the system was designed, components purchased, moorings assembled, and finally commissioned into service with an inaugural deployment on the July 2019 NGA LTER R/V Sikuliaq research cruise SKQ2019-15S. Murdock Trust "seed" funds ($42,600) are now available to bring new partners into the observatory consortium. Short proposals are sought for innovative new observing technologies that can be integrated into the upcoming May 2020 GEO deployment. The goal of this effort is to encourage new partnerships and technology developments that can be applied to ocean observing from moorings in Alaska's marine environment.

**Background and Scope**

The GEO is a platform for year-round data collection in the marine environment. While moorings offer an opportunity to monitor a wide range of parameters, their capabilities are limited primarily by sensor placements and the types and costs of sensor technologies that are available for these demanding applications. As such, seed funding represents a unique opportunity to add novel observations to the mooring platform or supplementary observations that can be collected from passing research vessels or autonomous underwater vehicles, extending the proposed observatory's utility and applications.

Seed funding could facilitate the design, construction, testing, and deployment of new sensors with capabilities that are not widely commercially available for this particular application. Alternatively, seed funding could support the collection of physical, biological or geochemical samples that would permit mooring-centric data analyses that go beyond the standard field calibrations the Gulf Watch Alaska and LTER programs are equipped to carry out. The moorings will be serviced annually; the LTER program visits the mooring site in May, July and September of each year.

The GEO (https://nga.lternet.edu/research/gulf-of-alaska-ecosystem-observatory-geo/) is one node of similarly outfitted observatories operating in and planned for Alaskan continental shelves in partnership with other ecosystem monitoring programs. Consortium partners include the Exxon Valdez Oil Spill Trustee Council (EVOSTC), the North Pacific Research Board (NPRB), the National Science Foundation (NSF), and the Alaska Ocean Observing System (AOOS). An Arctic node is located in the Northeastern Chukchi Sea (www.ChukchiEcosystemObservatory.com). For additional details, see Appendix A (below).

**Proposal Guidelines and Review Process**

Proposals should include a project description (2-page limit, exclusive of references and budget) and an itemized budget. Proposals should be emailed to sldanielson@alaska.edu prior to Friday, October 4th, 2019. Funds will be available immediately upon notification of proposal success (by November 1st) and need to be spent before the end of FY20. We anticipate funding 1-3 proposals. By stipulation of the Trust, all seed funds must go to UAF-based researchers. Costs are exempt from UAF F&A. Budgeting for salary is allowable. Existing GEO partners are not eligible for seed funds.

Submissions will be judged by a committee based on the following criteria:

- Degree to which the proposal is innovative
- Value of the proposed activity to the ecosystem mooring objectives (see Appendix A)
- Ability of the proposed plan to be integrated with the ongoing activities
- Overall feasibility of the proposed work and likelihood of success
- Timeline to readiness
- Budget appropriateness

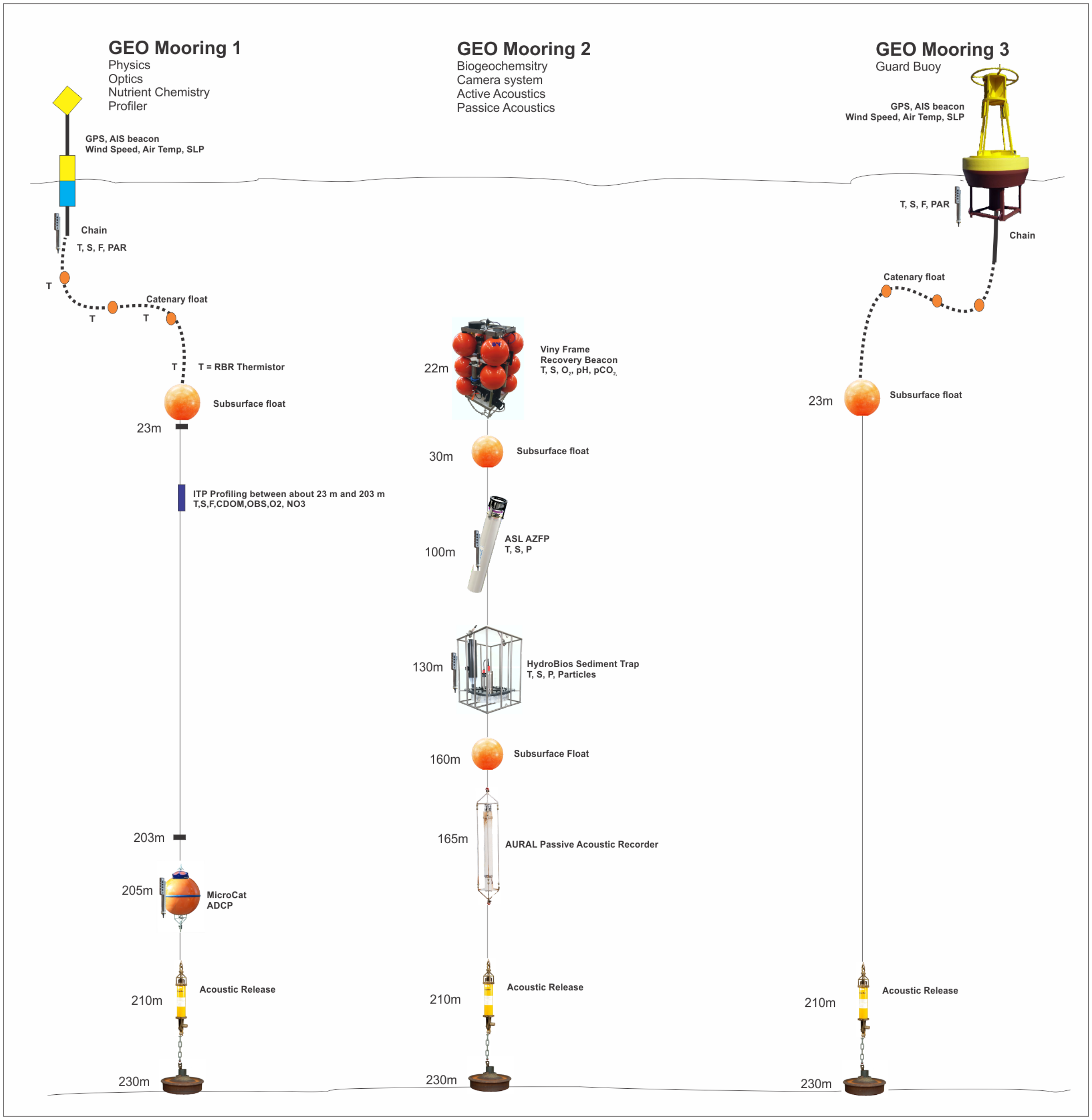



**Figure 1.** The configuration of the GEO mooring array.

## Appendix A: Program Description (from GEO proposal)

Temporally-indexed measurements are essential for understanding long period, time-dependent marine and ocean- atmosphere interactions. With the selected suite of sensors, the proposed Northern Gulf of Alaska ecosystem mooring will expand our ability to monitor and understand environmental conditions and ecosystem linkages [*Forest et al.,* 2013; *Church et al*., 2013] that are changing at seasonal and annual time scales. Maintained over periods of multiple years to decades, ocean observatories and their data will become reference points for marine research, resource management, and ecosystem modeling [*OSB and NRC,* 2003; *Wassmann et al*., 2011]. We note that observatories are identified as providing positive cost-benefit returns on investment from economic, environmental and social perspectives, and that integrated data collections generate greater benefits than fragmented systems [*Christini et al.,* 2016]. We anticipate that the Northeast Pacific will continue to undergo transformative changes over the century as warming continues and episodic El Nino and marine heat-wave events [*Bond et al*., 2015] amplify temperature effects on the ecosystem. These changes in the physical environment can initiate a cascade of biological consequences that reduce an ecosystem's resiliency (ability of the system to withstand disturbances) and increase its vulnerability to detrimental impacts (extent of harm from stressors).

We propose to assemble and deploy a moored observatory in the northern Gulf of Alaska (Figure 1 and Figure 2) to collect concurrent datasets spanning multiple trophic levels. A variety of instruments will measure the biological and physical environment with high temporal and spatial resolution, including the under-sampled and poorly-understood winter season when waves, wind, and freezing spray often preclude ship-based sampling. Observations will include physical, nutrient and carbonate chemistry, particulate, phytoplankton, zooplankton, fisheries and marine mammal datasets, providing unprecedented views into the biogeochemical pump and major ecosystem components in the Gulf of Alaska. These measurements will facilitate the monitoring, detection and diagnosis of anticipated ecosystem change. Access to such high-resolution data will increase our understanding of the processes that shape the Gulf of Alaska's ecosystem structure and resilience to environmental shifts. This project will augment ongoing stock assessments and ecosystem monitoring programs that are funded by the Exxon Valdez Oil Spill Trustee Council (EVOSTC), the North Pacific Research Board (NPRB), the National Science Foundation (NSF), and the Alaska Ocean Observing System (AOOS) by collecting observations at times of year that no other programs conduct regular sampling.

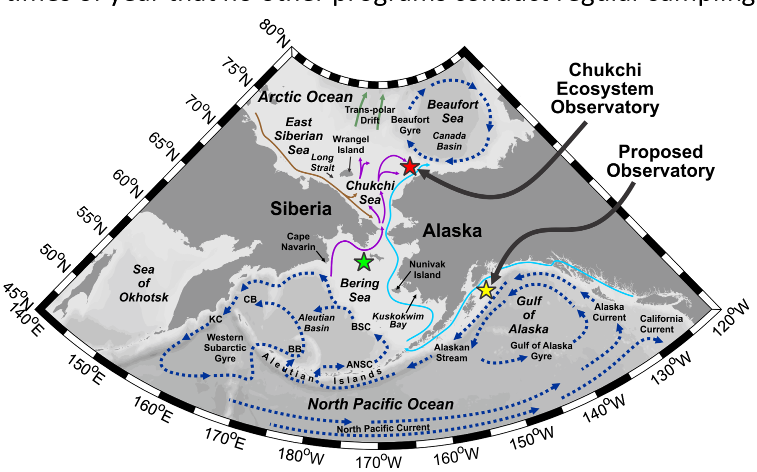



**Figure 1.** Schematic of oceanic circulation in the North Pacific and Pacific Arctic that connects and helps structure this region's Large Marine Ecosystems. The location of the existing Chukchi Ecosystem Observatory (CEO) is shown with a red star; a yellow star shows the location of the proposed Gulf of Alaska observatory and a green star shows the location a planned future Bering Sea observatory.

Using the same design as a recently established observatory in the Arctic (red star in Figure 1; also see Figures 3 and 4), this proposal seeks funds to outfit a second observatory in the sub-Arctic Gulf of Alaska (yellow star in Figure 1). Operational support for the observatory will be leveraged through the newly awarded NSF Northern Gulf of Alaska (NGA) Long-Term Ecological Research (LTER), the ongoing EVOSTC Gulf Watch Alaska (GWA), and AOOS's plus NPRB's Long-term Monitoring (LTM) programs (Figure 2).

High-latitude regions are predicted to exemplify the impacts of altered climate [*Serreze and Barry*, 2011]. The mooring data will allow us to document changes in temperature, salinity and ocean stratification and their impacts on chemical and biologic systems [e.g., *Danielson et al.,* 2017]. It will estimate particulate fluxes to the seafloor that supply the benthic community with organic matter. The mooring will collect acoustic data to determine presence and density of nekton (i.e. fish and mesozooplankton), and will complement other direct sampling and acoustic surveys in the region. The site location will enable the monitoring of vocal marine mammals and vessel noises [e.g., *Woodgate et al*., 2015], ocean acidification, changes to the shelf's nutrient and carbon cycles; and how changing wind, waves, and currents affect the regional oceanography. Mooring data will be used to validate biogeochemical models and will improve our understanding of the marine carbon pump and shelf-basin exchanges.

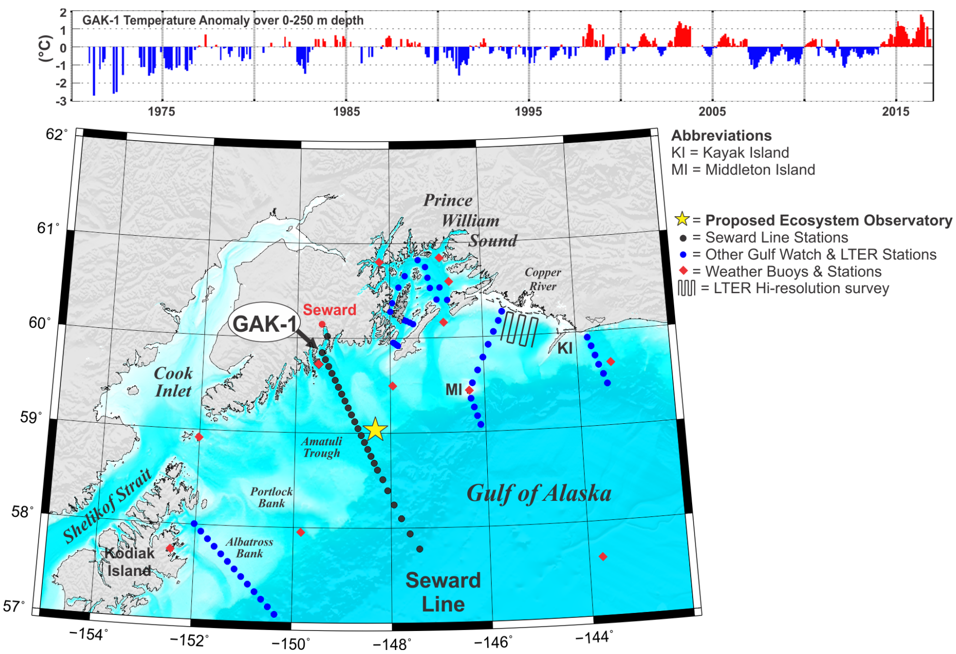
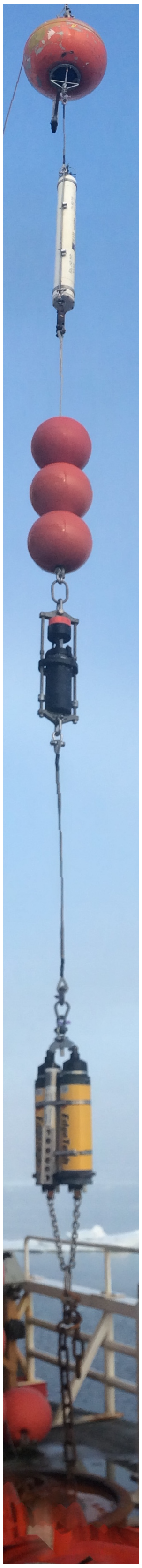



**Figure 2.** The time series on the upper panel shows the 47-year trend of gradually increasing temperatures in the northern Gulf of Alaska along with the recent extreme temperatures of the 2014-2016 North Pacific marine heat wave as observed at oceanographic station GAK1. The lower panel shows the anticipated location of the proposed ecosystem mooring (yellow star), station GAK1, other Seward Line stations (black circles) and other LTER, GWA and LTM sampling sites (blue circles).

The Gulf of Alaska shelf supports a thriving marine ecosystem, despite physical processes that are not typically associated with high levels of marine productivity [*Weingartner et al*., 2002]. In contrast with the world's biologically rich wind-forced upwelling continental shelves (e.g. the Benguela, Humbolt and California currents), the northern Gulf of Alaska encompasses a highly productive ecosystem that is subject to downwelling winds through most of the year. Moreover, freshwater coastal discharges help maintain the salinity-controlled shelf stratification with terrestrial runoff that is deplete of major macronutrients. We now nderstand that marine productivity here is maintained in part by strongly seasonal winds and currents that interact with the complex land and ocean topography to supply the surface layers with nutrients [*Weingartner* et al., 2005; *Childers et al.,* 2005] at special places and times. Other important factors that mediate primary production include light availability, iron (a limiting



micronutrient) and grazing [*Wu et al*., 2009; *Aguilar-Islas et al.,* 2016; *Strom et al., 2010*]. Two decades of ship-based observations have quantified the basic spatial, annual, and seasonal fluctuations of lower trophic levels [e.g., *Sousa et al., 2016*] **but sub-seasonal variations remain poorly understood and no regular oceanographic observations are made between October and April.** This proposal directly targets data collection for both of these critical information gaps.

This proposal also has many direct and indirect links to projects that the M. J. Murdock Charitable trust has supported. This project will extend the utility, increased understanding and benefits of these past investments. For example, the ocean optics sensors purchased by co-I McDonnell for use on the *R/V Sikuliaq* will provide spatially explicit data to complement the single-depth time series optics data that the mooring will collect. Computationally intensive 3-D ocean circulation hindcast models are run on UAF's Research Computing Systems (RCS) supercomputers. The latest versions of these models – including numerical modeling to be undertaken by the LTER program - require the data that this mooring will provide, both for tuning and ground-truth validation of model predictions.

A better understanding of the ecosystem and relations between the carbon pump and Alaska's fisheries is needed to protect and manage Alaska's ocean resources through the 21st century. The seafood industry ranks third behind the petroleum industry and the federal government for generating economic activity in Alaska. Commercial catch landings represent ~60% of the total US fisheries volume and ~40% of the total US value (*Northern Economics*, 2011).

The objective of this proposal is to purchase the instrumentation required to outfit a continuously operating moored observatory. This requires two full sets of instrumentation: while one set is deployed, the other set can have its data downloaded, batteries replaced, instruments refurbished/reprogrammed, and the system prepared for the following year's deployment. Purchasing the equipment will allow us to:

1. Annually build, deploy, and recover a mooring capable of monitoring biological, chemical, and physical conditions in the northern Gulf of Alaska.
2. Process data, apply calibrations, conduct data quality control procedures, and post data online for community use.
3. Quantify hourly, daily, seasonal, annual, and inter-annual variations in physical, chemical, and biological parameters.
4. Relate the timing and magnitude of fluctuations in nutrient and carbonate chemistry, particulates, and fish/zooplankton parameters to currents, wind, and light conditions.
5. Provide researchers and resource managers with a broad-spectrum of measurements over multiple years that can be used to evaluate and improve regional and global-scale biogeochemical, ocean circulation, ecosystem, and stock-assessment models.

**Figure 3** (left). August 2016 deployment of the first of two moorings that comprise the CEO site. Due to the shallow 45 m water depth and risk from deep ice keels we need two moorings to hold all CEO equipment. The Gulf of Alaska observatory will be in about 200 m of water so only one mooring string will be required there.

### *Conceptual Design*

Advances in instrumentation technology allow us to autonomously sample ecosystems throughout the year from a perspective that includes multiple disciplines and multiple trophic levels [*Forest et al.*, 2013]. There are few fully instrumented moorings on any continental shelves, especially in waters surrounding Alaska [*McCammon,* 2013]. Building on the successes of mooring-based measurements made by the Chukchi Ecosystem Observatory (CEO; http://mather.sfos.uaf.edu/~seth/CEO/; Figure 1), this proposal will initiate a second mooring in the sub-Arctic northern Gulf of Alaska. Our overall goal is a network of three such moorings that will form a distributed observatory (i.e., Gulf of Alaska, Bering Sea, and Chukchi Sea) to record the time history and connectivity [*Danielson et al.,* 2014] of each of Alaska's primary Large Marine Ecosystems (LMEs).

The general location for each of the LME observatories has been selected because of the biological, economic, and cultural importance associated with each region and because each site is well-positioned to document the effects of shelf-canyon exchanges that regulate biological production, biodiversity, and community structure. Building these moorings will establish this observatory consortium at the forefront of Alaska-region marine research by providing the research community with unparalleled datasets for discovery and improvements in both resource management and ecosystem modeling. We propose to deploy a fully instrumented mooring (combining the moorings shown in Figures 3 and 4) to monitor the Gulf of Alaska shelf ecosystem beginning in mid-2019. The mooring would be annually recovered and re-deployed at the same location using an identical companion set of instruments.

The objective is to build multi-year, high-resolution time series of oceanographic and biological measurements. This data will be used to assess natural ecosystem variability, track indicators of environmental change, and conduct process-based studies of oceanographic and ecosystem dynamics. This approach is only possible with a high-fidelity and all-season time series of physical, chemical, and biological properties as will be provided by the proposed mooring.

Oceanographic monitoring at coastal Gulf of Alaska station GAK1 reveals that we would realistically need at least 10-20 years of observations to capture the dynamic range of the system's physical variability [*Royer et al., 2005*] and, by extension, at least this long to assess associated biogeochemical responses. Our plan is to begin this long-term effort in the Gulf of Alaska with a fully functional and outfitted set of instrumentation that will achieve the scientific goals.

**Figure 4** (right). Configuration of the second CEO mooring, showing the acoustic releases (yellow cannisters), sediment trap (frame) and the upper instrument package that houses acoustic and optical sensors. Orange and red spheres are hard plastic buoyant floats.

**Procedure**

We anticipate a two-stage process to bring the moored observatory online (Table 1). In the first stage we will purchase the equipment, finalize the site selection, and complete the mooring design based on instrument weights, buoyancy, expected current speeds and other relevant factors. To identify the mooring site we will consult with commercial fishermen from Seward, Homer, and Kodiak who will guide us to locations with reduced risk of fouling fishing gear on the mooring. All equipment purchase orders would be submitted in 2018 as funds become available. The second stage will fabricate frames that affix equipment to the mooring line and ready the gear for deployment. Tasks include but are not limited to cutting line to length, splicing connector thimbles, installing batteries, installing zinc anodes for cathodic protection, programming the instruments, servicing O-rings, adding fixative to the sediment trap cups, pre-conditioning pH and pCO2 sensors, and running calibration samples.

The first mooring deployment would occur in summer or possibly spring of 2019, depending which Seward Line cruise the *R/V Sikuliaq* will support that year. The moorings will be deployed for 12 months and then recovered and replaced with an identical set of gear. Vessel support for the mooring operations will be provided by the Gulf of Alaska LTER program.

**Table 1.** Proposed timeline for the Gulf of Alaska marine ecosystem moored observatory build-out, construction and operations.

| | Observatory Build-out | | Observatory Operations | | | | |
|---|---|---|---|---|---|---|---|
| **Calendar Year** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
| **Proposal Submission** | Apr | | | | | | |
| **Murdock Trust Funding Decision** | Nov | | | | | | |
| **Project Start** | | Jan 1st | | | | | |
| **Match Funds Available** | | Jan $156k<br>Oct $144k | | | | | |
| **Instrumentation Purchases** | | Jan & Oct | | | | | |
| **Site Selection & Final Design** | | Jan-Dec | | | | | |
| **Mooring Construction** | | | Feb-May | Feb-May | Feb-May | Feb-May | Feb-May |
| **Deployment & Recovery** | | | Jun | Jun | Jun | Jun | Jun |
| **Instrument Calibrations** | | | | Jul-Oct | Jul-Oct | Jul-Oct | Jul-Oct |

The mooring instrumentation and measured parameters are shown in Table 2, along with the deployment depth of each, the vertical resolution of profiling instruments, and their temporal resolution.

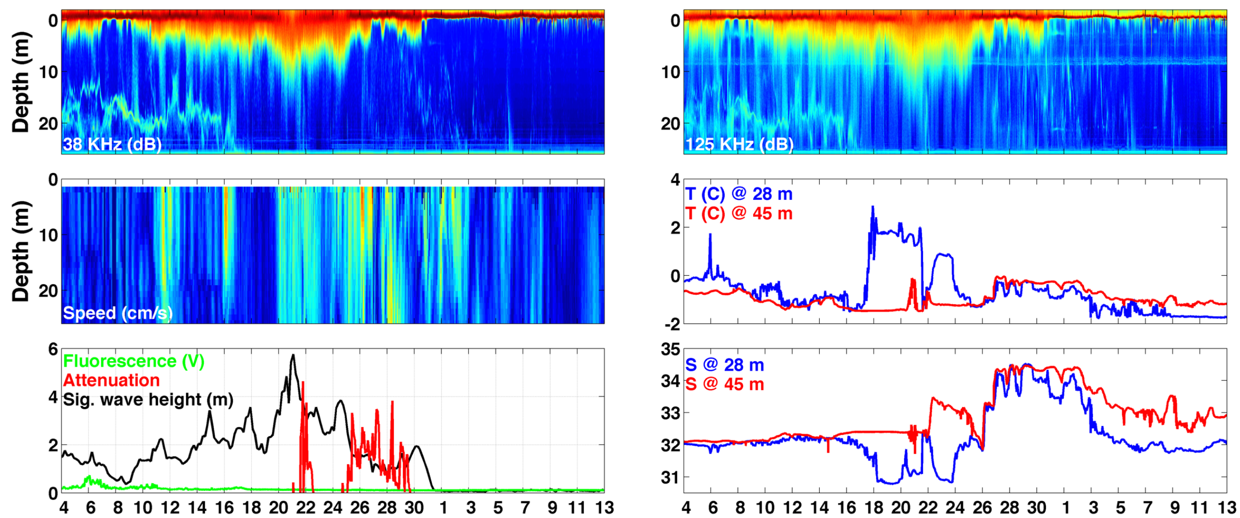
Four SeaBird Scientific Inc. (Seattle, WA) conductivity-temperature-depth (CTD) data-loggers will be attached to the mooring: a SeaBird SBE-16 SeaCat and three SeaBird SBE-37 MicroCats (example data shown in lower two panels of right-hand column of Figure 5). The near-surface SeaCat will be outfitted with a Seabird WetLabs photosynthetically available radiation (PAR) sensor, a SeaBird Wetlabs ECO-Triplett Flurometer/Optical Backscatter (OBS)/Colored Dissolved Organic Matter (CDOM) instrument, a SeaBird dissolved oxygen (DO) probe, and a SeaBird Satlantic, Inc. (Halifax, NS, Canada) SUNA V2 nitrate sensor. The SBE-16 and associated suite of co-located optical sensors will enable fairly comprehensive analyses of the physical environment and chemical processes that take place at the lowest trophic level. The MicroCats will be distributed across the remainder of the mooring line in order to provide density stratification, heat content and salt content measurements throughout the water column.

**Table 2.** Proposed instruments, data types and resolution of data. These all match the setup of the Arctic CEO mooring but some sample depths are adjusted here to better sample the deeper Gulf of Alaska shelf.

| Manufacturer & Instrument | Measurements | Sample Depth(s) | Temporal Resolution |
|---|---|---|---|
| TRDI ADCP* | Current velocity & 300 KHz signal strength | 230-80 m (2 m bins) | 1 hr |
| TRDI ADCP | Current velocity & 600 KHz signal strength | 3-24 m (1 m bins) | 1 hr |
| TRDI ADCP | Significant Wave Height, Period, & Direction | Surface | 3 hr |
| TRDI ADCP | Temperature & Pressure | 24 m | 1 hr |
| ASL AZFP | 38, 125, 200 & 455 KHz Acoustic Backscatter | 0.5-50 m (5 cm bins) | 20 s |
| Multi-Electronique AURAL | Marine Mammal Vocalizations & Underwater Vessel Noise | N/A | 1 hr |
| Seabird SeaCat & Ancillary sensors | Temperature, Salinity, Pressure, Colored Dissolved Organic Matter, Optical Backscatter, PAR, Chlorophyll-a Fluorescence | 25 m | 1 hr |
| Satlantic SUNA | Nitrate | 25 m | 1 hr |
| Contros HydroC | Partial Pressure of $CO_2$ | 25 m | 1 hr |
| SeaBird SeapHOx | pH, Dissolved Oxygen, Temperature, Salinity | 25 m | 1 hr |
| Sequoia LISST | Particle size spectra & concentrations | 25 m | 1 hr |
| Seabird MicroCat* | Temperature, Conductivity, Salinity | 240, 150 & 50 m | 15 min |
| HydroBios Multi Sediment Trap | Chlorophyll *a,* Phytoplankton species, Total particulate matter (dry wt.), Particulate organic carbon & nitrogen, Zooplankton species & fecal pellets | 100 m | 5 days to 4 weeks |

* Two MicroCat instruments and the 300 KHz ADCP will be provided to each mooring deployment from the existing UAF Mooring Loft instrument inventory.

A multifrequency echosounder will be used to measure acoustic backscatter at the mooring site (e.g. *Urmy et al.* 2012). The ASL Environmental Sciences' (Victoria, BC, Canada) Acoustic Zooplankton and Fish Profiler (AZFP) (Figure 5) will operate four frequencies: 38 kHz, 125 kHz, 200 kHz and 460 kHz. This broad frequency range will allow us to detect fish through macrozooplankton (e.g. euphausiids). The AZFP has sufficient battery and memory capacity to sample a 50 m range every 20 seconds at 5 cm vertical resolution over the course of the year. We expect to be able to sample animal density within approximately one-third to one-half a meter of the sea surface depending on surface conditions, and therefore sample targets above the instrument except in the narrow blanking zone near the surface**.**



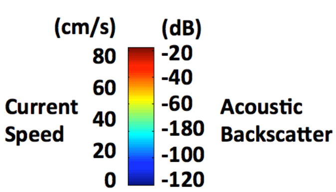




**Figure 5.** Representative data from the CEO in October-November 2014 showing acoustic backscatter of arctic cod and krill (top panels) and diel plankton migrations, strong currents (middle left), 6 meter peak wave heights and resuspended bottom sediment (lower left). The storm resulted in a basin-shelf exchange of nutrient-rich waters from deep in the Arctic basin (middle and lower right panels). The data in this figure are from the ADCP, AZFP, SeaCat and MicroCat instruments.

A Teledyne RDI (TRDI; San Diego, CA, USA) 600 KHz model V Waves acoustic Doppler current profiler (ADCP) will record hourly ocean current velocities in 1-m bins between the ADCP and just below the surface. Burst sampling for the directional surface wave spectra provide 3 hourly measures of the significant wave height, period, and direction. Based on experience at the CEO, interference between the AZFP and the ADCP signal is minimal or nonexistent. A 300 KHz Workhorse ADCP will be mounted near the seafloor in order to provide water velocity measurements through most of the water column.

An *in situ* laser particle size analyzer, the LISST-200X will be used to analyze the size distribution of particles and plankton in the water column [*Mikkelsen et al.,* 2001]. The Type C sensor configuration quantifies particle abundances in the size range from 2.5-500 $\mu$m, a range that captures re-suspended mineral particles, large phytoplankton, marine aggregates, and detritus. Particle size is measured by detecting the angles at which a laser beam is deflected as it passes through ambient water containing particles. This instrument also yields data on the beam attenuation coefficient and aggregate densities, important parameters that, combined with the particle size distribution, provide information to study the transport, coagulation, sinking, and resuspension of particulate matter and their effects on the supply and removal of organic matter to and from the benthic ecosystem.

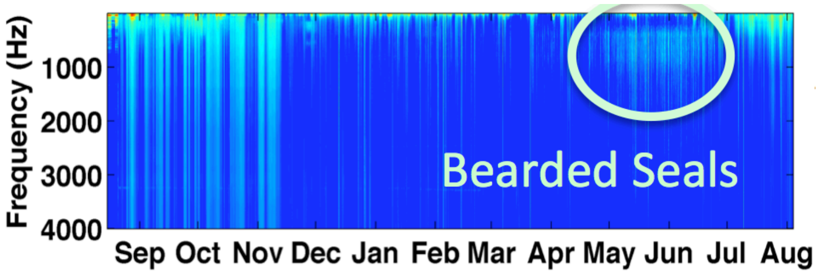



**Figure 6.** Spectra from the 2015-2016 CEO AURAL passive acoustic recorder, highlighting the presence of bearded seals in spring and early summer.

The passive acoustic recorder is a Multi-Electronique AURAL-M2 (Quebec, QC, Canada) hydrophone that will measure vocal marine mammals and underwater ship noises with low electronic noise, high sensitivity and high gain (Figure 6). It captures sounds between 10 Hz and over 16 kHz and contains sufficient memory and battery capacity for year-long deployments, saving hourly data samples to WAV audio files.

A 24-bottle sediment trap constructed by Hydro-Bios GmbH (Altenholz, Germany) is used to capture particles falling through the water column. These samples are used to cross-reference the optical LISST measurements and to provide material for speciation of the plankton community. Additional analyses allow quantification of the total particulate matter, particulate carbon and nitrogen and zooplankton fecal pellet fluxes. Phytoplankton and zooplankton caught in the trap are identified to species and stage (where possible) as shown in Figure 7.

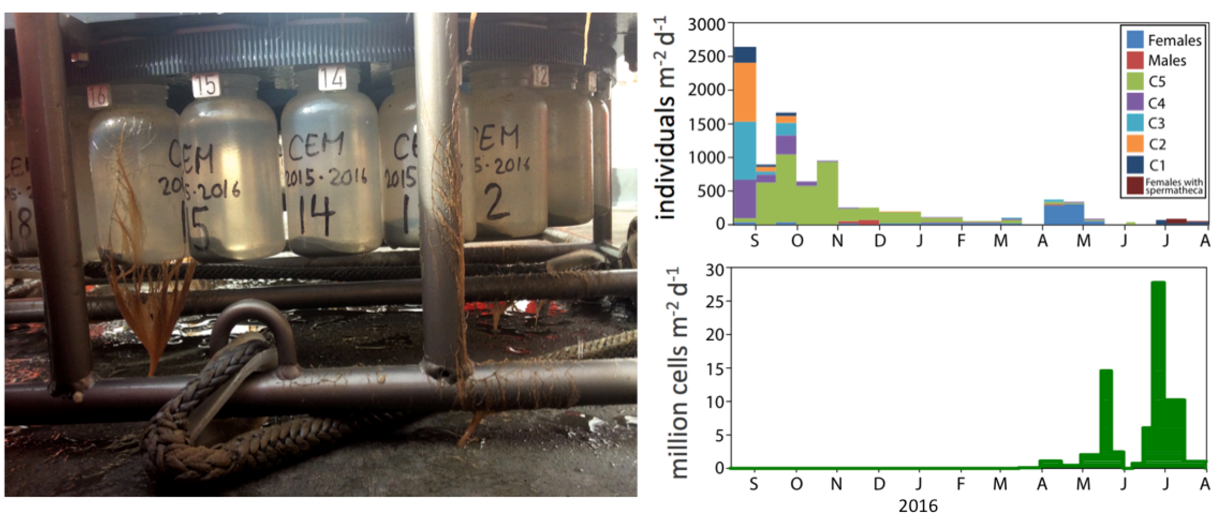



**Figure 7.** Sediment trap bottles showing mid-winter samples (left) along with time series of *Calanus glacialis/marshallae* copepods (upper right) and of ice algae *Nitzschia frigida* (lower right) from the 2015-2016 deployment.

The HydroC-$CO_2$ sensor (CONTROS GmbH, Kiel, Germany) autonomously measures $pCO_2$ based on membrane equilibration and Non-Dispersive Infrared spectrometry. Temperature and $pCO_2$ ranges expected in the Gulf of Alaska are within the operable range of the Arctic version of HydroC-$CO_2$. It operates at a precision of < 1 ppm with a good record of stability [*Fietzek et al.,* 2013], features that make it capable of detecting changes in $pCO_2$ resulting from the oceanic uptake of anthropogenic carbon from the atmosphere and entrainment of $CO_2$-rich subsurface waters.

The SeaFET Ocean pH sensor (SeaBird Satlantic, Inc., Halifax, NS, Canada) is based on a Honeywell Durafet pH sensor, which uses the Ion Sensitive Fields Effect Transistor (ISFET) technology [*Martz et al.,* 2010]. Initial estimated accuracy is ~ 0.01 pH units, with an estimated stability of 0.005 $month^{-1}$. This pH sensor has been successfully used at low temperatures in the Antarctic [*Matson et al.,* 2011]. The coincident deployment of the pH and $pCO_2$ sensors will enable us to fully define carbonate chemistry parameters, and thereby monitor progression of ocean acidification in the region and assess its potential impact on sensitive organisms.

The suite of mooring instruments was chosen based on their 1) demonstrated long-term reliability in demanding conditions, 2) appropriate specifications, accuracy, and precision of measurements, 3) commercial availability, and 4) cost-effectiveness. While the mooring's subsurface configuration and lack of cabled connection to shore prevents its use as a real-time sensor platform, this configuration does not diminish our ability to achieve project objectives and test our scientific hypotheses. The proposed mooring is designed to be an adaptable platform that can accommodate additional or improved sensors as technology improves. The value of the time series will grow with their duration, enabling better understanding of natural variability on inter-annual and decadal timescales, and improving our ability to detect the ongoing change that may accelerate in the coming years.

**Scientific Significance**

Through this mooring, we will be able to document ecosystem responses to climate alterations. The mooring data will provide a baseline dataset for quantitative hindcast comparisons in future years. Ship-based water column and benthic samples taken near the mooring site by the LTER, LTM, GWA and NOAA stock assessment programs will complement the point measurements by providing a spatial context, sampling additional components of the ecosystem that are not measured by the mooring, and aiding validation and calibration of the autonomous mooring observations. Concurrent data from other moorings in the Gulf of Alaska will facilitate studies of the nature of physical, chemical, and biological spatial-temporal variability throughout the region.

Our project will monitor a suite of environmental conditions that are representative of this ecosystem. Data from the mooring are well suited to address both monitoring- and process-oriented objectives and hypotheses. In particular, the likely mooring location is close to Amatuli Trough where the effects of shelf-canyon-basin exchanges will be monitored, and wave measurements will provide a better understanding of the shelf stratification in relation to the wind-wave environment. The data will also enhance ecosystem and biogeochemical modeling efforts (e.g., *Fiechter et al*., 2009; *Beaulieu et al*., 2016) by providing sorely-needed, concurrently-sampled, and multi-disciplinary baseline data for a wide variety of parameters [*OSB & NRC,* 2003; *AON Design and Implementation Task Force*, 2012]. The mooring data will provide insight on the timing of nitrate draw-down, nitrate replenishment, and their relationship to waves, currents, and phytoplankton concentrations. Over time, our mooring will reveal whether the frequency and magnitude of deep mixing changes as the stratification and wind fields evolve. It will help determine sources, transport, fluxes, and fate of suspended particulate matter, processes that together determine the regional carbon balance that sustains the local benthos and groundfish species. The data will also allow us to estimate the state of ocean acidification [*Hauri et al.,* 2013], causal factors in North Pacific waters, and the timing and duration of low pH conditions that may interfere with the sensitive life stages of organisms such as crabs, zooplankton, bivalves, or fish larvae.

The mooring will produce unique data products that are not available from other sources and hence valuable to researchers and resource managers with interest in local, regional, and global ecosystem processes [*Christini et al*., 2016]. Unrestricted and rapid data sharing increases the scope and value of our consortium's efforts by enabling new analyses of the region's ecology and comparative studies to other ecosystems. As a case in point, the value of providing long-term time series is demonstrated by the GAK1 time series. The GAK1 record now extends from 1970 to 2017 and there are more than 70 published journal articles, graduate theses and ecosystem assessments that have utilized these data.

While the GAK1 project monitors the inner continental shelf of the Gulf of Alaska, the proposed moored time series will provide a view of offshore conditions and many chemical and biological records that are not sampled at GAK1.

Fisheries management decisions are often hampered by a lack of data: a limited number of measured quantities describe too few aspects of the system over a limited period of time. Data sparsity precludes a robust ecosystem approach to resource management. Regular (typically once every one to three years) Federal and State abundance and distribution surveys for commercially important fish and invertebrate species are an important source of information about the biological resources that form the economic base of Alaska's fisheries. Nonetheless, stock abundance surveys are unable to measure the full suite of oceanographic variables that an ecosystem approach to resource management requires and are also limited to gathering data over periods of days to weeks. Some abundance fluctuations of ecologically and commercially important species – such as the mid 1970's Gulf-wide transition from shellfish to finfish in the GOA – are readily explained by changes in physical habitat [*Anderson and Piatt*, 1999]. Other fluctuations are not explainable with existing data. Undiagnosed variability constrains management of commercially important and ecosystem important marine animal populations. This data gap is filled, in part, by the AOOS-, NPRB-, and EVOSTC-funded programs, which monitor the northern Gulf of Alaska, including the Seward Line stations. Additional investments by the NSF LTER program over coming years will solidify oceanographic sampling along the Seward Line but will lack observations in the months between the research cruises. Hence, data collected by the proposed mooring will augment the two-decade Seward Line ecosystem monitoring data series, and the nearly five-decade water column monitoring on the inner Gulf of Alaska shelf at hydrographic station GAK1 (Figure 2). The proposed observatory will contribute data needed to unravel the complex bio-geo-chemical interactions that fundamentally structure the northern Gulf of Alaska ecosystem.

Other users of these data will include researchers associated with EVOSTC's GWA program and the NSF LTER programs. For example, biogeochemical time series datasets are sought by numerical modelers to help parameterize and validate global and regional ecosystem models [*Deal et al.*, 2014]. The newly funded NGA LTER core program includes a strong biogeochemical modeling component that can incorporate mooring measurements for model tuning and validation. The Forum for Arctic Modeling and Observational Synthesis (FAMOS), while focused primarily on the Arctic, also includes many global-scale models that require validation data in sub-Arctic regions.

Environmental monitoring seeks to understand past, current and future ecosystem conditions and concomitant changes. The nature and extent of environmental changes cannot usually be predicted, but it is critical to have measurements prior to, during, and after they occur. Therefore, we need to select a broad suite of parameters that will detect ecosystem changes that may manifest themselves in unanticipated ways. Acknowledging the well-publicized Gulf of Alaska Stellar Sea Lion declines of the last century, a National Academy of Science's report determined that *"elucidation of the complete spectrum of causes and consequences is unlikely because of gaps in the available data"* [*NRC*, 2003]. In other words, had we as a community made the effort to invest in sufficient monitoring, we may have been able to understand the reasons for the sea lion declines (e.g., changes in marine productivity or forage fish populations) and/or avoided some of the fisheries closures.