EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY18 CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Component Project

18120114-I—Long-term Monitoring of Oceanographic Conditions in the Alaska Coastal Current from Hydrographic Station GAK-1

Primary Investigator(s) and Affiliation(s)

Seth L. Danielson, Principal Investigator, University of Alaska Fairbanks

Thomas J. Weingartner, Co-Investigator, University of Alaska Fairbanks

Date Proposal Submitted

August 23, 2017

Project Abstract

This project continues a 45-year time-series of temperature and salinity measurements at hydrographic station GAK-1. The data set, which began in 1970, now consists of quasi-monthly conductivity-temperature versus depth casts and a mooring outfitted with seven temperature/conductivity recorders distributed throughout the water column and a fluorometer at 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 period variability in: 1) temperature and salinity throughout the 250 m-deep water column, 2) near surface stratification, 3) surface pressure fluctuations, 4) 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, including Prince William Sound and resources injured by the *Exxon Valdez* oil spill. We are aware of 69 publications utilizing data collected at station GAK-1, and since 2000 the citation list has grown by nearly three publications per year. Topics covered by these publications range from physical oceanography and climate through trophic (including commercial fisheries) level components and ecosystem analyses. Recent water temperatures have returned to average in the upper 100 m, but warmer than average water remains below 100 m. A newly awarded National Science Foundation Long-term Ecological Research program (awarded to GWA PIs R. Hopcroft and S. Danielson) will leverage and compliment this and other environmental drivers sampling within GWA. We are not proposing any major changes to this project in FY18.

EVOSTC Funding Requested* *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
$146,800	$148,400	$132,600	$125,600	$127,400	$680,800

Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)

FY17	FY18	FY19	FY20	FY21	TOTAL
$0	$0	$0	$0	$0	$0

1. EXECUTIVE SUMMARY

The goal of the GAK-1 project is to provide a long-term high-quality reference dataset for the coastal northern Gulf of Alaska (GOA) that enables scientists, students, commercial and subsistence fishers, and resource managers to better understand climatic and ecological conditions, their changes, and ramifications of change (Figure 1). Understanding, anticipating, and responding to change requires a stationary 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 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 exists no other full water column temperature and salinity time-series in the northern GOA with comparable data quality, temporal extent, and frequency of sampling. Hence, the GAK-1 dataset is the premier reference dataset for evaluating hypotheses that seek mechanistic descriptions of the regional ocean environment and ecosystem. 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 the passing years and 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 GOA ecosystems. To that end, many dozens of papers have examined this hypothesis from numerous perspectives (for a comprehensive listing, see the GAK-1 home page at http://www.ims.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. To date, the 45-year 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. 2003, 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 2009, Janout et al. 2010)
3. 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 GOA (Weingartner et al. 2005)
5. Variations in mixed-layer depth in the northern GOA, which affects primary production (Sakar et al. 2006)
6. Decadal scale trends in salinity and temperature,(Royer 2005, Royer and Grosch 2006, Weingartner et al. 2005, Janout et al. 2010, Kelley 2015)
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 record can guide understanding the variability in iron concentrations, a potentially limiting micro-nutrient required by many phytoplankton; preliminary efforts indicate that iron and surface salinity are correlated at least in certain seasons (Wu et al. 2008)

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

As shown and discussed by Mueter et al. (1994), Mueter (2004), and Spies (2009), these factors affect and relate to many ecosystem processes on both the shelf and within Prince William Sound and Lower Cook Inlet/Kachemak Bay.Therefore, GAK-1 provides critical contemporary and historic reference points for all components of the Gulf Watch Alaska Program

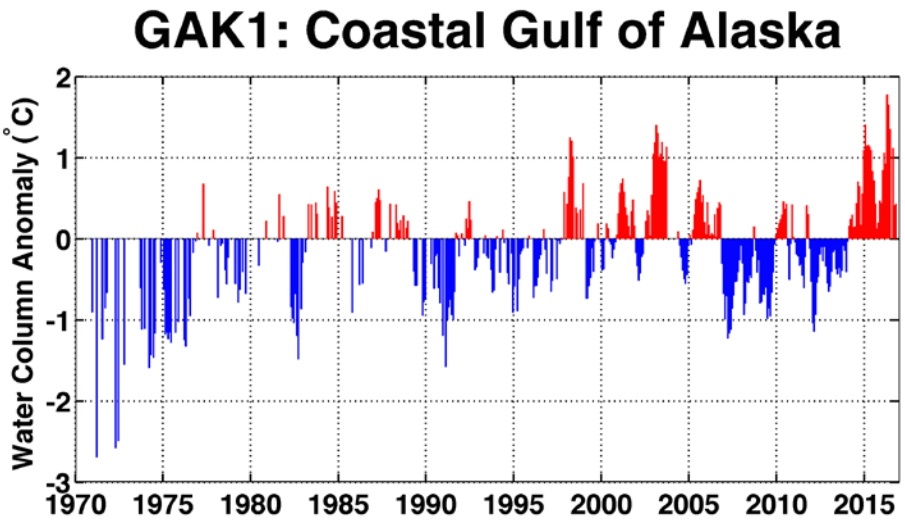

Figure 1. Time series 1970-2016. Temperature anomalies from the GAK-1 dataset at 50 m depth exhibit a long-term trend in warming along with signals associated with the cycles of El Nino and other phenomena.

2. COORDINATION AND COLLABORATION

GAK-1 data provide high-resolution long-term contextual environmental data for the Gulf Watch Alaska scientific team, other researchers and agency personnel and the public at large. Data are available online at the GAK-1 website home page (http://www.ims.uaf.edu/gak1/) and through the Alaska Ocean Observing System (AOOS) Gulf of Alaska Data Portal served by Axiom. After processing, the data are posted to the GAK-1 website, submitted to the Gulf Watch Alaska data management team for archiving, and published to the AOOS-Axiom Gulf of Alaska Data Portal.

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This project is part of the EVOSTC-funded Long-term Monitoring Program associated with the Environmental Drivers portion of Gulf Watch Alaska. We share data with all other projects within this portion of the Gulf Watch Alaska program including the following: Continuous Plankton Recorder, Seward Line, Oceanographic Condition in Lower Cook Inlet, and Oceanographic conditions in Prince William Sound. We share logistics at least twice per year with the Seward Line project. We are examining the spatial and temporal coherence in temperature and salinity with the Cook Inlet and Prince William Sound projects. The latter effort is to determine the degree of spatial heterogeneity in these variables over the inner shelf of the Gulf of Alaska.

Herring Research and Monitoring

The primary value of the GAK1 data set is to provide the PIs of other programs an appreciation of the longer-term variability of the Gulf of Alaska as they examine their data sets. The GAK1 project makes physical and biological data available to the Herring Research and Monitoring program and has been used to assess energetic costs of overwintering herring (Heintz, pers. comm).

Data Management

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.

B. With Other EVOSTC-funded Projects

This project will coordinate with other EVOSTC-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications.

C. With Trustee or Management Agencies

Our data has been used in the National Oceanic and Atmospheric Administration Gulf of Alaska Ecosystem Considerations report to the North Pacific Fishery Management Council annually since 2009 (Zador 2013). Like other Environmental Driver components, GAK1 data also are available to the Alaska Department of Fish and Game for salmon forecasting.

Also, 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 collected upstream in terms of the general circulation characteristics 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 shelf 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 26-year Glacier Bay time-series provides the opportunity to assess variability in the northeast and northwest GOA and to understand how these regions co-vary and how the ACC evolves as if flows westward toward PWS.

GAK-1 data are also used by the AOOS-supported ocean acidification monitoring study on the surface buoy nearby to GAK-1, which is known as mooring GAK-OA (Evans et al. 2013). Many other similar examples can be found in the extensive publication list at the GAK-1 website (http://www.ims.uaf.edu/gak1/).

3. PROJECT DESIGN – PLAN FOR FY18

A. Objectives for FY18

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 northern GOA. Specifically, we will:

Objective 1. Measure temperature and salinity throughout the water column

Objective 2. Measure near-surface pressure fluctuations

Objective 3. Measure water column stratification since this affects phytoplankton bloom dynamics

Objective 4. Measure chlorophyll fluorescence as an index for phytoplankton standing crop

B. Changes to Project Design

We note that the UAF-SMC coastal research vessel, the R/V Little Dipper, recently suffered an engine failure. The Dipper will likely be repaired and usable at least as a fair weather vessel but this is not an ideal long-term or year-round solution. In the meantime, we will likely need to charter the M/V Dora on a more regular basis, at a somewhat more costly day rate to the project, although at the moment we do not see need for a revised budget. The age of the vessel, its hull condition, safety for the crew and other factors have propelled us to begin seeking replacement options. In an optimistic scenario, we may be able to take delivery of a new vessel mid-way through the 2018 sampling year; however, full funding for this has not been secured to date. We do not anticipate disruptions to our annual sampling schedule.

4. SCHEDULE

A. Project Milestones for FY18

- **Task 1**
  Collect monthly CTD profiles; process profile data and upload to the GAK-1 and AOOS websites.
- **Task 2**
  Annually deploy and recover GAK1 mooring; process mooring data and upload to the GAK-1 website and Gulf of Alaska Data Portal.
- **Task 3**
  Determine seasonal changes in the water column stratification since this affects phytoplankton bloom dynamics. Updated annually in accordance with the processing of the mooring data.

B. Measurable Project Tasks for FY18

FY18, 1st quarter	**(February 1, 2018 - April 30, 2018)**
Feb, March, April:	*Monthly CTD profile cruise*
February:	*Prior year datasets available to public*
March 1:	*Submit Annual Report to EVOSTC*
March:	*Mooring recovery and redeployment cruise*
	Process prior quarter's CTD profile data and update webpage

FY18, 2nd quarter	**(May 1, 2018 - July 31, 2018)**
	Ship recovers mooring instrumentation to SeaBird, Inc. for post-deployment calibrations
June and July:	*Monthly CTD profile cruise (May survey is conducted on Seward Line cruise)*
	Process prior quarter's CTD profile data and update webpage.
FY18, 3rd quarter	**(August 1, 2018 - October 31, 2018)**
August 23:	*Submit Annual Work Plan*
August and October:	*Monthly CTD profile cruise (September profile is done on Seward Line cruise).*
September:	*Data compliance on Research Workspace*
	Process prior quarter's CTD profile data and update webpage
FY18, 4th quarter	**(November 1, 2018 - January 31, 2019)**
October/November:	*Attend annual PI meeting*
	Update webpage with prior year's mooring data
Nov, Dec, Jan:	*Monthly CTD profile cruise*
	Process prior quarter's CTD profile data and update webpage
	Process prior year's recovered mooring data when all instruments are returned from calibration facility
	Begin annual analysis and report writing

5. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes to report.

6. BUDGET

A. Budget Forms (See GWA FY18 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Proposal

No changes to report.

C. Sources of Additional Funding

The new National Science Foundation-funded Gulf of Alaska Long-Term Ecological Research (LTER) program, listed under the Seward Line project, leverages, complements, and enhances the GWA program activities. The LTER program will provide many years of additional significant research activities that will naturally blend and add value to the Gulf Watch Alaska program. For example, the first five-year block of the LTER program will fund at least three UAF graduate students who will spend time working with both Gulf Watch Alaska and LTER data collections.

7. RECENT PUBLICATIONS AND PRODUCTS

Publications

Aguilar-Islas, A., Seguret, M.J., Rember, R., Buck, K.N., Proctor, P., Mordy, C.W., Kachel, N.B. 2016. Temporal variability of reactive iron over the Gulf of Alaska shelf. Deep-Sea Res. II, 132 90-106.

Batten, S.D., Raitsos, D.E., Danielson, S., Hopcroft, R.R., Coyle, K., and McQuatters-Gollop, A. (in press). Interannual variability in lower trophic levels on the Alaskan Shelf. Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what

have we learned since the *Exxon Valdez* oil spill? Published online at http://www.sciencedirect.com/science/article/pii/S0967064516302806.

Danielson, S.L. 2017. Gulf of Alaska Mooring GAK1 long-term monitoring. Contribution in the 2017 NOAA Ecosystems Considerations Report to the North Pacific Fisheries Management Council.

Helser, T., C. Kastelle, A. Crowell, T. Ushikubo, I.J. Orland, R. Kozdon, and J.W. Valley. 2017. A 200-year archaeozoological record of Pacific cod (Gadus macrocephalus) life history as revealed through ion microprobe oxygen isotope ratios in otoliths (Journal of Archaeological Science: Reports (2017), http://dx.doi.org/10.1016/j.jasrep.2017.06.037.

Olson, A.P. 2016. Spatial variability in size at maturity and reproductive timing of golden king crab (*Lithodes aequispinus*) in southeast Alaska. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska.

Stabeno P.J., S. Bell, W. Cheng, S.L. Danielson, N.B. Kachel and C.W. Mordy. 2016. Long-term observations of Alaska Coastal Current in the northern Gulf of Alaska. Deep-Sea Research. https://doi.org/10.1016/j.dsr2.2015.12.016 .

Tanedo, S. 2017. Using remote camera techniques to study Black-legged Kittiwake (*Rissa tridactyla*) productivity in Resurrection Bay in the northern gulf of Alaska, M.S. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska.

Weingartner, T.J., and S.L. Danielson. 2017. Long-term monitoring of oceanographic conditions in the Alaska Coastal Current from hydrographic station GAK1 over 1970-2016. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-P), University of Alaska Fairbanks, AK.

Published dataset

Danielson, S. L., and T. J. Weingartner. 2017. GAK1 Mooring Timeseries data, Seward, AK, from the GAK1 project, 2012-2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.24431/rw1k18.

Danielson, S. L., and T. J. Weingartner. 2017. CTD profile time series data from the GAK1 project, 2012-2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program. Research Workspace. https://doi.org/10.24431/rw1k1b.

Presentations

Danielson, S.L., J. Horne, C. Hauri, R. Hopcroft, C. Lalande, A. McDonnell and K. Stafford, Northern Gulf of Alaska Marine Ecosystem Monitoring, Proposal Site Review, M.J. Murdock Charitable Trust, Oral Presentation, August 2017, University of Alaska Fairbanks, Fairbanks, Alaska.

Danielson, S.L., G. V. Khen and P. J. Stabeno, Currents and water mas structure in and near the Gulf of Anadyr, Oral presentation. Annual North Pacific Marine Science Organization (PICES) meeting in San Diego, in November 2016.

Outreach

Danielson, S.L. 2017. "Gulf Watch Alaska, Mystery of the Blob." Interview. Available at http://www.alaskasealife.org/gulfwatchblobvft_investigation.

LITERATURE CITED

Anderson, P. J., and J. F. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series 189:117–123.

Childers, A. R., T. E. Whitledge, and D. A. Stockwell. 2005. Seasonal and interannual variability in the distribution of nutrients and chlorophyll a across the Gulf of Alaska shelf: 1998 – 2000. Deep Se Res., Pt. II 52(1-2):193-216.

Evans, W., J. T. Mathis, P. Winsor, H. Statscewich, and T. E. Whitledge. 2013. A regression modeling approach for studying carbonate system variability in the northern Gulf of Alaska, J. Geophys. Res. Oceans 118:476–489, doi:10.1029/2012JC008246.

Hallmann, N., Schöne, B.R., Irvine, G.V., Burchell, M., Cockelet, E.D., Hilton, M.R. 2011. An improved understanding of the Alaska coastal current: the application of a bivalve growth temperature model to reconstruct freshwater-influenced paleoenvironments. Palaios 26, 346e363.

Janout, M. A., T. Weingartner, P. Stabeno. 2013. Air-sea and oceanic heat flux contributions to the heat budget of the northern Gulf of Alaska shelf. 2013. J. Geophys. Res., 118, doi:10.1002/jgrc.20095.

Janout, M.A, T. J. Weingartner, T. Royer, and S. Danielson. 2010. On the nature of winter cooling and the recent temperature shift on the northern Gulf of Alaska shelf, J. Geophys. Res., 115, C05023, doi:10.1029/2009JC005774.

Kelley, J. 2015. An Examination of Hydrography and Sea Level in the Gulf of Alaska. M.S. Thesis, University of Alaska Fairbanks.

Mueter, F.J., B.L. Norcross and T.C. Royer. 1994. Do cyclic temperatures cause cyclic fisheries? Can. Spec. Publ. Fish. Aquat. Sci. 121:119-129.

Mueter, F.J. 2004. Gulf of Alaska. In: Marine Ecosystems of the North Pacific. PICES Special Publication 1, pp.153-175.

Munro, A. R., and C. Tide, editors. 2014. Run forecasts and harvest projections for 2014 Alaska salmon fisheries and review of the 2013 season. Alaska Department of Fish and Game, Special Publication No. 14-10, Anchorage.

Royer, T.C. 2005. Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing, Deep-Sea Research Part II-Topical Studies in Oceanography 52(1-2):267-288.

Royer, T. C. and C. E. Grosch. 2006. Ocean warming and freshening in the northern Gulf of Alaska, Geophysical Research Letters, 33 (16), L16605,doi:10.1029/2006GL026767.

Spies, R. B., editor. 2007. Long-Term Ecological Change in the Northern Gulf of Alaska, Elsevier B.V., Amsterdam, 589 pp.

Weingartner, T.J. 2007. The Physical Environment of the Gulf of Alaska (Section 2.2, p 12 – 47), IN: Long Term Ecological Change in the Northern Gulf of Alaska, edited by R. B. Spies, Elsevier B.V., Amsterdam, 589 p.

Weingartner, T.J., S. Danielson, and T. C. Royer. 2005. Freshwater Variability and Predictability in the Alaska Coastal Current Deep-Sea Res., 52:169-192.

Weingartner, T.J., K. Coyle, B. Finney, R. Hopcroft, T. Whitledge, R. Brodeur, M. Dagg, E. Farley, D. Haidvogel, L. Haldorson, A. Hermann, S. Hinckley, J. Napp, P. Stabeno, T. Kline C. Lee, E. Lessard, T. Royer, S. Strom. 2002. The Northeast Pacific GLOBEC Program: Coastal Gulf of Alaska, Oceanogr. 15:48-63.

Wu, J., A. Aguilar-Islas, R. Rember, T. Weingartner, S. L. Danielson, and T. Whitledge. 2009. Size-fractionated iron distribution on the northern Gulf of Alaska, Geophys. Res. Lett., 36, L11606, doi:10.1029/2009GL038304.

Zador, S. 2013. North Pacific Fisheries Management Council Ecosystem Considerations - 2013. National Marine Fisheries Service, Seattle, WA