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

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Project

18120114-L - The Seward Line: Marine Ecosystem monitoring in the Northern Gulf of Alaska

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

August 23, 2017

Project Abstract

Long times-series are required for scientists to tease out pattern and causation in the presence of substantial year-to-year variability. For the 5 year period beginning in 2017, we propose continued multi-disciplinary oceanographic observations begun in fall 1997 in the northern Gulf of Alaska. Cruises occur in early May and early September to capture the typical spring bloom and summer conditions, respectively, along a 150-mile cross shelf transect to the south of Seward, Alaska. The line is augmented by stations in the entrances and deep passages of Prince William Sound. We determine the physical-chemical structure, the distribution and abundance of phytoplankton, microzooplankton, and mesozooplankton, and survey seabirds and marine mammals. These observations enable descriptions of the seasonal and inter-annual variations of this ecosystem. Our goal is to characterize and understand how different climatic conditions influence the biological conditions across these domains within each year, and what may be anticipated under future climate scenarios. We are not proposing any major changes to this project for FY18. Newly acquired funding as one of National Science Foundation's 30 Long-term Ecological Research (LTER) sites, will allow us to expand sampling on the shelf upstream of Prince William Sound, including near Middleton Island.

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$132,700	$136,100	$139,500	$143,000	$146,600	$697,900

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

FY17	FY18	FY19	FY20	FY21	TOTAL
$1,424,000	$1,438,000	$1,411,800	$1,466,000	$1,450,500	$7,180,300

1. EXECUTIVE SUMMARY

We live in a constantly changing world, influenced by a combination of stochastic events, natural cycles, longer-term oscillations, and impacts of human activities. Once thought to house relatively stable ecosystems, the oceans are now known to fluctuate between multiple states or "regimes" apparently coupled to major climatic shifts such as the Pacific Decadal Oscillation (PDO). This knowledge derived initially from long-term and global views of physical changes in the ocean and atmosphere, but most importantly from long-term biological observations that demonstrate the impact of "regime shifts" (Francis and Hare 1994, Manuta *et al.* 1997). Such regime shifts may be common (Hare and Mantua 2000), and we are beginning to identify the mechanisms by which these physical changes impact ecosystems (McGowan *et al.* 1998, Beaugrand 2004).

Our understanding of community level changes would not be possible without long-term observation programs like Gulf Watch Alaska, whose value is becoming increasingly apparent as our understanding of ecosystem change and its drivers becomes more sophisticated. Biological time-series such as the North Atlantic CPR (Beaugrand 2004), the North Pacific CalCOFI (McGowan *et al.* 1998), Station/Line P (Mackas *et al.* 2004), and the younger CPR program (Batten and Freeland 2007) in the subarctic Pacific are proving invaluable at documenting regime shift-related changes in species distributions (Beaugrand and Reid 2003) and timing of life histories (Mackas *et al.* 1998). The 1976 Pacific Decadal Oscillation (PDO; Mantua *et al*. 1997) triggered an ecological regime shift by pushing the Northern Gulf of Alaska (NGA) over a tipping point, resulting in a change from a shrimp-dominated fishery to one dominated by pollock, salmon, and halibut (Anderson and Piatt 1999). The PDO and the second mode of North Pacific variability as expressed by the North Pacific Gyre Oscillation (Di Lorenzo *et al*. 2008) are dominant extremes among a continuum of Pacific-wide patterns of oceanic variability.

Dominated by a strong seasonal cycle (Waite and Mueter 2013), the NGA ecosystem does not respond in a currently predictable way to intermittent basin-scale events such as El Niño or to longer-term regime shifts such as the PDO (Stabeno *et al*. 2004), perhaps because the ecosystem is highly adapted to great variability. Nonetheless, it is profoundly affected by warmer years, fresher years, and light conditions in spring, that influence the timing of planktonic processes, but not necessarily their ultimate abundance or biomass (Figure 1). In contrast, temperature is much less variable during late summer, although biological communities continue to show high variability, including increased prevalence of southern species during warmer years. Furthermore, our observations suggest that the recent North Pacific warm-water anomalies impacted rates of *Neocalanus* lipid accumulation and their overwintering health.

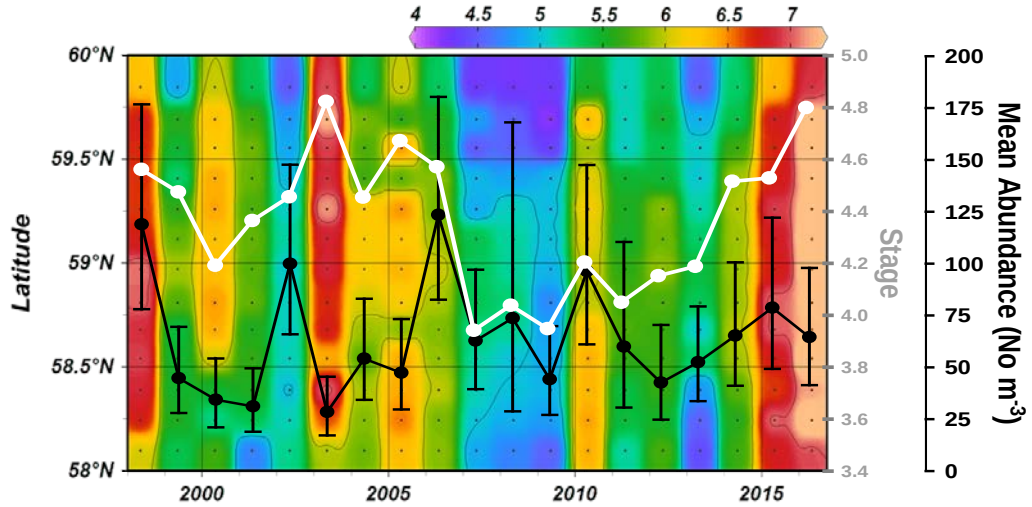

Figure 1. Early May temperature average of the upper 100m along the Seward Line, with abundance (black) and mean stage (white) of *Neocalanus* spp.

Our proposed research will continue long-term multi-disciplinary oceanographic sampling in the Gulf of Alaska, to provide insights into ongoing ecosystem changes in the North Pacific. We are not proposing any major changes to this project for FY18.

Project hypotheses:

- *Climate variations propagate through changes in physical and chemical oceanography, impacting the biological communities in the Gulf of Alaska in terms of composition, magnitude and phenology.*
- *Cross-shelf zonation arises from gradients in the availability of nutrients as well as mixing energy, and is associated with significant gradients in the composition and biomass of phyto-, micro- and mesozooplankton; these in turn result in cross-shelf gradients in seabird communities.*
- *Standing stocks of plankton communities along the Seward Line, and within PWS, provide useful indices of favorable conditions for higher trophic levels such as fish and seabirds.*

While the September 2016 ranks as the warmest cruise in the past 20 years, May 2017 saw a return to mean temperatures in the upper 100 m, although a significant amount of heat still remains in deeper waters from the Blob/El Nino years. The mixture of copepods in May was somewhat anomalous in composition, likely due to warm oceanographic temperature throughout much of the winter. Most chemical and biological analyses from this cruise are still underway.

2. COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This project links tightly with the GAK1 mooring, providing a cross shelf context for its observations. It complements the continuous plankton recorder, Prince William Sound, and Lower Cook Inlet/Kachemak Bay long-term monitoring efforts by providing more detailed oceanographic evaluation of the Gulf of Alaska shelf and the major passages in Prince William Sound than is provided by the other programs. These components overlap relatively little in their sampling locations — enough to ensure comparability between

datasets, but not enough to be duplicative and wasteful of resources. The addition of monthly sampling in Resurrection Bay aligns sampling periodicity with the other Environmental Driver components

Hopcroft has served on the Gulf Watch Alaska Science Steering Group since its inception, with Danielson now also involved, ensuring all components are linked to environmental drivers that assess oceanographic change in the region. The additional monthly sampling in Resurrection Bay and at GAK1 provide oceanographic context for the GWA nearshore activities underway within Resurrection Bay.

Herring Research and Monitoring

The Seward Line makes physical and biological data available to the Herring Research and Monitoring Program.

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

Like other Environmental Driver component projects, Seward Line data are available to Alaska Department of Fish and Game biologists for salmon forecasting, and provided to the National Oceanic and Atmospheric Administration for their Gulf of Alaska Ecosystem Status reports.

3. PROJECT DESIGN – PLAN FOR FY18

A. Objectives for FY18

The scientific purpose of this project is to develop an understanding of the response of this marine ecosystem to climate variability, and provide baselines against which to access any anthropogenic influences on the Gulf of Alaska ecosystem. Toward this end, the Seward Line cruises on the Gulf of Alaska shelf determine the physical-chemical structure, primary production and the distribution and abundance of zooplankton, along with their seasonal and inter-annual variations. Some of the data are compared with historical data sets whereas other data sets are a product of this continuing systematic sampling effort on this shelf.

Specifically, cruises:

1. Determine thermohaline, velocity, and nutrient structure of the Gulf of Alaska shelf, emphasizing the Seward Line, and Prince William Sound stations (Figure 2).

2. Determine the state of carbonate chemistry (i.e., Ocean acidification – AOOS funded)

3. Determine the patterns of macronutrient availability across the sampling domain

4. Determine phytoplankton biomass distribution (as chlorophyll)

5. Determine composition and biomass of phytoplankton and microzooplankton (NPRB funded)

6. Determine the distribution, abundance and taxonomic composition of zooplankton.

7. Determine the distribution and abundance of seabirds and marine mammals (NPRB funded)

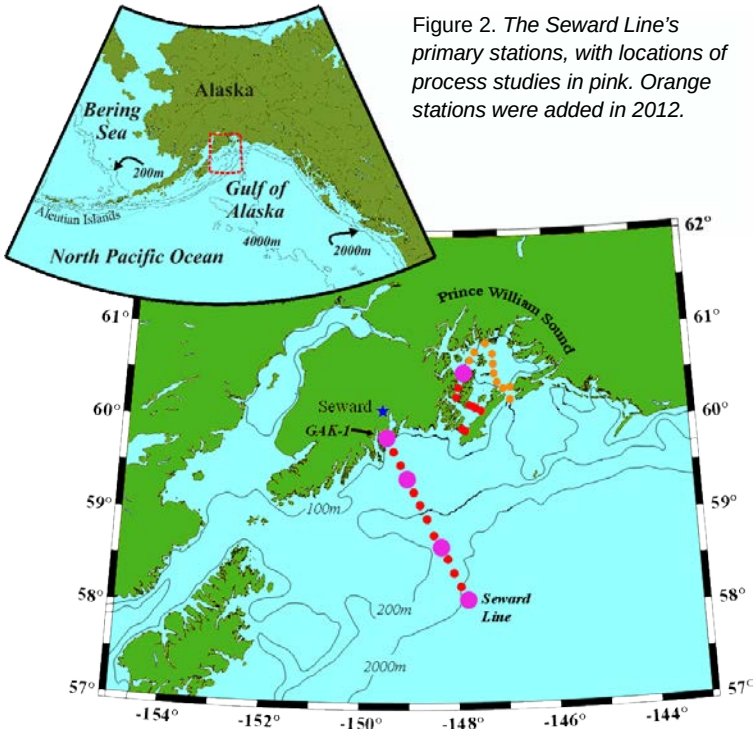

Figure 2. *The Seward Line's primary stations, with locations of process studies in pink. Orange stations were added in 2012.*

B. Changes to Project Design

Since the submission of the proposal, the Seward Line is now funded as one of the National Science Foundation's 30 Long-term Ecological Research (LTER) sites. This designation will result in expanded sampling on the Gulf of Alaska shelf, as well as an additional cruise each June/July. The suite of routine measurements will increase, with experimental studies added to help us understand why the region is so productive. Importantly, the expanded sampling will encompass Middleton Island, creating clearer linkages of it to the Gulf Watch Alaska program.

4. SCHEDULE

A. Project Milestones for FY18

Project Milestones essentially revolve around the execution of cruises each May and September and the delivery of data. Dependent on the type of data, delivery occurs within 6 months to 1 year of collection. Other milestones include the annual principal investigators meeting and presentation of results at the Alaska Marine Science Symposium.

B. Measurable Project Tasks for FY18 (year 7)

FY18, 1st quarter (February 1, 2018 - April 30, 2018)

February:	*Data compliance - prior year data sets available to the public*
March 1:	*Annual reports submitted*
March:	*Daytrip-cruise (Little Dipper)*
April:	*Daytrip-cruise (Little Dipper)*

FY18, 2nd quarter (May 1, 2018 - July 31, 2018)

May:	*Sampling cruise (R/V Sikuliaq)*

June:	*Daytrip-cruise (Little Dipper)*
July:	*Sampling cruise (R/V Tiglax)*

FY17, 3rd quarter (August 1 2018 - October 31, 2019)

August:	*Daytrip-cruise (Little Dipper)*
August 23:	*Submit annual Work Plan (FY19)*
September:	*Sampling cruise (R/V Tiglax)*
	Data compliance on Research Workspace
October:	*Daytrip-cruise (Little Dipper)*

FY18, 4th quarter (November 1, 2018 - January 31, 2019)

Oct.-Nov.:	*Attend Annual PI meeting*
December:	*Daytrip-cruise (Little Dipper); most sample processing completed for cruises through May, preliminary data available for summer and fall cruises*
January:	*Results presented at AMSS*

5. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes to those funded through EVOSTC.

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 major changes anticipated

C. Sources of Additional Funding

NPRB, Danielle Dickson (Program Manager) – ~$200K/yr – to support cruises and associated science for their long-term monitoring program

AOOS, Molly McCammon (Executive Director) – $100K/yr – to support ship-time for cruises

NSF, Dave Garrison (Biological Oceanography Program Manager) – $1,127K/yr, plus ship-time – to support an expanded cruise domain, increase number of cruises, increase measurement suite (NSF awarded the LTER funding in spring 2017 and was not included in the original FY17-21 proposal)

7. RECENT PUBLICATIONS AND PRODUCTS

Publications

Batten, S.D., D.E. Raitsos, S. Danielson, R.R. Hopcroft, K.O. Coyle & A. McQuattors-Gollop. *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? DOI:10.1016/j.dsr2.2017.04.023.

Hopcroft, R. R., S. L. Danielson, and S. L. Strom. 2017. The Seward Line: Marine ecosystem monitoring in the Northern Gulf of Alaska. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-J). Institute of Marine Science, University of Alaska, Fairbanks.

Published datasets

Hopcroft, R. R. 2017. Seward Line Conductivity, Temperature, and Depth (CTD) Data, 2012 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1l.

Hopcroft, R. R. 2017. Prince William Sound Zooplankton Data, 1997 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1k.

Hopcroft, R. R. 2017. Prince William Sound Chlorophyll-A and Nutrient Data, 2012 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1j.

Kuletz, K. J. 2017. Seward Line and Lower Cook Inlet Marine Bird Survey Data, 2006-2016, Gulf Watch Alaska Nearshore Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1m.

Presentations

Hopcroft, R. R. 2017. Latest observations and collections made along the Seward Line, Alaska. Oral presentation. Alaska Marine Science Symposium, January 23-25.

Hopcroft, R. R. 2017. Latest observations and collections made along the Seward Line, Alaska. Oral presentation. Arctic Frontiers conference, Tromso, Norway. January.

Hopcroft, R. R. 2017. Latest observations and collections made along the Seward Line, Alaska. Oral presentation. ASLO Ocean Science conference, Hawaii. February.

Hopcroft, R. R. 2017. Latest observations and collections made along the Seward Line, Alaska. Oral presentation. Kodiak Area Marine Science Symposium, Kodiak. April.

Hopcroft, R. R. 2017. Latest observations and collections made along the Seward Line, Alaska. Oral presentation. International Conference on Copepoda, Los Angeles. June.

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Beaugrand G, Edwards M, Legendre L (2010) Marine biodiversity, ecosystem functioning, and carbon cycles. Proc Nat Acad Sci 107:10120-10124.

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Francis RC, Hare SR (1994) Decadal-scale regime shifts in the large marine ecosystems of the North-east Pacific: a case for historical science. Fish Oceanogr 3:279-291.

Mackas DL, Goldblatt R, Lewis AG (1998) Interdecadal variation in developmental timing of Neocalanus plumchrus populations at Ocean Station P in the subarctic North Pacific. Can J Fish Aquat Sci 55:1878-1893.

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Waite JN, Mueter FJ (2013) Spatial and temporal variability of chlorophyll-a concentrations in the coastal Gulf of Alaska, 1998-2011, using cloud-free reconstructions of SeaWiFS and MODIS-Aqua data. Prog Oceanogr 116:179-192.