EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY19 (YEAR 8) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Project

19120114-L - The Seward Line: Marine Ecosystem monitoring in the Northern Gulf of Alaska

Primary Investigator(s) and Affiliation(s)

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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 are continuing 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 FY19. Beginning in 2018, funding as one of the National Science Foundation's Long-term Ecological Research sites is allowing expanded sampling on the shelf upstream of Prince William Sound, including near Middleton Island, to help better understand spatial variability on the shelf.

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. PROJECT 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 continuous plankton recorder (CPR) (Beaugrand 2004), the North Pacific California Cooperative Oceanic Fisheries Investigations (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 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 (Fig. 1), fresher years, and light conditions in spring that influence the timing of planktonic processes, but not necessarily the ultimate abundance of the keystone species. 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 such as those during the Blob (Fig. 2), but a return to more normal during 2017 & 2018 for spring but not late summer.

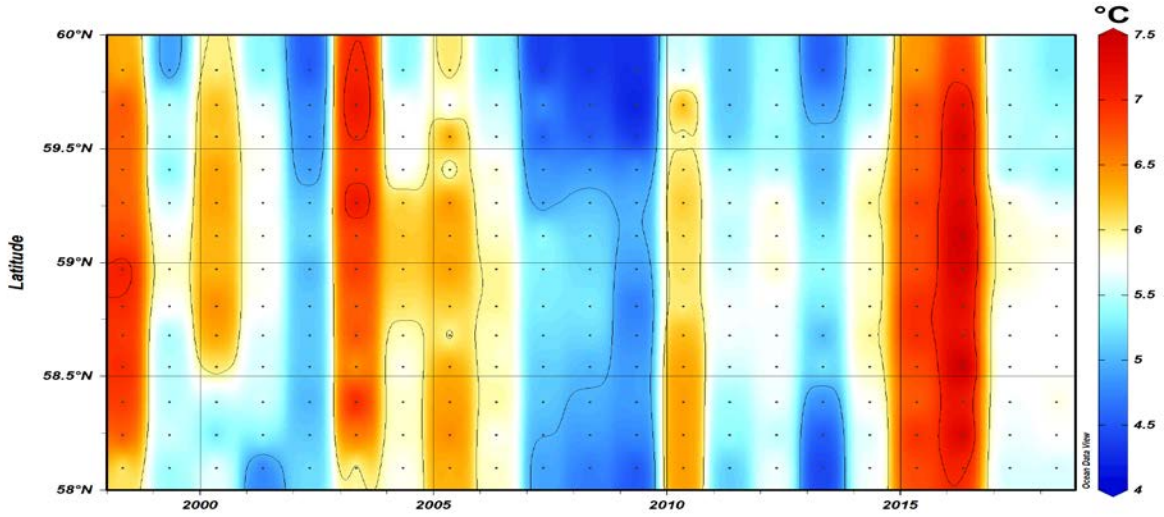

Figure 1. Early May temperature averages for the upper 100m along the Seward Line.

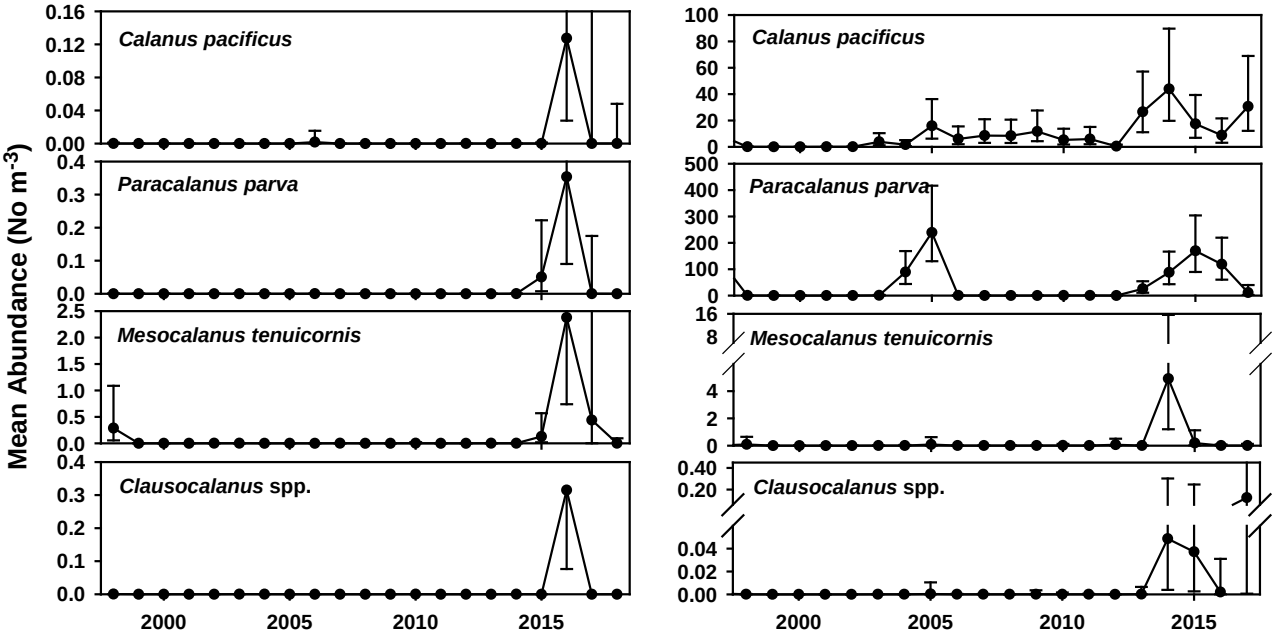

Figure 2. Abundance of the 4 most prevalent California Current copepods along the Seward Line, during May and late summer. Although these warm-water species have recently disappeared from May, some still remain during late summer.

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 spending for FY19, although the overall scope of work has increased with as a result of National Science Foundation NGA-long term ecological research (LTER) funding.

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.*

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 1. Project milestone and task progress by fiscal year and quarter, beginning February 1, 2017.
C = completed, X = not completed or planned. Fiscal Year Quarters: 1= Feb. 1-April 30; 2= May 1-July 31; 3= Aug. 1-Oct. 31; 4= Nov. 1-Jan 31.

	FY17				FY18				FY19				FY20				FY21			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Cruises																				
GAK1 sampling	C	C	C	C	C	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X

May survey		C				C				X				X				X		
Sept survey			C				X				X				X				X	
Milestone 2: Data delivery	C			C	C			X	X			X	X			X	X			X
Milestone 3: Reporting																				
Annual reports	C				C				X				X				X			
Annual PI meeting				C				X				X				X				X
FY work plan (DPD)			C				C				X				X					

B. Explanation for not completing any planned milestones and tasks (N/A)

Milestones and tasks have been completed as planned.

C. Justification for new milestones/tasks

No new milestones/tasks proposed.

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This project links tightly with the GAK-1 mooring, providing a cross shelf context for its observations. It complements the continuous plankton recorder, Prince William Sound, and Lower Cook Inlet/Kachemak Bay oceanographic 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 GAK-1 provide oceanographic context for the Gulf Watch Alaska nearshore activities underway within Resurrection Bay (Kenai Fjords). The new sampling line added through NGA-LTER funding now connects Middleton Island into the Environmental Drivers sampling domain.

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.

4. PROJECT DESIGN – PLAN FOR FY19 (YEAR 7)

A. Overall Project Objectives

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 the shelf.

B. Changes to Project Design and Objectives

Since the submission of the proposal, the Seward Line is now funded as one of the National Science Foundation's 30 LTER sites. This designation has resulted in expanded sampling on the Gulf of Alaska shelf, as well as an additional cruise each June/July (not considered here). The suite of routine measurements has increased, 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.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

No changes to those funded through EVOSTC.

6. PROJECT BUDGET FOR FY19

A. Budget Forms (See GWA FY19 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Project Proposal

No major changes anticipated with GWA funds

C. Sources of Additional Project Funding

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

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

National Science Foundation, 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. FY18 PROJECT PUBLICATIONS AND PRODUCTS

Publications

Hopcroft, R. R., S. L. Danielson, and K. Coyle. 2018. The Seward Line – Marine Ecosystem monitoring in the Northern Gulf of Alaska. FY17 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-L.

Hopcroft, R. R., S. L. Danielson, S. L. Strom, and K. Kuletz. 2018. The Seward Line: Marine ecosystem monitoring in the Northern Gulf of Alaska. Exxon Valdez Oil Spill Long-Term Monitoring Program (Gulf Watch Alaska) Final Report (Exxon Valdez Oil Spill Trustee Council Project 16120114-J). Exxon Valdez Oil Spill Trustee Council, Anchorage, Alaska.

Roncalli, V., M. C. Cieslak, S. A. Sommer, R. R. Hopcroft, and P. H. Lenz. 2018. De novo transcriptome assembly of the calanoid copepod Neocalanus flemingeri: A new resource for emergence from diapause. Mar. Gen. 37: 114-119.

Roncalli, V., S. A. Sommer, M. C. Cieslak, C. Clarke, R. R. Hopcroft, and P. H. Lenz. accepted. Physiological characterization of the emergence from diapause: A transcriptomics approach. Nature Sci. Rep.

Published datasets

DataONE: https://doi.org/10.24431/rw1k1k, published data updated in August 2018 with final 2016 zooplankton data.

Research Workspace: 2017 chlorophyll, CTD, nutrient, and seabird data uploaded to Research Workspace and undergoing QC. Data will be added to Gulf of Alaska Data Portal on schedule. 2017 zooplankton data still being processed per schedule.

Presentations

Collins, E. 2018. Microbial community structure in Prince William Sound. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Coyle, K. O. 2018. Modeled spatial-temporal distribution of production and biomass relative to field observations in the northern Gulf of Alaska (RS41A-02). Oral presentation presented at the 2018 Ocean Sciences Meeting, Portland, OR, February.

Hauri, C. 2018. Influence of ocean acidification and climate change on the biogeochemistry of the Gulf of Alaska (HE13A-06). Oral presentation presented at the 2018 Ocean Sciences Meeting, Portland, OR, February.

Hopcroft, R. R. 2018. The Northern Gulf of Alaska Long-term Ecological Research Program. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Hopcroft, R. R. 2018. The Seward Line - 2017. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Lenz, P. H. 2018. The physiological ecology of the calanid copepod, Neocalanus flemingeri in the northern Gulf of Alaska. Oral presentation and poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Monacci, N. M. 2018. Ocean acidification observations along the Seward Line: 2008-2017. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Monson, D. 2018. Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; the "Blob" washes ashore. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Piatt, J. F. 2018. Unprecedented scale of seabird mortality in the NE Pacific during the 2015-2016 marine heatwave. Oral presentation presented at the Alaska Marine Science Symposium, Anchorage, AK, January.

Roncalli, V. 2018. Physiological ecology of the calanoid Neocalanus flemingeri in the Gulf of Alaska. Invited presentation presented at the Pacific Biosciences Research Center, University Hawaii Manoa, Honolulu, HI, February.

Roncalli, V. 2018. Consequences of regional heterogeneity on the physiology of a calanoid copepod, Neocalanus flemingeri in the northern Gulf of Alaska (RS41A-06). Oral presentation presented at the 2018 Ocean Sciences Meeting, Portland, OR, February.

Strom, S. L. 2018. Planktonic communities in the coastal Gulf of Alaska: strong dichotomies in structure and function (RS41A-03). Oral presentation presented at the 2018 Ocean Sciences Meeting, Portland, OR, February.

Outreach

Hopcroft, R., and S. Danielson. 2018. Website: Seward Line. http://research.cfos.uaf.edu/sewardline/. The Seward Line website has been overhauled to accommodate the new LTER dimension. The website provides context for results via summaries of the program's history, hypotheses, methods and publications.

Trotter, M. H. 2018. Our May 2018 cruise hosted a media group lead by Michele Hoffman Trotter (Columbia College) that has prepared various video clips chronicling our research. She provided for outreach to K-12 teachers and students and to adult audiences in the Chicago area where she is based. Her K-12 audience also included homeschool students in California. Michele's outreach team included Carlee Belt, a media and education specialist, and Katherine Brennan, a cinematographer. The team provided 15 daily dispatches from the ship that included videos of ship operations and interviews with scientists and the crew deploying sampling equipment. They also collected footage for the on-going Microcosm film project that will feature the diversity and roles of microscopic life in the ocean.

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Beaugrand G, Reid PC (2003) Long-term changes in phytoplankton, zooplankton and salmon related to climate. Global Change Biol 9:801-817.

Di Lorenzo E, Schneider N, Cobb KM, Chhak K, Franks PJS, Miller AJ, McWilliams JC, Bograd SJ, Arango H, Curchister E, Powell TM, Rivere P (2008) North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophys Res Lett 35:L08607 doi:08610.01029/02007GL032838.

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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.

Mackas DL, Peterson WT, Zamon JE (2004) Comparisons of interannual biomass anomalies of zooplankton communities along the continental margins of British Columbia and Oregon. Deep-Sea Res II 51:875–896.

Mantua N, Hare SR, Zhang Y, Wallace JM, Francis RC (1997) A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bull Am Met Soc 78:1069 – 1079.

McGowan JA, Cayan DR, Dorman LM (1998) Climate-Ocean variability and ecosystem response in the Northeast Pacific. Science 281:210-217.

Stabeno PJ, Bond NA, Hermann AJ, Kachel NN, Mordy CW, Overland JE (2004) Meteorology and oceanography of the northern Gulf of Alaska. Cont Shelf Res 24:859-897.

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.