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

Does this proposal contain confidential information? ☐Yes ☒No

Project Number and Title

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

22120114-L Seward Line

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

August 13, 2021

Project Abstract (maximum 300 words)

Long times-series are required for scientists to tease out pattern and causation in the presence of substantial year-to-year variability. For the 10-year period beginning in 2022, we propose to continue multi-disciplinary oceanographic observations begun in fall 1997 in the Northern Gulf of Alaska. Cruises occur in early May, July, and mid-September to capture the typical spring bloom, summer conditions, and fall transition, 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.

EVOSTC Funding Requested* (must include 9% GA)

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$236,108	$242,009	$248,059	$254,264	$231,089	$1,211,529
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$176,338	$180,745	$185,264	$189,895	$194,644	$926,886
				FY22-31 Total	*$2,138,414*

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

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

1. EXECUTIVE SUMMARY (maximum ~1500 words, not including figures and tables)

We live in a constantly changing world, influenced by a combination of stochastic events, natural cycles, longer-term oscillations, and the accelerating impact 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, Beaugrand et al. 2019).

Our understanding of community level changes would not be possible without long-term observation programs, whose value is becoming increasingly apparent as our understanding of ecosystem change and its drivers becomes more sophisticated (Harvey et al. 2020). Biological time-series such as the North Atlantic 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, Batten et al. 2018) in the subarctic Pacific have proven 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 (NPGO; 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, Coyle et al. 2019), perhaps because the ecosystem is highly adapted to great variability. In contrast, recent awareness of Marine Heatwaves (Hobday et al. 2016, Oliver et al. 2019) has shown the NGA to be highly impacted by them (Piatt et al. 2020, Arimitsu et al. 2021, Rogers et al. 2021, Suryan et al. 2021). Our observations reveal that the NGA is profoundly affected by warmer years, fresher years, and light conditions in spring, that influence the timing and magnitude of planktonic processes. In contrast, temperature is much less variable during summer and early fall, although biological communities continue to show high variability, including increased prevalence of energy-poor southern species during warmer years.

Understanding how complex pelagic ecosystems work, and how they might be affected by climate change, was the fundamental goal of the Global Ocean Ecosystems Dynamics (GLOBEC) program that occupied the Seward Line from 1997 to 2004. The core questions and related hypotheses can only be addressed by an observational program of sufficient length to encompass long-term (decadal scale) change and repeated observations of disturbance at different temporal and spatial scales. Conclusions about the impact of the recent North Pacific Marine Heatwave and its recovery would not be possible without having such routine observations in place. Thus, such observations allow us to elucidate the mechanisms underlying adaptation, resilience, diversity, and potential tipping points globally (e.g., Wiltshire et al. 2008, Beaugrand et al. 2010) as well as in the NGA ecosystem (Litzow et al. 2020).

2. RELEVANCE TO THE INVITATION (maximum 300 words)

Our proposed research will continue the Long-term Ecological Research (LTER) observations in the NGA. Given the potential for profound climatic impact, the Seward Line/LTER Program (https://nga.lternet.edu/) provides these critical observations on the current state of the NGA ecosystem. For example, springtime abundance of zooplankton along the Seward Line appears to be an index of generally favorable years for higher trophic levels throughout the Gulf of Alaska. This work seeks to build a clearer understanding of the dynamics of the North Pacific ecosystems that enables effective long-term management and sustainable use of marine resources through the long-term multidisciplinary monitoring of marine environment.

The Seward Line represents the most comprehensive long-term multidisciplinary oceanographic sampling program in the Coastal Gulf of Alaska; it provides observation of changes in the oceanography of this region that is critical to Alaska's fisheries, subsistence, and tourist economies. Seward Line observations over the past 25 years have fundamentally revised our understanding of the coastal Gulf of Alaska ecosystem and allow us an appreciation of not only its major properties, but also their inter-annual variability. It is also essential that time-series are already in place when unforeseen events occur, either due to human activities (e.g., oil spills) or natural events such as the recent North Pacific warming, marine heatwaves, and El Niño Southern Oscillation (ENSO) cycles. Recent warm years have shown an influx of California Current System zooplankton, several of which have not been previously observed in these waters; these may be previews of changes that will occur in a future warmer Gulf of Alaska.

3. PROJECT HISTORY (maximum 400 words)

Begun in fall 1997 as part of the joint National Oceanic and Atmospheric Administration (NOAA) and National Science Foundation's (NSF's) GLOBEC program, the Seward Line has become the most comprehensive long-term multidisciplinary sampling program in the coastal Gulf of Alaska, monitoring changes in the oceanography of a region that is critical to Alaska's commercial and subsistence fisheries, and tourism economies. From 1998 to 2004, conditions along the Seward Line were sampled on 6-7 cruises per year spanning from March to December. When field studies ended in December 2004, the North Pacific Research Board (NPRB) continued to fund the program, reducing its scope to a cruise each May and September, with a focus along the Seward Line and the main passageways in western Prince William Sound. In 2010, the Alaska Ocean Observing System (AOOS) began to also provide financial support for the Seward Line observations. During 2011-2013, the Seward Line was embedded within the NPRB's Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP) which added determination of microzooplankton analysis to many cruises. With the addition of *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) support through Gulf Watch Alaska (GWA) in 2012, additional sampling stations were added in eastern Prince William Sound passageways. Elevation of the Seward Line to a long-term monitoring program by NPRB during the summer of 2014 has allowed the permanent addition of microzooplankton, seabird, and marine mammal observations to cruise activities. Finally, the importance of this time-series was recognized by NSF when they added the NGA to the nation's 28 LTER sites during 2018, allowing expansion of survey lines, reinstatement of a summer cruise, increased breath of measurements (e.g., trace metal chemistry, particle flux), and enhanced process studies while also bringing significant contribution in academic fleet ship-time. Since the 2000 (i.e., GLOBEC), Seward Line data has been used in over 140 publications, over 150 presentation at scientific meeting, published numerous publicly available datasets, and yielded 20 graduate degrees (with more in progress). Fuller details can be found at https://nga.lternet.edu/. Table 1 summarizes the history of sampling in the vicinity of the Seward Line.

Table 1. History of sampling in the Northern Gulf of Alaska (NGA) and the funding sources for the sampling. See text for the definition of acronyms.

Year	Program or Activity	Cruises annually	Funding agency
1974-1978	ECO-Foci (physical profiles, larval fish ONLY)	variable	NOAA
1997-2004	GLOBEC- multidisciplinary sampling begins	6 or 7	NSF/GLOBEC
2005-2010	Seward Line	2	NPRB
2011, 2013	GOA-IERP	3	NPRB
2012-2017	Seward Line	2	NPRB, AOOS, EVOSTC
2018-present	Seward Line / NGA-LTER	3	NPRB, AOOS, EVOSTC, NSF
2019-present	GEO mooring deployed mid-shelf	-	Murdock/AOOS

4. PROJECT DESIGN

A. Objectives and Hypotheses

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. Meeting these objectives requires shared costs across multiple funding sources as indicated.

Specifically, cruises:

1. Determine thermohaline, velocity, and nutrient structure of the Gulf of Alaska shelf, emphasizing the Seward Line, and Prince William Sound. (AOOS, EVOSTC, NPRB, NSF)
2. Determine the patterns of macronutrient availability across the sampling domain (AOOS, EVOSTC, NPRB, NSF)
3. Determine the patterns of micronutrient availability (iron & other metals) across the sampling domain (NSF)
4. Determine phytoplankton biomass distribution (as chlorophyll) (AOOS, EVOSTC, NPRB, NSF)
5. Determine composition and biomass of phytoplankton and microzooplankton (NPRB, NSF).
6. Determine the distribution, abundance, and taxonomic composition of zooplankton (AOOS, EVOSTC, NPRB, NSF).
7. Determine the distribution and abundance of seabirds and marine mammals (NPRB, EVOSTC).

<u>Hypotheses</u>

- *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 Prince William Sound, provide useful indices of favorable conditions for higher trophic levels such as fish and seabirds.*

B. Procedural and Scientific Methods

The Seward Line stretches across the Gulf of Alaska Shelf approximately 150 nautical miles and is augmented by more than a dozen stations in Prince William Sound. Our cruises capture the major spring-late summer gradient in this seasonality, while retaining a focus on important periods for the life cycles of various zooplankton species. Until recently, it consisted of two cruises each year. The early May period was selected to capture the peak productivity associated with the spring bloom. The consistent timing of the May cruise has allowed us to look at phenological shifts in the large *Neocalanus* copepods that dominate the spring. The September cruise coincides with the end of the low productivity oceanographic summer, when smaller phyto- and zooplankton dominate, and precedes the stormy fall overturn. Elevation to a national LTER site has provided the resources to add a summer cruise and add additional transects incorporating a fuller range of oceanographic features of the NGA. Using the academic fleet's R/V *Sikuliaq* and the U.S. Fish and Wildlife Service (USFWS) vessel *Tiglax*, these cruises collect data on the physical-chemical structure, algal biomass, and the distribution, abundance, biomass, and productivity of micro-, meso-, and macro-zooplankton. Together, these cruises enable us to explore seasonal and inter-annual variations, as we seek to understand how different climatic conditions influence the biological conditions in each year. It provides a reference dataset against which other GWA - Long-Term Research and Monitoring (LTRM) components can index basic environmental conditions.

Methods remain as employed for the past 10-25 years, with details provided on the project workspace (Program Management > Sampling Protocols > Revise Protocols). In brief, physical parameters are measured with a Seabird conductivity and temperature at depth (CTD) profiler (Janout et al. 2010). Water samples are collected at up to 16 depths per station with a CTD rosette, then analyzed for nutrient (Childers et al. 2005). Samples for chlorophyll, phytoplankton and microzooplankton are removed from a subset of the same bottles (Strom et al. 2007a,b 2019). Zooplankton are collected to 100 m depth with three types of plankton nets: 1) a vertically hauled 150-µm net CalVet during daytime that targets the smaller and most numerous animals, 2) an obliquely towed 505-µm Multinet during nighttime that targets larger and more mobile animals (Coyle and Pinchuk 2003, 2005; Coyle et al. 2019), and 3) a 2x3-mm Methot trawl collects near-surface jellyfish during nighttime (Mendoza-Islas 2019) and forage fish in collaboration with PI Arimitsu (project 22120114-C). Seabird and marine mammal observations are made from the flying bridge using strip-transect methodology (USFWS 2008) on all daytime transits between stations.

As with the last 5-year cycle, we added chemical and biological observations to the monthly daytrip CTD casts presently ongoing at GAK1, as well as to the RES2.5 station (centrally located in Resurrection Bay and sampled during Seward Line cruises). This sampling is conducted with an SBE-25 CTD and 12-bottle SBE-32SC rosette at depth. Macronutrients and chlorophyll are collected from the bottles at depths consistent with the Seward Line cruises, filtered and frozen for later analysis. Zooplankton is sampled at these stations with the same 150 µm nets employed by Seward Line cruises and analyzed following established protocols.

C. Data Analysis and Statistical Methods

Physical and chemical datasets are examined for trends, often after reducing them to anomalies and variances calculated over the observation period. Biological data sets are also examined for species trends, while

community analyses often consider similarity coefficients and use nonparametric multi-dimensional scaling (nMDS) to look for patterns across space and time, and relate these to associated meteorological, physical, and biological parameters (Clarke et al. 2014). The NGA-LTER contains a modelling team that is creating a Second Generation coupled biophysical dynamic model (i.e., ROMS-NPZ) to simulate the greater GWA-LTRM domain (see Coyle et al. 2012, 2013, 2019 for first generation model)

D. Description of Study Area

The main Seward Line (Fig. 1) consists of 15 stations stretched from Resurrection Bay (~60°N 149.5°W) 150 nm across the shelf to deep offshore waters (to 57.8°N 147.5°W) and includes an equal number of stations within the main passages and entrances to Prince William Sound, plus 2 tidewater glaciers (59.9-61°N 146.75-148.25°W). LTER funding has expanded our domain from Kayak Island (~144°W) to Kodiak Island (~151.6°W).

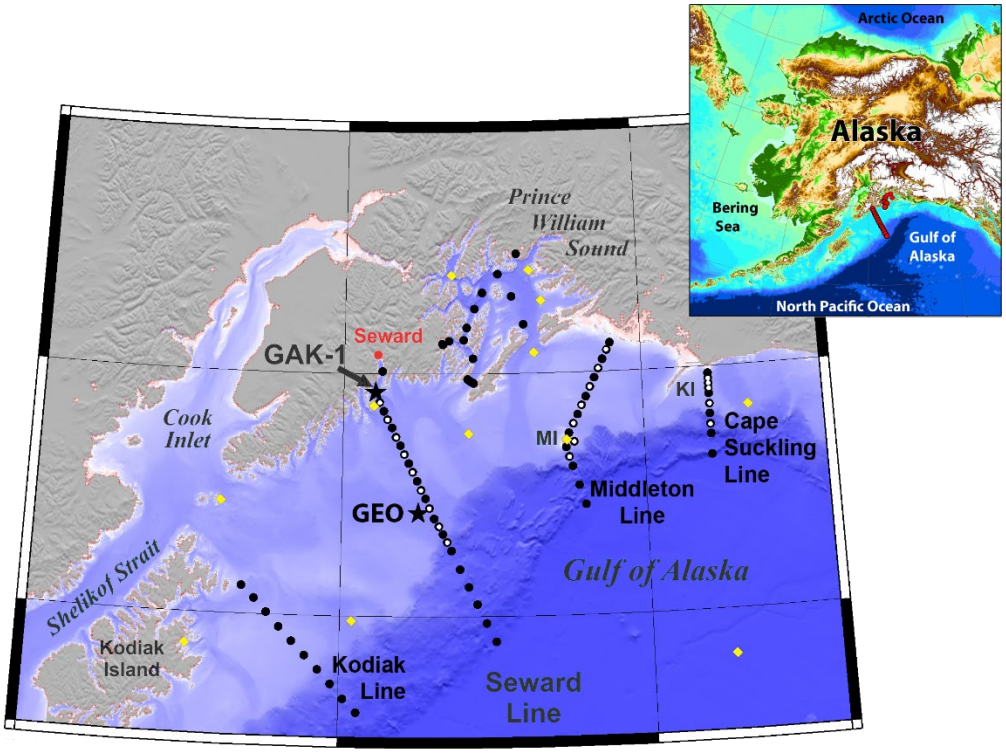

Figure 1. Seward Line study area and sampling locations.

5. COORDINATION AND COLLABORATION

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

The Seward Line works closely with Prince William Sound Science Center (PWSSC) who administers and coordinates GWA-LTRM activities.

B. Within the EVOSTC LTRM Program

Environmental Drivers Component

This project links tightly with the GAK1 mooring (project 22120114-I), providing a cross shelf context for its observations. It complements the continuous plankton recorder (project 22120114-D), Prince William Sound (project 22120114-G), and Lower Cook Inlet/Kachemak Bay (project 22120114-J) 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 near monthly sampling in Resurrection Bay aligns sampling periodicity with the other environmental driver component projects. In addition, principal investigator (PI) Hopcroft serves as the component lead for the Environmental Drivers component, ensuring coordination and cohesion with all projects in the component.

Pelagic Monitoring Component

PI Hopcroft has served on the GWA Science Coordinating Committee since its inception, ensuring all components are linked to Environmental Drivers that assess oceanographic change in the region. The NGA program has an active bird and mammal observer on all cruises (funded through project 22120114-M) and has recently begun to sample forage fish (including coordination with project 22120114-C). The placement of our eastern-most line through Middleton Islands helps connect the seabird studies with observation of oceanographic conditions and seabird prey-fields (project 22120114-C).

Nearshore Monitoring Component

PI Hopcroft's role on the GWA Science Coordinating Committee links the Environmental Drivers component to the nearshore monitoring component. PI Danielson has worked extensively with nearshore component PIs to analyze the data form their temperature recorders and determine the scales of data coherence. The additional monthly sampling in Resurrection Bay and at GAK1 provide oceanographic context for the GWA nearshore activities underway within Resurrection Bay.

Lingering Oil Monitoring Component

Because lingering oil data are collected once in a 5-year period and the oil is not currently bioavailable, we do not anticipate incorporating these data into our project. We look forward to status reports from the lingering oil component.

Herring Research and Monitoring component

The Seward Line makes physical and biological data available to projects and PIs in the Herring Research and Monitoring component.

Synthesis and Modeling Component

PIs Hopcroft and Danielson have been active in three of the recent GWA synthesis publications. Hopcroft will be supervising a GWA post-doctoral fellow, Bia Dias, May 2021-2023 that will refine an EcoPath-EcoSim model for the GWA domain that pulls data from Environmental Drivers, pelagic and nearshore monitoring components. The NGA-LTER is interested in collaborating on the development of a higher-resolution subdomain for its ROMS-NPZ model within Prince William Sound and will be collaborating with the GWA-LTRM Synthesis and Modeling Component (PI Suryan) on these efforts.

Data Management Project

The NGA-LTER works closely with Axiom and AOOS, and funds them for aspects of its data management. The NGA is held to national standards, where all datasets are published within 2 years of collection.

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

As within program connections, the Seward Line contributes environmental context for other EVOSTC efforts. As the EVOSTC funds future projects outside the GWA-LTRM program we will evaluate their applicability to our project and coordinate as appropriate.

D. With Proposed EVOSTC Mariculture Focus Area Projects

We look forward to working with the EVOSTC's Mariculture Program and projects they embark on. We anticipate they will be interested in GWA-LTRM datasets and we expect there will be opportunities for coordination and collaboration.

E. With Proposed EVOSTC Education and Outreach Focus Area Projects

The GWA-LTRM program will develop an outreach plan that includes coordination and collaboration with the Trustee's Education and Outreach Program and projects. We look forward to participating in education and outreach opportunities where our project findings can contribute to a better understanding of the Gulf of Alaska ecosystem by the general public. The Seward Line has well developed outreach programs through GWA and the LTER network. We look forward to continued engagement with EVOSTC education and outreach focus area efforts.

F. With Trustee or Management Agencies

Like other environmental driver components, Seward Line data are available to the Alaska Department of Fish and Game (ADF&G) for salmon forecasting, with both temperature and zooplankton time-series provided to NOAA for their Gulf of Alaska Ecosystem Status reports (Ferriss and Zador 2020)

G. With Native and Local Communities

The GWA-LTRM program and this project are committed to involvement with local and Alaska Native communities. Our vision for this involvement will include active engagement with the EVOSTC Education and Outreach Focus Area (see above), program-directed engagement through the GWA-LTRM Program Management Outreach Coordinator (project 22120114), and project-level engagement. During the first year of the funding cycle (FY22), the GWA-LTRM program will reach out to local communities and Alaska Native organizations in the spill affected area to ask what engagement they would like from us and develop an approach that invites involvement of PIs from each project, including this one. Our intent as a program is to provide effective and meaningful community involvement that complements the work of the Education and Outreach Focus Area and allows communities to engage directly with scientists based on local interests.

In addition, this project will continue engaging with local communities through school and citizen-science efforts that provide local monitoring efforts of physical and biological variables also measured by the Seward Line.

6. DELIVERABLES

The Seward Line/LTER effort has averaged around seven manuscripts and eight presentations annually over the last two decades, so a conservative estimate of roughly one each per quarter (typically concentrated within Q1 and Q4) can be anticipated. Our website is updated regularly, with data submitted and published annually.

7. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

Project Milestones essentially revolve around the execution of cruises each May, July and September and the delivery of data. Dependent on the type of data, delivery occurs to the program workspace within 6 months to 1 year of collection and data are published after 2 years (as per NSF requirements). Other milestones include the annual principal investigators meeting and presentation of results at the Alaska Marine Science Symposium.

May – Sampling cruise (*R/V Sikuliaq*)
July – Sampling cruise (*R/V Sikuliaq*)
September – Sampling cruise (*R/V Tiglax*)
Monthly (January-December) – Daytrip-cruises (*R/V Nanuq*) for months not sampled by large vessels
October/November – Annual PI meeting (Anchorage)
December – Most samples completed from May cruise preliminary data available for September cruises
January – Results presented at the Alaska Marine Science Symposium (AMSS)
February – Annual reports submitted
May – Sample processing completed for prior season

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

	FY22				FY23				FY24				FY25				FY26			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone: Cruises																				
May Survey		X				X				X				X				X		
July Survey		X				X				X				X				X		
Sept Survey			X				X				X				X				X	
Resurrection Bay Daytrips	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Milestone: Reporting																				
Annual Reports					X				X				X				X			
Annual PI meeting				X				X				X				X				X
Milestone: Deliverables																				
Peer reviewed papers	X			X	X			X	X			X	X			X	X			X
Data delivery	X			X	X			X	X			X	X			X	X			X

	FY27				FY28				FY29				FY30				FY31			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone: Cruises																				
May Survey		X				X				X				X				X		
July Survey		X				X				X				X				X		
Sept Survey			X				X				X				X				X	
Resurrection Bay Daytrips	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Millstone: Reporting																				
Annual Reports	X				X				X				X				X			
Annual PI meeting				X				X				X				X				X
Final report																				X
Millstone: Deliverables																				
Peer reviewed papers	X			X	X			X	X			X	X			X	X			X
Data delivery	X			X	X			X	X			X	X			X	X			X

8. Budget

A. Budget Forms (Attach)

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

Budget Category:	Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5- YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$164,676	$168,792	$173,013	$177,340	$160,099	$843,922	
Travel	$1,555	$1,564	$1,573	$1,582	$1,592	$7,866	
Contractual	$6,000	$6,000	$6,000	$6,000	$6,000	$30,000	
Commodities	$1,059	$1,265	$1,476	$1,693	$1,915	$7,408	
Equipment	$0	$0	$0	$0	$0	$0	
Indirect Costs Rate = 25% non-equipment	$43,323	$44,405	$45,515	$46,654	$42,402	$222,299	
SUBTOTAL	$216,613	$222,026	$227,577	$233,269	$212,008	$1,111,494	
General Administration (9% of subtotal)	$19,495	$19,982	$20,482	$20,994	$19,081	$100,034	N/A
PROJECT TOTAL	$236,108	$242,009	$248,059	$254,264	$231,089	$1,211,529	
Other Resources (In-Kind Funds)						$0	

Budget Category:	Proposed FY 27	Proposed FY 28	Proposed FY 29	Proposed FY 30	Proposed FY 31	5- YR TOTAL PROPOSED	ACTUAL CUMULATIVE	TEN YEAR TOTAL
Personnel	$119,677	$122,668	$125,734	$128,879	$132,101	$629,059		$1,472,981
Travel	$1,602	$1,612	$1,623	$1,633	$1,644	$8,114		$15,980
Contractual	$6,000	$6,000	$6,000	$6,000	$6,000	$30,000		$60,000
Commodities	$2,143	$2,377	$2,616	$2,861	$3,113	$13,110		$20,518
Equipment	$0	$0	$0	$0	$0	$0		$0
Indirect Costs Rate = 25% non-equipment	$32,356	$33,164	$33,993	$34,843	$35,715	$170,071		$392,370
SUBTOTAL	$161,778	$165,821	$169,967	$174,216	$178,573	$850,354		$1,961,848
General Administration (9% of subtotal)	$14,560	$14,924	$15,297	$15,679	$16,072	$76,532	N/A	$176,566
PROJECT TOTAL	$176,338	$180,745	$185,264	$189,895	$194,644	$926,886		**$2,138,414**
Other Resources (In-Kind Funds)						$0		**$0**

University of Alaska Fairbanks Budget Justification

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

Salaries:

80 hours (0.5 mo.) per year are requested for PI Hopcroft (at $65.24/hour) to lead the Seward Line effort, participate on cruises, and perform reporting functions. 1,740 hours (10.0 mos.) per year are requested for Stockmar (at $30.87/hour) to perform taxonomic analysis on zooplankton samples. 522 hours (3.0 mos.) per year in years 1-4 and 348 hours (2.0 mos.) in year 5 are requested for post-doctoral fellows Questel and Hennon (at $35.00/hour) to participate on cruises, conduct data analysis and contribute to publications that may synthesize across different LTRM projects and component. No salary is requested for Co-PI Danielson.

Salaries are listed at the current FY21 rate and include a leave reserve of 20.6% for faculty and 24.1% for professionals as well as an annual inflation increase of 2.5%. Should the inflation increase not occur as planned, the project will be charged actual salary at the time of effort.

Benefits:
Staff benefits are applied according to UAF's FY21 provisional fringe benefit rates. Rates are 30.4% for faculty salaries and 42.5% for professionals. A copy of the rate agreement is available at http://www.alaska.edu/cost-analysis/negotiation-agreements/.

Travel:
Domestic: One trip per year is requested for one person to travel from Fairbanks, AK to Anchorage, AK (at $300/ticket for airfare) to attend PI meetings. Per Diem for Anchorage is estimated at a rate of $299 x 4 days/trip. $50/trip is requested for ground transportation. An inflation rate of 2.5% per year has been included for all transportation costs. All airfare cost data is based on Internet research. All Per Diem is in accordance with GSA/JTR Regulations.

Commodities (Materials & Supplies):
$20,518 (average ~2K/year) is requested for miscellaneous project supplies, such as chemicals, filters, bottles, nets, and other consumables.

Contractual Services and Other Direct Costs:
$60,000 is requested for lab analysis of macronutrient samples taken on the GAK1 and Resurrection Bay monthly daytrips (~25/trip each of 12 months=300/year x $20 each).

Indirect Costs:
Facilities and Administrative (F&A) Costs applicable to State of Alaska sponsored activities are agreed to in an ongoing MOU between UA and the State. The State of Alaska rate for sponsored research at UA is calculated at 25% (FY17–FY18 State negotiation agreement) of Modified Total Direct Costs (MTDC). MTDC includes Total Direct Costs minus tuition and associated fees, scholarships, participant support costs, rental/lease costs, subaward amounts over $25,000, and equipment. A copy of the rate agreement is available at: http://www.alaska.edu/cost-analysis/negotiation-agreements/.

B. Sources of Additional Funding

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

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

Breakdown of Non-EVOSTC funding:

UAF prohibits committing leveraged resources coming from or through the university when not specifically required, hence we will not be reporting or tracking any match/cost share on this project. However, we note that the Seward Line currently receives long-term funding, typically in five-year blocks, from 3 non-EVOSTC funding agencies that provide allocations annually. We assume these will all continue uninterrupted long-term, but have no way to guarantee that will be the case, particularly when they are up for competitive renewal. In FY22, we should have 2 more years of tentatively committed funds from NSF-LTER, 3 from NPRB, and 4 from AOOS. These numbers do not include any short-term add-on projects (of which there are usually several ongoing) annually.

Furthermore, we can anticipate both Hopcroft & Danielson contributing significant time annually to this program. UAF also provides several tuition waivers to LTER annually that will support students who advance the aims of this project. The LTER includes 6-8 additional PIs, many of whom contribute effort to core measurements, but they have not been included in these estimates. Finally, *Sikuliaq's* several weeks of ship-time annually has not been included but represents an additional leveraging of resources from NSF.

9. LITERATURE CITED

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

Arimitsu, M., J. Piatt, S. Hatch, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, W.S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V.R. von Biela. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. Global Change Biology doi:10.1111/gcb.15556.

Batten, S.D., and H.J. Freeland. 2007. Plankton populations at the bifurcation of the North Pacific Current. Fish Oceanography 16:536-546

Batten, S.D., D.E. Raitsos, S. Danielson, R.R. Hopcroft, K.O. Coyle, and A. McQuattors-Gollop. 2018. Interannual variability in lower trophic levels on the Alaskan Shelf. Deep Sea Research II 147:58-68

Beaugrand, G. 2004. The North Sea regime shift: evidence, causes, mechanisms and consequences. Progress in Oceanography 60:245-262

Beaugrand, G., M. Edwards, and L. Legendre. 2010. Marine biodiversity, ecosystem functioning, and carbon cycles. Proceedings of the National Academy of Science 107:10120-10124

Beaugrand, G., and P.C. Reid. 2003. Long-term changes in phytoplankton, zooplankton and salmon related to climate. Global Change Biology 9:801-817

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-Sea Research II 52:193-216

Clarke, K.R., R.N. Gorley, P.J. Somerfield, R.M. Warwick. 2014. Change in marine communities: an approach to statistical analysis and interpretation, 3rd edition, Vol. PRIMER-E, Plymouth

Coyle, K.O., and A.I. Pinchuk. 2003. Annual cycle of zooplankton abundance, biomass and production on the northern Gulf of Alaska shelf, October 1997 through October 2000. Fish Oceanography 12:227-251

Coyle, K.O., and A.I. Pinchuk. 2005. Cross-shelf distribution of zooplankton relative to water masses on the northern Gulf of Alaska shelf. Deep-Sea Research II 52:217-245

Coyle, K.O., W. Cheng, S. Hinckley, E.J. Lessard, T. Whitledge, A.J. Hermann, and K. Hedstrom. 2012. Model and field observations of effects of circulation on the timing and magnitude of nitrate utilization and production on the northern Gulf of Alaska shelf. Progress in Oceanography 103:16-41

Coyle, K.O., G.A. Gibson, K. Hedstrom, A.J. Hermann, and R.R. Hopcroft. 2013. Zooplankton biomass, advection and production on the northern Gulf of Alaska shelf from simulations and field observations. Journal of Marine Systems 128:185-207

Coyle, K.O., A.J. Hermann, and R.R. Hopcroft. 2019. Modeled spatial-temporal distribution of production, chlorophyll, iron and nitrate on the northern Gulf of Alaska shelf relative to field observations. Deep-Sea Research II 165:163-191

Di Lorenzo, E., N. Schneider, K.M. Cobb, K. Chhak, P.J.S. Franks, A.J. Miller, J.C. McWilliams, S.J. Bograd, H. Arango, E. Curchister, T.M. Powell, and P. Rivere. 2008 North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophysical Research Letters 35:L08607 doi:08610.01029/02007GL032838

Doubleday, A.J., and R.R. Hopcroft. 2015. Seasonal and interannual patterns of larvaceans and pteropods in the coastal Gulf of Alaska, and their relationship to pink salmon survival Journal of Plankton Research 37:134-150

Evans, W., and J.T. Mathis. 2013. The Gulf of Alaska coastal ocean as an atmospheric CO_2 sink. Continental Shelf Research 65:52-63

Ferriss, B., and S.G. Zador. 2020. Ecosystem Status Report 2020: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. Ecosystem Status Report 2020 Gulf of Alaska | NOAA Fisheries

Francis, R.C., and S.R. Hare. 1994. Decadal-scale regime shifts in the large marine ecosystems of the North-east Pacific: a case for historical science. Fish Oceanography 3:279-291

Harvey, C.J., J.L. Fisher, J.F. Samhouri, G.D. Williams, T.B. Francis, K.C. Jacobson, Y.L. deReynier, M.E. Hunsicker, and N. Garfield. 2020. The importance of long-term ecological time series for integrated ecosystem assessment and ecosystem-based management. Progress in Oceanography 188:102418

Hobday, A.J., L.V. Alexander, S.E. Perkins, D.A. Smale, S.C. Straub, E.C.J. Oliver, J.A. Benthuysen, M.T. Burrows, M.G. Donat, M. Feng, N.J. Holbrook, P.J. Moore, H.A. Scannell, A. Sen Gupta, and T. Wernberg. 2016. A hierarchical approach to defining marine heatwaves. Progress in Oceanography 141:227-238

Janout, M.A., T.J. Weingartner, T.C. Royer, and SL. Danielson. 2010. On the nature of winter cooling and the recent temperature shift on the northern Gulf of Alaska shelf. Journal Geophysical Research 115:C05023

Litzow, M.A., M.E. Hunsicker, E.J. Ward, S.C. Anderson, J. Gao, S. McClatchie, S. Zador, S. Batten, S. Dressel, J. Duffy-Anderson, E. Fergusson, R.R. Hopcroft, B.J. Laurel, and R. O'Malley. 2020. Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. Progress in Oceanography 186

Mackas, D.L., R. Goldblatt, and A.G. Lewis. 1998. Interdecadal variation in developmental timing of *Neocalanus plumchrus* populations at Ocean Station P in the subarctic North Pacific. Canadian Journal of Fishery and Aquatic Science 55:1878-1893

Mackas, D.L., W.T. Peterson, and J.E. Zamon. 2004. Comparisons of interannual biomass anomalies of zooplankton communities along the continental margins of British Columbia and Oregon. Deep-Sea Research II 51:875–896

Mantua, N., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bulletin of American Meteorological Society 78:1069-1079

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

Mendoza-Islas, H.M. 2020. Abundance and distributions of gelatinous zooplankton in the Northern Gulf of Alaska. MSc. Thesis. University of Alaska

Mundy, P., D. Allen, J.L. Boldt, N.A. Bond, S. Dressel, E. Farley Jr., D. Hanselman, J. Heifetz, R.R. Hopcroft, M.A. Janout, C. Ladd, R. Lam, P. Livingston, C. Lunsford, J.T. Mathis, F. Mueter, C. Rooper, N. Sarkar, K. Shotwell, M. Sturdevant, A.C. Thomas, T.J. Weingartner, and D. Woodby. 2010. Status and trends of the Gulf of Alaska Coastal region, 2003-2008. In: S.M. McKinnell and M. Dagg (eds), The North Pacific Ocean; status and trends, 2003-2008. PICES Special Publication 4

Oliver, E.CJ., M.T. Burrows, M.G. Donat, A. Sen Gupta, L.V. Alexander, S.E. Perkins-Kirkpatrick, J.A. Benthuysen, A.J. Hobday, N.J. Holbrook, P.J. Moore, M.S. Thomsen, T. Wernberg, D.A. Smale. 2019. Projected Marine Heatwaves in the 21st Century and the Potential for Ecological Impact. Frontiers in Marine Science 6

Piatt, J.F., J.K. Parrish, H.M. Renner, S.K. Schoen, T.T. Jones, M.L. Arimitsu, K.J. Kuletz, B. Bodenstein, M. García-Reyes, R.S. Duerr, R.M. Corcoran, R.S.A. Kaler, G.J. McChesney, R.T. Golightly, H.A. Coletti, R.M. Suryan, H.K. Burgess, J. Lindsey, K. Lindquist, P.M. Warzybok, J. Jahncke, J. Roletto, and W.J. Sydeman. 2020. Extreme mortality and reproductive failure of common murres resulting from the northeast Pacific marine heatwave of 2014-2016. PLoS ONE 15:e0226087

Rogers, L.A., M.T. Wilson, J.T. Duffy-Anderson, D.G. Kimmel, and J.F. Lamb. 2021. Pollock and "the Blob": Impacts of a marine heatwave on walleye pollock early life stages. Fisheries Oceanography 30:142-158

Stabeno, P.J., N.A. Bond, A.J. Hermann, N.N. Kachel, C.W. Mordy, and J.E. Overland. 2004. Meteorology and oceanography of the northern Gulf of Alaska. Continental Shelf Research 24:859-897

Strom, S.L., E.L. Macri, and M.B. Olson. 2007. Microzooplankton grazing in the coastal Gulf of Alaska: Variations in top-down control of phytoplankton. Limnological Oceanography 52:1480-1494

Strom, S.L., M.B. Olson, E.L. Macri, and C.W. Mordy. 2007. Cross-shelf gradients in phytoplankton community structure, nutrient utilization, and growth rate in the coastal Gulf of Alaska. Marine Ecology Progress Series 328:75-92

Suryan, R.M., M.L. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S.J. Barbeaux, S.D. Batten, W. Burt, M.A. Bishop, J.L. Bodkin, R. Brenner, R.W. Campbell, D.A. Cushing, S.L. . Danielson, M.W. Dorn, B.A. Drummond, D. Esler, T. Gelatt, D.H. Hanselman, S.A. Hatch, S. Haught, K. Holderied, K. Iken, D.B. Irons, A.B. Kettle, D.G. Kimmel, B. Konar, K.J. Kuletz, B.J. Laurel, J.M. Maniscalco, C.O. Matkin, C.A.E. McKinstry, D.H. Monson, J.R. Moran, D. Olsen, W.A. Palsson, W.S. Pegau, J.F. Piatt, L.A. Rogers, N.A. Rojek, A. Schaefer, I. Spies, J.M. Straley, S.L. Strom, K.L. Sweeney, M. Szymkowiak, B. Weitzman, E.M. Yasumiishi, and S.G. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports doi:10.1038/s41598-021-83818-5

USFWS. 2008. North Pacific Pelagic Seabird Observer Program Observer's Manual. In. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK

Waite, J.N., and F.J. Mueter. 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. Progress in Oceanography 116:179-192

Wiltshire, K.H., A.M. Malzahn, K. Wirtz, W. Greve, S. Janisch, P. Mangelsdorf, B.F.J. Manly, and M. Boersma. 2008. Resilience of North Sea phytoplankton spring bloom dynamics: An analysis of long-term data at Helgoland Roads. Limnological Oceanography 53:1294-1302

10. PROJECT PERSONNEL

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RELEVANT PROFESSIONAL EXPERIENCE

- Steering Groups – Gulf Watch Alaska, Gulf of Alaska Integrated Research Program, Census of Marine Life's (CoML) Arctic Ocean Biodiversity (ArcOD) & Census of Marine Zooplankton (CMarZ), Executive Committee member - Northeast Pacific GLOBEC, US member – Plankton Experts Lead, Circumpolar Biodiversity Monitoring Program, ICES Zooplankton Ecology Group
- Editorial Board – Marine Biodiversity (Springer), Plankton and Benthic Research (Japan)
- Reviewer: manuscripts reviewed for ~15 primary journals, proposals for 6 funding agencies, NSF OPP & BO panel member.
- Submersible & ROV Experience - Johnson-Sea-Link, Ventana, Tiburon, Global Explorer (~120 dives total)
- Research Cruise Experience - ~1300 sea days on cruises up to 45 days duration aboard vessels ranging in size from 15-120 m.

MOST RELEVANT PUBLICATIONS

Suryan, R. M. and 47 others. *(Accepted).* Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. Nature Sci. Rep.

Litzow, M. A., M. E. Hunsicker, E. J. Ward, S.C. Anderson, J. Gao, S. McClatchie, S. Zador, S. Batten, S. Dressel, J. Duffy-Anderson, E. Fergusson, **R.R .Hopcroft**, B.J. Laurel, & R. O'Malley. 2020. Evaluating ecosystem change as Gulf of Alaska temperate exceeds the limits of preindustrial variability. *Prog. Oceanogr.* **186**:102393.

Doyle, M. J., S.L. Strom, K.O. Coyle, A.J. Hermann, C. Ladd, A.C. Matarese, S.K. Shotwell, & **R.R. Hopcroft.** 2019. Early life history phenology among Gulf of Alaska fish species: strategies, synchronies, and sensitivities. *Deep-Sea Res. II.* **165**: 41-73.

Coyle, K.O., A.J. Hermann, & **R.R. Hopcroft**. 2019. Modeled spatial-temporal distribution of production, chlorophyll, iron and nitrate on the northern Gulf of Alaska shelf relative to field observations. *Deep-Sea Res. II*. **165**: 163-191.

Roncalli, V., M.C. Cieslak, M. Germano, **R.R. Hopcroft**, & P.H. Lenz. 2019. Regional heterogeneity impacts gene expression in the sub-arctic zooplankter *Neocalanus flemingeri* in the northern Gulf of Alaska. *Commun. Biol.* **2:**324

Batten, S.D., D.E. Raitsos, S. Danielson, **R.R. Hopcroft**, K.O. Coyle & A. McQuattors-Gollop. 2018. Interannual variability in lower trophic levels on the Alaskan Shelf. *Deep-Sea Res. II*. **147**: 58-68.

Sousa, L., K.O. Coyle, R.P. Barry, T.J. Weingartner, & **R.R. Hopcroft**. 2016. Climate-related variability in abundance of mesozooplankton in the northern Gulf of Alaska 1998-2009. *Deep-Sea Res. II.* **132:** 122-135.

Li, K.Z., A.J. Doubleday, M.D. Galbraith, & **R.R. Hopcroft**. 2016. High abundance of salps in the coastal Gulf of Alaska during 2011: a first record of bloom occurrence for the northern Gulf. *Deep-Sea Res. II.* **132:** 126-145.

Doubleday, A. & **R.R. Hopcroft.** 2015. Seasonal and interannual patterns of larvaceans and pteropods in the coastal Gulf of Alaska, and their relationship to pink salmon survival. *J. Plankton Res.* **37**:134-150.

Coyle, K.O., G.A. Gibson, K. Hedstrom, A. Hermann, & **R.R. Hopcroft.** 2013. Zooplankton biomass, advection and production on the northern Gulf of Alaska shelf from simulations and field observations. *J. Mar. Sys.* **128**: 185-207.

OTHER SIGNIFICANT PUBLICATIONS

Mundy, P., and 22 others. 2010. Status and trends of the Gulf of Alaska Coastal region, 2003-2008. pp. 142-195. *In:* S.M. McKinnell & M. Dagg (ed.) Marine Ecosystems of the North Pacific Ocean; 2003-2008. *PICES Spec. Pub. 4. 393p.*

Pinchuk, A.I., K.O. Coyle & **R.R. Hopcroft**. 2008. Climate-related variability in abundance and reproduction of euphausiids in the northern Gulf of Alaska in 1998-2003. *Prog. Oceanogr.* **77**:203-216.

Liu, H. & **R.R. Hopcroft**. 2008. Growth and development of *Pseudocalanus* spp. in the northern Gulf of Alaska. *J. Plankton Res.* **30**: 923-935.

Pinchuk, A.I. & **R.R. Hopcroft**. 2007. Seasonal variations in the growth rate of euphausiids (*Thysanoessa inermis*, *T. spinifera*, and *Euphausia pacifica*) from the northern Gulf of Alaska. *Mar. Biol.* **151**: 257-269

Liu, H. & **R.R. Hopcroft**. 2006. Growth and development of *Neocalanus flemingeri/plumchrus* in the northern Gulf of Alaska: validation of the artificial cohort method in cold waters. *J. Plankton Res.* **28**: 87-101.

EDUCATION

University of Guelph, Ontario, Canada	Marine Biology	B.Sc. 1983
University of Guelph	Marine Ecology	M.Sc. 1988
University of Guelph	Marine Biology	Ph.D. 1997
Monterey Bay Aquarium Research Institute (MBARI)	Zooplankton Ecology	1997-1999
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Research Associate Professor of Oceanography, IMS-UAF, Fairbanks, AK, 2016-2018
Research Assistant Professor of Oceanography, IMS-UAF, Fairbanks, AK, 2013-2016
Technician, Research Analyst/Professional, Institute of Marine Science, UAF, Fairbanks, AK, 1997–2013
Driller, Polar Ice Coring Office, University of Nebraska, Lincoln, NB, 1996-1997
Research Assistant, Institute of Marine Science, UAF, Fairbanks, AK, 1994-1996
Driller, Polar Ice Coring Office, Institute of Marine Science, UAF, Fairbanks, AK, 1993-1994
Junior Engineer, Allen Organ Company, Macungie, PA, 1990-1992

Peer-Reviewed Publications (10 relevant)

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

Danielson, S.L., O. Ahkinga, C. Ashjian, E. Basyuk, L.W. Cooper, L. Eisner, E. Farley, K.B. Iken, J.M. Grebmeier, L. Juranek, G. Khen, S. Jayne, T. Kikuchi, C. Ladd, K. Lu, R. McCabe, G.W.K. Moore, S. Nishino, S.R. Okkonen, F. Ozenna, R.S. Pickart, I. Polyakov, P.J. Stabeno, K. Wood, W.J. Williams, T.J. Weingartner, 2020. Manifestation and consequences of warming and altered heat fluxes over the Bering and Chukchi Sea continental shelves. *Deep-Sea Res. II: Topical Studies in Oceanogr.*, 177, 144781, https://doi.org/10.1016/j.dsr2.2020.104781

Hauri, C., Schultz, C., Hedstrom, K., **Danielson, S**., Irving, B., Doney, S.C., Dussin, R., Curchitser, E.N., Hill, D.F. and Stock, C.A., 2020. A regional hindcast model simulating ecosystem dynamics, inorganic carbon chemistry, and ocean acidification in the Gulf of Alaska. *Biogeosciences*, *17*(14), pp.3837-3857.

Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, **S. Danielson**, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Sweeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. in press. Ecosystem response to a prolonged marine heatwave. Scientific Reports.

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

Walsh, J. E., R.L. Thoman, U.S. Bhatt, P.A. Bieniek, B. Brettschneider, M. Brubaker, **S. Danielson**, R. Lader, F. Fetterer, K. Holderied, K. Iken, A. Mahoney, M. McCammon, and J. Partain, 2018. The high latitude marine

heat wave of 2016 and its impacts on Alaska [in "Explaining Extreme Events of 2016 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, 9 9 (1), S39–S43, doi:10.1175/BAMS-D-17-0105.1.

Stabeno PJ, Bell S, Cheng W, **Danielson S.L.**, Kachel NB, Mordy CW., 2016. Long-term observations of Alaska Coastal Current in the northern Gulf of Alaska. *Deep Sea Res. II: Topical Studies in Oceanogr.* http://dx.doi.org/10.1016/j.dsr2.2015.12.016

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

Weingartner, T. J**., S.L. Danielson**, T.C. Royer, 2005. Fresh Water Variability in the Gulf of Alaska: Seasonal, Interannual and Decadal Variability, *Deep-Sea Res. II*, 52 (1-2): 169-191.

Okkonen, S.R., T.J. Weingartner, **S.L. Danielson**, D.L. Musgrave and G.M. Schmidt, 2003. Satellite and Hydrographic Observations of Eddy-Induced Shelf-Slope Exchange in the Northwestern Gulf of Alaska, *J. Geophys. Res*, 108 (C2): Art. No. 3033

Peer-Reviewed Publications (4 significant)

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

Danielson, S.L., T. W. Weingartner, K. Hedstrom, K. Aagaard, R. Woodgate, E. Curchitser, and P. Stabeno, 2014. Coupled wind-forced controls of the Bering–Chukchi shelf circulation and the Bering Strait through-flow: Ekman transport, continental shelf waves, and variations of the Pacific–Arctic sea surface height gradient. *Prog. Oceanogr*. http://dx.doi.org/ 10.1016/j.pocean.2014.04.006

Danielson, S., K. Hedstrom, K. Aagaard, T. Weingartner, and E. Curchitser, 2012. Wind-induced reorganization of the Bering shelf circulation, *Geophys. Res. Lett*., 39, L08601, doi:10.1029/2012GL051231.

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

Collaborators

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

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

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July 29, 2021

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

Re: Letter of Commitment

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

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

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

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

Sincerely,

S. Bradley Moran, Dean
College of Fisheries and Ocean Sciences