EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY21 (YEAR 10) CONTINUING PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Environmental Drivers Project

21120114-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

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. Beginning in 2018, funding as one of the National Science Foundation's Long-term Ecological Research (LTER) sites allowed expanded sampling on the shelf upstream of Prince William Sound, including near Middleton Island, to help better understand spatial variability on the shelf. Last year (2019) saw near record summer temperatures on the shelf that persisted through fall offshore, a harsh winter drew most of this heat out of the system, returning May 2020 to the climatological mean. Warm-water associated zooplankton with smaller body size and lower lipid content rebounded during fall 2019.

Some LTER components have been impacted by COVID-19. March and April GAK1 monthly trips did not occur but the May 2020 survey was executed using a skeleton science team of 3 and the summer survey with half the normal science compliment. The September cruise will continue as planned. We are not proposing or anticipating any major changes to this project for FY21.

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	$7,190,300

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 (GWA), 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, Batten et al. 2018) 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 flip (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 North Pacific Gyre Oscillation (Di Lorenzo et al. 2008) are dominant extremes among a continuum of Pacific-wide patterns of oceanic variability (Liu and Di Lorenzo, 2018).

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. May 2019 saw temperatures return to well above average, with shelf temperatures rising to near records during summer, and offshore temperature remaining hot until winter cooling returned the system to the 23-year mean.

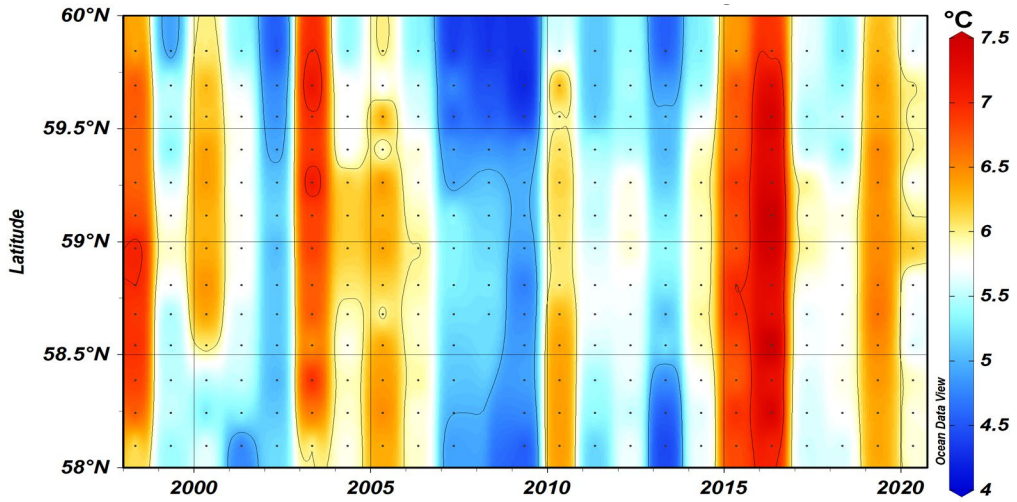

Figure 1. Early May temperature averages for the upper 100 m along the Seward Line.

Warmer years result in reduced body size and typically lower lipid storage by the large-bodied spring copepods (i.e., *Neocalanus* spp.). In contrast to spring, 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 marine heatwave (Fig. 2). Thus, while lipid accumulation during 2019 appeared low, it was relatively normal during 2020. Several southern species rebounded during fall 2019, preliminary observations for 2020 suggests low abundances during 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 GWA deliverables in FY21, although the overall scope of work has increased with as a result of National Science Foundation (NSF) NGA-long term ecological research (LTER) funding, and some of its objectives has been impacted by COVID-19 (i.e., transect lines and sampled parameters).

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.

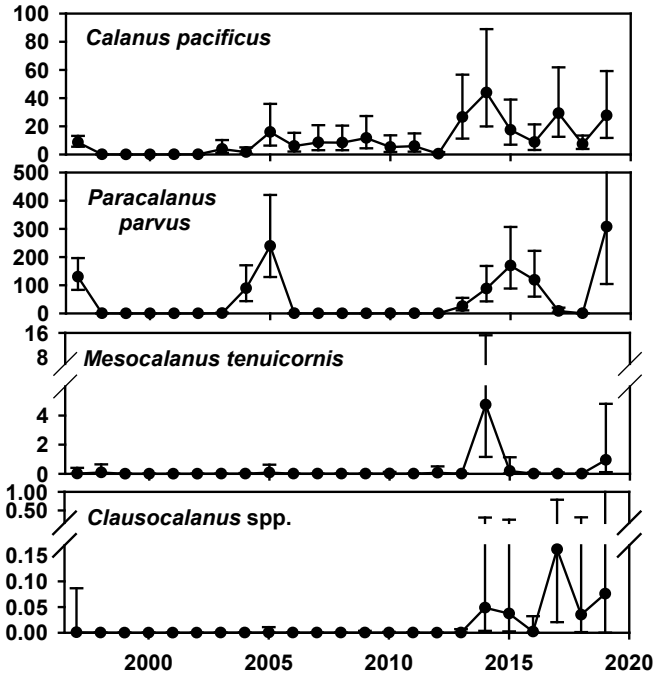

Figure 2. Abundance of the 4 most prevalent California Current copepods along the Seward Line, during late summer. Several species rebounded during 2019, and in case to record numbers.

2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

A. Project Milestones and Tasks

Table 1. This table breaks down project deliverables and their status into milestones and task progress by fiscal year and quarter, beginning February 1, 2017. C = completed, X = planned or not completed, V = cancelled due to COVID-19, P = partially completed, due to constraints of COVID-19. 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	C	C	C	C	C	C	V	C	X	X	X	X	X	X
May survey		C				C				C				C				X		
Sept survey			C				C				C				X				X	
Milestone 2: Data delivery	C			C	C			C	C			C	C	C		X	X			X
Milestone 3: Reporting																				
Annual reports	C				C				C				C				X			
Annual PI meeting				C				C				C				X				X
FY work plan (DPD)			C				C				C				C					

In addition to the primary project deliverables in Table 1, we led or contributed to twenty presentations and have produced seven peer-reviewed publications (Section 7). We are contributing ecosystem indicators for the Annual Ecosystem Status Report to the North Pacific Fishery Management Council and our data and expertise were used in three of the four GWA science synthesis manuscripts. We anticipate completing FY20 and FY21 milestones and tasks largely as planned, with the notable exception that several GAK1 monthly trips did not occur during the COVID-19 shutdown.

B. Explanation for not completing any planned milestones and tasks

Nearly all sampling, milestones, and tasks for 2019 and first two quarters of 2020 were completed in accordance with our proposal and with sampling protocols available on the GWA Research Workspace. The May 2020 survey was executed using a skeleton science team of only 3 principal investigators (PIs), and the summer survey with half the normal science compliment. With support from NSF, we successfully transferred our September cruise to the R/V Sikuliaq when the US Fish and Wildlife Service (USFWS) cancelled the R/V Tiglax's 2020 field season. A notable exception occurred for March and April GAK1 monthly trips that did not occur during the COVID-19 shutdown. We appreciate new funding from the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) for maintaining the Seward Line marine bird and mammal surveys aboard the now expanded LTER cruises during May and September. See Project 20120114-M PI Kuletz/Kaler work plan for details.

C. Justification for new milestones/tasks

No new milestones/tasks proposed specific to EVOSTC funding.

3. PROJECT COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This project links tightly with the GAK-1 mooring (project 20120114-I), providing a cross shelf context for its observations. It complements the CPR (project 20120114-D), Prince William Sound (project 20120114-G), and Lower Cook Inlet/Kachemak Bay (project 20120114-J) 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 projects. 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 GWA Science Steering Group (Environmental Drivers Component Lead) 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 GWA Nearshore component (20120114-H) activities underway within Resurrection Bay (Kenai Fjords). The new sampling line added through NGA-LTER funding now connects Middleton Island (associated with Pelagic Component project 20120114-C) 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 (NOAA) for their Gulf of Alaska Ecosystem Status reports. The Seward Line/LTER program now provides ichthyoplankton samples to NOAA to augment their spring surveys and helps compensate for years they do not sample. This is particularly true for 2020 when the NOAA fleet did not sail due to COVID-19.

4. PROJECT DESIGN

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 5-year GWA proposal, the Seward Line has been funded as one of the NSF's 28 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 reported upon 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 now encompasses Middleton Island, creating clearer linkages of it to the overall GWA program.

5. PROJECT PERSONNEL – CHANGES AND UPDATES

Dr. Ken Coyle will semi-retire during the current University of Alaska Fairbanks (UAF) fiscal year and can be removed from the PI list.

6. PROJECT BUDGET

A. Budget Forms (See GWA FY20 Budget Workbook)

Please see project budget forms compiled for the program.

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$83.2	$85.2	$87.2	$89.3	$91.4	$436.3	
Travel	$3.9	$4.0	$4.1	$4.3	$4.4	$20.7	
Contractual	$8.0	$8.3	$8.6	$8.8	$9.0	$42.6	
Commodities	$2.3	$2.4	$2.5	$2.7	$2.8	$12.7	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*25% of non-equip.*)	$24.4	$25.0	$25.6	$26.2	$26.9	$128.1	
SUBTOTAL	$121.8	$124.9	$128.0	$131.2	$134.5	$640.3	$0.0
General Administration (9% of	$11.0	$11.2	$11.5	$11.8	$12.1	$57.6	N/A
PROJECT TOTAL	$132.7	$136.1	$139.5	$143.0	$146.6	$697.9	
Other Resources (Cost Share	$1,424.0	$1,438.0	$1,411.8	$1,466.0	$1,450.5	$7,190.3	

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.

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

Documentation of additional funding is provided in a separate PDF document.

7. FY17-20 PROJECT PUBLICATIONS AND PRODUCTS

Publications

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. DOI:10.1016/j.dsr2.2017.04.023.

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 https://doi.org/10.1016/j.dsr2.2019.05.006

Doyle, M.J., S.L. Strom, K.O. Coyle, A.J. Hermann, C. Ladd, A.C. Matarese, S.K. Shotwell, and **R.R. Hopcroft**. 2019. Early life history phenology among Gulf of Alaska fish species: strategies, synchronies, and sensitivities. Deep Sea Research II 165: 41-73 https://doi.org/10.1016/j.dsr2.2019.06.005

Hauri, C., C. Schultz, K. Hedstrom, S. Danielson, B. Irving, S.C. Doney, R. Dussin, E.N. Curchitser, D.F. Hill, and C.A. Stock. In press. A regional hindcast model simulating ecosystem dynamics, inorganic carbon chemistry, and ocean acidification in the Gulf of Alaska, Biogeosciences Discussions, https://doi.org/10.5194/bg-2020-70

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, and K. Coyle. 2019. The Seward Line – Marine Ecosystem monitoring in the Northern Gulf of Alaska. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120114-L.

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

Kobari, T., A. Sastri, L. Yebra, H. Liu, and **R.R. Hopcroft**. 2019. Evaluation of trade-offs in traditional methodologies for measuring metazooplankton growth rates: assumptions, advantages and disadvantages for field applications. Progress in Oceanography 178:102137 https://doi.org/10.1016/j.pocean.2019.102137

Litzow, M.A., Hunsicker, M.E., Ward, E.J., Anderson, S.C., Gao, J., McClatchie, S., Zador, S., Batten, S., Dressel, S., Duffy-Anderson, J., Fergusson, E., Hopcroft, R.R., Laurel, B J. and O'Malley, R. 2020. Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. Progress in Oceanography 186: https://doi.org/10.1016/j.pocean.2020.102393.

Ormseth, O.A., M.M. Baker, **R.R. Hopcroft**, C. Ladd, C.W. Mordy, J.H. Moss, F.J. Mueter, S.K. Shotwell, and S.L. Strom. 2019. Introduction to understanding ecosystem processes in the Gulf of Alaska, volume 2. Deep Sea Research II 165: 1-6. https://doi.org/10.1016/j.dsr2.2019.06.019

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. Marine Genomics 37:114-119 doi: 10.1016/j.margen.2017.09.002.

Roncalli, V., M.C. Cieslak, R.R. Hopcroft, and P.H. Lenz. 2020. Capital breeding in a diapausing copepod: A transcriptomics analysis. Frontiers in Marine Science *7* doi:10.3389/fmars.2020.00056

Roncalli, V., S.A. Sommer, M.C. Cieslak, C. Clarke, **R.R. Hopcroft**, and P.H. Lenz. 2018. Physiological characterization of the emergence from diapause: A transcriptomics approach. Scientific Reports 8:12577

Roncalli, V., M.C. Cieslak, M. Germano, **R.R. Hopcroft**, and P.H. Lenz. 2019. Regional heterogeneity impacts gene expression in the sub-arctic zooplankter *Neocalanus flemingeri* in the northern Gulf of Alaska. Communications Biology 2:324 https://doi.org/10.1038/s42003-019-0565-5

Strom, S.L., K.A. Fredrickson, and K.J. Bright. 2019. Microzooplankton in the coastal Gulf of Alaska: regional, seasonal and interannual variations. Deep-Sea Research II 165:192-202 https://doi.org/10.1016/j.dsr2.2018.07.012

Thesis/Dissertations

Mazur, C.M. 2020. Comparing the bioavailability of a natural and synthetic iron source: Do past experiments accurately model phytoplankton response to episodic iron addition. Western Washington University.

Mendoza-Islas, H.M. 2020. Abundance, composition and distribution of predatory gelatinous zooplankton in the Northern Gulf of Alaska. University of Alaska Fairbanks.

Pretty, J.L. 2019. Particles in the Pacific: how productivity and zooplankton relate to particles in the deep sea. University of Alaska Fairbanks.

Published and updated datasets

DataONE Published Datasets

Aguilar-Islas, A. 2020. Dissolved Aluminum and Manganese concentrations from sampling at select stations on seasonal cruises for the Northern Gulf of Alaska LTER site, 2018-2019. Dataset under review

Aguilar-Islas, A. 2020. Dissolved Inorganic Nutrient Data from seasonal cruises for the Northern Gulf of Alaska LTER site, 2018. Dataset under review.

Aguilar-Islas, A. 2020. Surface Dissolved Iron from seasonal cruises for the Northern Gulf of Alaska LTER site, 2018. Dataset under review.

Danielson, S. 2020. Hydrographic, optical, and meteorological parameters measured by R/V Sikuliaq's underway systems during the Northern Gulf of Alaska LTER cruises, 2018 and 2019. https://doi.org/10.24431/rw1k45a.

Danielson, S. 2020. Temperature and salinity time series measurements from the GAK1 Mooring in the Northern Gulf of Alaska near Seward, AK. https://doi.org/10.24431/rw1k44x.

Danielson, S., and E. Dobbins. 2020. Water columns properties measured by CTD sensors during seasonal cruises in the Gulf of Alaska for the Northern Gulf of Alaska LTER project, 2018 and 2019. https://doi.org/10.24431/rw1k459.

Danielson, S., and E. Dobbins. 2020. Ocean currents measured by R/V Sikuliaq's Shipboard Acoustic Doppler Current Profiler (SADCP) during the Northern Gulf of Alaska LTER Spring 2018 cruise. https://doi.org/10.24431/rw1k43u.

Hauri, C. 2020. Gulf of Alaska ROMS-COBALT Hindcast Simulation 1980 - 2013. https://doi.org/10.24431/rw1k43t.

Hauri, C., and B. Irving. 2020. Inorganic Carbon data from water samples collected during CTD casts at stations during the Northern Gulf of Alaska LTER seasonal cruises, 2018. https://doi.org/10.24431/rw1k45g.

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. Seward Line Zooplankton Data, 2012 to 2015, 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. Seward Line 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.

Hopcroft, R.R. 2018. Seward Line Zooplankton Data, final 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., and C. Clarke-Hopcroft. 2020. Gelatinous zooplankton abundance and biomass observations from research cruises for the Northern Gulf of Alaska (NGA) LTER site, 2018. Dataset under review.

Hopcroft, R., and C. Clarke-Hopcroft. 2020. Zooplankton abundance and biomass observations obtained from a 0.5 mm MultiNet, as analyzed by traditional microscopy, during research cruises in the Northern Gulf of Alaska (NGA) LTER Program, 2018. Dataset under review.

Hopcroft, R., and C. Clarke-Hopcroft. 2020. Zooplankton abundance observations collected from 150 um Quad-Nets, as analyzed by Zooscan, from research cruises in the Northern Gulf of Alaska (NGA) LTER Program, 2018. Dataset under review.

Hopcroft, R., and C. Clarke-Hopcroft. 2020. Zooplankton abundance observations collected from 505 um Bongo Net, as analyzed by Zooscan, from research cruises in the Northern Gulf of Alaska (NGA) LTER Program, 2018. Dataset under review.

Hopcroft, R., S. Danielson, and E. Dobbins. 2020. Temperature and Salinity measured by a flow-through thermosalinograph (TSG) during research cruises aboard the R/V Tiglax and R/V Wolstad for the Northern Gulf of Alaska (NGA) LTER site, 2018 and 2019. https://doi.org/10.24431/rw1k45o.

Hopcroft, R., C. Smoot, and C. Clarke-Hopcroft. 2020. Zooplankton abundance and biomass observations obtained from 150 um Quad-Nets, as analyzed by traditional microscopy, during research cruises in the Northern Gulf of Alaska (NGA) LTER Program, 2018. Dataset under review.

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.

Kuletz, K., D. Cushing, and E. Labunski. 2020. Marine bird survey observation and density data from Northern Gulf of Alaska LTER cruises, 2018. Dataset under review.

McDonnell, A. 2020. Zooplankton abundance and volume size distributions from an Underwater Vision Profiler 5 aboard seasonal cruises for the Northern Gulf of Alaska LTER site 2018. Dataset under review.

McDonnell, A., B. Irving, J. Pretty, and S. O'Daly. 2020. Particle abundance and volume size distributions from an Underwater Vision Profiler 5 aboard seasonal cruises for the Northern Gulf of Alaska LTER site 2018. https://doi.org/10.24431/rw1k45h.

Strom, S. 2020. MIcrozooplankton abundance and biomass from research cruises for the Northern Gulf of Alaska (NGA) LTER site, 2018. https://doi.org/10.24431/rw1k45e.

Strom, S. 2020. Primary production estimates from research cruises for the Northern Gulf of Alaska LTER site, 2018. https://doi.org/10.24431/rw1k45b.

Strom, S., and K. Fredrickson. 2020. Chlorophyll-a concentrations from research cruises for the Northern Gulf of Alaska (NGA) LTER site, 2018. https://doi.org/10.24431/rw1k45f.

Strom, S., and K. Fredrickson, K. 2020. Dissolved organic carbon concentrations from NGA-LTER research cruises in the Gulf of Alaska, 2018-present. https://doi.org/10.24431/rw1k45c.

Strom, S., and K. Fredrickson. 2020. HPLC-derived pigment data from research cruises for the Northern Gulf of Alaska LTER site, 2018. Dataset under review.

Strom, S., and K. Fredrickson. 2020. Particulate carbon concentrations from research cruises for the Northern Gulf of Alaska (NGA) LTER site, 2018-present. https://doi.org/10.24431/rw1k45d.

Gulf of Alaska Data Portal Datasets

Hopcroft, R.R. 2019. Seward Line Conductivity, Temperature, and Depth (CTD) Data, 2012 to 2017, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.

Hopcroft, R.R. 2019. Seward Line zooplankton biomass and abundance data from Spring and Summer cruises aboard the Tiglax, 2012 to 2017, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez Oil* Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.

Hopcroft, R.R. 2019. Seward Line Chlorophyll-A and Nutrient Data, 2012 to 2017, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.

Kuletz, K.J. 2019. Seward Line and Lower Cook Inlet Marine Bird Survey Data, 2006-2017, Gulf Watch Alaska Nearshore Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.

Research Workspace

Hopcroft, R.R. 2019. Seward Line Conductivity, Temperature, and Depth (CTD) Data, 2018, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.

Hopcroft, R.R. 2019. Seward Line Chlorophyll-A and Nutrient Data, 2018, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.

Kuletz, K.J. 2019. Seward Line and Lower Cook Inlet Marine Bird Survey Data, 2018, Gulf Watch Alaska Nearshore Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.

Presentations

Aguilar-Islas, A.M. 2020. The Northern Gulf of Alaska Long Term Ecological Research Site: Nutrient dynamics across the shelf from Kayak to Kodiak islands. University of South Florida, Invited talk. Tampa, FL.

Aguilar-Islas, A.M., M. Kaufman, and S. Strom. 2020. Nutrient dynamics and their influence in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.

Arimitsu, M., Bishop, M.A., Cushing, D., Hatch, S., Kaler, R., Kuletz, K., Matkin, C., Moran, J., Olsen, D., Piatt, J., Schaeffer, A., Straley, J. 2020. Changes in Marine Predator and Prey Populations in the Northern Gulf of Alaska: Gulf Watch Alaska Pelagic Update 2019. Alaska Marine Science Symposium. Anchorage, AK.

Barbeau, K., R.R. Hopcroft, O. Schofield, and H. Sosik. 2018. Pelagic LTER site: site overviews, inter-comparisons and synthesis planning. Workshop. LTER All Scientists Meeting, Pacific Grove, CA, October.

Brydie, A. and S.L. Danielson. 2020. Copper River discharges in the Northern Gulf of Alaska: freshwater distribution and evolution during the July 2019 freshet. Ocean Sciences Meeting. San Diego, CA.

Burt, W., R.R. Hopcroft, S.L. Strom, and S.L. Danielson. 2020. Quantifying Phytoplankton Biomass and Productivity at Unprecedented Spatial Scales in the Northern Gulf of Alaska LTER Program Using Ship-Board Optical Measurements. Alaska Marine Science Symposium. Anchorage, AK.

Burt, W., R.R. Hopcroft, S.L. Strom, and S.L. Danielson. 2020. Use of ship-board optical measurements to quantify plankton biomass and productivity across multiple trophic levels in the Northern Gulf of Alaska LTER program. Ocean Sciences Meeting. San Diego, CA.

Busse, H., S. Strom, J. Fiechter. 2020. Grazing by mixotrophic nano- and dinoflagellates in the Northern Gulf of Alaska in response to gradients in light, inorganic nutrients, and prey availability. Ocean Sciences Meeting. San Diego, CA.

Collins, R.E. 2018. Microbial community structure in Prince William Sound. Poster Presentation, Alaska Marine Science Symposium, January.

Coyle, K.O., A.J. Hermann, and R.R. Hopcroft. 2018. Modeled spatial-temporal distribution of production and biomass relative to field observations in the northern Gulf of Alaska. Oral Presentation Ocean Sciences Meeting – Portland, OR, February.

Cushing, D., K. Kuletz, R.R. Hopcroft, S.L. Danielson, and E. Labunski. 2017. Shifts in cross-shelf distribution of seabirds in the northern Gulf of Alaska under different temperature regimes, 2007-2015. Poster Presentation. Pacific Seabird Group, Tacoma, WA, February.

Cushing, D., K. Kuletz, E. Labunski, and R.R. Hopcroft. 2019. Seabird Studies During the Northern Gulf of Alaska Long Term Ecological Research Program. Poster Presentation. Alaska Marine Science Symposium, January.

Danielson, S.L., A. Aguilar-Islas, J. Fiechter, R.R. Hopcroft, K. Kuletz, H. Statscewich, and S.L. Strom. 2018. Acrobat Observations along the Gulf of Alaska Hydrographic Tightrope. Poster Presentation. LTER All Scientists Meeting, Pacific Grove, CA, October.

Fredrickson, K., H. Busse, D. Walker-Phelan, C. Mazur, and S. Strom. 2020. Unexpected importance of the smallest phytoplankton in the Northern Gulf of Alaska ecosystem. Alaska Marine Science Symposium. Anchorage.

Hauri, C., K Hedstrom, C. Schultz, S.L. Danielson, J. Beamer, S. Dony, D.F. Hill, and C. Stock. 2019. Influence of Ocean Acidification and Climate Change on the Biogeochemistry in the Gulf of Alaska: A Regional Modeling Study. Presentation. Alaska Marine Science Symposium, January.

Hernandez, A., and R.R. Hopcroft. 2020. The Effects of Environmental Changes in the Northern Gulf of Alaska on the Synthesis of Lipid in N.flemingeri and N.plumchrus from 2018 to 2019. Ocean Sciences Meeting. San Diego, CA.

Hopcroft, R.R., K.O. Coyle, and S.L. Danielson. 2018. The Seward Line - 2017. Poster Presentation. Alaska Marine Science Symposium, January.

Hopcroft, R.R., K.O. Coyle, S.L. Danielson, and S.L. Strom. 2017. Twenty Years of Observations Along the Gulf of Alaska's Seward Line: Impact of Continued Warm Conditions. Oral Presentation. Kodiak Marine Science Symposium, Kodiak, April.

Hopcroft, R.R., K.O. Coyle, S.L. Danielson, and S.L. Strom. 2017. Oceanography in the Northern Gulf of Alaska: the Seward Line. Public Presentation for Osher Lifelong Learning Institute, Fairbanks, December.

Hopcroft, R.R., and D. J. Lindsay. 2018. Gelatinous zooplankton in Alaskan waters: from nets to ROVs. Invited PICES Annual Meeting, Yokohoma, Japan, October.

Hopcroft, R.R, S.L. Strom, A. Aguilar-Islas, S.L. Danielson, and J. Fiechter. 2018. The Northern Gulf of Alaska Long-term Ecological Research Program. Poster Presentation. Alaska Marine Science Symposium, January.

Hopcroft, R.R., S.L. Strom, A. Aguilar-Islas, S.L. Danielson, and J. Fiechter. 2018. The Northern Gulf of Alaska Long -term Ecological Research program: coming to an ocean near you in 2018. Poster Presentation. Ocean Sciences Meeting – Portland, OR, February.

Hopcroft, R.R., S.L. Strom, A. Aguilar-Islas, S.L. Danielson, and J. Fiechter. 2018. A new Long-term Ecological Research (LTER) site in the Northern Gulf of Alaska. Poster PICES Annual Meeting, Yokohoma, Japan, October.

Hopcroft, R.R., S.L. Strom, K.O. Coyle, and S.L. Danielson. 2017. Three in a row: continued warm conditions along the Gulf of Alaska's Seward Line. Oral Presentation. Association for the Sciences of Limnology and Oceanography, Honolulu, March.

Jones, J., et al. 2018. Climate Change at LTER sites. Workshop. LTER All Scientists Meeting, Pacific Grove, CA, October.

Kandel, A., and A.M. Aguilar-Islas. 2020. Temporal variability of dissolved aluminum and manganese in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.

Kuletz, K., D. Cushing, R.R. Hopcroft, S.L. Danielson, and E. Labunski. 2017. Running Hot and Cold: Shifts in Seabird Distribution in the Northern Gulf of Alaska under Different Temperature Regimes, Based on Seward Line Surveys, 2007-2015. Poster Presentation. Alaska Marine Science Symposium, January.

Kuletz., K., B. Hoover, D. Cushing, J. Santora, W. Sydeman, R. Hopcroft, S. Danielson, and E. Labunski. 2019. Seabird distribution relative to biophysical oceanographic properties in North Pacific Ecosystems. Annual meeting of the Pacific Seabird Group. Lihue, HI.

Kuletz, K., R.R. Hopcroft, S.L. Danielson, J. Santora, W. Sydeman, B. Hoover, and D. Cushing. 2018. Seabird distribution relative to biophysical oceanographic properties in North Pacific ecosystems. Poster LTER All Scientists Meeting, Pacific Grove, CA, October.

Lindeberg, M., K. Holderied, D. Aderhold, K. Hoffman, M. Arimitsu, B. Ballachey, H. Coletti, S. Danielson, D. Esler, and R. Hopcroft. 2017. Gulf Watch Alaska: Results from Five Years of Ecosystem Monitoring in the Northern Gulf of Alaska. Oral Presentation Alaska Marine Science Symposium, January.

Lenz, P.H., V. Roncalli, Hartline, M. Germano, M.C. Cieslak, S.L. Strom, and R.R. Hopcroft. 2018. The physiological ecology of the calanid copepod, *Neocalanus flemingeri*, in the northern Gulf of Alaska. Oral Presentation. Alaska Marine Science Symposium, January.

Mayer, K., C. Clarke-Hopcroft, and R.R. Hopcroft. 2020. Spatial and Temporal Patterns of Zooplankton Species in the Gulf of Alaska as Revealed by Image Analysis. Ocean Sciences Meeting. San Diego, CA.

Mazur, C., S. Strom, and A. Aguilar-Islas. 2020. Comparing the Bioavailability of a Natural and Synthetic Iron Source: Do past experiments adequately model diatom growth in response to episodic iron addition. Ocean Sciences Meeting. San Diego, CA.

Mendoza-Islas, H.M., and R.R. Hopcroft. 2019. First year pollock and their zooplankton predators in the Gulf of Alaska. Poster Presentation. Alaska Marine Science Symposium, January.

Mendoza-Islas, H.M., and R.R. Hopcroft. 2020. Abundance and Distributions of Gelatinous Zooplankton in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.

Mendoza-Islas, H., and R.R. Hopcroft. 2020. Abundance and Distributions of Gelatinous Zooplankton in the Northern Gulf of Alaska. Alaska Marine Science Symposium. Anchorage, AK.

Monell, K., V. Roncalli, P.H. Lenz, and R.R. Hopcroft. 2020. Characterization of Cell Division During Early Oogenesis in Copepod Females Emerging From Diapause. Ocean Sciences Meeting. San Diego, CA.

Monacci, N.M., J. Cross, and J. Mathis. 2019. Ocean acidification observations along the Seward Line: 2008-2017. Poster Presentation. Alaska Marine Science Symposium, January.

Monson, D., K. Holderied, R. Campbell, S.L. Danielson, R.R. Hopcroft, B. Ballachey, J. Bodkin, H. Coletti, T. Dean, K. Iken, K. Kloecker, B. Konar, M. Lindeberg, B. Robinson, B. Weitzman, and R. Suryan. 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 Presentation. Alaska Marine Science Symposium, January.

O'Daly, S., S. Strom, and A. McDonnell. 2020. Particulate carbon flux, flux attenuation, and export efficiency in the summer of 2019 across the northern Gulf of Alaska shelf. Alaska Marine Science Symposium. Anchorage.

Piatt, J.F., T. Jones, K. Kuletz, J. Parrish, R. Corcoran, S. Schoen, B. Bodenstein, M. Garcia-Reyes, H. Coletti, M. Armitsu, R. Duerr, K. Lindquist, J. Lindsey, and W. Sydeman. 2018. Unprecedented scale of seabird mortality in the NE Pacific during the 2015-2016 marine heatwave. Oral Presentation. Alaska Marine Science Symposium, 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., M. Cieslak, R.R. Hopcroft, and P.H. Lenz. 2019. Environmental heterogeneity in the northern Gulf of Alaska impacts physiological status in the copepod *Neocalanus flemingeri.* Poster Presentation. Alaska Marine Science Symposium, January.

Roncalli, V., M.C. Cieslak, P.H. Lenz, and R.R. Hopcroft. 2020. Energy allocation in a diapausing copepod: a transcriptomics analysis. Ocean Sciences Meeting. San Diego, CA.

Roncalli, V., D.K. Hartline, M. Germano, M.C. Cieslak, S.L. Strom, R.R. Hopcroft, and P.H. Lenz. 2018. Consequences of regional heterogeneity on the physiology of a calanid copepod, *Neocalanus flemingeri,* in the northern Gulf of Alaska. Oral Presentation Ocean Sciences Meeting – Portland, OR, February.

Roncalli, V., M.C. Cieslark, S. Mathews, C. Clarke-Hopcroft, R.R. Hopcroft, and P.H. Lenz. 2017. Physiological changes in *Neocalanus flemingeri* females during the transition from diapause to reproduction. Oral Presentation. Association for the Sciences of Limnology and Oceanography, February.

Smoot, C., K.O. Coyle, and R.R. Hopcroft. 2020. Warm-water zooplankton in the Northern Gulf of Alaska: Observations from the Seward Line. Alaska Marine Science Symposium. Anchorage, AK.

Strom, S.L, K.J. Bright, and K.A. Fredrickson. 2019. Mixotrophy in the Gulf of Alaska: Abundant plant-animal cells have major implications for ecology and biogeochemistry. Presentation Alaska Marine Science Symposium, January.

Strom, S.L., and R.R. Hopcroft. 2018. Planktonic Communities in the Coastal Gulf of Alaska: Strong Dichotomies in Structure and Function. Oral Presentation Ocean Sciences Meeting – Portland, OR, February.

Strom, S.L., R.R. Hopcroft, A. Aguilar-Islas, S.L. Danielson, and J. Fiechter. 2019. Resilience Amidst a Sea of Change: The Northern Gulf of Alaska LTER Program. Keynote Alaska Marine Science Symposium, January.

Suryan, R., Lindeberg, M., Arimitsu, M., Coletti, H., Hopcroft, R., Aderhold, D., Hoffman, K. 2020. Ecosystem Response to a Prolonged Marine Heatwave in the Gulf of Alaska: Perspectives from Gulf Watch Alaska. Alaska Marine Science Symposium. Anchorage, AK.

Suryan, R., S. Zador, M. Lindeberg, D. Aderhold, J. Moran, B. Laurel, H. Coletti, M. Arimitsu, J. Piatt, D. Monson, S. Hatch, J. Straley, R. Campbell, S. Pegau, R.R. Hopcroft, S.L. Danielson, B. Konar, K. Iken, S. Batten, and T. Dean. 2018. Ecosystem variability and connectivity in the Gulf of Alaska. Oral Presentation. PICES Annual Meeting, Yokohoma, Japan, October.

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.

Kaler, R., K. Kuletz, D. Dragoo, and H. Renner. 2017. Unusual observations of seabirds in the Gulf of Alaska following the 2015-2016 mass die-off. Delta Sound Connections. http://pwssc.org/wp-content/uploads/2017/06/DSC-2017-web2.pdf.

Trotter, M.H. 2018. Our May 2018 cruise hosted a media group led by Michele Hoffman Trotter (Columbia College) who 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.

8. 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.

Batten, S.D., and H.J. Freeland. 2007. Plankton populations at the bifurcation of the North Pacific Current. Fisheries 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., and P.C. Reid. 2003. Long-term changes in phytoplankton, zooplankton and salmon related to climate. Global Change Biology 9:801-817.

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.

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. Fisheries Oceanography 3:279-291.

Hare, S.R., and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47:103-145.

Liu, Z., and E. Di Lorenzo. 2018. Mechanisms and predictability of Pacific decadal variability. Current Climate Change Reports 4:128-144.

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 Fisheries and Aquatic Science 55:1878-1893.

Mackas, D.L., W.T. Peterson, 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 F.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78:1069-1079.

McGowan, J.A., D.R. Cayan, L.M. Dorman. 1998. Climate-Ocean variability and ecosystem response in the Northeast Pacific. Science 281:210-217.

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.

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.