Northern Gulf of Alaska LTER

Photo credit: Ana Anguilar-Islas

The Northern Gulf of Alaska (NGA) LTER is based in the coastal Gulf of Alaska and mobilizes field expeditions from the Seward Marine Center of the University of Alaska, Fairbanks. The program seeks to understand how this subarctic shelf system generates the high productivity that sustains one of the world's largest commercial fisheries, as well as iconic seabird and marine mammal species. Ocean physics in the Gulf of Alaska have been monitored for nearly 50 years, and chemistry and biology have been recorded for the last 20 years. Together, this provides foundational information about the structure and function of this subarctic ecosystem.

Scientists in the region have developed a solid understanding of annual cycles and are beginning to appreciate the scales and drivers of observed interannual variability (i.e. ENSO, marine heat waves). Through sustained measurements, NGA LTER aims to determine how resiliency arises, how emergent properties provide community level structure, and whether longer term environmental changes will impact this resiliency. Findings will inform biological resource management in the Gulf of Alaska.

At present:

15 investigators

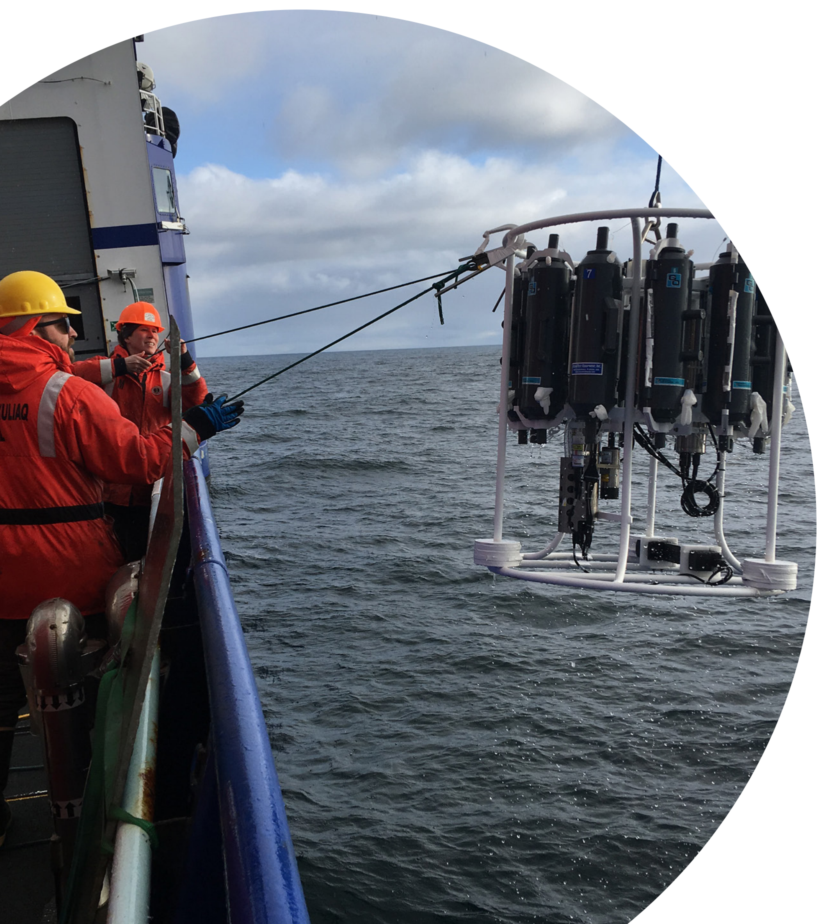
6 institutions represented

9 graduate students

Marine	Principal Investigator: Russ Hopcroft University of Alaska, Fairbanks	Est. 2017 Funding Cycle: LTER I	NSF Program: Geosciences / Division of Ocean Sciences

Key Findings

Stratification is changing. The coastal Gulf of Alaska water column is becoming progressively more stratified — the entire water column is warming, but more rapidly at the surface than near the seafloor, while near surface waters are becoming fresher. This is due to multiple factors including the air-sea heat flux, ocean heat flux convergences, the stabilizing influence of runoff, the destabilizing effects of cooling and vertical mixing, and the wind driven cross-shelf buoyancy flux. Stratification impacts the water column mixing in winter that helps reset the shelf for the next season's biological production. Therefore, the concentration and composition of the phyto- and zooplankton community shows direct and indirect connections to the thermal conditions of the Gulf of Alaska shelf. These far reaching implications for upper trophic levels could only be detected using a high quality, multi-decade dataset. [Products 1-3]



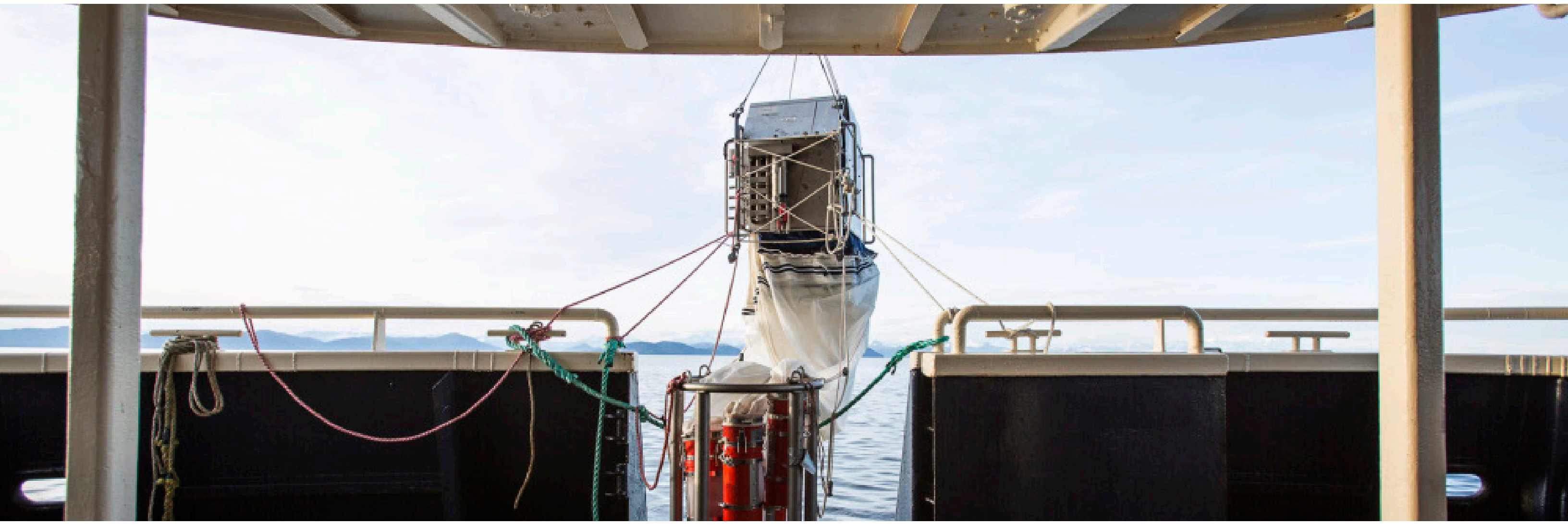
Anomalous warming in 2015-16 led to profound reorganization of lower trophic levels. Reductions in primary producer average cell size and biomass followed the 2015-2016 warming, as did corresponding reductions at higher trophic levels. In addition, southern zooplankton species of smaller body size invaded the region and anomalous increases in gelatinous zooplankton population were observed. These changes, which could represent a window into the future of the Northern Gulf of Alaska, were associated with widespread seabird mortality, reduced forage fish abundance, and range shifts or reductions in commercially important groundfish species. The anomalous nature of the warm period was only evident in the context of long term observations establishing the typical subarctic character of this pelagic ecosystem. [3-5]

Iron-deficient surface waters are common during spring. Although glacial input leads to high iron concentrations during summer and fall within the narrow Alaska Coastal Current, the ratio of iron to nitrate over the Northern Gulf of Alaska shelf in spring can be low enough to lead to nutritional stress in diatoms. This mismatch in essential nutrients likely affects phytoplankton community evolution during the spring bloom [6].

Photo credits: Seth Danielson (left); NGA LTER (right)

Modeling illuminates eddy-induced cross-shelf transport. Modeling at NGA LTER investigates how the complex interplay between the strongly seasonal freshwater discharge at the coast and offshore eddies controls horizontal gradients of limiting nutrients (nitrate and iron). This work builds on previous modeling studies in the region that utilized Seward Line observations to improve the accuracy of simulated physical and biogeochemical fields. Moreover, previous models quantified the importance of eddy induced entrainment of shelf iron to offshore primary production, which extends to phyto- and zooplankton community structure. [7-9]

Photo credit (below): Anne-Lise Ducluzeau; https://anneliseducluzeau.com



Synthesis

As a new LTER site, NGA LTER has only recently become engaged in cross-site synthesis. However, during its early involvement with the Global Ocean Ecosystem Dynamics (GLOBEC) program, the Northern Gulf of Alaska was compared to the LTER sites that are now the California Current Ecosystem, Northeast U.S. Shelf, and Palmer Station. Discussions at the recent LTER All Scientists' Meeting indicate that several cross-site comparisons are expected in the near future.

Data Accessibility

Much of the legacy data from the Seward Line and the Gulf of Alaska 1 (GAK1) oceanographic station are already available online through the Alaska Ocean Observing System (AOOS), with even earlier GLOBEC data within the Biological and Chemical Oceanography Data Management Office (BCO-DMO). Our accumulated knowledge is allowing more judicious evaluation of the legacy data and, where possible, reanalysis of the original data sets. As a new site, our new website and portal (Axiom) are still undergoing active development.

Photo credit: NGA LTER

Broader Impacts

Graduate education. During the Northeast Pacific Program (NEP) GLOBEC, the Northern Gulf of Alaska produced 12 graduate students. Nine additional graduate students will be involved in the project by the end of the 2019 season.

From science to fiction. Associated projects (e.g., Gulf Watch Alaska and North Pacific Research Board's Gulf of Alaska Project) have produced web content and videos outlining the basic ecological function of the region's ecosystem. This research formed the basis of "pH. A novel" by Nancy Lord.

Partnerships

NOAA | GLOBEC | Northern Pacific Research Board (NPRB) | Exxon Valdez Oil Spill Trustee Councils (GAK1)

The Legacy of Exxon Valdez. The NGA LTER continues the ecosystem monitoring that is a key legacy of the 1989 Exxon Valdez oil spill. The data have helped distinguish between the effects of the oil spill on the Gulf of Alaska ecosystem and intrinsic and climate-driven variability.

Bringing the ocean to the classroom. By participating in NOAA's teacher-at-sea program, NGA LTER is helping spread knowledge about the region's ecosystems and scientific endeavors into the K-12 system.

Engaging tourists and residents. Site researchers contributed stories to "Delta Sound Connections," an annual natural history and science publication of the Prince William Sound Science Center, which reaches visitors at dozens of activity hotspots in Alaska.

Top Products

1. Kelley, J. 2015. An examination of hydrography and sea level in the Gulf of Alaska. **M.S. Thesis,** University of Alaska Fairbanks.
2. Janout, M et al. 2010. On the nature of winter cooling and the recent temperature shift on the northern Gulf of Alaska shelf. **J. Geophys. Res.** doi:10.1029/2009JC005774
3. Batten, SD et al. 2017. Interannual variability in lower trophic levels on the Alaskan Shelf. **Deep-Sea Res. II.** doi: 10.1016/j.dsr2.2017.04.023
4. Strom, SL et al. 2016. Spring phytoplankton in the eastern coastal Gulf of Alaska: Photosynthesis and production during high and low bloom years. **Deep-Sea Research II.** doi: 10.1016/j.dsr2.2015.05.003
5. Strom, SL et al. 2019. Microzooplankton in the coastal Gulf of Alaska: regional, seasonal and interannual variations. In press, **Deep-Sea Research II.** doi: 10.1016/j.dsr2.2018.07.012
6. Aguilar-Islas, AM et al. 2016. Temporal variability of reactive iron over the Gulf of Alaska shelf. **Deep-Sea Res. II.** doi: 10.1016/j.dsr2.2015.05.004
7. Coyle, KO et al. 2013. Zooplankton biomass, advection and production on the northern Gulf of Alaska shelf from simulations and field observations. **J. Mar. Sys.** doi: 10.1016/j.jmarsys.2013.04.018
8. Fiechter, J. et al. 2011. A data assimilative, coupled physical-biological model for the Coastal Gulf of Alaska. Dyn. **Atm. Oceans.** doi: 10.1016/j.dynatmoce.2011.01.002
9. Fiechter, J. and Moore, A.M. 2012. Iron limitation impact on eddy-induced ecosystem variability in the coastal Gulf of Alaska. **J. Mar. Sys.** doi: 10.1016/j.jmarsys.2011.09.012

Photo credit (top): Russ Hopcroft