Variability and trends in the Northern Gulf of Alaska ecosystem

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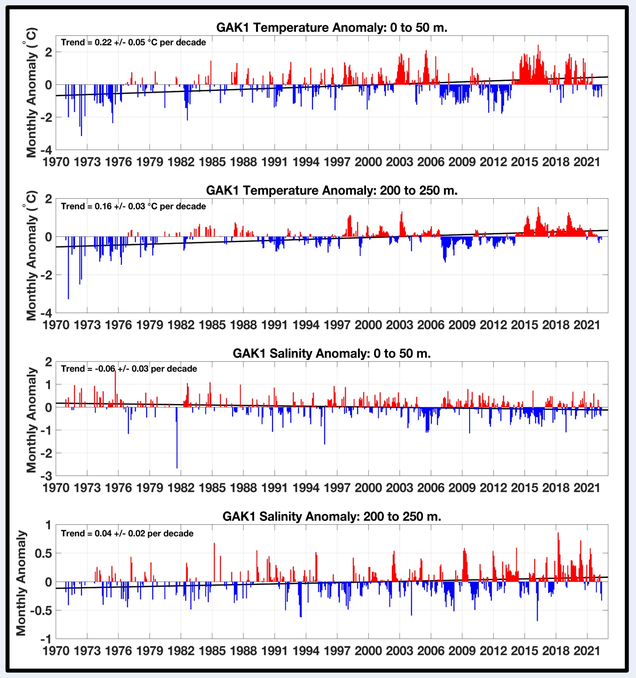
Environmental Trends: GAK1 Station

Background

- Temperature and salinity profiles have been taken at oceanographic station GAK1 (near Seward, Alaska) since December 1970.
- GAK1 is one of the longest running station in the North Pacific. It has contributed data to over 100 peer reviewed journal articles, graduate theses, and planning documents.

Key Findings

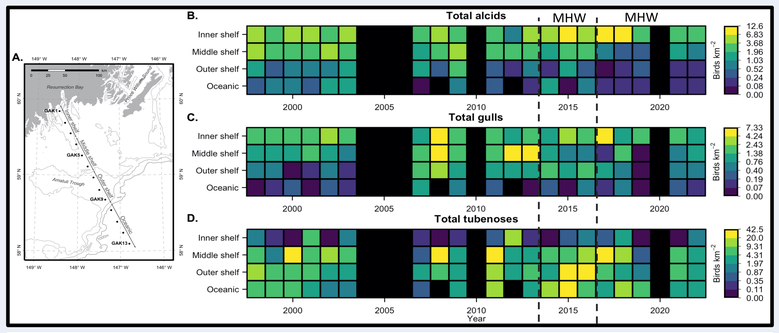
- GAK1 data indicates that surface and near seafloor waters are warming, but the trend is larger near the surface. It also indicates a significant long-term freshening trend near the surface and salinization near the bottom.
- The thermal and haline trends both force the system into greater stratification.
- The near-surface freshening is attributed to increased ice melt associated with warming air temperatures.

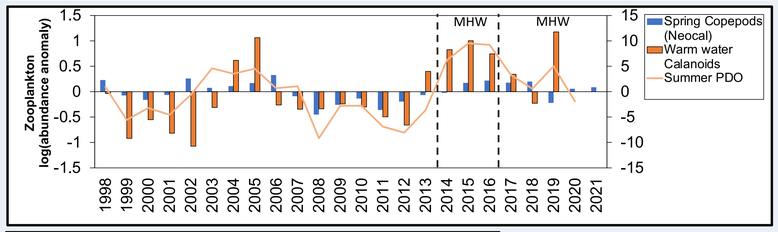


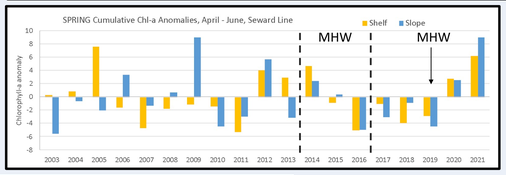
Reference: Danielson et al. (2022). Temperature variations in the northern Gulf of Alaska across synoptic to century-long time scales. DSR II, p.105155.

Long-term time series are critical to detect environmental trends and evaluate whether similar trends are identifiable over a range of ecological responses.

Extreme Events: Marine Heatwaves







Background

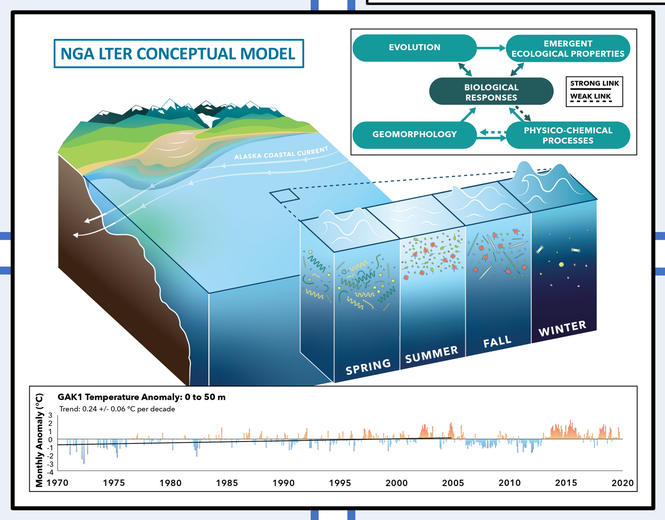
- Seabirds and plankton from Gulf of Alaska (GAK) line from have been observed since 1998 yielding multi-decadal timeseries.
- Marine heatwaves (MHW) occurred in 2014-2016 and in 2019

Key Findings

- Alcids and gulls (feed primarily on forage fish) redistributed inshore during MHWs; concurrent with reproductive failures and mass-starvation
- Tubenoses (feed primarily on oceanic prey) had higher abundance during 2014-2016 MHW, with increased use of shelf
- Warm water copepods increased in MHW years and were significantly correlated with PDO, suggesting importance of shifts in oceanic transport.
- Chlorophyll decreased over the shelf and oceanic slope and did not fully recover between MHW events.

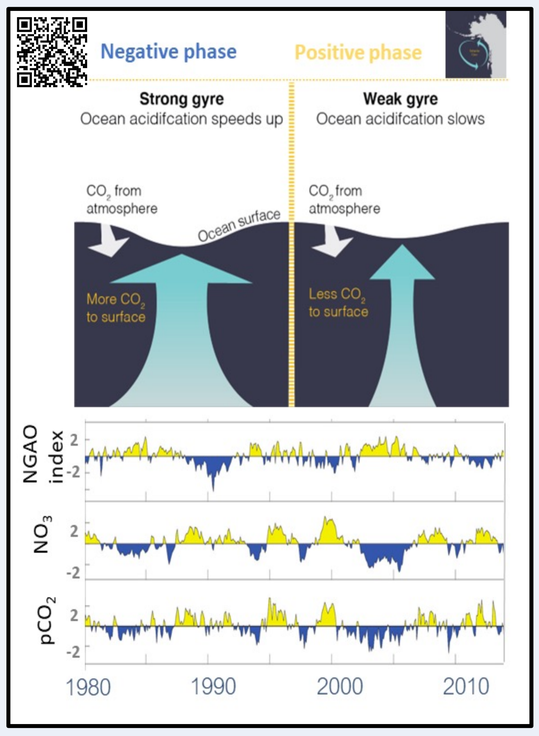
References: Seabird Data from 1998–2003 courtesy of R. Day (ABR, Inc. Environmental Research & Services) and L. Sousa (University of Alaska Fairbanks), 2003-2022 D. Cushing and K. Kuletz. Zooplankton data R. Hopcroft (UAF) and chlorophyll data S. Strom (WWU).

High spatial resolution in long-term time series can differentiate whether species have changed in abundance or have shifted habitat use in response to extreme events.



Long-term time series are critical to identify environmental drivers of low-frequency variability and predict recovery of ecosystem properties following higher frequency disturbances.

Long-term time series are critical to characterize trophic relationships and emergent food web properties, such as shifts in diet composition and bottom-up vs. top-down controls.



Background

- The Northern Gulf of Alaska Oscillation (NGAO) index is based on the first EOF of monthly SSH within the northern Gulf of Alaska.
- SSH was derived from a coupled physical-biogeochemical hindcast simulation for the Gulf of Alaska at 4.5 km resolution for 1980-2013.

Key Findings

- The NGAO is a sea surface height variability caused by large-scale atmospheric forcing.
- The atmospheric forcing influences local winds and upwelling strength over decade-long intervals, thereby regulating the upwelling of nitrate and dissolved inorganic carbon-rich waters.
- NGAO variability enhanced the apparent ocean acidification rate and caused extreme acidification events between 1980 and 2013.

Reference: Hauri et al. (2021). Modulation of ocean acidification by decadal climate variability in the Gulf of Alaska. *Commun Earth Environ*. 2, 191.

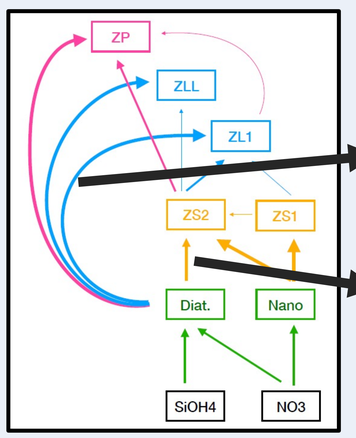
Model-Derived Regional Climate Indices

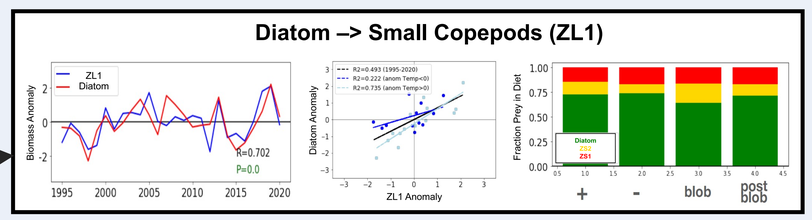
Background

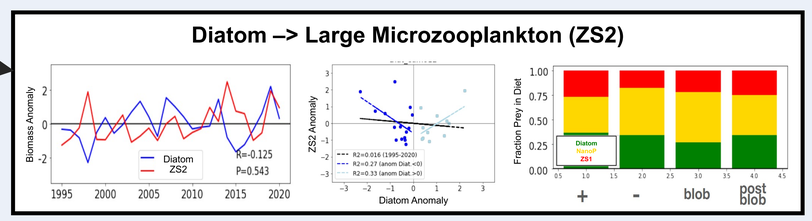
- Coupled physical-biogeochemical simulation for NGA region at 4.5 km resolution spanning 1995-2020.
- Complexity and parameterization of biogeochemical model informed by NGA LTER field research.

Key Findings

- Long-term historical simulations can provide useful information on trophic linkages and energy transfer under various environmental conditions (inc. extreme events) and prey/predator abundances.
- Example 1: large microzooplankton are positively linked to diatoms when diatoms are abundant, and negatively when they are scarce.
- Example 2: small copepods exhibit stronger relationship with diatoms during warm years and shifted diet from diatom to small flagellates during 2014-16 large marine heatwave (the “Blob”).







Food Web Dynamics from Hindcast Simulations

Additional support from:

We acknowledge that we work on the ancestral lands and waters of the Eyak and Sugpiaq-Alutiiq peoples.We recognize their unique relationships with and knowledge of this place and are grateful for their stewardship past, present, and future. We strive to be in good relations with the original peoples and with this place.