Monitoring the high-latitude coastal climate signal with coordinated multi-platform ecosystem studies

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Why ecosystem monitoring of the coastal climate signal ?

The physical manifestation of changing climate is broadly predictable in the coastal zone in coming decades (e.g., warming waters, continuation of coastal erosion, flooding, sea level rise). Many existing monitoring systems are in place to detect actual impacts (e.g., NOAA tide stations).

But we lack a good understanding of how changing climate may reorganize biogeochemical cycling, ecosystem structure, and relationships that bind coastal communities to the sea. Existing models lack sufficient field data for robust validation and parameterization; satellites don't image subsurface structure.

Monitoring the state of the coastal marine ecosystem is critical for assessing biodiversity and ecological functioning, and to understand limits of ecologically and socially important ecosystem services (e.g., fisheries production). Time series data improve our ability to assess change relative to some baseline and to anticipate, model, plan for, and adapt to future conditions.

Ships

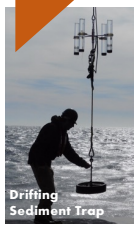
- Countless biological field samples, water collections, and experimental studies can only be practically and affordably collected and carried out by scientists on ships.
- Ships are deployment and recovery platforms for moorings, gliders, cores, trawls, grabs, and net tows.
- Ship data are key for ecosystem assessments and model validations; they place glider and mooring data in a quasi-synoptic spatial context.

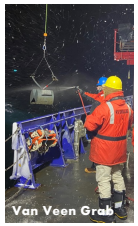
Moorings

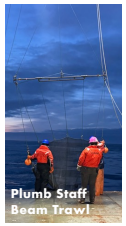
- Moorings provide high-resolution time series that collect data and samples year-round between ship expeditions.
- Moorings accommodate sensor packages that are too bulky or power-hungry for gliders.
- Select physical specimens (e.g., time series of discrete water samples and sediment trap materials) can be collected from moored platforms.

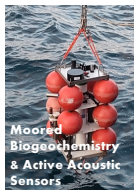
Gliders

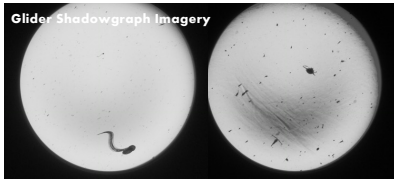
- Gliders fly through all seasons and weather conditions (though sea ice limits operations) and they collect water column profile data that extend from the sea surface to within meters of the seafloor.
- Gliders provide Transect or Station-Keeping modes of operation with multi-month missions.
- Near-real time delivery of autonomously collected data facilitates timely decision-making in adaptive sampling and resource management applications.
- Low-power sensors and advanced on-board processing enables near-real time acoustic and photographic image datasets.

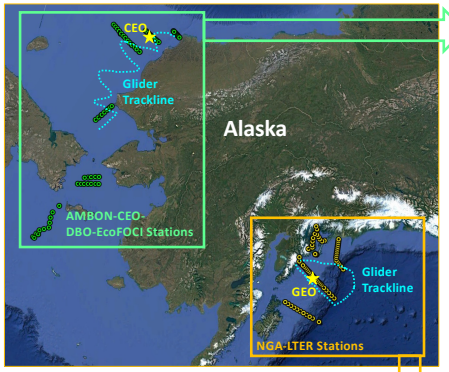






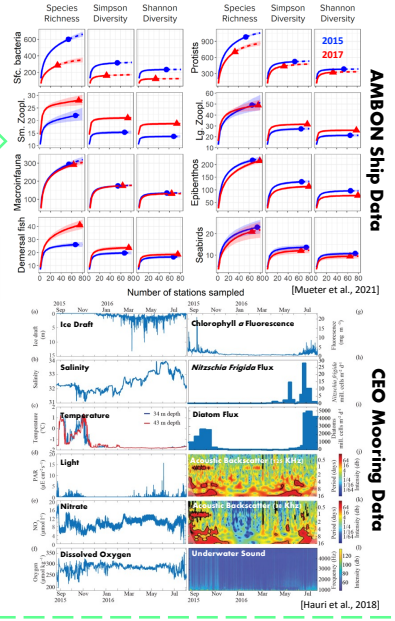




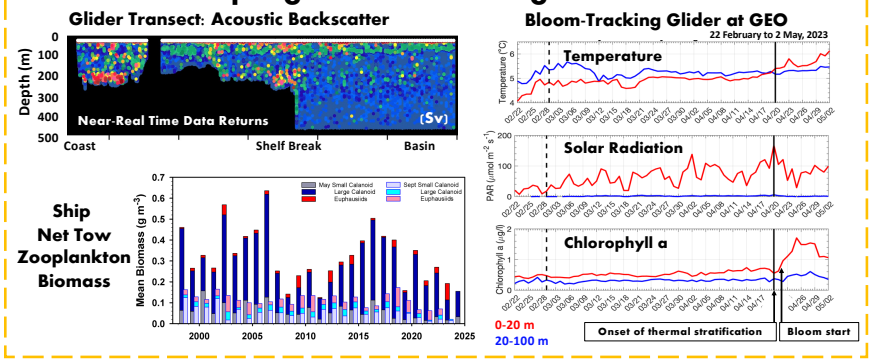


Two Alaska Examples: The sub-Arctic Seward Line-GEO-GAK1-NGA LTER projects & the Arctic AMBON-CEO-DBO-EcoFOCI projects carry out 1-3 research cruises per year. Both sets of efforts are associated with repeat glider transects (cyan dots) and highly instrumented ecosystem moorings (CEO & GEO yellow stars). Only a subset of all regional moorings and glider transects are shown here.

Arctic Biodiversity & Ecosystem Monitoring



Gulf of Alaska Spring Bloom Monitoring



What is special about high latitudes?

- Sea ice prevents year-round ship access, limits glider deployments, precludes near-surface mooring sensors, and precludes mooring real-time data delivery.
- The Arctic is warming at a rate more than twice that seen for the rest of the planet.
- Seasonal sea ice loss creates new opportunities and challenges for people and is driving transformational changes across the marine ecosystem.
- Remoteness and lack of built infrastructure limits science support options and increases costs of operations.
- Relationship-building between scientists and coastal communities is critical for scientific success here.
- Policy and management issues newly impacted by loss of sea ice and critically informed by science include global shipping, endangered species protections, fishing rights, and Indigenous self-determination.

Next Steps

New technologies offer exciting new data streams but require maturation. Maximum societal benefit depends on standardization of equipment and protocols. Sustained long-term observations are critical for monitoring the coastal climate signal.

Acknowledgements

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Physics
- Temperature & Salinity
- Sea Surface Height & Wave Height
- Current Speed & Direction
- Ice Draft, Speed & Direction
- Irradiance
- Turbidity

Bio/Geo-chemistry
- Nutrients: NO_3, PO_4, SiO_4, NH_4
- Trace Metals
- Oxygen-18 Isotopes
- Dissolved Oxygen
- pCO_2 & pH
- Colored Dissolved Organic Matter
- Sinking & Suspended Particles

Underwater Sound
- Biophonic Noise (marine mammal sounds)
- Anthropogenic Noise (vessels, seismic)
- Geophonic Noise (ice, wind)

Mid & UTL Animal Density & Behavior
- Fish/Zooplankton Acoustic Backscatter
- Epibenthic Time Lapse Photography

Planktonic Density & Fluxes
- Chlorophyll-a fluorescence
- Sediment Trap Phyto- & Zooplankton
- Fecal Pellet Flux

Biodiversity
- Species presence (via eDNA: microbes to whales)
- Sediment Trap (phyto- and zooplankton)
- Time Lapse Photography

A moored 5-trophic-level ecosystem monitoring effort

Data cross all trophic levels, the physico-chemical environment, and the state of the marine carbon pump.

Parameters listed here are collected at the Chukchi Ecosystem Observatory (CEO) and the Gulf of Alaska Ecosystem Observatory (GEO) moorings (see map).