Observing the biogeochemistry of Alaska's subarctic fjords to detect ocean acidification

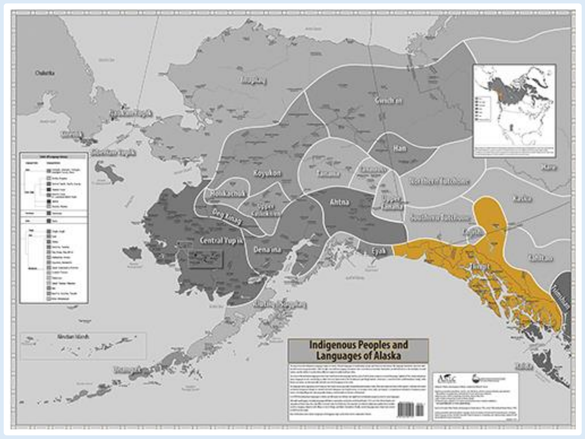
Natalie Monacci, University of Alaska Fairbanks, nmonacci@alaska.edu

S. Alin[2], S. Cellan[3], J. Cross[4], S. Danielson[1], W. Evans[5], T. Hennon[1], R. Hopcroft[1], E. Kennedy[1], K. Lanphier[6], M. Masotti[3], J. Questel[1], J. Womble[7]

[1]UAF, [2]NOAA PMEL, [3]Sitka Tribe of Alaska, [4]PNNL, [5]Hakai, [6]SEATOR, [7]National Park Service

Ocean acidification

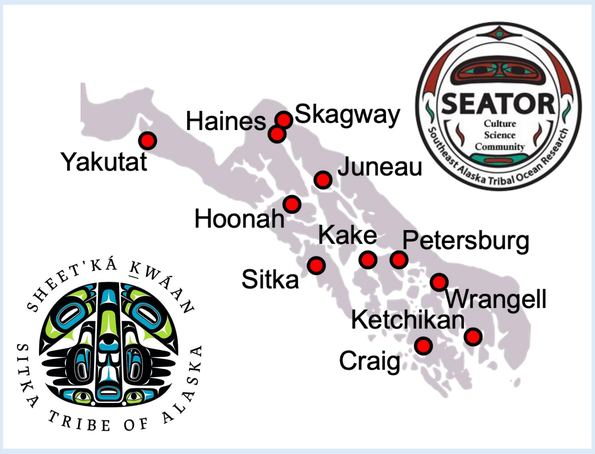
Alaska's coastal waters are vulnerable to ocean acidification due to natural processes such as cold seawater temperatures and freshwater input. The northeastern Gulf of Alaska receives a significant amount of rain, snow, and glacial meltwater, amplifying acidification in this region by lowering the buffering capacity of seawater.



Lingít Aaní

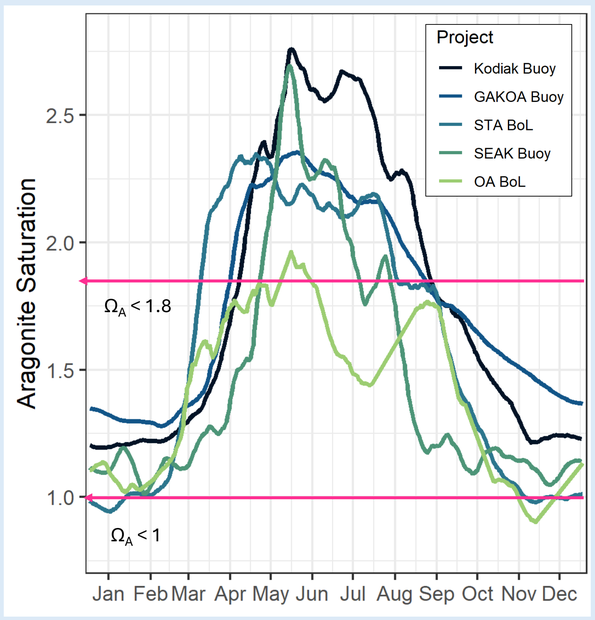
Alaska's southeast region, Lingít Aaní, is the ancestral and current homeland of the Lingít People who have stewarded their land and waters since time immemorial.

Partnerships in Lingít Aaní provide a more holistic understanding of ocean acidification in the region by merging information from offshore oceanographic surveys, coastal monitoring led by the Southeast Alaska Tribal Ocean Research (SEATOR) program, and local and Indigenous expertise.



Surface observations

The Sitka Tribe of Alaska (STA) leads a continuous surface ocean monitoring station using a Burkeolator (BoL). Other current and past surface monitoring efforts include the UAF surface ocean buoys in the Gulf of Alaska (GAKOA), Kodiak, and Southeast Alaska (SEAK) and the OceansAlaska BoL in Ketchikan, as well as underway systems on vessels such as the MV Columbia. These surface data are public and contribute to the Surface Ocean CO_2 Atlas (SOCAT).

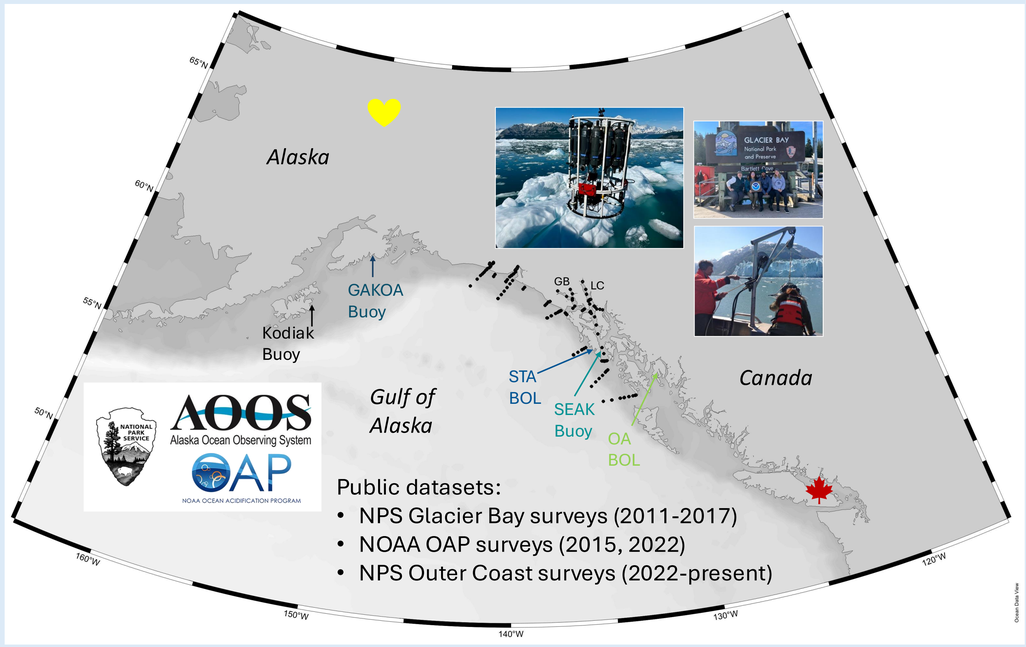


Aragonite Saturation (Ω_A)

Ocean acidification decreases carbonate availability for shell building organisms by lowering the saturation state for the calcium carbonate mineral aragonite. In the Gulf of Alaska, favorable conditions (Ω_A > 1.8) are generally observed during the summer, except for the OceansAlaska site in Ketchikan (OA BoL). The STA BoL is the longest continuous record in the region (2017–present) which show stressful conditions (Ω_A > 1) for sensitive marine species in the winter (Nov–Feb).

Oceanographic Surveys

We are preparing a synthesis product of biogeochemical observations from 2011 to 2024 across Lingít Aaní from three offshore observing programs. 1) The National Park Service (NPS) Oceanography program in Glacier Bay National Park and Preserve leads monthly surveys at 24 core stations. 2) The NPS Outer Coast program began annual surveys in 2022 in the coastal region of Wrangell-St. Elias National Park and Preserve. 3) The NOAA Ocean Acidification Program (OAP) and UAF led surveys in Lingít Aaní in 2015 and 2022.



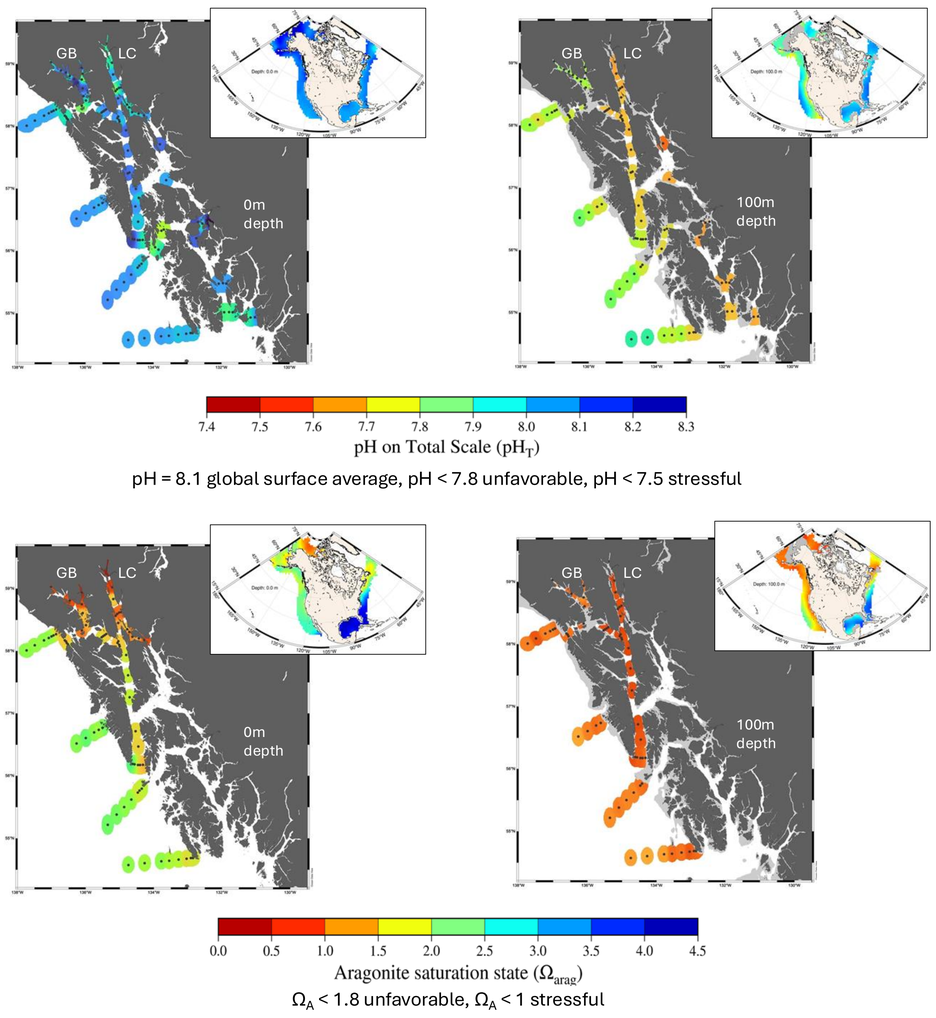
Public datasets:

- NPS Glacier Bay surveys (2011-2017)
- NOAA OAP surveys (2015, 2022)
- NPS Outer Coast surveys (2022-present)

2022 Survey Results

Results from the surface observing programs and the region's heavy reliance on marine ecosystem resources focused the July 2022 survey's objectives aboard the RV Rachel Carson. This research cruise, RC0083, was the first survey to collect full water column observations for marine carbonate parameters throughout Lingít Aaní.

Inside waters, including those heavily influenced by freshwater input (i.e., GB- Glacier Bay and LC- Lynn Canal) generally have lower surface pH and Ω_A than Outside waters on the outer shelf transects. As expected, results show seawater pH and Ω_A generally decrease with depth. As demonstrated by the surface observation summary, conditions during the summer are generally more favorable than winter. Since most oceanographic observations take place in the summer, it is important to consider the sensitivity of the species' life stage when applying survey results to biological and ecological implications.

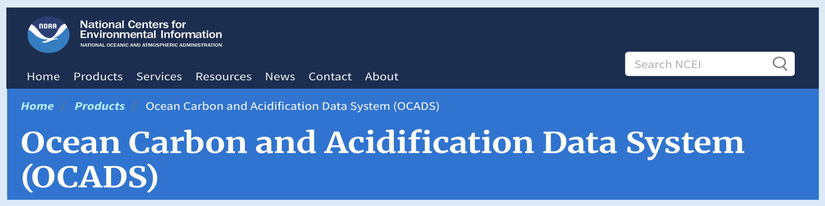


pH = 8.1 global surface average, pH < 7.8 unfavorable, pH < 7.5 stressful

Ω_A < 1.8 unfavorable, Ω_A < 1 stressful

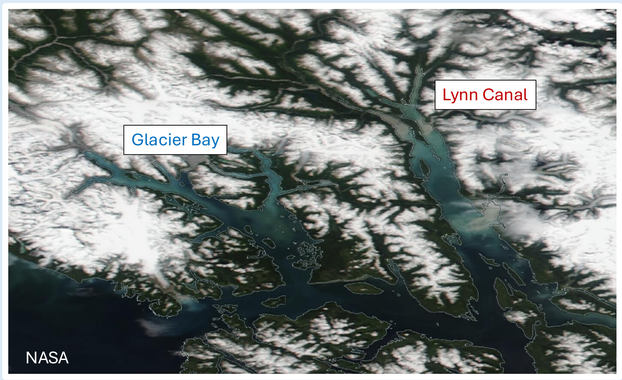
NOAA NCEI OCADS

Three distinct project's datasets are all publicly archived in the NOAA NCEI Ocean Carbon and Acidification Data System (OCADS) and follow best practices for metadata, vocabulary, and formatting. OCADS provides data management support for quality control, synthesis, and data product development. Since our data are public, any interested user can merge our results with their data, including the Global Ocean Data Analysis Product (GLODAP).



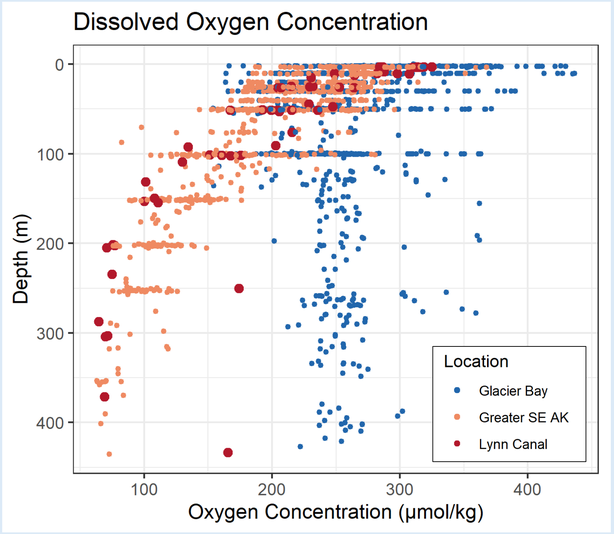
Glacial fjords

Lingít Aaní is home to some of the largest tidewater and piedmont glaciers in North America. Many recently deglaciated tidewater fjords provide a sheltered and productive marine habitat for species that are culturally, economically, and environmentally important.



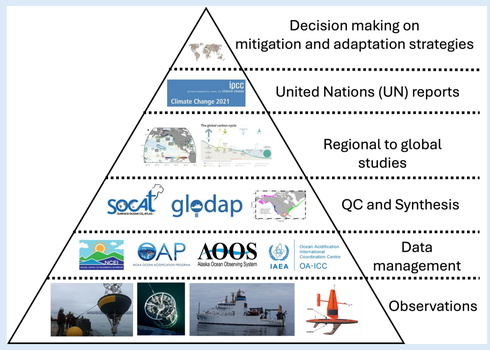
Co-stressors

Integrated datasets include full water column biogeochemical profiles for carbonate parameters, dissolved oxygen, and macronutrients, from multiple glacially influenced fjords. The biogeochemistry complements ongoing research on fjord ventilation physics, zooplankton community structures, and community-led observing programs. Results show Glacier Bay could provide refugia from low oxygen (< 100 µmol/kg) conditions found on the Outer Shelf.



Impact

Our archived datasets are free and publicly accessible at NOAA NCEI OCADS, a platform that promotes data use through an efficient data value chain. The schematics below show the promotion of observational data to decision making on a global scale (e.g., UN Ocean Decade SDG Goals), as well as a more local pathway for community-led adaptation and resilience plans (e.g., Tribal climate adaptation plans).



Future work

Ocean acidification is a global issue with local impacts. Our efforts to publicly archive and synthesize data from observing programs contributes to determining the rates of ocean acidification for a specific region, validates biogeochemical models and projections, and provides environmental context for regional vulnerability assessments. We hope to expand synthesis efforts with international partners and PICES working groups.

OARC Ocean Acidification Research Center