# Ocean Acidification Observations in Alaska's Four Large Marine Ecosystems

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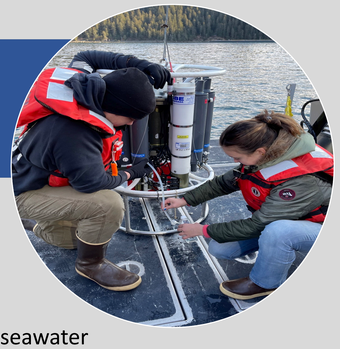
## Gulf of Alaska



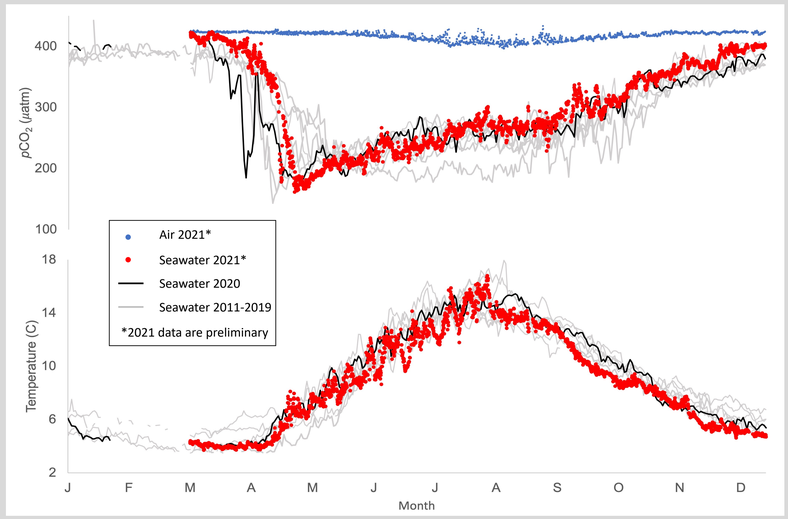
### GAKOA

59.91 N, 149.35 W
Resurrection Bay
2011-2022
MAPCO2 sensor: Carbon dioxide ($CO_2$) of air and seawater
Seabird sensors: seawater temperature, salinity, oxygen, fluorescence, pH

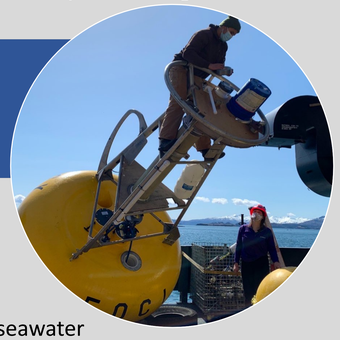
The surface buoy GAKOA is a year-round mooring site in the northern Gulf of Alaska, at the mouth of Resurrection Bay, just south of Seward, AK. This coastal site is part of the National Ocean Acidification Observing Network (NOA-ON) which maps the distribution of key indicators of ocean acidification (OA). The coastal oceans are highly variable relative to the open ocean and sites such as GAKOA allow us to better understand biogeochemical cycling between the terrestrial, atmospheric, and marine carbon cycles.

Preliminary data from 2021 are displayed in the panel below with 2021 air data (1m above the sea surface) shown in blue and seawater data (1m below the sea surface) shown in red. Seawater data from 2020 are shown in black and data from 2011-2019 are shown in gray. All finalized data are publicly available for download on the OARC website and included in the Surface Ocean Carbon Atlas (SOCAT) which enables quantification of the global ocean carbon sink and OA and evaluation of ocean biogeochemical models.

The 2021 spring bloom at the GAKOA mooring was rapid and intense, with seawater $pCO_2$ drawdown from near air values (~420µatm) to a minimum of 164µatm. Seawater $pCO_2$ returned to near air values in the winter, a season with less photosynthetic activity and water column stratification. Sea surface temperature was mostly cooler in 2021, a La Niña year, than previous years.

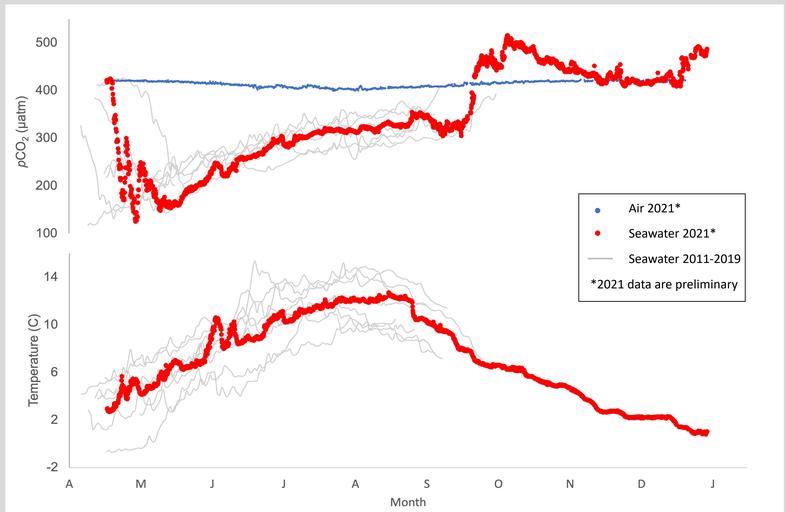



## Bering Sea

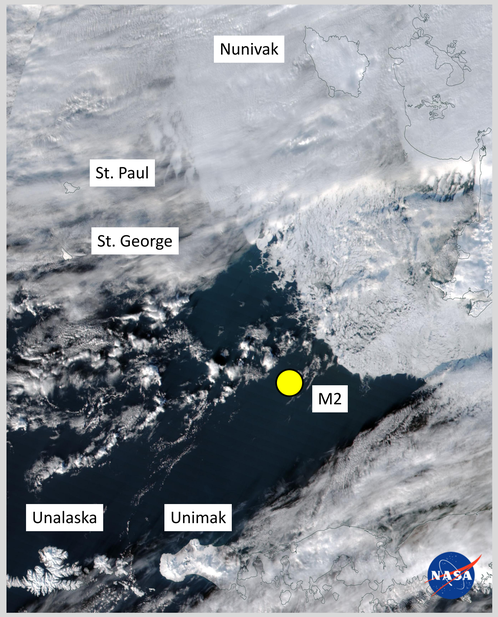


### M2

56.85 N, 164.06 W
Southeastern Bering Sea
2011-2022
MAPCO2 sensor: Carbon dioxide ($CO_2$) of air and seawater
Seabird sensors: seawater temperature, salinity, oxygen, fluorescence, pH



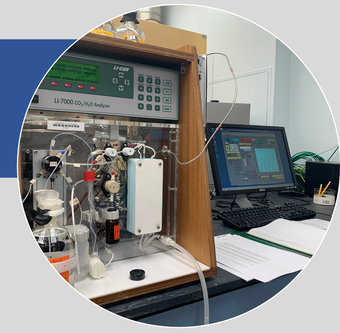

The surface buoy M2 is a seasonal mooring in the southeastern Bering Sea, typically deployed April to October. The M2 site is part of a long-term monitoring program led by NOAA's EcoFOCI group that researches the varying biological and physical attributes of the Bering Sea, one of Alaska's four large marine ecosystems. The knowledge obtained improves the understanding of the ecosystem dynamics, which is applied to the management of living marine resources.




The 2021 spring bloom at the M2 mooring was rapid and intense, with seawater $pCO_2$ drawdown from near air values to a minimum of 125µatm. Seawater $pCO_2$ returned to near air values in the autumn, around the time we typically recover the surface buoy. The recovery cruise was canceled due to COVID and this site is still collecting data as of Jan. 19, 2022. This has given us the extraordinary opportunity to continue surface observations in winter months. This includes collecting data during outgassing events, which occurs when the seawater $pCO_2$ values are higher than the atmosphere. The high $pCO_2$ observed in October and January are likely due to storms with high winds bringing deep water to the surface.

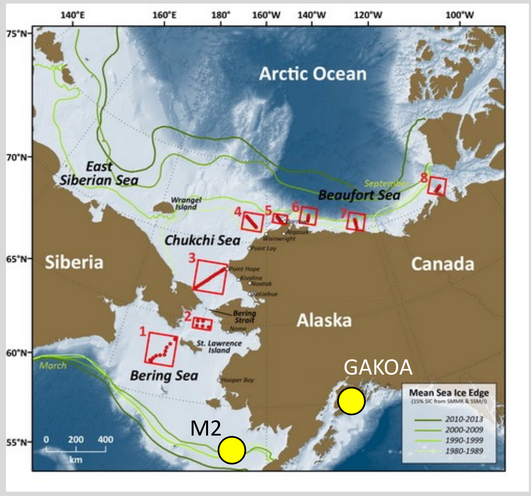
Sea ice extent in the Bering Sea during 2022 is expected to be higher than the last several years. To the left is a snapshot from NASA Worldview on Jan. 12, 2022. On this date, the ice edge was ~60km from M2. If the sea ice reaches M2 before we can recover the buoy, the ice will certainly win.

## Chukchi and Beaufort Sea



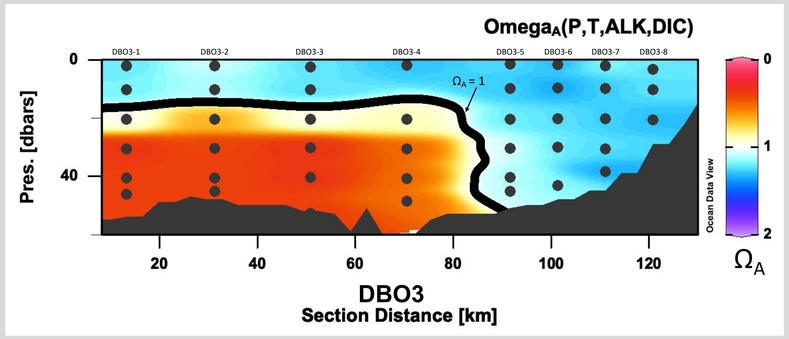
### DBO

Distributed Biological Observatory
Bering, Chukchi, and Beaufort Seas
2017-2021
Seawater sample collection for laboratory analyses




The Distributed Biological Observatory (DBO) is a change detection array along a latitudinal gradient with study areas in the northern Bering Sea, Chukchi Sea, and the Beaufort Sea. DBO sampling is focused on transects centered on locations of high productivity, biodiversity and rates of biological change. The original 2021 cruise was canceled due to COVID. Fortunately, data was collected in the DBO aboard the UAF RV Sikuliaq, but some transects, including DBO5, 6, 7, and 8, were not visited as planned. Therefore, we do not have 2021 data from the Beaufort Sea. Here we are presenting preliminary data from the USA portion of the DBO3 transect.

The preliminary data shown below are the saturation states of the biomineral aragonite ($\Omega_A$) calculated from measuring the Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA) of seawater samples, paired with the hydrographic data (temperature, salinity, and pressure). The DBO3 section distance 0km is closest to Tikiġaq (Point Hope) and the transect moves in the southwestern direction offshore. The dark line corresponds to the gridded depth where $\Omega_A = 1$.




Seawater that is undersaturated ($\Omega_A$ < 1; warm colors above) can lead to the dissolution of calcium carbonate minerals, a phenomenon that previous studies have observed in the northern Bering and Chukchi Seas (i.e. Cross et al., 2013; https://doi.org/10.1016/j.marchem.2013.05.012). The corrosive water is likely due to a buildup of respiration products combined with anthropogenic ocean acidification. At $\Omega_A$ < 0.5, we would expect dissolution if the water remained undersaturated for a duration of 5 days. Since these data are preliminary, the calculated marine carbonate parameters, including Ω, may change when additional parameters, i.e. nutrient concentrations, are applied. Final data are publicly available on our website and new releases are posted on our Twitter page.

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