Ocean Acidification Research: Using Observations and Models to Support Alaska's Blue Economy

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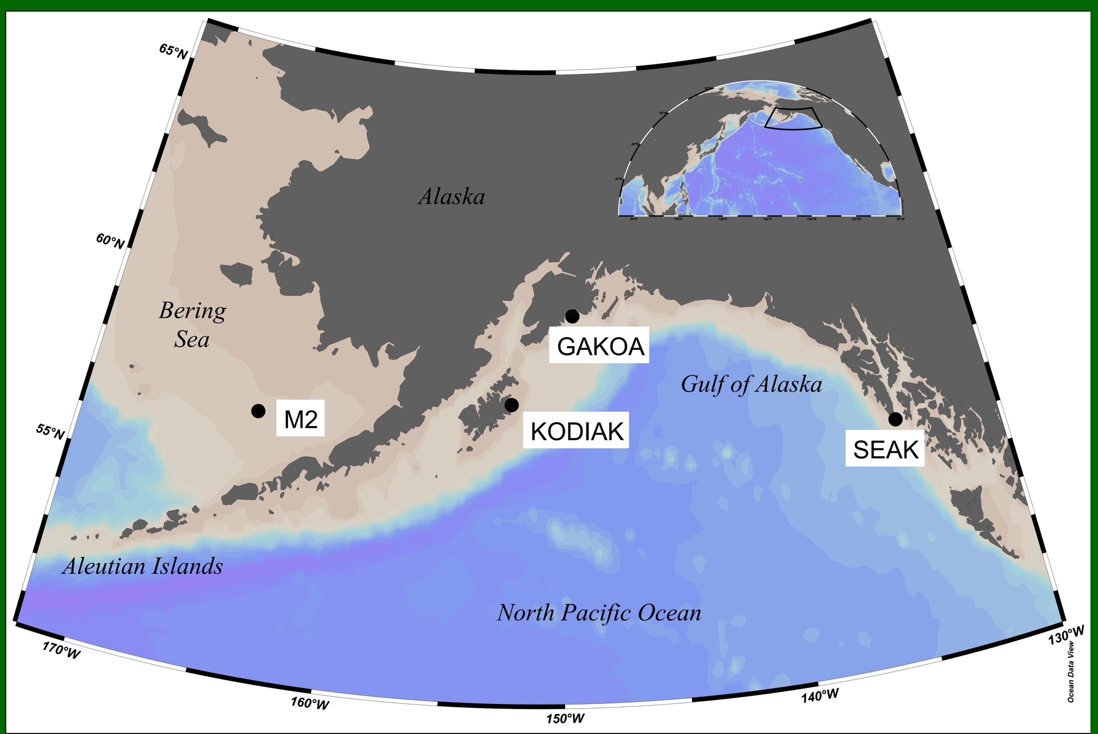
Alaska OA Mooring Network

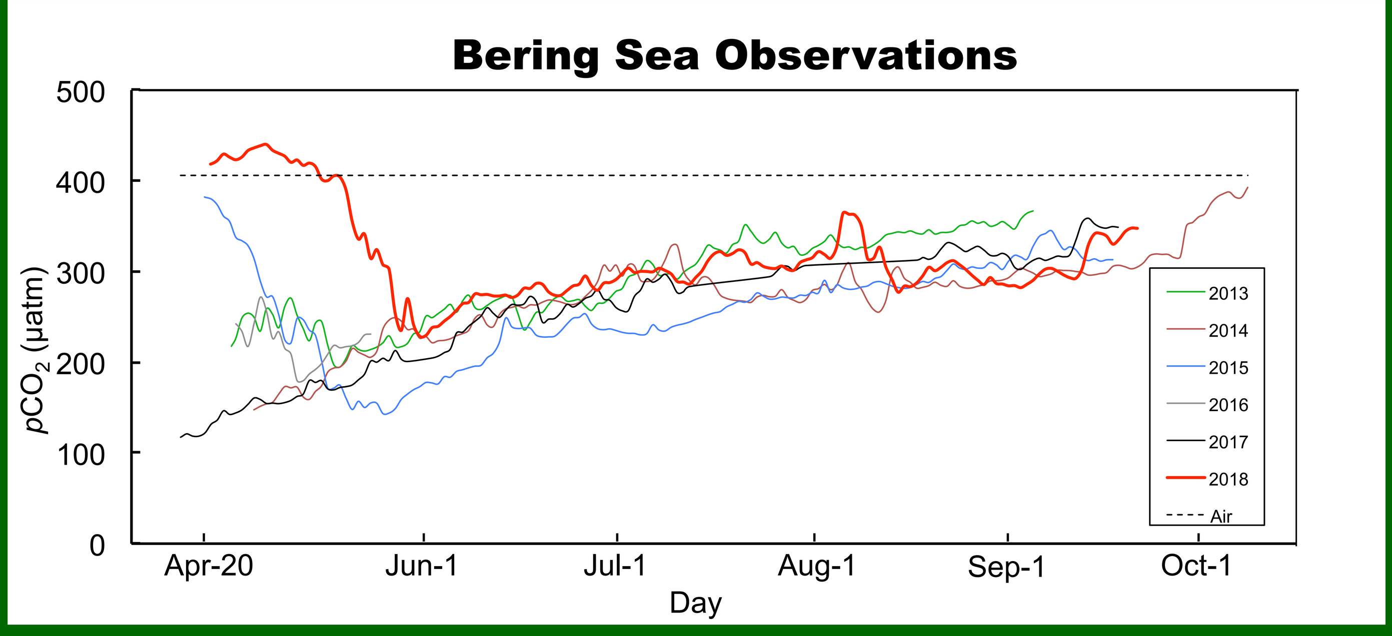
High latitude regions are experiencing the rapid onset of ocean acidification (OA) resulting from the uptake of anthropogenic carbon dioxide (CO_2) from the atmosphere. Alaska is more vulnerable to the effects of OA than other regions, and could rapidly impact Alaska's fisheries. In order to monitor the rate of OA and help understand its impacts, the Ocean Acidification Research Center (OARC) at the University of Alaska Fairbanks (UAF) leads the Alaska Ocean Acidification Mooring Network.



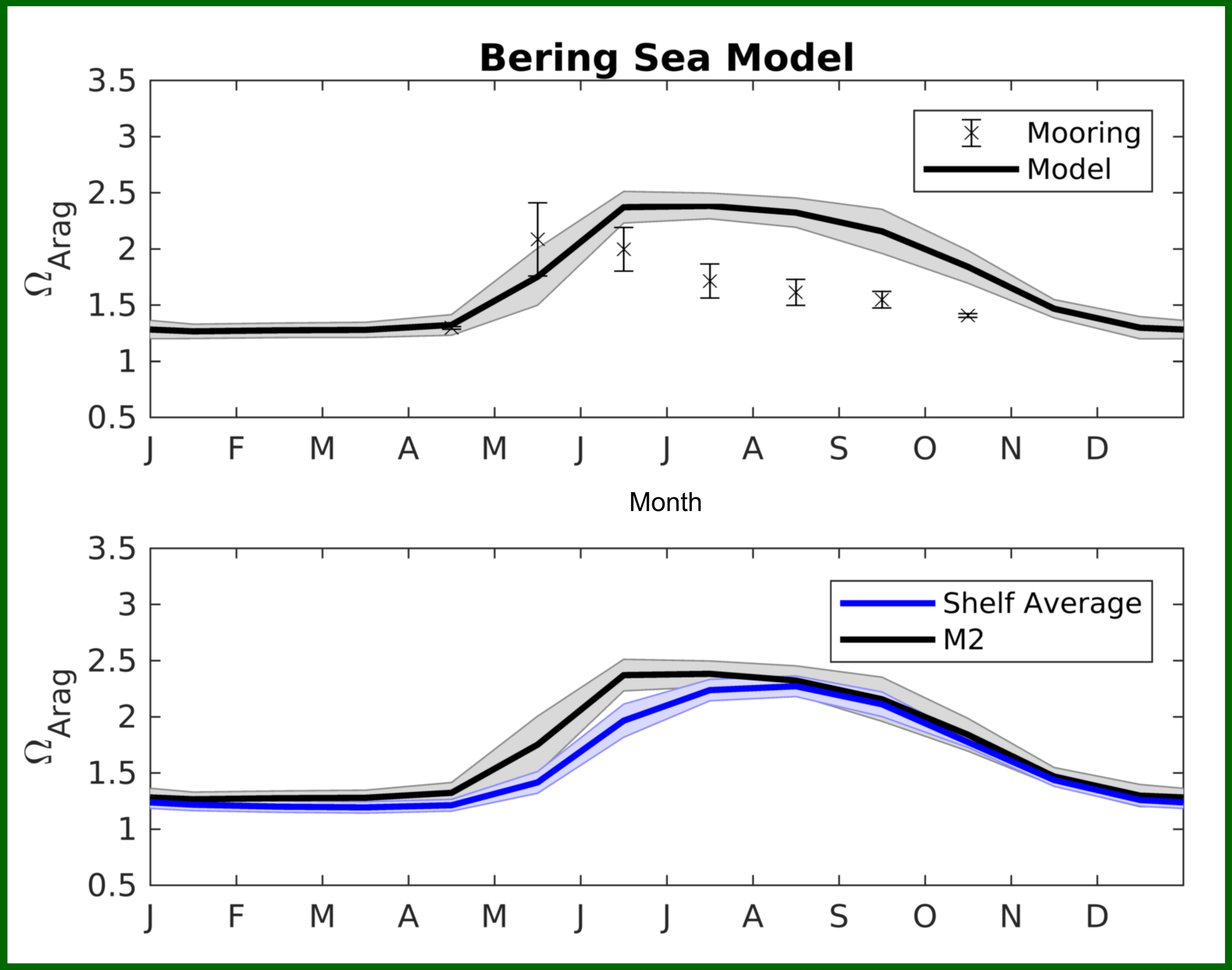
Surface mooring locations: SEAK, Port Conclusion, 2013-2015; GAKOA, Resurrection Bay, 2013-2019; KODIAK, Chiniak Bay, 2013-2016; M2, Bering Sea, 2013-2019.

Bering Sea: M2 Mooring Site

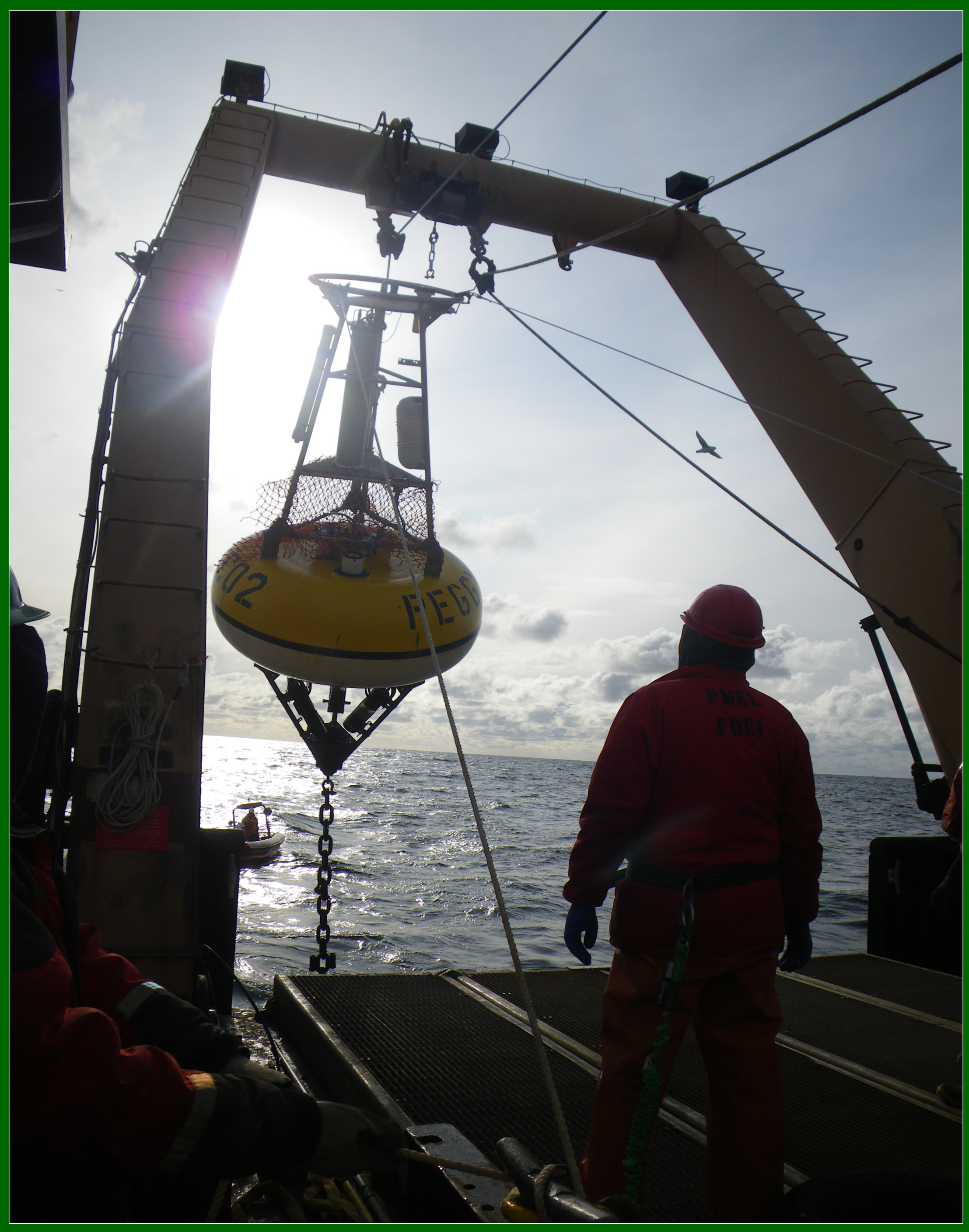
Here we present observational data and modeled data at mooring site M2 to help identify important natural mechanisms that can exacerbate OA. Our direct surface measurements in the Bering Sea are constrained to the sea ice free months of April to October, though we have projected our modeled data over the entire year. The Bering Sea shelf is a wide (>600 km), relatively shallow (<100 m) continental shelf with high productivity. Since this region covers the harvest grounds for the largest United States' fishery, understanding the habitat and change is crucial for sustainability. Due to the physical characteristics of the shelf, we have high confidence in projecting our model across the majority of the shelf with limited observations.



Daily averages of partial pressure of carbon dioxide (pCO_2) of seawater at the surface of mooring location M2. The 2018 deployment was the first time we captured the entire drawdown of pCO_2 from the spring bloom. The dashed line is the average atmospheric pCO_2 (Air) at the site from 2013-2018.



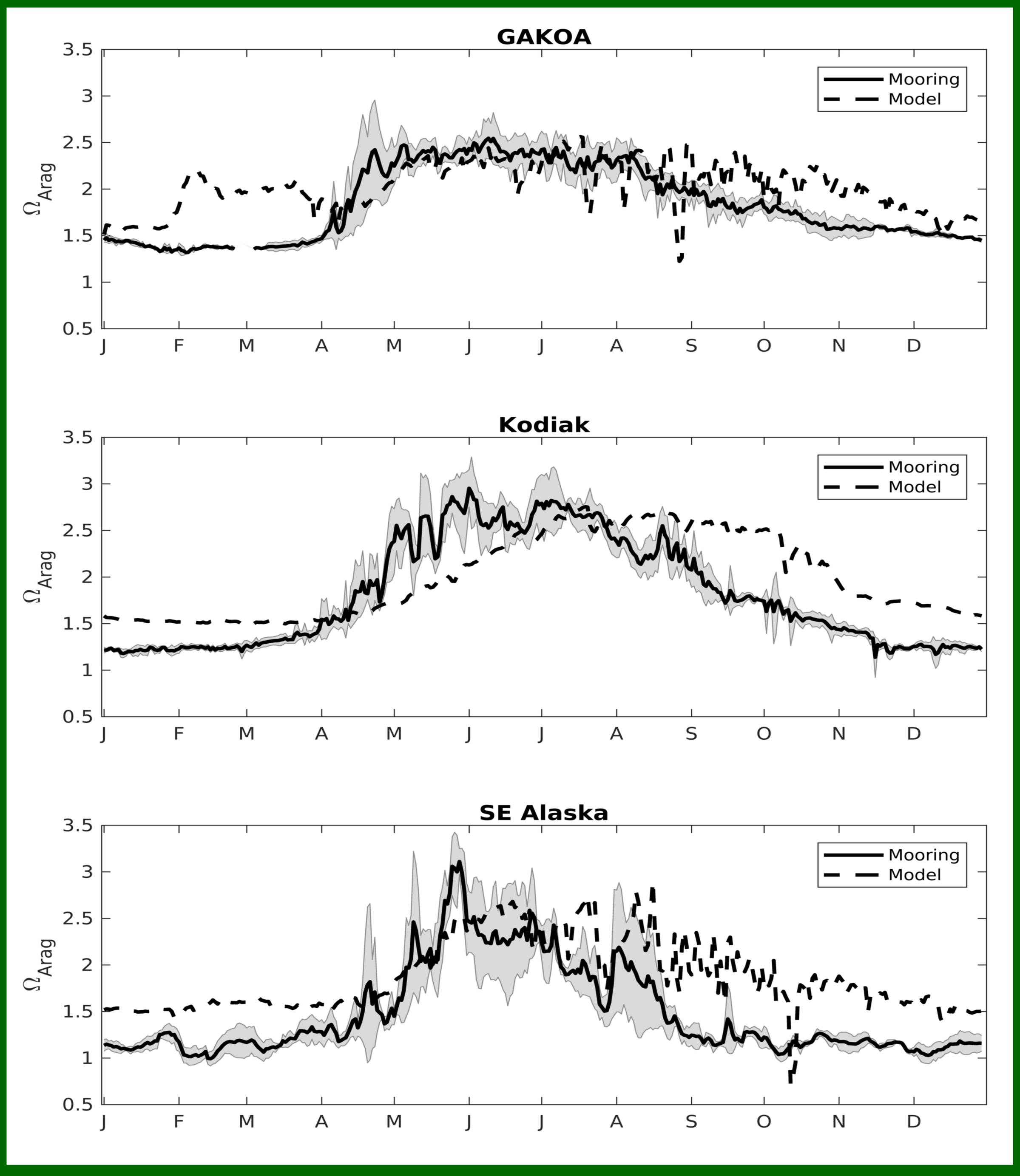
Time series monthly average mooring data (symbol) and model data (black line) at mooring location M2 for aragonite saturation states (Ω_{arag}). Gray shaded area represents the mooring standard deviation. Ω_{arag} is calculated from observed measurements and is a good indicator to determine ideal habitat for various species.



OA Surface Mooring Platform sensors:
Battelle Seaology MApCO_2 Monitoring System
Seabird SeaFET Ocean pH sensor
Seabird SeaCAT: Temperature (T), Salinity (S), and Oxygen (O_2)

Gulf of Alaska

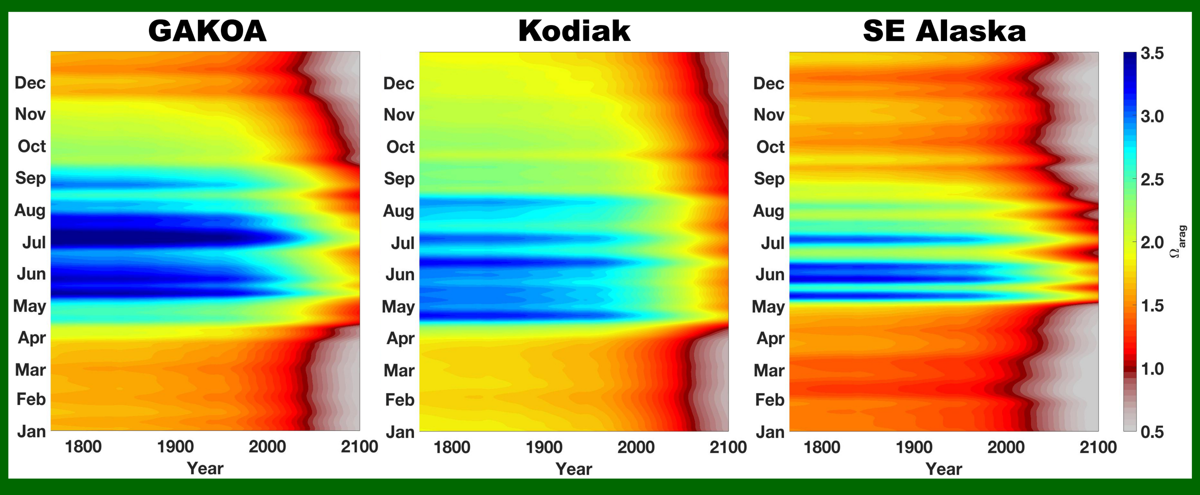
Here we present observational data with modeled data from three mooring locations in the Gulf of Alaska. Naturally acidified waters can be upwelled to the surface, where waters are already affected by anthropogenic impacts. This region also has a unique chemical signature from high freshwater inputs and glacial discharge, which exacerbates OA. This study has helped build our understanding of how OA works in Alaska. The Gulf of Alaska regional model, developed by Siedlecki et al. (2017), is being fine tuned and validated with our observations. Models are an important tool that will help project how OA will impact this region in the future.



Time series of average mooring data (solid line) and model data (dashed line) at mooring location for the GAKOA (top), Kodiak (middle), and Southeast (SE) Alaska (bottom) sites. Gray shaded area represents the mooring standard deviation. Model output is from 2009 (Siedlecki et al., 2017).

Planning with Fishermen

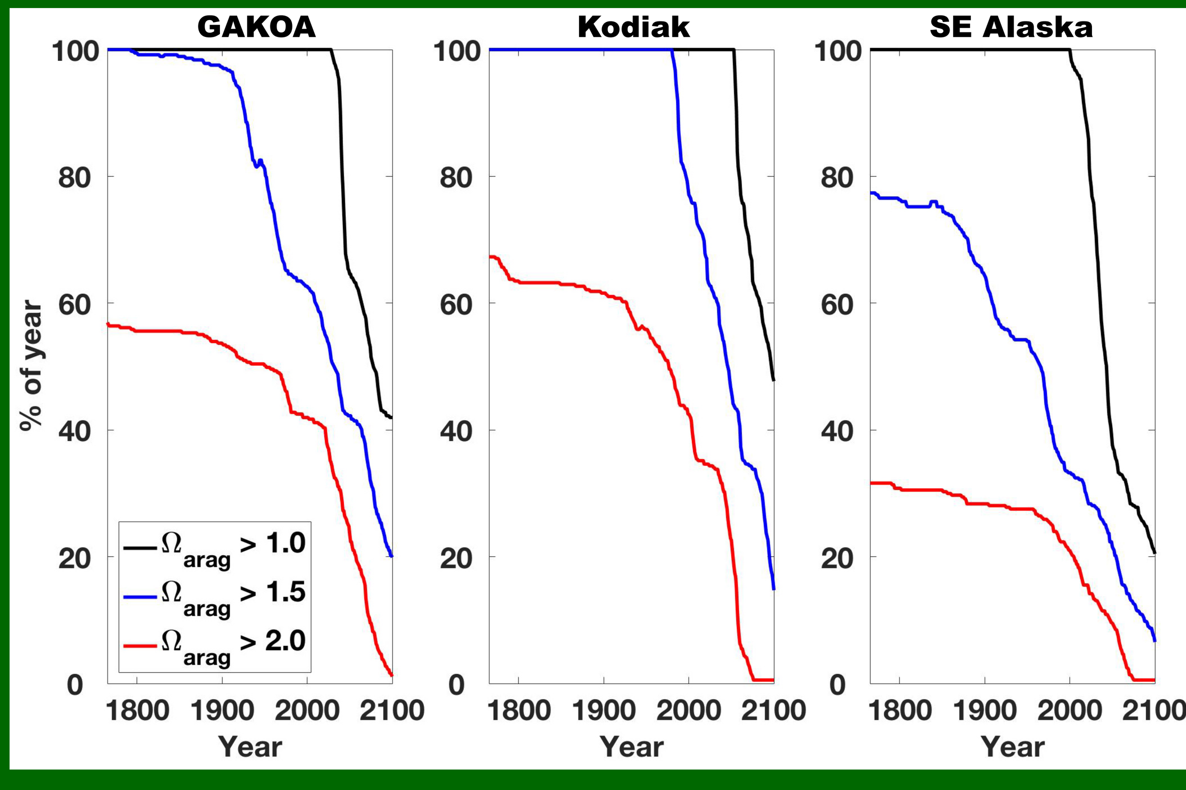
We know that OA is already happening in Alaska, and that fishermen, managers, and communities need information now about its potential impacts in order to make important decisions. OARC also works with simpler models, or projections, to help identify the potential progress of OA. We do this by projecting how acidification changed in the past and how it might change in the future. These projections rely on direct observations so they are much more limited than the in-progress regional model to the left, but they can be a valuable intermediate tool.



This Hovmöller plot shows how acidification might change through the end of the century. The cool colors indicate ideal habitat for important species. In general, cooler colors are more prevalent during the summer, but this season of good habitat shortens across the coming decades.

Predicting Available Habitat

Measuring and predicting aragonite saturation states (Ω_{arag}) are tools to help determine if a habitat is suitable to a species' preferred growing conditions. Different species can tolerate various Ω_{arag} conditions and understanding these limits help fishermen, aquaculture facilities, and resource managers plan for their fishing, growing and harvesting seasons. Through the end of the century, the number of days of ideal habitat declines at all sites. We see that each system hits important tipping points when conditions begin to more rapidly deteriorate.



These plots show the decline in ideal habitat for certain species over time. Here, we are using a proxy of Ω > 2 to describe ideal habitat for pteropods, an important food source for pink salmon. We use a proxy of Ω > 1.5 to describe ideal habitat for oysters, which are slightly more resilient; and Ω > 1 to describe ideal habitat for very resilient organisms such as adult crabs.

Next Steps

We have succeeded in matching our observations to the regional models in the Bering Sea and Gulf of Alaska on a yearly average and will continue to fine tune our model outputs to better match the seasonal observations. The GAKOA and M2 mooring sites are the cornerstones of our monitoring grid, and we will maintain ongoing OA measurements at these sites.

In 2020, we plan to add OA observations to key fishery surveys, in order to better understand how OA is interacting with multiple stressors across a variety of fishery populations. Our next key step is starting to work directly with fisheries managers on short-term models– effectively creating a seasonal forecast of OA, and directly linking this forecast with predicted impacts on key fishery components like vulnerable life stages and prey species.

NOAA
CIFAR Cooperative Institute For Alaska Research
UAF COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks
AOOS Alaska Ocean Observing System
The Seal of the State of Alaska