

State Ferry Reveals Ocean Acidification Conditions in Southeast Alaska

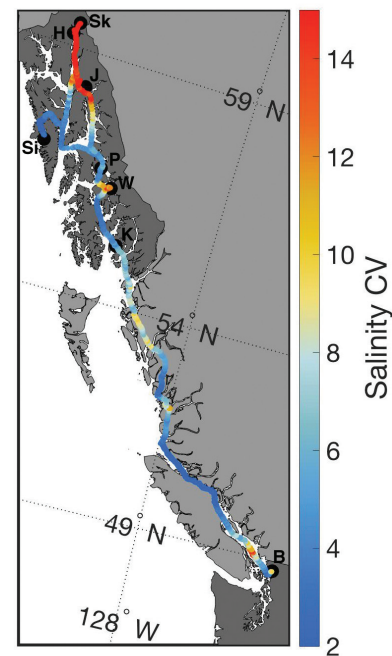
The Alaska Marine Highway System (AMHS) ferry *Columbia* has been collecting ocean acidification data since late October 2017 during its ~1,600 km route between southeast Alaska and Bellingham, WA. In southeast Alaska the ferry transits between Ketchikan, Wrangell, Petersburg, Juneau, Haines, Skagway, and Sitka, collecting measurements of temperature, salinity, oxygen and carbon dioxide (CO_2) content every 2 minutes while underway. More than 290,000 measurements have been collected during 135 transits during the project's first two years. 2019 also brought a new collaboration to this project, as Yui Takashita from the Monterey Bay Aquarium Research Institute teamed up with project lead Wiley Evans (Hakai Institute) to directly measure seawater pH and nitrate concentrations.

What have we learned so far?

The information generated from this project has detailed a complicated mosaic of changing surface ocean conditions along the entire ferry route. One of the main take-homes is that water chemistry along Alaska's inside passage is not uniform, and the data document a variety of factors influencing the acidity and corrosivity of the water, creating hotspots and potential refugia for sensitive species.

Using the parameters collected by the ferry, Evans has been able to calculate the aragonite saturation state, which is a measurement of the corrosiveness of seawater to shell-building organisms (written Ω_{arag}). Generally, $\Omega_{\text{arag}} > 1$ represents favorable conditions for shell forming organisms while $\Omega_{\text{arag}} < 1$ can be stressful for shell builders. The data reveal changes in Ω_{arag} within seasons, across seasons, and between years in different parts of southeast Alaska. For example, large changes in salinity during summer in Lynn Canal, the waterway between Juneau, Haines, and Skagway, is a result of melt from glaciers. Salinity and temperature can influence the level of acidity and corrosiveness, and in this area during summer, Ω_{arag} declines from levels above 2 (favorable) to conditions less than 1 (stressful), as salinity decreases due to the seasonal snow and ice melt.

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Map of ferry route from Bellingham (B) to Skagway (SK) showing salinity coefficient of variation (Salinity CV) or the degree of variation in salinity relative to the mean. This map shows high salinity variation at the northern end of the route.

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Gulf Watch Alaska Providing Insights into GOA Ecosystems



Gulf Watch Alaska (GWA) is the long-term monitoring program of the *Exxon Valdez* Oil Spill Trustee Council for the marine ecosystem affected by the 1989 oil spill. The GWA program aims to provide sound scientific data and products that inform management agencies and the public of changes in the environment and the impacts of these changes on spill-injured resources. The program began as an integrated effort in 2012, building on and sustaining long-term data sets (some extending back almost 50 years) about the spill-affected regions of the Gulf of Alaska, including Prince

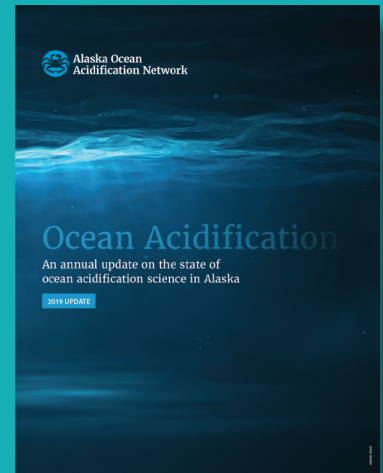
William Sound and Kachemak Bay/Cook Inlet. Data and program information are provided through the AOOS-hosted Gulf of Alaska Data Portal (<https://portal.aos.org/gulf-of-alaska#>) and GWA program website (<https://gulfwatchalaska.org/>).

In 2019, GWA scientists conducted a synthesis of ecosystem monitoring results, with a focus on the environmental and species responses to the 2014–2016 Pacific marine heatwave. Some preliminary key findings include:

- AOOS and GWA-supported ocean observations showed that waters were consistently warmer across nearshore and shelf regions of the northern Gulf during the heatwave.
- Biological oceanographers observed cold water, more nutritious zooplankton species declined during warmer years, while warm water species persisted.
- Researchers found that blooms of toxic phytoplankton increased in number, location and intensity, with more paralytic shellfish poisoning events and shellfish harvest closures in Kachemak Bay.
- GWA scientists observed the intersecting effects of the heatwave on the nearshore ecosystem. There were Gulf-wide responses of nearshore species to the heatwave, despite large spatial variability in these ecosystems. This included widespread sea star mortalities from wasting disease exacerbated by the warm temperatures.
- For open ocean species, the dramatic seabird mortality event in 2015–2016 was attributed primarily to starvation from insufficient food. Observed changes in the distributions, behavior, and diets of humpback whales and killer whales were attributed to responses to food web changes.

The GWA long-term legacy datasets have been an important resource for understanding changing environmental conditions and marine heat wave events. Lessons learned from multi-disciplinary ecosystem monitoring through the 2014–16 heatwave event, followed by more average environmental conditions in 2017–2018, are being applied to manage marine resources in the face of the renewed warm conditions in 2019. Based on that knowledge, starting 2020 with colder than normal conditions is seen as a welcome change! Even these most recent trends underscore the value of continued monitoring in Alaska's large marine ecosystems. ■

A field worker samples an important prey species, the Pacific blue mussel (*Mytilus trossulus*), from a quadrat as part of the Nearshore Ecosystem component of the Gulf Watch Alaska long-term monitoring program. Katmai coast, 2018



Latest on Ocean Acidification in Alaska

In fall 2018 the Alaska Ocean Acidification Network produced the first Alaska Ocean Acidification State of the Science report in response to a request from the fishing community for the latest OA information. Specifically, they wanted a description of the latest research on species response in the lab, current forecasting efforts, and what we know so far about regional drivers and influences. The 2019 update to this report was just published highlighting what has been learned about OA conditions, forecasts, and species response through research projects in 2019. Included in this year's update are new research on species response in herring, bivalves, and pteropods; 40 years of change in the Gulf of Alaska; two years of ocean acidification monitoring on the Alaska Marine Highway System ferries; and observations from Alaska's Burke-o-Lators. The update is available in hard copy and if you'd like some to circulate in your community, please email dugan@aos.org. Thanks to the researchers and reviewers that made this publication possible. ■

Fall 2019 Kodiak Wave Buoy Turnaround Completed

In July 2019, AOOS entered a two-year agreement with the National Renewable Energy Laboratory (NREL) to take over the operations and maintenance of their off-shore wave buoy near Kodiak Island in order to keep the asset operating in this important maritime region through 2021. In October 2019 the F/V *Anna D*, owned and operated by Dan Miller of Kodiak, transported CDIP engineer Andrew Gray and *Anna D* crew member Marko Patticui to the station to complete mooring repairs and a buoy turnaround. Conditions were optimal, and with transit time, the operation took about 10 hours.

This moored buoy is located approximately 17 nautical miles southeast of Chiniak Island, and consists of a Datawell Mark III directional buoy at a depth of 282 ft. It measures significant wave height, wave direction, sea surface temperature, and derived information on dominant and average wave periods and wave energy spectra and climatology. As with the other two AOOS supported wave buoys, CDIP is providing quality controlled data in real time, which is shared via the following pages:

- AOOS real time data portal (<https://portal.aos.org/#metadata/75578/station/data>)
- CDIP webpage (<https://cdip.ucsd.edu/m/products/?stn=236p1>)
- National Data Buoy Center (Station WMO 46264) (https://portal.aos.org/#metadata/18/sensor_source)

AOOS acknowledges Levi Kilcher of NREL for offering AOOS the opportunity to keep this buoy on location longer than planned, and to Dan Miller, Captain of the F/V *Anna D* for his support and guidance on logistics from Kodiak. AOOS would also like to thank Chris Long at the NOAA National Marine Fisheries Service in Kodiak for coordinating delivery of the buoy to Kodiak and storing the buoy prior to deployment, Marko Patticui for attending crew, and Glenn Dick at Arc-N-Spark, Kodiak for shuttling the buoys on and off the F/V *Anna D* on short notice during our weather window. ■



On New Years Eve 2019, the *Scandies Rose* crab fishing vessel sank near Sutwik Island, southwest of Kodiak Island. AOOS staff were monitoring the Kodiak wave buoy conditions during the search and rescue operations New Year's Day. The buoy located about 150 miles northeast of Sutwik Island was reporting over 20-foot waves the night of December 29 into the morning hours of the 30th, and 11-12 foot waves at the time of the incident and during the search and rescue. These are harrowing conditions at freezing temperatures. AOOS staff express sincere condolences to the families and friends of those lost on the *Scandies Rose*, December 31, 2019. ■



Don Miller

Andrew Gray (CDIP) and Marko Patticui (R/V *Anna D* crew) on the deck of the *Anna D* preparing the refurbished buoy for deployment near Kodiak.



Generally, winter time is the most corrosive season in Alaska, and variation across seasons is largest in the transition from winter to summer in areas where phytoplankton growth is high. During winter, phytoplankton growth is uniformly low (meaning less CO₂ in the water column is taken up through photosynthesis), and storms are frequent and drive intense mixing of the surface ocean. During this time of year, Ω_{arag} conditions are near or below values of 1 (stressful). Some areas with Ω_{arag} values below 1 are waterways with strong tidal mixing. As storms become less frequent and intense in spring, photosynthesis by phytoplankton increases, thereby consuming carbon dioxide in the water column (and producing oxygen) and raising Ω_{arag} values to favorable conditions above 2. This transition occurs quickly: typically, over a week. Some areas do not exhibit these dramatic seasonal changes because of continual mixing by tides, and in these regions Ω_{arag} values stay low all year in a state of perpetual winter.

The two years of observations made thus far show that the seasonal transition and the patterns of summer Ω_{arag} conditions can look different from year to year. This was evident in both the Salish Sea in Washington and British Columbia, and in southeast Alaska where the intensity of the spring phytoplankton bloom and the peak summer Ω_{arag} values were different between 2018 and 2019. These year-to-year differences were also apparent in the oxygen measurements, which provides evidence for differences in phytoplankton productivity between these years.

The *Columbia* will continue operating in 2020 as a collaborative project between AOOS, the Alaska Department of Transportation, Hakai Institute, University of Alaska Southeast Alaska Coastal Rainforest Center, the University of Washington Joint Institute for the Study of Atmosphere and Ocean, Monterey Bay Aquarium Research Institute, and NOAA's Pacific Marine Environmental Laboratory. The monitoring will help identify ocean acidification hotspots and refugia, validate other data collection efforts in Southeast, and provide estimates on the rate of change of acidification for the region. ■



Wiley Evans of the Hakai Institute explains ocean acidification and the ferry monitoring program to passengers aboard the *Columbia*.

Alaska Regional Ocean Data Sharing Initiative Focuses on Bering Sea

AOOS received funding this year as part of a White House initiative to implement Executive Order 13840 and “enhance capacity for sharing and integration of Federal and non-Federal data in support of regional coastal, ocean, and Great Lakes management priorities.” The AOOS board decided to focus efforts the next two years on responding to the rapid ecosystem change in the Bering Sea/Strait region. Funds will be used to increase regional data sharing among federal, state, community and private sector partners, facilitate stakeholder response, support agency management decision making, and enhance regional economic opportunities.

AOOS is hiring a coordinator for the project who will work with partners Axiom Data Science on increasing access to Bering Sea data and establishing a Bering Sea Data Dashboard; with the Alaska Center for Climate Assessment and Policy on outreach materials, including regional newsletters, web products, road shows, and other stakeholder engagement; and with the Interagency Arctic Policy Committee collaboration teams to increase coordination among the research community. The project will be guided by a Steering Committee. Contact AOOS Executive Director Molly McCammon for more information. ■



AOOS Gathers Input for Next 5-year Plan

In preparation for its next five-year cooperative agreement with NOAA, AOOS has begun collecting input from stakeholders, reviewing its current suite of observing activities, and will soon be soliciting new project ideas for 2021-26. The cooperative agreement forms the framework for the next AOOS five-year strategic plan. In recent years AOOS has focused on four priority areas: marine operations, coastal hazards (erosion and sea level rise), water quality (harmful algal blooms and ocean acidification), and ecosystem and climate trends (fisheries).

AOOS is interested in hearing from Alaskans about:

- emerging ocean and coastal issues and concerns;
- new and potential projects that fill gaps in ocean observations and models;
- new data tools and products for management and decision support; and
- innovations in technologies, techniques, synthesis and forecasting to provide knowledge for action.

AOOS will submit its funding proposal next November. AOOS will solicit feedback at a number of venues such as the Alaska Marine Science Symposium and the Alaska Forum on the Environment (with a special session on microplastics) and through networks such as the Alaska Ocean Acidification Network, the Alaska Harmful Algal Bloom Network, and Alaska Water Level Watch. You can provide direct input by submitting feedback through the AOOS data portal, emailing 5yearplan@aoos.org, or by talking directly to an AOOS staff or board member. ■