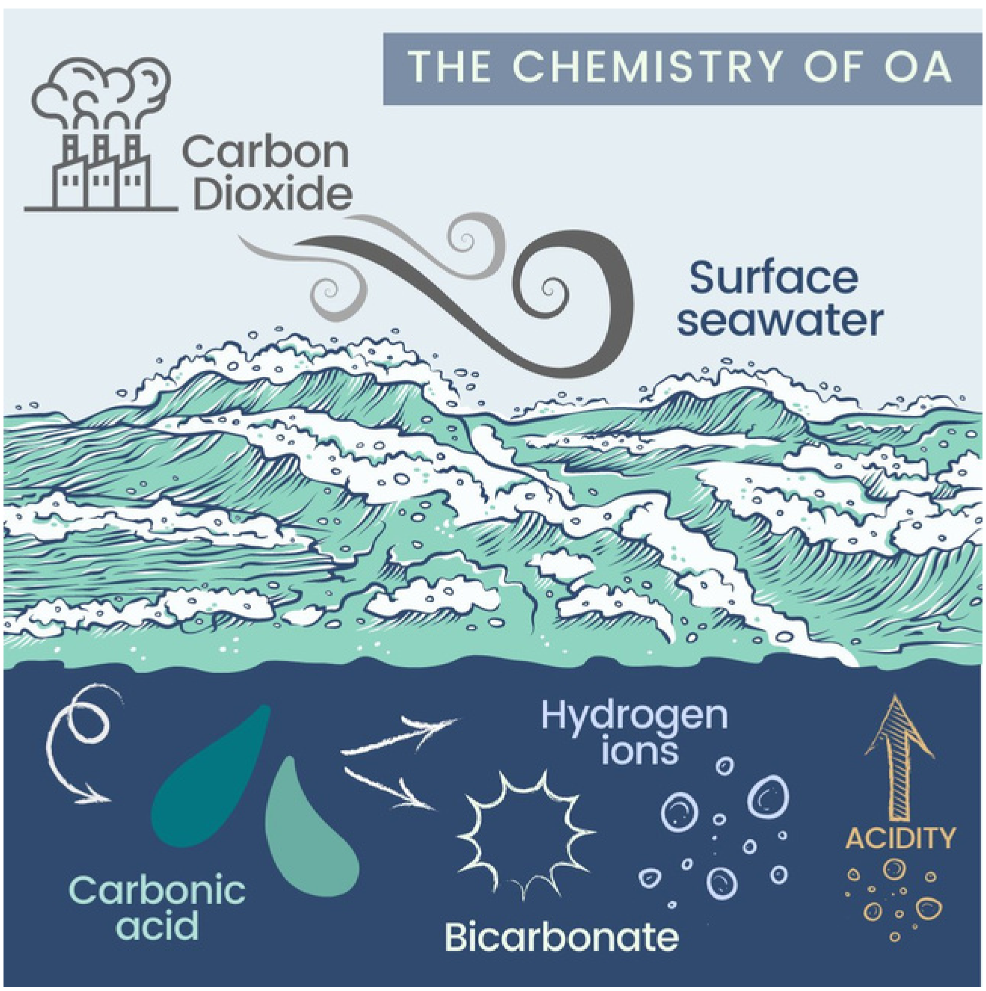
Ocean Acidification

A Brief Introduction for Kodiak Communities

What is ocean acidification?

Ocean acidification is a chemical process that occurs when human-generated carbon dioxide (CO_2) is absorbed into the ocean. The additional CO_2 changes the chemistry of seawater and makes it more acidic. This process has been accelerating since the industrial revolution as we burn fossil fuels to generate electricity, fuel cars and planes, and contribute to land-use changes such as deforestation. Scientists estimate that the ocean is 30% more acidic than it was 300 years ago and this rate is expected to accelerate without rapid policy changes to reign in global emissions. Because seawater acidity can directly impact marine life, ocean acidification will affect the health of the oceans around the world and the people that depend on them. When we study ocean acidification, we study one pathway of how carbon reacts under a certain set of conditions.



How exactly does the ocean become more acidic? When carbon dioxide mixes with ocean water, most of it eventually breaks down into hydrogen ions and bicarbonate. The increase in hydrogen ions is what decreases the pH and makes the ocean more acidic. These hydrogen ions also combine with carbonate, which decreases the amount of carbonate available that many marine organisms use to build their shells.

Image source: Alaska Ocean Acidification Network

Impacts in Alaska

Ocean acidification is a threat to marine environments around the world. However, Alaska is expected to feel the impacts of ocean acidification earlier and more intensely than communities at lower latitudes. Alaska's waters naturally store more carbon dioxide year round because colder water has the ability to hold more gas. Seasonal cycles caused by phytoplankton blooms and sea ice also influence the amount of carbon dioxide stored in the ocean.

The health of marine environments is critical to the existence of native communities in Alaska due to their close connection with the land and water. For example, many species in Alaska which are important to subsistence lifestyles may be impacted by ocean acidification. Increased acidity can impact the survival, size, growth rate, and reproduction of some species of fish. Shell-building organisms, like crabs and clams, may have difficulty building and maintaining their shells which are made of calcium carbonate. See "Impacts of Ocean Acidification on Alaska Fish & Shellfish" on page 7 to see how various Alaskan species may respond to ocean acidification changes, but note that there are many resident Alaska organisms that have yet to be studied (National Oceanic and Atmospheric Administration (NOAA) & Alaska Ocean Acidification Network (AOOS)). Ocean acidification is just one of the stressors that these species experience. Other stressors, such as pollution and changing climate, can combine with ocean acidification to intensify the negative effects. Ongoing research aims to understand which species will be positively or negatively impacted, as well as how we can adapt to these changes.



Ocean Acidification Monitoring in Kodiak

Along the Pacific Coast, there is a network of scientists, tribes, and organizations collecting water samples to monitor ocean acidification. In Alaska, there are three monitoring hubs, including Kodiak. Each hub utilizes a Burke-o-Lator, an instrument that continuously monitors for ocean acidification parameters like pH. This instrument can also process samples sent in from remote locations.

Attendees at the
2019 Marine Water Quality Workshop

In Kodiak, the monitoring program is a partnership between four Kodiak Tribes and the National Oceanic and Atmospheric Administration (NOAA), facilitated by the Kodiak Area Native Association (KANA). Participating tribes include Alutiiq Tribe of Old Harbor, Native Village of Larsen Bay, Native Village of Ouzinkie, and Native Village of Port Lions. Tribal Environmental Samplers from each community collect water samples once a week throughout the year. Samples are also collected below the surface of the water because ocean conditions can change with depth. In addition, NOAA collects monthly water samples from South Trident Basin. KANA coordinates the logistics of sample collection and data sharing. All samples are processed on the Burke-o-=Lator at the Kodiak Laboratory of the Alaska Fisheries Science Center (NOAA) for analysis of ocean acidification parameters.

The Burkolator in Kodiak, run by the NOAA Laboratory

The data collected as part of this program are considered baseline data because they allow us to measure environmental conditions that have never been monitored to this extent on Kodiak Island. Baseline data are important because it allows us to observe change over time. Tribal communities can use these data to better understand, adjust and adapt to changing water quality conditions that can impact subsistence resources, economic development, and overall livelihoods.

The goals of this monitoring program are to:

1. Develop tribal capacity for residents to meaningfully engage in ocean chemistry monitoring by collecting, sharing, and comparing local environmental data relevant to their communities

2. Create a picture of how ocean acidification parameters change between seasons, years, and different locations by establishing a baseline of environmental data

Left images: Tribal samplers collect ocean acidification samples
Right image: Tribal samplers attending water quality workshop

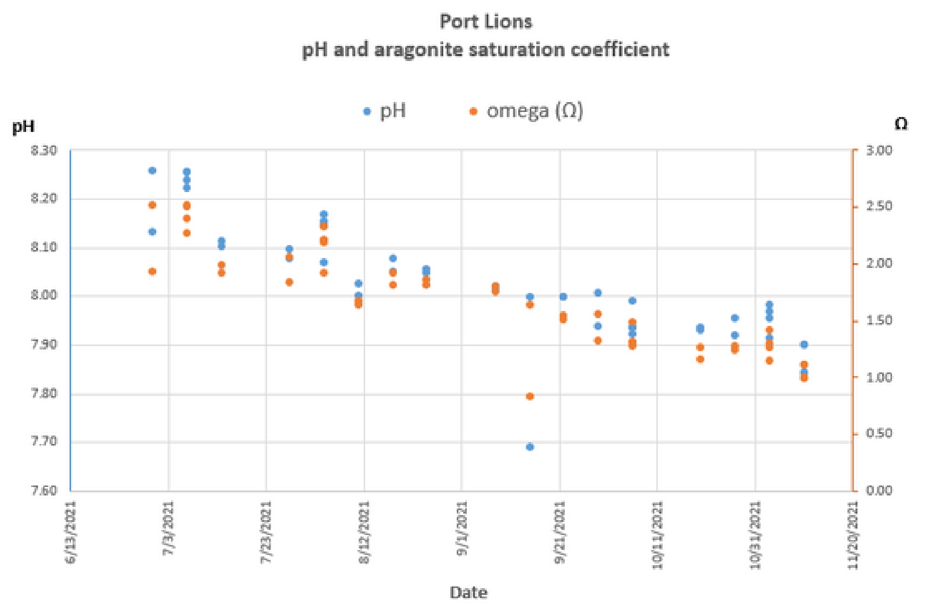
What Parameters do Tribal Environmental Samplers Help Monitor?

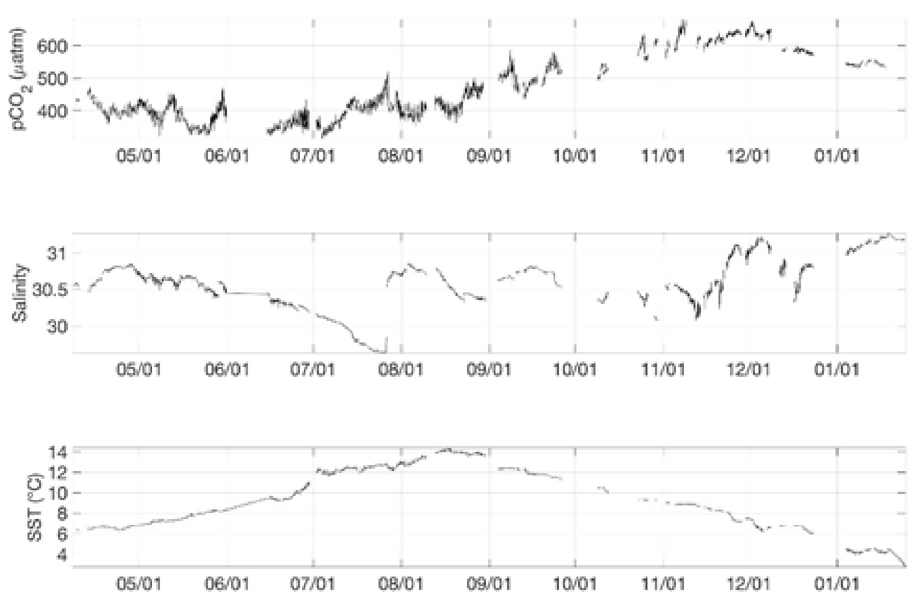
Parameter	Description
Temperature	The temperature of the water is collected with a thermometer in degrees Celsius (°C). Temperature can impact the ability of water to hold gasses, including carbon dioxide. Colder waters are able to hold more carbon dioxide than warmer waters.
Salinity	Salinity is a measurement that describes how salty the water is, or how much dissolved salts are present in the water. The measurements are recorded in parts per thousand, or ppt. There is a strong relationship between salinity and alkalinity, another important water quality parameter (see alkalinity on page 6).
Dissolved Oxygen (DO)	Dissolved oxygen, or DO, describes how much oxygen is dissolved in the water. DO levels impact the overall health of ocean ecosystems and can therefore impact a variety of chemical processes in the ocean. Colder waters are able to hold more dissolved oxygen than warmer waters.
Acidity (pH)	pH is measured on a logarithmic scale, that describes how acidic or alkaline the water is. The pH scale ranges from 0 to 14, with lower values being more acidic. A decrease in pH levels is what is called “acidification.” The global average pH of the ocean is 8.1

Parameter	Description
Partial CO_2 (pCO_2)	pCO_2 is the carbon dioxide dissolved in seawater. Seasonal trends around Alaska tend to follow a pattern of higher values in the winter and lower values in the summer, because sunlight fuels the growth of phytoplankton, which absorb CO_2 by photosynthesis.
Total CO_2 (TCO_2)	TCO_2 stands for total inorganic carbon dioxide, which measures the total of all forms of carbon in the water. Carbon can exist in small amounts as a gas, combined with water as carbonic acid, as a bicarbonate ion (most common), or as a carbonate ion.
Alkalinity	Alkalinity is a measure of the water's ability to resist changes in pH. A higher value indicates that the water is more likely to keep a stable pH even when ocean chemistry is changing. Alkalinity usually decreases as salinity decreases.
Aragonite Saturation Coefficient (Ω)	Aragonite saturation can be thought of as the favorability of the water for shell builders to build their shells. Alaska is already experiencing low aragonite saturation levels in some places on a seasonal basis (AOOS). One impact of ocean acidification is a decrease in carbonate ions, which makes it difficult for shell-building organisms, like clams and crabs, to build their shells.

Examples of Preliminary Data

The data shown in this graph is a result of tribal samplers in Port Lions conducting weekly water sampling from June to November 2021. The graph shows the results for pH and aragonite saturation coefficient (Ω) over time. This graph provides us with valuable information about seasonal trends in Port Lions, and how multiple parameters can impact each other. Collecting this data consistently will allow for comparisons over multiple seasons and years.





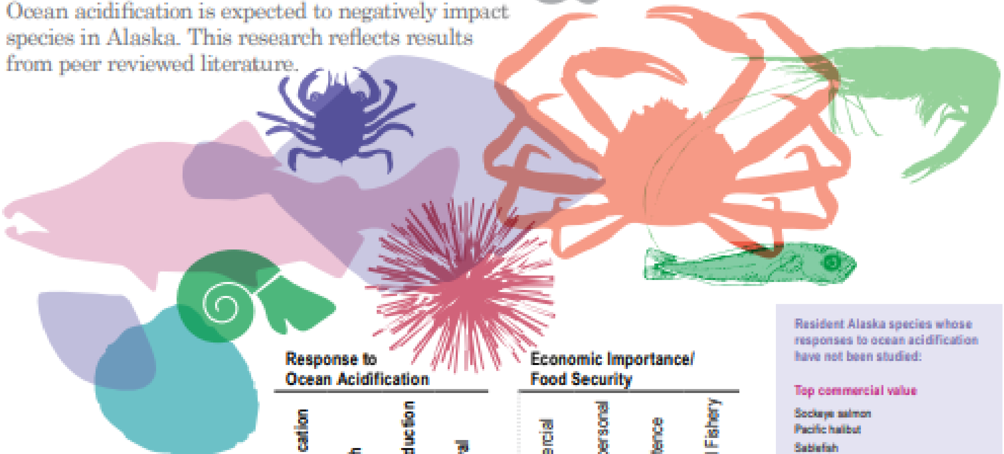
This graph shows pCO_2, Salinity, and Sea Surface Temperature (SST) measurements from Trident Basin. The labels on the x-axis indicate the first day of each month, for example 05/01 indicates May 1st. This graph shows measurements from May to January of 2019. Continuous datasets like this one allow us to observe change over time and better understand why and how ocean acidity is changing.

Data presentation courtesy of Switgard Dursterloh, Kodiak NOAA Laboratory and Wiley Evans, Hakai Institute.

Alaska Ocean Acidification Network

Impacts of Ocean Acidification on Alaska Fish & Shellfish

Ocean acidification is expected to negatively impact species in Alaska. This research reflects results from peer reviewed literature.



Resident marine species		Response to Ocean Acidification: Calcification	Growth	Reproduction	Survival	Economic Importance/ Food Security: Commercial	Sport/personal	Subsistence	Closed Fishery
Red king crab	Embryo				—	●	●	●	◓
	Larvae	▲			▼				
	Juvenile	—	▼		▼				
	Adult	▲							
Dungeness crab*		▼	▼	—	▼	●	●	●	
Blue king crab	Juvenile	▲	▼		▼	●		●	◓
Golden king crab	Juvenile		▼		▼	●	●		
Tanner crab	Embryo				▼	●	●	●	
	Larvae	▼			▼				
	Juvenile	▼	▼		▼				
	Adult	▼							
Snow crab	Embryo				—	●	●		
	Larvae	—			—				
	Adult	▼							
Pink salmon*	Juvenile	N/A	▼	▼		●	●	●	
Pacific Cod	Larvae		▲▼						
Northern rock sole	Embryo	N/A	—		—	●		●	
	Larvae	N/A	▼		▼				
Walleye pollock*	Embryo	N/A	—		—	●		●	
	Larvae	N/A	—		—				
Northern shrimp*			▼		▼	●		●	
Pteropod	Juvenile, Adult	▼			▼				
Pinto abalone	Adult		▼						●
Baltic clam*		▼	▼	▼	▼		●	●	
Common cockle*		▼	▼				●	●	
Red sea urchin*				▼				●	

*Non-Alaska populations studied

KEY: ▲ Increase ▼ Decrease ▲▼ Mixed — Unaffected N/A Not applicable ◓ Only certain populations

NOTE: The species listed above are the *only* Alaska species that have been studied to date.

Resident Alaska species whose responses to ocean acidification have not been studied:

Top commercial value

Sockeye salmon
Pacific halibut
Sablefish
Chum salmon
Atka mackerel
Yellowfin sole
Pacific rockfish
Chinook salmon
Coho salmon
Rockfishes
Pacific herring

Highest biomass in bottom trawl surveys

Pacific ocean perch
Giant grenadier
Atka mackerel
Pacific sleeper shark
Salmon shark
Yellowfin sole
Redstripe rockfish
Canary rockfish
White sea urchin
Arrowtooth flounder
Pacific hake
Shortraker rockfish
Clonal plumose anemone
Sharpchin rockfish
Silvergray rockfish

Other important species

Broad whitefish
Capelin
Crescent gunnel
Dolly varden
Longfin smelt
Ninespine stickleback
Pacific sand lance
Rainbow smelt
Threespine stickleback
Sidestriped shrimp

Acknowledgments:
Results from peer reviewed literature. Data compiled by the Alaska Ocean Acidification Network.
https://aoos.org/alaska-ocean-acidification-network/

Partners: Alaska Ocean Observing System, Alaska Fisheries Science Center (NOAA Fisheries), University of Alaska Fairbanks (Kelley Lab)

JUNE 2021

We would like to extend a special thank you to all the tribal community samplers and partners that make this work possible. Your sampling efforts contribute to larger statewide monitoring that will provide a better understanding of ocean acidification in our region and across Alaska!

KODIAK AREA NATIVE ASSOCIATION

For more information, please visit our website *kodiakhealthcare.org*
or contact the Environmnental Coordinator at *andie.wall@kodiakhealthcare.org*

Photography by Hallie Brown, Phil Lampron, and Andie Wall