Ocean Acidification in Glacier Bay

Is it really happening in Glacier Bay?
How do we know?

Principal Researchers:
Stacey C. Reisdorph (University of Alaska-Fairbanks)
Dr. Jeremy T. Mathis (NOAA-PMEL/University of Alaska Fairbanks)
Lewis Sharman (National Park Service)

Project Dates:
-Oceanographic sampling July 2011–July 2014;
-Data analyses/reporting through July 2015

Did You Know?

Seawater's alkalinity (a chemical property) gives it the ability to buffer against decreases in pH. In other words, seawater is naturally "basic" rather than "acidic." Glacial meltwater, however, has lower alkalinity than seawater. When glacial runoff is added to the marine waters of Glacier Bay, it dilutes the ocean's alkalinity, allowing the atmospheric CO_2 taken up by the surface waters to more easily cause a decrease in pH, leading to ocean acidification (OA).

"CTD" instrument used to measure water properties and sample seawater for chemical analyses.

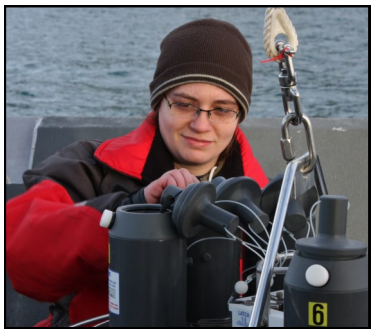
Introduction

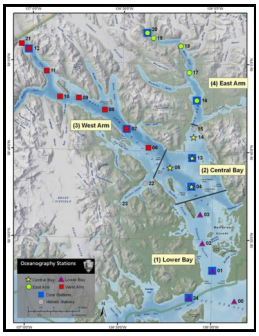
When the surface waters of Glacier Bay absorb CO_2 from the atmosphere, the CO_2 reacts with seawater and produces a series of chemical reactions that ultimately reduce seawater pH. This takes the form of reductions in carbonate ion concentrations and the saturation states of the biologically-important calcium carbonate minerals calcite and aragonite (used by marine organisms in the formation of shell and bone). Saturation states serve as a numerical index to describe water chemistry in terms of the degree of OA. When the saturation state is greater than 1.0, waters are considered supersaturated with respect to calcium carbonate minerals (generally "good). This means there is an abundant supply of these minerals for calcifying organisms to use. However, continued ocean acidification causes many parts of the ocean to become *under*saturated with respect to these minerals (saturation state <1.0, generally "bad"), which likely impacts the ability of some organisms (e.g., clams, snails, some larval fishes) to produce and maintain their shells or skeletons. In some cases, undersaturated conditions can actually be corrosive to shelled organisms. While increased CO_2 emissions and uptake by ocean surface waters are typically thought to be the major cause of OA in marine systems, this is only part of the story in Glacier Bay. Additions of glacial meltwater are also important.

Methods

Researchers carried out near-monthly oceanographic water sampling between July 2011 and July 2012, after which the sampling frequency was semi-annual (mid-summer and mid-winter) through July 2014. We described OA-related characteristics at locations throughout Glacier Bay using a combination of methods. We generated vertical water profiles of basic oceanographic parameters using a Conductivity-Temperature-Depth ("CTD" - see images) probe that continuously records water temperature, salinity, and depth as it is lowered through the water column from the surface to the bottom. At the same time, we collected discrete water samples from pre-determined depths.

We used the resulting data to describe water chemistry and to detect any seasonal patterns in ocean acidification events. We performed chemical analyses for dissolved inorganic carbon (including CO_2), alkalinity, and the nutrients phosphate, nitrate, and silicate. Those results were then used to calculate saturation states with respect to calcium carbonate minerals important to shell-building organisms.





Findings

Our data show that ocean acidification occurs seasonally in Glacier Bay. Glacier Bay experiences seasonal aragonite undersaturation events that vary in intensity and extent throughout the year. During the spring and summer "growing season," phytoplankton remove dissolved CO_2 from the surface waters because they use it for photosynthesis. This contributes to increases in calcium carbonate saturation states (good). However, during these same seasons, atmospheric temperatures are highest, which accelerates glacial melting. This low-alkalinity glacial meltwater flows into the ocean and reduces the alkalinity of surface waters, thus leading to net reductions in aragonite saturation states (bad).

Surface waters with the highest percentage of fresh water (i.e., within the "arms" of upper Glacier Bay) directly corresponded to areas of aragonite undersaturation or near-undersaturation. This was most notable during the peak glacial melt season, and can influence waters throughout the bay. Low saturation states were well correlated with the timing of maximum glacial discharge events, and they were most prominent within the two arms where glacial discharge was highest. Saturation states with respect to aragonite reached a minimum of 0.40 (undersaturated) at the surface during the summer of 2011 before returning to supersaturated conditions (saturation states >1.0) in the winter and early spring of 2012 when glacial melt was greatly reduced. Also in spring, as phytoplankton growth (photosynthesis) accelerated with the return of longer days and more sunlight, some dissolved inorganic carbon (CO_2) was removed from the surface waters. This caused an increase in the aragonite saturation states before conditions in the upper arms became undersaturated once again during the summer with increasing glacial runoff.

Learn More

NOAA-PMEL Carbon Program: http://www.pmel.noaa.gov/co2/
NOAA-PMEL Ocean Acidification: http://oceanacidification.noaa.gov/