The effect of ocean acidification on marine nitrification

Motivation

Nitrification is an important process in the marine nitrogen (N) cycle in which microbes utilize the oxidation of ammonia (NH$_3$) to nitrate (NO$_3^-$) to reduce carbon dioxide (CO$_2$) into organic carbon. Previous work has suggested that ocean acidification (OA) may cause a decrease in oceanic nitrification rates. In contrast to experiments in the open ocean, OA nitrification experiments in coastal waters have shown neutral or positive effects. A reduction in nitrification may cause a redistribution in the bioavailable N species supplied to phytoplankton communities. The availability of N species in the ocean shapes planktonic communities and processes, which can have a profound effect on organic matter export from the surface ocean to the deep, affecting food webs, fisheries, and C sequestration in the interior ocean. It is vital to understand the interaction between OA and nitrification in order to better predict the effects of climate change on the future ocean.

Goals

The objective of this study is to examine the effect of OA on nitrification rates in an urbanized estuary (Hood Canal, WA) that experiences relatively large variations in pH due to both natural and anthropogenic activities and to assess whether regular exposure to relatively acidic conditions has preconditioned resident nitrifiers to be more tolerant to OA.

Accomplishments

Sample and hydrographic data collection and analysis

A custom-built, autonomous in situ incubator (McLane Labs Inc.) was used to carry out nitrification experiments. At pre-programmed times, water samples were taken into Tedlar bags which were preloaded with $^{15}$NH$_4^+$ tracer and different amounts of HCl to mimic pH decreases of 0 (control), 0.3, and 0.7. Nitrification rates were determined by measuring the production of $^{15}$NO$_3^-$ from the $^{15}$NH$_4^+$ tracer. The incubator was programmed to carry out one OA nitrification experiment per month during the spring transition March – May 2020.

The incubator was moored below the euphotic zone in Hood Canal, adjacent to the Hoodsport Oceanic Remote Chemical Analyzer (ORCA) buoy (Northwest Environmental Moorings, UW/Applied Physics Lab), from March – July 2020 by the PMEL Engineering Development Division using the R/V S.P. Hayes (Fig. 1). The ORCA buoy profiled the water column up to 4 times per day measuring hydrographic parameters (temperature, salinity, O$_2$, and surface pH) during the course of this experiment.

Figure 1. Markers are locations of all ORCA buoys. The Hoodsport ORCA buoy, the location of the incubator in this study, is the furthest west marker.
Due to COVID restrictions placed on the crew of the R/V Hayes at the time of the target incubator recovery date (May 2020), Gravity Marine (Fall City, WA) was contracted to carry out the recovery operation. The first recovery attempt (July 3) failed due to a problem with the acoustic release. The second attempt employed an underwater remote operated vehicle (July 14 – 17) and was ultimately successful (Fig. 2).

The incubator deployment was overall successful. It took a full set of 48 samples over the course of three OA experiments on: 1) March 25, 2) April 20, and 3) May 15. Samples were aliquoted for the following analyses: stable isotopes ($^{15}$NO$_3^-$, $^{15}$NO$_2^-$, $^{15}$N$_2$O), nutrient concentrations (NO$_3^-$, NO$_2^-$, NH$_4^+$, PO$_4^{3-}$, SiO$_4^{2-}$), and pH (Fig. 3).

**Preliminary results**

The first of the three OA experiments (March 25, 2020) has been analyzed (Fig. 4). The nitrification rates for each treatment were: 0.82 nmol L$^{-1}$ d$^{-1}$ ($\Delta$pH = 0/control), 0.73 nmol L$^{-1}$ d$^{-1}$ ($\Delta$pH = -0.3), and 0.93 nmol L$^{-1}$ d$^{-1}$ ($\Delta$pH = -0.7). The regressions for all three treatments were significant ($p < 0.01$). Additionally, the slopes of the regressions were compared using a t-test and both the $\Delta$pH = -0.3 or -0.7 were not significantly different from the control ($p < 0.05$). These preliminary results suggest that nitrifiers in Hood Canal at the time of this experiment were not affected by a decrease in pH of up to 0.7 which supports the argument that regular exposure to relatively acidic conditions has preconditioned resident nitrifiers to be more tolerant to OA. This is the first data to be reported from the novel in situ incubator commissioned by the PMEL Innovative Technology for Arctic Exploration.
Due to COVID restrictions, sample analyses have been delayed. We need to finish analyzing samples (nutrients, $^{15}$NO$_3^-$, pH) from the remaining two OA experiments (April 20 and May 15) and write up results for publication in peer-reviewed journal.

Additional participants
Calvin Mordy – PMEL/Innovative Technology for Arctic Exploration
Nicolas Delich – PMEL/Engineering Development Division
Timothy Nesseth – PMEL/Engineering Development Division
Daniel Devereaux – PMEL/Engineering Development Division
Laura Bristow – University of Southern Denmark/Department of Biology
Beth Curry – UW/Applied Physics Lab/Washington Ocean Acidification Center
Chris Archer – UW/Applied Physics Lab/Washington Ocean Acidification Center