The Effects of Ocean Acidification on Bonefish (*Albula vulpes*)

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Introduction:

Ocean acidification is expected to be a consequence of global climate change. Since the Industrial Revolution, there has been a gradual increase in CO_2 released into the atmosphere due to anthropogenic influences (Figure 1). Because gas concentrations tend towards equilibrium, the increasing amount of CO_2 in the atmosphere results in a greater amount of CO_2 in the ocean (Figure 2) (Brierley et al. 2009). This leads to an increased concentration of H+ ions and therefore a decrease in ocean pH.

Figure 1. Factories emitting carbon dioxide.

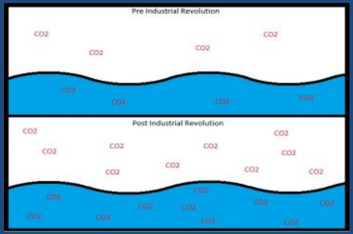

Figure 2. Pre Industrial Revolution there is much lower quantity of CO2 in both the atmosphere and the ocean. Due to human activity post Industrial Revolution, mass amounts of CO2 have been released into the atmosphere, and dissolved into the oceans.

Marine ecosystems in the tropics are especially susceptible to climate change (Pörtner et al. 2008). A common ecosystem in the tropics is flats (Figure 3), which experience regular fluctuations in temperature, salinity, and acidity. The species living in this ecosystem are adapted to these varying conditions. Bonefish commonly use this ecosystem often traveling in with incoming tides to feed and back out with the outgoing tides. Bonefish are economically important to The Bahamas, bringing in \$141 million yearly (Danylchuk et al. 2007). However, there has been little research done on the effects of climate change on bonefish (Roessig et al. 2004).

Figure 3. A mangrove flat, the bonefish's natural habitat.

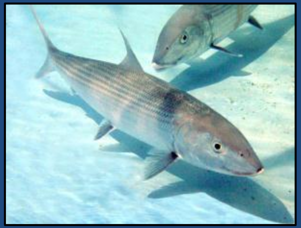

Figure 4. A bonefish in a tank at The Cape Eleuthera Institute (CEI).

Purpose: To determine the pH tolerance limits of bonefish at which they lose equilibrium, in order to see the potential effects climate change may have on bonefish in the future.

Hypothesis: The critical pH limit will be below the pH of 7.

Methods: Critical pH experiment

Bonefish were caught using seine nets. Fish were transferred to the Cape Eleuthera Institute (CEI) wet lab and given one week to acclimate. For the experiment four bonefish were transferred into individual totes and given fifteen minutes to acclimate. The pH was decreased by adding CO_2 using a solenoid by approximately 0.1 units every two minutes. Ventilations – defined as one cycle of the gills opening and closing – were counted for fifteen seconds at a time, every two minutes. The process was continued until the fish lost equilibrium, which is when the fish flips over completely and is unable to turn back over (Figure 5) (Shultz et al. 2011).

Figure 5. A bonefish that has lost equilibrium.

Figure 6. Performing the critical pH experiment.

Results:

Bonefish (mean FL of 401.92 cm ± 10.92 SE) were exposed to a steady decrease in seawater pH from a mean pH of 8.16 units ± 0.17 SE until they lost equilibrium at a mean pH of 6.16 units ± 0.09 SE over a mean time of 54 minutes ± 3.13. As pH decreased over time the following behaviors were noted: gasping at the surface for air and erratic movement until the bonefish lost equilibrium. The ventilations per 15 seconds decreased as the pH decreased (Figure 7).

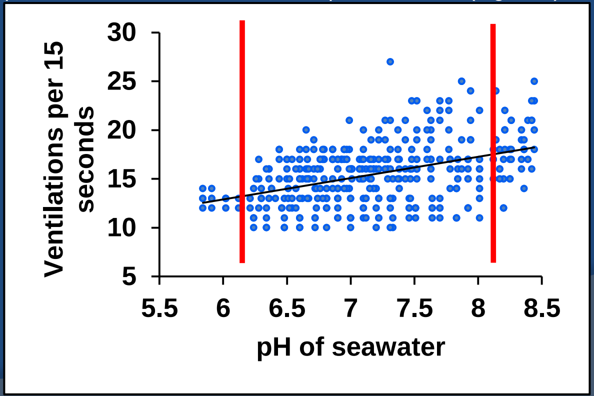

Figure 7. The number of ventilations per 15 seconds over pH. The line on the left represents the mean pH at which bonefish lost equilibrium (6.16 units) and the line on the right represents the typical pH of sea water (8.1-8.2).

Discussion:

Loss of equilibrium occurred at a pH lower than 7 units. This is relatively low because pH is variable in shallow water systems due to an accumulation of fresh water from rain storms. Fresh water has a pH of 7 units, which is lower than that of ocean water with a pH of 8.1-8.2 units. Although the tolerance level of bonefish is low (6.16 units), a similar study shows tetras fish that are exposed to naturally low pH waters have a pH tolerance of 3.5 units. This indicates that bonefish are exposed to some variation in pH but conditions are not as extreme as some tropical backwater species. (Dunson et al. 2005).

The bonefish's ventilations decreased as pH dropped because bonefish have chemoreceptor cells that sense CO_2 concentrations. With a high accumulation of CO_2 in seawater there are excess free H+ ions. H+ ions can easily diffuse through a gradient and into the fish's blood stream. With the presence of H+ ions and CO_2 in the fish's blood stream at a certain pH the fish will lose equilibrium because all cells operate at an optimum pH (Hill et al. 2008).

According to the Intergovernmental Panel on Climate Change, pH is expected to drop 0.3-0.4 units by 2100 – pH levels that are still within the tolerance levels of bonefish (Dixson et al. 2010). However, it is uncertain how other flats species may be affected by lowering pH levels indirectly affecting bonefish.

Topics of interest for future studies include how pH cascades down the ecosystem and the behavioral affects of lowering pH on bonefish faced with predation.

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