This project focuses on the effects increasing atmospheric carbon dioxide has on organisms inhabiting aquatic environments. The global mean concentration of CO_2 in the atmosphere is 398 ppm, up from 290 ppm at the beginning of the industrial age. Due to air-sea gas exchange, the rise in CO_2 is "acidifiying" the ocean, thereby threatening aquatic life, especially organisms with shells or otoliths composed of calcium carbonate.

Project Name
Potential Impact of Ocean Acidification on Estuarine and Marine Fish

Who cares and why?

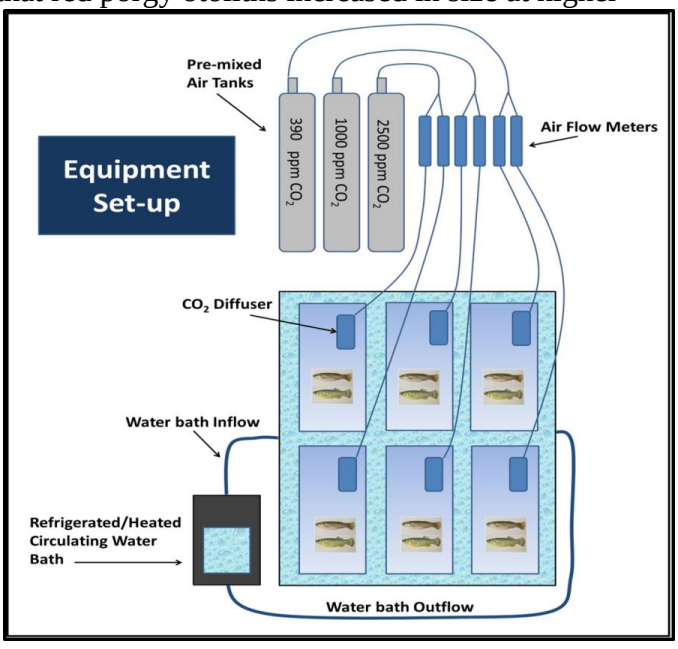
The increase in atmospheric carbon dioxide due to the burning of fossil fuels, cement manufacturing and land use changes is expected to increase from its present concentration of 398 ppm to 1000 ppm by the year 2100. The world's oceans absorb one-third of the anthropogenic carbon dioxide. Therefore, the predicted decrease in oceanic pH is approximately 0.5 units, causing a more acidified ocean.

The impact of ocean acidification (OA) on estuarine and marine fish, as well as calcifiers, such as coccolithophorids, corals and mollusks, is of utmost importance to assess. Thus far, this study has been seeking to determine OA's impact on fish otoliths, or "earbones", which are composed of calcium carbonate and could be impacted by more acidic conditions. Fish use otoliths for hearing and to aid in their sense of balance, and acceleration. A change in fish otolith shape and/or size could negatively affect fishes' interaction with their environment, including their ability to obtain food and avoid predators.

What has the project done so far?

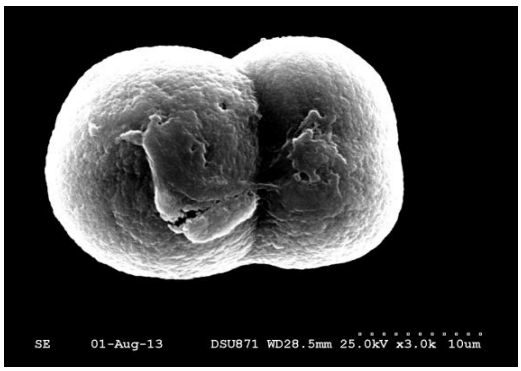
Two species of larval fish under three CO_2 treatments have been grown under the current atmopheric concentration, 390 ppm, the predicted 2100 level of 1000 ppm, and an extreme level of 2500 ppm. Sagittal otolith pairs were then extracted from each larval fish. The otolith pairs were then imaged using a scanning electron microscope. Sizes of images were compared using the program Image J. Other parameters measured in the water were pH, alkalinity, temperature, aragonite (calcium carbonate) saturation state and the partial pressure of carbon dioxide was calculated.

The estuarine fish species was the mummichog (*Fundulus heteroclitus*). The results showed no difference in otolith size between the three treatments. A marine fish species was also studied. This was the red porgy (*Pagrus pagrus*). The red porgy was reared under the same CO_2 treatments as the mummichog; however, there was a statistical difference between trreatments for the red porgy otoliths. Although calcium carbonate usually dissolves under acidic conditions, this study found that red porgy otoliths increased in size at higher



aquatic carbon dioxide partial pressures. This was expected as other studies showed similar outcomes.

The study also found many of the larval fish grew deformed otoliths. Some fish, both mummichogs and red porgy, had overly crystallized otoliths. Red porgy were the only fish to present double otoliths.



In addition, the double otoliths in red porgy were only associated with higher carbon dioxide concentrations.es.

Impact Statement

Estuarine fish experience a wider range of fluctuations in water temperature and pH than marine species; therefore, marine fish species may be more susceptible to ocean acidification thatnestuarine fish species.

Ocean acidification may have a detrimental effect on marine fish otolith shape and size, which in turn impacts fish hearing, balance and acceleration.

Deformed otoliths were found in mummichogs and red porgy. Red porgy otolith deformations were only associated with higher carbon dioxide concentrations.

What research is needed?

More ocean acidification research is necessary to determine the potentially devastating effects of ocean acidification on aquatic organisms, especially marine fish. Thus far, only a handful of fish species have been studied, with some studies determining that OA can impact fish-environment interactions. In addition to laboratory "microcosm" studies, outdoor "mesocosm" studies - studying fish in a more natural habitat - could add more dimension to the growing body of knowledge about increased carbon dioxide in the aquatic environment and climate change and ocean acidification implications in general.

Want to know more?

Dr. Stacy Smith
slsmith@desu.edu, (302) 857-7668

Strategic Priority: Climate Change; natural resources and the environment
Additional Links: http://www.umes.edu/ard/Default.aspx?id=46285
Year and Institution: 2014, Delaware State University, 1200 N. Dupont Highway, Dover, DE 19901

Funding

This project was supported by NOAA EPP/Living Marine Resources Cooperative Science Center