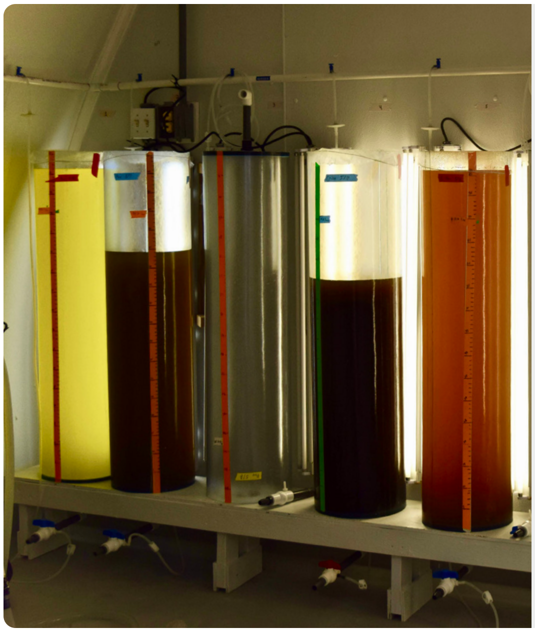
AQUACULTURE AND CLIMATE CHANGE:

Ocean Acidification

Gulf of Maine Research Institute



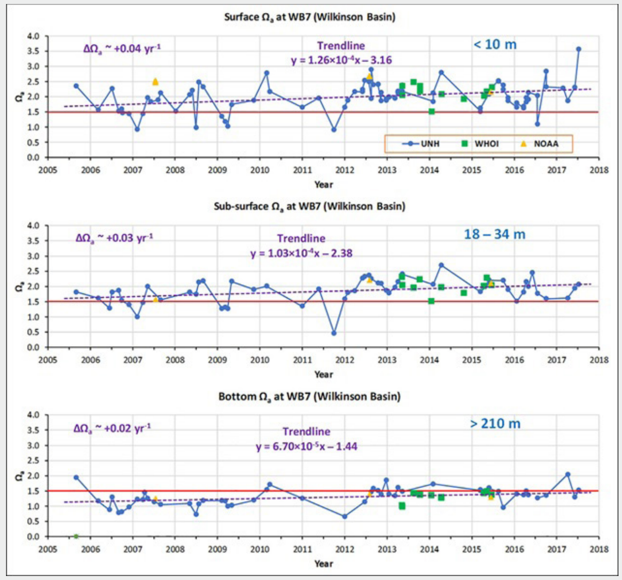


Figure: Aragonite saturation rate at select locations in the Gulf of Maine between 2005-2018. Saturation rates above 1.5 reduce the ability of shellfish to form shells. Credit: Siedlecki et al., 2021

Overview

Ocean acidification (OA) is the result of several earth system processes that cause the pH levels in the ocean to decrease. One of the primary causes of OA is due, in part, to the role the ocean plays in absorbing excess carbon dioxide from the atmosphere. The absorbed carbon reacts with the ocean water, creating carbonic acid. Since the pre-industrial era, ocean acidity has already increased 30%. As the ocean acidifies, it becomes harder for shellfish to build shells, making them more vulnerable to predation, and increases the stress placed on major organs, especially at early stages of life. As OA progresses, aquaculturists are likely to encounter difficulties catching wild spat (young shellfish), a process that is integral to many operations.

Common Impacts

- **Future of OA:** The ocean is on track for a 0.2–0.3 unit decline in pH by 2100. Because acidity is determined on a logarithmic scale, this equates to an ocean environment that is up to 100% more acidic.
- **Shell Formation:** The main threat of acidification is its impact on shellfish's ability to form shells by reducing the availability of carbonate, a key building block. With weaker shells, shellfish are at a higher risk of predation, lower rates of metabolism, and lower resistance to diseases.

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(Common impacts continued)

- **Byssal Threads:** Some shellfish, like mussels, rely on byssal threads to attach and settle on host objects so they can grow. These byssal threads are considerably weaker under acidic conditions, leading to further challenges for the success and survival of mussels. This is particularly impactful for mussel farmers who rely on mussels to settle on grow out gear set in the ocean. Weaker byssal threads can mean fewer wild caught spat (juvenile shellfish) and potential loss of product due to detachment.
- **Environment of Stress:** Acidification also amplifies other stressors like ocean warming and reduced food availability. In several lab-controlled studies, the impact of acidic water was greatest when combined with other environmental stressors, such as warm water or large swings in salinity.

Risk Mitigation Strategies

- **Hatchery reliance:** Controlled environments for early life stages reduce vulnerability during critical growth phases, reduces harvest pressure on wild spat, and improves the mortality rate of shellfish in juvenile stages of life.
- **Diversification:** Several trials have explored the ability of macroalgae to reduce the impact of acidification at specific sites. If this proves successful, growing macroalgae, such as kelp, near shellfish farms could buffer them from the impacts of acidification.
- **Shell Return:** A potentially promising strategy is to collect and return used and empty shells to the ocean, creating artificial reefs that can boost the availability of building blocks for shell formation and increase the area where wild shellfish can settle.

Case Studies

Projects, like the Basin Oyster Project, seek to understand how artificial oyster reefs impact shellfish growth cycles as well as local impacts of acidification. As an added benefit, projects like these can help to divert spent oyster shells from landfills to more ecologically beneficial uses.

These resource sheets were created in collaboration with the USDA Northeast Climate Hub to improve understanding of the likely impacts of climate change on the region's aquaculture industry. If you have questions, or would like to learn more, you can reach out to jwildwistle@gmri.org, cmaurin@gmri.org, or scan the QR Code to see a list of resources used in the creation of these materials.