Ocean acidification killing oysters by inhibiting shell formation, study finds

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A screen covered with oyster larvae, taken in 2007 at the Whiskey Creek Shellfish Hatchery near Netarts Bay, Ore. Credit: Lynn Ketchum, Oregon State University

(Phys.org) —For the past several years, the Pacific Northwest oyster industry has struggled with significant losses due to ocean acidification as oyster larvae encountered mortality rates sufficient to make production non-economically feasible.

Now a new study led by researchers at Oregon State University has documented why oysters appear so sensitive to increasing acidity. It isn't necessarily a case of acidic water dissolving their shells, researchers say. Rather it is a case of water high in carbon dioxide altering shell formation rates, energy usage and, ultimately, the growth and survival of the young oysters.

Results of the study have been published online in the journal *Geophysical Research Letters*.

"From the time eggs are fertilized, Pacific oyster larvae will precipitate roughly 90 percent of their body weight as a calcium carbonate shell within 48 hours," said George Waldbusser, an OSU marine ecologist and lead author on the study. "The young oysters rely solely on the energy they derive from the egg because they have not yet developed feeding organs."

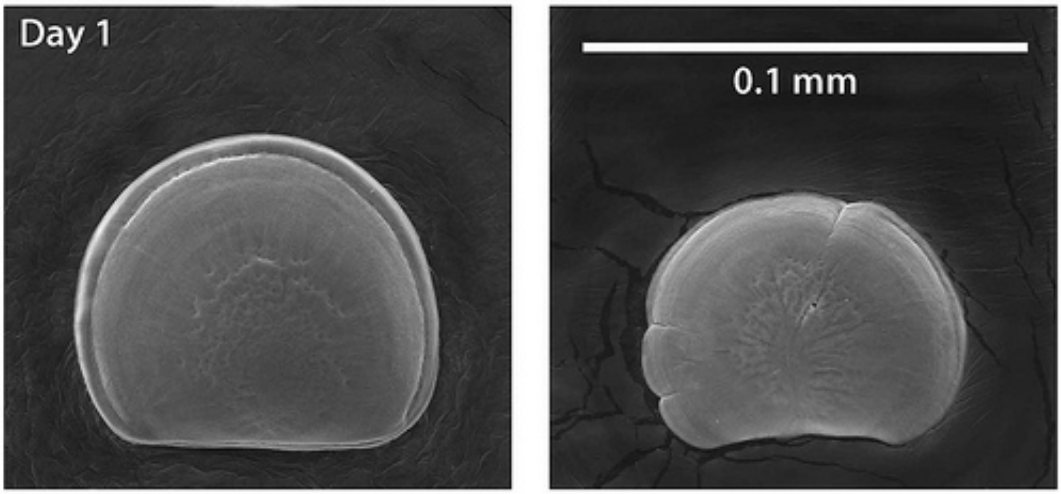
Under exposure to increasing carbon dioxide in acidified water, however, it becomes more energetically expensive for organisms to build shell. Adult oysters and other bivalves may grow slower when exposed to rising CO2 levels, other studies have shown. But larvae in the first two days of life do not have the luxury of delayed growth, the researchers say.

"They must build their first shell quickly on a limited amount of energy – and along with the shell comes the organ to capture external food more effectively," said Waldbusser, who is in OSU's College of Earth, Ocean, and Atmospheric Sciences. "It becomes a death race of sorts. Can the oyster build its shell quickly enough to allow its feeding mechanisms to develop before it runs out of energy from the egg?"

The study is important, scientists say, because it documents for the first time the links among shell formation rate, available energy, and

sensitivity to acidification.

"The failure of oyster seed production in Northwest Pacific coastal waters is one of the most graphic examples of ocean acidification effects on important commercial shellfish," said Dave Garrison, program director in the National Science Foundation's Division of Ocean Sciences, which funded the study. "This research is among the first to identify the links among organism physiology, ocean carbonate chemistry and oyster seed mortality."



This image shows 1-day old Pacific oyster larvae from the same parents, raised by the Taylors Shellfish Hatchery in natural waters of Dabob Bay, Wash. The larvae on the left were reared in favorable carbonate chemistry; on the right in unfavorable chemistry. The waters were not manipulated and differences in the chemistry were accounted for by shallow and deep water intake pipes at the hatchery. The 0.1 mm scale bar is about the diameter of a human hair. Credit: George Waldbusser and Elizabeth Brunner, Oregon State University

The authors say that the faster the rate of shell formation, the more energy is needed and oyster embryos building their first shell need "to

make a lot of shell material on short order."

"As the carbon dioxide in seawater increases, but before waters become corrosive, calcium carbonate precipitation requires significantly more energy to maintain the higher rates of shell formation found during this early stage," Waldbusser said.

The OSU researchers worked with Whiskey Creek Shellfish Hatchery in Netarts Bay, Ore., on the study. Using stable isotopes, they found that on the second day of life, 100 percent of the larval tissue growth was from egg-derived carbon.

"The oyster larvae were still relying on egg-derived energy until they were 11 days old," said Elizabeth Brunner, a graduate student working in Waldbusser's laboratory and co-author on the study.

The earliest shell material in the larvae contained the greatest proportion of carbon from the surrounding waters, with increasing amounts of carbon from respiration incorporated into the shell after the first 48 hours, indicating ability to isolate and control shell surfaces where calcium carbonate is being deposited.

Waldbusser notes that adult bivalves are well-adapted to grow shell in conditions that are more acidified, and have evolved several mechanisms to do including use of organic molecules to organize and facilitate the formation of calcium carbonate; pumps that remove acid from the calcifying fluids; and outer shell coatings that protect the mineral to some degree from surrounding waters. These adaptations allow bivalves to generate calcium carbonate more rapidly than is possible without biological intervention.

The study notes that kinetics, or the rate of reaction, provides a physical constraint on the calcification process in seawater absent of life; for

calcium carbonate the rate is proportional to the amount of carbon dioxide (CO_2) present, before water actually becomes corrosive to the mineral

Waldbusser said the study helps explain previous findings at Whiskey Creek Hatchery of larval sensitivity to waters that are elevated in CO_2 but not corrosive to calcium carbonate. They also explain carryover effects later in larval life of exposure to elevated CO_2, similar to neonatal nutrition.

The discovery may actually be good news, scientists say, because there are interventions that can be done at the hatcheries that may offset some of the effects of ocean acidification.

Some hatcheries have begun "buffering" water for larvae – essentially adding antacid to the incoming water – including the Whiskey Creek Hatchery and the Taylor Shellfish Farm in Washington. The OSU-led study provides a scientific foundation for the target level of buffering.

"Whiskey Creek Hatchery figured this out by trial and error in the last couple years arriving at an amount of buffering that was more than we initially thought would be needed," Waldbusser said. "On the energy side, you can make sure that eggs have more energy before they enter the larval stage, so a well-balanced adult diet may help larval oysters cope better with the stress of acidified water."

Breeding for specific traits is another strategy, researchers say. Chris Langton, a co-author on the study, who for years directed the Molluscan Broodstock Program at OSU's Hatfield Marine Science Center in Newport, Ore., is leading an effort to use selective breeding to isolate certain favorable traits in oysters.