Ocean acidification means major changes for California mussels

January 7, 2018

McCoy and her team found that ocean acidification has begun to change California mussel shells on a basic structural level. Credit: Sophie McCoy

Accelerating ocean acidification could be transforming the fundamental structure of California mussel shells, according to a new report from a Florida State University-led team of scientists.

For thousands of years, California mussel shells have shared a relatively uniform mineralogical makeup — long, cylindrical calcite crystals ordered in neat vertical rows with crisp, geometric regularity. But in a study published this week in the journal *Global Change Biology*, researchers suggest that escalating rates of ocean acidification are shaking up that shell mineralogy on its most basic structural levels.

“What we’ve seen in more recent shells is that the crystals are small and disoriented,” said Assistant Professor of Biological Science Sophie McCoy, who led the study. “These are significant changes in how these animals produce their shells that can be tied to a shifting ocean chemistry.”

To document these changes, the research team studied an archival record of natural California mussel specimens collected from Tatoosh Island off the northwestern tip of Washington. Modern mussel shells were compared to shells from the 1970s as well as shells provided by the local Makah Cultural and Research Center dating back thousands of years.

Researchers found that while shell mineralogy had remained consistent for centuries, shell specimens collected within the past 15 years had experienced dramatic structural changes.

“When the mussels are ready to build their shells, they first lay down an amorphous soup of calcium carbonate, which they later order and organize,” McCoy said. “More recent shells have just started heaping that calcium carbonate soup where it needs to go and then leaving it there disordered.”

The team also found that recent shells exhibited elevated levels of magnesium — a sign that the process of shell formation has been disrupted.

Typically, healthy shells are composed primarily of calcium carbonate, and any magnesium incorporated in a shell is a product of trace amounts of ambient magnesium present in the environment.

“When more magnesium is found in the skeleton, it signals that the organism has less control over what it's making," McCoy said.

Increased skeletal magnesium also causes changes in the strength of important magnesium-oxygen bonds. The robustness of these bonds is an instructive proxy for the level of organization in a shell.

"When there's not a clear geometric pattern in the skeleton, the bond strengths become more variable, and that's what we're seeing in modern shells," McCoy said. "They're not being organized."

This trend toward disorganized, variable shell structures over the past decade corresponds with the rapidly increasing rate of climate change-related ocean acidification. But while these environmental stressors have rendered the California mussel particularly vulnerable, McCoy said that the same variation that stems from disordered skeletons could also offer the species a glimmer of hope.

"An important theme of climate change science is that increased variability might be the new rule," she said. "We know that climate change right now is happening faster than what the Earth has experienced before, but we also see that over these long timescales, things tend to plateau and stabilize. Variability is the basis of natural selection, and the fact that we now see so much variability in the mussels' individual traits means there is potential for natural selection to act."

McCoy first began investigating California mussel shell structure in 2009 when, soon after she began working toward her doctorate, she noticed stark visual differences between older and more recent shells.

"My job was to slice mussels in half and drill out the shell for isotope measurements, and by chance I noticed that older shells looked completely different," she said. "They were twice as thick, massive and took twice as long to cut. Eventually, we found that this was true for other older shells found at various sites throughout the region. It was sort of by accident. We could see the shells were changing, but we weren't exactly sure what was going on."

Now, years after those initial observations, McCoy and her team have found the culprit: global climate change and its destabilizing effects on our oceans.

But according to McCoy, this is no cause for outright pessimism.

"I don't know if this species will succeed in the future, but I have too much confidence in the natural processes of ecology and evolution to think that we'll have barren oceans," she said. "It's true that we might not have as many mussel species, or that their populations might be smaller and have a more restricted range, but I don't think that we'll have an ocean with no mussels."

Story Source:

Materials provided by **Florida State University**. *Note: Content may be edited for style and length.*

Journal Reference:

1. Sophie J. McCoy, Nicholas A. Kamenos, Peter Chung, Timothy J. Wootton, Catherine A. Pfister. **A mineralogical record of ocean change: Decadal and centennial patterns in the California mussel**. *Global Change Biology*, 2018; DOI: 10.1111/gcb.14013

The Ocean Carbon & Geochemistry Program (video)

January 5, 2018

This video has also been archived under the Projects tab on this website.

(Information on the Ocean Carbon and Biogeochemistry Program's ocean acidification work starts at ca. 7 minutes.)

Sponsored by NASA and NSF, the Ocean Carbon and Biogeochemistry (OCB) program was established in 2006 to coordinate and facilitate activities relevant to carbon cycle science, climate, and global change issues. The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

OCB is a network of scientists who work across disciplines, such as ocean chemistry, biology and physics, to understand the ocean's role in the global carbon cycle and the response of marine ecosystems and biogeochemical cycles to environmental change. OCB is a bottom-up organization that responds to the continually evolving research priorities and needs of its network.

Ocean Carbon and Biogeochemistry (OCB) Program (via YouTube), 18 December 2017. [Video](#).

Paving a path for the shellfish industry to adapt to ocean acidification

January 5, 2018

Shellfish growers in the Pacific Northwest have been feeling the impacts of ocean acidification for nearly a decade now and are concerned about how to keep their businesses thriving in the face of this change. Some have moved their operations to places as far flung as Hawaii. Others who operate hatcheries are ensuring their baby oysters are no longer exposed to corrosive waters by essentially putting antacid into their hatchery waters when elevated carbon dioxide waters upwell onto the coast. Scientists at Oregon State University (OSU) and at the Pacific Shellfish Institute (PSI) just started work on a project to make it easier for the shellfish industry and other stakeholders to identify potential pathways for adaptation to ocean acidification. Natural and social scientists are pooling their expertise to create tools to map which shellfish species and growing locations are most vulnerable to acidification, evaluate economic impact of ocean acidification, quantify the costs of potential adaptations, and evaluate the options most likely to succeed in avoiding adverse consequences.

Dr. David Wrathall, a geographer with OSU’s College of Earth, Ocean, and Atmospheric Science (CEOAS), is leading this work and has a keen interest in the impacts of climate change on human communities, and their livelihoods. “Climate change will have negative consequences for jobs. The key variable to reducing harmful consequences is our capacity to adapt,” he shares. The team is interested in evaluating the costs and barriers to adaptation in order to identify strategies that are most likely to succeed. Dr. George Waldbusser,an oceanographer also at the CEOAS, has been working for years to understand how shellfish, like oysters and mussels, respond to changes in ocean chemistry. He is looking forward to connecting the biological research he has been conducting to the human dimensions of this change. “This is an opportunity for us to learn how industry members are adapting and to provide them with planning tools to assess the best way to deal with acidification,” he explains.

With close to $300,000 in funding from NOAA’s Ocean Acidification Program, this team will get a sense of which shellfish operations are at highest risk to ocean acidification by identifying where mussels and oysters growing areas coincide with hot-spots of OA hazards along the Pacific Northwest coast. Wrathall explains that this mapping exercise will give them a sense of where the shellfish industry might be most affected by ocean acidification, when they will feel the effects, and how much is at stake.

Then researchers will really hone in on the “who” to understand what shellfish operations exist in these high risk regions, which shellfish are species being cultivated, the cultivation methods used, and any adaptation measures already in place. With this information in hand, the group can then assess the value each operation would gain in adapting by looking at challenges, feasibility, costs, and benefits of making a change to the operation.

Ocean chemistry conditions in the Pacific Northwest today are equivalent to what they will be in other parts of the country far in the future, and has served as an incubator for innovation in understanding and adapting to OA. Dr. Wrathall sees this region serving “as an analog for future changes that will eventually affect the rest of the world.” The novel approach applied in this new project will not only provide shellfish farmers in the Pacific Northwest with the tools they need now, but will also develop a tool set that other people around the globe can use to identify successful adaptation pathways.

Those wanting to learn more can read the project summary and main goals of the research.

Oregon State University, 2017. Press release.

The Combined Effects of Acidification and Hypoxia on pH and Aragonite Saturation in the Coastal Waters of the California Current Ecosystem and the northern Gulf of Mexico

12.29.2017

Dear Co-authors and Colleagues:

Our paper, The Combined Effects of Acidification and Hypoxia on pH and Aragonite Saturation in the Coastal Waters of the California Current Ecosystem and the northern Gulf of Mexico, has been published and is now available online and is attached. I want to sincerely thank all of the co-authors for their outstanding work and attention to detail. I greatly appreciate all of your work on this effort and excellent suggestions along the way.

[PDF download]

The Combined Effects of Acidification and Hypoxia on pH and Aragonite Saturation in the Coastal Waters of the California Current Ecosystem and the northern Gulf of Mexico

Richard A. Feely, Remy R. Okazaki, Wei-Jun Cai, Nina Bednaršek, Simone R. Alin, Robert H. Byrne, Andrea Fassbende

(2018): The combined effects of acidification and hypoxia on pH and aragonite saturation in the coastal waters of the California current ecosystem and the northern Gulf of Mexico, Continental Shelf Research, 152, 50-60, doi.org/10.1016/j.csr.2017.11.002.

New Webinar Series

12/27/2017

The California Current Acidification Network (C-CAN) is delighted to announce a new series of educational webinars in 2018. Co-sponsored by NOAA's Ocean Acidification Program and Northwest Fisheries Science Center, we have scheduled the series to run at 1 PM Pacific Standard Time (4 PM Eastern) on the 8th day of each month beginning in January 2018.

Please join us for our first C-CAN Roundtable discussion of this series on Monday, January 8 2018 at 1pm PST (4pm EST)

Forecasting pH and aragonite saturation state in the Pacific Northwest: progress and needs

Join Drs. Parker MacCready, University of Washington, and Samantha Siedlecki, University of Connecticut, the scientists who have created these models, to learn about these two forecast systems. Joe Schumacker, Quinault Indian Nation, will also share his perspective on the needs and utility of such tools. As noted above, this webinar is co-sponsored by C-CAN and NOAA Ocean Acidification Program and Northwest Fisheries Science Center, with assistance from Dr. Shallin Busch. The host for this presentation is Dr. Jan Newton, Washington Ocean Acidification Center and NANOOS.

Abstract: Ocean acidification of coastal waters is of increasing concern to local fisheries in the Pacific Northwest. This area enjoys a bountiful marine ecosystem that has supported coastal tribes, fishing communities, and a $100 million shellfish industry. The ability to forecast acidification conditions and, further, to develop useful tools for visualization and indices of impact can provide considerable benefit to diverse stakeholders. Implementation of biogeochemical tracers into high-resolution models provides regional simulations that can improve our understanding of

processes difficult to observe, investigate relationships between the ecology of marine organisms and ocean health, and generate forecasts and projections of changes to the region. Two such forecast systems now exist on the Washington and Oregon coasts. First, LiveOcean is supported by the Washington Ocean Acidification Center and provides a three-day forecast through the NANOOS portal. For decisions farther out into the future, seasonal forecasting is possible in the region with JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem, J-SCOPE, (Siedlecki et al, 2016) through the support of NOAA. Results indicate JSCOPE forecasts have measurable skill on seasonal timescales, for variables relevant to management decisions for fisheries, protected species, and ecosystem health. Skill assessment and quantification of model performance for both forecasts systems focus on key variables of interest for local shellfish species: examples include bottom oxygen for adult crab and Ω for oyster and crab larvae. Work now includes implementing a forecast specifically targeting key shellfish species in the region. We plan to showcase our initial results of these pH forecasts and targeted products, including their forecast skill, and discuss the needs of this kind of tool in the region through the eyes of the tribal users from the Quinault Indian Nation.

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More info on the series and upcoming webinars can be found on the C-CAN website at http://c-can.info/workshopswebinars/

The Fine Print: Important Notes for participating in the Webinar

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Required: Mac OS® X 10.6 or newer
Mobile attendees
Required: iPhone®, iPad®, Android™ phone or Android tablet

Please also mark your calendars for the second webinar in this series:
February 8, 2018 at 1pm PST (4pm EST)
Summary of a Workshop on Monitoring for Acidification Threats in West Coast Estuaries: A
San Francisco Bay Case Study

Presenters: Phil Trowbridge, Manager of the Regional Monitoring Program for Water Quality
in San Francisco Bay, San Francisco Estuary Institute, and Karina Nielsen, Director of the
Estuary & Ocean Science Center and Professor of Biology, San Francisco State University.

This webinar is hosted by Bruce Steele, C-CAN Steering Committee member, and Dr. Shallin

Busch, NOAA Ocean Acidification Program and Northwest Fisheries Science Center

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