Ocean acidification impacts olfactory functions of salmon

November 20, 2017

By The Cordova Times
Washington Sea Grant studies how acidity of ocean affects ability of cohos to find their way home

Researchers at the University of Washington are observing in laboratory studies that ocean acidification affects a fundamental sensory function of coho salmon, which may impact their ability to feed, avoid danger and find their way home.

While the acidification of ocean waters caused by an increase in carbon dioxide is known to stress shellfish trying to pull calcium carbonate out of seawater to form shells, a lesser known impact of growing ocean acidification is how the changing chemistry of ocean waters is messing with the brains of salmon, says Meg Chadsey, an ocean acidification specialist with Washington Sea Grant.

The Pacific Northwest shellfish industry became aware of the threat of ocean acidification in the early 2000s, when growers began to realize that acidified water was killing hatchery-spawned oysters. Now studies by Chase Williams and others with Washington Sea Grant are looking at how the behavior of coho salmon is affected by increased levels of carbon dioxide, including their ability find their way home and avoid danger.

Their research was the subject of a panel discussion on Nov. 17 during the 2017 Pacific Marine Expo in Seattle.

Salmon can smell a compound that comes from torn salmon skin and if such skin is dipped into a laboratory tank where they are swimming, the fish will swim away, Chadsey said. In research underway, Williams has been rearing juvenile coho salmon in laboratory tanks, and adding extra carbon dioxide into the water in the tank. At different levels of carbon dioxide he has run the cohos through mazes to see if they would notice and turn away from the salmon skin compound.

The salmon mazes are shaped like a letter “Y” and the salmon were put at the bottom of the “Y” while at the left side of the maze at the top the salmon skin compound would be dripped in, with none of the compound dripped into the right side of the “Y”.

When more carbon dioxide is added into the water, the salmon seemed to lose their ability to smell or respond appropriately to the predator, Chadsey said. As the concentrations of carbon dioxide increased, the fish didn’t seem able to sense the predator or to respond appropriately, she said.

Chadsey, Williams and others, led by Evan Gallagher of the UW Department of Occupational and Health Sciences, have already published some of their research work on the effects of ocean acidification on salmon and sablefish neurobehavioral function.

In one report published by Washington Sea Grant researchers noted that studies elsewhere showed that anticipated marine carbon dioxide concentrations can alter vital smell-mediated behaviors in fish, even repelling fish from prey and drawing them to predators.

No such studies, however, had examined fish in Washington state, where dissolved carbon dioxide already has reached elevated levels and waterborne chemicals cause neurobehavioral impairment in juvenile salmon. So the researchers engaged in a project to expose coho salmon and sablefish, also known as black cod, to actual and anticipated levels of carbon dioxide and to odorant signals for food, predators and schooling.

Williams and Gallagher also published in a 2016 edition of the

Society of Toxicology their research results on cadmium exposure differentially altering odorant-driven behaviors of olfactory receptors in juvenile coho salmon.

They noted that salmon exposed to waterborne metals can experience olfactory impairment leading to disrupted chemosensation, the ability to perceive chemicals in the environment that are odorants or tastants.

They investigated the effects of cadmium on salmon olfactory function by modeling an exposure scenario where juvenile salmon transiently migrate through a polluted waterway.

Cadmium is a poisonous metal that is among common pollutants in urban and agricultural waterways. Cadmium can be electroplated to other materials to protect them from corrosion, and is also used in rechargeable nickel-cadmium batteries.

In this study coho salmon were exposed to environmentally relevant concentrations of waterborne cadmium for 16 days, followed by a 16-day depuration associated with outmigration. Researchers noted that olfaction is a critical sensory system in fish species, and that for salmon the olfactory system serves a central role in their life cycle. The salmon rely on their olfactory system to detect chemosensory cues in locating prey, avoiding predators and in migration.

This olfactory system is also a potential target for waterborne pollutants, and researchers observed that close contact of the olfactory sensory epithelium with the surrounding water slows for interaction with dissolved pollutants which can lead to a loss of olfactory function.

This pollutant-based disruption of olfactory driven neurobehavioral function is a factor implicated in the declining Pacific salmon populations, many of which are threatened or endangered, they said.

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Assessment of the suitability of Durafet-based sensors for pH measurement in dynamic estuarine environments

November 2017

Highlights

• We deployed a SeapHOx sensor package in a dynamic estuarine environment.
• We evaluated Durafet performance over a wide salinity range (S = 3.25 to 29.33).
• We evaluated Durafet performance over rapid pH fluctuations of >1 pH unit.
• The sensor performed well (pH RMSE = 0.011 to 0.036) relative to discrete samples.
• We highlighted aspects of electrode response in estuaries requiring further study.

Abstract

The suitability of the Honeywell Durafet to the measurement of pH in productive, high-fouling, and highly-turbid estuarine environments was investigated at the confluence of the Murderkill Estuary and Delaware Bay (Delaware, USA). Three

different flow configurations of the SeapHOx sensor equipped with a Honeywell Durafet and its integrated internal (Ag/AgCl reference electrode containing a 4.5 M KCl gel liquid junction) and external (solid-state chloride ion selective electrode, Cl-ISE) reference electrodes were deployed for four periods between April 2015 and September 2016. In this environment, the Honeywell Durafet proved capable of making high-resolution and high-frequency pH measurements on the total scale between pH 6.8 and 8.4. Natural pH fluctuations of >1 pH unit were routinely captured over a range of timescales. The sensor pH collected between May and August 2016 using the most refined SeapHOx configuration exhibited good agreement with multiple sets of independently measured reference pH values. When deployed in conjunction with rigorous discrete sampling and calibration schemes, the sensor pH had a root-mean squared error ranging between 0.011 and 0.036 pH units across a wide range of salinity relative to both pH_T calculated from measured dissolved inorganic carbon and total alkalinity and pH_{NBS}measured with a glass electrode corrected to pH_T at *in situ* conditions. The present work demonstrates the viability of the Honeywell Durafet to the measurement of pH to within the weather-level precision defined by the Global Ocean Acidification Observing Network (GOA-ON, ≤ 0.02 pH units) as a part of future

Gonski S. F., Cai W.-J., Ullman W. J., Joesoef A., Main C. R., Pettay D. T. & Martz T. R., in press. Assessment of the suitability of Durafet-based sensors for pH measurement in dynamic estuarine environments. *Estaurine, Coastal and Shelf Science*. Article (subscription required).

Advancing ocean acidification biology using Durafet® pH electrodes

October 12, 2017

Kapsenberg L., Bockmon E. E., Bresnahan P. J., Kroeker K. J., Gattuso J.-P. & Martz T. R., 2017. Advancing ocean acidification biology using Durafet® pH electrodes. *Frontiers in Marine Science* 4:321. doi: 10.3389/fmars.2017.00321. Article.

Research assessing the biological impacts of global ocean change often requires a burdensome characterization of seawater carbonate chemistry. For laboratory-based ocean acidification research, this impedes the scope of experimental design. Honeywell Durafet® III pH electrodes provide precise and continuous seawater pH measurements. In addition to use in oceanographic sensor packages, Durafets can also be used in the laboratory to track and control seawater treatments via Honeywell Universal Dual Analyzers (UDAs). Here we provide performance data, instructions, and step-by-step recommendations for use of multiple UDA-Durafets. Durafet pH measurements were within ±0.005 units pH_T of spectrophotometric measurements and agreement among eight Durafets was better than ±0.005 units pH_T. These results indicate equal performance to Durafets in oceanographic sensor packages, but methods for calibration and quality control differ. Use of UDA-Durafets vastly improves time-course documentation of experimental conditions and reduces person-hours dedicated to this activity. Due to the versatility of integrating Durafets in laboratory seawater systems, this technology opens the door to advance the scale of questions that the ocean acidification research community aims to address.

Read the full article: https://www.frontiersin.org/articles/10.3389/fmars.2017.00321/full

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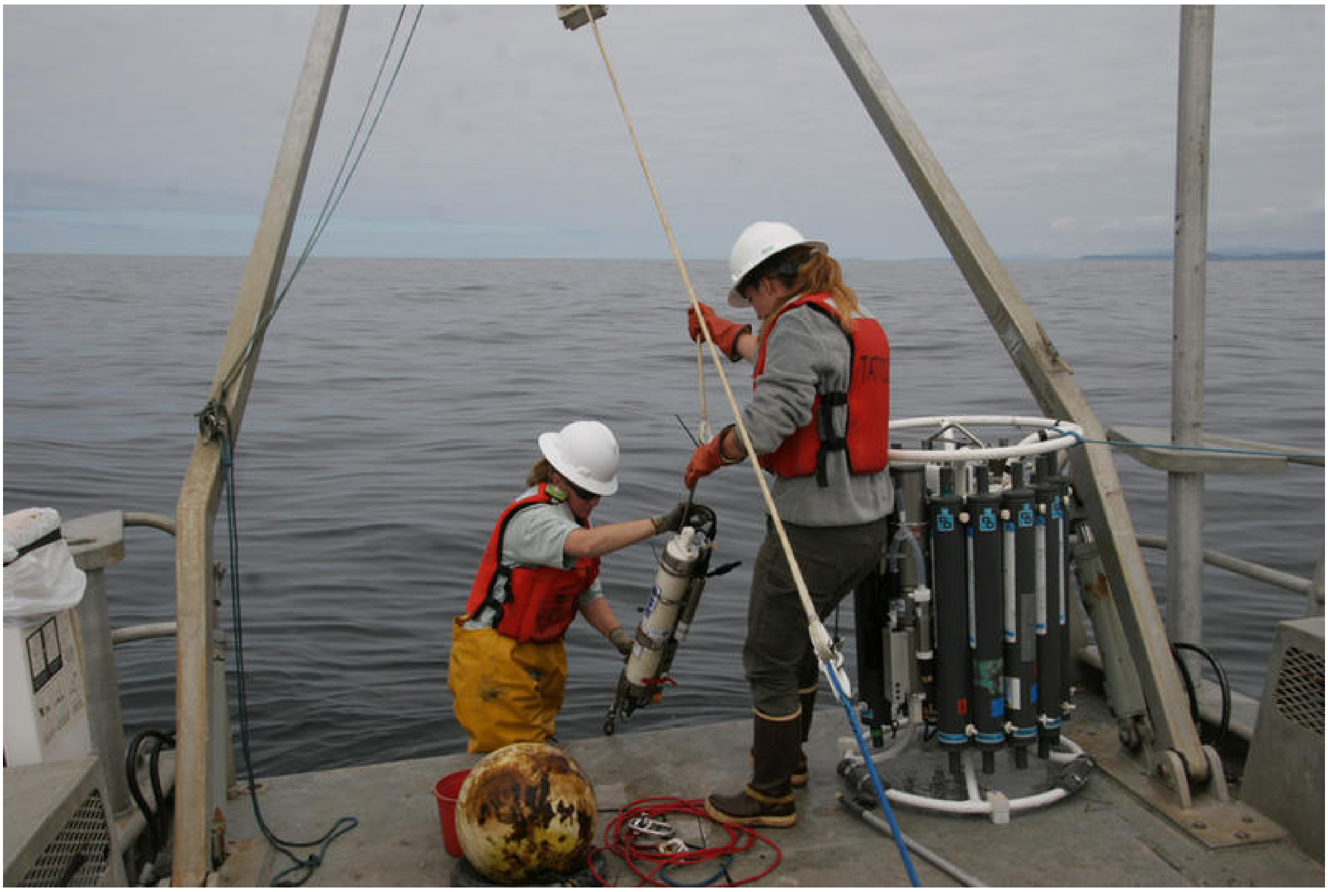
Coastal Researchers, Fishermen Worried About More Frequent Low Oxygen Zones

October 7, 2017



Olympic Coast National Marine Sanctuary research team members, Kathy Hough and LTJG Alisha Friel, recover sensors deployed seasonally off the coast of Washington from the research vessel Tatoosh in July 2017. — S. Maenner / NOAA

Scientists in Oregon and Washington are noticing a disruptive ocean phenomenon is becoming more frequent and extreme. It involves a suffocating ribbon of low oxygen seawater over our continental shelf.

The technical term is hypoxia, sometimes called “dead zones,” It’s an unwelcome variation on normal upwelling of cold, nutrient rich water from the deep ocean. When the dissolved oxygen drops too low, it drives away fish and can suffocate bottom dwellers such as crabs and sea worms who can’t scurry away fast enough.

It seemed to marine ecologist Francis Chan like this is happening most every summer lately. So the Oregon State

University researcher looked back as far as coastal oxygen readings go—to about 1950—to see if it's always been this way.

"The ocean starting in 2000 really looked different from the ocean we had between the 1950s and 1990s," Chan said.

Chan said climate change could affect oxygen levels via disrupted circulation and ocean warming. A September storm flushed away this year's low oxygen zone by churning Northwest coastal waters. But Chan described the severity of the low oxygen readings recorded this summer as among the worst ever observed locally.

"It's very much a patchy ribbon," he said from his post in Newport, Oregon. Marine surveys and fixed instruments recorded notably low oxygen values from south of Yachats up past Newport.

Ten oceanographic moorings deployed by the Olympic Coast National Marine Sanctuary also found very low (hypoxic) oxygen values between Cape Elizabeth and Cape Flattery, Washington, this summer.

"This is not a happy year for organisms out on the coast," said Jenny Waddell, the marine sanctuary's research coordinator.

Waddell added that at least one sensor dipped into anoxic conditions, "where there's literally no oxygen."

"We had indications of a relatively persistent hypoxia event along the Quinault Reservation coastline," wrote marine scientist Joe Schumacker of the Quinault Department of Fisheries in an email Friday. "Dead fish and shellfish at various locations and times beginning near the end of July and extending through most of August."

More frequent and severe near-shore hypoxia concerns fishermen and crabbers. Commercial harvesters face reduced catches and economic losses when crabs suffocate and fish and prawns flee the oxygen-starved waters.

One of the tip-offs to OSU researchers of the onset of low oxygen conditions this summer was when Oregon Department of Fish and Wildlife biologists monitoring crab populations noticed crabs dying from lack of oxygen in a research trap. Other observers noted crabs leaving the ocean to seek more oxygenated waters in coastal estuaries and bays.

Earlier this year, researchers and fishery advocates found a receptive ear at the Oregon Legislature when they presented their concerns about silent changes in the ocean. Legislators approved the creation of a new council to be co-chaired by the state Fish and Wildlife director and an OSU leader.

The council is tasked with recommending and coordinating a long-term strategy to address hypoxia as well as ocean acidification.

Originally posted: http://nwnewsnetwork.org

What scientists are learning about the impact of an acidifying ocean

October 4, 2017

The effects of ocean acidification on marine life have only become widely recognized in the past decade. Now researchers are rapidly expanding the scope of investigations into what falling pH means for ocean ecosystems.

The ocean is becoming increasingly acidic as climate change accelerates and scientists are ramping up investigations into the impact on marine life and ecosystems. In just a few years, the young field of ocean acidification research has expanded rapidly – progressing from short-term experiments on single species to complex, long-term studies that encompass interactions across interdependent species.

“Like any discipline, it takes it time to mature, and now we’re seeing that maturing process,” said Shallin Busch, who studies ocean acidification at the National Oceanic and Atmospheric Administration’s (NOAA) Northwest Fisheries Science Center in Seattle.

As the ocean absorbs carbon dioxide from the burning of fossil fuels, the pH of seawater falls. The resulting increase in acidity hinders the ability of coral, crabs, oysters, clams and other marine animals to form shells and skeletons made of calcium carbonate. While the greenhouse gas effect from pumping carbon dioxide into the atmosphere has been known for decades, it wasn’t until the mid-2000s that the impacts of ocean acidification became widely recognized. In fact, there is no mention of acidification in the first three reports from the United Nations Intergovernmental Panel on Climate Change, issued in 1990, 1995 and 2001. Ocean acidification did receive a brief mention in the 2007 report summarizing the then-current state of climate science, and finally was discussed at length in the latest edition released in 2014.

But about halfway through that brief dozen years of acidification research, a shift started taking place.

“The early studies were just a first step and often quite simple," said Busch of ocean acidification research. "But you can't jump into the deep end before you learn how to swim."

That started to change about five or six years ago, according to Philip Munday, who researches acidification effects on coral reefs at Australia's James Cook University. "The first studies were often single species tested against ocean acidification conditions, often quite extreme conditions over short periods of time," he said. "Now people are working on co-occurring stresses in longer-term experiments."

That includes studying how acidification could change how organisms across a community or ecosystem interact — in other words, how the impacts on one species affect those it eats, competes with or that eat it. It also means looking at how impacts could change over time, due to species migrating or adapting, either in the short term or across a number of generations and how such effects may vary within the same species or even with the same population.

Nine examples of this new generation of acidification research are included in the latest issue of the journal Biology Letters. One study, for example, found that the ability to adapt to pH changes differed in members of the same species of sea urchins based on location. Another discovered that a predatory cone snail was more active in waters with elevated carbon dioxide levels but was less successful at capturing prey, reducing predation on a conch species. Another highlights that an individual organism's sex can affect its response to acidification.

Munday, who edited the series of papers, said one of the major takeaways is that researchers are increasingly studying the potential for species to adapt to ocean acidification and finding those adaptations can be quite complex.

He pointed to a study on oysters. Previous work had shown that oysters whose parents were exposed to acidification conditions do better in those conditions than those whose parents weren't. But in a new study, researchers found that when they exposed the offspring to additional stressors – such as hotter water temperatures and higher salinity – those adaptive advantages decreased.

All the studies call for including often-overlooked factors such as sex, location or changes in predation rate in future studies. Otherwise, researchers warn, impacts will be increasingly difficult to predict as the ocean continues to acidify.

"It's far too early to make any sort of generalities," Munday said.

The latest paper from NOAA's Busch also cautions against generalities. By building a database of species in Puget Sound and their sensitivity to changes in dissolved calcium carbonate, she found that summarizing species' sensitivity by class or order rather than the specific family can result in overestimating their sensitivity.

She compared it to similarities between people in the same immediate family versus people who are distant cousins. "There would be a lot more variation among those people because they're not super closely related," she said. "But when people started summarizing data really early in the field, there wasn't much data to pull from. So it was done at a class level.

"Now that we have many more studies and information to pull from, how we draw summaries of species response should be nuanced," she added.

Acidification research is likely to get only more nuanced in the years ahead. From the broad initial projections of average, ocean-wide surface acidity, for instance, researchers have started to pinpoint local pH projections, local impacts and local adaptations.

“We know the ocean is changing in a number of ways,” said Busch. “So just studying one of those factors without looking at the other changes in what’s going on in the ocean is not going to yield useful results.”

Matthew O. Berger, *NewsDeeply*, 2 October 2017. Article.
