Declining Oxygen on the British Columbia Continental Shelf, Atmosphere-Ocean

Posted on Hypoxia Listserv: 29 Mar 2013 – Article of interest by William R. Crawford & M. Angelica Peña (2013)

The first thorough examination of oxygen concentrations in Canadian waters of the Pacific Ocean reveals several patterns in space and time. Sub-surface concentrations of oxygen tend to be lower in shelf waters than in deep-sea waters on the same isopycnal and lower in southern waters of the continental shelf than farther north. The lowest near-bottom concentration was 0.7 ml L−1 (31 μmol kg−1) in mid-shelf waters in summer off southwest Vancouver Island in the Juan de Fuca Eddy region. Oxygen concentration there declined at a rate of 0.019 ml L−1 y−1 (0.83 μmol kg−1 y−1) from 1979 to 2011. This decline is attributed mainly to changes in oxygen concentrations on the same density surfaces, rather than to changes in the depth of constant-density surfaces. A numerical simulation of ocean currents and nutrient concentrations in and surrounding the Juan de Fuca Eddy in summer reveals persistent upwelling into the centre of this eddy and slow bottom currents within the eddy. Upwelled water at bottom of the Juan de Fuca Eddy has water properties associated with the California Undercurrent on the 26.6 sigma-t surface at 200 m depth, where oxygen concentration is typically 2.0 ml L−1 (87 μmol kg−1) and declined at a rate of 0.025 ml L−1 y−1 (1.1 μmol kg−1 y−1) from 1981 to 2011, mainly as a result of changes on constant-density surfaces rather than to uplifting isopycnals. We propose that upwelling advects deep, oxygen-poor water onto the continental shelf bottom, and the slow bottom currents allow time for oxidation of organic material in bottom waters to further reduce the oxygen concentration.

Reprints of this article can be obtained here: http://www.tandfonline.com/eprint/YWBF6RUI3JRSCQSiszeU/full

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How climate change threatens the seas

Posted on USA Today: 28 Mar 2013 – By Dan Vargano

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OYSTER BAY, Wash. — The tide rolls out on a chilly March evening, and the oystermen roll in, steel rakes in hand, hip boots crunching on the gravel beneath a starry, velvet sky.

As they prepare to harvest some of the sweetest shellfish on the planet, a danger lurks beyond the shore that will eventually threaten clams, mussels, everything with a shell or that eats something with a shell. The entire food chain could be affected. That means fish, fishermen and, perhaps, you.

“Ocean acidification,” the shifting of the ocean’s water toward the acidic side of its chemical balance, has been driven by climate change and has brought increasingly corrosive seawater to the surface along the West Coast and the inlets of Puget Sound, a center of the $111 million shellfish industry in the Pacific Northwest.

USA TODAY traveled to the tendrils of Oyster Bay as the second stop in a year-long series to explore places where climate change is already affecting lives.

The acidification taking place here guarantees the same for the rest of the world's oceans in the years ahead. This isn't the kind of acid that burns holes in chemist's shirt sleeves; ocean water is actually slightly alkaline. But since the start of the industrial revolution, the world's oceans have grown nearly 30% more acidic, according to a 2009 Scientific Committee on Oceanic Resources report. Why? Climate change, where heat-trapping carbon dioxide emitted into the air by burning coal, oil and other fossil fuels ends up as excess carbonic acid absorbed into the ocean.

"As fresh as they get, you could eat one now," says Dewey of Taylor Shellfish Farms in Shelton, Wash., shucking an oyster open, mud running from its shell to reveal the opulent meat within, silver and white in the starlight. The black lip curling around the sweet-tasting shellfish reveals it to be a Pacific oyster, farmed worldwide.That shift hurts creatures like oysters that build shells or fish that eat those creatures or folks like shellfish farmer Bill Dewey, who makes his living off the ocean.

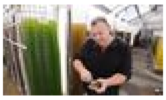
"Folks think we just get rich picking oysters off the ground. A lot of work goes into every one of these, and we can't afford to lose any of them," Dewey says.

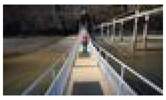
Lose them they have, and lose them they will, to the water lapping at Dewey's hip boots where the low tide meets the flats.

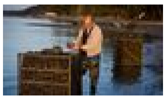
“We are looking into the future happening now,” Dewey says. And researchers are seeing similar corrosive effects on Florida’s coral reefs that shelter young fish and on the tiny sea snails that feed salmon and other species in the Pacific Ocean.

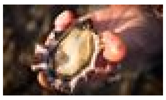
Bill Dewey of Taylor Shellfish Farms, in Shelton, Wash., shucks a freshly harvested Pacific oyster. Plumes of acidic water from the deep ocean threaten the growth of very young oysters. Scott Eklund, Red Box Pictures, for USA TODAY

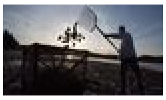
Fullscreen

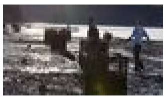


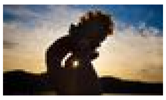


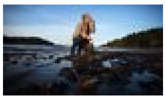












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Too much of ‘a good thing’

Because of ocean chemistry, water three times more acidic resides at greater ocean depths. When conditions are right, strong winds blowing over ocean water along steep coasts, such as along the West Coast of North America, generate “upwelling” of these deep waters. The results bring this more corrosive seawater to the shallows of places such as Puget Sound, a foreshadowing today of how the oceans will look in a few decades.

“We are able to see the effects of ocean acidification,” says oceanographer Richard Feely of the National Oceanic and Atmospheric Administration. He first charted upwelling of deeper, corrosive ocean water on the surface of the Pacific Ocean along the West Coast on a 2007 expedition.

How did it get there in the first place? Atmospheric carbon ends up absorbed directly by the ocean, where plankton sucks up carbon dioxide via photosynthesis. “That’s a good thing,” Feely says, because the carbon dioxide they ingest means less warming of the atmosphere.

But when those sea plants and creatures die, they fall to the depths. Some of the consumed carbon ends up dissolved in deep ocean waters.

“Once we had the canary in the coal mine; now we have the oyster in the ocean,” Washington Gov. Jay Inslee says.

An oyster mystery

In the same year that Feely and his colleagues made their upwelling discovery, disaster struck the Whiskey Creek Shellfish Hatchery in Netarts Bay, perched on the edge of Oregon’s Pacific Coast. Baby oysters grown there to be shipped to shellfish farms worldwide were dying en masse, tens of millions of millimeter-size larvae filling hatching tanks, all dead.

“We were very close to going out of business. It was a major deal,” says Sue Cudd of the Whiskey Creek hatchery. Bankruptcy threatened because of unfilled orders, and the entire industry faced collapse without the larvae, the seeds that shellfish growers needed to raise Pacific oysters over the next 18 months. A second hatchery run by Dewey’s employers, Taylor Shellfish – one of four in the region – saw the same die-off the next year, with the same failure to spawn striking wild oysters in Washington’s Willapa Bay, a longtime source of seeds for the industry.

It was only at the end of 2008 at a shellfish farmer’s meeting that Feely delivered the bad news: On days in the summer along the West Coast when northerly winds blew, deep ocean water was likely dissolving the fragile young oysters.

Without industrial emissions of greenhouse gases, the upwelling wouldn’t be a problem because really corrosive water wouldn’t get high enough to reach the surface, says Burke Hales of Oregon State University in Corvallis. “That extra kick from (man-made) carbon is what pushes the saturation point high enough,” Hales says. “Anyone who says this is a natural thing just doesn’t get it or is missing that key point.”

Shellfish rely on calcium to build their shells, and a more corrosive water makes that harder for them to the point of becoming impossible.

Alan Barton, the staff scientist at Whiskey Creek, realized the seawater was far too acidic and started making phone calls to Hales to have the water examined. Last year, Barton, Hales and colleagues, including Feely, definitively showed that those deep waters do dissolve baby oysters only a few days old, ones which rely on a very soft form of calcium for their initial growth spurt.

“A lot of people out here I talk to don’t believe in climate change, but ocean acidification – to them that’s real – because they can see it eating into their livelihoods,” Hales says. “The chemistry is really simple and really inevitable: More carbon in the air means more carbon in the ocean, and there is no getting around it.”

An ocean-size challenge

Benoit Eudeline, staff scientist for Taylor Shellfish, and colleagues such as Barton at Whiskey Creek have become evangelists on the topic for the seafood industry, warning their colleagues on the East Coast of what is coming. There, deep-water upwelling is not a problem, but warmer waters have shifted crab and fish populations while acidic mud on the Maine seafloor has hurt clamming.

Benoit Eudeline, chief hatchery scientist for Taylor Shellfish Farms, watches oyster hatchery water quality levels March 4 in Quilcene, Wash.(Photo: Scott Eklund/Red Box Pictures for USA TODAY)

“We were joking about what size antacid tablet you would need to fix the ocean,” Eudeline said. “It is so tremendous that you can only make jokes about it.”

That’s because the ocean absorbs 23% of all man-made carbon dioxide emissions, according to a 2012 Earth System Science Data journal report, more than 8 billion tons of the stuff every year. It would take a very large Alka-Seltzer tablet to fix that. “That’s why talk about just avoiding warming from here on out in the atmosphere is missing the effects that are already locked in due to ocean acidification,” Feely says.

Back on the tidal inlet at Oyster Bay, Dewey walks along rotting wooden dike walls placed there more than a century ago, by earlier shellfish farmers, down to where the low tide has fallen. All kinds of shellfish and other sea life, including the famed salmon of the Pacific Northwest, live in these same waters, enjoying the bounty of these waves.

“We only know what is happening to shellfish because they have spokesmen,” Dewey says. “Only the good Lord knows what is happening to everything else out there.”

According to scientists, climate change is making oceans more acidic, threatening the young oysters on which shellfish famers make a living.

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Threatened Puget Sound marine life shows global threat of ocean acidification

Posted in the Bellingham Herald: 27 March 2013 – By Ginny Broadhurst and Bill Dewey (Opinion)

Chemistry is not always easy to learn or communicate about, but it is at the very root of the problem our oceans face today. The chemistry of the world's oceans and inland marine waters, such as Puget Sound, is changing significantly and with unprecedented speed. The most serious of these radical changes is ocean acidification. We must pay attention to this problem and act to reduce the threat it poses.

The ocean is 30 percent more acidic than it was before the industrial revolution began 250 years ago. If current trends continue, the increase may reach 100 percent by mid-century. The primary cause is carbon dioxide emissions from burning fossil fuels – coal, gas, and oil. The oceans absorb roughly 30 percent of those emissions from the atmosphere. When carbon dioxide mixes with seawater, it forms carbonic acid, and the chemical building blocks needed for the shells or skeletons of species such as mollusks, crustaceans and corals (called calcifiers) are reduced, making it difficult for these creatures to develop.

For years, scientists thought that the carbon dioxide absorbed by the oceans was a benefit to all because it reduced the amount of carbon in the atmosphere, lessening the effects of global warming. Only within the last decade have the true costs of this "benefit" been recognized and documented.

While this is clearly a global issue, the effects of acidification are being felt first here in Washington because of the way the deep corrosive waters of the Pacific Ocean upwell and surface off our coast. Between 2005 and 2009, up to 80 percent of the oyster larvae in some Pacific Northwest hatcheries were killed by these corrosive waters. The oyster seed industry was on the verge of collapse.

Once the problem was identified and understood, the shellfish industry took action to change practices and adapt, at least temporarily, to the circumstances. But what happened to those larvae should be a wake-up call to all of us that more than oysters are at risk. Roughly a third of all of the organisms in Puget Sound are calcifiers, including such foundations of the marine food web as plankton. Any disruptions at the bottom of the food chain ripple upwards, affecting such commercially important species as salmon.

In 2012, then-Gov. Gregoire created the 28-member Washington State Panel on Ocean Acidification, bringing scientists, policymakers and various leaders together to determine how to address this problem. The panel was co-chaired by Bill Ruckelshaus, the first administrator of the Environmental Protection Agency, and Jay Manning, former director of the Washington Department of Ecology. Last November the panel released its 42 recommendations.

The panel recognized that we can do little here in Washington to directly reduce the 70 million tons of carbon dioxide that the world pumps into the atmosphere every day. But we can be a model for educating ourselves and others about acidification. Like the proverbial canary in the coal mine, we can warn the world of the impending danger. We can make our own environment as resilient as possible to its effects and demonstrate the many ways to reduce greenhouse gas emissions. We can reduce local, land-based contributors to acidification, such as runoff containing nitrogen and phosphorus. We can invest in monitoring and researching the causes and effects of acidification and devising effective counter-measures to it.

The science of ocean acidification and some of the panel’s recommendations will be discussed at a seminar from 6 to 8 p.m. Thursday, March 28, at the Port of Bellingham Ferry Terminal's Dome Room, 355 Harris Ave. Brady Olson of the Western Washington University's Shannon Point Marine Center; Betsy Peabody, founder of the Puget Sound Restoration Fund; and Brad Warren, director of the Global Ocean Health Program, will make presentations. Peabody and Warren served on the ocean acidification panel.

We hope many of you will be able to join us. It is essential for us to learn about ocean acidification and then move from knowledge to action. The fate of our marine waters and the way of life and livelihoods that depend upon them hang in the balance. Come do your part.

ABOUT THE AUTHORS

Ginny Broadhurst is the executive director of the Northwest Straits Commission and Bill Dewey is communications and policy director at Taylor Shellfish Farms. Learn more about the Washington State Panel on Ocean Acidification and its findings and recommendations athttp://www.ecy.wa.gov/water/marine/oceanacidification.html.

Ginny Broadhurst & Bill Dewey, The Bellingham Herald Opinion, 27 March 2013. Article.

The influence of food supply on the response of Olympia

oyster larvae to ocean acidification

Posted on EPOCA: 26 Mar 2013 – Hettinger A., Sanford E., Hill T. M., Hosfelt J. D., Russell A. D. & Gaylord B., 2013. Biogeosciences Discussions 10: 5781-5802.

Increases in atmospheric carbon dioxide drive accompanying changes in the marine carbonate system as carbon dioxide (CO2) enters seawater and alters its pH (termed "ocean acidification"). However, such changes do not occur in isolation, and other environmental factors have the potential to modulate the consequences of altered ocean chemistry. Given that physiological mechanisms used by organisms to confront acidification can be energetically costly, we explored the potential for food supply to influence the response of Olympia oyster (Ostrea lurida) larvae to ocean acidification. In laboratory experiments, we reared oyster larvae under a factorial combination of pCO2 and food level. High food availability offset the negative consequences of elevated pCO2 on larval shell growth and total dry weight. Low food availability, in contrast, exacerbated these impacts. In both cases, effects of food and pCO2 interacted additively rather than synergistically, indicating that they operated independently. Despite the potential for abundant resources to counteract the consequences of ocean acidification, impacts were never completely negated, suggesting that even under conditions of enhanced primary production and elevated food availability, impacts of ocean acidification may still accrue in some consumers.

Hettinger A., Sanford E., Hill T. M., Hosfelt J. D., Russell A. D. & Gaylord B., 2013. The influence of food supply on the response of Olympia oyster larvae to ocean acidification. Biogeosciences Discussions 10: 5781-5802. Article.

Blue mussels 'hang on' along rocky shores: for how long?

Posted on EPOCA: 22 Mar 2013 – Cheryl Dybas, NSF, 21 March 2013

Mussels' anchors—byssal threads—weakened by ocean acidification

The following is part nine in a series on the National Science Foundation's Science, Engineering and Education for Sustainability (SEES) investment. Visit parts one, two, three, four, five, six, seven and eight in this series.

Imagine trying to pitch a tent in a stiff wind. You just have it secured, when a gale lifts the tent—stakes and all—and carries it away.

That's exactly what's happening to a species that's ubiquitous along the rocky shores of both the U.S. West and East Coasts: the blue mussel.

Mussels make use of what are called byssal threads—strong, silky fibers—to attach to rocks, pilings and other hard substrates. They produce the threads using byssus glands in their feet.

Now, scientists have discovered, the effects of ocean acidification are turning byssal threads into flimsy shadows of their former selves, leaving mussels tossed about by wind and waves.

At high levels of atmospheric carbon dioxide—levels in line with expected concentrations over the next century—byssal threads become weaker, less able to stretch and less able to attach to rocks, found scientists Emily Carrington, Michael O'Donnell and Matthew George of the University of Washington.

The researchers recently published their results in the journal Nature Climate Change; O'Donnell is the lead author.

Oceans turning caustic

The pH of the seas in which these and other marine species dwell is declining. The waters are turning more acidic (pH dropping) as Earth's oceans change in response to increased carbon dioxide in the atmosphere.

As atmospheric carbon rises as a result of human-caused carbon dioxide emissions, carbon in the ocean goes up in tandem, ultimately resulting in ocean acidification, scientists have found.

To study the effects of ocean acidification on marine organisms, Carrington has been awarded an NSF SEES (Science, Engineering, and Education for Sustainability) Ocean Acidification grant.

"We need to understand the chemistry of ocean acidification and its interplay with other marine processes—while Earth's seas are still hospitable to life as we know it," says David Garrison, program director in NSF's Division of Ocean Sciences. "In the rocky intertidal zone, blue mussels are at the heart of those processes."

Land between the tides

Visit the land between the tides, and you'll see waves crashing on boulders tinged dusky blue by snapped-closed mussels.

“Their shells are a soft color, the misty blue of distant mountain ranges,” wrote Rachel Carson more than 50 years ago in her best-selling book The Edge of the Sea.

For blue mussels trying to survive, the rocky intertidal zone indeed may be akin to scaling a mountain range.

The rocky intertidal is above the waterline at low tide and underwater at high tide—the area between tide marks.

It’s home to such animals as starfish and sea urchins, and seaweed such as kelp. All make a living from what floats by rocky cliffs and boulders.

It can be a hard go. Rocky intertidal species must adapt to an environment of harsh extremes. Water is available when the tide washes in; otherwise residents of this no man’s land between sea and shore are wide open to the elements.

Waves can dislodge them, and temperatures can run from scalding hot to freezing cold.

Hanging on for dear life

In the rocky intertidal, blue mussels hang on for dear life.

That may not always be the case.

Combining results from laboratory experiments with those from a mathematical model, Carrington and colleagues show that at high carbon dioxide concentrations, blue mussels can be dislodged by wind and wave forces 40 percent lower than what they are able to withstand today.

Mussels with this weakened ability, once dislodged from their homes, could cause ecological shifts in the rocky intertidal zone—and huge economic losses in a global blue mussel aquaculture industry valued at U.S. $1.5 billion each year.

“Mussels are among the most important species on rocky shores worldwide," says O'Donnell, "dominating ecosystems wherever they live. The properties in their byssal threads are also of interest to biochemists and have been studied as possible medical adhesives."

Blue mussels may make important contributions to the field of materials science, says Carrington.

"Some species of mussels are experts at gluing onto seagrass, some to other shells, some even adhere to rocks in the harsh conditions of deep-sea hydrothermal vents. Each may have different genes that code for different proteins, so the adhesives vary."

Will their potential be realized? Carrington, O'Donnell and George have found a disturbing answer.

The scientists allowed mussels to secrete byssal threads in a range of ocean water chemistries from present-day through predicted near-future conditions, then tested the threads to see how strong they were.

At levels considered reasonable for a near-future coastal ocean (given current rates of acidification), byssal threads were less able to stretch and therefore less able to adhere. Further testing revealed that the problem was caused by weakening of the glue where the threads attach to rocks and other hard surfaces.

Ocean acidification beyond shells and corals

"Much ocean acidification research has focused on the process of calcification," says Carrington, "through which animals and some plants make hard parts such as shells."

In acidifying oceans, marine species that depend on calcium carbonate have a more difficult time forming shells or, in the case of coral reefs, skeletons.

"But there's more to marine communities than calcified parts," says O’Donnell. Other species such as mussels and their byssal threads, he says, are equally important.

“Understanding the broader consequences of ocean acidification requires looking at a variety of biological processes in a range of species.”

A need that didn’t exist when Rachel Carson wrote The Edge of the Sea.

“When we go down to the low-tide line, we enter a world that is as old as the Earth itself—the primeval meeting place,” mused Carson, “of the elements of earth and water.”

And of mussels and rock. Fifty years hence, will the mussels still be here?

Related Websites
NSF SEES Discovery Articles Publication: http://www.nsf.gov/pubs/2012/disco12001/disco12001.pdf
NSF Awards Grants to Study Effects of Ocean Acidification: http://nsf.gov/news/news_summ.jsp?cntn_id=117823
Ocean Acidification: Finding New Answers Through National Science Foundation Research Grants: http://www.nsf.gov/news/news_summ.jsp?cntn_id=125523
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Cheryl Dybas, NSF, 21 March 2013. Article.