Northwest Ocean Acidification

The hidden costs of fossil fuel pollution

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Sue Cudd couldn't keep a baby oyster alive.

Four summers ago, she'd start with hundreds of millions of oyster larvae at the Whiskey Creek Shellfish Hatchery on Oregon's Netarts Bay. Sometimes, they'd swim for a couple of weeks. Then they'd stop growing before a crucial shell structure developed, or maybe the foot or eyespot. They'd feed poorly. Eventually the larvae would all die.

"They just sort of fade away," said Cudd, who owns the hatchery with her husband. "In all the years I've been here, I've never seen this kind of consistent problem."[1]

For months, the hatchery produced virtually no oysters. Because the commercially popular Pacific oyster spawns unreliably in Northwest waters, hatcheries grow larvae for everyone from multi-million-dollar seafood producers to beachfront shellfish gardeners. When those hatchery incubators have problems, the effects ripple across the $73 million West Coast oyster industry, which pumps more money into the regional economy than farmed clams, mussels, geoduck, and other forms of shellfish combined.[2] It would be like every tomato farmer in the state plowing the ground in spring and getting ready to plant, only to find they can't get their hands on any tomato seeds.

It's also a preview of what may be in store for the Northwest as fossil fuel pollution from cars, power plants, and other human sources changes the chemistry of our marine waters, making them more acidic and inhospitable to sea life. A mix of currents and chemistry has put the region's waters on the leading edge of what scientists call "ocean acidification,"[3] a phenomenon that could introduce profound changes to the marine food web[4] and the industries and economies built upon it.

To change a trajectory that could disrupt essential ocean ecosystems, we must act quickly and decisively. Proven policy solutions can reduce carbon dioxide emissions and other drivers of ocean acidification, but political will is needed. Responsible stewardship of our oceans—which provide us with far more than just food or income—depends upon it.

Every day, the oceans do us a huge favor. Across the planet, they absorb nearly one million metric tons of carbon dioxide each hour,[5] removing about a third of the carbon dioxide[6] released into the atmosphere by human activities such as burning fossil fuels—coal, oil, and natural gas—and clearing forests that would otherwise speed up global warming. This seems, at first, to be a massively beneficial service.

But as oceans absorb carbon dioxide, they also become more acidic.[7] And they become potentially lethal to a wide swath of sea creatures, from clams to corals to plankton that play a role in the diets of many things you might see at a local aquarium.[8] Many of those species wind up on fishing boats and then dinner plates around the world.

As oceans absorb carbon dioxide, they become potentially lethal to a wide swath of sea creatures.

The animals that struggle or dissolve in more corrosive seawater range from oysters,[9] a bedrock species in the Northwest's lucrative commercial shellfish industry, to British Columbia's endangered northern abalone,[10] to the tiny cornerstones in the marine food chain like krill and pteropods,[11] sea snails propelled by wing-like feet that make up more than half of the diet of some young Alaska pink salmon. So what might increasingly acidic oceans look like?

"We won't see a total collapse of food chains, but we will see substitutions," said University of Washington associate professor Terrie Klinger during a Congressional hearing on the possible effects of ocean acidification. "We may end up with food chains or food webs that are highly undesirable and not productive for the means we use them today."[12]

Those predictions rattle Charissa Sigo, 18, who comes from a long line of fishermen and women in the Suquamish Tribe. Last year, the Washington tribe commercially harvested more than 415,000 pounds of geoduck clams, using those profits to fund social service programs and disbursements to elders. Individuals caught more than 750,000 pounds of crab, clams, shrimp, and salmon.[13] It fed their families, bought new appliances, sent kids to college, and upheld their traditions.

"My people come from water so we basically live off the water. We go canoeing and a lot of our food comes from the water, the salmon and the crab and the shellfish. If sea life is suffering, our people are too, or will be," said Sigo. "My fear is that…our culture will die off, and we're going to have to adapt and change to something else."[14]

There is still much we don't know about how changes from ocean acidification will ripple through local waters and the region's economy. We're essentially conducting the world's largest chemistry experiment, and results are just starting to come in. Yet we do know the basics, and they're important for the Northwest:

- **Surprisingly corrosive water[15] has already been found off our shores.**
- **Acidified water showed up decades before scientists expected[16] to see it.**
- **The best way to prevent more serious acidification is to reduce carbon dioxide emissions.[17]**

What do we know about ocean acidification?

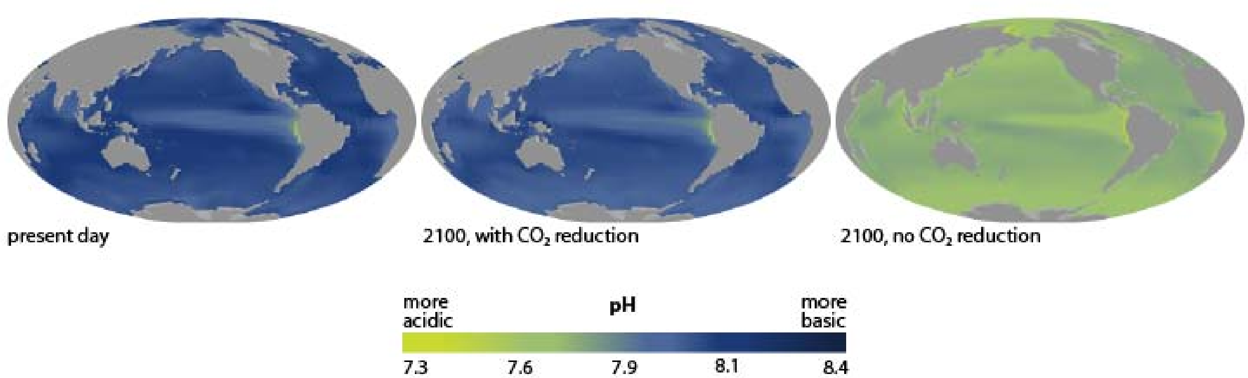
Put simply, carbon dioxide lowers the pH of the oceans, causing them to become more acidic and corrosive. The basic chemistry is simple: as seawater at the surface of the ocean absorbs carbon dioxide from the atmosphere, it forms carbonic acid, the same weak acid found in soda pop. Carbonic acid breaks down into hydrogen ions, which make water more acidic. Seawater is not technically an acid because it measures above 7 on the pH scale, but this excess carbon dioxide shifts the pH of the ocean farther towards the acidic end of the scale.[18]

That basic chemical process also robs the water of carbonate ions,[19] which are important to so many marine creatures that they've been called "the soil of the marine world." Animals like mussels, scallops, corals, sea urchins, barnacles, abalone, crabs, lobster, and tiny plankton use carbonate ions to build shells and skeletons. As that key building block becomes scarce in more acidic seas, those creatures must expend more energy to assemble the calcium carbonate minerals they need.[20] As water grows even more corrosive, the creatures' protective shells and structures can simply dissolve.[21]

This chemical transformation is already well underway. Since the beginning of the Industrial Revolution when we started powering our industries and transportation networks with fossil fuels, the world's oceans have become roughly 30 percent more acidic.[22] Unless we substantially reduce emissions from cars and power plants and other pollution sources, the trend toward acidification will accelerate at an extraordinary rate.

Researchers estimate the ocean's acidity may double or triple by the end of this century, compared to pre-industrial times, if carbon dioxide emissions continue to rise at current levels. The resulting pH level would likely be lower, and the rate of change 10 times faster, than anything the oceans have experienced in 20 million years.[23]

To change that course, we must reduce carbon dioxide emissions and shift our economy away from the same fossil fuels that cause global warming. The maps below from the National Oceanic and Atmospheric Administration illustrate the difference that responsible climate policies can make. The one on the left shows ocean conditions today. The map in the middle shows projected pH levels in the world's oceans if countries take swift and aggressive action to reduce carbon dioxide emissions. The map on the right shows how corrosive the oceans are likely to become if we continue on our current course.[25]



Some creatures will do fine in a more corrosive ocean. Others will die. Beyond that, the universe of what we don't know is staggeringly large, including how those tradeoffs will play out or just how far up the food chain they'll reach. But results from laboratory experiments testing how marine creatures fare in more acidic waters have ranged from alarming to puzzling.[26] Some species are weakened, rendered incapable of reproducing, or killed in more acidic conditions. Yet others have thrived in low-pH waters. What's worrisome, though, is how some of the lynchpins of the entire marine ecosystem fare:

Plankton: Some forms of plankton that are cornerstones of the marine food chain struggle or die in low pH conditions. Scientists have watched pteropods, a critical food for some juvenile salmon in Alaska, dissolve in low pH water.[27] Embryos of Antarctic krill—a major food source for creatures like penguins, fur seals, and humpback whales in southern oceans—have failed to hatch in highly acidified waters.[28]

Shellfish: Among commercially valuable shellfish, mollusks appear to be at the highest risk. In recent years, two Northwest oyster hatcheries have had massive mortalities, and naturally reproducing oysters have failed to spawn. Mussels,[29] clams, and scallops[30] exposed to carbon-dioxide-rich water in labs have had trouble building shells or have grown more slowly. Sea urchins have become deformed and stopped reproducing.[31] Abalone larvae have died.[32] Yet some crustaceans have actually grown thicker shells in low-pH waters.[33]

Habitat: If oyster populations crash, eventually the oyster beds that help support sea anemones, crabs, fish, and other creatures may suffer. Coral reefs, storehouses of huge arrays of the world's biodiversity, are particularly vulnerable to low pH waters.[34] In other words, the problem of ocean acidification could be amplified if the species that provide habitat, like coral and oysters, are harmed.

Finfish: It's not clear whether acidification will have direct effects on fish like salmon or pollock or rockfish, but they may have to expend more energy or compete for food if the species they normally eat, such as pteropods, start to struggle. And they could run into other problems; in lab experiments, Australian clownfish larvae lost their sense of smell and their ability to find suitable reef habitat, distinguish their parents from other fish, and avoid predators.[35]

Other impacts: Some animals experience other metabolic changes when exposed to acidified water. Jumbo squid that cruise deep Pacific waters became lethargic and sluggish as their ability to deliver oxygen to blood cells was compromised.[36] Brittle stars actually increased their metabolism and rate at which they built skeletal structures, but that coping strategy was offset by muscle wastage in their arms.[37] And a cascade of chemical changes due to acidification could alter the composition of everything from nutrients to microscopic plant communities.

It's a chemical certainty that oceans will change as a result of the fossil fuels we're burning today. It also appears that the Northwest may be one of the first places to experience how marine creatures fare in that changed environment.

Why is the Northwest at risk?

Just five years ago, models predicted that the effects of ocean acidification would be confined to deep ocean waters for some time.[38] Scientists expected it would take another 50 or 100 years for that corrosive water to reach the shallow continental shelf off the Pacific Coast, where an abundance of sea life lives.[39]

"What we found, of course, was that it was everywhere we looked,"[40] said Richard Feely, an oceanographer at NOAA's Pacific Marine Environmental Laboratory in Seattle.[41]

In 2007, he and other colleagues found pockets of surprisingly acidified water at relatively shallow depths all the way from British Columbia to Baja California.[42] The most corrosive seawater had a pH of 7.6, which is roughly three times more acidic than the worldwide average and powerful enough to begin dissolving some shells and skeletons.[43]

The explanation for the acidified water turned out to be "upwelling events," which occur seasonally along the Pacific coastline. Winds push surface water away from the shore and draw water up from the deep ocean—which is richer in carbon dioxide and therefore more acidic—towards the continental shelf, shorelines, and beaches.[44]

Moreover, the upwelled water the scientists were finding was last exposed to the atmosphere 30 to 50 years ago, when carbon dioxide emissions from cars and power plants were lower than they are now. Seawater that is absorbing higher levels of carbon dioxide pollution from the atmosphere today will follow a similar pattern, sinking to the deep and reappearing at the surface decades from now. Oregon State University oceanographer Burke Hales compares those deteriorating ocean conditions to a package that we've mailed ourselves. "You can't refuse delivery," he said. "They're just going to show up."[45]

Next, the researchers decided to look in Washington's Puget Sound. In 2010, they announced their findings: surface water collected in the Sound's main basin had an astonishingly low pH of 7.7.[46] In the southern depths of Hood Canal, they found water with a pH of 7.4, some of the most corrosive seawater recorded anywhere on earth.[47]

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Carbon dioxide emissions are not the only cause of the corrosive waters in Hood Canal.[48] Natural processes, poor water circulation, and other forms of pollution also contribute. For instance, microscopic plants found in great abundance there release carbon dioxide as they die and sink to the bottom. That process further lowers pH and also robs the water of dissolved oxygen, a phenomenon that can kill fish[49] and routinely drives octopus, wolf eels, shrimp, rockfish, and others to the surface looking for oxygen.[50] Pollution from lawns, streets, septic tanks, and farm fields that add nutrients and stimulate plant growth makes the problem worse in Hood Canal and other estuaries.[51]

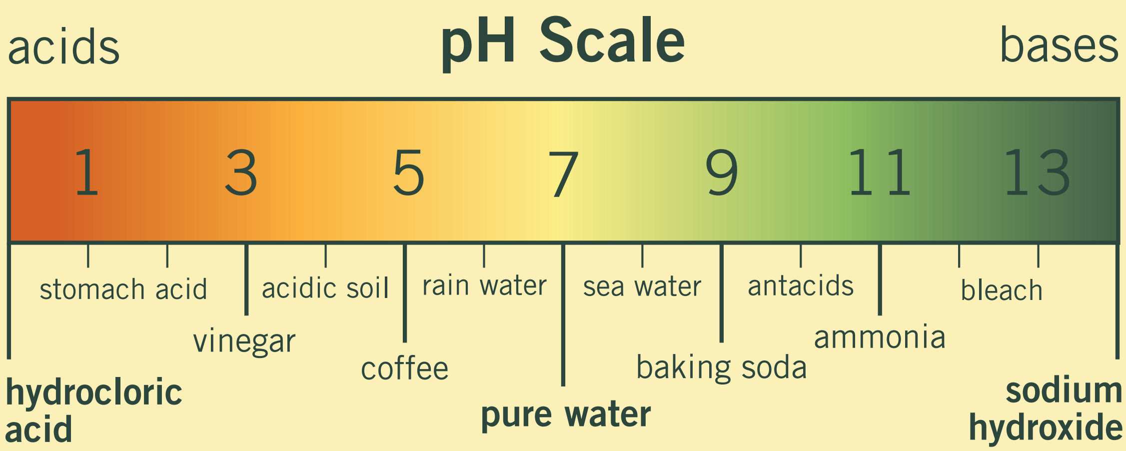
Still, Feely and his colleagues estimate human-generated ocean acidification is responsible for 24 to 49 percent of the reduction in Hood Canal's pH levels since preindustrial times. If nothing is done to reduce carbon dioxide pollution, they expect ocean acidification to have a growing influence on how corrosive that water becomes in the future.[52]

The low pH levels found in Puget Sound and its Hood Canal arm pose a tantalizing riddle: Have the animals there grown accustomed to more acidic waters, possibly making them better prepared to adapt to changes ahead? Or are the creatures in this low-pH environment already so stressed that they'll be among the first to wink out?

"This is the big question we as scientists have to address," Feely said. "We don't know."[53]

Oceans and pH

The pH scale runs from 0 to 14. Things like battery acid, coffee, and orange juice with a pH below 7 are acids, and things like eggs, toothpaste, and bleach that have a pH higher than 7 are considered basic, or alkaline.



Seawater is not an acid—nor is it expected to become one anytime soon—because it measures above 7 on the pH scale. But as oceans absorb more carbon dioxide, the pH of seawater drops and moves closer towards the acidic end of the scale.

Since the Industrial Revolution, the average pH of surface seawater around the globe has dropped from 8.2 to 8.1,[54] a 30 percent increase in acidity.[55] (Each whole number on the scale represents a tenfold increase in acidity or alkalinity, so a lime with a pH value of 2, for instance, is 100 times more acidic than a tomato with a pH of 4.)

The Northwest appears to be a geographic hotspot for ocean acidification, where natural ocean currents and chemistry combine to make the problem worse. The 7.7 pH level found at the surface of Puget Sound is more than twice as acidic as the current worldwide average. The water with a pH of 7.4 found in Hood Canal is 340 percent more acidic.

What marine species may be affected?

In a cramped Seattle laboratory near the Montlake Cut, researchers thread their way between shelves filled with giant jars. Overhead, a rainbow of colored tubes bubble gases into what look like water heater tanks. They're running experiments on some of the region's most valuable marine species: geoducks, oysters, rockfish, crab, and tiny shrimp like copepods that are linchpins of the food chain.

To try to determine how local species may fare under future conditions, they're rearing them in baths of acidified seawater. Then, they assess their most basic functions. How big do they get? Can they grow shells? Are they developing normally? And, most importantly, do they survive?

The harder question to answer is how those changes will ripple through an entire marine ecosystem. As Paul McElhany, lead ocean acidification researcher for NOAA's Northwest Fisheries Science Center puts it:

"You're changing the predators and prey at the same time. You're altering the abundance of competition. You've got physical and structural changes—eelgrass does better and corals do poorly. I feel confident saying it's going to cause change. Predicting exactly what those changes are going to be—we can identify the most vulnerable species but the indirect effects are much harder."

McElhany shifted from researching salmon to ocean acidification after realizing that all the habitat restoration projects in the world may become band-aid solutions if the fundamental chemistry of the ocean changes. "It seemed like a big enough problem that could shuffle the entire ecosystem," he said.[56]

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To begin to understand what that altered landscape might look like, research on Northwest-specific creatures is essential. Experiments done elsewhere may not tell us much, since even closely related species can react differently to acidified water. In one test, for instance, the larvae of common sea urchins died in greater numbers while green sea urchins thrived.[57] Another experiment found that 10 out of 18 marine calcifiers had trouble building shells as efficiently. Yet seven species—including a crab, shrimp, lobster, calcifying algae, temperate urchin, and a limpet—produced shells more rapidly.[58]

The NOAA researchers are rearing important Northwest species in three different batches of seawater. The first mimics preindustrial conditions before fossil fuels were widely burned, the second mimics current conditions, and the third mimics conditions that creatures might experience by the end of the century if we do nothing to reduce carbon dioxide emissions. They're also able to adjust other variables like temperature, oxygen, and food.

All those things matter in the ocean, said McElhany. "If you're well fed, you might be able to suffer through the effects of ocean acidification. If you're temperature stressed, maybe you can't deal with the pH change as well. It's the complex interplay between a lot of different factors."[59]

Other university and government scientists are investigating related questions, such as how the animals respond to stress and disease under different climate scenarios and how acidification affects animals on a molecular level. At the University of Washington's Friday Harbor Laboratories in the San Juan Islands, researchers are testing whether corrosive water could weaken the amazingly strong byssal threads that allow mussels to stay anchored in rough waves. Others are isolating parts of the natural ecosystem with plastic bags and seeing how chemical changes affect the tiny creatures at the base of the food web.[60]

There's a lot of money riding on what they discover.

What are the economic consequences of ocean acidification?

Soon after Sue Cudd started having problems in Oregon, the country's largest producer of farmed shellfish started seeing massive mortalities in its oyster tanks too. Taylor Shellfish Farms relies on its Dabob Bay hatchery, located on a finger of Washington's Hood Canal, to produce oyster seed for its shellfish beds and other customers. In 2008 and 2009, production plummeted from average levels by 60 and 80 percent, respectively.

"You'd do your thing and feed them and grow them and suddenly at a certain stage they'd just die," said chief hatchery scientist Benoit Eudeline. "Like pretty much the whole group. Over and over again."[61]

The Pacific Oyster favored by commercial growers is native to Japan and spawns reluctantly in the Northwest's cooler waters. So most West Coast shellfish growers depend on hatcheries for their "seed"—or larvae—and then grow them out to maturity on shellfish beds or in bags or racks.[62] Because oysters take several years to grow and harvest, the total costs to the regional economy from recent seed shortages aren't yet known. But from 2005 to 2009, West Coast oyster production dropped from 94 million pounds to 73 million pounds, resulting in an $11 million loss in sales.[63] Nearly 80 percent of those sales are in Washington state.[64]

It's tough to say with scientific certainty that ocean acidification is the sole cause of the Northwest's oyster die-offs.[65] But scientists have linked the mortalities at Whiskey Creek to upwelling events that bring deeper and more acidic water to the surface. Researchers at Oregon State University are working to identify exactly what kills the young oysters, and to see whether native Olympia oysters or other strains are less vulnerable. They aren't sure if it's the carbon dioxide, the low pH, the lack of carbonate ions to build shells, some kind of algae or trace metals, or bacteria that exist in upwelled water. It could be some combination of all of the above.[66]

In the last two summers, federal funding has helped the hatcheries deploy monitoring equipment that lets operators know when pH levels begin to drop in the surrounding seawater. They've adjusted spawning times and other operations to try to avoid the worst ocean conditions. Taylor Shellfish, which has also benefited from favorable winds that kept acidified water near the bottom of the bay and below their shallowest intake pipe, has had two banner years for oyster growing. Whiskey Creek hasn't been as lucky.[67]

Yet concerns about ocean acidification aren't confined to the hatcheries. In the last six years, oysters have failed to spawn in Washington's Willapa Bay, one of the few places where the commercially popular oysters used to reproduce naturally.[68] No one knows which species may be affected next, said Margaret Barrette, executive director of the Pacific Coast Shellfish Growers Association. Moreover, the large and lucrative oyster crop supports regional processing and distribution infrastructure that's necessary to bring clams, mussels, geoduck, and other shellfish to market.

"These are people's jobs," Barrette said. "Rural economies are fueled by these shellfish farms and without the larvae being successful, nothing can happen."[69]

Yet hatcheries are places where variables like food, temperature, and water chemistry can be controlled to boost the chances that a young oyster or clam or mussel will live. In the real ocean, marine creatures won't have that helping hand. Some may argue that oceans are resilient, that nature abhors a vacuum, and that different types of algae or grasses that can thrive in more acidic seas could replace losses at the bottom of the food chain. In truth, no one knows how complicated marine ecosystems will adapt to ocean acidification. The effects could range from minor to apocalyptic.

In that sense, people can decide how worried they want to be. But Brad Warren, who directs the Sustainable Fisheries Partnership's ocean acidification program, argues that a smart businessperson pays attention to signs of trouble, tries not to get caught behind the curve, and rethinks outdated strategies when they're no longer working. You can view the problem with a gambler's instinct or a stewardship instinct, he said.

"If you think of someone who has a fiduciary duty for the systems that feed us and provide jobs to half a billion people in the world," he said, "what would you rather be—a banker or a gambler—with this resource?"[70]

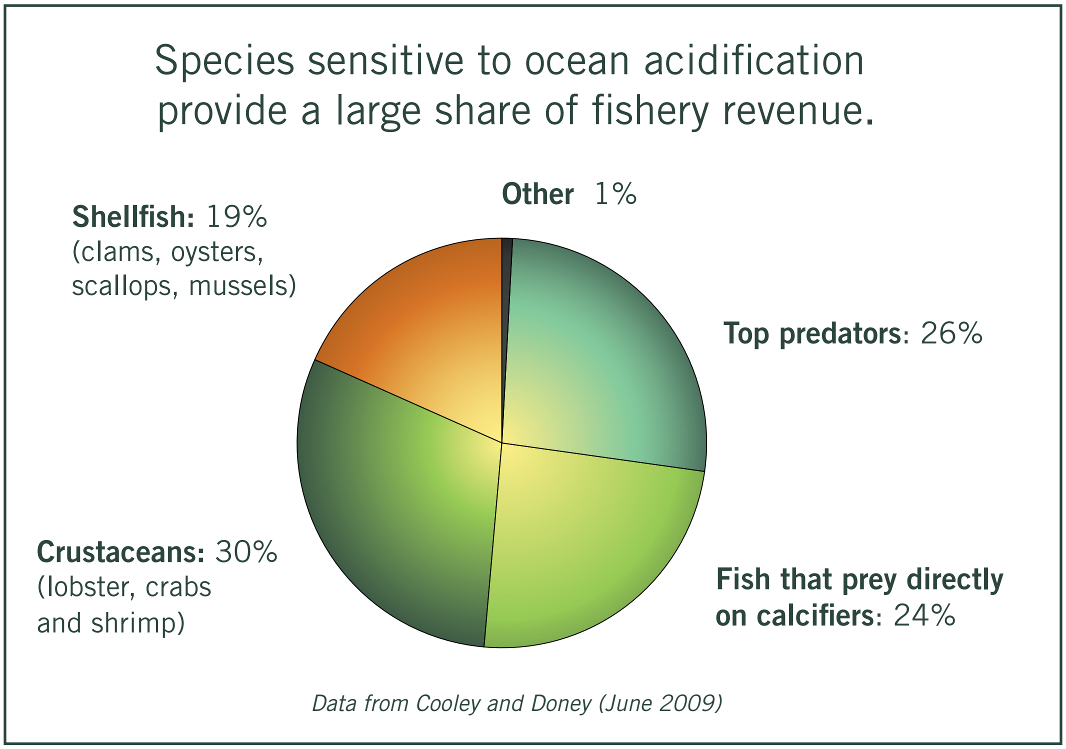
Mark Vinsel ranked his concerns about ocean acidification this way: "I'd say probably on a scale of 1 to 10, it would be 20 or 30."

It's an important question for a state like Washington, where a study conducted for the Seattle Marine Business Coalition found the commercial fishing industry contributes $3.9 billion in personal income, or 2 percent of the state's net earnings.[71] In Oregon, a state study puts those numbers at $400 million in personal income, or the equivalent of 12,000 jobs.[72] In Alaska, where much of the Northwest fleet fishes, one study estimates that commercial fishing generates 78,000 direct and indirect jobs and is the third largest driver of economic activity in the state.[73]

The executive director of Alaska's largest commercial fishing organization, Mark Vinsel, ranked his concerns about ocean acidification this way: "I'd say probably on a scale of 1 to 10, it would be 20 or 30."[74]

That's because many of the fish likely to wind up in a trawler's hold or on your dinner plate—salmon, cod, flounder, pollock, tuna—eat shelled creatures at some point in their lives, or prey on something that does. It's unclear whether ocean acidification will directly affect these commercially valuable finfish, but it could make it more difficult for them to find food.[75]

As the chart below shows, about half of the $4 billion that commercial fishing and at-sea processing generates annually in the US comes from mollusks and crustaceans, many of which depend on calcium carbonate that could become harder to assemble as oceans acidify. Another 24 percent comes from animals that directly feed upon those calcifiers.[76]



Of the $4 billion in ex-vessel revenue that US commercial fishing generated in 2007, three-quarters came from animals that need calcium carbonate or fish that prey directly on "calcifiers." [77]

Without knowing how far up the food chain problems may reach, it's impossible to estimate the total economic damage from ocean acidification. One narrow case study estimates that if oysters and mussels decline in the wild at the same rate as in the laboratory, we could expect $75 million to $187 million in annual losses in the US mollusk harvest. The indirect economic losses could range from $1.5 to $6.4 billion over the next 50 years, the study found.[78]

Moreover, not all fisheries may be affected equally. New England's mollusk-heavy fisheries could initially be more vulnerable than Alaska's. But the Alaskan catch could also decline because fish like haddock, halibut, herring, flounder, and cod eat mollusks. And if those species decline, it could harm top predators like swordfish, tuna, shark, and salmon, according to Sarah Cooley, a Woods Hole Oceanographic Institution researcher working to put a dollar value on ocean acidification's potential consequences.[79]

Her research suggests that the fishing industry itself—along with our eating habits—may be in for a change. As oceans become more acidic, we may have to eat different species, protect more marine habitat, manage fisheries differently in light of carbon dioxide threats, and shift aquaculture production to species or geographic areas that are less vulnerable to decline.[80]

Jeremy Brown, a Bellingham-based commercial fisherman who has spent nearly three decades fishing for salmon, halibut, black cod, and albacore tuna, said ocean acidification may be a second-order threat to the fish he catches. But he sees it as one of the most fundamental challenges facing the industry.

"People say 'well, we've just got to manage fisheries better and maybe create some marine protected areas and everything will be fine in the garden,'" but that's not really true, Brown said. "We've really got to figure out how to burn a lot less fossil fuel and shift away from carbon-based policies."[81]

What can we do about ocean acidification?

We cannot reverse the chemical changes that are already underway in our oceans. But there are steps we can take today to prevent the problem from becoming more catastrophic in the future:

- Reduce damaging emissions by developing policies that limit or put a price on carbon dioxide pollution.
- Use existing laws to curb pollutants that worsen the impacts of acidification.
- Invest in research and monitoring to determine how species will be affected, better manage fisheries, protect important habitat, and help seafood producers adapt.

Reduce emissions

The root cause of ocean acidification is carbon dioxide emissions. Pollution from cars and coal plants and other industries that burn fossil fuels is the catalyst that makes seawater more acidic and makes carbonate ions less available. Without that essential ingredient, economically important species such as oysters and ecologically important plankton at the bottom of the food chain can run into trouble.

Any comprehensive attempt to address ocean acidification must include carbon dioxide reductions. An effective strategy will likely need a blend of approaches, including:

- Carbon taxes or cap-and-trade systems that rely on price signals to shift the behavior of industry and consumers away from carbon-intense activities.
- Regulations that reduce greenhouse gas emissions in specific sectors or industries, such as higher vehicle mileage standards or requirements for buildings to be more energy efficient.
- Investments in technology to replace fossil fuels with cleaner sources of energy.

The solutions may not be easy, yet they're not as hard as some make them out to be. There are other examples where we've successfully gotten the flow of harmful emissions under control, such as the US sulfur dioxide trading program, a cap-and-trade system,[82] that has reduced acid rain-causing pollution quickly and cheaply.[83]

"We've done it before, we can probably do it again," said Warren, with the Sustainable Fisheries Partnership. "You can use taxes, carbon markets, implement other controls, energy efficiency, increased use of cleaner power. There are many tools, but no one I think can credibly argue that you can do it without some kind of carbon policy."[84]

Use existing laws

Coastal communities don't need to wait for an international climate treaty to start addressing problems in their back yard. They have the power to control other forms of pollution that compound acidification problems. Using existing laws on the books, state and local governments can start tackling ocean acidification right now by:[85]

- reducing stormwater runoff that dumps nutrients into local waters by incorporating green drainage systems into street design and building codes.[86]
- effectively regulating septic systems and other sources of nutrient pollution.
- reducing coastal erosion, which dumps sediment into ocean habitat.
- adopting land use policies that create compact communities, preserve rural areas, and encourage less driving.
- investing in alternative transportation systems that move people more efficiently and burn less fossil fuel.[87]

The Clean Water Act is another potential tool to curb carbon dioxide emissions that drive ocean acidification.[88] The US Environmental Protection Agency, for instance, recently agreed to consider the issue after being sued for failing to acknowledge that ocean acidification had impaired waters off Washington state's coast.[89] In late 2010, the EPA put states on notice that they should begin listing waters that have been damaged because of ocean acidification, in places where that information is available.[90] Unfortunately, few states have monitoring programs or plans to collect the necessary data.[91]

Invest in monitoring and research

Accurately measuring pH in the ocean is nothing like checking a hot tub or watching a test strip change color in grade school chemistry. It requires expensive instrumentation, precise calibration, and expertise to make valid comparisons. A substantial national investment in ocean acidification research and monitoring will be crucial to establish baseline data, help scientists determine the extent of the problem, and allow seafood producers to adapt.

So far, though, federal investment in ocean acidification research has been meager. In March 2009, Congress passed the Federal Ocean Acidification Research and

Monitoring Act that establishes a comprehensive research and monitoring plan for the federal agencies involved in climate and ocean policy. But funding has not materialized in the volumes that supporters had hoped.[92] In 2009, the federal government spent $10.9 million on studies primarily focused on ocean acidification,[93] compared to a $6 billion budget for the National Science Foundation[94] and $17 billion for NASA.[95]

If we choose to pursue them, solutions are within our reach to move economies away from harmful fossil fuels that speed global warming and threaten our oceans. We have tools at our disposal to prevent the collapse of marine ecosystems and be responsible stewards of that vital resource.

But the longer we fail to act, the worse the picture becomes. And life gets harder for people like Paul Williams, the shellfish policy management advisor for the Suquamish Tribe. On a blue-sky summer day, he found himself trying to explain to a group of teenagers why they were inside a stuffy tribal science classroom learning about ocean acidification instead of playing outside in the sun like other kids. In the end, all he could think to do was apologize:

"This is your future," Williams said. "If any of you want to be fishermen or fisherwomen, it's really up to you guys. This is something that's happening right now, and it's getting worse. If we want to have any alternative to McDonald's, we're going to have to work on this. And I have to apologize to you because my generation couldn't do it. It's a shame to have to tell you guys that this is your problem. . . but it's the truth, and I think you guys are old enough to be told the truth."[96]

About the Author

Jennifer Langston applies her hard-hitting journalism skills to the most pressing issues in the Northwest. Before joining Sightline, Jennifer spent a decade as a reporter covering environment and sustainability issues across the Northwest. She wrote about land use, housing, urban design, transportation, food policy and climate change for the *Seattle Post-Intelligencer*. Jennifer also covered the energy and environment beat in Idaho and South Carolina. She has English and journalism degrees from Yale University and the University of Maryland.

Sightline Institute is a not-for-profit research and communication center—a think tank—based in Seattle. Sightline's mission is to make the Northwest a global model of sustainability—strong communities, a green economy, and a healthy environment. Sign up for email news and updates at http://www.sightline.org.

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