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Ocean Acidification: Oyster Crisis Could Spread To Other Fisheries

By Peter McDougall

How will ocean acidification affect commercial fishermen along the Pacific coast of North America? The best clue may be close at hand. Oyster growers in the Pacific Northwest are weathering a severe multi-year reproductive failure that researchers have linked to changing ocean chemistry.

The larval die-offs are a preview of troubles that could threaten many commercial fisheries if the world's oceans continue to increase in acidity.

Production of Northwest oyster seed has already fallen sharply. The hardest hit facility, which supplies oyster farms up and down the west coast, lost 80% of its larvae in 2008 and is now struggling to stay in business.

Wild oysters in Washington's Willapa Bay– which produces one sixth of the US harvest– also have taken a major reproductive hit since 2005, though some pockets of production remain.

The impacts have been patchy. Some hatcheries and natural oyster beds are suffering partial reproductive declines while others have virtually collapsed. But the multi-year duration of this problem has brought the West Coast oyster industry a dubious distinction: Many consider it the "canary in the coal mine" of ocean acidification– the first major sector of the seafood industry known to get hit from this cause.

Many fishermen suspect that other fisheries are suffering from the same problem, but ocean acidification and its impacts aren't yet regularly monitored in most areas. So the suspicion that ocean acidification may have caused the poor pink salmon returns in Prince William Sound during 2009, for example, can't yet be either proved or refuted scientifically.

The evidence for ocean acidification's impacts on oysters is strong. Growers have raised money to support research on the problem and to hunt for ways to cope– or at least to buy time. And so far most are still producing.

However, they're up against a global problem. Every year billions of tons of CO_2 from the world's tailpipes and smokestacks settle from the atmosphere into the oceans. The gas forms carbonic acid when it mixes with seawater, resulting in increasingly corrosive water that can dissolve shells and harm fish, shellfish and corals.

If left unchecked, acidification promises to erode production in commercial fisheries by undercutting food webs that sustain fish stocks.

Even modest increases in acidity– to levels already found in some West Coast and Alaskan waters– can dissolve shell-forming plankton that supply much of the food for young salmon, cod, pollock, halibut and other commercially harvested stocks.

"Anything that has a shell on it, which is just about everything that fish eat, could be affected and probably would be," said Dick Sheldon, a longtime Dungeness crabber and oysterman on the southern Washington coast.

"We could be facing a question of having resources or having no resources in a very few years if they keep dumping more carbon in the oceans," said Erling Skaar, a Bering Sea crab vessel owner. "We don't know the time line, but we don't want to find out that it's too late."

Skaar traveled to the U.N. negotiations on climate policy in Copenhagen in December 2009 to help drive home the message that strong carbon limits are necessary to protect fisheries– and to learn about fuel efficiency and energy-management practices in Europe.

More and more commercial fishermen are growing concerned about this issue. In September 2009, fishermen and other mariners in Homer, Alaska, assembled some 100 vessels into the phrase "SOS: Acid ocean," calling international media attention to the problem. The event was sponsored by the Sustainable Fisheries Partnership (SFP), with local organizing work by Alan Parks, a Homer fisherman and representative of the Alaska Marine Conservation Council.

In November and December 2009, SFP sponsored 12 fishermen and seafood producers from around the country to visit Washington D.C. and ask lawmakers to sharply limit carbon emissions in order to protect productive fisheries from acidification.

The Sustainable Fisheries Partnership's program on ocean acidification itself is the brainchild of Brad Warren, who has worked as a journalist and consultant to the industry since the early 1980s. Warren's program has raised funds to support workshops and the writing of a series of articles to inform fishermen around the country about acidification.

The group has also sponsored work to help the fishing industry boost fuel efficiency and reduce emissions without cutting into production, and to give fishermen and processors a preview of emerging carbon regulations. But it's the industry's voice, not its emissions, that can make the most difference, Warren argues.

"The world's fishing fleets account for only 0.2% to 0.6% of global CO_2 emissions," said Warren. "If you're a fisherman, your tailpipe matters a lot less than your ability to mouth off about the problem. The best thing you can do is to start pushing lawmakers to protect fisheries by limiting total emissions."

Exactly What Is Ocean Acidification?

The chemistry of ocean acidification is fairly straightforward: When CO_2 mixes with seawater (H_2O), it forms carbonic acid (H_2CO_3). The presence of this acid increases the number of hydrogen ions (H^+) in seawater, lowering its pH (percentage of hydrogen ions). The hydrogen ions, which are chemically very active, then attack carbonate ions, which are the building blocks for shells and skeletons of many organisms, such as shellfish and coral reefs.

Since the Industrial Revolution, the average pH of the ocean surface has dropped 0.1 pH units, from 8.2 to 8.1. This number seems small, but it represents a 30% increase in acid concentration above normal ocean conditions because these numbers are on a logarithmic scale (i.e., each pH unit represents a factor of 10).

If current CO2 emissions trends continue, the increase in sea water acidity will amount to 150% to 200% above pre-industrial normal conditions by the end of this century, according to Dr. Richard Feely of NOAA's Pacific Marine Environmental Laboratory in Seattle, one of the pioneering researchers who confirmed this change in ocean chemistry. Because hydrogen ions dissolve more readily in colder waters than warm, some parts of the west coast already experience acidity at similar levels to this projection during the summer's cold water ocean upwellings. This is what is killing off many of the west coast's oysters and other shellfish.

The main cause of ocean acidification is a rapid increase in atmospheric CO2 resulting from human activities– chiefly increased emissions from burning fossil fuels. Compounding these emissions is a decline in the planet's ability to absorb CO2 due to deforestation and other land development.

But "ocean acidification" is really short-hand for changes that reach far beyond calcifying species. Scientists have now documented many impacts on fish, corals, shellfish and plankton. A few highlights:

Heart failure: Slightly acidified water induced heart failure in halibut and amberjack in one Japanese experiment.

Muscle atrophy: Brittlestars suffer muscle loss even as they bulk up their protective shells in acidified water, making them weak and vulnerable to predators, according to researchers at Plymouth Marine Lab in England

Asphyxiation: Squid exposed to acidified water asphyxiated in one study published in 2006.

Torpor: Squid also lost the zip to hunt or dodge predators effectively.

Reduced growth: Most studies on shellfish, calcifying plankton and corals show significant decline in growth.

Reduced reproductive success: Several studies have documented reproductive consequences in oysters and other shellfish.

How Much CO_2 Is Too Much?

One vital question for fisheries is where the limits on CO_2 must be set in order to protect fish stocks and their habitat. Scientists studying ocean acidification say that aggressive reductions in emissions can prevent a lot of damage if governments act swiftly. Leading researchers believe the impacts can be minimized for fisheries and marine life if emissions are capped and total atmospheric concentration of carbon dioxide peaks at no higher than 450 parts per million (ppm)– followed by a rapid decline to lower levels.

Strong evidence suggests that 450 ppm represents a dangerous tipping point for at least some marine ecosystems, but sound resource management may argue for setting long-term emissions targets that are significantly lower. Many scientists and conservation groups argue that the safe limit for atmospheric concentration should be set at 350 ppm– Today's atmospheric CO_2 concentration averages about 387 ppm. If they're right, protecting fisheries would require emissions reductions deeper than any currently contemplated by world leaders.

Can Fisheries Adapt To Acidification?

Many fishermen find it tempting to imagine that acidification is just another change to get used to.

It's a comforting notion, but misleading. Ocean temperature and currents do change occasionally, resetting the table for harvestable species in the water. Alaska fishermen recall that several lucrative shrimp, crab and herring fisheries dwindled away, while Alaska's groundfish stocks swelled with warmer waters in recent decades. Fishermen adjusted, and many prospered.

Acidification is different. Commercial fisheries *cannot* adapt to an ocean that is *no longer chemically capable* of producing abundant fish and shellfish stocks.

If it continues unchecked, this change in ocean chemistry will result in reduced productivity for commercially important fish stocks. The rate and depth of that decline are not yet known, but the consequences for fisheries are grimly predictable. When harvestable stocks shrink, fishery managers will impose increasingly strict limits on harvests and access to resources.

Carbonate rocks on the sea floor will eventually neutralize the acid and bring the ocean's pH back to its slightly alkaline normal. *But that process takes at least tens of thousands of years.* Even patient fishermen can't wait that long.

Dissolving The Young

One clear sign of trouble comes from a series of photographs taken by researchers on the East Coast. They show tiny young clams dissolving in water acidified to pH 7.5.

These conditions frequently occur in parts of many East Coast bays where local inputs of acidifying nitrogen, sulfur and carbon pour in from nearby human activities, including farm waste, industrial plants and sewage.

In the photographs, the clams start out as miniatures of the mature clams people eat. After just 24 hours, they've shriveled to about half their original size and their shells are visibly fraying apart. After 72 hours they've shrunk to remnants, barely identifiable as clams.

Mark Green, a biologist at St. Josephs College of Maine, says these dissolving clams are another preview of the future ocean. If CO_2 emissions keep growing unchecked, by the turn of the century the corrosive conditions that now kill young clams in parts of these bays will prevail throughout much of the world's ocean.

Some marine areas, especially at high latitudes and in upwelling zones like the West Coast, are already approaching these conditions during periods of peak acidity.

Many commercially important species– including crabs, urchins, oysters, clams, squid, plus the various crustaceans and plankton that provide their food– are especially vulnerable during their first few days of life. In most cases, the larvae of shell-builders such as oysters, mussels, clams and scallops suffer high mortality rates at pH levels expected by the middle of this century.

But it's not just mollusks that are affected:

Research suggests that lobsters might be at greater risk for shell disease when pH drops.

A preliminary experiment by NOAA scientists in Alaska showed that 67% of larval blue king crab died when pH dropped 0.5 units using hydrochloric acid; that's especially troubling because Japanese research has shown that carbonic acid is deadlier then hydrochloric for at least some marine species.

Even shrimp are affected by acidic conditions, with a decrease in the size of hatching larvae when raised in water with a pH of 7.6.

Species vary in their responses to lower pH conditions, and not every fishery is likely to feel the effects of ocean acidification equally. But a major concern to researchers and fishermen alike is the vulnerability of the base of the ocean food chain.

North Pacific salmon, mackerel, herring, cod and baleen whales (among many other species) all feed on tiny winged snails known as *pteropods*, which swim by flapping their wings. But *pteropods* dissolve much like Green's tiny clams when exposed to water acidified to levels that now occur periodically along parts of the West Coast.

Pteropods make up as much as 45% of the diet for pink salmon.

Forecasting impacts from a decline in prey is tricky because species can often find new things to eat. But one modeling exercise conducted by NOAA scientist Kerim Aydin and colleagues suggests that even a small decline in *pteropod* abundance might take a disproportionately large bite out of pink salmon fisheries. Aydin's model indicates that a 10% drop in *pteropod* numbers could translate into a 20% decline in mature body weight of pink salmon due to prey limitation.

Acidification also threatens cold water corals, indirectly affecting commercially important coral-dwellers like rockfish. In lab experiments, coral polyps survive adequately well in lower pH conditions, but their external skeletons simply dissolve. Not only does this leave polyps more exposed, it also removes the structured coral habitat that shelters many commercially important finfish.

Early Impacts Are Here Now

The effects of ocean acidification are particularly acute in upwelling regions, like the West Coast. In such areas, new CO_2 emissions just compound the effects of cold upwelling waters that already have naturally high concentrations of CO_2.

In the West Coast oyster industry, the clues linking larval die-offs to acidification fell into place in 2008. That's when Dr. Feely and other researchers showed that CO_2 was aggravating the normally high seasonal concentration of acidified water along the coast, reaching corrosive levels that weren't expected to occur for decades.

Many oyster growers believe this acidification may drive the die-offs of larvae in West Coast hatcheries disrupting the creatures' ability to grow aragonite shells. But increasing CO_2 concentration also affects many other chemical constituents in seawater– including oxygen and trace metals– which could affect survival.

It's not clear whether the causes of mortality are the same at other Northwest shellfish hatcheries, but the folks at Whiskey Creek Shellfish Hatchery **near Tillamook**, Oregon, are convinced. **Whiskey Creek is** one of the main sources of seed for independent shellfish farms on the West Coast.

"We know that when we have problems with larvae, our aragonite saturation is too low to make shell," explained **Sue Cudd, who owns and operates the Whiskey Creek hatchery with her husband Mark Wiegardt.**

"After killing more larvae than probably anyone else ever, it's becoming very obvious to us that the low pH, under-saturated upwelling water is the culprit," said Cudd.

Some shellfish species survive better, Cudd said:

"Interestingly enough, a lot of the clam larvae are not as affected as the oyster species. Even mussels aren't doing as badly."

The effects of acidification on the West Coast are likely to get worse– and spread to more species– before they get better. That's because the fossil fuel emissions now working their way through the region's upwelling system first came out of smokestacks and tailpipes about 50 years ago. Given that world CO_2 emissions have roughly doubled since 1970, it's sobering to consider what pent-up trouble may reach west coast fisheries in the future– even if CO_2 emissions can be radically reduced tomorrow. Given how much excess CO_2 is already in the atmosphere, it will take many decades to stabilize CO_2 absorption levels in the world's oceans even after such radical reductions.

Dr. Feely and other scientists argue that aggressive emissions reductions can probably preserve much of the ocean's capacity to support fisheries. And even if some harm is now inevitable, it's fair to ask: Is that any reason not to prevent even greater harm?

Can Geoengineering "Cures" Work?

Stare into this troubled water long enough, and you'll find yourself wishing for some kind of global Alka-Seltzer® pill. Can't we just buffer the oceans so that fossil fuel CO_2 emissions no longer cause acidification, as some have suggested? The answer is no.

A consortium of the world's national academies of science, the Interacademy Panel on International Issues (www.interacademies.net/CMS/8900.aspx), discounts these geoengineering tactics. The panel cites high cost, limited effectiveness and scale, and potentially large hazards to the marine environment as reasons for skepticism. The sheer global scale of acidification renders most techno-fixes impractical: oceans cover more than 70% of Earth's surface and absorb *22 million tons of CO_2 daily*.

One popular idea for reducing excess CO_2 in the atmosphere is to capture the gas at power plants and pump it underground. Small-scale pilot projects (in aging oil fields, for example) are underway today. Still, any application on a global scale is at least decades away, leaving oceans and fisheries to face ever-increasing CO_2 emissions in the meantime.

Some entrepreneurs are pitching schemes to "fertilize" the oceans with iron dust in order to capture CO_2 in vast plankton blooms. Yet so far, experiments with this method have failed to keep much CO_2 from escaping back into the sea and the air as the algae die off. And even if ocean fertilization can eventually be made to work, scientists warn that such mass produced approaches could cause significant but still largely unknown damages to already stressed fisheries and marine ecosystems as unintended consequences.

Can CO_2 Emissions Be Cut?

Efforts to curtail emissions now center on climate policy, a timely issue in Washington, DC this spring. Federal lawmakers have a chance to pass a US energy and carbon law during early 2010. After that, looming mid-term elections will likely distract Congress.

Protecting fisheries will require steep worldwide reductions in emissions of CO_2. Technically such reductions are feasible, and much of the necessary technology is already widespread and profitable to use. What is really lacking is simply the political will to make the needed changes.

The good news for fishermen is that they're not alone in wanting a robust emissions-reduction regime.

Many Fortune 1000 companies are advocating policies to cap emissions and create a carbon trading scheme similar to the systems that many fisheries employ to trade quota for target and bycatch species. A cap-and-trade system is one way of putting a price on carbon emissions– designed to economically penalize those who pollute while rewarding those who cut their emissions.

Even without that extra incentive, energy management and efficiency practices are already benefiting many firms.

DuPont, the huge chemical and materials company, reports that it reduced its greenhouse gas emissions by 72% between 1990 and 2007 while increasing industrial production by 40%. The company managed to cut its energy bills by a total of $3 billion along the way, saving $800 million in 2007 alone.

Some coal and oil-dependent utilities and industrial firms have fought to block legislation to limit US CO_2 emissions. Their political allies helped to scuttle hopes for a global treaty limiting carbon dioxide emissions in Copenhagen in December, 2009.

Even so, the US House of Representatives has twice passed legislation to require deep emissions reductions and institute a cap-and-trade system, once in 2008 and again in 2009. The Senate, with its procedural rules requiring a 60-vote majority to overcome stubborn resistance, poses a taller hurdle. Yet even there, the interests lining up behind passage of climate legislation are potent.

If politicians fail to act, the US Environmental Protection Agency (EPA) may take over. In September, 2009, under US Supreme Court Order to act, the EPA proposed regulating CO_2 and other greenhouse gas emissions from new vehicles.

Fishermen can fill a crucial role in this political mix. No one else can speak for the ocean like those who depend on it for a living. Now that lawmakers and international negotiators are working to limit carbon emissions, fishermen have a window of opportunity to speak up.

Getting Involved

Fishermen can do a lot to protect the ocean that feeds us all. Our most important work now is speaking up for the resource. A few suggestions:

Encourage your Senators and Congressmen to pass a climate law that's strong enough to protect productive fisheries from acidification. Such a law would require steep cuts in emissions and would create mechanisms that can be counted on to deliver.

Urge lawmakers to fund research and monitoring of ocean acidification and its impacts under the new national research program authorized last year, the Federal Ocean Acidification Research and Monitoring Act (FOARAM). Data from this research will strengthen the case for protecting ocean resources.

Ask lawmakers to make sure the new carbon laws are workable and fair for fishermen. This will mean different things to different fishermen. For some, it means making sure fishermen get "dealt in" when a new market for emissions credits is created. Some fishermen want federal funding for fuel-efficient engines to help them cope with a future where carbon pricing is likely to push up fuel prices. Some hope for policy changes that allow North Pacific trawlers to consolidate permits and build new, fuel-efficient vessels.

Encourage your port and local trade associations to get involved. Fishermen and processors can get more done by acting together.

Share your wisdom. You have direct practical experience about the advantages and pitfalls that will face any future carbon market that lawmakers may create. Fisheries leaders have forged dozens of these market-based tools to solve similar environmental and economic problems. Designing a robust mechanism to solve the carbon dioxide emissions problem requires experience. No one has more relevant experience than commercial fishermen.

Boost fuel efficiency in your own operation. You'll save money, cut emissions, and build confidence in your right to speak up for strong measures to protect the ocean from unchecked CO_2 emissions.

PCFFA's guest columnist for this article, Peter McDougall, is a marine biologist and freelance writer living in Maine. He has been interested in ocean acidification for the past four years and has written a number of professional articles on the subject.

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