Article 1: Acidified seawater showing up along coast ahead of schedule; by: Sandi Doughton

Doughton, Sandi. "Acidified Seawater Showing up along Coast Ahead of Schedule." *The Seattle Times*. The Seattle Times, 23 May 2008. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/nationworld/2004433462_acidoceans23m.html>

Christopher Sabine, of NOAA's Pacific Marine Environmental Laboratory in Seattle, works with an instrument that collects seawater samples off the West Coast.

Senate hearing on ocean acidification

Sen. Maria Cantwell, D-Wash., will hold a field hearing in Seattle on Tuesday on "Climate Change and Ocean Acidification: Impacts on Puget Sound." The hearing will be from 10 a.m. to noon in the Seattle Aquarium's Puget Sound Great Room. For more information, call Cantwell's office at 206-220-6400.

Climate models predicted it wouldn't happen until the end of the century.

So a team led by Seattle researchers was stunned to discover that vast swaths of acidified seawater already are showing up along the Pacific Coast as greenhouse-gas emissions upset the oceans' chemical balance.

In surveys from Vancouver Island to the tip of Baja California, reported Thursday in the online journal Science Express, the scientists found the first evidence that large amounts of corrosive water are reaching the continental shelf — the shallow sea margin where most marine creatures live.

Off Northern California, the acidified water was only four miles from shore.

"What we found ... was truly astonishing," said oceanographer Richard Feely, of the National Oceanic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory in Seattle. "This means ocean acidification may be seriously impacting marine life on the continental shelf right now."

All along the coast, the scientists found regions where the water was acidic enough to dissolve the shells and skeletons of clams, corals and many of the tiny creatures at the base of the marine food chain. Acidified water also can kill fish eggs and a wide range of marine larvae.

"Entire marine ecosystems are likely to be affected," said co-author Debby Ianson, an oceanographer at Fisheries and Oceans Canada.

Though it hasn't received as much attention as global warming, ocean acidification is a flip side of the same phenomenon. The increase in atmospheric carbon dioxide from power plants, factories and cars that is raising temperatures worldwide also is to blame for the increasing acidity of the world's oceans.

Normally, seawater is slightly alkaline. When carbon dioxide from the atmosphere dissolves into the water, it forms carbonic acid — the weak acid that helps give soda pop its tang. The process also robs the water of carbonate, a key ingredient in the formation of calcium carbonate shells.

Since the Industrial Revolution, when humans began pumping massive amounts of carbon dioxide into the atmosphere, Feely estimates the oceans have absorbed 525 billion tons of the man-made greenhouse gas — about one-third of the total released during that period.

By keeping some of the carbon dioxide out of the atmosphere, the oceans have blunted the temperature rise due to global warming. But they've suffered for that service, with a more than 30-percent increase in acidity.

The acidified water does not pose a direct threat to people. "We're not talking battery acid here," said co-author Burke Hales, an oceanographer at Oregon State University.

On the pH scale, which measures acidity, strongly alkaline materials such as oven cleaner measure about 13. Hydrochloric acid has a pH of 1. Seawater usually measures around 8.1. The most acidic water the scientists found off the Pacific Coast measured 7.6 on the pH scale. The numerical difference may seem slight, but it represents a threefold increase in acidity, Hales said.

Until now, researchers believed the most acidified water was confined to the deep oceans. Cold water, which holds more carbon dioxide, sinks. Deep waters also are naturally high in carbon dioxide, which is a byproduct of the decay of plankton.

Feely and his NOAA colleague Christopher Sabine previously have shown that zones of acidified water are growing and moving closer to the surface as the oceans absorb more man-made carbon dioxide.

During surveys on the Pacific Coast last year, a team including Feely and Sabine discovered the natural upwelling that occurs along the West Coast each spring and early summer is pulling the acidified water onto the continental shelf.

"I think this is a red flag for us, because it's right at our doorstep on the West Coast," said Victoria Fabry, a biological oceanographer at California State University, San Marcos, who was not involved with the study. "It's telling us that we really need more monitoring to figure out what's going on."

Climate scientist Ken Caldeira, of the Carnegie Institution at Stanford University, said the finding underscores the limitations of computer models.

"This is another example where what's happening in the natural world seems to be happening much faster than what our climate models predict," he said.

And there's worse to come, the scientists warn.

A network of currents shuffles ocean water around the globe. The acidified water upwelling along the coast today was last exposed to the atmosphere about 50 years ago, when carbon-dioxide levels were much lower than they are now. That means the water that will rise from the depths over the coming decades will have absorbed more carbon dioxide and will be even more acidic.

"We've got 50 years worth of water that's already left the station and is on its way to us," Hales said. "Each one of those years is going to be a little bit more corrosive than the one before."

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Article 2: The Bergen Mesocosm-a case study; January 7, 2009

EPOCA. "Ocean Acidification." *Ocean Acidification*. EPOCA, 07 Jan. 2009. Web. 30 July 2012. <http://oceanacidification.wordpress.com/2009/01/07/the-bergen-mesocosm-a-case-study/>.

The Bergen mesocosm experiment was one of several major research efforts in recent years to try to untangle the complex consequences of ocean acidification. Project leader Dr. Ian Joint explains the research, and gives a taste of what it found.

One of the least-understood consequences of increasing carbon dioxide concentrations in the atmosphere is that the oceans are becoming more acidic.

This is because CO2 in the air dissolves in seawater to form carbonic acid – a weak acid that makes the oceans slightly more acidic. The rate of change is extremely rapid and it is expected that by the end of this century, the oceans will be more acidic that they have been for more than 20 million years.

Over geological time scales, the pH of the seas has changed significantly in response to variations in atmospheric CO2. Indeed, the ocean has in the past been more acidic than we expect it to become over the coming decades.

But what is different this time is the speed of change. Ecosystems have proved their ability to accommodate change when it is gradual, usually over hundreds of thousands of years. We do not know how well the marine ecosystem will adapt to changes that will occur over decades.

Microbes are the most important organisms in the sea. In contrast to the land, where plants are large and long-lived, in the seas most of the primary production comes from microscopic algae, or phytoplankton. These have tiny biomass and their generations last only days.

The productivity of this phytoplankton depends in turn on bacteria and archaea to regenerate nutrients. So it was a priority to determine how marine microbes would respond to a high-CO2 world.

Microbes control biogeochemical cycles and keep the planet habitable. This means we need to know how microbial populations will respond to rapid climate change.

As a first step to address this question, a NERC-funded experiment took place in May 2006 to test the effect of an instantaneous change of CO2 concentration to the level that is projected for the year 2100. The aim was to identify the components of the microbial ecosystem that are most sensitive to pH change.

These experiments are complex because pH varies naturally over the course of a year. When phytoplankton populations begin to grow in the spring they consume CO2 that is dissolved in seawater. The result is that pH increases for a period of a few weeks.

The dissolved CO2 gradually increases as a result of bacterial activity and the pH declines to a more typical values. In a high CO2 world, this seasonal variability will still exist but the microbial populations will be exposed to a different range of pH values than in the present day. So we need to understand how marine microbes will adapt to the new conditions.

We used the latest approaches to study the problem, including metagenomics – the analysis of the genetic information of all of the microbes present in the system. Recent advances in the technology to sequence DNA mean that it is now possible to analyze the genetic information from organisms living in their natural environment.

We have used these approaches to investigate which parts of the microbial population might be most vulnerable to the changes in pH that will occur by the end of the century. In addition, we have used novel approaches to investigate changes in metatranscription – that is, to find out which genes are switched on or off as a result of pH change.

The approaches used in this mesocosm experiment have told us how the existing population responds to pH change. But these short-term experiments do not indicate how populations might adapt over time; some bacteria might find the new conditions preferable and so they might become more abundant.

Answers to these questions will require a different type of experiment, which will last for many months or even years.

Article 3: Ocean researchers dive deeper into Puget Sound's acidification; by: Craig Welch; February 27, 2012

Welch, Craig. "Ocean Researchers Dive Deeper into Puget Sound's Acidification." *The Seattle Times*. The Seattle Times, 27 Feb. 2012. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/localnews/2017613197_acidification28m.html>.

FRIDAY HARBOR, San Juan Island —

To understand the bizarre ways changes in ocean chemistry may affect Northwest sea life, there may be no simpler creature to start with than mussels. When scientists in a Friday Harbor laboratory exposed mussels to slightly acidic marine water, they found the tiny fibers the shellfish use to cling to rocks stayed as strong as ever. But when the water warmed, those fibers, called byssal threads, became less adhesive — and that could prove deadly. "Crabs, fish and sea stars love to eat mussels, but it's hard for predators to pull them off rocks," said Emily Carrington, a University of Washington professor who has studied mussels for 20 years.
"But when waves crash and they're not firmly attached, mussels get knocked off. Then they fall to the bottom. And that's crab city."

It's the kind of subtle but important change that has become the focus of new marine research trying to grasp how human-caused increases in carbon-dioxide emissions may change Puget Sound and the oceans. It's also a sign of a new sophistication in ocean acidification research.

Scientists long have predicted climate change eventually would make waters more corrosive as oceans take up carbon dioxide. The oceans typically measure a slightly alkaline 8.1 on the pH scale that separates an acid from a base. But in 2007 and 2008, researchers from the National Oceanic and Atmospheric Administration discovered surface-chemistry changes off the West Coast already were happening. In 2010, they found the pH of some Puget Sound waters already was an astonishingly low 7.7. For most of the past few years, those studying how the changes may harm marine life have made astounding discoveries. As the pH of seawater drops, for example, sea urchin larvae change shape, squid metabolisms slow, some brittle stars and barnacles begin to die, and the shells of oyster larvae start dissolving while they form.

Scientists now are asking more complicated questions as they try to analyze how those changes may alter the way creatures function. They're no longer looking at simple questions of life or death. Nor are they studying chemistry in isolation, but in combination with other factors — such as shifts in water temperature or changes in wave action in tide pools. "To do an experiment in a lab to say, 'How much CO_2 does it take for something to die?' isn't the only important question," Carrington said. "So often, it's not just acidification that may put animals over the limit, but that in combination with something else."

That combination can prove significant. Mussels are as important to many rocky sea environments as topsoil is to the agricultural breadbasket of the Midwest: They are a key to the ecological health of near-shore waters. But northwest commercial growers already are seeing problems with mussel attachment.

Or, take fish. Researchers long had believed that warming seas would drive more fish into colder waters, so commercial fishermen in places such as the North Atlantic could see increases in their catch. But University of British Columbia scientists recently discovered the catch declined when ocean acidification is factored in. "The field is so young that we've really only answered the first stage of questions," said biologist Michael "Moose" O'Donnell, who works with Carrington. "But the paint is still wet on this picture. We're still trying to see what it all really means."

At the Friday Harbor marine lab one recent morning, Emma Timmins-Schiffman, a University of Washington graduate student, plucked a handful of oysters from a tank where she was controlling temperature and water chemistry. In Willapa Bay, where acidic water regularly wells up from the deep, oyster larvae have been dying for years. Scientists suspect acidification is at least one factor. But is it the driving one?

Oysters, like many creatures in the near-shore, are exposed to a range of temperatures throughout a given day, as the sun rises and sets and as tides move in and out. In fact, organisms living close to shore deal with some of the most variable conditions of any creatures on Earth.
"Some seaweed gets so dry you can crumble it with your hand, then they rehydrate within minutes," O'Donnell said. "Then they're back up and humming as if nothing happened." So Timmins-Schiffman not only is exposing these shellfish to lower-pH water. She also is changing water temperature and triggering the oysters' stress response. In some cases, she's checking for changes in respiration and feeding efficiency. Her results are expected this year.

Meanwhile, at a related lab in Seattle, researchers with the Northwest Fisheries Science Center lab in Montlake are trying to look at impacts across the food web. Because the marine food chain is complex and confounding, they've determined that, while some species may crash as acidification takes a toll, others may thrive. For example, when one type of plankton declines, so do the herring that eat it. But when populations of a different herring food collapse, the herring population increases. "There can be this dampening effect as impacts on predators and prey counter-balance each other," said Paul McElhany, with the Montlake lab. "In some cases, it's more than you would have expected. In a lot of cases it's less."

Until recently, researchers presumed that fish — unlike shellfish and some important plankton species — largely would escape direct effects from carbon-dioxide emissions. But an Australian scientist working with clown fish found the exposure to more-acidic water affected their ability to flee predators. So McElhany's lab has been looking at the impacts of pH changes on China rockfish and surf smelt — important Northwest species.
Results are expected this spring or summer.
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Article 4: The Coming Diatom Economy; by: Jeremy Elton Jacquot; October 4, 2007

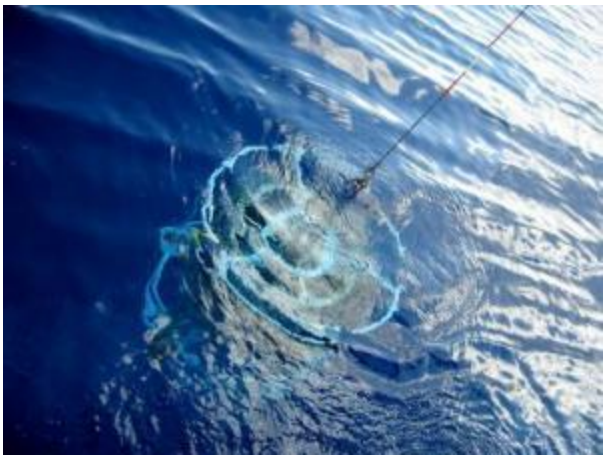
Jacquot, Jeremy Elton. "The Coming Diatom Economy." *TreeHugger*. Discovery Communications, 4 Oct. 2007. Web. 30 July 2012. <http://www.treehugger.com/clean-technology/the-coming-diatom-economy.html>.

British scientists are betting that diatoms - a group of unicellular, eukaryotic algae found (mostly) in the open oceans - could provide the ideal solution for making the manufacture a variety of consumer products, including cosmetics and fabrics, more cost-effective and eco-friendly. The plentiful phytoplankton possess a characteristic silica shell, known as a frustule, that is capable of displaying a stunning array of colors that fluctuates depending on its orientation towards light - similar to the effect produced by having light reflected from a thin layer of oil on water.

The team of researchers from the University of Oxford has found a very cost-effective way of growing the miniature organisms in controlled lab conditions (using a special culture medium), laying the groundwork for industrial-scale production. They envision the frustules being incorporated into everything from paints and clothing to credit card holograms and other polymers. Adopting this technology would eschew what has typically been a high impact, resource intensive process to build artificial reflectors - growing diatoms only requires standard conditions, including normal room temperature and pressure, and, under the right circumstances, has the advantage of being extremely speedy.

"It's a very efficient and cost-effective process, with a low carbon footprint. Its simplicity and its economic and environmental benefits could in future encourage industry to develop a much wider range of exciting products that change color as they or the observer move position. What's more, the shells themselves are completely biodegradable, aiding eventual disposal and further reducing the environmental impact of the process life cycle ... Whatever the case, exploiting their tiny shells' remarkable properties could make a big impact across industry. They could even have the potential to be incorporated into paint to provide a water-repellent surface, making it self-cleaning," said Andrew Parker, one the project's lead scientists.

In light of the anticipated (and decidedly) harmful effects of ocean acidification on the diatoms' future ability to produce their frustules, this scheme may prove (unfortunately) relatively short-lived.



Article 5: Ocean Acidification Changes Nitrogen Cycling in World Seas; December 20, 2010

ScienceDaily. "Ocean Acidification Changes Nitrogen Cycling in World Seas." *ScienceDaily*. ScienceDaily, 21 Dec. 2010. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2010/12/101220163258.htm>.

Increasing acidity in the sea's waters may fundamentally change how nitrogen is cycled in them, say marine scientists who published their findings in this week's issue of the journal *Proceedings of the National Academy of Sciences* (PNAS).

This image shows water samples in the Sargasso Sea being collected for studies of ocean acidification. (Credit: Cheryl Chow)

Nitrogen is one of the most important nutrients in the oceans. All organisms, from tiny microbes to blue whales, use nitrogen to make proteins and other important compounds.

Some microbes can also use different chemical forms of nitrogen as a source of energy.

One of these groups, the ammonia oxidizers, plays a pivotal role in determining which forms of nitrogen are present in the ocean. In turn, they affect the lives of many other marine organisms.

"Ocean acidification will have widespread effects on marine ecosystems, but most of those effects are still unknown," says David Garrison, director of the National Science Foundation (NSF)'s Biological Oceanography Program, which funded the research along with NSF's Chemical Oceanography Program.

"This report that ocean acidification decreases nitrification (the amount of nitrogen) is extremely important," says Garrison, "because of the crucial role of the nitrogen cycle in biogeochemical processes-processes that take place throughout the oceans."

Very little is known about how ocean acidification may affect critical microbial groups like the ammonia oxidizers, "key players in the ocean's nitrogen cycle," says Michael Beman of the University of Hawaii and lead author of the PNAS paper.

In six experiments spread across two oceans, Beman and colleagues looked at the response of ammonia oxidation rates to ocean acidification.

In every case where the researchers experimentally increased the amount of acidity in ocean waters, ammonia oxidation rates decreased.

These declines were remarkably similar in different regions of the ocean indicating that nitrification rates may decrease globally as the oceans acidify in coming decades, says David Hutchins of the University of Southern California, a co-author of the paper.

Oceanic nitrification is a major natural component of production of the greenhouse gas nitrous oxide. From the seas, nitrous oxide then enters the atmosphere, says Beman. "All else being equal, decreases in nitrification rates therefore have the potential to reduce nitrous oxide emissions to the atmosphere."

Oceanic emissions of nitrous oxide are second only to soils as a global source of nitrous oxide.

With a pH decrease of 0.1 in ocean waters (making the waters more acidic), the scientists estimate a decrease in nitrous oxide emissions comparable to all current nitrous oxide emissions from fossil fuel combustion and industrial activity.

An important caveat, they say, is that nitrous oxide emissions from oceanic nitrification may be altered by other forms of global environmental change such as increased deposition of nitrogen to the ocean, or loss of oxygen in some key areas.

"That could offset any decrease due to ocean acidification, and needs to be studied in more detail," says Hutchins.

Another major implication of the findings is equally complex, the researchers say, but just as important.

As human-derived carbon dioxide permeates the sea, ammonia-oxidizing organisms will be at a significant disadvantage in competing for ammonia.

Over time, that would shift the available form of dissolved nitrogen in the surface oceans away from forms like nitrate that are produced by nitrification, and toward regenerated ammonium.

With a decrease in average ocean pH from 8.1 to 8.0 (greater acidity), the scientists estimate that up to 25 percent of the ocean's primary production could shift from nitrate- to ammonium-supported.

The consequences of such a shift are not easily predicted, says Hutchins, but would likely favor certain drifting, microscopic plant species over others, with cascading effects throughout marine food webs.

"What makes ocean acidification such a challenging scientific and societal issue is that we're engaged in a global, unreplicated experiment," says Beman, "one that's difficult to study--and has many unknown consequences."

Other co-authors of the PNAS paper are: Cheryl-Emiliane Chow, Andrew King, Yuanyuan Feng and Jed Fuhrman of the University of Southern California; Andreas Andersson and Nicholas Bates of the Bermuda Institute of Ocean Sciences; and Brian Popp of the University of Hawaii.

Article 6: A Wave of Toxic Green Beaches, Saint-Michel-en- Greve, Brittany, France; by: Sharlene Pilkey

Pilkey, Sharlene. "Wave of Toxic Green Beaches, France." *Coastal Issues / Coastal Care*. N.p., 1 Oct. 2009. Web. 30 July 2012. <http://coastalcare.org/2009/10/saint-michel-en-greve-brittany-france/>.

With beaches and coastlines all over the world already under attack from sea level rise, pollution, mining, driving, seawall construction and human development encroachment, another menace is mounting an assault. Humans are behind this one too. According to various media reports in France, and the United Kingdom, lethal green algae has invaded heavily used vacation beaches in Brittany, northern France and along England's coastline from Wales to Portsmouth. Layering in deep piles, up to a meter thick with hard crusting on top, these stinking masses are ticking gas bombs.

Vincent Petit, a 27-year-old veterinarian, was riding horse-back on a Brittany beach near Saint-Michel-en-Greve, when his horse broke through the crust and went down. A cloud of hydrogen sulfide gas (H_2S) was released from the rotting algae, reportedly killing the horse within 30 seconds. Fortunately a tractor was nearby which was used to clear away algae and drag Mr. Petit to safety. He was rescued in an unconscious state and hospitalized. Now he is suing the local municipality responsible for beach maintenance.

On June 22, 2009 on the Cotes d'Armor, a 48 year old maintenance worker, clearing the green algae from the beach, was stricken and died apparently from a heart attack, but in recent medical reports the lethal green algae is suspected in his death.

These lethal algae on the French Coast was apparently a product of over fertilization of nearby fields with drainage emptying into the ocean. Towns along the Brittany coastline have hired bulldozers to scrape the seaweed away, but the algae keeps right on coming back.

Earlier, on a beach close to where Mr.Petit's horse died, two dogs strolling by were killed by the sulfur dioxide. In a strange coincidence indicating the global nature of this problem, the death of two dogs running on an algae encrusted beach was recently reported from north of Auckland, New Zealand, not to mention the four dogs killed in 2009 by toxic beach algae near Elkton, Oregon.

The more one learns about this beach hazard, the more apparent its global scope becomes. Last year, the Chinese government brought in the Army to clear away the slimy green growths so the Olympic sailing competition could be held and so observers could safely view the event. In Italy, near Genoa, a sixty year old man had to be taken to the hospital this year because he swam in algae infested water, and last year in Genoa, more than 200 people were sent to hospital after swimming in the algae or inhaling toxins carried to the beach by the wind. This summer, officials in Massachusetts put out a toxic beach algae warning but did not close the beaches. It's a problem for fresh water lakes as well.

Some are attributing the algae outbreaks to global warming. Although this may indeed be a factor as our seas warm up, it is clear that excess nitrate rich fertilizers, along with animal wastes and poorly treated or untreated sewage, are the main villains.

The problem is deeper than just hazards to humans. When a beach is covered with algae virtually everything that lives on and within the beach is killed while access is denied to nesting and to food for local birds, fish, sea turtles and various crustaceans. Thus, an entire beach/near-shore ecosystem that includes microscopic organisms (meiofauna) living between sand grains at the bottom of the food chain up to sharks cruising offshore, is wiped out. Simultaneously oxygen is usually depleted in near-shore waters, a threat to marine mammals and sea birds.

Politicians at a high level are finally beginning to pay attention to this problem. After all, beaches are a critical part of the economy of most coastal regions. The French Prime Minister Francois Fillon, announced that the "state would take over the responsibility for cleaning the beaches most affected." He is also creating an interdepartmental committee to fight proliferation of the green algae and to protect the population and beaches. In other countries local municipalities or health organizations are trying to cope. The problem is of course, the coastal communities themselves did not usually create the toxic situation. At fault is the agribusiness along the coast and nearby rivers using fertilizers to boost production of food.

Hot weather, warm water, fertilized farms near rivers running into the sea are the problem, which disappears with the arrival of fall and winter. Unfortunately, it is always summer somewhere on our planet, and the problem flows from the land to the sea. With over 70 beaches in Northern France In trouble, as is the English coastline from Cardiff Bay to Portsmouth Harbor, coastlines worldwide are under attack. We wonder if this could be the toxic green wave of the future for developed coasts.

Article 7: Melting Ice Sheets Can Cause Earthquakes, Study Finds; by: Mason Inman; March 14, 2008

Inman, Mason. "Melting Ice Sheets Can Cause Earthquakes, Study Finds." *National Geographic*. National Geographic Society, 14 Mar. 2008. Web. 30 July 2012. <http://news.nationalgeographic.com/news/2008/03/080314-warming-quakes.html>.

As ice sheets melt, they can release pent-up energy and trigger massive earthquakes, according to new study.

Global warming may already be triggering such earthquakes and may cause more in the future as ice continues to melt worldwide, the researchers say.

A series of large earthquakes shook Scandinavia around 10,000 years ago, along faults that are now quiet, the scientists point out.

The timing of each earthquake roughly coincided with the melting of thick ice sheets from the last ice age in those same places.

Researchers had suspected that the melting had triggered these earthquakes by releasing pressure that had built up in Earth's crust.

Now a new study, the first to use sophisticated computer models to simulate how ice sheets would affect the crust in the region, bolsters this scenario.

The study showed that earthquakes are "suppressed in presence of the ice and promoted during melting of the ice," said study leader Andrea Hampel of the Ruhr University Bochum in Germany.

Hampel and a colleague had earlier found evidence that the shrinkage of a huge lake at the end of the last ice age had triggered a series of large earthquakes in Utah.

The new study shows this can happen even along faults that are normally quiet and are not prone to slip. The new research will be published soon in the journal *Earth and Planetary Science Letters*.

Ancient Quakes Rocked Scandinavia

The ancient earthquakes marched northward through Scandinavia as ice sheets retreated.

They began in the south of what is now Sweden about 12,000 years ago, then hit south-central Sweden near modern-day Stockholm around 10,500 years ago (see Sweden map).

Finally the earthquakes hit Lapland, in northern Scandinavia, about 9,000 years ago.

Based on the amount that the faults slipped, it seems these ancient earthquakes were massive, registering about magnitude 8—bigger than the quake that devastated Kashmir in 2005.

Today those Scandinavian faults rarely cause quakes, and when they do, the temblors are small, usually less than magnitude 5.

"With our new modeling technique we can model faults themselves and directly compare the slip on the model fault to the slip on natural faults," Hampel said.

The models showed that thick ice could weigh down the land, preventing a fault from slipping and thereby causing it to store up that energy.

The thicker the simulated ice sheets—from 325 to 6,500 feet (100 to 2,000 meters) thick—the more they suppressed earthquakes, and the bigger the earthquakes were after the ice sheets melted.

Since the amount of movement on the fault in the model matched the actual amount of slippage measured in the field, this supports the idea that the melting of ice sheets had triggered the earthquakes, Hampel said.

Global Warming Causing Quakes?

Such melt-induced earthquakes are not just a thing of the past and could be happening today, since global warming is melting ice worldwide, the team says.

"The frequency of earthquakes should increase in the future if the ice continues to melt," Hampel and colleagues write in their study.

"The current low level of seismicity in Greenland and Antarctica may be caused by the presence of the large ice sheets."

Jeanne Sauber of NASA's Goddard Space Flight Center in Greenbelt, Maryland, has led research showing a recent increase in earthquakes in Alaska when the ice was melting the most.

"All of sudden, between 2002 and 2006, we had warmer temperatures and much more rapid ice wastage," Sauber said.

Even though ice thickness shrank 10 percent or less, this was apparently enough to trigger small earthquakes in the summers when the ice was melting, the study showed.

"It's harder to see if there's an influence on large earthquakes, because they don't happen as often," Sauber added.

"We expect that in Greenland and Antarctica, if they start rapidly losing lots of ice, you would expect at least some little earthquakes."

Article 8: Global Climate Change and Infectious Diseases; by: Emily K. Shuman, M.D. of New England Journal of Medicine; March 25, 2010

Shuman, Emily K. "The New England Journal of Medicine." *Global Climate Change and Infectious Diseases" NEJM*. NEJM, 25 Mar. 2010. Web. 30 July 2012. <http://www.nejm.org/doi/full/10.1056/NEJMp0912931>.

The 2009 United Nations Climate Change Conference in Copenhagen ended on December 18 without passage of a binding resolution for tackling global climate change. With the debate over U.S. health care reform raging, this event went largely unnoticed by the U.S. health care community. However, climate change will have enormous implications for human health, especially for the burden of vector-borne and waterborne infectious diseases.

Climate change is occurring as a result of an imbalance between incoming and outgoing radiation in the atmosphere. As solar radiation enters the atmosphere, some of it is absorbed by the earth's surface and reemitted as infrared radiation, which is then absorbed by greenhouse gases — primarily carbon dioxide, methane, and nitrous oxide — which result from the combustion of fossil fuels and which cannot be effectively removed from the atmosphere because of deforestation. This process generates heat. As the concentrations of greenhouse gases in the atmosphere have reached record levels, global temperatures have risen at a faster rate than at any time since records began to be kept in the 1850s, and temperatures are expected to increase by another 1.8 to 5.8°C by the end of this century. The hydrologic cycle will be altered, since warmer air can retain more moisture than cooler air. Some geographic areas will have more rainfall, and some more drought, and severe weather events — including heat waves and storms — are expected to become more common. For these reasons, the term "climate change" is now preferred over the term "global warming." Because of rising temperatures and changing rainfall patterns, climate change is expected to have a substantial effect on the burden of infectious diseases that are transmitted by insect vectors and through contaminated water.

Insect vectors tend to be more active at higher temperatures. For example, tropical mosquitoes such as anopheles species, which transmit malaria, require temperatures above 16°C to complete their life cycles.2 Some vectorborne diseases such as malaria are also thought of as water-vectored diseases, since mosquitoes typically thrive in aquatic habitats, where they lay their eggs in water-filled containers. Thus, epidemics of malaria tend to occur during rainy seasons in the tropics. In contrast, epidemics of the mosquito-borne West Nile virus infection can occur during times of drought. This happens because mosquitoes and birds (the primary hosts of the virus) are brought into proximity at scarce water sources, enhancing the transmission of the virus. In addition, the populations of the natural predators of mosquitoes are greatly reduced during times of drought, as wetlands dry up.

Like vector-borne diseases, waterborne infectious diseases are also strongly affected by climate. During times of drought, water scarcity results in poor sanitation, and much of the population can be exposed to potentially contaminated water. For example, there is currently an epidemic of cholera in northern Kenya in the wake of a severe drought. Like drought, excess rainfall and flooding can also contribute to epidemics of waterborne infectious diseases, in this case due to poor sanitation resulting from runoff from overwhelmed sewage lines or the contamination of

water by livestock. An example is the 1993 epidemic of diarrheal disease due to cryptosporidium in Milwaukee after heavy spring rains3 — or the typical seasonality of bacterial and protozoal diarrheal illnesses.

There are some widely cited examples suggesting that climate change has already resulted in the introduction of certain infectious diseases into previously unaffected geographic areas. One such example is the spread of malaria into highland regions of East Africa, where this disease previously did not exist.2 This spread occurred in the setting of weather that was much warmer and wetter than usual; it resulted in high rates of illness and death, because the disease was introduced into a largely non-immune population.

Numbers of Disability-Adjusted Life-Years Due to Causes That Are Attributable to Climate Change, as of 2000.*

Region	Total DALYs	DALYs/Million Population
Africa	1,894,000	3071.5
Eastern Mediterranean	768,000	1586.5
Latin America and Caribbean	121,000	188.5
Southeast Asia	2,572,000	1703.5
Western Pacific	169,000	111.4
Developed countries	8,000	8.9

* Disability-adjusted life-years (DALYs) are life-years that are lost owing to disability or premature death. Causes that may be attributable to climate change include diarrheal disease, vectorborne disease, malnutrition, and injury from natural disasters. Data are from the World Health Organization.[4]

To describe the effect of climate change on a more global scale, the World Health Organization (WHO) has released data regarding the estimated effects on human health as of the year 2000 (see table Numbers of Disability-Adjusted Life-Years Due to Causes That Are Attributable to Climate Change, as of 2000.).4 What is readily apparent from these data is that developing regions of the world have been disproportionately affected by climate change relative to developed regions. This imbalance stands in stark contrast to the imbalance in greenhouse-gas emissions, which are almost entirely attributable to developed countries, such as the United States, and countries with rapidly developing economies, such as China and India.

The WHO report also includes estimates of the future global burden of disease that will result from climate change.4 It is predicted that by 2030 there will be 10% more diarrheal disease than there would have been with no climate change and that it will primarily affect the health of young children; indeed, the impact on children might well be amplified by the effects of such diseases on malnutrition, development, and cognition. If global temperatures increase by 2 to 3°C, as expected, it is estimated that the population at risk for malaria will increase by 3 to 5%, which means that millions of additional people would probably become infected with malaria each year.

In an attempt to halt climate change, international efforts to reduce emissions have already been put in place. The Kyoto Protocol has now been ratified by 187 nations (but most notably not by the United States) and went into effect in 2005. The purpose of the recent meeting in Copenhagen was to establish a framework for tackling climate change beyond 2012, when the Kyoto Protocol expires. In the end, no binding resolution was passed. Rather, several countries

(including the United States) developed a nonbinding agreement to halt the increase in global temperature at 2°C, with no mention of targets for emissions. One of the major sticking points at the conference was the question of the responsibility that developed countries have to assist developing countries (including China and India) in reducing emissions, and the United States ultimately did pledge financial assistance to help poor countries deal with climate change. On a national level, the American Clean Energy and Security Act (Waxman–Markey bill), which sets limits on emissions through a cap-and-trade system (in which companies that produce fewer emissions than the cap allows receive credits that may be sold to heavier polluters), was passed by the House of Representatives in June 2009 but still awaits a vote in the Senate.

Although governments must take the lead in tackling climate change, I believe that it is also our responsibility as members of the health care community to do our part. Recommendations for ways in which individuals and businesses can reduce their greenhouse-gas emissions are available from the Environmental Protection Agency.5 In addition, though reducing emissions is of the utmost importance, we must remember that the best-case scenario would be a global temperature increase of about 2°C. Therefore, we must also focus our efforts on mitigating the effects of climate change, including its potential impact on the global burden of infectious diseases. Additional research is needed on the ecology and epidemiology of infectious diseases that will probably be affected by climate change. The best means for accomplishing this aim would be to incorporate research on the effect of climate change into existing infrastructures, such as the ambitious malaria-eradication program recently launched by the Bill and Melinda Gates Foundation. One of the goals of research on climate change should be the development of early warning systems to help populations prepare for impending epidemics. As we move forward, it is imperative that organizations such as the WHO continue their missions of treating and preventing otherwise neglected infectious diseases, as part of a multifaceted approach to improving global health. Effective treatments and vaccines will go a long way in preventing human suffering that could otherwise occur as a result of climate change.

Source information: From the Department of Internal Medicine, Division of Infectious Diseases, University of Michigan, Ann Arbor.

Article 9: Global Photosynthesis: New Insight Will Help Predict Future Climate Change; by: ScienceDaily; October 5, 2011

ScienceDaily. "Global Photosynthesis: New Insight Will Help Predict Future Climate Change." *ScienceDaily*. ScienceDaily, 04 Oct. 2011. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2011/10/111005111811.htm>.

— A new insight into global photosynthesis, the chemical process governing how ocean and land plants absorb and release carbon dioxide, has been revealed in research that will assist scientists to more accurately assess future climate change.

Photo caption: Understanding the exchange of gases, including CO2 and water vapour is especially significant to science because of its relevance to global management of carbon emissions. (Credit: Willen van Aken, CSIRO)

In a paper published September 28 in *Nature*, a team of US, Dutch and Australian scientists have estimated that the global rate of photosynthesis, the chemical process governing the way ocean and land plants absorb and release CO_2, occurs 25% faster than previously thought.

From analyzing more than 30 years of data collected by Scripps Institution of Oceanography, UC San Diego including air samples collected and analyzed by CSIRO and the Bureau of Meteorology from the Cape Grim Air Pollution Monitoring Station, scientists have deduced the mean rate of photosynthesis over several decades and identified the El Nino-Southern Oscillation phenomenon as a regulator of the type of oxygen atoms found in CO_2 from the far north to the south pole.

"Our analysis suggests that current estimates of global primary production are too low and the refinements we propose represent a new benchmark for models to simulate carbon cycling through plants," says co-author, Dr. Colin Allison, an atmospheric chemist at CSIRO's Aspendale laboratories.

The study, led by Dr. Lisa Welp from the Scripps Institution of Oceanography, California, traced the path of oxygen atoms in CO_2 molecules, which tells researchers how long the CO_2 has been in the atmosphere and how fast it had passed through plants. From this, they estimated that the global rate of photosynthesis is about 25 percent faster than previously thought.

"It's difficult to measure the rate of photosynthesis for forests, let alone the entire globe. For a single leaf it's straightforward, you just put it in an instrument chamber and measure the CO_2 decreasing in the chamber air," said Dr. Welp.

"But you cannot do that for an entire forest. What we have done is to use a naturally occurring marker, an oxygen isotope, in atmospheric CO_2 that allows us to track how often it ended up

inside a plant leaf, and from oxygen isotopic CO_2 data collected around the world we can estimate the mean global rate of photosynthesis over the last few decades."

In other studies, analysis of water and oxygen components found in ocean sediments and ice cores have provided scientists with a 'big picture' insight into carbon cycling over millions of years, but the search for the finer details of exchanges or uptake through ocean algae and terrestrial plant leaves has been out of reach.

Dr. Allison said understanding the exchange of gases, including CO_2 and water vapour, in the biosphere -- oceans, land and atmosphere -- is especially significant to climate science, and to policymakers, because of its relevance to global management of carbon emissions.

The authors said that their new estimate of the rate of global photosynthesis will help guide other estimates of plant activity, such as the capacity of forests and crops to grow and fix carbon, and help re-define how scientists measure and model the cycling of CO_2 between the atmosphere and plants on land and in the ocean.

Dr. Allison said understanding the exchange of gases, including CO_2 and water vapor, in the biosphere -- oceans, land and atmosphere -- is especially significant to climate science, and to policymakers, because of its relevance to global management of carbon emissions.

"Quantifying this global production, centered on the exchange of growth-promoting CO_2 and water vapour, has been historically difficult because there are no direct measurements at scales greater than leaf levels. Inferences drawn from atmospheric measurements provide an estimate of ecosystem exchanges and satellite-based observations can be used to estimate overall primary production, but as a result of this new research we have re-defined the rate of biospheric carbon exchange between atmosphere, land and ocean. These results can be used to validate the biospheric components included in carbon cycle models and, although still tentative, may be useful in predicting future climate change," Dr. Allison said.

Dr. Allison said a critical element of the research was access to long data sets at multiple locations, such as Cape Grim, Mauna Loa and South Pole, extending back to 1977 when Cape Grim was established in Tasmania's north-west, together with more recent samples from facilities such as Christmas Island, Samoa, California and Alaska. The Cape Grim Baseline Air Pollution Station provides vital information about changes to the atmospheric composition of the Southern Hemisphere.

CSIRO's Dr. Roger Francey was a co-author on the project, led by Scripps' Drs Welp and Ralph Keeling. Other co-authors of the study are Harro Meijer from the University of Groningen in the Netherlands; Alane Bollenbacher, Stephen Piper and Martin Wahlen from Scripps; and Kei Yoshimura from the University of Tokyo, Japan.

The Cape Grim Baseline Air Pollution Station, funded and managed by the Australian Bureau of Meteorology, detects atmospheric changes as part of a scientific research program jointly supervised by CSIRO's Marine and Atmospheric Research Division and the Bureau.

Article 10: Whale poop is vital to ocean's carbon cycle; by Wendy Zukerman, NewScientist; April 22, 2010

Zukerman, Wendy. "Whale Poop Is Vital to Ocean's Carbon Cycle." *Whale Poop Is Vital to Ocean's Carbon Cycle*. Reed Business Information, 22 Apr. 2010. Web. 30 July 2012. <http://www.newscientist.com/article/dn18807-whale-poop-is-vital-to-oeans-carbon-cycle>.

Saving endangered baleen whales could boost the carbon storage capacity of the Southern Ocean, suggests a new study of whale feces. Whale feces once provided huge quantities of iron to a now anemic Southern Ocean, boosting the growth of carbon-sequestering phytoplankton.

So says Stephen Nicol of the Australian Antarctic Division, based in Kingston, Tasmania, who has found "huge amounts of iron in whale poo". He believes that before commercial whaling, baleen whale feces may have accounted for some 12 per cent of the iron on the surface of the Southern Ocean.

Previous studies have shown that iron is crucial to ocean health because plankton need it to grow. "If you add soluble iron to the ocean, you get instant phytoplankton growth," says Nicol. The amount of iron in whale feces means that protecting Antarctic whales could swell populations of phytoplankton, which absorb carbon dioxide.

Antarctic krill (*Euphausia superba*) feed on the phytoplankton, concentrating the iron in their tissue. And in turn, baleen whales eat the krill.

Iron rations

It had already been suggested that whales recycled iron in the ocean by eating it in krill and making it available to phytoplankton in feces. But until this study, no one had analyzed whale feces to confirm if it indeed contained significant quantities of iron.

Nicol's team analyzed 27 samples of feces from four species of baleen whales. He found that on average whale feces had 10 million times as much iron as Antarctic seawater.

The team confirmed the iron came from krill by analyzing the iron content in whole krill and sampling genetic material from the whale feces for krill DNA. "We confirmed the vast majority of the iron in the poo came from krill," says Nicol.

Big eaters

Using estimates of the whale population before commercial whaling in the Southern Ocean began early last century, Nicol predicts that baleen whales – now endangered – once consumed about 190 million tons of krill every year and produced 7600 tons of iron-rich feces.

Larger populations of whales would have produced more of this "bio-available" iron, leading to bigger phytoplankton and krill populations in turn, says Nicol.

"Allowing the great whales to recover will allow the system to slowly reset itself," he says. And this will ultimately increase the amount of CO_2 that the Southern Ocean can sequester.

David Raubenheimer, who researches marine nutritional ecology at Massey University in Auckland, New Zealand, says the findings are convincing and important. They highlight a specific ecological role for whales in the oceans "other than their charisma", he says.

Peter Gill, a whale ecologist at Deakin University in Warrnambool, Victoria, Australia, calls the research "exciting stuff".

"So many whales were moved from the ocean before we could understand the ocean ecology," says Gill. "It's exciting when we can reconstruct the past, and all these bits fall into place."

Journal reference: *Fish and Fisheries*, DOI: 10.1111/j.1467-2979.2010.00356.x

Article 11: Adding Iron to Ocean Won't Stop Global Warming, by Eric Bland, Discovery News; April 13, 2009

Bland, Eric. "Adding Iron to Ocean Won't Stop Warming." *Adding Iron to Ocean Won't Stop Warming*. Discovery Communications, 13 Apr. 2009. Web. 30 July 2012. <http://dsc.discovery.com/news/2009/04/13/ocean-iron-carbon.html>.

April 13, 2009 -- An ambitious plan to slow global warming by locking CO_2 deep in the ocean has hit a stumbling block, according to a new study that shows the geoengineering technique is not as effective as scientists had previously hoped.

"The amount of carbon dioxide that could be taken up is less than we assumed," said Victor Smetacek, a scientist at Alfred Wegener Institute who co-led the expedition. Don't discount ocean fertilization yet, say scientists working both inside and outside the research study.

"With other climate change initiatives, ocean fertilization could still play a role in reducing climate change," said Smetacek.

The idea behind ocean fertilization is a simple one. Carbon dioxide is slowly raising the average temperature of the Earth. If some of the carbon dioxide in the atmosphere could be removed the Earth wouldn't heat up as fast.

Scientists have come up with a wide variety of plans to remove CO_2 from the atmosphere. Some scientists want to pump $C0_2$ deep into the underground. Others want to use carbon nanotubes to turn CO_2 into methane or other compounds.

Smetacek and his colleagues want to lock up the excess carbon dioxide inside the world's oceans, or more specifically, inside the bodies of microscopic creatures known as plankton, that would die and fall to the bottom of the ocean.

A certain class of plankton, known as phytoplankton, already remove carbon dioxide from the atmosphere through photosynthesis. If there were more phytoplankton, the German and Indian scientists reasoned, then the microscopic creatures would lock away more carbon dioxide.

Phytoplankton need iron to grow. In the open ocean usable iron is difficult to come by, so adding iron to the ocean would lead to more phytoplankton.

Over the course of two and a half months the team of scientists "administered," as Smetacek says, more than six tons of dissolved iron (the kind found in most home improvement stores) over a 300-square-kilometer (116-square-mile) patch of the southwest Atlantic.

The additional iron certainly encouraged more phytoplankton. The amount of biomass in the test area doubled, which scientists determined during marathon 36 hour sampling sessions.

The scientists created more plankton, but the plankton didn't perform as the scientists had hoped. Instead of dying and sinking to the bottom of the ocean, the additional plankton were eaten, first by copepods, then by amphipods. As the carbon moved up the food chain some of was released back into the atmosphere as carbon dioxide.

The scientists concluded that fertilizing the southwest Atlantic was not a good way to lock away carbon dioxide, but that ocean fertilization needs additional testing before it's discounted.

Other oceans and other materials, like silicon instead of iron, might be better candidates for geoengineering, says Ken Buesseler, a scientist at Woods Hole Oceanographic Institute in Massachusetts who has conducted his own ocean fertilization experiments.

"No one is saying that [ocean fertilization] alone will solve the greenhouse gas problem," said Buesseler. "But if we try many different solutions at the same time it could have a significant impact."

Buesseler says that more experiments are necessary to find the best section of the ocean and the best material to encourage plankton to take oxygen out of the atmosphere and to then sink to the bottom of the ocean.

"There is no one solution to solving global warming," said Buesseler, "But doing nothing doesn't seem very satisfying to me."

Article 12: More Carbon Dioxide May Create a Racket in the Seas; by: Henry Fountain; December 29, 2009

Fountain, Henry. "More Carbon Dioxide May Create a Racket in the Seas." *The New York Times*. The New York Times, 28 Dec. 2009. Web. 30 July 2012. <http://www.nytimes.com/2009/12/29/science/earth/29obsound.html?_r=3>.

Here is another consequence of rising carbon dioxide emissions: the oceans are getting louder.

It has long been known that chemical compounds in seawater, including boric acid, absorb sound, as energy from sound waves stimulates certain reactions. As the oceans grow more acidic, a result of increasing absorption of atmospheric CO_2, the seawater chemistry changes, resulting in fewer reactions and less acoustic energy used. That means sounds will travel farther and be louder at a given distance from a sound source.

Tatiana Ilyina and Richard E. Zeebe of the University of Hawaii and Peter G. Brewer of the Monterey Bay Aquarium Research Institute looked at the future impact of this phenomenon. Using a global ocean model and projections of CO_2 emissions, they predicted regional changes in acidity, and thus sound absorption.

Writing in Nature Geoscience, they report that in high latitudes and deepwater formations (where acidification is expected to be worse), sound absorption could fall 60 percent by 2100.

So the oceans will not be as quiet — what's wrong with that? Plenty, potentially.

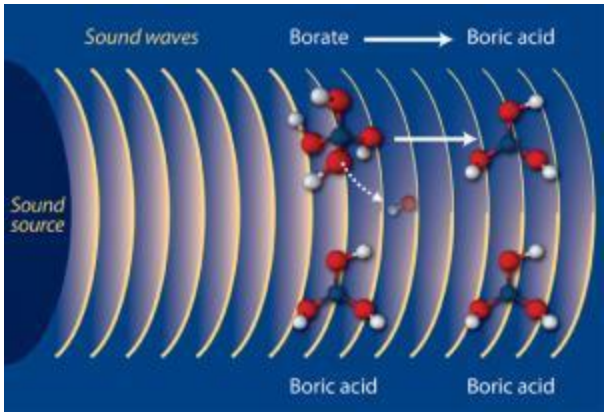
Most of the chemical absorption of sound occurs at relatively low frequencies, from about 1,000 to 5,000 hertz. Propeller noise and other ship sounds fall in the same range, as does some military and research sonar. So this "background" noise, especially prevalent near shipping lanes, will be louder. That may be bad news for marine mammals, which use sounds in the same range for communication and echolocation while foraging.

"We're not saying that during the next 100 years all dolphins will be deafened," Dr. Zeebe said. "But the background noise could essentially override or mask the sounds that they're depending on."

Then again, he said, because sounds will travel farther, the animals may be able to communicate over longer distances. The researchers are continuing their studies using more sophisticated models and more precise sound sources.

Article 13: Ocean Acidification Poses Little Threat to Whales' Hearing, Study suggests, by ScienceDaily, October 11, 2010

ScienceDaily. "Ocean Acidification Poses Little Threat to Whales' Hearing, Study Suggests." *ScienceDaily*. ScienceDaily, 13 Oct. 2010. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2010/10/101011215015.htm>.



Contrary to some previous, highly publicized, reports, ocean acidification is not likely to worsen the hearing of whales and other animals, according to a Woods Hole Oceanographic Institution (WHOI) scientist who studies sound propagation in the ocean.

Image caption: *Low-frequency sound waves in the ocean cause borate to lose an -OH group and become boric acid (top). In the process, the sound waves lose energy. An identical sound wave has no effect on boric acid (bottom). More-acidic conditions reduce the amount of borate in seawater, which led some researchers to suggest that ocean acidification will lead to less absorption of sound energy, allowing sound waves to travel farther in the ocean than they do at present. WHOI scientists showed that the effect will be minimal. (Credit: Illustration by Jack Cook, Woods Hole Oceanographic Institution)*

Tim Duda, of WHOI's Applied Ocean Physics & Engineering Department, undertook a study in response to warnings that as the ocean becomes more acidic -- due to elevated levels of atmospheric carbon dioxide (CO_2)--noise from ships will be able to travel farther and possibly interfere with whales and other animals that rely on sound to navigate, communicate, and hunt.

Duda and WHOI scientists Ilya Udovydchenkov, Scott Doney, and Ivan Lima, along with colleagues at the Naval Postgraduate School, designed mathematical models of sound propagation in the oceans. Their models found that the increase would be, at most, 2 decibels by the year 2100 -- a negligible change compared with noise from natural events such as storms and large waves. Noise levels are predicted to change even less than this in higher-noise areas near sources such as shipping lanes, Duda said.

Their work is published in the September 2010 issue of the *Journal of the Acoustical Society of America*.

Article 14: Ocean Acidification Leaves Clownfish Deaf to Predators; by: ScienceDaily; May 31, 2011

ScienceDaily. "Ocean Acidification Leaves Clownfish Deaf to Predators." *ScienceDaily*. ScienceDaily, 04 June 2011. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2011/05/110531201221.htm>.

Baby clownfish use hearing to detect and avoid predator-rich coral reefs during the daytime, but new research from the University of Bristol demonstrates that ocean acidification could threaten this crucial behavior within the next few decades.

Since the Industrial Revolution, over half of all the CO_2 produced by burning fossil fuels has been absorbed by the ocean, making pH drop faster than any time in the last 650,000 years and resulting in ocean acidification. Recent studies have shown that this causes fish to lose their sense of smell, but a new study published in *Biology Letters* shows that fish hearing is also compromised.

Working with Professor Philip Munday at James Cook University, lead author Dr. Steve Simpson of the School of Biological Sciences at the University of Bristol reared larvae straight from hatching in different CO_2 environments.

"We kept some of the baby clownfish in today's conditions, bubbling in air, and then had three other treatments where we added extra CO_2 based on the predictions from the Intergovernmental Panel on Climate Change for 2050 and 2100," Dr. Simpson said.

After 17-20 days rearing, Dr. Simpson monitored the response of his juvenile clownfish to the sounds of a predator-rich coral reef, consisting of noises produced by crustaceans and fish.

"We designed a totally new kind of experimental choice chamber that allowed us to play reef noise through an underwater speaker to fish in the lab, and watch how they responded," Dr. Simpson continued. "Fish reared in today's conditions swam away from the predator noise, but those reared in the CO_2 conditions of 2050 and 2100 showed no response."

This study demonstrates that ocean acidification not only affects external sensory systems, but also those inside the body of the fish. The ears of fish are buried deep in the back of their heads, suggesting lowered pH conditions may have a profound impact on the entire functioning of the sensory system.

The ability of fish to adapt to rapidly changing conditions is not known. Dr. Simpson said: "What we have done here is to put today's fish in tomorrow's environment, and the effects are potentially devastating. What we don't know is whether, in the next few generations, fish can adapt and tolerate ocean acidification. This is a one-way experiment on a global scale, and predicting the outcomes and interactions is a major challenge for the scientific community."

Article 15: Jellyfish are taking over the oceans: Population surge as rising acidity of world's seas kills predators; by: David Derbyshire of Mail Online; December 3, 2010

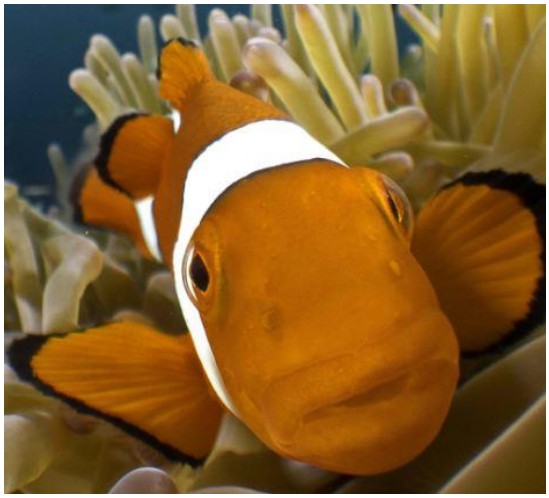
Derbyshire, David. "Science | Mail Online." *Mail Online*. Associated Networks Ltd., 3 Dec. 2010. Web. 30 July 2012. <http://www.dailymail.co.uk/sciencetech/article-1335337/Jelly-fish-alert-Population-surge-ri>.

Britain's beaches could soon be inundated with records numbers of jellyfish, marine experts warned today. Scientists say the number of jellyfish are on the rise thanks to the increasing acidity of the world's oceans. The warning comes in a new report into ocean acidification – an often overlooked side effect of burning fossil fuel. Studies have shown that higher levels of carbon dioxide in the atmosphere doesn't just trigger climate change but can make the oceans more acid.

Image Caption: *A jellyfish floats in the Mediterranean sea on the west coast of the Spanish island of Mallorca*

Since the start of the industrial revolution, acidity levels of the oceans have gone up 30 per cent, marine biologists say.

The new report, published by the UN Environment Programme during the Climate Change talks in Cancun, Mexico, warns that the acidification of oceans makes it harder for coral reefs and shellfish to form skeletons – threatening larger creatures that depend on them for food.



The decline in creatures with shells could trigger an explosion in jellyfish populations.

The report, written by Dr. Carol Turley of Plymouth University, said: 'Ocean acidification has also been tentatively linked to increased jellyfish numbers and changes in fish abundance.'

Jellyfish are immune to the effects of acidification. As other species decline, jellyfish will move in to fill the ecological niche.

Image Caption*: A Clownfish on the reef in Raja Ampat Islands, West Papua province, in Indonesia. The fish is*

particularly susceptible to rising acidity

Populations have boomed in the Mediterranean in recent years. Some marine scientists say the changing chemistry of the sea is to blame.

Studies have shown that clown fish – the species made famous by the movie Finding Nemo – find it harder to navigate through more acidic waters.

They are also less likely to avoid predators, and may actively seek them out, scientists have shown.

Tests on laboratory fish have found that more acidic water rewires their brains, turning them into fish with a death wish.

The report says acidification may push overstressed oceans into disaster with far reaching consequences the billions of people who rely on fish as their main protein source.

The effects of extra carbon dioxide may be greater in colder waters such as the North Sea and north Atlantic, the report says.

The damage to corals and shellfish could affect the whole food chain – hitting species such as salmon which feed on smaller shell building animals.

'The basic chemistry of sea water is being altered on a scale unseen within fossil records over at least 20 million years,' the report said.

Oceans are naturally alkaline – and had a pH level of about 8.2 in 1750. Since the industrial revolution, the acidity has increased by 30 per cent.

As more carbon dioxide enters the oceans it produces carbonic acid.

As the acid breaks down it makes sea water less alkaline and more acidic.

'If we continue at this rate, the ocean pH will decline by a further 0.3 by the end of this century, an unprecedented 150 percent increase in ocean acidity,' the report states.

'This rate of change has not been experienced for around 65 million years, since the dinosaurs became extinct.'

Achim Steiner, UNEP executive director, said: 'Ocean acidification is yet another red flag being raised, carrying planetary health warnings about the uncontrolled growth in greenhouse gas emissions.

'It is a new and emerging piece in the scientific jigsaw puzzle, but one that is triggering raising concern.'

Article 16: Land - Rising temperatures and shifting precipitation patterns are changing the geographic areas where mammals, birds, insects, and plants that live on land can survive – and are affecting the timing of lifecycle events, such as bud bursts, leaf drop from trees, pollination, reproduction, and bird migration; by: Union of Concerned Scientists

Union of Concerned Scientists. "Global Warming Effects on Land." *Global Warming Effects on Land*. Union of Concerned Scientists, n.d. Web. 30 July 2012. <http://www.climatehotmap.org/global-warming-effects/plants-and-animals.html>.

See how global warming threatens wildlife in Etosha National Park in northern Namibia.


Frank Vassen

- **Forced migrations and extinctions**. Plants and animals are migrating to higher altitudes and latitudes. Land-based species that already live in extreme habitats—such as plants and animals found only in alpine regions—may become extinct because they literally have no place to go, while other shrubs and boreal trees encroach on the warming tundra. Plant-hardiness zones are shifting as formerly low-latitude plants survive at higher latitudes.
- **Increase in agricultural pests**. Agricultural pests formerly constrained to low-latitude locales are moving to higher latitudes as those regions warm. And some pests are reproducing more often as warm seasons last longer. In the now beetle-infested forests of the Kenai Peninsula of Alaska, for example, the pine bark beetle often completes two or three reproduction cycles per year instead of only one.
- **Desynchronization of life-cycle events**. Many formerly synchronized life-cycle events are now out of whack. For example, bird migrations timed to seasonal changes or temperatures may begin earlier. And these birds may find that the insects and other creatures on which they feed along migration routes are not available. Meanwhile warmer temperatures in late winter may force flowers to bud early, leaving them vulnerable to late-season frost.
- **Changing woodlands**. Many tree species are adapted to particular temperature and moisture conditions. As these conditions change, habitats become unsuitable for saplings to grow, and species attempt to migrate. Because trees are so long-lived, the effects may not be noticeable for many years. However, species that now grow only in certain areas—such as the sugar maple, now found in parts of the United States and Canada—may be quite rare in their southern range by the end of this century.
- **Increase in allergens and noxious plants**. Rising concentrations of CO2 in the atmosphere act as fertilizer to many plants. These changes may stimulate growth in certain crops, trees, and weeds—at least under moderate temperature increases as the climate warms. Some potent allergens and noxious plants, such as poison ivy—to which roughly 80 percent of people are allergic—seem to especially thrive in warm and CO_2-rich conditions.

Article 17: Acidity in ocean killed NW oysters, new study says; by: Craig Welch, Environment Reporter of Seattle Times; April 11, 2012

Welch, Craig. "Acidity in Ocean Killed NW Oysters, New Study Says." *The Seattle Times*. The Seattle Times, 11 Apr. 2012. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/localnews/2017961101_oceanacidification12m.html>.

Researchers said Wednesday they have conclusive evidence that ocean acidification is at least partly responsible for killing oysters on the West Coast.

It's been eight years since baby oysters started dying by the billions at an Oregon hatchery and in Washington's Willapa Bay.

In 2009, top scientists drew global attention when they said evidence suggested the culprit might be changing ocean chemistry from the same greenhouse gases that contribute to global warming. They just couldn't prove it — until now.

Researchers said Wednesday they can definitively show that ocean acidification is at least partly responsible for massive oyster die-offs at the hatchery in Netarts Bay, Ore. It's the first concrete finding in North America that carbon dioxide being taken up by the oceans already is helping kill marine species. "This is the smoking gun for oyster larvae," said Richard Feely, an oceanographer and leading marine-chemistry researcher with the National Oceanic and Atmospheric Administration in Seattle and one of the paper's authors.

Said Alan Barton, another of the paper's authors: "It's now an incontrovertible fact that ocean chemistry is affecting our larvae."

In a paper published this week in the journal Limnology and Oceanography, the scientists studied the water that gets pumped from the Pacific Ocean into the Whiskey Creek Hatchery, which supplies baby shellfish for most of the West Coast's $110 million-a-year oyster industry.

Here's why: Since 2005, wild oysters along the Washington coast and at the hatchery had been dying inexplicably in their larval stages. At first the suspect was a bacterial disease, but hatchery workers soon noticed that the die-offs only occurred after high winds drew water from the ocean deep.

Unlike the complex mechanics of climate change, ocean acidification is just basic chemistry. Scientists long had predicted that as carbon dioxide from fossil fuels gets taken up by the seas, ocean waters — typically slightly alkaline — would slide closer to the acidic side of the pH scale. They just expected it would take 50 to 100 years.

But Feely and other top researchers in 2007 and 2008 had discovered that the pH of marine waters along the West Coast had dropped decades earlier than expected. Netarts Bay naturally experiences a wide range of ocean-chemistry fluctuations, and the Northwest's regular wind-driven upwelling events are what drive nutrients to the surface, making the West Coast one of the world's most-productive marine systems. But Feely and other scientists began to suspect that deep water was the real problem.

Because deep, dark water is so far removed from sunlight and photosynthesis, it already contains more carbon dioxide than surface water. The researchers suspected that when ocean acidification from greenhouse gases was added in, the pH of water was pushed over the edge for some oyster species.

There were reasons to think they were right. The Pacific oyster, an import from Japan, is particularly vulnerable to more acidic waters. Its shells are formed from an easily eroded form of calcium carbonate and its larvae get more exposure to marine waters than those of native oysters, like the Olympia.

So, to be certain, the scientists took water from the hatchery and controlled it for temperature and bacteria and pollutants. They let oysters grow in water from the surface and water that upwelled from the deep. But only when the wind blew and drew corrosive waters from the deep just as oysters were spawning did the shellfish not survive to adulthood.

"We'd develop the eggs and that egg development would look good, but they'd grow a little bit and two days later they'd still be the same size and two days after that they'd all be dead," Barton said.

Burke Hales, an Oregon State University chemical oceanographer and the study's lead author, said they found that the corrosive water was most dangerous just before the oysters developed their shells. "It's not that the shell dissolved," he said. "It's that their ability to make shells was very critically affected." The most significant part of their work, scientists said, was that they were using real marine water under normal conditions, not seawater manipulated based on computer models. "This is not just some lab experiment," Barton said. "This is real ocean water — from today, not from some predicted future — impacting shell formation. It's a pretty important finding."

Said George Waldbusser, a professor of ocean ecology and biogeochemistry at Oregon State University: "We're not talking about something we may see a few hundred years into the future. It's now."

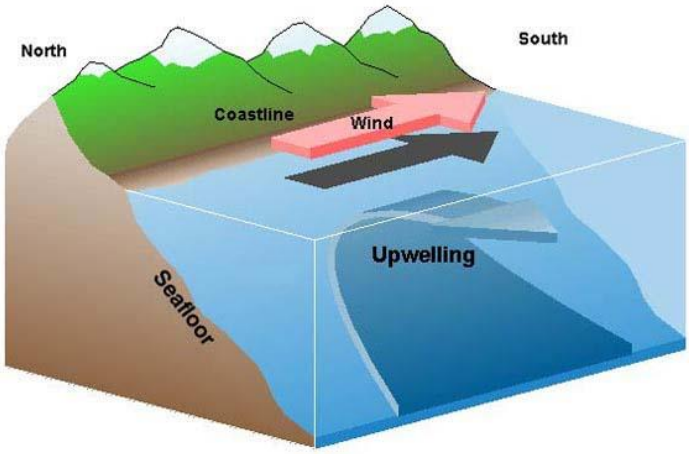
For now, the hatchery has been able to grow oysters again by controlling when it takes in water and by adding in calcium carbonate when needed. But the oyster industry in general is gravely concerned about the future in part because ocean chemistry problems are expected to get worse.

Not only is ocean acidification expected to grow more severe in coming years, but one predicted impact of climate change is more frequent upwelling events. "There are things that could compound all these issues," Waldbusser said.

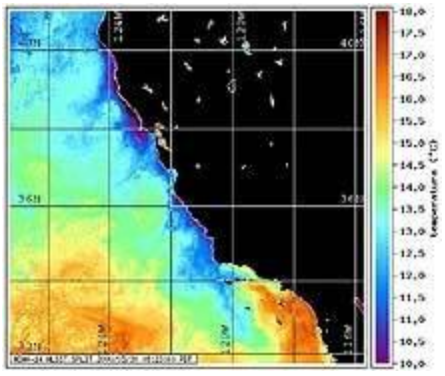
Article 18: Upwelling; by: Dr. Steve Gaines
Director, Marine Science Institute & Professor, Ecology, Evolution, and Marine Biology, University of California, Santa Barbara

Gaines, Steve. "Upwelling." *NOAA Ocean Explorer: Sanctuary Quest: Background*. NOAA, 16 Jan. 2012. Web. 30 July 2012. <http://oceanexplorer.noaa.gov/explorations/02quest/background/upwelling/upwelling.html>.

Winds powerfully affect the oceans and are an important force in creating currents. From global circulation of entire oceans to microscopic patterns of turbulence, winds move water and its resident animals and plants in complex and interesting patterns.



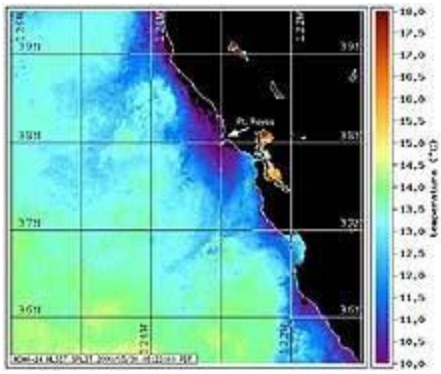
When the wind blows parallel to the coastline, an intriguing and biologically important event occurs. Affected by the rotation of the earth, winds can move water at right angles to the direction the wind is blowing, a phenomenon known as the Coriolis Effect. Along a coastline oriented North-South, like much of the west coast of the U.S., winds that blow from the north tend to drive ocean surface currents to the right of the wind direction, thus pushing surface waters offshore. As surface waters are pushed offshore, water is drawn from below to replace them. The upward movement of this deep, colder water is called upwelling.



Effects of Upwelling

The ecological effects of upwelling are quite diverse, but two impacts are especially noteworthy. First, upwelling brings up cold, nutrient-rich waters to the surface, which encourage seaweed growth and support blooms of phytoplankton. The phytoplankton blooms form the ultimate energy base for large animal populations higher in the food chain, including fish, marine mammals and seabirds. Coastal upwelling ecosystems like the U.S. west coast are some of the most productive ecosystems in the world and support many of the world's most important fisheries. Although coastal upwelling regions account for only one percent of the ocean surface, they contribute roughly 50 percent of the world's fisheries landings.

The second major consequence of upwelling involves its effect on animal movement. Most marine fish and invertebrates produce microscopic larvae as young which drift in the water as they develop. Depending on the species, they may drift in ocean currents for weeks to months. For adult marine creatures that live in shallow waters near-shore, upwelling that moves surface water offshore can potentially move drifting larvae long distances away from their natural habitat, thus reducing their chances for survival. Therefore, upwelling can be a mixed blessing to coastal ecosystems. It can infuse coastal waters with critical nutrients that fuel dramatic productivity, but it can also rob coastal ecosystems of offspring required to replenish coastal populations.



(Figure 3). A closer look at upwelling in the central California region. Note the prominent upwelling center around Pt. Reyes.

Though the diagram in Figure 1 implies that upwelling is a consistent process with surface waters moving uniformly offshore, reality is quite different. As scientists collect more detailed data on patterns of circulation in upwelling regions from satellite remote sensing and moored instruments in the water, they have found that upwelling is extremely variable from one place to the next and over time. Although the coastline from Washington to Southern California experiences winds favorable to upwelling, the strength, frequency and dynamics of upwelling vary enormously.

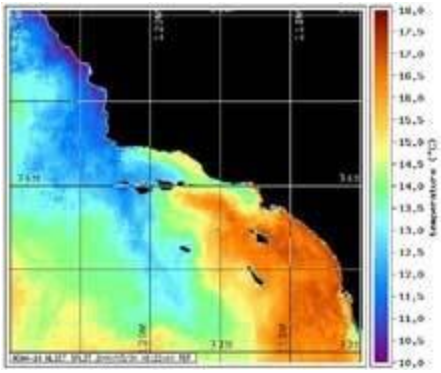
Factors such as variability in the strength and direction of the winds, and the topography of the coastline create an extremely dynamic pattern of upwelling (see Figure 2). In some areas, the cold, upwelled water forms a relatively narrow band near the coastline. Elsewhere, enormous filaments of cold, upwelled water extend hundreds of miles from shore at specific locations, such as Pt. Arena, Pt. Reyes, Pt. Ano Nuevo, and Pt. Sur. Finally, at Pt. Conception, where the coastline abruptly changes direction, upwelling does not occur because the orientation of the coastline and winds are no longer conducive to pushing surface waters offshore.

Upwelling in the Sanctuaries

Upwelling plays an important role for the rich marine resources in each of the five sanctuaries along the west coast. However, the effects on each vary. For example, winds favorable to upwelling tend to be somewhat weaker and more seasonal in the Pacific Northwest than further to the south. Nonetheless, they draw up a rich pool of nutrients that is enhanced by the presence of several deep water canyons near-shore. The resulting food web diversity is spectacular. More species of kelps and marine mammals exist here than anywhere else in the world.

By contrast, one of the strongest regions of upwelling along the California coast is located south and west of Pt. Reyes (see Figure 3). The upwelling filament that extends from the Point bathes Cordell Bank and the Gulf of the Farallones. The resulting nutrient-rich water supports one of the most productive food webs in the marine world. When the winds slow or reverse direction, the upwelling ceases and warm surface waters from the Gulf of the Farallones move back north and

toward the coast. These surface waters may transport larval fish and invertebrates to mainland reefs, where they eventually settle and grow.



(Figure 4). The abrupt change in coastline orientation at Pt. Conception creates a sharp transition between upwelling regions to the north of the Point and warmer waters of the Santa Barbara Channel.

The vast extent of the Monterey Bay Sanctuary, spanning 300 miles of coastline, is characterized by its diversity of oceanographic settings. Upwelling centers located north and south of Monterey Bay (see Figure 3) are the primary source of cool, nutrient-rich water in the sanctuary. No scientific evidence supports the commonly-held belief that the deep Monterey Submarine Canyon contributes to upwelling within the Bay itself. The spatial variability in upwelling and the equally large variation in upwelling intensity over time likely play key roles in the recruitment of fish and invertebrates to coastal reefs.

Finally, the complex geography of Pt. Conception has a profound influence on the oceanographic conditions in the Channel Islands National Marine Sanctuary. The primary direction of the coastline abruptly shifts from north-south to east-west at Pt. Conception (see Figure 4). During the spring and summer months, cool, nutrient-rich waters are upwelled off the coast south of Pt. Conception. These waters are transported to the western islands (San Miguel and Santa Rosa) of the sanctuary where they facilitate high productivity. By contrast, the eastern islands in the sanctuary (Anacapa & Santa Cruz) are bathed by warmer waters, and are associated with subtropical species, which are transported north from Baja California. The sharp boundary between nutrient-rich upwelled waters and nutrient-depleted warmer waters creates a biological transition zone between temperate and subtropical species that is unique to this area.

For more detailed information about research efforts on the connections between upwelling and coastal ecosystems, see the descriptions of ongoing studies in the sanctuaries provided by PISCO (http://www.piscoweb.org), Plumes and Blooms (http://www.icess.ucsb.edu/PnB/PnB.html) and the Santa Barbara Coast LTER (http://sql.lternet.edu/scripts/lter/lter_site_info.pl?sbc).

Article 19: Excess Nitrogen Favors Plants that Respond Poorly to Rising CO_2; by: ScienceDaily; June 30, 2010

ScienceDaily. "Excess Nitrogen Favors Plants That Respond Poorly to Rising CO2." *ScienceDaily*. ScienceDaily, 03 July 2010. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2010/06/100630132742.htm?utm_source=feedburne...>.

(Figure 1) Scientist Adam Langley sprays plants in a test chamber with nitrogen. The additional nutrients changed the composition of the plants inside the chamber, spurring the growth of grasses that respond weakly to elevated levels of CO2. (Credit: SERC)

As atmospheric carbon dioxide levels rise, so does the pressure on the plant kingdom. The hope among policymakers, scientists and concerned citizens is that plants will absorb some of the extra CO_2 and mitigate the impacts of climate change. For a few decades now, researchers have hypothesized about one major roadblock: nitrogen.

Plants build their tissue primarily with the CO_2 they take up from the atmosphere. The more they get, the faster they tend to grow -- a phenomenon known as the "CO_2 fertilization effect." However, plants that photosynthesize greater amounts of CO_2 will also need higher doses of other key building blocks, especially nitrogen. The general consensus has been that if plants get more nitrogen, there will be a larger CO_2 fertilization effect. Not necessarily so, says a new paper published in the July 1 issue of *Nature*.

Adam Langley and Pat Megonigal, two ecologists at the Smithsonian Environmental Research Center, conducted a four-year study on plants growing in a brackish Chesapeake Bay marsh. In 2006 they began feeding sedge-dominated plots a diet rich in CO_2 and nitrogen. Just as atmospheric CO_2 levels are rising, so is nitrogen pollution in estuaries due farming, wastewater treatment and other activities. Because the sedge has previously shown a large CO_2 fertilization effect, Langley and Megonigal expected that adding nitrogen could only enhance it.

The sedge, *Schoenoplectus americanus*, initially reacted as expected. However, after the first year something unanticipated happened. Two grass species that had been relatively rare in the plots, *Spartina patens* and *Distichlis spicata*, began to respond vigorously to the excess nitrogen. Eventually the grasses became much more abundant. Unlike sedges, grasses respond weakly to extra CO_2 and do not grow faster. Thus, the nitrogen ultimately changed the composition of the ecosystem as well as its capacity to store carbon.

The experiment unfolded on the Smithsonian Global Change Research Wetland, located on the Chesapeake's western shore in Maryland. The Smithsonian site has a history of climate change research that dates back to the 1980s. For this study, Megonigal and Langley placed 20 open-top

chambers over random plots of plants. The chambers were 6 feet in diameter and had 5-foot-tall transparent plastic walls.

The large, plastic pods allowed the scientists to manipulate CO_2 concentrations in the air and nitrogen levels in the soil. Half of the plots grew with normal, background CO_2 levels; the other half were raised in an environment with CO_2 concentrations roughly double that amount. Similarly, half of the chambers were fertilized with nitrogen and the other half were untreated.

Langley and Megonigal began and ended each growing season with a census of the plants in each chamber. They noted the individual plant species, measured the above-ground biomass and the root growth. In the chambers that received the high-nitrogen diet, the plant composition changed dramatically; it went from 95 percent sedge in 2005 to roughly half grass in 2009. "It's a fact that not all plants will be able to respond optimally to all changes," said Megonigal. "The things they do respond to reflects their strategy for making a living in the environment."

"The study underscores the importance of considering the mix of species when you're trying to predict how terrestrial ecosystems will react to global climate change factors," said Langley. Rising CO_2 levels will favor some plants and excess nitrogen will favor others. This lesson will be important to understand as scientists consider additional global change factors such as precipitation, temperature and, in tidal wetlands, sea-level rise. The plant species that gain a competitive edge under these evolving conditions will determine how ecosystems respond to global change.

This study was supported by the U.S. Geological Survey and U.S. Department of Energy. The Smithsonian scientists recently received funding from the National Science Foundation that will sustain the research for another 10 years.

Article 20: Global Warming's Impact May be Detected in Genes, Suggests Study of How Seagrasses React to Heat Waves; by: ScienceDaily; November 16, 2011

ScienceDaily. "Global Warming's Impact May Be Detected in Genes, Suggests Study of How Seagrasses React to Heat Waves." *ScienceDaily*. ScienceDaily, 16 Nov. 2011. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2011/11/111116062148.htm>.

Seagrass populations thrive in the shallow coastal regions and offer an ideal habitat for many fish, crustacean and microbes. The worldwide decline of seagrass populations in recent years is therefore of major concern to science and to nature conservation. Researchers believe that climate change plays an important role as the increase in extreme events such as heat waves is a major challenge for the seagrass. How exactly the seagrass species are impacted by extreme events is examined by scientists from the Kiel University, the University of Münster and the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in a study recently published in the *Proceeding of the National Academy of Sciences*.

Image caption: *Divers transplant seagrass during a field experiment in the Kiel Bay. (Credit: T. Reusch, IFM-GEOMAR)*

Scientists led by Professor Dr. Thorsten Reusch from the IFM-GEOMAR are tackling the questions if heat waves have an effect on the genetics of the widespread seagrass species *Zostera marina* (eelgrass).

"In the Mediterranean grasses can resist higher temperatures than in Northern Europe. Here the sea grass populations are endangered by the occurrence of heat waves with temperatures over 25 degrees in the summer," Reusch says, explaining the background of the research project. The adaptability to heat seems to have a genetic basis which is the main interest of the scientists involved in the project.

For the analysis the PhD candidates Susanne Franssen and Nina Bergmann collected sea grasses from different locations in Northern and Southern Europe and exposed them to controlled heat waves in a special test site, the AQUATRON, in the laboratory. Afterwards the scientists analyzed the activity of almost all genes of the plants.

Regardless of their origin, plants showed activation of genes known to buffer heat stress. Only after the heat wave, the southern European plants proved to be resilient, going back to their normal gene activity immediately after the heat wave. The northern European plants, however, showed signs of irreversible protein damage. Apparently, the critical process whether or not a plant continues to grow or eventually dies occurs during the recovery period after the acute heat

wave. To predict the adaptability of organisms to extreme events, such as heat waves, the examination of gene expression during the recovery period seems to be the better parameter.

"These results raise further questions. For example, we are now particularly interested in the ability of particular genotypes within the northern populations to also have the ability to regulate their gene activity back to the normal levels. If this was true our populations in the North and the Baltic Sea would be able to adapt to climate change," says Reusch.

Article 21: Ocean Acidification is latest manifestation of global warming; by: Robin McKie of The Guardian / The Observer; May 28, 2011

McKie, Robin. "Ocean Acidification Is Latest Manifestation of Global Warming." *The Guardian*. Guardian News and Media, 28 May 2011. Web. 30 July 2012. <http://www.guardian.co.uk/environment/2011/may/29/global-warming-threat-to-oceans>.

The infernal origins of Vulcano Island are easy to pinpoint. Step off the hydrofoil from Sicily and the rotten-egg smell of hydrogen sulfide strikes you immediately. Beside the quay, there are piles of yellow sulfurous rocks and chunks of pumice; the beach is made of thick, black volcanic sand; while the huge caldera that dominates the bay emits a constant stream of smoke and steam.

According to legend, this was the lair of the Roman god of fire, Vulcan, who gave his name to the island and subsequently to all other volcanoes. An early eruption here also provided history with one of the first recorded descriptions of a volcano in action.

But Vulcano's importance today has nothing to do with the rock and lava it has spewed out for millennia. It is the volcano's output of invisible carbon dioxide – about 10 tons a day – that now interests scientists. They have found that the gas is bubbling through underground vents and is making the island's coastal waters more and more acidic. The consequences for sea life are grim with dozens of species having been eliminated.

That discovery is highly revealing, and worrying, because Vulcano's afflictions are being repeated today on a global scale, in every ocean on the planet – not from volcanic sources but from the industrial plants, power stations, cars and planes that are pumping out growing amounts of carbon dioxide and which are making our seas increasingly acidic. Millions of marine species are now threatened with extinction; fisheries face eradication; while reefs that protect coastal areas are starting to erode.

Ocean acidification is now one of the most worrying threats to the planet, say marine biologists. "Just as Vulcano is pumping carbon dioxide into the waters around it, humanity is pouring more and more carbon dioxide into the atmosphere," Dr. Jason Hall-Spencer, a marine biologist at Plymouth University, told a conference on the island last week.

"Some of the billions of tons of carbon dioxide we emit each year lingers in the atmosphere and causes it to heat up, driving global warming. But about 30% of that gas is absorbed by the oceans where it turns to carbonic acid. It is beginning to kill off coral reefs and shellfish beds and threaten stocks of fish. Very little can live in water that gets too acidic."

Hence science's renewed interest in Vulcano. Its carbon dioxide springs – which bubble up like burst water mains below the shallow seabed – provide researchers with a natural laboratory for testing the global impact of ocean acidification. "These vents and the carbonic acid they generate

tell us a great deal about how carbon dioxide is going to affect the oceans and marine life this century," said Hall-Spencer. "And we should be worried. This problem is a train coming straight at us."

Scientists estimate that oceans absorb around a million tons of carbon dioxide every hour and our seas are 30% more acidic than they were last century. This increased acidity plays havoc with levels of calcium carbonate, which forms the shells and skeletons of many sea creatures, and also disrupts reproductive activity.

Among the warning signs recently noted have been the failures of commercial oyster and other shellfish beds on the Pacific coasts of the US and Canada. In addition, coral reefs – already bleached by rising global temperatures – have suffered calamitous disintegration in many regions. And at the poles and high latitudes, where the impact of ocean acidification is particularly serious, tiny shellfish called pteropods – the basic foodstuff of fish, whales and seabirds in those regions – have suffered noticeable drops in numbers. In each case, ocean acidification is thought to be involved.

The problem was recently highlighted by the head of the US National Oceanic and Atmospheric Administration, Dr. Jane Lubchenco. She described ocean acidification as global warming's "equally evil twin". It is a powerful comparison, though it is clear that of the two, the crisis facing our seas has received far less attention. The last UN climate assessment report was more than 400 pages long but had only two pages on ocean acidification – mainly because studies of the phenomenon are less well advanced than meteorological and atmospheric research in general.

The workshop, held last week on Vulcano, is part of the campaign to understand the likely impact of ocean acidification. Dozens of young oceanographers, geologists and ecologists gathered for the meeting run by the Mediterranean Sea Acidification (MedSeA) program. Dr. Maoz Fine, of Bar-Ilan University in Israel, reported work on coral reef organisms that had been exposed to waters of different levels of acidity, temperature and light in his laboratory.

"We found that species of coral reef respond differently to rising carbon dioxide levels," he said. "Bigger corals suffer but survive while smaller, branching varieties become less able to fight disease and die off. That sort of thing just makes it even more difficult to predict exactly what is going to happen to our oceans."

Few scientists doubt that the impact on reefs will be anything short of devastating, however. The Caribbean has already lost about 80% of its coral reefs to bleaching caused by rising temperatures and by overfishing which removes species that normally aid coral growth. Acidification threatens to do the same for the rest of the world's coral reefs.

"By the middle of the century there will probably be only a few pockets – in the North Sea and the Pacific. Millions of species of fish, shellfish and micro-organisms will be wiped out," said Fine.

Acidification has affected the oceans in the past. However, these prehistoric events occurred at a far slower rate, said Dr. Jerry Blackford of Plymouth Marine Laboratory. "The waters of the

world take around 500 years to circulate the globe," he said. "If carbon dioxide was rising slowly, in terms of thousands of years, natural factors could then compensate. Sediments could buffer the carbonic acid, for example."

But levels of carbon dioxide are rising much faster today. By the end of the century, surface seawater will be 150% more acidic than it was in 1800. "There is simply not enough time for buffering to come into effect and lessen the impact," said Blackford. "The result will be significant acid build-up in the upper parts of the oceans which, of course, are the parts that are of greatest importance to humans."

A vision of the seas we are now creating can be seen at Vulcano. On the eastern side of its main bay, beyond an open-air thermal spa filled with elderly bathers wallowing in volcanically heated mud, there is a long stretch of black sand.

Just offshore, in about four feet of water, silver beads of carbon dioxide stream up from stones that lie over an underground vent. The water, although cold, looks like a huge, frothing Jacuzzi. Water here is highly acidic and there is no marine life around the vent – not even seaweed.

"The acidity here is far greater than even the worst ocean scenario for 2100, so we have to be careful about making comparisons," said Dr. Marco Milazzo, of Palermo University. "However, currents carry that acid water round the bay and it becomes more and more dilute. We can then study waters which reflect the kind of acidity we are likely to get at the end of the century."

Milazzo and his colleagues have placed open boxes containing coral and other forms of marine life in the waters round the bay and monitor the effects of the different levels of acidity in the sea water on these samples and also on the bay's natural marine life. "When I look one way, out to sea, where there is little acidity, the plant life is rich in reds, whites, greens and other colors. There is abundance and variety in the habitat," said Milazzo.

"However, when I look the other way – back towards the carbon dioxide vent – that habitat gets less and less varied as the water gets more acidic. It is reduced to a dark brown bloom of macro-algae. There is no richness or variety here. In effect I am looking at the oceans of tomorrow. It is profoundly depressing."

Deep Water: Acidity is measured by its pH (power of hydrogen) value. Fresh water has a pH reading of 7. Readings below that are considered to be acidic. Those above 7 are alkaline. Surface sea water had a reading of 8.2 a century ago. Today it has dropped to 8.1 because so much carbon dioxide has been absorbed by the world's oceans. That may seem a small amount but the pH scale is logarithmic which means that 0.1 difference actually represents an increase in acidity of 30%. By the end of the century, the pH of surface sea water could have dropped to 7.8, which represents a decrease in alkalinity – or an increase in acidity, depending on your viewpoint – of around 150%.

Article 22: Ocean Acidification and Its Impact on Ecosystems; by: ScienceDaily; May 26, 2008

ScienceDaily. "Ocean Acidification And Its Impact On Ecosystems." *ScienceDaily*. ScienceDaily, 29 May 2008. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2008/05/080526162652.htm>.

Emissions of carbon dioxide (CO_2) through human activities have a well known impact on the Earth's climate. What is not so well known is that the absorption of this CO_2 by the oceans is causing inexorable acidification of sea water. But what impact is this phenomenon having on marine organisms and ecosystems? This is a question to which researchers have few answers as yet.

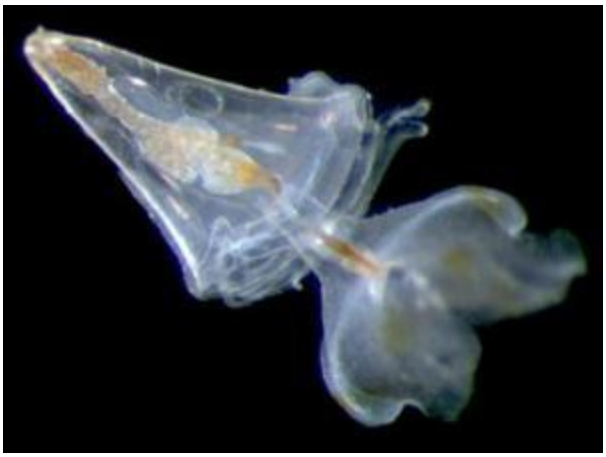


Image caption: *Cavolinia inflexa, a mollusk that lives in open water, has a calcareous shell that is very sensitive to pH. (Credit: Copyright Steeve Comeau, LOV – CNRS)*

That is why the European Union has recently given its support to EPOCA, the European Project on Ocean Acidification, which will be launched in Nice (France) on 10 June 2008.

EPOCA's goal is to document ocean acidification, investigate its impact on biological processes, predict its consequences over the next 100 years, and advise policy-makers on potential thresholds or tipping points that should not be exceeded. The project is coordinated by Jean-Pierre Gattuso, a CNRS researcher at the Oceanography Laboratory at Villefranche-sur-mer (LOV), and brings together a consortium of 27 partners, including CNRS and the French Atomic Energy Agency (CEA), from 9 countries. Many of the leading oceanographic institutions across Europe and more than 100 permanent scientists are involved. The budget is €16.5 million over 4 years, including €6.5 million from the European Commission.

Over 71% of the Earth's surface is covered by the oceans, which are home to an incredibly diverse flora and fauna. They play a key role in regulating the climate and levels of carbon dioxide (CO_2), one of the main greenhouse gases. Over the last 200 years (since the beginning of the industrial revolution), the oceans have absorbed about one third of the carbon dioxide produced by human activities, a total of 120 billion tons. Without this absorption, the amount of CO_2 present in the atmosphere and its effects on the climate would undoubtedly be far greater.

In fact, over 25 million tons of CO_2 dissolve in seawater every day. However, the oceans do not escape unscathed. When CO_2 dissolves in sea water, it causes the formation of carbonic acid, which leads to a fall in pH (the pH scale is used to measure acidity). This change is called “ocean acidification” and is happening at a rate that has not been experienced probably for the last 20 million years.

The effects of this huge input of CO_2 into the oceans only began to be studied in the late 1990s and are still poorly understood. One of the most likely consequences will be slower growth of organisms with calcareous skeletons, such as corals, mollusks, algae, etc. Obtaining more information about ocean acidification is a major environmental priority because of the threat it poses to certain species and ecosystems.

EPOCA should help us to understand the effects of the acidification of sea water as well as its impact on marine organisms and ecosystems. More specifically, the project has four goals:

1. Document the changes in ocean chemistry and biogeography across space and time. Paleo-reconstruction methods will be used on several natural/biological archives, including foraminifera and deep-sea corals, to determine past variability in ocean chemistry and to tie these to present-day chemical and biological observations.
2. Determine the sensitivity of marine organisms, communities and ecosystems to ocean acidification. Molecular to biochemical, physiological and ecological approaches will be combined with laboratory and field-based perturbation experiments to quantify biological responses to ocean acidification, assess the potential for adaptation, and determine the consequences for biogeochemical cycling. Laboratory experiments will focus on key organisms selected on the basis of their ecological, biogeochemical or socio-economic importance. Field studies will be carried out in systems (areas/regions) deemed most sensitive to ocean acidification.
3. Integrate results on the impact of ocean acidification on marine ecosystems in biogeochemical, sediment, and coupled ocean-climate models to better understand and predict the responses of the Earth system to ocean acidification. Special attention will be paid to the potential feedbacks of the physiological changes in the carbon, nitrogen, sulfur and iron cycles.
4. Assess uncertainties, risks and thresholds ("tipping points") related to ocean acidification at scales ranging from sub-cellular to ecosystem and local to global. It will also assess the decrease in CO_2 emissions required to avoid these thresholds and describe the change and the subsequent risk to the marine environment and Earth system, should these emissions be exceeded.

Notes

1) LOV, a component of the Observatoire océanologique de Villefranche-sur-Mer, CNRS / Université Pierre et Marie Curie-Paris VI

2) The lower the pH of a solution, the higher is its acidity.

3) This area of research has been receiving backing at national level for several years through INSU's project-based actions.

Article 23: Climate Change Affects Ants and Biodiversity, by Newswise - University of Tennessee; November 4, 2011

University of Tennessee. "Climate Change Affects Ants and Biodiversity." *Climate Change Affects Ants and Biodiversity*. Newswise Inc, 4 Nov. 2011. Web. 30 July 2012. <http://www.newswise.com/articles/climate-change-affects-ants-and-biodiversity>.

Some people may consider them pests, but ants are key to many plants' survival.

In the eastern US, ants are integral to plant biodiversity because they help disperse seeds. But ants' ability to perform this vital function, and others, may be jeopardized by climate change, according to Nate Sanders, Associate Professor of Ecology and Evolutionary Biology at the University of Tennessee, Knoxville.

Sanders and his collaborators have received a grant for nearly $2 million from the National Science Foundation to examine the cascading effects of climate change on ant communities and the ecosystem functions they provide.

"Ants are critically important to most ecosystems," Sanders said. "They eat other insects, circulate nutrients, increase turnover in the soil, and move seeds around."

Sanders and his colleagues are testing the effects of climate change on ants by heating up patches of forest and tracking how the ants respond. Inside Duke Forest in North Carolina and Harvard Forest in Massachusetts lie twelve five-meter wide, open-top chambers. Air temperature is incrementally increased by half a degree Celsius in each chamber for a total of a six-degree changes and ant behavior observed.

The researchers, led by Katie Stuble from UT and Shannon Pelini at Harvard Forest, noticed dramatic changes in the ants' daily activity in each chamber. "If the temperature increases by just a half a degree Celsius, the most important seed-dispersing ants basically shut down," said Sanders. "They do not go out and forage and do the things they normally do."

Stuble observed that, on average, the ants foraged for about ten hours a day at normal temperatures. When temperatures were raised just a half a degree, the ants stayed in their nests underground and foraged just an hour. The absence of ants' seed dispersal and nutrient cycling could have profound influence on biodiversity. For instance, it is believed that more than half of the plants in the forest understory of the Great Smoky Mountains National Park rely on ants for seed dispersal. Ants are found in ecosystems everywhere but in Antarctica and Iceland.

The researchers' goal is to provide information about the effects of climate change on biodiversity and ecosystems. "We know that climate change is happening," Sanders said. "Lots of models make predictions about how biodiversity is going to respond. It will either respond by adapting, moving or going extinct. If you can't keep up with climate change, you will go extinct."

Sanders and his team will collect data through 2015. He is collaborating with colleagues from Harvard University, North Carolina State University, and University of Vermont. The project began in 2007 with funding from the Department of Energy. The team's papers can be read at http://web.utk.edu/~nsanders/.

Article 24: Whales, Like Trees, Slow Warming; by Jessica Marshall, DiscoveryNews; February 26, 2010

Marshall, Jessica. "Whales, Like Trees, Slow Warming." *Discovery News*. Discovery Communications, 26 Feb. 2010. Web. 30 July 2012. <http://news.discovery.com/earth/whales-carbon-climate-change.html>.

THE GIST:

- **Whaling may have removed as much carbon from the oceans as deforesting much of northern New England.**
- **Industrial whaling removed 90 -95 percent of many whale populations over the last 100 years.**
- **Restoring whale populations may have the added benefit of sequestering carbon.**

Whales, like the blue whale here, act like the world's forests, sucking climate-changing carbon dioxide out of the atmosphere over their lifetime and socking it away.

It's their parting gift to the world: Each dying whale carries tons of carbon to the sea floor as its massive body sinks, storing it there for centuries where it can't harm the climate.

In this way, whales are like the world's forests, sucking climate-changing carbon dioxide out of the atmosphere over their lifetime and socking it away. And according to new research, repopulating the oceans with whales could be as good for battling climate change as planting trees.

"If you think about whales and fish in terms of their carbon, there is a potential for using carbon offset credits as an additional incentive for rebuilding this population," said Andrew Pershing of the University of Maine School of Marine Science and the Gulf of Maine Research Institute who presented his results yesterday at a meeting of ocean scientists convened by the American Geophysical Union in Portland, Ore.

Conversely, Pershing noted, commercial whaling may have released large amounts of carbon dioxide into the atmosphere by pulling whales out of the ocean that would otherwise have fallen to the sea floor.

Pershing estimates that whaling released around 105 million tons of carbon over the last 100 years -- as much carbon as burning most of Oregon's forests, or driving 128,000 Hummers for 100 years -- although these calculations carry several uncertainties.

While the amount of carbon possibly released by whaling over the last 100 years is small compared with the amount that is released annually worldwide -- 7 billion tons -- the amount is comparable to some of the proposed strategies for combating warming, like many reforestation projects or seeding the ocean with iron to increase CO2 uptake by phytoplankton, Pershing said.

Trees convert CO2 directly into wood and leaves through photosynthesis. Whales capture CO2 indirectly. Marine phytoplankton build their tissues through photosynthesis and are eaten by zooplankton, which whales then eat and use to build their colossal bodies. A 90-ton blue whale, the largest animal on Earth, holds about 9.4 tons of carbon, which would be converted to 34 tons of CO2 if it were burned or decomposed completely.

"One key difference between whales and forests is what happens when you've reached your steady state, your maximum population size," Pershing said.

At some point, the forest reaches its maximum density where dying trees are balanced by new growth, and the forest can no longer store any additional carbon, he said. "Marine systems are unique in that the animals and plant life in the surface waters of the ocean, when they die, they can take that carbon with them down to the bottom. A fully populated whale stock will continue to export carbon through sinking of dead whales."

And Pershing notes that other large top predators like bluefin tuna and sharks can have the same effect.

"These guys are huge. They don't have predators. When they die they are very likely to sink and take their biomass to the bottom of the ocean."

Over the last 100 years, whaling removed more than 2 million whales from the Southern Hemisphere alone, said Phillip Clapham, director of the cetacean program at the National Oceanic and Atmospheric Association's National Marine Mammal Laboratory in Seattle. For many species, this represented 90-95 percent of their total numbers.

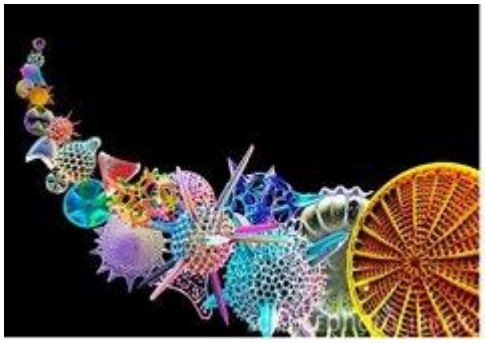
Whale blubber was used to make margarine, as lamp or industrial oil, and the meat was sometimes consumed by animals or humans.

Some species have done better than others since the moratorium on whaling, which took effect in 1986. Humpback whales are doing extremely well in most places, Clapham said. But there are only about 2000 blue whales in the Antarctic now, compared to the 369,000 killed by whaling.

As for sequestering carbon, "It's a great idea. I love it." Clapham said. He cautions that he has no way of evaluating Pershing's calculations, but "presuming that they are correct, it certainly is a very novel and innovative idea and another reason to save whales."

Article 25: IISc to extract oil from Diatoms, algae; by: Biotech News Update; July 04, 2009

Biotch News Update. "IISc to Extract Oil from Diatoms, Algae." *Biotech News Update: IISc to Extract Oil from Diatoms, Algae*. N.p., 4 July 2009. Web. 30 July 2012. <http://biotechnewsupdate.blogspot.com/2009/07/iisc-to-extract-oil-from-diatoms-algae.html>.

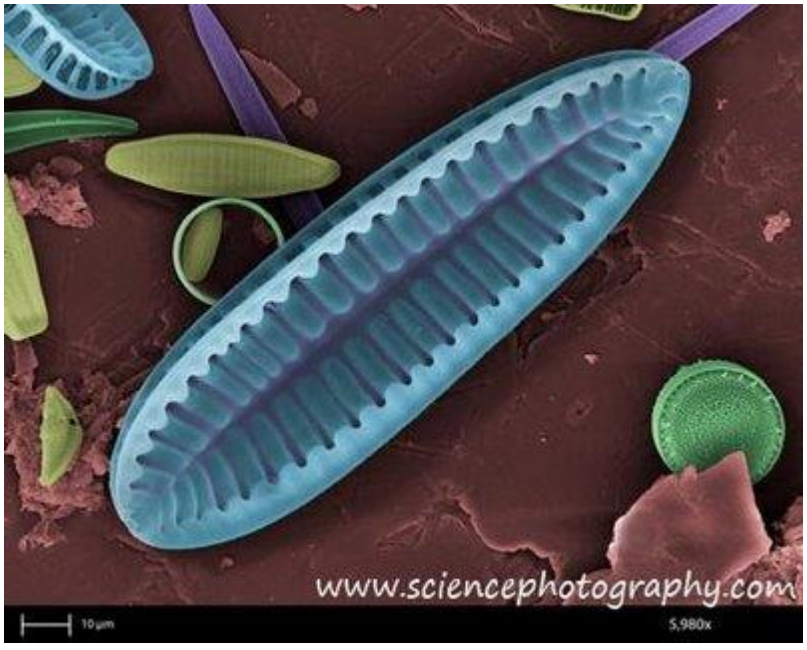


Driving will soon be a pollution-friendly activity if a small team of scientists from India and Canada have their way. Scientists at the **Indian Institute of Science (IISc)** have collaborated with their counterparts in Canada to ensure that global warming becomes a thing of the past.

According to the scientists, the answer to a clean and sustainable energy production lies in the **microscopic algae — diatoms.**

Some geologists believe that a majority of the world's crude oil originated from diatoms. "Diatoms are the lowest in the order of the food chain, but are known to have oil glands that can yield an effective amount of oil. They also act as carbon sequesters trapping in carbon and releasing oxygen. We hope that this could work as a replacement for conventional energy or gasoline paving the way for a clean fuel that can effectively work as a solution to tackle global warming," said Dr. T.V. Ramachandra at IISc.

The research, that will soon be published in an international journal, indicates that a solution to the impending crude oil scarcity exists. It offers solutions for a cost-effective renewable source of alternative energy and also helps stop the emission of carbon dioxide into the atmosphere to an extent. Diatoms can trap and store carbon, sending out emissions free of any pollutants.



The team that comprises IISc professors Durga Madhab Mahapatra, Karthick B. and Dr. Ramachandra and Richard Gordon from the University of Manitoba in Canada have also proposed a new approach to sustainable energy that uses solar panels by incorporating altered diatoms that secrete oil products.

Article 26: Mercury in Seal's Diet Linked to Warming; by: Emily Sohn; May 05, 2009

Sohn, Emily. "Mercury in Seal's Diet Linked to Warming." *Mercury in Seal's Diet Linked to Warming*. Discovery Communications, 5 May 2009. Web. 30 July 2012. <http://dsc.discovery.com/news/2009/05/05/seal-mercury-fish-print.html>.

May 5, 2009 -- As sea ice vanishes from the Arctic, levels of mercury will rise in the region's seals -- and in the people who eat them, suggests a new study.

It's a complicated relationship, and far too soon to recommend that native seal-hunters stop eating their traditional diet. But the study, which found a shift in what the seals eat -- and an increase in mercury-contaminated foods -- when climate is at extremes, provides yet another example of global warming's reverberating effects.

"Knowing what we know, if we continue to lose sea ice, the mercury concentration in seals may go up," said Gary Stern, senior research scientist at the Department of Fisheries and Oceans in Winnipeg. Arctic seals already face a number of threats, including a changing habitat. "Mercury contamination is just one additional stressor on top of the others."

Researchers have been monitoring mercury levels in ringed seals in the western Canadian Arctic since the 1970s. Over that time, they've seen absolutely no trend whatsoever, Stern said. What they have seen is lots of variability. Some years, levels are high. Some years, levels are low.

But further investigation showed that mercury levels in the seals is linked to the amount of cod the animals eat. And researchers found the amount of mercury-containing fish the seals eat is highest when ice-free days are at the extremes.

Stern and colleagues looked at mercury levels in seal muscle tissues collected a handful of times between 1973 and 2007. Samples came from adult seals that were caught by hunters, and 13 to 20 seals were analyzed each time.

For each year in the study period, the researchers also looked at available ice charts to see how many days were ice-free. Every winter, floating sea ice grows around the Arctic, and every summer, it melts again. But the number of ice-free days varies from year to year.

Finally, the scientists compared the two sets of data. In the current issue of *Environmental Science & Technology*, they report that mercury levels in seals were highest in years with the most ice-free days and in years with the least ice-free days, but lowest in the less extreme years.

"Lo and behold, we had a strong correlation suggesting a link between mercury in seals and sea-ice extent," Stern said. "It works extremely well."

To explain the relationship, the team turned to cod. These fish make up a significant portion of a ringed seal's diet, and they are a key part of the food chain that passes mercury upwards, and magnifies the toxic metal as it goes.

In the coldest years, Stern said, when ice-free seasons are shortest, smaller cod suffer and die, so seals end up eating more big fish, which contain more mercury. In the warmest years, on the other hand, more cod of all sizes survive through the longer ice-free seasons, so cod makes up a larger proportion of the seal's diet. That also leads to a larger intake of mercury than in the intermediate years, when seals eat more low-mercury invertebrates.

Stern is looking now at the relationship between sea ice coverage and concentrations of other contaminants, including PCBs and DDT. Like mercury, these toxins accumulate in fat and can harm an animal's health, especially when the animal faces other stresses, like a changing environment.

More work needs to be done to confirm that cod are doing what the scientists suspect they're doing, said Robie Macdonald, a geochemical oceanographer at the Institute of Ocean Sciences in Sidney, British Columbia. For now, though, the link is plausible enough to warrant a deeper look.

"It's particularly important because seals are a keystone species in this region," Macdonald told Discovery News. Seals depend on cod, and polar bears, narwhals, and people depend on seals. "They're important enough that we worry about their health."

As for the region's seal-hunters, Canada's public health agency still encourages them to continue eating their traditional diet.

"There are all sorts of vitamins and minerals in those tissues," Stern said, as well as advantages for the people in maintaining an active, hunting lifestyle that involves few processed and store-bought foods. "The benefits far outweigh the risks."

Article 27: Satellite images of Antarctic emperor penguins will benefit climate change research; by: Mary Ormsby; April 13, 2012

Ormsby, Mary. "Satellite Images of Antarctic Emperor Penguins Will Benefit Climate Change Research." *Print Article*. TheStar, 13 Apr. 2010. Web. 30 July 2012. <http://www.thestar.com/printarticle/1161346>.

Emperor penguins are seen in Dumont d'Urville, Antarctica. Counting emperor penguins in their icy Antarctic habitat was not easy until researchers used new technology to map the birds from space, and they received a pleasant penguin surprise for their efforts.

Call them the penguins from outer space.

Because that's how an international science team got pictures of emperor penguins in Antarctica — and counted nearly double what was previously thought to be the birds' population.

An orbiting satellite called QuickBird, which performs all sorts of Earth observation, carried out a non-invasive mapping technique that scoured inhospitable, inaccessible places where humans could not tread safely.

The super-sharp, pixilated satellite images, taken in October 2009, detailed 595,000 penguins in 44 colonies — seven of them never seen before — along the coastline of Antarctica.

"If you wanted to do what we did (from space) by putting people on the ground and counting heads at every single (penguin) location in one month in Antarctica, I would put money on it that it would never happen," says researcher Michelle LaRue of the University of Minnesota's Polar Geospatial Center. It took about one month to collate enough images of the continent to count the birds.

"It's just too dangerous, too harsh, and you just can't get to (some of) those locations. Really, this is the only way to do it effectively, safely, safe for the environment, and obviously we don't bother the penguins at all."

The satellite also zoomed in on poop. The imaging technique called pan-sharpening (it boosts resolution) allowed scientists to differentiate among birds, ice and mounds of penguin poop (a.k.a. guano). The space probe of the ice-capped continent made for a more precise count on difficult mottled terrain, says LaRue, one of the co-authors of a report appearing this week in the

science journal *PLoS ONE*. Though the satellite snaps don't show penguin features such as beaks or eyes, the waddling birds' dark bodies are distinct from their surroundings — including piles of poop.

But despite much bigger population assessment, the new census is not an indication of frisky penguins mating twice as fast.

"By no means does it mean they have doubled in numbers; it means we didn't know they were there before," LaRue says.

The previous estimate pegged the bird count between 270,000 and 350,000.

Researchers will now be able to monitor the penguins via satellite for accurate increases or decreases in numbers, for regional versus continent-wide trends, and for basic biology, such as which factors influence their numbers. If, for instance, there's a sharp decline in one region, that might prompt a team of researchers to go to that area for further study.

The emperor penguin, anthropomorphized in Hollywood movies like *Happy Feet*, has distinctive gold patches on its ears and atop its chest. The giant of all penguins, it is one of Earth's largest birds. The emperor is long-lived (20 years in the wild, with some reports of emperors lasting four decades) if it can make it to its first birthday: LaRue says 80 per cent of chicks do not survive a full year in the harsh landscape.

Mapping the emperor penguins has ramifications around the planet.

"The thing about emperor penguins in this research, in particular, is they are the proverbial canary in the coal mine as far as ecosystem health and climate change go," says LaRue.

"The implication for climate change is the ice loss. We already know one (previous to 2009 research) colony is gone due to the lack of sea ice in the area. So by understanding the relative health and status of the emperor penguin population, we can better understand the health of the Southern Ocean. And the reason people should care about that is because we fish in the Southern Ocean; we fish for krill, for Chilean sea bass. There are resources in the Southern Ocean that are important to us."

British geographer Peter Fretwell of the British Antarctic Survey was the lead author of the published report. He notes this is the first comprehensive census of a species taken from space.

Article 28: Scientists cite global warming for more heat waves, heavier rainfall; by: Juliet Eilperin and Brian Vastag of the Washington Post; April 02, 2012

Eilperin, Juliet. "Scientists Cite Global Warming for More Heat Waves, Heavier Rainfall." *The Seattle Times*. The Seattle Times, 02 Apr. 2012. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/nationworld/2017895407_climate03.html>.

WASHINGTON — Scientists are increasingly confident that the uptick in heat waves and heavier rainfall is linked to human-caused greenhouse-gas emissions, posing a heightened risk to the world's population, according to two recent reports.

On Wednesday, the U.N. Intergovernmental Panel on Climate Change (IPCC) released a 594-page study suggesting that when it comes to weather observations since 1950, there has beena "change in some extremes," which stem in part from global warming.

The report — the product of a collaboration of 220 authors from 62 countries — makes distinctions among different phenomena. It shows there is "limited to medium evidence" that climate change has contributed to changes in flooding, for example, and there is "low confidence" that long-term hurricane trends over the past 40 years have been driven by the world's growing carbon output.

But the IPCC team projects that there is a 90 to 100 percent probability that sea level rise "will contribute to upward trends in extreme coastal high-water levels in the future."

Chris Field, who co-chairs the IPCC's Working Group II and serves as the director of the Carnegie Institution's Department of Global Ecology at Stanford University, said in an interview that although many uncertainties still exist when it comes to extreme weather, "We also know the risk people face is changing as a result of climate change."

Asking whether a particular extreme weather event can be blamed on human-caused global warming is the wrong question to ask, said Dim Coumou, a climate scientist at the Potsdam Institute for Climate Impact Research in Germany. There's no way to determine whether a single event was triggered by climate change, he said.

Instead, a new analysis from Coumou and a colleague, published in the journal Nature Climate Change, examines patterns of extreme weather since 2000 and asks whether the likelihood of these events was heightened by human-driven climate change.

For extreme heat waves and unusual downpours, the answer, Coumou and his colleagues found, is yes.

"The evidence is solid," he said: Extra heat in the atmosphere from human-caused greenhouse gases has made these two types of events much more likely. The climate has already changed, and the sheer number of these events over the past decade reflects it, they find.

Linking hurricanes, tornadoes and other storms to climate change is much harder, as records for these events are poorer than temperature and rainfall records.

Coumou pointed to the 2010 heat wave in Moscow and western Russia as an example of an extreme event made much more likely by climate change. The hottest summer in 500 years of temperature records caused 15,000 deaths, shaved billions off Russia's economic output, triggered 500 wildfires and destroyed 30 percent of the country's grain harvest.

"We found very strong warming since 1970s in the Moscow region," said Coumou, "and this warming has dramatically increased the chances that a record summer would occur."

Across the United States this year so far, warm-weather records have outnumbered cold records by a factor of 12, according to the National Oceanic and Atmospheric Administration's National Climatic Data Center.

Coumou used a "loaded dice" analogy that's become popular with climate scientists. Rolling one six is not evidence of a loaded die. Rolling 10 in a row? Now you're suspicious. Human-induced climate change has loaded the dice toward certain extreme events, Coumou said.

Both environmentalists and several major insurers argue policymakers must move quickly to cut carbon emissions and devise strategies to adapt to climate impacts.

"The IPCC report is yet another reminder of the pressing need to tackle climate risk in both the near and long term," said Mark Way, head of Swiss Re's sustainable-development activities in the Americas. "Last year in the United States, even with the absence of major hurricane impacts, the insurance industry paid out approximately $35 billion in losses due to weather-related events. Severe weather will continue to impact the economy, and society in general, until we take the necessary measures to increase our resilience."

Although extreme weather in developed countries exacts a higher human toll than in industrialized nations, the high economic cost associated with recent U.S. disasters is shifting more of the financial burden on taxpayers.

Cynthia McHale, who runs the insurance program at the nonprofit Ceres, said the National Flood Insurance Program now has $1.2 trillion of commercial and residential assets on its books. Beyond flood risk, the risk pools backed by state guarantees known as "residual markets" grew from $55 billion in 1990 to $758 billion in 2010.

"If we continue on this path, extreme weather is certain to cause more homes and businesses to be uninsurable in the private insurance market, leaving the costs to taxpayers or individuals," McHale said.

Last week, Lloyd's of London posted its first pretax loss in six years, citing the costs it incurred related to natural catastrophes last year. That year now ranks as the second-most expensive on record in terms of insured disaster claims, with industry estimates ranging between $100 billion and $116 billion.

The IPCC report identifies "no regrets" strategies policymakers can pursue that reduce the risk of disasters while promoting sustainable development and climate adaptation, including early-warning systems for hurricanes and better building design and regulation to lower the impact of flash floods.

"There are lots of opportunities which pay off," said Field, who coedited the new report.

Article 29: Killer whales facing an airborne threat; by: Craig Welch; April 20, 2012

Welch, Craig. "Killer Whales Facing an Airborne Threat." *The Seattle Times*. The Seattle Times, 19 Apr. 2012. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/localnews/2018025831_orcas20m.html>.

New research shows that killer whales are inhaling bacteria, fungi and viruses once believed to be found only on land. Some of the pathogens are highly virulent. And some are even antibiotic-resistant.

Researchers use a pole with petri dishes attached on the end to sample the misty spray from a killer whale's blowhole for bacteria and other pathogens once believed to be found only on land. "It's pretty disturbing and opens a whole new can of worms," says an expert.

The scientists followed the killer whales by boat, trying to catch the precise moment the animals broke the surface.

Then, using a 25-foot pole strung with petri dishes, researchers leaned out and gathered samples of the moist exhaled air that shot like a geyser from each whale's blowhole.

For four years a team of researchers gathered these orca breath samples from the waters of Washington and British Columbia. And by comparing them to surface waters and orca death records, the scientists stumbled upon a trend.

Killer whales — from Puget Sound's endangered southern residents to the transient whales living hundreds of miles offshore — are inhaling bacteria, fungi and viruses once believed to be found only on land. Some of the pathogens are highly virulent. And some are even antibiotic-resistant.

The discovery comes as researchers also learn that respiratory ailments may be a leading cause of orca deaths, and that leads biologists to a new question:

Given that Puget Sound's orcas are stressed and potentially more susceptible to illness, how much risk could exposure to new sources of infection pose?

"It's pretty disturbing and opens a whole new can of worms," said marine-mammal veterinarian Pete Schroeder. "We have an iconic species of animal that is in danger and whose ability to withstand a severe infection is in question. Now we know they can inhale antibiotic-resistant bacteria and it can live in their upper respiratory tract."

The research is so new, it's hard to draw firm conclusions.

"Just because you detect a particular pathogen, does that mean it will cause a problem? It may or may not," said Brad Hanson, a marine-mammal biologist with the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center in Seattle. "Are we detecting them because we've never looked before? We don't know."

But while none of the orcas sampled were sick, researchers said their findings suggest that contagions may be of greater concern for orcas than previously thought.

"It means we need to worry about disease outbreaks as a threat to the very survival of the population," said David Bain, an orca expert and affiliate professor at the University of Washington. "We need to improve the barrier between our lives on land and whales' lives at sea."

Trouble with runoff

It's no secret that a stew of microbes from land regularly invades Puget Sound. Bacteria and nutrients from humans and animals have for decades been funneled into estuaries and bays, causing oxygen problems in Hood Canal and resulting in shellfish-bed closures.

Chicken and cow waste has flowed from farms into rivers. Other nutrients from humans spread through leaky septic tanks or poor sewage treatment or from dumping by pleasure boats or cruise ships. Stormwater runoff over roads and parking lots washes in animal waste with other dangerous chemicals that rise through the food web and settle in the flesh and fat of marine mammals, including orcas.

But in the last decade a largely unheralded potential pollution source has started garnering new attention — the super-thin film that floats atop marine waters, called the sea-surface microlayer. This millimeter-thick sheen on the surface has long been known to carry fungi and bacteria, and those pathogens can easily become airborne.

So in the mid-2000s, after Puget Sound's orcas were listed for protection under the Endangered Species Act, Schroeder and a group of whale scientists began wondering if the marine mammals could inhale contaminants when they break the surface.

It seemed like an important question. Whale respiration is particularly sensitive. With each breath, humans exchange up to 20 percent of the air in their lungs. Killer whales may exchange 70 percent at once. And whales don't have a sinus network to extract harmful particles before they settle in the lungs.

Plus, marine biologists suspect Puget Sound's southern residents already have weakened immune systems. Because they are at the top of the food chain, they're loaded up with such toxic chemicals as DDT, and the long-lived banned solvent polychlorinated biphenyls (PCBs) found in fish. And the decline of Puget Sound chinook, their preferred food, means they have to work harder for each meal.

While that could make them more vulnerable to disease, scientists rarely know what kills a Puget Sound orca. Only two in the last 10 years have washed up dead in the U.S.

"When southern residents die, most of the time, they just disappear," Hanson said. "We don't have a good idea what happens to them."

So Schroeder and several colleagues got access to a boat. They attached petri dishes to a shaft and followed whales as they traveled in pods. They gathered 23 breath samples from 14 whales, from Puget Sound to Vancouver Island. They also sampled the sea-surface microlayer.

Both the whale breath and the sea-surface samples contained bacteria that didn't appear to belong there. Some bacteria did belong, but was antibiotic-resistant. There were strains of Salmonella and a rare bacteria known to cause pneumonia in humans. There was a pathogen responsible for gastroenteritis and gangrene, and a form of Staphylococcus resistant to penicillin. One pathogen normally found in marine waters was, surprisingly, resistant to six different antibiotics.

"In some of the bacteria we found some isolates were almost identical to what we recover in dairy cattle," said Stephen Raverty, a veterinarian pathologist with B.C.'s Ministry of Agriculture.

Many of the bacteria were nonpathogenic, but a few appeared potentially dangerous.

"It's not like there was a soup of terribly virulent bacteria out there. But there was enough to be concerned," Schroeder said.

Why they die

As researchers tried to understand their findings, Raverty and others took on a new challenge — tracking why killer whales die. Of the 222 documented killer-whale strandings in the northeastern Pacific between 1944 and 2003, a thorough analysis had been done on 46 animals. Half of those died while sick with pneumonia.

Raverty and others also published a paper in 2010 about a killer whale that had washed up dead years earlier in California. It had been infected with a strain of Salmonella normally associated with birds, humans and livestock. It had never been seen before in a killer whale — and this particular animal was a transient that had spent most of its life far out to sea.

The researchers know their work just raises more questions, but few now dispute that the answers may matter.

"We're beginning to see that understanding disease is going to be important — and a big challenge," Hanson said.

Article 30: Ocean Acidification: 'Evil Twin' Threatens World's Oceans, Scientists Warn; April 1, 2010

ScienceDaily. "Ocean Acidification: 'Evil Twin' Threatens World's Oceans, Scientists Warn." *ScienceDaily*. ScienceDaily, 01 Apr. 2010. Web. 30 July 2012. <http://www.sciencedaily.com/releases/2010/03/100330092821.htm>.

The rise in human emissions of carbon dioxide is driving fundamental and dangerous changes in the chemistry and ecosystems of the world's oceans, international marine scientists have warned.

"Ocean conditions are already more extreme than those experienced by marine organisms and ecosystems for millions of years," the researchers say in the latest issue of the journal *Trends in Ecology and Evolution*.

"This emphasizes the urgent need to adopt policies that drastically reduce CO_2 emissions."

Ocean acidification, which the researchers call the 'evil twin of global warming', is caused when the CO_2 emitted by human activity, mainly burning fossil fuels, dissolves into the oceans. It is happening independently of, but in combination with, global warming.

"Evidence gathered by scientists around the world over the last few years suggests that ocean acidification could represent an equal -- or perhaps even greater threat -- to the biology of our planet than global warming," co-author Professor Ove Hoegh-Guldberg of the ARC Centre of Excellence for Coral Reef Studies and The University of Queensland says.

More than 30% of the CO_2 released from burning fossil fuels, cement production, deforestation and other human activities goes straight into the oceans, turning them gradually more acidic.

"The resulting acidification will impact many forms of sea life, especially organisms whose shells or skeletons are made from calcium carbonate, like corals and shellfish. It may interfere with the reproduction of plankton species which are a vital part of the food web on which fish and all other sea life depend," he adds.

The scientists say there is now persuasive evidence that mass extinctions in past Earth history, like the "Great Dying" of 251 million years ago and another wipeout 55 million years ago, were accompanied by ocean acidification, which may have delivered the deathblow to many species that were unable to cope with it.

"These past periods can serve as great lessons of what we can expect in the future, if we continue to push the acidity the ocean even further" said lead author, Dr. Carles Pelejero, from ICREA and the Marine Science Institute of CSIC in Barcelona, Spain.

"Given the impacts we see in the fossil record, there is no question about the need to immediately reduce the rate at which we are emitting carbon dioxide in the atmosphere," he said further.

"Today, the surface waters of the oceans have already acidified by an average of 0.1 pH units from pre-industrial levels, and we are seeing signs of its impact even in the deep oceans," said co-author Dr. Eva Calvo, from the Marine Science Institute of CSIC in Barcelona, Spain.

"Future acidification depends on how much CO_2 humans emit from here on -- but by the year 2100 various projections indicate that the oceans will have acidified by a further 0.3 to 0.4 pH units, which is more than many organisms like corals can stand," Prof. Hoegh-Guldberg says.

"This will create conditions not seen on Earth for at least 40 million years."

"These changes are taking place at rates as much as 100 times faster than they ever have over the last tens of millions of years" Prof. Hoegh-Guldberg says.

Under such circumstances "Conditions are likely to become very hostile for calcifying species in the north Atlantic and Pacific over the next decade and in the Southern Ocean over the next few decades," the researchers warn.

Besides directly impacting on the fishing industry and its contribution to the human food supply at a time when global food demand is doubling, a major die-off in the oceans would affect birds and many land species and change the biology of Earth as a whole profoundly, Prof. Hoegh-Guldberg adds.

Article 31: Climate change will impact infectious diseases worldwide, but questions remain as to how; by: Katherine Harmon; March 03, 2010

Harmon, Katherine. "Climate Change Will Impact Infectious Diseases Worldwide, but Questions Remain as to How | Observations, Scientific American Blog Network." *Climate Change Will Impact Infectious Diseases Worldwide, but Questions Remain as to How | Observations, Scientific American Blog Network*. Nature America Inc, 3 Mar. 2010. Web. 30 July 2012. <http://blogs.scientificamerican.com/observations/2010/03/03/climate-change-will-impact-infectious-diseases-worldwide-but-questions-remain-as-to-how/>.

NEW YORK—As climatologists weather the IPCC controversy, another storm is brewing, and this one is filled with not with bloggers but with beasts, bugs and bacteria. It is the potential plague of infectious diseases—threatened to be made worse, many scientists propose, by projected changes in the Earth's climate.

At a symposium held yesterday at the New York Academy of Sciences, researchers from public health, climate, medicine and other fields gathered to discuss some of the big questions that remain in uniting these evolving fields. "The relation between climate change and infectious diseases is highly controversial to say the least," Richard Ostfeld, of the Cary Institute of Ecosystem Studies, said here.

Basic assumptions, such as the notion that rising temperatures will increase the number of mosquitoes that can transmit malaria among humans (rather than just shift their range), have been the subject of painstaking parsing over the past decade. But to Otsfeld, who is a disease ecologist, the question of whether climate change will expand the prevalence of infectious diseases "is an unequivocal 'yes,'" he said. "Climate has a strong impact on the incidence of disease." And now it is time to move on, the researchers noted, and start trying to develop real-word strategies to curtail potential pandemics before they can get started.

Stemming the tide, however, depends on a thorough understanding of both the dynamics of climate change and the behaviors of the more than 1,400 species of organisms that are pathogenic to humans—and, crucially, how the former might impact the latter.

Modeling the global climactic shifts itself—past, present or future—has proved to be no walk in the park, but the current science nearly breaks down when scientists try to pinpoint forecasts for specific locations or specific years, noted NASA researcher Gavin Schmidt. "Climate change scientists are not fortune tellers," he said. But for public health officials, government decision makers and even the biologists studying the diseases, the devil (and transmission rates) is in the details. Without a clear picture of how rainfall or daily minimum temperatures are going to change in many areas of the globe, it has been difficult to establish predictions about just how

infectious diseases, such as malaria or Lyme disease, are likely to spread—or plans about how to cope with them.

One thing that Schmidt is certain of is the unexpected: "We have a lot of confidence that there are more surprises in the system," he said. Models can help predict some aspects of climate change—but only to the extent that the researchers understand possible inputs and dynamics. "They can't tell you about the unknown unknowns," Schmidt said.

And the same might be said for the current understanding of many infectious diseases—especially those that might emerge or reemerge in the future. Even for a relatively well-studied vector-borne disease such as malaria, crucial information about historical and current case numbers are often shaky in the areas that need the most intervention. "You need to know what the baseline is—and that in itself has been a huge problem" in the field, noted Madeline Thomson, of Columbia University's International Research Institute for Climate and Society.

As many of the researchers hastened to point out, however, climate is not the only force at work in increasing the spread of infectious diseases into the future. Other factors, such as expanded rapid travel and evolution of resistance, are already changing the ways pathogens infect people, plants and animals. As climate change accelerates, it is likely to work synergistically with many of these factors, especially in populations increasingly subject to massive migration and malnutrition.

But as Thompson noted, despite its challenges, climate change can be a relatively solid rock on which to moor infectious disease planning. Many functions of human populations—from geographical displacement to lifestyle changes—that influence disease transmission can be exceedingly hard to track, she said. "Climate is one thing you can actually measure."

Article 32: New 'ocean acidification' monitoring equipment deployed off LaPush; by: Peninsula Daily News; July 18, 2010

Peninsula Daily News. "New 'ocean Acidification' Monitoring Equipment Deployed off LaPush - - Port Angeles Port Townsend Sequim Forks Jefferson County Clallam County Olympic Peninsula Daily News." *Peninsula Daily News*. Black Press Ltd., 18 July 2010. Web. 30 July 2012. <http://www.peninsuladailynews.com/article/20100718/news/307189981/0/SEARCH>.

This sophisticated buoy, shown during testing before its deployment near LaPush on Friday, is now monitoring the composition of seawater coming into Puget Sound and Hood Canal. -- Photo by Matthew Alford/UW Applied Physics Laboratory

Eight years of research off Cape Flattery

NEAH BAY -- In 2008, measurements of ocean acidification off the North Olympic Peninsula coast at Tatoosh Island -- about a half mile off Cape Flattery, at the tip of the North Olympic Peninsula just west of Neah Bay -- showed acidity is rising more than 10 times faster than climate models had predicted.

The eight years of research also increased worries that growing corrosive effects of acidic ocean waters could trigger a dramatic shift in coastal species and jeopardize some shellfish stocks.

Scientists say increased carbon dioxide emissions from human activities (industrial emissions, car exhaust and the burning of fossil fuels) have led to a 30 percent rise in ocean acidity in the past 200 years.

Oceans absorb about a third of the carbon-dioxide released into the atmosphere, and when the carbon-dioxide dissolves in water, it forms carbonic acid, which alters the ocean's chemical balance.

The resulting acidification prevents marine life such as coral in coral reefs, as well as crabs,

lobsters and oysters, from building calcium carbonate skeletons and shells, impairing their ability to survive and reproduce.

LAPUSH -- Scientists are optimistic that sophisticated monitors now operating off the North Olympic Peninsula coast will help them understand acidity levels that are skyrocketing both in the ocean and in Puget Sound and Hood Canal.

To check the composition of seawater coming into the Sound and Hood Canal, a high-tech buoy was deployed Friday about 15 miles off LaPush.

It will keep track of the weather, the atmosphere, water chemistry and plankton growth.

Nearby, a seaglider -- a remote-controlled underwater vehicle that looks like a torpedo with wings -- will continuously dive and surface to relay data from the depths.

The new monitoring equipment comes as a new scientific study released last week (http://www.noaanews.noaa.gov/stories2010/20100712_pugetsound.html) said that a combination of carbon dioxide, emitted by industries, power plants and vehicles, and nutrient runoff is acidifying Puget Sound's main basin and Hood Canal as fast as the ocean along the Olympic Peninsula coast.

These water-chemistry changes could have considerable negative impacts on the region's shellfish industry over the next several decades, according to lead author Richard Feely, a senior scientist at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle.

In sampling Puget Sound and Hood Canal, Feely and his team discovered that those waters were surprisingly acidic -- and in some areas, probably corrosive to shelled creatures like oysters and deadly to oyster larvae.

On the pH scale, strongly alkaline materials such as oven cleaner measure about 13. Hydrochloric acid has a pH of 1. Seawater usually measures around 8.1. In some places, the waters of Puget Sound measured 7.7, similar to some of the lowest measurements taken along the Olympic Peninsula coast. Parts of Hood Canal were as low as 7.4

Feely and other scientists blamed a combination of natural processes. One is the increasing acidification caused by oceans' absorption of carbon dioxide from the atmosphere.

Scientists say oceans are now absorbing more than 1 million tons of carbon dioxide an hour. And deep, cold waters typically hold more carbon dioxide than warm, surface waters.

In Hood Canal, poor water circulation and nutrient-rich runoff from pollution and leaky septic tanks stimulates the growth of phytoplankton and other organic matter.

As the phytoplankton dies and sinks, it produces carbon dioxide, which starves the stagnant water of oxygen and lowers its pH.

"These processes combined together to decrease pH further than what we would expect from one or another by themselves," Feely said.

Feely noted that a previous study showed that corrosive water is already upwelling each summer off the Pacific coast with levels of acidity that scientists had predicted wouldn't occur until 2050.

Some of that water is making its way into Puget Sound through the Strait of Juan de Fuca, Feely said -- and that's where the high-tech buoy and the seaglider come into play.

Jan Newton, a physical oceanographer at the University of Washington who was a co-author on the pH study for Puget Sound and Hood Canal, said the buoy and seaglider comprise the most sophisticated array of monitoring instruments ever put into Washington waters. (For more information, click on http://uwnews.org/article.asp?articleID=59194)

Quileute named it

The equipment -- operated by NOAA and the University of Washington's Applied Physics Laboratory -- is funded with about $500,000 from the M.J. Murdock Charitable Trust and $200,000 from various UW programs.

LaPush is the home of the Quileute tribe. The tribe had a contest to name the buoy and chose "Cha ba" (pronounced chay buh), meaning "whale tail." Quileute Tribal Council Chairwoman Anna Rose Counsell-Geyer said tribal members chose the name because much of the yellow buoy's instrument array is below the surface. The tribe is watching the project carefully.

The ocean is important to tribal members, Counsell-Geyer said, many of whom rely on salmon fishing and shellfish farming.

With so much at stake, other research efforts are also on the rise -- including new equipment to continually measure acidity in Dabob Bay on Hood Canal and Totten Inlet near Shelton.

Increasing ocean acidity has been linked to the deaths of free-swimming oyster larvae at oyster hatcheries on the Oregon Coast, Newton said, and something similar may be happening at hatcheries on Hood Canal.

Bill Dewey of Taylor Shellfish Farms, which operates an oyster hatchery on Dabob Bay, said oyster larvae production dropped by 60 percent in 2008 and 80 percent last year.

It is too early to know how things will turn out this year, he said.

Oyster larvae

Tiny free-swimming oyster larvae are most vulnerable when they are first developing a shell, Dewey said. The composition of the shell is amorphous calcium carbonate, which simply dissolves at a low pH level, killing the organism.

"The science is pretty irrefutable about that," he said.

"When the pH drops, the shells start to erode faster than the larvae can produce them."

Some early evidence suggests that more acidic water in Hood Canal is brought to the surface during storms, Dewey said. Unlike the ocean hatcheries, where acidity is linked directly to oyster mortality, there may be other factors at play in Hood Canal. Taylor Shellfish increasingly relies on a hatchery in Kona, Hawaii, where the pH of the water is higher.

Article 33: Ocean off North Olympic Peninsula 10 times more acidic than thought; by: Peninsula Daily News; November 30, 2008

Peninsula Daily News. "Ocean off North Olympic Peninsula 10 times More Acidic than Thought -- Port Angeles Port Townsend Sequim Forks Jefferson County Clallam County Olympic Peninsula Daily News." *Peninsula Daily News*. Black Press Ltd., 30 Nov. 2008. Web. 30 July 2012. <http://www.peninsuladailynews.com/article/20081130/news/311309992/0/SEARCH>.

Interesting levels of acidity in North Olympic Peninsula waters off Tatoosh Island, shown here, "raises a warning flag that the oceans may be changing faster than people think," according to a University of Chicago marine biologist. -- Peninsula Daily News photo

NEAH BAY -- Measurements of ocean acidification off the North Olympic Peninsula coast at Tatoosh Island show acidity is rising more than 10 times faster than climate models have predicted.

The researchers cannot say whether the trend is widespread.

The eight years of research also revealed that the corrosive effect of acidic ocean waters could trigger a dramatic shift in coastal species and jeopardize some shellfish stocks.

"The increase in acidity we saw during our study was about the same magnitude as we expect over the course of the next century," said study co-author Timothy Wootton, a marine biologist from the University of Chicago.

While the waters off the Peninsula may be a unique environment, "this raises a warning flag that the oceans may be changing faster than people think," he said.

Wootton warned that an acidity-driven shift in coastal ecosystems could spell disaster for shellfish industries that rely on mussels and other similar species.

His team's findings were published last week in the Proceedings of the National Academy of Sciences.

Increased carbon dioxide emissions from human activities and the burning of fossil fuels have led to a 30 percent rise in ocean acidity in the past 200 years.

Oceans absorb about a third of the CO_2 released into the atmosphere, and when the CO_2 dissolves in water, it forms carbonic acid, which alters the ocean's chemical balance.

The resulting acidification prevents marine life such as coral in coral reefs, as well as crabs, lobsters and oysters, from building calcium carbonate skeletons and shells, impairing their ability to survive and reproduce.

Wootton did not intend to measure the effects of ocean acidification when he installed his ocean monitors in the waters near Tatoosh Island in 2000.

Tatoosh Island lies about a half mile off Cape Flattery, on the Makah tribal reservation, just west of Neah Bay.

But as global concern over ocean acidification grew, "I realized we'd been sitting on all this data that we could use to determine whether it was happening," Wootton said.

His instruments recorded changes in pH -- a measure of acidity that lowers as acidity rises.

"The expectation was that the pH would change so slowly that it would be hard to see a change.

"We were sort of surprised to find in general just how much it was changing over time."

From there, Wootton looked at his biological observations to try to assess how much these pH changes matter to the ecosystem of the area.

Tatoosh's shifting balance

Wootton and colleagues built models of an ecosystem based on field data of how species interact along Tatoosh Island's rocky shores.

Surprisingly, in a scenario of increasing acidity, not all species with calcium carbonate shells faired badly.

Instead, a shift took place.

Larger mussels and barnacles suffered, leaving smaller barnacles and some calcium-based seaweeds better off.

In nature, "species are competing for space, they are eating each other, it's an incredibly dynamic system," said James Forester, a Harvard University ecologist and a co-author of the study.

"When you change the playing field -- in this case by altering acidity -- you can get unexpected responses," he said.

Said Wootton: "Mussels usually dominate the ecosystem because they are good at overgrowing and crushing out other species that grow on the rocks.

"But when the mussels decline, it means other species -- no matter whether or not they have a shell -- can do better."

And, Wootton added, "the changes we see in the dynamics of the ecosystem may magnify over time."

The study contained the first data on ocean acidity from temperate -- rather than tropical -- waters. No one knows whether similar rapid changes are taking place elsewhere.

"The rules might be quite different on Tatoosh Island," Wootton suggested.

"There could be mechanisms going on in the waters around our island that are unique.

"We really need to get more data from other sites away from the equator to see what patterns are there."

Agreeing with him was Richard Zeebe of the University of Hawaii at Manoa.

He pointed out that Wootton's study was on a coastal site, not in the open ocean, so "one needs to be cautious about extrapolating the pH findings to other locations."

The part of the ocean that Wootton studied also experiences a great deal of upwelling, so it's not completely surprising to find changes in acidity, said Zeebe.

Alaska's reefs damaged?

Earlier this month, Oceana, a Washington-based conservation group, said coral reefs in the cold deep seas off Alaska may now be among the first victims of global warming in a marine environment that is home to half of the U.S.'s commercial fishing.

The loss of Alaska's cold-water reefs may be a precursor to the extinction of reefs worldwide because of acidification, according to an analysis by Ocean. Cold water absorbs more carbon dioxide than tropical waters.

Article 34: Ocean 'Time Machine' Illustrates Global Warming's Impact on Marine Life; by: Tom Banse; October 11, 2010

Banse, Tom. "Ocean 'Time Machine' Illustrates Global Warming's Impact on Marine Life." *VOA*. Voice of America, 11 Oct. 2011. Web. 30 July 2012. <http://www.voanews.com/english/news/special-reports/american-life/Ocean-Time-Machine-Shows-How-Global-Warming-Impacts-Marine-Life-104770004.html>.

Image: *NOAA researchers Mike Maher and Shallin Busch check the pH of a seawater tank.*

Baby oysters could be the "canaries in the mine shaft" for another dimension of global warming.

Pacific Northwest scientists are studying how the oceans suck in excess carbon dioxide from the atmosphere. The process changes seawater chemistry - locally and globally. An experiment now under way in Seattle, Washington to find out how sea critters are coping with the changes.

Time machine

Paul McElhany's lab is like an ocean time machine.

"In one of the tanks we're simulating pre-industrial conditions, before people started burning fossil fuels," says McElhany, a federal biologist working at the Northwest Fisheries Science Center in Seattle.

Multicolored tubes and pipes run every which way in the cramped aquatic lab. The researcher controls his time machine by bubbling carbon dioxide into the seawater at different concentrations.

"The next tank over, we're setting conditions of doubling of the current CO_2 levels, which the models that have been done project we'll reach by 2100, by the end of the century or before," says McElhany.

Image: *NOAA Fisheries biologist Paul McElhany in his Seattle lab.*

Ocean acidification

There's one additional setup with an even worse scenario. McElhany explains the oceans absorb a big chunk of the CO_2 we pump into the atmosphere. This is the lesser known twin of atmospheric warming. Scientists call it "ocean acidification."

"As the CO_2 that's put out by burning fossil fuels goes into the ocean, it changes the chemistry of the ocean itself and makes it more acidic," he says. "It's sort of the same way as when you have carbon dioxide in a soda pop that makes the soda pop more acidic."

Ocean acidification is not going to affect all species equally. McElhany's team is trying to determine just who wins and who loses. On the one hand, algae and seaweed could prosper under elevated carbon dioxide levels. On the other, shellfish in the larval stage seem quite vulnerable.

"If the acidity gets low enough," says McElhany, "they can actually start to dissolve."

First into the bath are baby oysters. The little creatures are taking an extended dip now with the ghosts of oceans past, present and future. Next up are abalone, geoducks, clams, mussels and krill. Grad students check the tanks and jars every day to monitor how many larvae survive and in what condition.

Oyster test

At Oregon State University, researchers are waiting to hear if the National Science Foundation will provide money for a similar experiment. Fisheries professor Chris Langdon says oysters are likely to show the effects of a more acidic ocean first. "From what we can tell, the larvae of the Pacific oyster seem to be much more sensitive to what's going on than larvae of mussels or clams. So they are kind of the canary in the mine shaft."

Pacific Northwest oyster growers already report having serious problems with oyster seed survival. They blame it on acidified water. Langdon says a frustrating discovery is that it's hard to get high levels of dissolved carbon dioxide out of seawater once it's in there.

So where does that leave people like western Washington oysterman and clam grower Bill Dewey?

"The likelihood of turning it around anytime soon is not good," says Dewey. "So we're definitely, in our industry, we're in the adaptation mode, trying to find things we can do to the seawater chemistry in our hatcheries to allow us to produce the seed." Researchers hope to explore possible water treatments for aquaculture farms and Dewey says he's heartened by the scientific attention directed at his industry's problem.

Future of the world's oceans

Separately, Norwegian, German and British scientists are looking at how marine species from their waters respond to rising acidity. American researchers met recently with counterparts from the United Kingdom to coordinate experiments and discuss how best to model the future of the world's oceans.

Another area with high vulnerability are coral reefs. They are already showing the effects of a warmer and more acidic ocean. For purposes of science, the rub is that corals are harder to keep alive in a lab. But there's an important reason to keep trying. Coral reefs are hugely important breeding grounds for many fish. And although reefs cover less than one percent of the sea floor, they support about 25 percent of all life in the ocean.

Article 35: Changing the Chemistry of Earth's Oceans; by: New York Times; March 09, 2012

The New York TImes. "EDITORIAL; Changing the Chemistry of Earth's Oceans." *The New York Times*. The New York Times, 10 Mar. 2012. Web. 30 July 2012. <http://www.nytimes.com/2012/03/10/opinion/changing-the-chemistry-of-earths-oceans.html>.

The oceans have always served as a sink for carbon dioxide, but the burning of fossil fuels since the beginning of the industrial revolution, especially over the last 40 years, has given them more than they can safely absorb. The result is acidification — a change in the chemical balance that threatens the oceans' web of life.

In earth's history, there have been many episodes of acidification, mainly from prolonged volcanic eruptions. According to a new research review by paleoceanographers at Columbia University, published in Science, the oceans may be turning acid far faster than at any time in the past 300 million years.

Changing something as fundamental as the pH of seawater — a measurement of how acid or alkaline it is — has profound effects. Increased acidity attacks the shells of shellfish and the skeletal foundation of corals, dissolving the calcium carbonate they're made of. Coral reefs are among the most diverse ecosystems on the planet. Ocean acidification threatens the corals and every other species that makes its living on the reefs.

The authors tried to determine which past acidification events offer the best comparison to what is happening now. The closest analogies are catastrophic events, often associated with intense volcanic activity resulting in major extinctions. The difference is that those events covered thousands of years. We have acidified the oceans in a matter of decades, with no signs that we have the political will to slow, much less halt, the process.

Article 36: Willapa Bay oyster grower sounds alarm, starts hatchery in Hawaii; by: Craig Welch; The Seattle Times, June 22, 2012

Welch, Craig. "Willapa Bay Oyster Grower Sounds Alarm, Starts Hatchery in Hawaii." *The Seattle Times*. The Seattle Times Company, 21 June 2012. Web. 30 July 2012. <http://seattletimes.nwsource.com/html/localnews/2018496037_oysters22m.html>.

A Willapa Bay shellfish company is shifting some of its business to Hawaii because of ocean acidification that scientists believe is killing tiny oyster larvae in shellfish farms along Washington's coast.

The owners of Goose Point Oysters have been raising oysters in Willapa Bay since the mid-1970s but recently opened a hatchery in Hawaii because ocean acidification made it harder to raise oysters in the Northwest.

After 34 years rearing shellfish in Willapa Bay, Dave Nisbet was in a bind: nature had stopped providing.

Oysters were no longer reproducing naturally on the Washington Coast. Oyster larvae were even dying in nearby hatcheries, which use seawater to raise baby shellfish that get sold as starter seed to companies like Nisbet's Goose Point Oysters.

But when, in 2009, Nisbet heard oceanographers identify the likely culprit — increasingly corrosive ocean water, a byproduct of the same greenhouse gases that contribute to global warming — the oysterman did the unthinkable.

Nisbet took out a loan and spent three years testing and building a new hatchery that opened recently. In Hawaii.

Most of Washington's $100 million-a-year oyster industry has been whipsawed in recent years by ecological problems. But Nisbet's oyster company appears to be one of the first businesses in the Northwest — perhaps anywhere — to shift part of its business to a new region in response to ocean acidification.

"I just got nervous," Nisbet said. "I was afraid if I didn't do something, then our business would just slowly die."

Now, rather than relying on oysters that have spawned in Willapa Bay or on juvenile oysters purchased from a nearby hatchery — as he has for years — Nisbet raises larvae in tanks in a million-dollar, 20,000-square-foot plant in Hilo, Hawaii. The tiny larvae are then sent by mail to Washington, where Nisbet and his team oversee the rest of the multiyear growing cycle in Willapa Bay.

"It would have been much easier and cheaper to start a hatchery here," Nisbet said. "But we just saw the hatcheries having failures, the larvae dying in the tanks and just decided to sidestep the issue completely."

Nisbet's move is just the latest sign of how the threat of ocean acidification is altering the way Washington's shellfish growers do business.

Changes come fast

Scientists for years have warned that excess carbon dioxide from the burning of fossil fuels eventually would be taken up by marine waters and begin lowering the pH of the world's oceans.

In the last five years, oceanographers at the National Oceanic and Atmospheric Administration (NOAA) working along the U.S. West Coast repeatedly have documented that ocean chemistry is already changing, decades earlier than anyone predicted.

Scientists are still learning just how those changes ultimately may upend marine food webs. Researchers have shown that less-alkaline seawater causes sea urchin larvae to change shape, makes squid more lethargic and prompts clown fish to race toward rather than away from predators.

But the type of calcium carbonate used by juvenile oysters during the initial stage of forming their shells is particularly vulnerable to even slight increases in acidity. And the dark, frigid water that wells up from the deep along the Northwest coast during north winds already is naturally richer in carbon dioxide than most ocean surface water.

Those natural conditions combined with greenhouse-gas emissions, scientists reported earlier this year, have turned the tidal currents on Washington's once oyster-rich coast into a death trap for juvenile oysters.

"We're the tip of the spear for the worst of the worst because of the way the ocean circulates," said Bill Dewey, with Taylor Shellfish.

Oysters now haven't reproduced on their own in Willapa Bay since 2005, so every grower now relies on hatchery-produced larvae. Once the oysters make it to that stage they can survive acidic conditions just fine.

But even producing larval oysters has become a complex game.

Already, the Taylor Shellfish hatchery on Hood Canal and the owners of the Whiskey Creek Hatchery on Oregon's Netarts Bay have started tracking breezes because heavy north winds draw water from the deep that tends to be more damaging. Both now use expensive carbon-dioxide monitors to time the uptake of water into their growing tanks.

Taylor has even begun a series of experiments to add sodium carbonate — similar to baking soda — to its hatchery waters to counteract Hood Canal's increasingly acidity.

"We have a huge investment in that hatchery and we can't just turn off the lights and walk away," Dewey said. "We're investing instead in the science to try and find a way to make it work."

But the Nisbets took another approach.

"We're on an escalator"

Goose Point Oysters employs 70 people and processes several million pounds of shellfish a year, which are sold all over the world. Since water quality is as important to an oyster grower as air to a human, the company had been following the changes closely.

"We didn't know what was going on but we knew by 2009 that we could no longer depend on our current seed supply," said Kathleen Nisbet, Dave's daughter.

When her father attended a meeting with NOAA oceanographers the depth of the problem became clear.

"They said, 'We're on an escalator with this thing,' " she said. "The problem is going to get worse and we're going to have to adapt."

Kathleen Nisbet had attended the University of Hawaii-Hilo and had contacts there, including Maria Haws, an associate professor of aquaculture. Hawaii also doesn't experience the same upwelling events and acidification doesn't appear to be a problem — at least not yet.

"The Northwest is really the canary in the coal mine, though sooner or later we won't have any place to run if we don't somehow reverse the trend," Haws said.

She and the Nisbet family spent several years working out kinks and started operating the hatchery earlier this year.

"Luckily we've come out of this not too scarred," Kathleen Nisbet said. "We think we've come up with a way to work around things."

But she said the experience has opened her eyes to how quickly acidification is taking hold.

"What I think is scary is that not everybody knows this is real, that it's actually started to impact people," she said.

"For now, here, it's oysters. But it's going to start affecting a lot of other fish and a lot of other food that we get from the sea."

Article 37: Report: Coastal waters to rise 6 inches by 2030; by: KTVU; June 22, 2012

KTVU and Wires. "Report: Coastal Waters to Rise 6 Inches by 2030." *San Francisco, Oakland & San Jose: Bay Area News, Weather &...* Cox Media Group, 22 June 2012. Web. 30 July 2012. <http://www.ktvu.com/news/news/local/report-coastal-waters-rise-6-inches-2030/nPck7/>.

SAN FRANCISCO —

The West Coast will see an ocean several inches higher in coming decades, with most of California expected to get sea levels a half foot higher by 2030, according a report released Friday.

The study by the National Research Council gives planners their best look yet at how melting ice sheets and warming oceans associated with climate change will raise sea levels along the country's Pacific coast. It is generally consistent with earlier global projections, but takes a closer look at California, Oregon and Washington.

Although the six inches expected for California by 2030 seem minor, the report estimated that sea levels there will be an average of three feet higher by 2100. About 72 percent of the state's coast is covered by sandy cliffs, and the rest include beaches, sand dunes, bays and estuaries.

Seaside cliffs will be cut back about 30 yards over the next 100 years, and sand dunes will be driven back even more, said Robert A. Dalrymple, a professor of civil engineering at Johns Hopkins University and chairman of the group that wrote the report. Coastal wetlands will be able to keep pace for about 50 years, but will eventually be overwhelmed without new sources of sand, and room to move inland.

The report noted that dams hold back about a third of that sand, which once washed into the sea from the Klamath River in Northern California.

Northern California, Oregon and Washington can expect a less dramatic increase -- about four inches by 2030 and two feet by 2100 -- because seismic activity is causing land to rise north of the San Andreas Fault, offsetting increasing sea levels, and drop south of it. The fault runs out to sea at Cape Mendocino.

Oregon has the advantage of tough basalt formations on much of the coast, but long stretches of Washington are low-lying sandy beaches.

"Anything close to the seas is vulnerable," Dalrymple said.

The most immediate threat over the next few decades will come from periodic ocean-warming El Nino events, said Gary Griggs, director of the Institute for Marine Sciences at the University of California at Santa Cruz, who was one of the scientists assembled by the council to produce the report.

"During those events, sea level is elevated as much as a foot above normal and then we've got typically larger waves coming in with the high tides," particularly in the Northwest, he said.

The report noted that some computer models suggest storms will be stronger as global warming progresses. But Dalrymple said there was no clear consensus in scientific literature, and data from ocean buoys showing waves getting bigger in the Northwest don't go back far enough to conclude that trend will continue.

If a major earthquake occurs beneath the Pacific Ocean off Oregon and Washington, in what is known as the Cascadia subduction zone, that would cause the land to drop, allowing sea level to rise another three to six feet immediately, the report said. Such a major temblor occurred 300 years ago, but becomes more likely as time passes.

The report was commissioned by states and federal agencies looking for detailed information so they can plan for an accelerated rate of erosion along beaches, bluffs and sand dunes that are already crumbling into the sea. It projected that sea level will rise a little lower in 2100 than the projections currently used by California officials.

"A lot of the data we had before was worldwide data or has the caveat, `Can't be used for planning purposes,'" said Susan Hansch, chief deputy director of the California Coastal Commission. "It all comes down to the better data you have, the better decisions you can make." Sea levels rise for two reasons due to global warming.

Warmer water expands, which can cause as many as 23 inches of sea level to rise by 2100, according to the Nobel Prize winning Intergovernmental Panel on Climate Change. Warmer temperatures also cause ice sheets in Greenland and west Antarctica to melt slowly, adding another foot or more to sea levels by 2100, scientists said.

Those estimates, however, were for the planet as a whole. Some places will see higher seas, while others will get less dramatic increases.

Globally, sea levels have risen about eight inches over the last century, but the rate has been increasing significantly, said Griggs.

The report summarized published projections and updated it with an analysis of tidal gauge readings and satellite measurements along specific sites on the West Coast.

Article 38: Sea rise faster on East Coast than rest of globe; by: Seth Borenstein; June 24, 2012

Borenstein, Seth. "Sea Level Rising Faster on East Coast than Rest of Globe." *Salt Lake City and Utah Breaking News, Sports, Entertainment and News Headlines*. Deseret News, 25 June 2012. Web. 30 July 2012. <http://www.deseretnews.com/article/765585691/Sea-level-rising-faster-on-East-Coast-than-rest-of-globe.html?pg=all>.

From Cape Hatteras, N.C., to just north of Boston, sea levels are rising much faster than they are around the globe, putting one of the world's most costly coasts in danger of flooding, government researchers report.

U.S. Geological Survey scientists call the 600-mile swath a "hot spot" for climbing sea levels caused by global warming. Along the region, the Atlantic Ocean is rising at an annual rate three times to four times faster than the global average since 1990, according to the study published Sunday in the journal Nature Climate Change.

It's not just a faster rate, but at a faster pace, like a car on a highway "jamming on the accelerator," said the study's lead author, Asbury Sallenger Jr., an oceanographer at the agency. He looked at sea levels starting in 1950, and noticed a change beginning in 1990.

Since then, sea levels have gone up globally about 2 inches. But in Norfolk, Va., where officials are scrambling to fight more frequent flooding, sea level has jumped a total of 4.8 inches, the research showed. For Philadelphia, levels went up 3.7 inches, and in New York City, it was 2.8 inches.

Climate change pushes up sea levels by melting ice sheets in Greenland and west Antarctica, and because warmer water expands.

Computer models long have projected higher levels along parts of the East Coast because of changes in ocean currents from global warming, but this is the first study to show that's already happened.

By 2100, scientists and computer models estimate that sea levels globally could rise as much as 3.3 feet. The accelerated rate along the East Coast could add about 8 inches to 11 inches more, Sallenger said.

"Where that kind of thing becomes important is during a storm," Sallenger said. That's when it can damage buildings and erode coastlines.

On the West Coast, a National Research Council report released Friday projects an average 3-foot rise in sea level in California by the year 2100, and 2 feet in Oregon and Washington. The land mass north of the San Andreas Fault is expected to rise, offsetting the rising sea level in those two states.

The USGS study suggests the Northeast would get hit harder because of ocean currents. When the Gulf Stream and its northern extension slow down, the slope of the seas changes to balance against the slowing current. That slope then pushes up sea levels in the Northeast. It is like a see-saw effect, Sallenger theorizes.

Scientists believe that with global warming, the Gulf Stream and other ocean currents are slowing and will slow further, Sallenger said.

Jeff Williams, a retired USGS expert who wasn't part of the study, and Stefan Rahmstorf, a professor of ocean physics at the Potsdam Institute in Germany, said the study does a good job of making the case for sea level rise acceleration.

Margaret Davidson, director of the Coastal Services Center for the National Oceanic and Atmospheric Administration in Charleston, S.C., said the implications of the new research are "huge when you think about it. Somewhere between Maryland and Massachusetts, you've got some bodaciously expensive property at risk."

Sea level projections matter in coastal states because flood maps based on those predictions can result in restrictions on property development and affect flood insurance rates.

Those estimates became an issue in North Carolina recently when the Legislature proposed using historic figures to calculate future sea levels, rejecting higher rates from a state panel of experts. The USGS study suggests an even higher level than the panel's estimate for 2100.

The North Carolina proposal used data from University of Florida professor Robert Dean, who had found no regional differences in sea level rise. Dean said he can't argue with the results from Sallenger's study showing accelerating sea level rise in the region, but he said it's more likely to be from natural cycles. Sallenger said there is no evidence to support that claim.

Article 39: Puget Sound's whales face intertwined obstacles, by The Seattle Times (adapted by Newsela staff), July 15, 2014

A sheet of water cascades off the back of an Orca that surfaced in Haro Strait near a whale watching charter boat. Photo: Dean J. Koepfler/Tacoma News Tribune/MCT

The killer whales in Puget Sound face a lot of dangers. The whales became protected a decade ago. Since then, scientists have figured out where they go in winter and they've documented how these majestic mammals change their behavior in response to noise from passing boats.

They've learned that these whales can tell a Chinook salmon from a Sockeye salmon by using sonar to detect small differences in the swim bladders.

Yet despite the vast rise in knowledge since killer whales were listed under the Endangered Species Act, the killer whale population still is not growing, according to a new research on the whales. The research was carried out by the National Oceanic and Atmospheric Administration (NOAA).

Scientists are "trying to understand ... why the whales haven't increased more than they have," said Mike Ford, with the conservation biology program at NOAA's Northwest Fisheries Science Center.

Orcas Deal With Many Issues

In one sense, they already know: An explosion in whale science reveals that orcas face complex and overlapping threats that tend to make each other worse.

"Part of what I hoped at the beginning was that it would be mostly one thing that was wrong," said Brad Hanson, a whale expert with the fisheries center. "But they all appear to be intertwined."

In the early 1960s, Puget Sound's killer whales numbered 140 — and some scientists suspect that a century before there might have been 200 or more. By the early 1970s, after companies began capturing orcas for sale to marine parks, the population had dropped to just 71.

Capture was outlawed a few years later, and the orca population climbed to 99 in the mid-1990s, but as of last year, only 82 remain.

Three main factors appear to contribute to the declining numbers. These include a lack of food, the buildup of pollutants in their bodies and disturbance by boats. Still, understanding the subtle ways these and other marine-world changes interact only makes the issue more complicated.

Look Out For Boats!

These whales, it turns out, mostly prefer Chinook salmon, which face severe shortages of their own. The region has spent tens of millions of dollars to try and increase the numbers of this other protected species, but an extremely critical 2011 report suggested too little progress was being made.

In addition, noise from boats causes orcas to speed up, work harder, slap their tails more and hunt less. This may mean they burn more calories just as they're getting less food.

New rules require boaters and whale-watching ships to stay 200 yards from whales. But the captains haven't always followed the new rules, said Lynne Barre, head of protected resources for NOAA's Seattle office.

Pollution Is A Big Factor

Meanwhile, these long-lived mammals already are among the most polluted animals on Earth. Chemicals from pollution accumulate in their fat over decades, which potentially affects their health and reproduction.

Efforts to clean up Puget Sound are underway. But the whales' position at the top of the food chain means they still ingest old pesticides like DDT and banned chemicals like PCBs from the fish and mammals they eat.

All these issues are more complex than they first appear.
For example, some orca pods are more heavily affected by DDT than others, most likely because they rely on fish from rivers in California. The rivers get runoff water from farms where DDT once was used to kill insects.

Whales feeding on fish from the north, in cities like Seattle and Vancouver, carry a bigger load of PCBs.

"They pick up contaminants from where they're going," Ford said.

The numbers of orcas are decreasing just as other Northwest marine mammals that eat fish actually are on the rise. These sea mammals include seals, sea lions, even other killer whales.

Diet Plays A Role As Well

The northern killer whale population has tripled to nearly 300 since the 1960s. Northern and southern whales share similar diets. But Puget Sound's southern whales range from California to Alaska, while the northern whales travel mostly between northern Washington and Alaska.

The growth of the northern population may even be helping keep the southern resident populations down.

"It's possible that some of those increases influence the rate at which southern resident populations grow," Ford said.

For starters, northern whales may have a food advantage.

"One thing we're considering is that the northern-resident population may have first crack at the best salmon stocks," Hanson said. "A lot of the West Coast fish, they come out of the rivers, they turn right and head north."

Other problems make life hard for southern residents.

Two of the three southern pods have a shortage of young females. This population already gives birth to fewer young less often than northern residents. "It doesn't take much to tip the balance the wrong way," Hanson said.

Whales also tend to be born to parents within their pod. This could reduce genetic diversity and make whales more vulnerable to disease or genetic problems.

And there's no shortage of other mysteries.

When killer whales die, they rarely wash up on the beach for researchers to find and study, Barre said. Instead, they just disappear and scientists never know why they died.

Much of their behavior remains unpredictable. "Why do they sometimes decide to turn out toward the ocean and stay there for two weeks?" he asked.

Article 40: Pain remains from the Exxon Valdez oil spill 25 years later, by McClatchy, Washington Bureau, (adapted by Newsela staff), March 28, 2014

Exxon Valdez oil spill workers recover and clean birds soiled by crude oil spilled when the tanker ran aground in Prince William Sound, Alaska, on April 6, 1989. Photo: Bob Hallinen/Anchorage Daily News/MCT

WASHINGTON — Andy Wills was laying on a friend's couch in Cordova, Alaska, on March 24, 1989. He was up early, ready to head out and harvest spring herring in Prince William Sound.

"My buddy had just handed me a cup of coffee in the morning and we're watching 'Good Morning America,'" Wills said. "And there's the Exxon Valdez on TV, spilling oil."

He added, "We were like, 'No!' It was just the start of a nightmare."

The herring of Prince William Sound still have not recovered. Neither have killer whales, and legal issues remain unresolved a quarter of a century later. Monday was the 25th anniversary of the disaster, in which the tanker Exxon Valdez ran aground on Bligh Reef and spilled at least 11 million gallons of oil into the clean, unspoiled waters of the sound.

Persistent Pockets Of Oil

Prince William Sound today looks spectacular, a stunning landscape of mountainous fjords — cliffs framed by blue-green waters, and thickly forested islands. Pick up a stone on a rocky beach, maybe dig a little, though, and it is possible to still find pockets of oil.

"I think the big surprise for all of us who have worked on this thing for the last 25 years has been the continued presence of relatively fresh oil," said Gary Shigenaka. He's a marine scientist for the National Oceanic and Atmospheric Administration.

The question of how well Prince William Sound has recovered from what at the time was the nation's largest oil spill is open to debate. Exxon Mobil Corp., which owned the Valdez, says studies show the area is bouncing back.

"The sound is thriving environmentally and we've had a very solid, complete recovery," said Richard Keil, a spokesman for Exxon Mobil.

Government scientists have a different view.

The Exxon Valdez Oil Spill Trustee Council, a state-federal group, was set up to oversee the revival of Prince William Sound. It considers the pink and sockeye salmon to be recovered, as well as the bald eagles and harbor seals. Several other species are listed as still recovering.

Sea otters have had a rough time. Thousands died in the months following the spill, and the population has struggled to recover in the 25 years since. The U.S. Geological Survey reported earlier this month that the sea otters of the area had finally returned to their pre-spill numbers.

Listed as still not recovering are the herring, a group of killer whales and a type of North Pacific seabird.

The Fate Of The Herring

Wills, who fished salmon as well as herring, said the spill left a huge mark on those who made a living from Prince William Sound.

Exxon sent money to people to make up for what they lost. But, the checks were too late and too little, he said.

"A lot of people got real hurt. I know a lot of guys committed suicide and all that stuff. I got divorced," said Wills, who now runs a bookshop and cafe in Homer, Alaska. "It was rough."

Among the scientific puzzles of the spill, the fate of the herring is a particular mystery. It's an extremely important species for the ecosystem, giving food and protein to whales, salmon, birds and others.

Prince William Sound was home to a booming spring herring fishery. It supported fishermen badly in need of cash coming off the long winter in between fishing seasons.

Researchers found physical changes in herring exposed to the oil. Then, four years after the spill, the herring population crashed dramatically. The reasons are a subject of intense debate, with suggestions that the effects of the spill could have made the herring weak against disease.

Drop In Killer Whales

"No other (fish) stock in Alaska crashed in 1993, so that's indirect evidence it is spill-related," said Jeep Rice. He studied the spill for more than 20 years as a federal scientist. "That's kind of weak, and yet it is about as good as we can get in terms of explaining why it happened in that year."

The herring never really recovered, and the current population is too low to fight off predators. Herring fishing, with a brief exception, has been closed for more than 20 years.

The killer whales of Prince William Sound also have suffered. Two groups were hit especially hard. Scientists saw killer whales from one of the groups swimming through oil floating on the ocean surface. A Los Angeles Times photo showed whales from the other group swimming near the tanker as it gushed oil. Populations dropped dramatically in the year after the spill.

"The evidence is pretty compelling that it was a spill-related effect on those two groups of killer whales," said federal marine scientist Shigenaka.

One of the groups continues its slow recovery. The other numbered 22 killer whales at the time of the spill and is down to just seven. Scientists now expect it to go extinct. If it does, it would be the end of a genetic line that researchers say has hunted in the area for thousands of years, maybe since the last ice age.

The federal and state governments are still weighing the science of the spill's effects. Court cases will decide whether to seek more money from Exxon Mobil for cleaning up the remaining oil.

Article 41: Scientists fear ocean acidification will drive the collapse of Alaska's iconic crab fishery, Craig Welch, The Seattle Times, September 12, 2013,

http://apps.seattletimes.com/reports/sea-change/2013/sep/11/alaska-crab-industry/
Photographs by Steve Ringman

DUTCH HARBOR, Alaska — For decades, the crab piled up in fishing boats like gold coins hauled from a rich and fertile sea.

But the very ocean that nursed these creatures may prove to be this industry's undoing.

New research earlier this year shows that Bristol Bay red king crab — the supersized monster that has come to symbolize the fortunes of Alaska's crab fleet — could fall victim to the changing chemistry of the oceans.

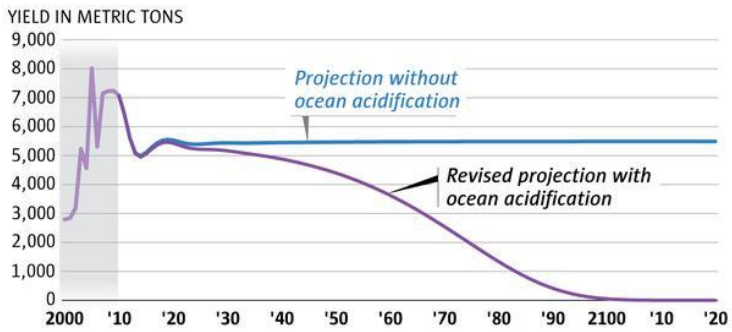
Barring a hasty reduction in carbon-dioxide emissions — or evidence that the creatures could acclimate to changing sea conditions — a team of scientists fears Alaska's $100 million red king crab fishery could crash in decades to come.

That grim possibility also raises alarm about the crab fleet's other major moneymaker, snow crab.

"With red king crab, it's all doom and gloom," said Robert Foy, who oversaw the crab research for the National Oceanic and Atmospheric Administration (NOAA) in Kodiak, Alaska. "With snow crab, there's so little known we just can't say. But we don't see anything from our experience that's good for any of these crab. Some is just not as bad as others."

Potential impact on Alaska's red king crab industry

Early projections suggest trouble ahead for red king crab fishing.



NOTE: Fisheries managers used survival rates from CO_2 research on red king crab, fishing data, population dynamics and economic models to make this projection, but they maintain their data is rough and incomplete.

Source: NOAA, Alaska Fisheries Science Center

SaidMark Gleason, director of the Seattle-based industry trade group Alaska Bering Sea Crabbers, "From my perspective, the chemistryis pretty clear-cut."

For decades, these storied crustaceans have drawn men and women from Seattle to the far reaches of the North Pacific. There, adventurers wrestled 800-pound steel cages amid raging seas and aprons of pack ice, hoping to strike it rich on a bounty of flaky meat and accordion legs.

The emerging issues with Alaska's crab underscore a predicament that stretches beyond the North Pacific. It gets to the difficulty of trying to comprehend the depth of fallout from ocean acidification.

For reasons scientists don't always understand, similar species, even those living side by side, often respond to changing water chemistry in remarkably different ways.

"The real issue here is unpredictability," said Richard Aronson, a Florida-based marine scientist who has tracked king crab in Antarctica. "There are all these unanticipated collateral impacts. The problem is, most of them are nasty surprises."

'We're scared to death'

Certainly the threat to king crab was unexpected.

As humans pump carbon dioxide into the atmosphere, a quarter of it gets absorbed by the seas. That lowers the water's pH and alters the availability of carbonate ions, which crab rely upon to build their exoskeletons.

Many crab species appear hardy in the face of souring seas, or at least not so frail. Exceedingly corrosive waters actually pump up Maryland blue crab to three times their size and turn them into voracious predators. Sour waters kill Dungeness crab, but far less often than Alaska red king crab.

When Foy and his colleagues exposed baby red king crab to CO_2 levels expected by midcentury, the young died more than twice as often as crab raised in normal water. When researchers boosted CO_2 to levels expected decades later, red king crab died in far larger numbers.

"The overall survival at the larval and juvenile stage is extremely low," Foy said. "It decreases to a point that is likely to affect the population of the crab."

Such a loss would exact quite a toll.

"You say king crab, and most people associate that with Alaska," said longtime crab-boat captain Kale Garcia, who lives outside Kent. "So, for it to go away, that's a huge part of the identity for Alaska. I think it'd be devastating. I know it'd be devastating for me."

Red king crab is the showboat of the Northwest's billion-dollar fishing industry. It is a television sensation and a marketer's dream, its image emblazoned on bumper stickers, mugs, caps and T-shirts throughout the Pacific Northwest and Alaska.

It is even a tourist attraction: Cruise-ship passengers stopping in Ketchikan pay $159 for a half-day ride to watch crews haul marine life aboard a 107-foot crab boat that appeared on Discovery Channel's "Deadliest Catch."

Alaska's commercial crabbers also catch small loads of golden king crab and Tanner crab, but the real cash comes from just two species — red king crab and snow crab. The 54 million pounds of snow crab caught in 2011 brought the fleet $115 million dockside. But a mere 14.8 million pounds of red king

Graduate student Asia Beder holds a mature red king crab pulled from a tank at the Alutiiq Pride Shellfish Hatchery in Seward, Alaska.

crab brought nearly as much — $92.5 million. And it can fetch $39.99 a pound at Pike Place Market.

Crabbing attracts tough adrenaline junkies who disappear for weeks into the storm-buffeted frontier of the Bering Sea. They lounge in cramped quarters watching bad movies and wait for crab to fill their cages. Then workers scramble day or night on icy decks through stomach-churning swells, amped on coffee and nicotine.

"A lot of people that are involved in the industry, it's something they've been in forever," Garcia said. "People like that don't plan an exit strategy out of the fishery. There is no exit strategy. They're like 'This is what we do. We fish.' "

NOAA researchers are using Bob Foy's research to develop models and a timeline that charts the potential collapse of king crab. But things are changing quickly.

"Bob reared those crabs under conditions that we thought were some time off in the future," said Jeremy Mathis, a NOAA oceanographer who specializes in Alaska and the Arctic. "And what we actually found is that in certain times of the year, the conditions near the bottom in the Bering Sea were actually worse than the conditions that Bob was raising his crabs under."

There's no evidence that souring seas have yet altered wild populations — the most corrosive seas now occur at times when red king crab aren't as susceptible. But Alaska's crab industry has followed the science closely.

"All of us in the fishing industry are looking at each other and going 'This sucks,' " said Ed Poulsen, former science adviser to the crab industry group. "I can tell you right now I'm doing all I can to get into other fisheries. I'm diversifying. With these changes in the environment, I think things are probably not going to get better."

Still, Jim Stone, of Lakewood, Pierce County, co-owner of the Bering Sea crab boat Arctic Hunter, is trying to remain optimistic.

"We're scared to death," Stone said. "But we've heard a lot of horror stories before."

Adaptation possible, but uncertain

The research comes with plenty of caveats. No laboratory setting can ever properly approximate what happens in nature. Scientists are still conducting genetic tests to see if king crab might have the ability to adapt.

"It's not unreasonable to assume, for example, that they might move, that some form of rapid evolution will occur, that they may become somewhat more robust," said Andre Punt, a University of Washington professor who worked on the research and assesses crab for fishing regulators.

But the situation also might be worse than first thought. Souring seas could hit crab at several additional stages of development or attack their food.

"They could be impacted in other parts of the water column," Punt said. "The prey that they're eating could be impacted."

Ocean acidification is also not the only marine-world change under way. Warming seas, also caused by carbon emissions, could compound crab's troubles.

"Anytime you're working with an organism at the edge of its threshold and you add another stressor, that's going to be an issue," Foy said. "When you're working in the subarctic environment like we are in the Bering Sea, these animals are always living at the edge of their tolerance in one season or another."

And while king crab's future has everyone scrambling, the future for snow crab, which brings in more money, could be equally disconcerting.

No two crab species react same way

No two Alaskan crab species have responded to CO_2 exactly the same way. They seem to react differently depending on where they live at certain stages of their lives.

Golden king crab, for example, live extremely deep, below 1,000 feet, where waters already are naturally rich in CO_2. That appeared to make them highly tolerant of sea-chemistry changes.

Meanwhile, baby Tanner crab exposed to high CO_2 died at a higher rate than normal — but nowhere near as often as king crab. Foy suspects that's because young Tanner crab live in water that already experiences vast swings in pH, depending on tides, time of day and photosynthesis.

"There's a lot of ifs, ifs, ifs," said Aronson, who documented Antarctica's crab during a cruise in 2010. "I've found that the number of times the surprise with carbon-dioxide emissions has been undesirable far outweighs the times it's been desirable."

The weird purgatory for these signature creatures unnerved Brett Robinson, who captains Stone's Arctic Hunter.

"It's scary as hell, if something doesn't get figured out," Robinson said. "I don't know."

"I guess you won't have to fish for them" in the future, he added. "They'll figure out how to grow these things in an aquarium or something."

Hatchery may be part of future

Young red king crab are being raised in a shellfish hatchery in Seward, Alaska, as part of an experimental effort to provide options for troubled wild populations.

Scientists in Seward, a thousand miles from the fishing grounds, are working toward just that.

For years, a shellfish hatchery has been learning how to raise baby king crab from scratch. The program started as an experiment to see if baby crab could be transplanted near Kodiak Island, where massive crab populations crashed in the 1970s and 1980s. But the rising threat from acidification has insiders closely watching their work.

Crab are most susceptible to corroding seas as babies, when a mere fraction of young survive even in perfect conditions. At the Alutiiq Pride Shellfish Hatchery, survival can be 500 times higher.

Still, no one expects this operation could ever replace wild king crab. The orders of magnitude required to get enough crab to populate the Bering Sea would be ridiculous.

But perfecting the science could provide options, such as the ability to repopulate a few previously devastated areas.

"We're hoping that it never gets to the point that they rely on the hatchery for that kind of work," hatchery manager Jeff Hetrick said. "If we get to that point I think we're in trouble. But it is a possibility."

The idea that crab might be partially grown in a lab instead of the ocean frustrated Mizrain Rodriguez, another Arctic Hunter crewman. But it also saddened him to think that humans could be doing such damage to the sea.

"Every single animal on this planet lives in balance with its surroundings except us," Rodriguez said. "We see it. We understand it. But we don't want to do anything about it. It seems like we are on this destructive path."

NOTE: Visit the web to see more pictures associated with this article.
http://apps.seattletimes.com/reports/sea-change/2013/sep/11/alaska-crab-industry/

Article 42: Scientists: Ocean acidification has arrived in the Northwest, by Christopher Dunagan, Kitsap Sun, May 2, 2014

http://www.kitsapsun.com/news/local-news/environment/scientists-ocean-acidification-has-arrived-in

SEATTLE -- When it comes to ocean acidification, the Pacific Northwest is becoming a living laboratory for studying the effects of changing oceans throughout the world, officials say.

During this week's Salish Sea Conference in Seattle, more than 20 researchers presented new findings about ocean acidification. Their general conclusion was that ocean acidification is not something to worry about in the future; it's something to worry about now -- because researchers are already seeing the effects on sea life.

A natural upwelling of deep ocean water off the coasts of Washington, Oregon and Northern California has been shifting the acidity of surface waters since prehistoric times, experts say. Even without human intervention, waters off the coast have a lower pH (higher acidity) than most regions of the world.

For the past century, increasing levels of atmospheric carbon dioxide have been absorbed by the ocean, further lowering the pH. A side effect is to reduce the available calcium carbonate, essential for organisms with calcium shells.

The Salish Sea Conference, held every two years, brings together hundreds of scientists and students studying dozens of research topics. Ocean acidification has become an urgent discussion.

On Thursday, Nina Bednarsek of NOAA's Pacific Marine Environmental Laboratory reported what has been called the first evidence of acidification causing widespread damage to a native species under natural conditions.

The shells of tiny sea snails, known as pteropods, are dissolving at a much higher rate than anyone thought possible, she said. In preindustrial times, it was estimated that 20 percent of pteropods were affected by low pH.

That has increased to 50 percent today and is expected to reach 70 percent by 2050.

Pteropods are among the sea creatures that play a critical role at the base of the food web, where they feed a variety of fish. If ocean acidification kills off significant numbers of pteropods, the effects could reverberate throughout the coastal ecosystem. Because pteropods are sensitive to change, Bednarsek said they could become an ongoing "indicator" of worsening ocean conditions -- the proverbial canary in a coal mine.

The new findings about pteropods, published this week in a British science journal, also raise questions about whether other organisms may already be injured by the effects of ocean acidification.

Anna McLaskey of the University of Washington reported on laboratory studies of krill and copepods -- two other creatures considered a primary link in the food web. Krill eggs continued to hatch at low pH, she said, but development to the first feeding stage was significantly affected at levels seen at times under natural conditions, such as in Hood Canal.

Copepods failed to hatch at low pH levels, she said, but more work needs to be done to determine the fatal level.

As several researchers reported, the acidity of seawater varies from place to place along the coast and throughout the Salish Sea, which includes Washington's Puget Sound and Canada's Strait of Georgia. Acidity also varies with time, with the more extreme conditions showing up in late summer.

Acidity also is affected by the growth of plants, including tiny phytoplankton, which can reduce carbon dioxide and increase oxygen. Bacteria, on the other hand, can reduce oxygen and increase acidity under certain conditions. Those effects, called respiration, play a role throughout Puget Sound -- especially in Hood Canal where low-oxygen conditions and increased acidity have been found to kill oyster larvae and probably other organisms.

Brooke Love of Western Washington University found that eelgrass can dramatically improve pH in shoreline areas. Daily changes occur in tune with the tides and available sunlight.

"You can think of acidification as a global process," Love said, "but when you get down into the much smaller spatial scales, you can start to see the effects of photosynthesis and respiration on a diurnal (day-night) cycle."

Water chemistry certainly can affect organisms, she noted, but organisms can also affect water chemistry. "Cultivating sea grass and shellfish together could help protect both."

Because pH varies over time, NOAA's Paul McElhany is developing a computer model to predict the long-term effects of ocean acidification on a variety of marine species. Some species can move to get away from dangerous conditions, he noted, but others simply have to endure the worst.

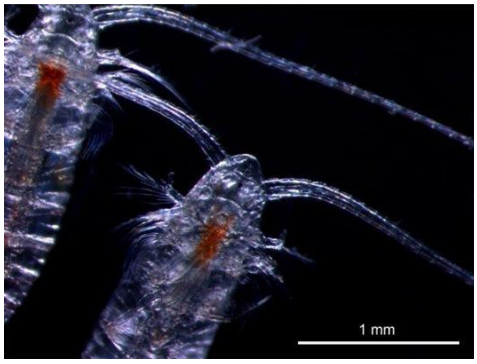
Will a species just die when conditions get bad enough, he wondered, or can the animals hang tough for a certain period of time? Do they require good conditions for at least part of their life cycle, or can they function at lower levels under continuing poor conditions?

His model will attempt to simulate behaviors, such as avoiding predators while seeking out prey essential for survival.

"Organisms do not exist in an environment with a flat (unchanging) pH," he said. "We have to understand the patterns of pH over time."

Article 43: Ocean's carbon budget balanced: Supply of food to midwater organisms balanced with demands for food, National Oceanography Center, March 20, 2014

Ocean scientists have, for the first time successfully balanced the supply of food to midwater organisms with their demands for this food.



Marine copepods.
Credit: photo courtesy of Daniel Mayor

The depth at which they consume this sinking material regulates our climate by determining how much carbon is stored by the ocean and how much remains in the atmosphere.

The results of the study in the North Atlantic are published in the journal *Nature* this week. The research focuses on 'marine snow' – bacteria, microscopic animals and sinking organic matter.

Dr. Richard Sanders, Head of Ocean Biology and Ecosystems at the National Oceanography Centre explained: "Phytoplankton -- marine plants -- grow in the surface ocean using CO_2 and sunlight to produce biomass in the same way that terrestrial plants do. This links atmospheric CO_2 to the processes in the oceans and it is this 'ocean carbon budget' that we are keen to quantify."

When phytoplankton die, they sink to depth and transport atmospheric CO_2 into the deep ocean. Massive quantities of CO_2 are stored in the deep ocean this way, keeping atmospheric CO_2 concentrations much lower than if the oceans were devoid of life.

"When predicting future atmospheric CO_2 levels, it is important to understand how much marine snow is sinking to depth and where it is being consumed."

Most of the food supplied to the deep sea sinks from the upper ocean in the form of marine snow, flakes of marine detritus -- dead plant and animal plankton and plankton feces. Animals living in the 'twilight zone', a layer between 50-1000 meters depth where light levels are extremely low, eat most of this marine snow.

Previous attempts to explain the loss of marine snow with biological activity in the twilight zone have failed, suggesting that the understanding of the processes within the ocean was incomplete.

"We show that a balance between food supply and demand is possible because of intricate linkages between zooplankton and microbes," explained lead author Dr. Sarah Giering. "When these microscopic animals eat marine snow, much of it is released as tiny suspended particles that are readily available to bacteria, which in turn convert it into biomass and CO_2."

Dr. Daniel Mayor from the University of Aberdeen, a co-author of the research, said:"The apparently wasteful process of zooplankton fragmenting, rather than ingesting, sinking detritus is central to understanding how the twilight zone works.

"CO_2 released at depth can stay there for thousands of year, providing a natural mechanism for carbon storage."

"This release is important, because marine snow is made of phytoplankton, microscopic plants that take up atmospheric CO_2," continued Dr. Giering.

"Our findings are a major step forward, allowing us to explore the role of deep-sea biota regulating our climate," said Dr. Sarah Giering.

1. Sarah L. C. Giering, Richard Sanders, Richard S. Lampitt, Thomas R. Anderson, Christian Tamburini, Mehdi Boutrif, Mikhail V. Zubkov, Chris M. Marsay, Stephanie A. Henson, Kevin Saw, Kathryn Cook, Daniel J. Mayor. **Reconciliation of the carbon budget in the ocean's twilight zone**. *Nature*, 2014; DOI: 10.1038/nature13123

Article 44: Inventory of Crap on the Ocean Floor by Elizabeth Preston, Discover, May 2, 2014
http://blogs.discovermagazine.com/inkfish/2014/05/02/inventory-of-crap-on-the-ocean-floor/#.U-FQT_ldWSo

Going to the bottom of the ocean isn't such a big deal. Sure, James Cameron generated a lot of fuss last year with his record-breaking descent into the Mariana Trench—but Uncle Ben has been to the deep sea without even using a sub. Yes, that picture shows a packet of Uncle Ben's microwaveable rice a kilometer deep in the Atlantic Ocean. It's one of the items an international group of scientists found in their detailed inventory of underwater garbage.

The scientists pooled data from 588 different surveys of the seafloor, covering 32 European sites. The studies had taken place in the Atlantic and Arctic Oceans and the Mediterranean Sea between 1999 and 2011. Some were surveys by remotely operated vehicles, scanning the seabed with video cameras. Others were brute-force sweeps with trawling nets. From all this, a few patterns emerged.

First, surprising no one, was plastic. Forty-one percent of all the trash items found were plastic. And that's not even counting plastic nets or fishing lines, which were grouped together with fishing gear (34% of items). Glass bottles made frequent appearances, although glass only accounted for 4% of the trash. There was also wood, paper, cardboard, fabric, and some mystery materials.

Coming in at 1% of garbage items was "clinker," the rocky leftovers of burned coal. Steamships used to dump this material overboard between the 18th and 20th centuries, and it still crisscrosses the Mediterranean in the shadows of old shipping routes. The researchers found especially high amounts of clinker in deep sea basins and continental slopes, though they note that there's probably even more of it hidden under a century's worth of sediment on the seafloor.

From plastic bags to used coal to Heineken cans (and more plastic bags), much of the trash was sadly expected. For most sites, "the concentrations were pretty much what we expected to find," says lead author Christopher Pham, a PhD student at the University of the Azores in Portugal. However, there was more debris in the Arctic than they thought they'd see—something "we are still trying to explain," he adds.

Looking at sites all around Europe gave the scientists a glimpse of the forces that push and pull debris through the oceans. Some bits of refuse sink right away, while others float for long distances before succumbing. The authors found lots of fishing debris on underwater mountains, ridges, and banks, which are areas targeted by commercial fishers. They also found a general increase in litter closer to shore, but low concentrations on continental shelves, Pham says, as currents presumably push trash off of them and into deeper waters.

It makes sense, then, that ocean canyons held the most garbage. These sites are dead ends for a drifting bit of junk. Pham thinks more hotspots and accumulation patterns will emerge as scientists survey the seafloor across the rest of the world.

One thing scientists probably *won't* find is a pristine space. "What was shocking was that all of the sites sampled had debris," Pham says. Whether they were looking 35 meters or 4500 meters (almost 3 miles) deep, the researchers found trash. Everywhere in the ocean there are tiny grains of plastic waiting to be eaten by tiny organisms; drifting bags that will be gulped down by sea turtles mistaking them for jellyfish; plastics containing toxic chemicals that can gradually travel up the food chain to humans. There are nets wrapped around corals. There are fish killed by "ghost fishing," the work of discarded fishing gear without a person at the other end.

Still, Pham isn't too gloomy. "I'm convinced there is still hope!" he says.

"The solution is rather simple," Pham says; "we need to produce less and recycle more." That's simple to say, but not so simple to enact on a global scale. It also doesn't address the question of cleaning up the trash that's already in the ocean. Maybe the next time James Cameron goes down there, he can pick some up.

Images: (both) National Oceanography Centre, UK.

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Article 45: Ocean Quickly Growing Acidic? Current Science, v 94 n13, Mar 13, 2009 http://search.proquest.com/docview/195881405/fulltext/DE6ABD08B2F1413DPQ/1?accountid=130952

Timothy Wootton and Cathy Pfister made a surprise discovery when they crunched the data they had collected on this tiny, windswept island in the Pacific Ocean. Since 2000, Wootton and Pfister had taken 24,519 measurements of the ocean water off the island.

They looked at factors such as temperature And salt content. But the factor that shocked them was pH - the acidity or alkalinity of a solution. In just eight years, the ocean water had become much more acidic.

Ocean acidity is something scientists worry about. Earth's atmosphere has 30 percent more carbon dioxide (CO_2) than it did 200 years ago. That percentage would be much higher if not for the ocean's ability to absorb CO_2. But the CO_2 absorbed by the oceans has made them more acidic. Scientists worry that as CO_2 levels continue to rise, the oceans will become so acidic that plants and animals can no longer survive in them.

Acidic water is especially hard on animals with shells. Wootton and Pfister, marine ecology professors at the University of Chicago, found that Tatoosh Island's mussel population had dropped between 10 and 20 percent. Mussels are mollusks - soft-bodied, hard-shelled animals.

No scientist has monitored acidity on the Pacific coast as regularly as Wootton and his team have. So it's unclear whether their acidity measurements reflect the state of the oceans elsewhere on Earth. Ocean chemistry varies from place to place. But if Tatoosh Island's water is a reliable sign of CO_2 acidification, then the process is happening much faster than any scientist has anticipated, says Wootton.

Shell Shock-How carbon dioxide acidifies seawater and affects marine life:

1. Carbon dioxide (CO_2) combines with water (H_2O) to form carbonic acid (H_2CO_3), the same acid that is put into carbonated water to give it fizz.

2. Like all acids, H_2CO_3 releases hydrogen ions into solution. An ion is an atom or a molecule with an electric charge. The concentration of H ions is measured by a pH test. A solution with a high concentration of H ions is acidic; a solution with a low concentration of H ions is alkaline.

3. The H ions combine with carbonate ions in the water, forming bicarbonate ions. That has an adverse effect on marine life that needs carbonate ions to build shells or skeletons.

Article 46: "Rock snot" algae sneaking into more rivers, causing headaches, by The Baltimore Sun, adapted by Newsela staff, June 13, 2014

BALTIMORE — Algae is a type of very simple plant, lacking roots, stems and leaves. Found in lakes and ponds, it provides nutrition for fish. When it becomes too abundant, however, algae can crowd out other plants and cause fish to die off.

This picture captures "rock snot" algae in Thurston, Washington.
Photo: teresatrimm/Flickr

For years, those who monitor East Coast waterways have been concerned about one particular algae, known as didymo. To combat the spread of the pervasive algae, felt-soled fishing boots have been banned.

Algae can stick to felt and be transported to other bodies of water. For the same reason, fishermen have been urged to scrub their gear. A recent Dartmouth College study could turn such thinking on its head, however.

Science Of Rock Snot

Didymo produces threadlike stalks called "rock snot" blooms, which can choke lakes and ponds. The algae has long been considered a threat to bodies of water across the nation. Many fear that it is spreading rapidly from one body of water to another.

According to the new Dartmouth study, however, the algae is far from being a rapidly spreading newcomer. Indeed, it is largely native to those areas where it has been seen.

The team of researchers found that cells of the algae had been present in rivers around the globe for centuries. In some cases, they had been present for thousands of years.

On the other hand, the team also found that significant changes had occurred. In the past, the environmental conditions that trigger rock snot blooms were rare or absent.

"A lot of the response to didymo has been, 'How can we keep it from spreading?'" study leader Brad Taylor said. "Our work suggests that in a lot of areas, in the areas just up the road in Pennsylvania and just south of Maryland and Virginia, didymo has been there at least 50 years. In some cases, in the case of Pennsylvania, it's been there thousands of years."

The team began the study in the summer of 2012.

"Didymo has always been in these rivers — we've known that for a long time — and it only blooms in some of them," Taylor said. "We started talking more about perhaps didymo is native and just had gone unnoticed in large parts of the world … It's been found all over the world and for a long time, not just the past 10 years."

How Climate Change Figures In

The extensive growth of rock snot blooms witnessed over the past several years hasn't resulted from its spread from river to river, as widely believed. Instead, Taylor said, it is caused by factors resulting from climate change. Chief among these is a shortage of phosphorous — a mineral that plants depend on for healthy development.

"When phosphorous concentrations are extremely low, didymo produces this stalk to push itself up into the water column to access nutrients," Taylor said. "It's very similar to beanstalks;

if you're going to grow a bean plant … when you starve the plants of light, they grow tall and spindly."

Blooms of rock snot, so named for its mucus-like appearance, harm salmon and trout populations by clogging ponds and lakes. In addition, the insects the fish feed on burrow into the stalks, making it harder for fish to get at them.

The research team is now trying to determine how humans are contributing to the growth of rock snot blooms.

"We spew nitrogen out of our cars and coal-fired power plants, and then that rains down and fertilizes systems with just nitrogen," Taylor said. "You then have plants that are fertilized by nitrogen but not phosphorous, and so that results in a decrease in phosphorous going into lakes and rivers."

Other factors resulting from climate change also deprive didymo of phosphorous, Taylor said.

Among those factors are "a shift toward earlier growing seasons and an earlier pulse of springtime stream flows," Taylor said. "Those occur earlier in the year, and the rivers are basically starved of phosphorous later in the year."

Cleaner Fishing Gear May Help

Taylor said the team's discoveries indicate that multimillion-dollar algae eradication efforts won't prove to be effective in combating rock snot blooms.

In 2011, in hopes of stopping didymo's spread, Maryland became the first state to ban felt-soled wading boots. Maryland's Department of Natural Resources also set up wader washing stations where those fishing on the river could wash their gear.

"If it's already there, it's not going to do any good to try and stop the spread of it, obviously," Taylor said. "So the action might be better put into figuring out what's causing it to bloom."

Once that's understood, he said, the focus should be on "ways to regulate that or ways to simply adapt to it and deal with it."

Poisoning the algae, Taylor thinks "isn't going to be doable, and it's probably not going to solve the root problem."

Didymo, Taylor said, could prove to be a valuable case study into climate change's effects on native species.

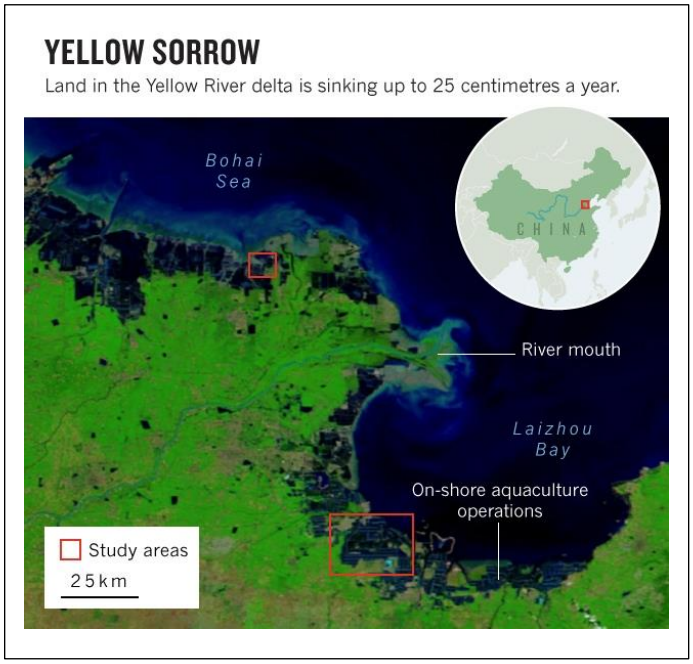
The algae "may be really sensitive to the climate-induced changes and environmental conditions," he said. "So it may be a good canary in the coal mine, if you will." It may, in other words, be a good indicator of "other changes that are going to happen in rivers."

Didymo, Taylor said, is a "native species that's being affected by changing environmental conditions and is causing a nuisance." That kind of problem, he added, is "something I think we need to be more aware of in the future, and it may be more common."

Article 47: Fish farms cause relative sea-level rise by Nicola Jones, Nature, 16 August 2013 http://www.nature.com/news/fish-farms-cause-relative-sea-level-rise-1.13569#auth-1

Groundwater extraction for fish farms can cause land to sink at rates of a quarter-meter a year, according to a study of China's Yellow River delta. The subsidence is causing local sea levels to rise nearly 100 times faster than the global average.

Global sea levels are rising at about 3 millimeters a year owing to warming waters and melting ice. But some places are seeing a much faster rise — mainly because of sinking land. Bangkok dropped by as much as 12 centimeters a year in the 1980s thanks to groundwater pumping. Oil fields near Houston, Texas, experienced a similar drop during the 1920s because of oil extraction. Deltas can also sink as old river sediments compact under their own weight and water carrying replacement sediments is held back by dams or diverted for irrigation. "You can get crazy rates of sea-level rise," says James Syvitski, a geologist at the University of Colorado Boulder and a co-author of the study, published online in *Geophysical Research Letters*.



The researchers found that parts of the Yellow River delta are dropping by up to 25 centimeters a year, probably because of groundwater extraction for onshore fish tanks. The link between aquaculture and subsidence has attracted little international notice. "This is a new one on me," says Stephen Brown, a fisheries scientist at the US National Marine Fisheries Service in Silver Spring, Maryland. "We are concerned about the effect of sea-level rise on fish; not the other way around," he says.

Robert Nicholls, who studies coastal engineering at the University of Southampton, UK, and who co-authored the chapter on coastal management for the 2007 Intergovernmental Panel for Climate Change report, is likewise surprised by the link. "I would not have thought of this as an issue previously," he says.

Subsidence was not mentioned in the United Nations Food and Agriculture Organization's 2012 report on the state of world aquaculture, says Stephanie Higgins, a PhD geology student at the University of Colorado Boulder who led the study. "This is not yet on the industry's radar, but it should be," she says.

Shifting shores

The Yellow River delta has been sinking for decades. Between 1976 and 2000, the shoreline receded by 7 kilometers. In the late 1980s, 30-meter-thick sea walls were built to stop erosion and protect oil rigs on land. But no one had measured the vertical subsidence or pinpointed the

Higgins and her colleagues used satellite-radar images to measure subsidence near the Yellow River delta. This technique requires a hard, reflective surface, such as a paved road, to

get accurate readings, so is used mainly in urban areas. But in the Yellow River region, the roofs of fish farms served that purpose.

Dams on the river have cut the flow of sediment to one-tenth of its normal levels, but this probably accounts for only a few millimeters per year of the overall subsidence, says Higgins. And the subsidence they saw was most extreme near fish farms, rather than nearby oil fields.

Asia produces 89% of the world's farmed fish and shrimp, much of it in river-delta regions freshened with groundwater, says Higgins. Planners should be aware of the impact that this kind of aquaculture can have on local sea-level rise, she says, and regulate groundwater extraction accordingly.

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Article 48: Plants have unexpected response to climate change, by Jennifer Balmer, Science, 8 August 2014

Not all species flee rising temperatures. As the mercury has inched upward across western North America over the last 40 years, many plant species have moved downhill, toward—not away from—warmer climates, according to the results of a new study. The finding adds to growing evidence that temperature isn't the only factor influencing how Earth's life will respond to climate change.

"This is a very cool study and demonstrates what many of us have been saying—that we will get surprises," writes Camille Parmesan, a climate change biologist at Plymouth University in the United Kingdom, in an e-mail to *Science*. She was not involved with the study.

Photo by Anna Wilson

Like animals, plants require specific environmental conditions—such as the right temperature, moisture, and light levels—in order to thrive. Even small changes in environmental parameters can affect the reproduction and survival of a species. As global temperatures rise, both animal and plant populations are projected to gradually shift toward northern latitudes and upward to higher elevations where temperatures are cooler in order to stay within their ideal range of environmental conditions.

In an effort to understand how plants may cope with changing climates, researchers at the University of Washington, Seattle, compiled geographic coordinate data for the locations of nearly 300 plant species within seven topographically distinct regions across western North America, ranging from the western Sierra Nevada mountain range in Nevada to the eastern Rocky Mountain Foothills of northern Canada, spanning the last 40 years. They then compared these findings with changing climate conditions, such as temperature, rain, and snowfall. The study is the most extensive of its kind to date.

The results of the analysis were unexpected. More than 60% of plants shifted their distributions downward, toward warmer, lower elevations—despite significant climate warming across the regions under study, the team reported online on 24 July in *Global Change Biology*. Even more striking, all plants within a region—regardless of species—moved in the same direction.

"Initially, we thought there was something wrong with our analysis—species distributions are expected to shift upward, not downward," says team leader and plant ecologist Melanie Harsch. "But we redid the analysis and we got the same results."

A closer look revealed that the downhill movement of plants was likely driven by the changes in precipitation that accompanied warming temperatures. Those regions that

experienced less rain and snow at high elevations were those with plants shifting toward lower elevations with wetter climates. “Less snow in winter translates into less water in summer, resulting in water-stressed plants and downward shifts,” Harsch says.

Although plant populations are shifting downward toward greater water availability, they will also have to contend with an increasingly warming climate. “It’s a double-edged sword,” Harsch states, “as temperatures rise, water needs will also increase.”

Although previous, smaller studies have also noted downhill movements in relation to water availability, others report uphill movements in relation to temperature, suggesting the direction of species movements is dependent on local environmental conditions as well as the types of species present. “These studies highlight the importance of understanding the complexities not only of future climate change but the climatological requirements of individual species,” says Anne Kelly, a plant ecologist at the Catalina Island Conservancy in Avalon, California, who was not involved in the work.

Future climate changes are projected to intensify precipitation patterns in western North America, leading to more pronounced shifts in plant distributions and potential subsequent effects on the wildlife that depend on them for food and habitat. “How we decide where to allocate limited resources such as money and manpower to conserve species in the face of long-term global warming is a primary concern right now,” Harsch notes. “We can’t monitor all species everywhere, but, by identifying the factors responsible for environmental changes, we can begin to predict effects and prioritize conservation management choices.”

Article 49: Cantwell: Shellfish Growers Are The Canary In The Coal Mine, by John Ryan, KUOW.org, AUGUST 12, 2014 http://kuow.org/post/cantwell-shellfish-growers-are-canary-coal-mine

Senators Maria Cantwell (D-Washington) and Mark Begich (D-Alaska) are calling for a national strategy to respond to ocean acidification and protect the nation's fishing industry.

On Monday, the senators called for federal funding for a national network of ocean-going devices — from high-tech buoys to aquatic drones that resemble small yellow missiles— to track just how fast the world's oceans are turning sour.

Sen. Maria Cantwell speaks at a press conference next to a "wave glider" of the kind currently being used to monitor ocean acidification in the Gulf of Alaska. *Credit KUOW Photo/John Ryan*

Such devices are being developed at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle, where the senators spoke on Monday.

Ocean acidification is sometimes called the evil twin of climate change: Both are caused by rising amounts of carbon dioxide in the atmosphere. More CO2 dissolved in the water is making it harder for many creatures to form shells.

Cantwell said the rising acidity of the world's oceans needs to be a national priority for economic reasons. "Ocean acidification is a jobs issue," Cantwell said. "Shellfish growers are the canary in the coal mine."

She said the small number of acid-monitoring devices already deployed along the Washington coast has already saved jobs in the shellfish industry. (http://nvs.nanoos.org/ShellfishGrowers)

Now, some oyster farmers can react quickly by adding acid-neutralizing baking soda to their water supplies when they see pulses of especially acidic water hitting their hatcheries.

Bill Dewey with Taylor Shellfish of Shelton, Wash., said his industry was one of the first in world to be affected by ocean acidification — and actually know it.

"That's because of the data we've been able to collect and see the seawater chemistry that's coming into our hatchery and killing our oyster larvae," he said.

By next year, scientists expect Washington oyster growers will be able to use acidity forecasts the way farmers rely on daily weather forecasts. Such forecasts can't help the oysters once they leave the controlled environment of a hatchery, and many more ocean fisheries and species are at risk.

"The fact that these pteropod, which is what salmon eat, aren't forming shells, is a very big problem for us," Cantwell said.

Cantwell and Begich said a nationwide network of drones and buoys could serve as a sort of early-warning system for industries threatened by acidification.

"More science, better science, is good business," said Begich.

Such a network would not address what University of Washington oceanographer Jan Newton called the top priority when it comes to ocean acidification.

"From a scientist's perspective, there is no doubt that ocean acidification is caused by the buildup of CO_2," Newton said. "Curtailing that is the number-one most important thing to do for ocean acidification."

China and the United States are the leading sources of the world's carbon dioxide emissions. Environmental activists concerned about American CO_2 emissions have focused on pressuring the Obama administration to block construction of the Keystone XL oil pipeline from Canada to refineries on the Texas Gulf Coast.

Cantwell declined to take a position on the Keystone pipeline. "I'm willing to continue to let the White House decide on this," she told reporters on Monday.

Begich supports completion of the pipeline as well as proposed oil drilling in the Arctic Ocean.

"For us to pretend that suddenly oil and gas will disappear overnight would be a mistake," he said.

President Obama said last year the State Department would allow the Keystone XL pipeline to be built "only if this project does not significantly exacerbate the problem of carbon pollution."

A new study by Seattle-based researchers with the Stockholm Environment Institute said the pipeline's effect on global carbon emissions would be four times worse than what the State Department estimated earlier this year.

Press release about the Stockholm Environment Institute study:
http://www.pressherald.com/2014/08/10/study-keystone-carbon-pollution-more-than-figured/

Article 50: Beef and climate change collide, by Los Angeles Times (adapted by Newsela staff), July 31, 2014

Cattle in a feedlot that sits on the northwestern edge of Garden City, Kansas. Photo: Keith Myers/Kansas City Star/MCT

Two new studies have found that beef is unhealthy — for planet Earth. Beef production is responsible for the release of gases that contribute to climate change, among other environmental effects.

One study focused on U.S. beef production. It found that producing beef uses 28 times more land and 11 times more water than other meats. The study, published in the journal Proceedings of the National Academy of Sciences, also said that beef production pumps at least five times more planet-warming gases into our atmosphere than chicken or pork.

A study in the journal Climate Change found that developing nations raising cattle have significantly increased the amount of gases they produce — or emit. Planet-warming gases from livestock increased 51 percent from 1961 to 2010.

"For people, the obvious answer is: whenever possible, replace beef with something else," said Gidon Eshel, a geophysicist at Bard College and lead author of the study in Proceedings of the National Academy of Sciences. "If you really need it to be from animal sources, that's still OK. You can still have bacon and eggs and whatever you want. As long as it's not beef, you have always made a significant step forward, because beef is so much more intensive than the rest."

Beef Industry Is Not Amused

The beef industry, not surprisingly, does not accept the results of these studies. These studies oversimplify the complex production of beef, the industry says. "The U.S. beef industry produces beef with lower greenhouse gas emissions than any other country," an industry statement reads.

Harmful gas emissions from developed countries such as the United States have been falling since 1970. Developing countries have more than doubled their emissions. These poorer countries are eating more beef.

Beef cattle produced more than half the emissions. Dairy cattle were responsible for 17 percent, sheep 9 percent, buffalo 7 percent, pigs 5 percent and goats 4 percent. The largest increases came in Congo, the Central African Republic and Oman, the study found. The study estimated production of greenhouse gases in 237 countries.

"More and more of the developing world is adopting the bad habits of the developed world," said study co-author Ken Caldeira.

Careful With The Resources

The other study, from the Proceedings of the National Academy of Sciences, focused on the industrialized food chain in the United States. This study looked at grazing, growing food for the cattle, and the use of irrigation water.

The study should not just guide consumer choice, but also government policy, Eshel said. He said this issue is an example of the "tragedy of the commons," where people each selfishly use a common resource. Eventually, the resource runs out.