Northwest Fisheries Science Laboratory biologist Paul McElhany collects plankton samples at NOAA's Mukilteo Research Station as part of his research on the effects of ocean acidification

PHOTOGRAPHS BY STUART ISETT

TROUBLED WATERS

Marine scientists call ocean acidification global warming's doppelgänger, and recent studies show Puget Sound is particularly susceptible to its effects

By Maria Dolan

Paul McElhany studies oysters in his Montlake lab; below, McElhany continues his research, knowing that even small changes in pH levels could affect the species interactions of the entire marine ecosystem

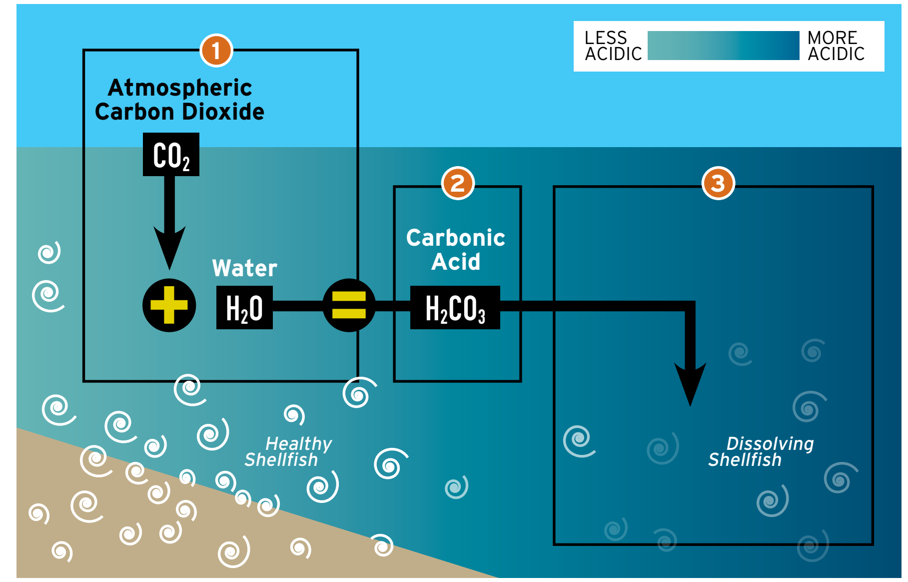
AT THE WARM, brine-scented Northwest Fisheries Science Laboratory (NFSL) in Montlake, soft-spoken biologist Paul McElhany and a team of scientists immerse geoduck larvae in a multitude of saltwater baths. The water, trucked in from Elliott Bay and another fisheries lab in Mukilteo, starts as the usual toe-numbing Puget Sound soup. Then the scientists—amid the beeping, burbling din of heaters, bubblers and microfilters—spin knobs and press buttons, changing the water's temperature, salinity, oxygen level and pH to simulate past, present and likely future seawater conditions in our region. Initiated this past January, the NFSL research continues today with other Puget Sound denizens (shellfish and zooplankton), in search of a better understanding of how each is responding to the acidification of oceans worldwide—a serious, immediate threat to Northwest sea life populations. ¶ Oceans soak up about 30 percent of anthropogenic (human-generated) carbon dioxide (CO_2), the leading greenhouse gas propelling climate change. For many years, the fact that oceans absorbed CO_2 seemed a lucky break among environmental woes—the more carbon dioxide sequestered in the ocean, the less of it left to overheat the atmosphere. Some environmental scientists even looked to oceans as a possible storage place for the climate-changing gas, going as far as to suggest that it be injected into the ocean floor.

But when mixed with seawater, CO_2 changes chemically and forms carbonic acid (H_2CO_3). With the amount of human-caused carbon in the oceans—currently 530 billion metric tons and counting—that carbonic acid is changing the pH of oceans from a naturally alkaline 8.2, close to baking soda, toward acidity. (A pH of 7 is neutral; greater than 7 is alkaline and lower than 7 is acidic.) Since the start of the Industrial Revolution, ocean pH has dropped to an average of 8.1, and scientists project that surface-water pH is likely to decrease to 7.8 or lower by the end of the 21st century.

That water won't be pure acid, but according to recent studies, even small changes in ocean pH—such as those already happening—can inhibit nascent shellfish from forming shells. Larger pH shifts can dissolve existing shells. A difference in pH can also corrode coral reefs and destroy plankton (a major food source for many fish species), and may interfere with the ability of some fish to navigate.

While some ocean dwellers appear to fail under these new conditions, others succeed. Sea grasses and jellyfish, for instance, seem to thrive in a more acidic ocean. But it appears that "calcifiers," organisms that make calcium carbonate (the same ingredient that's in a roll of Tums), including all shellfish and some types of zooplankton, such as krill, fare poorly when the pH is lowered even slightly. That's serious for Puget Sound, where 30 percent of the species are calcifiers. It's also serious for the U.S. seafood industry, as shellfish constitutes 50 percent of seafood production.

DAVID LITTSCHWAGER, NATIONAL GEOGRAPHIC STOCK; TAKEN AT DR. VICTORIA FABRY'S LAB,CALIFORNIA STATE UNIVERSITY AT SAN MARCOS



HOW OCEAN ACIDIFICATION HAPPENS

1. When fossil fuels are burned, carbon dioxide is released into the atmosphere, after which a large quanity is then absorbed by the ocean. **2.** When mixed with seawater, CO_2 chemically changes into carbonic acid. **3.** Carbonic acid lowers the ocean's pH level, nudging it toward acidity. It also increases the water's hydrogen ion concentration, which in turn limits organisms' access to carbonate ions—essential to the formation of hard parts, such as shells.

ACCORDING TO RECENT STUDIES, EVEN SMALL CHANGES IN OCEAN PH—SUCH AS THOSE ALREADY HAPPENING—CAN INHIBIT NASCENT SHELLFISH FROM FORMING SHELLS.

A PTEROPOD DISSOLVES

>> At right, a two-month time-lapse sequence showing what happens to a pteropod (2–3 mm) when exposed to surface seawater simulating CO_2 conditions at the century's end—assuming a "business-as-usual" CO_2 emissions scenario.

Dr. Richard Feely, senior scientist at NOAA, working with instruments designed to measure oceanic carbon levels at NOAA in Sand Point

OVER THE PAST SEVERAL YEARS, NORTHWEST SEAWATER HATCHERIES HAVE EXPERIENCED A SERIOUS PROBLEM IN WHICH OYSTER LARVAE DIE BEFORE ATTACHING TO A SHELL.

The sea change is bringing new urgency to the work of marine scientists, including McElhany, who recently set aside research on Northwest salmon recovery—also crucial in our region—to study how acidification is likely to affect Northwest ocean life. Given acidification's ubiquity, he says, his focus on restoring local fish habitat was no longer broad enough. "If the entire marine ecosystem were to shift, and species interactions were to change, then those could have much bigger effects," he says.

Acidification is also complicating the jobs of local shellfish growers, such as farmers growing Pacific oyster larvae. (Dabob, Penn Cove and Willapa are all varieties of Pacific oysters.) Over the past several years, Northwest seawater hatcheries have experienced a serious problem in which oyster larvae die before attaching to a shell. "As an industry, everything is at stake for us," says Bill Dewey of Washington's Taylor Shellfish Farms, a primarily Hood Canal–based, 100-year-old grower that sells shellfish to Seattle oyster bars and at neighborhood farmers' markets. "Oysters," he says, "are the workhorses of the West Coast shellfish industry."

Fortunately, one of the country's leading chemical oceanographers working on the acidification issue has thrown his clout and knowledge behind the cause. Dr. Richard Feely, a Seattle-based National Oceanic and Atmospheric Administration (NOAA) scientist at the Pacific Marine Environmental Laboratory at Sand Point—who won a 2010 Heinz Award for nearly 40 years of work investigating the changing chemistry of oceans—was one of the first people to measure the disturbing change in oceanic pH. He was also on a team that three years ago cruised from Canada to Baja California studying why some of the earliest signs of ocean acidification seem to show up first in the Northwest.

Upwelling of ocean water 100 to 300 meters deep happens on the West Coast from April to September when northwest winds blow. Such waters have a lower pH (trending toward acidity) than shallower waters—as low as 7.7 off the Washington coast. For years, scientists believed that this upwelling did not reach the continental shelf, or our near-shore waters, but Feely's team found otherwise. "It happened everywhere we looked," he says. The acidified water washes periodically into the Strait of Juan de Fuca and from there into Puget Sound, reaching places like Hood Canal, where much Northwest shellfish is raised.

Using this information, hatchery scientists were able to help Northwest oyster growers by installing ocean pH monitors, which take regular readings of water near oyster hatcheries during months of upwelling. When the pH in that water changes in the direction of acidity, growers can shut off intake to their hatcheries, or take from the less corrosive surface water rather than from deeper water.

The data provided by the monitors, combined with fewer upwellings than average, made this past season the most successful larvae-producing year in Taylor Shellfish's history. Dewey says that in his "generally conservative" industry, the findings, and the results, have led some climate-change skeptics to rethink the impact of carbon emissions. "It is pretty hard to refute," he says.

But this solution doesn't work for all oyster growers. Many, such as those in southwest Washington's Willapa Bay, rely not on hatchery larvae but on "natural sets," free-spawning larvae that swim until they find a shell to which they can attach themselves and create an oyster seed. For these businesses, 2010 was again a failure; Pacific oysters haven't reproduced in the wild since 2004, and the companies are forced to buy oyster seed from successful hatcheries.

In the long term, of course, they—and we—are all in the same boat. "At present, nearly half the oceans are considered corrosive," says Feely. "By the end of the century, up to 92 percent of oceans may be corrosive, under the most extreme projection of fossil fuel CO_2 emissions." In other words, beachside Dungeness crab feasts, mussel stews, oyster fests and even Ivar's famous Acres of Clams could become things of the past. That is, unless we significantly change how much carbon dioxide we release into the atmosphere, and stop expecting the ocean to mop up after us. S