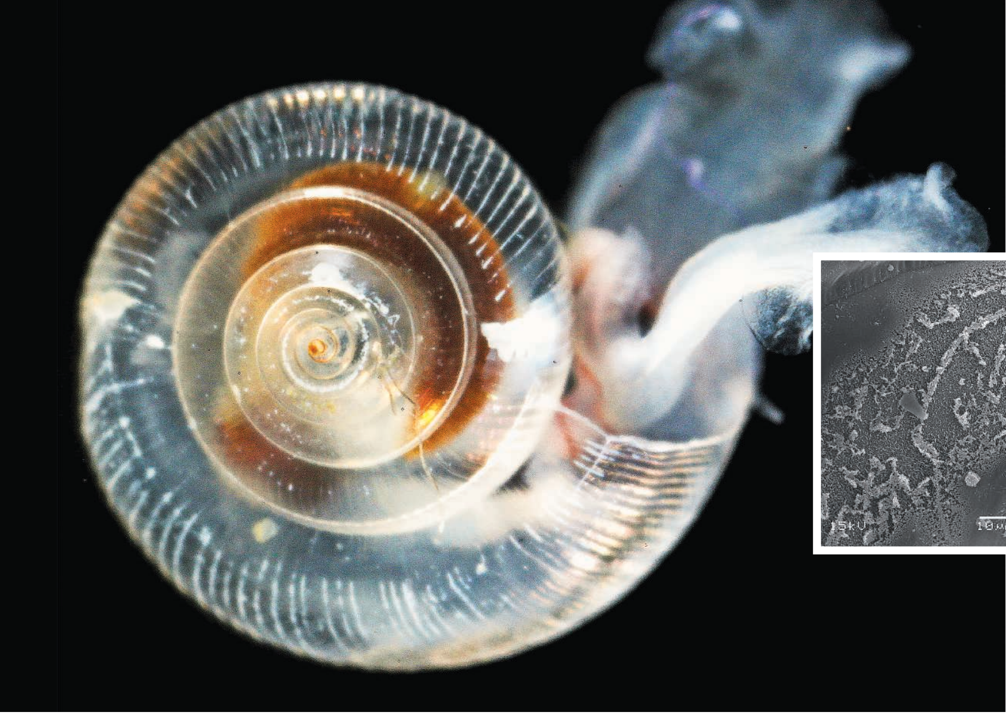

Vulnerable. Acidic waters are pitting and dissolving the shells (*inset*) of pteropod snails along North America's Pacific coast.

GLOBAL CHANGE

'Sea Butterflies' Are a Canary for Ocean Acidification

Marine scientists have long warned that rising CO_2 emissions are making the world's oceans more acidic, with worrisome implications for marine life. In the open ocean, the fears seemed largely theoretical—until last week. Along a 1500-kilometer swath of the U.S. Pacific coast, researchers found that acidifying waters are dissolving the shells of tiny sea snails. At least one-half of the damage appears to be linked to human-caused emissions, the scientists estimate.

"I was surprised by the sheer spatial extent" of the damage, says biological oceanographer Nina Bednaršek of the National Oceanic and Atmospheric Administration (NOAA) in Seattle, Washington, the study's lead author. Researchers figured the snails would show some resistance to corrosive waters, so "this is something we [had] not predicted before." The picture is likely to worsen as emissions continue, and it bodes ill for the marine food webs that depend on pteropods, the authors say.

The oceans have absorbed an estimated one-third of the carbon dioxide that humans have pumped into the atmosphere. That's helped slow global warming, but it has also triggered chemical reactions that are lowering the ocean's pH. Average pH in surface waters is now about 8.1—a 30% increase in acidity since the start of the Industrial Revolution—and researchers predict it could drop to 7.8 by 2100 if carbon emissions continue at current rates.

CREDITS: NOAA (2)

More corrosive water can harm the eggs and larvae of marine creatures, laboratory experiments have shown, and even dissolve the shells built by many invertebrates. Whether such dissolution was already occurring in the open ocean, however, has been unclear. To find out, Bednaršek and colleagues studied pteropods, marine snails nicknamed sea butterflies for their winglike body parts. They focused on the pteropod-rich California Current ecosystem, which stretches from British Columbia to Baja California.

The researchers collected more than 1000 samples of *Limacina helicina* from the top 100 meters of the ocean, at 17 sites along the current. Under the electron microscope, 38% of the normally smooth shells showed signs of severe dissolution, they reported online last week in the *Proceedings of the Royal Society B*. Damaged shells were etched or pitted, and their calcium crystals resembled "cauliflower," Bednaršek says.

The California Current is a known acidification hot spot. Winds along the grand southern flow drive extensive coastal upwelling of deeper, cooler water, which is naturally more acidic than surface waters. But many organisms are well adapted to the challenging conditions, so few researchers expected such a high proportion of damaged shells. "I'm a bit surprised by the severity of [the damage], but maybe I shouldn't be," says biological oceanographer David Mackas, now retired from Fisheries and Oceans Canada.

Human-caused acidification appears to explain the unexpected result, the NOAA team says, based on a model that allowed them to estimate shell damage in the past and future. The researchers found that the number of damaged shells was directly related to the corrosiveness of the water, which varies along the coast today. Based on data on past ocean conditions, they extrapolated that relationship to the preindustrial ocean. The result: Preindustrial acidification probably damaged some 18% of California Current pteropods living at the studied sites—suggesting that human-caused acidification has more than doubled the impact. It will get worse in the future, the analysis suggests. Damage rates at relatively shallow sites with particularly corrosive waters are forecast to rise from 53% today to 71% by 2050.

Although such models can be fraught with assumptions, this one appears "valid" to biological oceanographer Geraint Tarling of the British Antarctic Survey in Cambridge, U.K. Major questions remain, however. One is how the shell damage is affecting pteropod populations—and whether the creatures can ultimately adapt. Previous work has suggested that a damaged shell can make it harder for a pteropod to fight infection, maintain metabolic activity, defend itself against predators, and control buoyancy. But Tarling says experiments in his lab show that the snails can sometimes "patch up their shells from the inside," and he says more work is needed to understand the link between dissolution and mortality. The NOAA team didn't study such mechanisms, but the paper reports no evidence of evolved "resilience" among their pteropods, which are a major food source for West Coast fisheries.

More insight is expected soon. Researchers are busy studying the fates of pteropods in other areas, including the Gulf of Maine in the Atlantic Ocean, to understand how these marine butterflies are coping with an increasingly inhospitable habitat.

–ELI KINTISCH