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# What Happens When the Heat Repeats?

Two years later, the intertidal zone of the Pacific Northwest coast is still recovering from a devastating heat wave.

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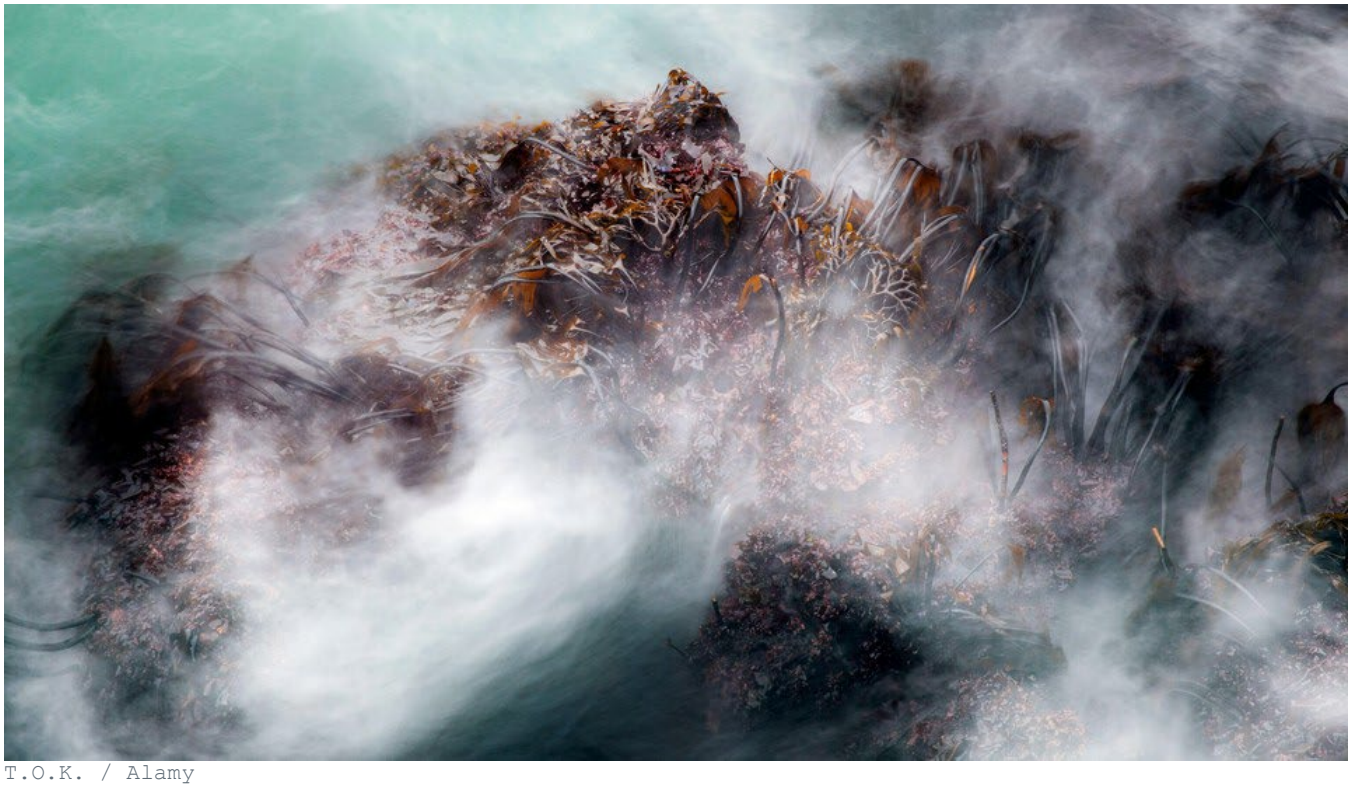

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For two years now, scientists, shellfish managers, and tribes have been working to understand how the heat dome that settled over the Pacific Northwest in the summer of 2021 affected the places where the ocean and land meet. That heat wave was like nothing in memory. Temperatures soaring as high as 121 degrees Fahrenheit buckled roads, melted power cables, and scorched forests. By the time the heat subsided, 650 people had died in the U.S. and Canada, and dead and dying shellfish and other marine critters littered beaches, cooking in their shells. Red algae were bleached white. Cockles tried to escape the heat by digging out of the sand, only to be greeted by more heat from the sun. Mussels gaped in an attempt to cool off. Tide pools became tubs of hot water. An estimated 1 billion marine animals perished in Canada alone.

These creatures all inhabited the intertidal ecosystems that exist between the ocean's high and low tide on both rocky and sandy shores. As the day and the tides turn, organisms there lead life above and underwater. Worms, snails, clams, oysters, barnacles, mussels, sea stars, algae, and kelp all thrive here, providing food, filtering water, and producing oxygen. The people studying these zones have seen how, when the heat dome settled in over these creatures, the places they lived helped determine their fate. Living inland was more dangerous than living closer to the coast, but even living on one side of a rock or another could make the difference between life and death. And although these ecosystems are on the path to recovery, they're changed—and recovery may be a temporary state.

The wide variety of impacts from the 2021 heat wave had almost everything to do with geography. Tides are like waves with very long wavelengths; experts liken the coast and Puget Sound to two ends of a bathtub, with water sloshing back and forth. During the summer in the Pacific Northwest, low tides hit the Olympic Peninsula first, in the morning when temperatures are cooler. That largely spared the Olympic National Park coastline, a biodiversity hot spot for marine invertebrates and seaweeds. Then, low tides move inland through the Strait of Juan de Fuca and down into Puget Sound; in the summer, they reach the Salish Sea in midafternoon, during the heat of the day. As a result, mortality was greater there. A clam in more-western Neah Bay "had a fundamentally different experience than a clam in Olympia because of the timing of the tide," Wendel Raymond, an intertidal and nearshore ecologist at the Washington Department of Fish and Wildlife, told me. "That's just how the oceanography of this place works."

To make matters worse, the heat dome corresponded with exceptionally low tides and some of the longest days of the year, exposing more organisms to the hot air for longer. Mussels and clams were hit hard inland and farther south. On sandy beaches in Puget Sound, clams deeper in the sand generally fared better than their counterparts closer to the surface. On the rocky Canadian coastline, the creatures that suffered the most—seaweeds, mussels, and barnacles—all had one thing in common: "They can't just pick up and crawl away, swim to deeper water, or hide under a rock," Christopher Harley, a marine biologist at the University of British Columbia, told me.

Harley noticed, though, that areas with seaweed, which functioned like a protective wet blanket, had less mortality. The dollops of shade cast by barnacles, which also trap water in their nooks and crannies, likely helped cool surrounding habitat too; in particular, barnacles on north-facing surfaces stayed cooler, reproduced, and have pretty much repopulated the area today, he said. Seaweeds took longer to rebound but are now doing well; mussels, which recover more slowly, have yet to fully bounce back.

Pacific oysters, however, are thriving in the spaces mussels haven't reclaimed. The popular seafood species, originally introduced from Japan, grows and reproduces quickly. Oysters' white or light-gray shells are more thermally tolerant than the shiny black shells of mussels—"If you have a black car, you know the difference," Raymond said. Mussel and oyster beds create habitats for other organisms, but "if you're a worm that loves being underneath a mussel or a hermit crab, it doesn't guarantee you'll love being in and amongst oysters**,**" Harley said. No one knows yet what more of one or the other shellfish will add up to—more biodiversity? less?—only that this place is now different than it was in the recent past.

Raymond does expect that, save the oyster boom, the shoreline around Vancouver, British Columbia, could roughly resemble its pre–heat wave self in about another year—if another heat wave doesn't stunt recovery first. Already, this hot summer has scorched the Pacific Northwest: High temperature records were set during an August heat wave.

The researcher Amelia Hesketh's Ph.D. work found that organisms struggled to reestablish themselves in hot temperatures, even when the death of other organisms opened up precious real estate. That could result in less biodiversity in the long term. "If you imagine a barnacle is like a forest and a heat wave is like a forest fire," she told me, "you may still have an opportunity for nutrients to grow—things can still live in a forest that's been burned—but ultimately, it's a less good habitat" for many creatures.

And scientists conducting beach surveys won't know for at least another year or two if oyster and clam reproduction was affected in the 2021 heat wave. Did some animals die before they got the chance to reproduce, potentially resulting in a smaller population? If they had already reproduced, were their young offspring more susceptible to dying in the heat than adults? Who lives, and who dies, could affect which genes get passed to future generations.

Researchers don't yet know whether, in the face of repeated heat waves, organisms will become more resilient or more vulnerable. Initial research by Sandra Emry, a postdoctoral researcher at the University of British Columbia, suggests the latter could be true. "It's like getting a sunburn on top of another sunburn," Harley said. Right before the 2021 heat wave, Emry happened to drag space heaters across the shoreline to blast patches with extra heat. So she was able, later, to see that macroalgae pre-exposed to heat stress did worse when the heat wave hit. "While it might seem intuitive that two heat waves are worse than one, I don't think we actually knew that before," Emry told me.

On Fidalgo Island in the U.S., the Swinomish tribe is working to protect the intertidal zone from future heat waves with clam gardens, an ancient practice that could help keep clams cool. One popular beach for subsistence clamming on the tribe's reservation is also highly restricted—no cockle harvesting is allowed—so the species can continue to recover. "These beds have been maintained for thousands of years by Swinomish tribal members," Joseph Williams (Squi-qui), a fisherman and the former vice chair of the tribe, told me; tribal members' ancestors signed a treaty that gave up much of their homeland in exchange for continued hunting and fishing rights in the region.

Others in this area depend on intertidal creatures financially: Commercial shellfish growers reported additional clam and oyster mortality following the 2021 heat wave. And for some, these losses are not just about food. "We were taught that our foods are more than just for physical nourishment," Williams told me. "Our foods are here to feed our soul also." The heat dome's consequences are rippling through life in a warmer world: In the intertidal zone, extreme heat changes how habitats function, which changes how the landscape may respond to future heat waves, which could affect entire ecosystems in yet-unknown ways. One extreme event might be devastating, but we can still only imagine the full consequences as these events repeat over and over again.