Heat wave of 2021 created 'perfect storm' for shellfish die-off

June 21 2022, by Michelle Ma

Dead oysters seen along a shoreline in Washington state, following a record heat wave in summer 2021. Credit: Blair Paul

It's hard to forget the excruciating heat that blanketed the Pacific Northwest in late June 2021. Temperatures in Oregon, Washington and British Columbia soared to well above 100 degrees Fahrenheit, with Seattle setting an all-time heat record of 108 degrees on June 28.

During the heat wave, also called a heat dome, scientists and community members alike noticed a disturbing uptick of dying and dead shellfish on some beaches in Washington and British Columbia, both in the Salish Sea and along the outer coast. The observers quickly realized they were living through an unprecedented event and they organized to document the shellfish die-offs as they happened in real time.

Now, a team led by the University of Washington has compiled and analyzed hundreds of these field observations to produce the first comprehensive report of the impacts of the 2021 heat wave on shellfish. The researchers found that many shellfish were victims of a "perfect storm" of factors that contributed to widespread death: The lowest low tides of the year occurred during the year's hottest days—and at the warmest times of day. The results were published online June 20 in the journal *Ecology*.

"You really couldn't have come up with a worse scenario for intertidal organisms," said lead author Wendel Raymond, a research scientist at UW Friday Harbor Laboratories. "This analysis has given us a really good general picture of how shellfish were impacted by the heat wave, but we know this isn't even the full story."

The research team leveraged existing collaborations across tribes, state and federal agencies, academia and nonprofits. They devised a simple survey and five-point rating system (1 = much worse than normal to 5 = much better than normal) and asked participants to provide ratings based on their knowledge of a species in that location. In total, they gathered 203 observations from 108 unique locations, from central British

Columbia down to Willapa Bay, Washington.

Joe Williams, front, and Darrell Williams with the Swinomish Indian Tribal Community's Fisheries Department dig clams on a beach in Skagit Bay as part of a survey that is conducted to estimate clam biomass. Credit: Northwest Indian Fisheries Commission

"The strength of this study and what it really highlights is the value of local knowledge and also the importance of understanding natural history," said co-author P. Sean McDonald, a UW associate teaching professor in environmental studies and aquatic and fishery sciences. "This is the first step and a snapshot, if you will, of what shellfish experienced on the beaches during the heat wave."

The researchers found that each species' ecology contributed to its general success or failure to survive the extreme heat. For example, some shellfish that naturally burrow deep beneath the surface, like butter clams, usually fared better than ones that typically ride out low tide just below the sand's surface, such as cockles.

They also found that location mattered. Shellfish on the outer coast experienced low tide about four hours earlier than shellfish on inland beaches. For inland shellfish, low tide—or when the most shellfish were exposed—hit around solar noon, when the sun was directly overhead.

Additionally, air temperatures were much higher at inland sites compared to the outer coast, causing more stress on inland populations. For example, California mussels, found almost exclusively on the outer coast, mostly survived the heat while bay mussels, found in more inner coastal sites, were more likely to die from heat exposure. More water movement and wave action on the outer coast also likely helped lessen the impacts of the heat on shellfish along those beaches.

Many shellfish don't tend to move much on any given beach, so where they naturally live in the intertidal zone also contributed to their success or failure, the researchers found. For example, acorn barnacles that live higher on the shore generally were more impacted than clams and oysters that are lower on the beach and more likely to remain under water.

Julie Barber, senior shellfish biologist with the Swinomish Indian Tribal Community, quantifying recent butter clam deaths on a beach in Skagit Bay, Washington, in July 2021, following a record heat wave. Credit: Northwest Indian Fisheries Commission

"Although this event had negative effects on marine life, there is hope that can be found in this work. Not all locations and species were

affected equally, offering clues to pathways to resiliency in the future," said co-author Annie Raymond, a shellfish biologist with Jamestown S'Klallam Tribe.

Perhaps most surprisingly, the researchers noticed interesting patterns in survival rates among shellfish on the same beach. In some locations, shellfish in the path of freshwater runoff on one section of beach survived, while others just a few miles away perished. If a tree hung over part of a beach and shaded the sand, those shellfish generally made it while others didn't. Co-author Julie Barber, senior shellfish biologist with the Swinomish Indian Tribal Community, remembers seeing those patterns while walking the beaches of Skagit Bay, and in some locations, being surrounded by dead cockles in every direction.

"It was pretty unsettling, and I've never seen anything like it," Barber said. She remembers exchanging emails with colleagues from around the region as they noticed similar mass die-offs on their local beaches, then realizing that they urgently needed to coordinate and document what was happening.

"This effort was a beautiful demonstration of how collaborators can come together with one common cause—which in our case was trying to understand what happened to these shellfish," Barber said.

Because the heat wave occurred during the time frame when many shellfish are reproducing, the mass die-offs could impact those populations for at least several years, highlighting the need for long-term monitoring, the researchers said. And as climate change continues to produce more frequent extreme heat events, shellfish deaths like those of last summer may become more of a common reality.

Dead cockles seen on a beach after record heat in July 2021 in Skagit Bay, Washington. Credit: James McArdle

"The Swinomish Indian Tribal Community is proud to be a leader in this important scientific research that assessed in real time the devastating impacts to our shellfish resources from the unprecedented heat dome last summer. Shellfish are a priority first food that our tribal community relies on for spiritual and subsistence nourishment. Last summer's extreme weather event reinforced to us that we must act faster to ensure climate resiliency for our community's long-term health and well-being," said Swinomish Tribal Chairman Steve Edwards.

"Once the effects of the heat wave started to become apparent, the collaboration that emerged was amazing as managers and scientists worked quickly to put together a rapid response to capture information," said co-author Camille Speck, Puget Sound intertidal bivalve manager for Washington Department of Fish and Wildlife. "We still have so much to learn about the effects of the heat wave on Salish Sea marine ecosystems, and more work to do as managers to prepare for the next

one and develop informed responses. These conversations are happening now, and it is our hope that we will be better prepared for whatever comes next."

Other co-authors are Megan Dethier of the UW; Teri King of UW-based Washington Sea Grant; Christopher Harley of University of British Columbia; Blair Paul of Skokomish Indian Tribe; and Elizabeth Tobin of Jamestown S'Klallam Tribe. More than two dozen individuals contributed data to this project.

More information: Wendel W. Raymond et al, Assessment of the impacts of an unprecedented heatwave on intertidal shellfish of the Salish Sea, *Ecology* (2022). DOI: 10.1002/ecy.3798

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