Ocean heat waves remake Pacific and Caribbean habitats

Enlarge / Although these corals are colored, they've been bleached, in that they have lost their photosynthetic symbiotes.

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Climate change tends to deal in averages. We measure its progress using the global mean temperature, and we use climate models to project what that value will be in the future. But those average changes don't always capture what future climate change will be like. While you can raise an average by increasing every day's temperature by a tiny amount, it's also possible to raise an average by throwing in an occasional extreme event. Heat waves and extreme storms have indicated that nature seems to be going for the latter option.

A new paper shows that this kind of climate change isn't just affecting the sorts of weather we typically experience; it's happening in the oceans as well. The study shows that, over the course of less than a century, the frequency of oceanic heat waves went up by more than 50 percent. The study looked into the effects these events are having on ecosystems, and it showed that we're pushing species toward the poles without affecting all of them equally.

Heating the ocean’s waves

When the subject is the atmosphere, the common practice is to track the frequency and extent of heat waves and even to determine if they have been influenced by climate change. By contrast, there was no widely accepted definition of when warming waters constituted a heat wave until 2016. That’s in part because of the differences in the driving process and scale. Localized ocean heat waves can be driven by a corresponding heat wave in the atmosphere, while El Niño events are driven by large-scale current patterns that influence most of the Pacific.

But the recent definition can encompass both of those. That’s because it defines heat waves as exceeding a seasonal-adjusted threshold (say, hotter than 90 percent of the typical readings in spring) for at least five days. This not only provides a yes/no answer on “is it a heat wave?” but it also helps define the geographic extent of the extreme water temperatures, which can in turn help us understand the processes driving it.

The authors took this definition and examined the historic record to track the frequency of marine heat waves (others have done a similar analysis and produced equivalent results). As you would expect on a warming planet, their results have gotten far more common: “As a global average, there were over 50 percent more [marine heat wave] days per year in the last part of the instrumental record (1987–2016) compared to the earlier part.”

- The number of days in a year with a heat wave happening somewhere in the ocean. Note the dramatic rise in recent years.
  Daniel Smale
- Areas most commonly affected by ocean heat waves shown in red. These include the area most strongly affected by El Niño in the Pacific and the Caribbean.

Daniel Smale

But that language obscures just how dramatic the change has been. As seen in the graph above, strong El Niño events over the last two decades have caused more heat waves than any in the historic record, and the recent one was roughly twice as strong as any prior to it. While many of these events are concentrated along the areas most affected by El Niños, the accompanying map shows that this is a global problem, with very few areas of the oceans unaffected.

Swimming with the fishes

This isn’t the first analysis of this sort, and the others have produced similar results. But the authors expand on this by looking at the ecology of the areas. These areas are affected by some of the larger marine heat waves on the record, and the authors take advantage of a large number of studies performed by other researchers (they determined that there are eight oceanic heat waves that have been studied in sufficient detail). They also focus their examination on three critical species: corals, sea grass, and kelp.

In general, ecosystems suffer under marine heat waves. The only things that clearly do OK are the ones that can move. Both fish and mobile invertebrates seem to manage the heat waves reasonably well; fish, in fact, saw an increase in diversity as tropic species began moving into unoccupied habitats. The authors suggest mobile species had two advantages: they can move to cooler waters if necessary, and their ability to change habitats has left them more tolerant to a broad range of temperatures. The exception to this is birds, which are among the most severely affected group; they suffered because of changes in prey availability. Corals, which bleach at high temperature, also did poorly.

The researchers then looked specifically at species that were near the edge of their temperature tolerance—where the heat

waves hit the part of their habitat that was closest to the equator. Data from a set of 300 species showed that these were especially sensitive to marine heat waves; the authors also cite data showing that these heat waves can shift the equatorial limits of species by as much as 100 kilometers.

Finally…

Finally, all three key species they focused on were hit in different ways by the oceanic heat waves. Corals tended to bleach, leaving them vulnerable to death; seagrass grew at lower densities; and the total biomass of kelp declined. These species tend to provide both habitats and resources for many others, so these problems can cascade across the ecosystem.

While these heat waves are taking place against a backdrop of general ocean warming, the dramatic effects seen here seem to be driven by the heat waves, which drive sudden, radical changes. While some of those may be reversed over time—assuming another heat wave doesn't come along—it's not clear whether all of them will or on what time scales. That, the authors argue, means understanding average temperatures isn't good enough here.

"The main focus of ecological research has been on trends in mean climate variables," they write, "yet discrete extreme events are emerging as pivotal in shaping ecosystems, by driving sudden and dramatic shifts in ecological structure and functioning."

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