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Scientists Identify Climate Change as Major Contributor to Record-Breaking Marine Heatwave

Scripps Oceanography team used a century of ocean data collected by the Shore Stations Program and new method of temperature analysis to put the 2018 marine heatwave in context

Two new studies led by scientists at Scripps Institution of Oceanography at the University of California San Diego highlight the significance of long-term observations for understanding ocean climate trends and events, including record-shattering marine heatwaves.

Both studies, which appear in the *Journal of Geophysical Research: Oceans,* utilize more than a century of ocean temperature data collected by the Scripps Shore Stations Program in their analysis. Since 1916, Scripps Oceanography scientists and Birch Aquarium staff have taken daily measurements manually off Scripps Pier with a weighted bucket and thermometer, efforts that have resulted in the longest continuous record of seawater temperature on the Pacific Rim.

One study identifies climate change as a major contributor to a record-breaking marine heatwave in August 2018. The heating event occurred in the Southern California Bight—the curved coastline of Southern California from Point Conception to northern Baja—and broke multiple sea-surface temperature records collected at Scripps Pier before peaking at 26.4°C (79.5°F) on Aug. 9, 2018. This reading still stands as the highest ocean temperature ever recorded in La Jolla, Calif.

A marine heatwave is a prolonged period of water temperature that is unusually warm over a specified time and space. In the case of the August 2018 marine heatwave, which lasted 43 days, researchers found that the amount of warming linked to climate change accounted for an

increase of 19 additional marine heatwave days and an increase in overall intensity.

Scripps researchers were able to analyze the 2018 heating event in the context of longer oceanographic trends by using measurements collected by the Shore Stations Program—which is currently funded by the California State Parks' Natural Resources Division—as well as temperature data obtained by underwater gliders and satellite measurements.

"The century-long duration of the sea-surface temperature record from Scripps Pier allows us to highlight a concrete example of marine heatwave intensification due to climate change," said lead author Jimmy Fumo, a staff research associate at Scripps. "Marine heatwaves have always occurred at Scripps Pier, however, the frequency and duration of these events have become more pronounced in recent years."

In a companion study, Scripps researchers present for the first time the full Scripps Pier time series of sea-surface temperature and describe a new method for minimizing historical biases. This method was applied to compensate for variations in the time of day samples were collected and more closely reflect the daily average.

Over the years, the time of day samples are taken at the pier has shifted, with samples from early years collected earlier in the morning and samples from later decades collected around mid-day, when the water is typically warmer due to exposure to the sun. The researchers used observations of solar radiation from the end of the pier to create a model of the estimated monthly heating and cooling cycle of the water. The model then tells researchers, for example, approximately how far off an 8:00 a.m. reading taken in August would be from the daily average.

Researchers say the Scripps Pier time series adjustment method, which took years to finalize, has large implications for future research because it is a data set that is used extensively, and one of very few that extend back to the early twentieth century.

"Researchers often need data that quantifies how much temperature has changed over time, but it was unclear how much change in the Scripps Pier data was from the shift in sampling time, and how much was from broader environmental trends," said Scripps scientist Linda Rasmussen, lead author of the study describing the new method. "Adjusting for the time of day of sampling makes the temperature time series more useful for evaluating long-term trends such as those that would be observed with large-scale ocean warming."

In the study of the century-long time series, the Scripps team calculated a long-term warming trend of 1.2°C (2.2°F) per century using sea-surface temperature data collected at Scripps Pier from 1916 to 2018.

This calculation played a crucial role in the marine heatwave study. By removing the long-term trend from the record and re-calculating the 2018 marine heatwave both with and without the trend present, researchers were able to isolate the anthropogenic, or human-caused, warming signal present in the data.

The research team involved with the marine heatwave study also looked at data collected by NOAA satellites, which showed that the 2018 heating event manifested offshore the northern half of the Baja California Peninsula, tapering off toward southern California. They used this data to categorize the marine heatwave as severe, noting its relatively long duration and high-intensity when compared to other events in the time series.

Satellite data also showed that the regional marine heatwave was mainly driven by solar heating of a thin ocean mixed layer in the Southern California Bight, coupled with decreased albedo due to unusually low cloud formation, high atmospheric moisture, and reduced winds. The heating event broke records mostly due to the anthropogenic warming trend and the fact that it occurred during summer, said the researchers.

Below the surface, researchers looked at what was going on using data collected by Spray underwater gliders. These autonomous profiling vehicles—part of the California Underwater Glider Network—have the ability to measure temperature and salinity to depths of 500 meters (1,640 feet). During the 2018 marine heatwave, glider profiles in the Southern California Bight showed that unusually warm temperatures were greatest near the surface and extended down to at least 100 meters (328 feet).

“Conditions off Southern California have changed markedly since the 2014 marine heatwave,” said Daniel Rudnick, a physical oceanographer at Scripps and study co-author. “In addition to the high temperatures in the upper 100 meters, we have also seen unusually high salinities since 2018. These anomalies point to fundamental changes in the circulation and source waters feeding into the Southern California Bight.”

Both studies underscore the importance of long-term observation programs which provide critical data that enable a better understanding of environmental changes. Reinhard Flick, a California State Parks oceanographer and Scripps research associate, said this kind of long-term dataset is important not just for scientists but also for state decision-makers.

“This valuable information enables us to understand the nature and scope of environmental change, in order to use the best available science to take action,” said Flick, a co-author of both studies and long-time manager of the Shore Stations Program.

These sentiments were echoed by the rest of the Shore Stations team and Fumo, who noted that the utility of the data set is increasing with time.

“The Shore Stations Program measurements have been lovingly collected by countless Birch Aquarium and Scripps employees for over a century. These studies highlight this magnificent data set, which helps us keep the program running.” said Fumo. “While we are hopeful that the record-high temperature of 2018 will stand for some time, we anticipate climate change will continue to drive high intensity marine heatwaves and we will continue collecting data to monitor these future events.”

The marine heatwave study was authored by Fumo, Rudnick, Rasmussen, Melissa Carter, and Sam Iacobellis of Scripps, and Flick of California State Parks and Scripps. The time series adjustment study was authored by Rasmussen, Carter, Fumo, Mary Hilbern, Bruce Cornuelle, and John McGowan of Scripps; Flick of California State Parks and Scripps; Bonnie Gordon of Curtis Instruments; Lee Bargatze of UC Los Angeles; and R. Lee Gordon of Doppler, Ltd.

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