The blob

Too much warmth and too little wind fueled a massive marine heat wave along the Pacific Coast.

By Laura Naranjo

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In 2013, a mysterious pool of warm water developed off of Alaska. This marine heat was so persistent and unusual that it initially defied explanation. The pool lingered in the sub-Arctic Bering Sea and Gulf of Alaska through winter, and then quickly expanded south along the Pacific Coast. By summer of 2014, the heated mass of water stretched from Alaska to Mexico and had been nicknamed "the blob."

As the blob spread, unusually warm waters triggered extended harmful algae blooms. Although such blooms are common, they usually only last a couple of weeks before dissipating. However, the blob fueled longer-lasting and more pervasive blooms, which became toxic to marine life and humans. Higher ocean temperatures also increased warm water algae species, which were less nutritious for marine life.

By the end of 2015, both blob and blooms had shut down much of the Pacific fishing industry and upended the marine food chain. Dead fin whales and sea otters began washing up along the Alaskan coast. Chinook salmon populations in Washington and Oregon plummeted. Hundreds of sea lions starved along California shorelines.

Scientists were left scratching their heads. Why had this warm pool of ocean water spread so far and lingered for so long?

A malnourished sea lion pup is stranded on shore in 2015. A marine heat wave lasting from 2013 to 2016 stranded sea lion pups along the California coast in record numbers. Rescued pups were in a malnourished state by the time they arrived at rehabilitation centers. (Courtesy National Oceanic and Atmospheric Administration Fisheries West Coast)

Whence the warming

One of these scientists, researcher Chelle Gentemann, grew up on the Pacific Coast, where she and her family spent summers fishing for salmon. Now an oceanographer, Gentemann tracks ocean temperatures, and the blob had caught her and her colleagues' attention.

In September 2014, NOAA scientists noted that a buoy off the coast of Newport, Oregon, recorded a seven-degree Celsius (thirteen-degree Fahrenheit) rise in temperature over the course of only one hour. "I know that area really well, and seven degrees is a huge jump," Gentemann said.

Typically, the surface of the ocean follows a daily temperature cycle: warming a bit when the sun is out and cooling again at night. But this spike was well out of normal daily ranges, an ominous sign of how unusually warm the blob was and how quickly it was expanding southward. "The timing of this warm event indicated that it wasn't due to the normal daily heating, but that it really was due to advection [spreading] of a warm patch of water into the area of the buoy," Gentemann said. "And that warm water was from the blob."

Although El Niño conditions were present in 2014, and typically cause warmer oceans and milder winters along the Pacific Coast, researchers ruled it out as a source for the blob. "The El Niño was very weak that year," Gentemann said. "And it has a very distinct signature in how the heat is transferred from the equatorial Pacific up through and along the California coast. And the pattern just didn't match." The blob had formed in the Gulf of Alaska, and spread south. Slight El Niño warming may have magnified some of the temperatures along Mexico and southern California, but it was not behind the blob's persistence or behind the marine die-offs stretching from California to Alaska.

During the Pacific marine heat wave that lasted from 2013 to 2016, hundreds of seabirds starved and died. This common murre was too weak to fly when it was found on the shore of Kodiak Island, Alaska. (Courtesy Robin Corcoran/US Fish and Wildlife Service)

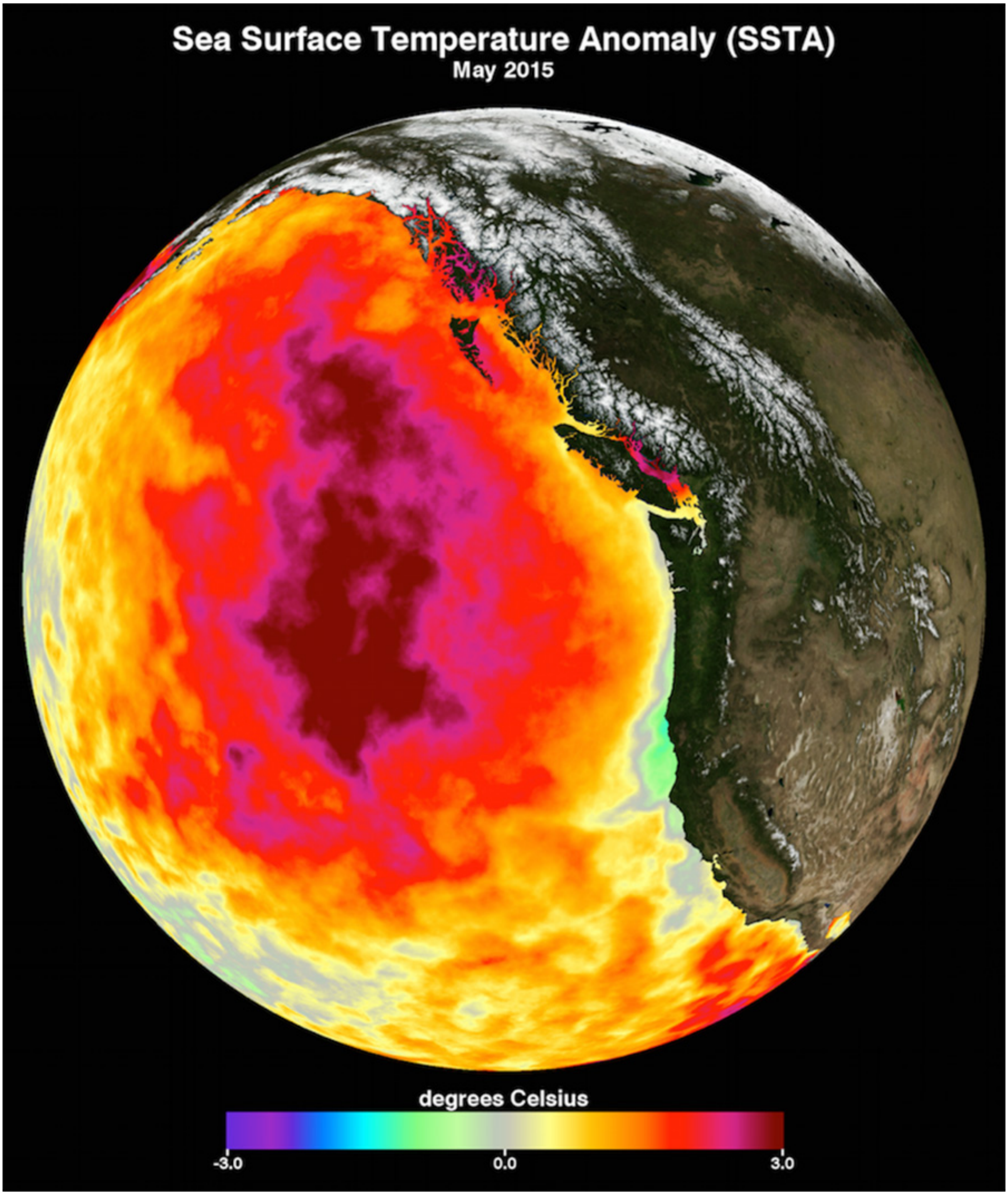
Missing the mixing

To figure out where this inexplicable warmth was coming from, Gentemann and her colleagues tracked ocean temperatures using an ensemble data set: the Multi-scale Ultra-high Resolution Sea Surface Temperature (MUR SST) Analysis. This ensemble product combines readings from several satellite sensors, and is available from the NASA Physical Oceanography Distributed Active Archive Center.

“Prior to the MUR SST with its one-kilometer resolution, we really didn’t have that glimpse into what was happening along the coast because the satellite data were very spotty,” Gentemann said. Getting a more detailed look at the coastal environment is crucial for understanding ocean mixing. This mixing helps disperse heat from the upper layers of the ocean into deeper waters, while at the same time upwelling cooler, nutrient-rich waters. Nutrients surfaced by upwelling form the basis of the marine food chain. When upwelling is disrupted, so is the coastal food supply.

Because upwelling is fueled in part by temperature, even just a few degrees of abnormal warmth can slow or halt the cycle. But upwelling also depends on winds to help push surface layers away from the coast, providing a horizontal assist to the vertical top-to-bottom upwelling circulation. To complete the emerging picture of a coast in distress, Gentemann incorporated two wind data sets. The Bakun Upwelling Index measures sea level pressure as a proxy for wind stress at the ocean surface, and the European Centre for Medium-Range Weather Forecasts Re-Analysis-Interim Winds product provided wind velocity data.

Gentemann and her colleagues found that prolonged heat from the blob, combined with unusually weak coastal winds, hindered upwelling along much of the Pacific Coast during the marine heat wave. Like the blob, the weakened winds were unusual. Atmospheric rivers normally delivered a steady stream of winds and precipitation from the Pacific. But these rivers were being blocked by a persistent ridge of high pressure in the atmosphere that hunkered over the north Pacific between 2012 and 2015. “It was preventing the winter storms from hitting the West Coast,” Gentemann said. Storms typically usher in windier weather along the coast that help churn the ocean surface and foster upwelling. “There were just no storms. It was just sunny the entire winter,” Gentemann said. “The storms would come up and then they’d hit this ridge and go north.” Fewer storms meant less wind, less upwelling, and fewer nutrients for fish, but ripe conditions for extensive algal blooms. This devastating combination starved whales, sea lions, fish, and a host of marine life. Even seabirds like common murres, which feed on fish and mollusks that flourish in typically cold coastal waters, starved along coasts from Alaska to California.



This data image shows the monthly average sea surface temperature for May 2015. Between 2013 and 2016, a large mass of unusually warm ocean water--nicknamed the blob--dominated the North Pacific, indicated here by red, pink, and yellow colors signifying temperatures as much as three degrees Celsius (five degrees Fahrenheit) higher than average. Data are from the NASA Multi-scale Ultra-high Resolution Sea Surface Temperature (MUR SST) Analysis product. (Courtesy NASA Physical Oceanography Distributed Active Archive Center)

Ominous impacts

Scientists do not yet know what caused the unprecedented atmospheric ridge, or why it persisted so long. Some research hints that overall ocean warming stimulated this response. Other research indicates the opposite, that the ridge caused the blob to form, and a persistent feedback compounded the multi-year endurance of both blob and ridge. Yet other studies implicate changes in Arctic sea ice that cause shifts in global atmospheric patterns.

The atmospheric ridge dissipated in 2015, and the blob finally subsided in early 2016, but marine animals—and the many coastal industries that depend on them—will take much longer to return to normal. Some species may take years to recover. Waylaid by the disaster, some fisheries and canneries shuttered their doors.

Although marine heat waves are nothing new, and have occurred in seas and oceans around the globe, climate change may amplify them. "You would in some sense expect them to be more common, because in general, the Earth is warming," Gentemann said. "But whether or not you get these extreme events, whether those increase in frequency, as well, is a question a lot of scientists are asking right now."

Gentemann and her colleagues plan to continue tracking sea surface temperatures using the MUR SST product. Not only can they monitor future marine heat waves, but develop better ways to characterize them and understand how they impact coastal regions. "Is it a ten-day warming, or is it a two-year warming?" Gentemann asked. "These high-resolution analyses are critical to being able to understand what is going on directly at our coasts, because it's such a dynamic region."

The blob of warm water that spread from Alaska to Mexico between 2013 and 2016 devastated many commonly-fished marine species, including Coho salmon. (Courtesy US Bureau of Land Management)

For more information

NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC)

References

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About the remote sensing data

About the remote sensing data	
Satellites	Various
Sensors	Moderate Resolution Imaging Spectroradiometer (MODIS) Advanced Very High Resolution Radiometer (AVHRR) Advanced Microwave Scanning Radiometer-EOS (AMSR-E) Advanced Microwave Scanning Radiometer 2 (AMSR2) WindSat Buoys/ships
Data set	Multi-scale Ultra-high Resolution (MUR) Sea Surface Temperature (SST) Analysis (MUR SST) v4.0
Resolution	1 kilometer
Parameter	Sea surface temperature
DAAC	NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC)