

## Ocean upwelling delay gives scientists sneak preview of what future may hold

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CORVALLIS — A one-month delay in the annual spring “upwelling” of the California current in 2005 provided scientists with a sneak preview of what conditions may be like if global climate change models prove accurate.

And those results, published this week online by the Proceedings of the National Academy, include numerous anomalies affecting West Coast marine ecosystems.

Though the scientists stop short of saying the upwelling delay and its associated impacts were caused by global warming, they acknowledge that the changes are consistent with what most climate change models predict will happen.

“Delays in the onset of upwelling and strong late-season upwelling are consistent with regional climate change models and that’s exactly what we saw in 2005 off the West Coast of the United States,” said Jack Barth, a professor in the College of Oceanic and Atmospheric Sciences at Oregon State University and lead author on the study. “The winds were late in arriving by one month, resulting in the lowest upwelling-favorable “wind stress” in the region during the past 20 years.

“The winds eventually picked up and triggered strong upwelling late in the season, but for some species that depend on those nutrients being there, it was too late,” Barth added. “The juvenile recruits for both barnacles and mussels, for example, were down considerably.”

Mussel recruits were down 83 percent, while barnacle recruits were only 66 percent of normal, the study pointed out.

During the spring of 2005, upwelling didn’t begin until June — a month later than usual. During that

time, nearshore waters were two degrees (Celsius) warmer than normal, while chlorophyll levels in the surf zone were only half of normal, and nutrient levels were about 30 percent lower.

Barth said the one-month delay was associated with 20- to 40-day wind oscillations that accompanied a southward shift of the Jet Stream in 2005. In recent years, the Jet Stream has experienced "wobbles" that can warm the waters of the Pacific Ocean of the Northwest coast and hamper upwelling when the shift is to the south, or it can accelerate upwelling when it shifts northward.

What causes these shifts isn't clear to scientists, but the influence of the enormous mountain ranges in Asia and North America on wind patterns may play a role.

"One major change has been the appearance of persistent wind patterns of 3-5 weeks overriding what used to be patterns that lasted more like two to five days," Barth said. "The shorter time frame was healthy for the upwelling system; the winds could trigger upwelling and when they died down the shelf would be a great incubator for growth.

"With wind patterns lasting a month or more, you can get a major delay in upwelling," Barth pointed out, "or you can long windy periods that result in super-charged upwelling like we had in 2006, when the ocean production was so great it created a major hypoxic event along the Pacific Northwest coast."

Although the researchers' PNAS study focused only on the 2005 delay, the last decade has seen significant variability outside the norm. The swing began in 1997-98 with one of the most powerful El Niño episodes on record, as ocean waters off the West Coast grew warmer, nutrients decreased, biological production was reduced, and species from zooplankton to salmon disappeared, were drastically reduced or moved from their typical habitats. The El Niño capped what had been a series of years through the 1990s characterized by warm waters and weak upwelling.

That regime ended abruptly in late 1998, and the California Current system entered a four-year period of cold ocean conditions that led to strong phytoplankton and zooplankton productions and a rebound in salmon runs.

The final hurrah of that cold-water period came during the summer of 2002, when the system received an influx of sub-arctic water that triggered massive phytoplankton production in the surface waters. As the organisms decayed and sank to the bottom, they sucked oxygen out of the lower water column, leading to hypoxia and marine die-offs of crabs and other species that were unable to move out of the area.

And though the ocean waters warmed over the next four years, the West Coast has experienced hypoxia events every summer, according to Francis Chan, a senior research assistant professor at Oregon State University and one of the authors of the PNAS study.

“When it comes to upwelling and phytoplankton production, there can be too much of a good thing,” Chan said. “Although the low-oxygen zone has varied in intensity from year to year, 2006 saw an unexpected expansion and degradation in oxygen conditions. At least 3,000 square kilometers of the continental shelf along the Oregon coast were affected.”

OSU’s Jane Lubchenco, who organized a symposium on West Coast variability for the annual American Association for the Advancement of Science meeting, said the bottom line is that the dramatic events of the past few years have shown how vulnerable our oceans are to changes in overall climate “and how quickly ecosystems respond.

“Wild fluctuations in the timing and intensity of the winds that drive the system are wreaking havoc with the historically rich ocean ecosystems off the West Coast,” Lubchenco said. “As climate continues to change, these arrhythmias may become more erratic. Improved monitoring and understand of the connection between temperatures, winds, upwelling and ecosystem responses will greatly facilitate capacity to manage those parts of the system we can control.”

Researchers in the study included Barth, Chan and Lubchenco, as well as OSU colleagues Bruce Menge, Anthony Kirincich and Stephen Pierce; John Bane, of the University of North Carolina at Chapel Hill; Margaret McManus, University of Hawaii at Manoa; Karina Nielsen, Sonoma State University; and Libe Washburn, University of California at Santa Barbara.

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