Climate variability has an opposing impact on marine life and tree growth

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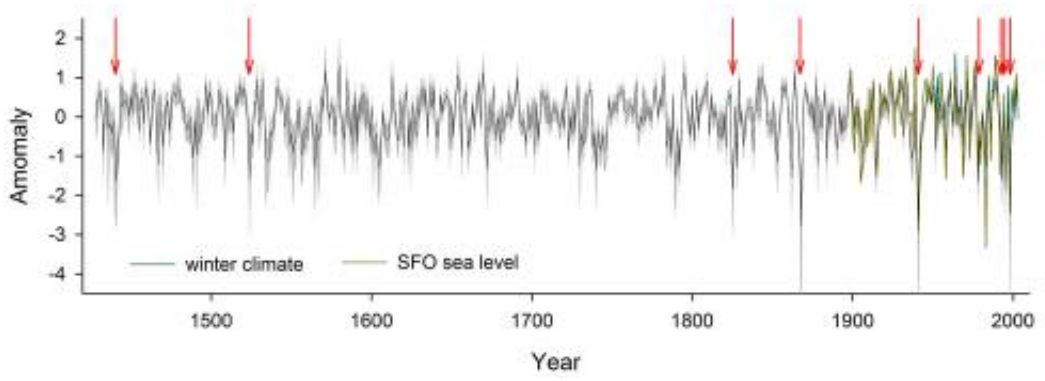

A history (1428-2003; black line) of winter climate in the California Current ecosystem derived from blue oak tree ring data.

The same climatic drivers that enhance upwelling of nutrient-rich ocean waters and support of marine productivity can result in lower precipitation on land and slower tree-growth. Tree-ring chronologies helped to explain how upwelling was happening during the past 600 years. This was outlined in a recent study published in *Science* by an international team of scientists including David Frank of the Swiss Federal Research Institute WSL and the University of Bern's Oeschger Center.

The new study, led by Bryan Black at The University of Texas at Austin's Marine Science Institute which has appeared in the September

19th issue of the journal *Science*, links short-term reductions in growth and reproduction of marine animals off the California coast to increasing variability in the strength of coastal upwelling currents. The upwelling of cold, deep, nutrient-rich waters towards the sunlit ocean surface is a key process in the oceans that fuels phytoplankton blooms that ultimately support fish, seabirds, and marine mammals.

"We know that the Earth's climate system is highly variable, but instrumental measurements in many parts of the world generally are shorter than 100 years. This is far to short to understand rare climatic phenomena and the impacts of extreme events", said David Frank, Dendroclimatologist at the Swiss Federal Research Institute WSL, and co-author of this study.

Tree-rings: a valuable archive of climate information

To quantify upwelling and understand the impacts on the marine ecosystem off the California coast, one of the most important upwelling zones globally, the team turned to a surprising source: tree-rings from long-lived blue oak trees. The researchers demonstrated that growth patterns in blue oak trees near the coast are highly sensitive to the same climate factors associated with upwelling. During the past 600 years, four of the 10 most extremely poor upwelling years occurred since 1950, and seven of 10 have occurred since 1850.

The team furthermore investigated the effects of changing strength of upwelling on marine life by integrated data on how quickly fish grew every year since the 1940s, the timing of seabird egg laying since the 1970s, and the fledgling success of seabirds since the 1970s.

The researchers found an exceptionally high correlation between climate and both marine and terrestrial productivity. "It's interesting to see how influential climate is on biology and what a synchronizing force it is,

especially across marine and terrestrial systems", said lead author Black.

Higher marine productivity coincident with less tree growth

High pressure systems that favor winter upwelling and support marine productivity block storm fronts and precipitation from falling on the land, and thus cause slower growth of the drought sensitive blue oak trees. Winters with extremely weak upwelling are associated with slower growth in fish and lower reproductive success for seabirds, underscoring the importance of upwelling for the conservation of endangered animals and management of commercially important fisheries.

"So in effect we see opposite effects of the same climatic conditions when we look at marine organisms or trees growing nearby on the land", says Frank. He continues "We see how interconnected and complex the earth's climate system is, especially when we are trying to understand interactions and feedbacks with biological systems."

"Our study underscores the fact that California is a place of high coastal upwelling variability", said Black. "You have to keep that in mind if you're managing a fishery—for example, you can't plan for every year being moderate or reliable. There are a lot of ups and downs."

More upwelling due to climate change?

One question that remains is if climate change has contributed to the changes in winter upwelling variability. The strength of upwelling does seem to be related to a climate pattern called the El Niño-Southern Oscillation (ENSO). And there is evidence that ENSO has been unusually variable during the past century, which may in part explain the pattern in upwelling extremes.

"This is consistent with what we expect from climate change, but at this point, we can't attribute it to that", said Black. This is something the research community needs to continue watching to see how climate variability plays out in the coming years. "We understand the atmospheric drivers behind winter upwelling, so now we plan to use climate models to see what they say about these drivers and whether they forecast change for those in the future", Black continues.

"We've made remarkable progress over the past decades towards greater understanding of the climate system. A few years ago, I wouldn't have expected to see such strong links between what is going on in the ocean and what is happening on land", concluded Frank.

More information: Bryan A. Black, William J. Sydeman, David C. Frank, Daniel Griffin, David W. Stahle, Marisol García-Reyes, Ryan R. Rykaczewski, Steven J. Bograd, William T. Peterson (2014): Six centuries of variability and extremes in a coupled marine-terrestrial ecosystem. *Science* 19 September 2014: Vol. 345 no. 6203 pp. 1498-1502. DOI: 10.1126/science.1253209

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