

# News Release

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## **Ocean upwelling becoming more intense with climate change, new research reveals**

**Authors: William J. Sydeman, Marisol García-Reyes, David S. Schoeman, Ryan R. Rykaczewski, Sarah Ann Thompson, Bryan A. Black, and Steven J. Bograd**

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**Petaluma, California, USA** – An international team of scientists has shown that winds that cause coastal upwelling off the west coasts of North and South America and southern Africa have increased over the past 60 years, indicating a global pattern of change.

The leader of the team, Dr. William J. Sydeman of the Farallon Institute for Advanced Ecosystem Research (FI; [www.faralloninstitute.org](http://www.faralloninstitute.org)), said, “We were amazed by the consistency of the wind trends found across the globe. This pattern suggests we have found an important general trend in winds, a response to climate change that is likely to have significant impacts on fisheries production and, more generally, the health of these coastal ocean environments.”

Co-author Dr. David Schoeman of the University of the Sunshine Coast in Australia commented, “This study is one of the first to statistically synthesize the literature on wind trends in these critical marine environments.” Drs. Schoeman and Sydeman were also contributing authors to the new chapter on ocean ecosystems (Chapter 30) for the Intergovernmental Panel on Climate Change Fifth Assessment Report. Dr. Schoeman notes, “In preparing sections on coastal upwelling ecosystems, it

was evident we didn't have a clear understanding of how upwelling-favorable winds are changing."

The team was inspired to undertake this study due to concern about the effects of climate change on coastal upwelling ecosystems that provide substantial services to society. Debate within the scientific community about the direction of changes in upwelling-favorable winds indicated a need for synthesis of information on wind trends. In 1990, fisheries oceanographer Andrew Bakun proposed that increased greenhouse gases would lead to intensification of upwelling in the world's eastern boundary current systems (EBCSs, see "Other Information" below). Scientists at the Farallon Institute and their collaborators synthesized and analyzed information from 22 different studies conducted in upwelling regions around the world since 1990. Their analysis tested whether published results support the conclusion that upwelling-favorable winds are increasing at global scales, as suggested by Bakun's theory.

### **What were our results and what do they mean for ecosystem productivity?**

The team found that the existing body of research generally supports Bakun's hypothesis, with evidence of wind intensification in EBCSs off North and South America, and southern Africa. They also found that at higher latitudes, the degree of wind intensification was more pronounced, which is in line with warming patterns observed with the onset of climate change. Evidence from other systems indicated either weakening of winds or unclear change.

While wind intensification could benefit ecosystems due to increased upwelling and nutrient input (see below), large changes in wind patterns could, in fact, harm ecosystems by throwing off the balance of ecological interactions and altering ocean chemistry. The complexity of natural systems makes it extremely difficult to predict the ecological effects of wind intensification.

Dr. Ryan Rykaczewski of the University of South Carolina, co-author of the report, said, "The populations in these ecosystems are sensitive to ocean acidification and de-oxygenation, both of which are related to upwelling. If the winds that cause coastal upwelling continue to rise, marine life could be exposed to more acidic and hypoxic waters sooner than expected."

The team acknowledges more work and time are necessary to understand if the wind trends are part of multi-decadal cycles. The study was funded by the National Science Foundation, the National Oceanic and Atmospheric Administration, and donors to the Farallon Institute. Future work will compare how wind-related changes in upwelling affect fish and seabirds off California and South Africa to strengthen understanding of how changing winds are impacting ecosystems and fisheries.

### **Other Information**

#### **What is upwelling and how do wind patterns relate to it?**

When blowing in the right direction, winds along the coast cause nutrient-poor surface waters to move away from the coast. This water gets replaced with cold water from deep in the ocean that has accumulated nutrients. The 'upwelling' provides a surge in the supply of nutrient-rich water that supports phytoplankton blooms and supplies energy for animals up the food chain, including the world's most productive fisheries such as those offshore of Peru in the Humboldt EBCS. As winds intensify, more water is

transported from the deep, delivering a steady supply of nutrients to these nearshore ecosystems.

### **What is the importance of eastern boundary upwelling systems?**

Eastern boundary current systems (EBCs) are areas at the eastern edges of ocean basins where winds, currents, and geological formations (i.e., coastlines) create a prime environment for upwelling, leading to extraordinary productivity and biodiversity. The California, Humboldt, Benguela, Iberian, and Canary current regions comprise the most important of the world's EBCs, and thus are the focus of this study. These essential upwelling systems are among the most heavily impacted in the world; humankind is exhausting fish populations, changing food-web dynamics, and altering habitats to the detriment of naturally stable cycles. EBCs are essential to global fisheries as well as our understanding of marine ecosystems in a rapidly changing world. They are key regions that should be studied in order to provide evidence that can be used in developing integrated ecosystem-based approaches to resource management.

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### **Additional Information**

*The Farallon Institute for Advanced Ecosystem Research is a non-profit scientific organization dedicated to the understanding and preservation of healthy marine ecosystems. Its research is designed to provide the scientific basis for ecosystem-based management practices and policy reforms consistent with a productive marine world. The Farallon Institute emphasizes long-term, multi-species, multi-disciplinary research into the interdependent aspects of the marine environment, including the effects of natural and human-based climate change, and the broad implications and influences of ocean currents, weather patterns, fishing practices and coastal development on marine food webs and ecosystem processes.*