

Fish, seabirds, and trees:

Long-term perspectives on climatic and ecological variability in the California Current

WHY In coastal upwelling zones like the California Current, winds flowing towards the equator lift deep, cold, nutrient-rich waters into sunlit surface layers, fueling some of Earth's most diverse and economically valuable marine ecosystems. The productivity of coastal upwelling zones depends on seasonal climate patterns, thus long-term environmental trends are of concern. However, the degree to which these climate trends in upwelling zones are exceptional is difficult to quantify given that observational records rarely span more than sixty to seventy years.

WHAT do we know about it, and what are the remaining big questions? In the California Current upwelling zone, we are integrating records of seabird reproductive success, composition of plankton communities, a newly developed network of rockfish growth-increment chronologies, and tree-ring data to:

- identify key climate variables most closely associated with ecosystem functions.
 - Determine whether these climate variables can be hind-cast over the past several centuries using tree-ring data.
- The long-term record indicates that California Current winter climate in the late 20th century has been unusually variable with a number of unusually potent climate events

associated with extremely low productivity. The reason for these extreme events remains unknown, but could be associated with unusually high variability in a broader climate phenomenon known as the El Niño Southern Oscillation.

FILLING THE KNOWLEDGE GAP The world's four major coastal upwelling zones are thought to be experiencing long-term changes in the winds that drive productivity. In the next phase of our research, my group will study relationships between biology and climate in the Benguela coastal upwelling zone, located along the west coast of Africa. In comparing our findings with those in the California Current, we hope to better generalize the impacts of environmental variability and change on the ecology of coastal upwelling zones.

IMPACT This work identifies the importance of winter climate to the California Current and illustrates the remarkable capacity of atmospheric climate patterns to synchronize ecosystems from the continental slope to treeline. Our research is providing important baseline information for fisheries management, which increasingly incorporates the effects of climate on productivity, especially in these highly productive upwelling zones.

Flora and fauna are intimately tied to climate. Positive winter climate values indicate upwelling-favorable conditions, but with drought on land. In these years, seabird lay date is early, fledgling survivorship is high, and rockfish growth is high, all of which indicate strong productivity in the California Current. Blue oak growth is poor due to moisture stress.

