The California State University
COUNCIL ON OCEAN AFFAIRS, SCIENCE & TECHNOLOGY (COAST)

Ocean Acidification Along California's Coast

What is ocean acidification?

Over the last 200+ years, the concentration of carbon dioxide (CO_2) in the atmosphere has increased due to human activities such as combustion of fossil fuels and changes in land use. About 30% of atmospheric CO_2 is absorbed by the earth's oceans[i]; therefore as CO_2 concentrations in the atmosphere increase, so do CO_2 concentrations in the ocean. In seawater, CO_2 undergoes a series of chemical reactions that decrease pH (i.e., the water is more acidic) and the availability of carbonate ions, which are crucial to shell-building organisms such as shellfish, corals and some plankton. Decreased carbonate availability makes it more difficult for calcifying organisms to build and maintain their shells and skeletons. They compensate for this difficulty by diverting energy from other critical functions including growth and reproduction. Behavior and physiology of non-calcifying organisms are also affected by changes in seawater chemistry. For example, increased acidity decreases the ability of fish to find food and avoid predators[ii] and reduces oxygen transport in squid[iii].

Ocean acidification (OA) results from a complex yet invisible chemical reaction in seawater. Despite its significance, there is a lack of societal understanding and appreciation of OA compared to sea-level rise, another significant climate change impact that has a much more obvious and easily understood physical impact. However, OA is one of the most daunting climate change related challenges we face because of its potential impacts to all marine life and the billions of humans who rely on the ocean for their livelihoods and sustenance.

Current and predicted levels of OA

Current atmospheric concentrations of CO_2 now exceed 400 ppm and are higher than they have ever been over the course of human history. Even with robust efforts to reduce greenhouse gas (GHG) emissions, the concentration of CO_2 in the atmosphere is predicted to increase over the next century[iv]. The pH of the surface ocean has already fallen 0.1 units, representing a 30% increase in acidity[v]. As the ocean continues to absorb more CO_2, it is predicted that pH could drop another 0.3-0.5 units by 2100, which would increase its acidity two to three-fold. This rapid increase is acidity is at least 100 times faster than anything marine organisms have experienced in the last few hundred thousand to millions of years and likely means that many marine species will not be able to adapt to the quickly changing conditions, eventually going extinct.

Select Experts: please feel free to contact the following CSU experts.

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Effects of OA and other environmental stressors on ecologically, commercially and recreationally important invertebrates.

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Carbonate chemistry, local CO_2 dynamics and impacts to marine organisms.

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Effects of OA and other environmental stressors on rocky intertidal communities and mitigating effects of surfgrass.

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Use of restored eelgrass to ameliorate OA on a local scale.

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Physiological responses of commercially and recreationally important fish and invertebrate species to OA and other stressors.

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How kelp forests and oceanographic processes affect water column chemistry and OA.

California coastal waters are particularly vulnerable to OA due to global ocean circulation patters and regional wind-driven upwelling, which together bring deep water that is nutrient rich but also hypoxic and acidic to the surface. These physical and biogeochemical processes will drive future increases in OA along the West Coast of North America for decades to come, with disruptive and cascading effects on marine food webs and ecosystems, economics, and communities.

What can we do to plan for the future?

Long-term reductions in OA will come only from the reduction of global GHG emissions. To effectively manage our resources in the near term however, we need to better understand the dynamics of OA at multiple spatial and temporal scales as well as its impacts on marine organisms from molecular to population levels. For example, a recent report by the Ocean Protection Council Science Advisory Team, supported by the California Ocean Science Trust[vi], highlights the potential for submerged aquatic vegetation (SAV) such as eelgrass and kelp to sequester carbon and ameliorate OA on a local scale. Scientists are also working to determine organisms' biological tolerances to acidic conditions at different life stages. This information may be used to develop regional water quality standards to protect against exacerbation of OA from terrestrial sources.

CSU Ocean Acidification Expertise

The CSU has a wealth of expertise related to OA. Faculty members and their students are investigating the biogeochemical processes that produce OA, particularly in CA, and its impacts on marine organisms and processes. They are also exploring strategies to remove carbon from seawater using natural materials such as SAV as well as the use of cutting edge synthetic materials to capture and sequester carbon from the atmosphere and seawater. The CSU is committed to training the future workforce and leaders in climate change research and adaptation for California and the nation.

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Environmental fluid mechanics and processes related to hypoxia in coastal and estuarine systems.

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[i] https://oceanservice.noaa.gov/facts/acidification.html
[ii] https://www.nature.com/articles/s41558-018-0224-8/
[iii] https://www.physiology.org/doi/full/10.1152/physiol.00061.2015
[iv] https://www.co2.earth/2100-projections
[v] https://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F
[vi] http://www.oceansciencetrust.org/wp-content/uploads/2018/01/OA-SAV-emerging-findings-report-1.30.18.pdf

The California State University Council on Ocean Affairs, Science & Technology (CSU COAST) is the umbrella organization for marine, coastal and coastal watershed related activities within the CSU, the nation's largest public four-year university system. Learn more at www.calstate.edu/coast.