SCCWRP FACT SHEET

Investigating the trajectory of coastal ocean acidification

As ocean acidification (OA) intensifies in California's coastal ocean, researchers are gaining foundational insights about where ecological effects will be greatest and how to reduce them

About 30% of carbon dioxide released into the atmosphere is being absorbed by the ocean, which is gradually shifting seawater toward a more acidic, corrosive state – a change known as ocean acidification (OA). Ocean circulation patterns make the North American West Coast especially vulnerable to OA. OA is reducing the habitable areas of coastal waters for a range of organisms, including fish and shell-forming organisms such as crabs and sea snails. Researchers are working on three main fronts to help managers combat OA's ecological effects:

- » Developing coordinated OA monitoring across the West Coast
- » Conducting exposure experiments to understand how certain changes to ocean chemistry can trigger disproportionately adverse effects
- » Using computer models to predict OA's trajectory and evaluate potential solutions for mitigating effects

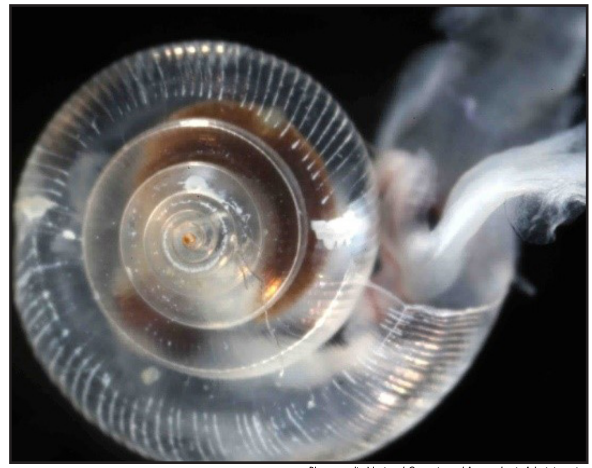


Photo credit: National Oceanic and Atmospheric Administration

A pteropod, or sea snail, shows signs of shell dissolution in response to ocean acidification. The dissolution, which is considered mild, is visible as white-colored pit marks on its shell.

Global problem, local effects

OA is a global phenomenon driven primarily by rising carbon dioxide emissions in the atmosphere. But two local drivers are compounding Southern California's OA problem:

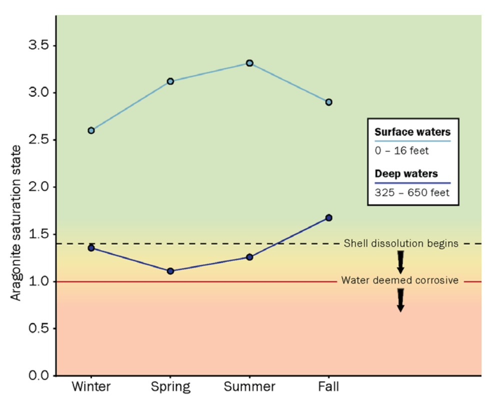
» **Natural upwelling events**: A seasonal phenomenon known as ocean upwelling brings low-pH, carbon dioxide-rich water from deep waters into shallow waters closer to shore.

» **Land-based nutrient discharges**: As nutrients are discharged from land-based sources, they trigger complex coastal ocean biogeochemical cycling processes that consume oxygen and produce carbon dioxide, which can trigger hypoxia and exacerbate OA, respectively.

OA vs. OAH
Because of the local role that nutrients play in both driving OA and hypoxia, the two phenomena are related in the context of nutrient management – hence the term OAH (OA and hypoxia) is commonly used.

Tracking the effects of changing seawater chemistry on Southern California marine life

Via the Southern California Bight Regional Monitoring Program, researchers are tracking how seasonally corrosive seawater conditions affect vulnerable shell-forming organisms. The first OA monitoring survey, which was part of the program's 2013 cycle (Bight '13), found that early signs of shell dissolution are pervasive across the coastal ocean, but the dissolution is considered mild, uneven among species, and confined mostly to colder, deeper waters.



Source: Bight '13 data

During spring, Southern California's deep coastal waters approach conditions considered corrosive to shell-forming organisms. Corrosiveness is measured by a property of seawater chemistry known as aragonite saturation state.

California's OA management strategy

California has long been a leader in developing robust, long-term strategies for managing OA in coastal waters.

Nearly a decade ago, California co-convened the **West Coast Ocean Acidification and Hypoxia Science Panel** to begin conceptualizing an OAH management strategy. Then, California convened the **Ocean Acidification and Hypoxia Science Task Force** to guide and refine the strategy's implementation. The California Ocean Protection Council subsequently codified the strategy as California's 10-year Ocean Acidification Action Plan.

Actions that have resulted from this work include:

» Developing biological thresholds for OA that define the inflection point at which aquatic organisms begin experiencing adverse effects from OA exposure – a foundational precursor for developing informed OA management strategies

» Drafting plans to encourage wastewater treatment agencies to look for ways to reduce nutrient levels in effluent while simultaneously improving energy efficiency

Three-pronged approach to understanding OA's trajectory

To combat coastal OA conditions, California needs to understand the trajectory of these changes, including when and where the ecological effects are the greatest, and how and when to effectively intervene. Researchers are working on three main fronts to generate these insights:

1 Building a West Coast picture of OA through monitoring

Researchers have developed a comprehensive picture of OA conditions along the West Coast by standardizing monitoring methods and coordinating monitoring across four programs:

A pair of plankton nets collects small, shell-forming marine organisms.

- Southern California Bight Regional Monitoring Program
- National Oceanic and Atmospheric Administration's West Coast Ocean Acidification Survey
- California Cooperative Fisheries Investigations (CalCOFI)
- Applied California Current Ecosystem Studies (ACCESS)

2 Replicating environmental conditions through laboratory experiments

To pinpoint the inflection points at which intensifying OA conditions begin to harm vulnerable aquatic life, researchers are conducting dynamic exposure experiments. These laboratory experiments simulate fluctuating environmental conditions in the real world, including changes to pH, dissolved oxygen, and water temperature.

SCCWRP's Dr. Christina Frieder conducts an experiment in a dynamic exposure lab.

3 Predicting OA's trajectory and evaluating potential solutions through modeling

Researchers are using a coastal ocean modeling tool known as ROMS-BEC (Regional Ocean Modeling System-Biogeochemical Elemental Cycling) in tandem with biological modeling tools to predict how intensifying OA conditions will affect vulnerable coastal aquatic life in the coming years.

- Researchers are using the same modeling tools to predict how this trajectory would change if local management interventions were implemented to mitigate the effects of OA and hypoxia – an investigation commonly referred to as scenario modeling.
- A major component of OA modeling is building confidence that the modeling predictions can be trusted as a basis for decision-making. To build this confidence, researchers focus on quantifying uncertainty in the model's predictions, including by comparing error in the model's predictions to error in OA field measurements. More recently, a panel of scientific experts independently evaluated the ROMS-BEC work, finding that it is built on fundamentally sound science and offering multiple recommendations to improve stakeholder confidence in management decisions made using these predictions.

Global solutions, local benefits

Among the local solutions being explored to remove carbon dioxide from the atmosphere is leveraging the ocean's capacity to absorb and store carbon, referred to as marine Carbon Dioxide Removal (mCDR).

While the primary benefit of mCDR is reduced carbon dioxide in the atmosphere, some mCDR techniques may be able to increase the pH of seawater – either via direct removal of carbon or addition of alkalinity – which could help alleviate OA's effects in Southern California coastal waters.

Photo credit: Captura Corporation

Electrodialysis is an mCDR technology for drawing down carbon dioxide in seawater.

More reading

SCCWRP fact sheet on coastal ocean modeling

California Ocean Protection Council's webpage on ocean acidification and hypoxia

California Ocean Protection Council's California Ocean Acidification Action Plan

National Oceanic and Atmospheric Administration's Ocean Acidification Program

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