Ocean Acidification and OA Observing Systems: Local to Global

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CO$_2$ added to seawater changes the water chemistry, reducing the pH and carbonate levels in the ocean.
Oceans are an important sink for the CO$_2$

Source: Le Quéré et al. 2012; Global Carbon Project 2012
Global condition:
OA trend consistent across ocean basins

Source: IPCC 2013
1. Atmospheric CO$_2$ has increased from human activity

2. The oceans absorb CO$_2$

3. The increased CO$_2$ causes ocean acidification (OA); this changes the water chemistry, reducing the pH and carbonate levels in the ocean

4. OA water chemistry changes reduce growth and survivorship in some organisms
Oyster larvae

Barton et al., 2012

Production is lower with lower pH

Growth in feeding stage slower with lower pH

Image: Waldbusser et al., OSU
Implications for Marine Food Webs & Ecosystem Services

Many biological processes are sensitive to changes associated with OA:

- Potential loss of water quality benefits provided by shellfish, which filter nutrients out of marine waters
- Impacts nervous system of some fish
- Potential increase in toxicity of harmful algal blooms
- Shell dissolution and increased mortality among pteropods (a type of plankton)

Photo: Russ Hopcroft
Bednarsek et al (2014)
Implications for Marine Food Webs & Ecosystem Services

Some responses could help us meet the challenge locally:

• Seagrasses and kelps could partially mitigate local effects

• Some species may be able to adapt

Photo: T. Klinger
History and future of OA at the ocean surface

![Graph showing pH, CO$_3^{2-}$, CO$_2$(aq) concentrations over time (1800-2100). The pH values range from 7.8 to 8.2. The CO$_3^{2-}$ concentration decreases significantly by 2000 and 2100. The CO$_2$(aq) concentration increases by 2000 and continues to rise by 2100.]

- **2000**
  - 30% acidity
  - 16% [CO$_3^{2-}$]

- **2100**
  - 150–200%
  - 50%
Ocean Acidification: what we know

• Approximately 26-28% of the CO₂ generated by human activities since the mid-1700s has been absorbed by the oceans.

• Ocean acidity has increased 30% since the start of the industrial age.

• Ocean acidity is projected to increase 100-150% percent by 2100.

• **Current rate of acidification is nearly 10x faster than any period over the past 50 million years.**
Implications for managers

• OA and hypoxia similarities and differences
• Restoration priorities and strategies
• Land-use planning
• Preservation (e.g., sea grass beds)

• OA is relatively new and it is complicated, but needs our high attention now
OA is a global condition with local effects
Ocean Acidification: challenges

1. Carbon chemistry in inland waters has high variability

2. Inland waters have high diversity re drivers of variation

3. Source attribution is hard, but do-able

4. OA has potential for widespread biological effects that we have little clue about
Variability is much larger in coastal waters than the open ocean, then there are estuaries.
Processes that fuel increased respiration yield higher CO$_2$ and lower pH

Photosynthesis consumes CO$_2$ at the surface

Respiration releases CO$_2$ near the bottom

Image: NOAA PMEL
Seasonal upwelling brings high CO$_2$, low pH water to surface.
Ocean Acidification: Upwelling

-Jiang et al., L&O, 2010-
What we know about ocean acidification in Pacific Northwest coastal waters

- Natural and anthropogenic contributions are additive.
- Anthropogenic contributions to ocean acidification are detectable and have increased the frequency, intensity, and duration of harmful conditions.

Shell mineral availability off Newport, Oregon

“Makes a bad day worse…”

Harris et al. 2013
Local effects
Are local stressors contributing too?
Are local stressors contributing too?

Green = WA coast at Cape Elizabeth
Blue = Seattle at Space Needle
How much coastal acidification is due to upwelling and respiration vs. rising CO₂ emissions?

<table>
<thead>
<tr>
<th>Coastline region</th>
<th>Upwelling</th>
<th>Respiration</th>
<th>Global CO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington</td>
<td>66%</td>
<td>20%</td>
<td>14%</td>
</tr>
<tr>
<td>Oregon</td>
<td>74%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>Northern California</td>
<td>67%</td>
<td>9%</td>
<td>24%</td>
</tr>
<tr>
<td>Central California</td>
<td>59%</td>
<td>16%</td>
<td>25%</td>
</tr>
<tr>
<td>Southern California</td>
<td>60%</td>
<td>13%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Feely, Alin, and others, in prep.
Ocean Acidification: Future directions

- What determines local nearshore CO$_2$ levels?
- How can CO$_2$ levels be measured easily and quickly?
- What management can reduce local OA?
- How fast and far can species acclimate and adapt? Are there crucial tipping points?
- Which ecosystems are more or less resilient?
OA is a global condition with local effects

- We need local through global scale observations in order to get either correct
- This issue demands our coordination, networked skill, and open analysis
Welcome to the IOOS Pacific Region Ocean Acidification Data Portal

Ocean acidification refers to the change in the chemistry of seawater caused primarily by the ocean’s absorption of carbon dioxide from the atmosphere.

From our data explorer, you can find data relevant to ocean acidification from partners in the Pacific region. This portal was funded by U.S. IOOS, with data streams contributed by regional IOOS observing systems in Alaska (AOOS), Washington and Oregon (NANOOS), Central and Northern California (CeNCOOS), Southern California (SCCOOS), and the Pacific Islands (PacIOOS) as well as through NOAA’s Ocean Acidification Program (OAP) and Pacific Marine Environmental Laboratory (PMEL). Data presented here were funded through NOAA OAP, U.S. IOOS, or regional observing system collaborators. For further information about ocean acidification, follow these national and regional links, which include FAQs and videos on the basic understanding of and consequences from ocean acidification, as well as links to information on sensors (Alliance for Coastal Technologies, ACT) and practices (California Current Acidification Network, C-CAN) used to monitor ocean acidification status.

The seawater chemistry changes from ocean acidification affect the ecology and economy of marine communities, and this is projected to grow with time. We can better prepare for potential impacts to marine communities, fisheries, and livelihoods by learning more about how the ocean absorbs carbon dioxide. IOOS is committed to working with a diversity of partners to provide data about ocean acidification conditions.

For ocean acidification relevant information from the organizations below, click on the icons.
The Global Ocean Acidification Observing Network (GOA-ON) is an international partnership to

- Document the status and progress of ocean acidification in open-ocean, coastal, estuarine, and coral reef environments
- Understand the impacts of ocean acidification on diverse marine ecosystems and societies
- Forecast ocean acidification conditions

www.goa-on.org
Integration of local through global

Partnerships:
Governments
Academia
Industry
NGOs
etc.
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