What we know about ocean acidification status and trends on the West Coast

Dr. Simone Alin

With thanks to Tessa Hill, Richard Feely, Brendan Carter, Adrienne Sutton, Jan Newton, Francis Chan, Brian Gaylord, Dana Greeley, and many others

Indicators of Climate Change in California Workshop (June 16, 2015)
“Between 2005 and 2009, disastrous production failures at Pacific Northwest oyster hatcheries signaled a shift in ocean chemistry that has profound implications for Washington’s marine environment.”

Washington Blue Ribbon Panel on Ocean Acidification 2012
CO$_2$ absorbed by the ocean changes ocean chemistry

Station Aloha

Station Mauna Loa

CO$_2$ (atmosphere)

CO$_2$ (ocean)

pH

National Climate Assessment (2014), after Feely et al. 2009
Ocean Acidification (OA) Chemistry 101

CO₂ + H₂O → H₂CO₃

H⁺ + HCO₃⁻ → H⁺ + CO₃²⁻

pH, ion, hydrogen,
carbonate, bicarbonate,
saturation state (Ω)
Socioeconomic benefits of West Coast fisheries

• $0.5B per year industry on West Coast
• About 60% of which is shellfish and vulnerable to decreasing saturation states
• Jobs and livelihoods
• Cultural and ceremonial importance
• Recreational value

Photos: Washington Blue Ribbon Panel on Ocean Acidification 2012
The ocean absorbs 30% of CO$_2$ emitted to the atmosphere by human activities.

CO$_2$-driven acidification brings corrosive water closer to the surface by 1–3 m/yr (3–10 ft/yr).

Feely et al. 2004
First West Coast observations of ocean acidification

*May–June 2007*

Corrosive waters reach the surface along the West Coast at times during the summer upwelling season.

*Feely et al. 2008*
Why are conditions so much worse along the coast?
Present-day conditions along the West Coast


• We also measure high-resolution changes in chemistry at several time-series moorings along the West Coast (Feely, Alin, Chan, Hill et al., in prep).

• Areas of corrosive conditions at the surface and everywhere at 125 m during summer. Upwelling, production/respiration, and rivers are important contributors.

Feely, Alin, Chan, Hill et al., in prep
Estimated chemistry changes since pre-industrial

Aragonite saturation state off Newport, Oregon

- Estimated mean present-day $\Omega_{\text{arag}}$ is 0.52 lower than during the pre-industrial (Oregon).
- Frequency of corrosive conditions in shelf water has increased by 20–26% (Oregon, Washington).

Harris et al. 2013
Projected change over next 35 years is accelerating and projected to be greater than since 1750.
Combines information about environmental conditions, economic sensitivity, and exacerbating factors.

- West Coast and Alaska have highest vulnerability, decreasing to south.
So what do we know about ocean acidification on the West Coast?

- Many areas experience corrosive conditions
- Strong variability
  - North to south
  - Onshore to offshore
  - Seasonal to decadal
- Ocean acidification will exacerbate naturally challenging conditions.
Indicators might track changes in:

- Annual CO$_2$, pH, $\Omega_{\text{aragonite}}$ extremes
- Annual averages
- Corrosive events (“carbonate weather”)
  - Frequency
  - Duration
  - Intensity
- Seasonal first & last appearance of corrosive waters in key habitats

OA indicators along West Coast: under development

Alin et al. in press, Sutton et al. in prep.
• Risk assessment for individual species is underway.

• Ultimately we hope to be able to overlay maps of species distributions with forecasts of biogeochemical conditions.
Closing thoughts

• Acidity is projected to increase (= pH decrease) and aragonite saturation state to decrease at accelerating rates in the future due to ongoing CO₂ emissions.

• Many potential indicators to track (under development).

• Clean Water Act specifies pH criteria that may provide a route for management/regulation based on changing chemistry.

• However, regional inputs through rivers and stormwater runoff may be more amenable to state level action.