Addressing Ocean Acidification

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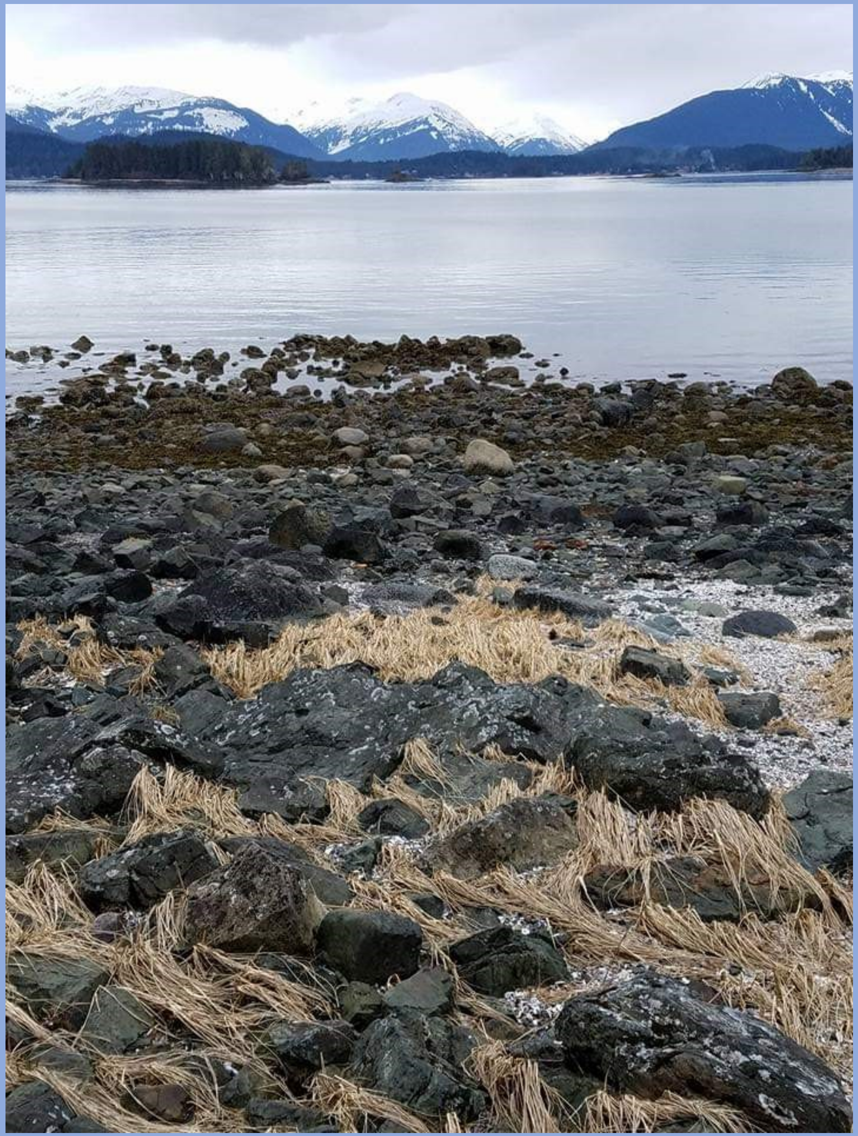
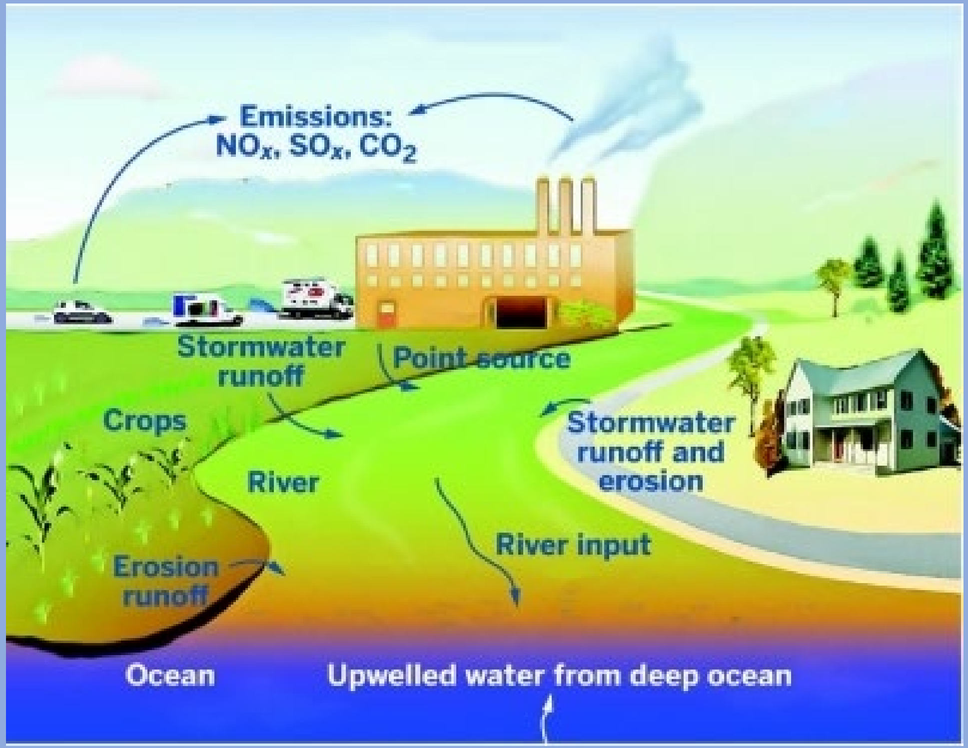
Region 10 Water Quality Standards Meeting

March 4, 2020

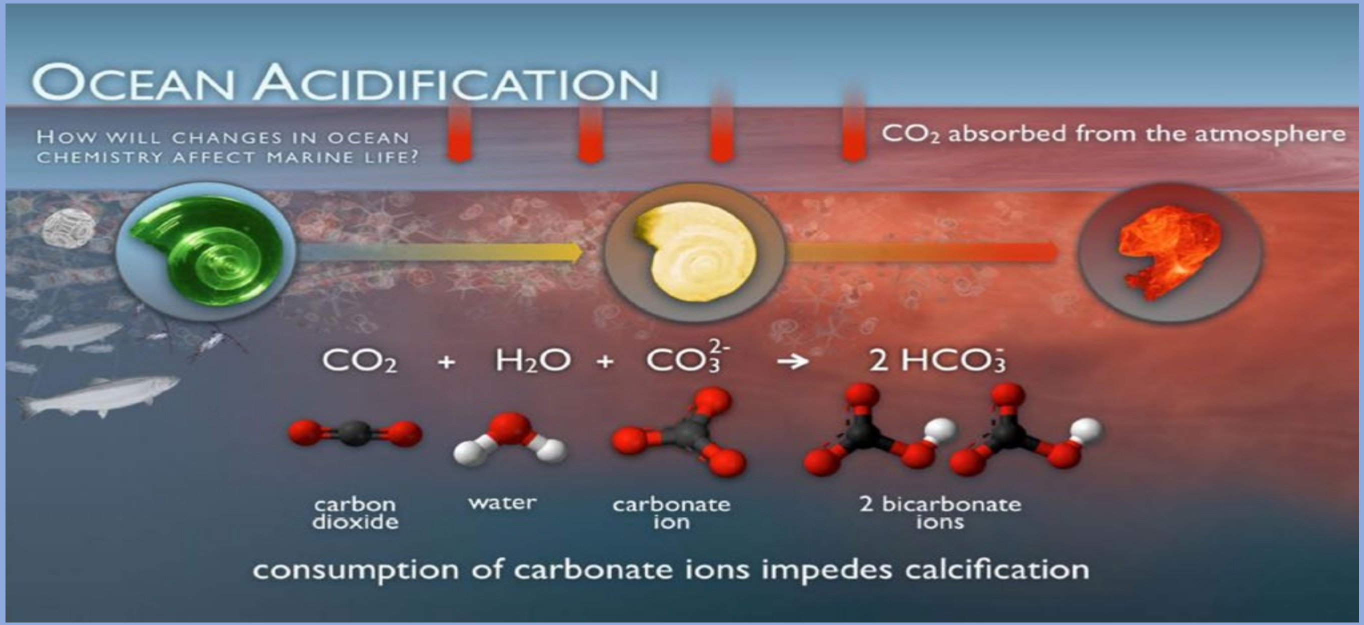


What is meant by Ocean Acidification and Coastal Ocean Acidification?



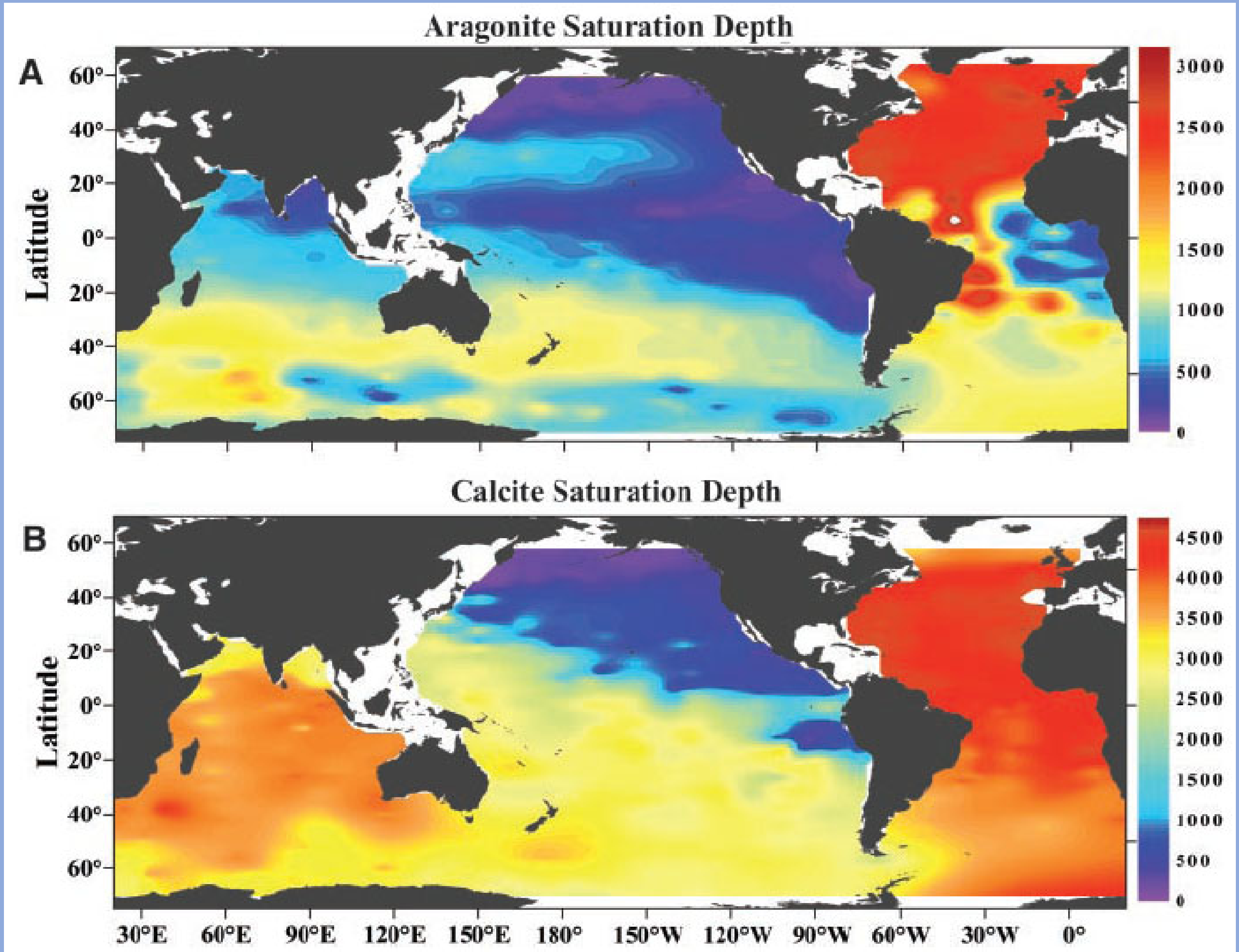
$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO^-_3$$

$$CO^{2-}_3 + H^+ \rightarrow HCO^-_3$$



NOAA PMEL
http://www.pmel.noaa.gov/co2/story/Coastal+Carbon+Dynamics
https://www.pmel.noaa.gov/co2/story/Ocean+Acidification

Aragonite Saturation



- **Aragonite** - crystalline form of calcium
- **Saturation state -** measure of the potential for dissolution
- **Aragonite saturation state (Ωar)-** less than 1 = dissolution
- **Saturation horizon** - depth where Ωar = 1
- **Upwelling** pushes horizon closer to surface

Feely *et al.*, 2004

303(d) Litigation and CWA Petitions

CBD sues EPA's approval of WA 2008 303(d) list

- 2009

CBD and EPA settle lawsuit: EPA issued 2010 OA 303(d) listing memo

- 2010

CBD petitions EPA to promulgate 304(a) recommended pH criteria. WA Department of Ecology requests EPA assess WQS related to OA.

- 2012

CBD petitions EPA to develop OA-specific WQS

- 2013

CBD sues EPA's approval of WA and OR 2010 303(d) lists

- 2013

CBD sues EPA for failing to set WQS to protect marine life from seawater turned corrosive by carbon emissions

- 2016

CBD FOIA on OR 2012 list approval

- 2019

The 2010 OR 303(d) List

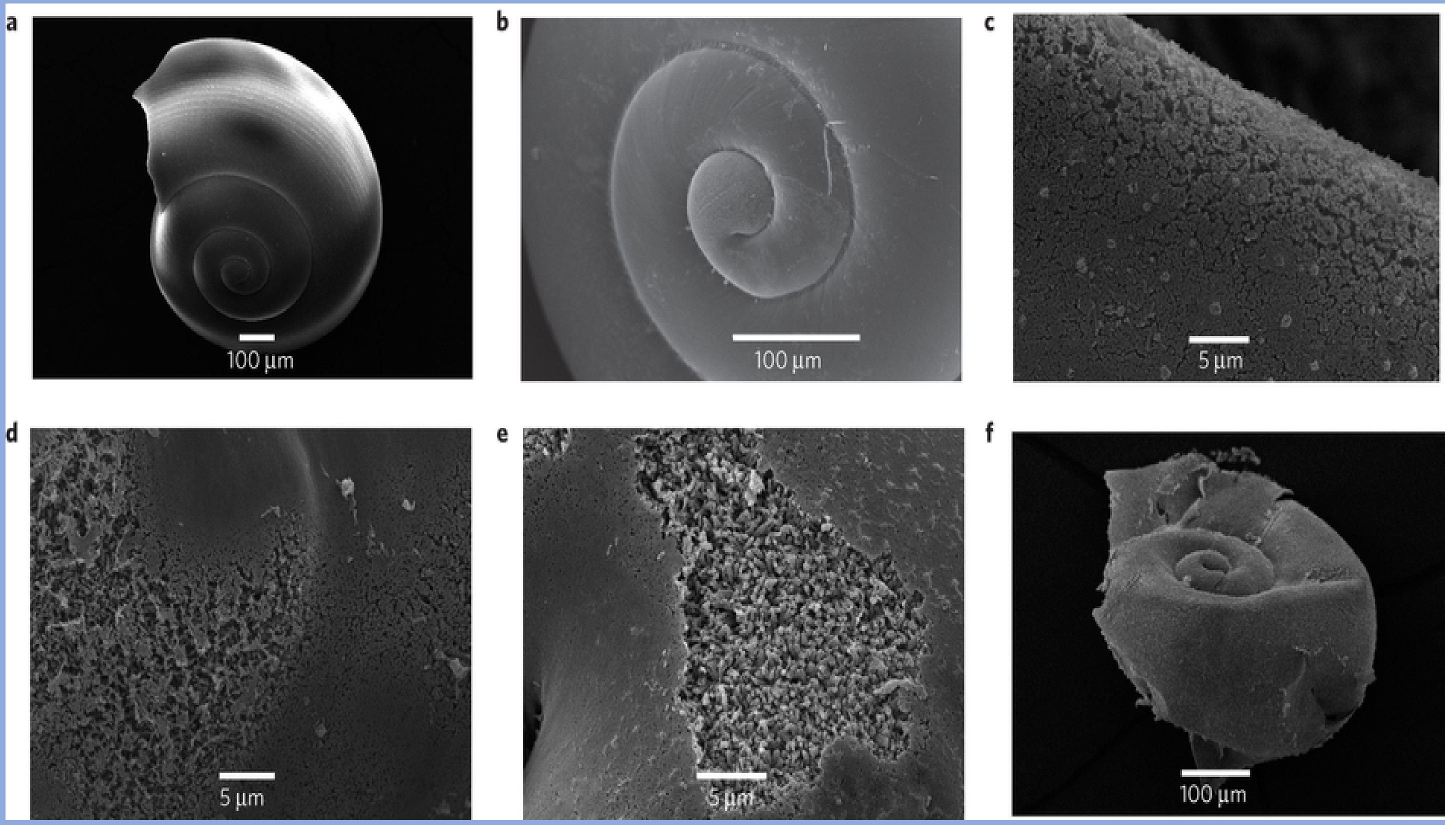
- R10 did not feel OA listings could be added because the data were from:
  - Geographically distant areas or species not found in the PNW
  - Outside state jurisdiction and too hydrogeographically distinct to be extrapolated
  - Laboratory experiments
  - Hatcheries

https://www.oregon.gov/deq/wq/Pages/2010-Integrated-Report.aspx

Available Data and Data Gaps for the 2012 Oregon List

- pH data indicate attainment of the numeric pH WQS.
- NOAA and UW have compelling pteropod biological data indicating impacts to aquatic life.
- Chemistry data link corrosive waters with a low aragonite saturation state to pteropod deformities.

- pH data are available for OR territorial waters.
- Published pteropod biological data were collected beyond the boundaries of OR territorial waters.
- Aragonite saturation state data are available within OR waters, but there is no WQS.



Bednarsek *et al., 2012*

https://www.epa.gov/tmdl/partial-approval-and-partial-disapproval-oregon-2012-303d-list

Options States are Considering for an OA Listing

- Category 5 using pH data
- Category 5 using an interpretation of the statewide aquatic life narrative (OAR 340-041-0007, OAR 340-041-0011)
    - Shell dissolution
    - Aragonite saturation
    - Multiple lines of evidence
- Category 5 sub-category
- Category 4c-non-pollutant-is this an argument that can be made?
- Category 4b-pollution control plan in place (other than a TMDL)
- Category 4a-TMDL—what would this look like??
- Category 3b-insufficient information/water of concern
- Category 2-waters of concern

https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1458

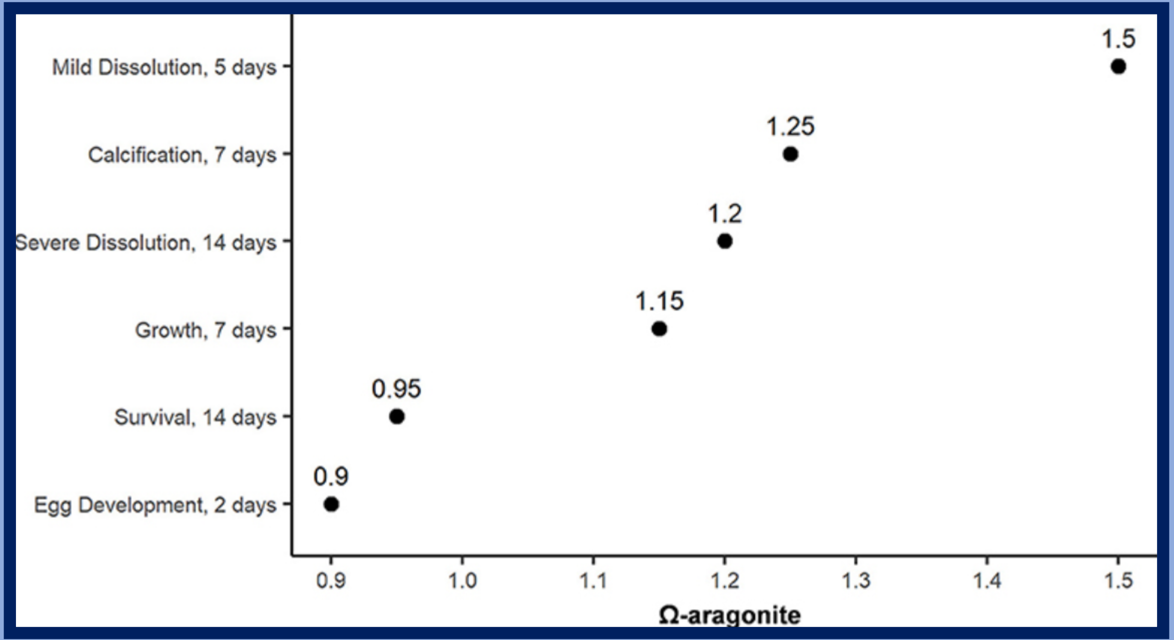
Narrative WQS - Interpretation Considerations

Pteropod example*

- Pteropods widely distributed
- Methods to assess shell condition published
- Shell condition impact from OA linked to organism growth and survival
- Early-warning indicator that is predictive of higher-level ecosystem effects

Cons

- Organism's range – mainly nearshore and offshore waters
- Collection/analysis methods intensive

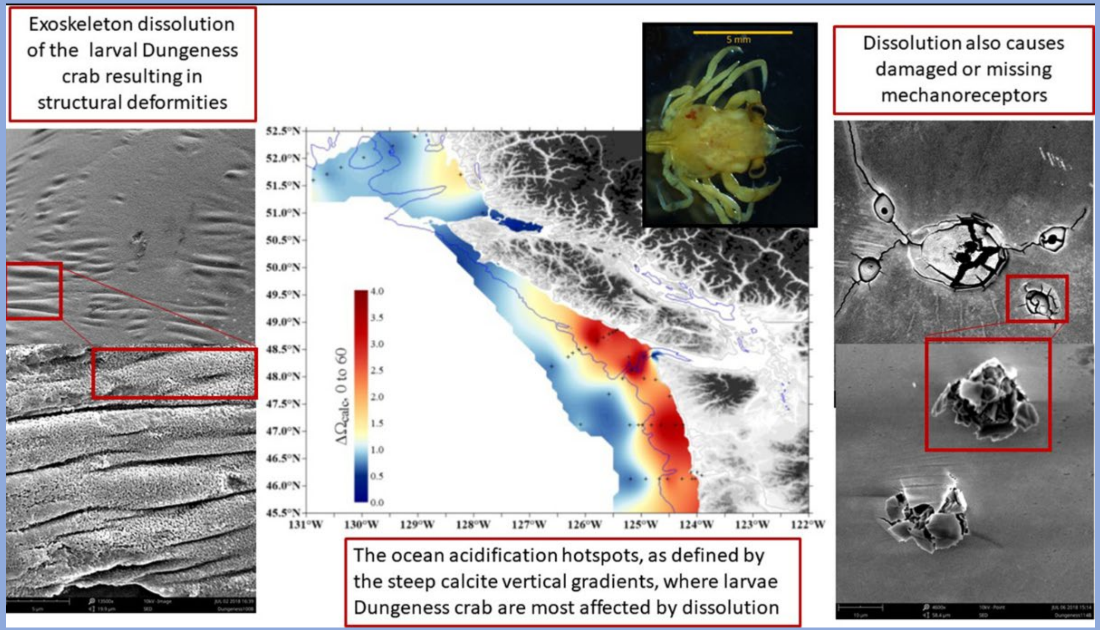


Bednarsek et al. 2019, Figure 6 – aragonite saturation state threshold magnitude and durations that consensus science demonstrates impacts to pteropods: https://www.frontiersin.org/articles/10.3389/fmars.2019.00227/full#F7

*Stanford Working Group, 2017 focused in the short term on pteropods: http://www.opc.ca.gov/webmaster/_media_library/2017/01/OA_Uncommon_Dialogue.pdf

Numeric Criteria Considerations

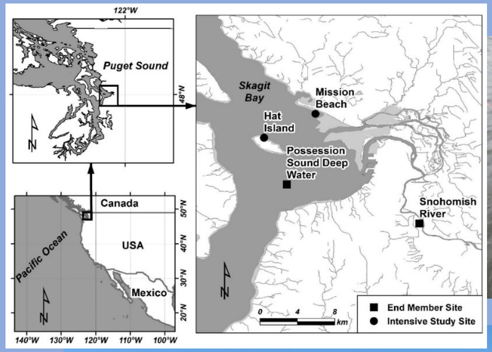
- Carbonate saturation state is tightly coupled indicator for multiple organisms
- Pteropods strong data
- Estuarine and tidepool species increasing data
  - Larval oysters and crabs documented responses
- Practical considerations – monitoring data, accessibility
- Reference type standards



Bednarsek et al. 2019: https://www.sciencedirect.com/science/article/pii/S0048969720301200

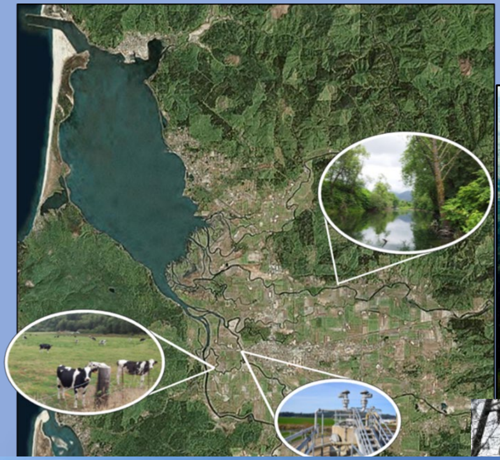
RARE: “Toward a unified understanding of coastal acidification processes in Puget Sound”

2015 - Present



RARE: Identifying local factors which may exacerbate coastal acidification in the Tillamook Estuary (Oregon)

2017 - Present



Snohomish Research- Filling Data Gaps

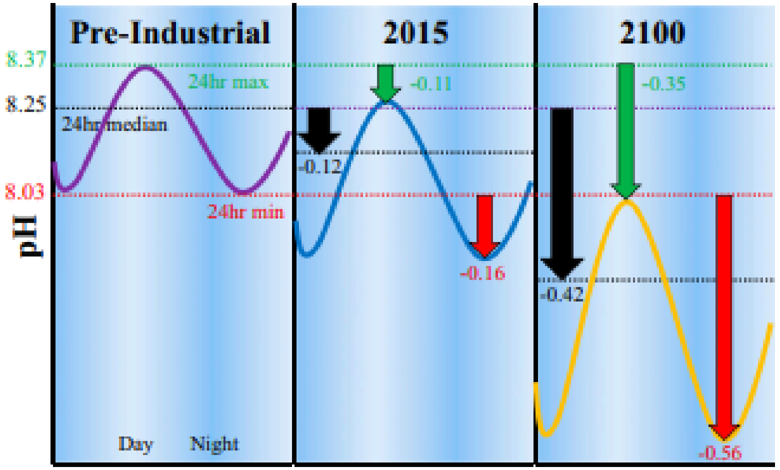


Fig. 4. Representative diel curves illustrating changes in daily pH medians (black), maximums (green), and minimums (red) from preindustrial values for years 2015 and 2100. Daily pH minimums have larger reductions than corresponding medians and maximums due to the additive anthropogenic and respiratory carbon reducing the pH buffering capacity of the system. Values shown are mean changes for the dry season of the designated year.

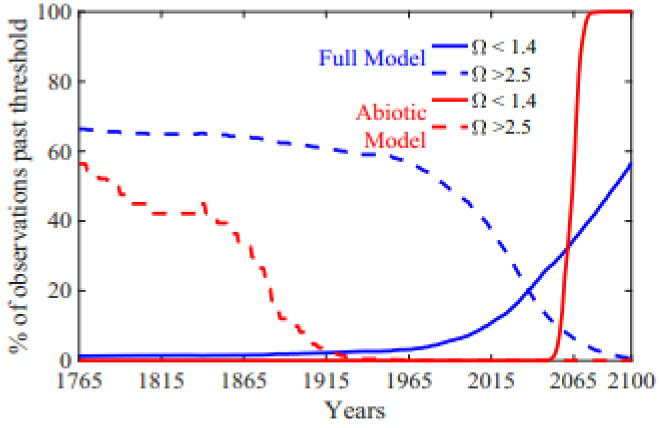


Fig. 6. Percentage of observations for each OA model simulation year exceeding published harmful (solid lines) and exceptionally favorable (dashed lines) thresholds of $\Omega_{aragonite}$ for biocalcification of larval bivalves. Compared is output from all model simulations for the full (with NCM; blue lines) and abiotic (without NCM; red lines) models. The $\Omega_{aragonite}$ thresholds from refs. 1 and 33. Conditions were similarly favorable for biocalcification in the preindustrial with or without NCM's influence on carbonate chemistry. Currently, NCM increased incidence of exceptionally favorable and harmful conditions. In future high-CO_2 scenarios, incidences of exceptionally favorable conditions are nearly absent, regardless of NCM; however, NCM greatly reduces the incidence of harmful conditions.

RESEARCH ARTICLE

Seagrass habitat metabolism increases short-term extremes and long-term offset of CO_2 under future ocean acidification

Stephen R. Pacella, Cheryl A. Brown, George G. Waldbusser, Rochelle G. Labiosa, and Burke Hales

PNAS April 10, 2018 115 (15) 3870-3875; first published April 2, 2018
https://doi.org/10.1073/pnas.1703445115

https://www.pnas.org/content/115/15/3870.short

Dry season results

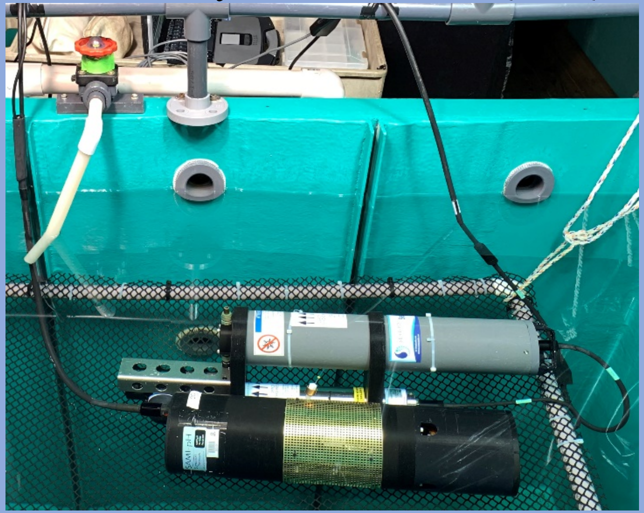
Tillamook OA Monitoring efforts and observations

July 2017 - Present

SeaFET pH
SAMI pCO_2
YSI sonde

Juvenile oyster outplants (USDA)

Laboratory calibration, QA/QC



July 2017 - Present

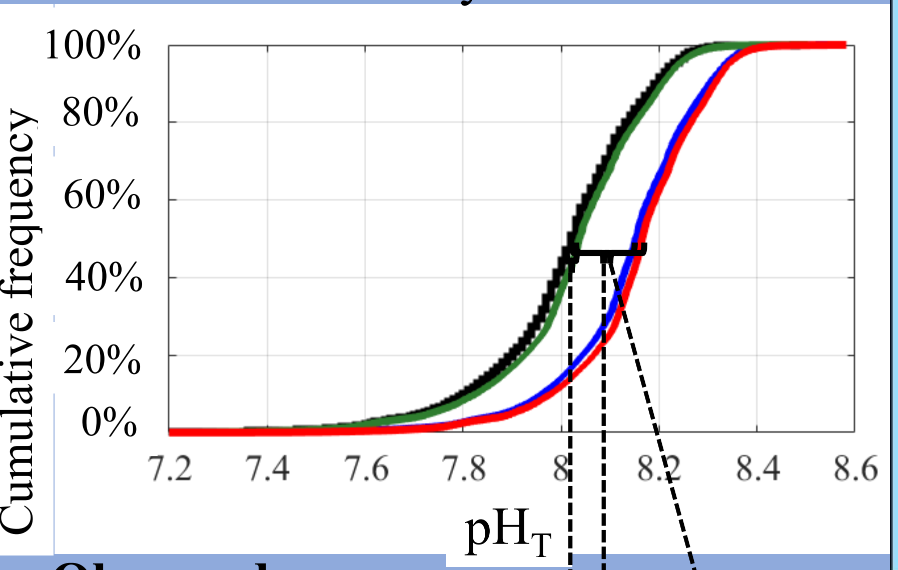
YSI sonde

Juvenile oyster outplants (USDA)

Estimating estuarine effects of coastal acidification

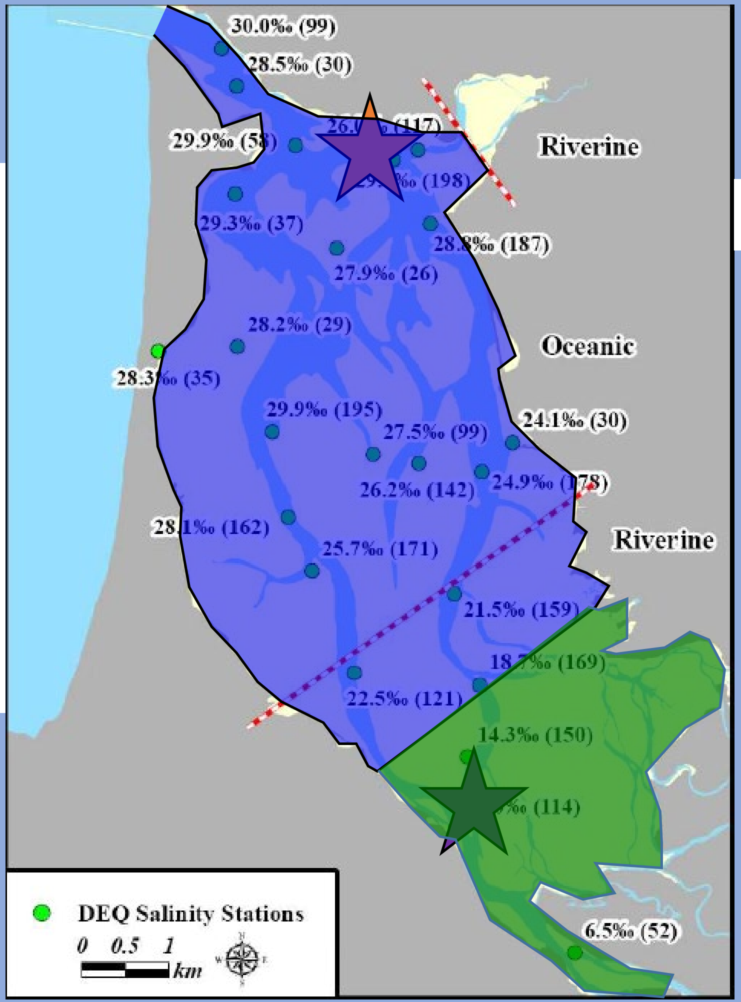
Polyhaline mooring

Mean salinity = 27.6



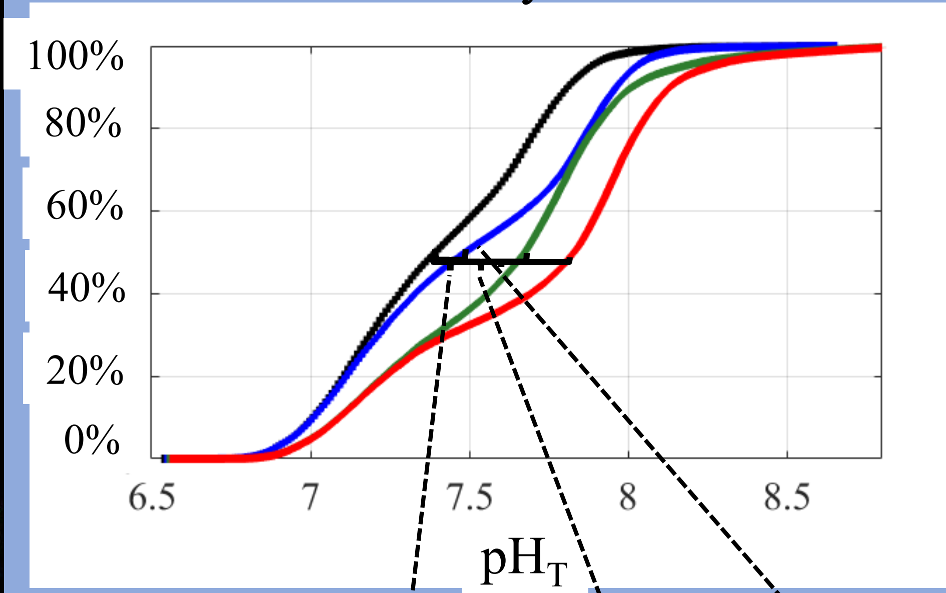
Observed
ΔOcean
ΔWatershed
ΔWatershed + ΔOcean

-0.02
-0.15
-0.13



Mesohaline mooring

Mean salinity = 10.3



-0.10
-0.44
-0.28

Spatial constraints on efficacy of local watershed management actions to improve bay conditions

Upcoming Webinar: State Legislation on Ocean & Coastal Acidification

Registration:
https://register.gotowebinar.com/register/7640467124031827211

U.S. EPA & Coastal States Organization

Coastal Webinar Series

State Legislation on Ocean & Coastal Acidification

Thursday, March 19, 2020

2 p.m. – 4 p.m. Eastern
1 p.m. – 3 p.m. Central
12 p.m. – 2 p.m. Mountain
11 a.m. – 1 p.m. Pacific
9 a.m. – 11 a.m. Hawaii- Aleutian

Ocean and coastal acidification threatens marine ecosystems and the coastal communities that rely on them. The U.S. EPA's Ocean and Coastal Acidification Program promotes awareness and conducts research and long-term monitoring to mitigate impacts of acidification and develop solutions. States play a critical role in guarding their coastlines against local causes of acidification.

Hear from three states who have successfully enacted state legislation on ocean and coastal acidification as they share their experience and discuss actions that have been implemented to address acidification in their state.

Speakers

Holly Galavotti, U.S. Environmental Protection Agency
Mike Molnar, Coastal States Organization
Justine Kimball, Ph.D., Senior Program Manager, California Ocean Protection Council
Caren Braby, Marine Resources Program Manager, Oregon Department of Fish and Wildlife
Donald Witherill, Director, Division of Environmental Assessment, Maine Department of Marine Resources

Register in advance at EPA's Watershed Academy:
https://attendee.gotowebinar.com/register/7640467124031827211
For questions, contact watershedacademysupport@cadmusgroup.com.

EPA's Watershed Academy provides self-paced training modules and webcast seminars on current information from national experts across a broad range of watershed topics. www.epa.gov/watershedacademy

Previous Webinar:

Adaptive Management for Ridge to Reef Conservation

Held Dec. 17, 2019 available at the EPA's Watershed Academy Webcast Archives

Upcoming Webinar Topics:

- Climate Adaptation
- Coastal Wetlands
- Vessels

Contact info

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- Research Questions: ORD Newport Lab – Cheryl Brown Brown.Cheryl@epa.gov; Stephen Pacella Pacella.Stephen@epa.gov