

Ocean Acidification in Pacific Northwest Waters

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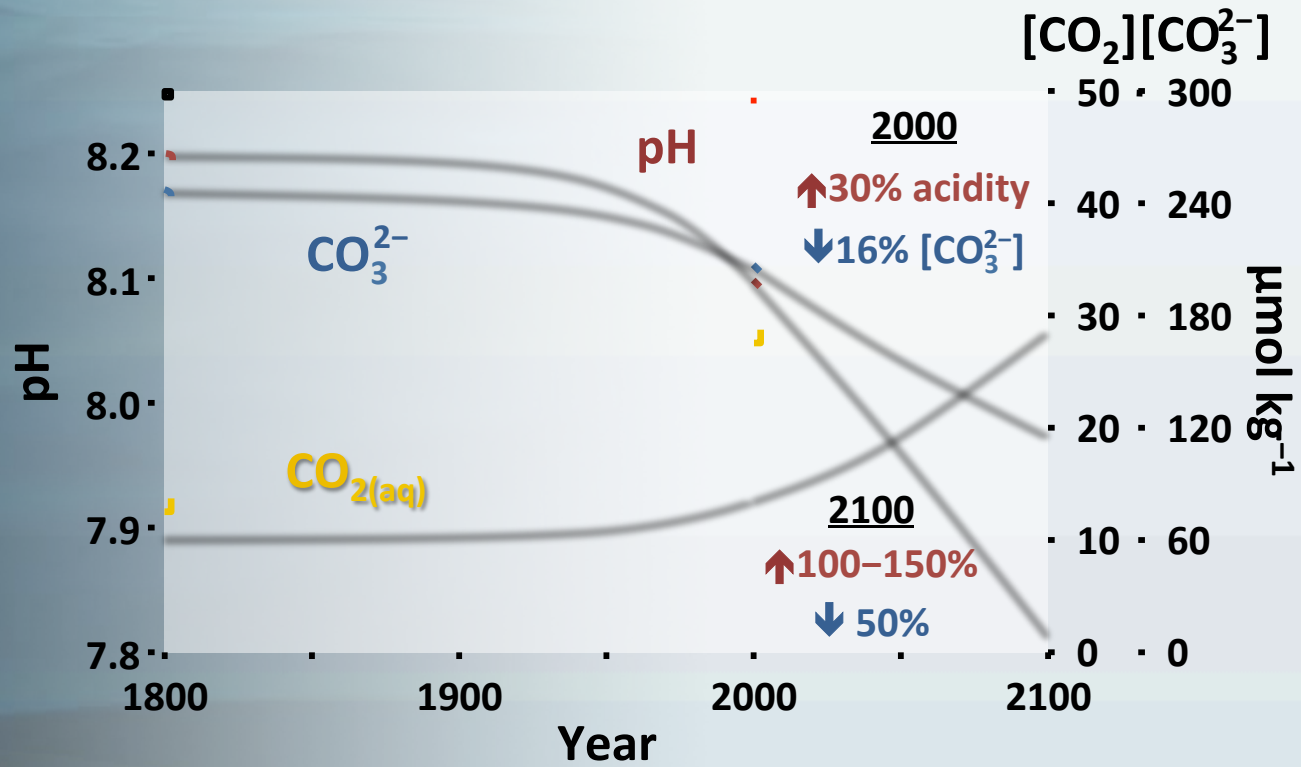
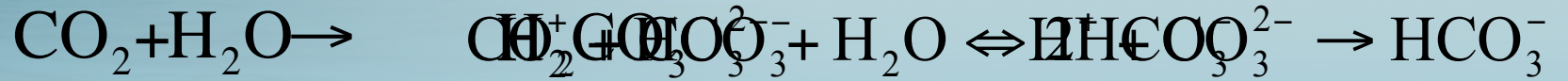
Outline

- Why coastal oceans are especially vulnerable
- Recent OA results for the U.S. West Coast
- OA in an estuarine environment: Hood Canal

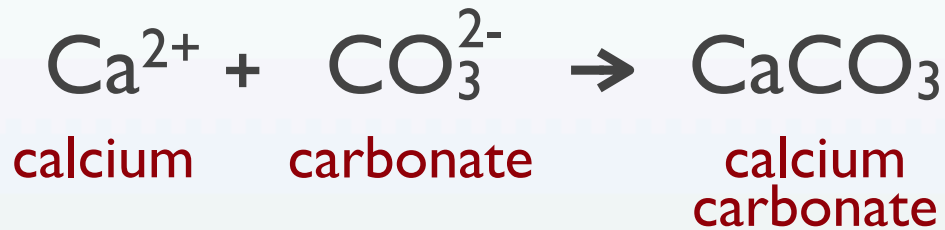
With Simone Alin (PMEL), Chris Sabine (PMEL), and Jan Newton (UW)



Ocean Acidification



Saturation State



Saturation State

$$\Omega_{\text{phase}} = \frac{[\text{Ca}^{2+}][\text{CO}_3^{2-}]}{K_{\text{sp,phase}}^*}$$

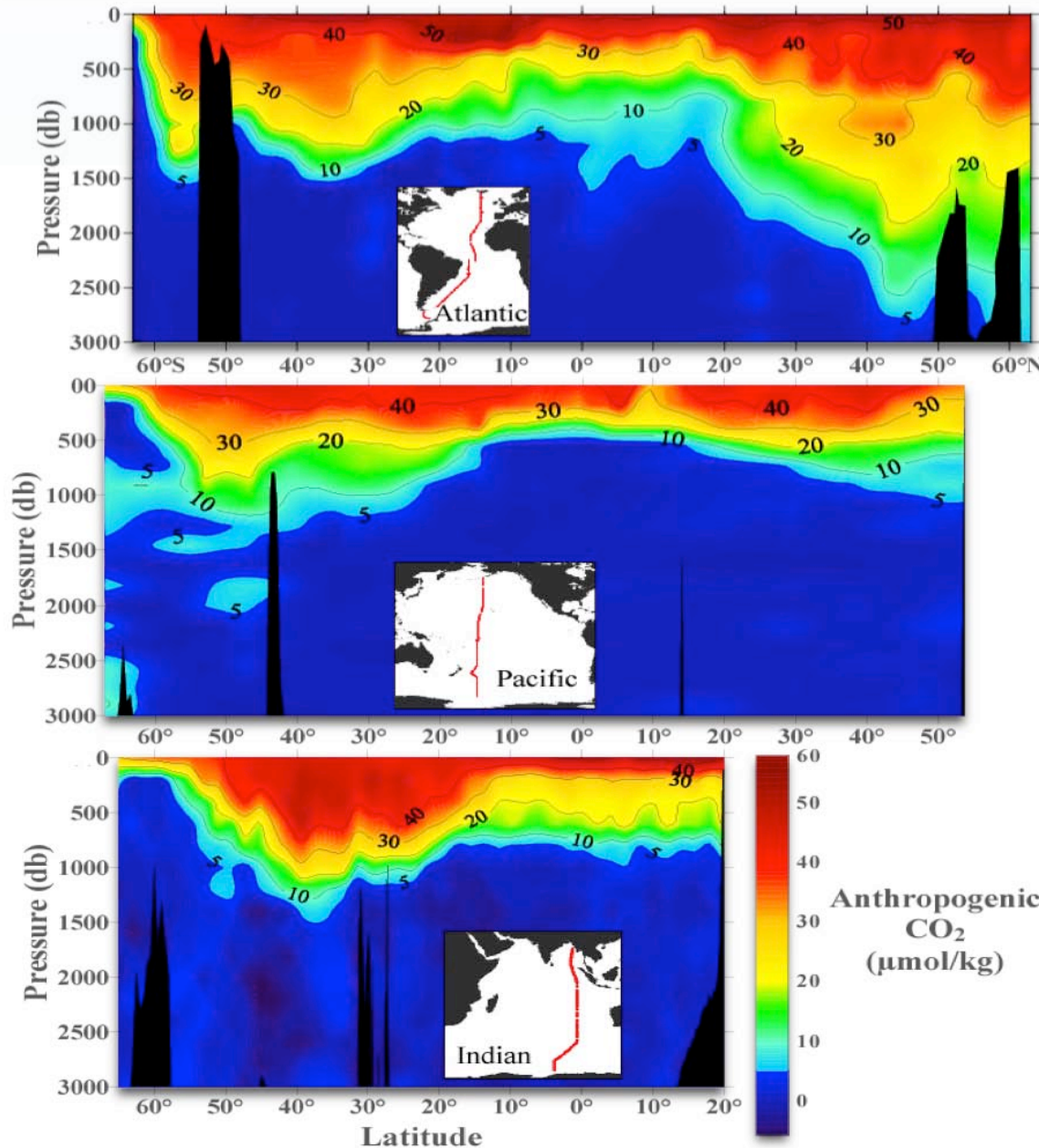
$\Omega > 1$ CaCO_3 precipitates

$\Omega = 1$ equilibrium

$\Omega < 1$ CaCO_3 dissolves

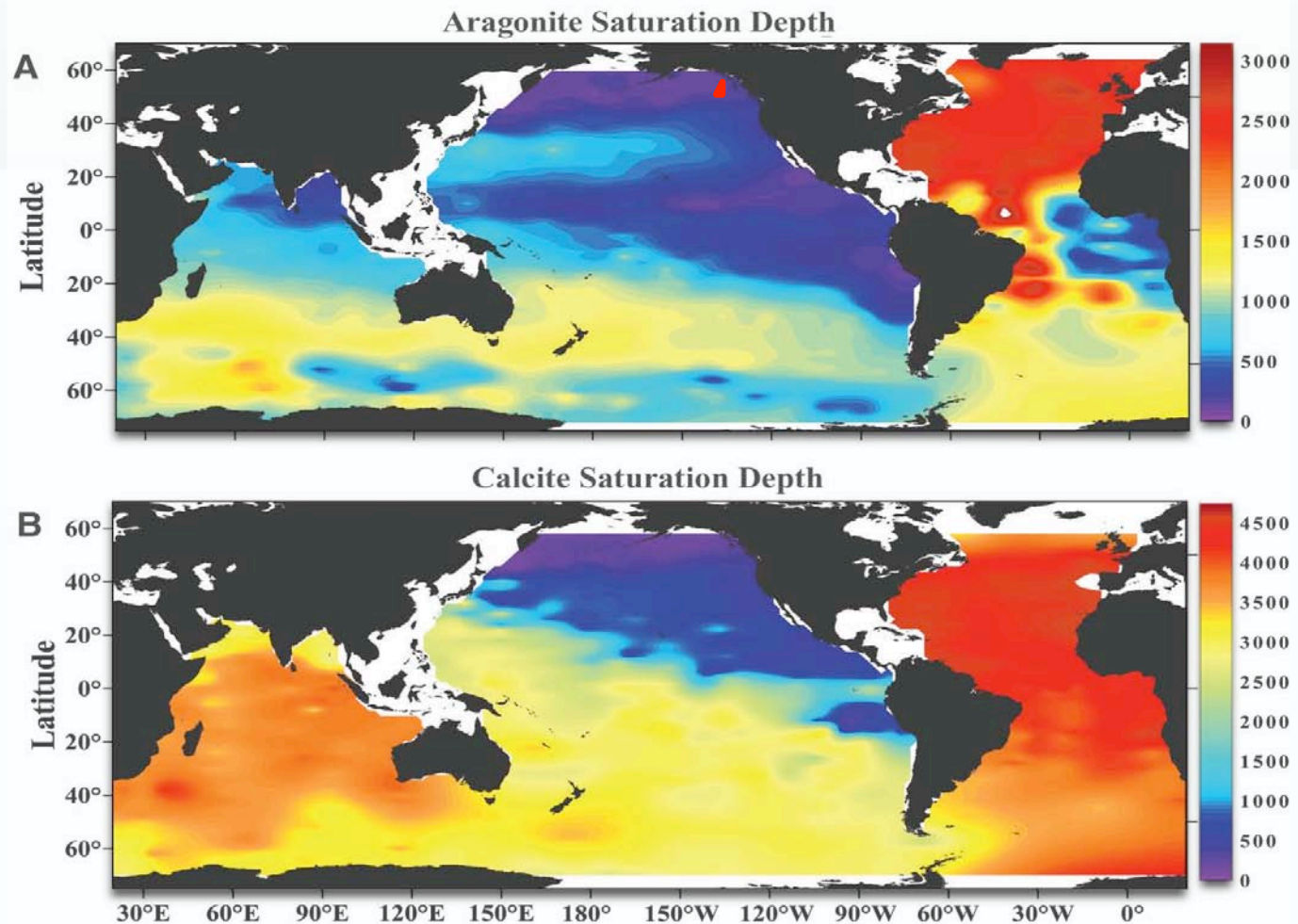
Common carbonate minerals:
aragonite (more soluble) and calcite (less soluble)

Penetration of Anthropogenic CO₂ into Ocean



- Difference of present-day levels minus pre-industrial (year 1800)
- Half trapped in upper 400 m
- Equivalent to about a third of all historical carbon emissions
- 148 Pg C since the beginning of the industrial era have accumulated in the oceans

Observed aragonite & calcite saturation depths



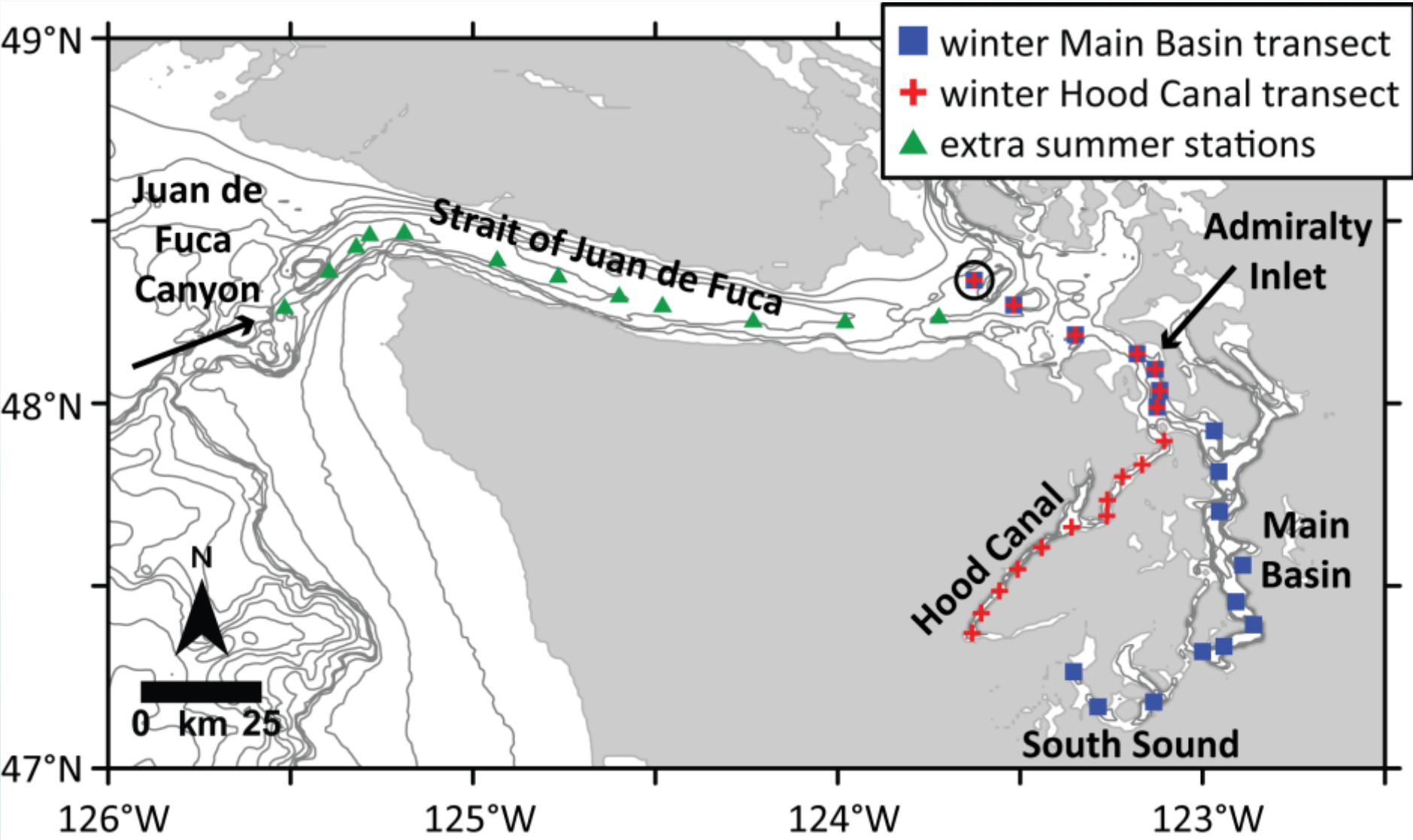
The **aragonite saturation horizon ($\Omega = 1$)** migrates towards the surface at the rate of 1-2 m yr⁻¹, depending on location.



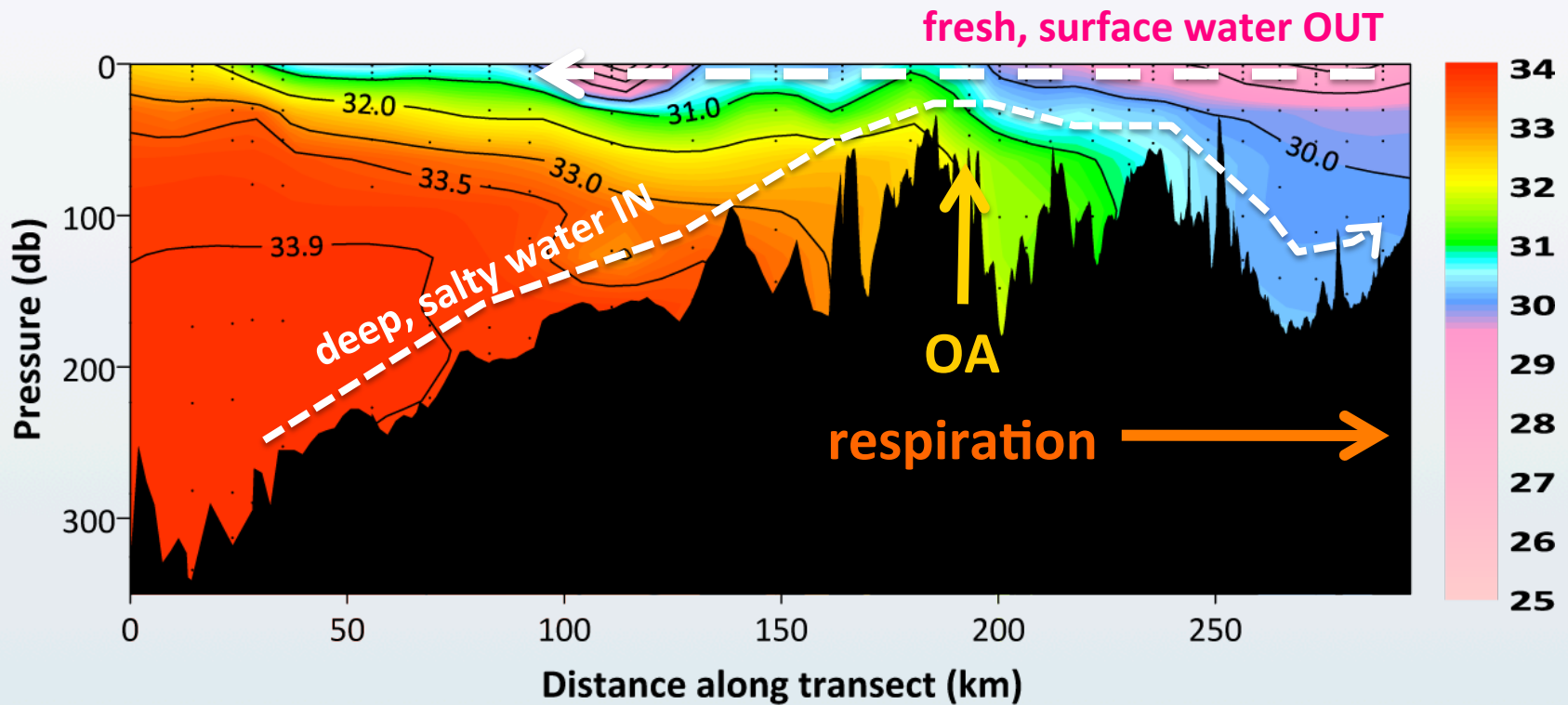
Why are coastal oceans particularly vulnerable to acidification?

Monitoring Ocean Acidification in Puget Sound

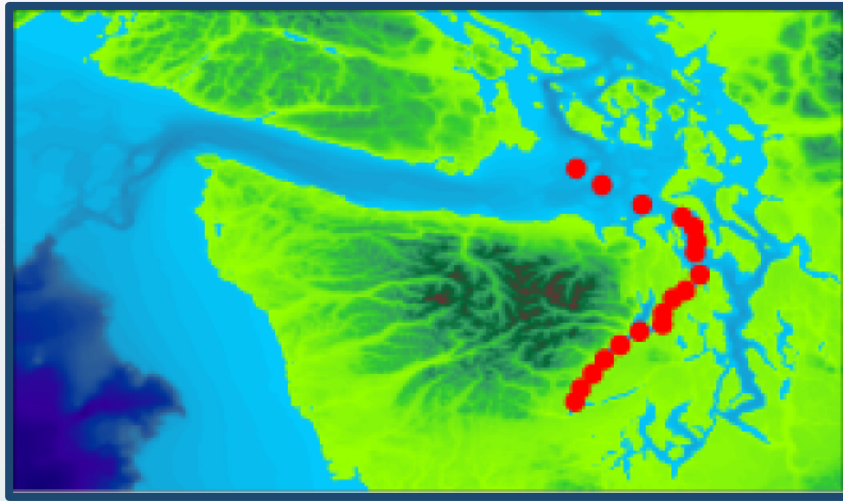
Interaction between ocean acidification and hypoxia: A case study from Puget Sound, Washington



Question: How much of the corrosive conditions in Hood Canal result from ocean acidification?

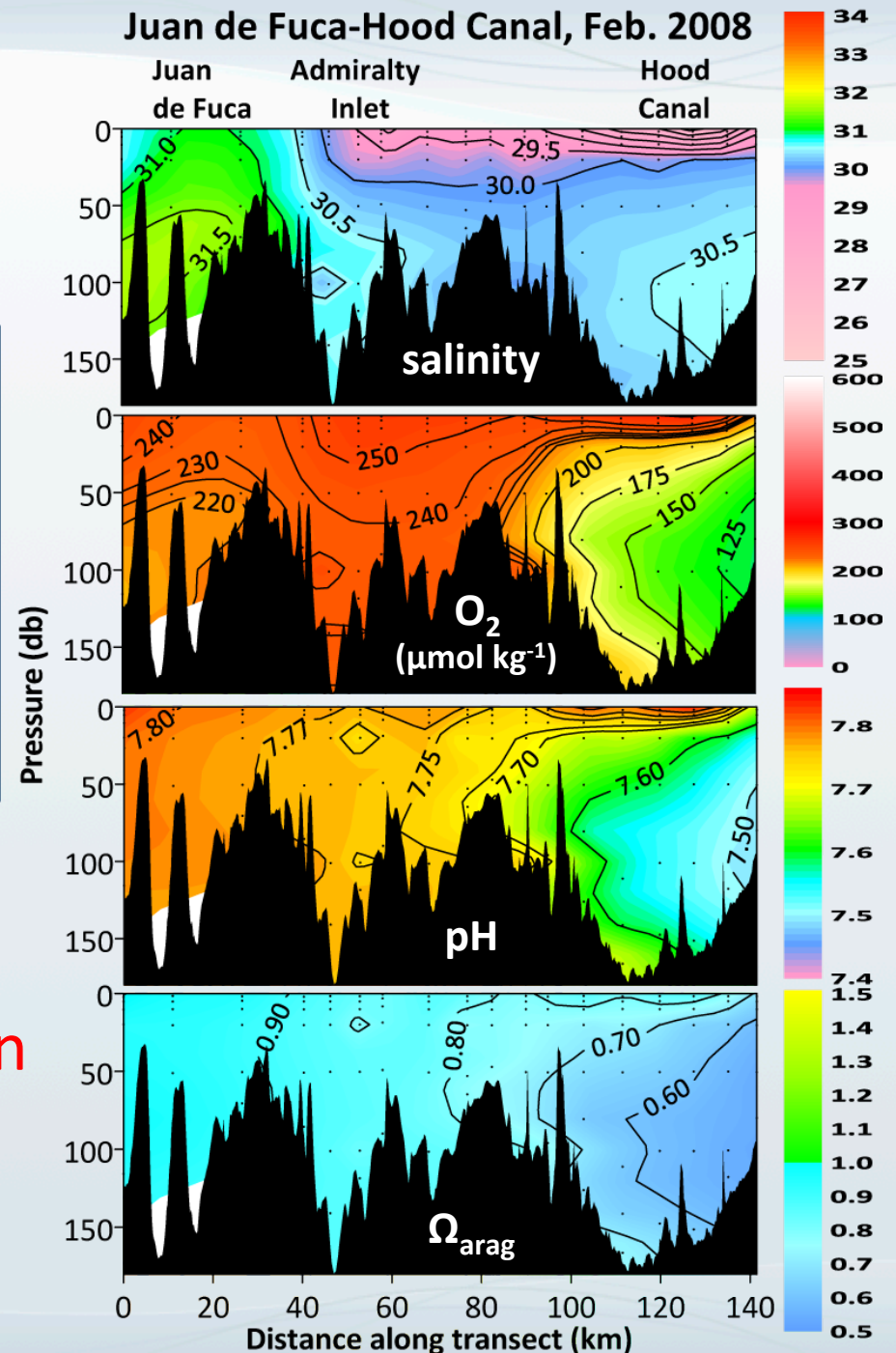


Winter 2008 transect: Juan de Fuca Strait to Hood Canal

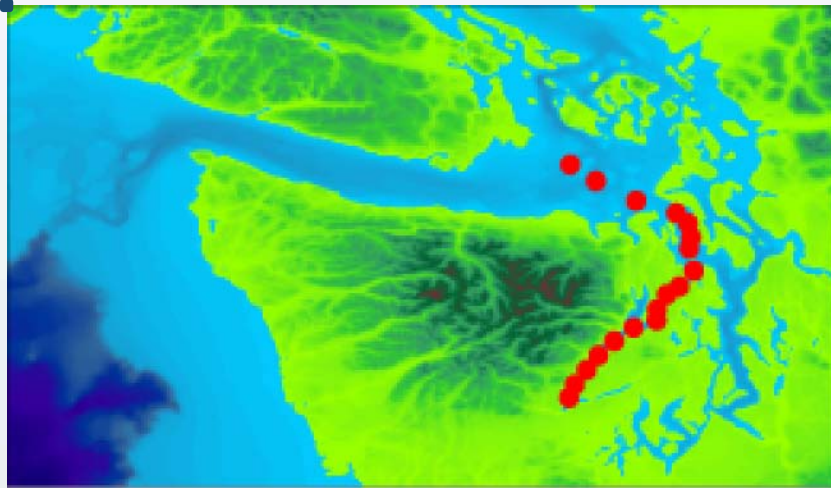


Corrosive undersaturated ($\Omega < 0.9$) water occurs throughout the water column in Winter with pH as low as 7.5

Feely et al. (2010)

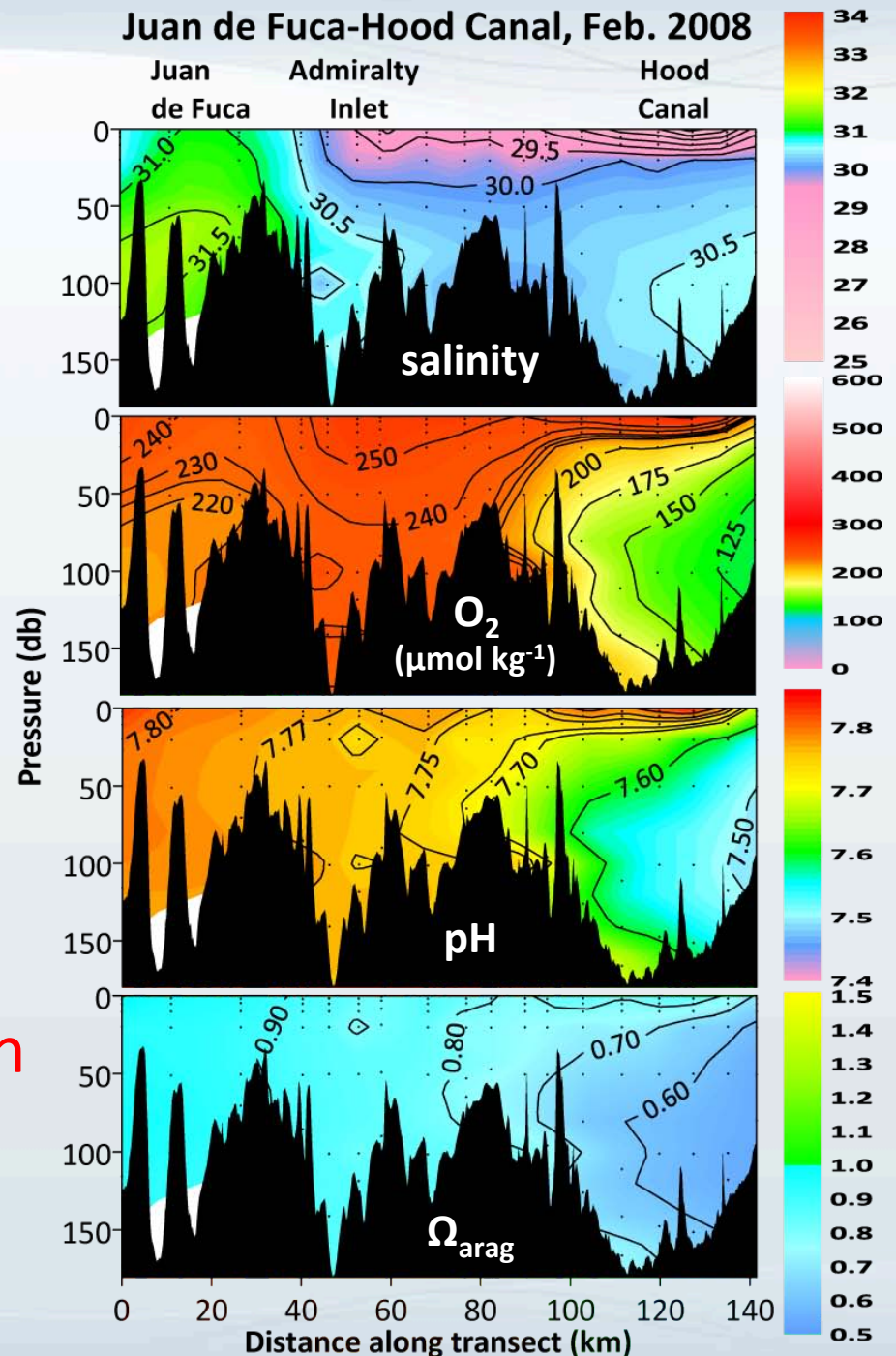


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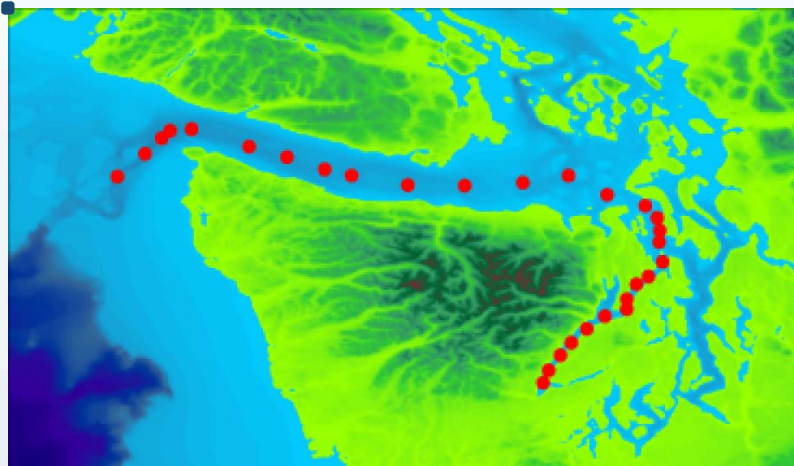


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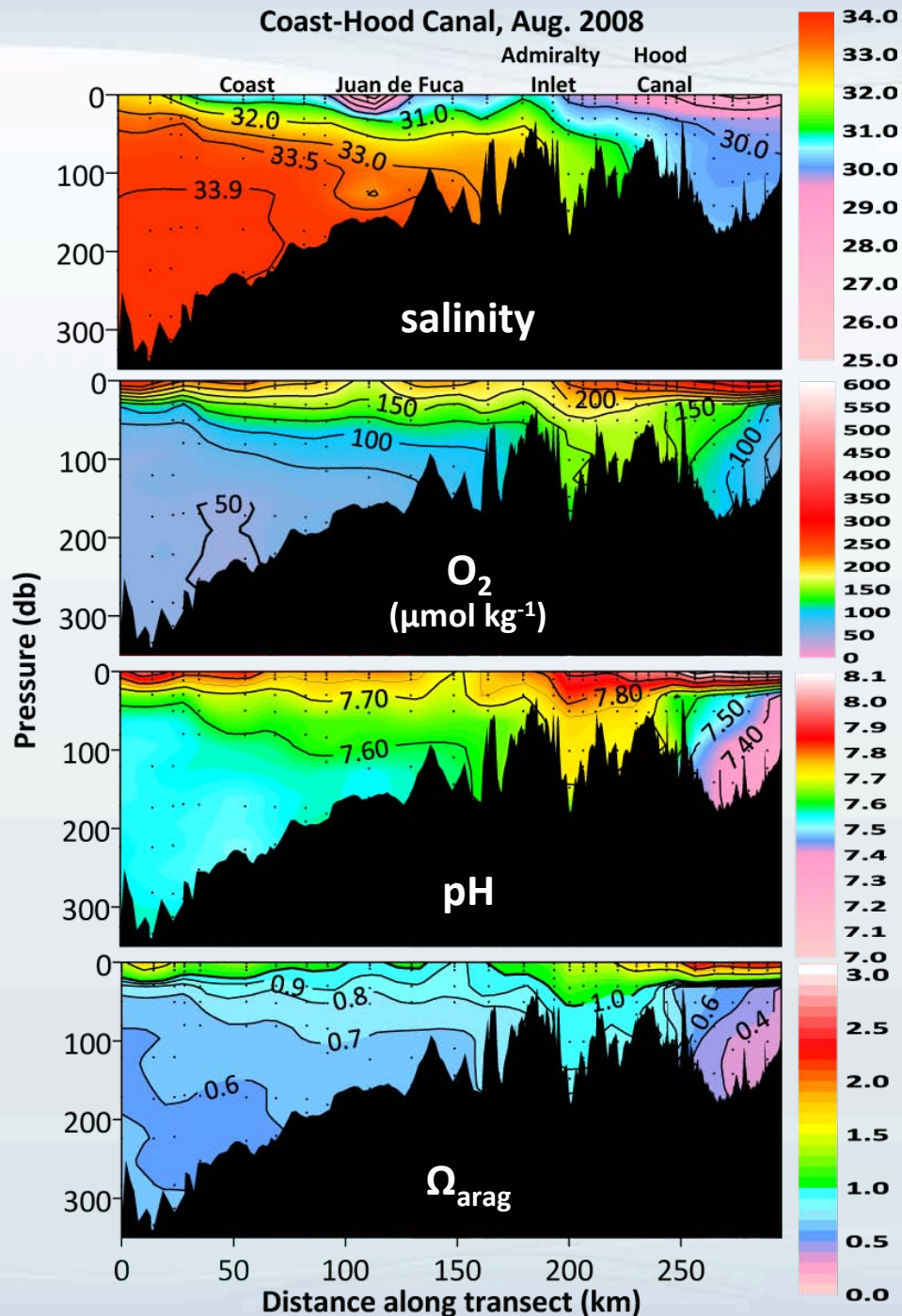


Summer 2008 transect: Coast to Hood Canal

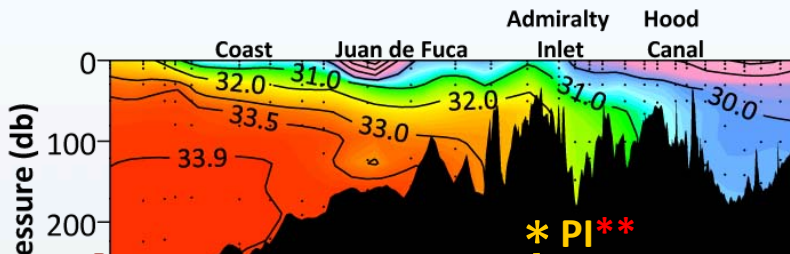


Corrosive undersaturated water ($\Omega < 1.0$) occurs in the lower 180 m of the water column, but is sometimes mixed upward into the surface layer during high-wind conditions.

Feely et al. (2010)



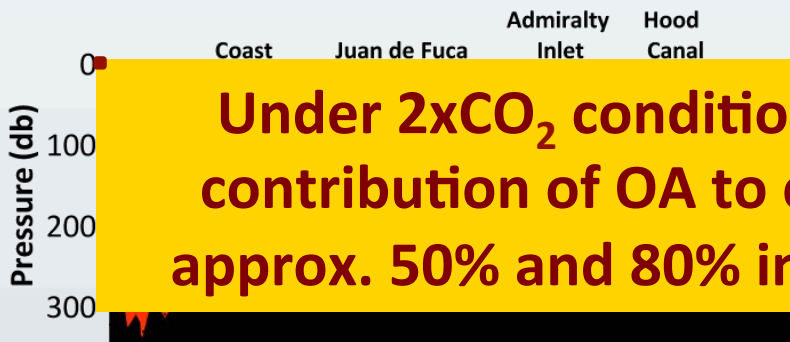
Question: How much of the corrosive conditions in Hood Canal result from ocean acidification?



$$\text{Ocean acidification (DIC}_{\Delta\text{OA}}) = \text{DIC}_{\text{AI}(\text{avg 2008})} - \text{DIC}_{\text{AI}(\text{avg PI})}$$

Ocean acidification accounts for 24% and 49% of corrosive conditions in summer and winter, respectively.

OA accounts for 27 $\mu\text{mol kg}^{-1}$ higher average CO_2 at Admiralty Inlet in 2008 relative to pre-industrial times.



Under 2x CO_2 conditions (atmo. $\text{CO}_2 = 560 \text{ ppmv}$), the contribution of OA to corrosive conditions would rise to approx. 50% and 80% in summer and winter, respectively.

- Respiration accounts for 54 and 18 $\mu\text{mol kg}^{-1} \text{ CO}_2$ in summer and winter, respectively.

Pacific Northwest Ocean Acidification Conclusions

- Both on the continental shelf and in some estuarine environments, undersaturated ($\Omega < 1$) low pH (<7.7) conditions can be present during some parts of the year, most often in near-bottom waters.
- Upwelling and respiration processes are major contributors to the high $p\text{CO}_2$ and low pH, undersaturated bottom waters that are highly vulnerable to further acidification in the future, *therefore there is a need for linkages with chemical and biological time-series measurements as well as laboratory observations.*

Pacific Northwest Ocean Acidification Summary

- **OA research in the Pacific Northwest Coastal Waters is growing and will benefit from better coordination and integration.**
- **Comparative field measurements and laboratory experiments are required for determining spatial and temporal dynamics.**
- **Societal impacts and economic assessments must be addressed directly.**
- **Education/outreach of research and policy results must be delivered to the public in a timely manner.**

Acknowledgments:

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A photograph of the Seattle skyline at dusk, viewed from across the water. The Space Needle is prominent on the left. The city lights are visible against the twilight sky, and a full moon is in the upper right. The water in the foreground is dark blue with some ripples.

Thank you!