

Ecosystem Effects of Ocean Acidification

NWFSC OA Research Core Team:
Shallin Busch, Jason Miller, Mike
Maher, Sarah Norberg



Paul McElhany,
Research Ecologist
Northwest Fisheries
Science Center

Future Oceans?



Not so much...



Calcium Carbonate and Acidification



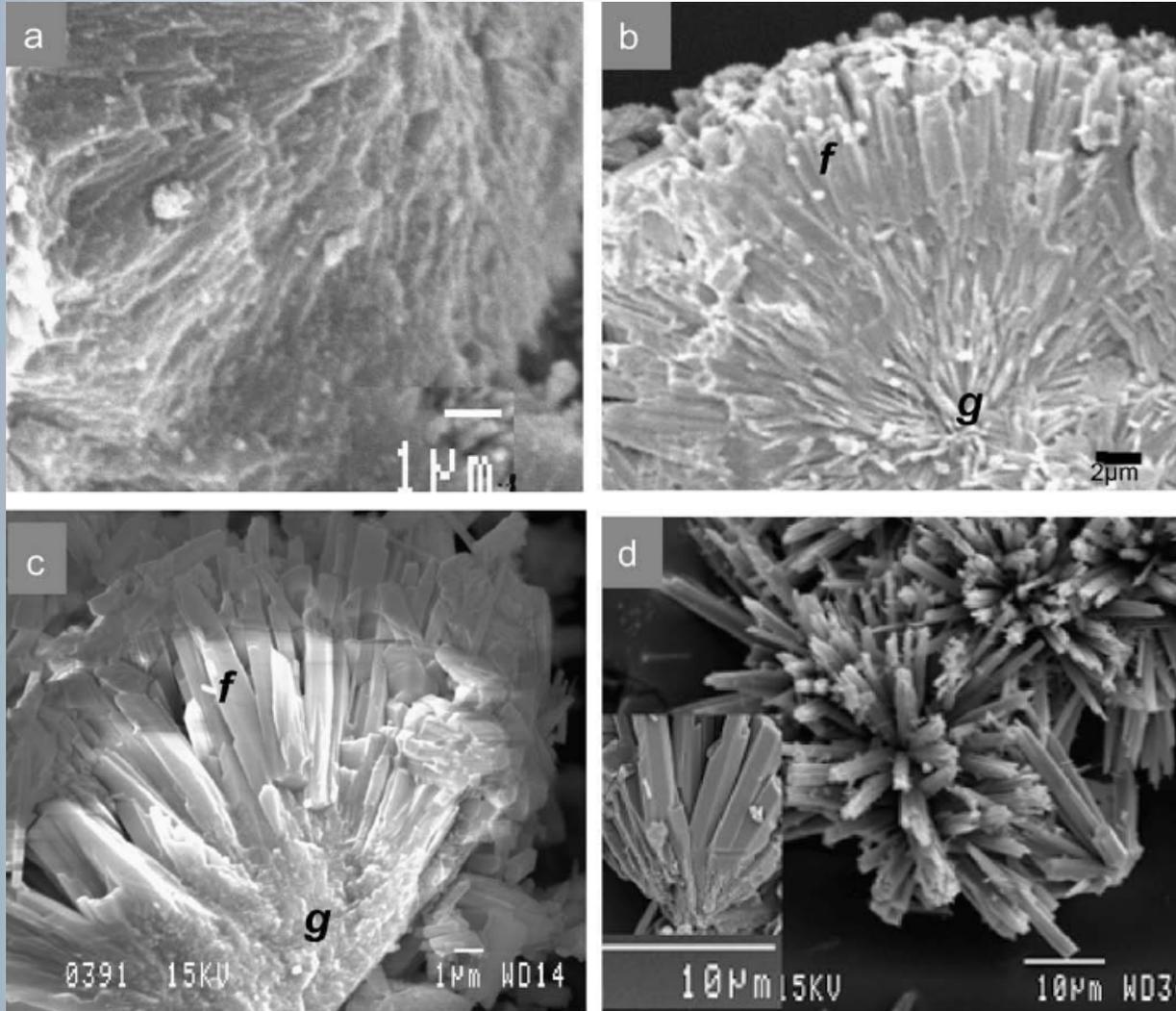
Time sequence of shell dissolution in an Antarctic pteropod in waters simulating 2100 conditions projected for the Southern Ocean under a business-as-usual CO₂ emissions scenario. Credit: David Liitschwager / National Geographic Stock

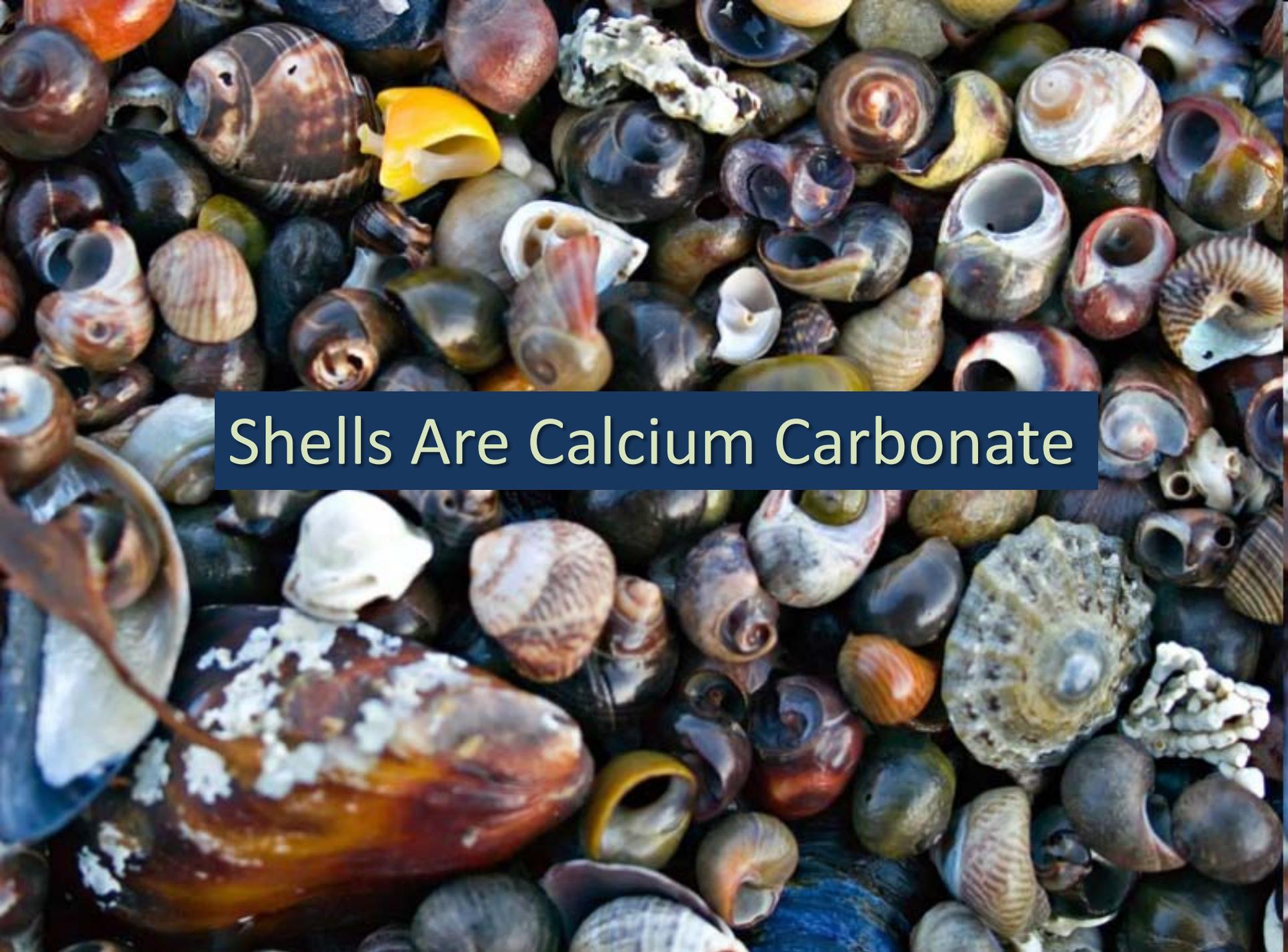
What is Calcium Carbonate?

Calcium carbonate \leftrightarrow Carbonate + Calcium



What is Calcium Carbonate?



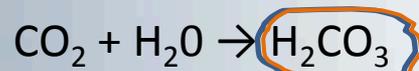


Shells Are Calcium Carbonate

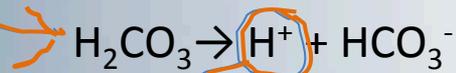
Why CO₂ is Bad for Shells

Acidification of Seawater

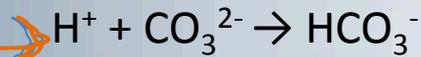
Carbon Dioxide + Water → Carbonic Acid



Carbonic Acid → Hydrogen Ion + Bicarbonate



Hydrogen Ion + Carbonate Ion → Bicarbonate Ion



Calcification

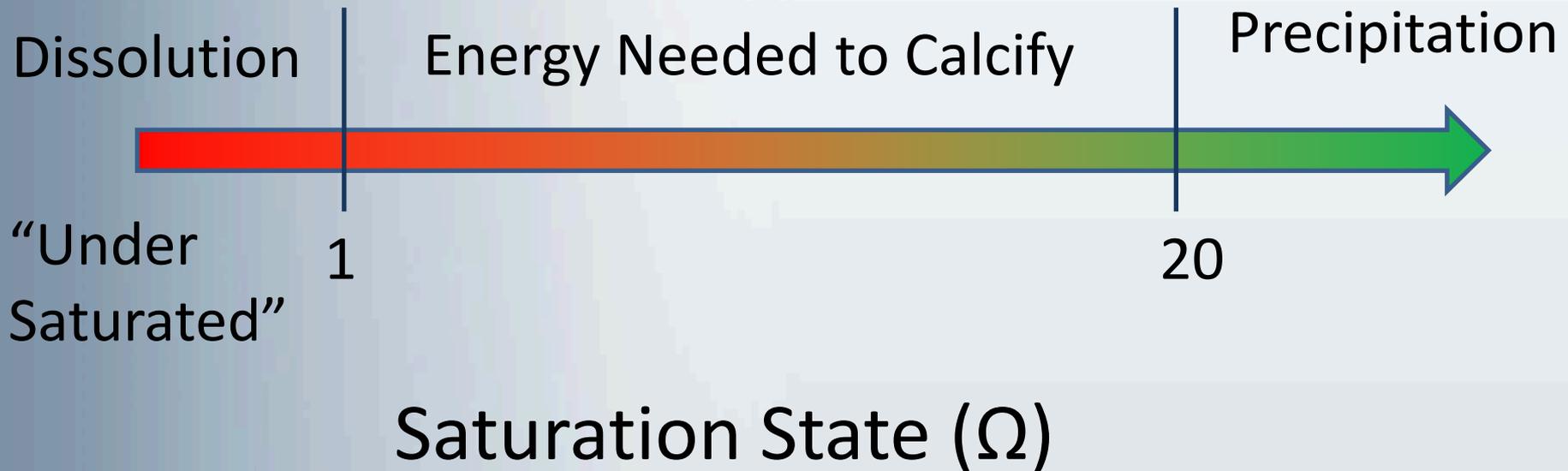
Calcium Ion + Carbonate Ion ↔ Calcium Carbonate



More CO₂
means harder
to make CaCO₃

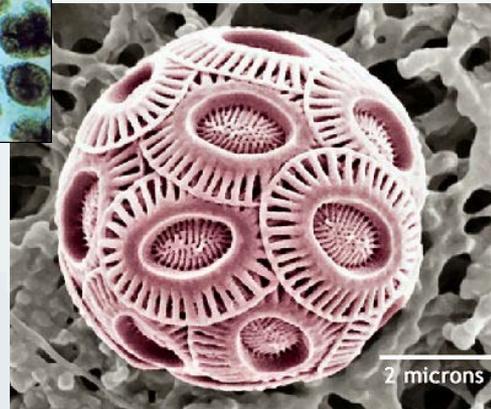
Saturation State

Saturation State (Ω) goes up with carbonate

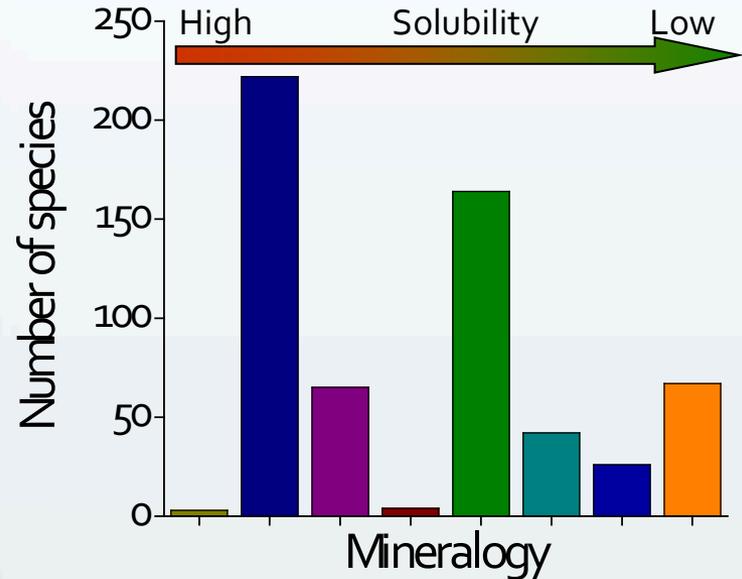
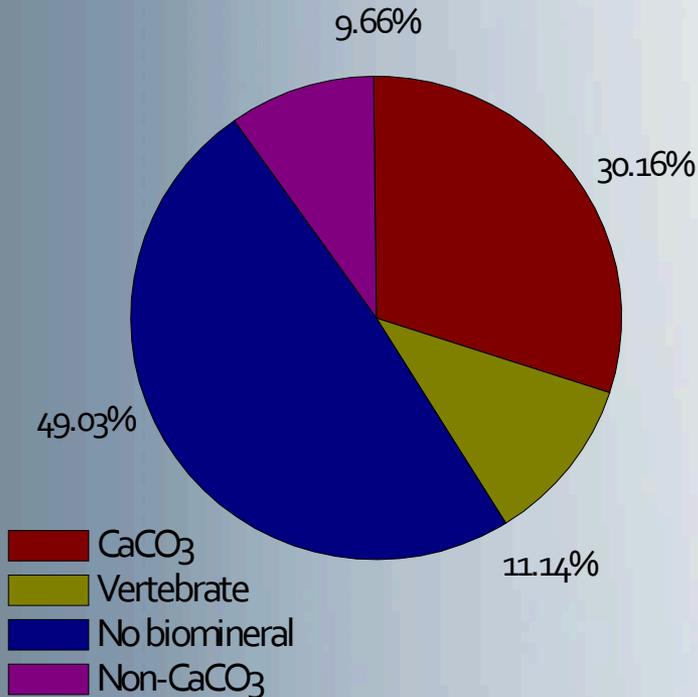


What makes CaCO_3 shells?

About 600 species in Puget Sound!!!



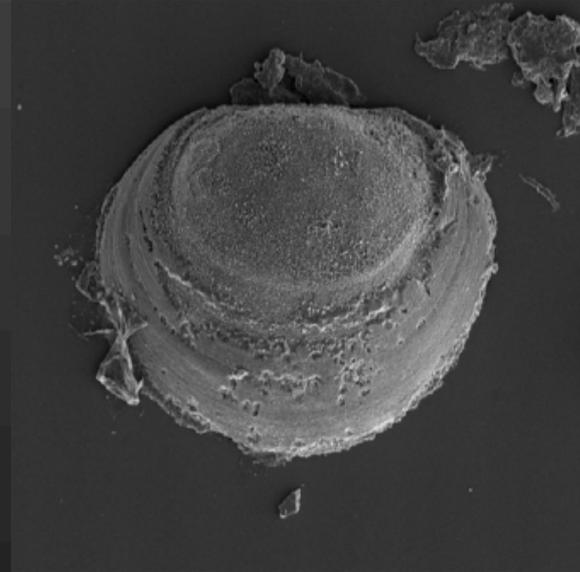
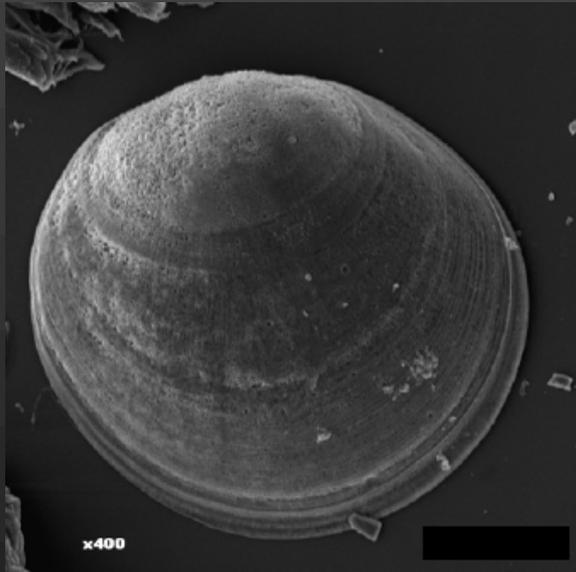
Calcium Carbonate Mineralogy



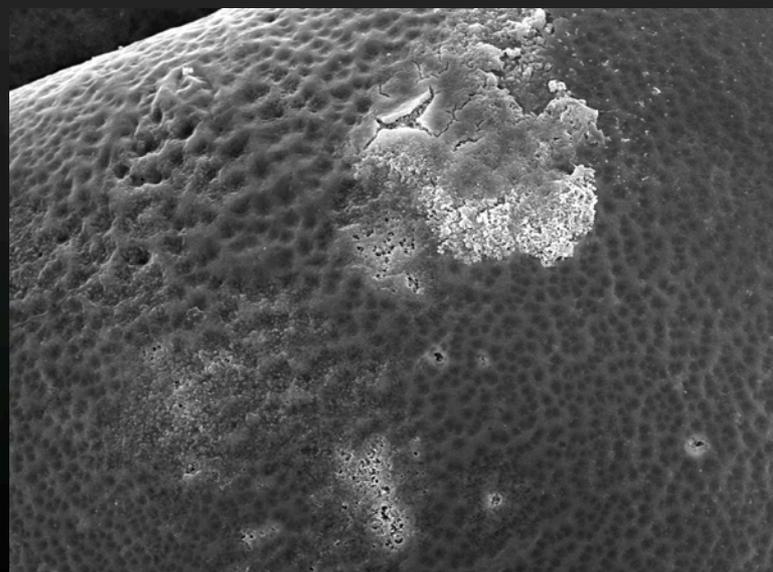
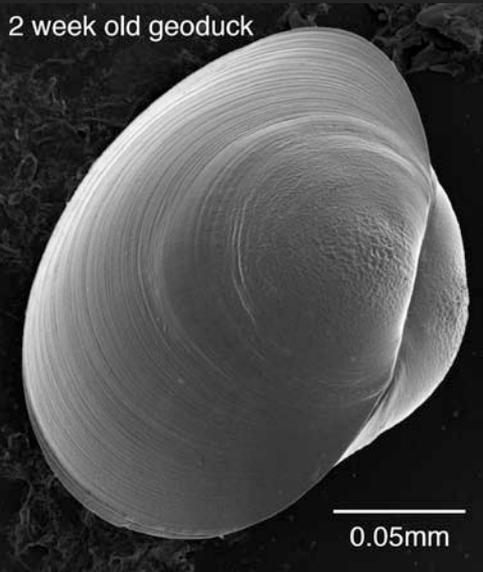
- Mostly amorphous CaCO₃, some calcite
- High Mg calcite, some aragonite, some high Mg calcite
- High Mg calcite
- Mostly aragonite, some high Mg calcite
- Aragonite
- Mostly aragonite, some calcite
- Mostly low Mg calcite, some aragonite
- Low Mg calcite

From Busch et al. in prep

Shells may dissolve



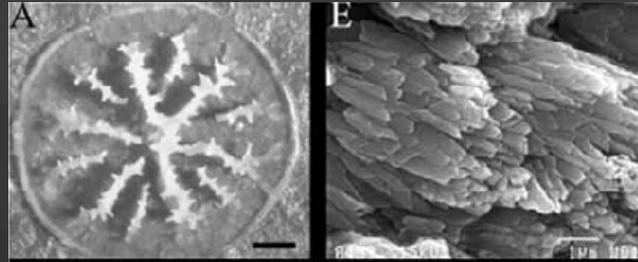
Green et al. 2009



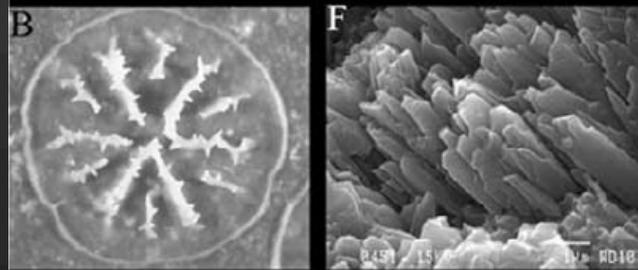
NWFSC 2009

Shells may be harder to build

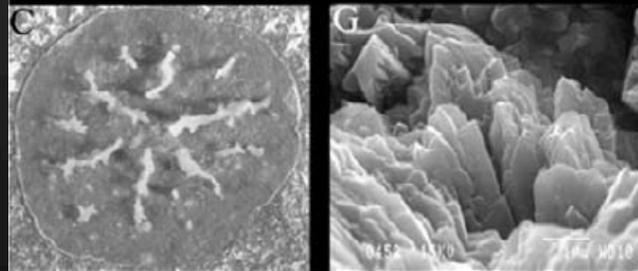
$\Omega = 3.71$ (control)



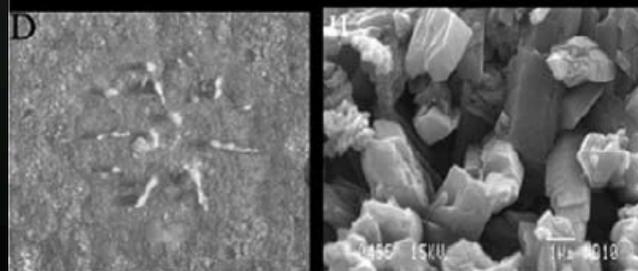
$\Omega = 2.40$



$\Omega = 1.03$



$\Omega = 0.22$ (under Sat.)



Calcification in Fish

Otolith

Seabass Larvae



Photo: Hubbs SeaWorld Research Institute

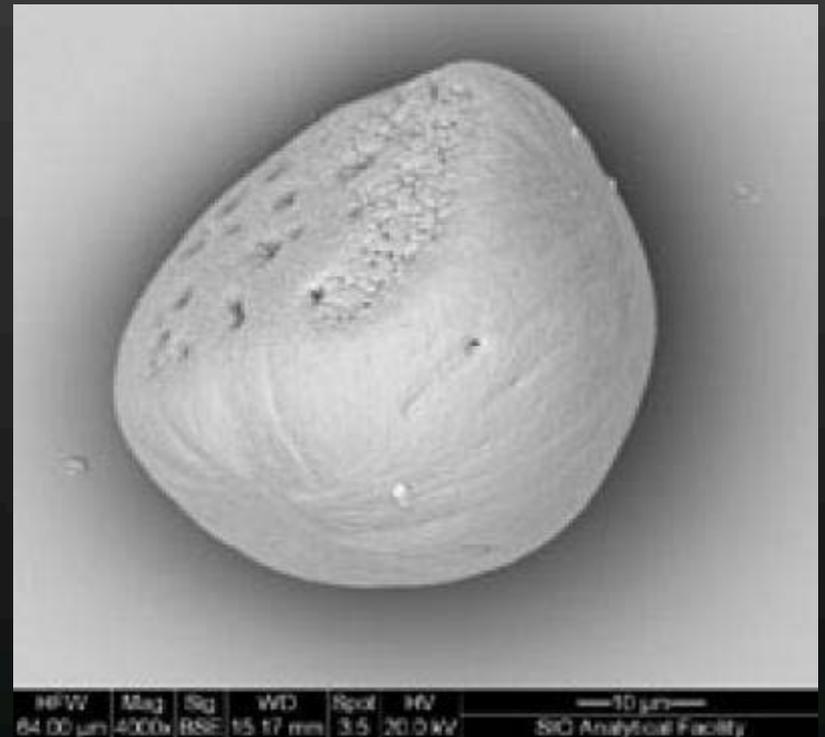
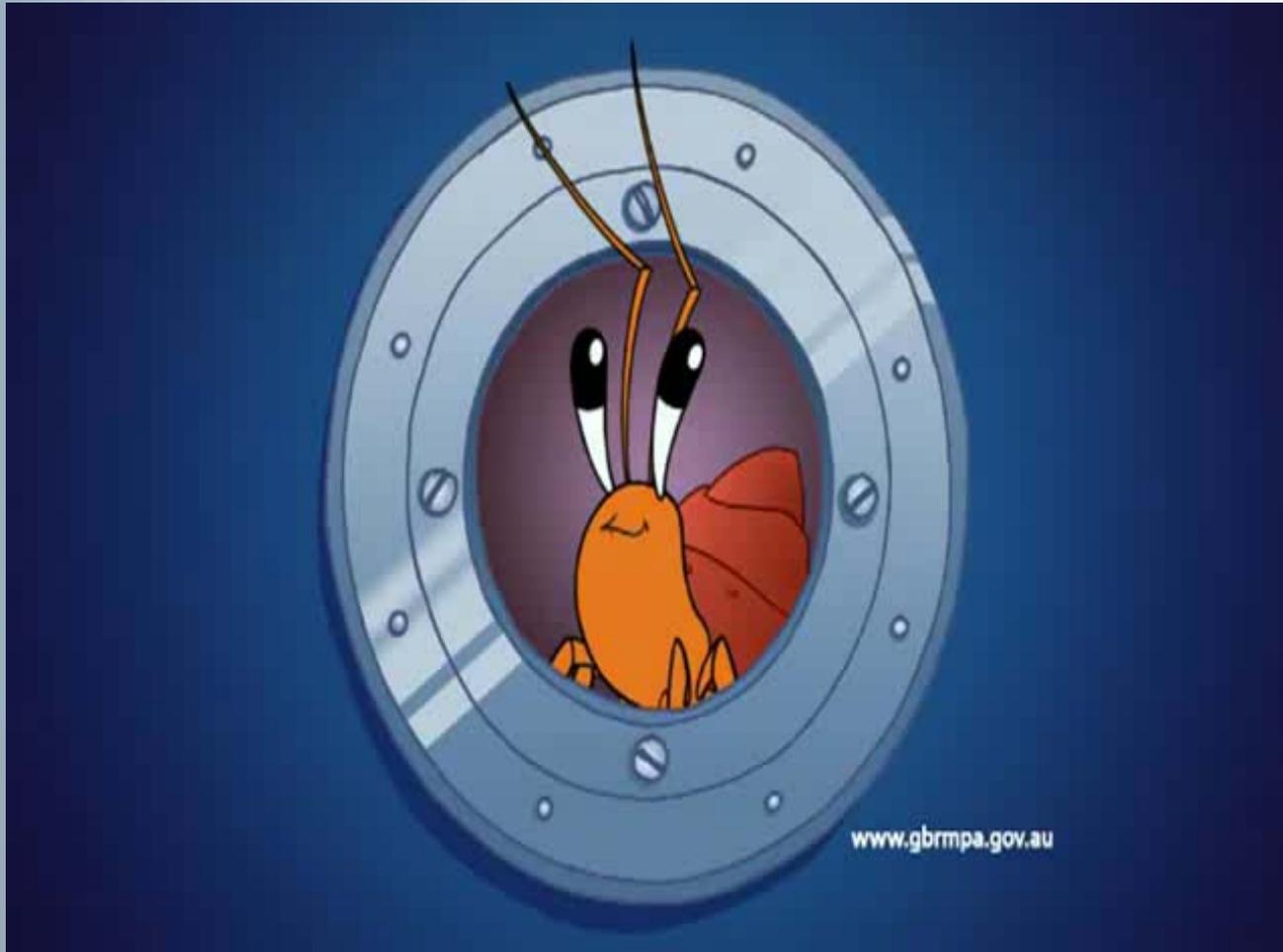


Photo: Scripps Institution of Oceanography, UC San Diego

Hermie the Hermit Crab



Are shells the only thing impacted?

NO

Sensory tissues are affected by OA



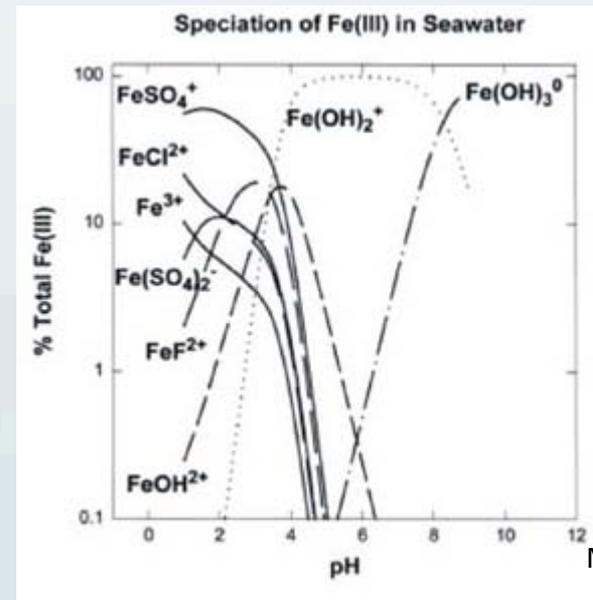
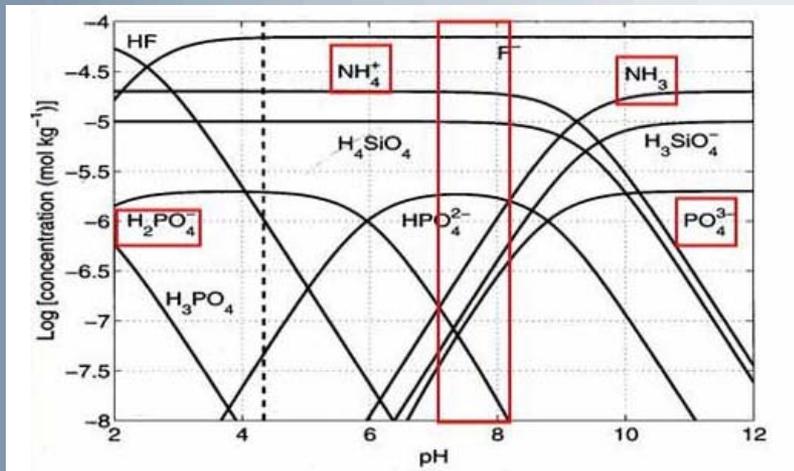
CO₂ and pH Affect Physiology



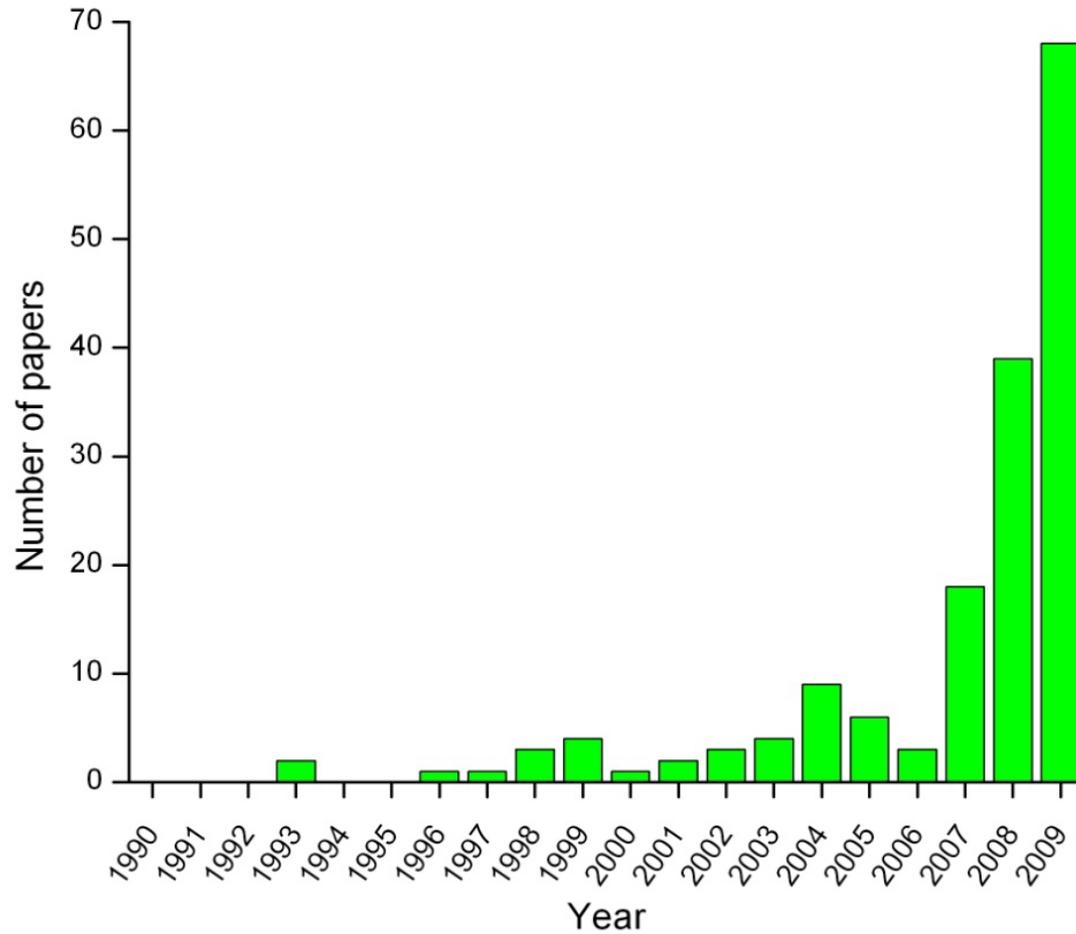
Photosynthesis is Affected by CO₂



Seawater Nutrient Changes



A lot to Learn...



West Coast Oyster Crisis

The Seattle Times

Monday, June 15, 2009 - Page updated at 11:38 AM

Permission to reprint or copy this article or photo, other than personal use, must be obtained from The Seattle Times. Call 206-464-3113 or e-mail resale@seattletimes.com with your request.

Corrected version

Oysters in deep trouble: Is Pacific Ocean's chemistry killing sea life?

By Craig Welch
Seattle Times environment reporter
WILLAPA BAY, Pacific County

The collapse began rather unexpectarlarly.

In 2005, when most of the millions of Pacific oysters in this tree-lined estuary failed to reproduce, Washington's shellfish growers largely shrugged it off.

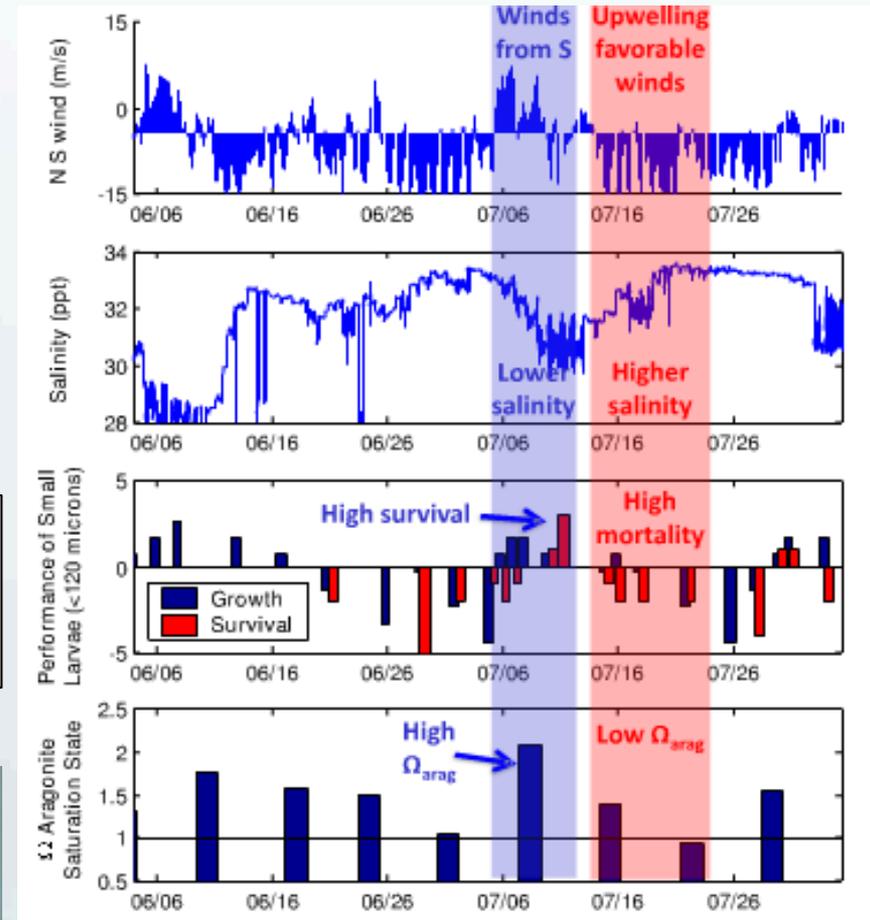
In a region that provides one-sixth of the nation's oysters - the epicenter of the West Coast's \$111 million oyster industry - everyone knows nature can be fickle.



STEVE RINGMAN / THE SEATTLE TIMES
Oysters' failure to reproduce will lead workers like Northern Oyster Co.'s Gildardo Mendoza to collect far more of their product from a state "oyster preserve" in Willapa Bay. Pacific oysters haven't successfully reproduced in the wild since 2004.



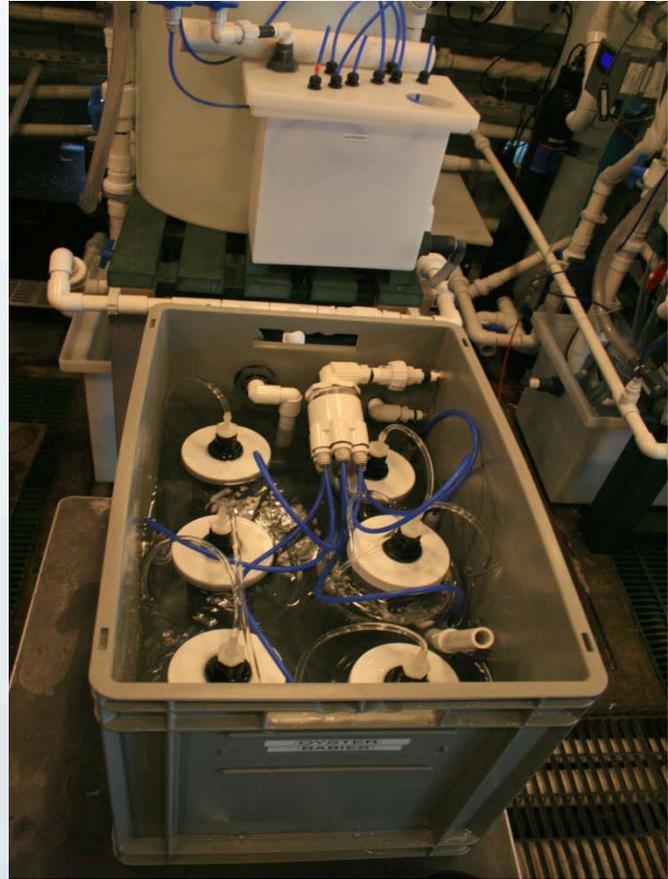
Widespread repeated larval failures linked to pH



NWFSC Research



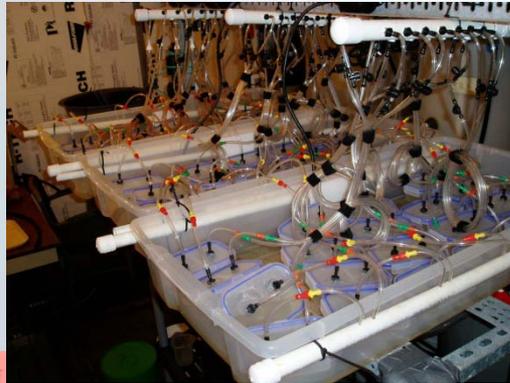
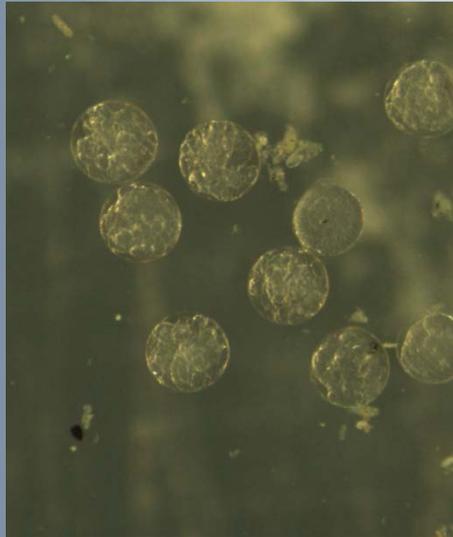
Larvae Culture



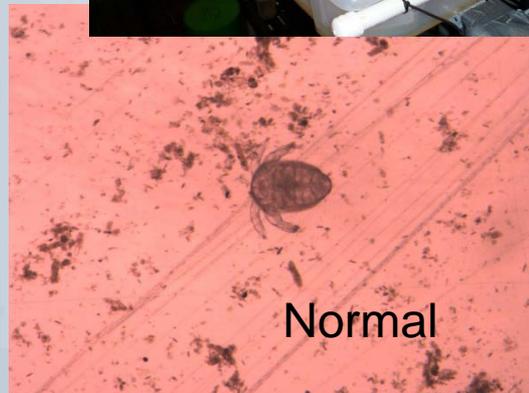
NWFSC Research



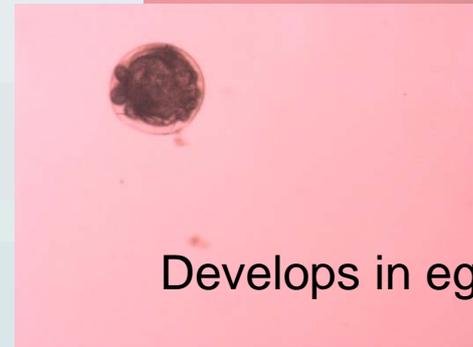
Deformed
late hatch



Deformed

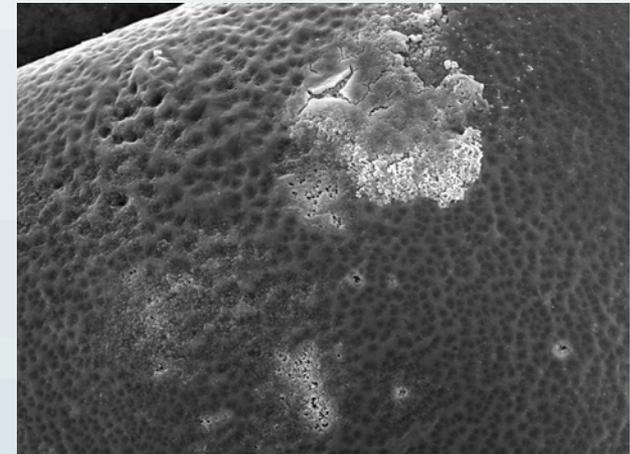
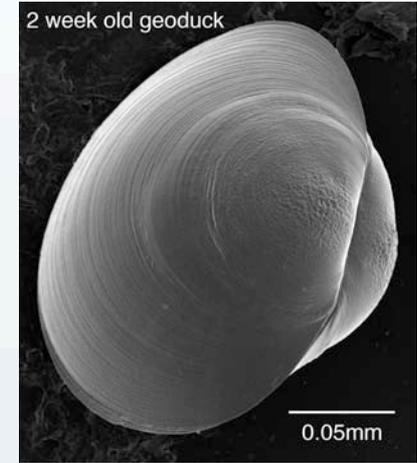
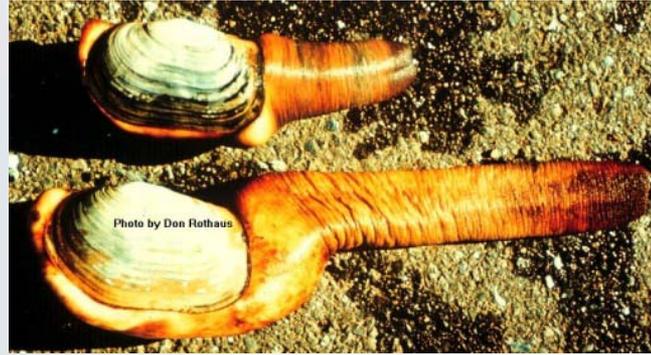


Normal



Develops in egg

NWFSC Research



Experiments at the NWFSC

(underway and planned)

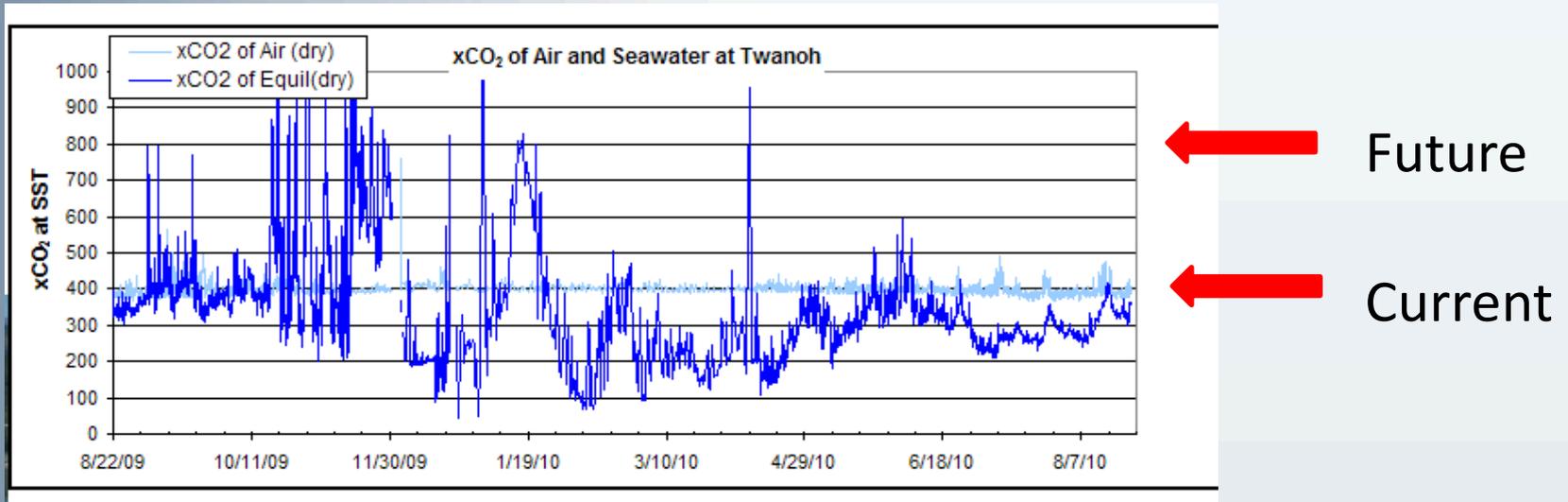
- CO₂, DO, temp and nutrient interactions
- Natural temporal patterns in CO₂



- Pacific oyster
- Rockfish larvae
- Krill
- Dungeness crab
- Olympia oyster
- Pinto abalone
- Geoduck
- Copepod
- Fish sperm
- Species assemblages

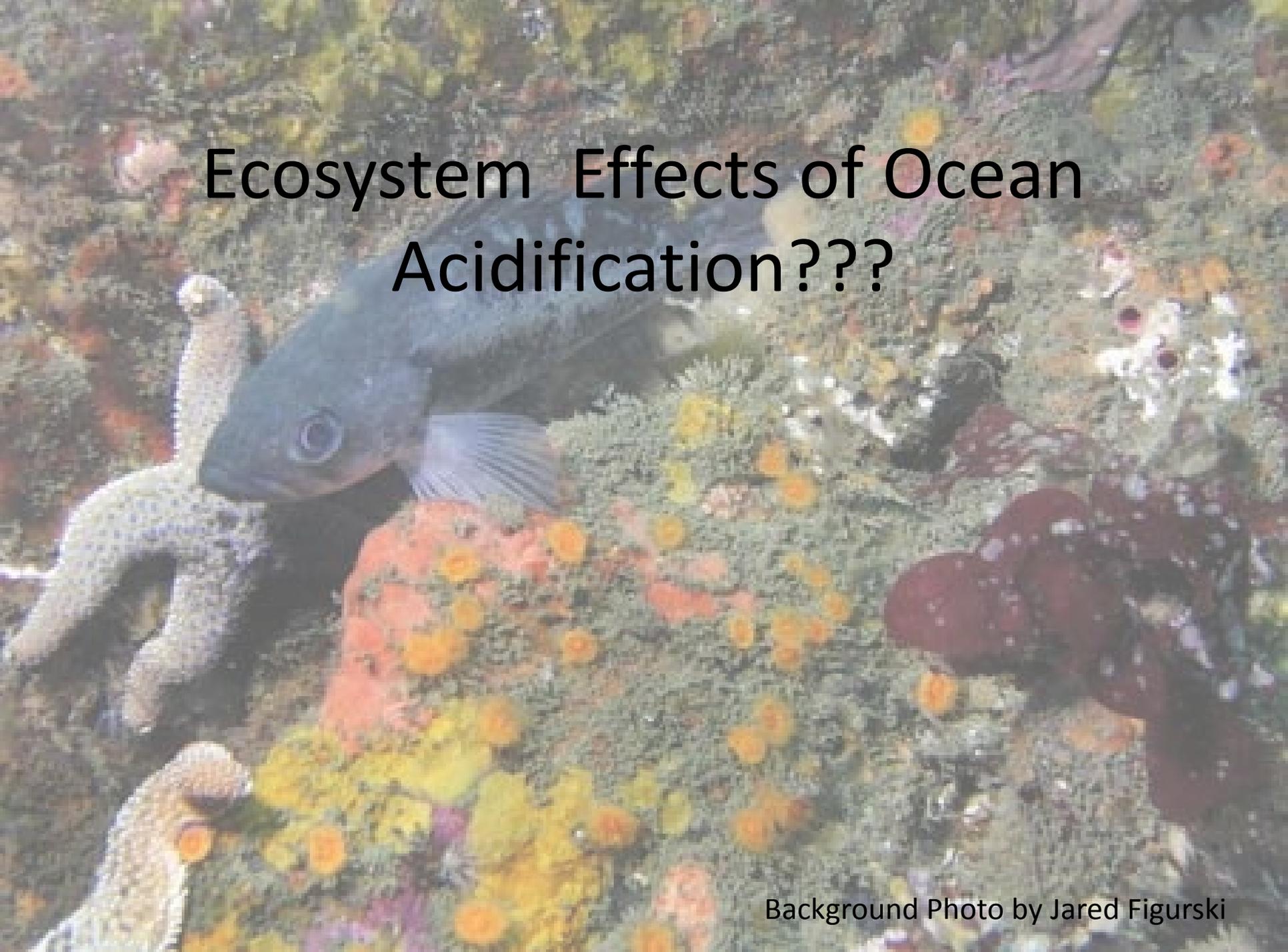
Collaborations with Universities, Tribes, State Agencies, NGOs

CO₂ Fluctuations



“Climate is what you expect, weather is what you get”

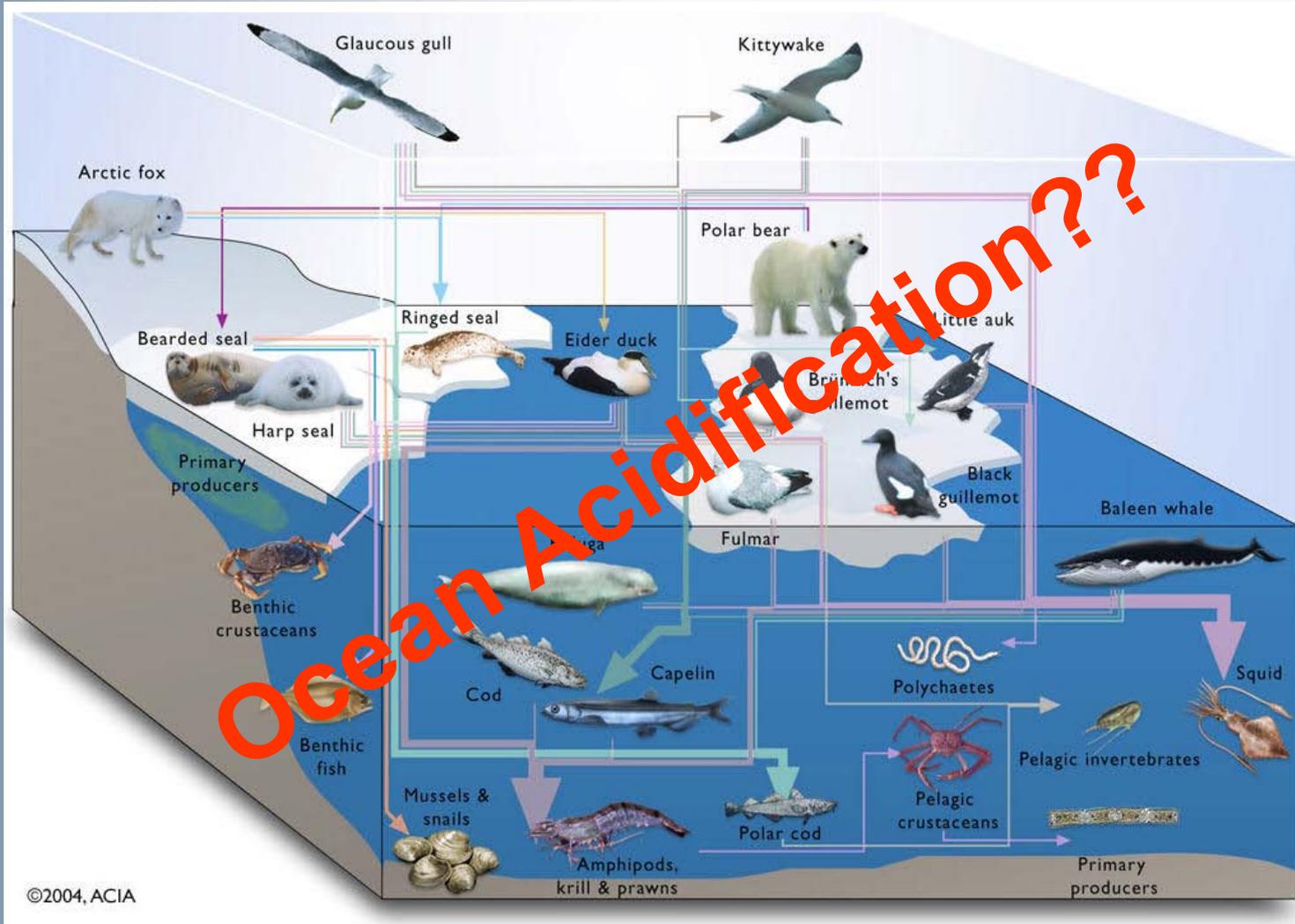
– Robert A. Heinlein

A photograph of a fish swimming over a diverse coral reef. The fish is dark-colored with a prominent eye. The reef is covered in various types of coral, including branching, table, and brain corals, as well as sea anemones. The colors range from bright yellow and orange to deep red and purple.

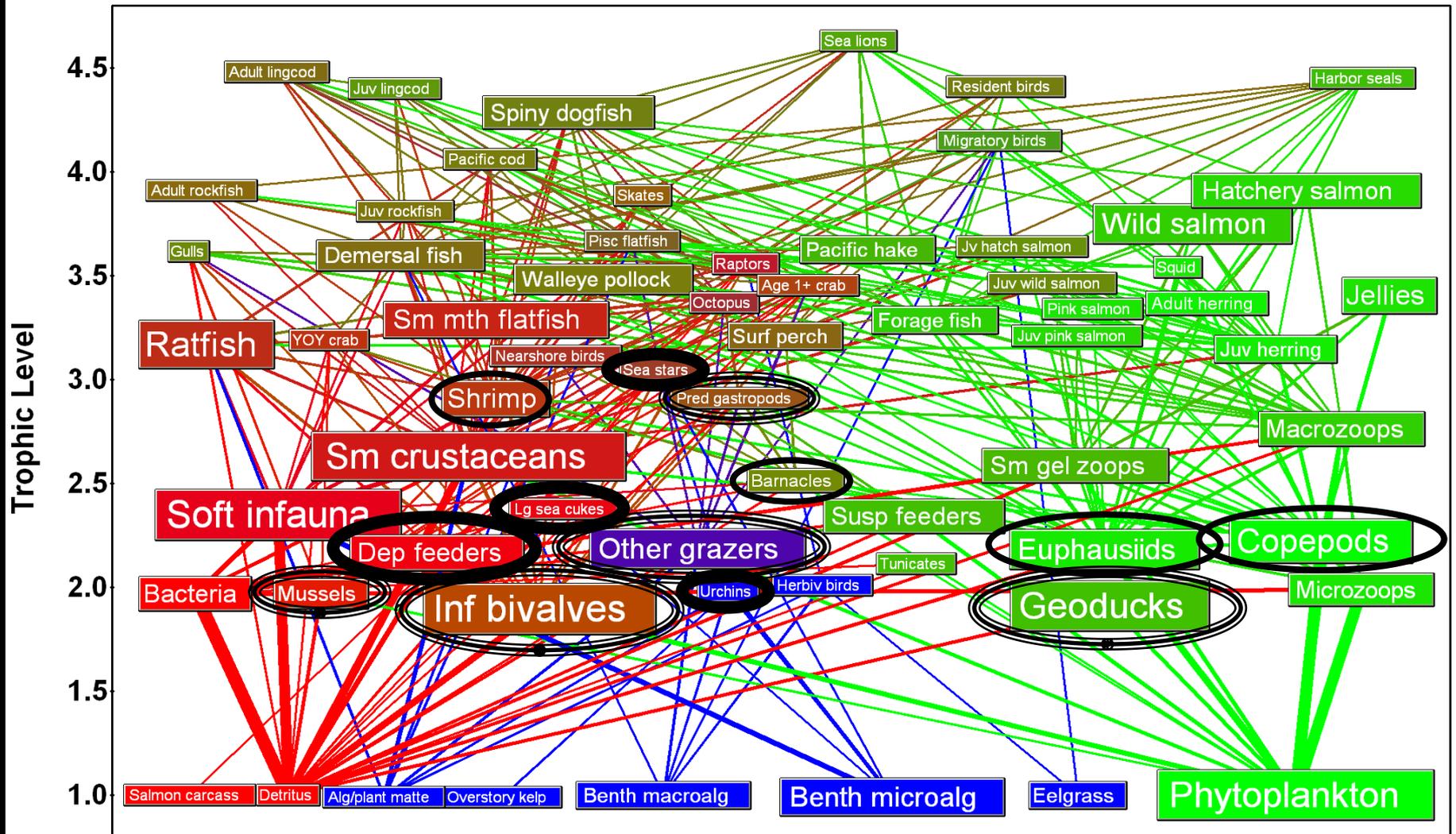
Ecosystem Effects of Ocean Acidification???

Background Photo by Jared Figurski

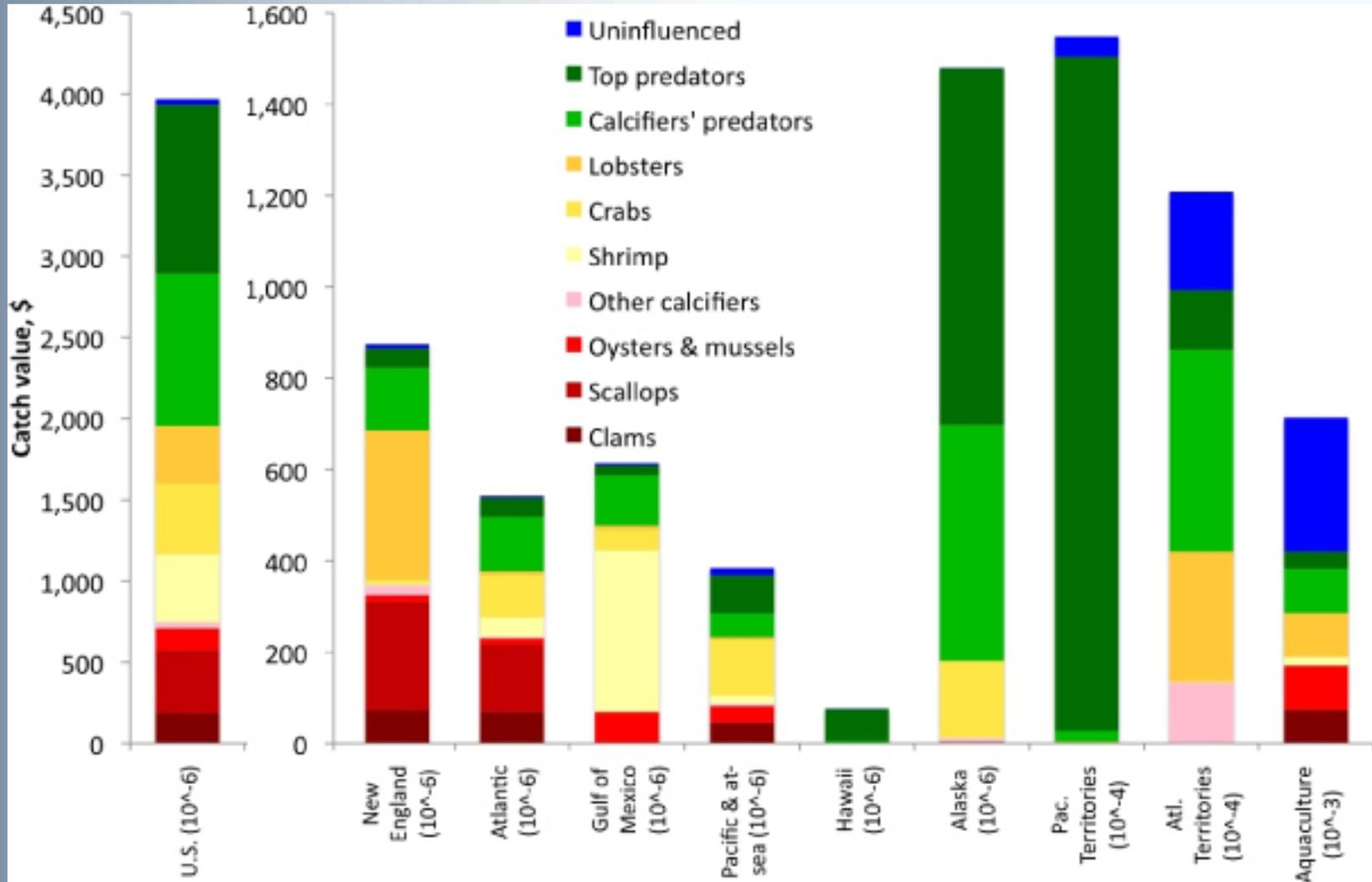
Species are Interdependent



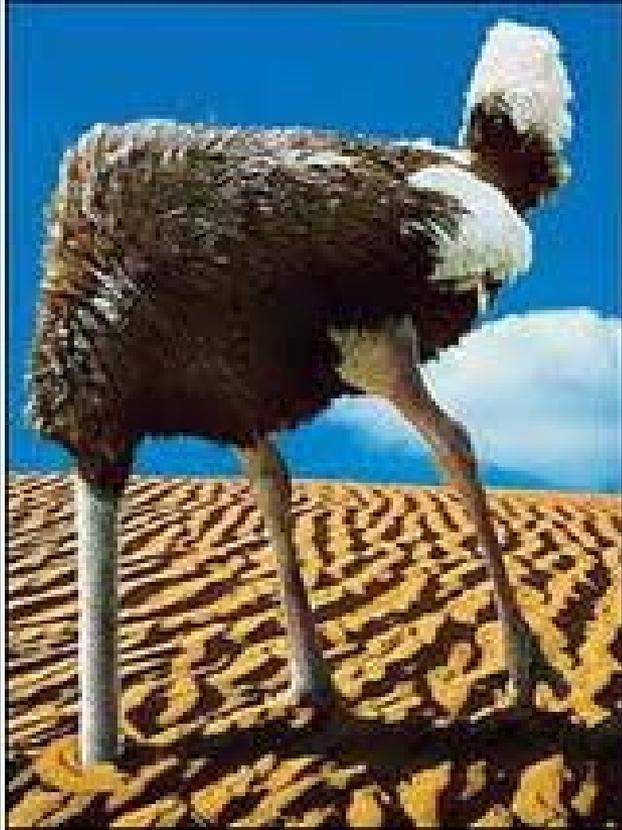
Puget Sound Ecosystem



Economic Cost of OA



What to Do About OA?



Reduce CO2

Reduce Other Stressors



Plan for Change



