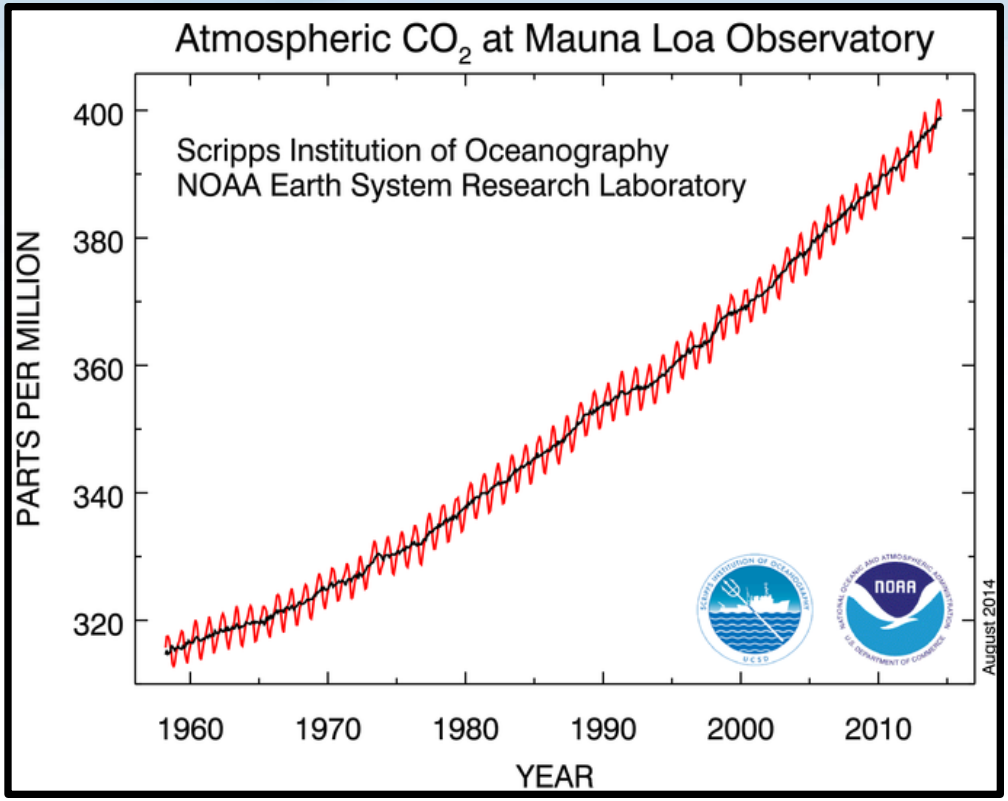
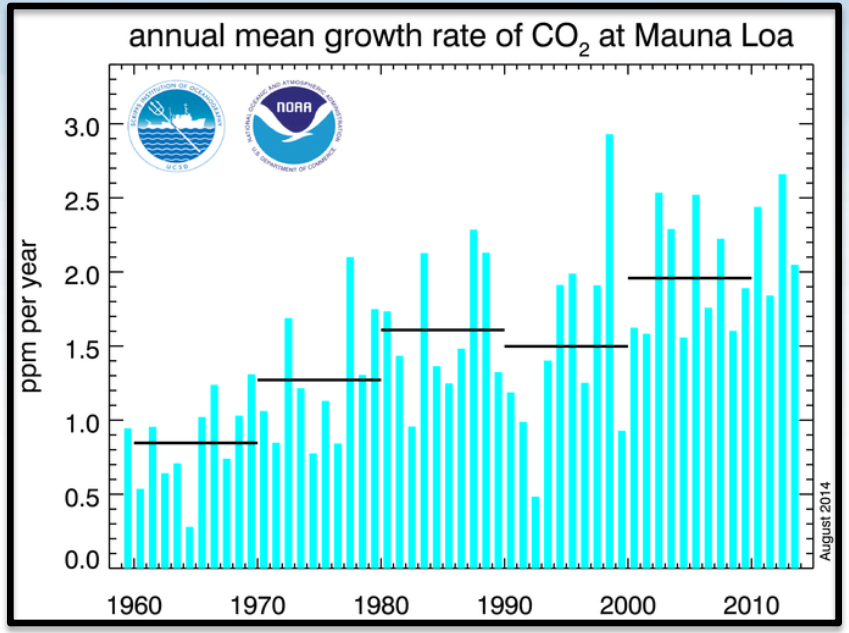
Alaska Ocean Acidification
Gauging the Risk and Monitoring the Environment

Jeremy T. Mathis, Ph.D.

September 15th, 2014

Fate of Anthropogenic CO_2 Emissions





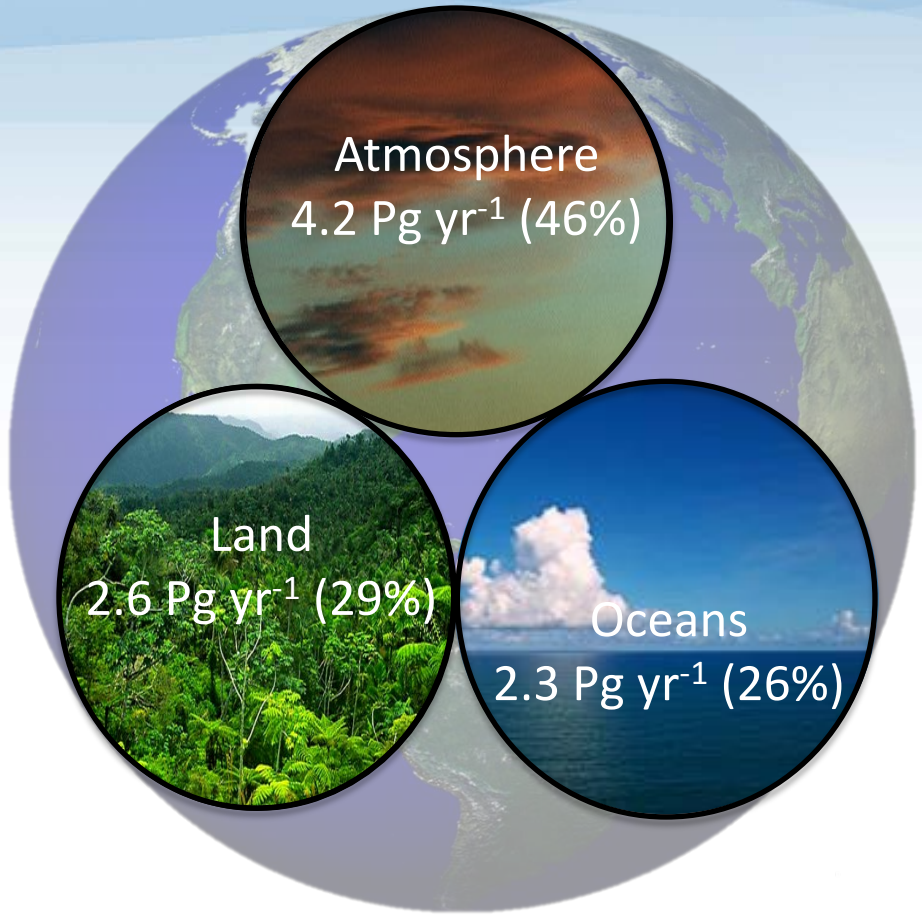
<u>Monthly Average Mauna Loa CO_2</u>

July 2014: 399.00 ppm

July 2013: 397.20 ppm

Fate of Anthropogenic CO_2 Emissions

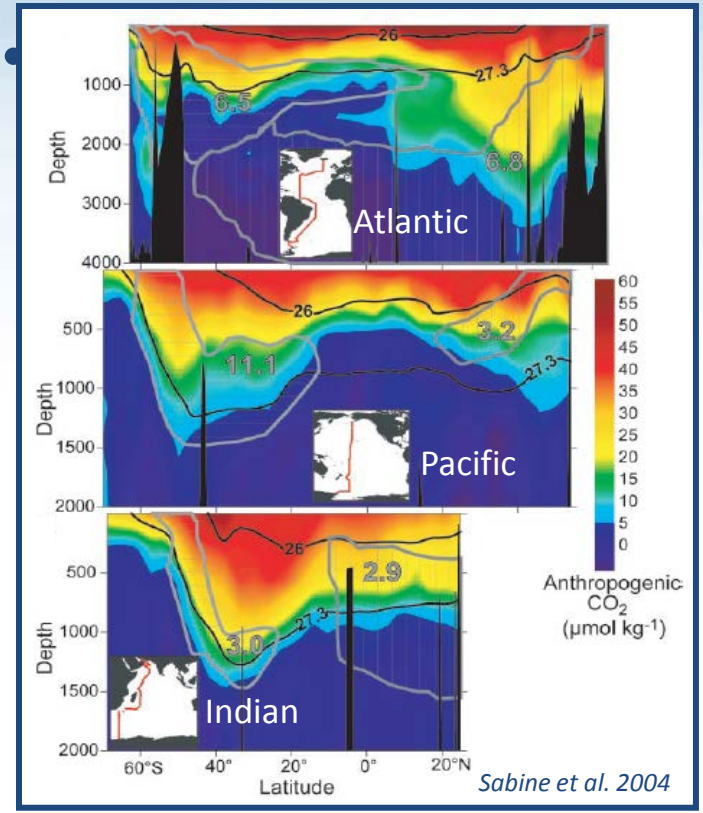
+



Canadell et al. PNAS 2007; LeQuere et al. Nature Geosciences 2009

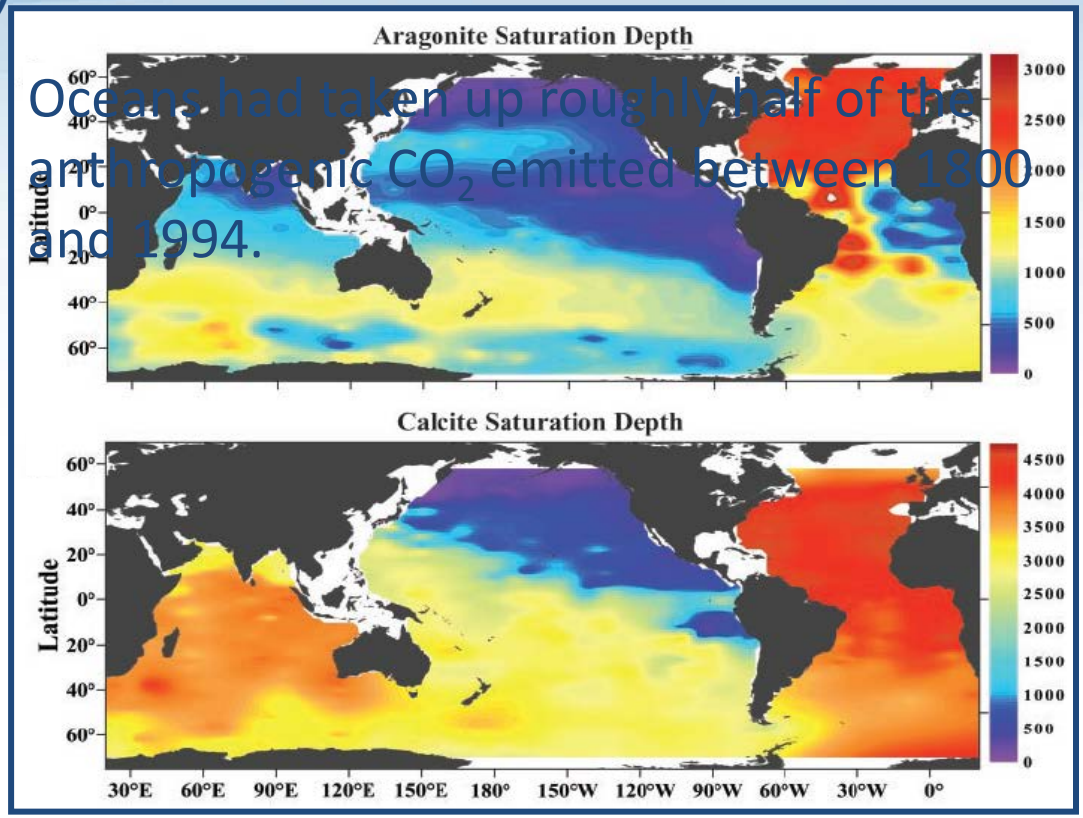
Ocean Acidification In Global Ocean Basins

Anthropogenic CO_2 Inventory



Sabine et al. 2004

Saturation State Depths

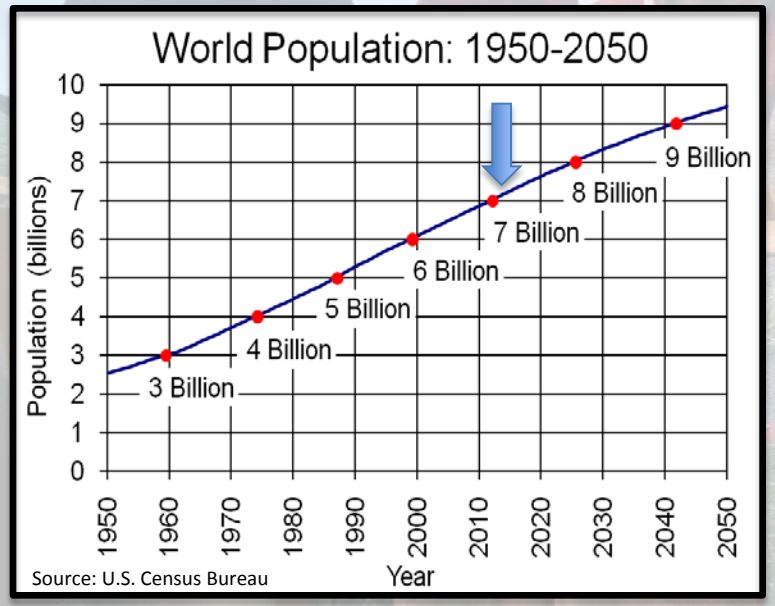


Feely et al. 2004

- Oceans had taken up roughly half of the anthropogenic CO_2 emitted between 1800 and 1994.

Why Ocean Acidification Is More Than Just Chemistry

OVER 1 BILLION PEOPLE DERIVE ALL OF THEIR DIETARY PROTEIN DIRECTLY FROM THE OCEANS



- Energy consumption could increase 56% by 2040. (U.S. EIA)
- Worldwide consumption of seafood could triple by 2030. (Standford Woods)
- Approximately 3 billion people live within 200 kilometers of a coastline. By 2025, that figure is likely to double. (U.N. Assessment)

Indicator Species That Show Effects of OA

- Dissolution of pteropods have been observed in the wild (e.g. Bednaršek et al., 2014).
- Other species, such as **crabs**, **clams**, and **oysters** have shown effects in laboratory settings.

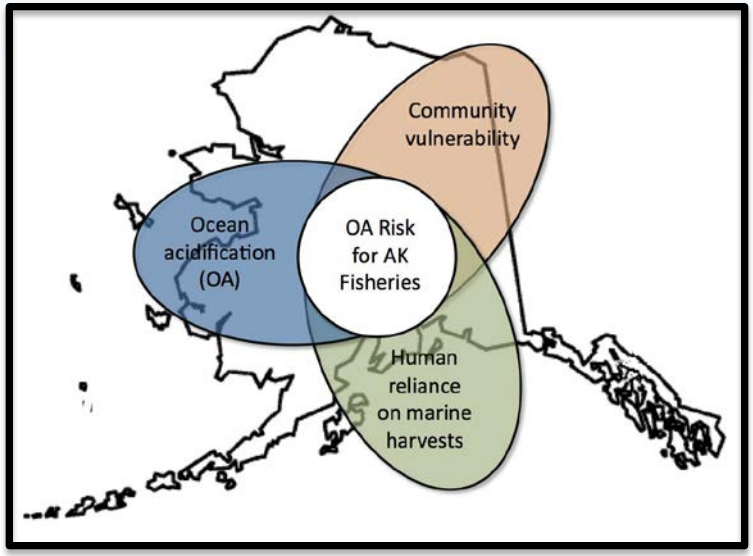
Evaluating the Risks of OA In Alaska

Risk - The chance that an investment's actual return will be different than expected. Risk includes the possibility of losing some or all of the original investment.

Ocean Acidification Risk Assessment for Alaska's Fishery Sector
J.T. Mathis, S.R. Cooley, N. Lucey, S. Colt, J. Ekstrom, T. Hurst, C. Hauri, W. Evans, J.N. Cross, and R.A. Feely.

- Highly productive Alaskan commercial and subsistence fisheries are located in seas projected to experience rapid transitions in temperature, pH, and other chemical parameters caused by global change, especially ocean acidification (OA).

- Many of the marine organisms that are most intensely affected by OA, such as mollusks are native to Alaska and contribute substantially to the state's highly productive commercial fisheries and traditional subsistence way of life.



Evaluating the Risks of OA In Alaska

Bad News for King Crab

A recent study by the NOAA Fisheries Lab in Kodiak showed that under end-of-century OA conditions:

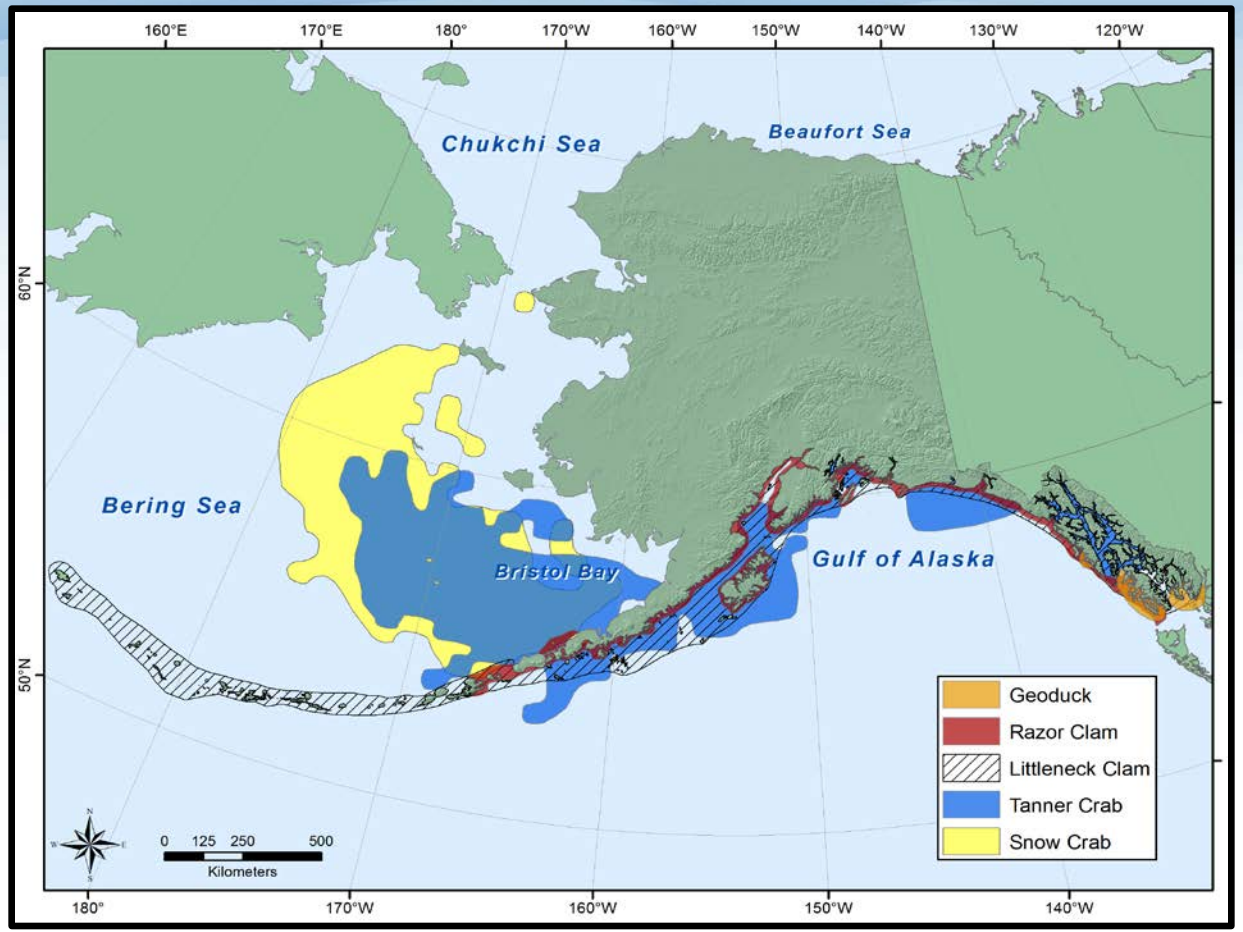
- Acidified embryos hatch duration was 33% longer and had lower survival.
- Calcium content of both larvae and female carapaces after molting increased by 5 and 19 %, respectively.
- Although ocean acidification may increase larval size and calcium content, the implications of this are unclear and decreased survival is likely to harm red king crab populations.

Better News for Pollock

A recent study by the NOAA Hatfield Lab in Oregon showed that under end-of-century OA conditions:

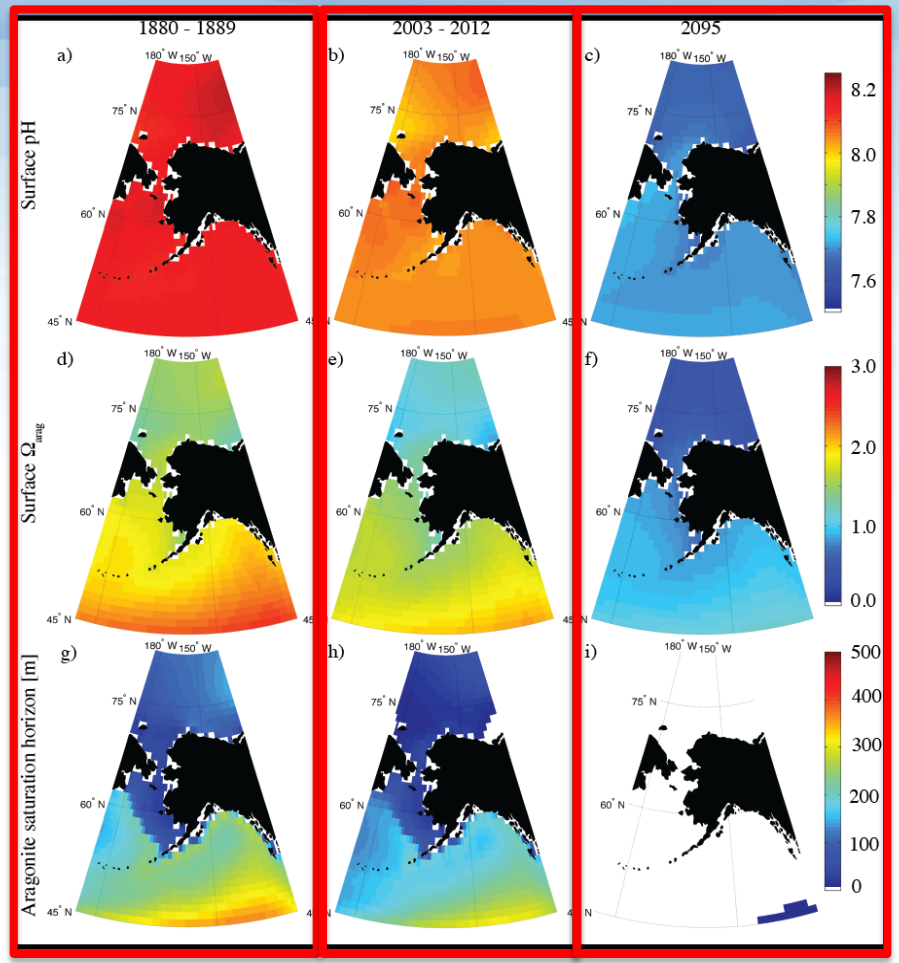
- In a short-term experiment with yearlings, CO_2 treatment had no significant effect on growth or condition after 6 wks of rearing.
- Growth in length of sub-yearlings over 12 wks at 8° C was 7.2% faster in the 2 higher CO_2 treatments (>1200 µatm) than in the lower CO_2 treatments (<900 µatm).
- However, Pollock prey stocks may be at risk and Pollock behavior may change.

Evaluating the Risks of OA In Alaska



Evaluating the Risks of OA In Alaska

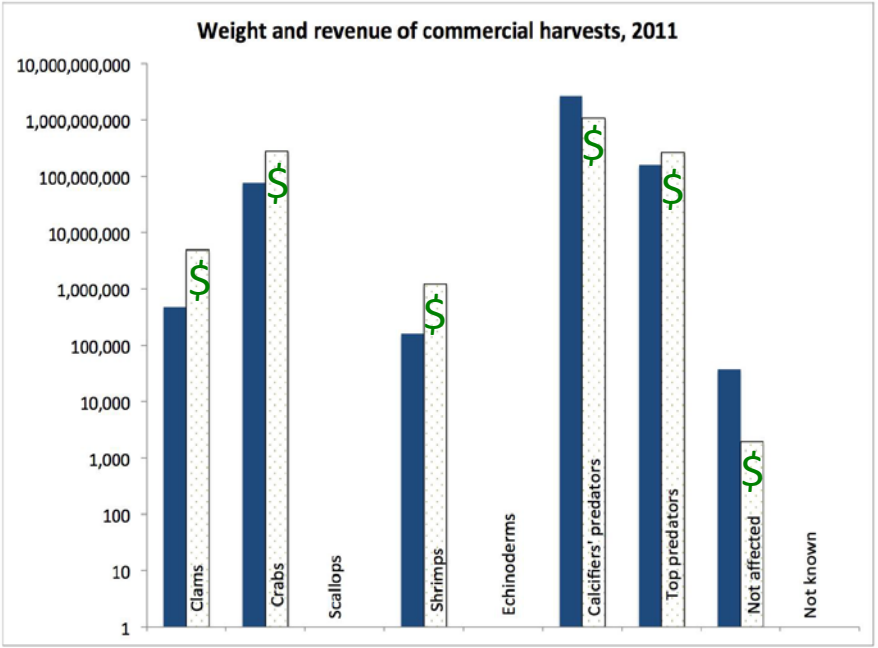
- We used hindcast models to analyze the changes associated with OA between preindustrial time and now.
- We compared present day model outputs to our observations made around Alaska to validate them.
- We then used predictive models to evaluate how water chemistry may change under current CO_2 emission scenarios.



Evaluating the Risks of OA In Alaska

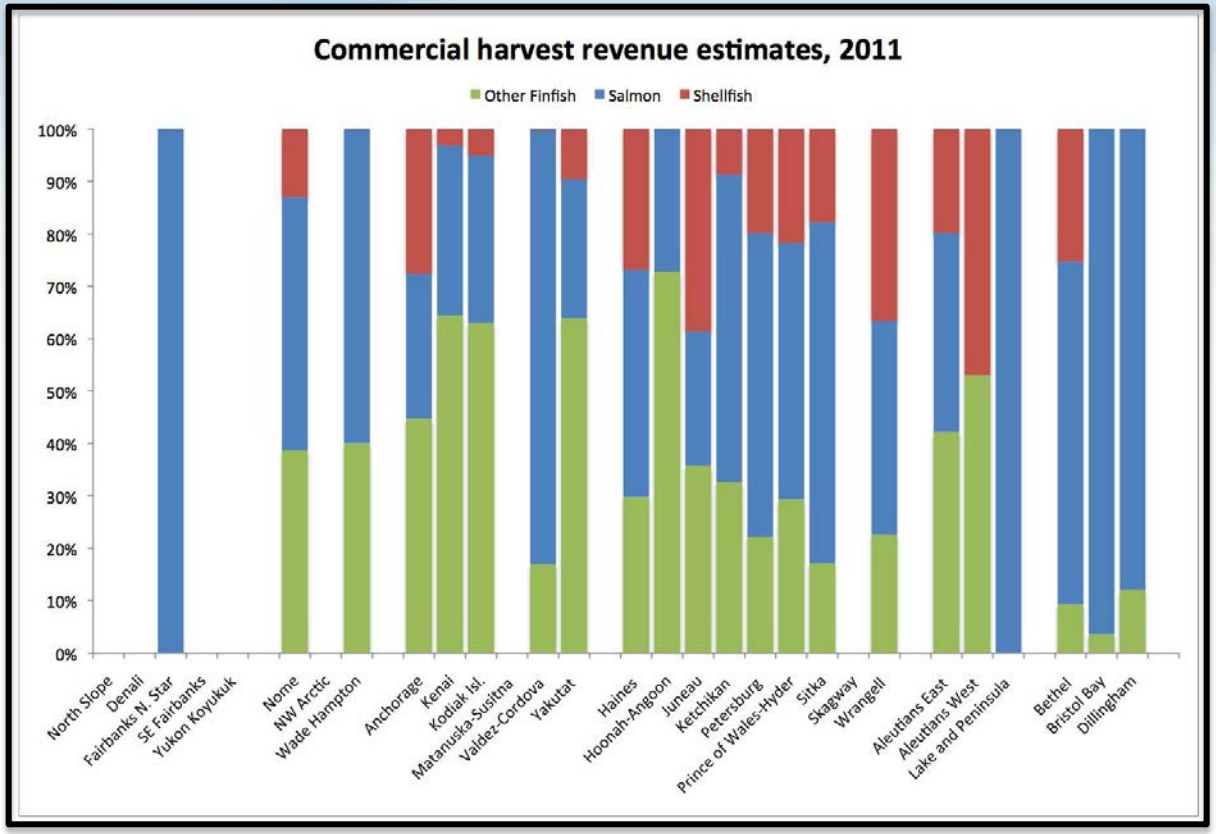
How Much Are The Fisheries Worth?

Mathis et al., In Press

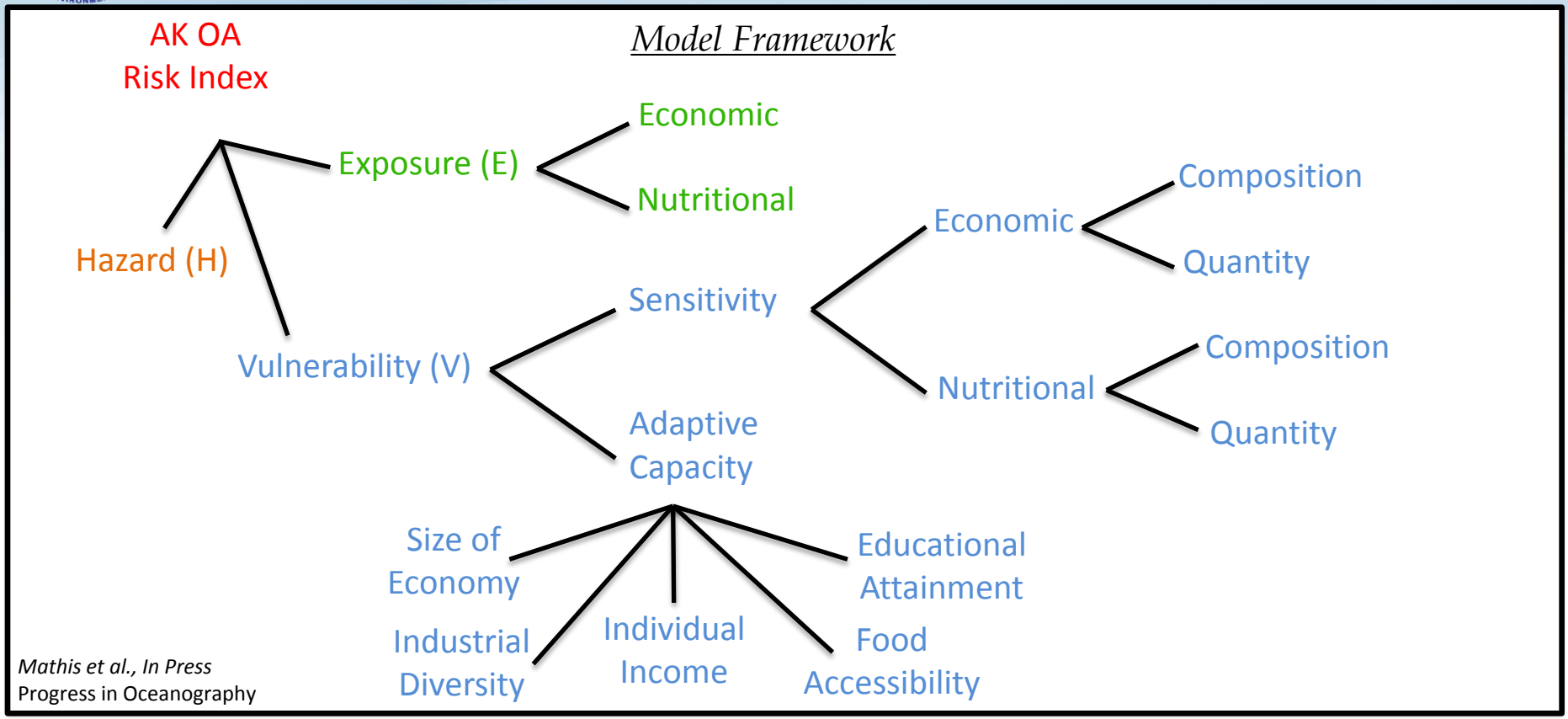


Commercial harvest (blue bars) and earnings (white bars) by category for 2011 (ADF&G)

Evaluating the Risks of OA In Alaska



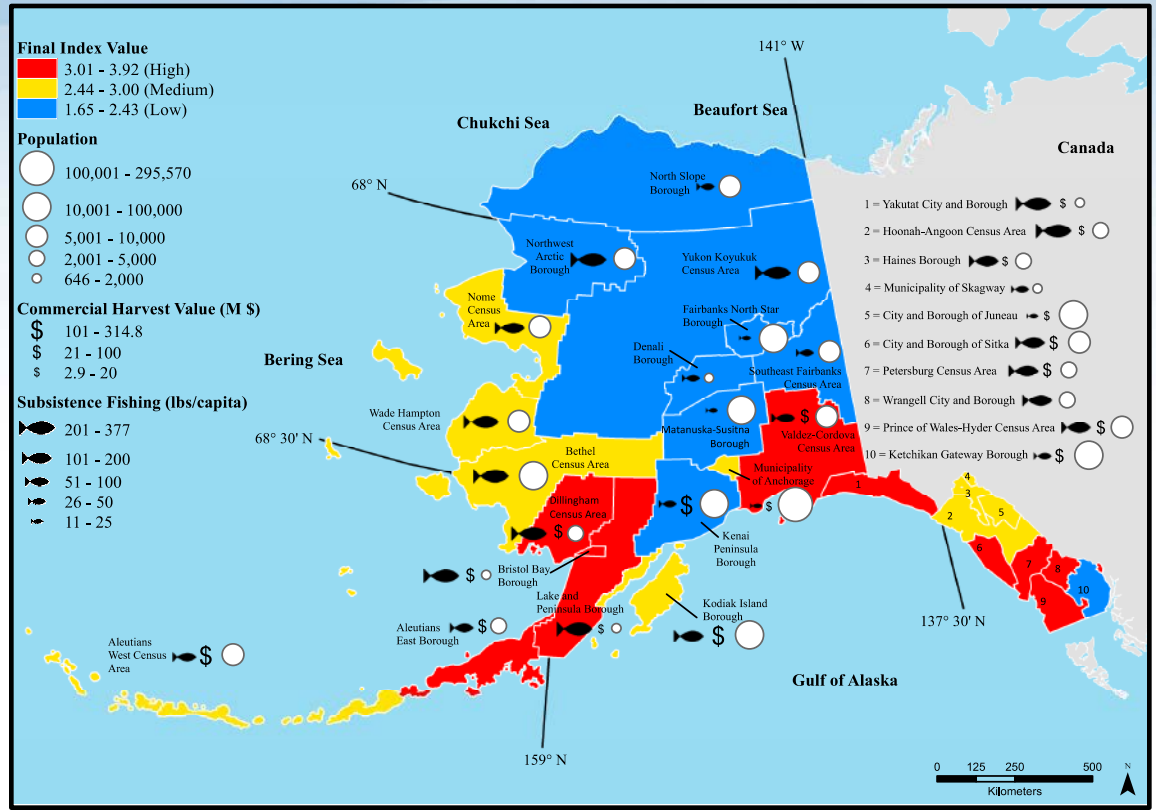
Evaluating the Risk of OA In Alaska



Mathis et al., In Press
Progress in Oceanography

Evaluating the Risks of OA In Alaska

Census Area/ Borough	Rank
Lake and Peninsula Borough	1
Wrangell City and Borough	2
Prince of Wales-Hyder Census Area	3
Aleutians East Borough	3
Petersburg Census Area	5
Sitka, City and Borough of	6
Yakutat City and Borough	7
Bristol Bay Borough	7
Dillingham Census Area	7
Valdez-Cordova Census Area	10
Hoonah-Angoon Census Area	11
Bethel Census Area	11
Juneau, City and Borough of	13
Kodiak Island Borough	14
Aleutians West Census Area	14
Wade Hampton Census Area	16
Municipality of Anchorage	17
Haines Borough	17
Skagway, Municipality of	19
Nome Census Area	20
Yukon Koyukuk Census Area	21
Fairbanks North Star Borough	22
Matanuska-Susitna Borough	22
Northwest Arctic Borough	24
Ketchikan Gateway Borough	24
Kenai Peninsula Borough	26
Southeast Fairbanks Census Area	27
Denali Borough	28
North Slope Borough	29

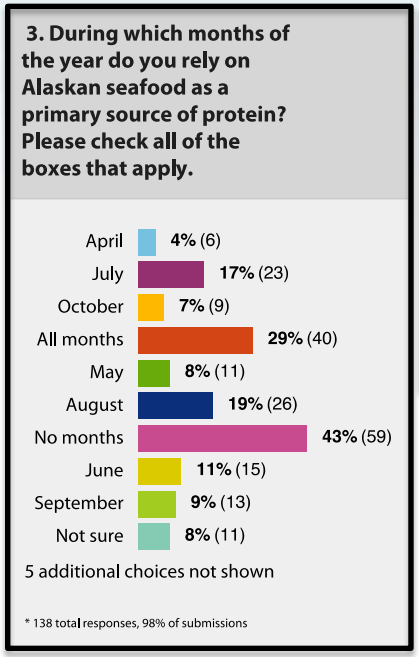


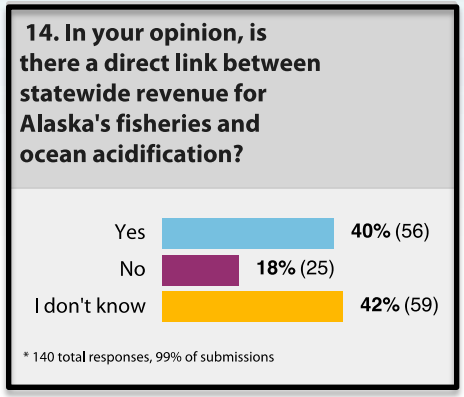
Mathis et al., In Press
Progress in Oceanography

Gauging Perceptions of Ocean Acidification in Alaska

Frisch et al., In Review Marine Policy

Lauren Frisch led an effort to determine public perception and understanding of OA as well as their willingness to accept mitigation solutions. She sent out 3,000 mail surveys around the state to gather feedback.





There is a critical and systemic lack of understanding of OA in the communities that are most vulnerable to it.

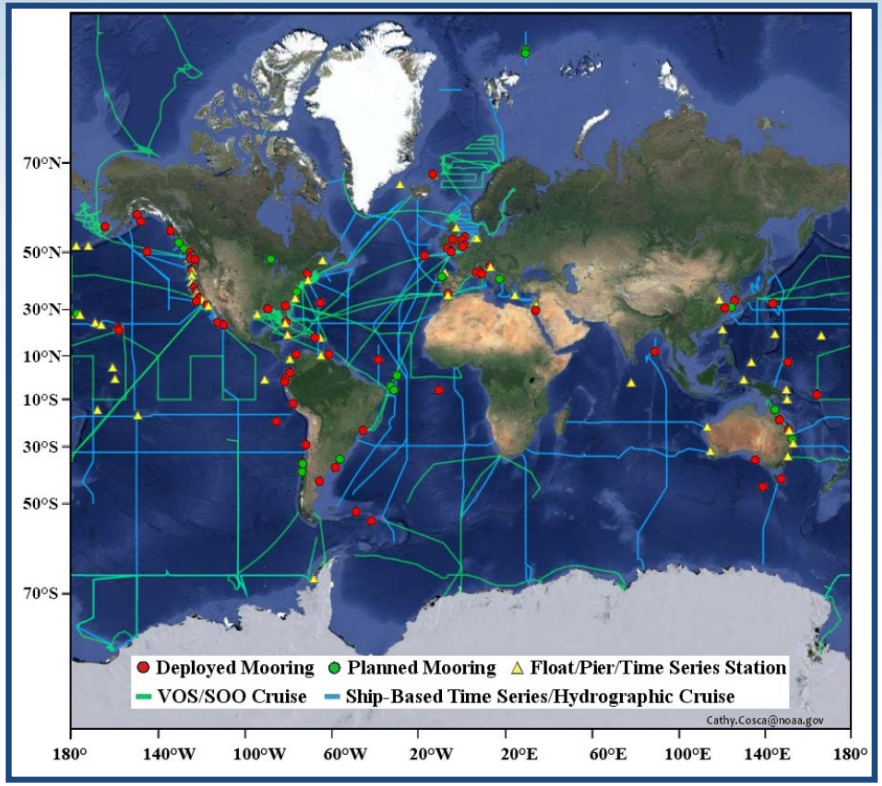
Evaluating the Risks of OA In Alaska

- OA has been well documented with global observations conducted over several decades by hundreds of researchers. It has been definitively attributed to human-generated CO_2 in the atmosphere that has been released primarily by fossil fuel combustion and land use changes.
- Changes in pH and carbonate chemistry force marine organisms to spend more energy regulating chemistry in their cells. For some organisms, this may leave less energy for other biological processes like grow, reproduction or responding to other stresses.
- The biological impacts of OA will vary, because different groups of marine organisms have a wide range of sensitivities to changing seawater chemistry.
- Impacts from OA at any life stage can reduce the ability of a population to grow or to recover from losses due to disturbance or stress.
- **Many of Alaska's commercial and subsistence fisheries are located in areas that have and will undergo significant changes due to ocean acidification.**

Creating an OA Observing System

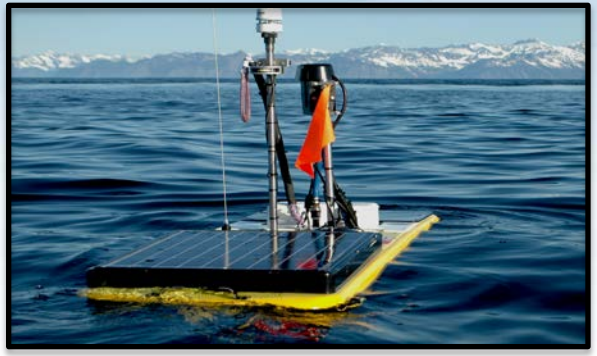
- Partnering with over 100 international scientists from 30 countries to build a global observing network for OA.
- Deployment of 21 OA moorings with two carbonate system measurements.

http://www.goa-on.org



Global OA Observing Network (GOA-ON)

Creating an OA Observing System



Carbon Wave Glider