Welcome

ARCUS Arctic Research Seminar Series

"Using An Environmental Intelligence Framework to Evaluate the Impacts of Ocean Acidification in the Arctic"

Presented by Jeremy Mathis
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ARCTIC RESEARCH SEMINAR SERIES

Using an Environmental Intelligence Framework to Evaluate the Impacts of Ocean Acidification in the Arctic

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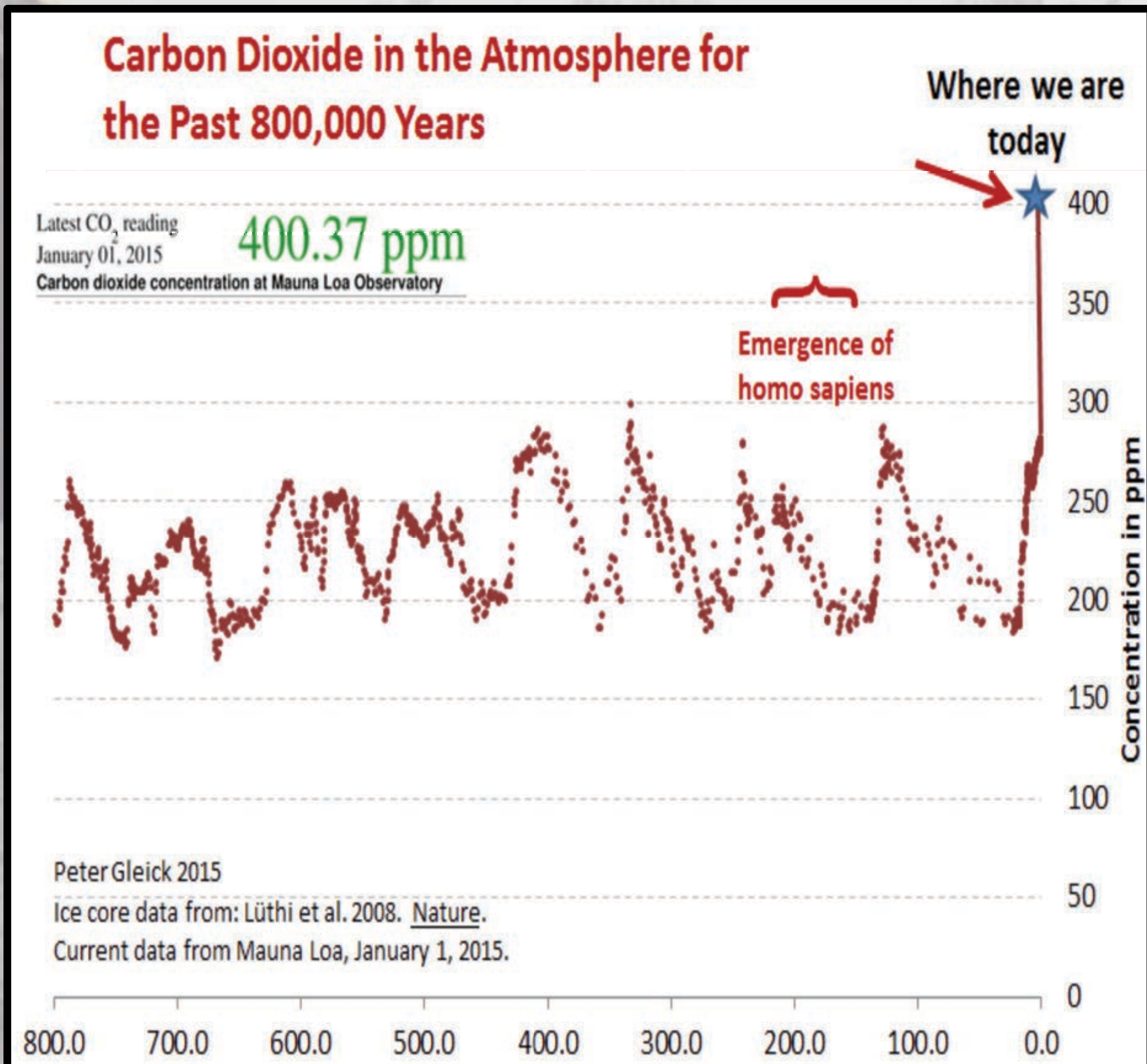
Arctic Research Program

What is Ocean Acidification?



- …he acidity of the ocean over …h is caused primarily by …. It can also be enhanced by …ean

CO_2 ↑ pH ↓

When Ω_{ARG} passes outside the range of natural variability, organisms can be impacted.

$\Omega_{ARG} < 1.0$ is bad

What is Ocean Acidification?

Indicator Species That Show Effects of OA

Pre-industrial

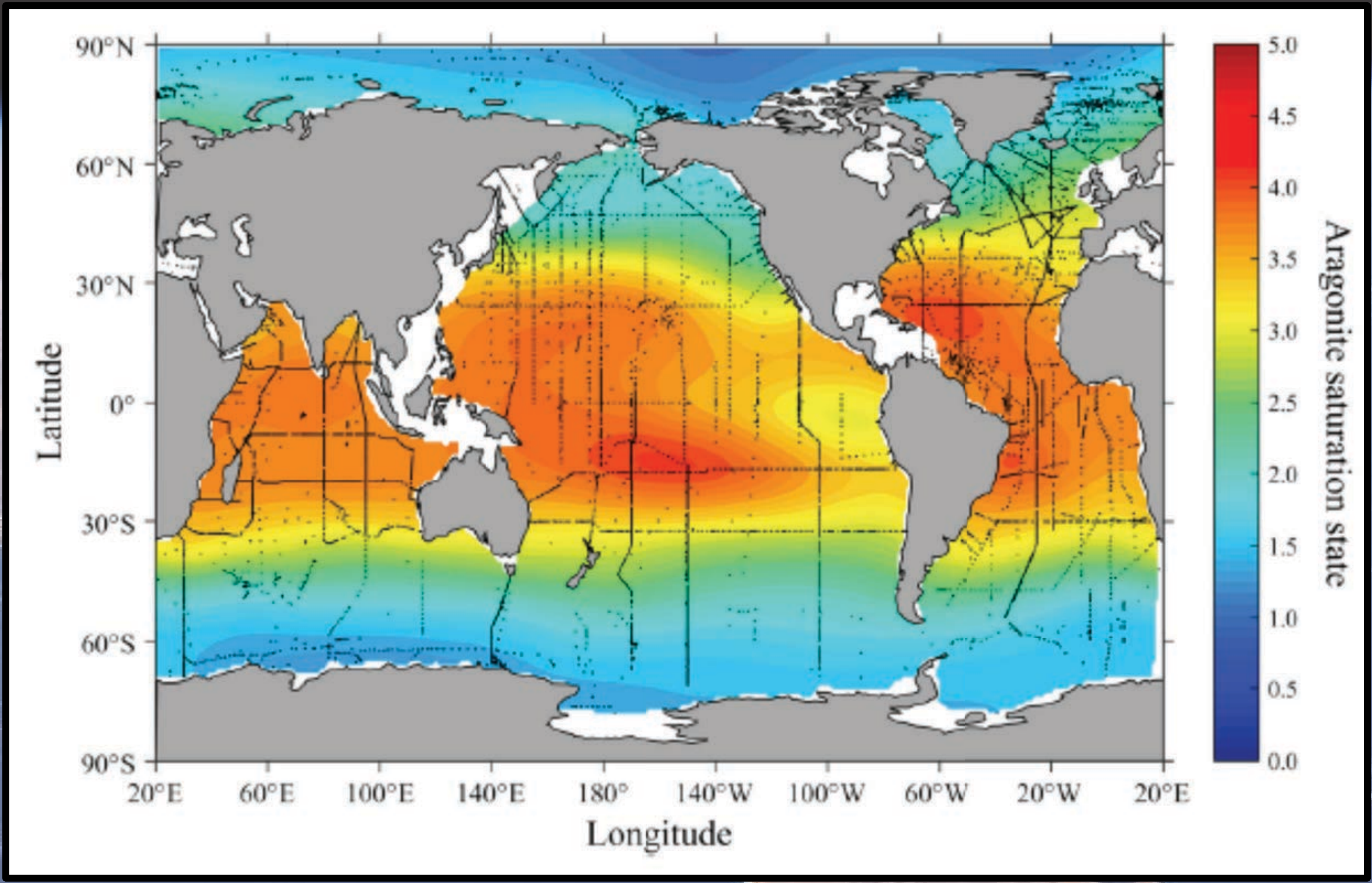
Present-day

2050

Photos: N. Bednaršek

- 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.

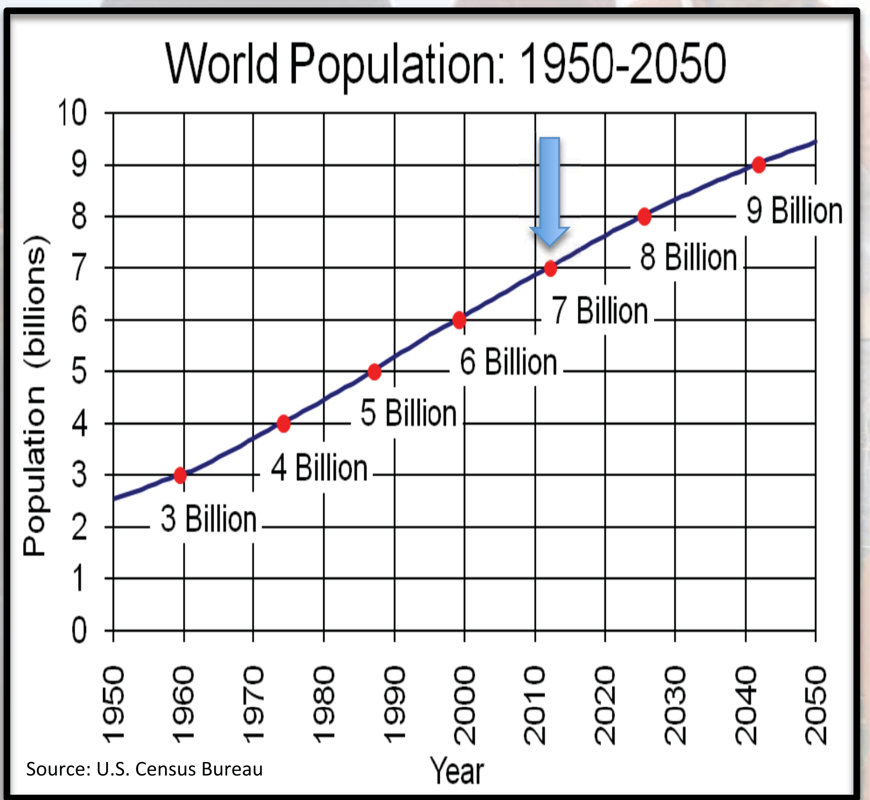
Acidification in the Global Ocean



Global climatological distributions of surface water aragonite saturation states based on data. *Jiang et al., 2015*

OA 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)
- Important commercial and subsistence fisheries in Alaska are co-located where enhanced ocean acidification will occur. (Mathis et al., 2015)

Gauging Public Perception in Alaska

- Alaska seafood is a primary source of protein for 30-46% of residents.

- Awareness of OA is 3X higher in Alaska than the rest of the US.

- Most respondents recognize CO_2 and human activity as drivers of OA.

- Only 28% of respondents recognize that OA could disproportionately impact Alaska.

Frisch et al., 2014

Evaluating the Risks

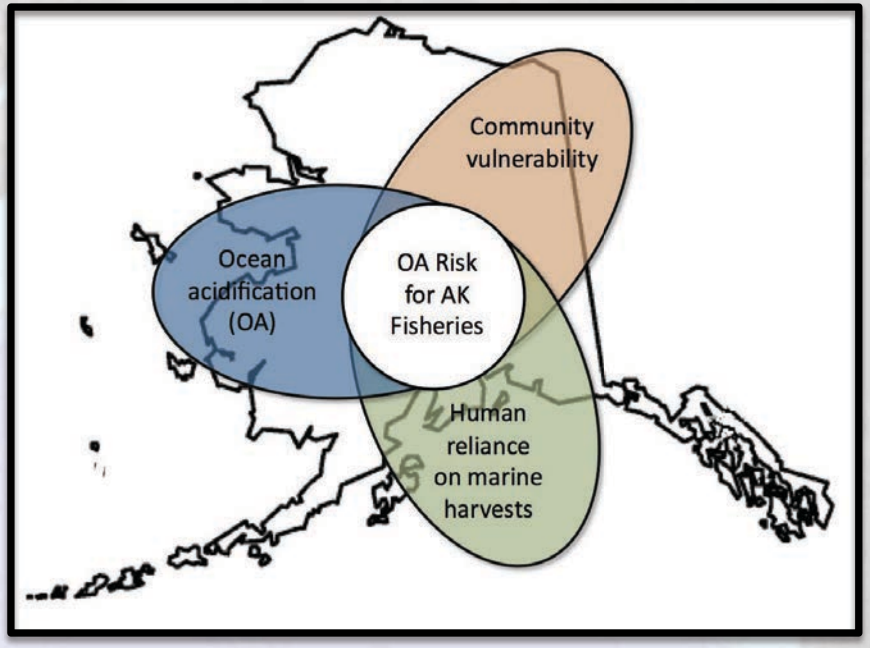
<u>Risk</u> - The chance that an investment's actual return will be different than expected. Risk includes the possibility of losing some or all of the original investment.

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.

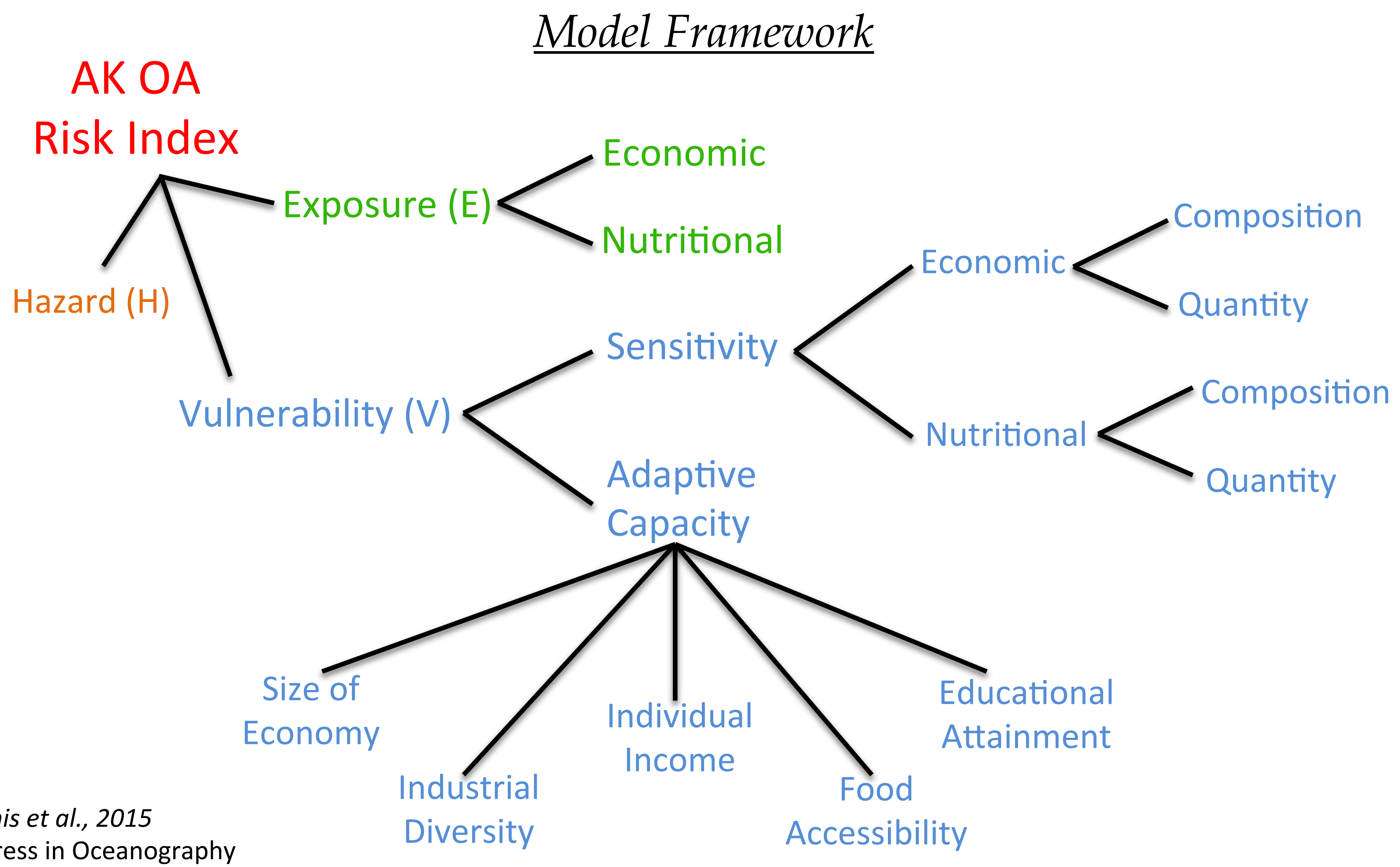
- Highly productive Alaskan commercial and subsistence fisheries are located in seas projected to experience rapid transitions in temperature, pH, and other chemical parameters caused by global change, especially ocean acidification (OA).

- 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.



Mathis et al., 2015
Progress in Oceanography

Evaluating the Risks

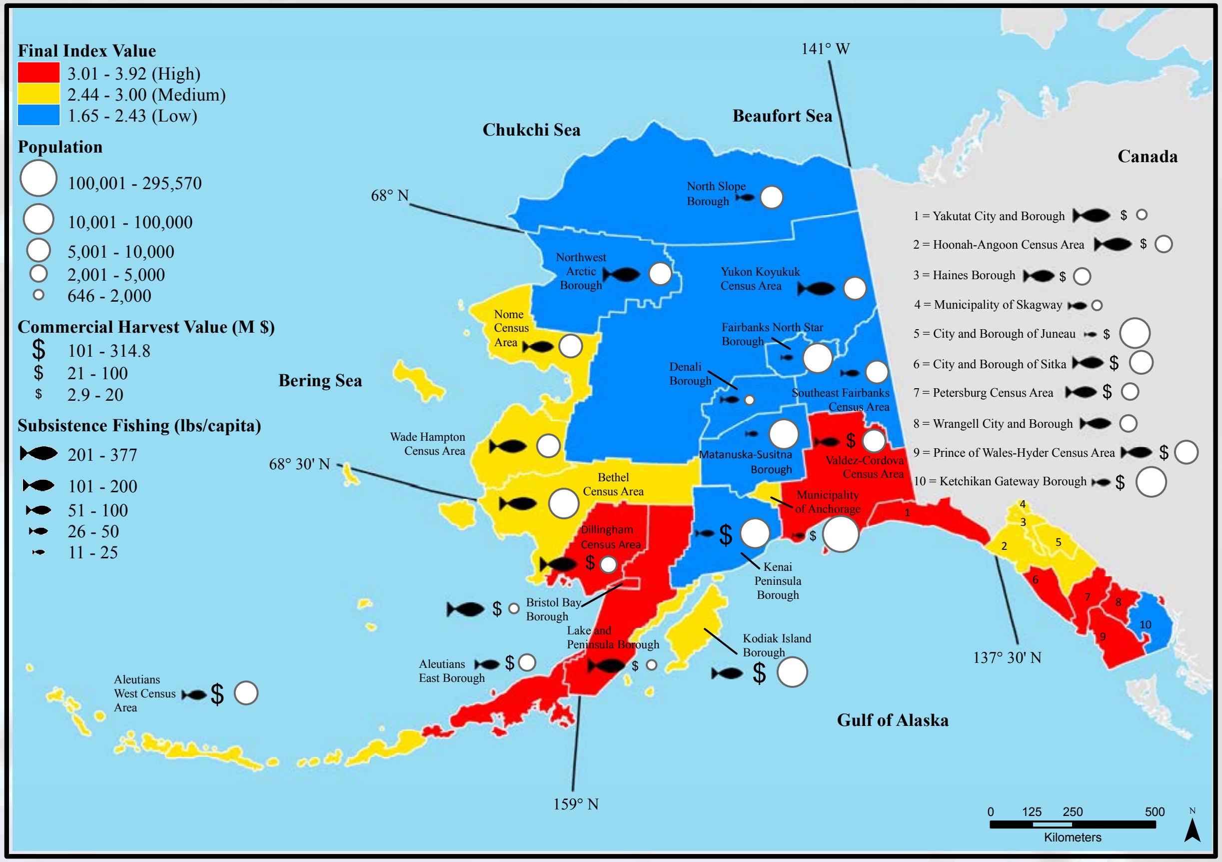


Mathis et al., 2015
Progress in Oceanography

Evaluating the Risks

The rank of final index indicates which region has the highest risk (#1) and lowest (#29) based on the worst case scenario for OA.

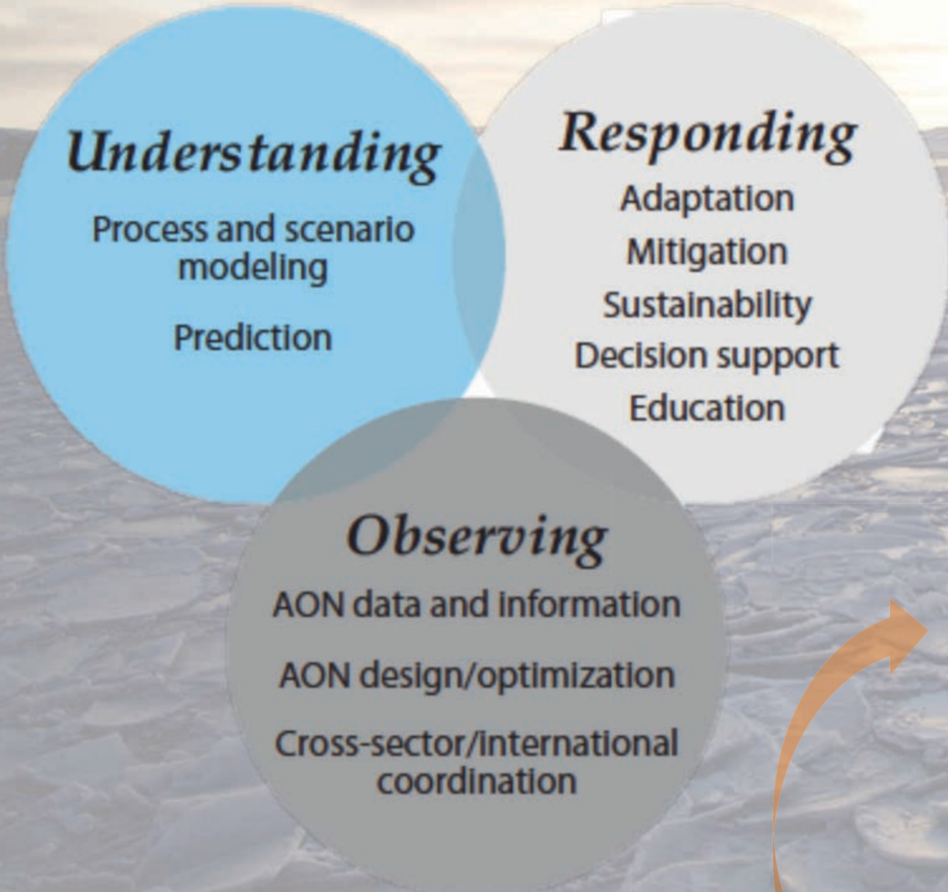
Census Area/ Borough	Rank
Lake and Peninsula Borough	1
Wrangell City and Borough	2
Prince of Wales-Hyder Census Area	3
Aleutians East Borough	3
Petersburg Census Area	5
Sitka, City and Borough of	6
Yakutat City and Borough	7
Bristol Bay Borough	7
Dillingham Census Area	7
Valdez-Cordova Census Area	10
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



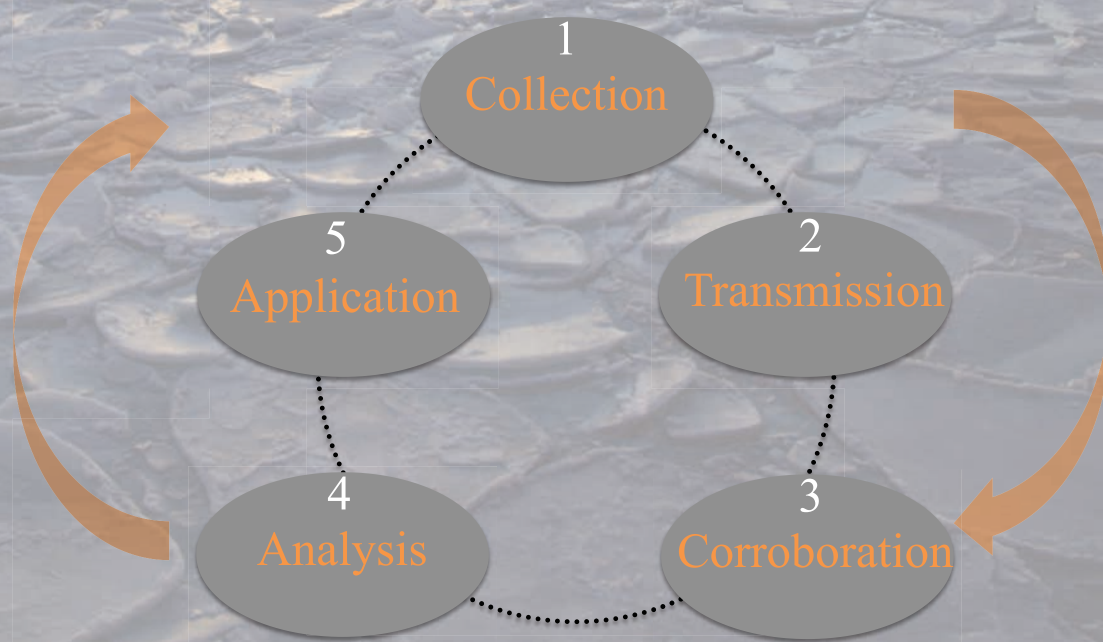
The analysis showed that regions in southeast and southwest Alaska that are highly reliant on fishery harvests and have relatively lower income and employment alternatives face the highest risk from OA.

Mathis et al., 2015
Progress in Oceanography

Building a Sustained OA Observing Network

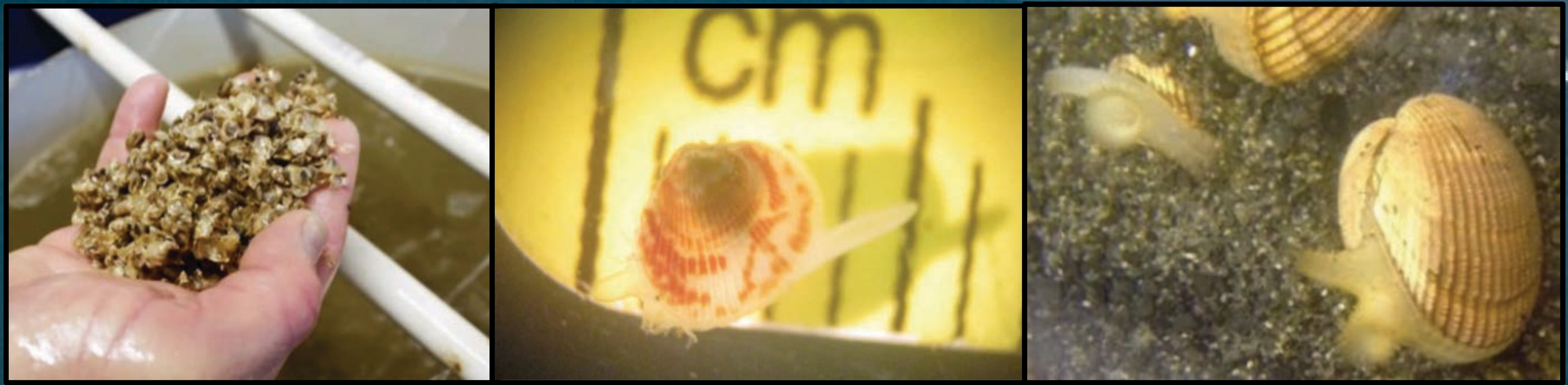


Environmental Intelligence Cycle

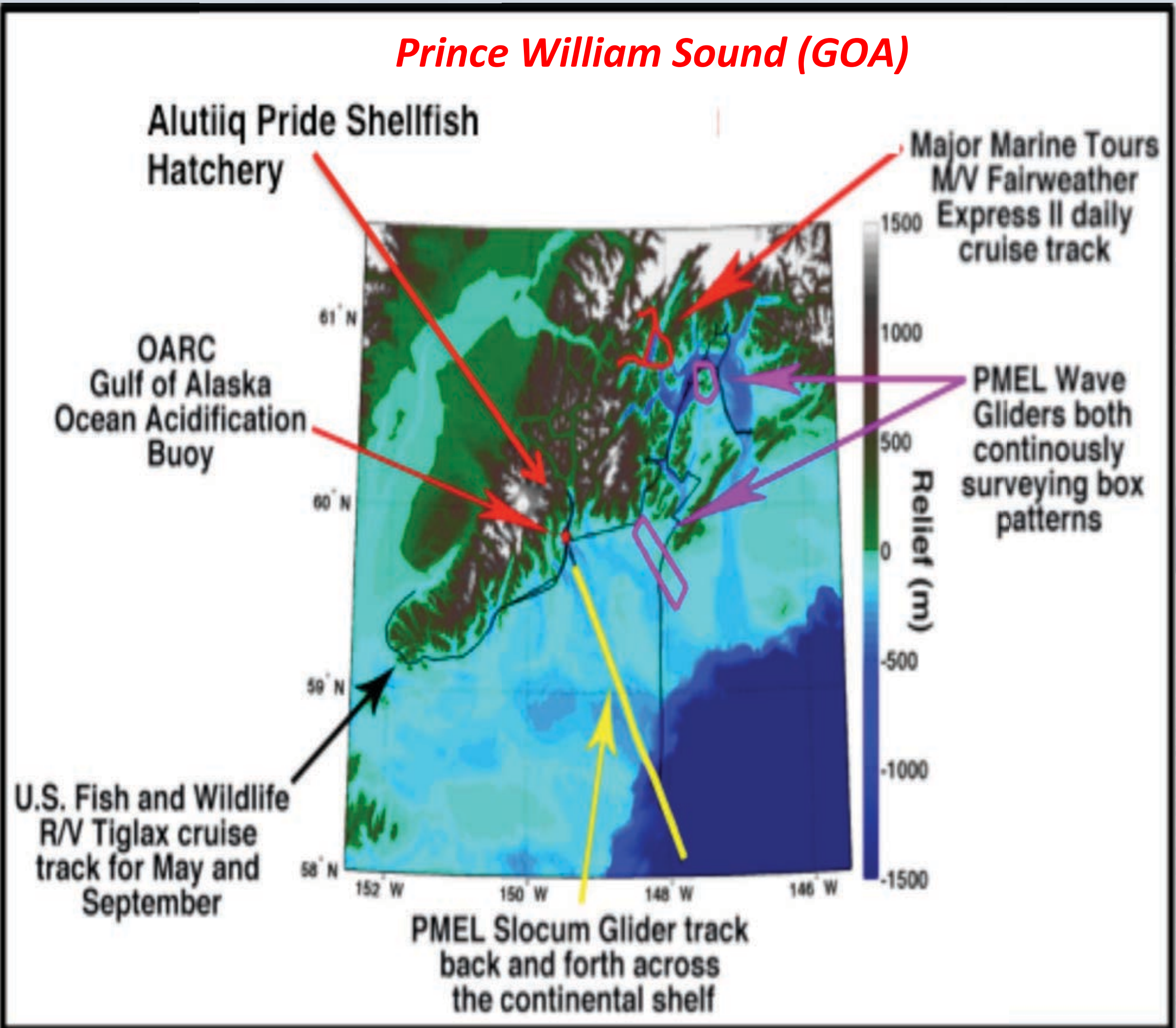


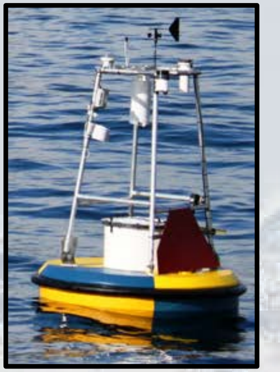
A Case Study

Alutiiq Pride Shellfish Hatchery



Integrated Environmental Intelligence

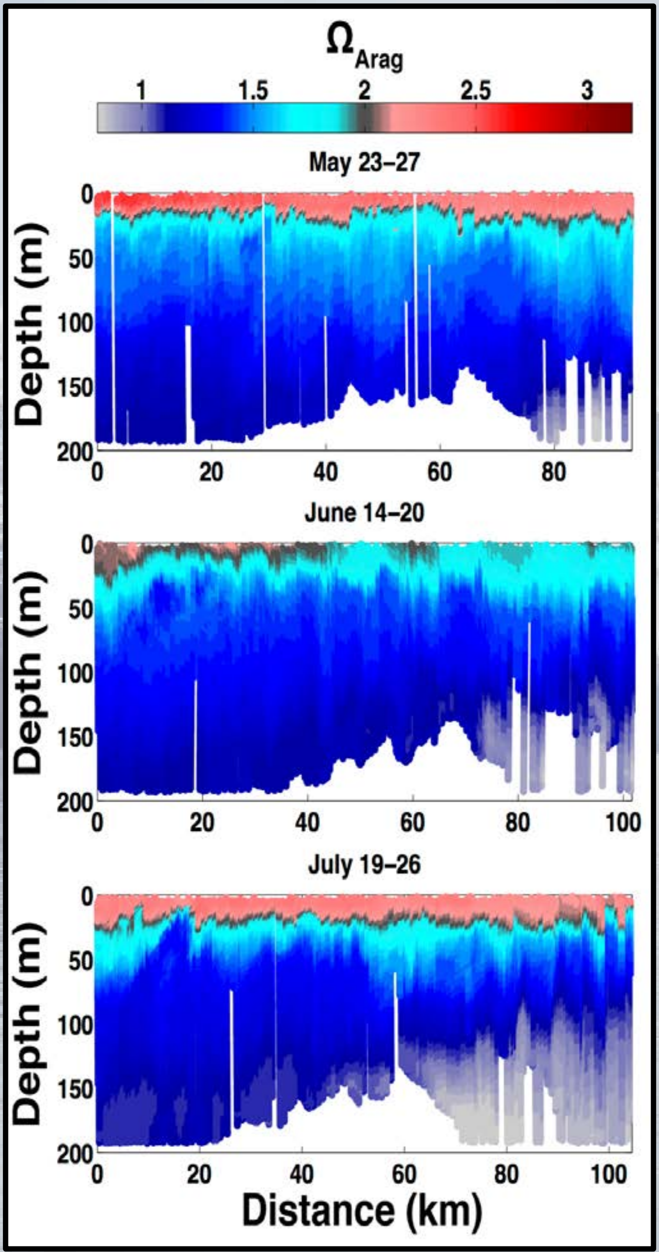




Integrated Environmental Intelligence

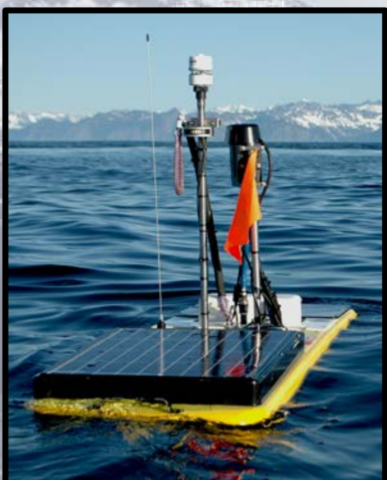
Slocum Glider

- 2,743 km
- 5,421 dives
- 135 days
- >1 M obs.

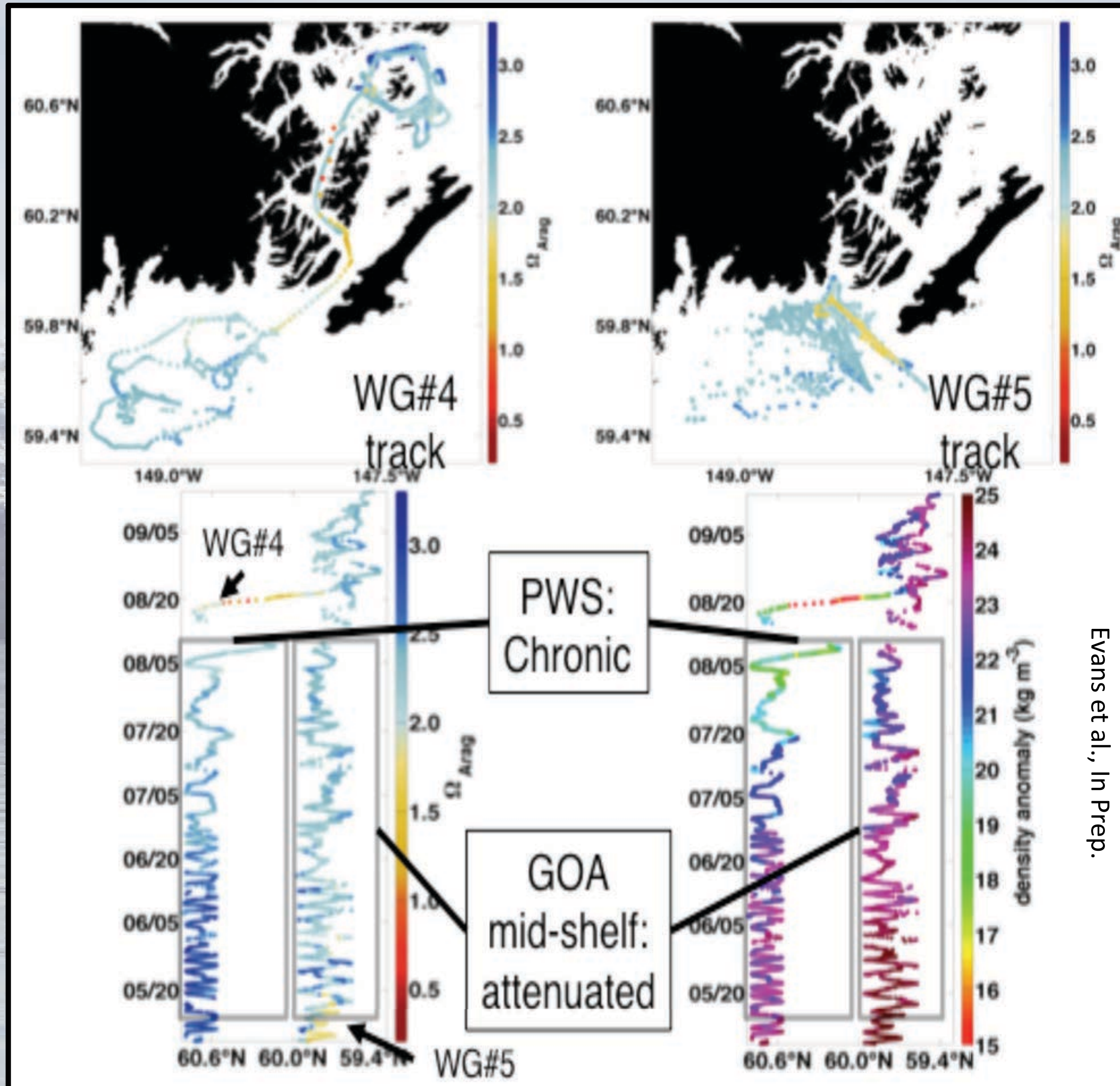


Integrated Environmental Intelligence

Wave Glider



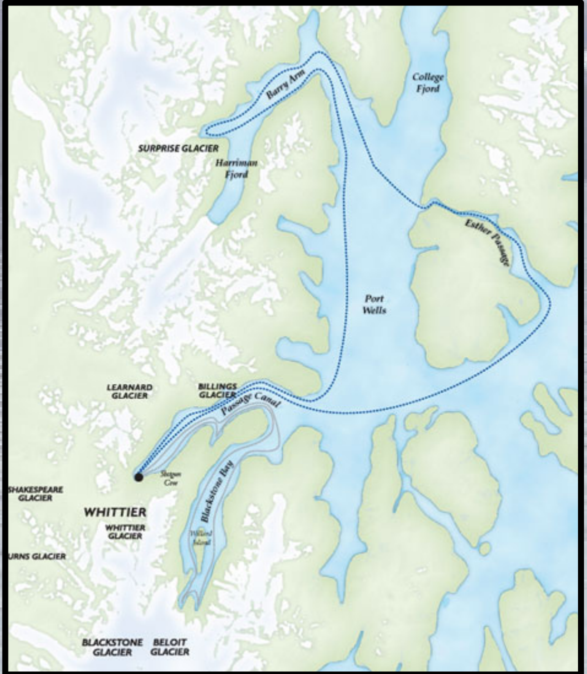
- 5,700 km
- 130 days
- >5,000 obs

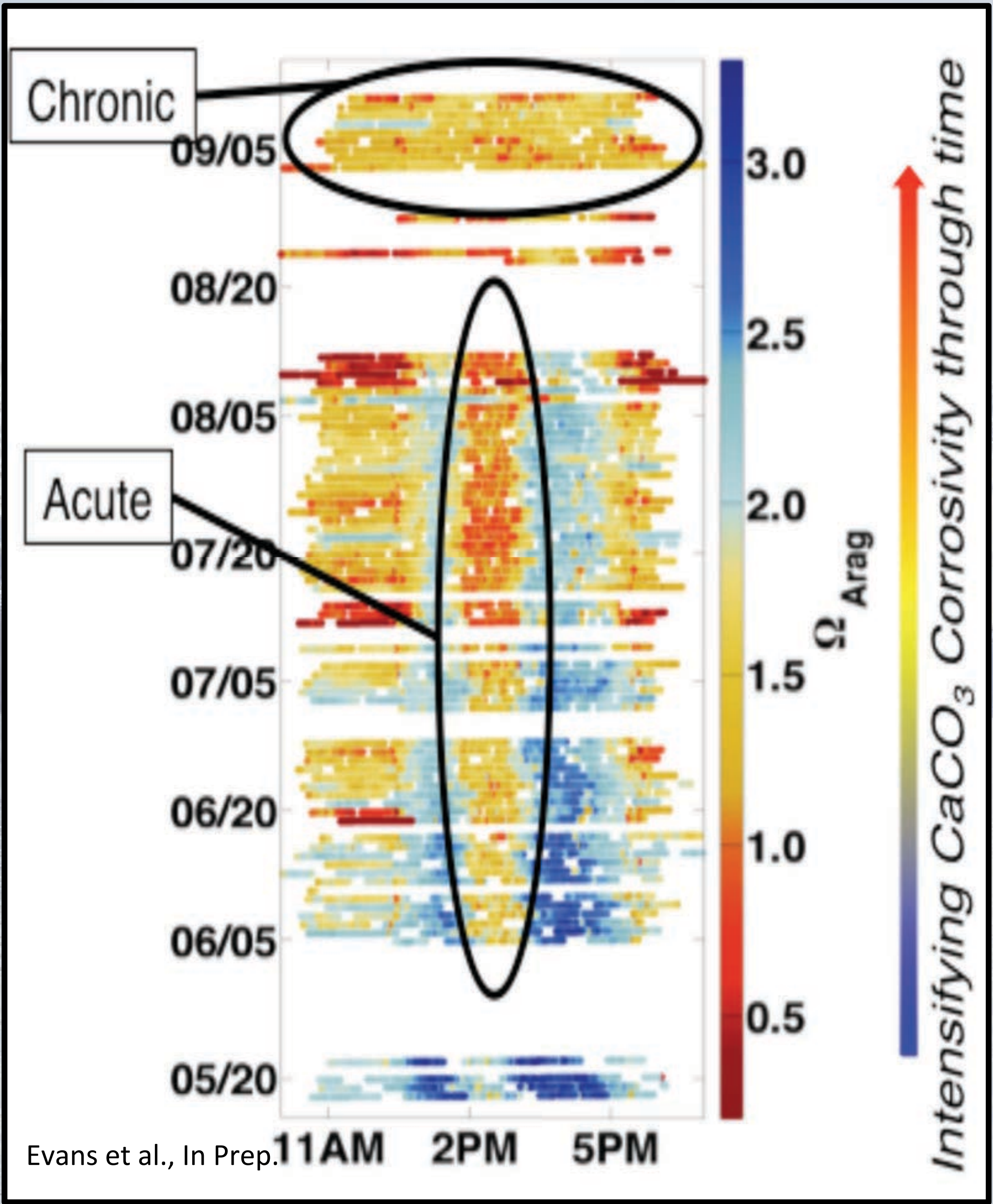


Evans et al., In Prep.

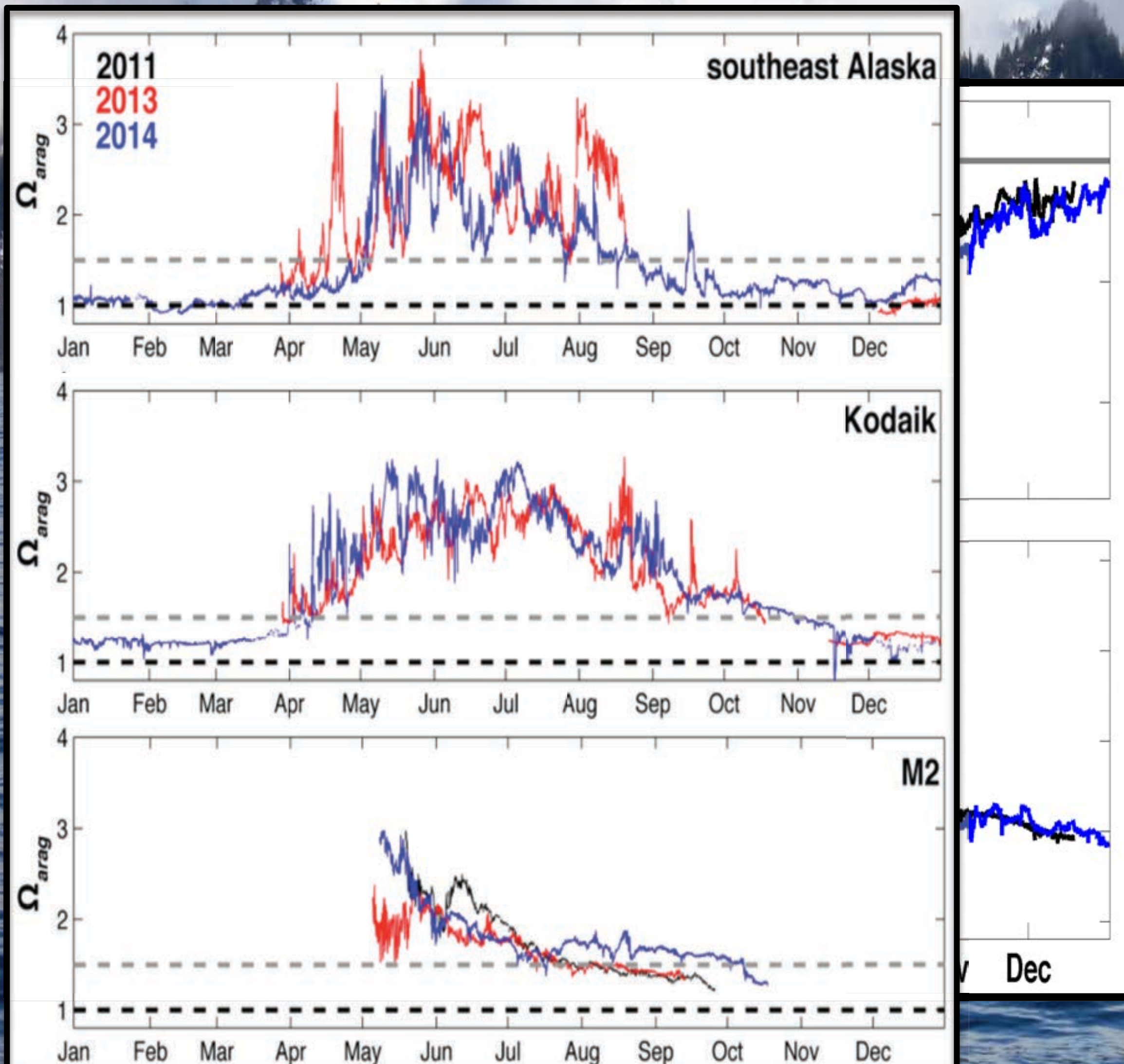
Integrated Environmental Intelligence

Glacier Tour Boat

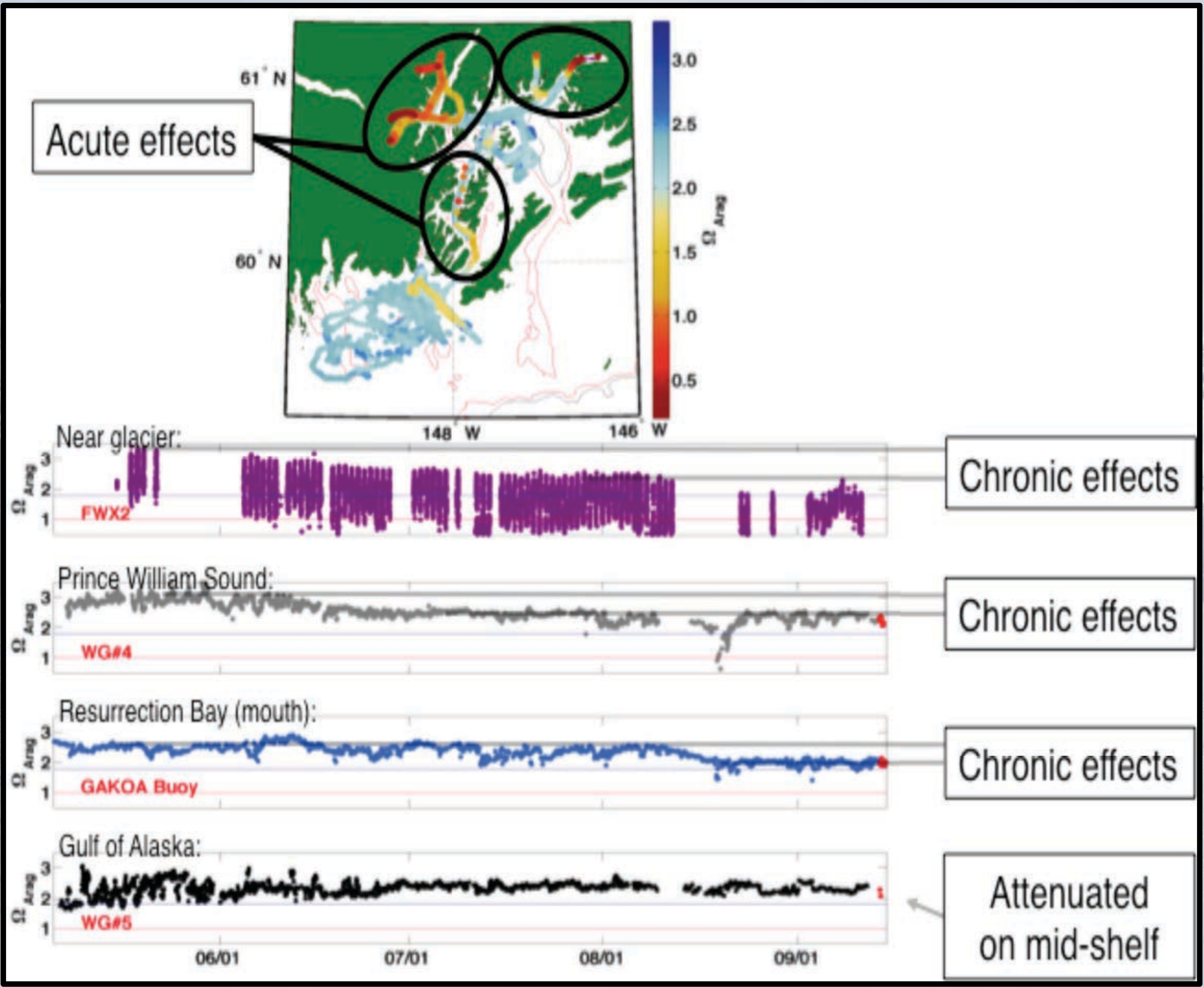




Integrated Environmental Intelligence

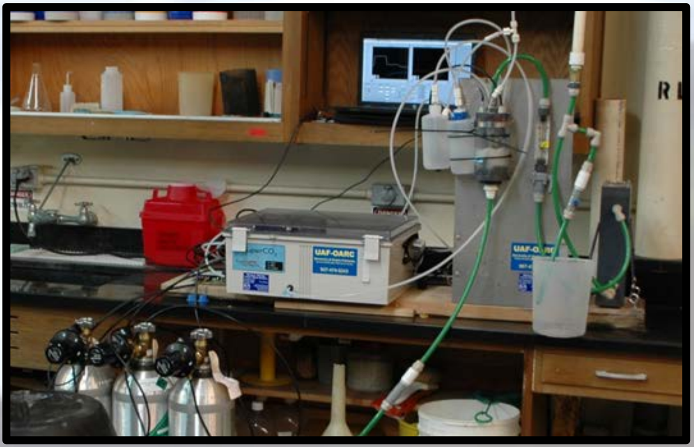


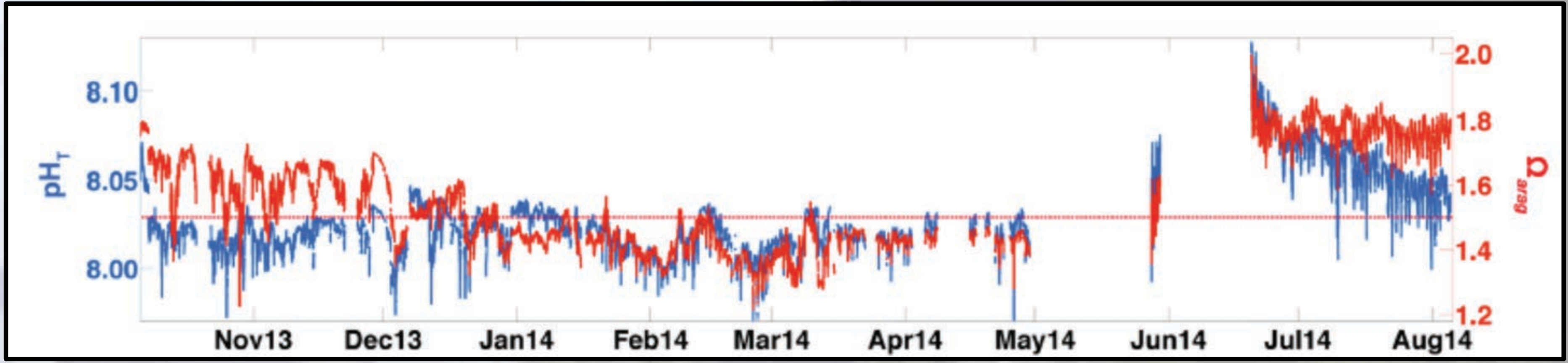
Integrated Environmental Intelligence



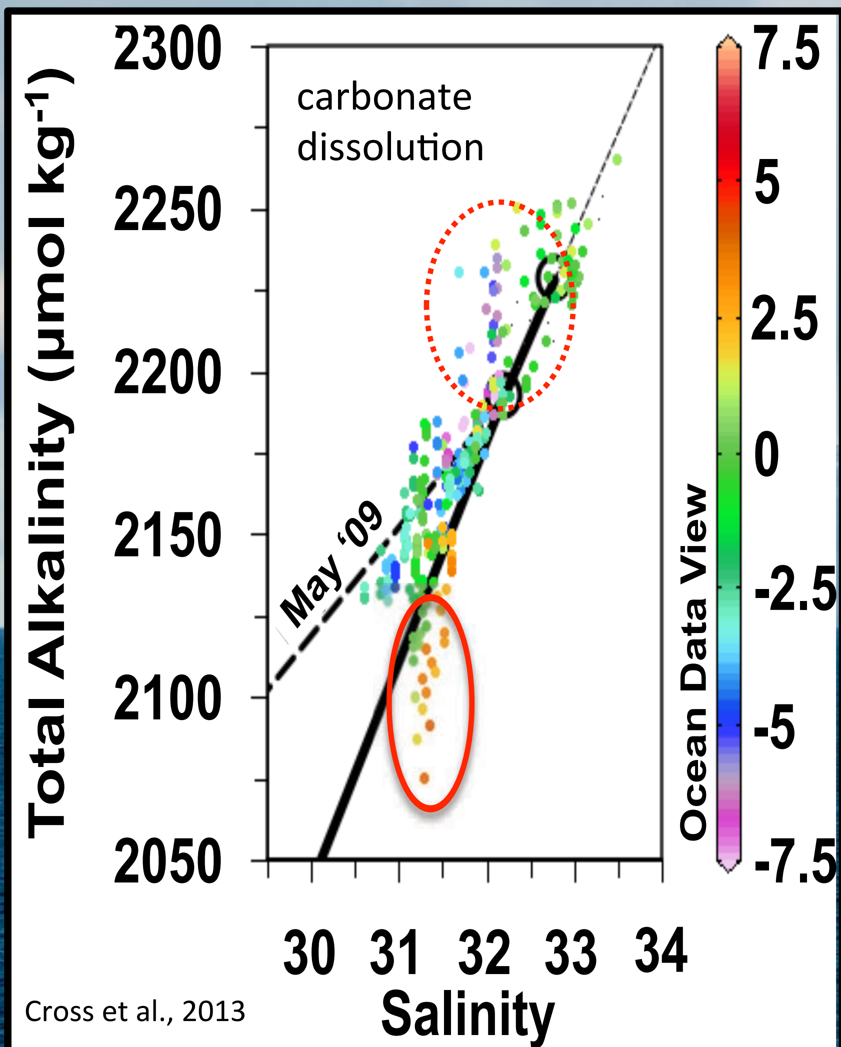
Integrated Environmental Intelligence

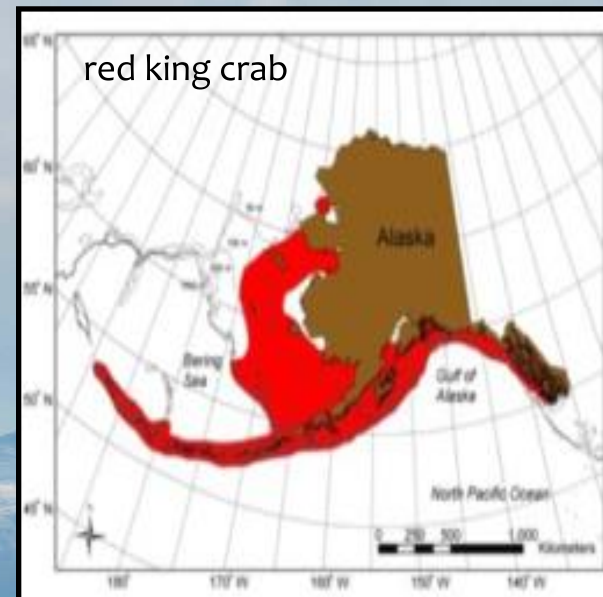
Monitoring revealed that currently there is a near 5-month window of optimal growing conditions for many species of juvenile shellfish, which is expected to close by 2040.





The Bering Sea





Integrated Environmental Intelligence

Northern Rock Sole

More Sensitive (Hurst et al., in review)

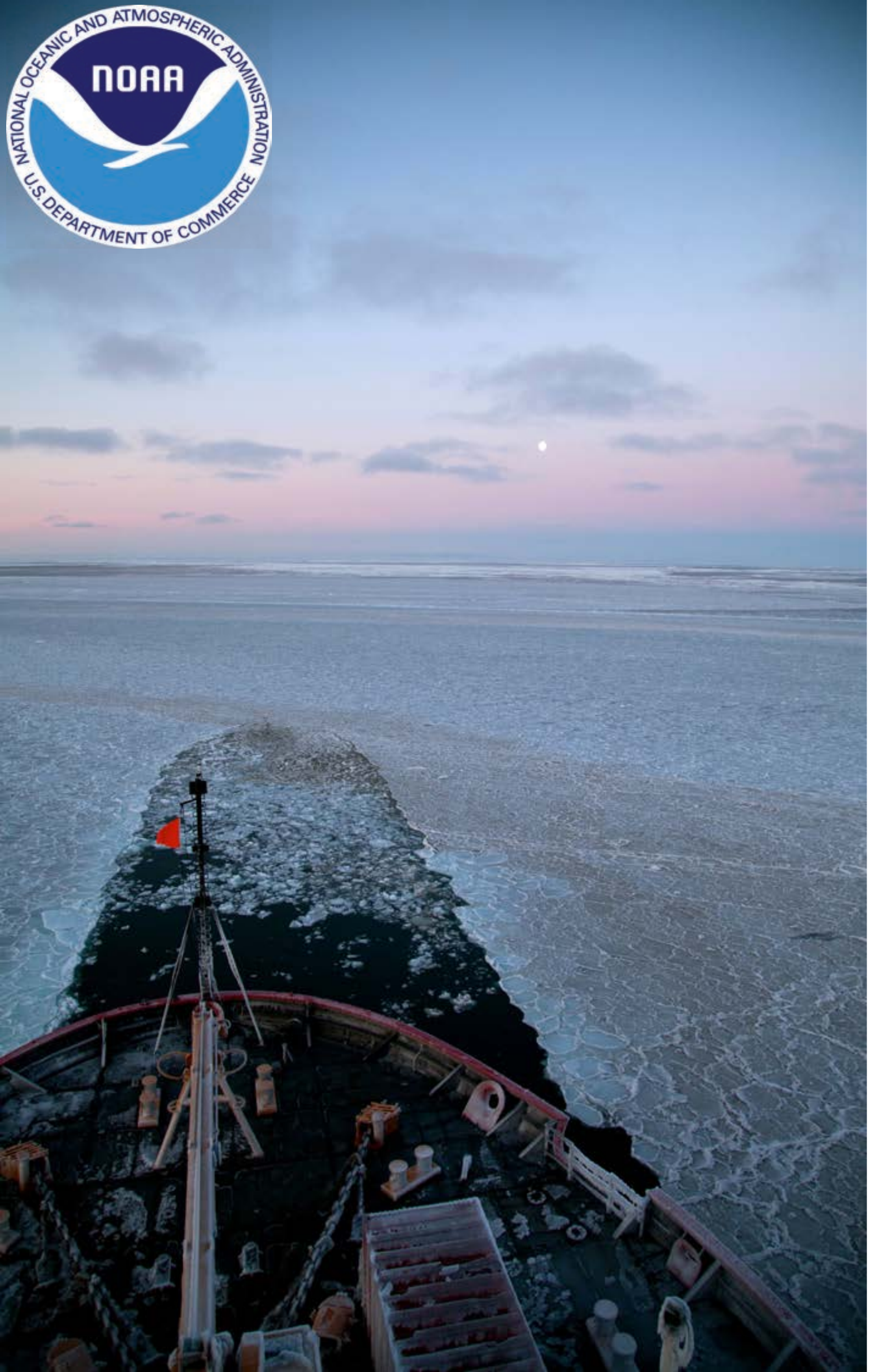
- No effect on hatch success or size at hatch
- Reduced growth and condition in post-flexion fish
- Trend toward higher mortality at high CO_2 levels

Walleye pollock

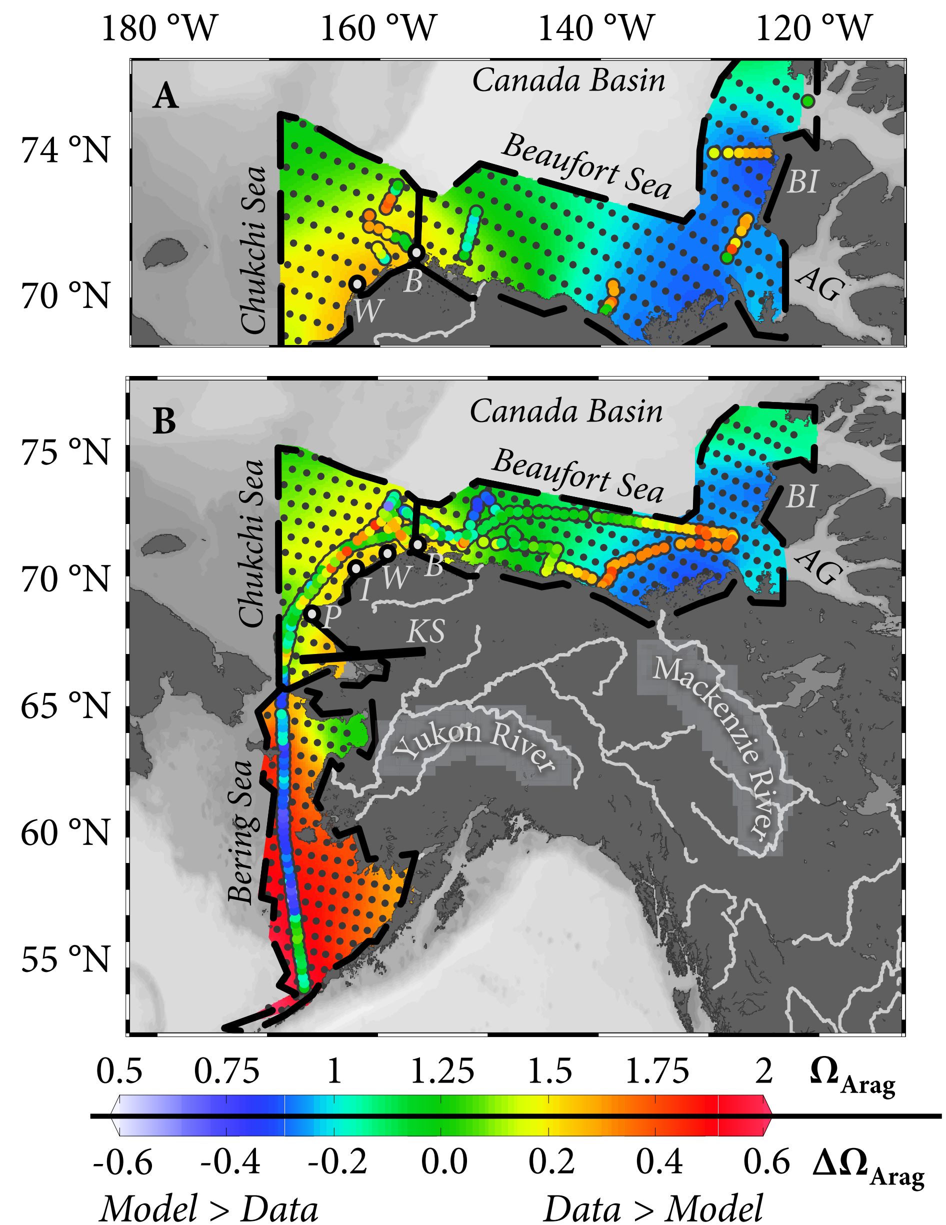
More Resilient (Hurst et al. 2012 & 2013)

- No effect on survival to hatch
- Slight growth improvement at intermediate CO_2
- No CO_2 effect on survival

Preliminary work indicates that OA may induce behavioral and/or sensory deficits, as demonstrated in some tropical species.

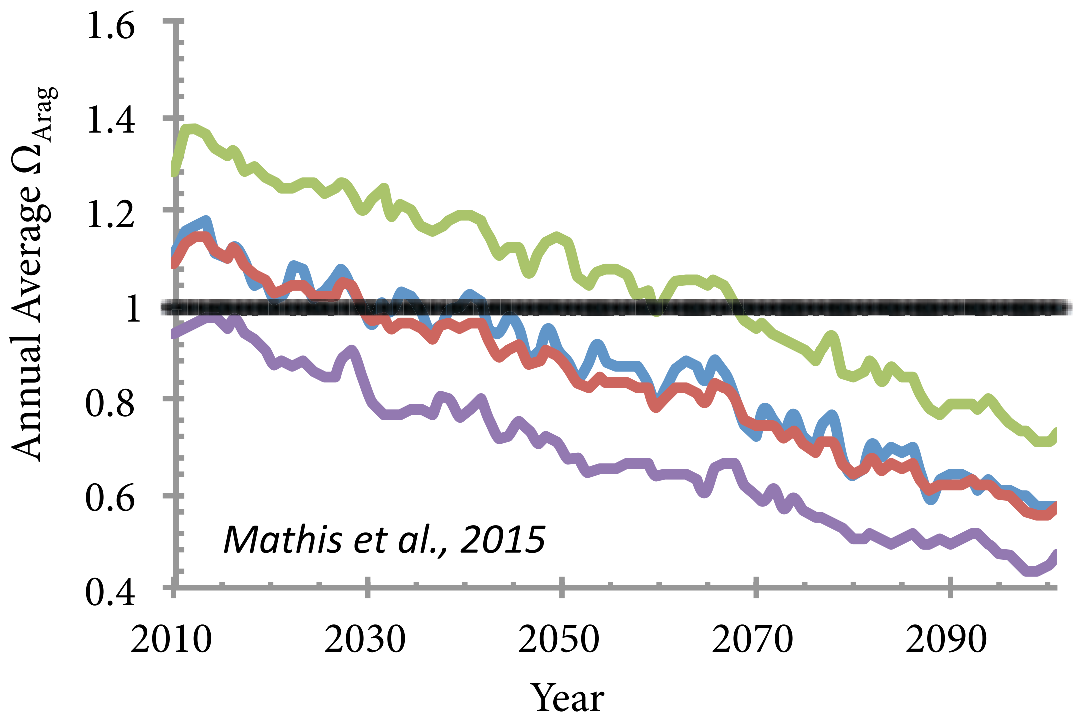


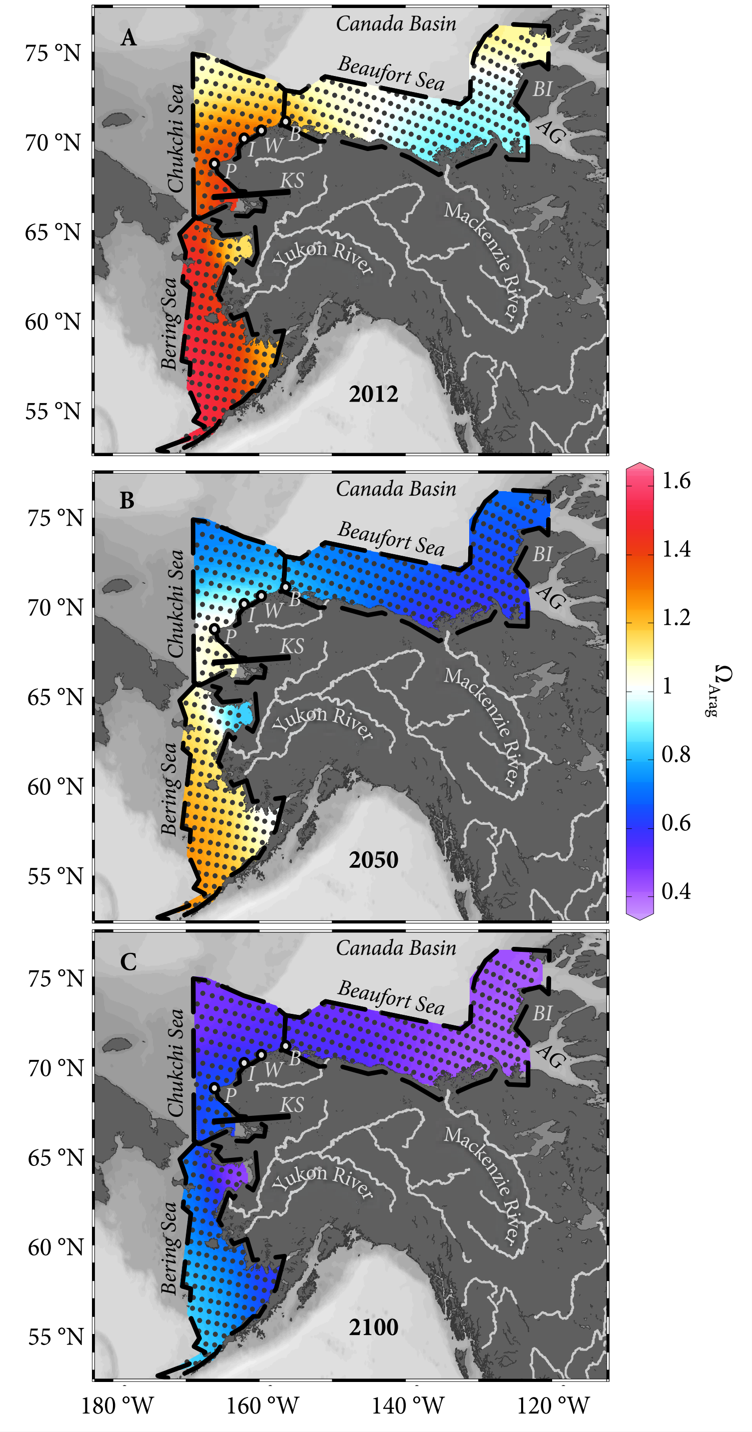
Regional OA Observations



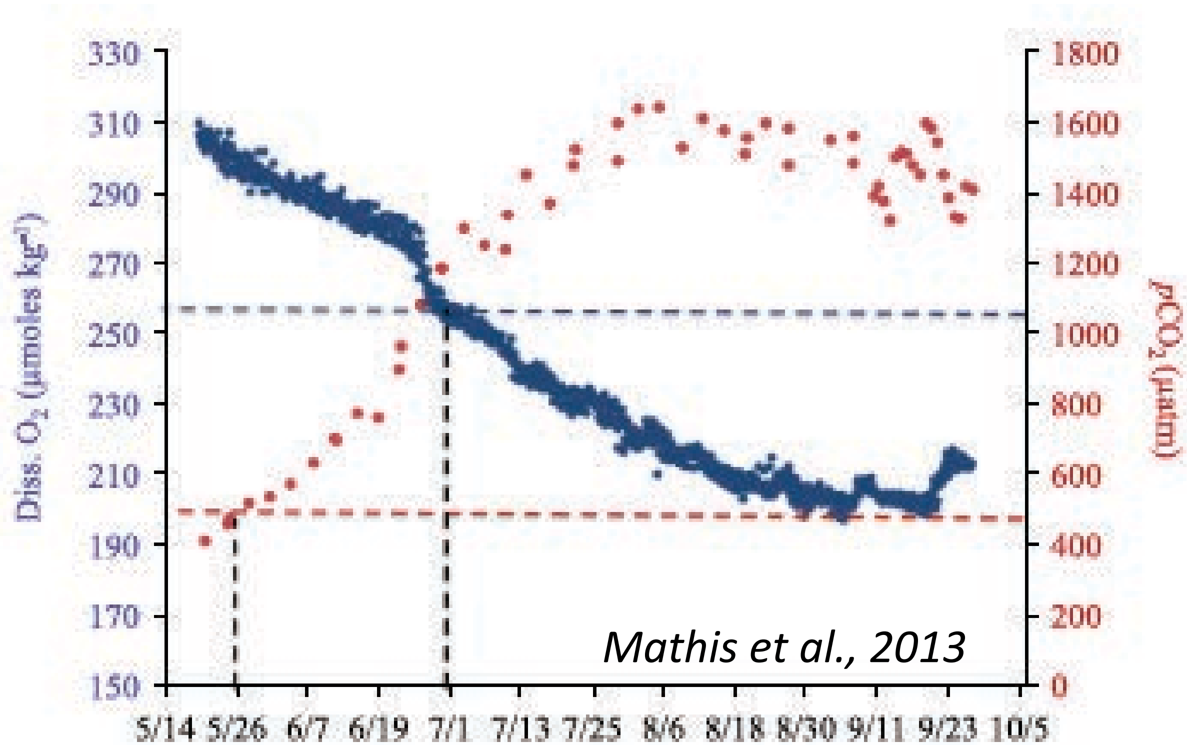
Mathis et al., 2015

Projecting OA in the PAR



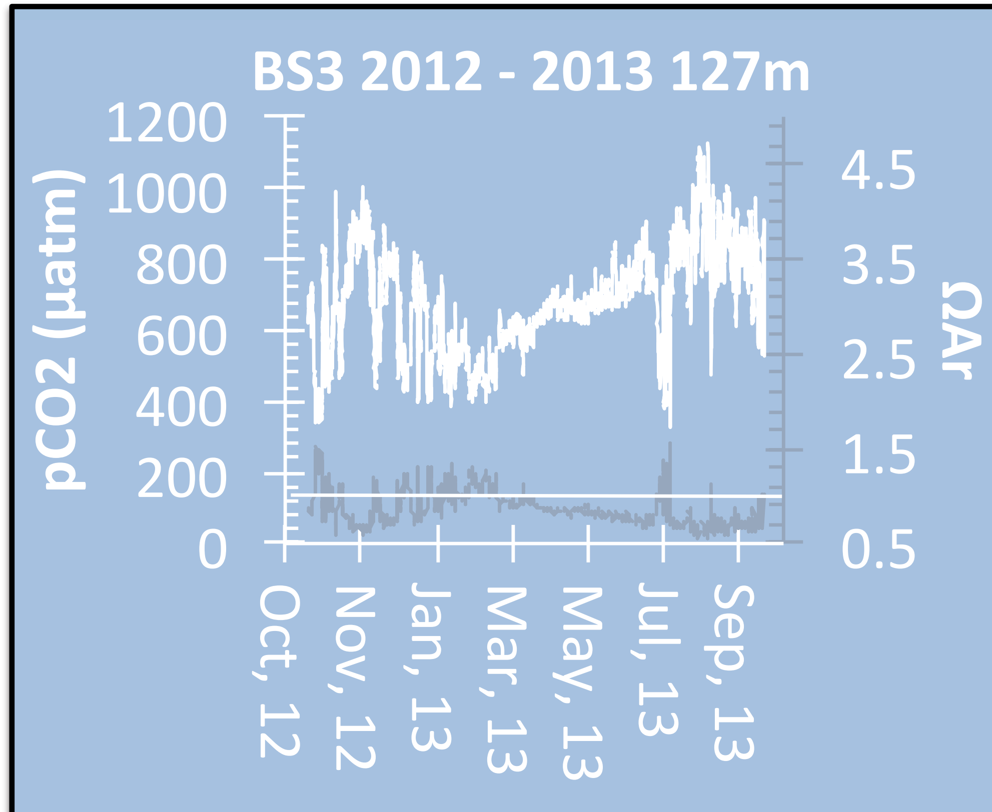


OA in Sub-Surface Waters (Bering Sea)



Nearly five months of bottom water aragonite undersaturations in the southern part of the Bering Sea.

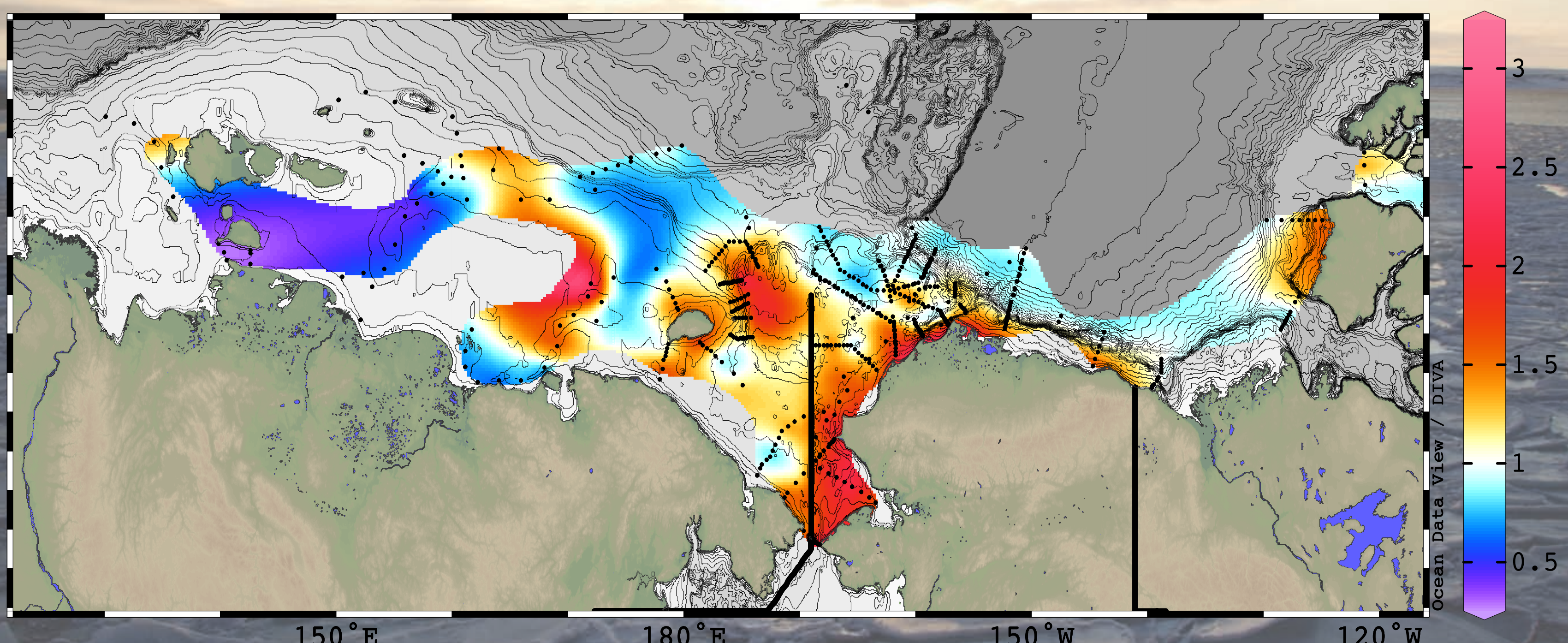
OA in Sub-Surface Waters (Beaufort Sea)



- Ω < 1 : 80% of the year
- Ω < 0.75 : 30% of the year

Cross et al., In Prep.

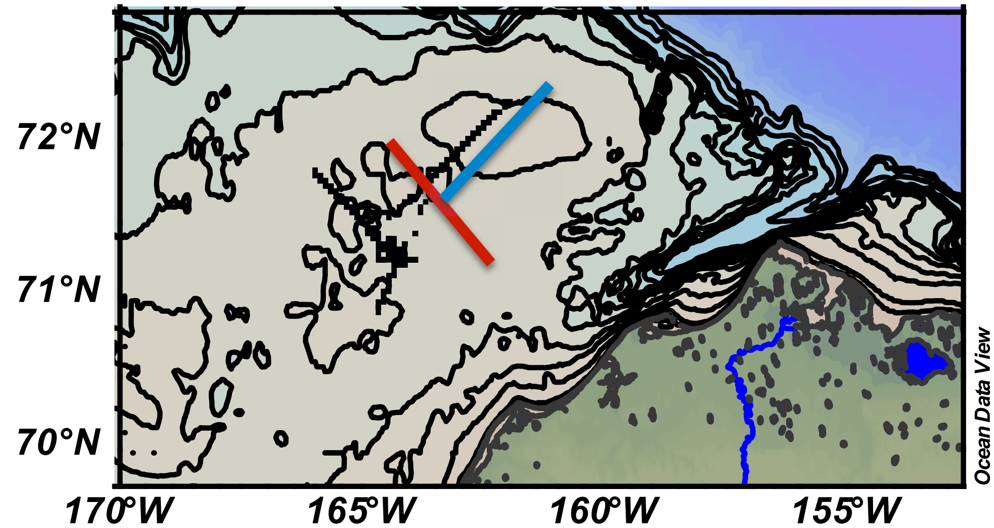
OA in Sub-Surface Waters



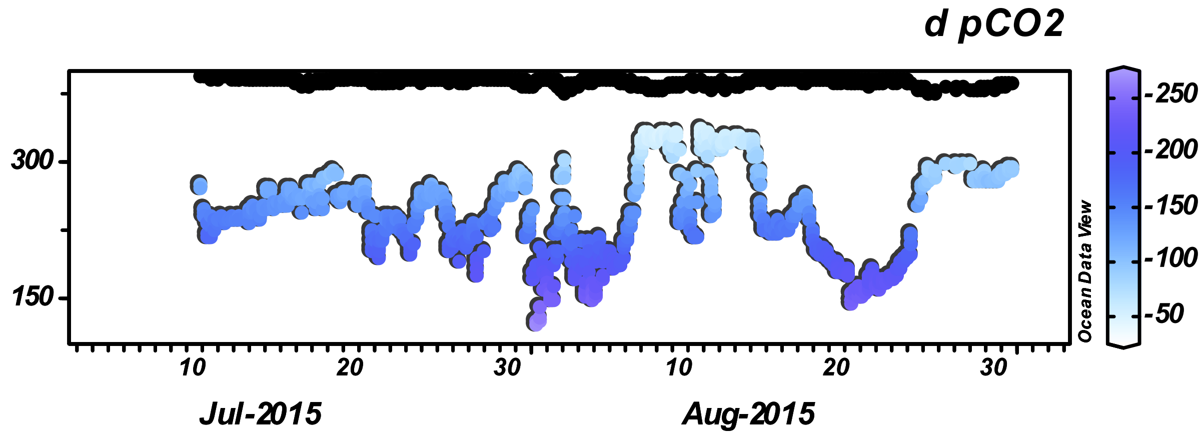
Cross et al., In Prep.

At least 40% of the Chukchi Sea benthos is exposed to bottom waters that are corrosive to $CaCO_3$ during summertime.
Bates et al., 2015

ARCTIC CARBON WAVE GLIDER

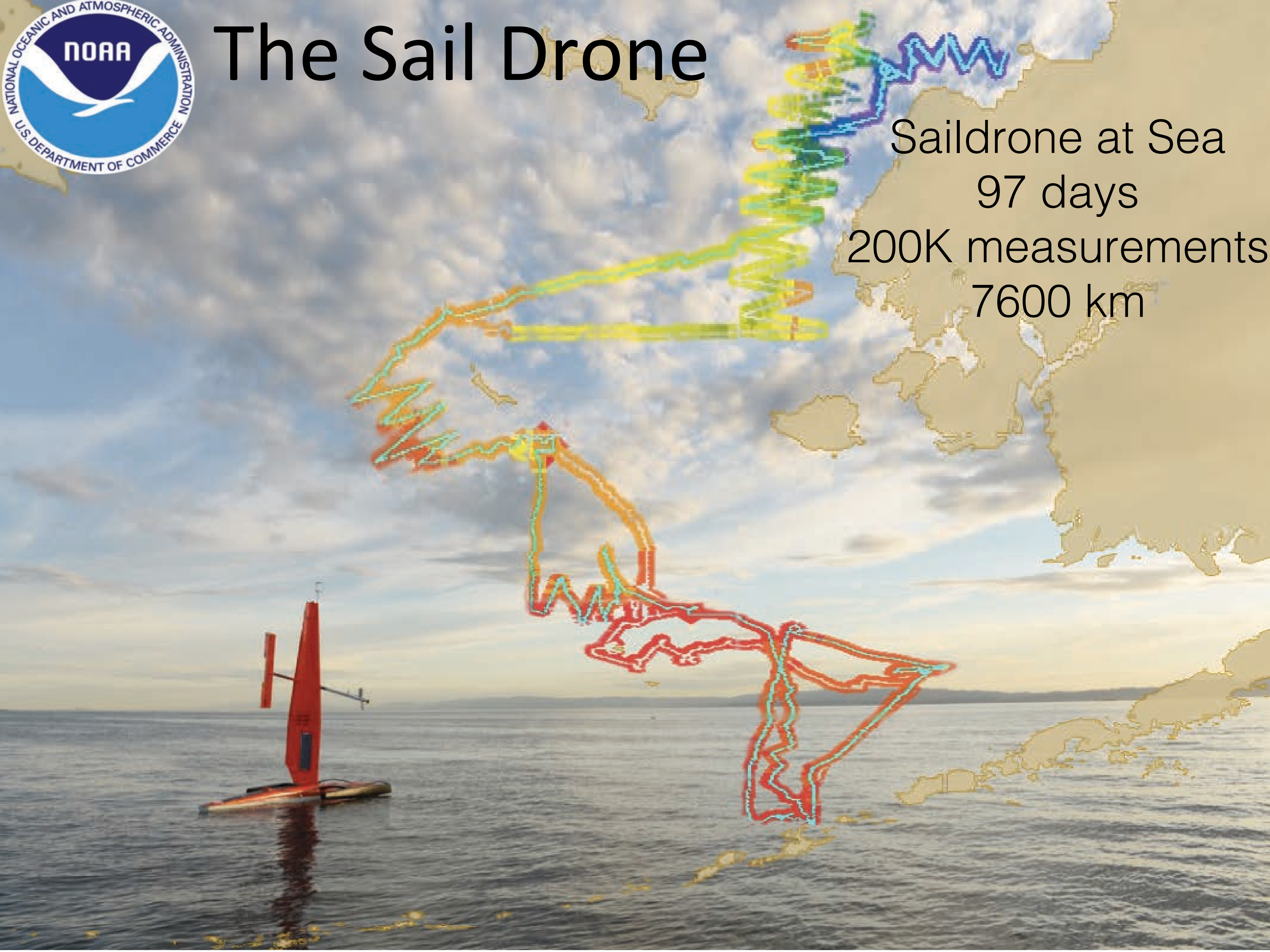


Annual wave glider mission will significantly enhance OA observations across the PAR.



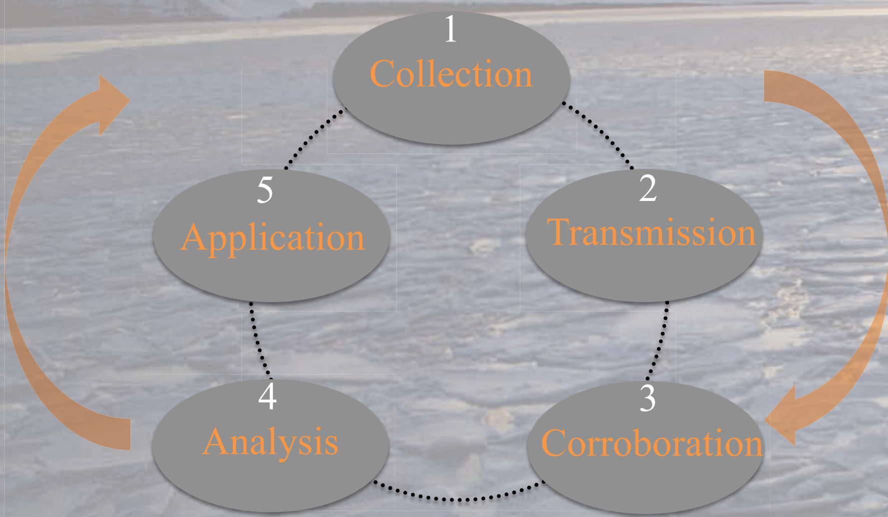
Cross et al., In Prep.

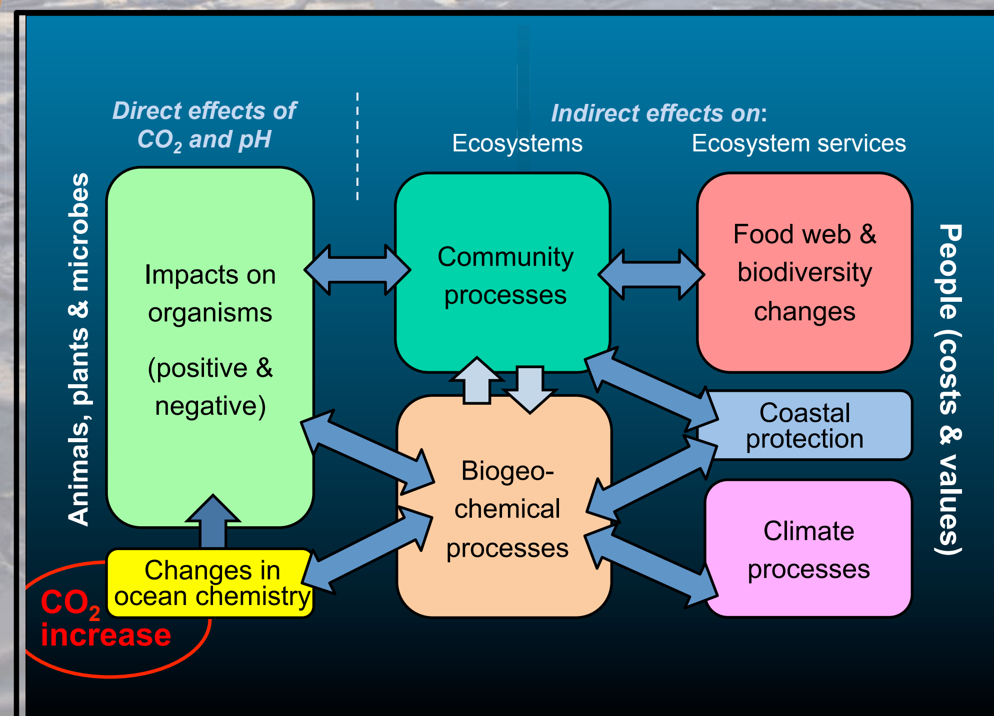
The Sail Drone



Integrated Environmental Intelligence

Environmental Intelligence Cycle





Mathis et al., 2015 (adapted from Williamson and Turley, 2012)

Conclusions

- Although progress is being made to reduce emission, CO_2 concentrations will continue to rise in the atmosphere and oceans for the rest of the century.

- Global and regional observations and climatological models show that the Pacific-Arctic Region will undergo the most rapid transitions due to ocean acidification, putting additional stress on vulnerable ecosystems.

- Surface waters in the Bering and Chukchi Sea are already near undersaturation for aragonite and will become perennially undersatruated by 2075.

- More than 40% of the Chukchi Sea shelf and at least parts of the Bering Sea shelf benthos is exposed to aragonite undersaturations for at least 4 months each year.

- We must effectively gather environmental intelligence on ocean acidification using all of the tools at our disposal.

Summary

- The intensity, extent and duration of ocean acidification in the coastal areas around Alaska will increase as anthropogenic CO_2 continues to rise.
- Important commercial and subsistence fisheries in Alaska are co-located where enhanced ocean acidification will occur.
- Coastal human communities in southeast and southwest Alaska are highly reliant on fishery harvests and face the highest risk from ocean acidification.

Risk Mitigation Strategies

1. Reduce other environmental stressors (EPA, DEQ, etc.)
2. Diversify the economies in high and moderate risk regions
3. Provide job training and educational opportunities
4. Increase access to alternative sources of protein
5. REDUCE CO_2 EMISSIONS – Everything else is just buying time

Mathis et al., 2015
Progress in Oceanography

Thanks

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http://cpo.noaa.gov/ClimatePrograms/ClimateObservation/ArcticResearch.aspx

Thank You!

- Please join us for our next seminar on Thursday, 28 April entitled *"Regional and Global Implications of Changing Permafrost"* by Ted Schuur from Northern Arizona University.
- An archive of this presentation will be available online at: https://www.arcus.org/research-seminar-series
- Please consider joining ARCUS as an individual member! More information at: https://www.arcus.org/arcus/member-information