

Addressing Ocean Change

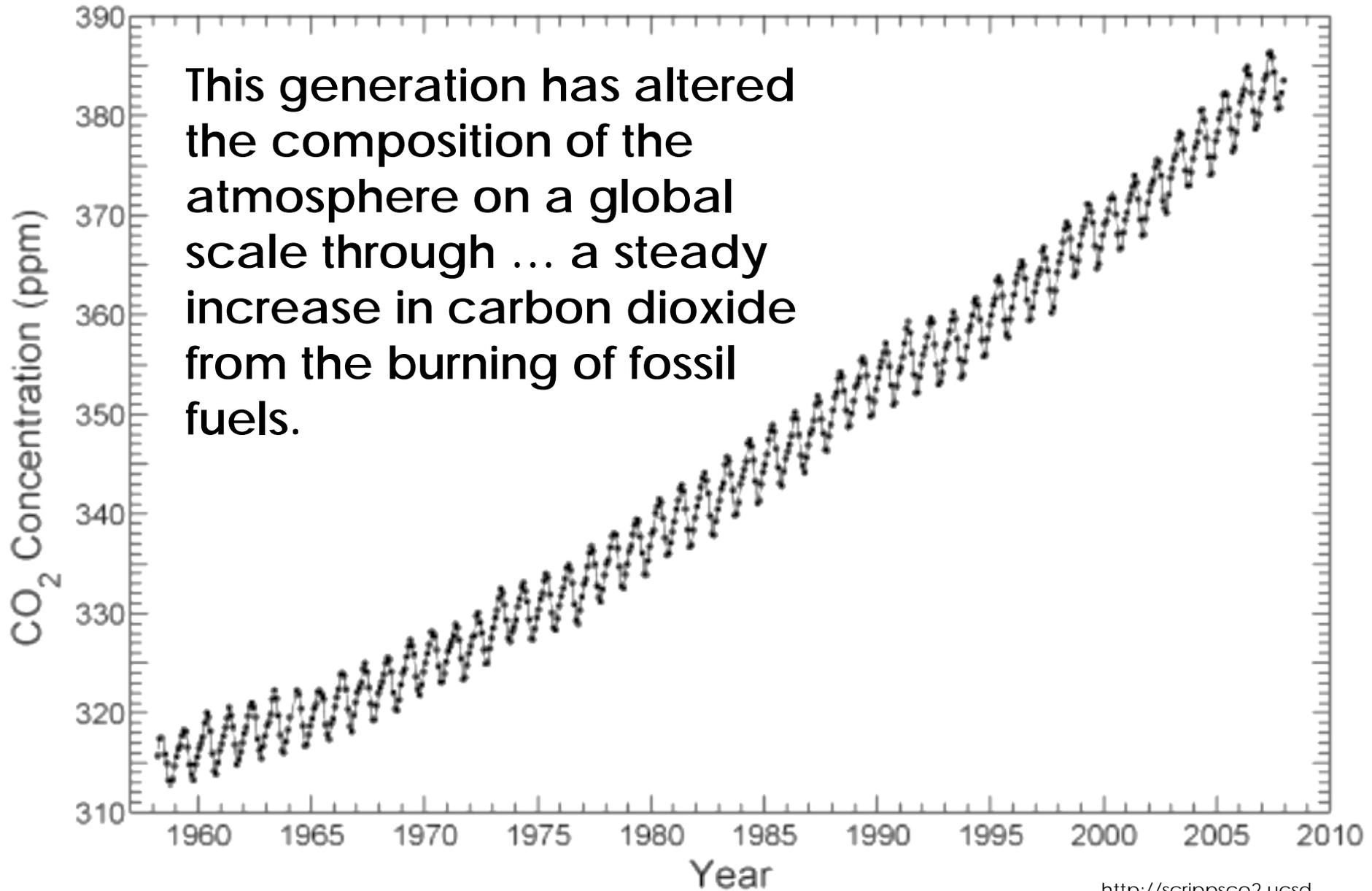
- Winners and losers – biological impacts of ocean acidification
- Solutions
- Why I'm optimistic

Paul Williams

Suquamish Shellfish Biologist

Mauna Loa Record

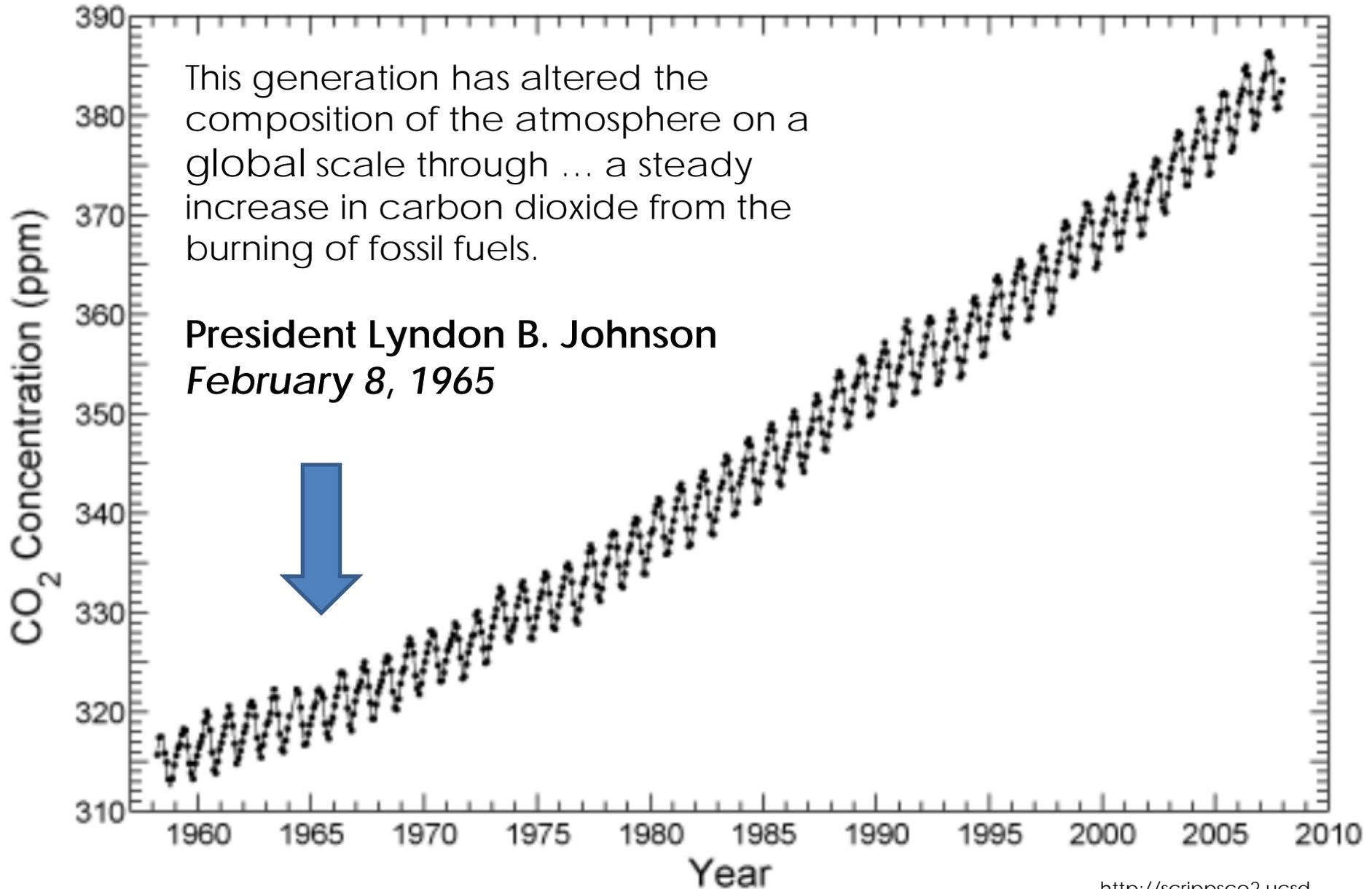
This generation has altered the composition of the atmosphere on a global scale through ... a steady increase in carbon dioxide from the burning of fossil fuels.

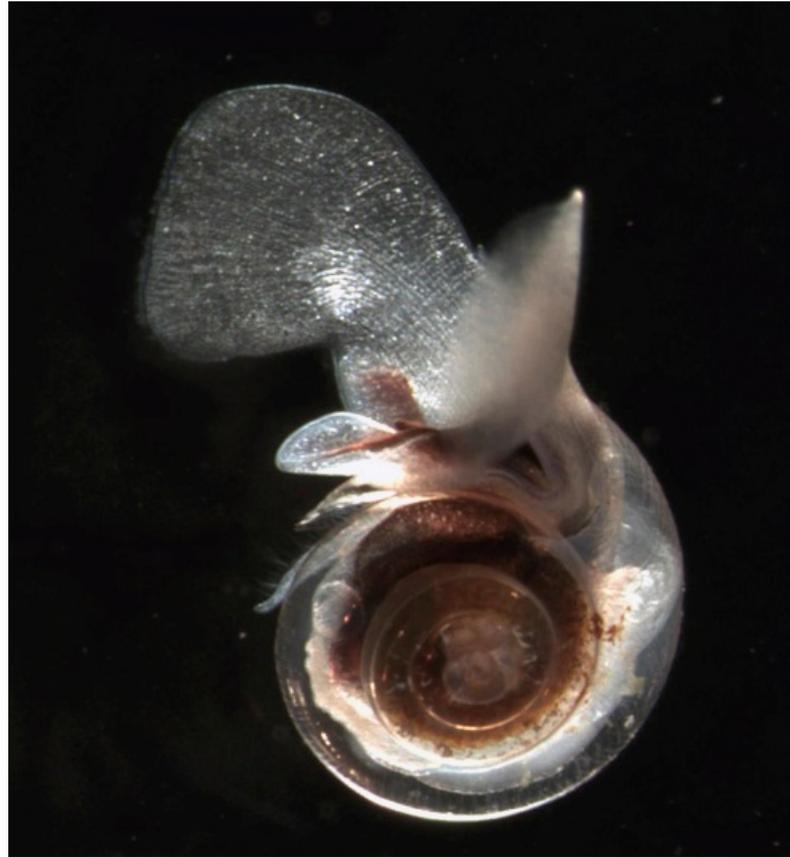


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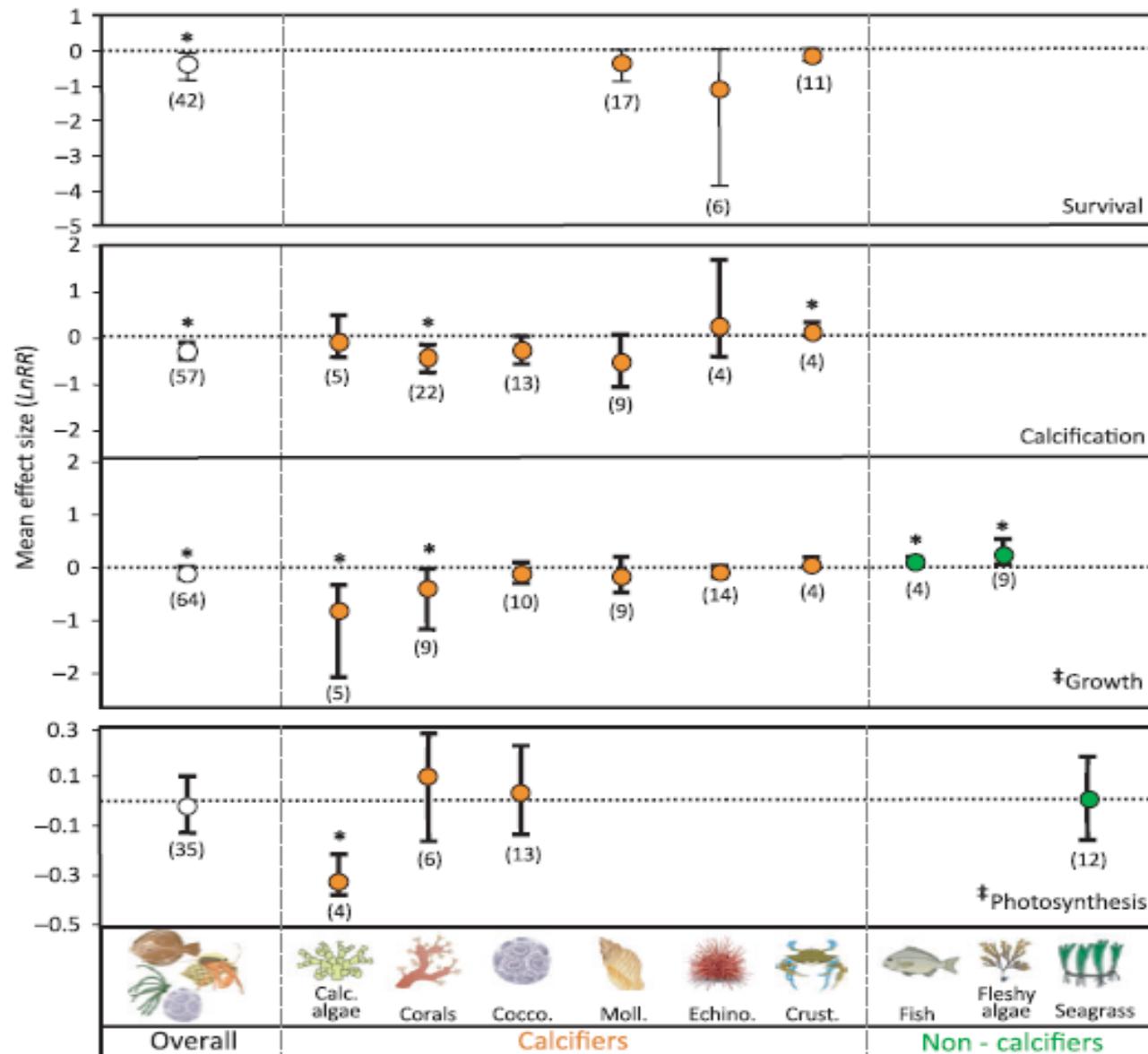
President Lyndon B. Johnson
February 8, 1965



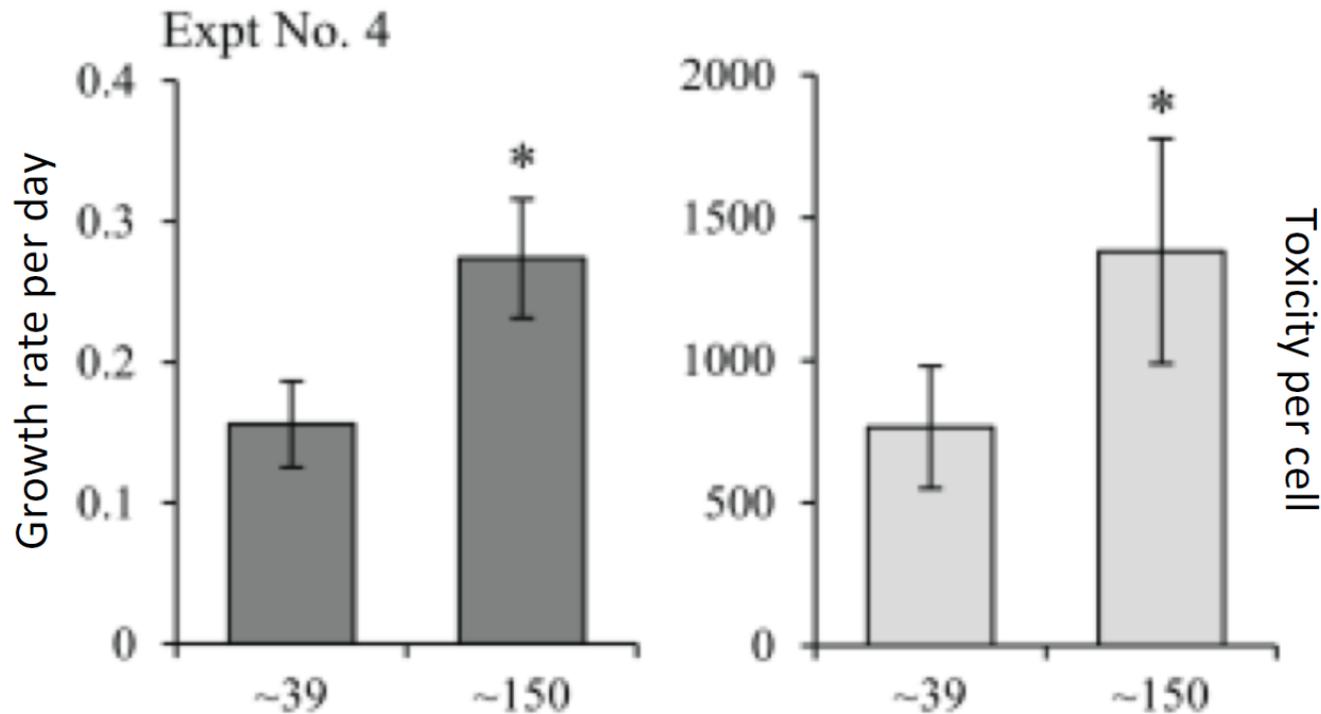


https://www.youtube.com/watch?v=6H_VDhXiFk4

Effects on different taxa

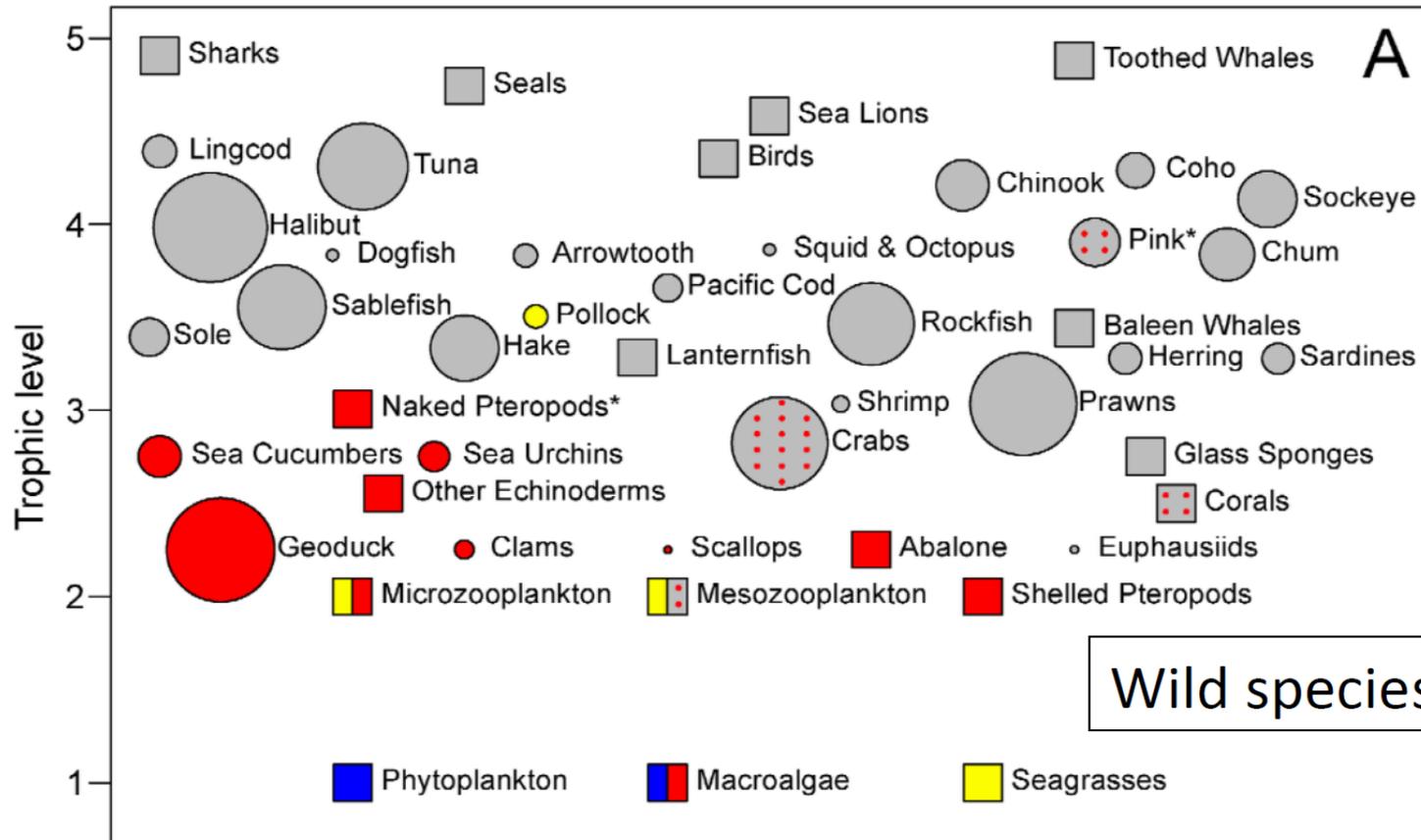


Harmful algae grow faster and are more toxic under OA conditions



Growth rate (left panel) and toxicity (right panel) of the dinoflagellate *Alexandrium fundyense* under low and high pCO₂ conditions

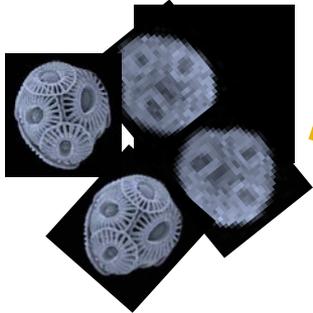
Effects occur across trophic levels



Red = likely negative Blue = likely positive Yellow = likely neutral
 Gray = no data

Circles: commercial species
 Size of circle: estimated landed value
 Solid color: likely effect
 Stippled: potential effect

Potential *food web* impacts



Coccolithophores



Copepods



V. Fabry
Vicki Fabry

Pteropods



Barrie Kovish

Pacific Salmon

Human Impacts

The rights of future generations

The rights of a fifth of the worlds population that depend on sea food for their only sores of protein.

The rights of tribes and others who make their living from the ocean

Potential Biological Impacts of Ocean Acidification

- Calcification
- Reduced energy for growth and reproduction
- Reduced tolerance of other environmental stressors (Oxygen and temp.) and reduced immune response
- Behavior change (disrupted predator avoidance behavior, homing ability)

More potential impacts

- Increase in sound transition in the water
- Shift of prey species range out of predator area
- Settlement (less sticky)
- Change in phytoplankton composition
- Biogeochemical cycles mediated by pH
- Other physiological effects e.g. protein synthesis
- Unknown impacts

Solutions:

- Shift to renewable energy sources to end excessive carbon emissions
- Mitigation / technological fixes
 - Kelp restoration - removes carbon, increases habitat
- Reduce other stressors to increase ecosystem resilience

What not to do:

- Mitigation / technological fixes that might not be good: iron fertilization
- Scare people too much

THURSDAY, SEP 26, 2013 05:10 AM PDT

Study: Everyone hates environmentalists and feminists

New research suggests people tend to hold negative views of political and social activists

BY TOM JACOBS



TOPICS: PACIFIC STANDARD, ENVIRONMENTALISM, UNIVERSITY OF TORONTO, ENVIRONMENTALISTS, FEMINISM, FEMINISTS, LIFE NEWS, POLITICS NEWS



Bashir, N. Y., Lockwood, P., Chasteen, A. L., Nadolny, D. and Noyes, I. (2013), The ironic impact of activists: Negative stereotypes reduce social change influence. *Eur. J. Soc. Psychol.*, 43: 614–626. doi: 10.1002/ejsp.1983

ZSL

HOPELESSNESS AMONG SCIENTISTS



“We contend that there is a continuing culture of hopelessness among conservation biologists.”

2010 editorial,
BioScience.

Growing evidence of children and adults feeling overwhelmed and hopeless about the state of the environment



- Ecophobia (Sobel, 1996)
- Environmental Grief (Windle, 1995; Kervorkian, 2010;)
- Environmental Depression (Lysack, 2009; Zeyer & Kelsey, 2011)
- Environmental Apathy (Renée Lertzman, 2008; Twenge, Campbell and Freeman, 2012)
- Compassion Fatigue (Moeller, 1999; Dominelli, 2012)



Reduce harm to increase ecosystem resiliency





Report Card on
the Status of Environmental Education in
Washington State 2014

SUMMARY OF SUBJECTS AND GRADES

EFFECTIVENESS OF ENVIRONMENTAL EDUCATION IN IMPROVING STUDENTS' STANDARDIZED TEST SCORES

GRADE

A

LEGAL AND ACADEMIC FOUNDATIONS OF ENVIRONMENTAL EDUCATION

GRADE

A

INDEPENDENT, INNOVATIVE APPROACHES TO ENVIRONMENTAL EDUCATION

GRADE

A

GENERAL AWARENESS OF ENVIRONMENTAL EDUCATION

GRADE

C

STATE SUPPORT OF ENVIRONMENTAL EDUCATION

GRADE

D

We don't support k-12 education as a viable solution to changing behaviors and fostering an informed electorate.

Why?

It takes too much money.

We already pay for the teachers and schools. We just need to spend a little bit more in professional development and materials to leverage the skills of 50,000 teachers.

There are 295 independent school districts that choose their own curriculum. We need to convince the each school principal to allow their teachers to attend trainings and adopt new curriculum.

Set stronger state standards in science and support them. The next generation science standards have been adopted but there are few resources to implement them.

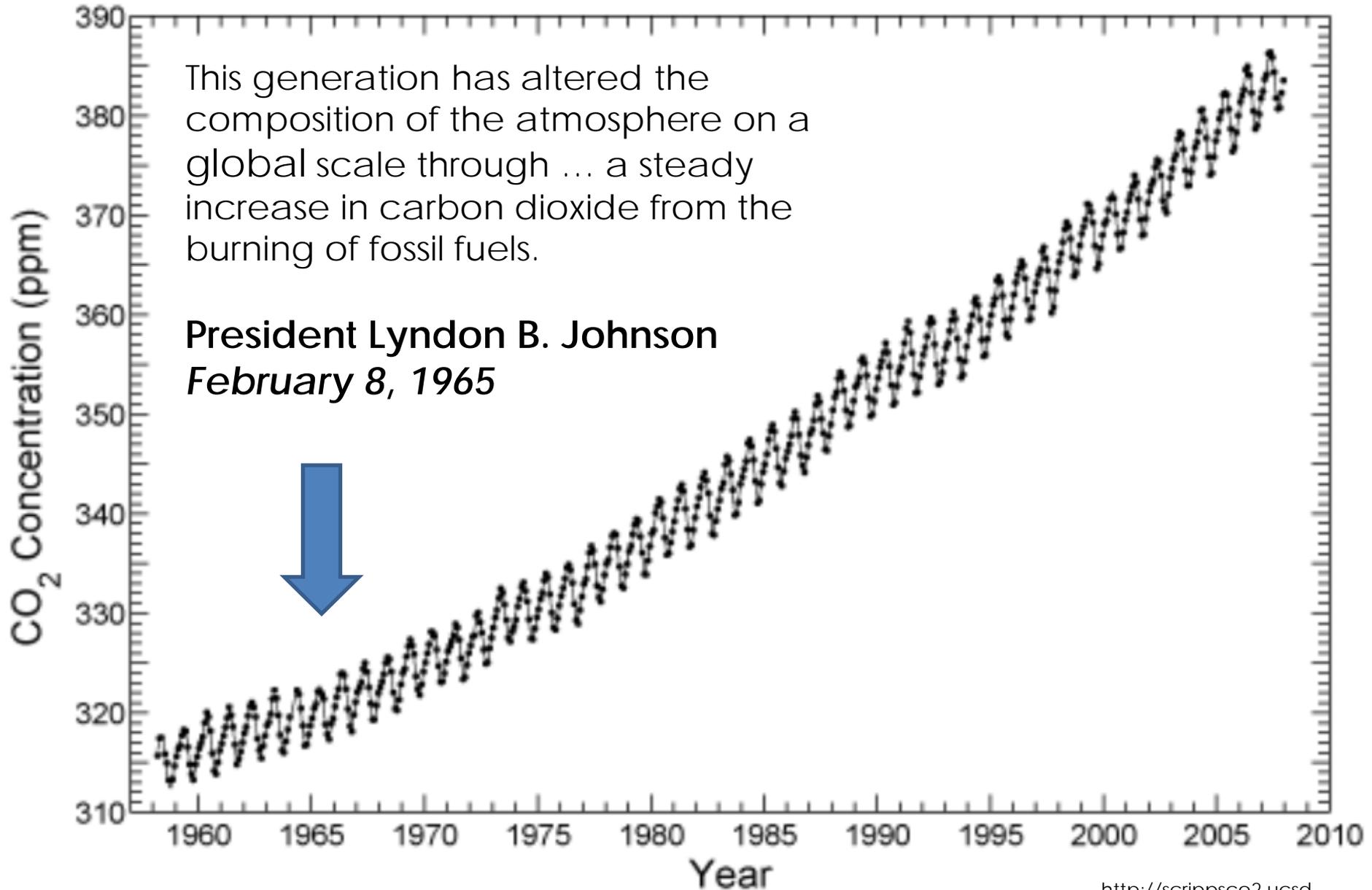
It takes too long we need to act now!

Yes we need to act now, but we can attack this on different fronts if we coordinate actions.

Mauna Loa Record

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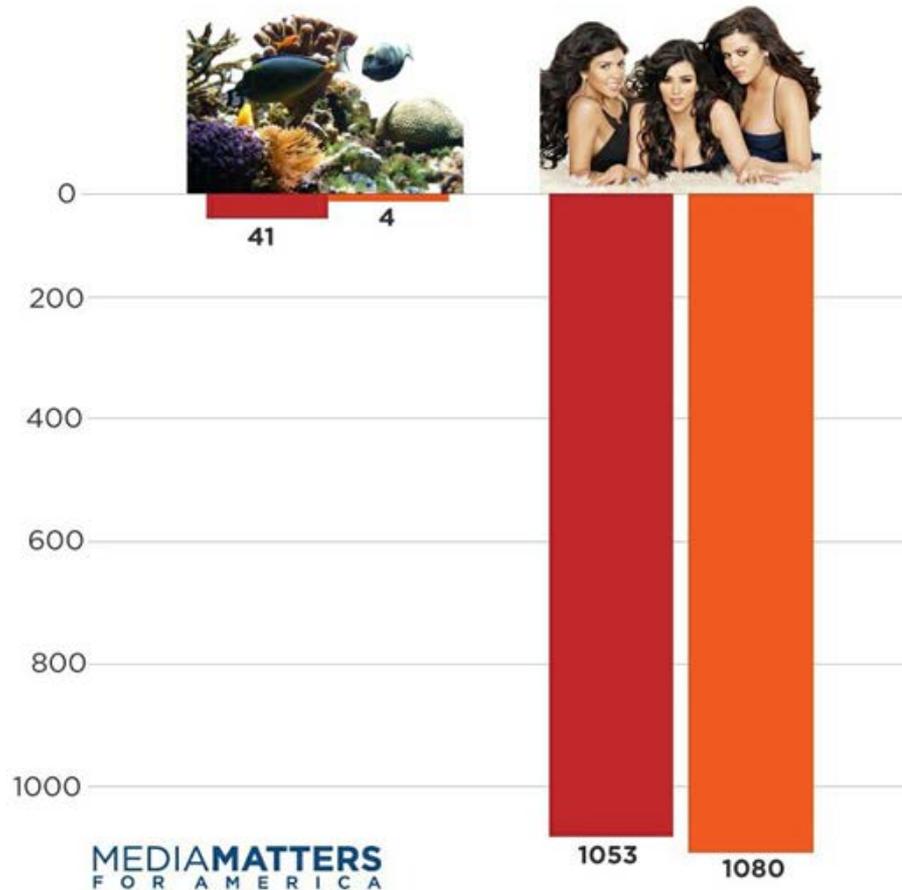
President Lyndon B. Johnson
February 8, 1965



THE KARDASHIANS VS. OCEAN ACIDIFICATION

News Coverage Between Jan. 1, 2011 - June 26, 2012

■ NEWSPAPERS ■ TELEVISION



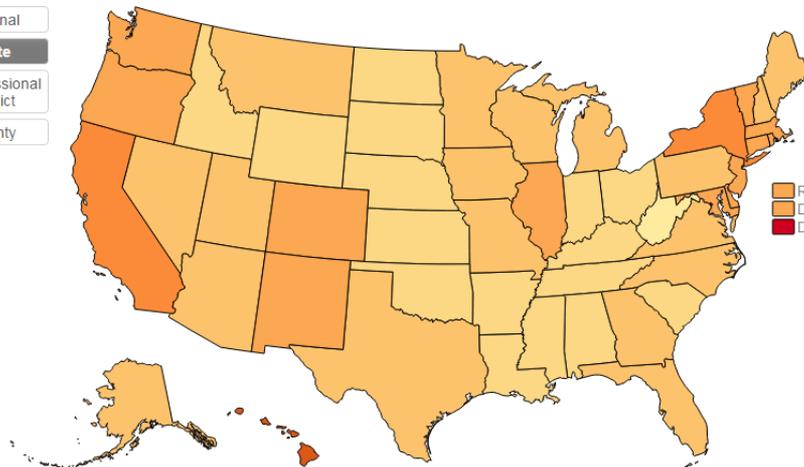
Newspapers: *New York Times*, *Washington Post*, *Associated Press*, *Wall Street Journal*, *Los Angeles Times*, *USA Today*. TV Channels: *MSNBC*, *CNN*, *Fox News*, *ABC*, *CBS*, *NBC*



Estimated % of adults who think global warming is happening, 2014

Display model output: Global warming is happening

- National
- State**
- Congressional District
- County



Tweet

7k

Like

United States

50%

Yes

63%

18%

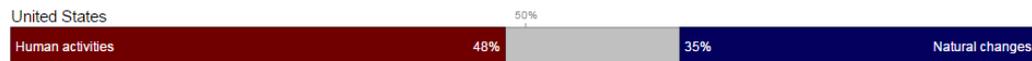
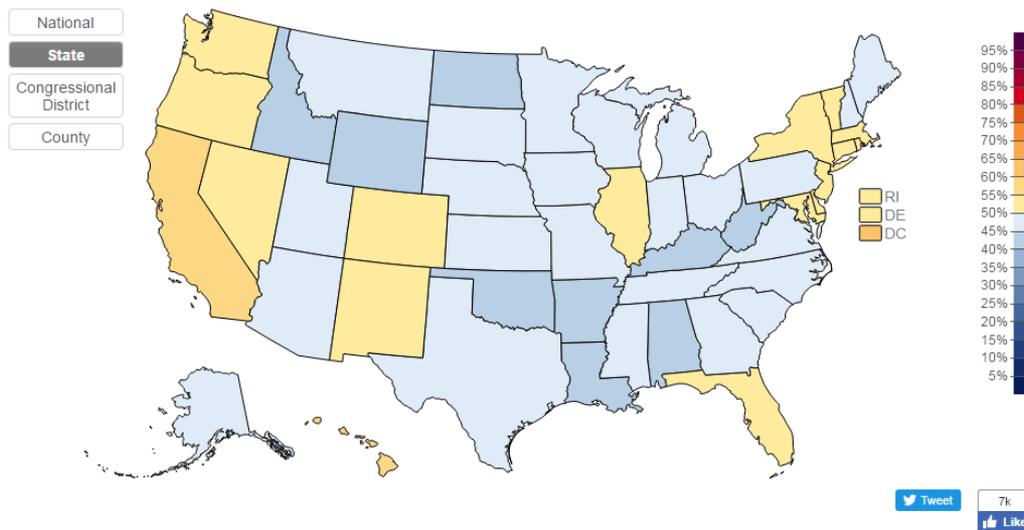
No

Public Opinion Estimates, United States, 2014



Estimated % of adults who think global warming is mostly caused by human activities, 2014

Display model output:

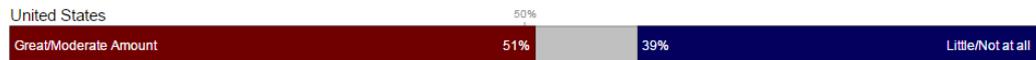
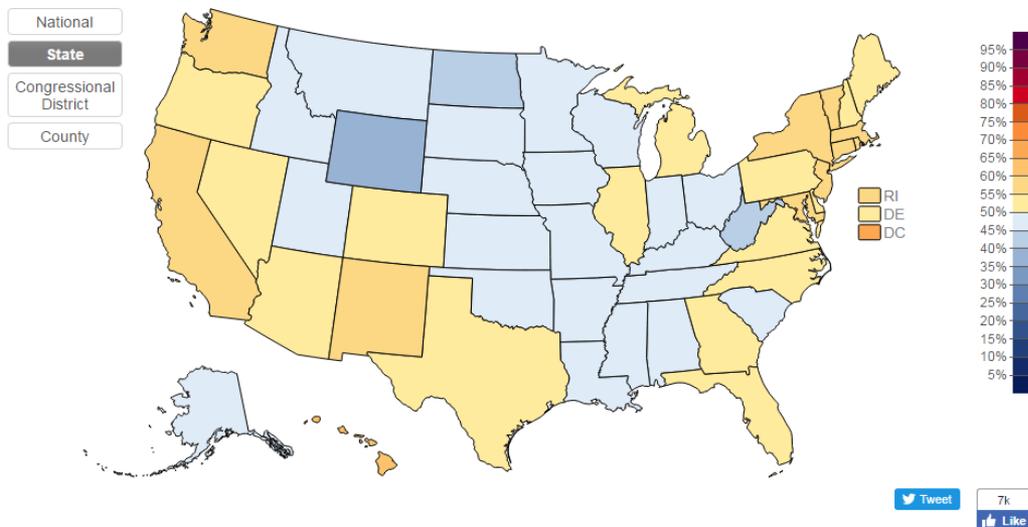


Public Opinion on Global Warming Causes, 2014



Estimated % of adults who think global warming will harm people in the US, 2014

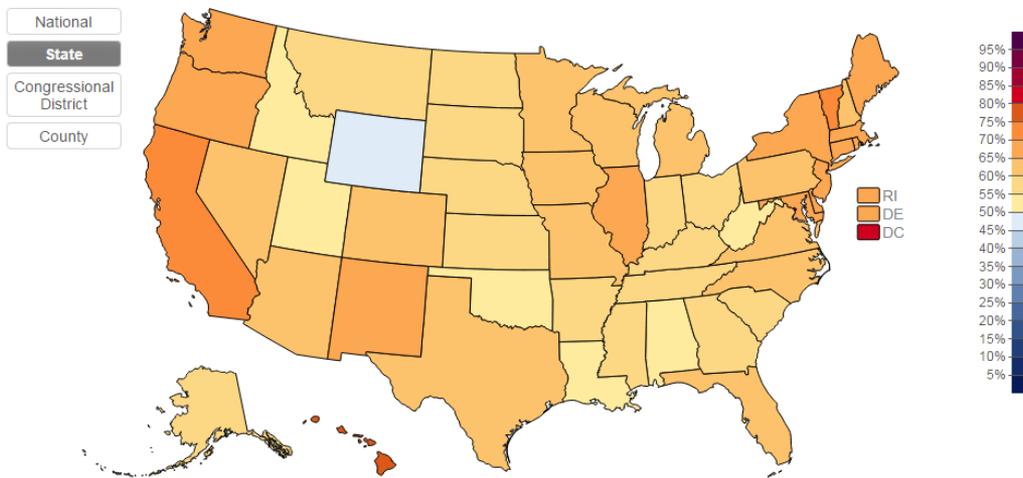
Display model output: Global warming will harm people in the US





Estimated % of adults who think global warming will harm future generations, 2014

Display model output: Global warming will harm future generations



Tweet 7k Like

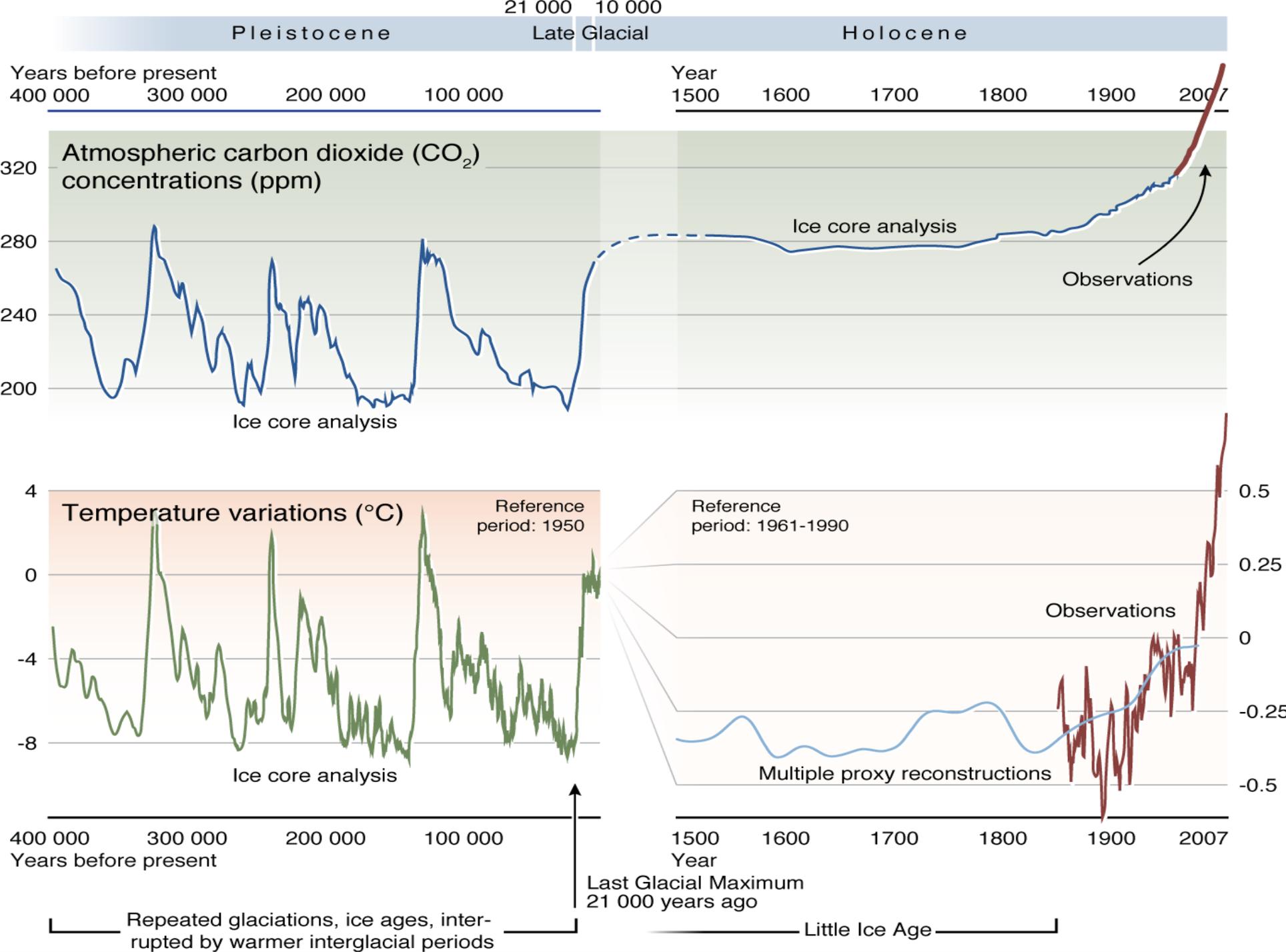




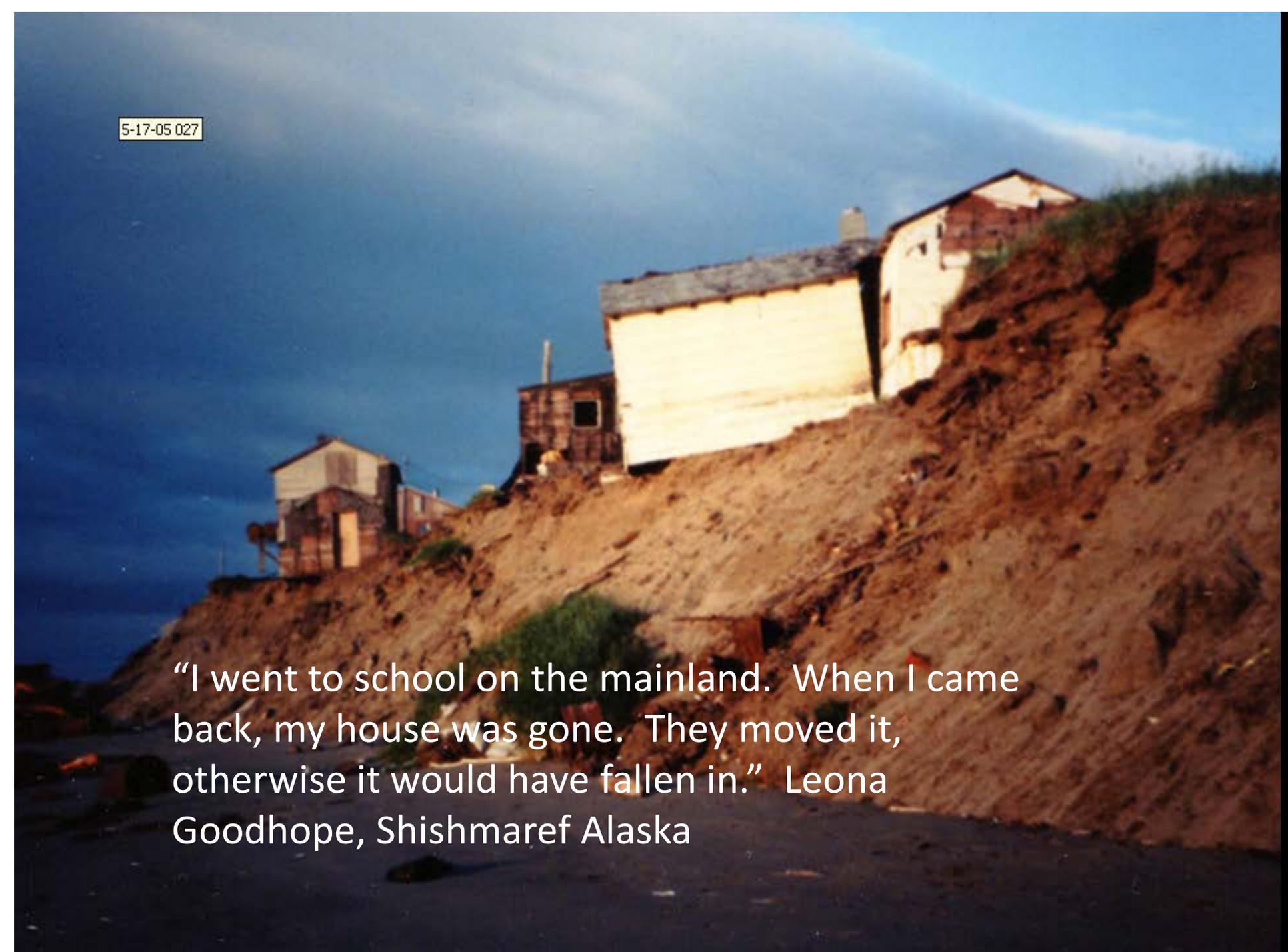


Why Ocean Acidification Education

- Scope of opportunity: Over 1.1 million students; 50,000 teachers. WA pop 6.8 M (16%)
- Standards changing - Next Generation Science Standards adopted 2013
- Students want it
- Teachers want:
 - High quality, well tested materials
 - More relevant ways to meet the standards
 - “Replace, don’t add to my list of things to cover
 - Low cost
- High level support for OA and Climate Change



5-17-05 027



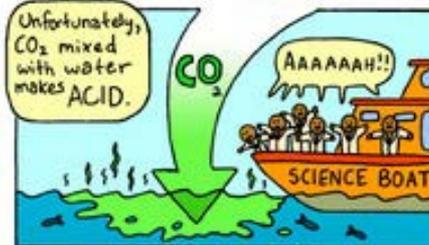
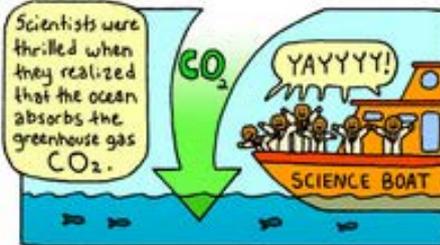
“I went to school on the mainland. When I came back, my house was gone. They moved it, otherwise it would have fallen in.” Leona Goodhope, Shishmaref Alaska

Artist: Rosemary Mosco; www.birdandmoon.com

Greenhouse gases don't just cause **GLOBAL WARMING...**

Meet a new threat:

OCEAN ACIDIFICATION



As the ocean becomes more acidic, the shells of sea animals dissolve.



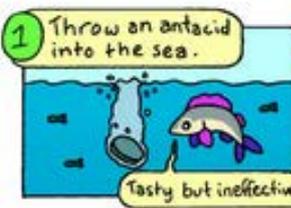
The acid also damages some animals' senses.



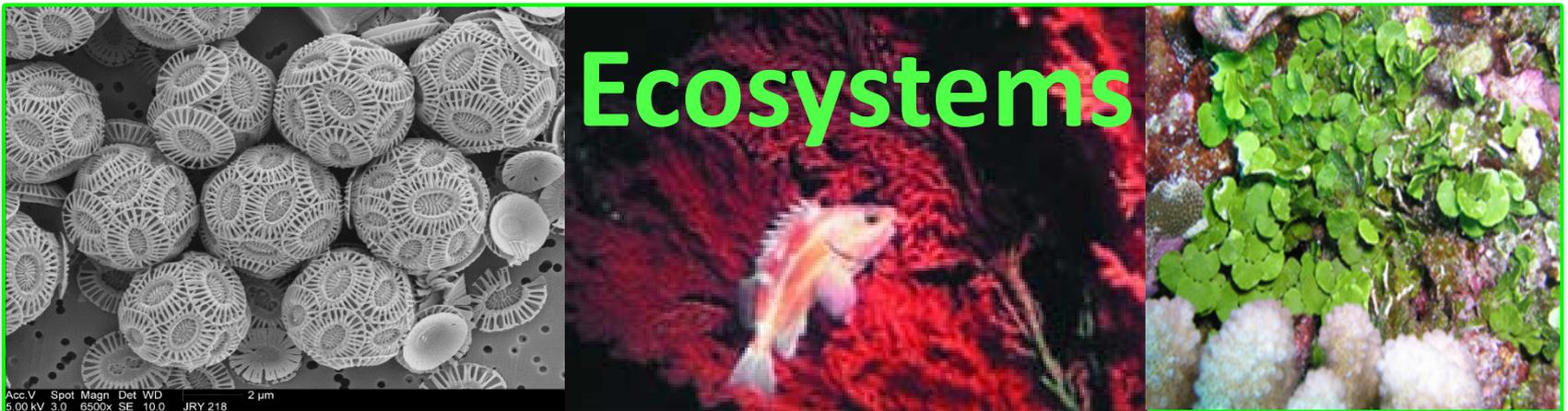
Since the 18th century, the ocean's surface waters have become 30% more acidic.

And the process is accelerating...
In the coming decades it'll reach deeper into the sea,
changing life as we know it.

So what can you do?

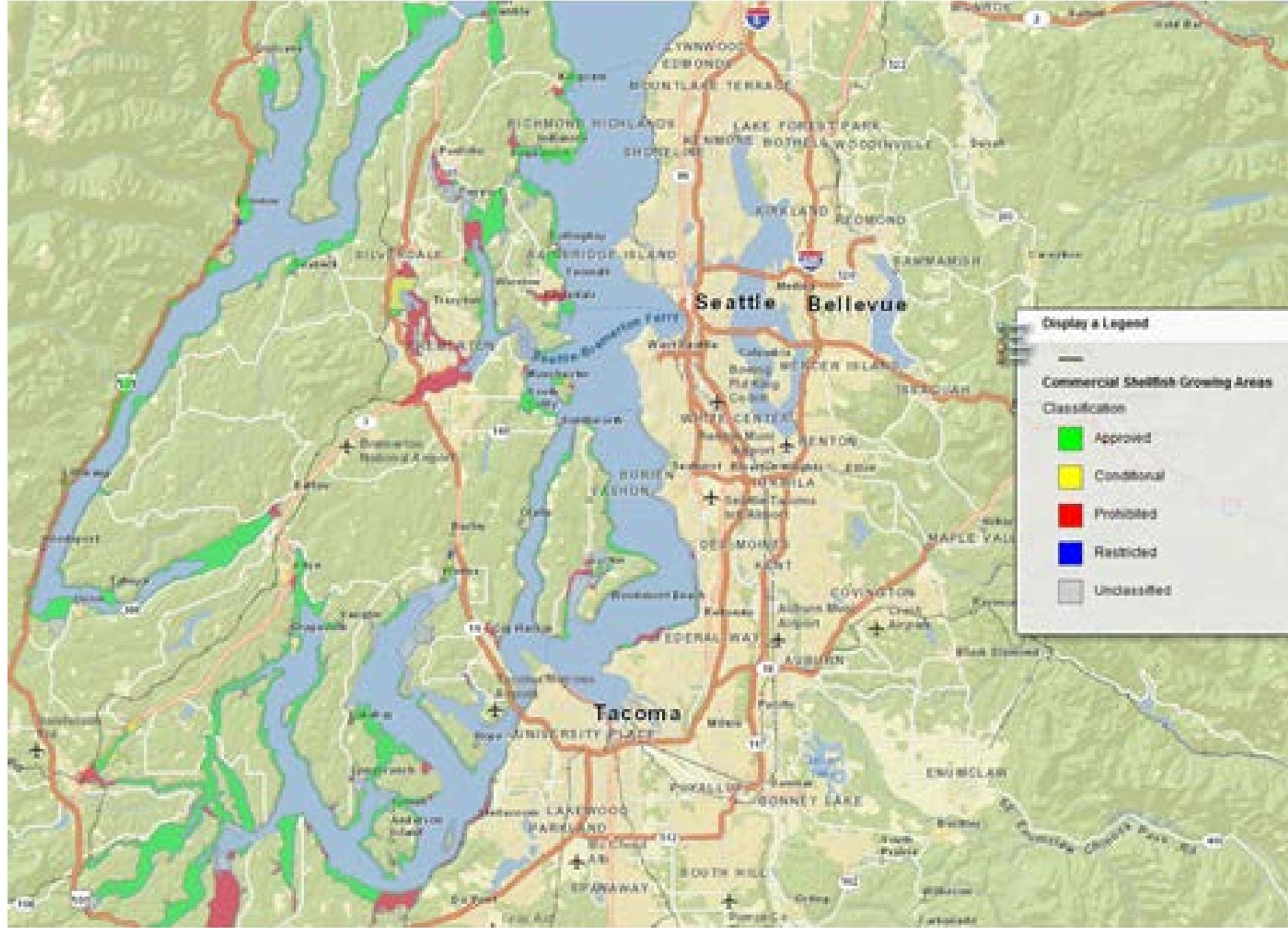


Also vulnerable to OA...



1. Correlation of pH values and Hydronium ion concentra

pH	Hydronium ion concentration (moles/L)
1	.1 (1 × 10 ⁻¹)
2	.01 (1 × 10 ⁻²)
3	.001 (1 × 10 ⁻³)
4	.0001 (1 × 10 ⁻⁴)
5	.00001 (1 × 10 ⁻⁵)
6	.000001 (1 × 10 ⁻⁶)
7	.0000001 (1 × 10 ⁻⁷)
8	.00000001 (1 × 10 ⁻⁸)
9	.000000001 (1 × 10 ⁻⁹)
10	.0000000001 (1 × 10 ⁻¹⁰)
11	.00000000001 (1 × 10 ⁻¹¹)
12	.000000000001 (1 × 10 ⁻¹²)
13	.0000000000001 (1 × 10 ⁻¹³)
14	.00000000000001 (1 × 10 ⁻¹⁴)

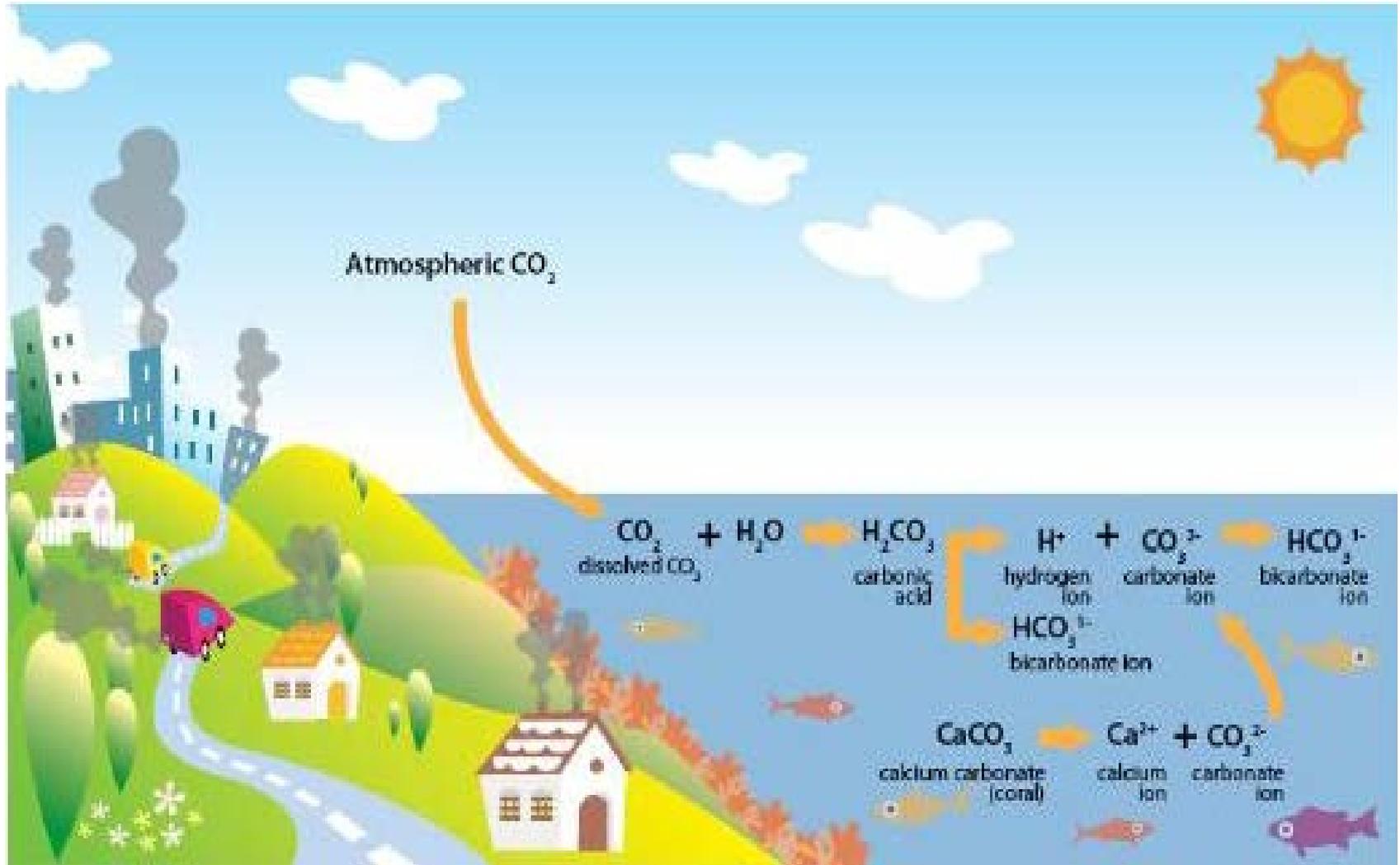


Display a Legend

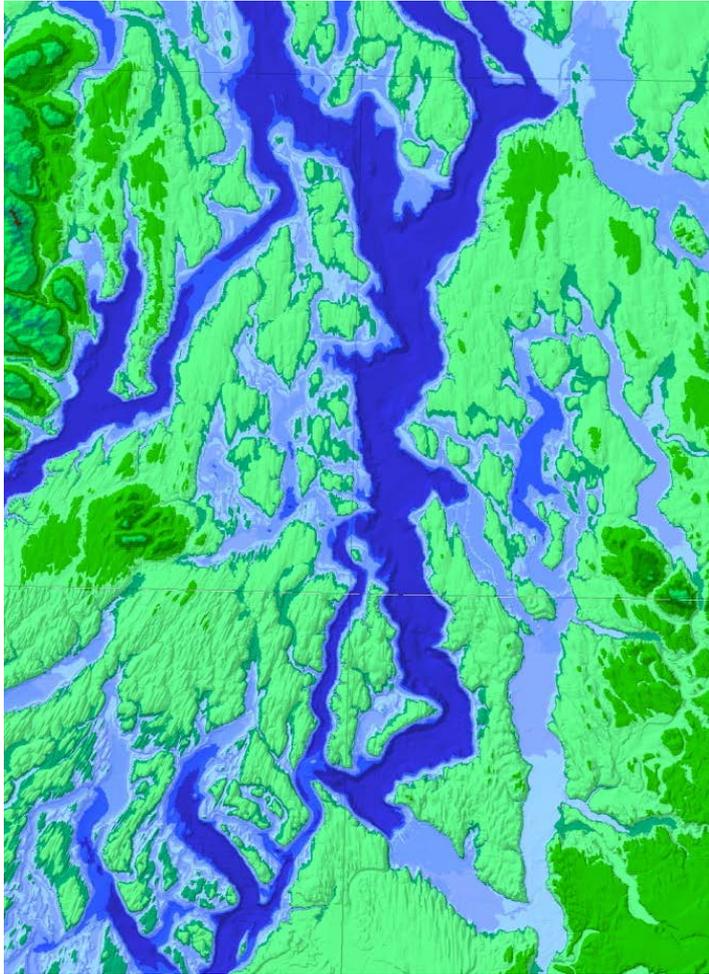
Commercial Shellfish Growing Areas

Classification

- Approved
- Conditional
- Prohibited
- Restricted
- Unclassified



Early Post-glacial 16,500 BP



Present

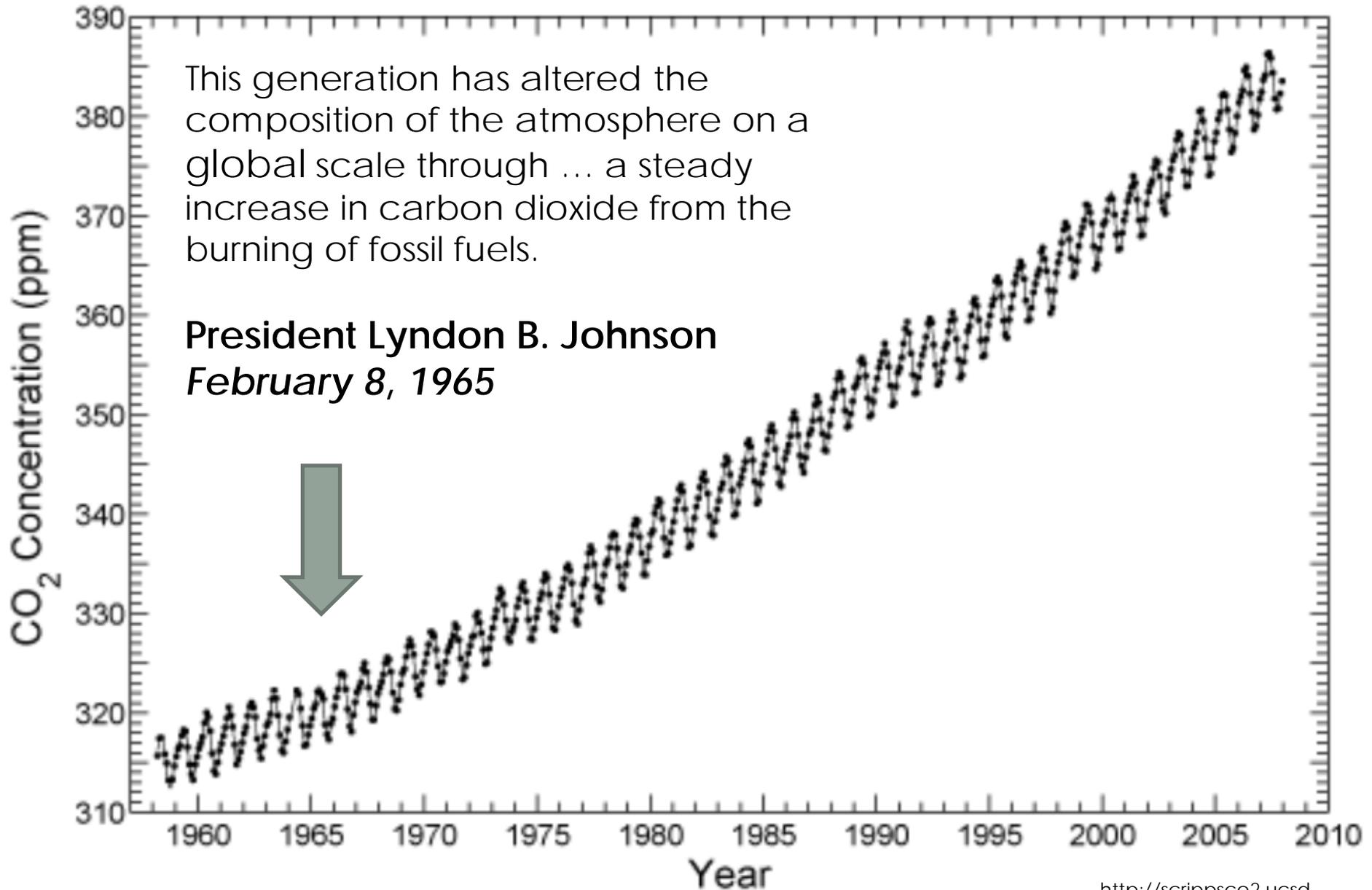


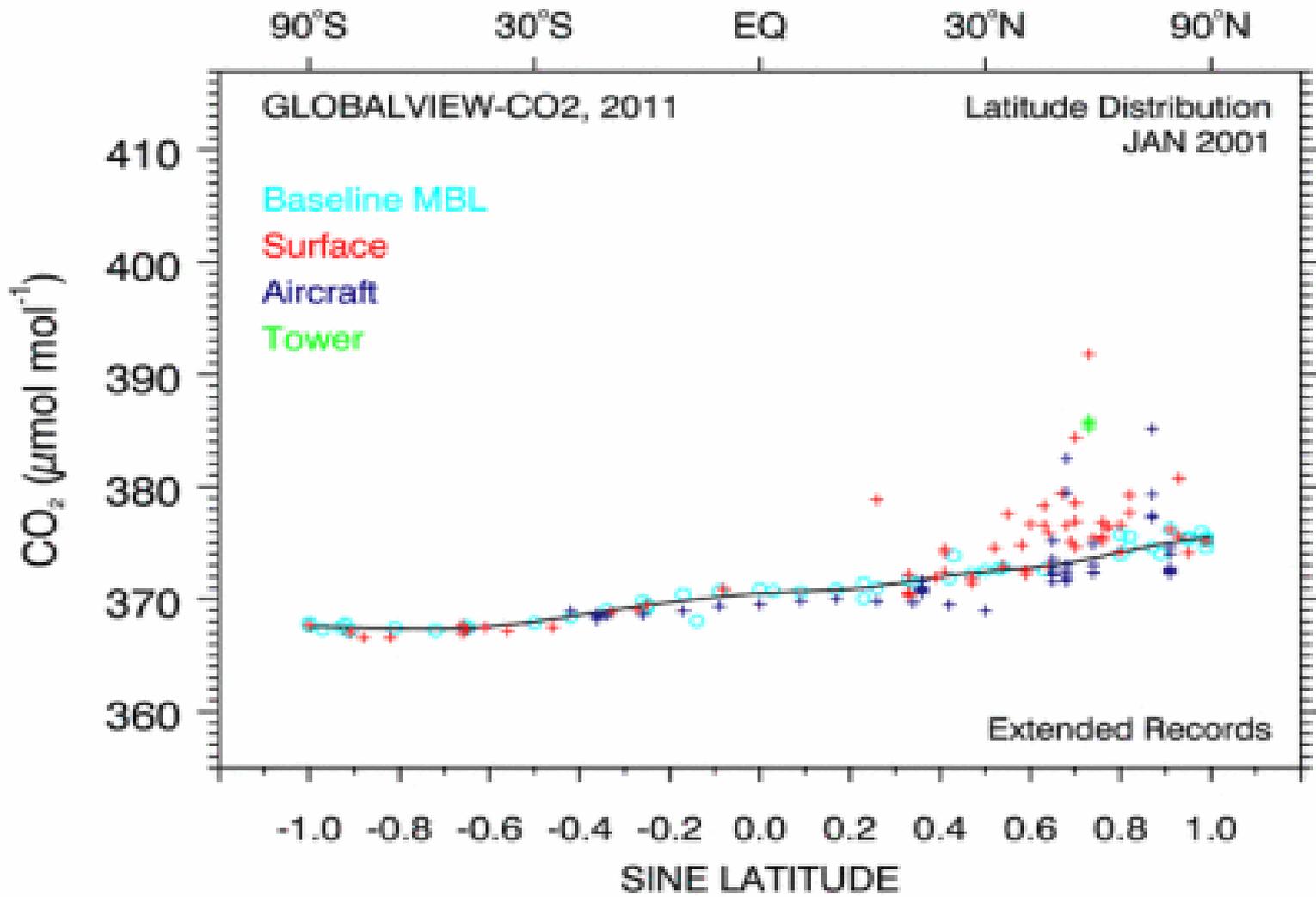


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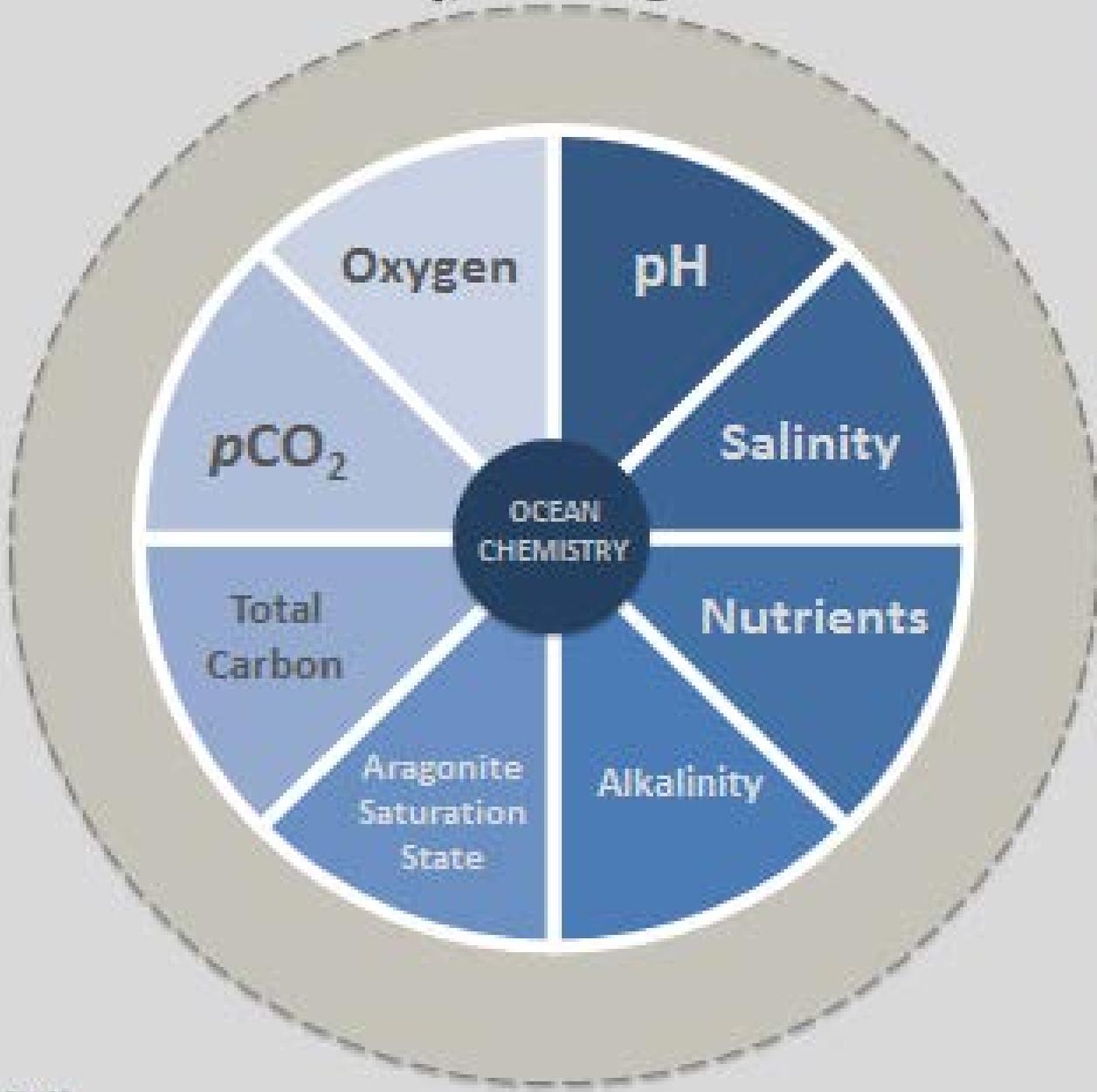
President Lyndon B. Johnson
February 8, 1965





Prepared by NOAA ESRL, 2011-09-16

IMPACTS



THINGS WE CARE ABOUT

Fish/Fisheries

Biodiversity

Ecosystem Services

Water Quality

DRIVERS OF CHANGE

Elevated atm. CO_2

Elevated seawater CO_2

Climate change

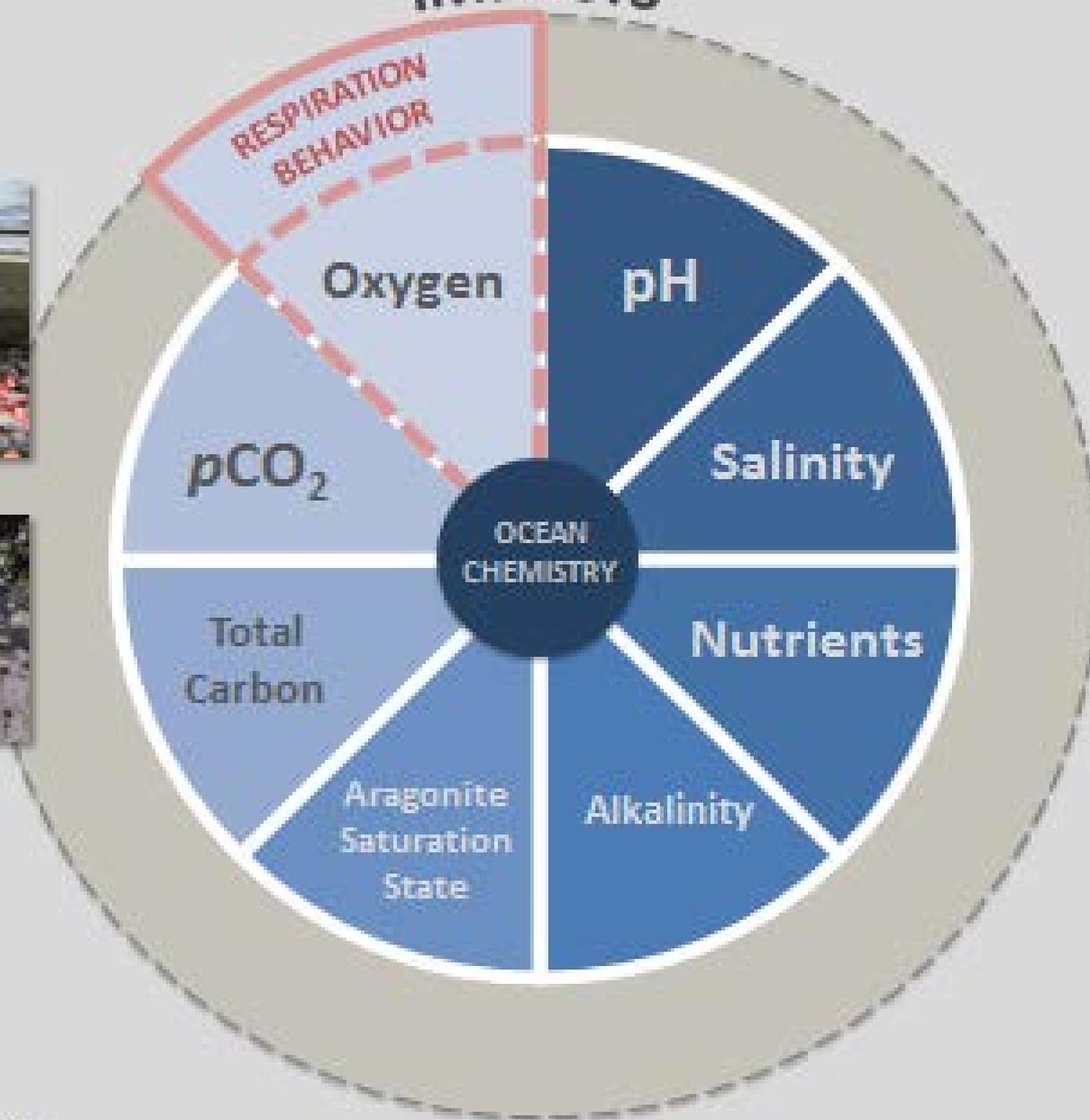
Increased nutrient runoff

Low O_2 water closer to surface

THINGS
WE CARE
ABOUT



IMPACTS

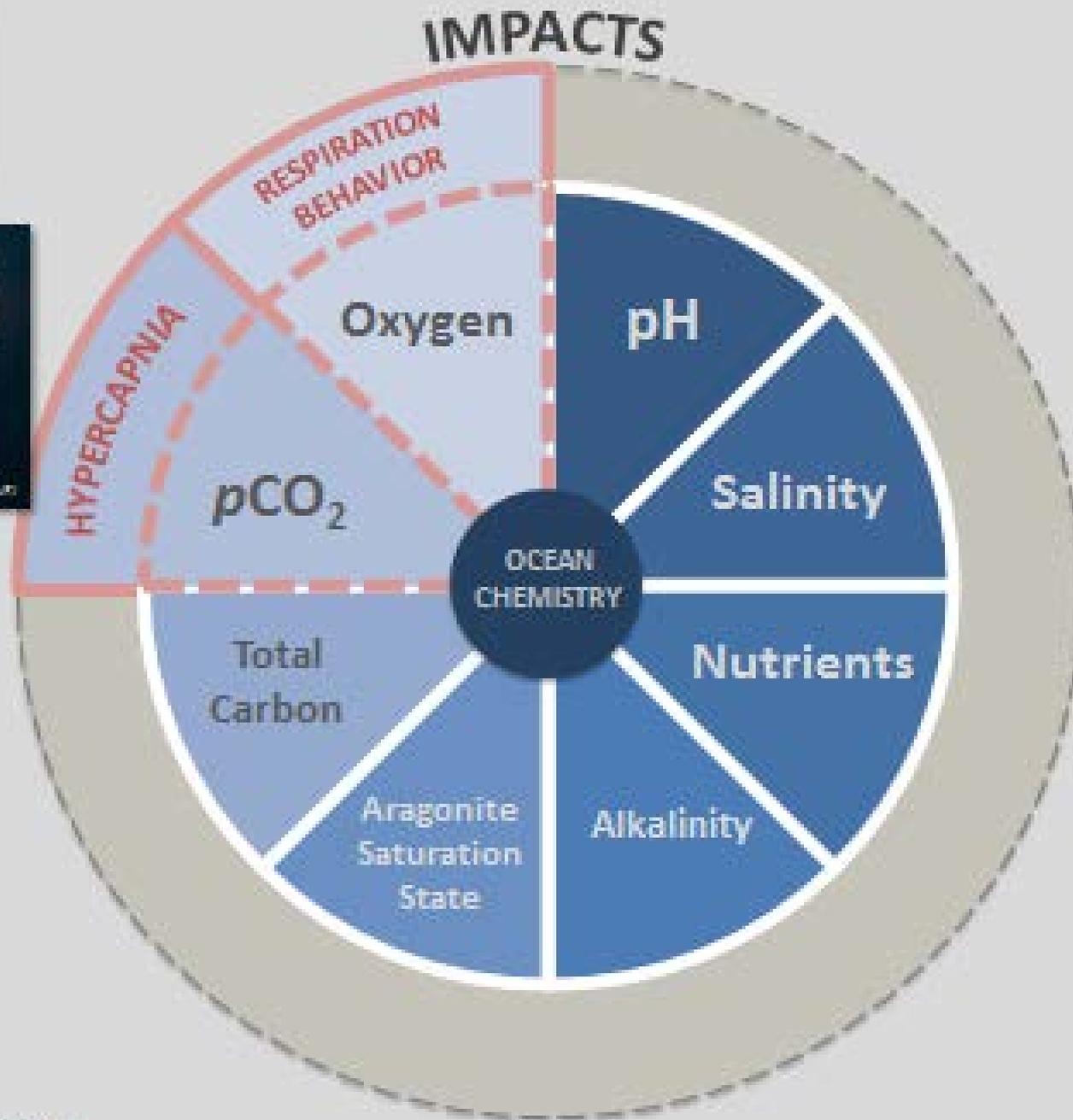


DRIVERS
OF
CHANGE

Elevated atm.
 CO_2

Climate change?

THINGS
WE CARE
ABOUT



DRIVERS
OF
CHANGE

Elevated
seawater CO₂

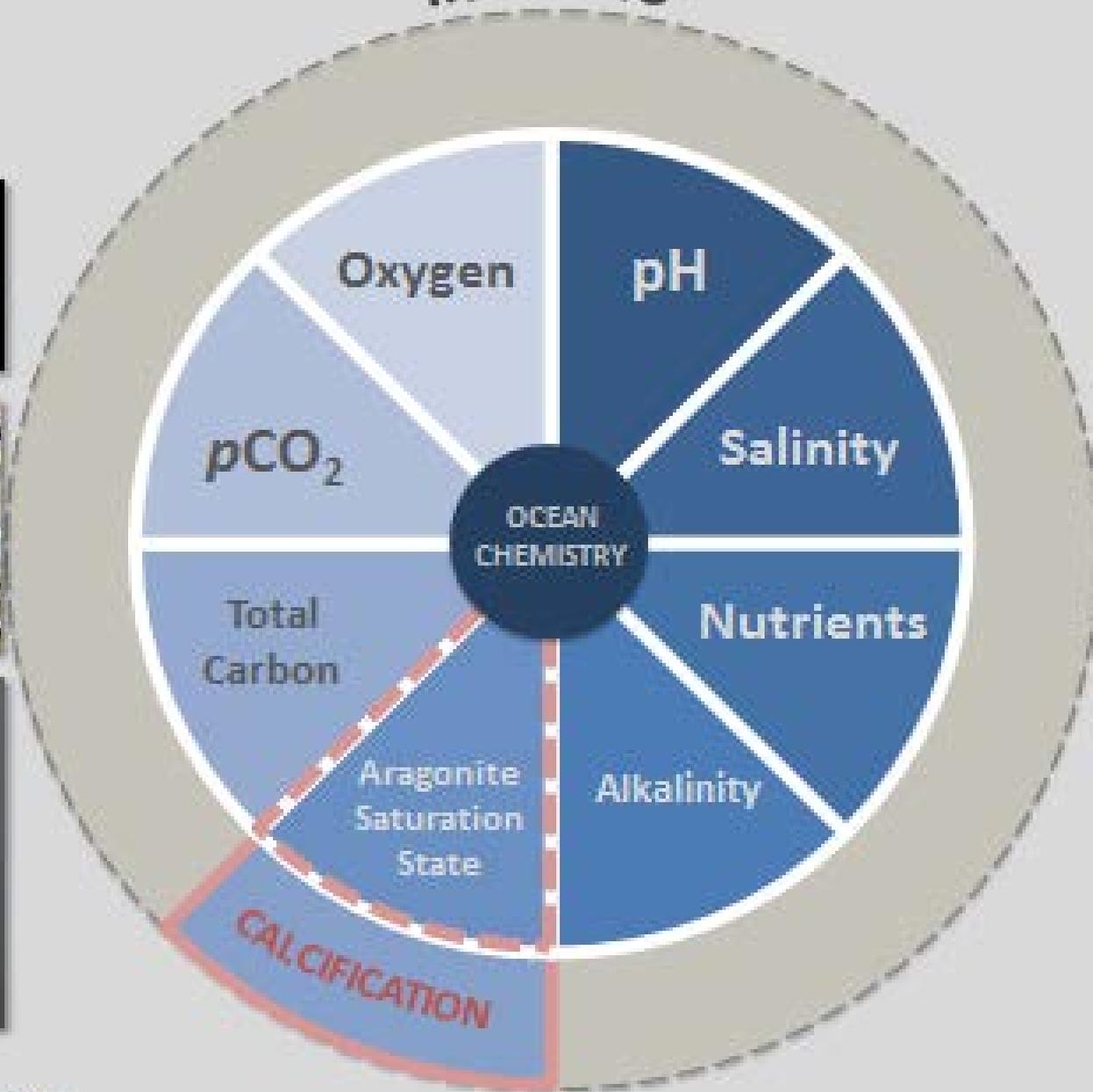
Low O₂ water
closer to surface

Climate change?

THINGS
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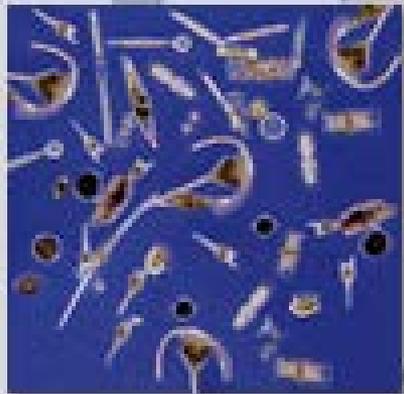
IMPACTS



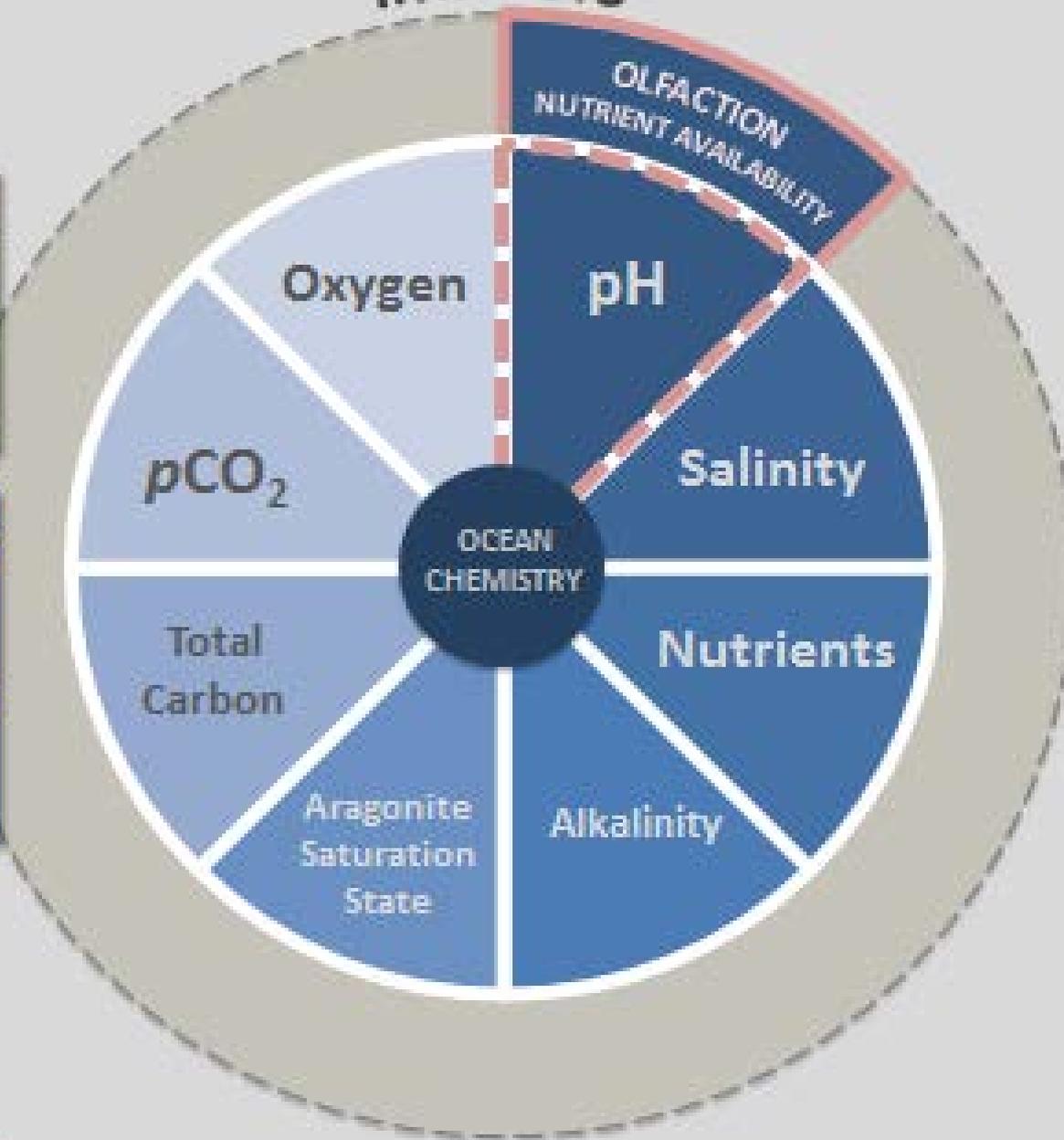
DRIVERS
OF
CHANGE

Elevated
seawater CO₂

THINGS
WE CARE
ABOUT



IMPACTS



DRIVERS
OF
CHANGE

Elevated
seawater CO_2

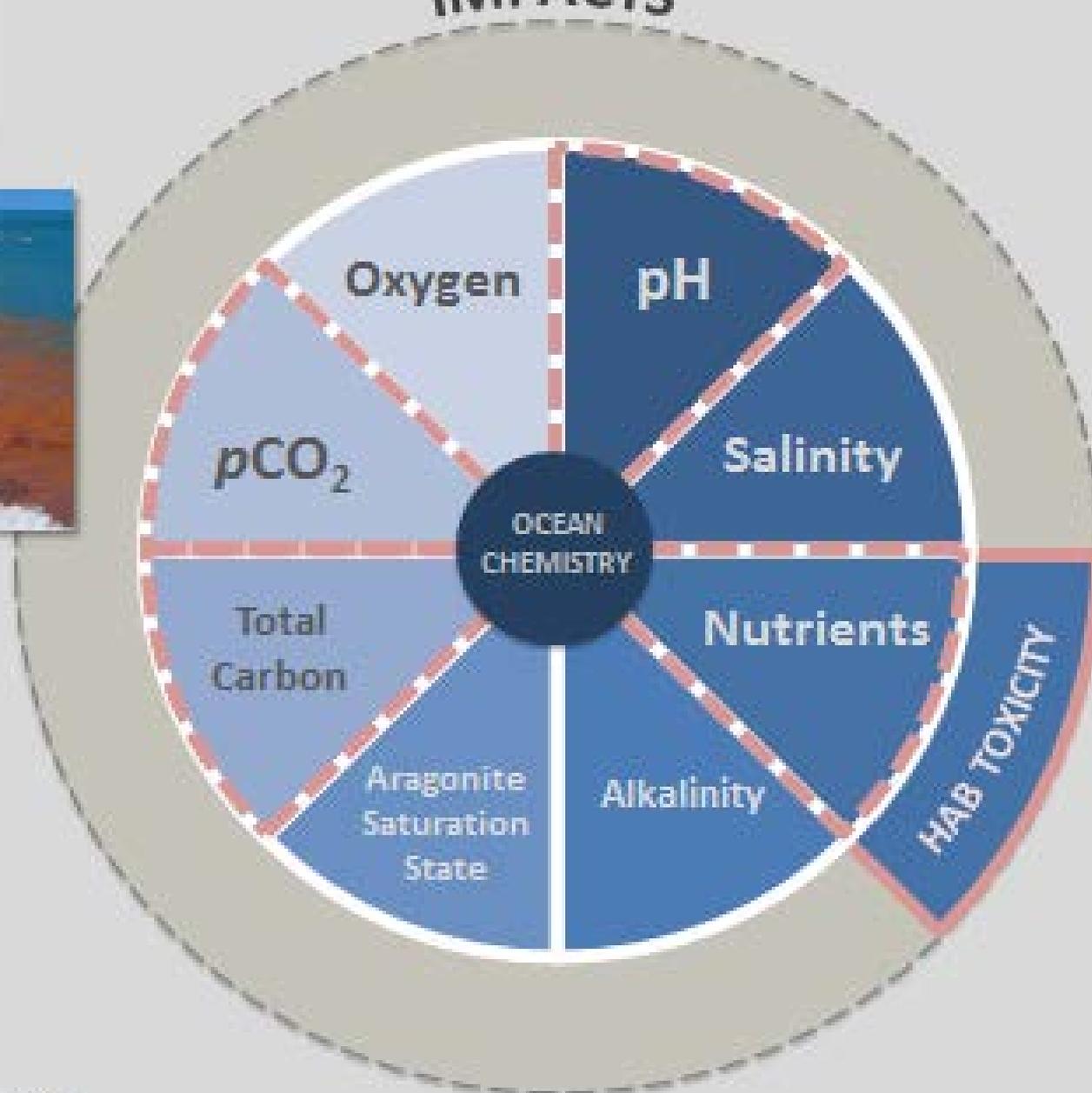
THINGS
WE CARE
ABOUT



IMPACTS

DRIVERS
OF
CHANGE

Increased
nutrient runoff



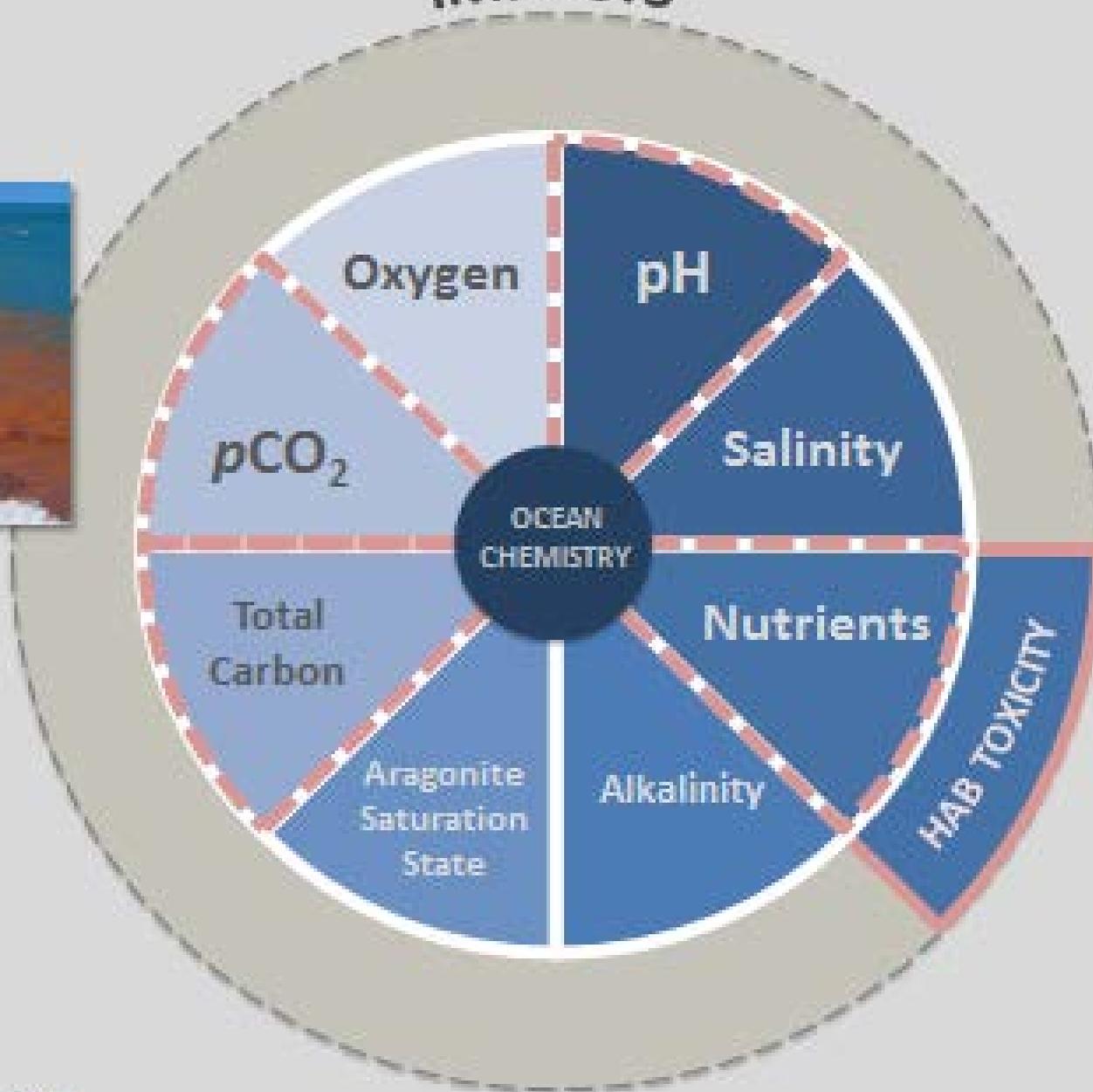
THINGS
WE CARE
ABOUT

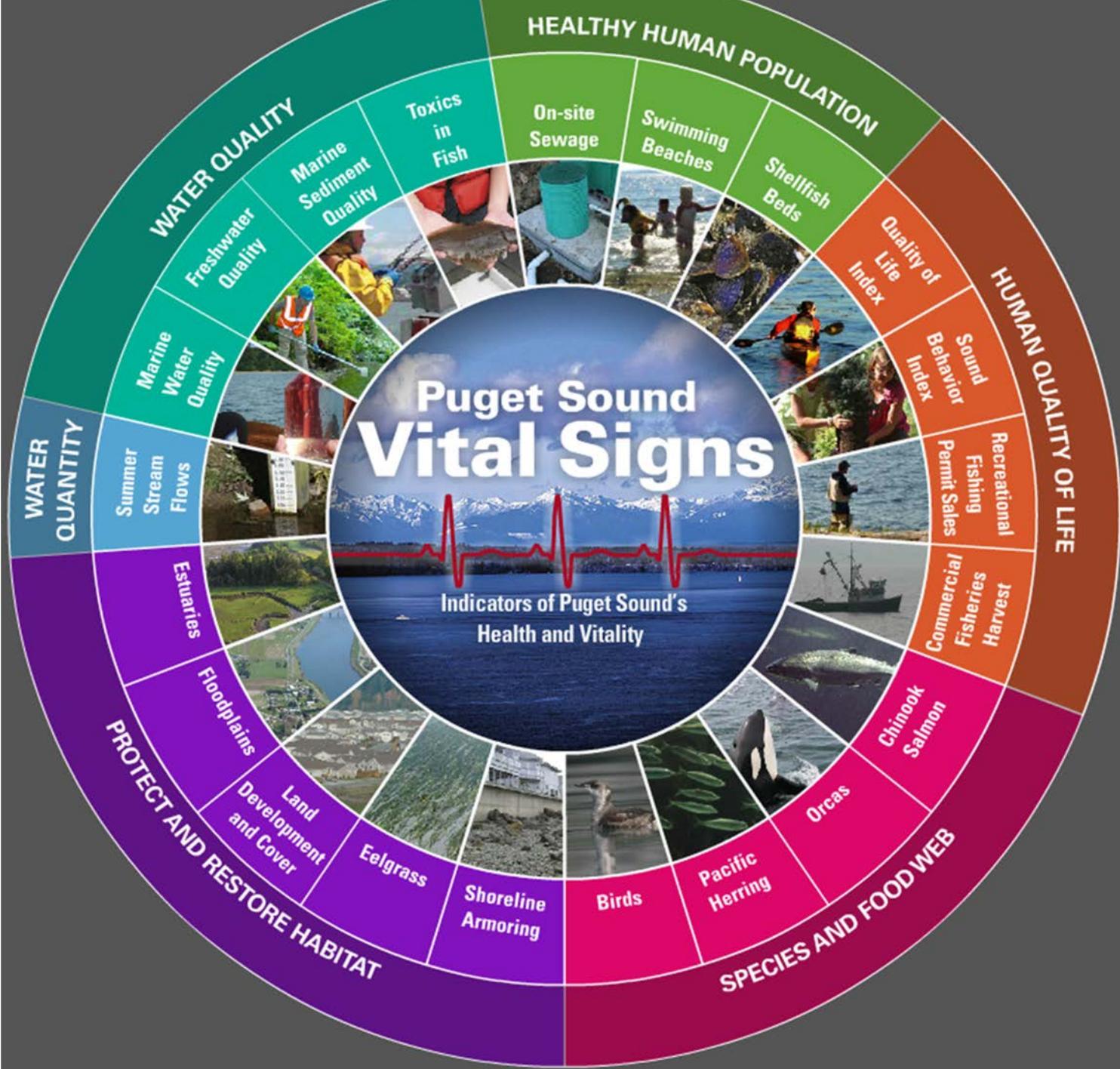


IMPACTS

DRIVERS
OF
CHANGE

Increased
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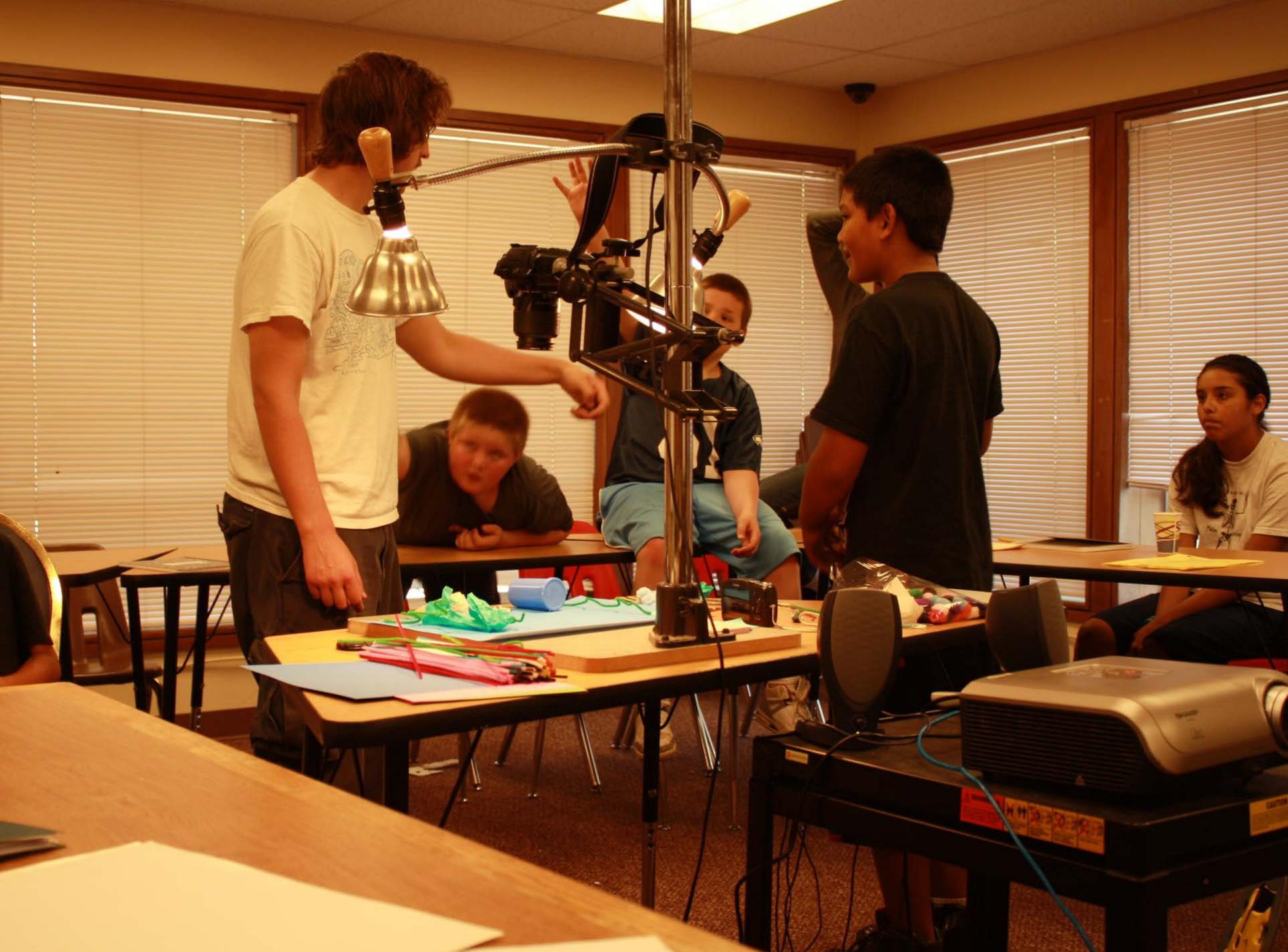




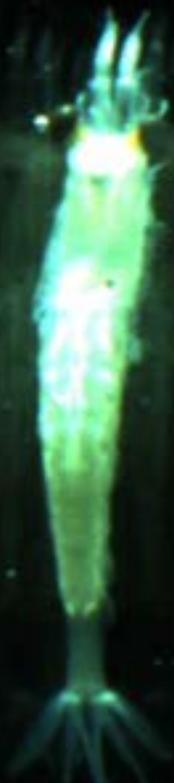
Stressors on marine ecosystems

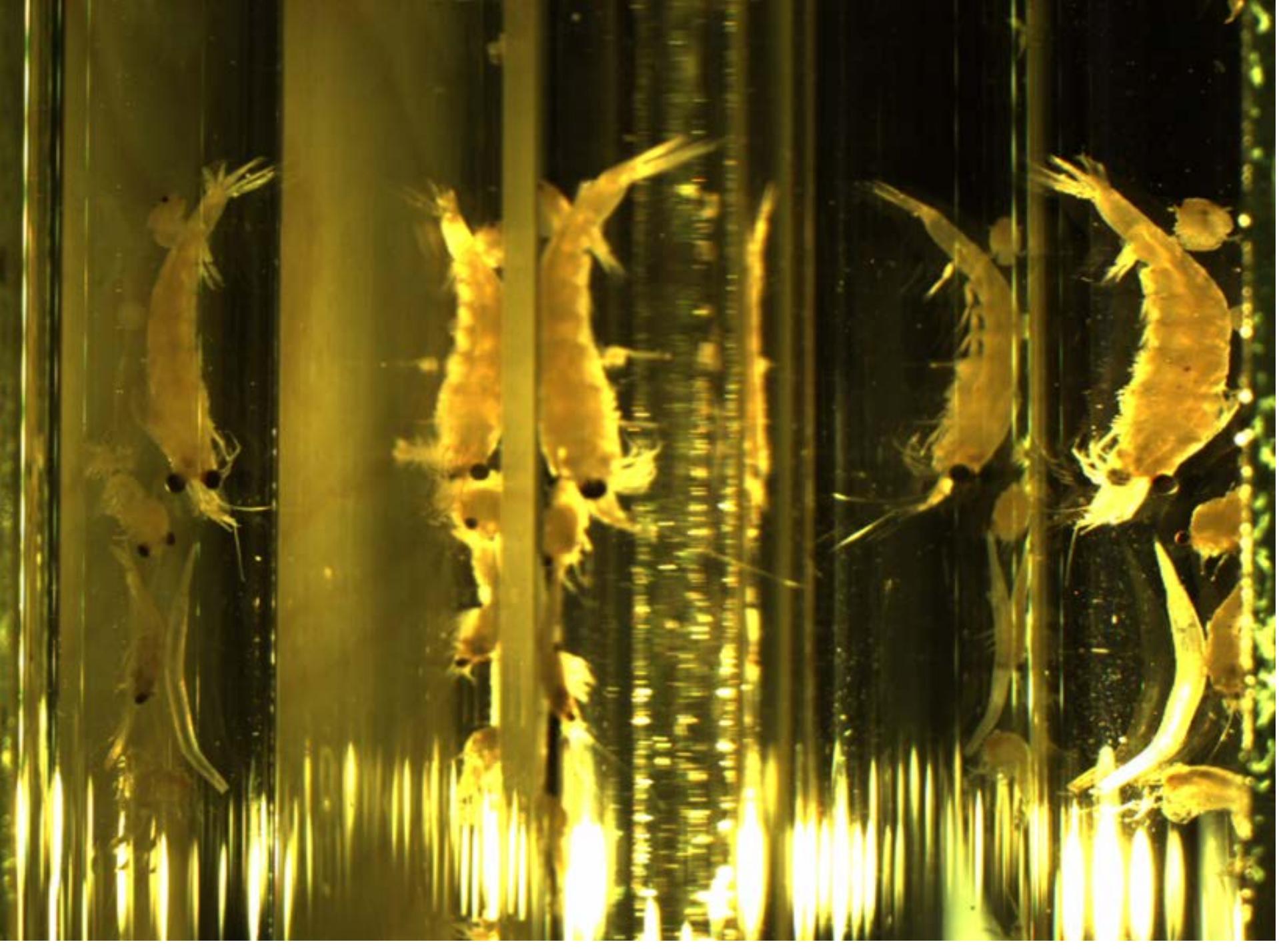
Over harvest, Increasing Temperature, Habitat loss, Toxics, Eutrophication Low oxygen Ocean acidification

Human Behavior



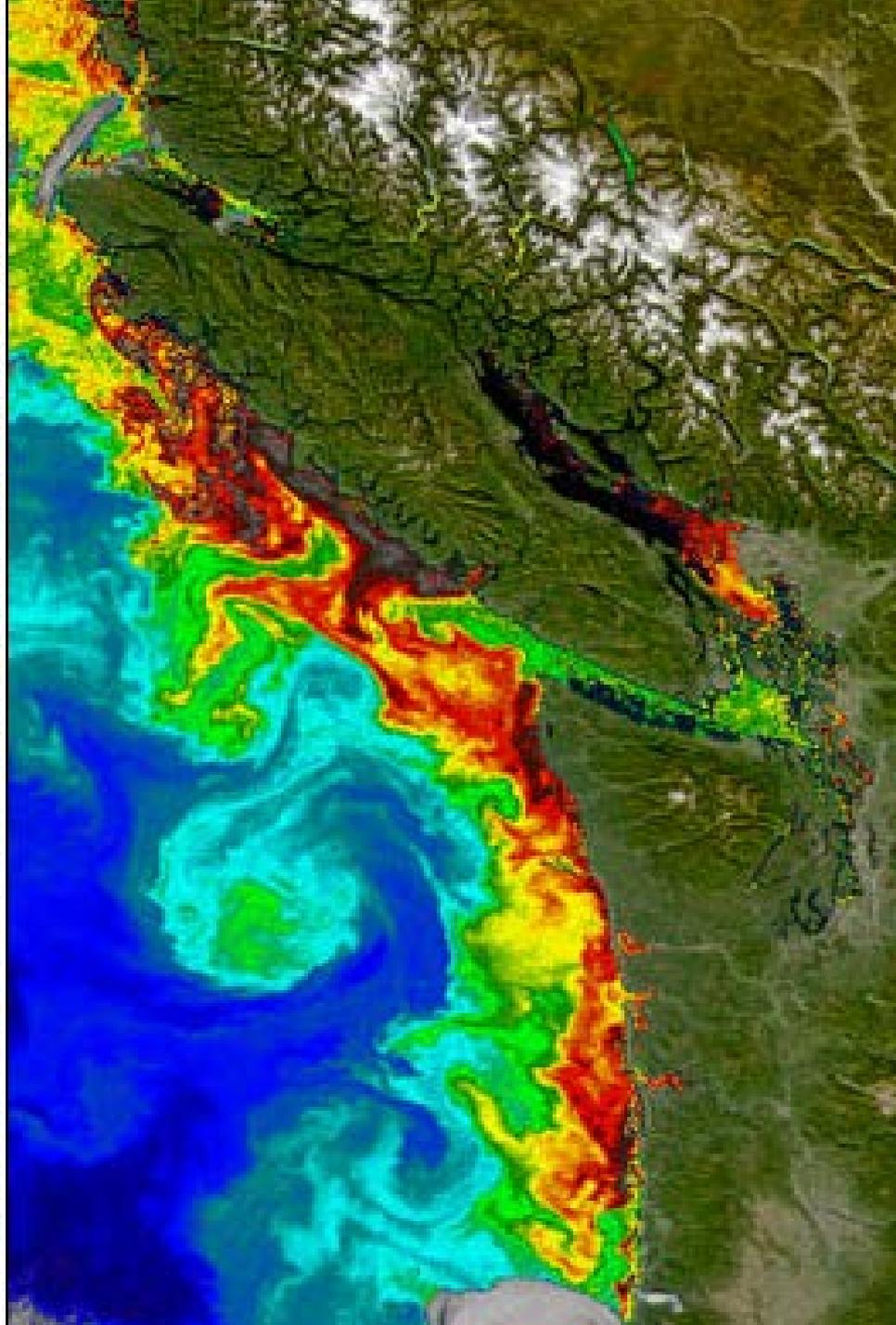
Welcome to the Northwest





A year in the life CO2

http://www.thenation.com/blog/197241/10-ways-help-keep-fish-healthy-and-water-clean?_ga=1.222291035.2128651219.1423328492#

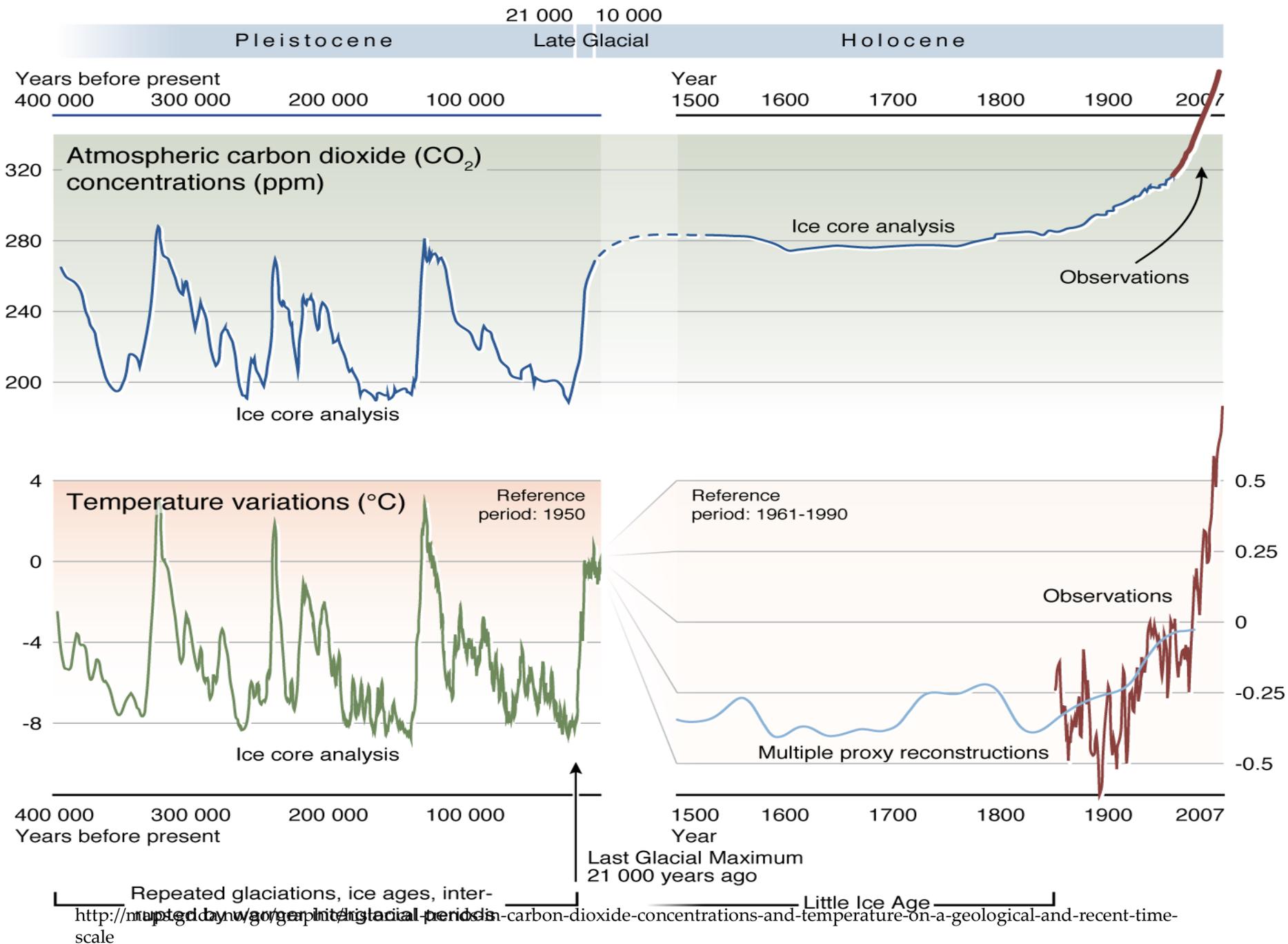




Time history of atmospheric carbon dioxide from 800,000 years before until Jan 2014.mp4

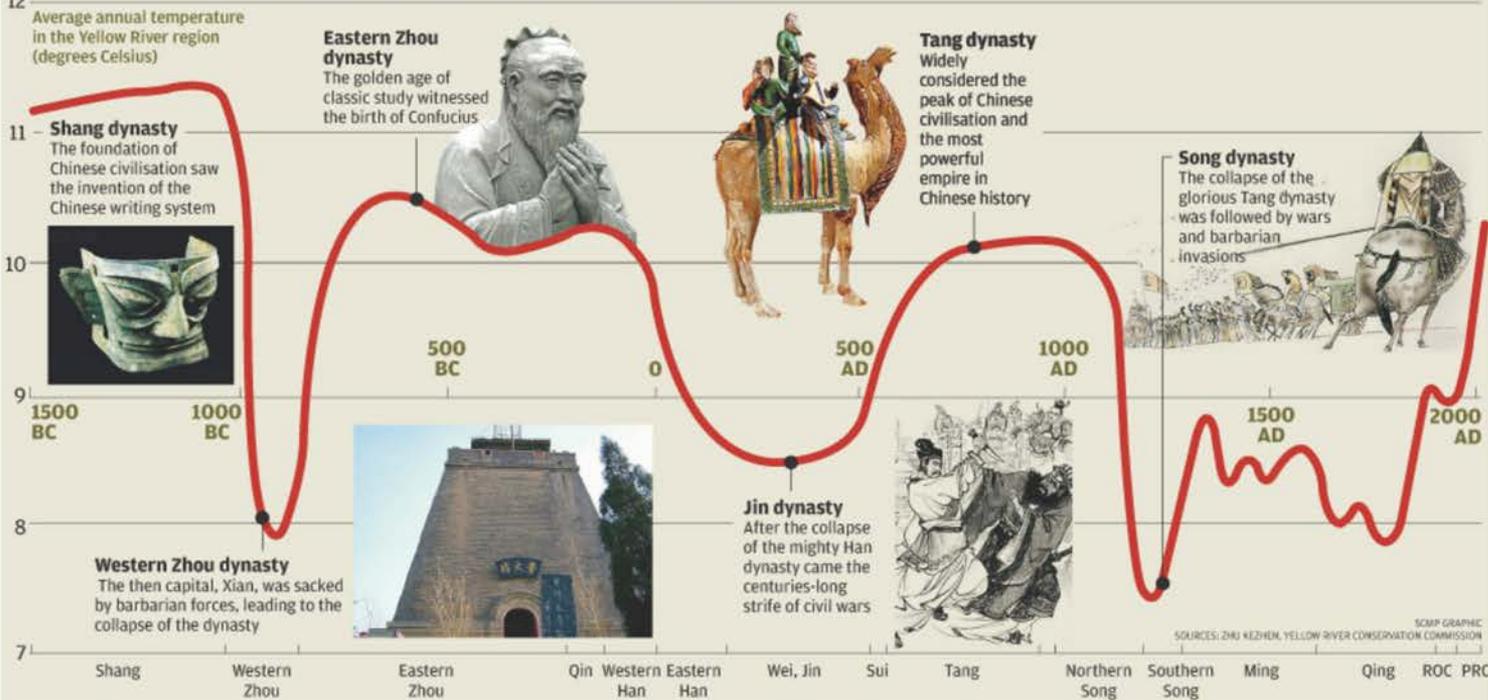
<http://www.carbonmap.org/#Area>

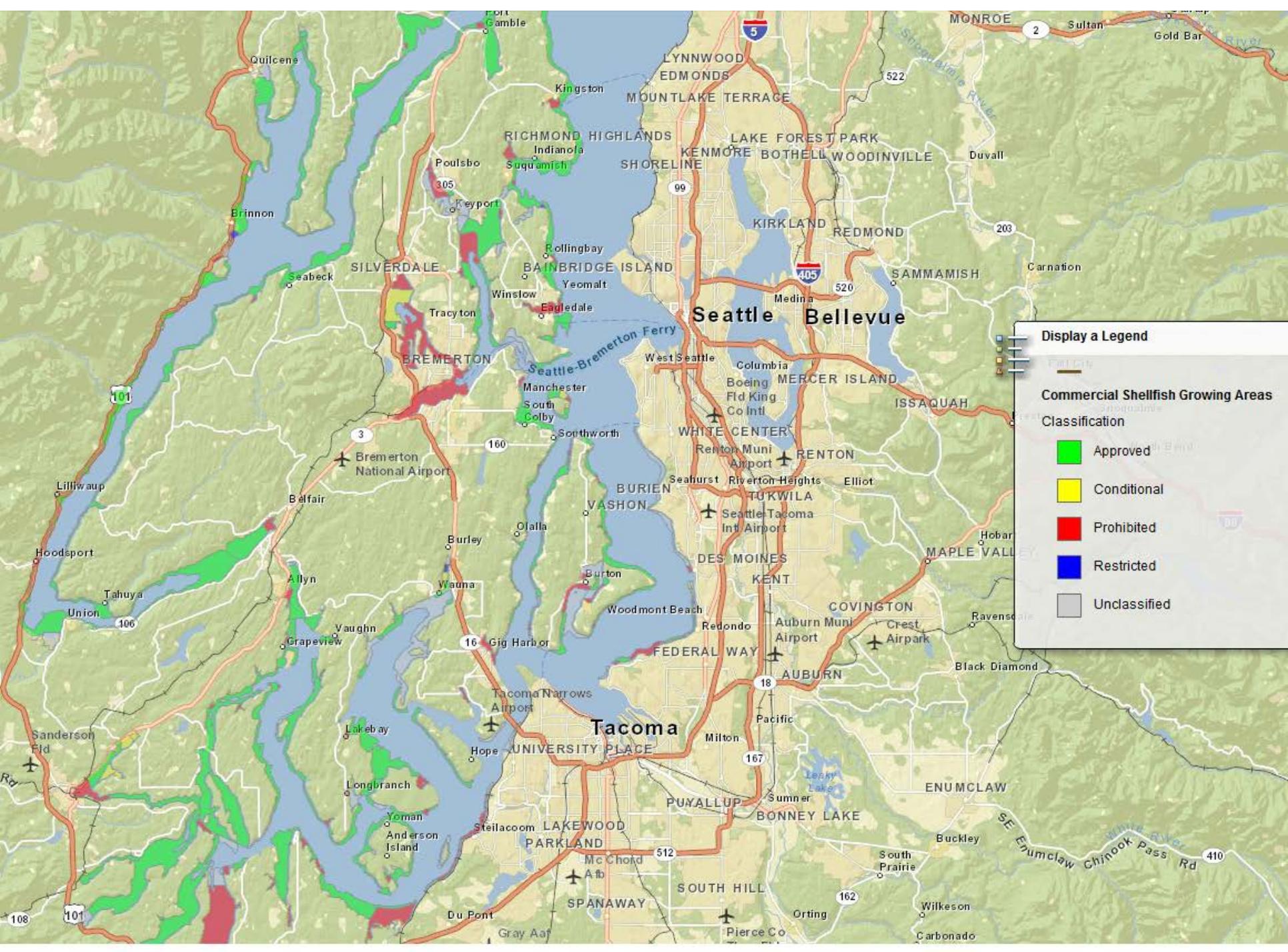
https://www.youtube.com/watch?feature=player_detailpage&v=x1SgmFa0r04



Hot and cold

How rises and falls in temperature coincided with highs and lows throughout Chinese history





Display a Legend

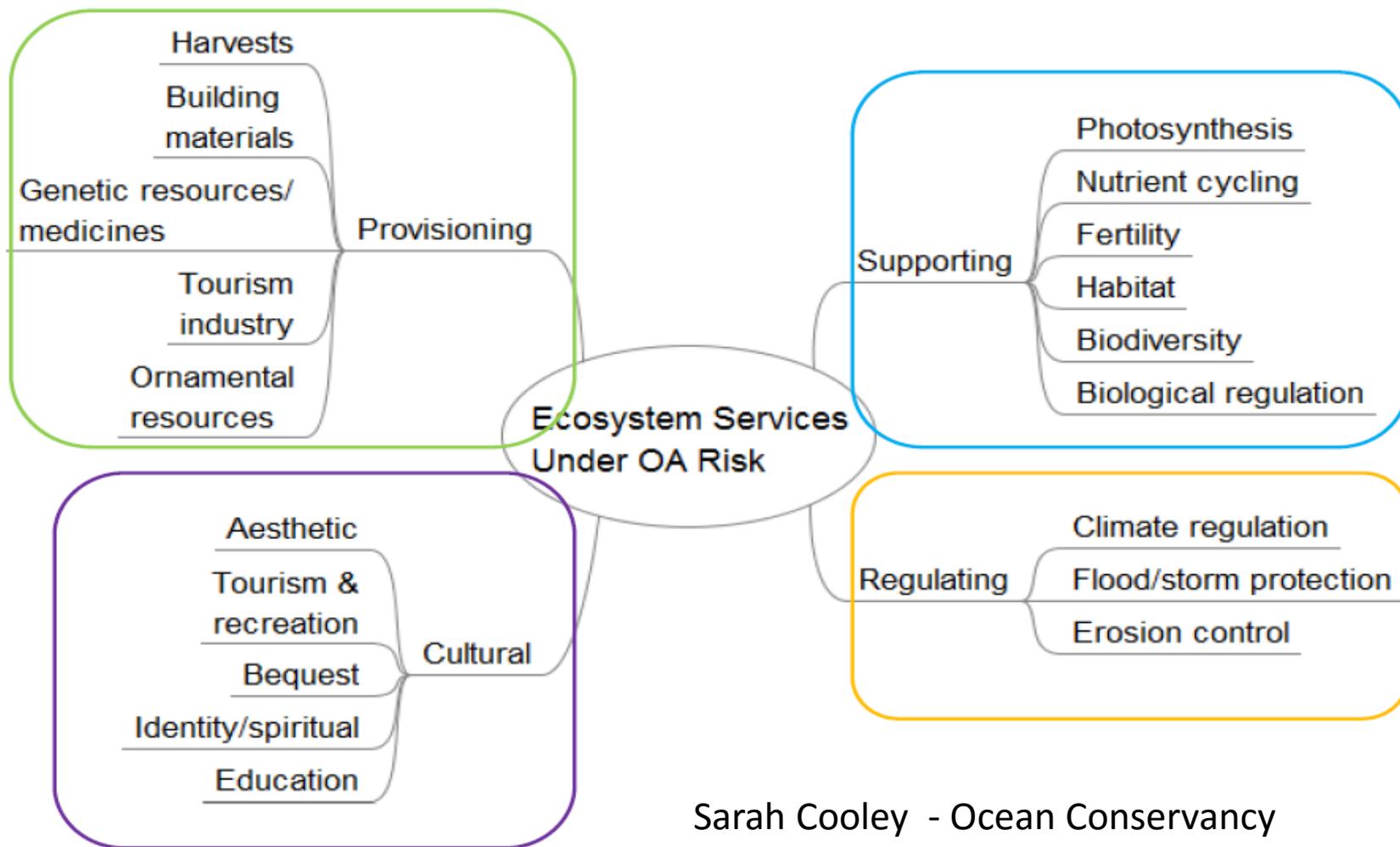
City

Commercial Shellfish Growing Areas

Classification

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- Restricted
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Figure 1: Ecosystem services under OA risk. Colors highlight main categories of services.



Sarah Cooley - Ocean Conservancy

