OCEAN NETWORKS CANADA

Climate Change Impacts on the Ocean

Dwight Owens
User Engagement Officer, User Services

Elder Academy | November, 2020

A UNIVERSITY OF VICTORIA INITIATIVE

Roadmap

- *Vital importance of the ocean*
- *Getting warmer*
- *Losing oxygen*
- *Becoming more acidic*
- *What can we do?*

I acknowledge with respect the **Lekwungen peoples** within whose traditional territory I live, and the **Songhees**, **Esquimalt** and **W̱SÁNEĆ peoples** whose historical relationships with the land and the ocean continue to this day.

Source: Amateria1121

Teaching of the Tsartlip & Tsawout People

People are linked to the land. The four winds, the trees, the birds, the animals, and the fish were all people, long ago.

Nature, animals, fish, fire and water are imbued with spiritual values that have the power to heal, give life, provide bounty and guidance.

Now I work for Ocean Networks Canada

Go to **www.menti.com** and enter code **83 13 16 8**

What does the ocean mean to you?

Source:: Kris Krüg

Source: mission-blue.org

By the numbers

71%

200,000+

750,000+

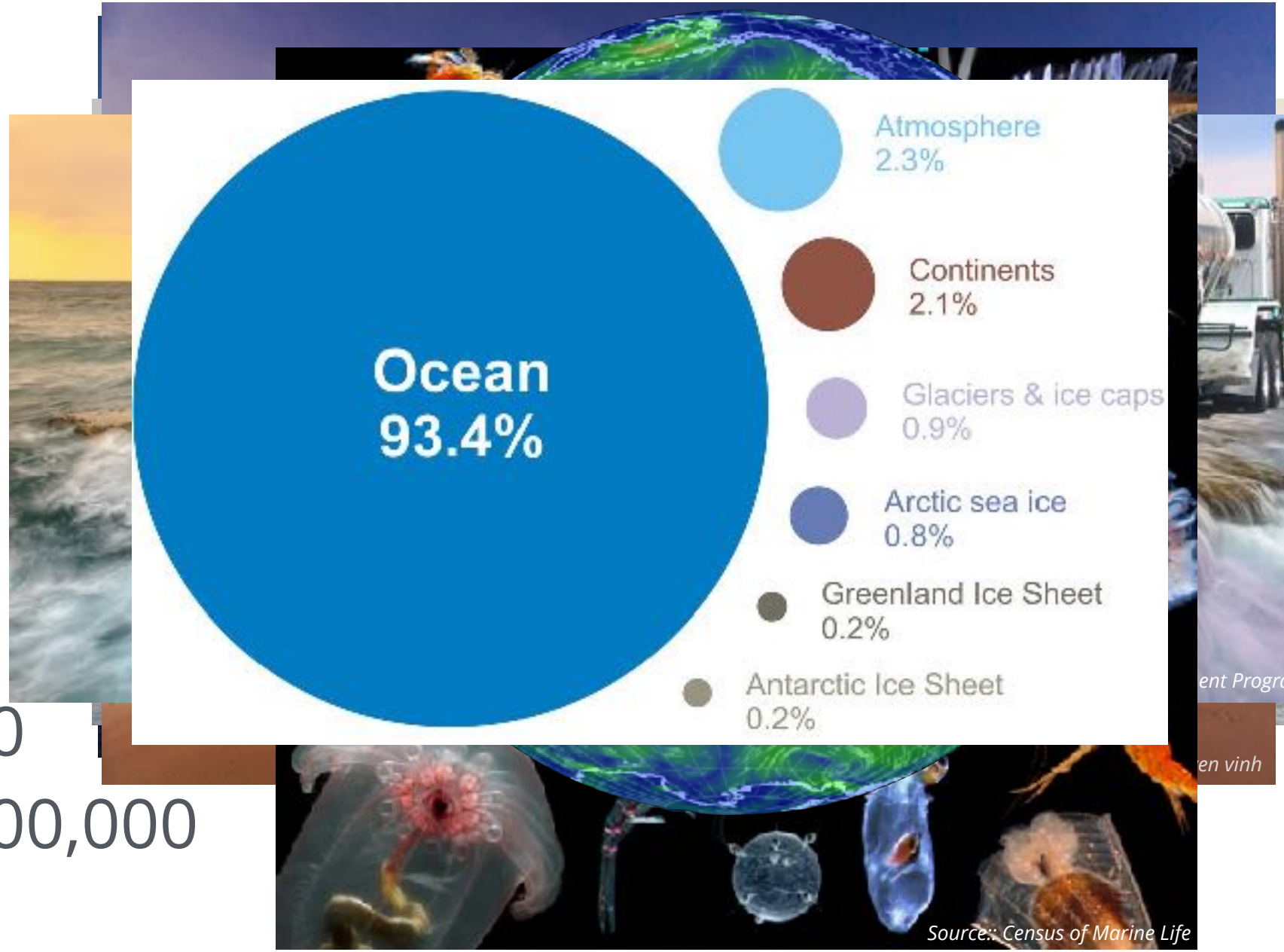
40%

93%

30%

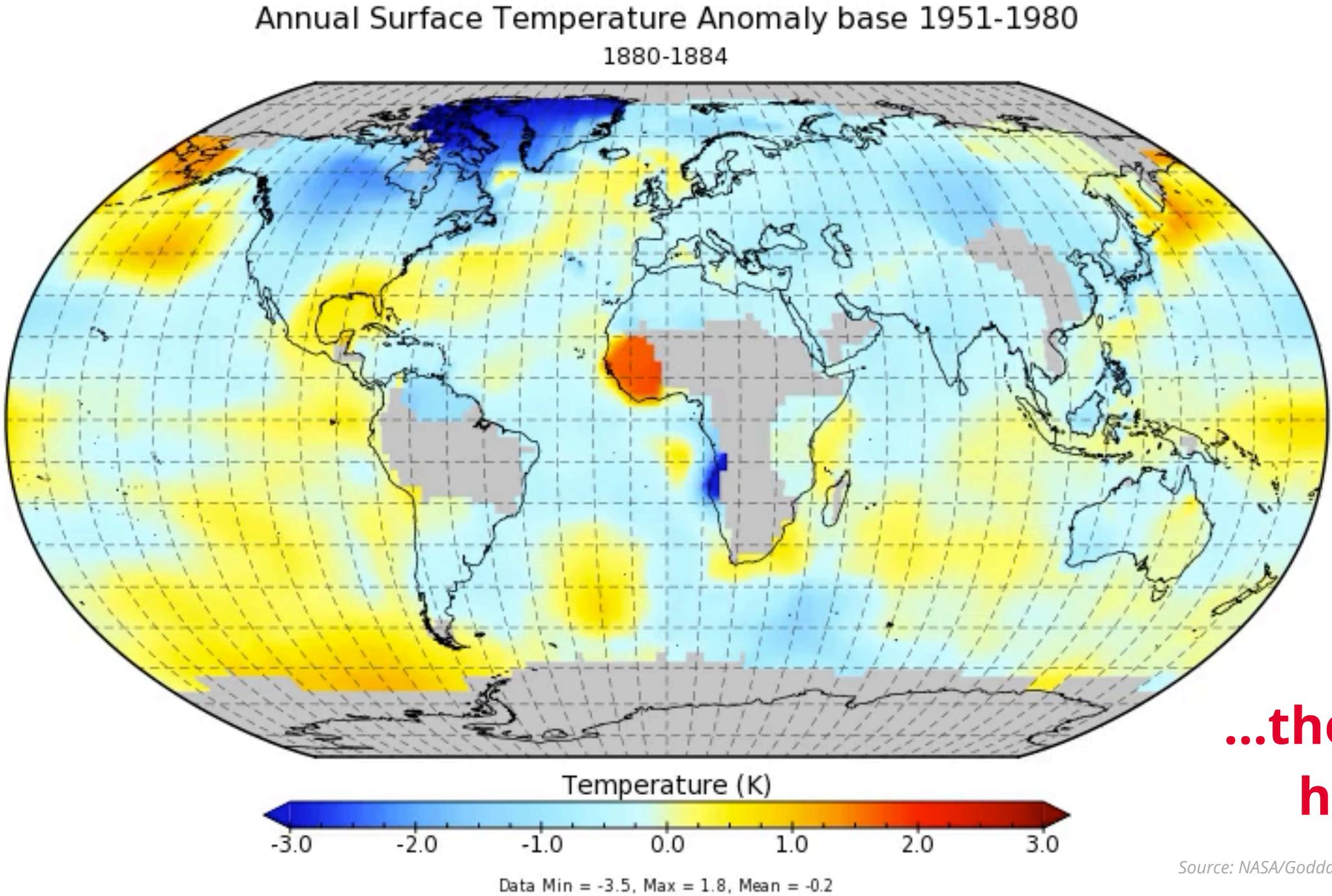
3,000,000,000

$3,000,000,000,000



Warming

Photo by iamNigelMorris, flickr.com

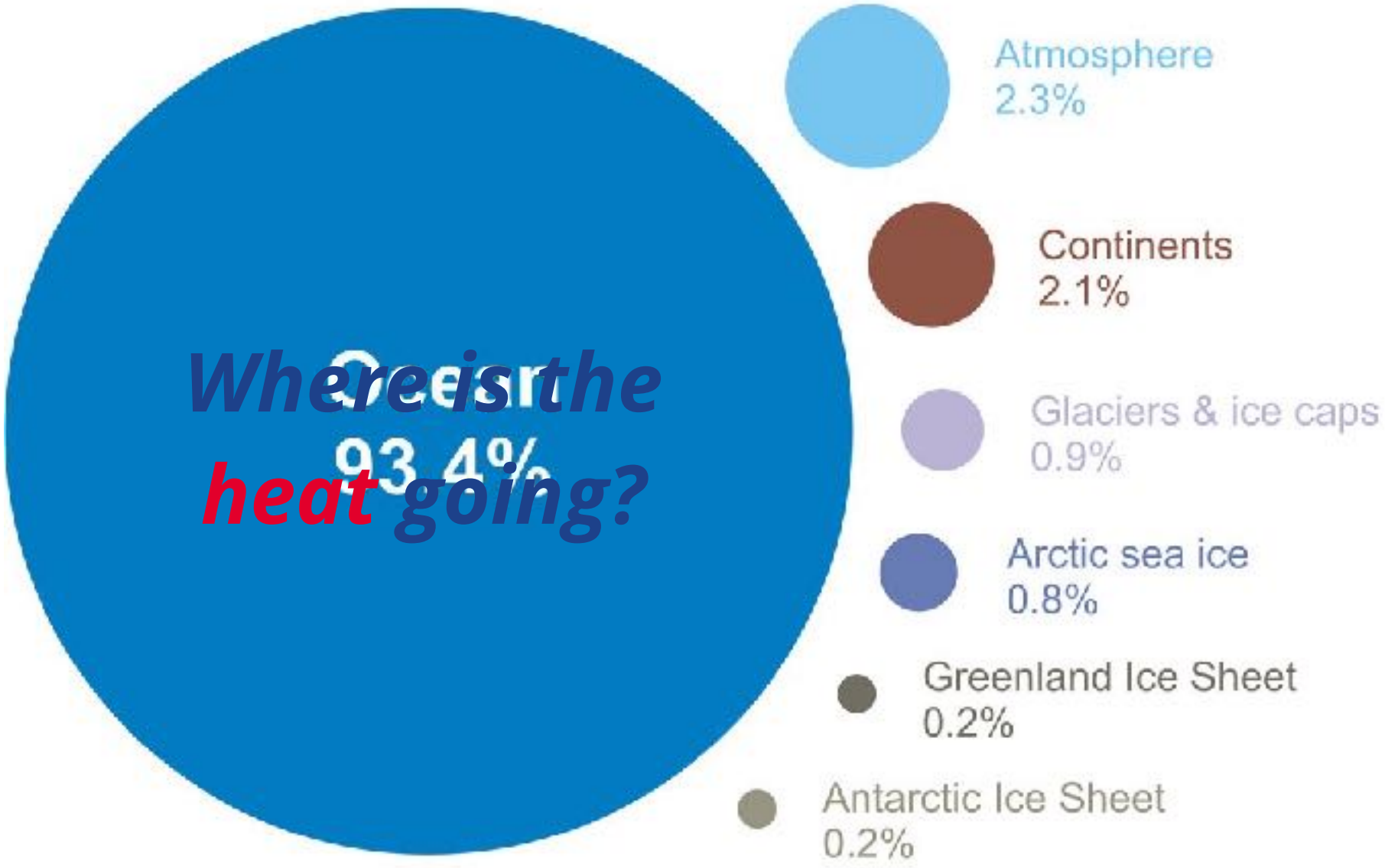


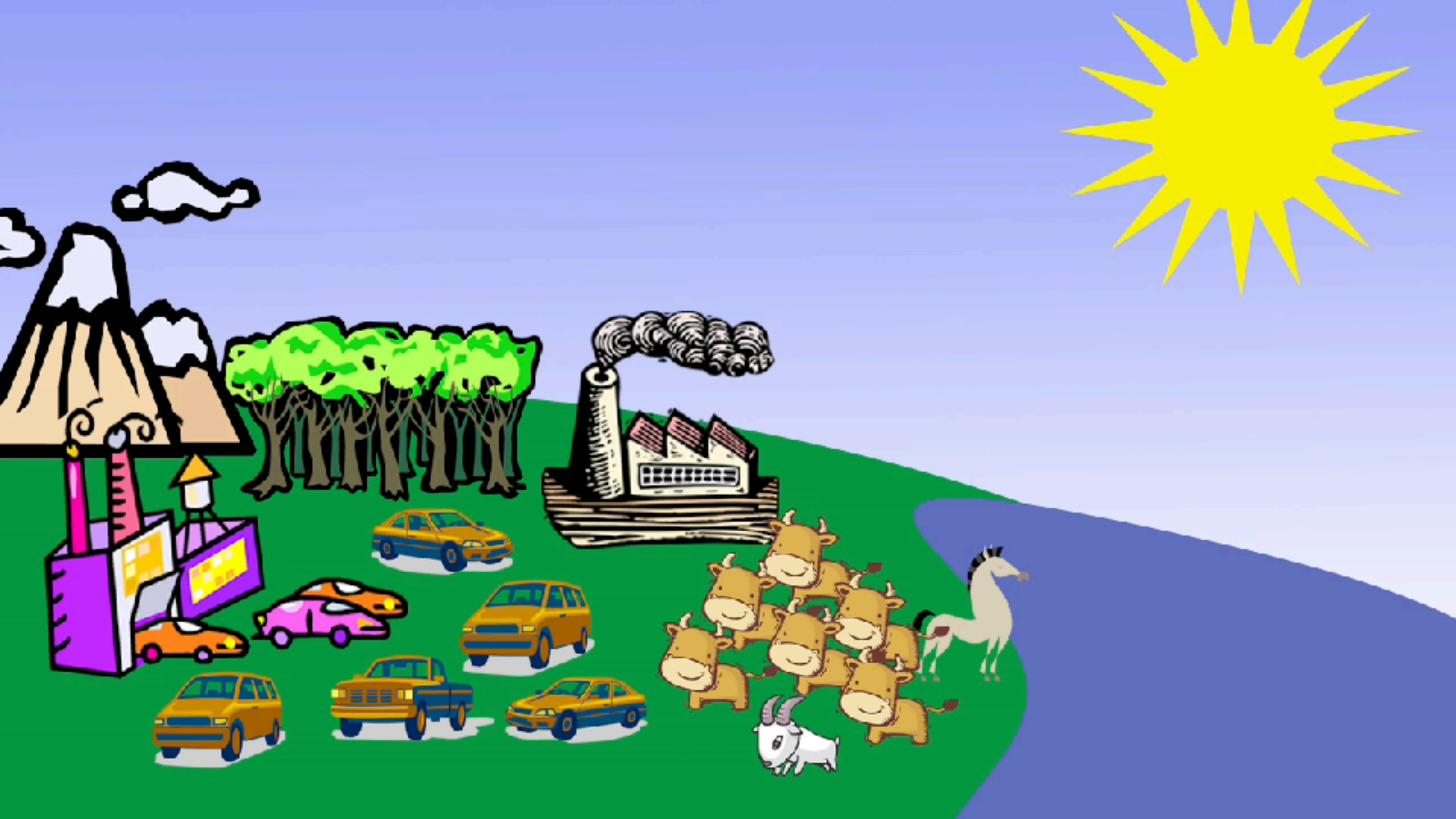
…the planet is heating up.

Source: NASA/Goddard Institute for Space Studies

19 of the 20 Hottest Years on Record Have Occurred Since the Year 2001

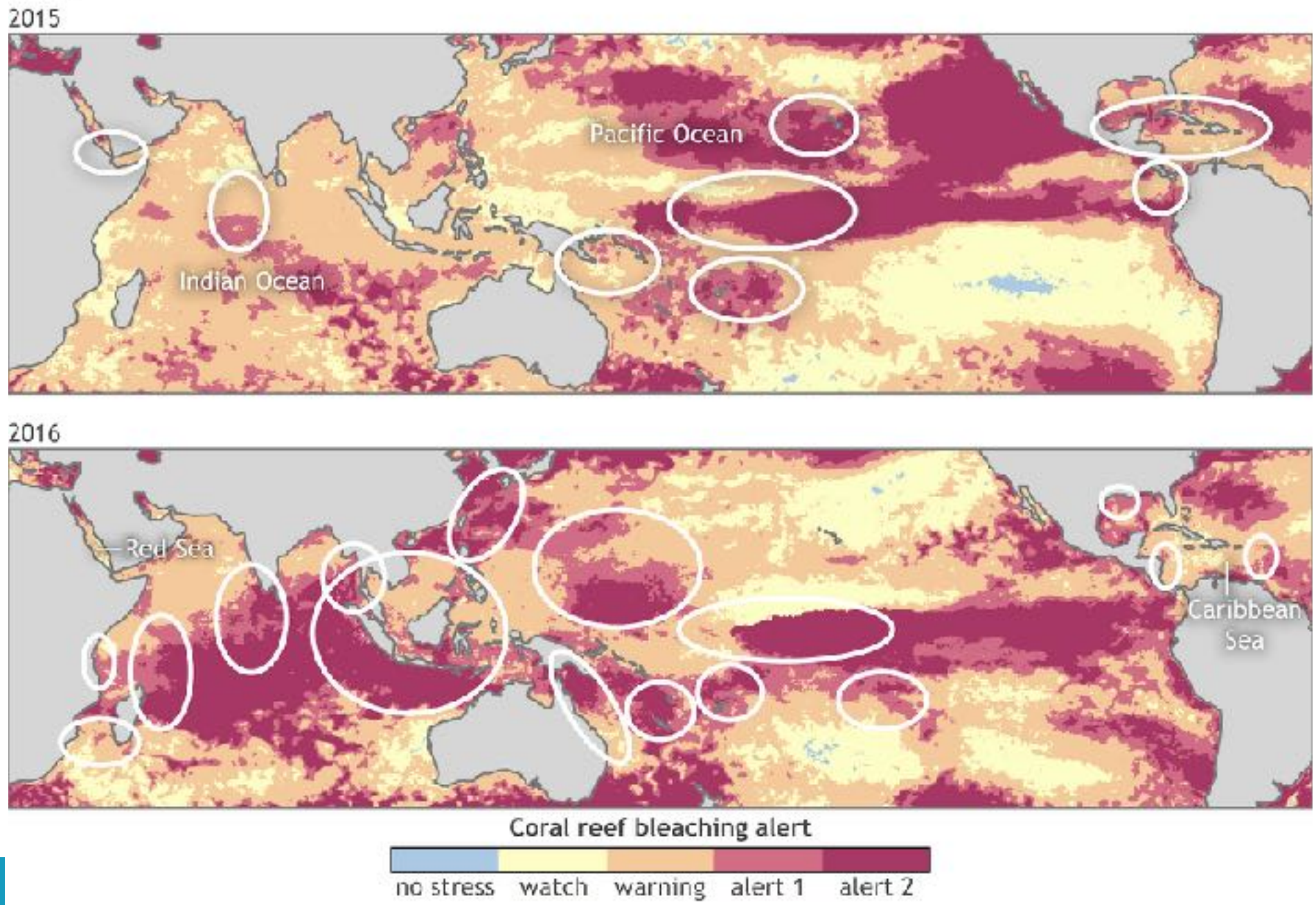
Data: NASA/GISS


Where is the heat going?
Oceans
93.4%
Atmosphere
2.3%
Continents
2.1%
Glaciers & ice caps
0.9%
Arctic sea ice
0.8%
Greenland Ice Sheet
0.2%
Antarctic Ice Sheet
0.2%



How can warming impact ocean ecosystems?

Example 1: Coral Bleaching



2 years of coral stress worldwide

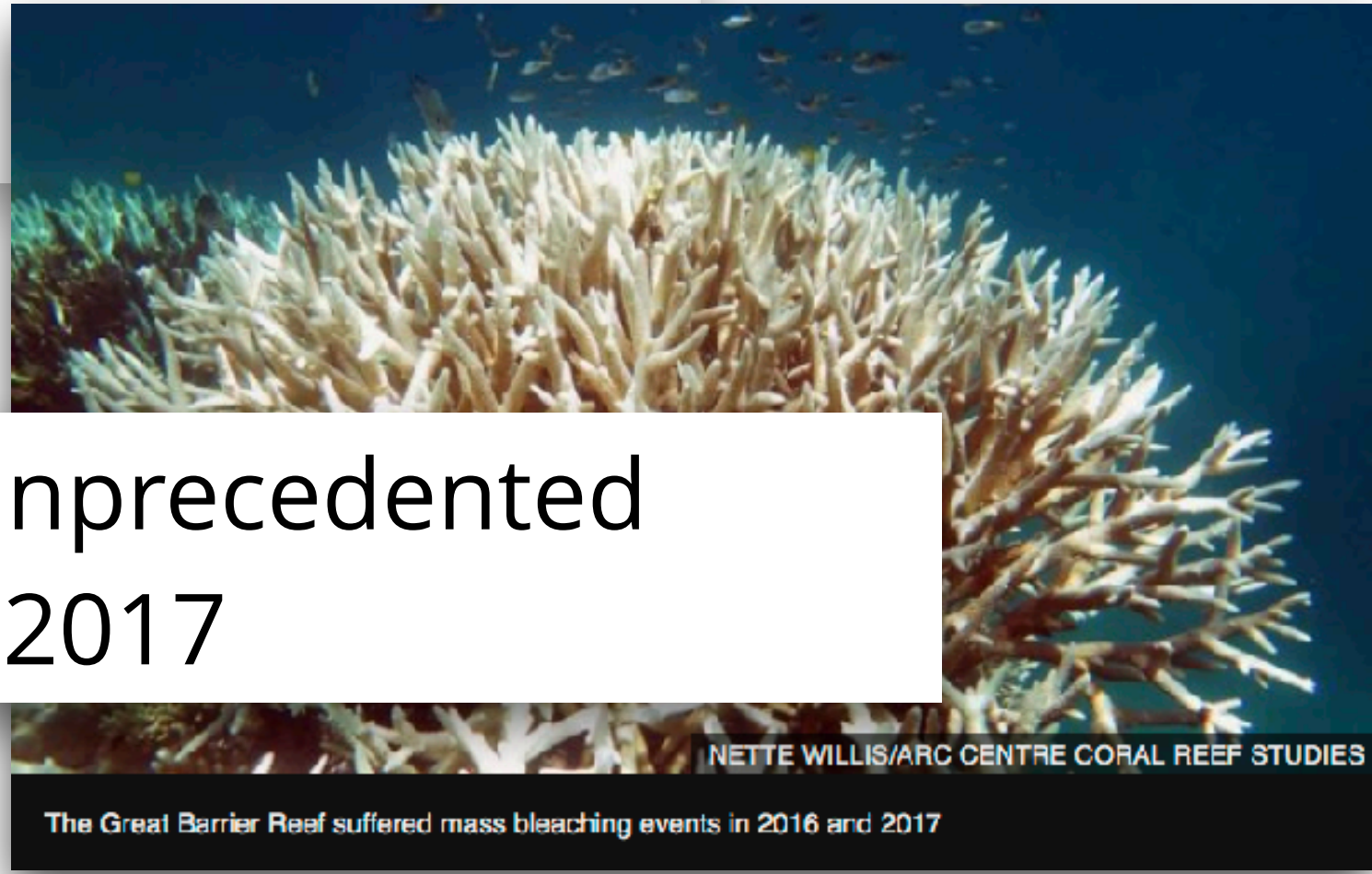
Source: ARC Centre of Excellence for Coral Reef Studies. Photo by Gergely Torda via Flickr


theguardian news

Missing coral babies

Great Barrier Reef: Mass decline in 'coral babies', scientists say

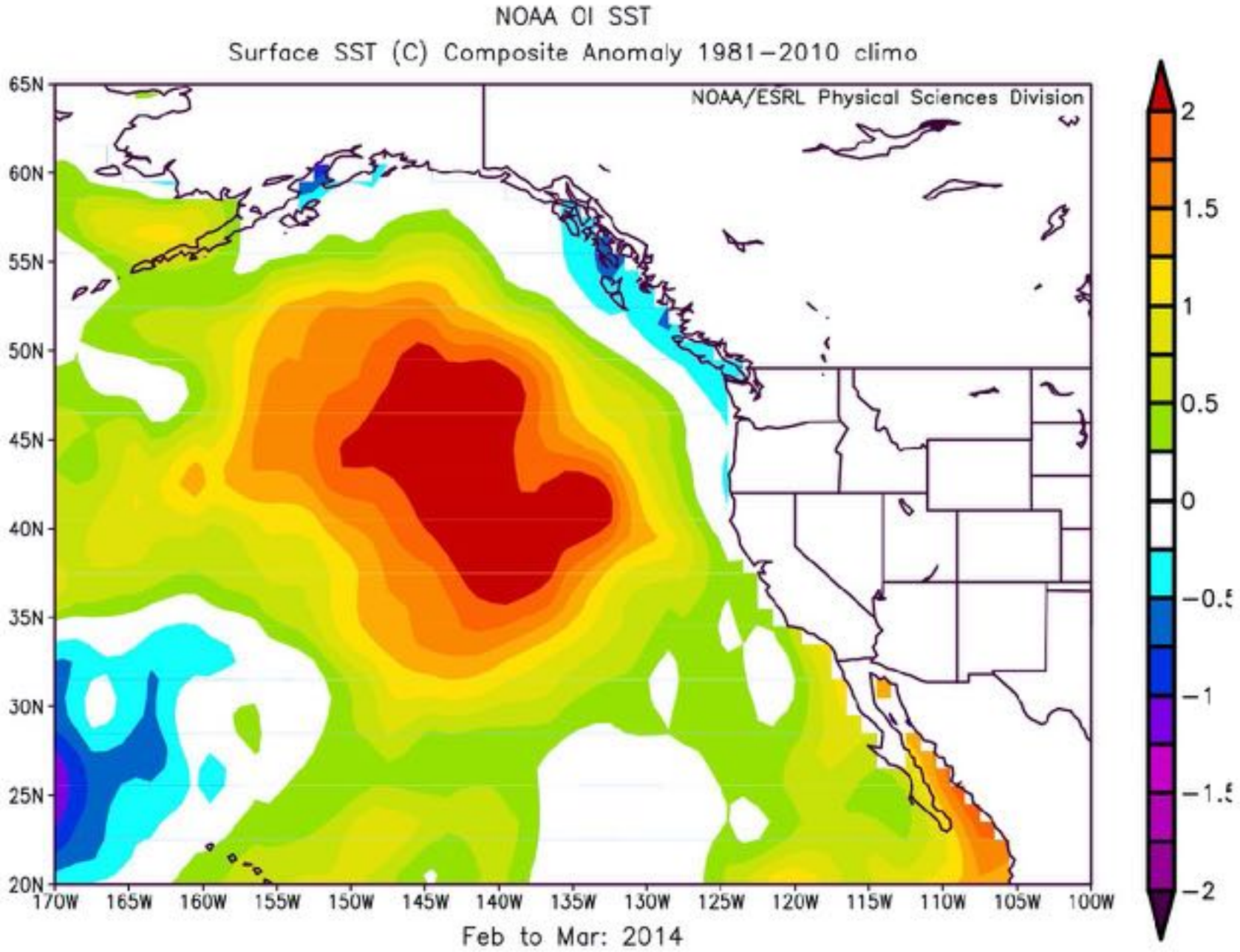
4 April 2019



Down **89%** since unprecedented bleaching in 2015-2017

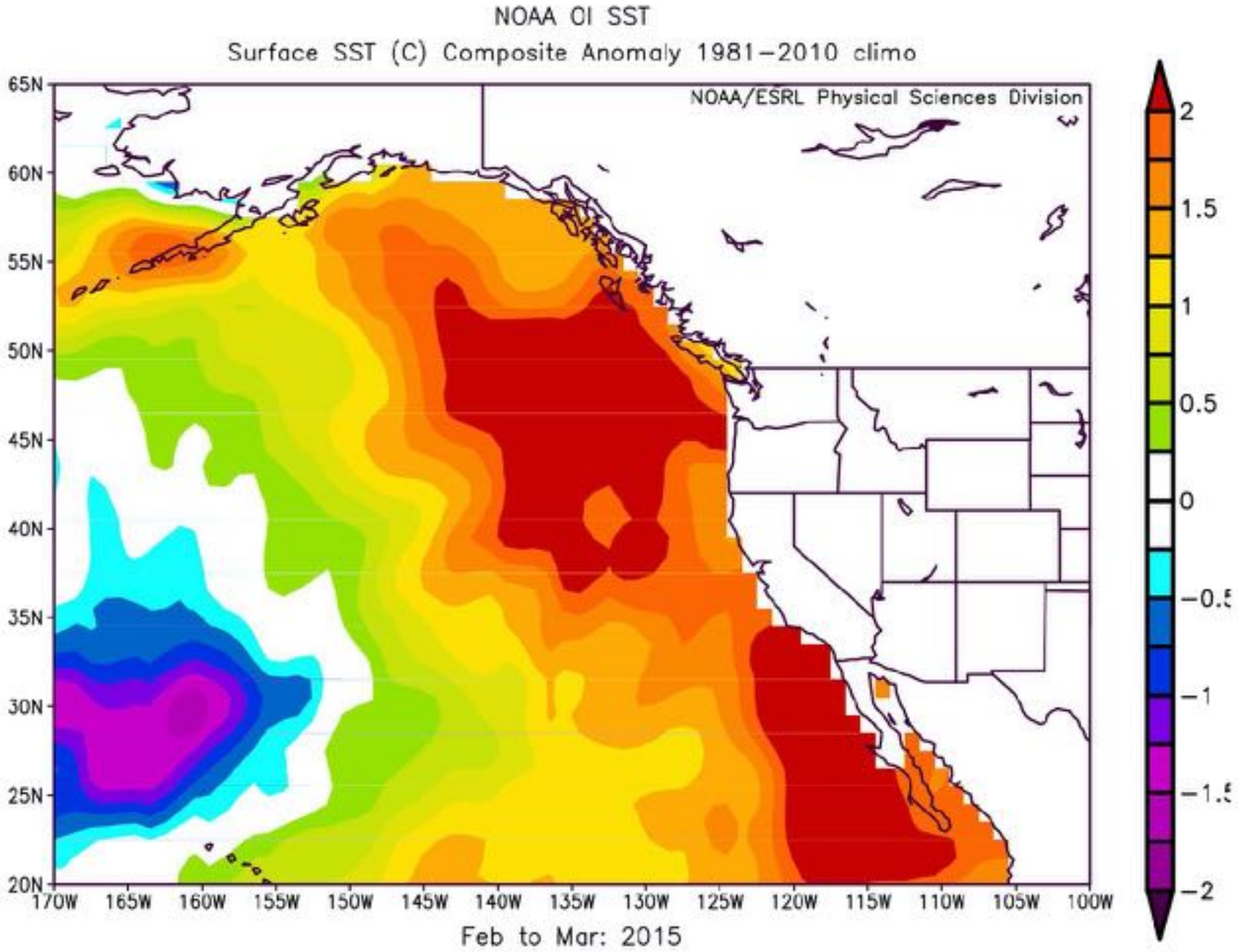
How can warming impact ocean ecosystems?

Example 2: Marine Heat Waves



Invasion of the warm blob

Source: Nicholas Bond, 2015



Blob + el niño
= hot mess

Source: Nicholas Bond, 2015

100 million pacific cod vanished from the southern Alaska fishery

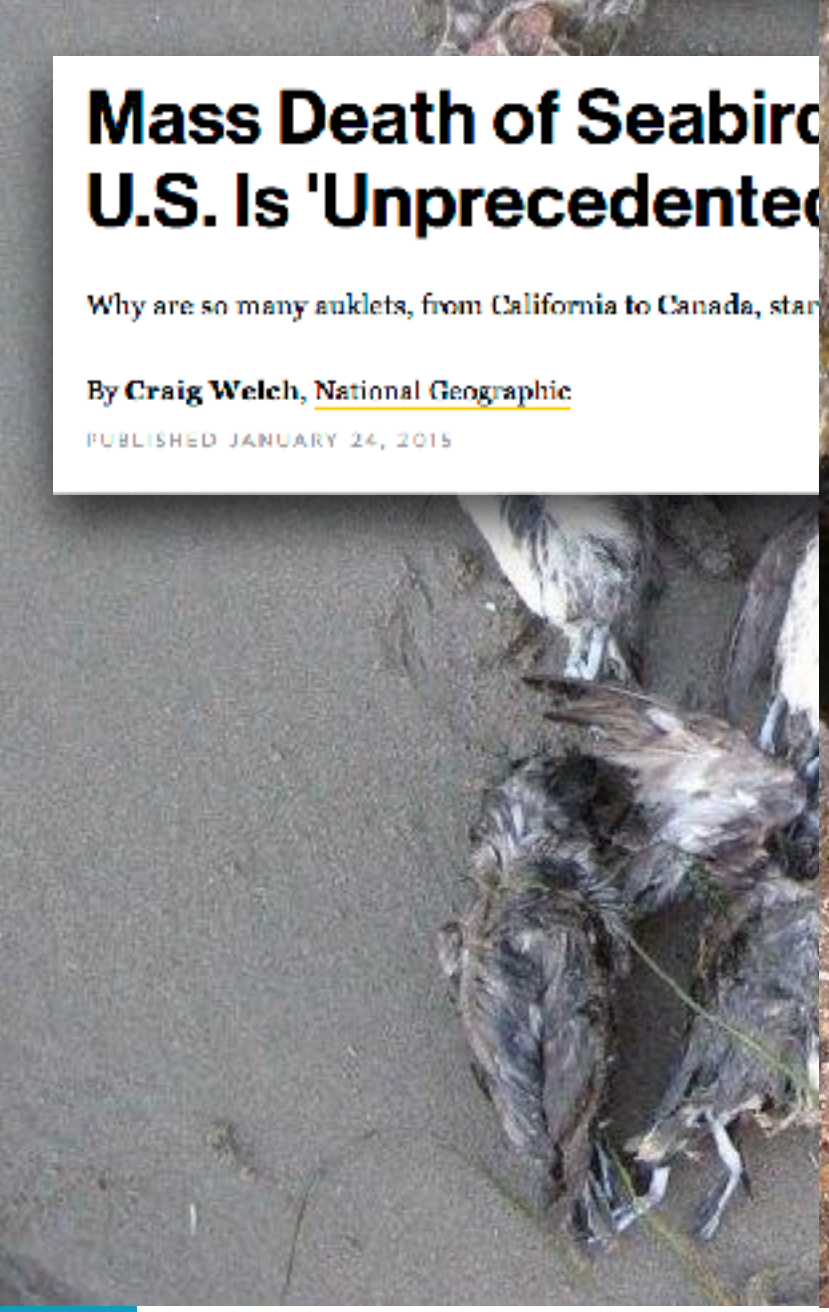
Source: NOAA Fisheries

Mass Death of Seabird
U.S. Is 'Unprecedented

Why are so many auklets, from California to Canada, star

By **Craig Welch**, National Geographic

PUBLISHED JANUARY 24, 2015



Photos by J. Forsythe, COASST / Duncan Wright

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North

8,000 common murres found dead on Whittier, Alaska, beach

Arctic seabirds washed ashore after apparently starving to death

Dan Joling - The Associated Press · Posted: Jan 12, 2016 1:41 PM CT | Last Updated: January 12, 2016

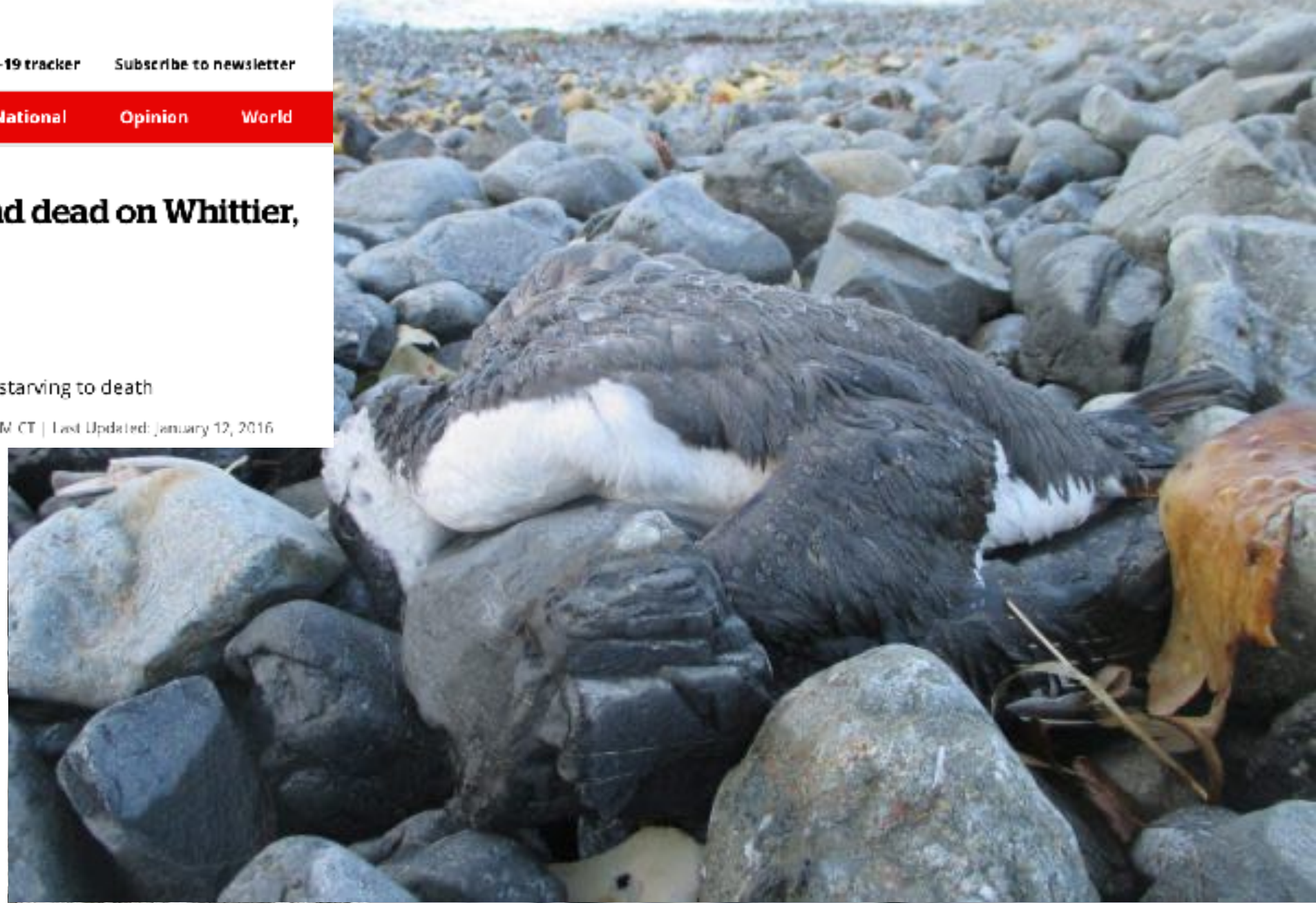


Photo by Richard Crossley / Robin Corcoran-USFWS

El Niño ocean warming 'causing havoc' for seals off California coast

Unprecedented numbers of dead or starving seals washing ashore as Pacific Ocean warms, with experts saying they are 'preparing for the worst' in 2016

Starving sea lions

Source: Oliver Milman, 2015. Photo by NOAA Fisheries West

Fin and humpback whale deaths

VANCOUVER ISLAND

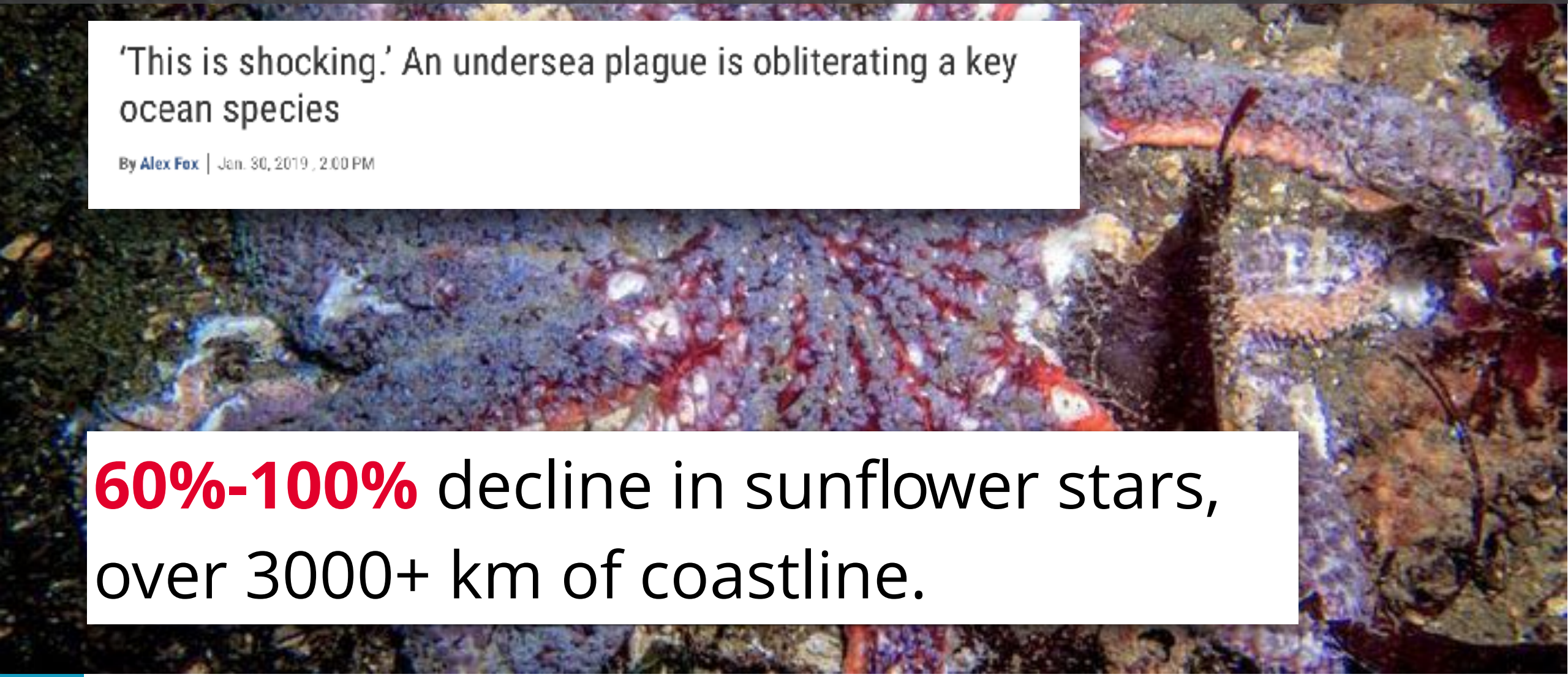
‘Smorgasbord’ of toxic algae likely behind dozens of whale deaths: expert

Jeff Lawrence Senior Digital Producer CTV Vancouver Island
@CTVNewsJeff | Contact

Published Tuesday, September 15, 2015 4:03PM PDT
Last Updated Tuesday, September 5, 2015 7:29PM PDT

CTV NEWS

“Underwater zombie apocalypse”

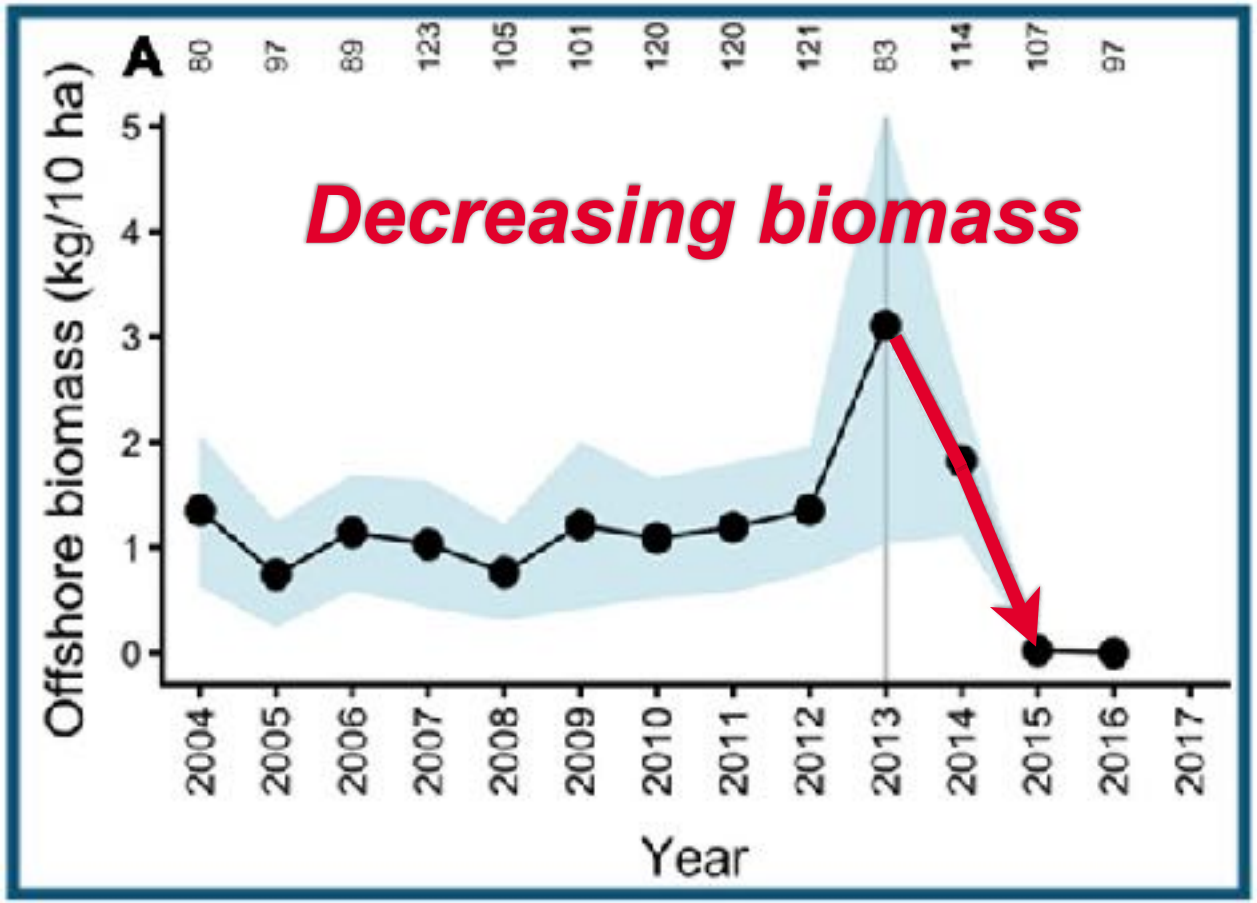


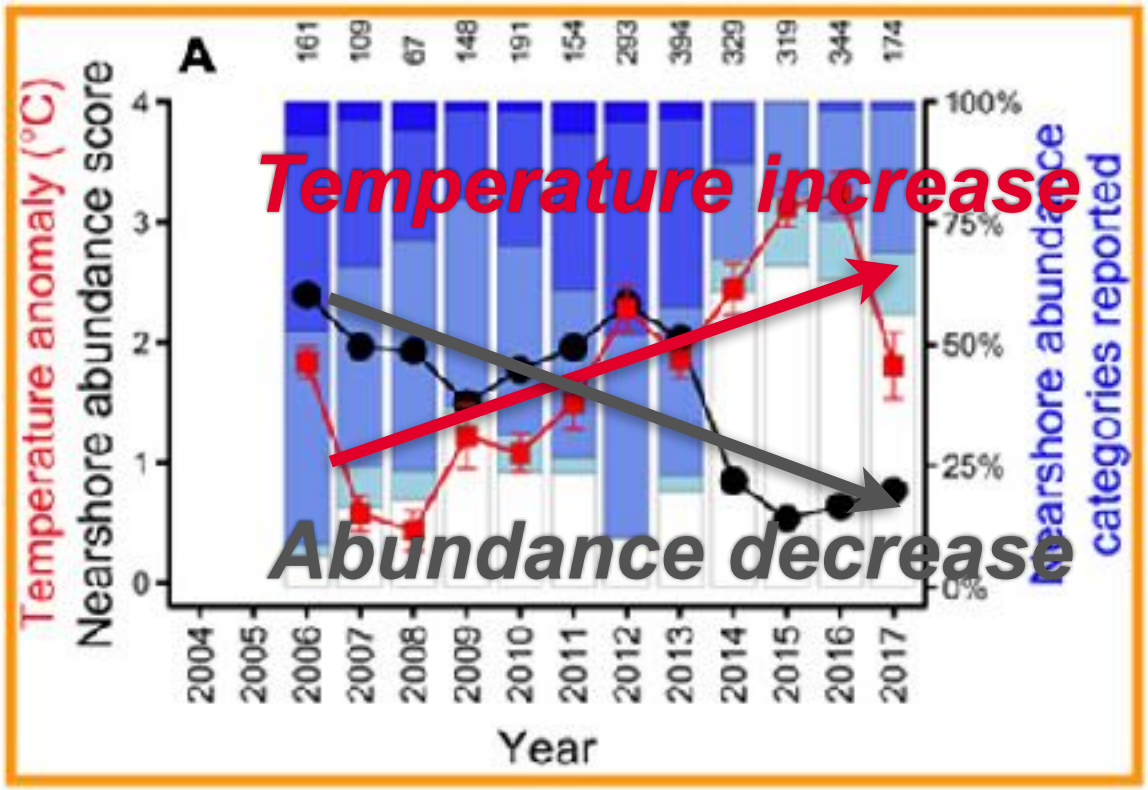
‘This is shocking.’ An undersea plague is obliterating a key ocean species

By Alex Fox | Jan. 30, 2019 , 2:00 PM

60%-100% decline in sunflower stars, over 3000+ km of coastline.

Sea star wasting disease

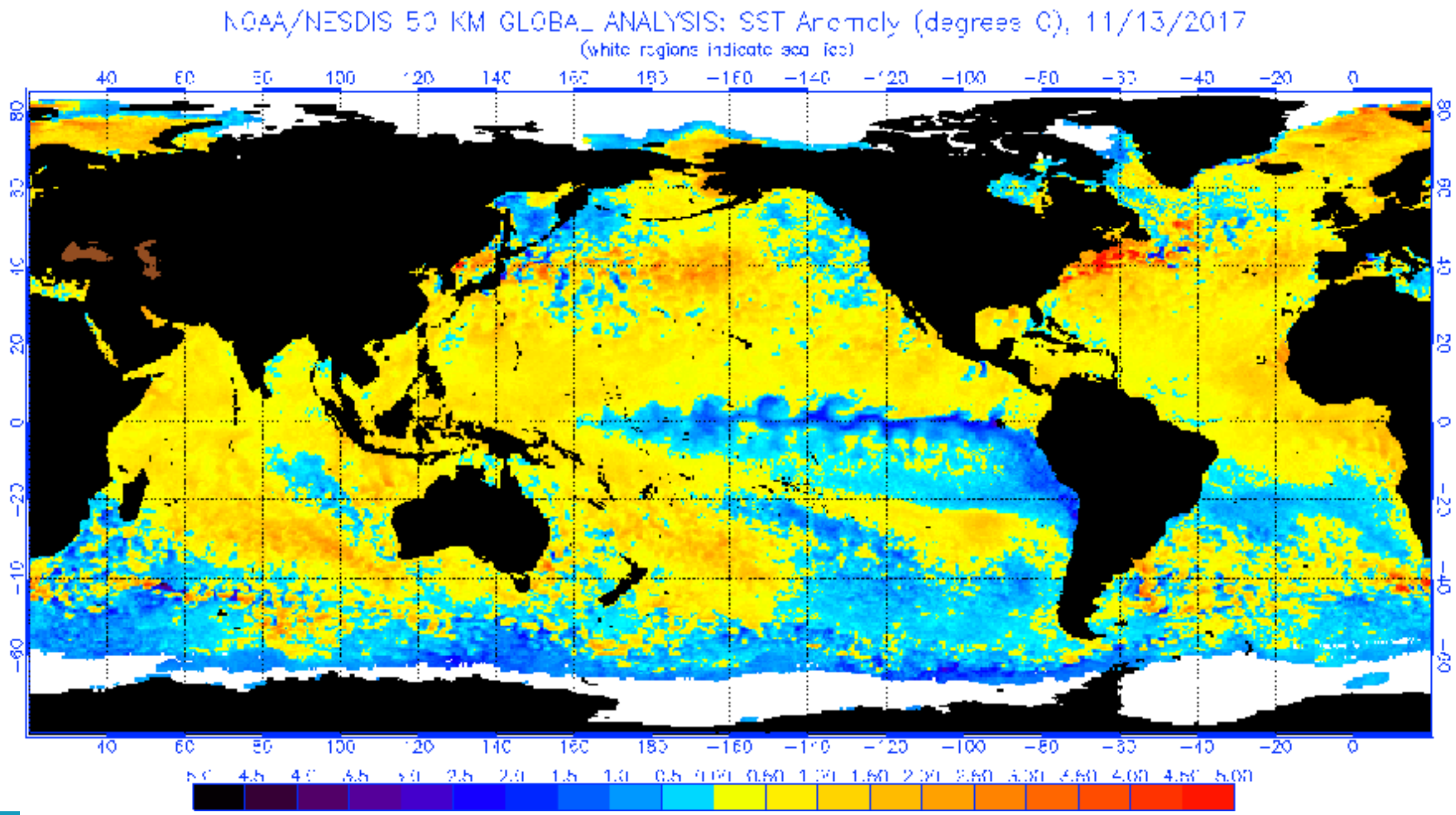


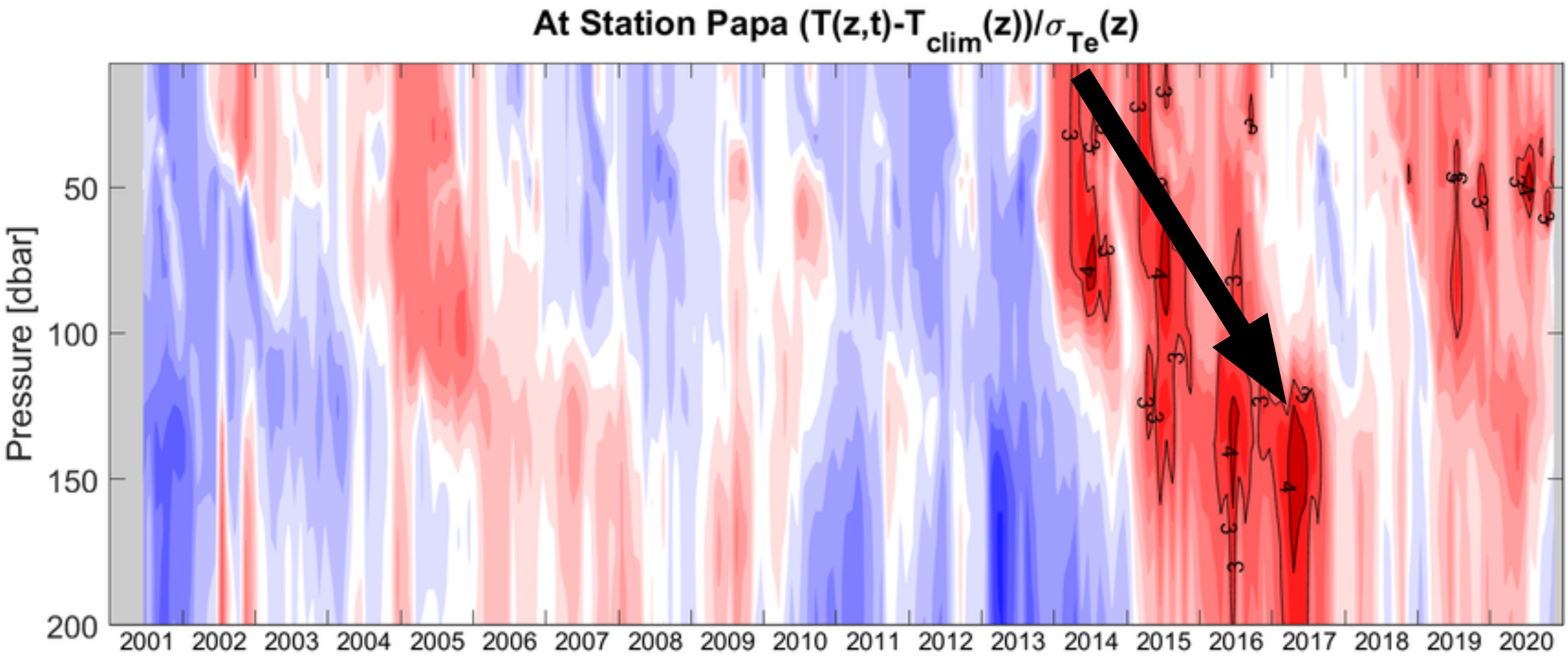


Source: Harvell et al, 2019

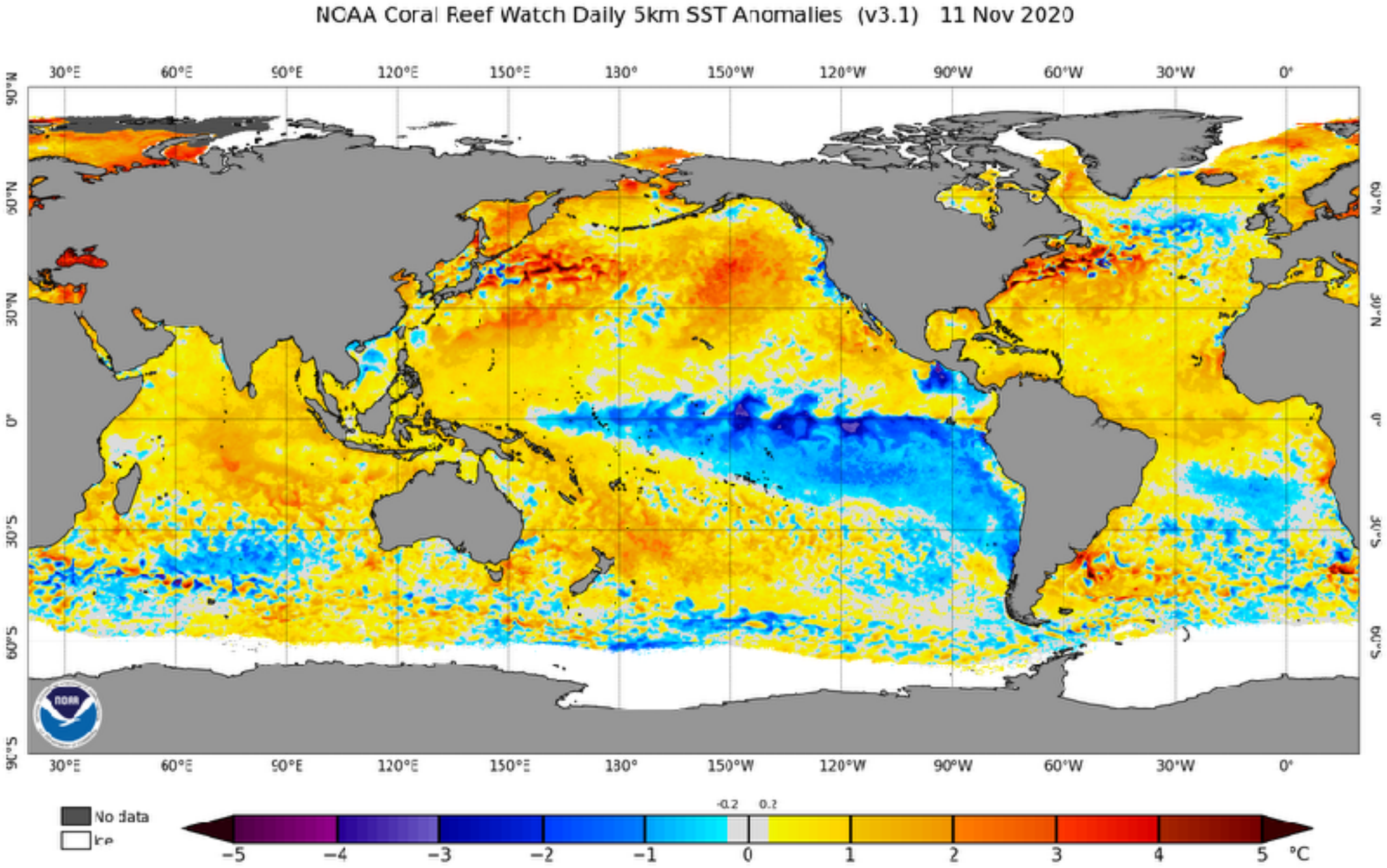
Urchin barrens

Source: California Sea Grant. Photo by Oregon Department of Fish and Wildlife


NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 11/13/2017
(white regions indicate sea ice)

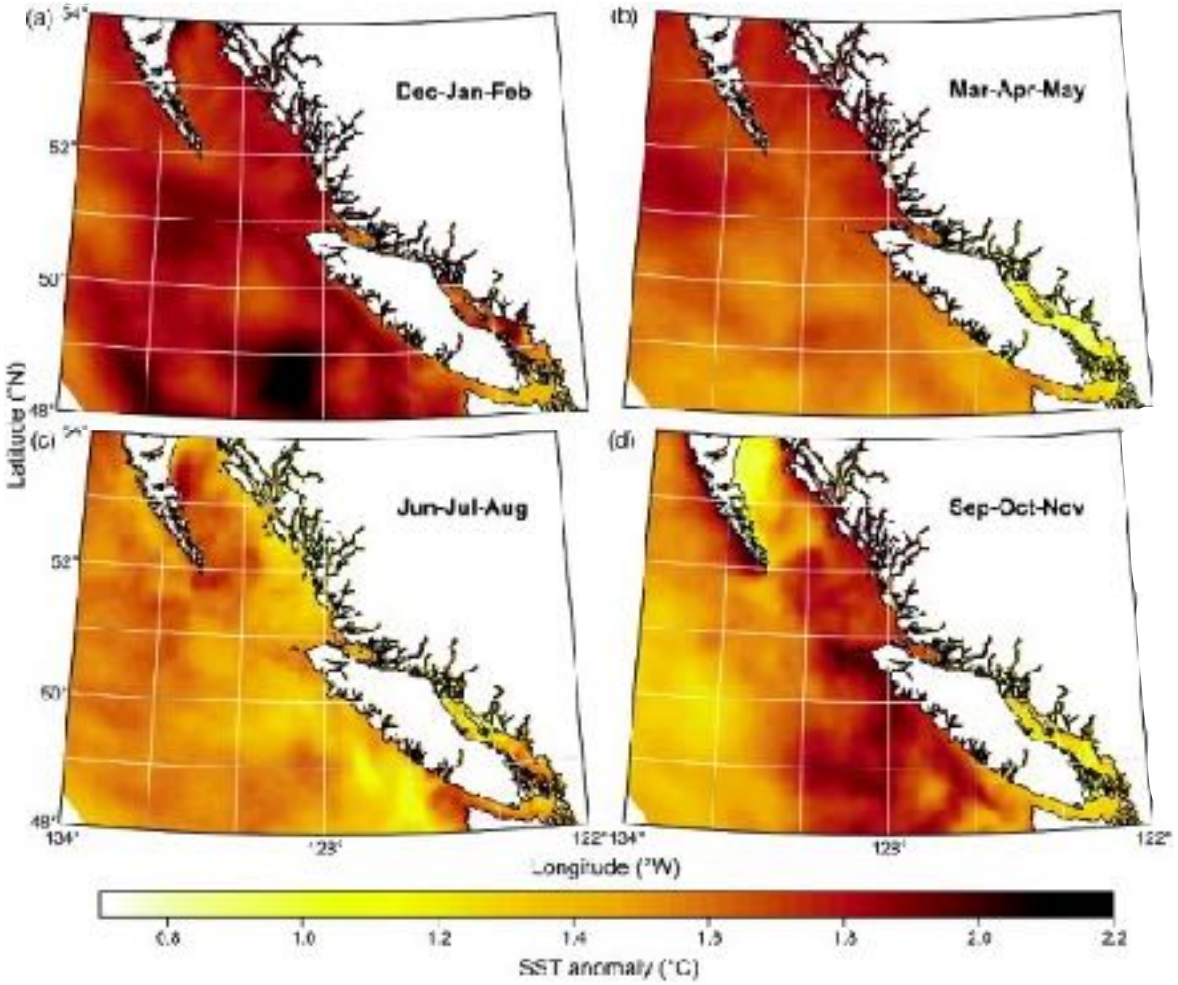


Source: Tetjana Ross, DFO

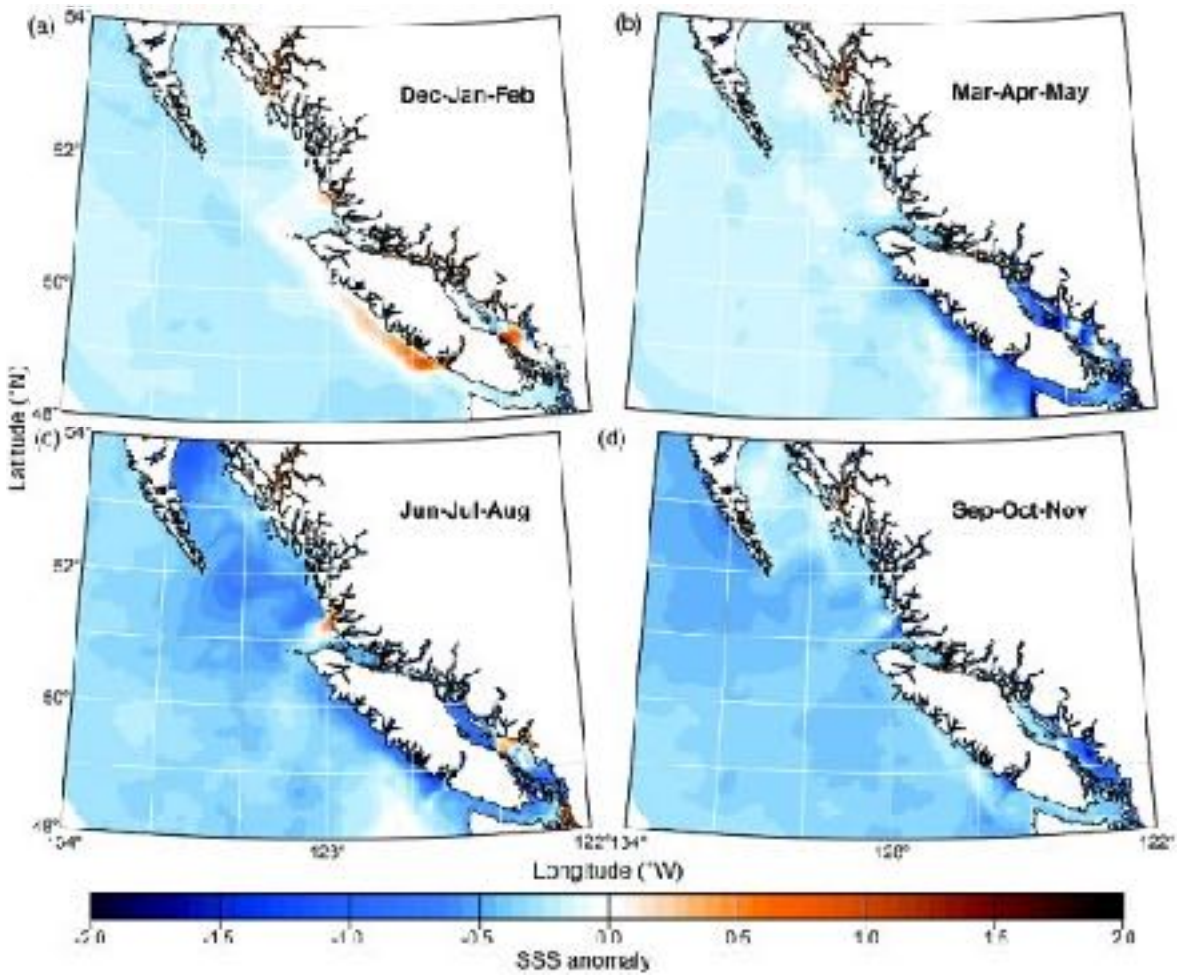


Source: NOAA/NESDIS

2065-2078



Warmer



Less Salty

Source: Foreman et al, 2014

"Ocean warming may well turn out to be the ***greatest hidden challenge*** *of our generation.*

The problem is that ***we know ocean warming*** *is driving change…,* ***but the consequences*** *of these changes decades down the line* ***are far from clear****."*

—IUCN, Explaining Ocean Warming

Go to **www.menti.com** and enter code **83 13 16 8**

On a scale of 1-10, how concerned are you about ocean warming?

Oxygen Decline

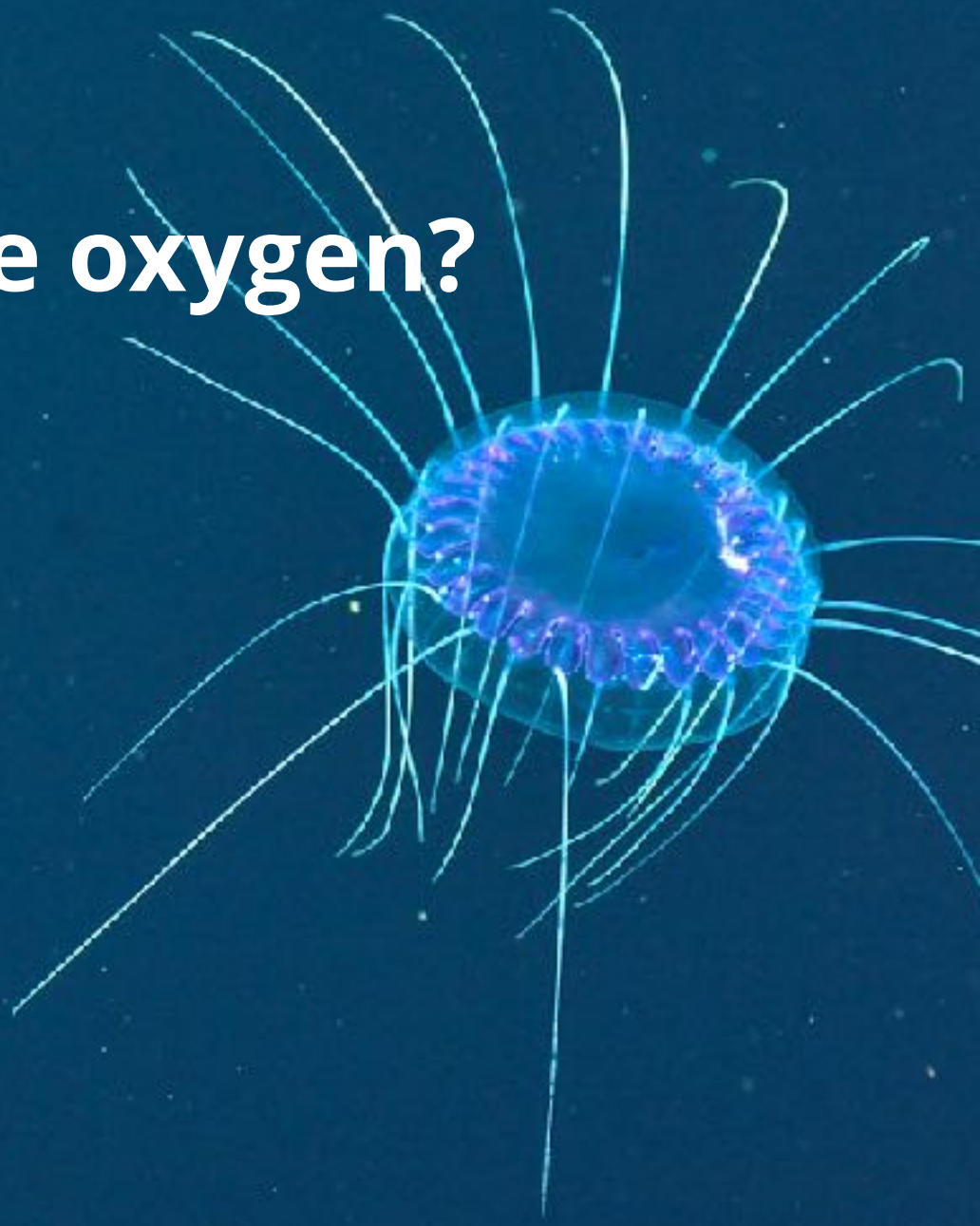
Source: George Hodan, publicdomainpictures.net

Different causes of low oxygen

- Upwelling
- Runoff
- **Warming** 

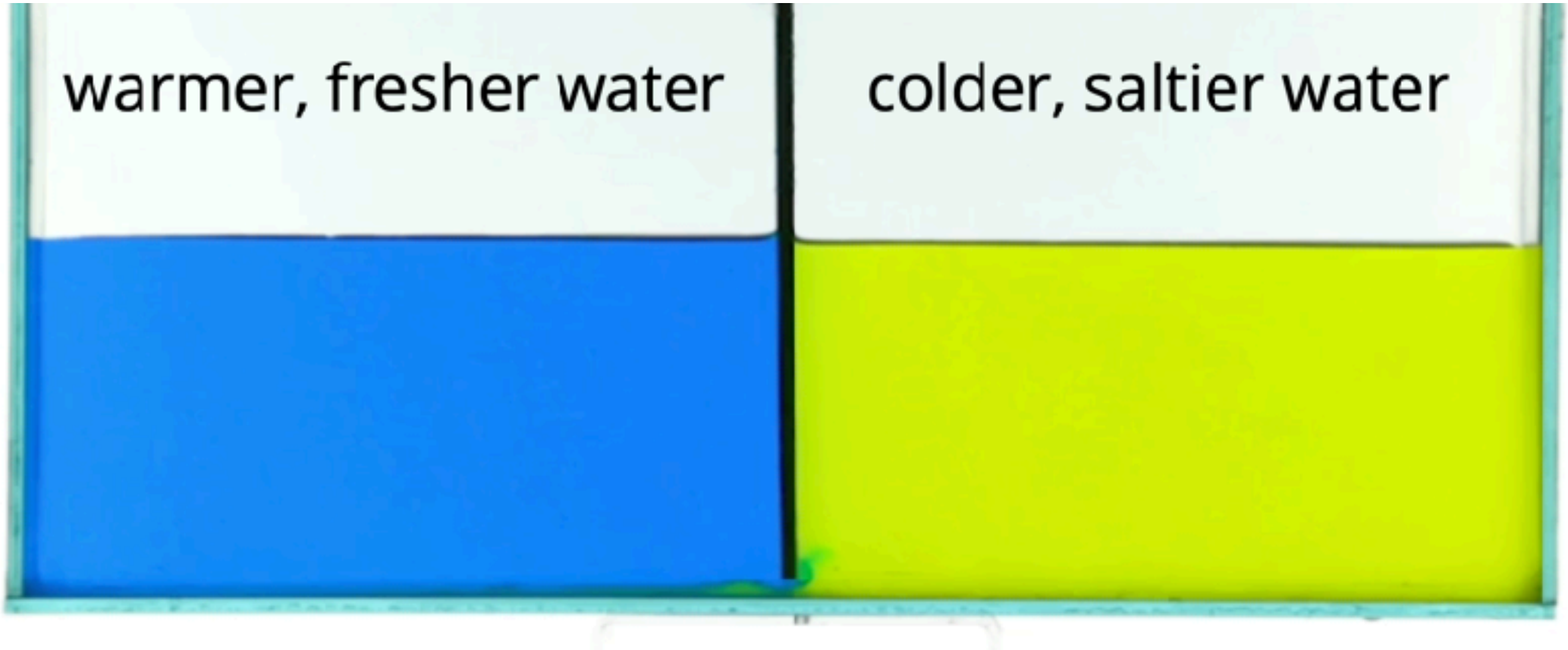
How does warming reduce oxygen?

- Warm water absorbs less oxygen.
- Warmer fresher water at the surface wants to stay at the surface.



Go to **www.menti.com** and enter code **83 13 16 8**

What do you think will happen when the barrier is removed?



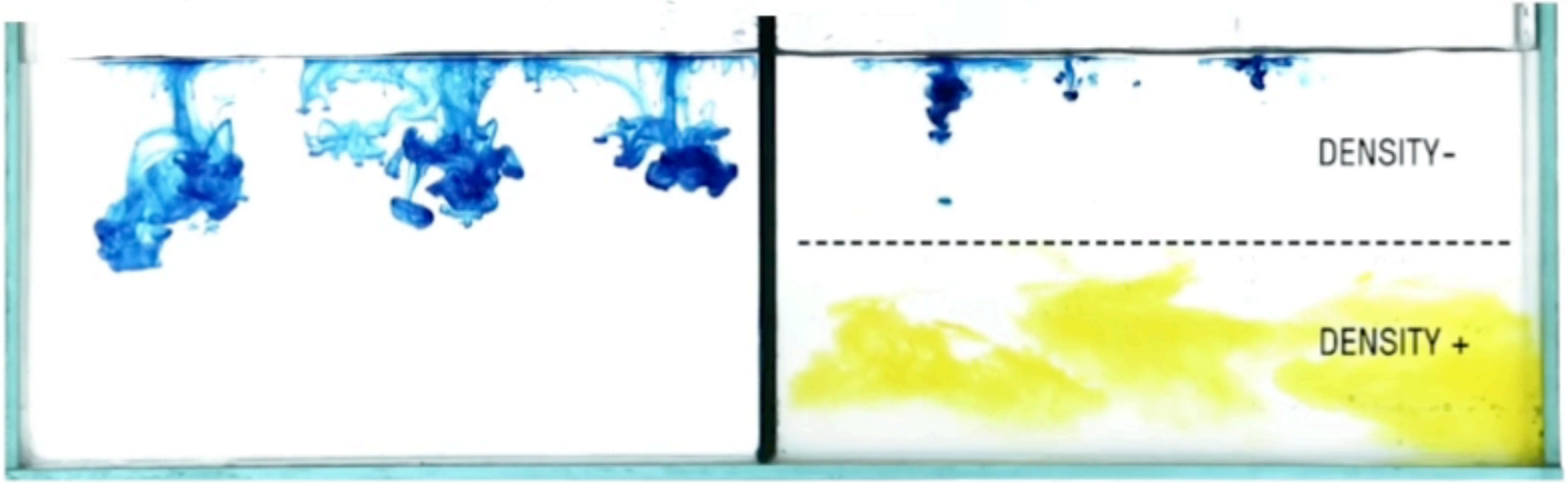
Stratification in the Arctic

Source: Parafilms

Stratification and Winds

single mixed layer

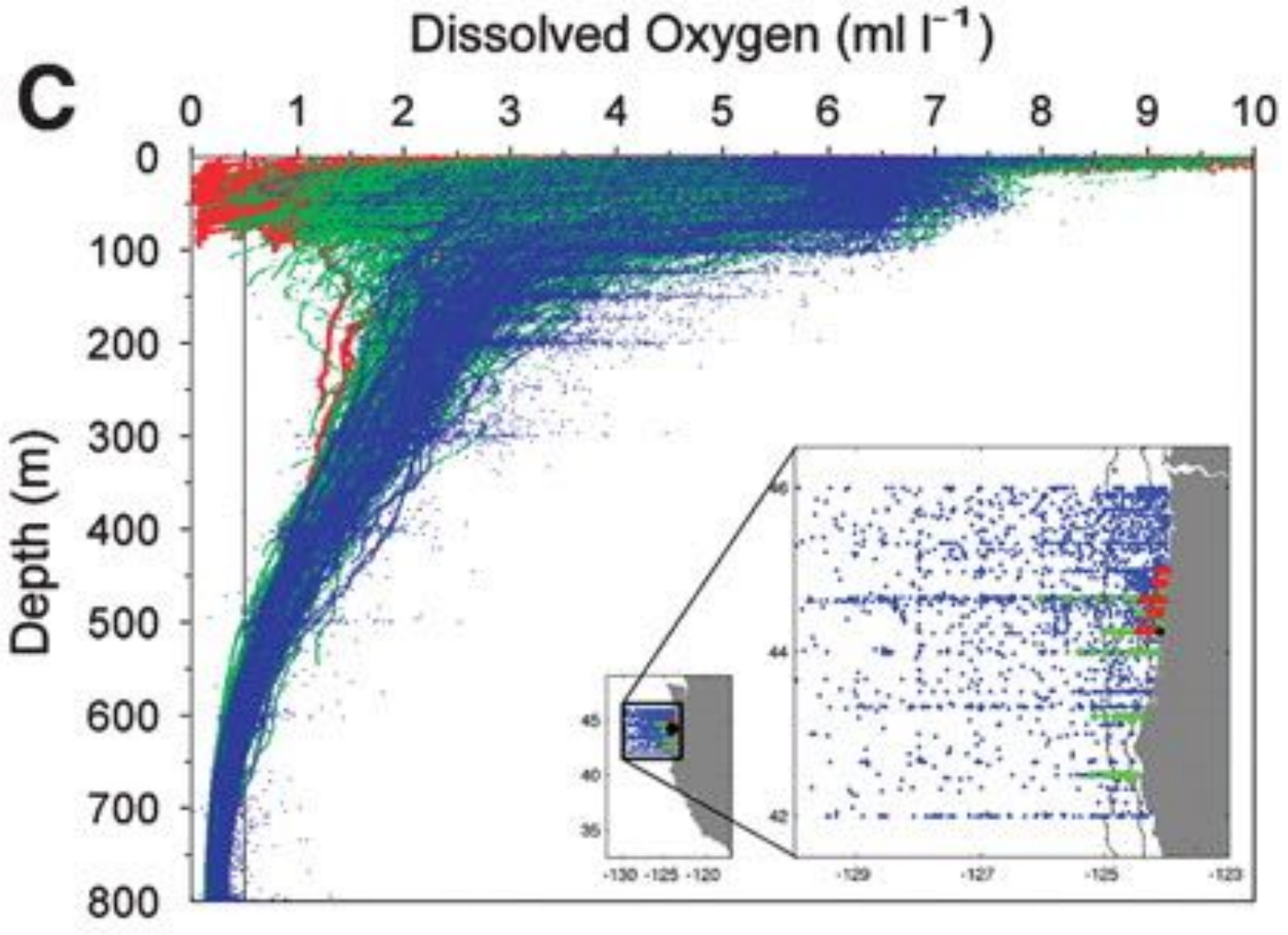
warm layer over cold layer



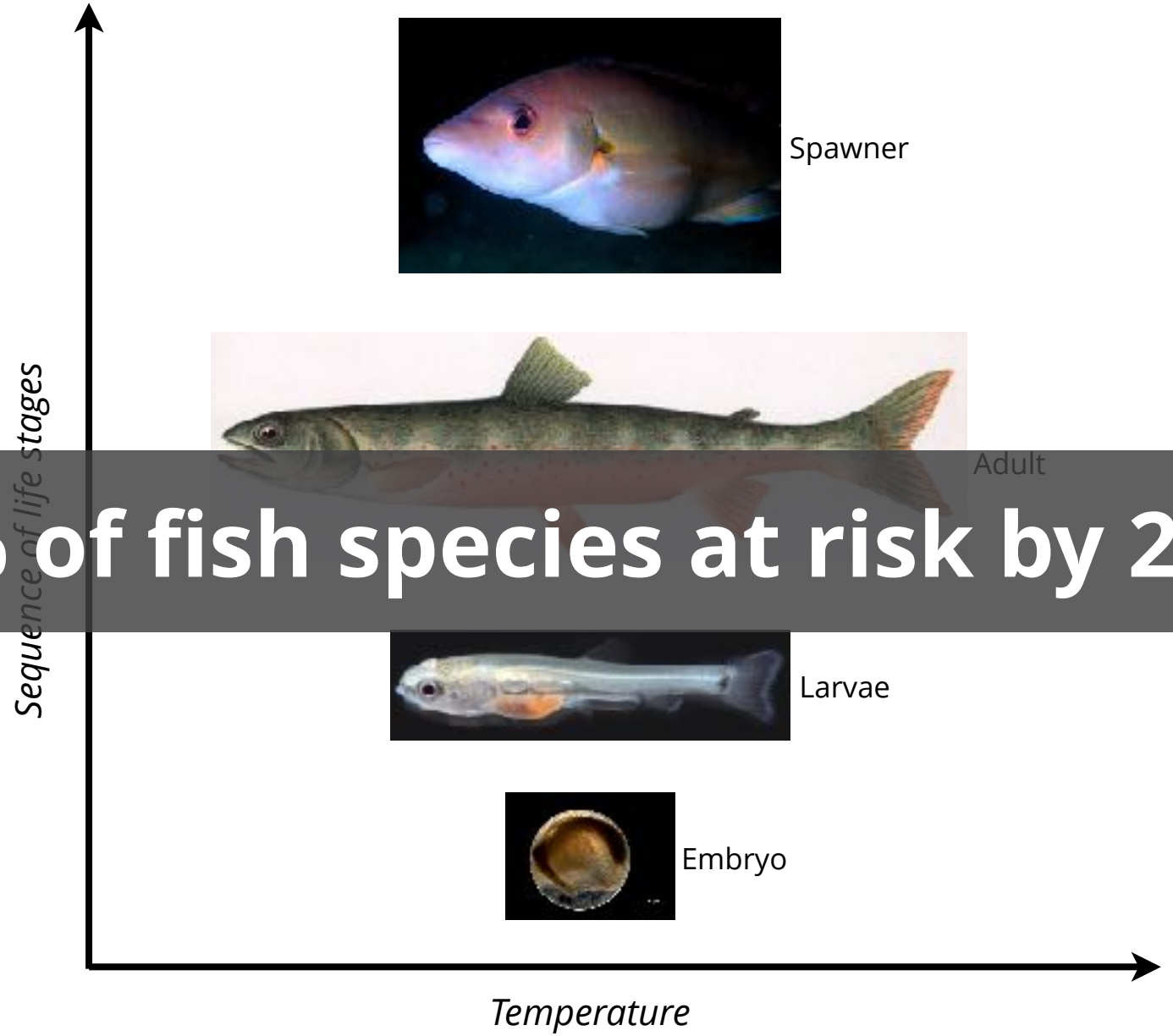
This fresh water floats on the surface of the ocean

Oxygen Profiles off Oregon

1950-1999
2000-2005
2006



Chan, Barth, Lubchenco, Kirincich, Weeks, Peterson, Menge, 2008



10-60% of fish species at risk by 2100

Source: Hans Hillewaert / sea_virtual / NYS DEC / Tony Gilbert via Flickr

SAANICH INLET

Ocean Networks Canada

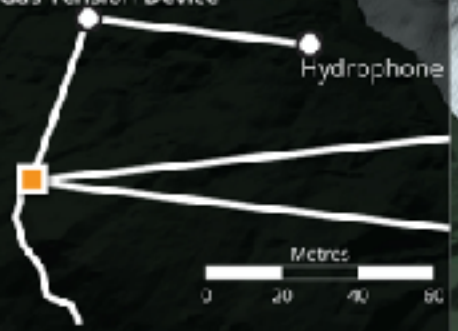
Satellite Channel

SILL Autonomous Mooring (-90 m)

> CTD
> Current Profiler
> Oxygen Sensor

Central (-100 m)

> CTD
> Oxygen Sensor (2)
> Echosounder
> Gas Tension Device



Inshore Profiling System (-195 m)

> Wind Monitoring System
> Air Temperature & Humidity Sensor
> Barometric Pressure Sensor
> Fluorometer
> Camera
> Meteorological Station
> Transmissometer
> Oxygen Sensor (2)
> CTD

Mill Bay

Patricia Bay

Coles Bay

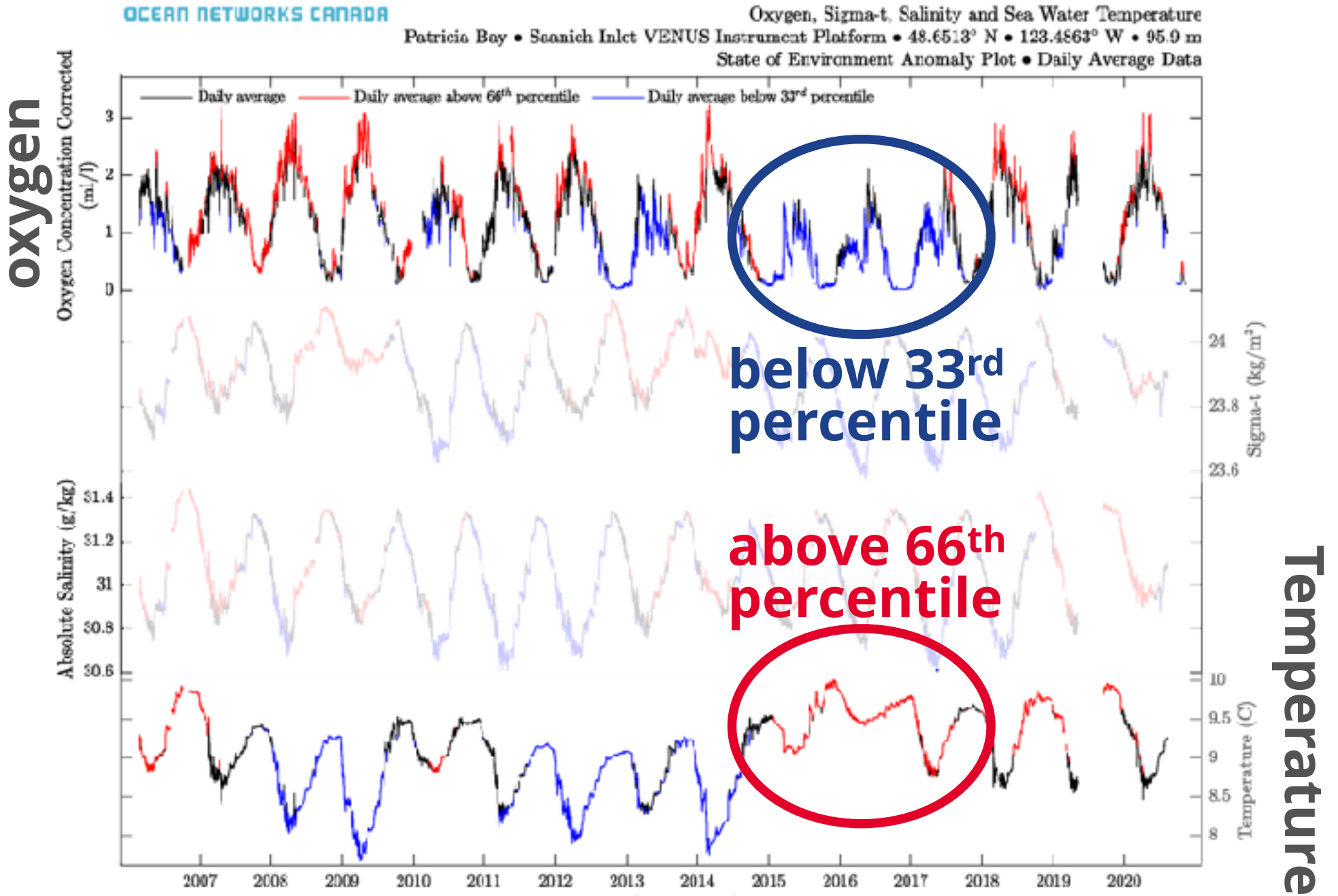
Shore Station
Node
Mooring
Instrument Platform
Fibre-optic Cable

1 km

University of Victoria


Slender sole (*Lyopsetta exilis*)
Oxygen ~ 0.01 ml/L (<0.2 % sat)

Saanich Inlet Anomalies



Oxygen decline summary

Complex life forms not limited

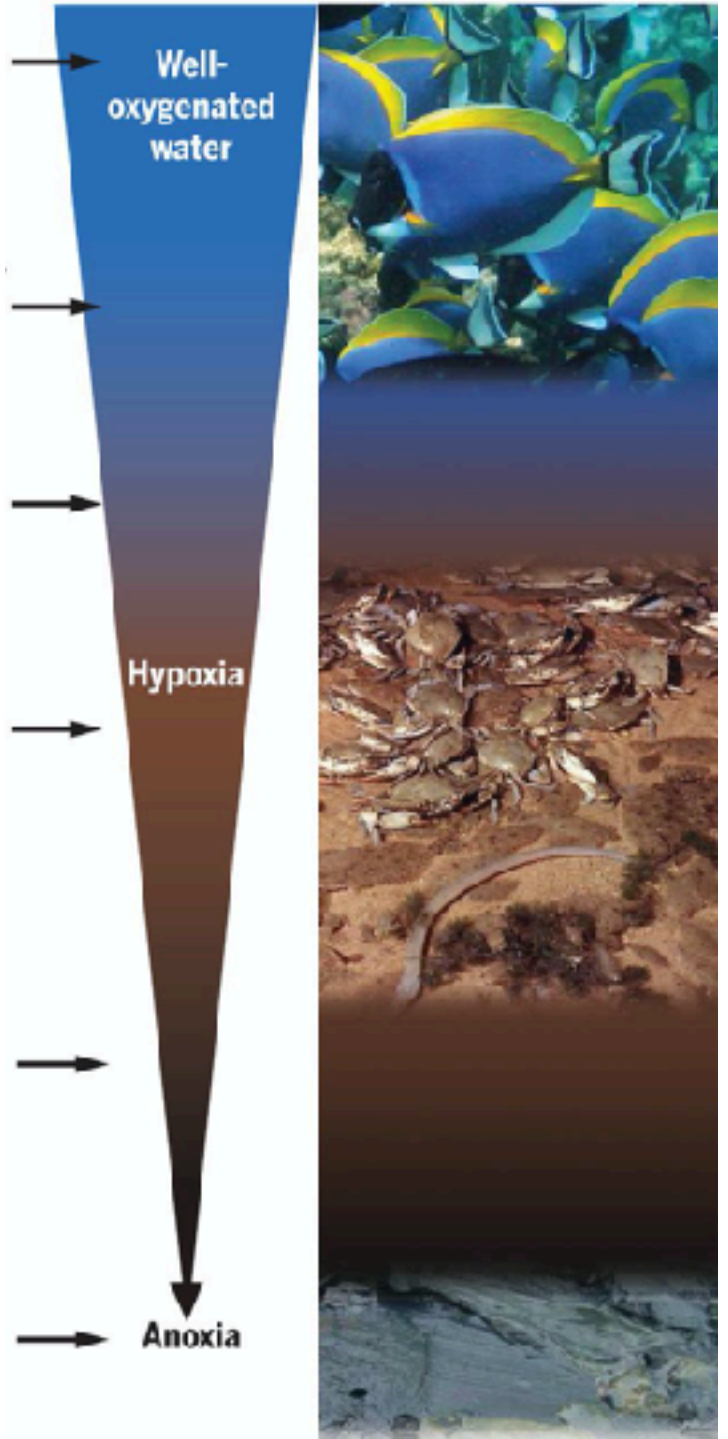
Finfish forced to low-oxygen boundaries

Fish die-offs when low-oxygen waters upwell

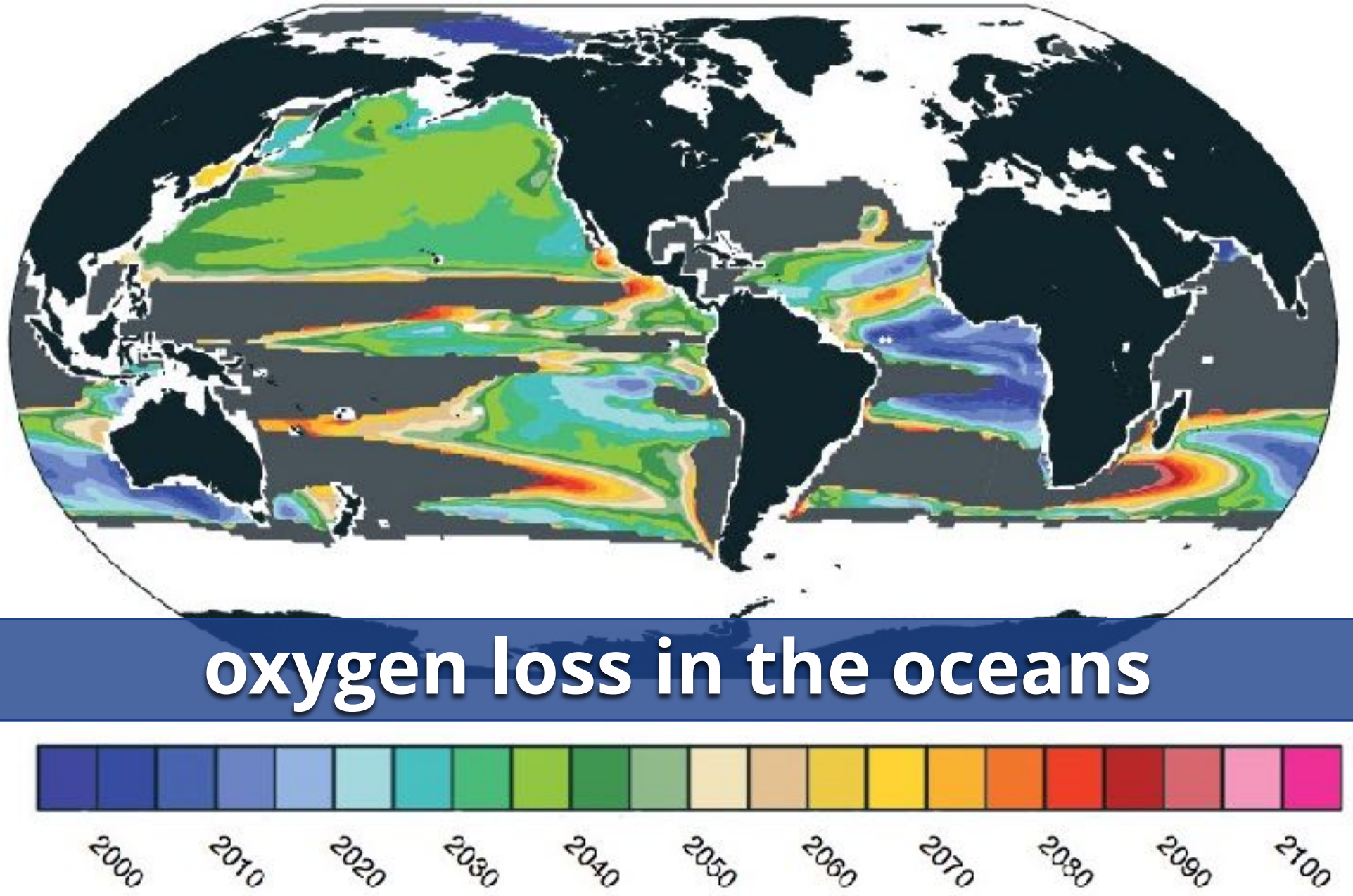
Only low-oxygen adapted organisms survive

Decreasing biodiversity

Only anaerobic bacteria can survive



Breitburg, Levin et al, 2018



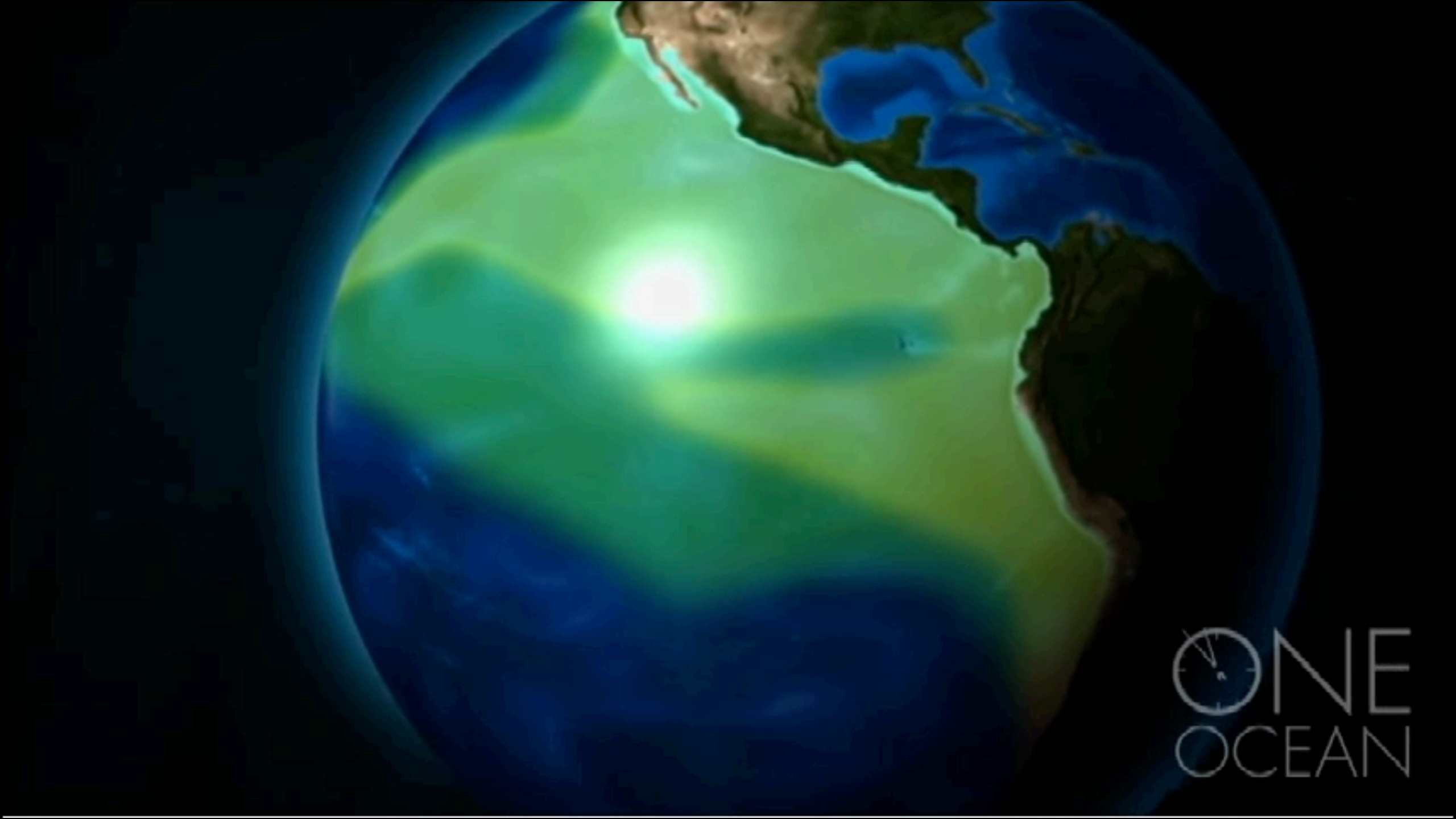
oxygen loss in the oceans

Source: Matthew Long, National Center for Atmospheric Research

Oxygen decline summary

According to the International Union for Conservation of Nature (IUCN):

- 2% decline since mid-20th century
- 3-4% decline by 2100
- Impacts: decreased biodiversity, species displacements, expanding algal blooms
- Disrupting ocean food webs


ONE
OCEAN

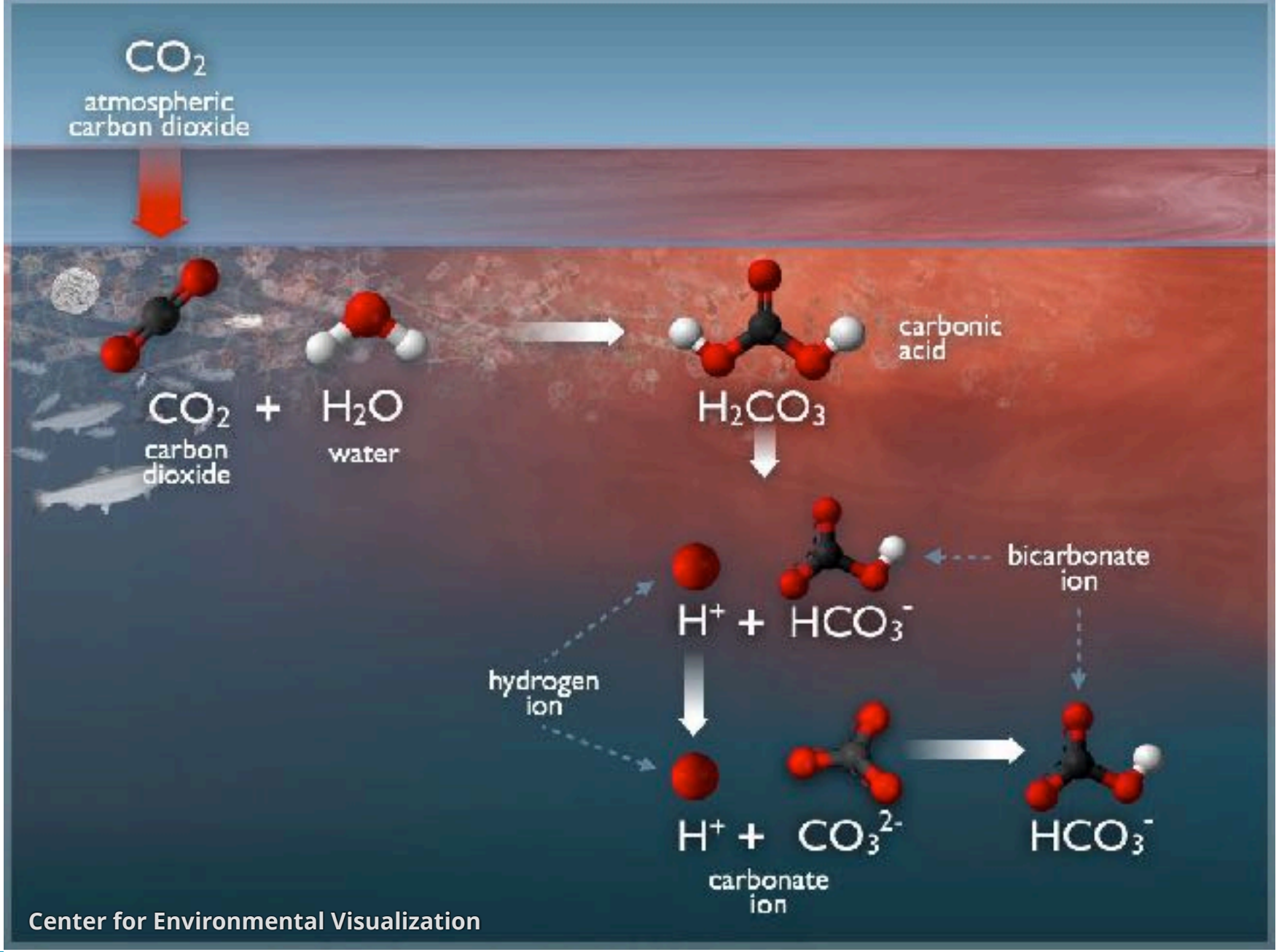
Break-out Discussion: 10 min

Let's talk about this.

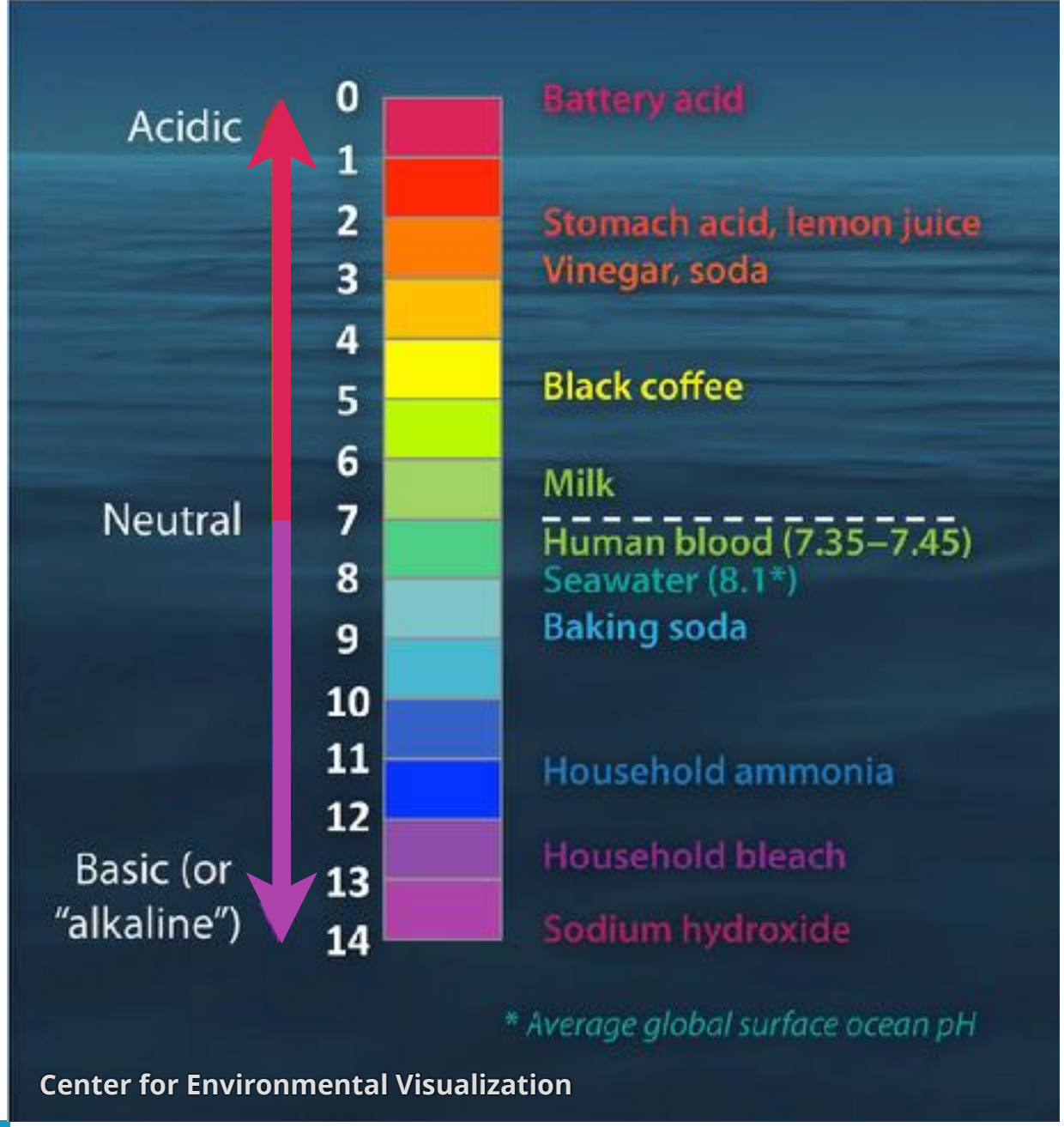
Considering all our other pressing issues (COVID-19, economy, global peace and security), ***does it really matter if marine ecosystems are disrupted by ocean warming and declining oxygen?***

Acidification

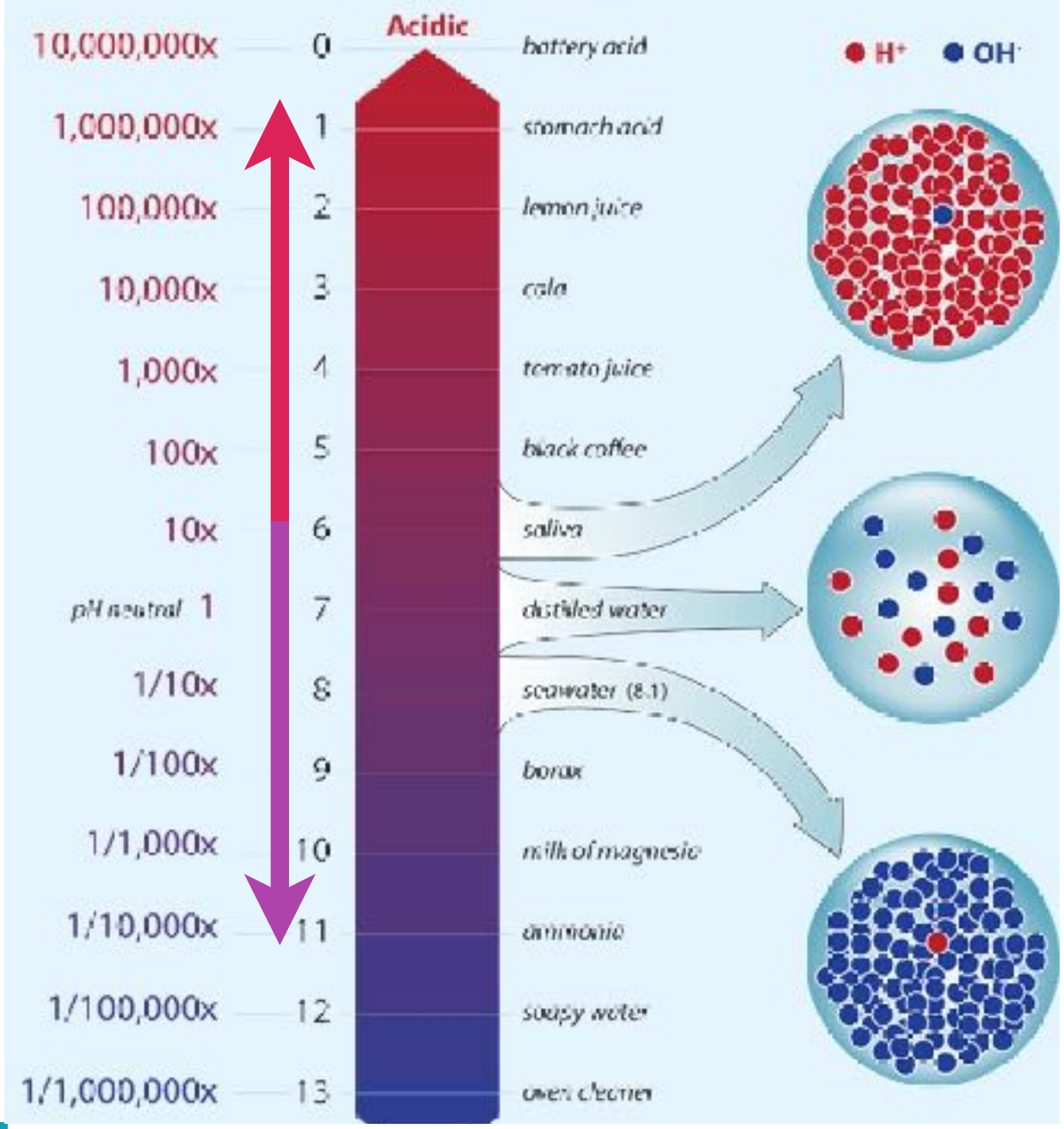
Photo by FelixMittermeier: Pixabay



...Chemistry in a nutshell


Acidic
Neutral
Basic (or "alkaline")
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
Stomach acid, lemon juice
Vinegar, soda
Black coffee
Milk
Human blood (7.35–7.45)
Seawater (8.1*)
Baking soda
Household ammonia
Household bleach
Sodium hydroxide
* Average global surface ocean pH
Center for Environmental Visualization

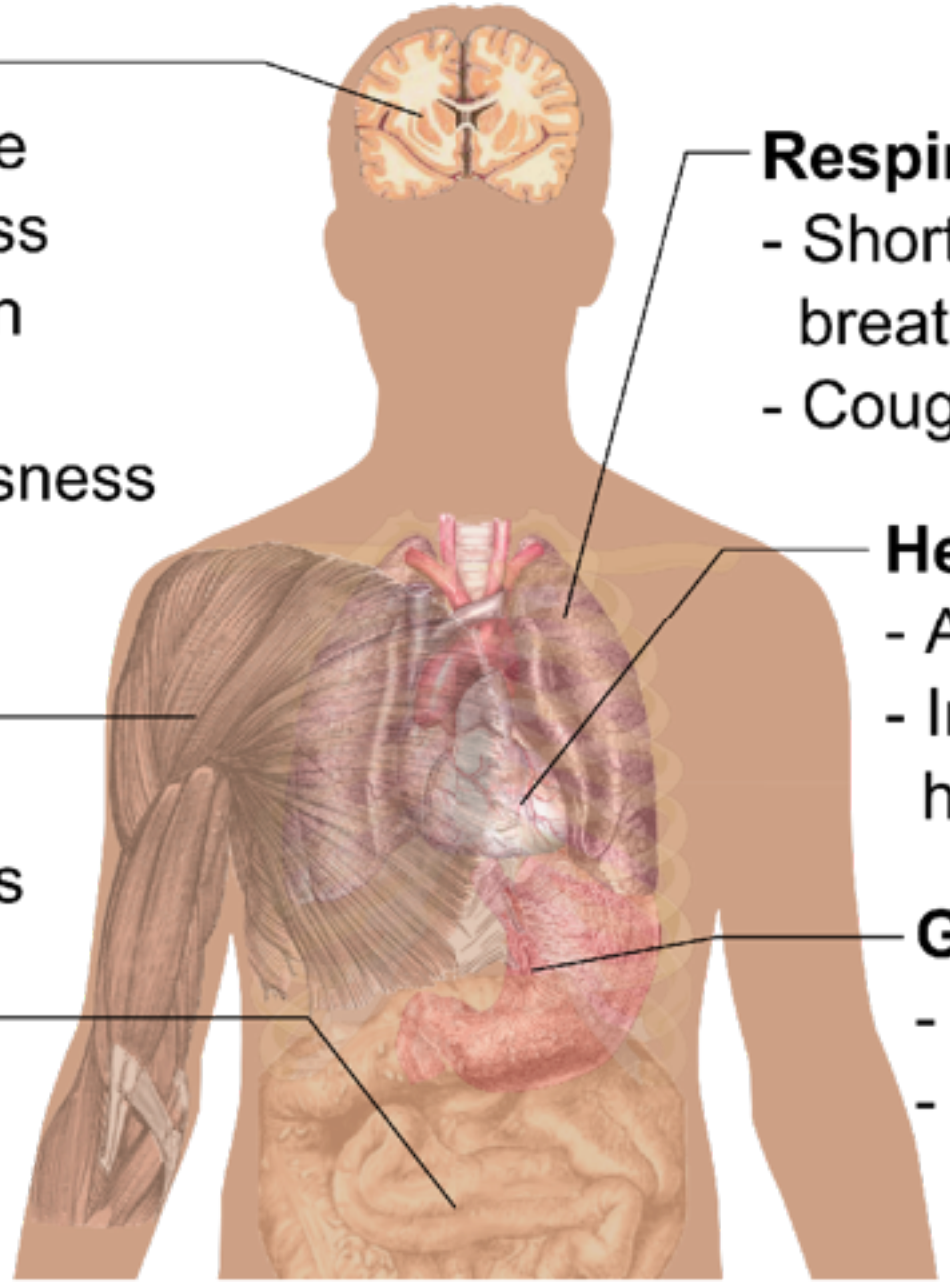
...the pH scale



Acidic: higher concentration of hydrogen ions (H+)

pH: the Power of Hydrogen

Alkaline: higher concentration of hydroxide ions (OH-)



Central
- Headache
- Sleepiness
- Confusion
- Loss of consciousness
- Coma

Respiratory
- Shortness of breath
- Coughing

Heart
- Arrhythmia
- Increased heart rate

Muscular
- Seizures
- Weakness

Gastric
- Nausea
- Vomiting

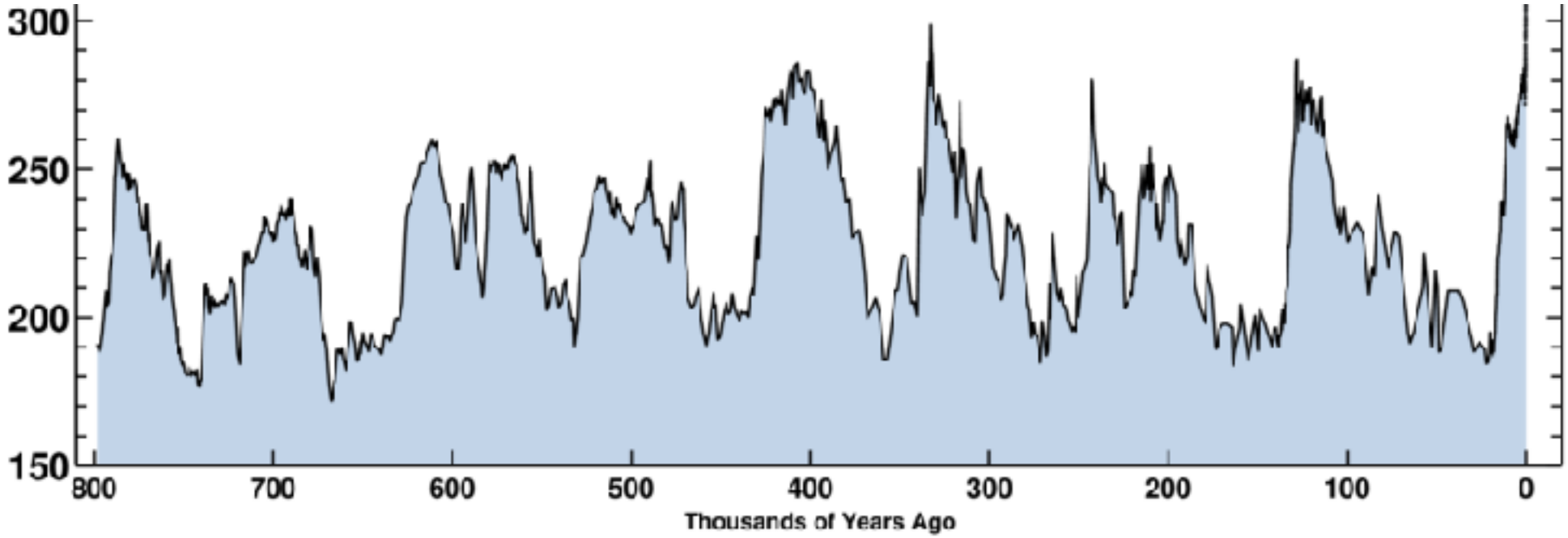
Intestinal
- Diarrhea

ACIDOSIS

pH below 7.35

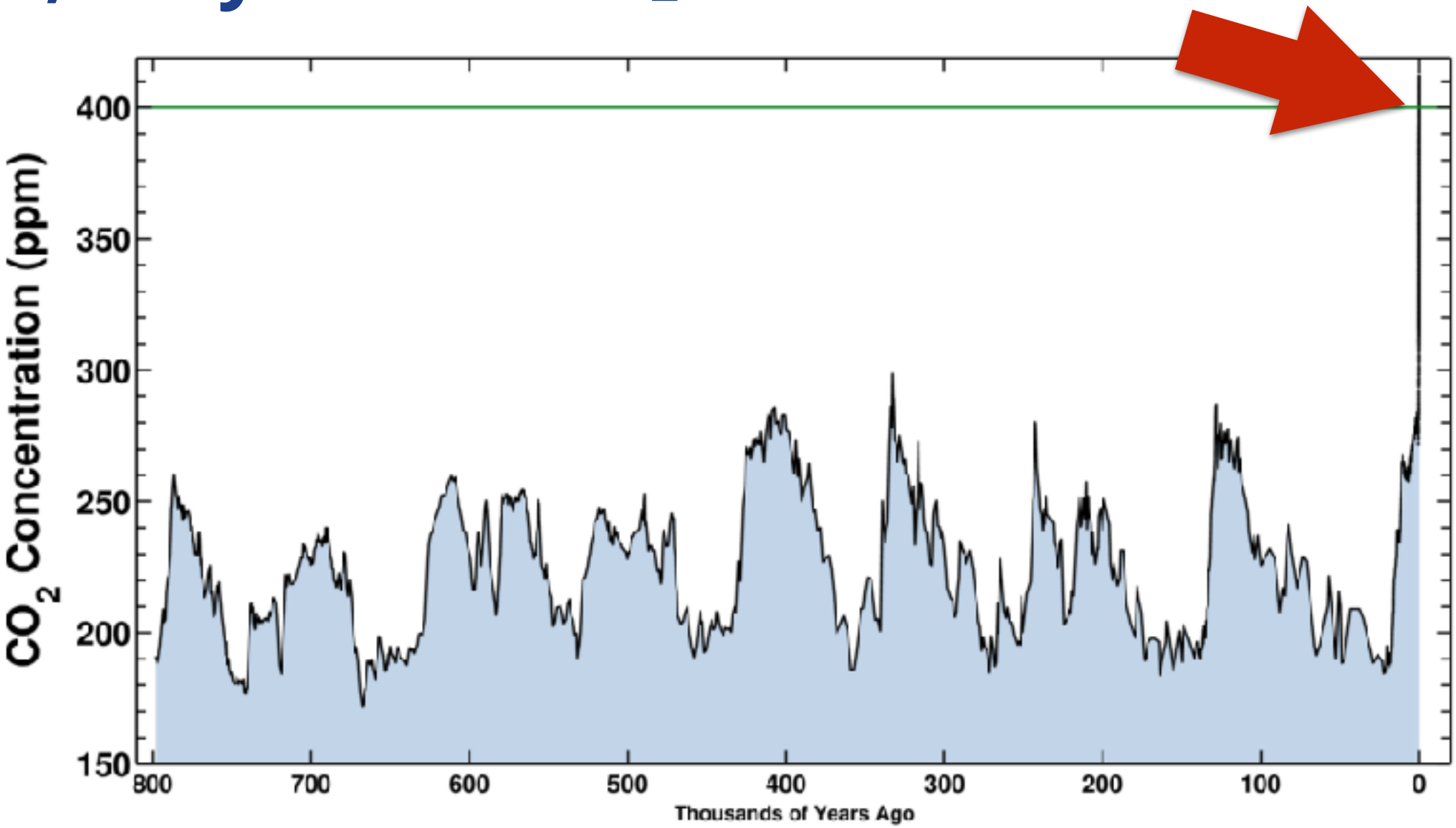
Illustration by Häggström, 2014

800,000 years of CO_2

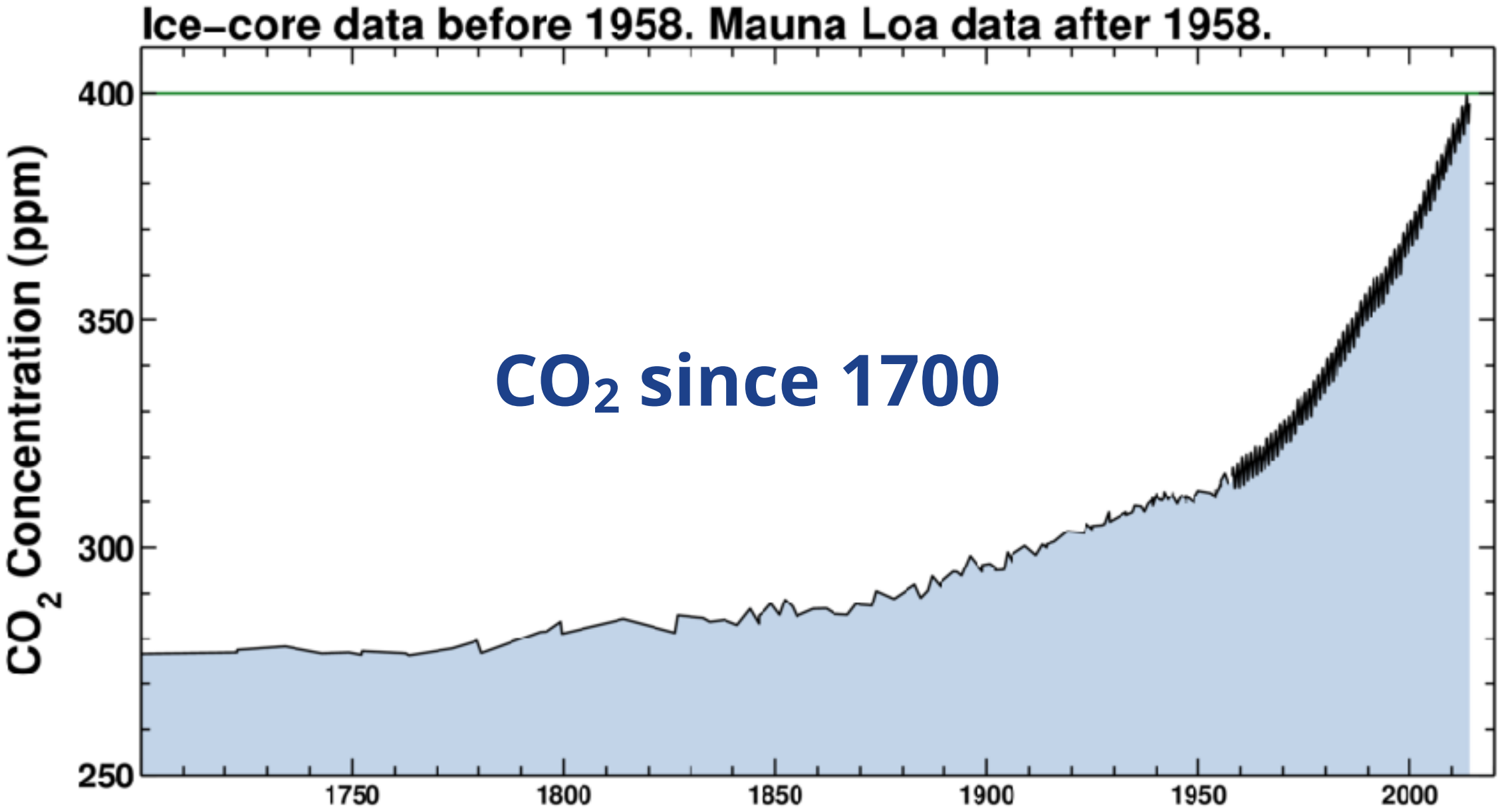


Source: Lüthi et al, 2008

800,000 years of CO_2

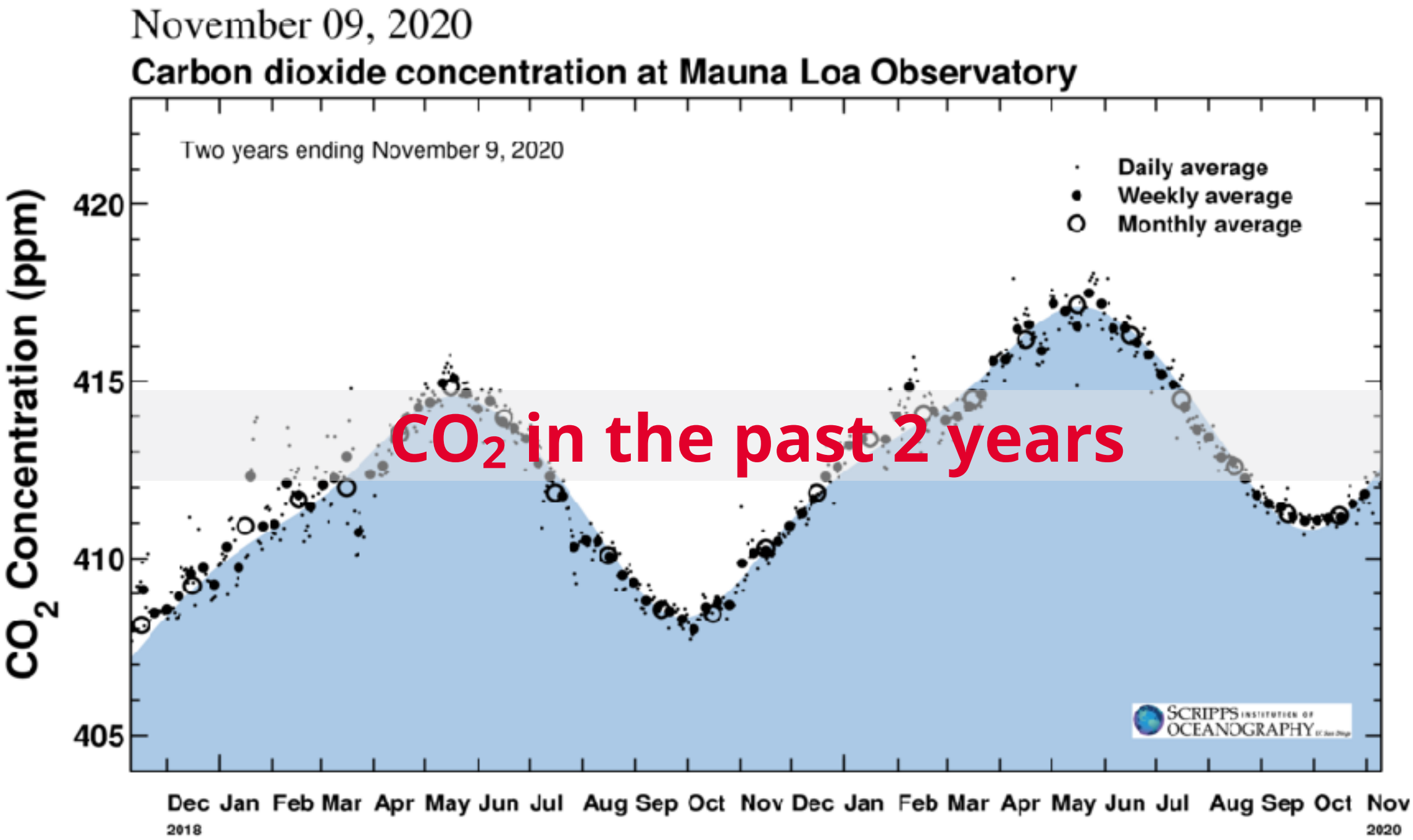


Source: Lüthi et al, 2008

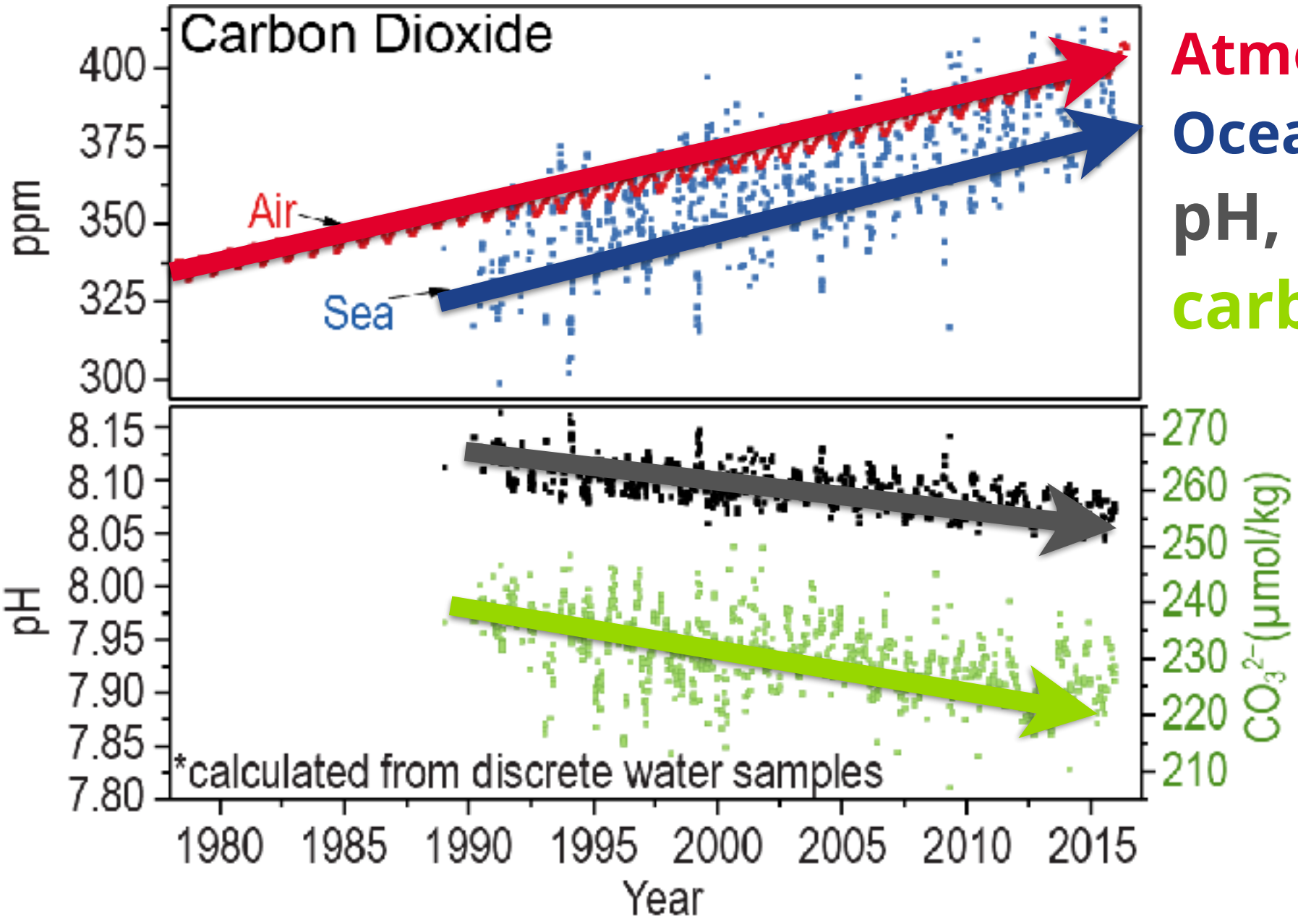


CO_2 since 1700

Source: Meure et al, 2006



Source: Scripps Institution of Oceanography SIO



Atmospheric CO_2,

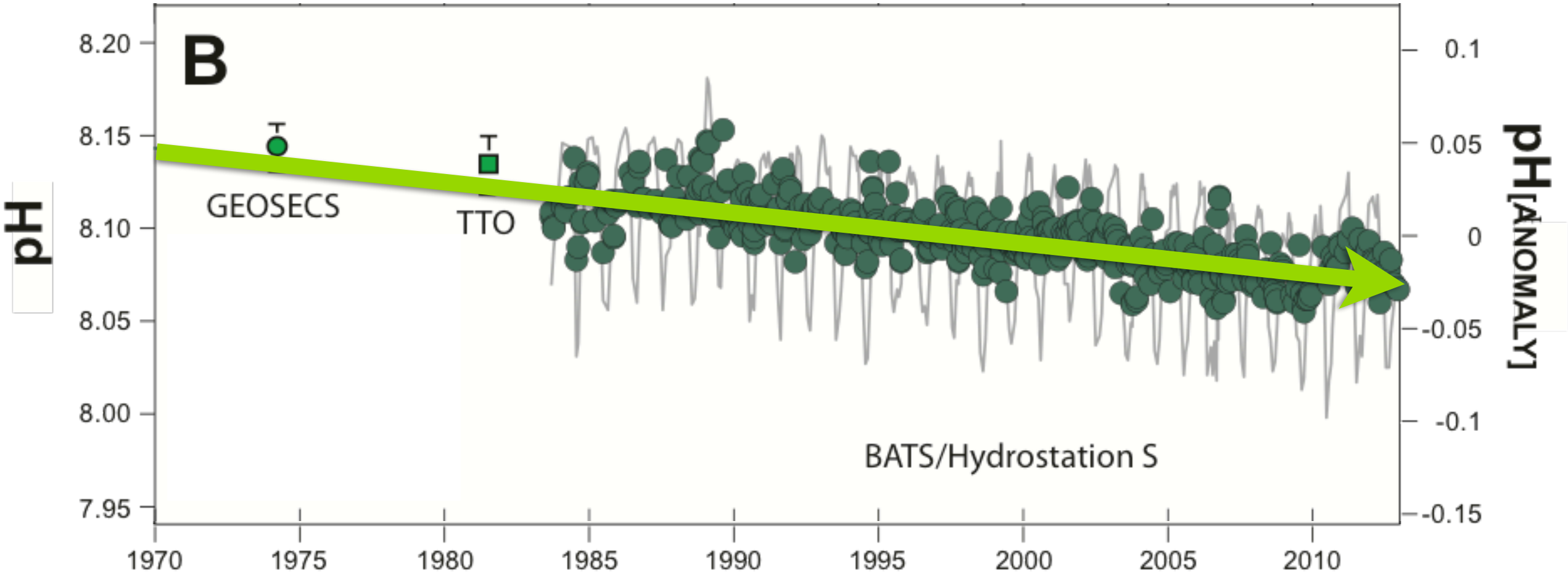
Oceanic CO_2,

pH,

carbonate ions.

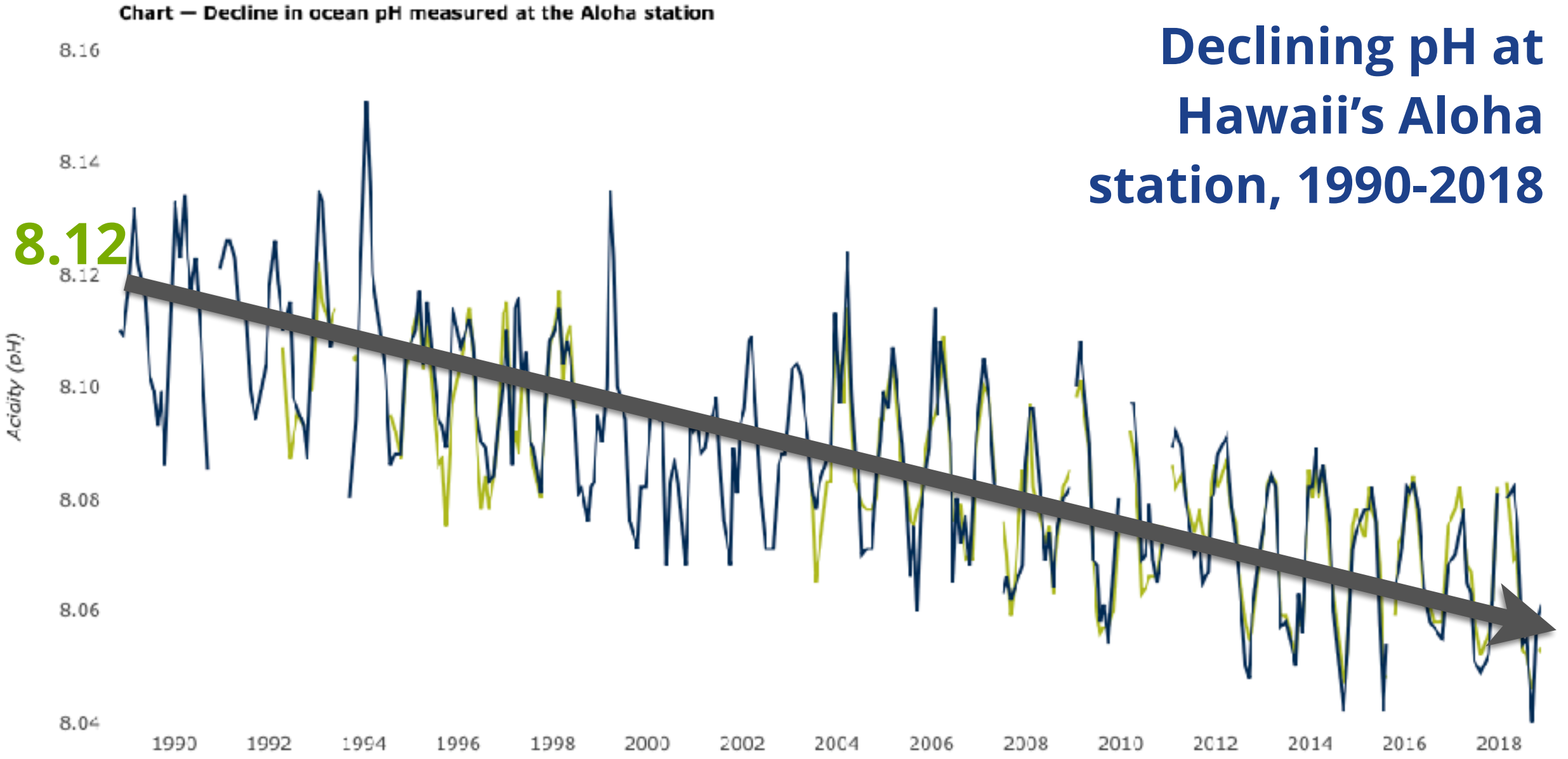
Source: NOAA

Declining pH at Bermuda's Hydrostation S, 1984-2015



Source: Bermuda Institute of Ocean Sciences

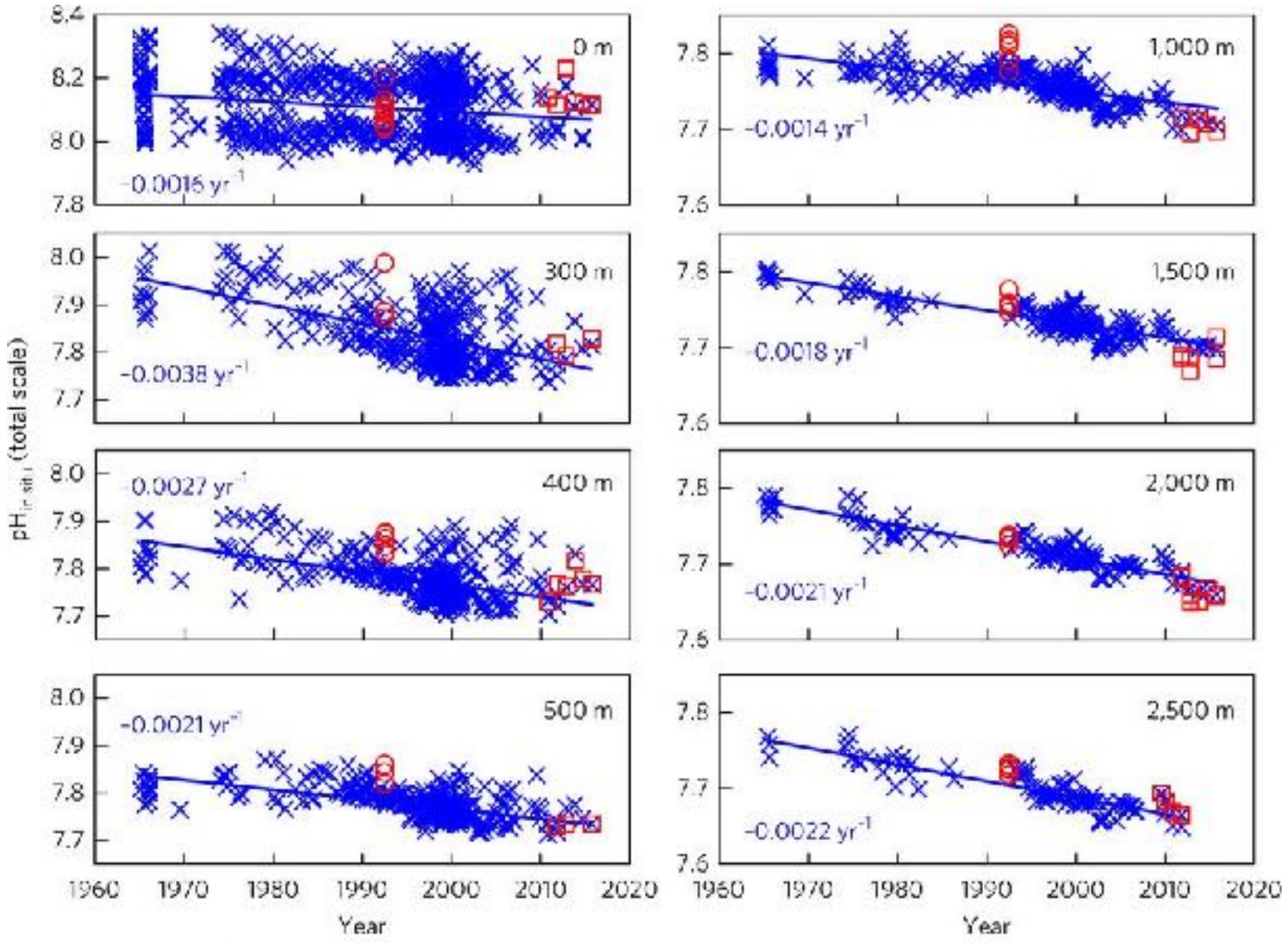
Declining pH at Hawaii's Aloha station, 1990-2018



8.12

8.05

Source: European Environment Agency



Sea of Japan:

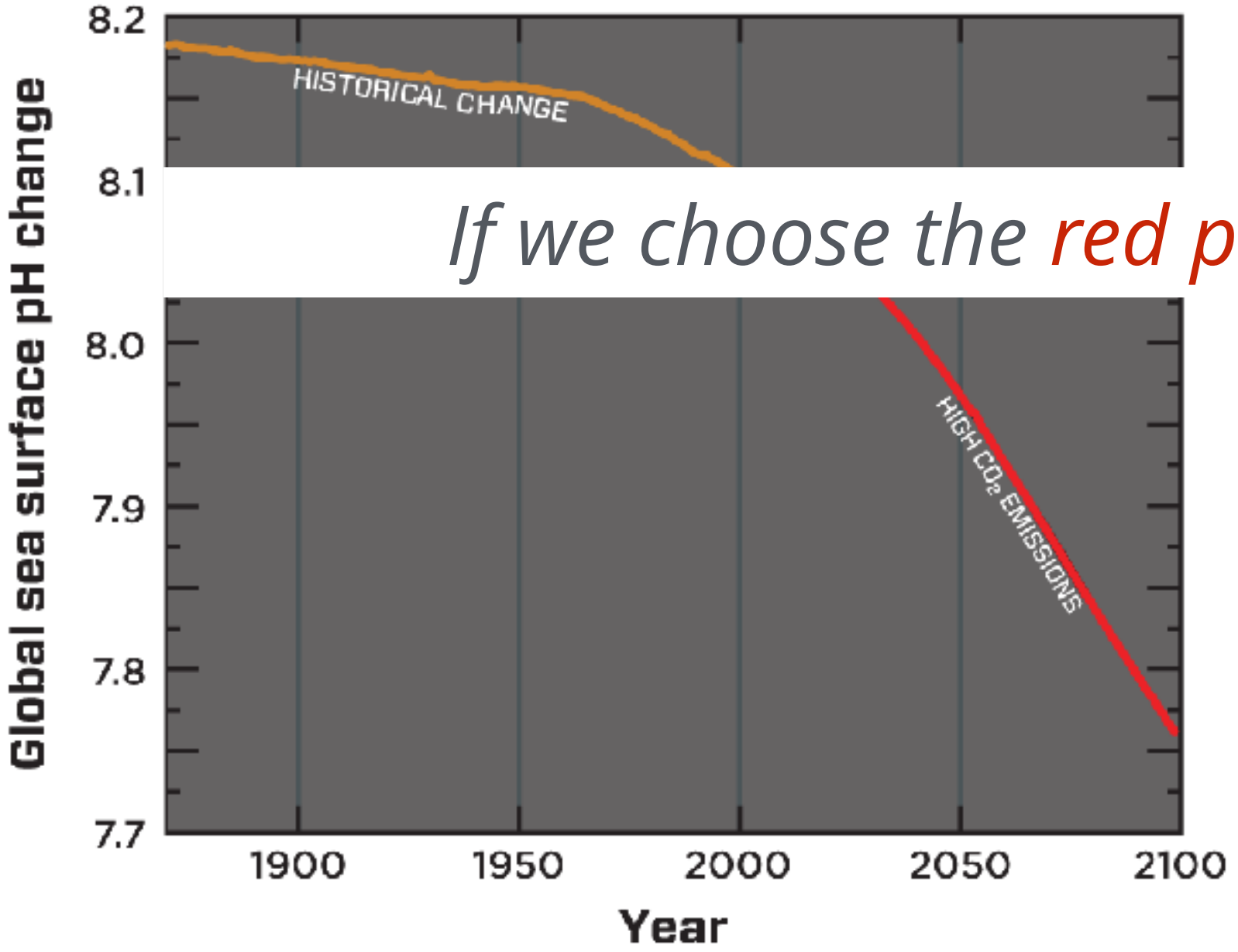
pH falling at every depth

Source: Chen et al., 2017

LOOKING BACK 300 MILLION YEARS…

*"The current **rate** of CO_2 release stands out as capable of driving … geochemical changes potentially **unparalleled** in at least the last ~300 million years of Earth history, raising the possibility that we are **entering an unknown territory** of marine ecosystem change."*

—Honisch et al, 2012 Geological Record of Ocean Acidification



If we choose the red path…

2 futures

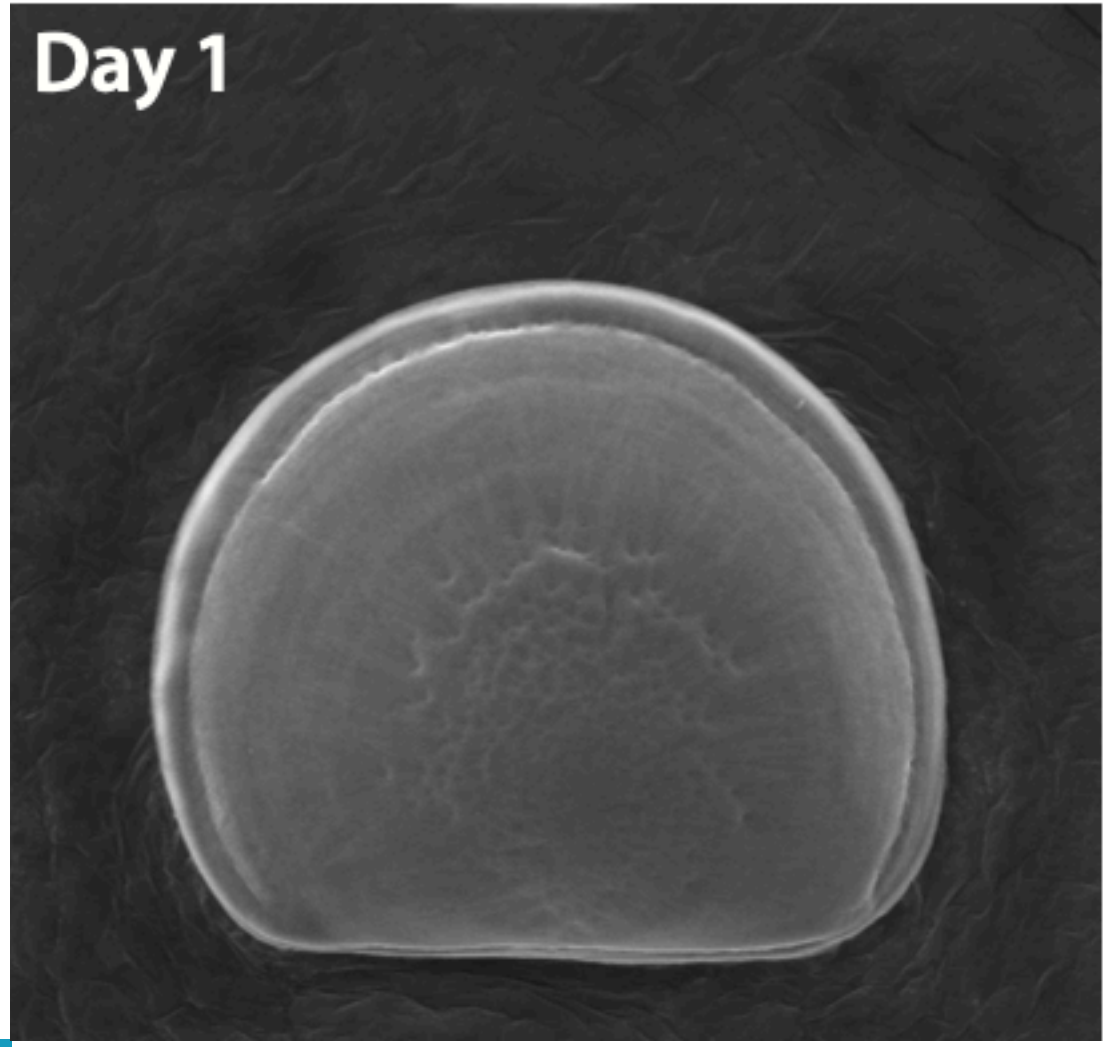
Source: International Geosphere-Biosphere Programme

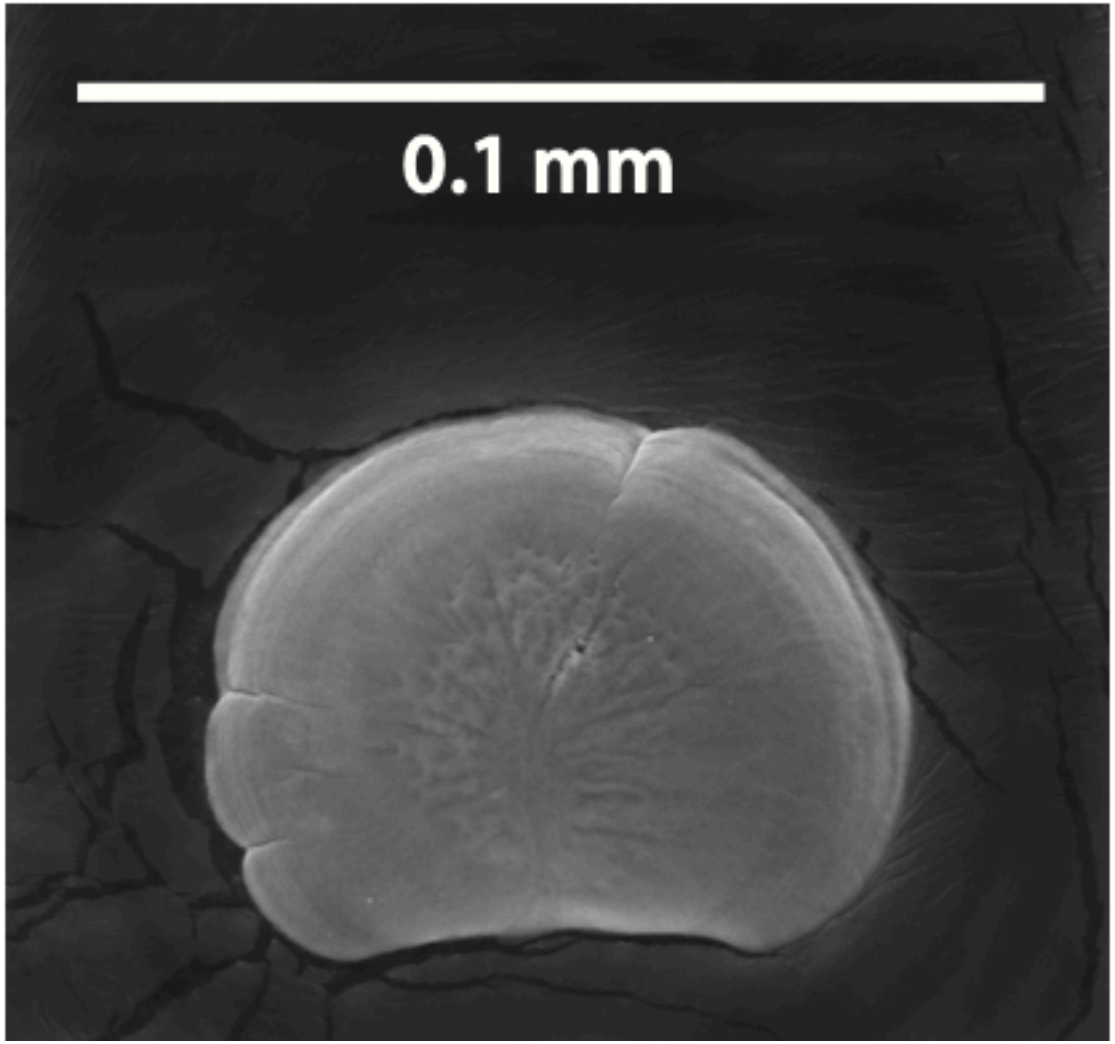
Taylor Shellfish Farms

- *5 generations, since 1890*
- *Hood canal hatchery*
- *Lost 3/4 of oyster larvae due to sudden change in acidity*

Source: Taylor Shellfish Farms

1-day old oyster larvae





Photos by Waldbusser/Brunner

Qualicum scallops: Feb 2014

- pH dropped from **8.1 to 7.3**
- 10 million scallops died

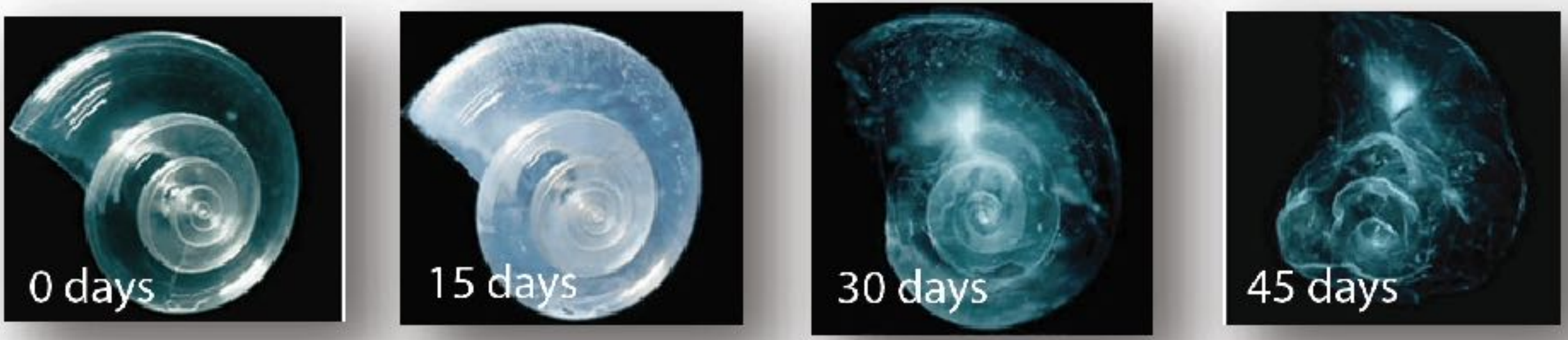
Source: The Huffington Post B.C., 2014 / JR Pardon, 2014. Photo by Hugh Blackmer via Flickr

Pteropods (a.k.a. *butterfly snails*)

Important food source for:

- *Salmon*
- *Mackerel*
- *Herring*
- *Cod*

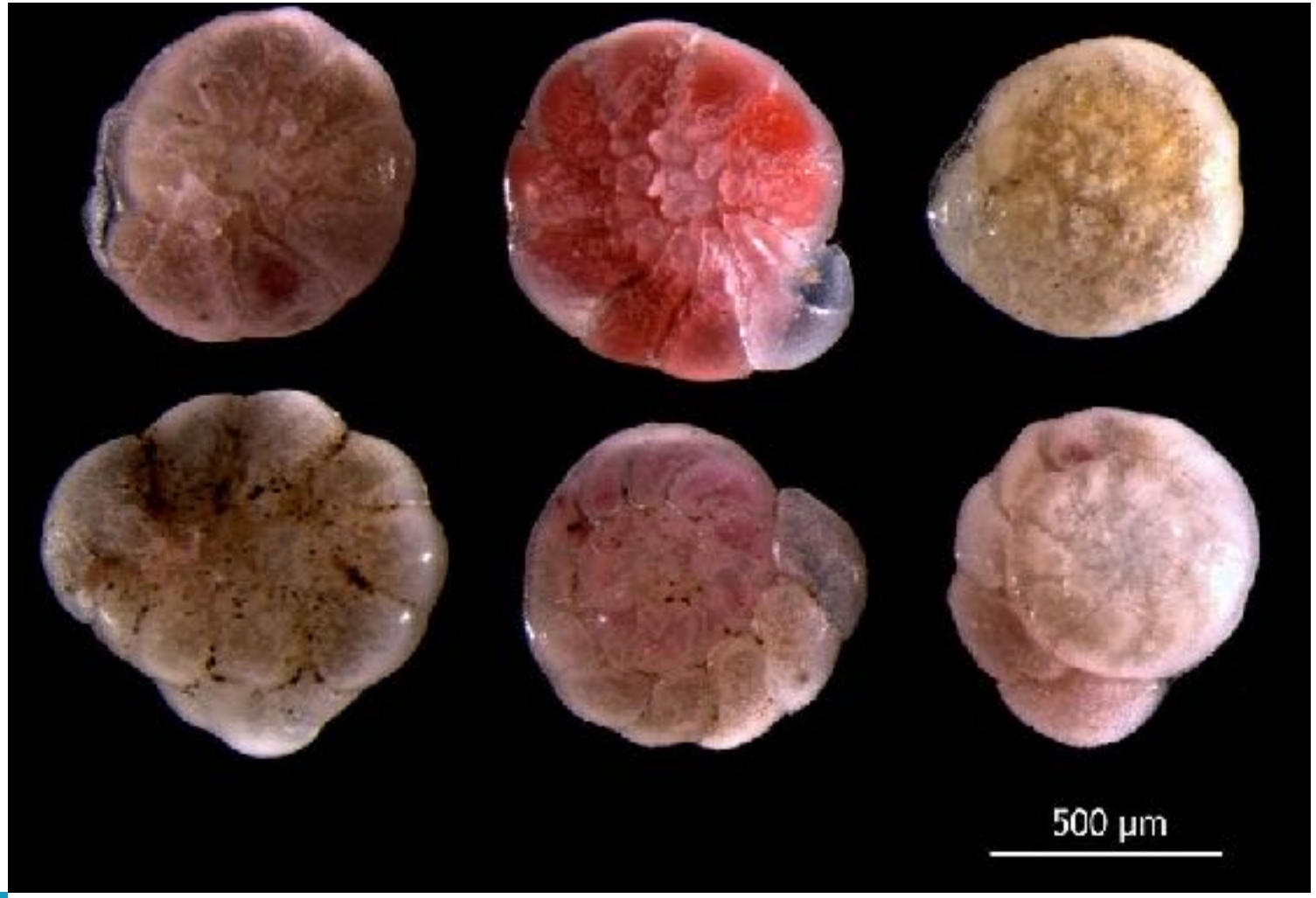
Dissolving pteropods



*Pteropod shells quickly **dissolve** in conditions predicted for the Southern Ocean by 2100*

Photos by David Liittschwager / National Geographic Stock

Other biotic impacts



Changes to:

- Photosynthesis
- Oxygen exchange
- Reproduction
- Nitrogen fixation
- Navigation
- Predator avoidance

Porcelain crabs

Higher temperatures at low tide + lower pH results in:

- Lower metabolism
- Less energy for reproduction, defence
- Behavioural changes

Source: Adam Paganini

Hypercapnia:

Carbon Dioxide toxicity

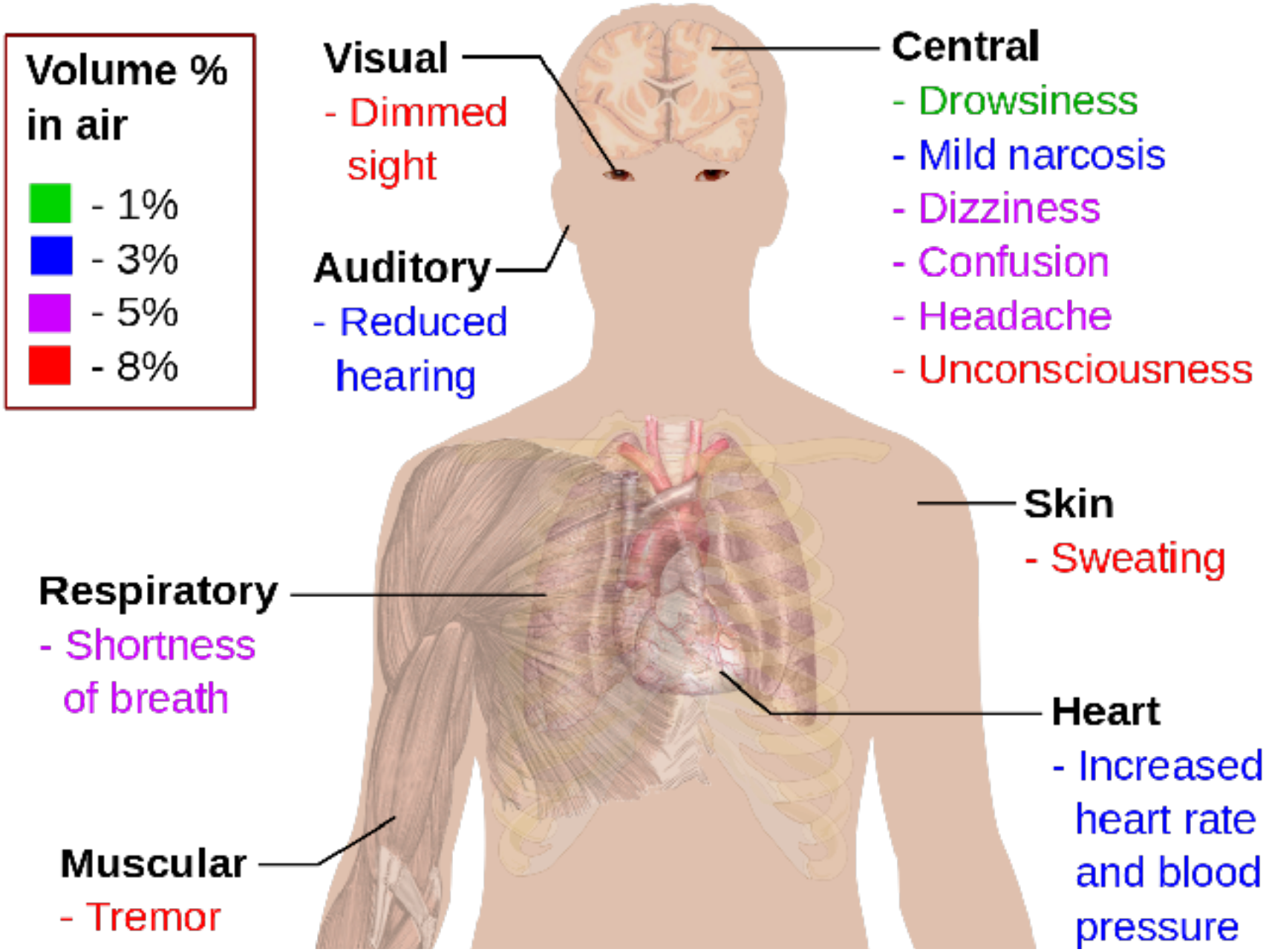


Illustration by Mikael Häggström, 2014

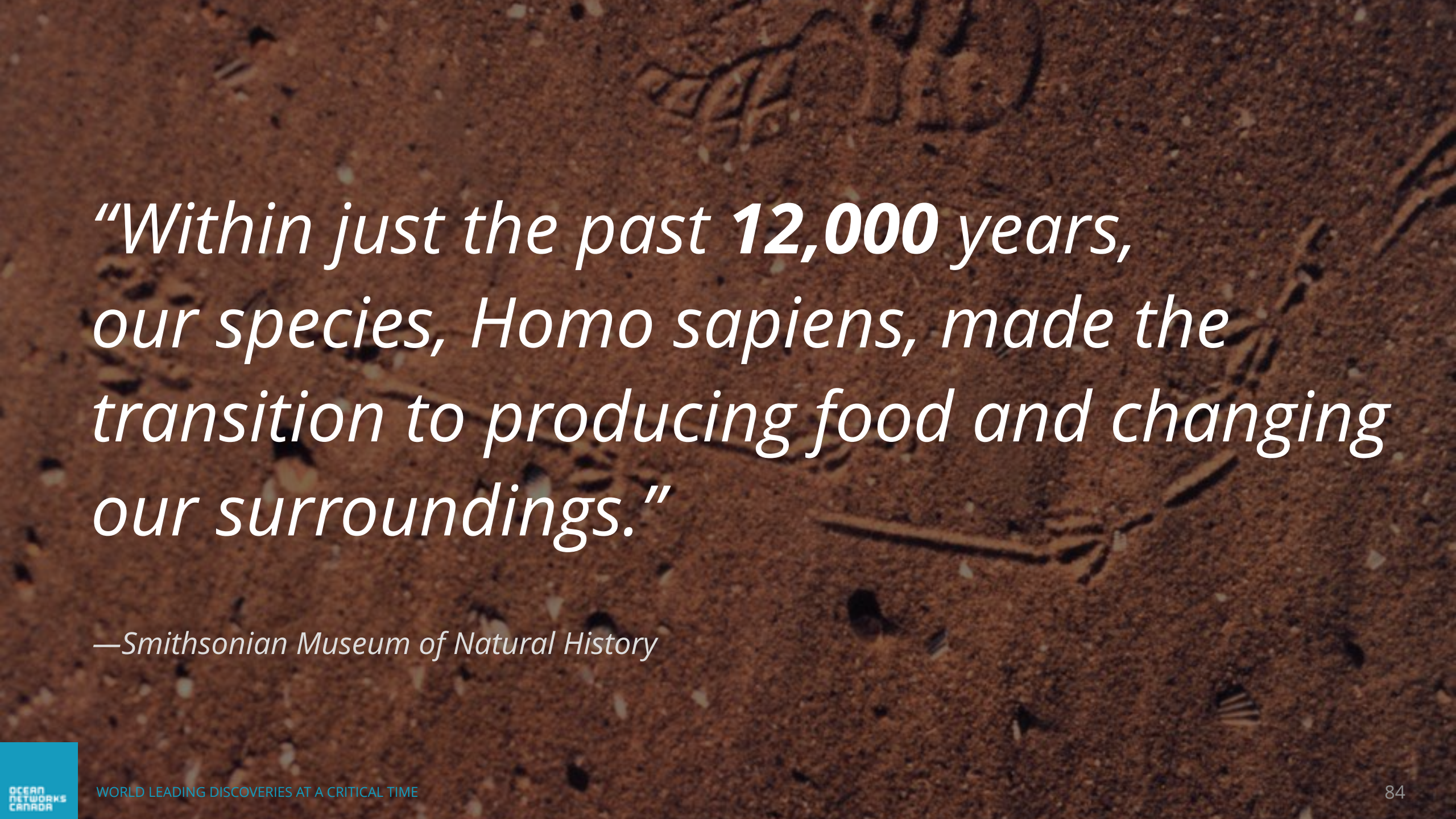

0:15 / 1:57

We're conducting an **uncontrolled experiment** on our oceans.

Cascading interdependent impacts from changes in pH are ***hard to predict***, but likely very ***difficult to undo***.

Go to **www.menti.com** and enter code **83 13 16 8**

How long do you think *Homo sapiens* have existed on Earth?


*"Within just the past **12,000** years, our species, Homo sapiens, made the transition to producing food and changing our surroundings."*

—Smithsonian Museum of Natural History

CO_2 pollution

warms the ocean, creating marine heat waves,

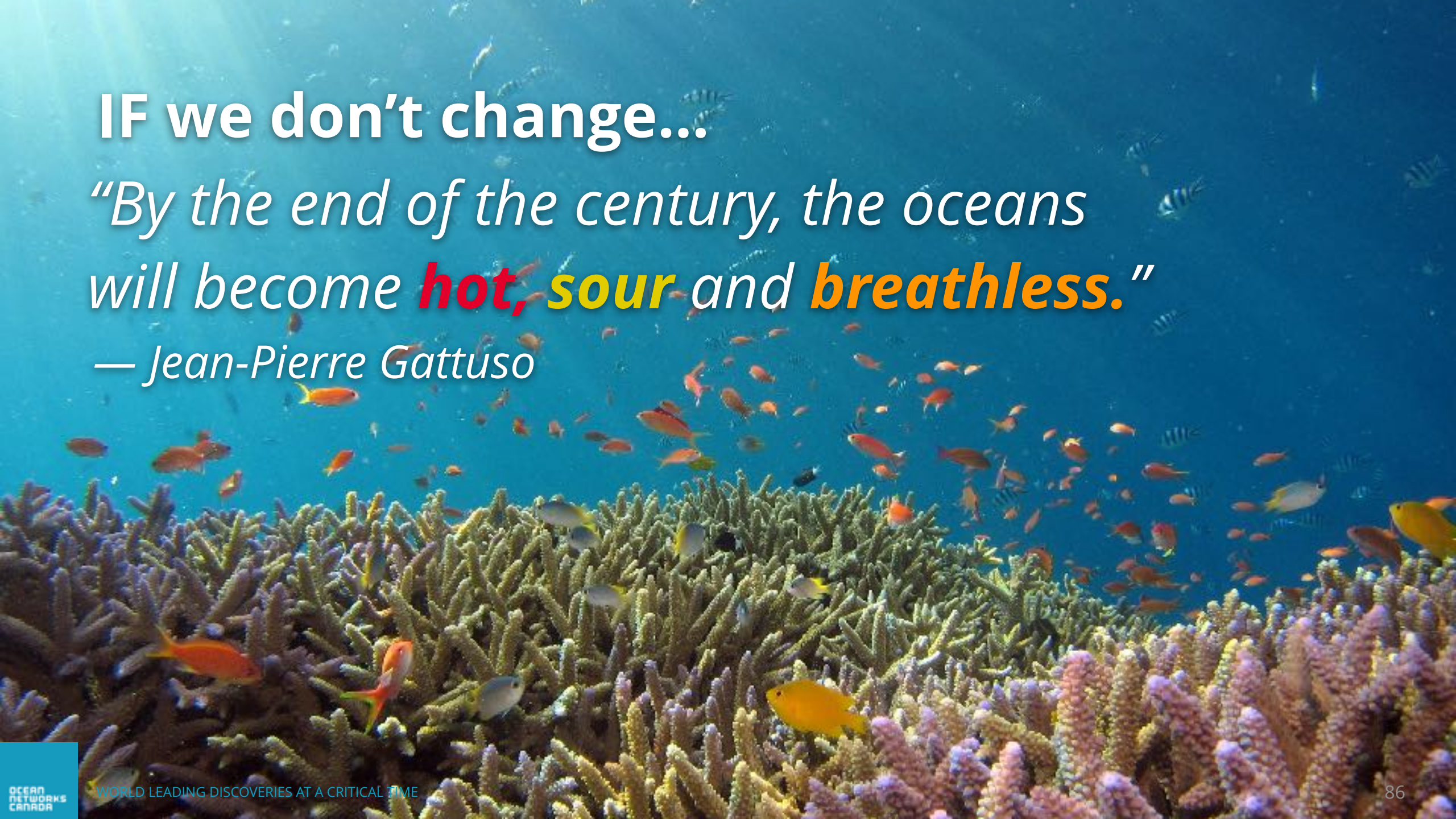
and **stratifies** the ocean,

which **reduces oxygen**.

…CO_2 pollution *also:*

makes the ocean more **acidic**,

which **impacts marine life.**



IF we don't change…

*"By the end of the century, the oceans will become **hot, sour** and **breathless.**"*

— Jean-Pierre Gattuso

Dangerous times

*"...We are at the **most dangerous moment** in the development of humanity. We now have the **technology to destroy the planet** on which we live, but have not yet developed the ability to escape it."*

— Stephen Hawking

Photo by Rogelio A. Galaviz C._via Flickr

Break-out Discussion: 10 min

Let's talk about this.

What can we can we do about these issues?


There are many things we can
do for our ocean.
Try to do *something*.


The ocean thanks you.

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THANK YOU!

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Q&A