Bigelow | Laboratory for Ocean Sciences

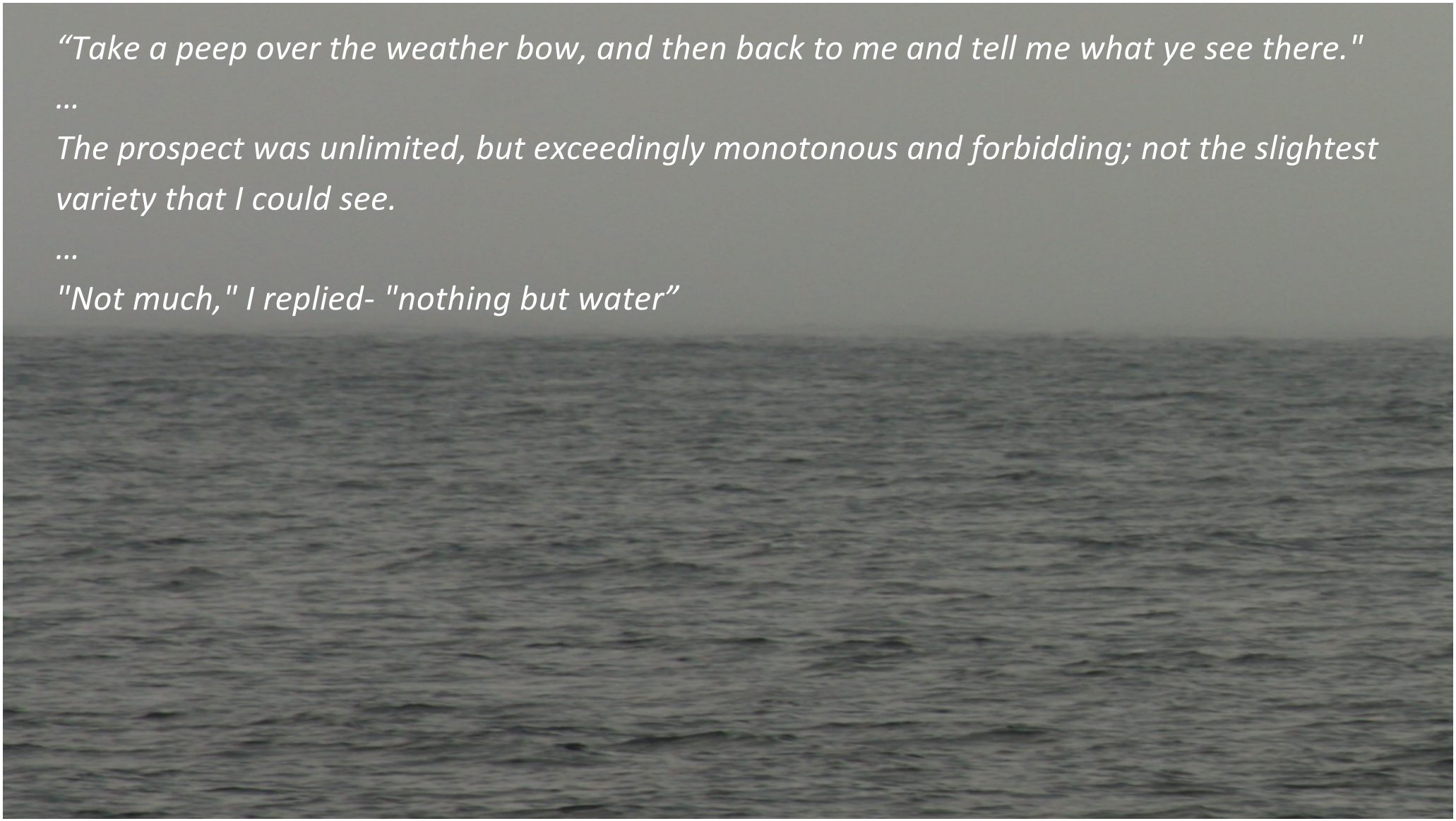
Ocean Science & Gulf of Maine

Primer

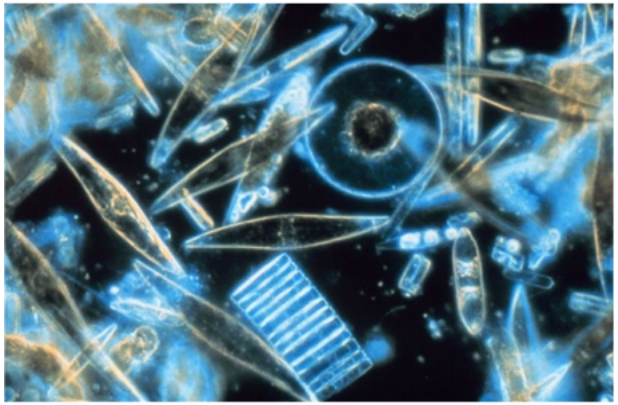
Nick Record

Tandy Center for Ocean Forecasting

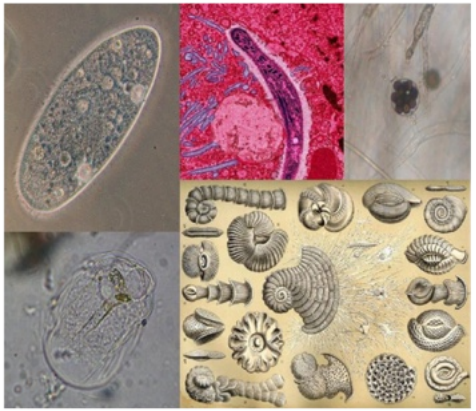
Colby Jan Plan: JP297Dj


“Take a peep over the weather bow, and then back to me and tell me what ye see there."
…
The prospect was unlimited, but exceedingly monotonous and forbidding; not the slightest variety that I could see.
…
"Not much," I replied- "nothing but water”

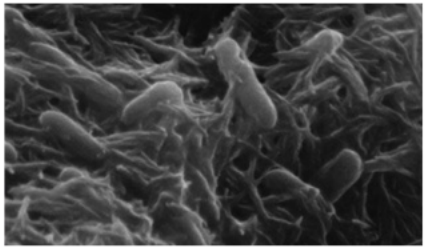
One liter of seawater can contain:



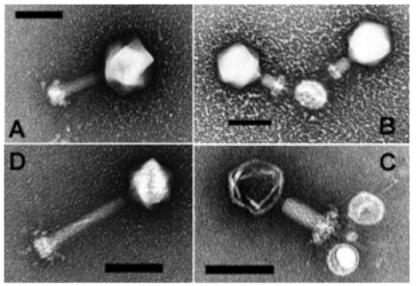
1,000,000 phytoplankton



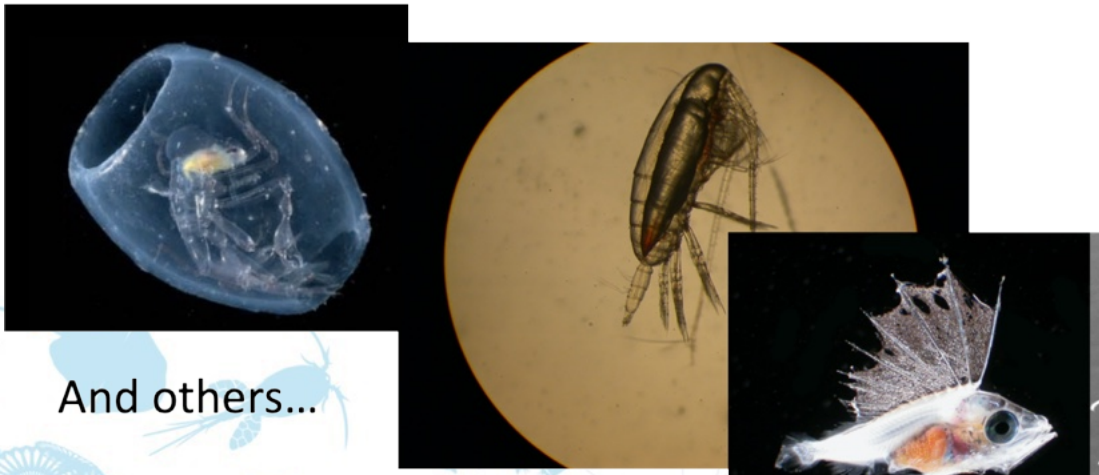
1,000,000 protists

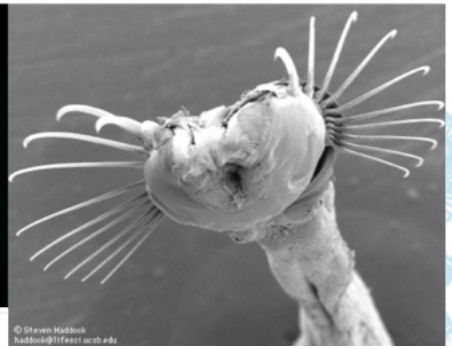


1,000,000,000 bacteria



10,000,000,000 viruses

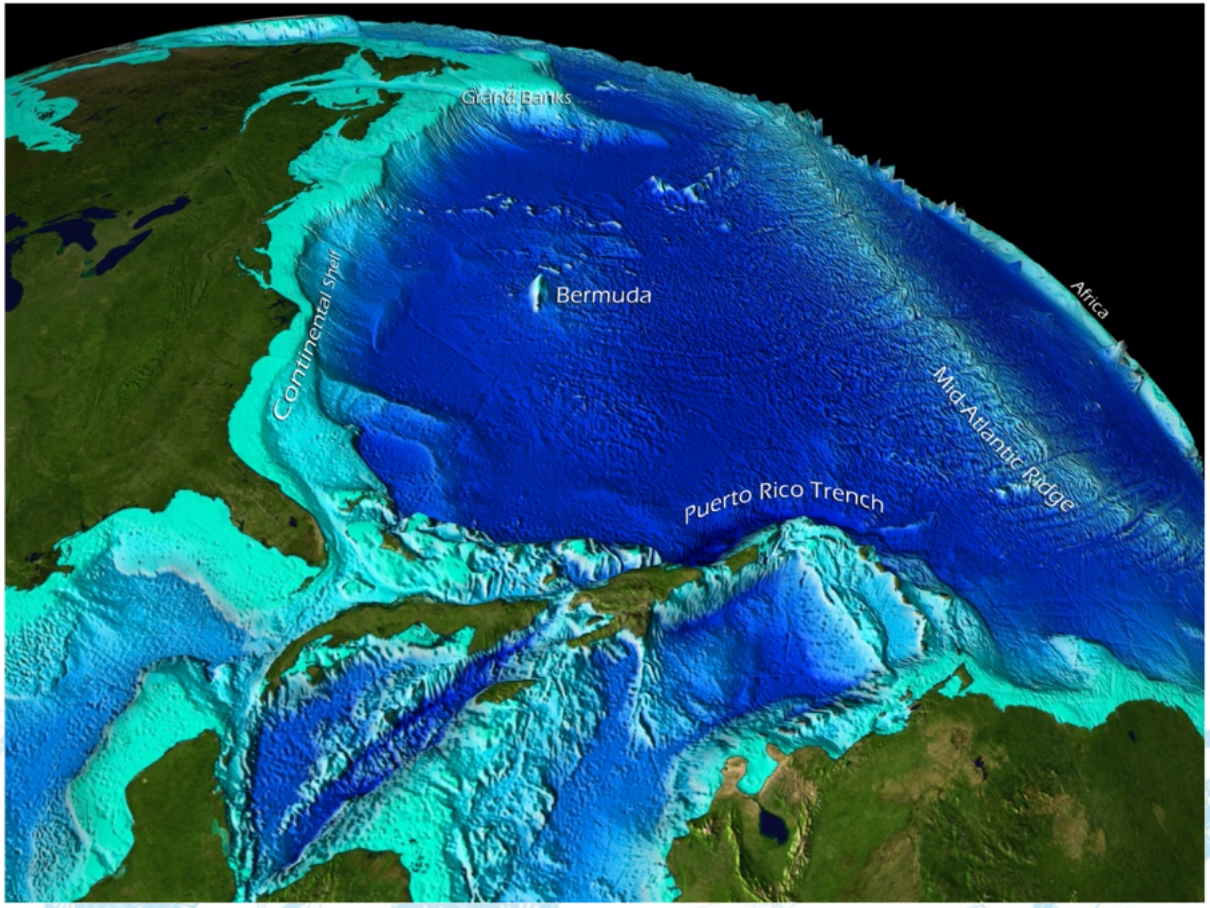




And others…

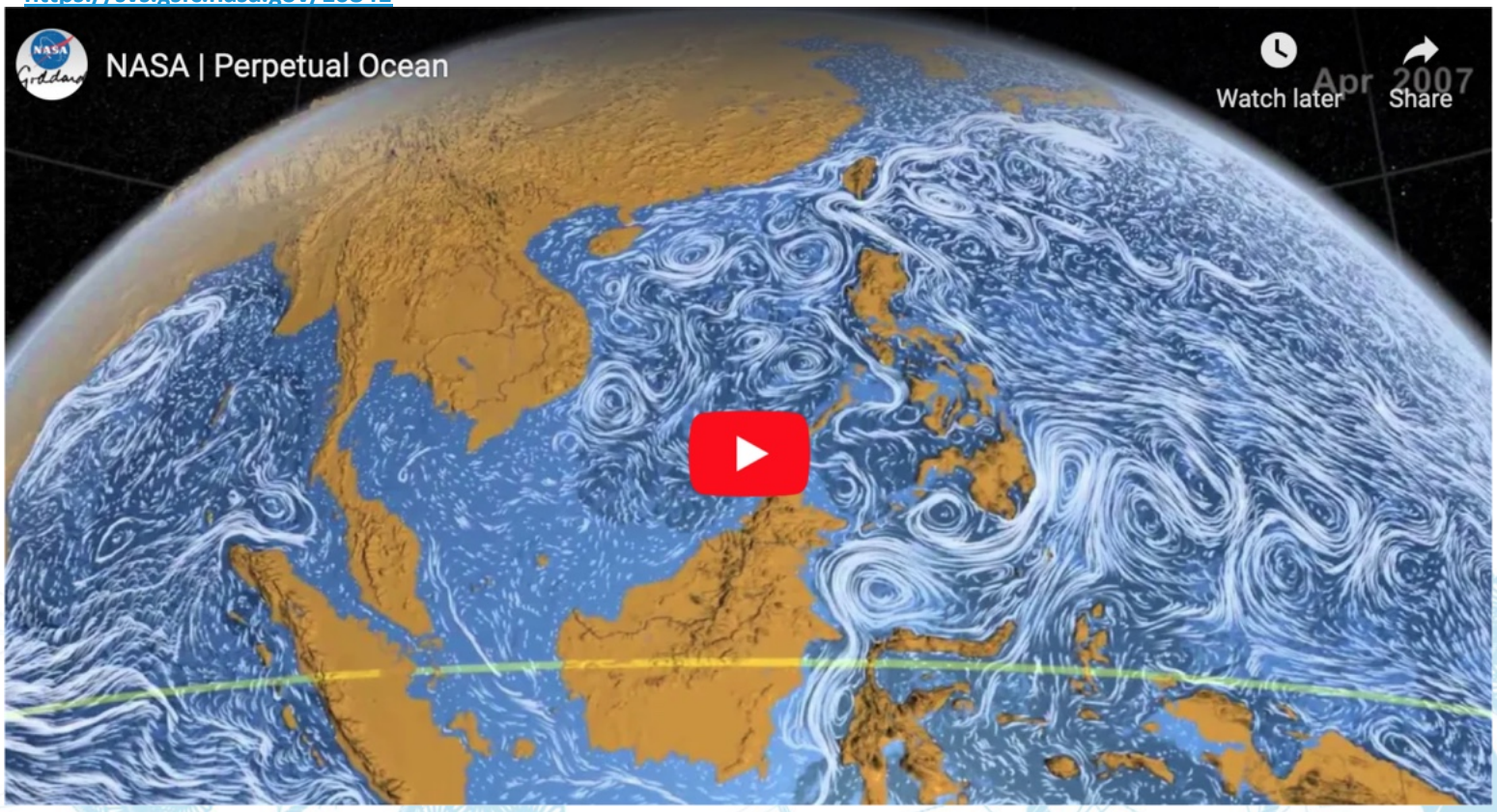
Ocean Science Disciplines

Geology


Grand Banks
Bermuda
Continental Shelf
Africa
Mid-Atlantic Ridge
Puerto Rico Trench

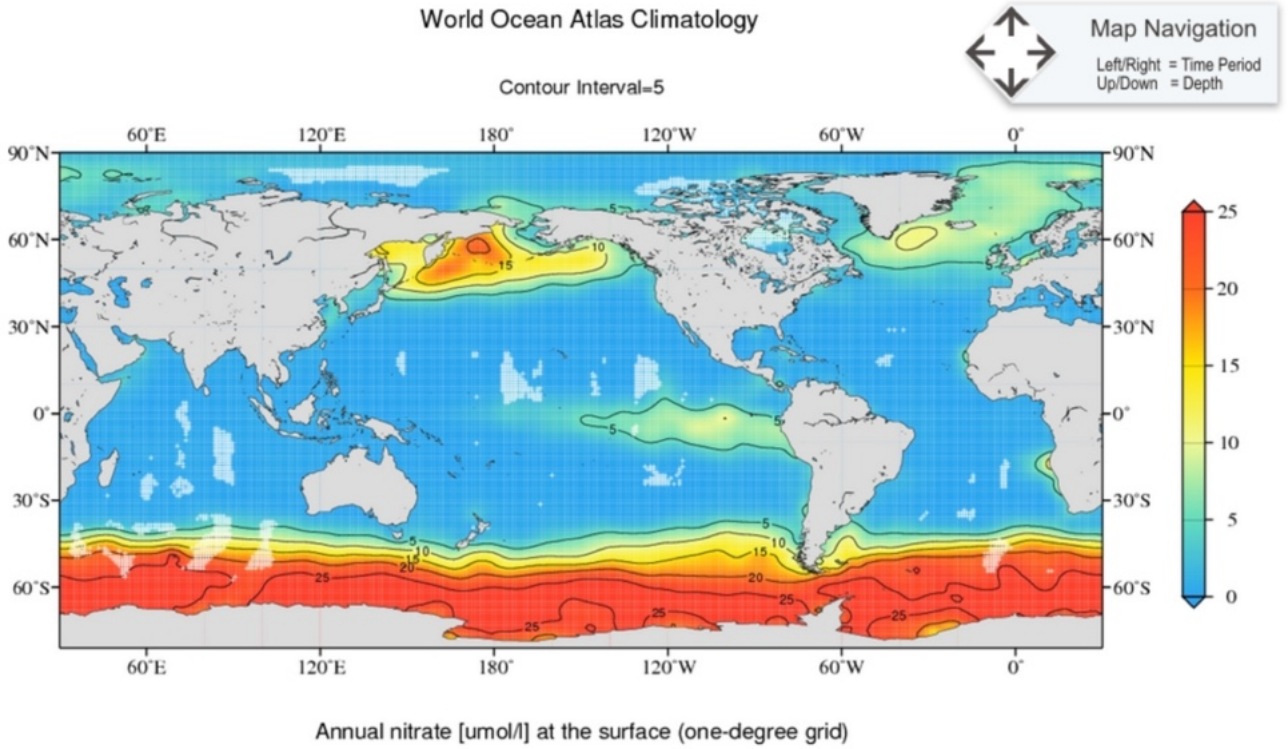
Physics

https://svs.gsfc.nasa.gov/10841



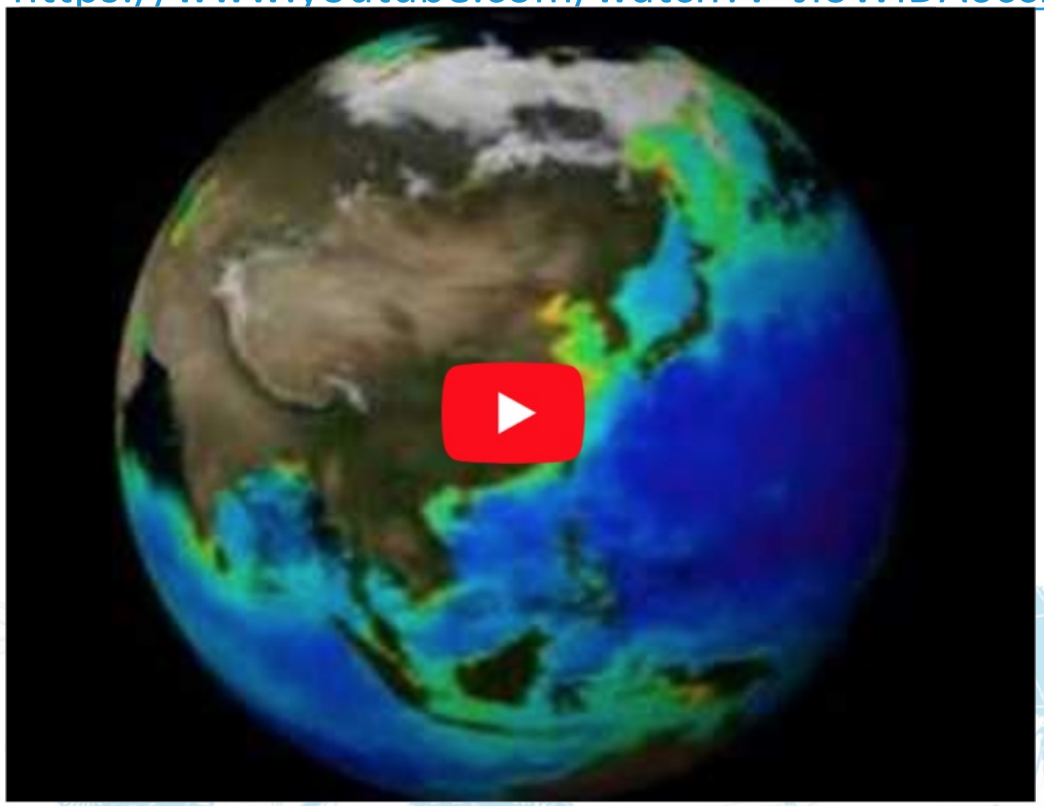
Chemistry

- Nutrients
- Trace metals
- Toxins
- pH
- …



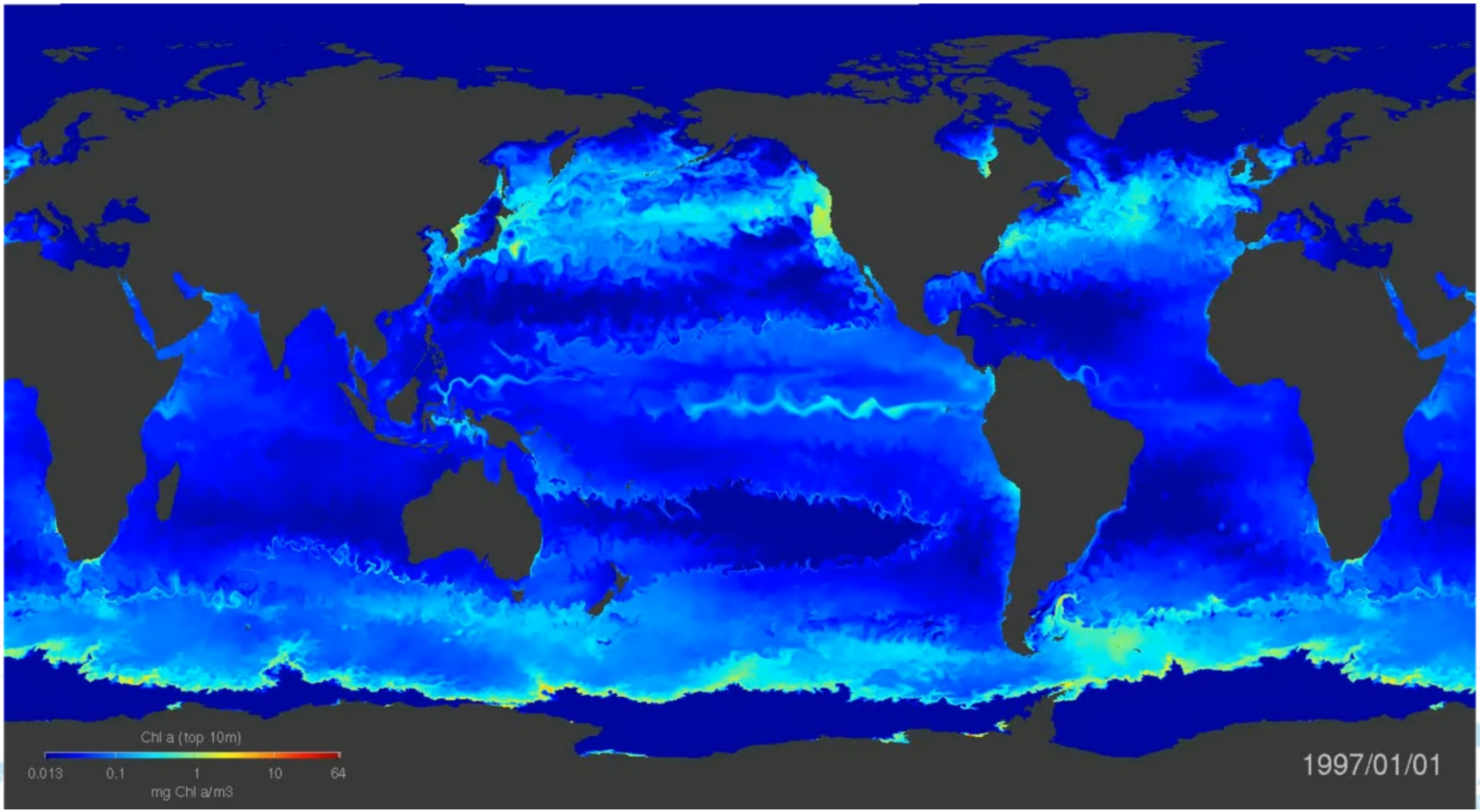
Biology

https://www.youtube.com/watch?v=JloWlDA6ccM



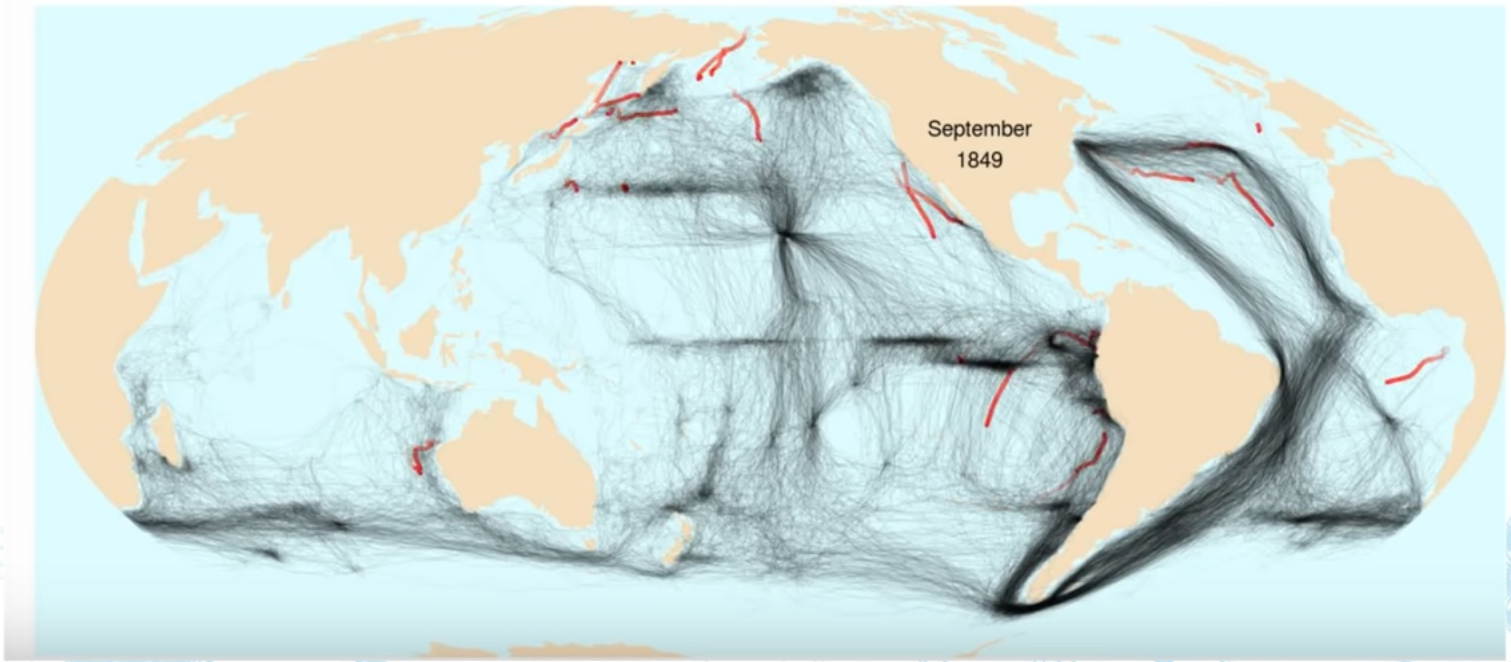
- Environmental DNA
- Viruses
- Bacteria
- Phytoplankon
- Zooplankton
- Fish
- Mammals
- …

Ecology



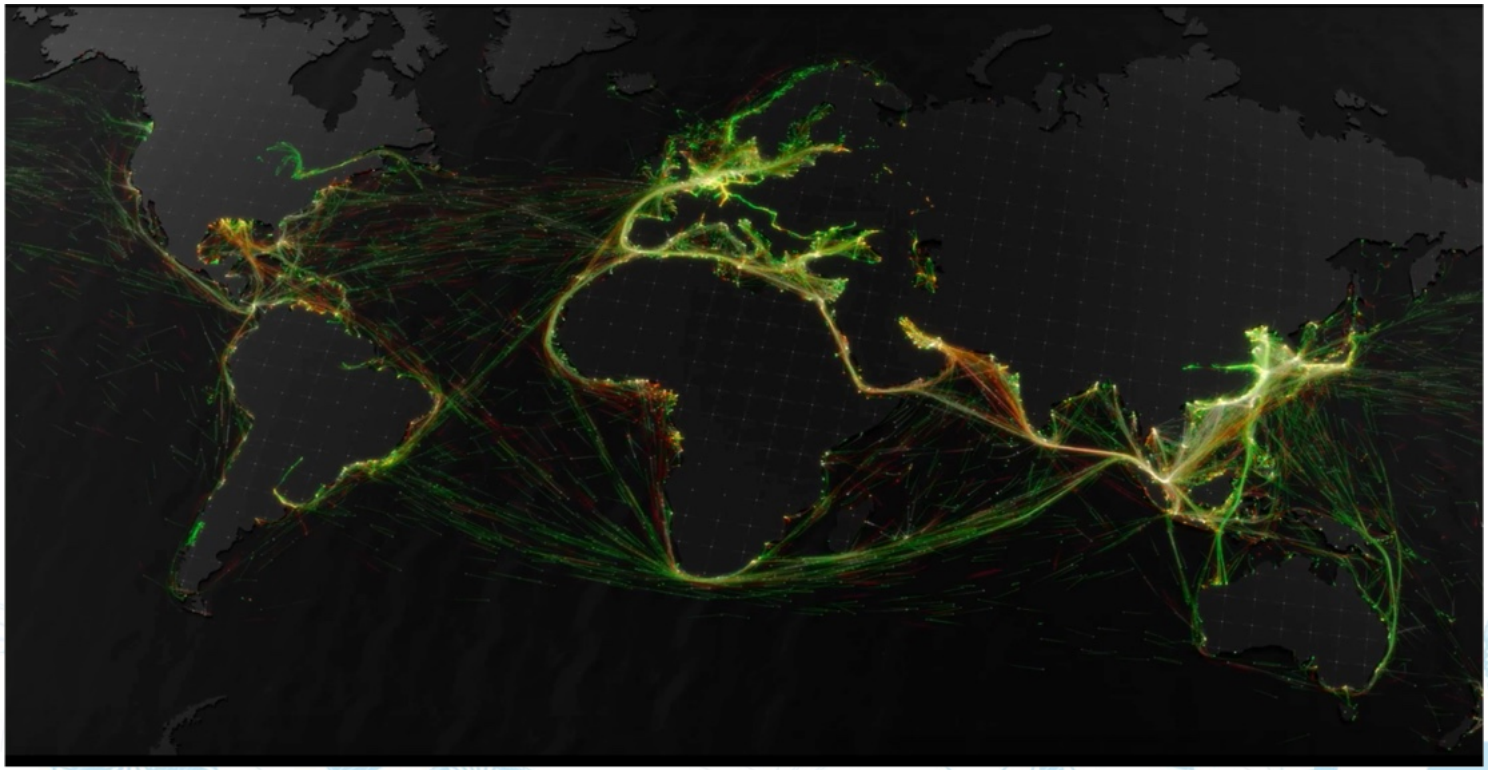
Human Systems

https://www.youtube.com/watch?v=Tn7fQ5mYHPA



Human Systems

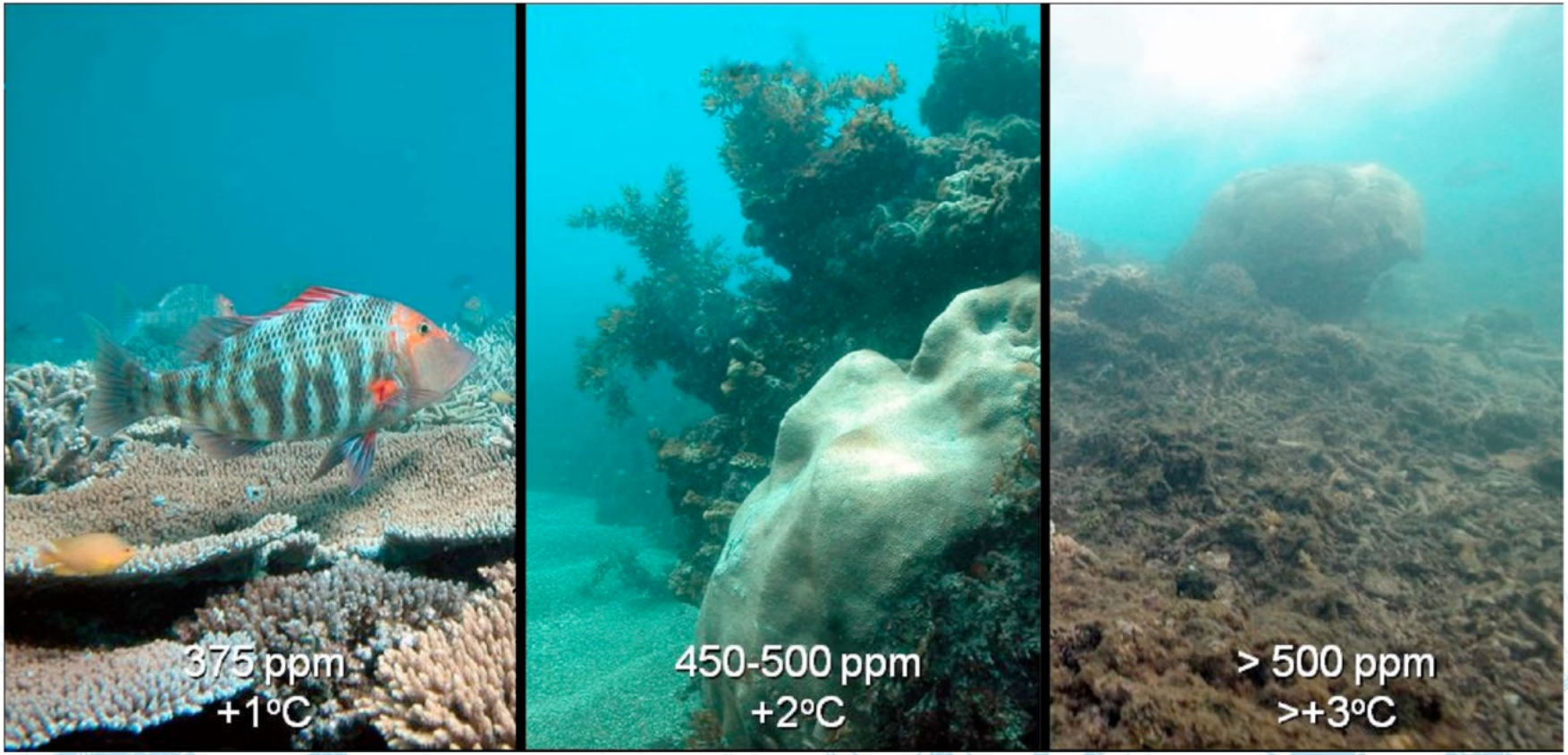
https://www.youtube.com/watch?v=JLg1_dnWXR8



Societal Issues (in no particular order)

Endangered / Threatened Species

Ocean Acidification



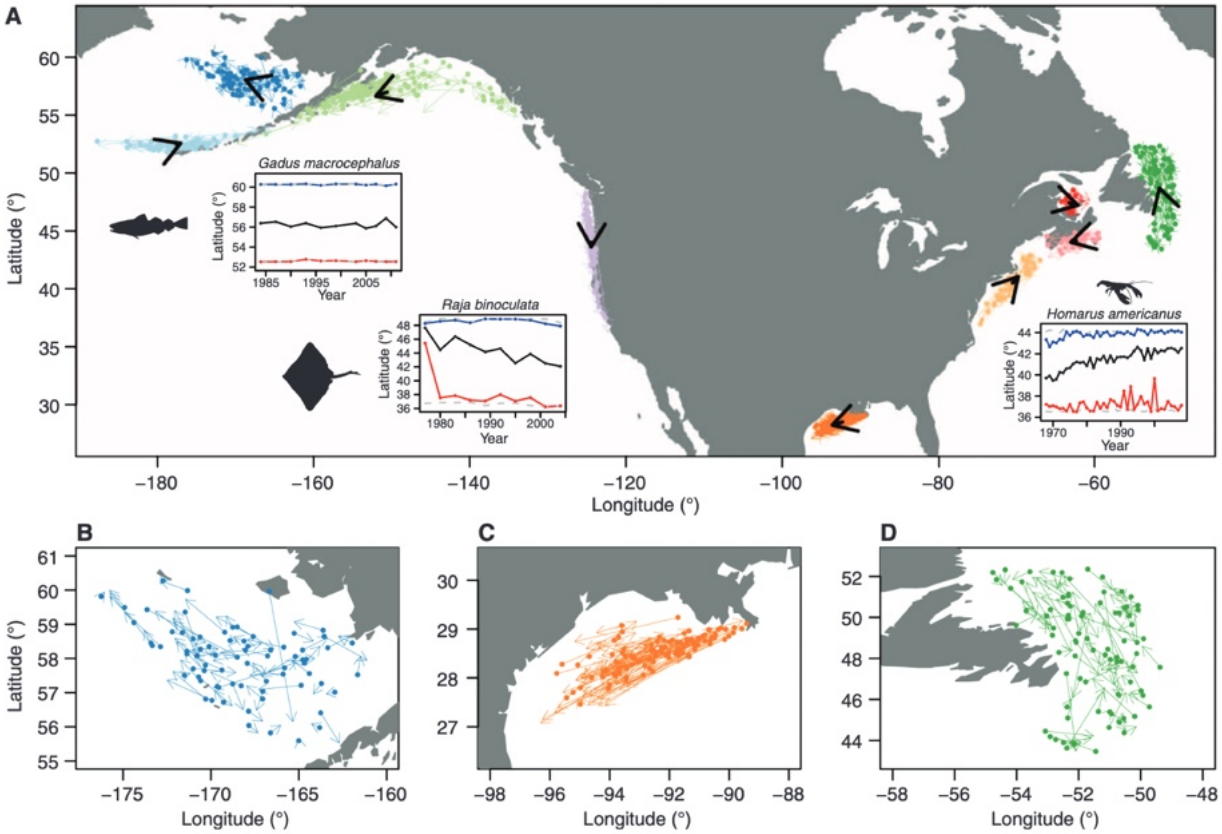
Climate Change Mitigation

Marine carbon dioxide removal

- Iron fertilization
- Sinking material
- Restoring large animal populations
- Chemical methods

https://www.bigelow.org/services/seafood-solutions/coast-cow-consumer.html

Range shifts



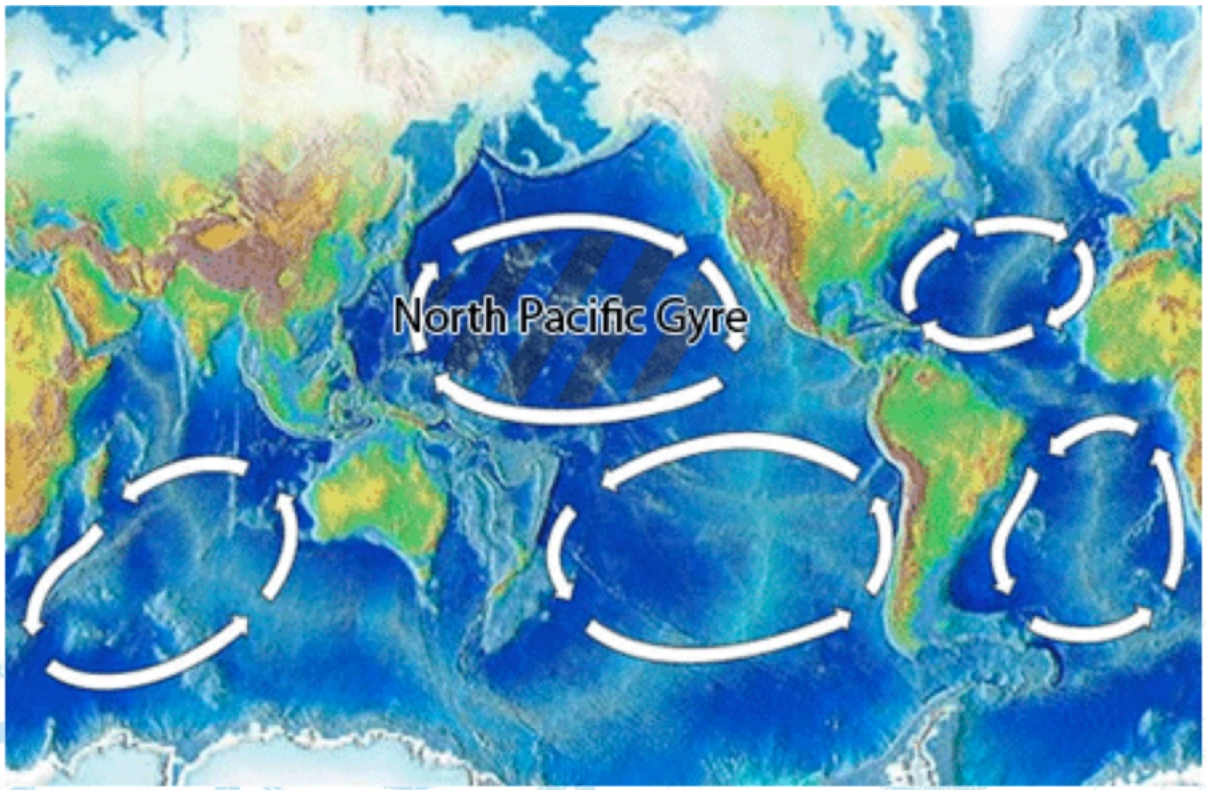
Pinsky ML, Worm B, Fogarty MJ, Sarmiento JL, Levin SA. Marine taxa track local climate velocities. Science. 2013 Sep 13;341(6151):1239-42.

Pollution

- Oil spills
- Toxins
- Mercury
- PCBs
- PFAS

Ocean Plastics

- Microplastics
- Macro trash



Invasive Species

Shiganova T, Mirzoyan Z, Studenikina E, Volovik S, Siokou-Frangou I, Zervoudaki S, Christou E, Skirta A, Dumont H. Population development of the invader ctenophore Mnemiopsis leidyi, in the Black Sea and in other seas of the Mediterranean basin. Marine biology. 2001 Sep;139:431-45.

Eutrophication

- Overfertilizing
- → dead zones

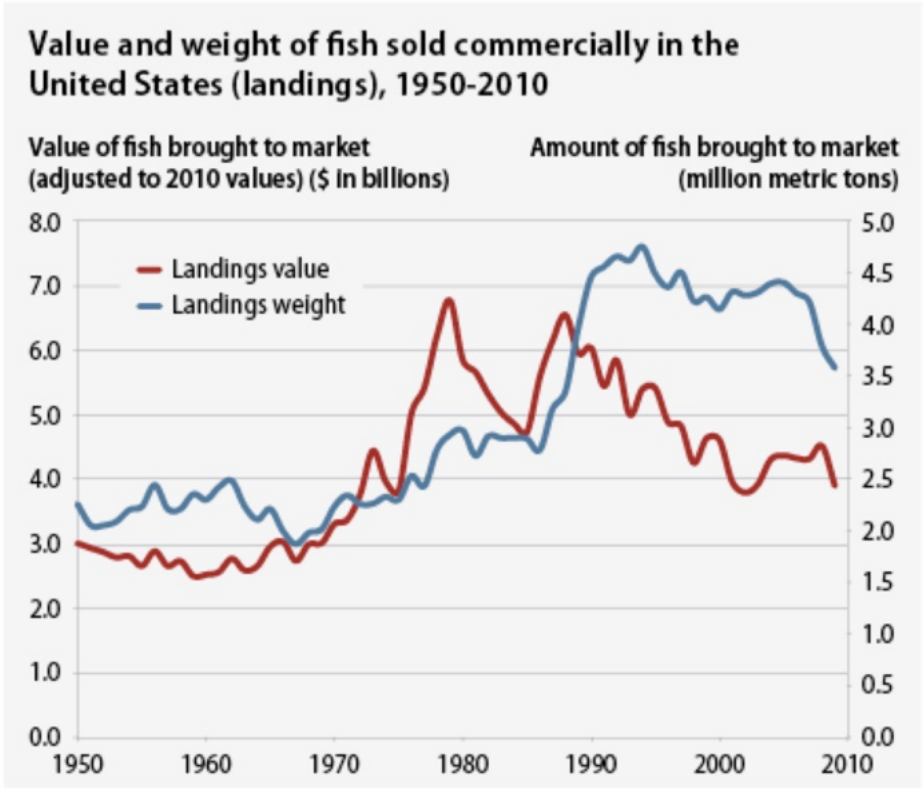
Harmful/Toxic Blooms

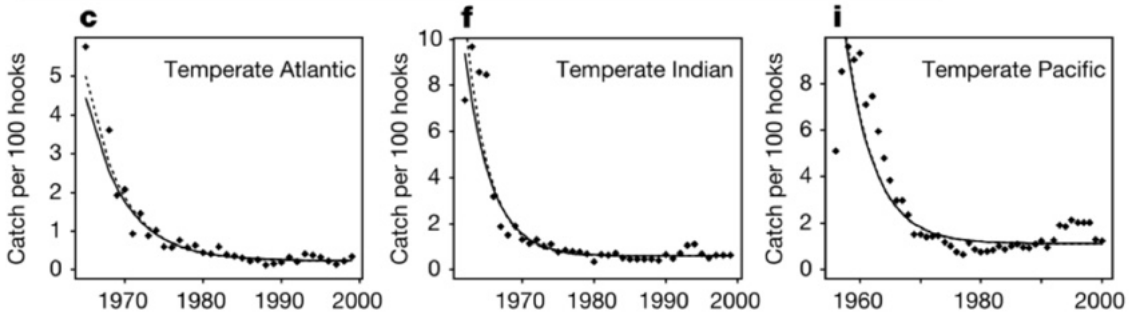
Red tides

Brown tides

Not visible ones

Overfishing





Sea level rise

https://maineboats.com/print/issue-181/solving-puzzle-maine%E2%80%99s-moving-coastline

UN Ocean Decade

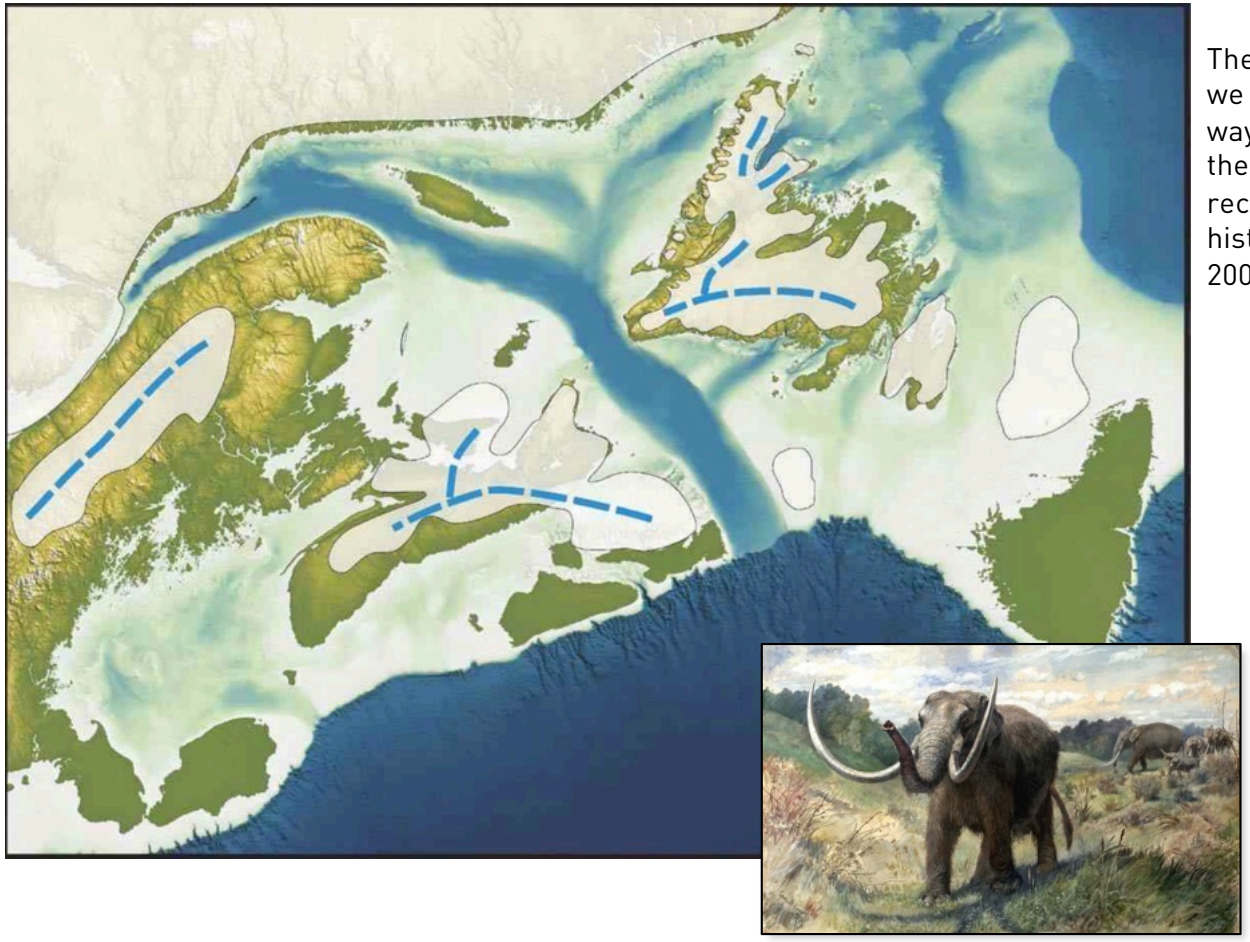
For most of human history, people considered the ocean so immense, bountiful, and resilient that it was impossible to deplete or disrupt it. The overarching narrative was, “The ocean is so vast, it is simply too big to fail.”

In healing the ocean, we can heal ourselves. The ocean sustains and feeds us. It connects us. It is our past and our future. The ocean is not too big to fail, nor is it too big to fix. It is too big to ignore.

Lubchenco J, Gaines SD. A new narrative for the ocean. Science. 2019 Jun 7;364(6444):911-.

Gulf of Maine

Ye olde Gulf of Maine

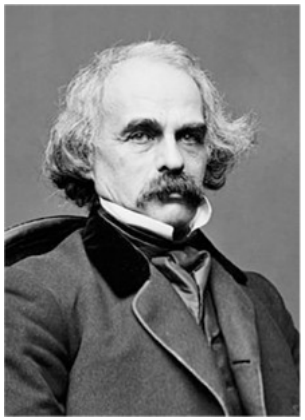


The Gulf of Maine as we know it is in many ways younger than the beginning of recorded human history. (Apollonio 2002)

Ye olde Gulf of Maine

... cod appeared so thick that a person "could walk across their backs."
John Cabot (NL)

Hunters in small watercraft pursued right whales from shore

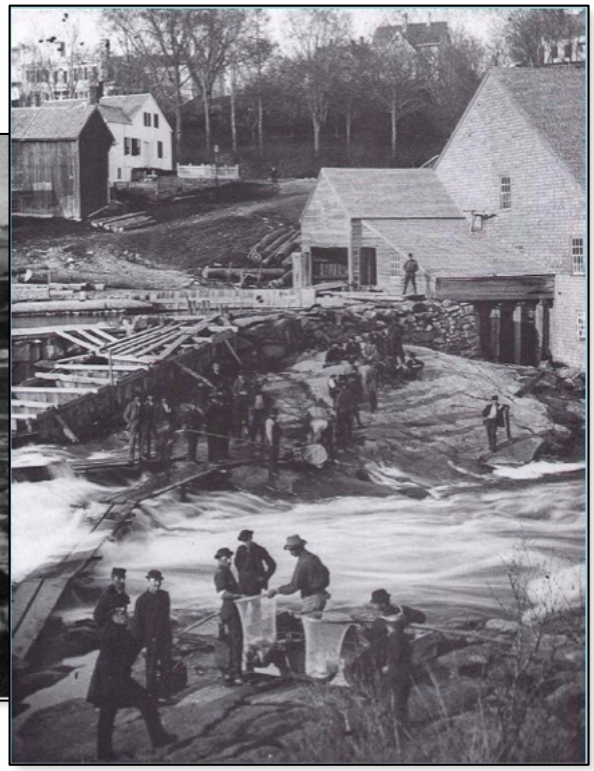


"...caught a black-spotted trout that was almost a whale. It weighed...eighteen and one-half pounds."
Nathaniel Hawthorne

Herring gulls hunted nearly to extinction
Early conservation focus for
Audubon Society

Ye olde Gulf of Maine

- Pilot whales harvested by the thousands annually on Cape Cod
- Diadromous fish numbered in the billions
- Tuna was bycatch of a coastal herring fishery
- Swordfish in Portland Harbor



from Levenworth, RARGOM 2014

Ye olde Gulf of Maine

- Difficult to define the **historical baseline**
- **How to live in a changing system?**

The environment now is changing more rapidly

1912

The Rodney & Otamatea Times
WAITEMATA & KAIPARA GAZETTE.
PRICE—10s per annum in advance
WARKWORTH, WEDNESDAY, AUGUST 14, 1912.
3d per Copy.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

1938

THE ARTIFICIAL PRODUCTION OF CARBON DIOXIDE AND ITS INFLUENCE ON TEMPERATURE

By G. S. CALLENDAR

(Steam technologist to the British Electrical and Allied Industries Research Association.)

(Communicated by Dr. G. M. B. Dobson, F.R.S.)

[Manuscript received May 19, 1937—read February 16, 1938.]

SUMMARY

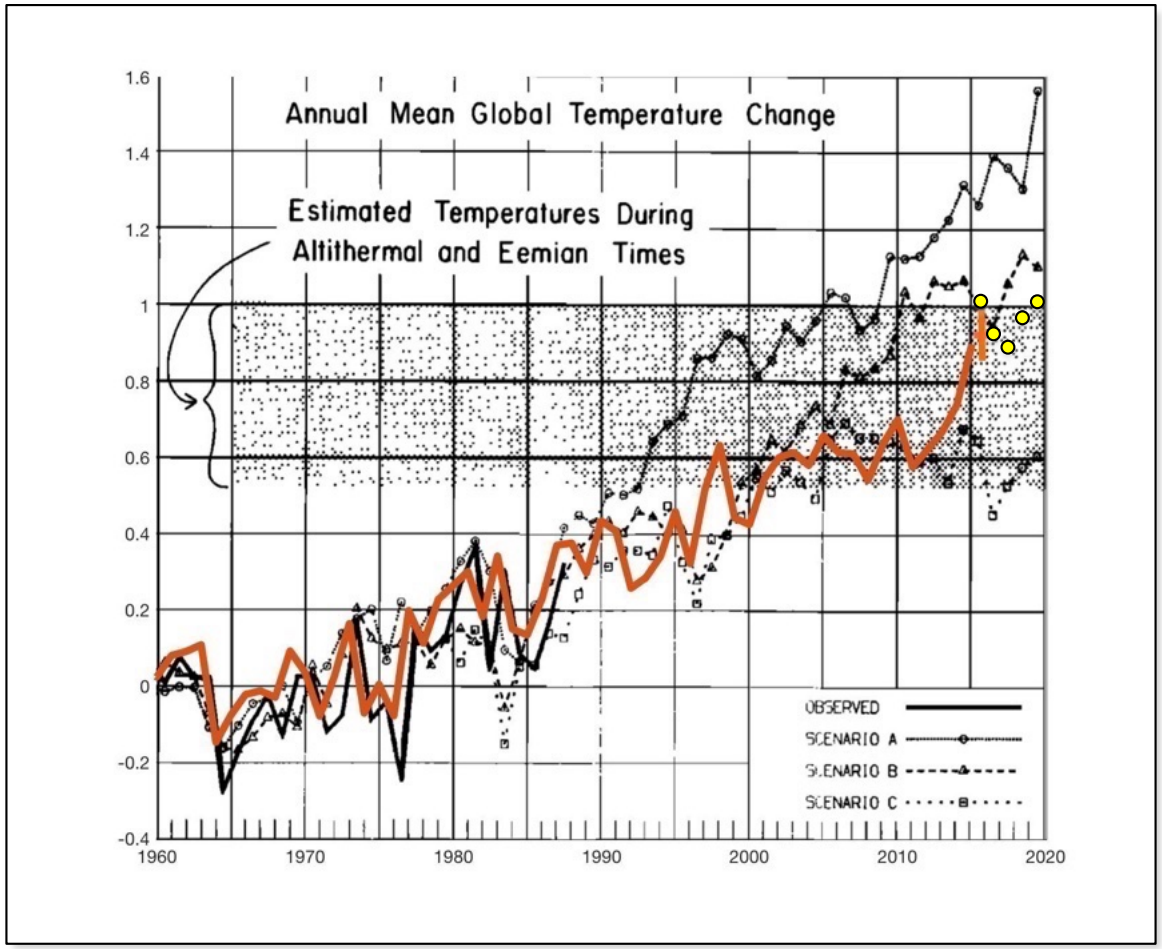
By fuel combustion man has added about 150,000 million tons of carbon dioxide to the air during the past half century. The author estimates from the best available data that approximately three quarters of this has remained in the atmosphere.

1965

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

- President Lyndon B. Johnson, 1965

1988



Hansen J, Fung I, Lacis A, Rind D, Lebedeff S, Ruedy R, Russell G, Stone P. Global climate changes as forecast by Goddard Institute for Space Studies three-dimensional model. Journal of geophysical research: Atmospheres. 1988 Aug 20;93(D8):9341-64.

1982

Industry Research – Exxon memos

required for doubling of atmospheric CO_2 depends on future world consumption of fossil fuels. Current projections indicate that doubling will occur sometime in the latter half of the 21st century. The models predict that CO_2-induced climate changes should be observable well before doubling. It is generally believed that the first unambiguous CO_2-induced temperature increase will not be observable until around the year 2000.

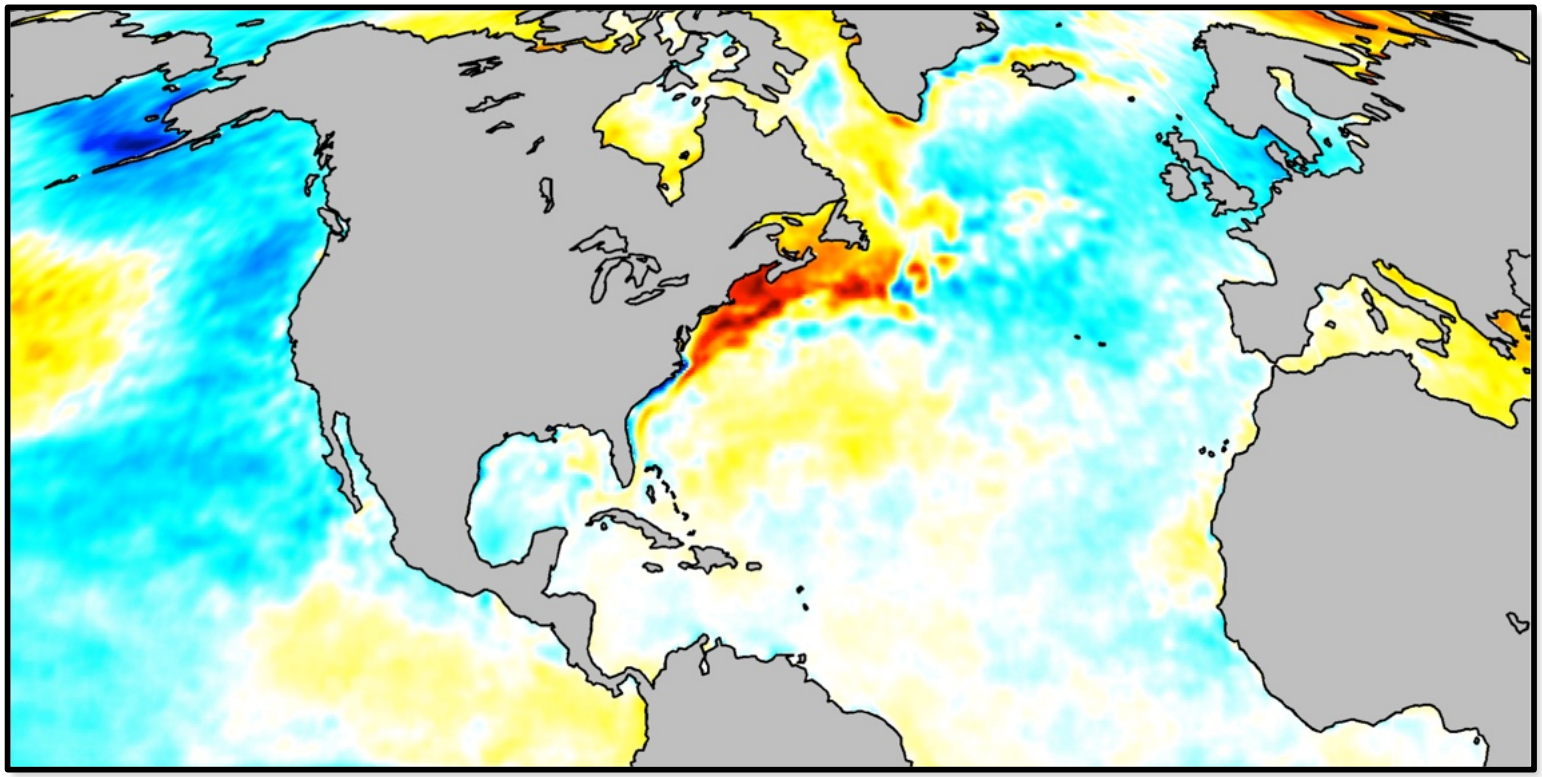
elevations in the polar regions and relatively small increases near the equator. There is unanimous agreement in the scientific community that a temperature increase of this magnitude would bring about significant changes in the earth's climate, including rainfall distribution and alterations in the biosphere. The time

As we discussed in the August 24 meeting, there is the potential for our research to attract the attention of the popular news media because of the connection between Exxon's major business and the role of fossil fuel combustion in contributing to the increase of atmospheric CO_2. Despite the fact that our results are in accord with those of most researchers in the field

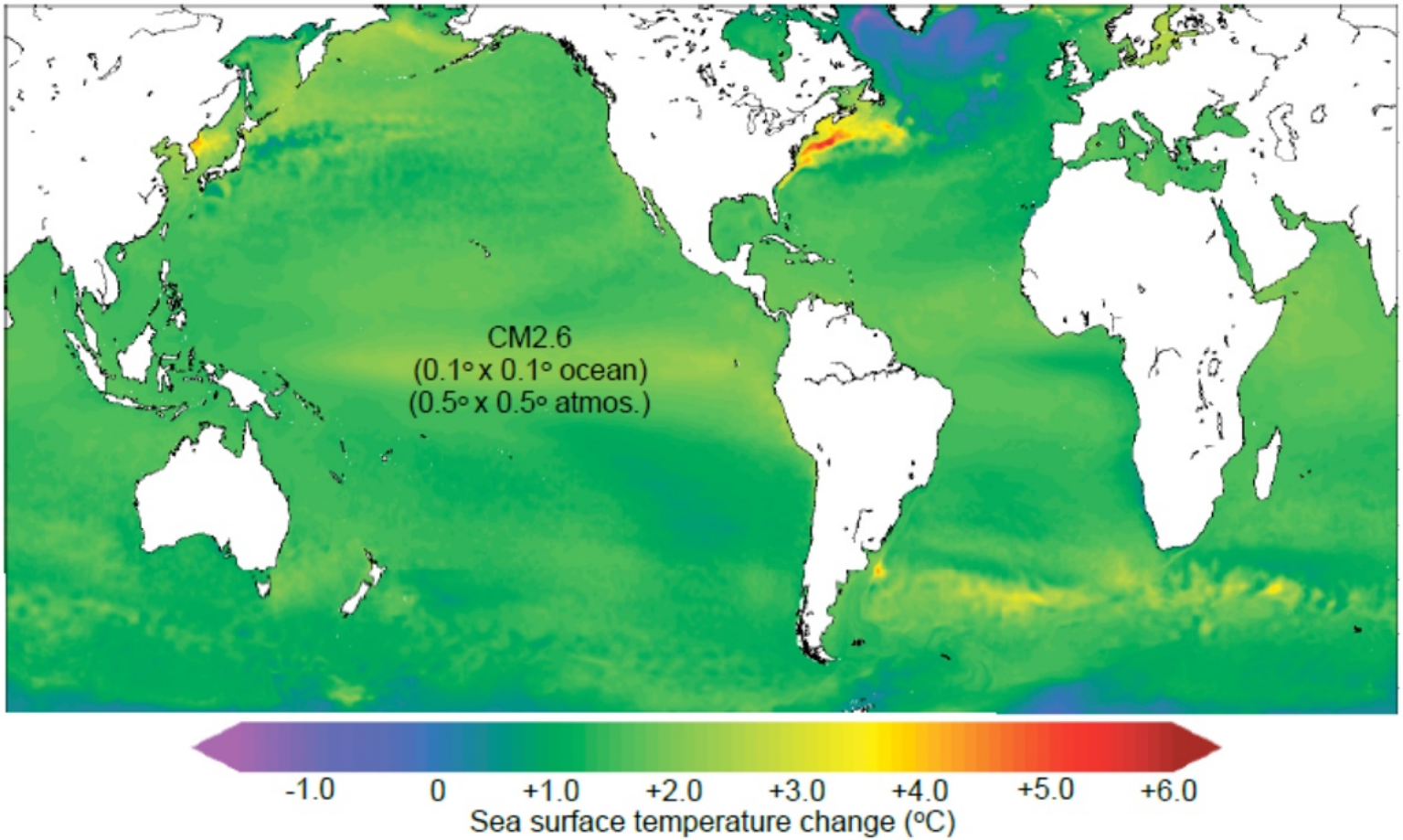
Some places more rapidly than others...

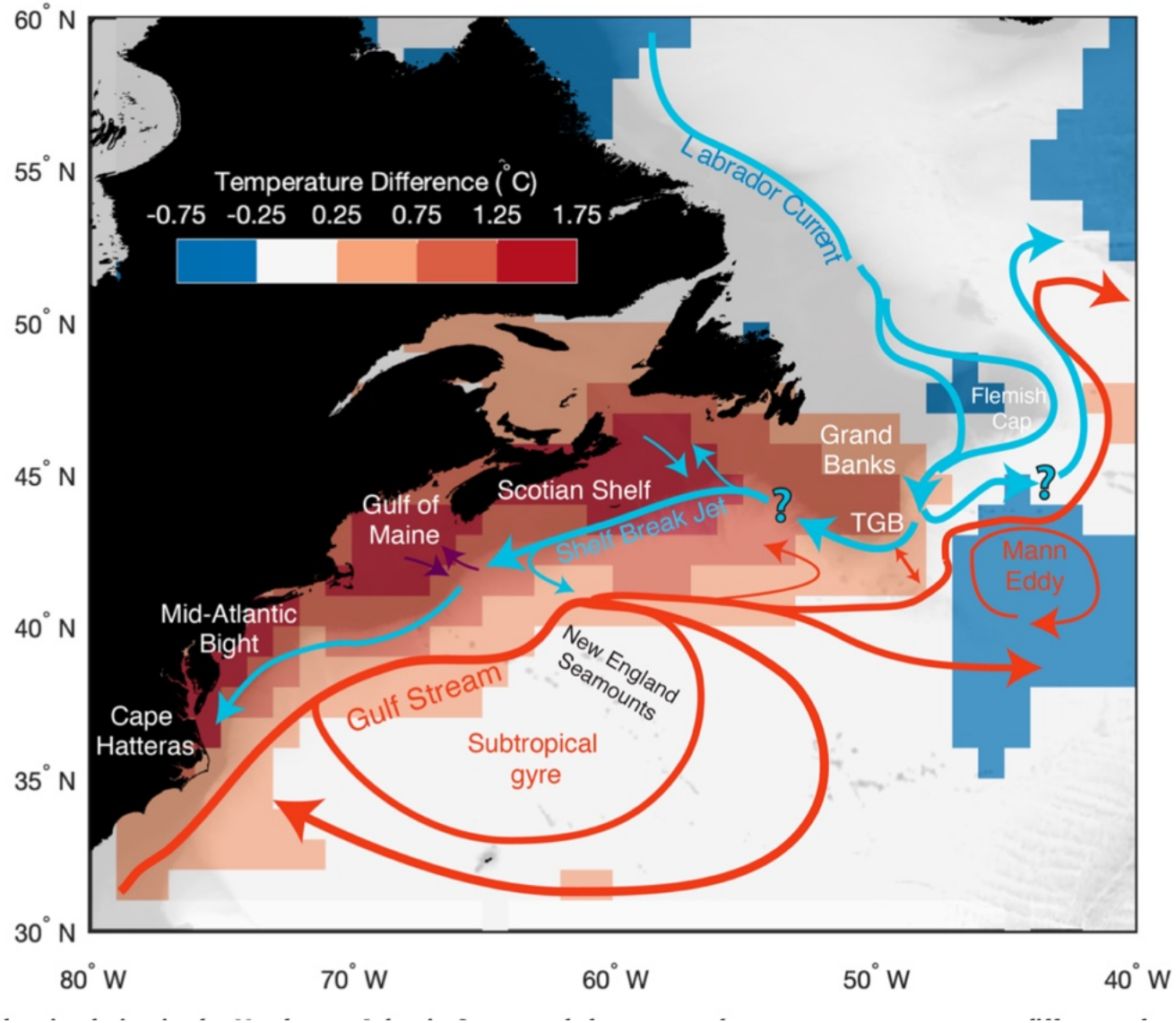
Gulf of Maine

2000s



The Gulf of Maine

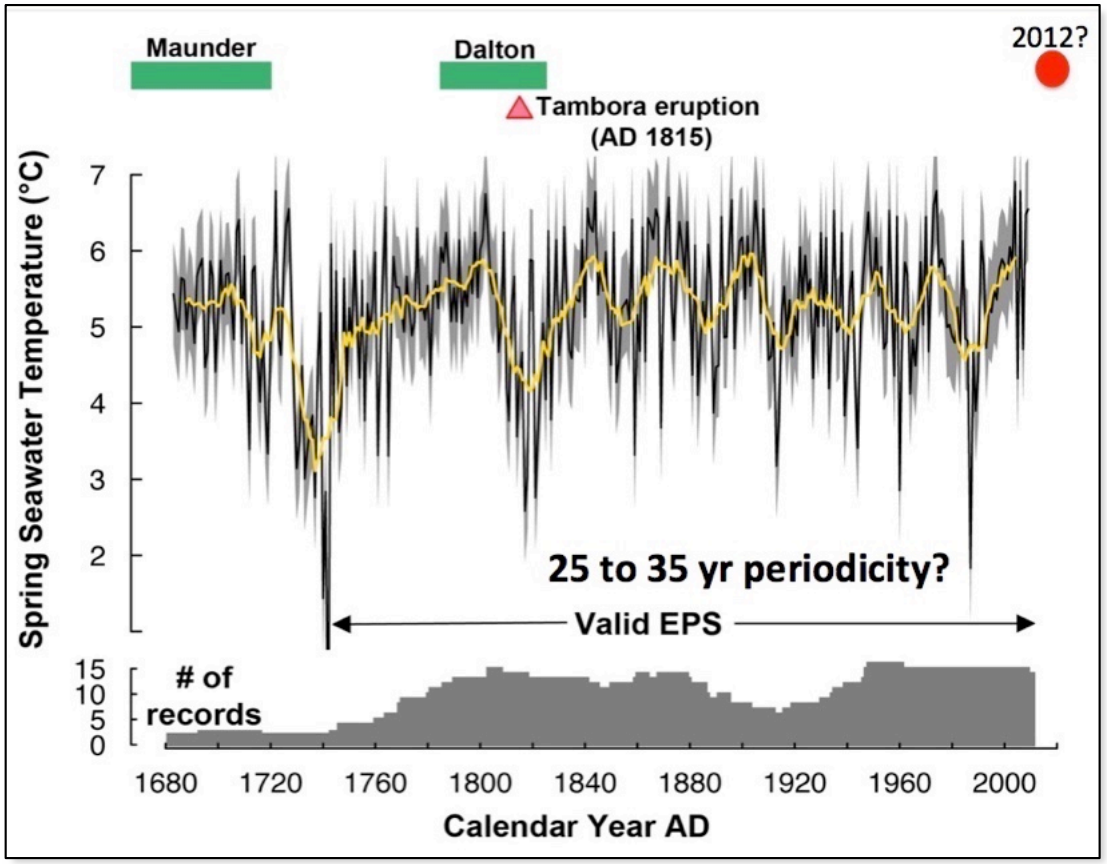




Gonçalves Neto A, Langan JA, Palter JB. Changes in the Gulf Stream preceded rapid warming of the Northwest Atlantic Shelf. Communications Earth & Environment. 2021 Apr 20;2(1):74.

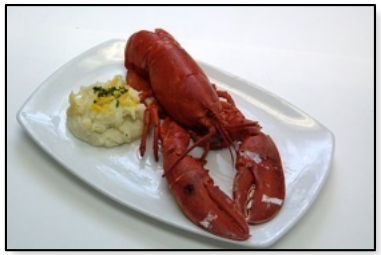
The year 2012

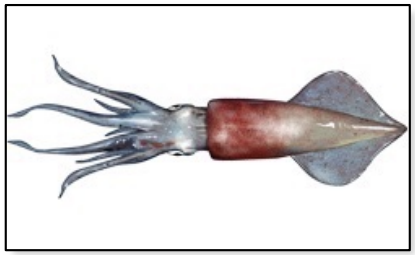
Rapid Change

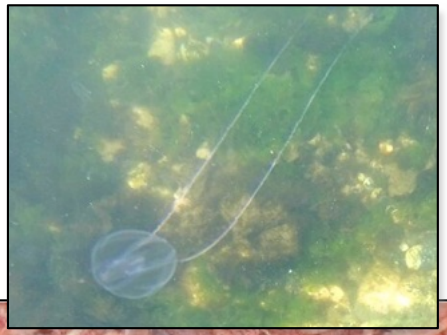


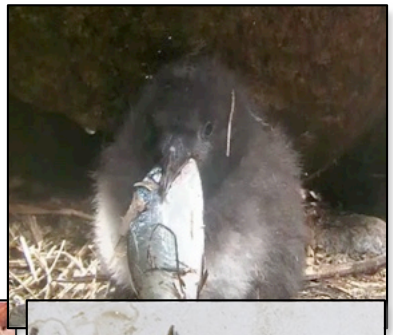
from Alan Wanamaker, RARGOM 2013

Rapid Change



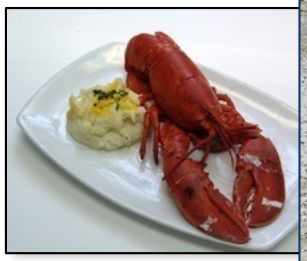






Freshly-caught Gulf of Maine cod in December 2011. Marine scientists say rising temperatures in the gulf have decreased reproduction and increased mortality among Atlantic cod. Gretchen Ertl for The New York Times

Rapid



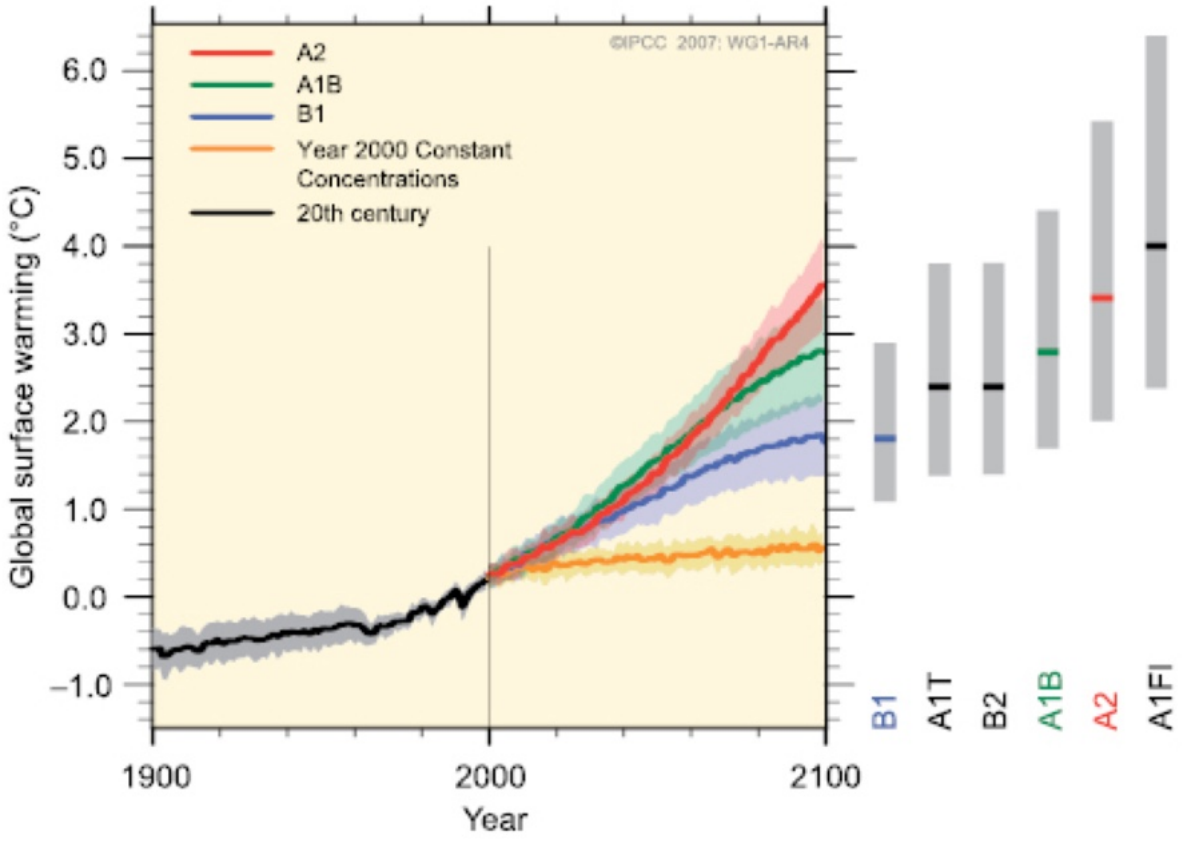
Freshly-caught Gulf of Maine cod in December 2011. Marine scientists say rising temperatures in the gulf have decreased reproduction and increased mortality among Atlantic cod. Gretchen Ertl for The New York Times

Rapid Change

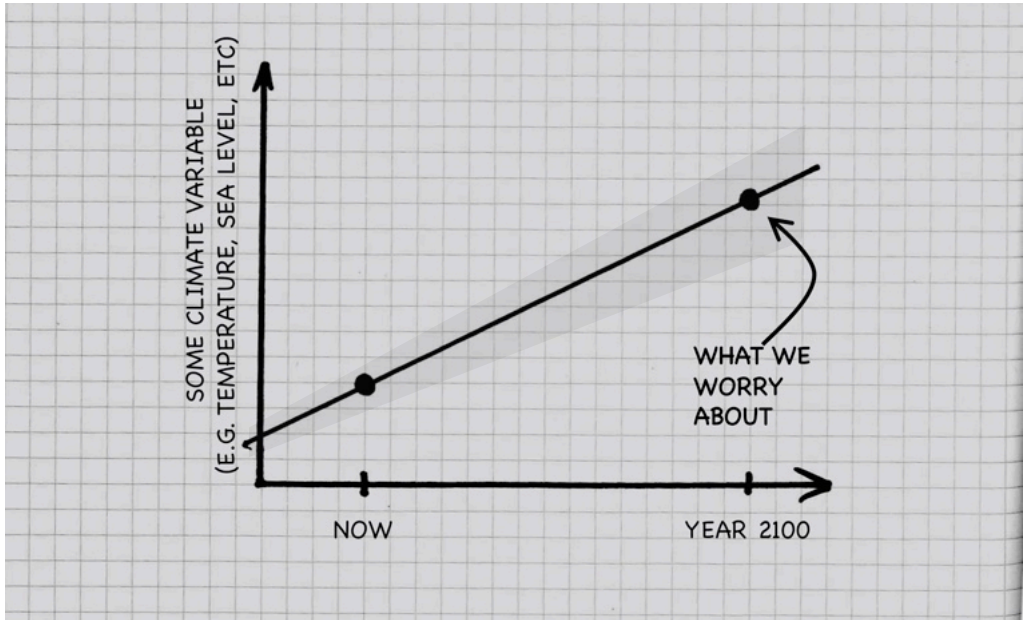
Freshly-caught Gulf of Maine cod in December 2011. Marine scientists say rising temperatures in the gulf have decreased reproduction and increased mortality among Atlantic cod. Gretchen Ertl for The New York Times

Pershing AJ, Alexander MA, Hernandez CM, Kerr LA, Le Bris A, Mills KE, Nye JA, Record NR, Scannell HA, Scott JD, Sherwood GD. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science. 2015 Nov 13;350(6262):809-12.

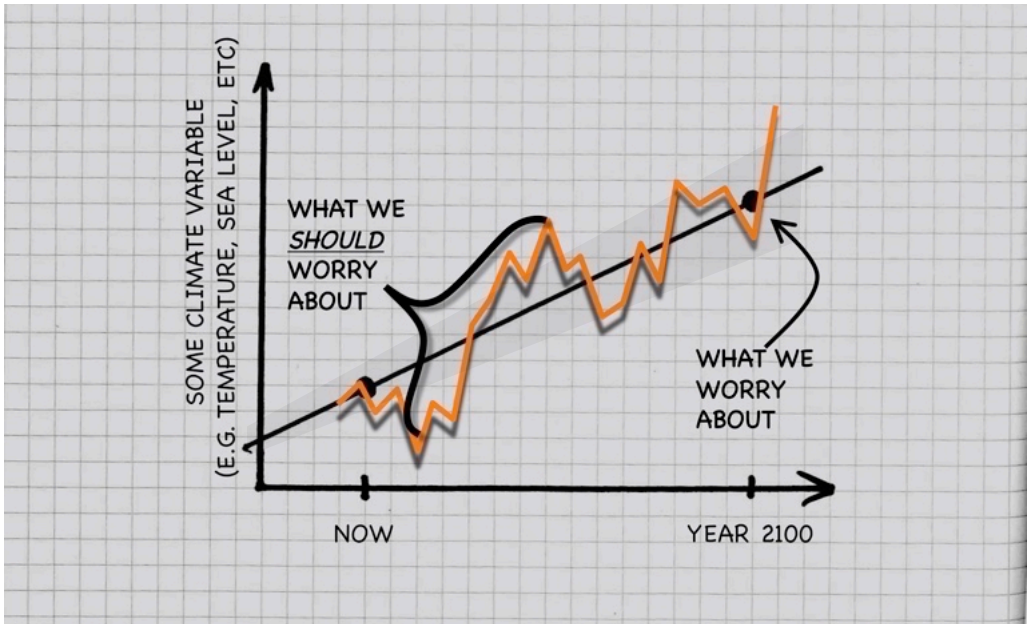
Rapid Change



Rapid Change



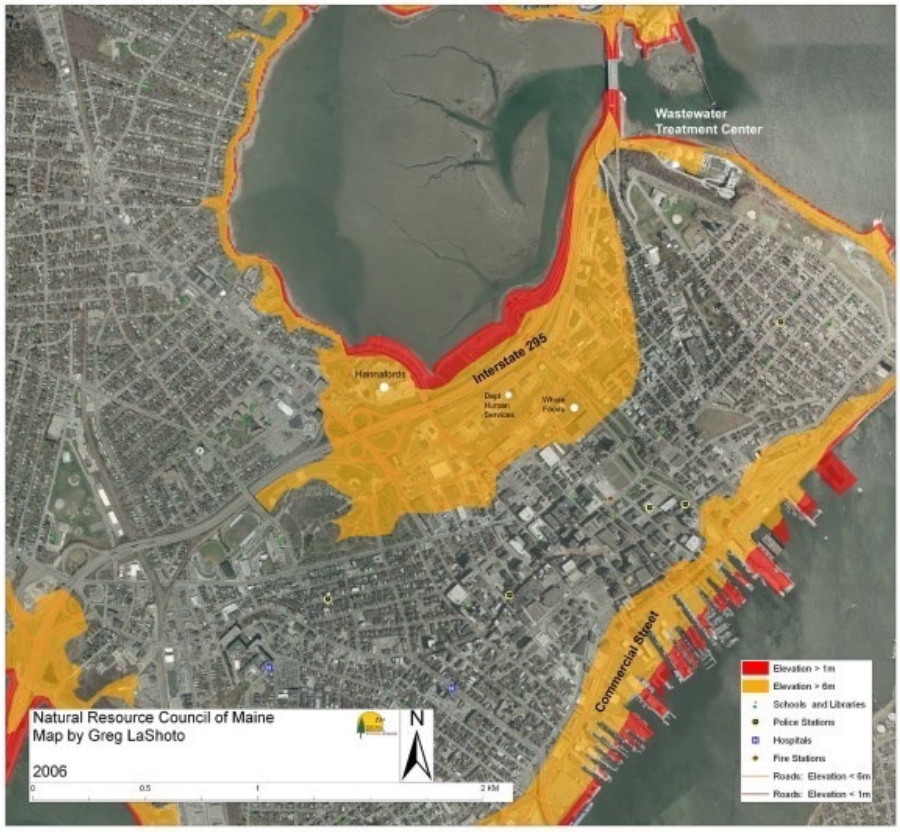
Rapid Change

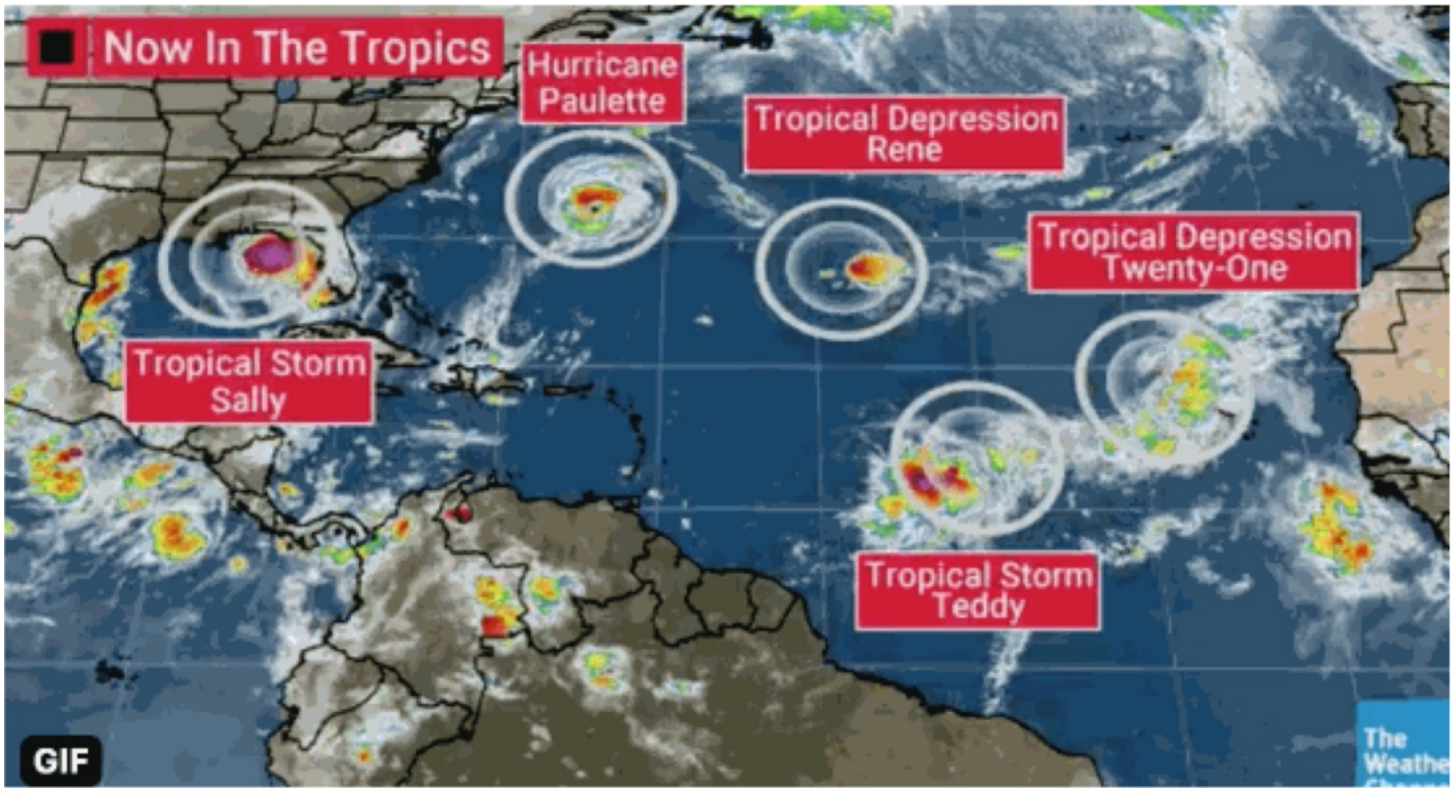


It’s not just temperature

Rapid Change

Impact of Sea Level Rise on Portland, ME




Now In The Tropics
Hurricane Paulette
Tropical Depression Rene
Tropical Depression Twenty-One
Tropical Storm Sally
Tropical Storm Teddy
GIF

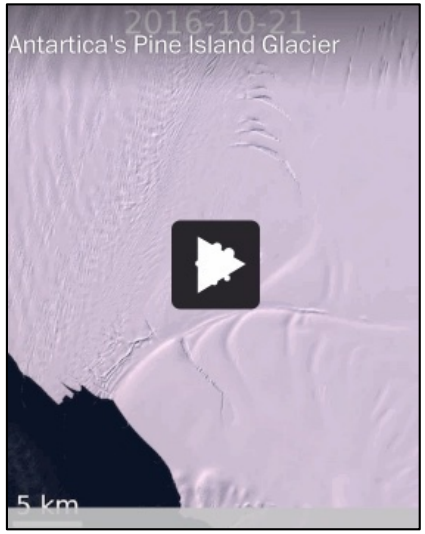
The Washington Post
Democracy Dies in Darkness

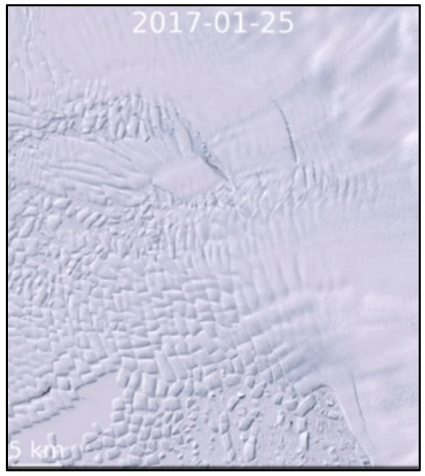
Climate and Environment

Two major Antarctic glaciers are tearing loose from their restraints, scientists say

Pine Island and Thwaites glaciers already contribute 5 percent of sea-level rise.

Enormous curved crevasses near the Pine Island Glacier shear margin. (Brooke Medley/NASA)





...and many others