



**NOAA
FISHERIES**

Changing Climate Changing Oceans

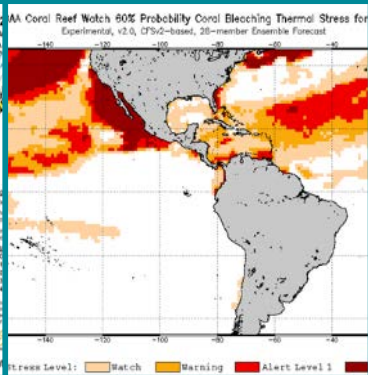
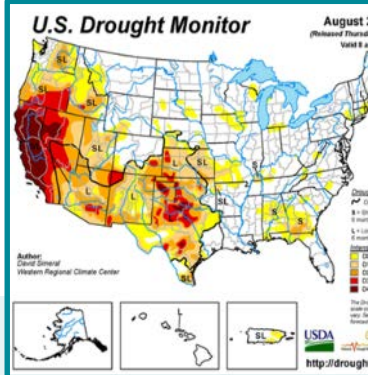
Roger Griffis, Climate Coordinator, NOAA Fisheries Service

MPA FAC Meeting, May 2017



NOAA FISHERIES

Growing Challenges for Effective Management



Droughts

Warming Oceans

Loss of Sea Ice

Rising Seas

Ocean Acidification

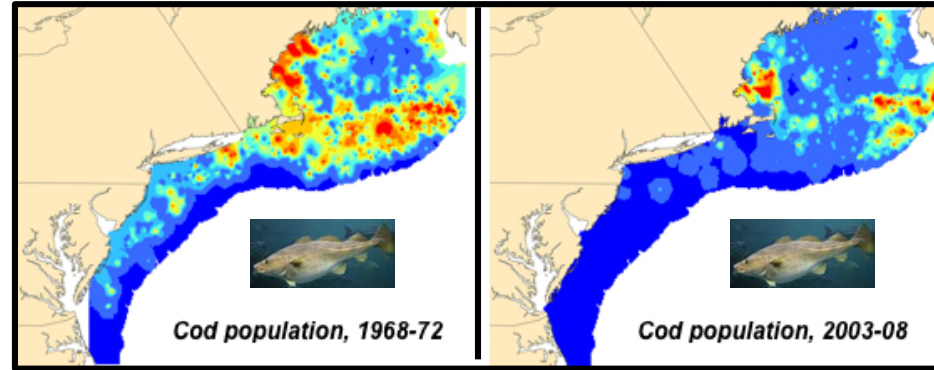


The impacts are real...

Changing Productivity



Shifting Distributions



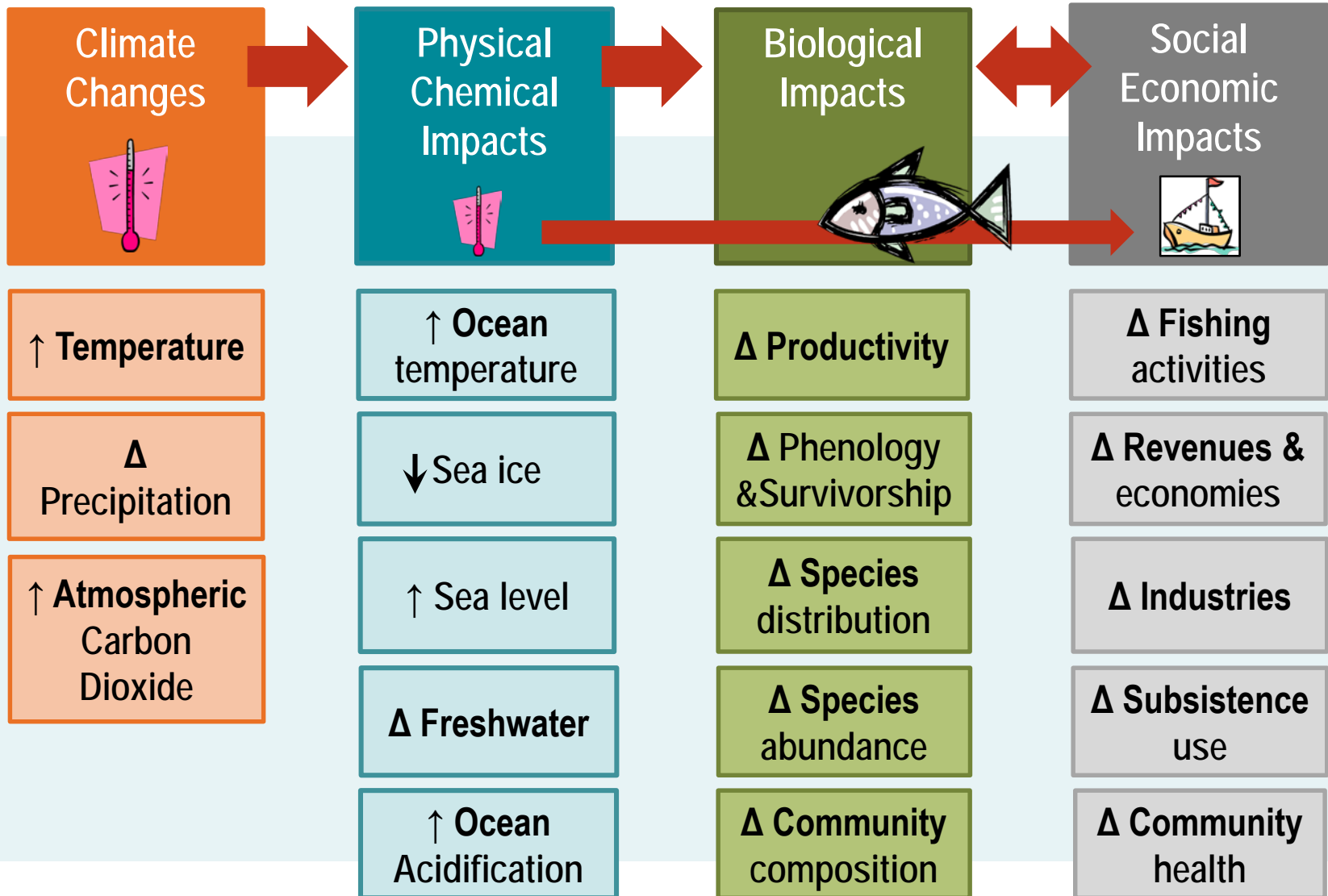
Changing Abundance



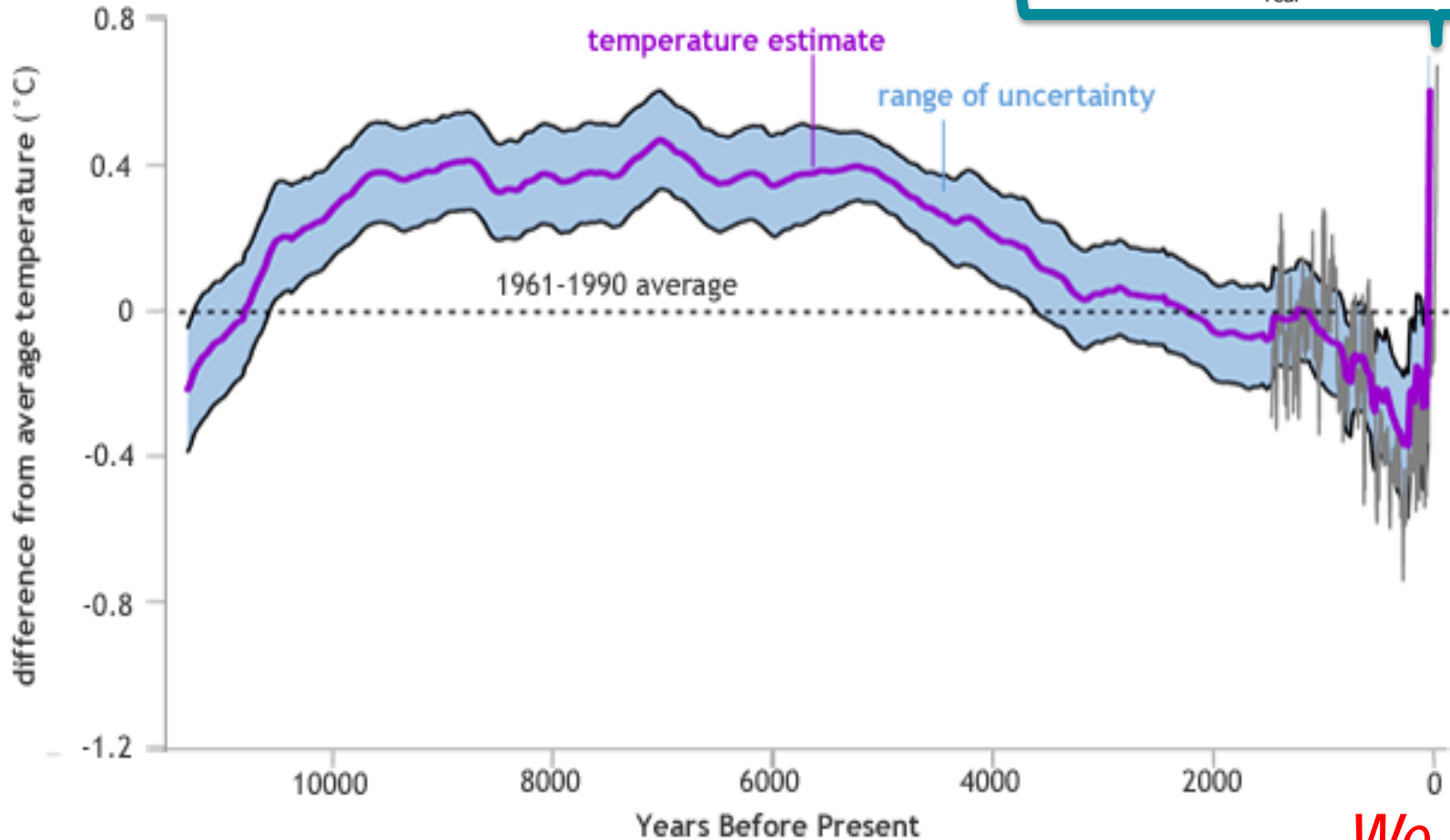
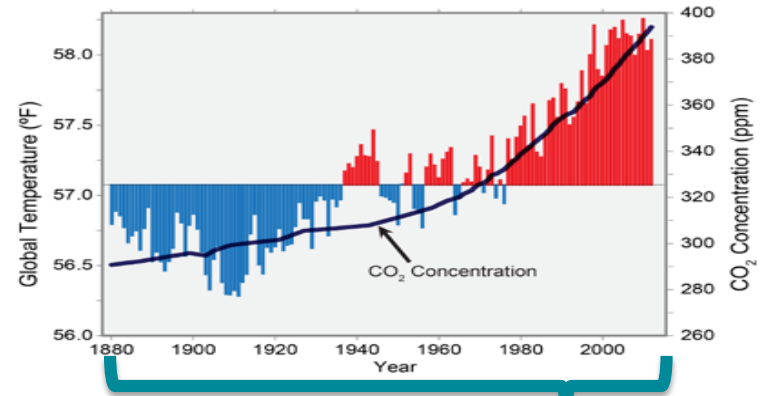
Changing Fisheries



The Impacts Are Expected to Increase



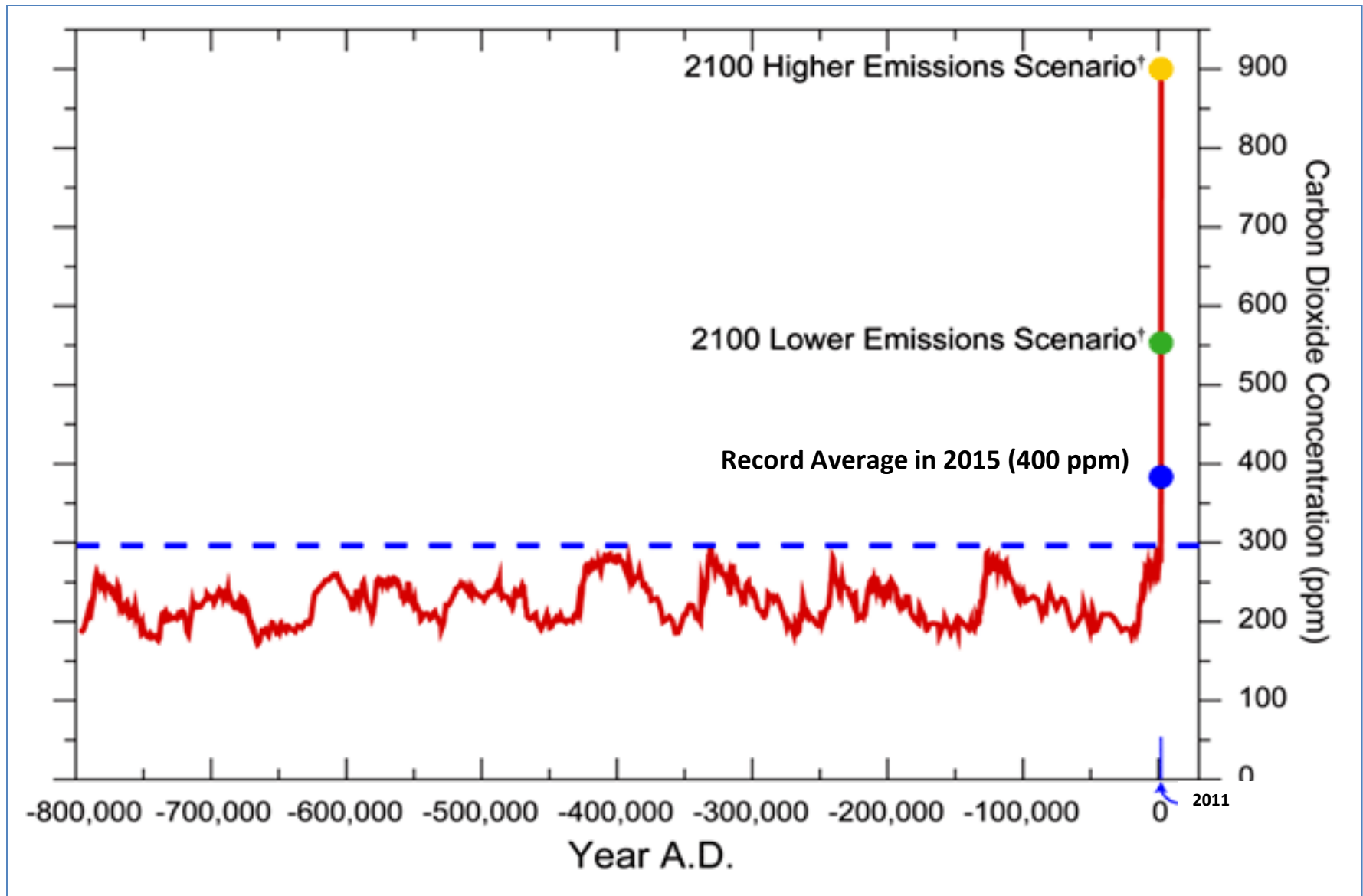
Our Warming Planet



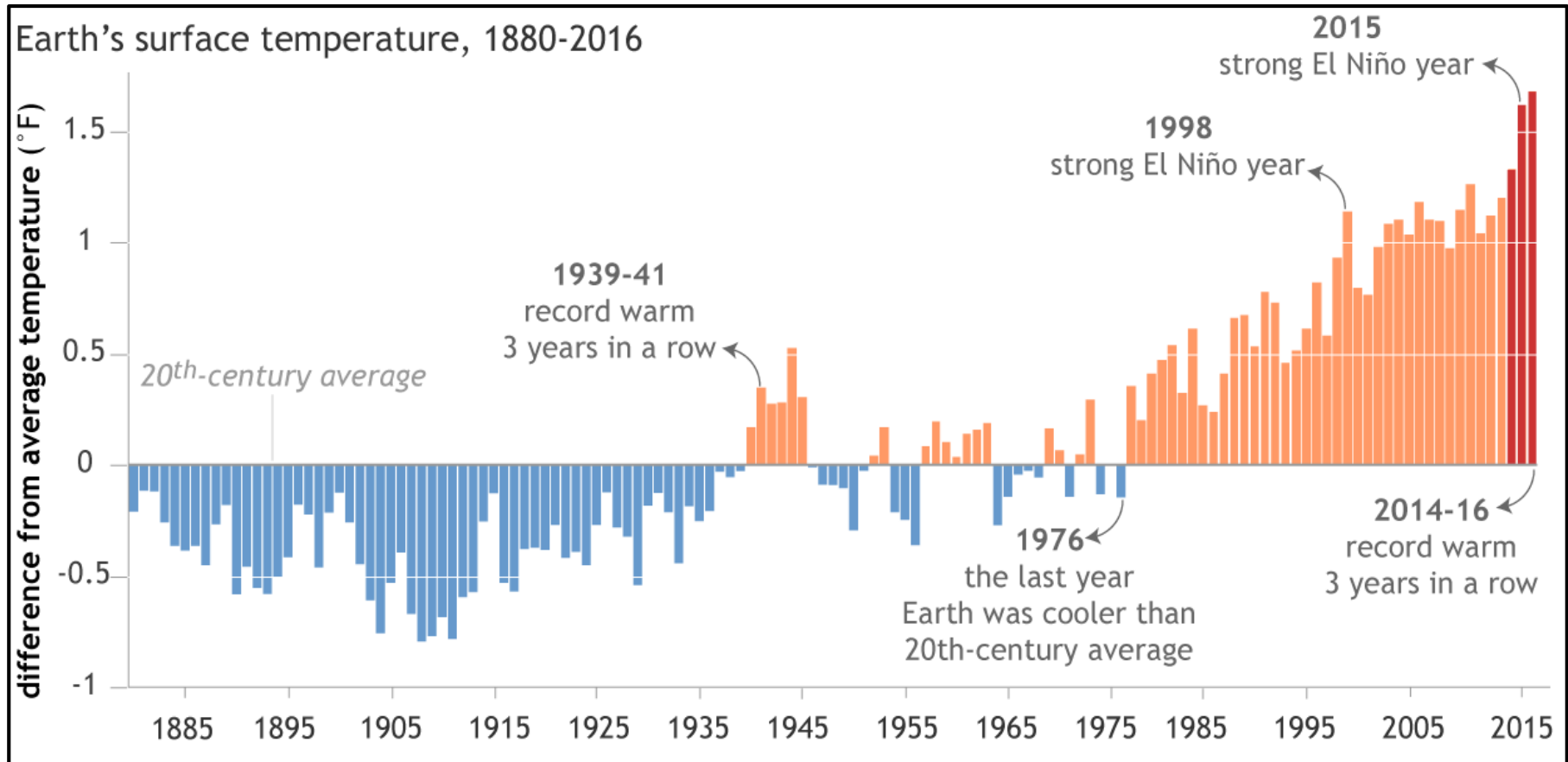
We are here

10,000 year record

Record Levels of CO2 in the Atmosphere

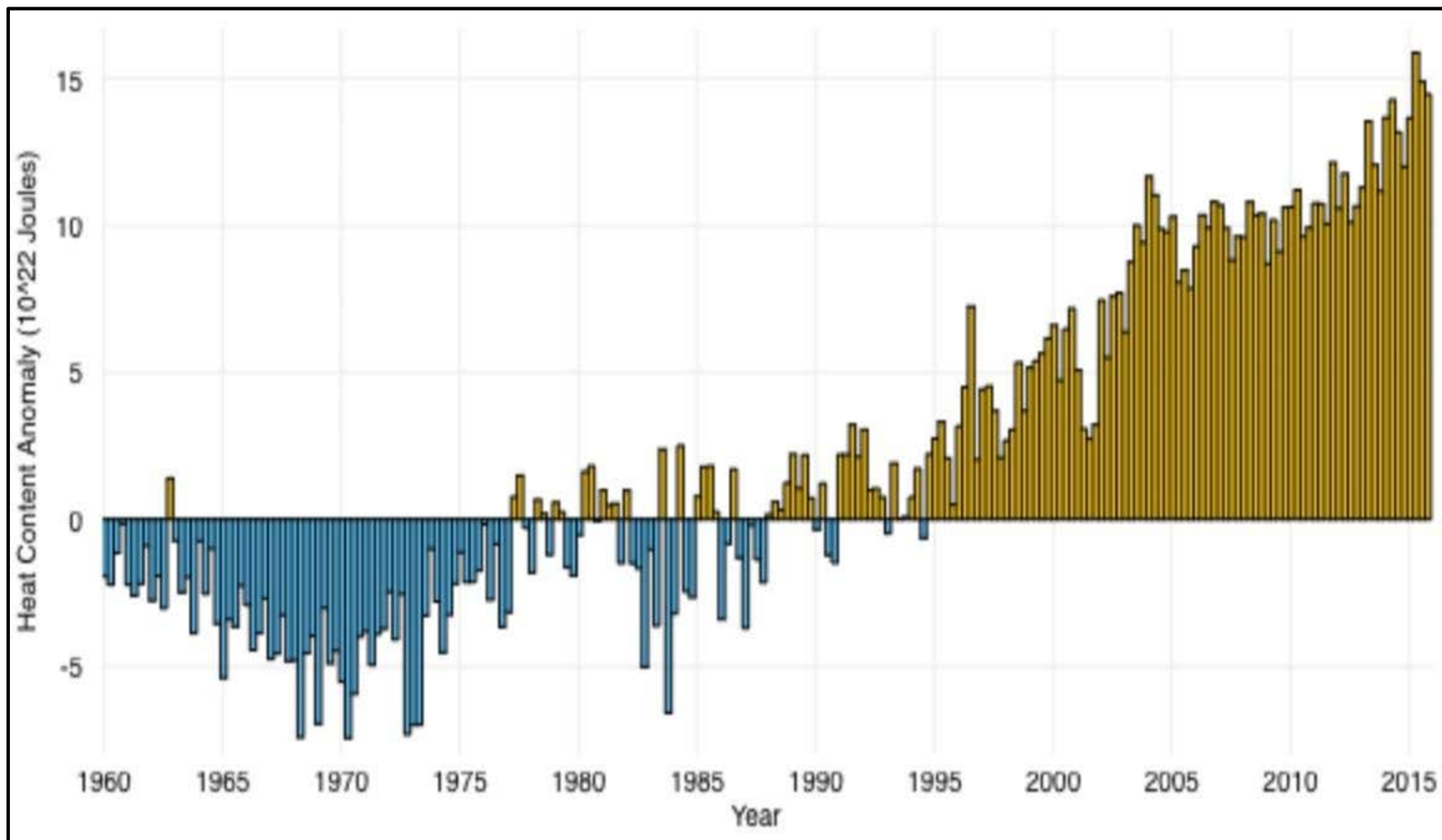


Earth is now 1.5°F warmer than 20th century Ave.



NOAA Climate.gov

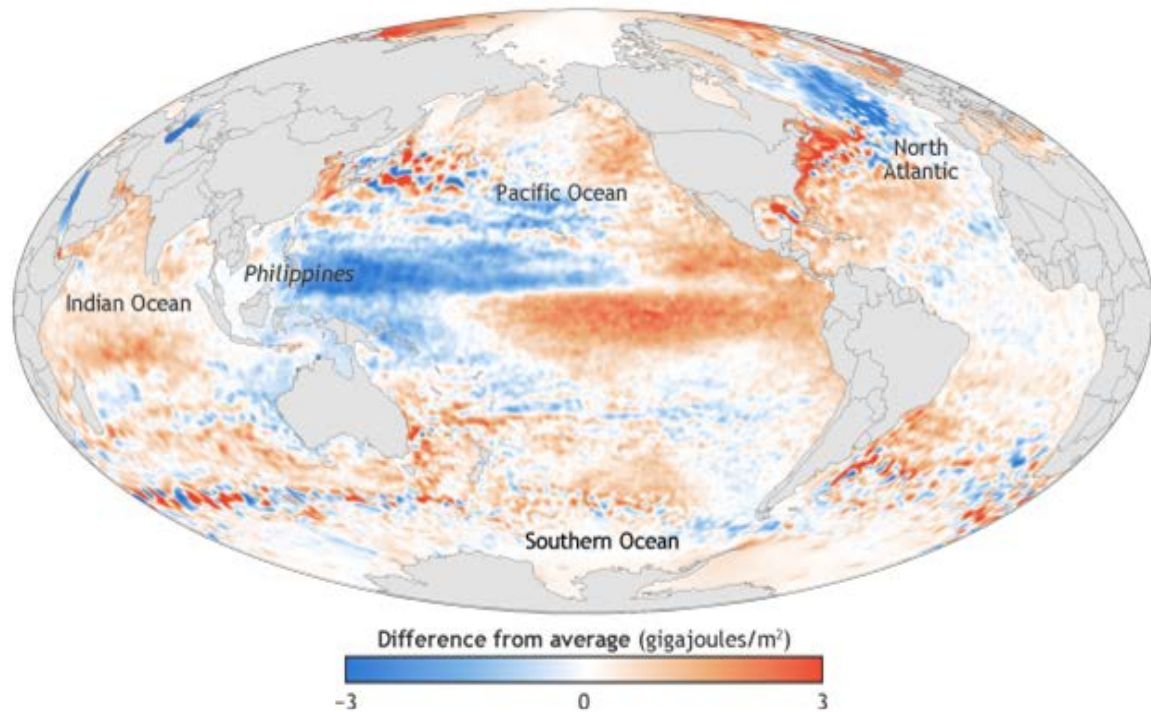
Most (>90%) of Earth's energy surplus has been absorbed by the ocean



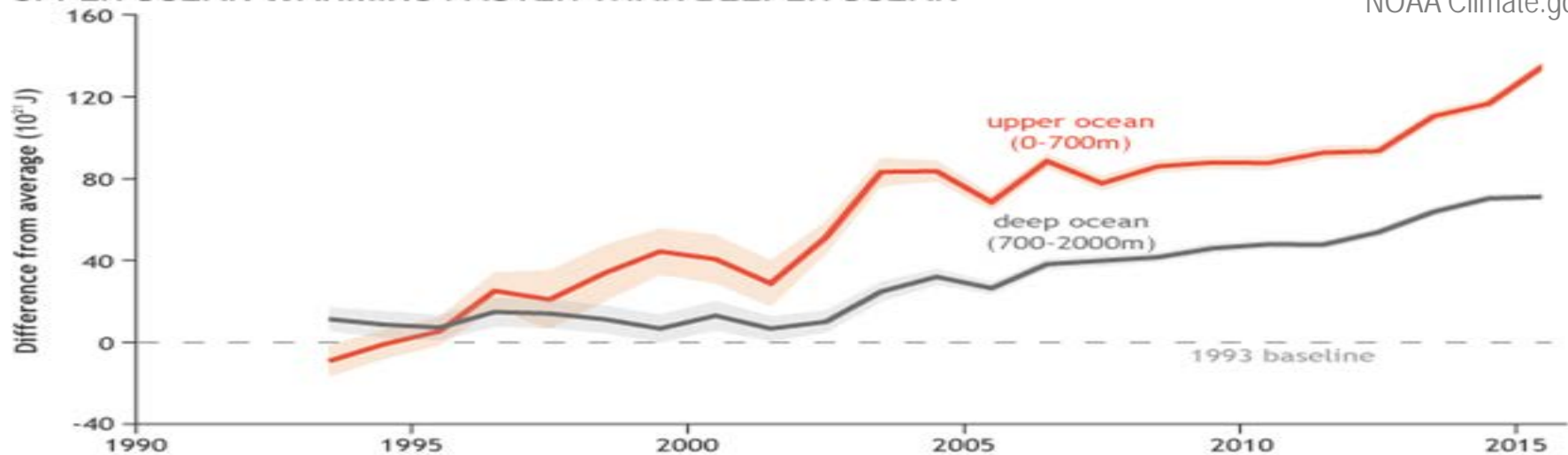
NOAA Climate.gov

Most (>90%) of Earth's energy surplus has been absorbed by the ocean

UPPER OCEAN HEAT CONTENT HITS RECORD HIGH IN 2015



UPPER OCEAN WARMING FASTER THAN DEEPER OCEAN



NOAA Climate.gov

NOAA Climate.gov, adapted from State of the Climate 2015

Ocean Warming Expected to Continue

Projected Temperature Change



Difference from
1986–2005 mean (°C)

Solid Color

Very strong
agreement

White Dots

Strong
agreement

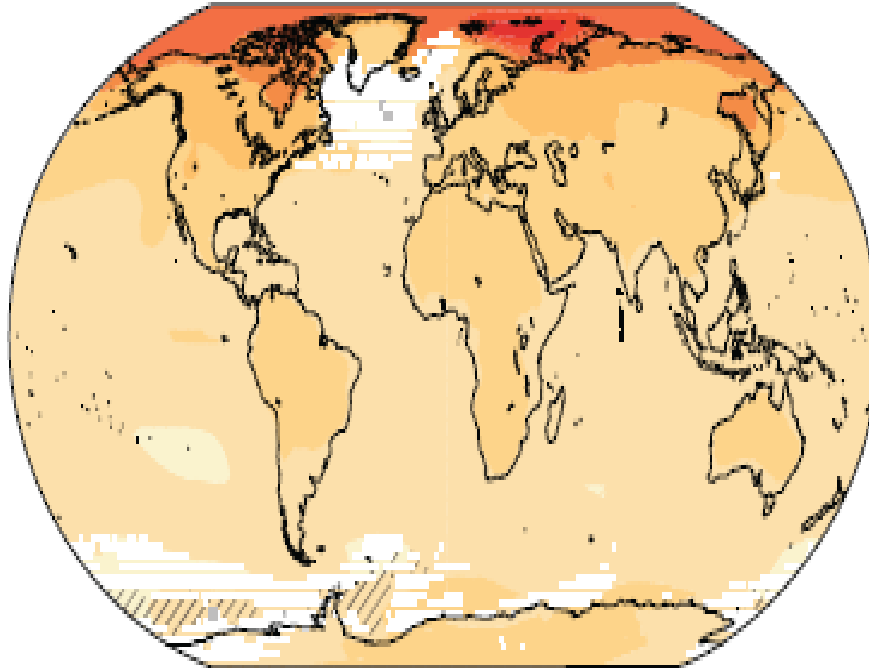
Gray

Divergent
changes

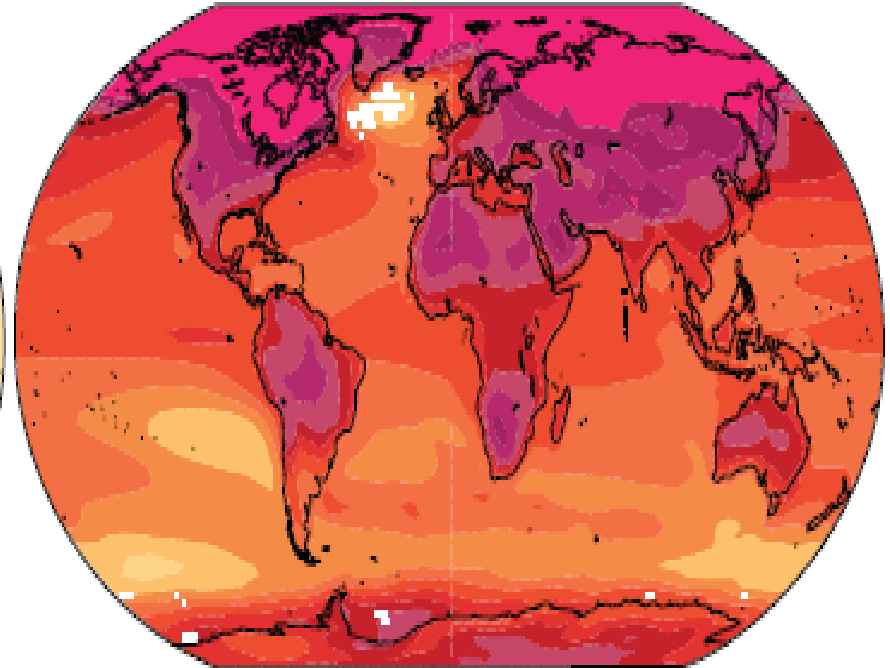
Diagonal Lines

Little or
no change

RCP2.6 2081–2100

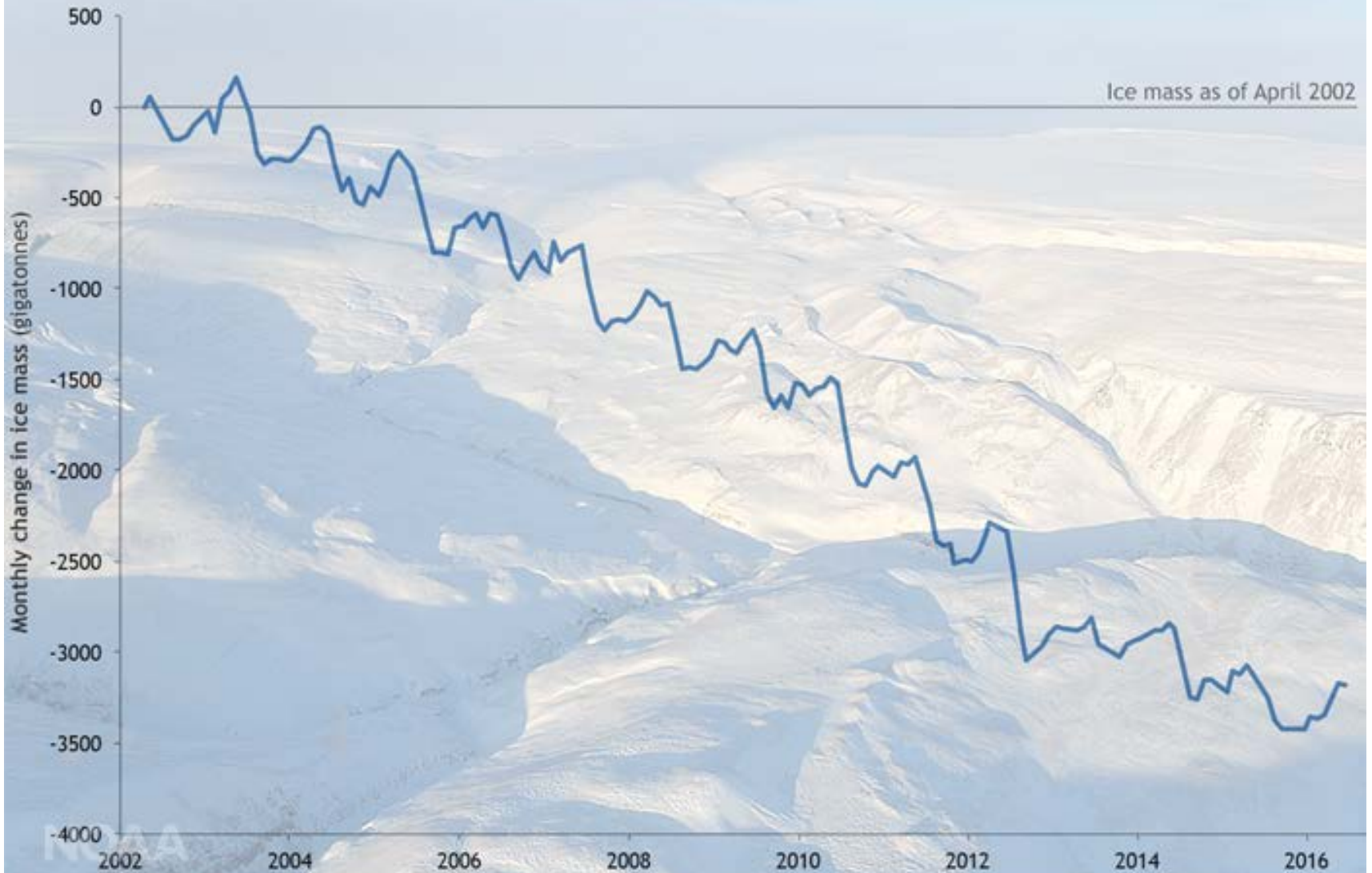


RCP8.5 2081–2100



Projected Average Annual Surface Temperature (IPCC AR5)

DECLINING ICE MASS IN GREENLAND



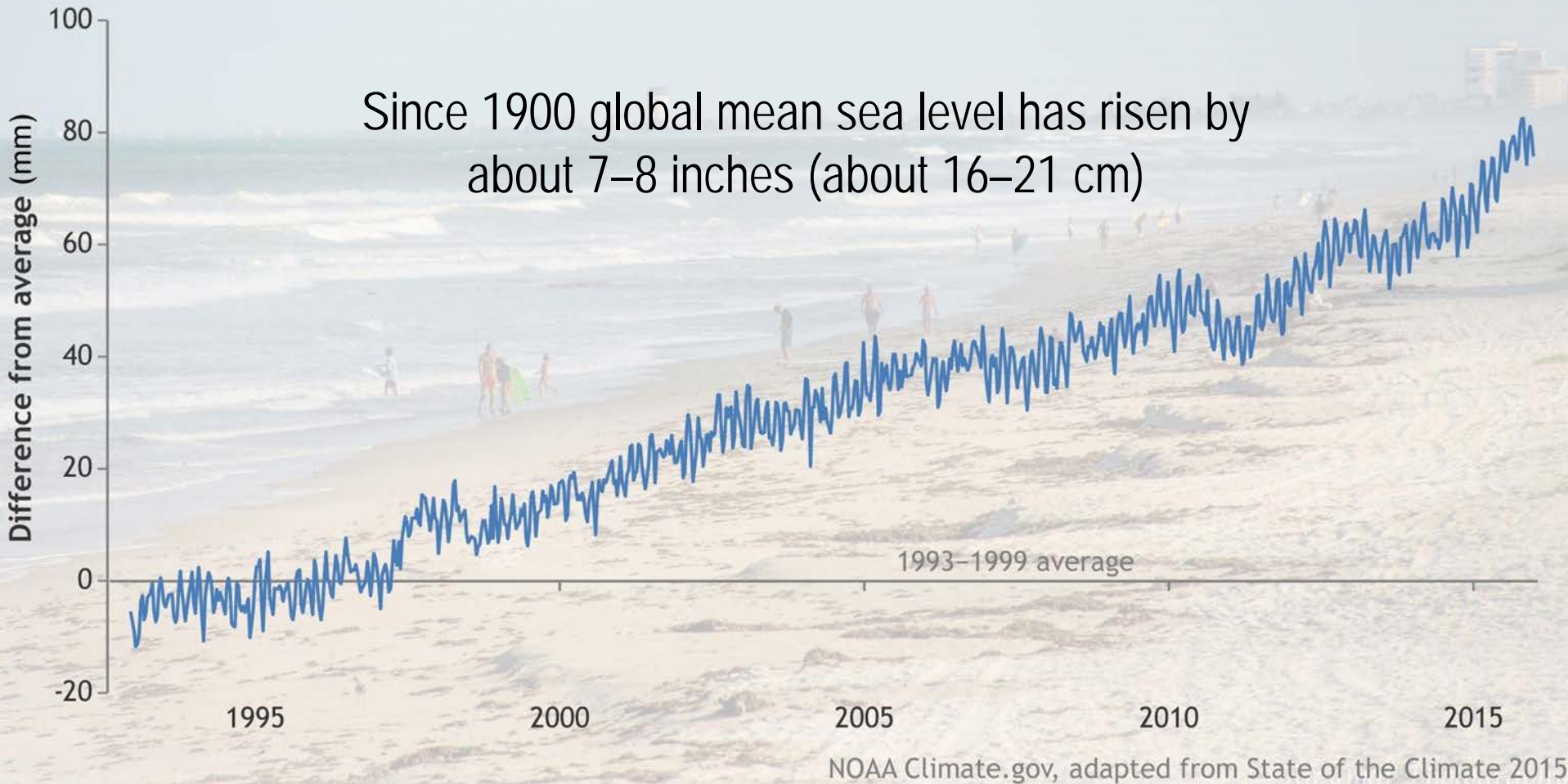
NOAA climate.gov, adapted from Arctic Report Card: Update for 2016



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Today, global sea level is rising at an accelerating rate

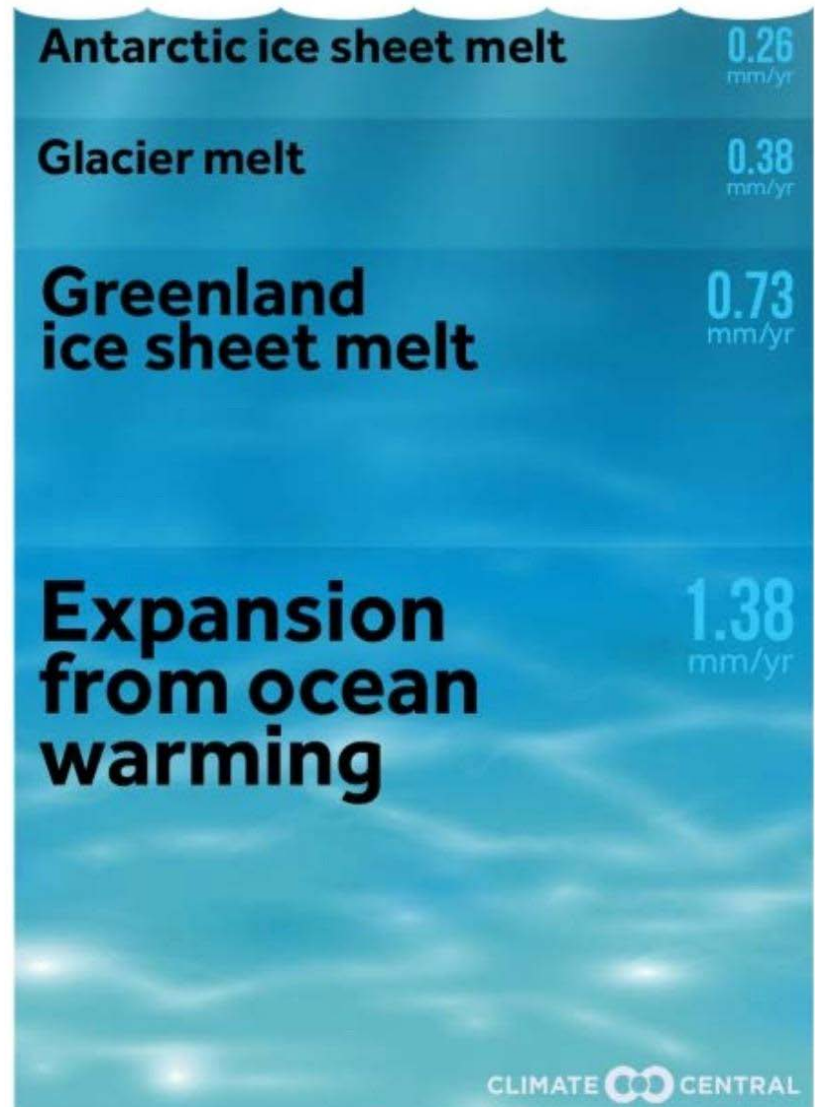
GLOBAL SEA LEVEL HITS NEW RECORD HIGH



Global warming affects global sea level rise in two main ways:

1. **Melting ice sheets and glaciers on land** directly contributes to SLR
2. **Thermal expansion of seawater** as the ocean absorbs Earth's surplus heat energy

MAIN CAUSES OF SEA LEVEL RISE 2002 - 2014



Source: Rietbroek et al., Revisiting the contemporary sea level budget on global and regional scales, PNAS



Sea Levels Expected To Rise

16 Sea-Level Rise Modeling Handbook: Resource Guide for Coastal Land Managers, Engineers, and Scientists

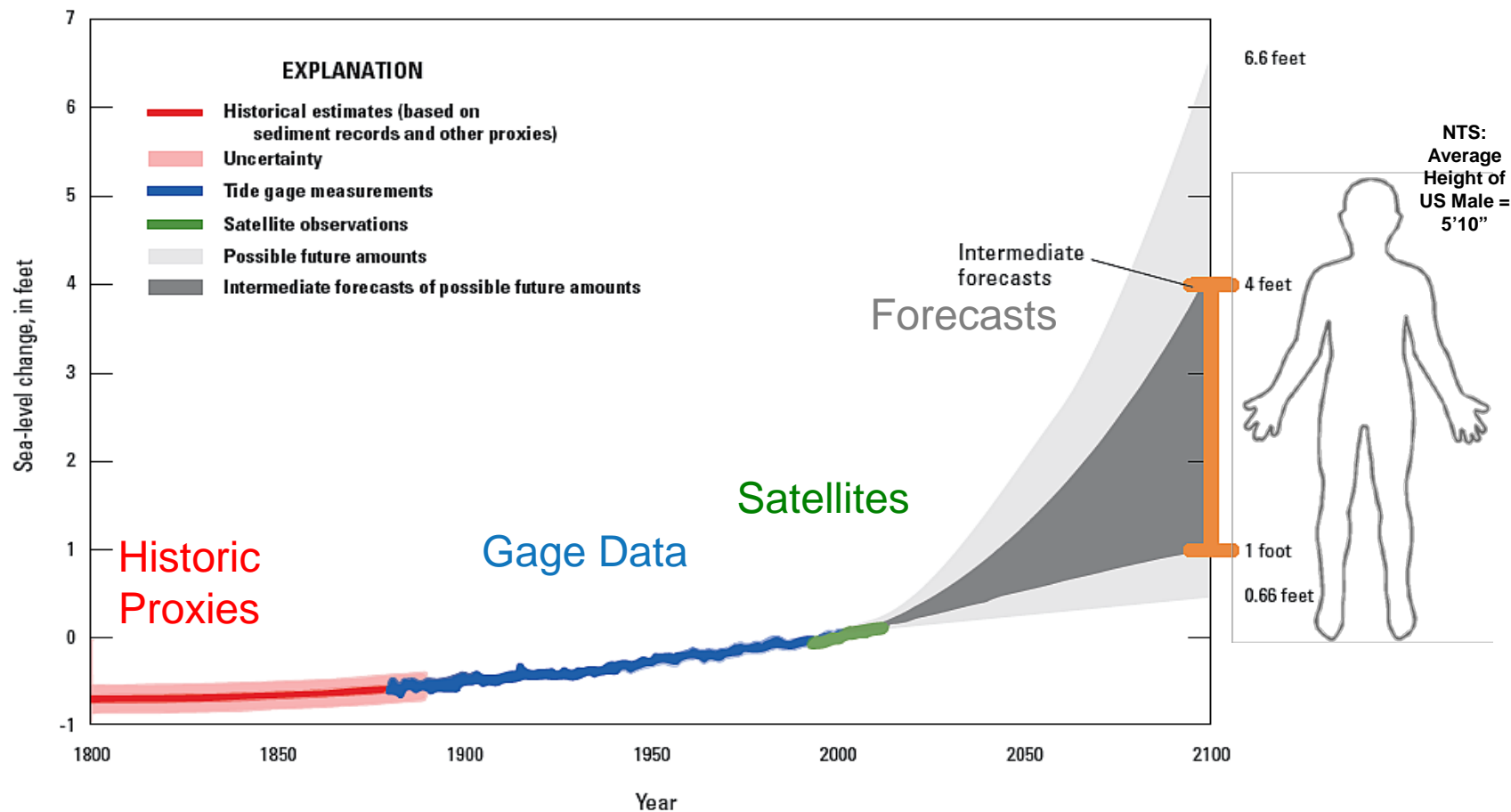


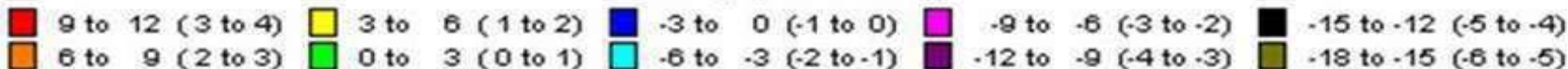
Figure 9. Historical, observed, and possible future amounts of global sea-level rise from 1800 to 2100 (from Melillo and others, 2014). Historical estimates (based on sediment records and other proxies) are shown in red (pink band shows uncertainty range), tide gage measurements in blue, and satellite observations in green.

Relative SLR trends for the United States



Source: NOAA, 2012

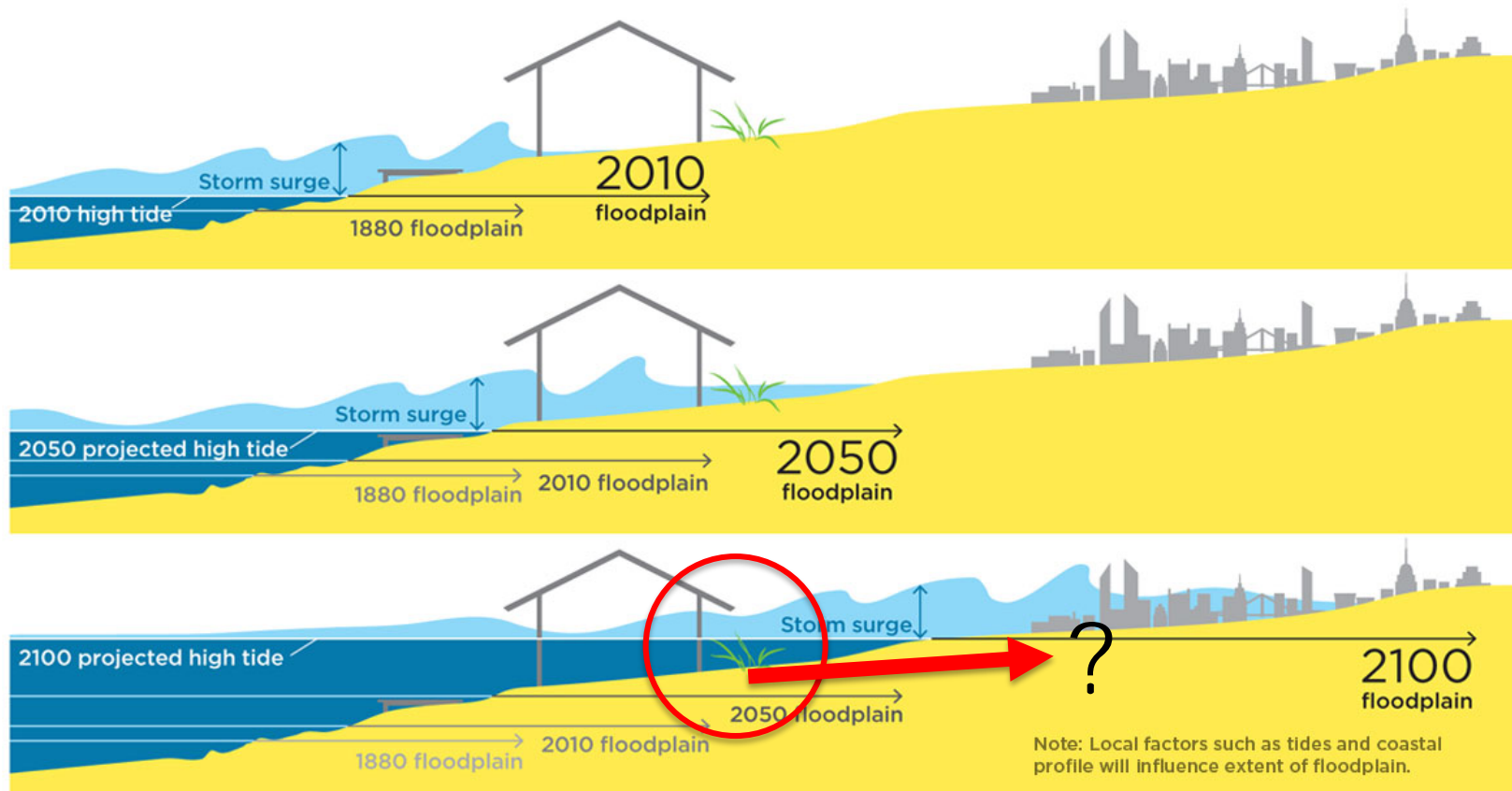
Sea Level Trends mm/yr (feet/century)



NOAA 2011

Sea Level Rise

FIGURE 3. Storm Surge and High Tides Magnify the Risks of Local Sea Level Rise

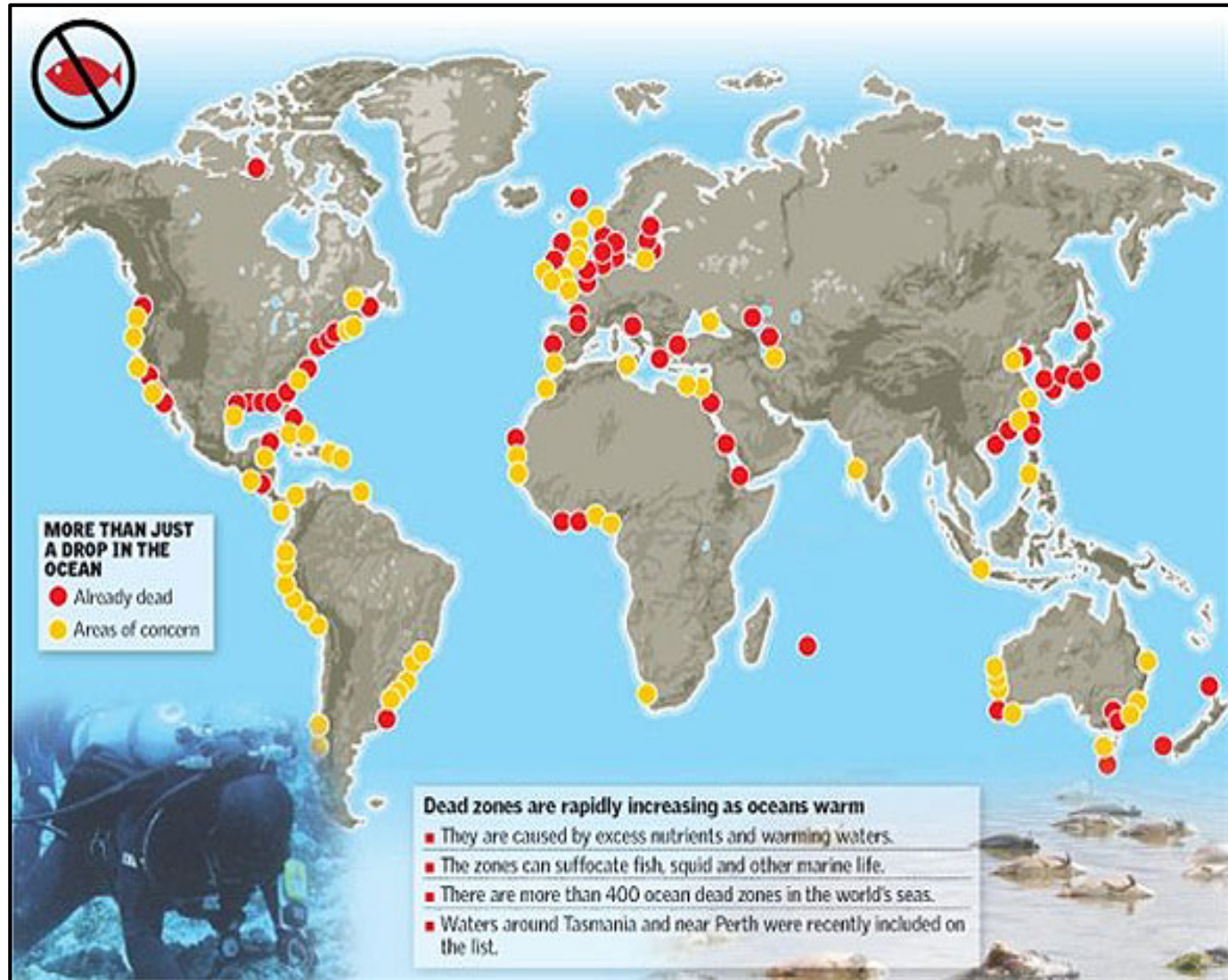


Sea level sets a baseline for storm surge—the potentially destructive rise in sea height that occurs during a coastal storm. As local sea level rises, so does that baseline, allowing coastal storm surges to penetrate farther inland. With higher global sea levels in 2050 and 2100, areas much farther inland would be at risk of being flooded. The extent of local flooding also depends on factors like tides, natural and artificial barriers, and the contours of coastal land.

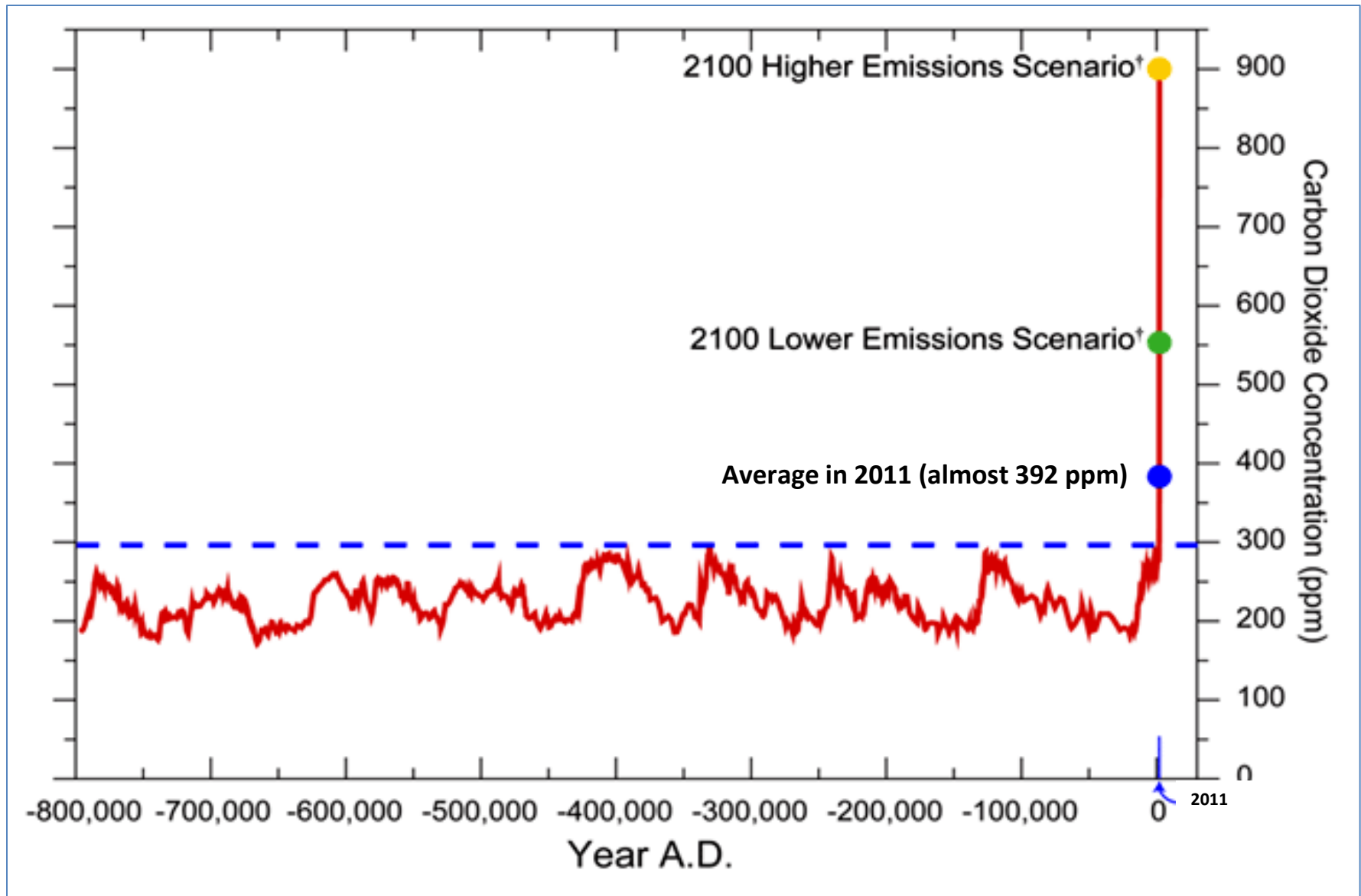
© Union of Concerned Scientists 2015; www.ucsusa.org/sealevelrisescience

Decreasing Ocean Concentrations

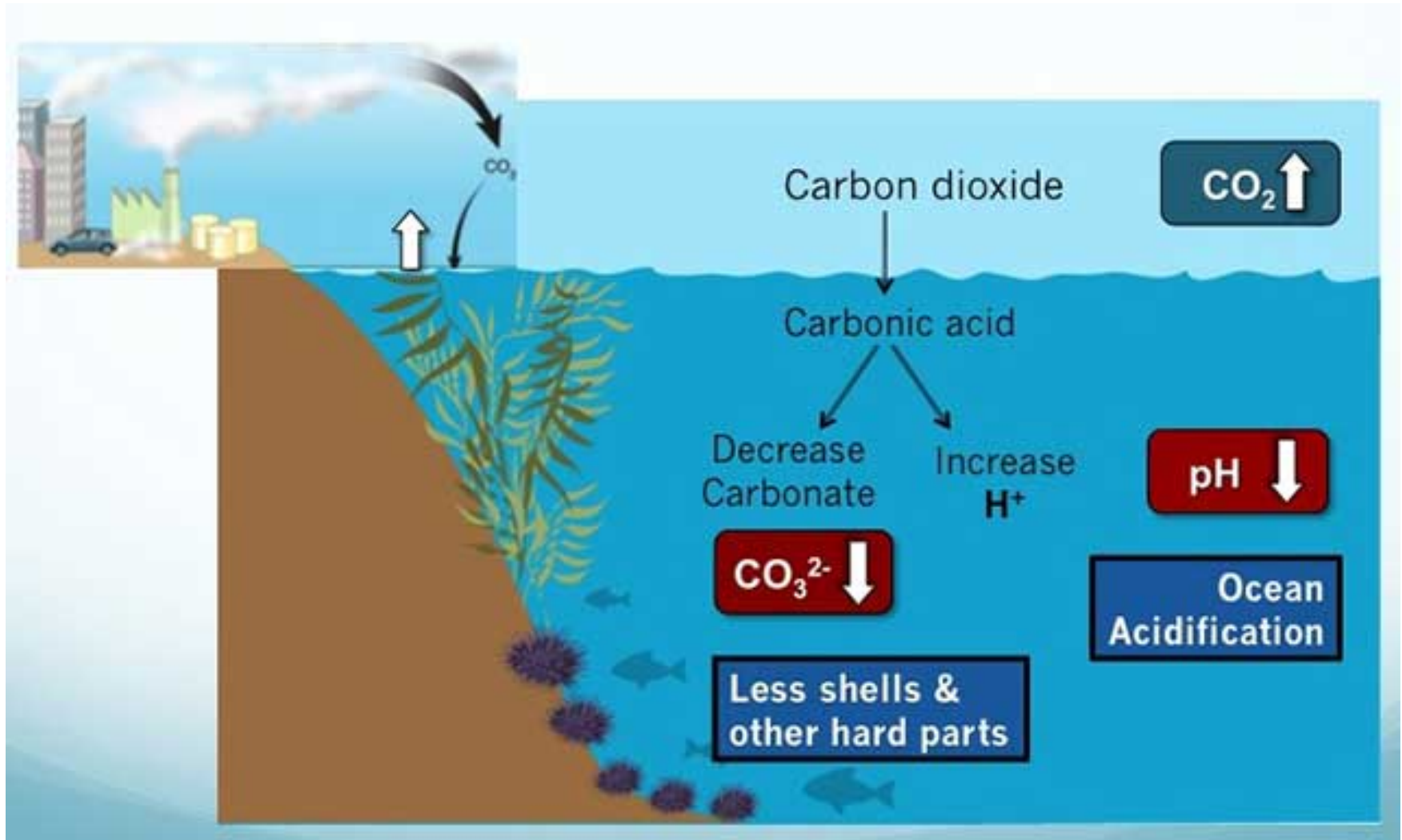
- More than 400 ocean dead zones reported between 2000 and 2008.
- 300 (1990s)
- 120 (1980s)



Record Levels of CO2 in the Atmosphere



Oceans Absorb Large Amounts of CO₂



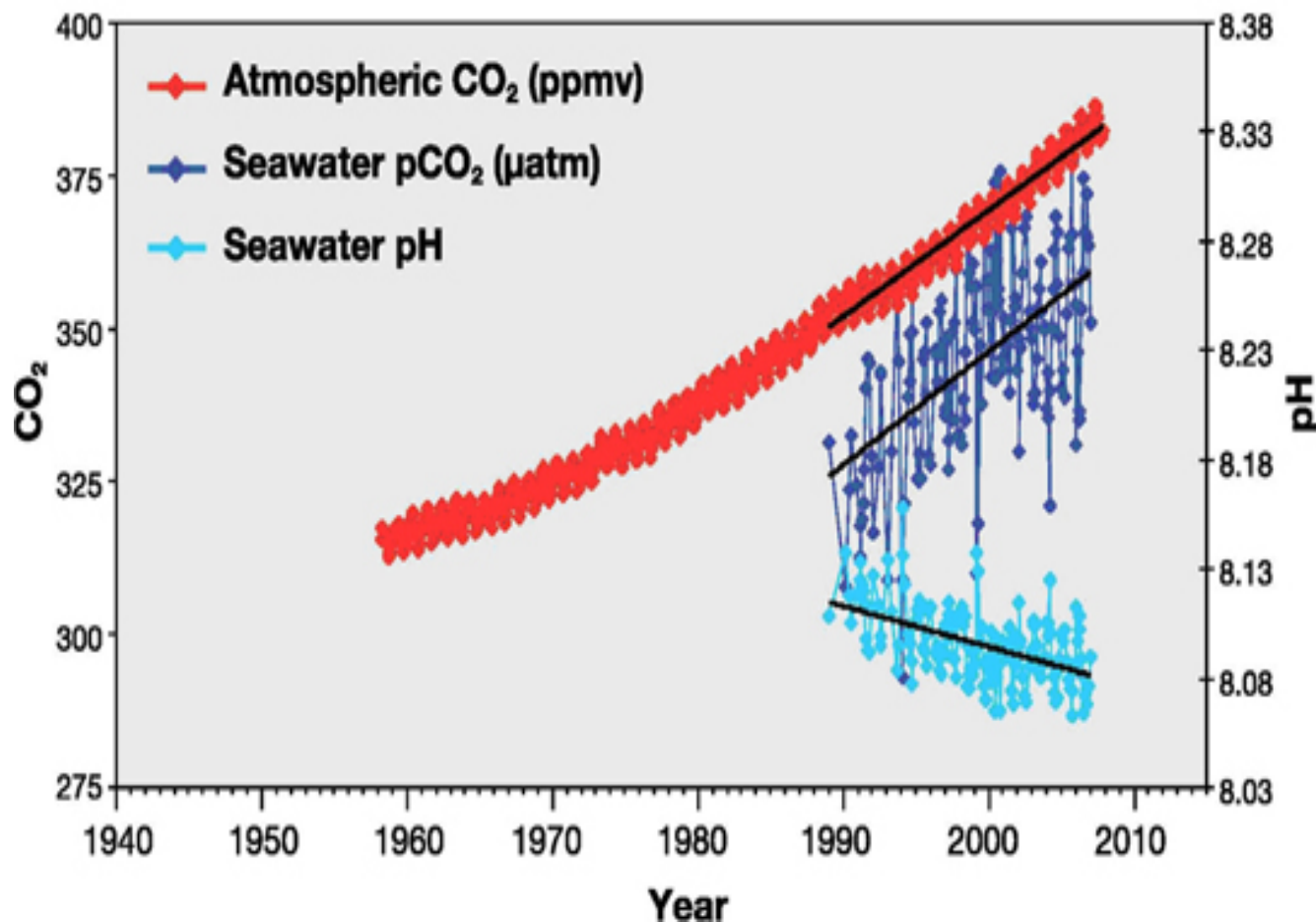
Monterey Bay National Marine Sanctuary

Increase in CO₂ → Ocean Acidification

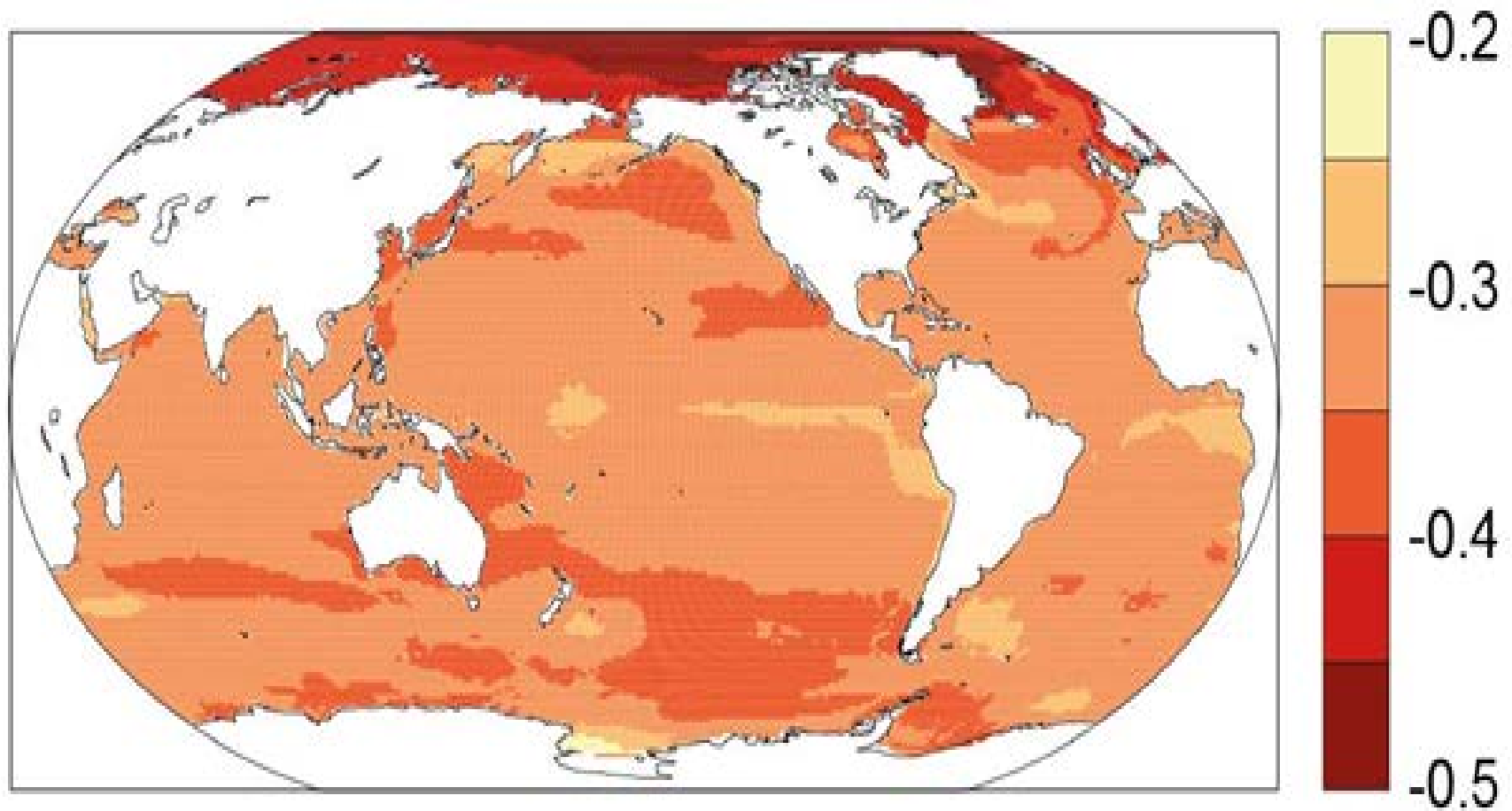
Ocean surface waters

- absorbed @ 25% emitted CO₂
- became 30% more acidic over the last 150 years
- higher-latitude systems typically have a lower buffering capacity against pH change

CO₂ and pH time series in the North Pacific Ocean

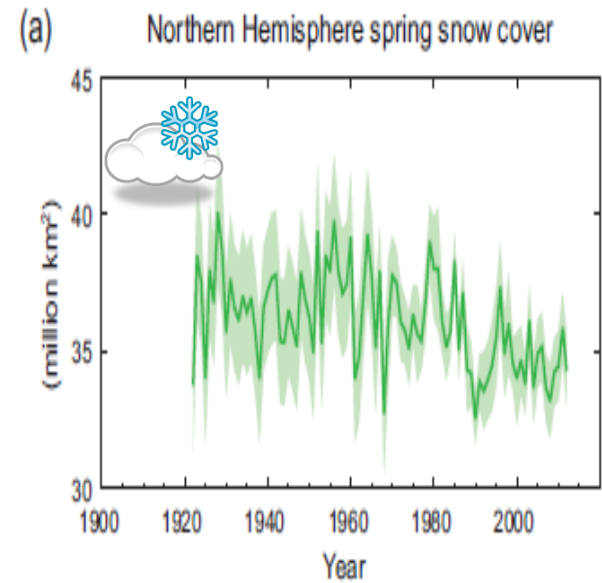
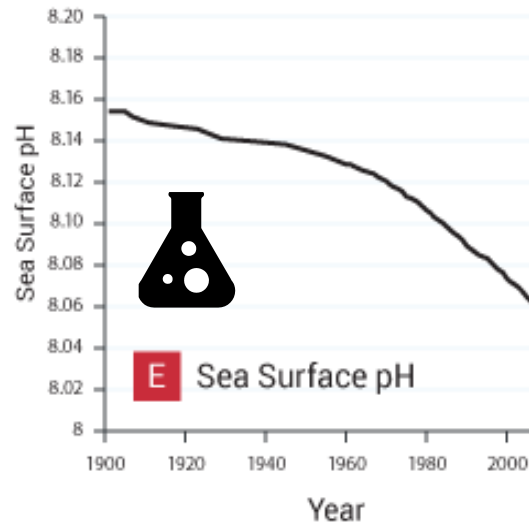
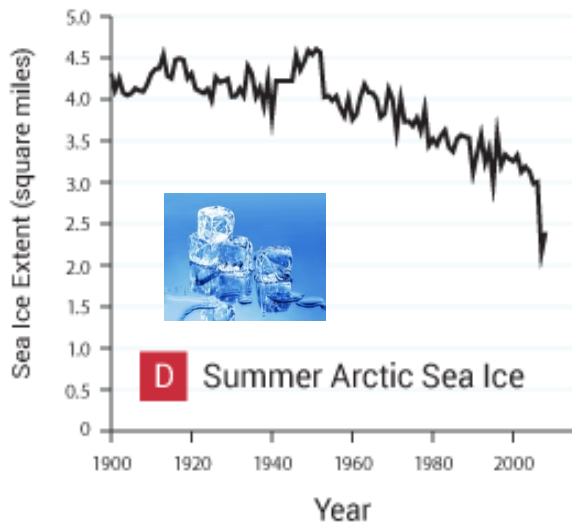
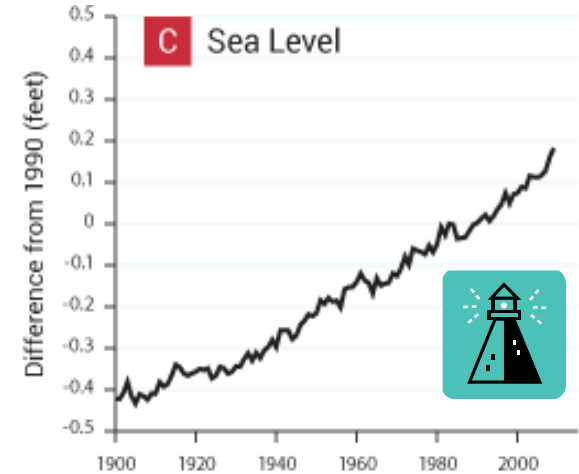
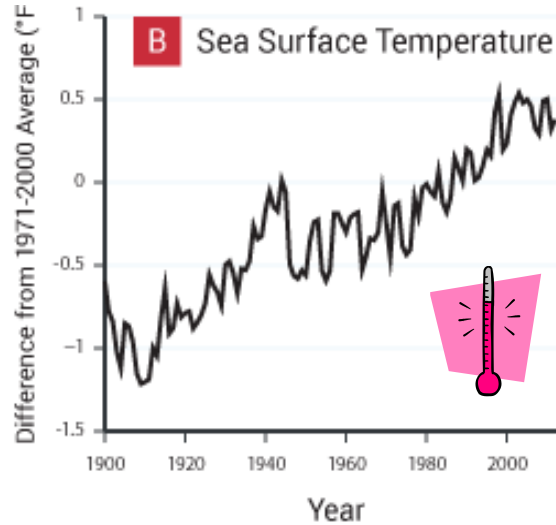
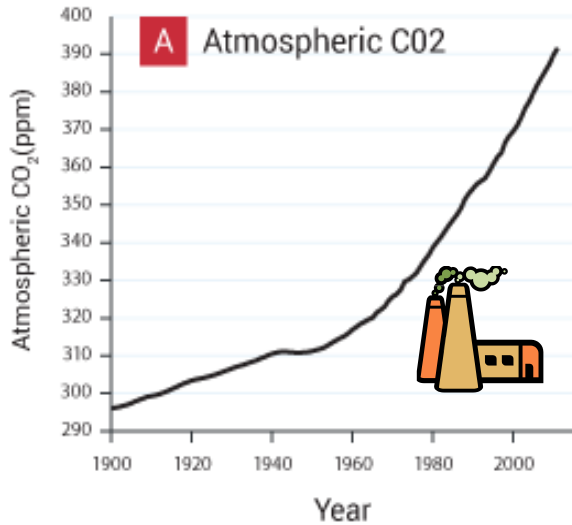


Ocean Acidification Expected to Increase



Predicted change in sea surface pH in 2090–2099 relative to 1990–1999 under RCP8.5, based on the Community Earth System Models–Large Ensemble Experiments CMIP5 (Figure source: adapted from Bopp et al. 2013).

Climate Impacts on Marine and Coastal Ecosystems





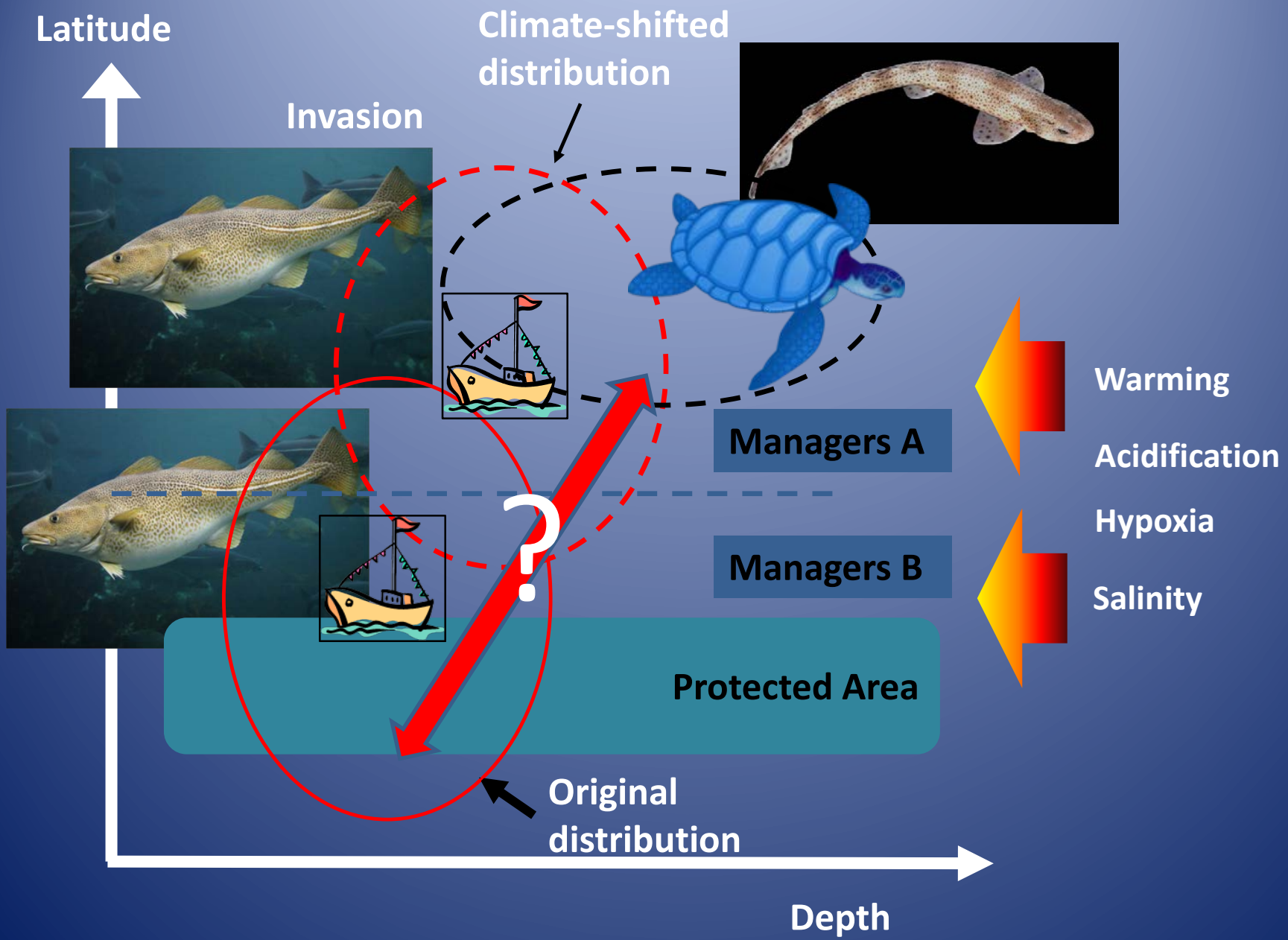
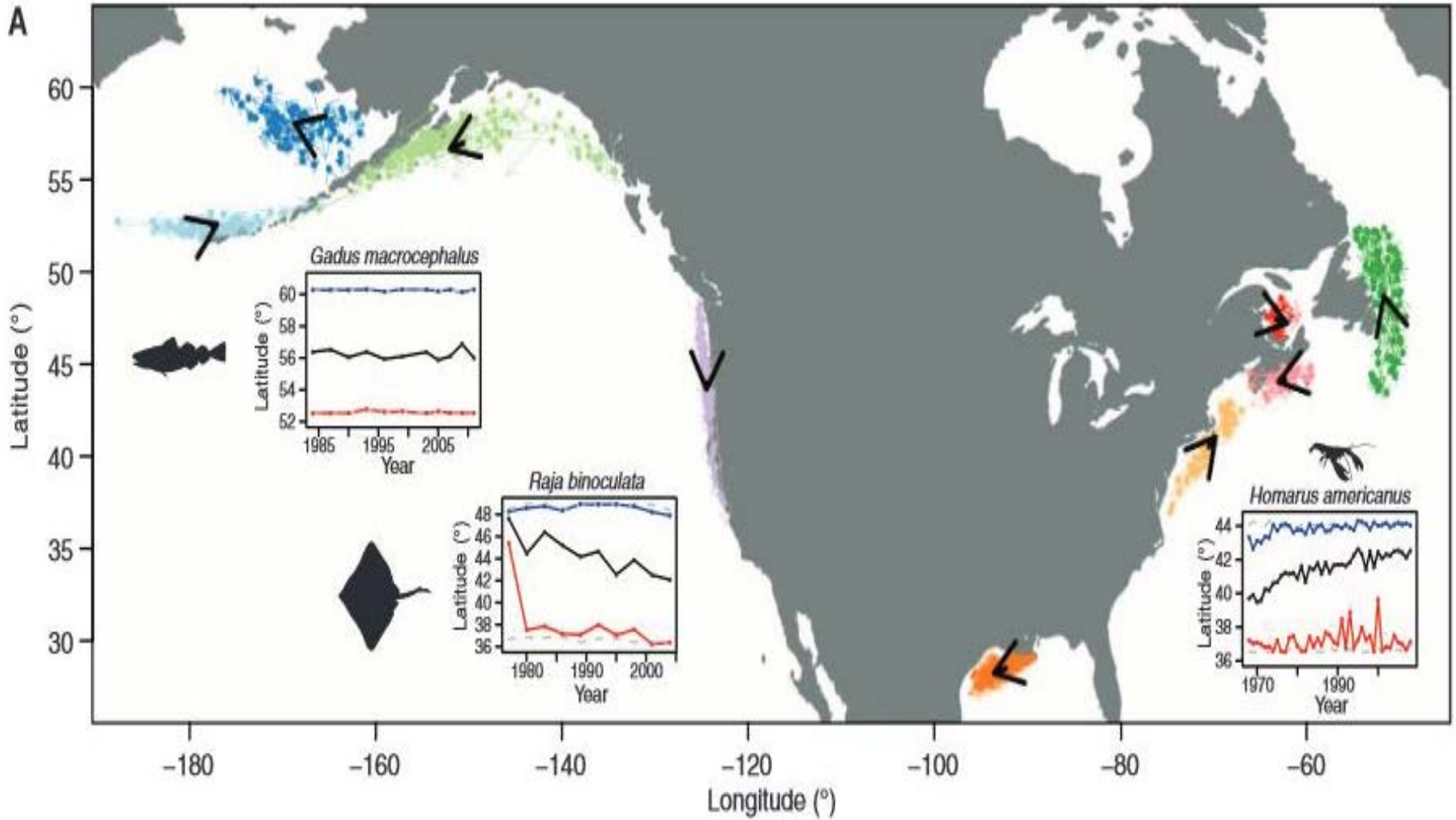


Figure courtesy of William Cheung, Univ. of British Columbia

Shifting Marine Species Distributions



East Coast Warming & Fisheries Management

Declines



Fisheries losses

Increases

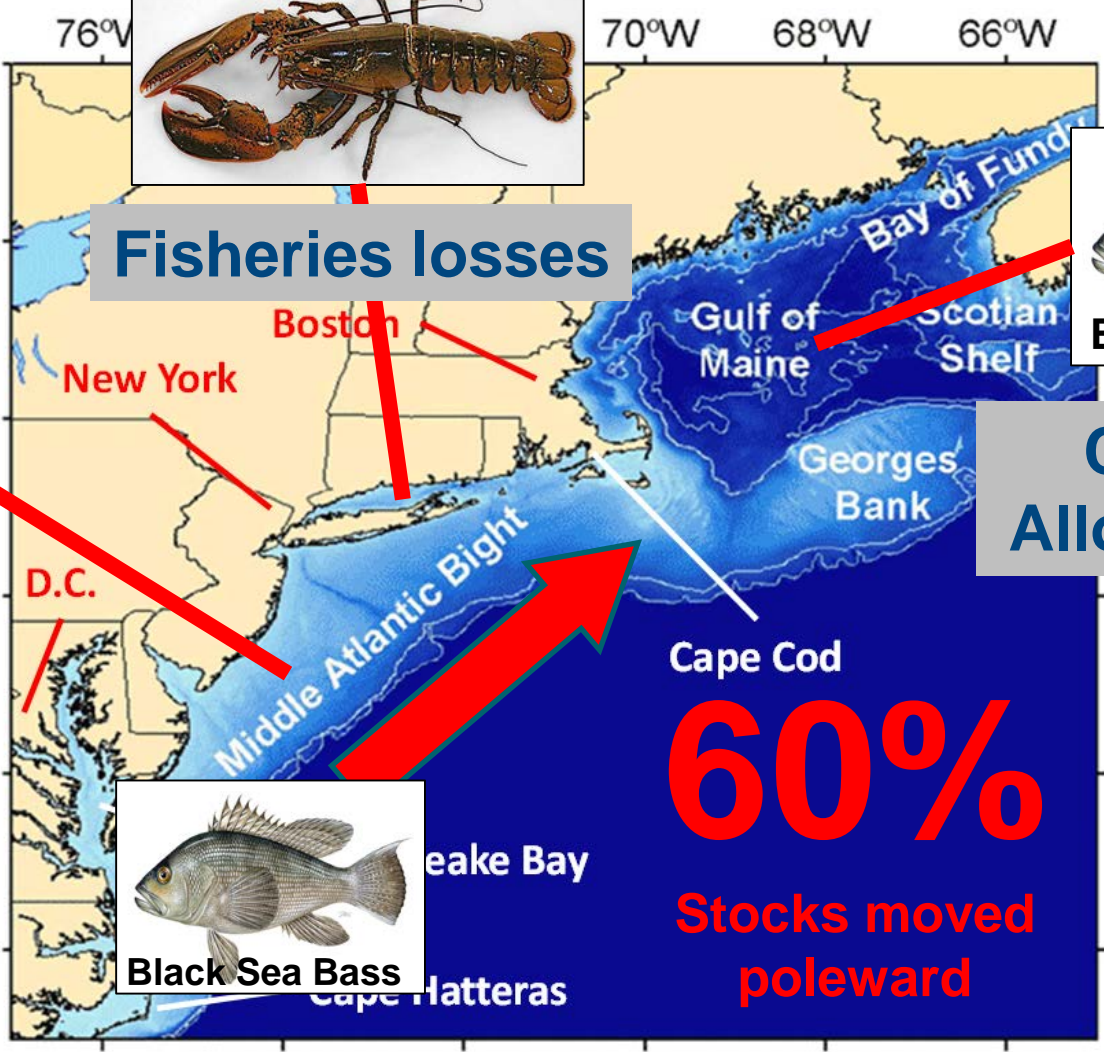


Black Sea Bass

Change Allocations?

60%

Stocks moved poleward



Increases

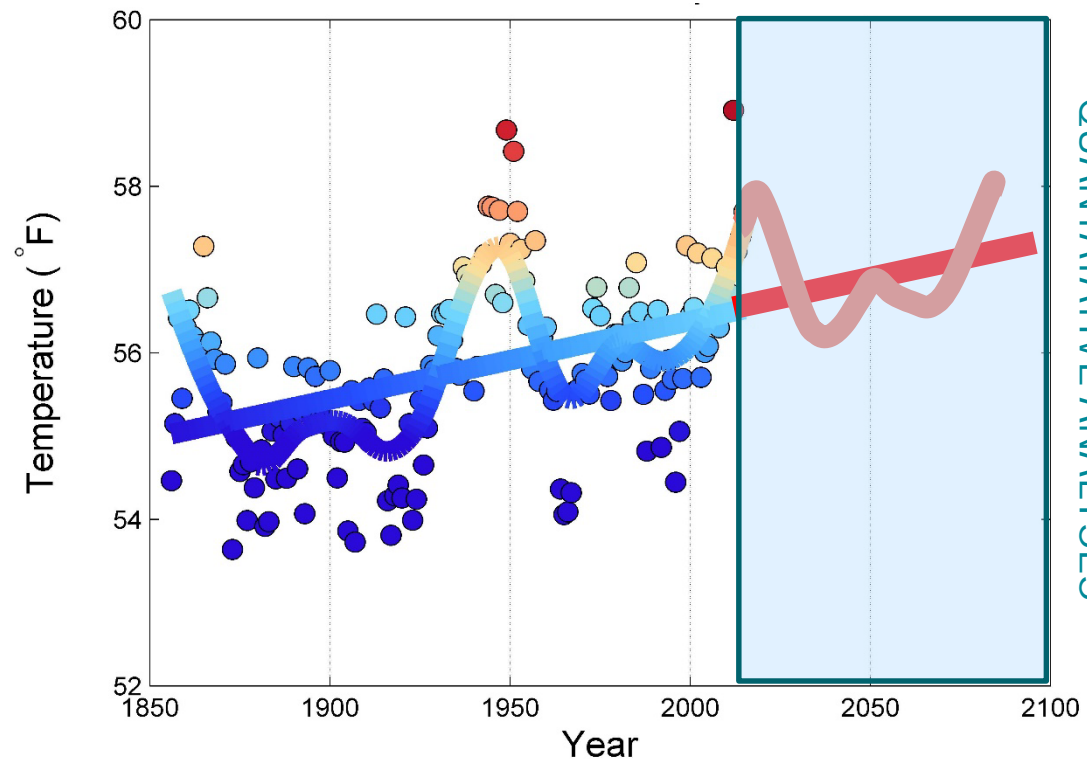


Tile Fish

Management Plan?

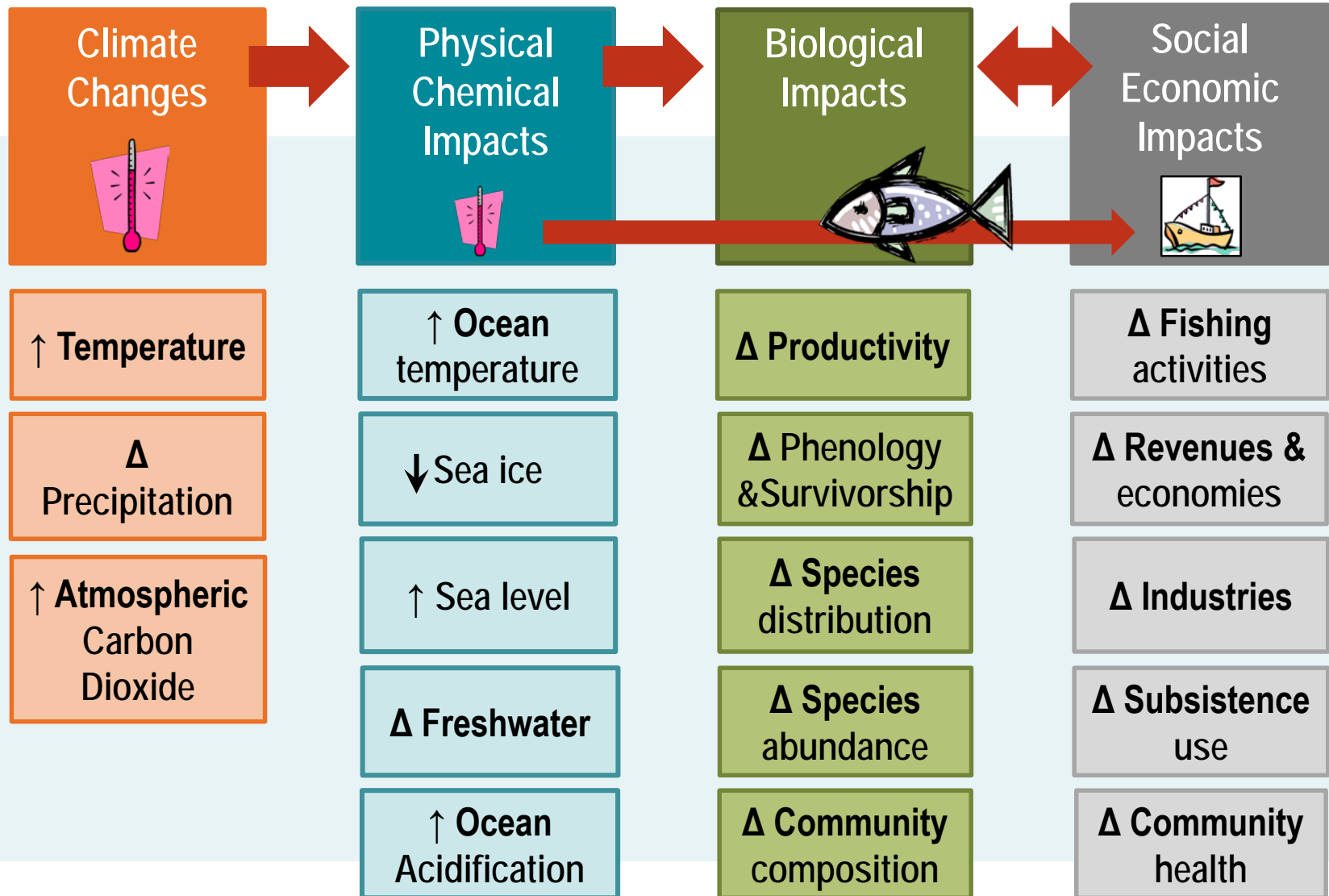
Preparing for Variability and Change in Northeast U.S. Oceans

- Uncertainty in how will ocean conditions will change over near-term (combo of natural variability and change).
- Long-term change signal is strong (30-100 years)
- How prepare for change (including surprises)?



AS SCHEMATIC – NOT BASED ON
QUANTITATIVE ANALYSES

Climate Impacts On Ocean Ecosystems



Thank You

www.st.nmfs.noaa.gov/ecosystems/climate

Ocean Warming Expected to Continue

CMIP5 ENSMN RCP8.5 anomaly (2050-2099)-(1956-2005)

