

Please note that this presentation was given during the United Nations Climate Change Conference (COP-15) in Copenhagen, December 7-18, 2009 for more information please visit <http://www.epa.gov/cop15/state.gov/> .





Impacts of Climate Change on Oceans

The Honorable Dr. Jane Lubchenco

Under Secretary of Commerce for Oceans and Atmosphere
& NOAA Administrator

National Oceanic and Atmospheric Administration | NOAA



Outline

Science and Society

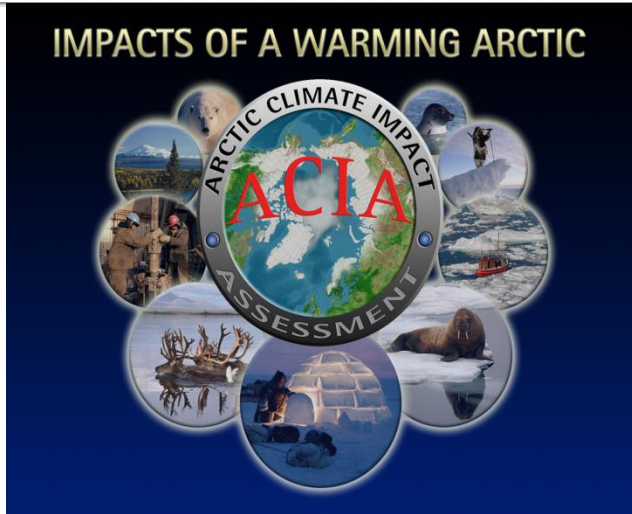
Global Changes in Oceans

Climate Impacts

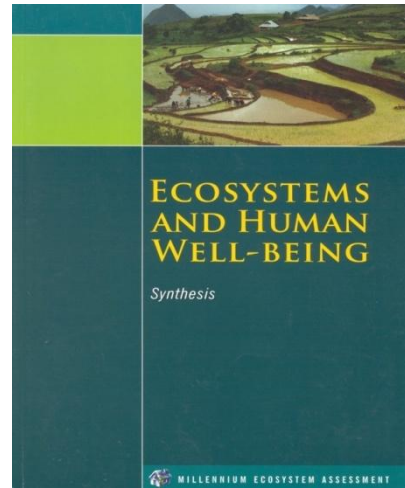
- 🌊 Predicted
- 🌊 Surprises



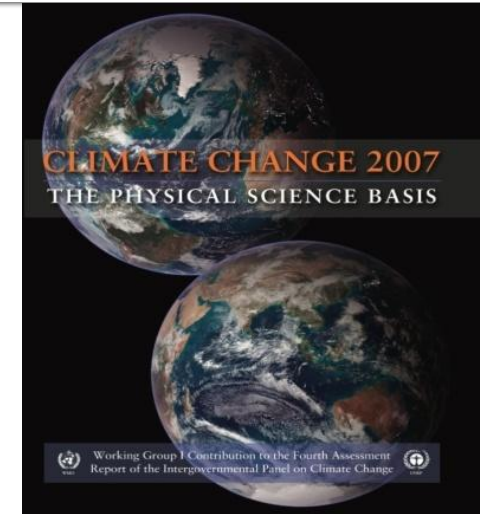
International Scientific Assessments



Arctic Climate Impact Assessment, 2005



Millennium Ecosystem Assessment, 2006



Intergovernmental Panel on Climate Change, 2007

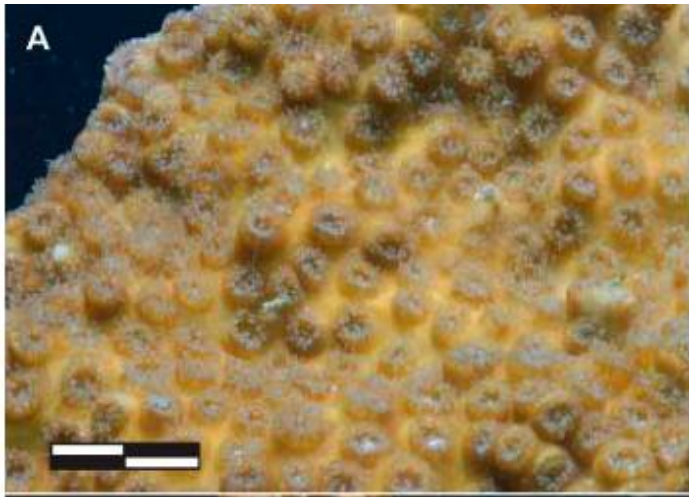
Global Climate Change Impacts in the United States, 2009



Global ocean trends

Depletion and disruption of ocean ecosystems

Loss of resilience (increased likelihood of abrupt changes)



Ocean acidification effect on coral:

(A) healthy coral with skeleton

(B) coral polyps without skeleton—unable to build reef

Ocean Ecosystem Services At Risk

Provisioning

- ✔ seafood
- ✔ habitat
- ✔ fuel wood
- ✔ genetic resources

Cultural

- ✔ spiritual
- ✔ recreational
- ✔ aesthetic
- ✔ educational

Regulating

- ✔ climate regulation
- ✔ disease & pest regulation
- ✔ coastal protection
- ✔ detoxification
- ✔ sediment trapping

Supporting

- ✔ Nutrient cycling
- ✔ Primary production

Causes

Overfishing, destructive fishing

Pollution, especially nutrient pollution

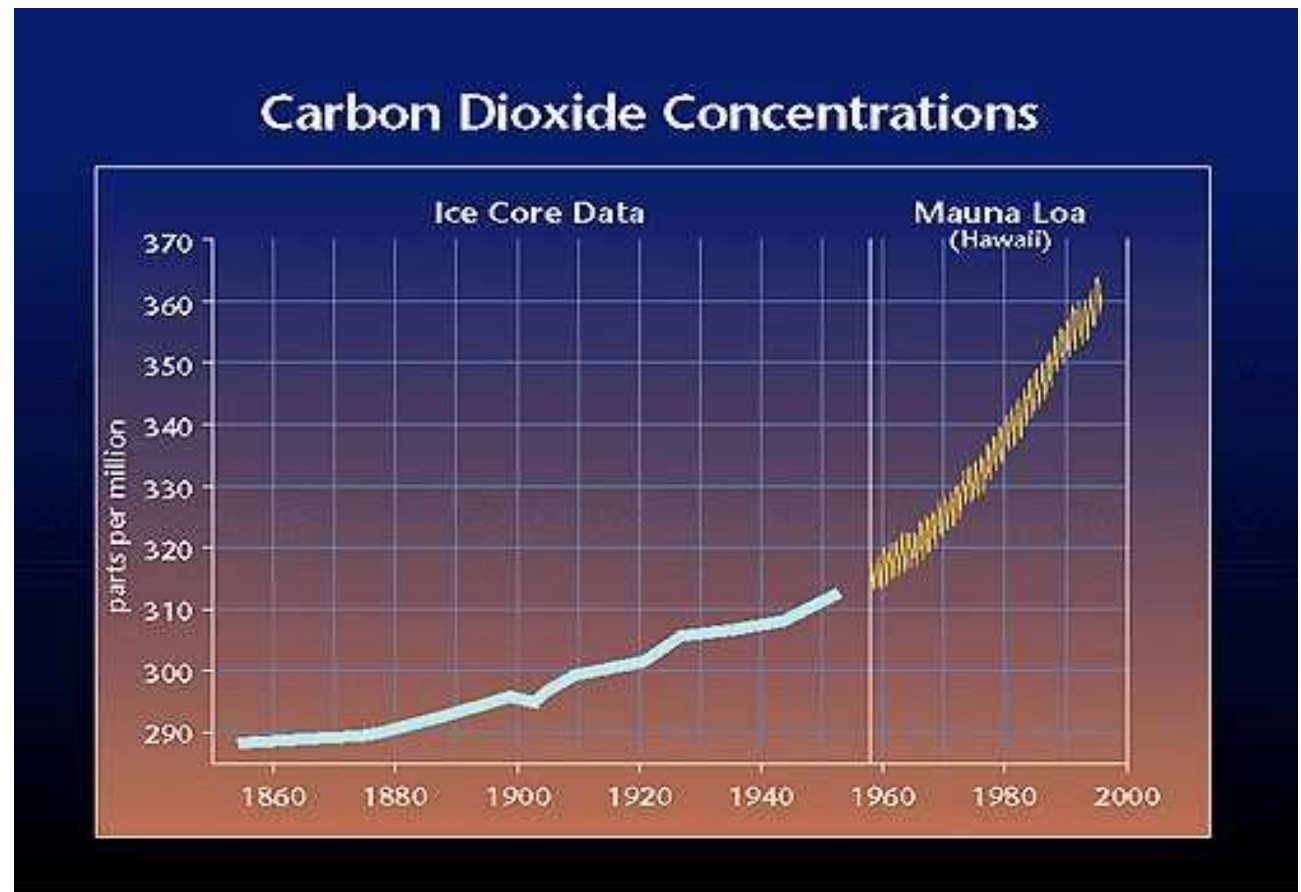
Coastal development: loss of critical coastal habitats

Climate change and ocean acidification

Climate Change and Oceans

A. Predicted changes

B. Surprises



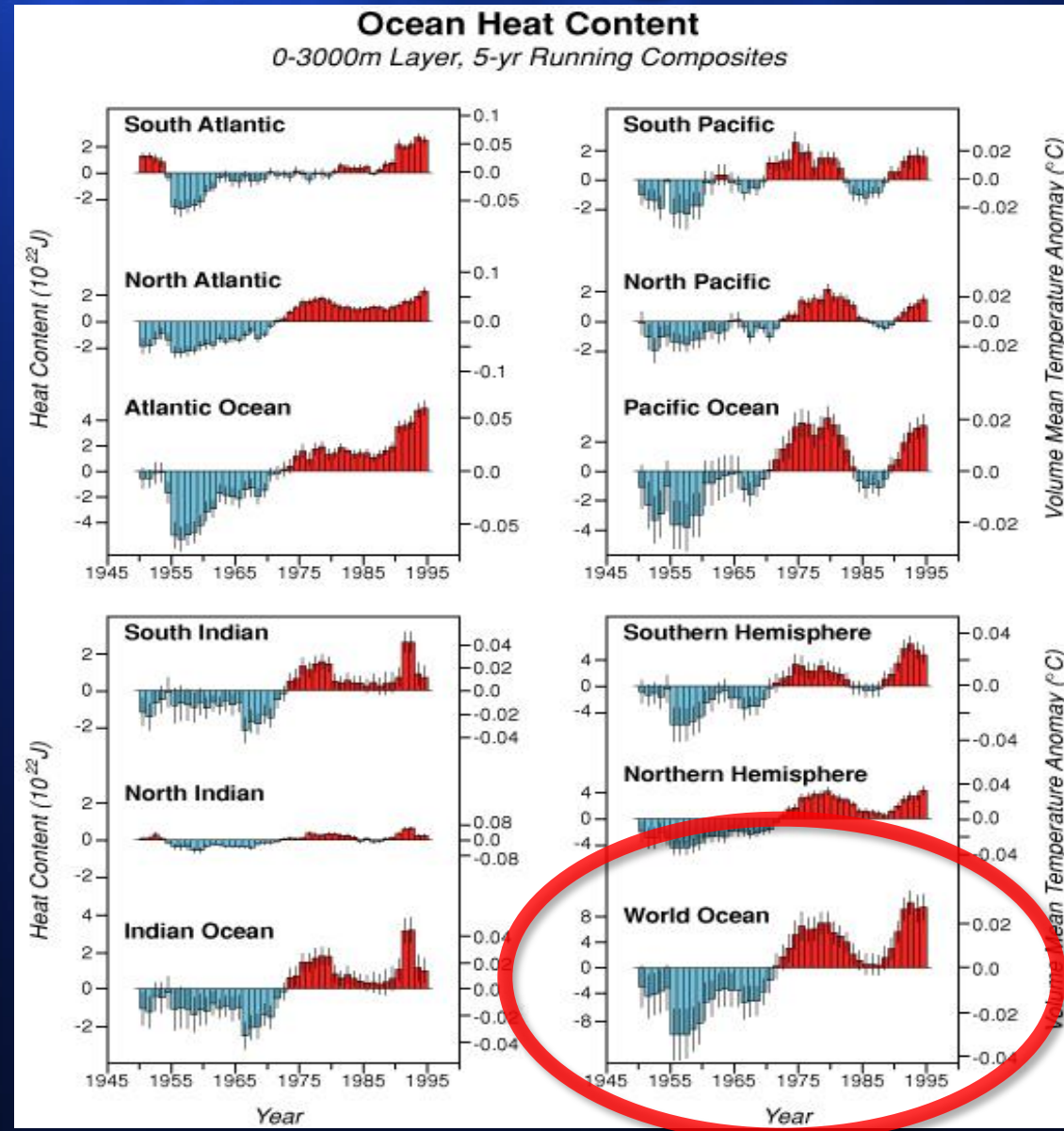
Predicted Physical Changes

- 1. Oceans temperatures will increase**
- 2. Sea level will rise**
- 3. Ocean circulation may change**
- 4. Wave heights will increase**
- 5. Storm tracks will change**
- 6. Storminess will increase**

The Oceans Are Warming

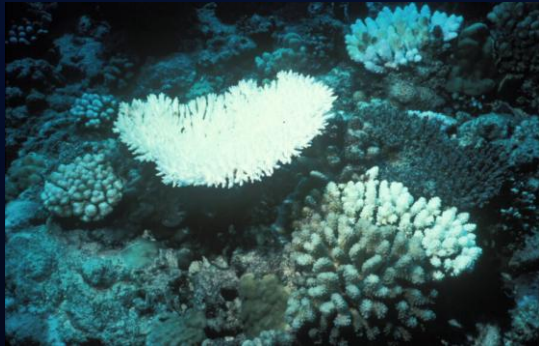
The heat content of the oceans increased in the 2nd half of the 20th century

Levitus et al., 2000

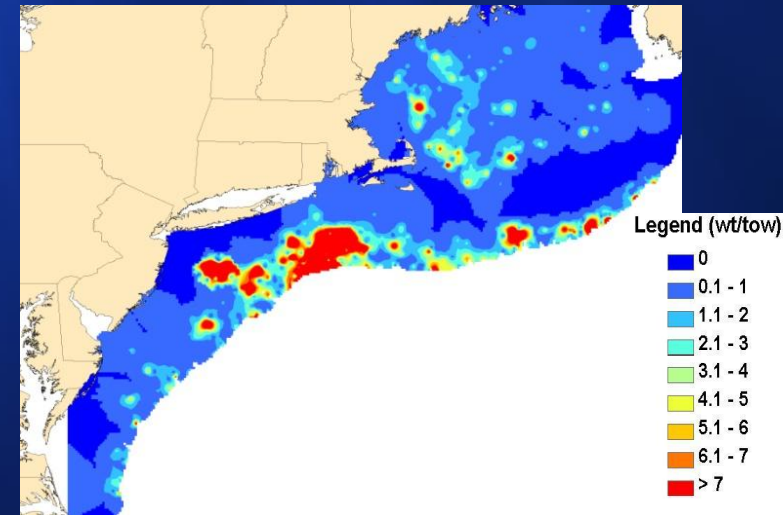


Biological Consequences of Warming Oceans

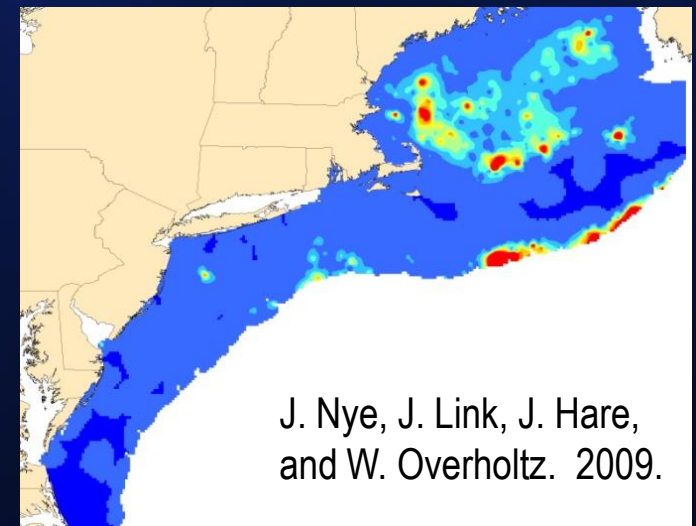
- a) Corals are bleaching
- b) Arctic Sea ice is melting
- c) Many species are shifting ranges or are at risk of extinction



Red Hake 1968-72

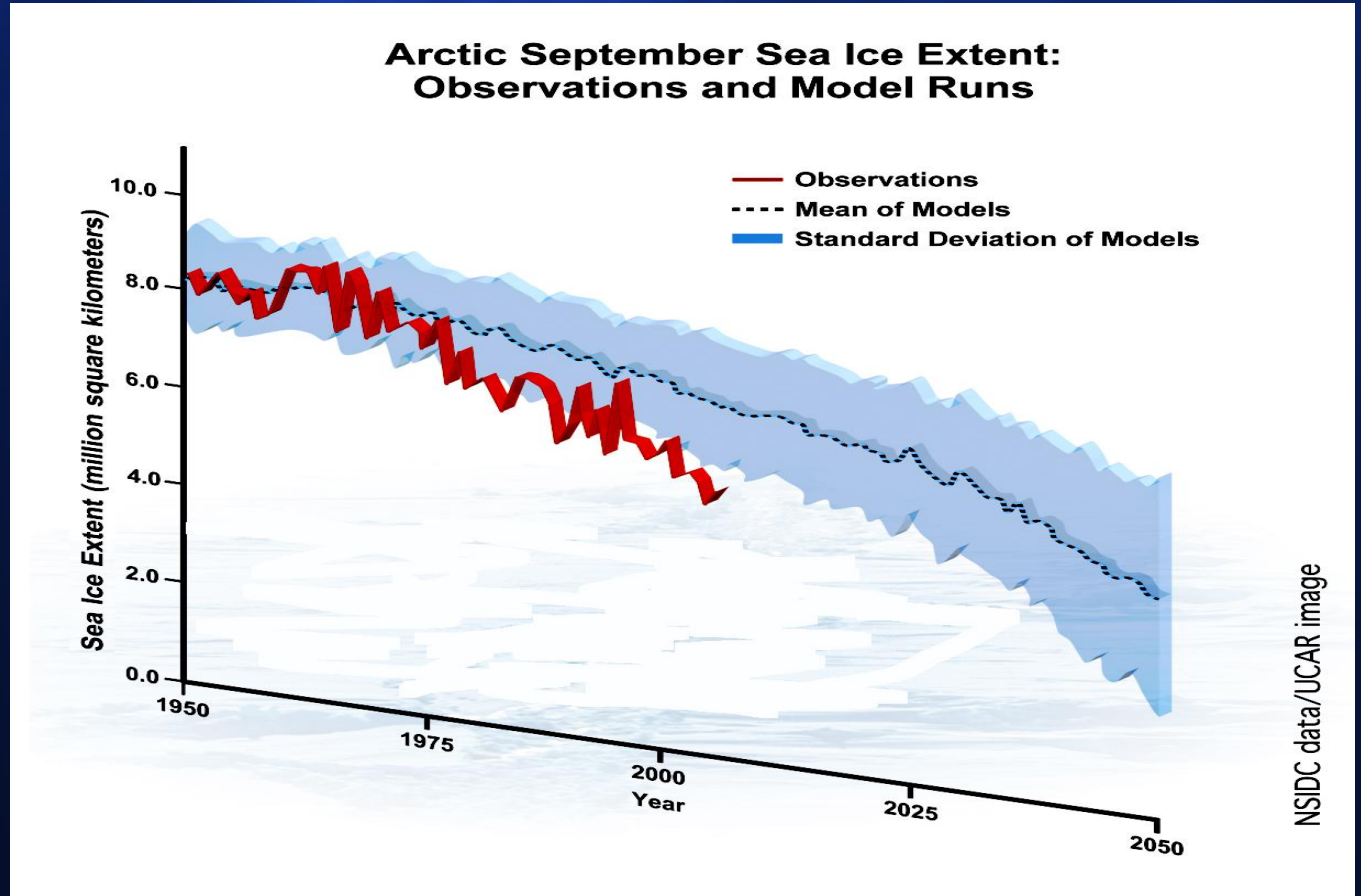
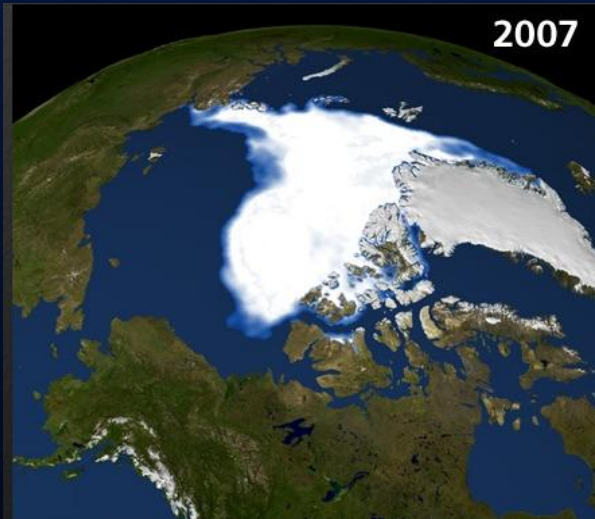
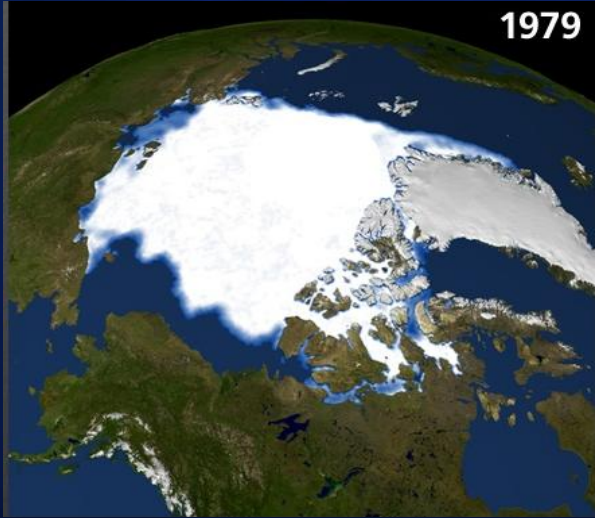


Red Hake 2003-2007



Arctic Sea Ice Extent

Annual Average

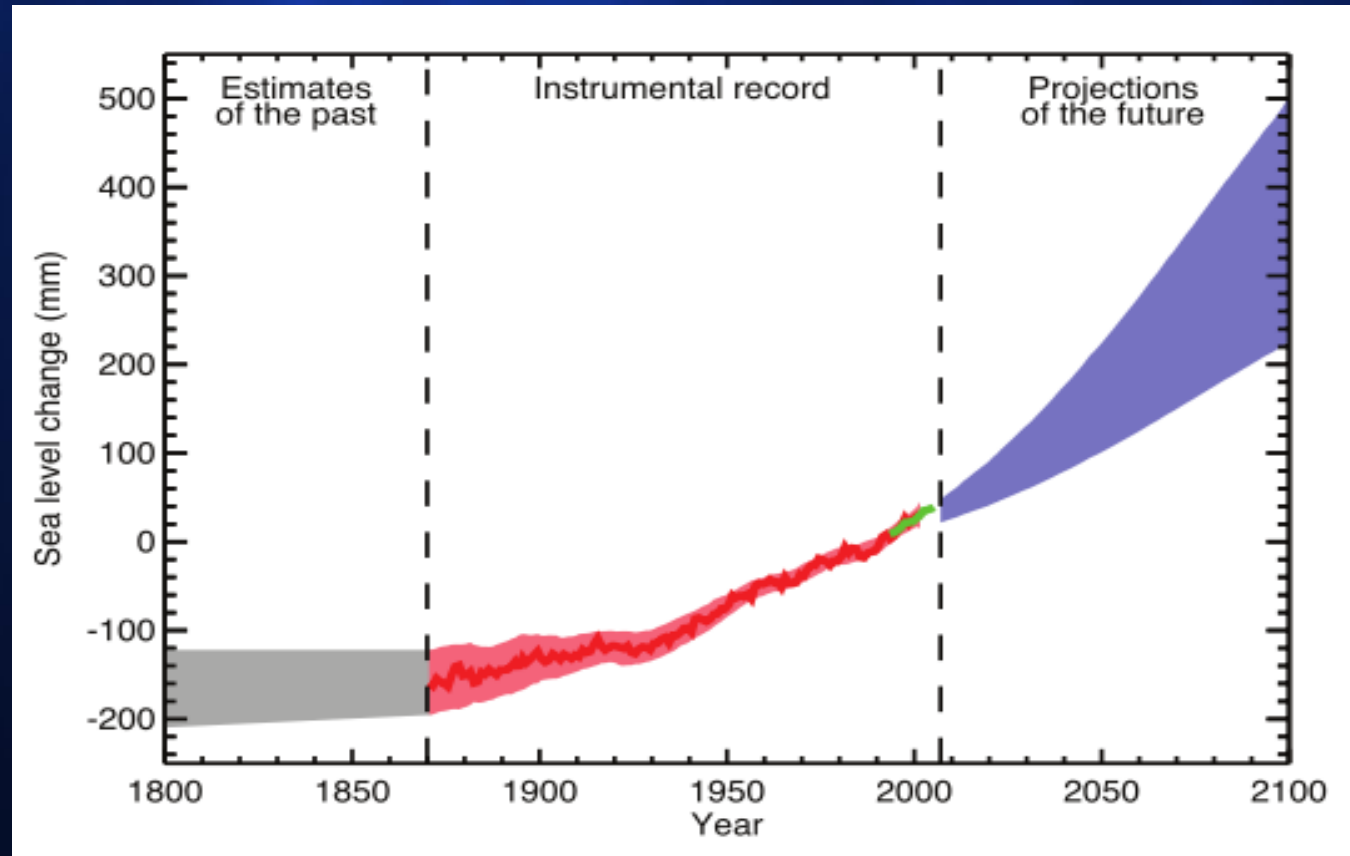


Sea-level Rise Is Accelerating and is Expected To Continue To Rise

Due to

- 1) Thermal expansion
- 2) Melting from glaciers on land
- 3) Melting ice sheets

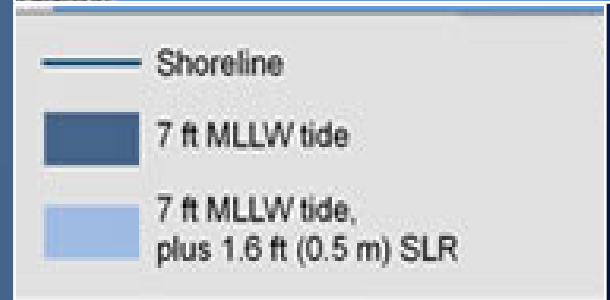
New estimates:
0.75-1.9m by
2100*



IPCC 2007

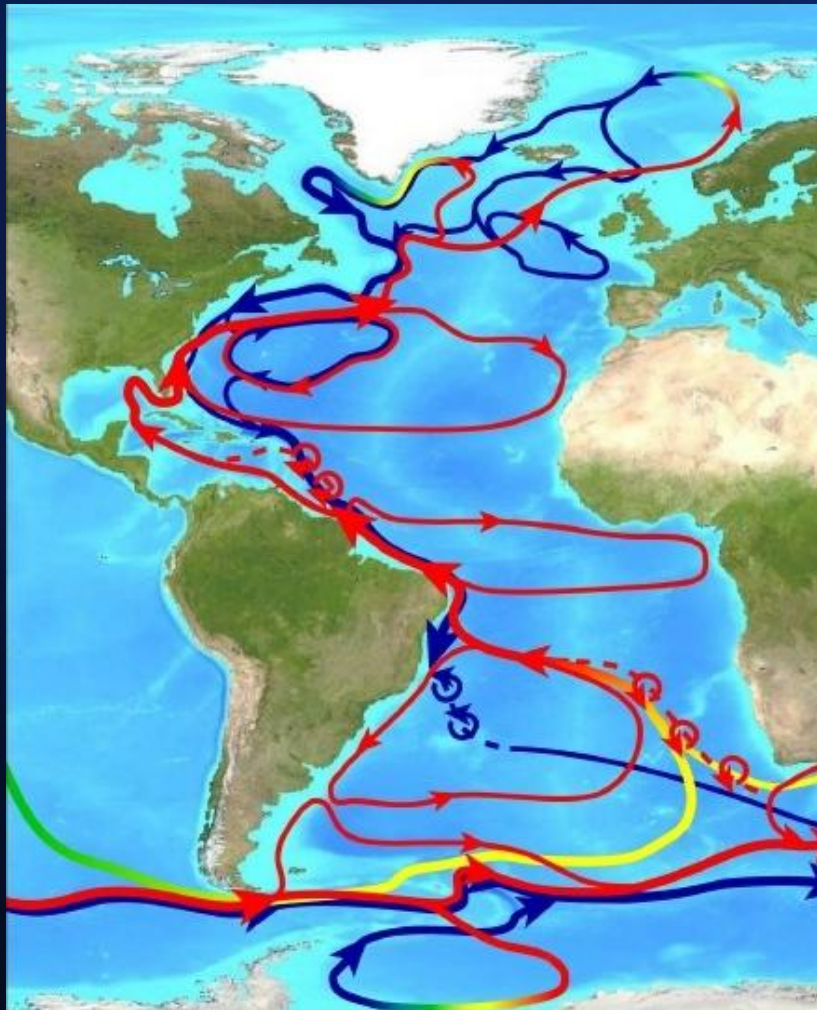
*Vermeer and Rhamstorf 2009

Rising Sea Levels Increase Coastal Vulnerability

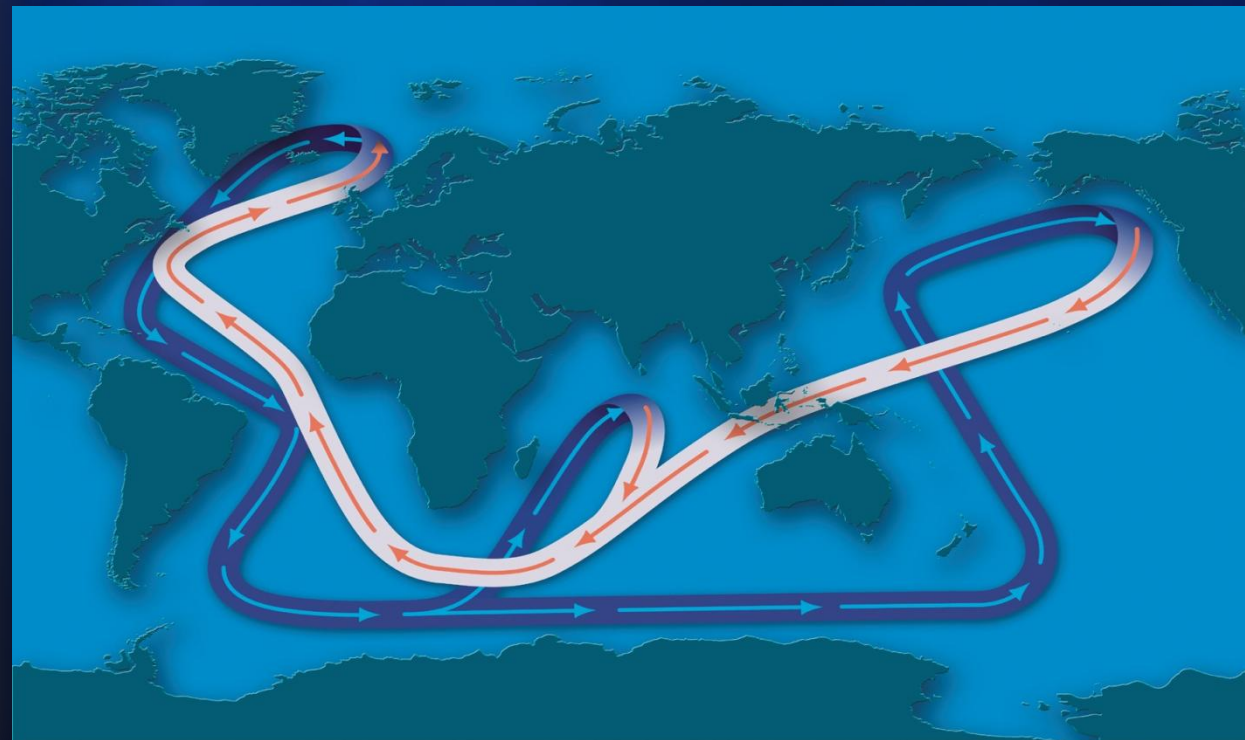


Lidar-derived elevation data for Charleston South Carolina

Large Scale Ocean Circulation Could Change



*'If' and 'When' are
not known*



Summary: Predicted Physical Changes

- 1) Ocean temperatures will increase
- 2) Sea level will rise
- 3) Ocean circulation may change

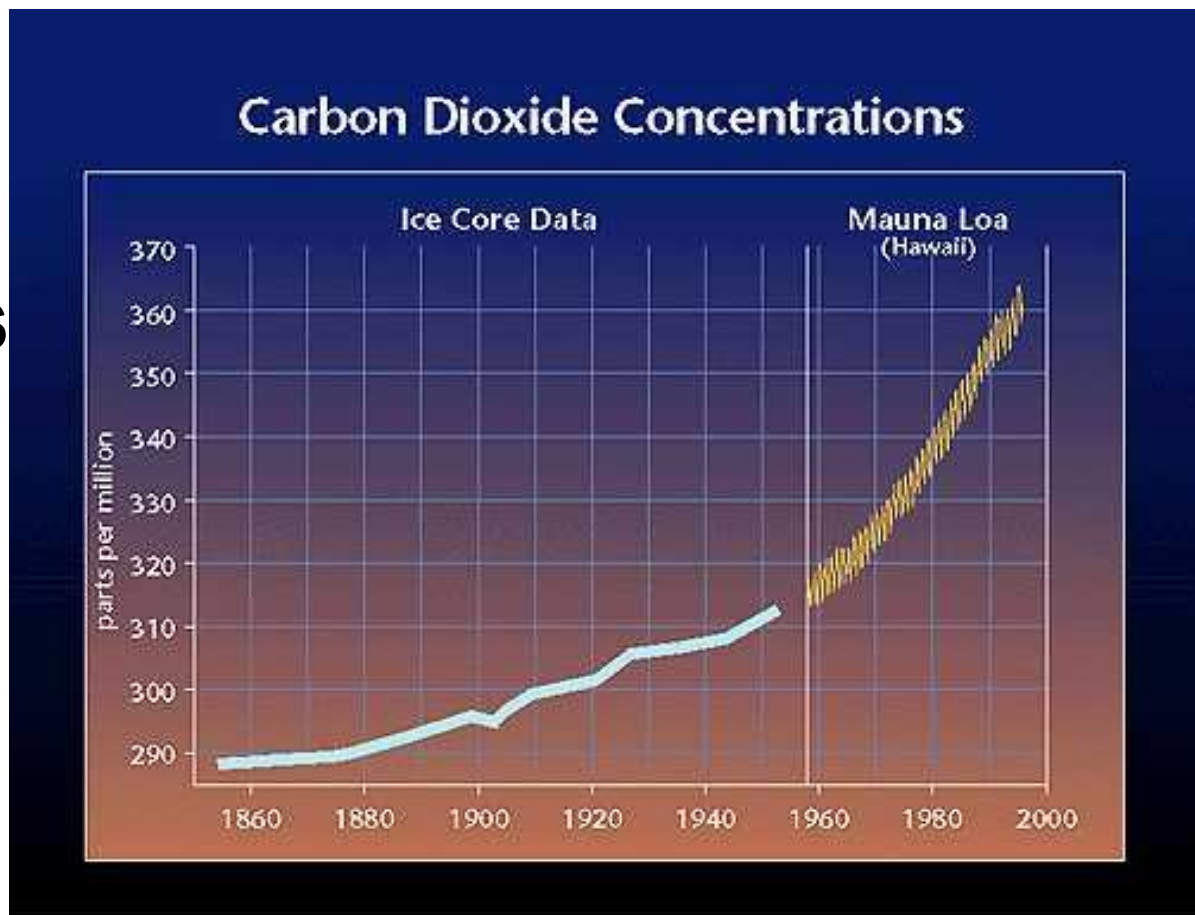
***1 & 2 are happening, faster than expected;
3 is possible
but highly uncertain***

Climate Change Impacts On Ocean Ecosystems

A. Predicted changes

B. Surprises

- 1) Changes in Coastal Upwelling Dynamics
- 2) Decreases in Dissolved Oxygen
- 3) Ocean Acidification

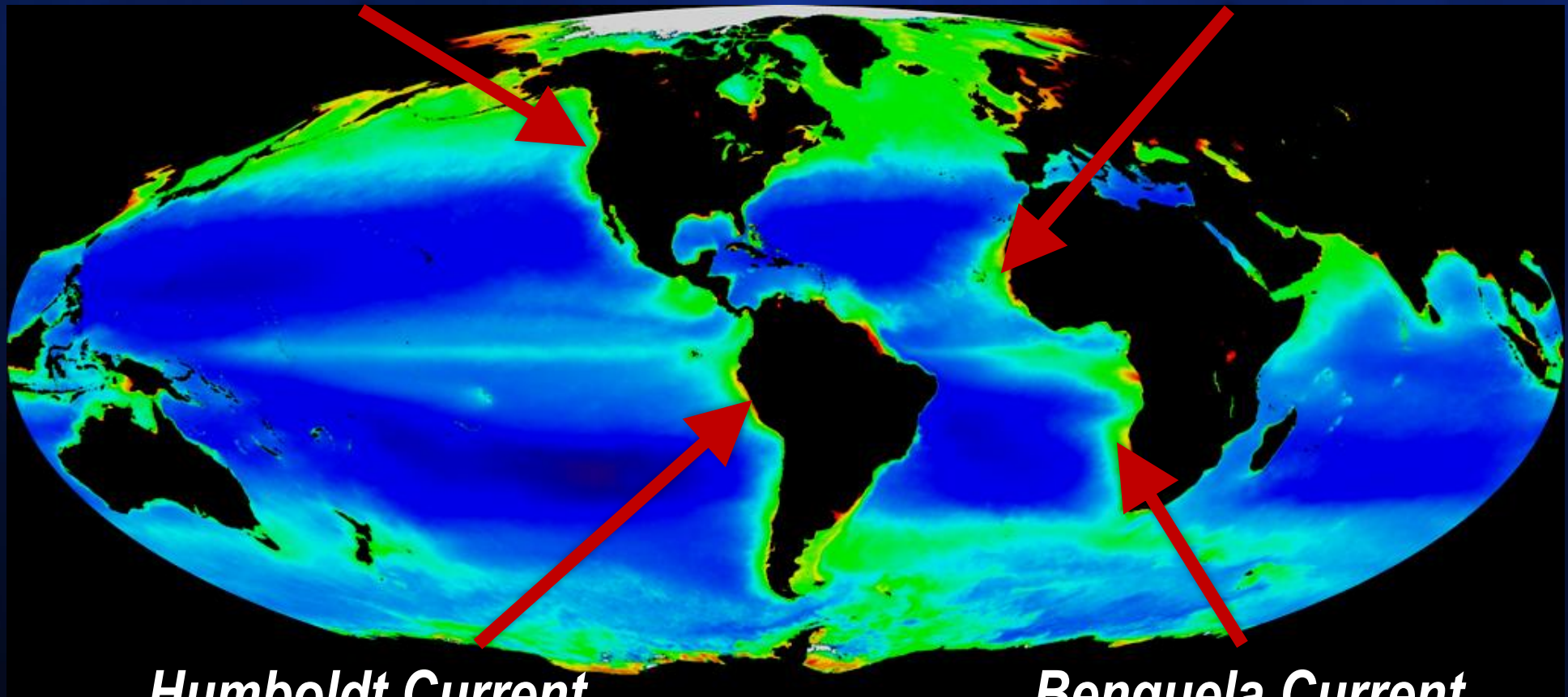


Changes in Coastal Winds & Upwelling

1% surface area; 20% of fisheries

California Current

Canary Current



Humboldt Current

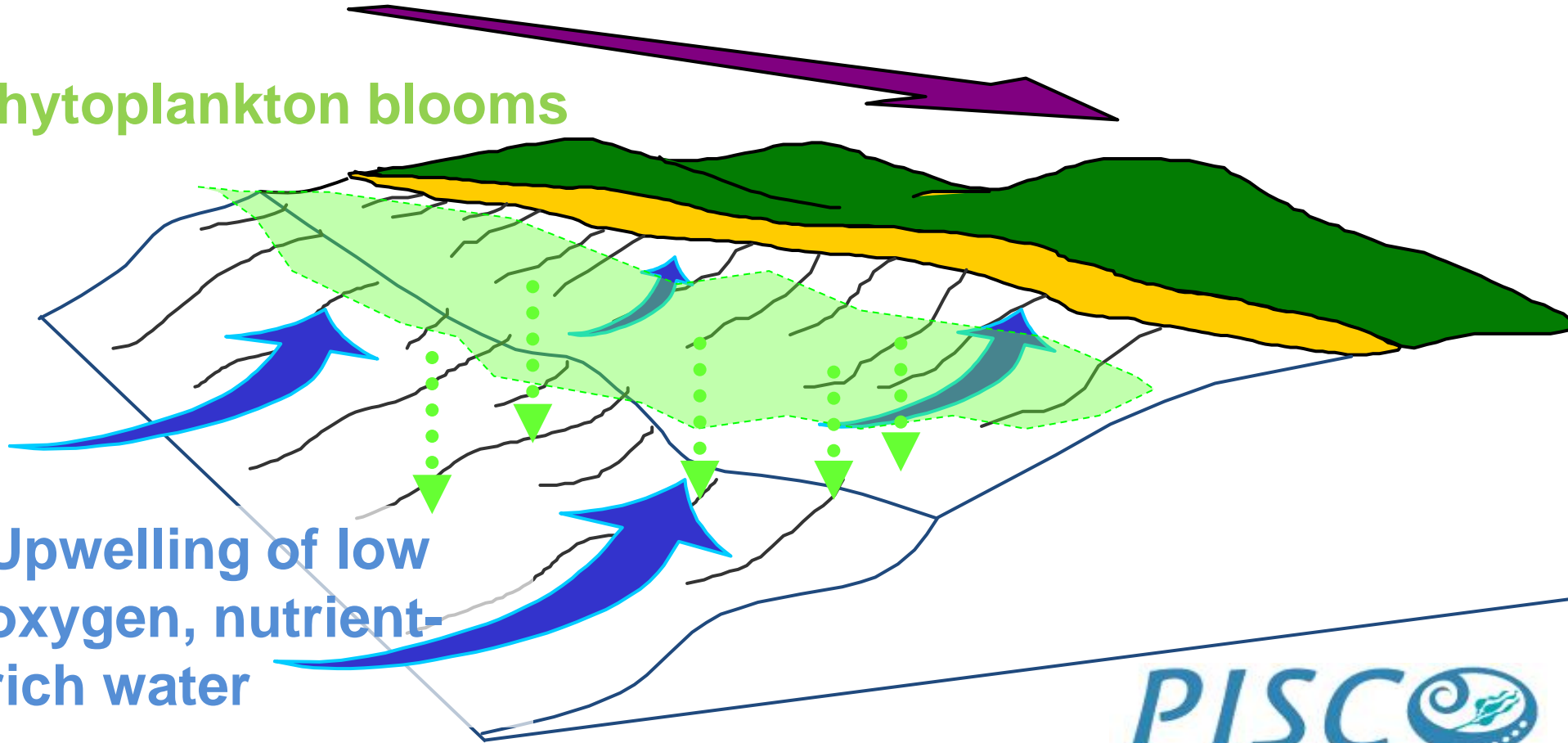
Benguela Current

What Causes Hypoxic Zones To Form Along Coasts?

1. Equatorward Winds Drive Upwelling Currents

3. Phytoplankton blooms

2. Upwelling of low oxygen, nutrient-rich water

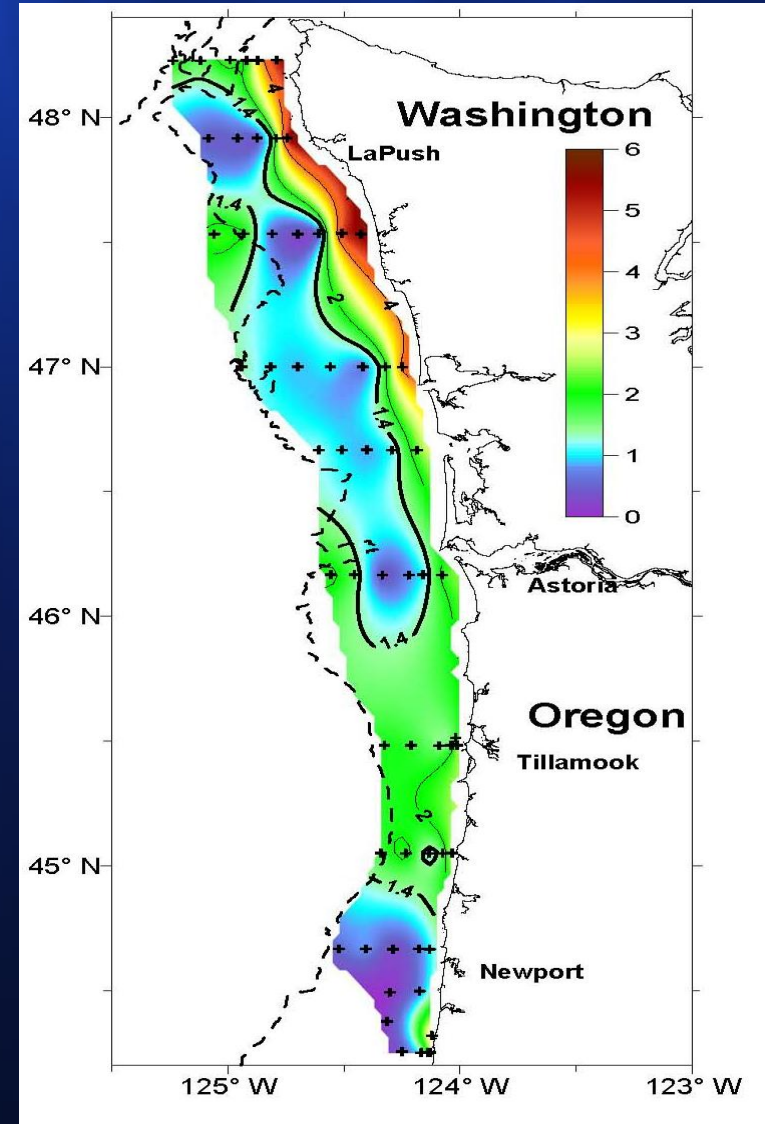


PISCO

8 hypoxic events in 8 years along the Oregon and Washington coast (2002-2009)



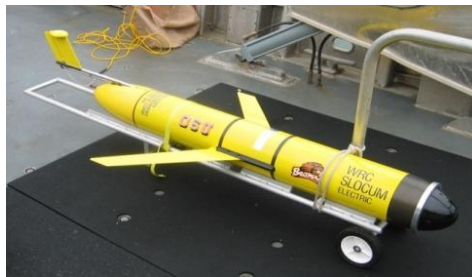
September 20-28, 2006 BPA
and PISCO cruises
(Figure Courtesy Bill Peterson,
Cheryl Morgan NOAA)



At Times 80% Of The Shelf Water Column was Hypoxic

2006:

- 🌊 Longest lasting – 4 months
- 🌊 Largest off Oregon and Washington
- 🌊 Thickest ~2/3 of water column
- 🌊 Most severe – anoxic = no oxygen



OSU glider

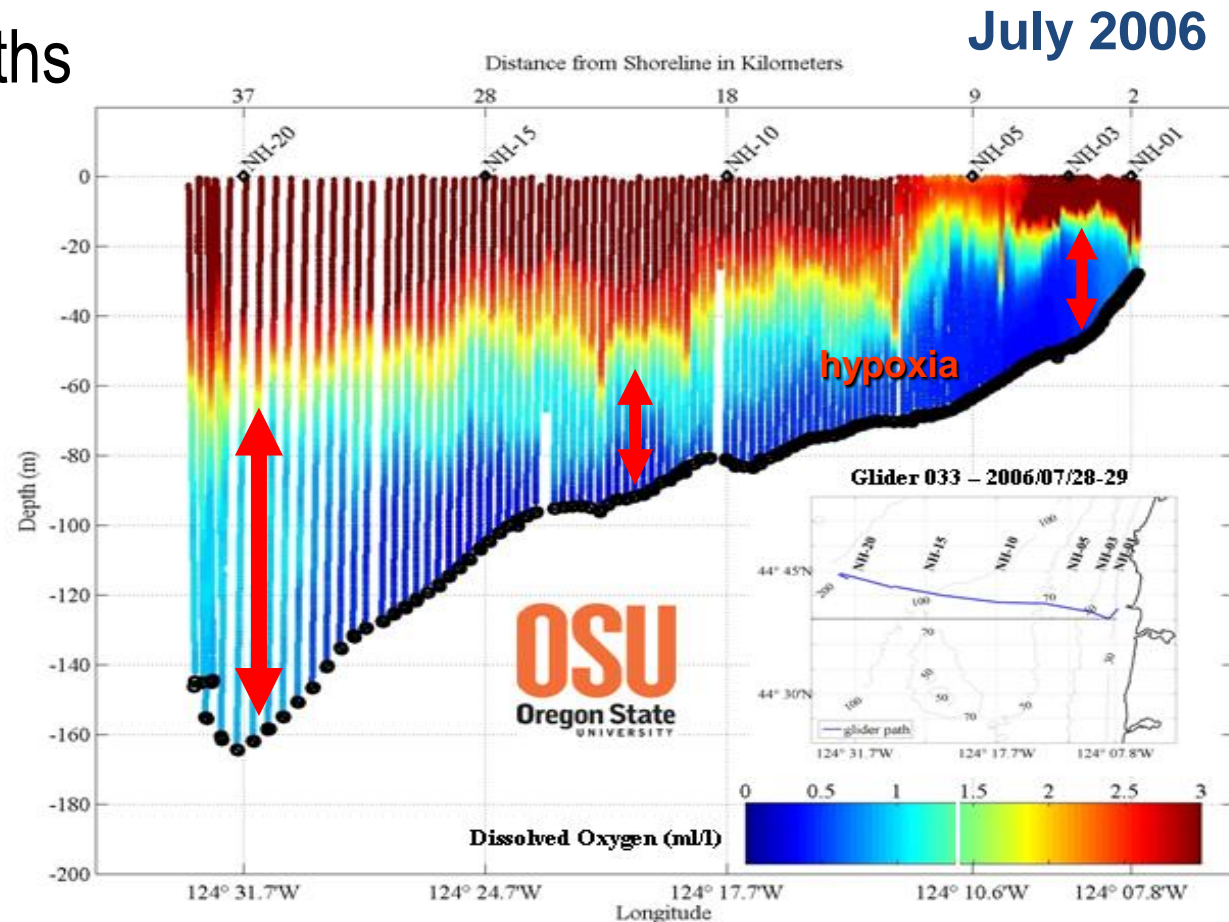
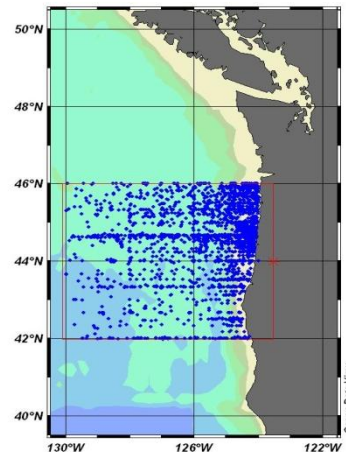
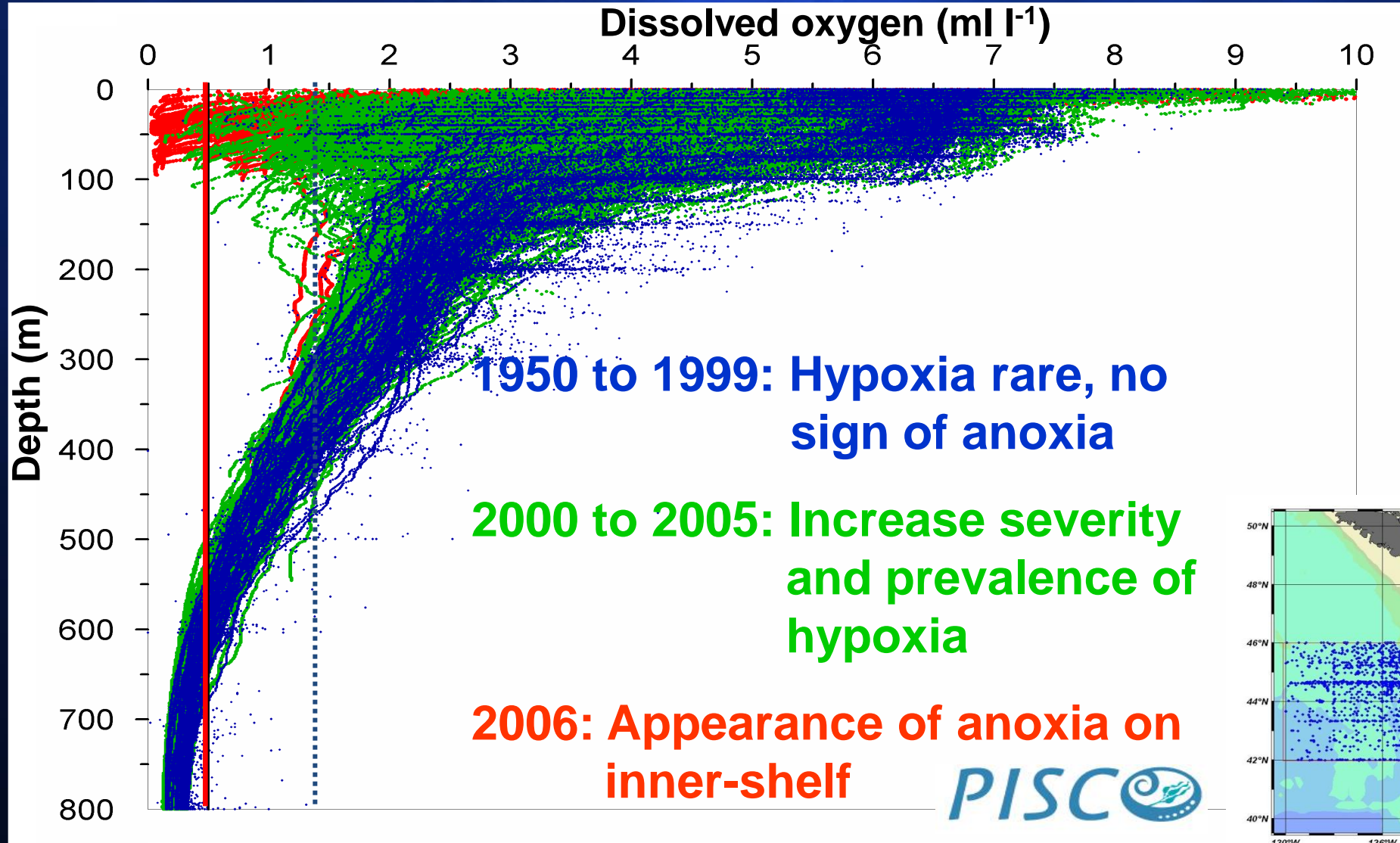


Figure: Jack Barth/ Kipp Shearman

No historical precedent



National Oceanographic Data Center, NOAA, OSU
Archives, GLOBEC LTOP, NOAA, PISCO

Chan et al. Science 2008

Working Hypotheses

Fundamental changes in oceanic and atmospheric conditions in the California Current Ecosystem

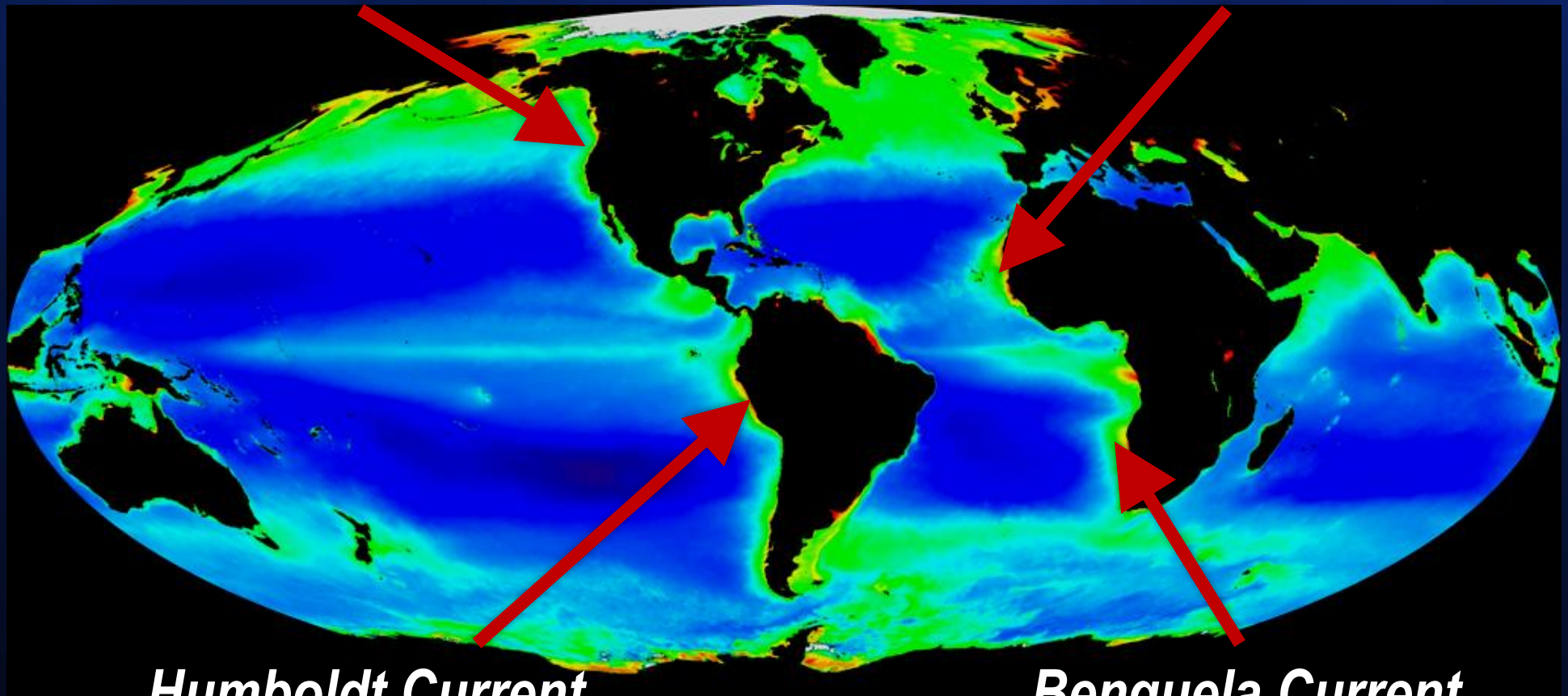
These changes in oceanic and atmospheric circulation may result from climate change

Surprise #1: Changes in Coastal Winds & Upwelling

1% surface area; 20% of fisheries

California Current

Canary Current



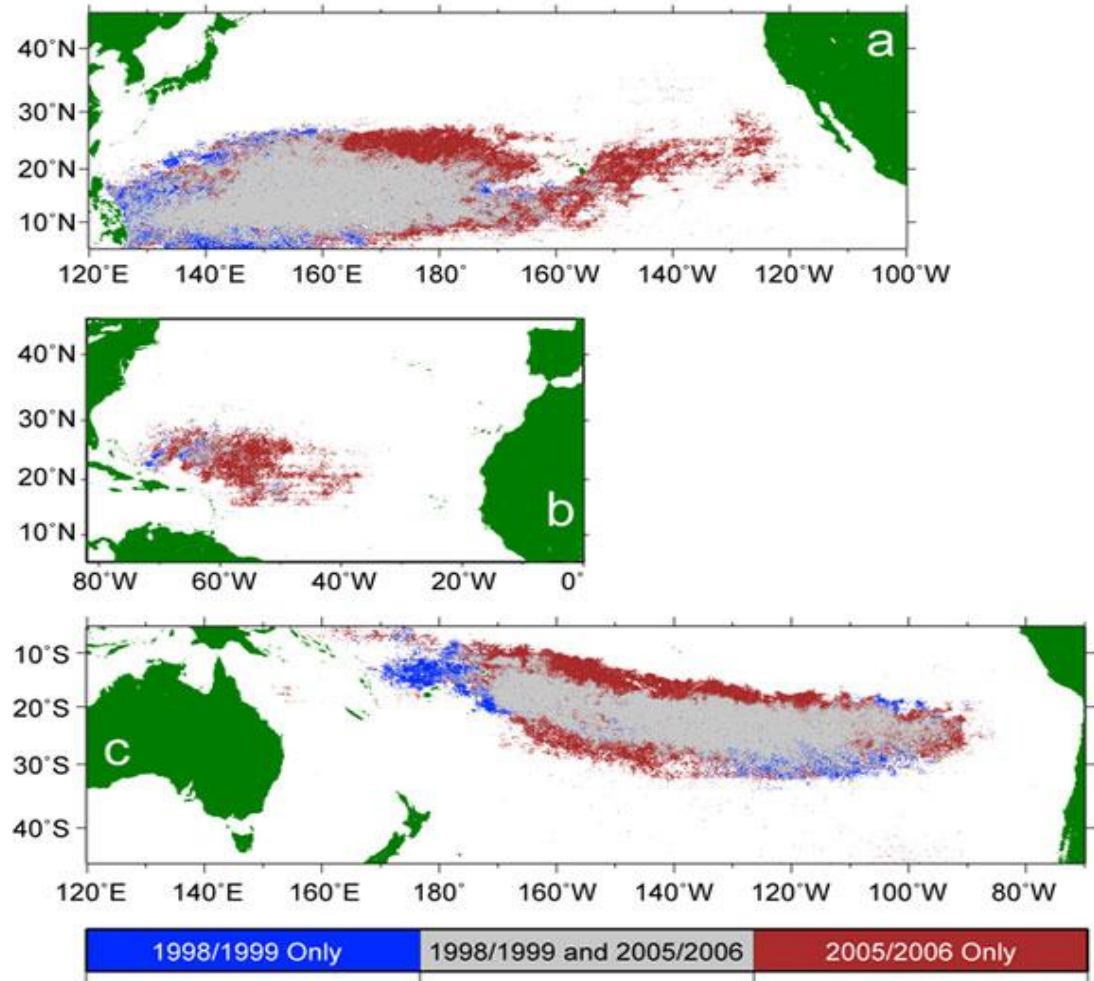
Humboldt Current

Benguela Current

Surprise #2: Expansion of the Oceans Least Productive Areas

Between 1998 and 2006, low productivity, oligotrophic areas expanded by 6.6 million km², or about 15%

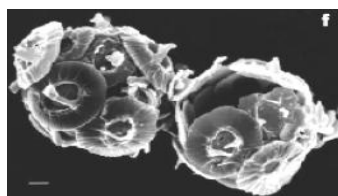
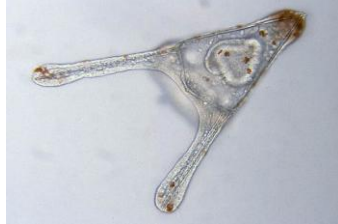
Rates of expansion already greatly exceed model predictions



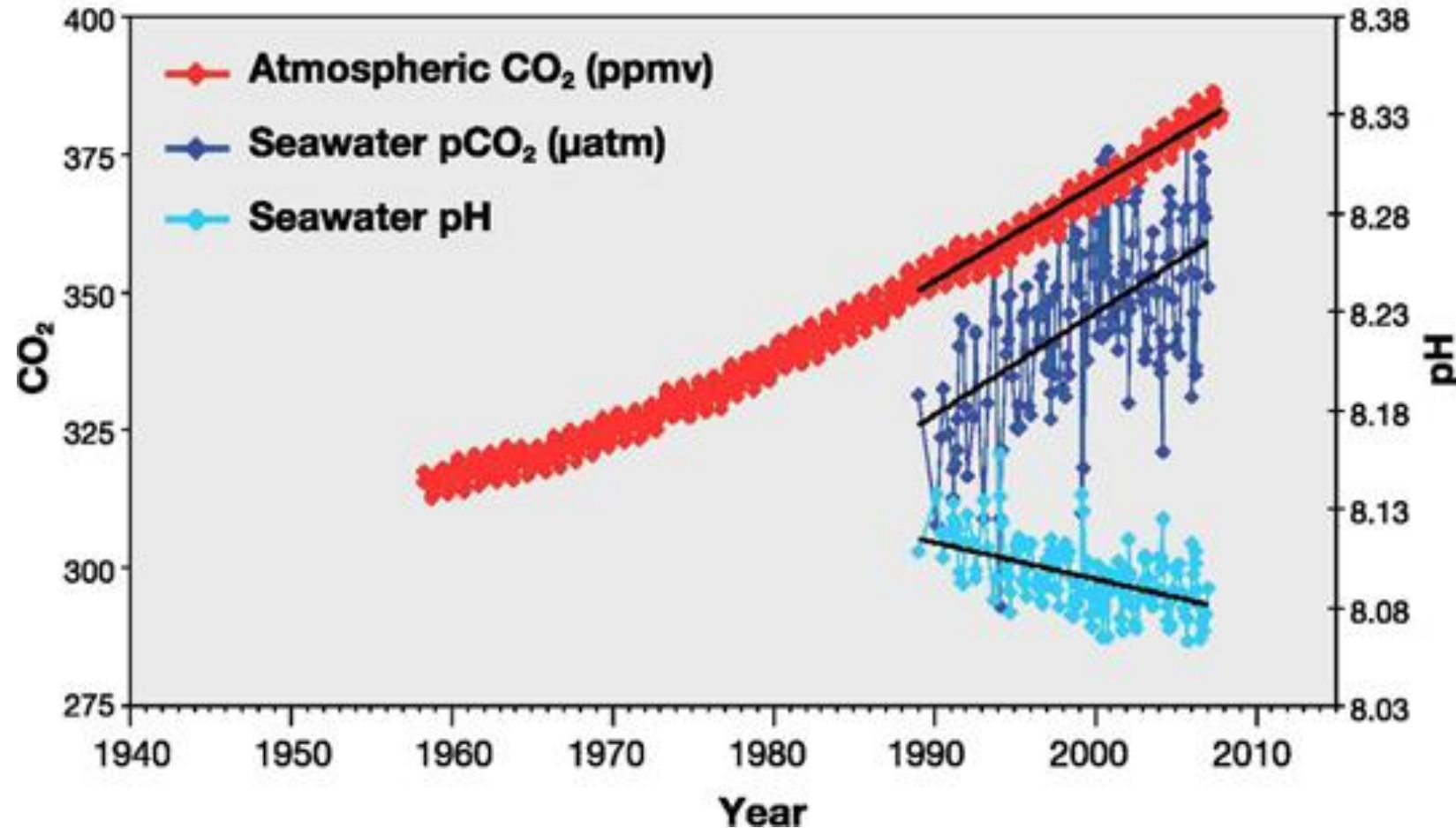
Polovina et al. 2008. *Geophysical Res. Lett.* 35(3), L03618, doi:10.1029/2007GL031745

Surprise #3: Ocean Acidification

Climate Change's "Equally Evil Twin"



CO₂ and pH time series in the North Pacific Ocean



Adapted from Feely (2008) in Levinson and Lawrimore (eds), *Bull. Am. Meteorol. Soc.*, 89(7): S58.

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Global Changes in Oceans

Climate Impacts

- 🌊 Predicted
- 🌊 Surprises



Global Approaches

- 1. Mitigate: avoid the unmanageable**
- 2. Adapt: manage the unavoidable**

Adaptation Strategies to Minimize Impacts of Climate Change

Reduce other stresses that can be controlled

- ☑ Reduce nutrient and chemical pollution
- ☑ Manage fisheries conservatively
- ☑ Control invasive species

Protect biodiversity and habitats to maximize likelihood of adaption

Invest in scientific research, monitoring and education



Thank You!

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Rising Sea Levels Increase Coastal Vulnerability



Charleston, South Carolina
1.0M Sea Level Rise