Changing Climate
Changing Oceans

Roger Griffis, Climate Coordinator, NOAA Fisheries Service

MPA FAC Meeting, May 2017
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

- **Climate Changes**
  - $\uparrow$ Temperature
  - $\Delta$ Precipitation
  - $\uparrow$ Atmospheric Carbon Dioxide

- **Physical Chemical Impacts**
  - $\uparrow$ Ocean temperature
  - $\downarrow$ Sea ice
  - $\uparrow$ Sea level
  - $\Delta$ Freshwater
  - $\uparrow$ Ocean Acidification

- **Biological Impacts**
  - $\Delta$ Productivity
  - $\Delta$ Phenology & Survivorship
  - $\Delta$ Species distribution
  - $\Delta$ Species abundance
  - $\Delta$ Community composition

- **Social Economic Impacts**
  - $\Delta$ Fishing activities
  - $\Delta$ Revenues & economies
  - $\Delta$ Industries
  - $\Delta$ Subsistence use
  - $\Delta$ Community health
Our Warming Planet

10,000 year record

We are here
Record Levels of CO2 in the Atmosphere

Record Average in 2015 (400 ppm)
Earth is now 1.5°F warmer than 20th century Ave.
Most (>90%) of Earth’s energy surplus has been absorbed by the ocean.
Most (>90%) of Earth’s energy surplus has been absorbed by the ocean.
Ocean Warming Expected to Continue

Projected Average Annual Surface Temperature (IPCC AR5)
Today, global sea level is rising at an accelerating rate.

Since 1900 global mean sea level has risen by about 7–8 inches (about 16–21 cm).
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
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 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.
More than 400 ocean dead zones reported between 2000 and 2008.

- 300 (1990s)
- 120 (1980s)
Record Levels of CO2 in the Atmosphere

Average in 2011 (almost 392 ppm)
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
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

A. Atmospheric CO2
B. Sea Surface Temperature
C. Sea Level
D. Summer Arctic Sea Ice
E. Sea Surface pH

2014 US National Climate Assessment
CHANGE AHEAD
Shifting Marine Species Distributions
East Coast Warming & Fisheries Management

Management Plan?

Declines

Increases

Fisheries losses

Black Sea Bass

Tiles Fish

Change Allocations?

60%

Stocks moved poleward
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)?
Climate Impacts On Ocean Ecosystems

Climate Changes

- ↑ Temperature
- Δ Precipitation
- ↑ Atmospheric Carbon Dioxide

Physical Chemical Impacts

- ↑ Ocean temperature
- ↓ Sea ice
- ↑ Sea level
- Δ Freshwater
- ↑ Ocean Acidification

Biological Impacts

- Δ Productivity
- Δ Phenology & Survivorship
- Δ Species distribution
- Δ Species abundance
- Δ Community composition

Social Economic Impacts

- Δ Fishing activities
- Δ Revenues & economies
- Δ Industries
- Δ Subsistence use
- Δ Community health
Ocean Warming Expected to Continue

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

- **Alaska**
  - Current SST change: +0.81°C

- **Northwest**
  - Current SST change: +0.45°C

- **Southwest**
  - Current SST change: +0.67°C

- **Northeast**
  - Current SST change: +0.73°C

- **Gulf of Mexico**
  - Current SST change: +0.24°C

- **Caribbean**
  - Current SST change: +0.51°C