Natural cycles in unnatural times
or
the limitations of linear thinking in an increasingly non-linear world

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Outline

• National Climate Assessment
• Marine Heatwaves
• Surprise!

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4th US National Climate Assessment

- Established under US Global Change Research Act
- “What do we value and what is at risk?”
- NCA currently underway
  - chapter drafts submitted
  - public comment/NAS review this winter
  - final version end of 2018
NCA Oceans and Marine Resources

- Goal: help the people of the US see how change in the oceans will impact the nation
- Draft key messages:
  1. Ecosystem disruption
  2. Impacts on fisheries
  3. Heatwaves and events
Marine heatwaves

• Marine heatwave:
  • “a discrete prolonged anomalously warm water event in a particular location”

Hobday et al. (2016) A hierarchical approach to defining marine heatwaves. Progress in Oceanography
Recent Heatwaves

2011
Recent Heatwaves

2011

Heatwave Days

2012

Heatwave Days
Recent Heatwaves

2015
Ecological & Socioeconomic Impacts

- Species on the move
Ecological & Socioeconomic Impacts

• Species on the move
• Impacts on fisheries

Ecological & Socioeconomic Impacts

- Species on the move
- Impacts on fisheries
- Impacts on people

2012 North Atlantic Heatwave

- Jet stream displaced northward
- Mild fall & winter

Climate change & climate variability

+ additive effects repeatable impacts
2016 = 2012 in the Gulf of Maine?

2016 Temperature Through 1/1, relative to 1982-2011

Maine Lobster Landings
2016 = 2012 in the Gulf of Maine?
Repeatability

• Humans learn from their mistakes (sometimes)
  • but our expectations strongly colored by the past
• Natural communities also evolve
  • an ecosystem with black sea bass will function differently than one without
Surprises

• Define a “surprise” as an event that is unlikely based on recent conditions
  • 30 year rolling climatology, \( p=0.03 \)
• Calculated theoretical probability of surprise, accounting for trend
Surprises

Frequency and Probability of Surprising Temperatures

ERSST $P_s$
Surprises

Frequency and Probability of Surprising Temperatures

Year

Frequency or Probability

ERSST F
ERSST $P_s$
Surprises

Frequency and Probability of Surprising Temperatures

- ERSST F
- ERSST P_s
- CMIP5 F

Year

Frequency or Probability

1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 2100
Surprises

Frequency and Probability of Surprising Temperatures

- ERSST F
- ERSST $P_s$
- CMIP5 F
- CMIP5 $P_s$

Surprising number of surprises
1931-1949

red: 29  blue: 36
Heatwaves of the Future

- Heatwaves are climate change + natural cycles
  - but, natural cycles no longer natural

Heatwaves of the Future

- Heatwaves are climate change + natural cycles
  - but, natural cycles no longer natural

Conclusions

• Marine heatwaves occurring all over the world
• Heatwaves and other surprising events are becoming more common
  • an increase is expected, but the increase is surprising
Recent Trends in North Atlantic


Adapted from Saba et al. (2016) JGR, 121:118-132
Heatwaves of the Future

• Depends on climatology
  • Fixed climatology: eventually, everything is a heatwave
  • Shifting climatology: underplays impact
Surprises

Frequency and Probability of Surprising Temperatures

- ERSST F

Year

Frequency or Probability

1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 2100

0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2