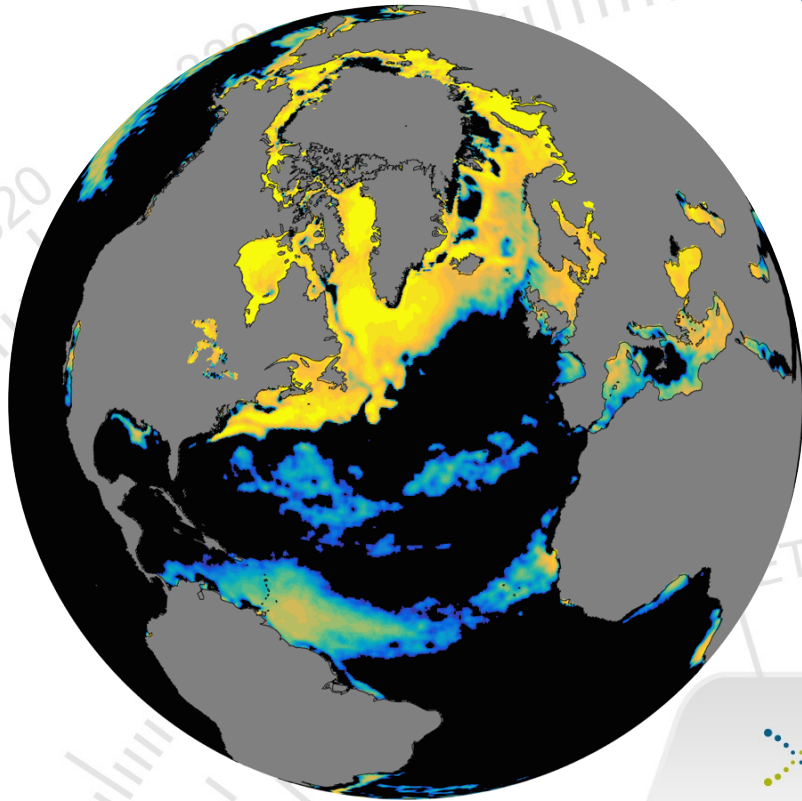


Natural cycles in unnatural times or the limitations of linear thinking in an increasingly non-linear world



Andrew Pershing
Gulf of Maine Research Institute

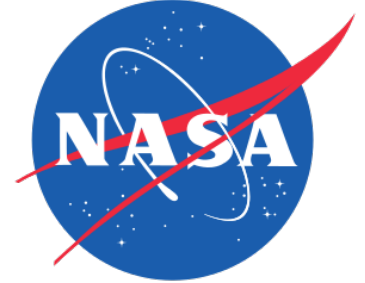


Gulf of Maine
Research Institute

Science. Education. Community.

Outline

- National Climate Assessment
- Marine Heatwaves
- Surprise!



- Acknowledgements
 - Kathy Mills, Chrissy Hernandez, Mike Alexander, Jamie Scott, Hillary Scannell, Andy Thomas, Janet Nye
 - Roger Griffis, Samantha Siedlecki, John Bruno, Shallin Busch, Desiree Tommasi, Alan Haynie, Taylor Armstrong, Libby Jewett



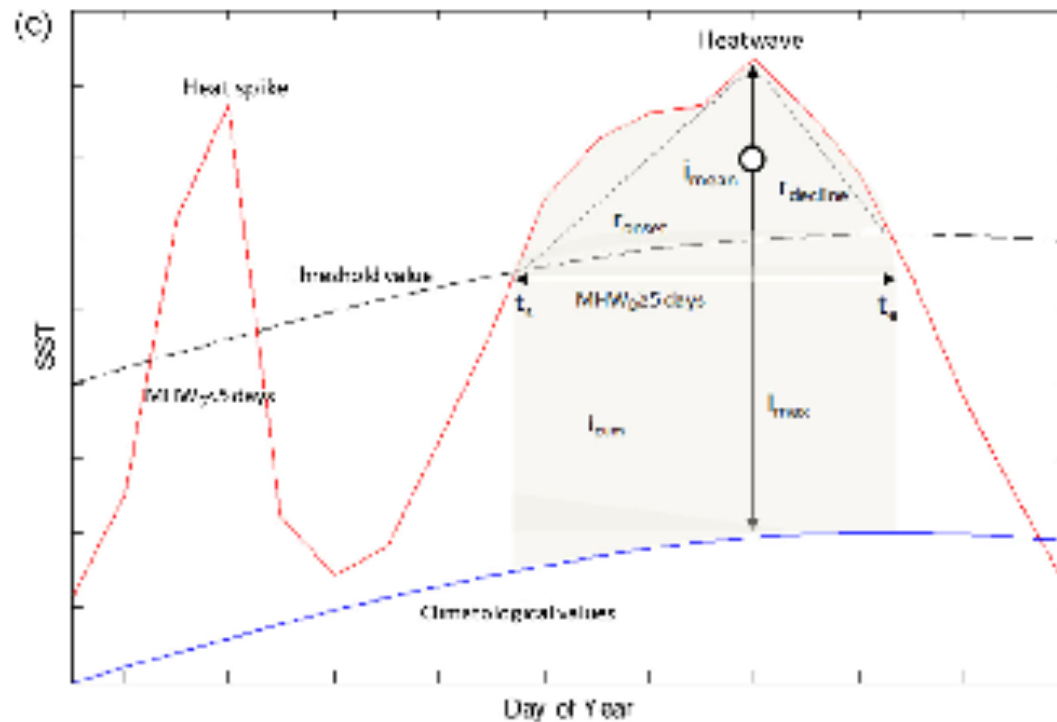
4th US National Climate Assessment

- Established under US Global Change Research Act
- “What do we value and what is at risk?”
- Assessments in 2000, 2009, and 2014
- NCA currently underway
 - chapter drafts submitted
 - public comment/NAS review this winter
 - final version end of 2018

- 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

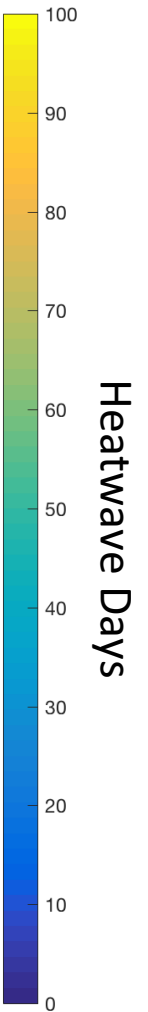
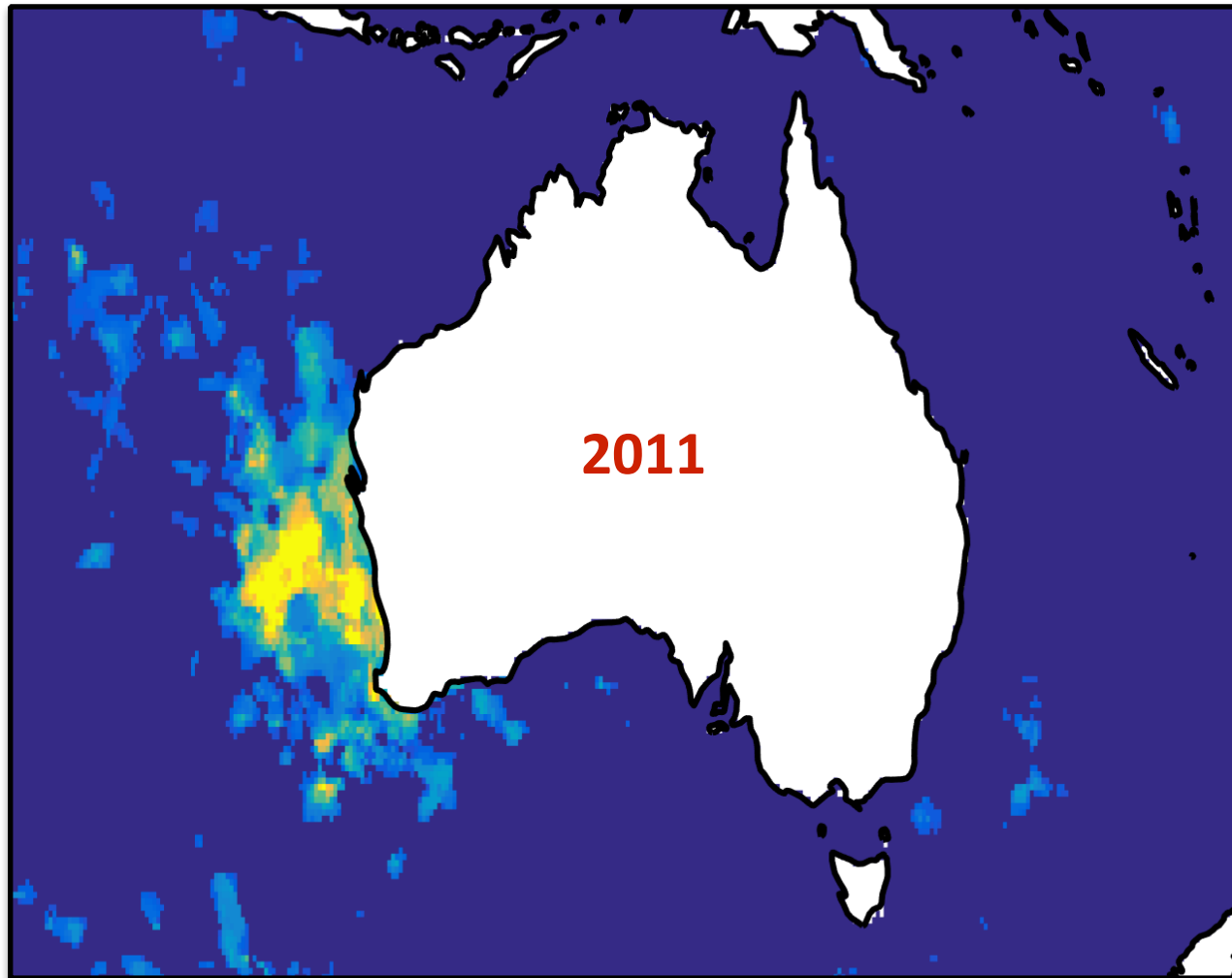
Marine heatwaves

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

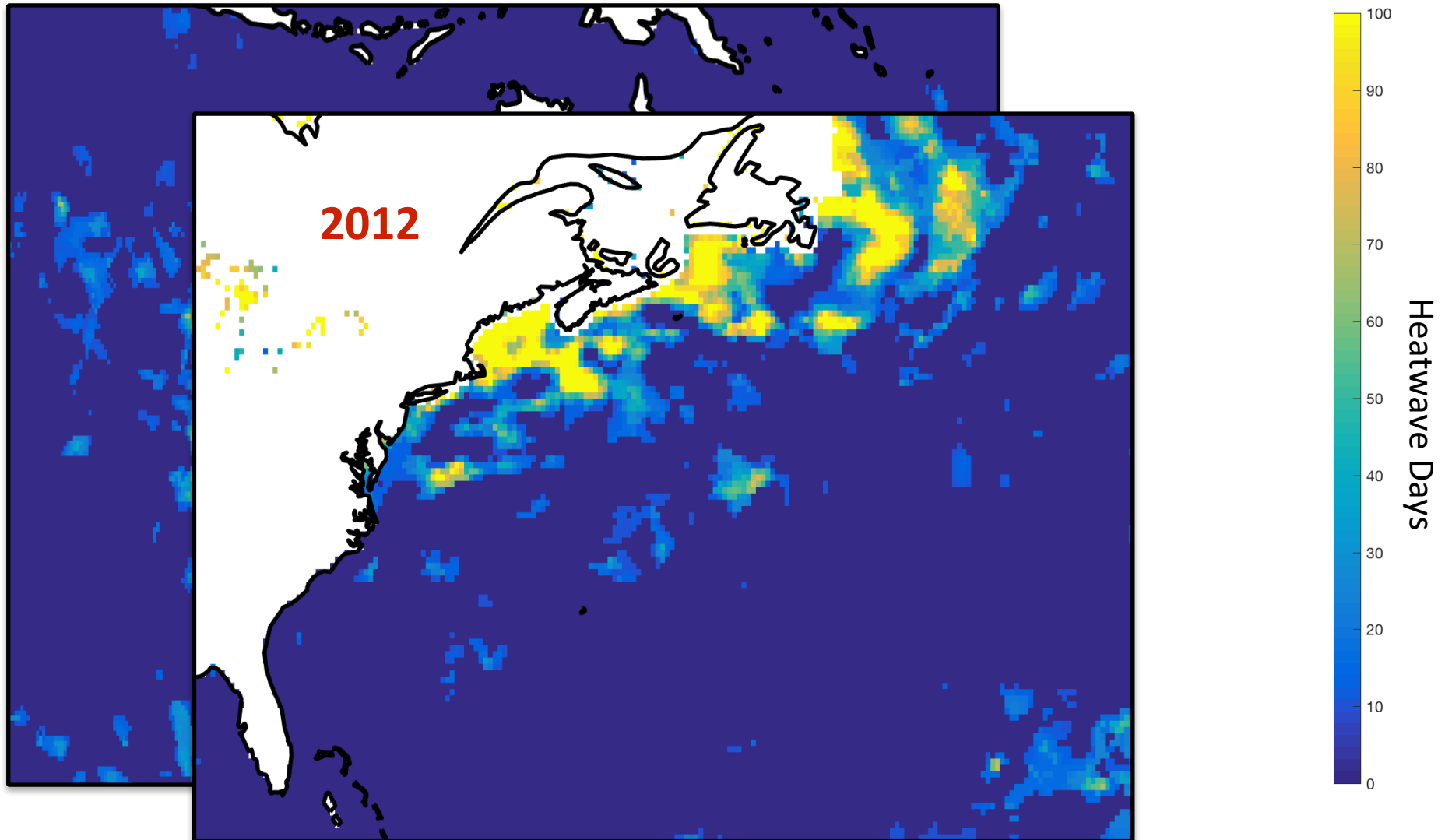


Hobday et al. (2016) A hierarchical approach to defining marine heatwaves. Progress in Ocean

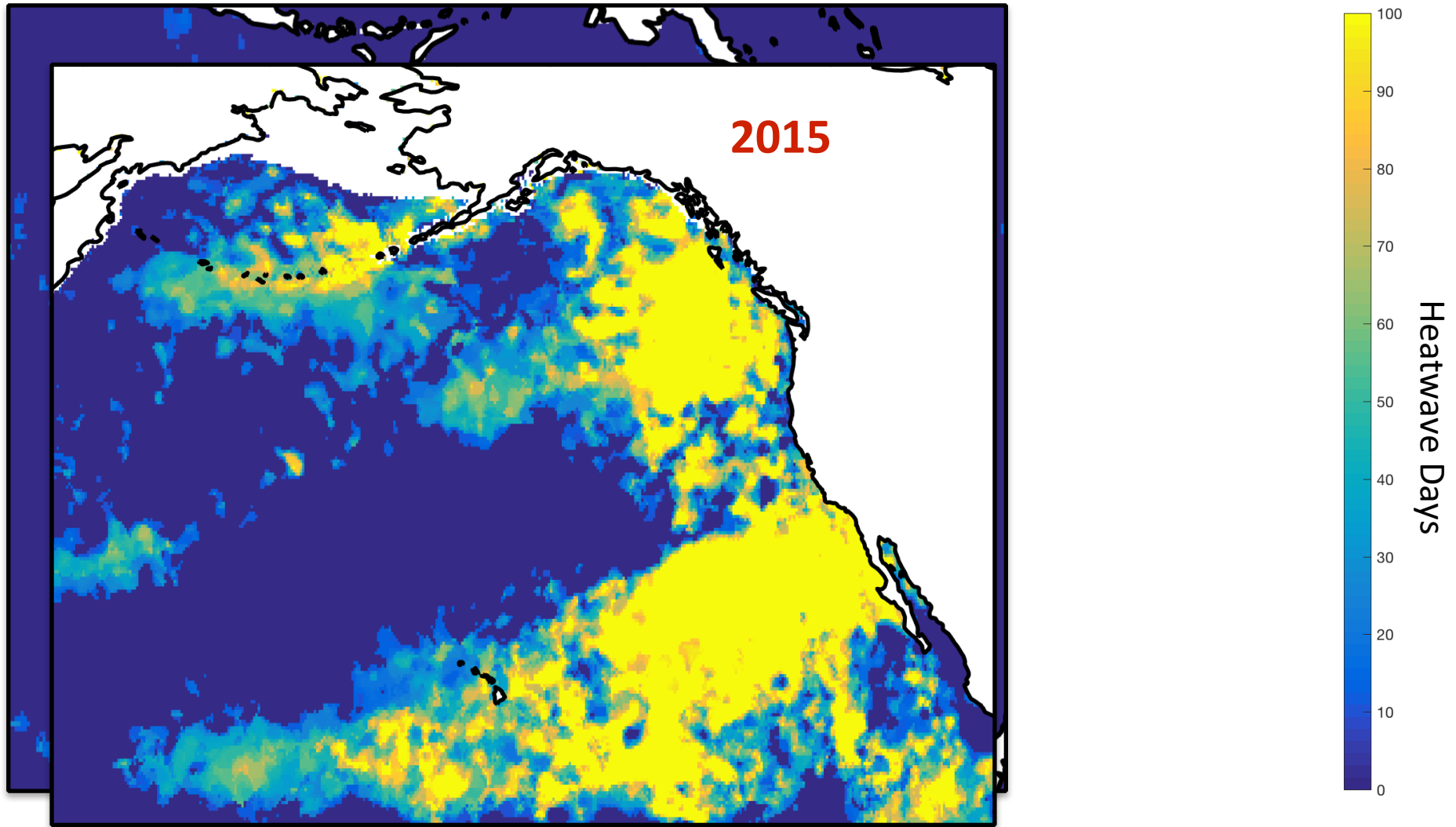
Recent Heatwaves



Recent Heatwaves

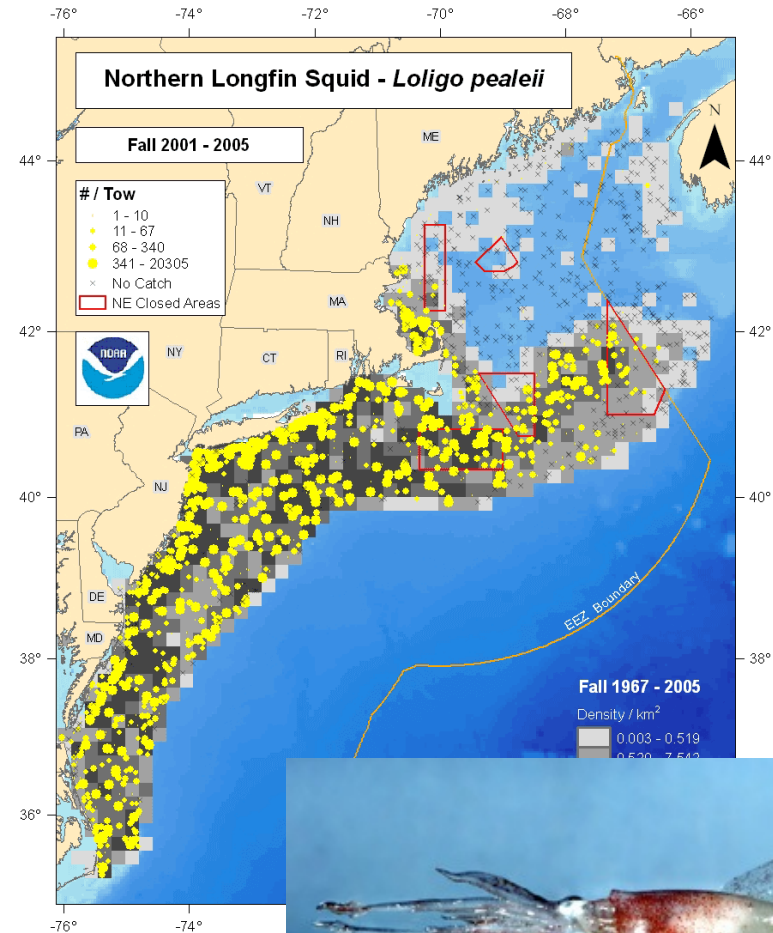


Recent Heatwaves



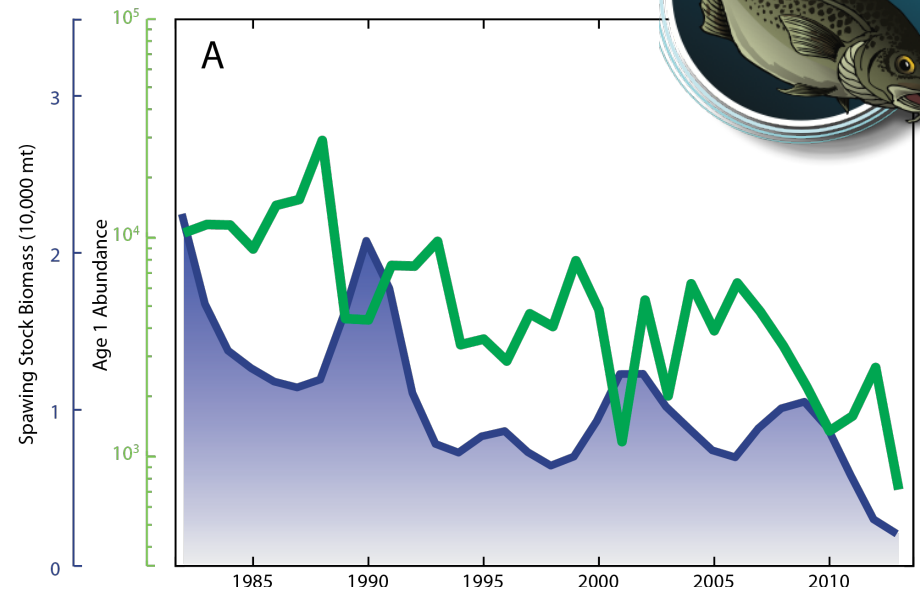
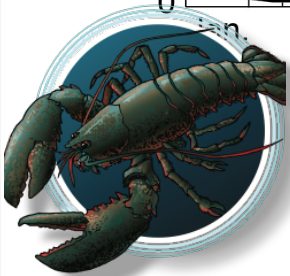
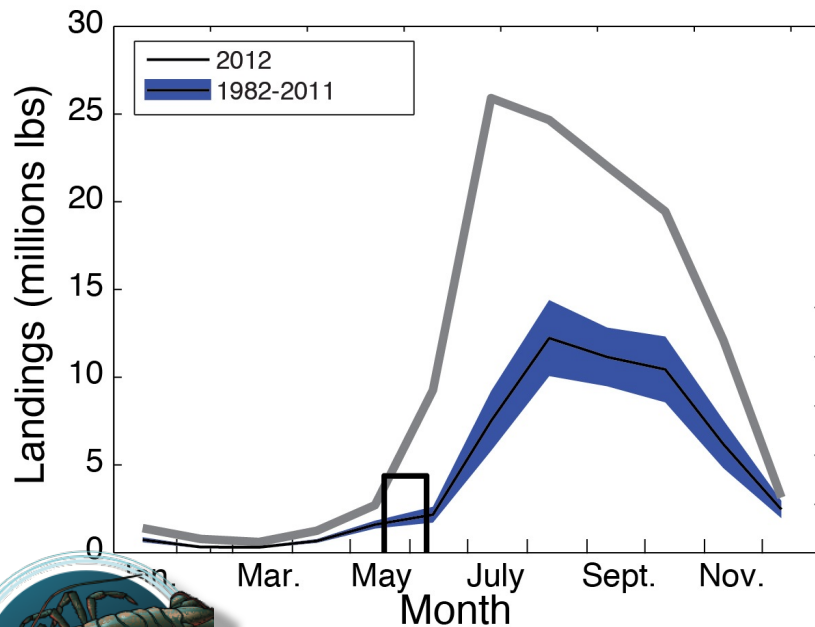
Ecological & Socioeconomic Impacts

- Species on the move



Ecological & Socioeconomic Impacts

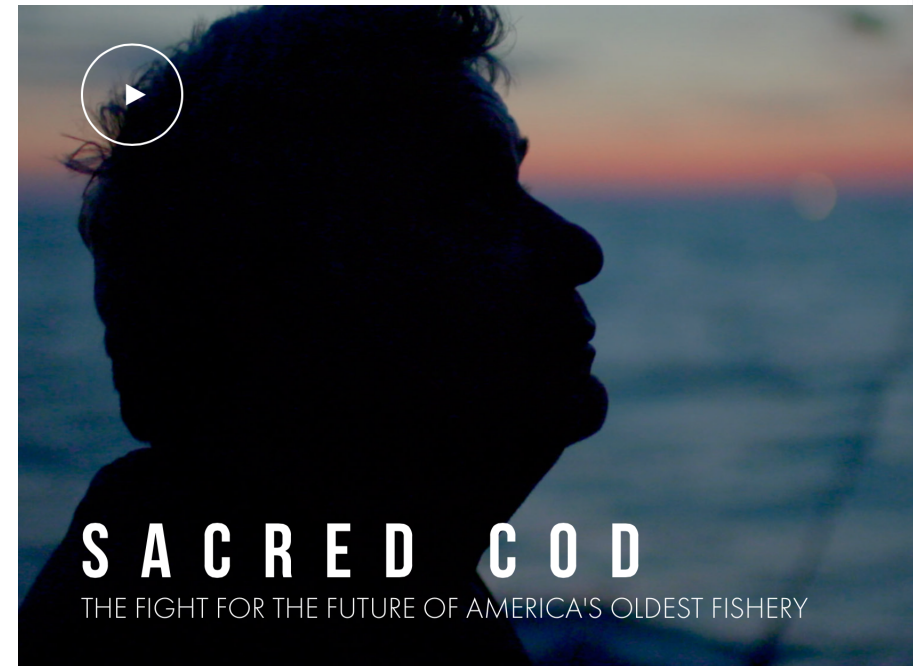
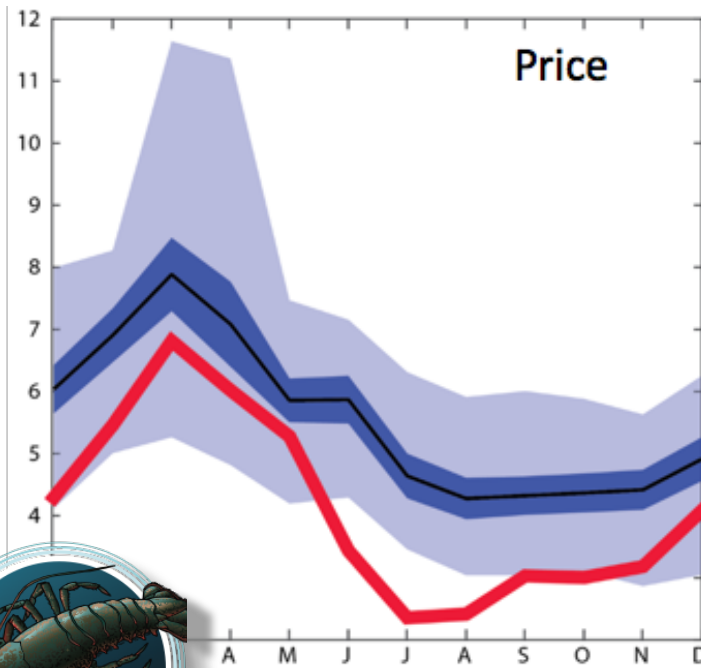
- Species on the move
- Impacts on fisheries



Ecological & Socioeconomic Impacts

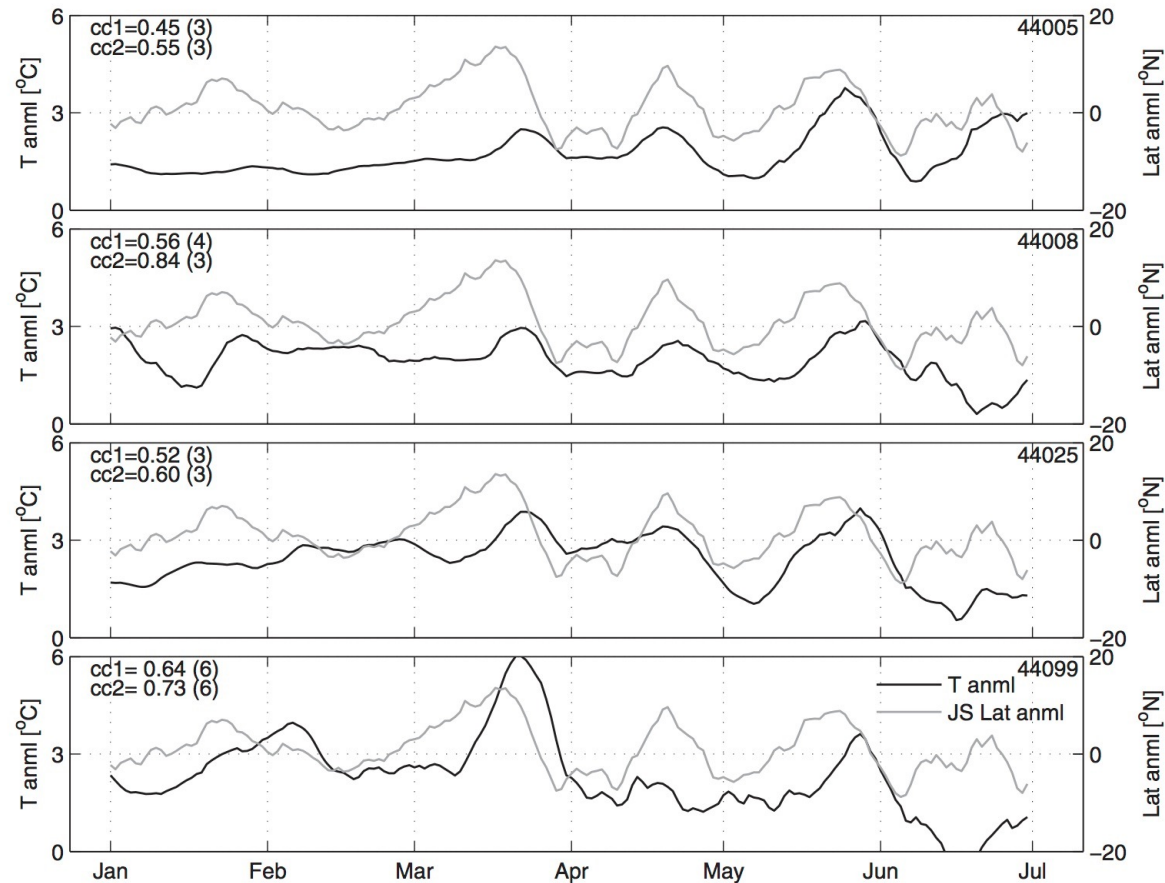


- Species on the move
- Impacts on fisheries
- Impacts on people



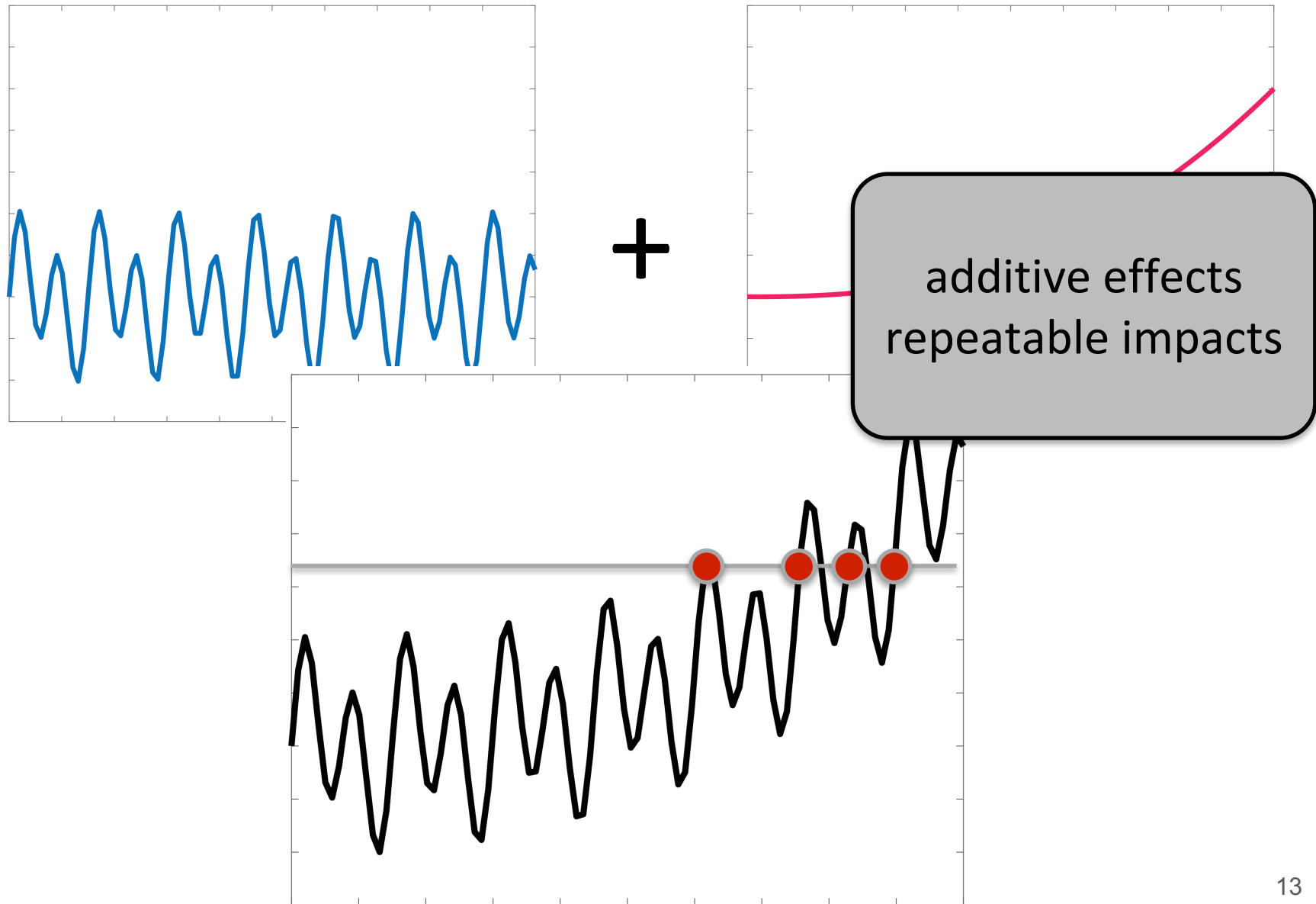
2012 North Atlantic Heatwave

- Jet stream displaced northward
- Mild fall & winter



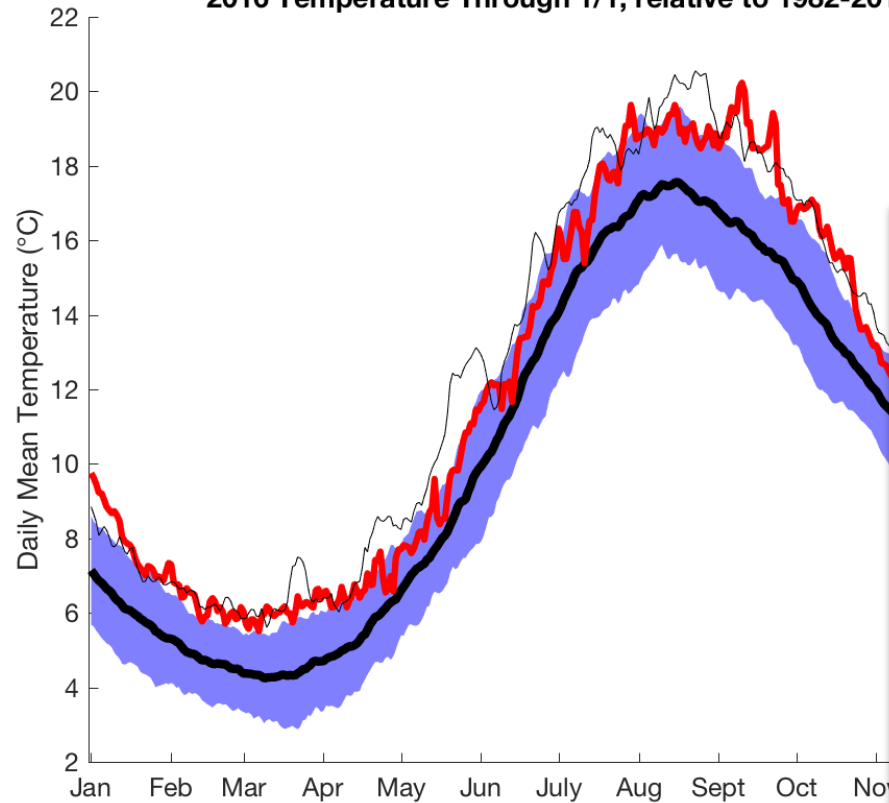
Chen et al. (2014) Diagnosing the warming of the Northeastern U.S. Coastal Ocean in 2012. *Journal of Climate*

Climate change & climate variability

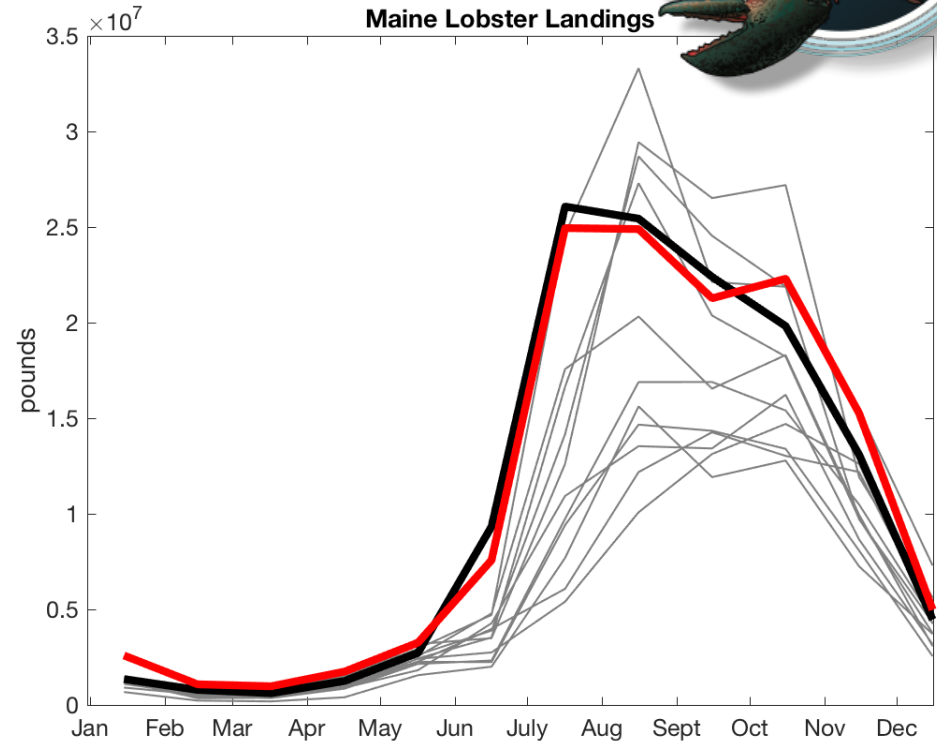


2016 = 2012 in the Gulf of Maine?

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



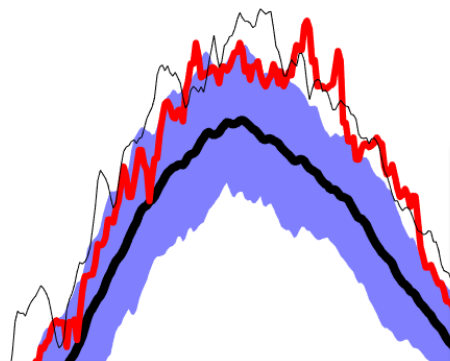
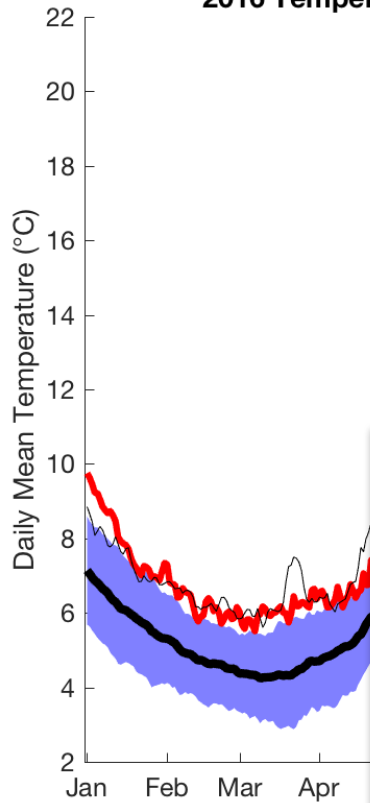
Maine Lobster Landings



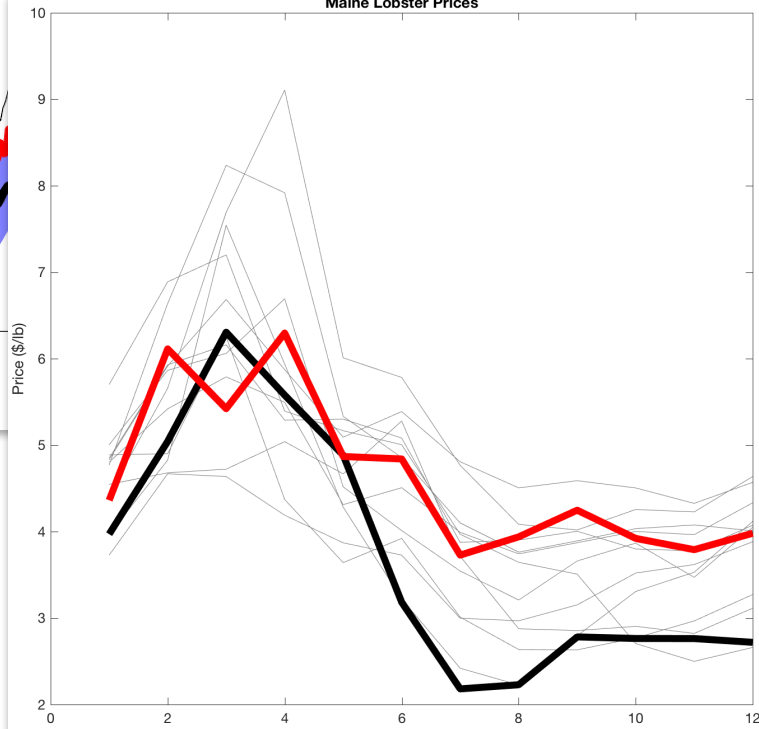
2016 = 2012 in the Gulf of Maine?



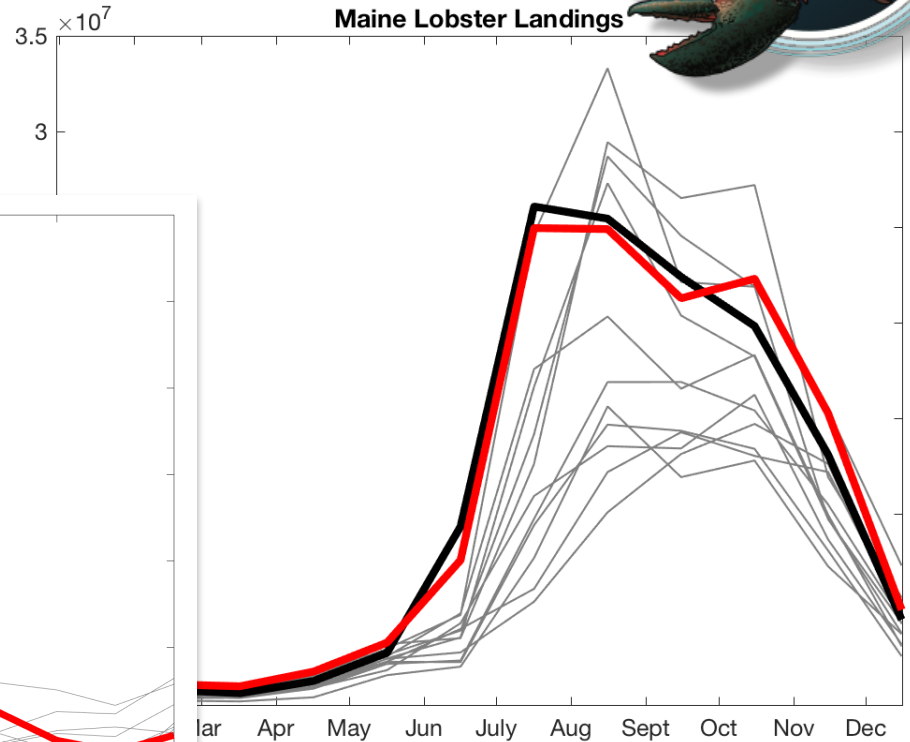
2016 Temperature Through 1/1, relative to 1982-2011



Maine Lobster Prices

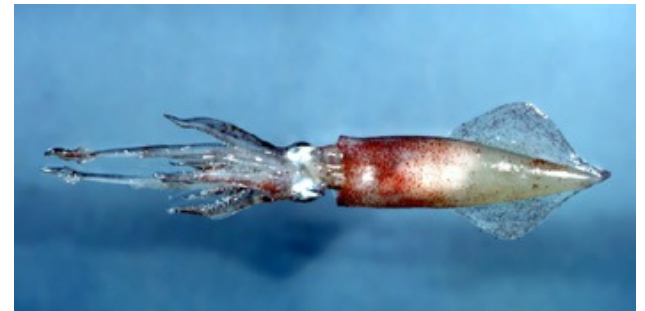


Maine Lobster Landings



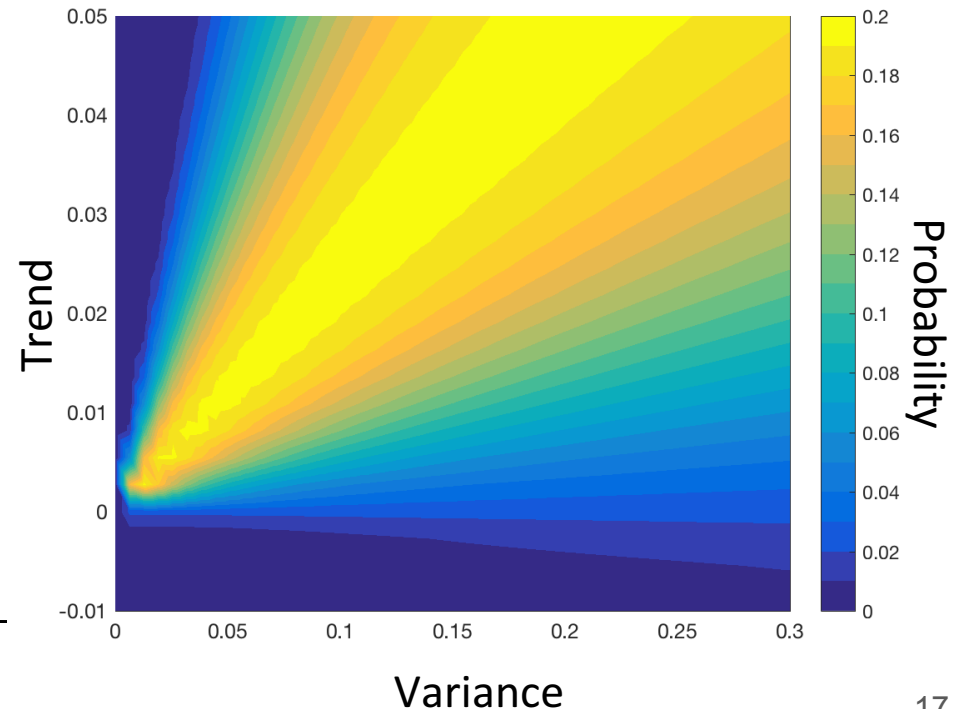
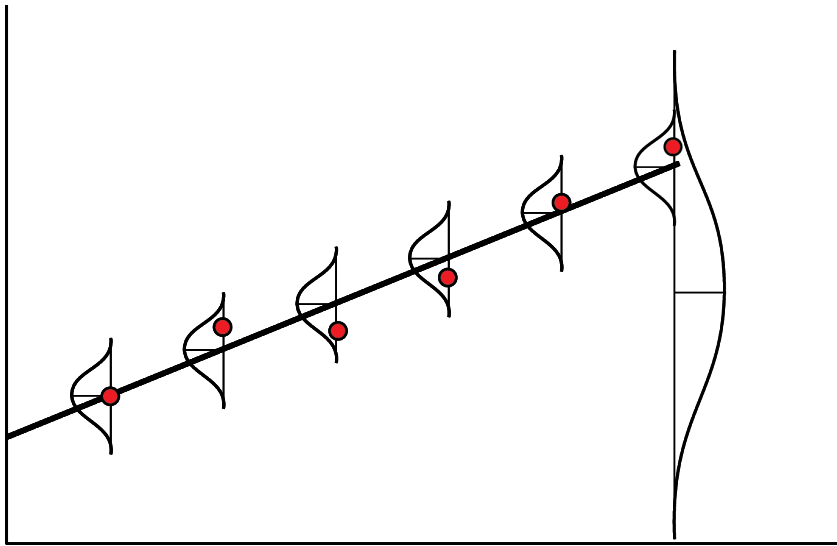
Repeatability

- 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

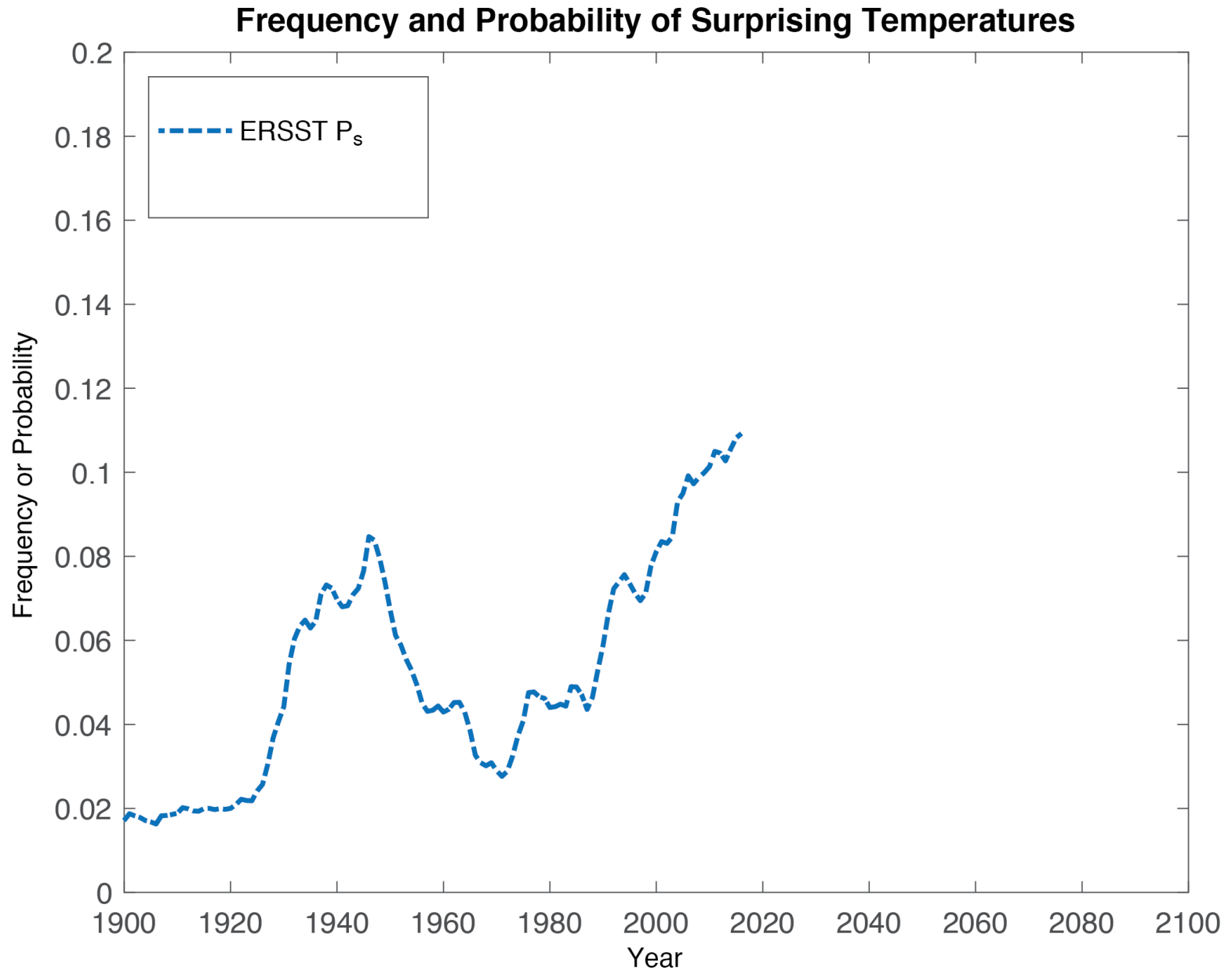


Surprises

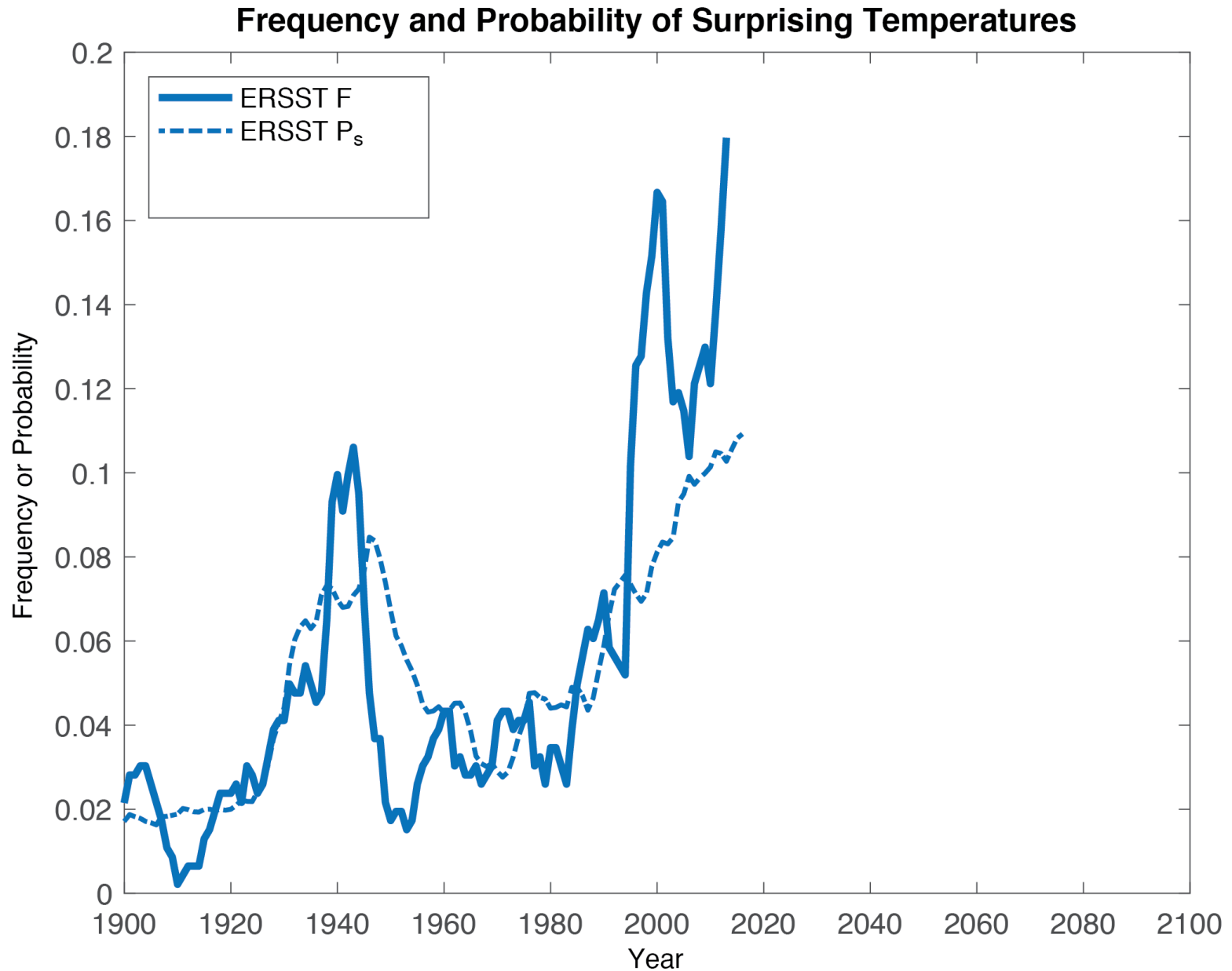
- Define a “surprise” as an event that is unlikely based on recent conditions
 - 30 year rolling climatology, $p=0.03$
- Calculated theoretical probability of surprise, accounting for trend



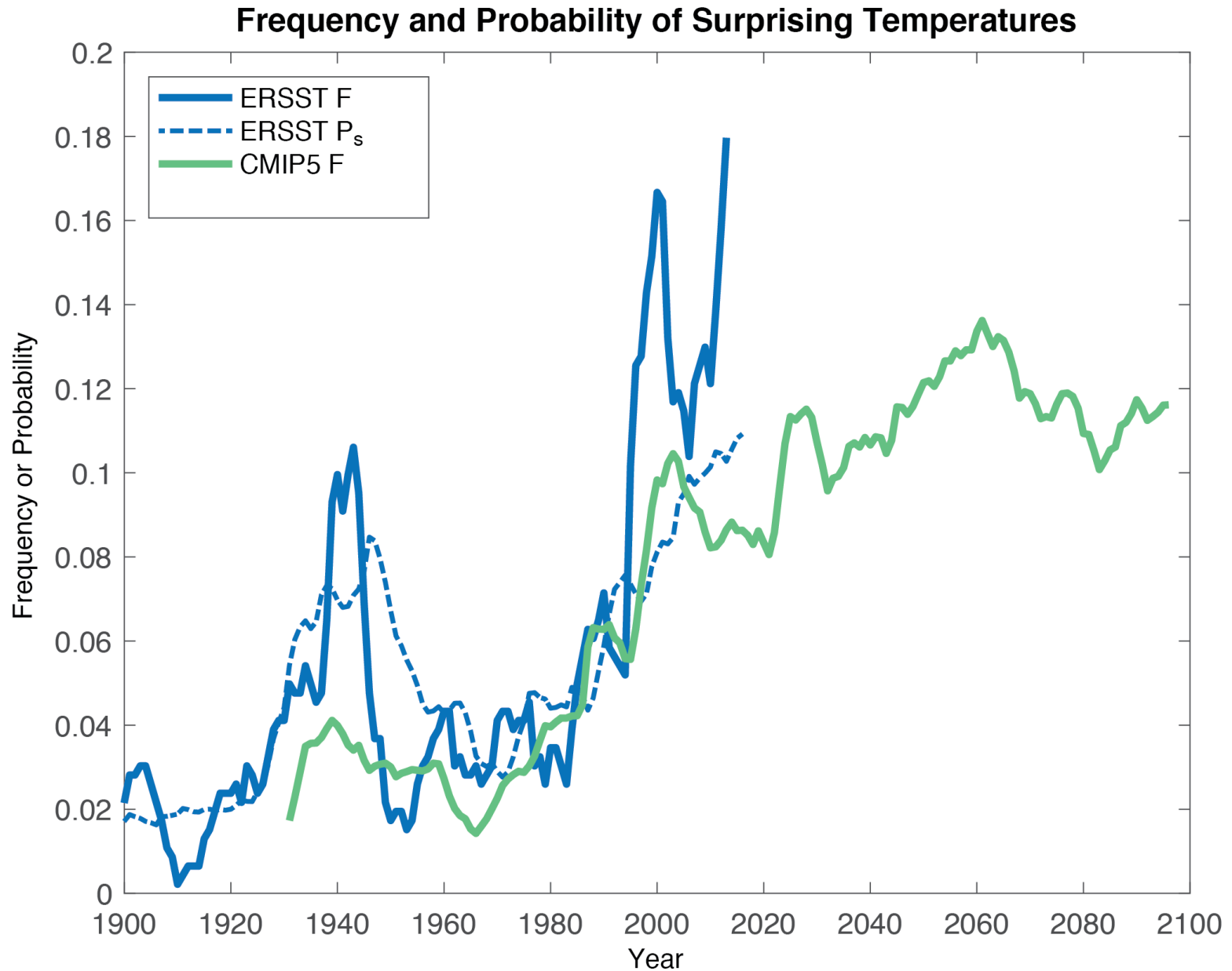
Surprises



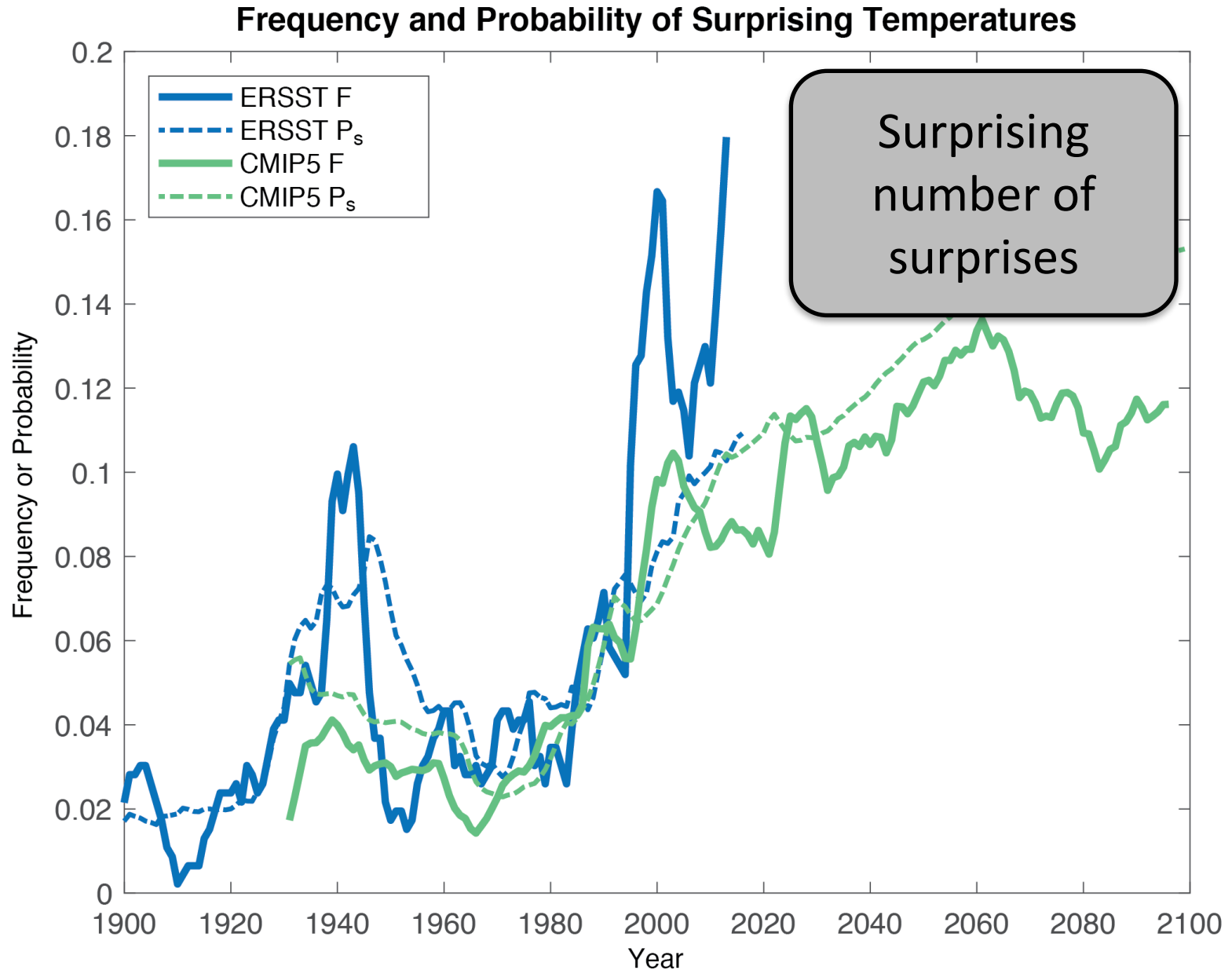
Surprises



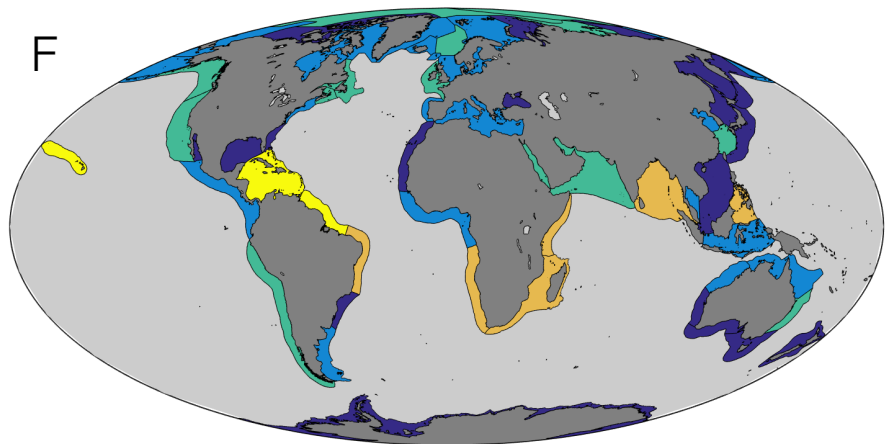
Surprises



Surprises

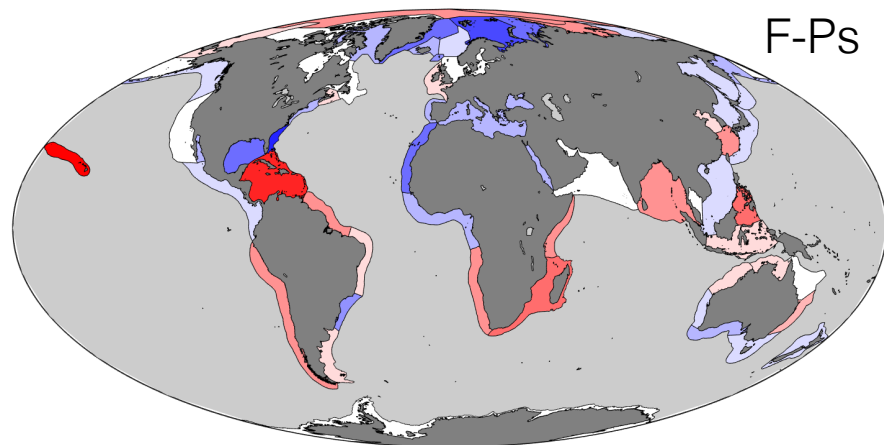


F

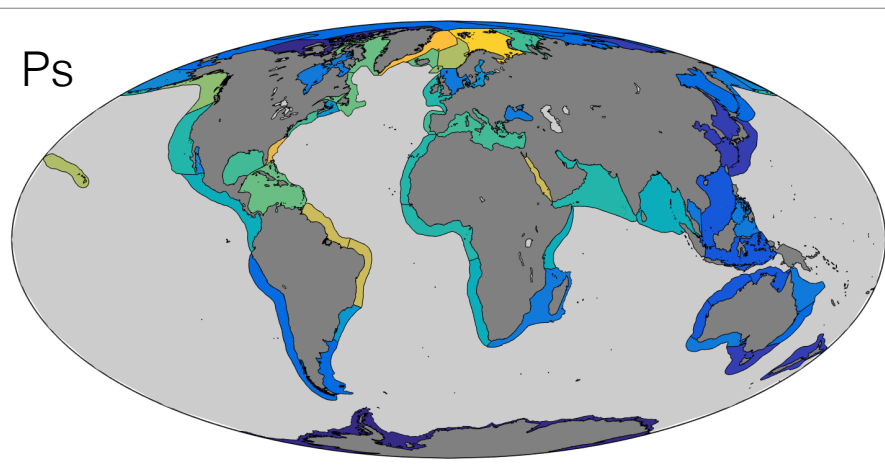


1931-1949

F-Ps

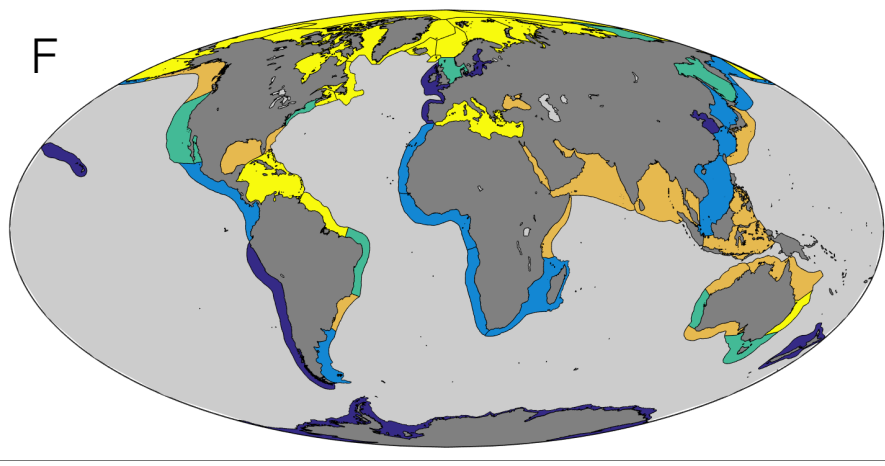


Ps

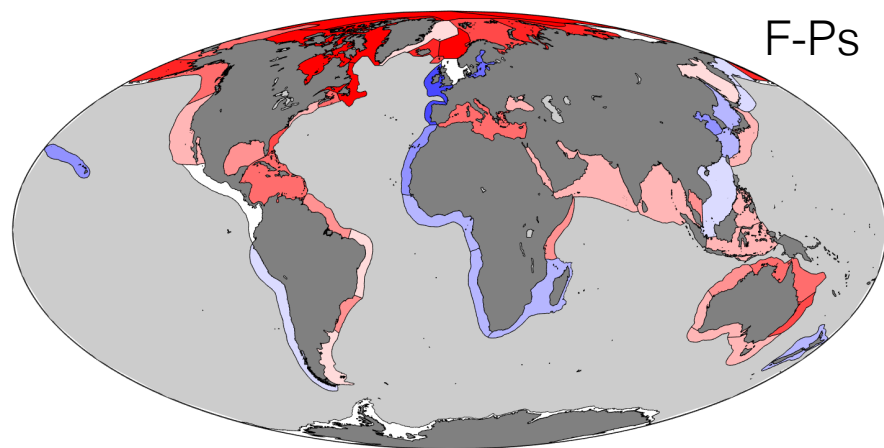


red: 29 blue: 36

F

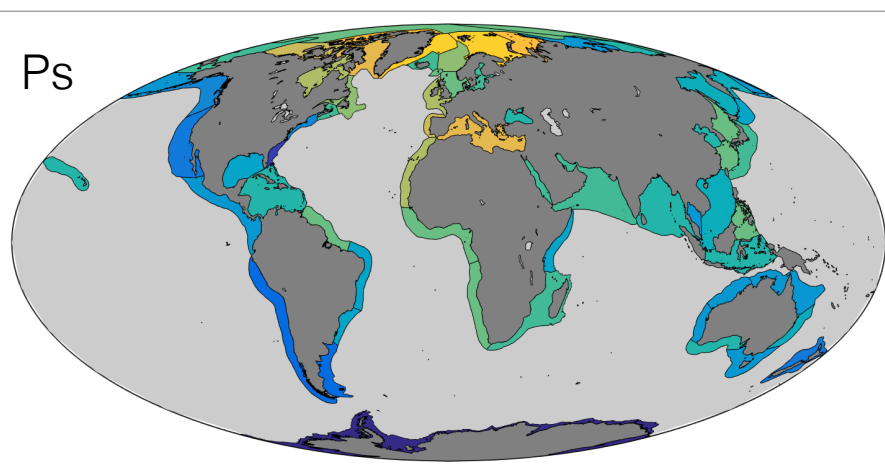


1998-2016



F-Ps

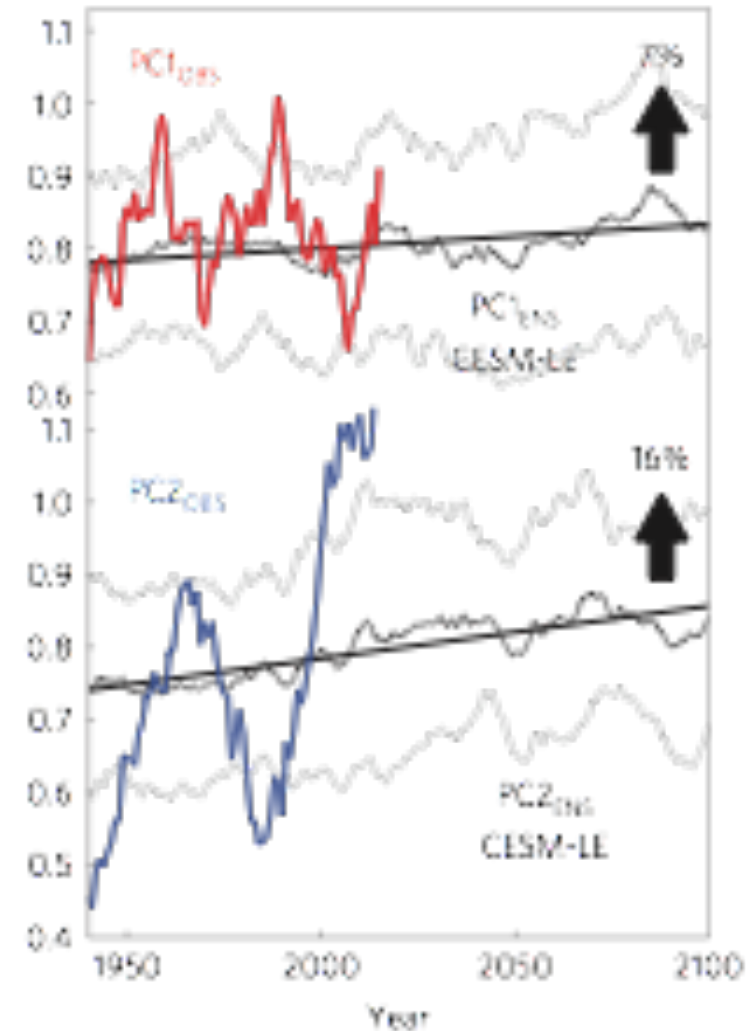
Ps



red: 46 blue: 19

Heatwaves of the Future

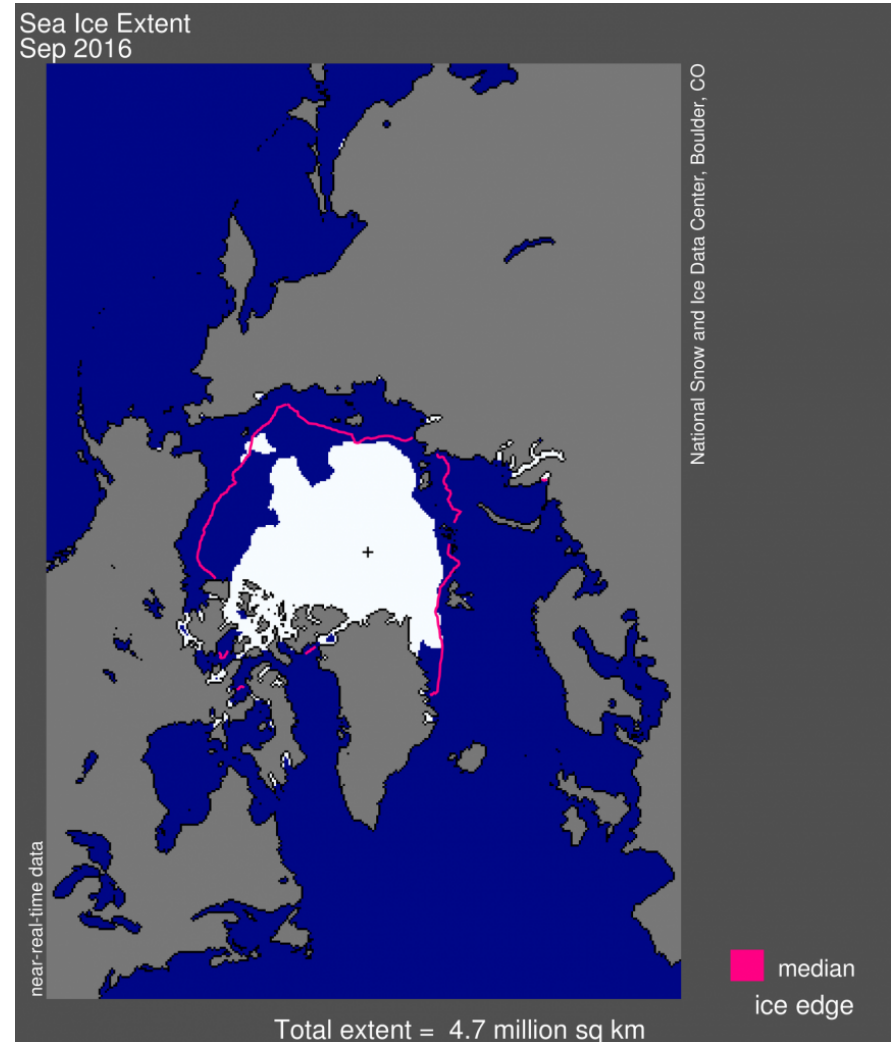
- Heatwaves are climate change + natural cycles
 - but, natural cycles no longer natural



Di Lorenzo E, Mantua N (2016) Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change

Heatwaves of the Future

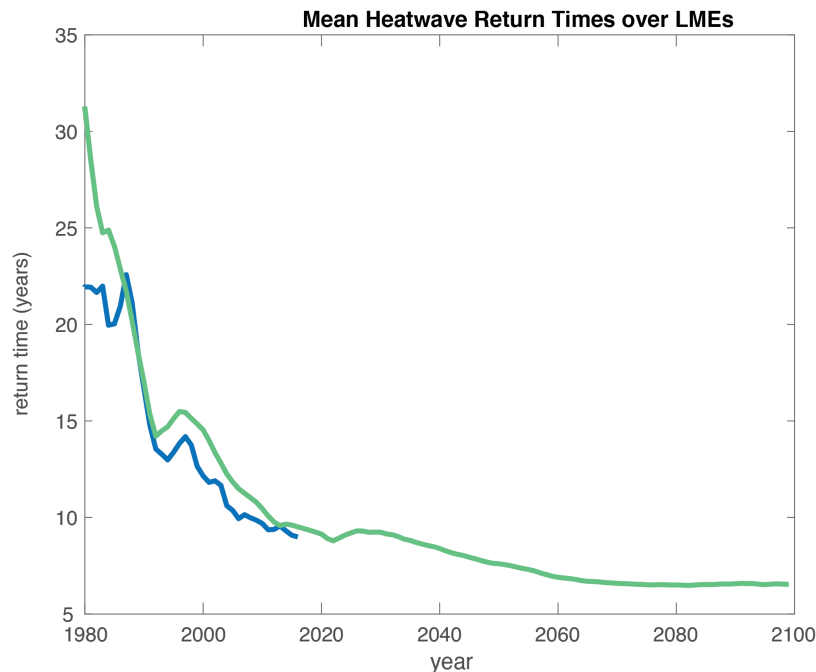
- Heatwaves are climate change + natural cycles
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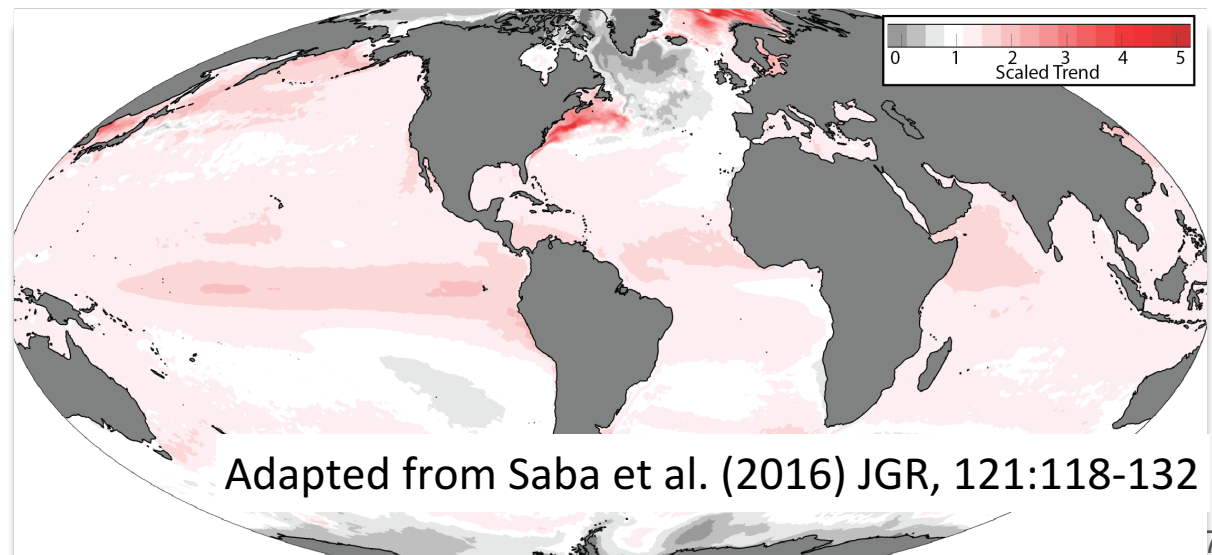
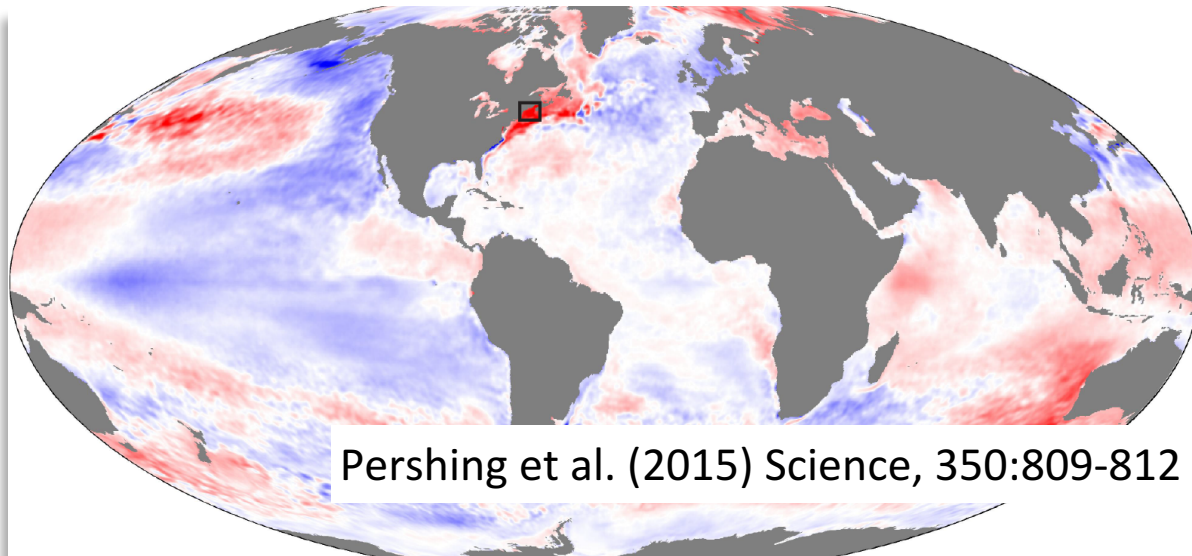
Di Lorenzo E, Mantua N (2016) Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change

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

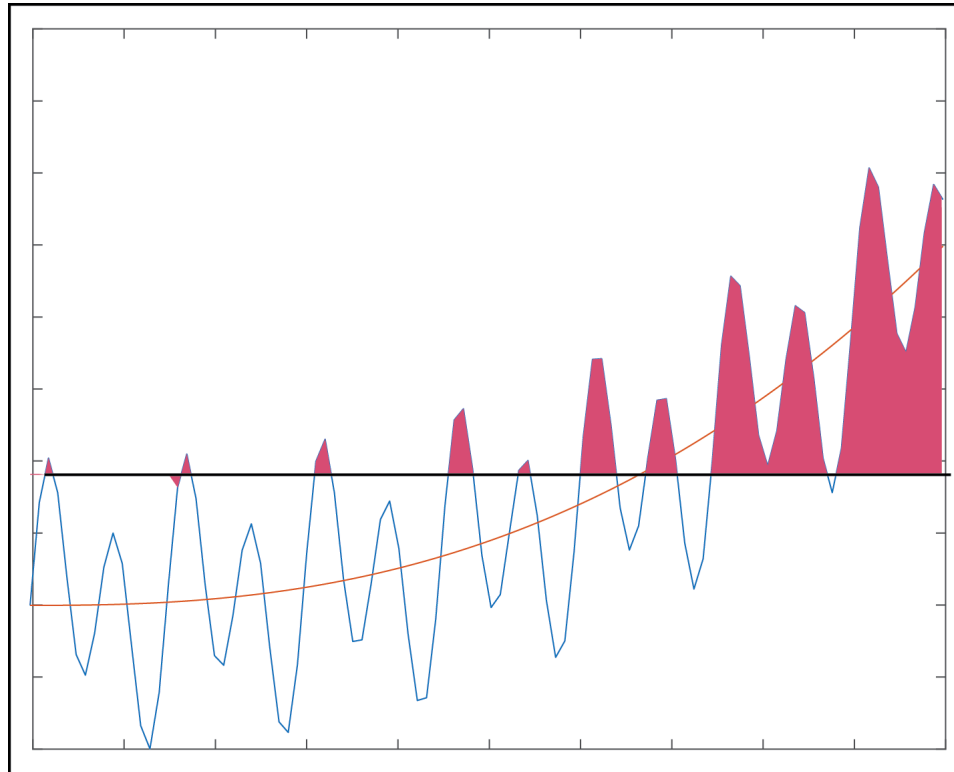


Recent Trends in North Atlantic



Heatwaves of the Future

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



Surprises

