



Warming in the Gulf of Maine

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30 June 2022

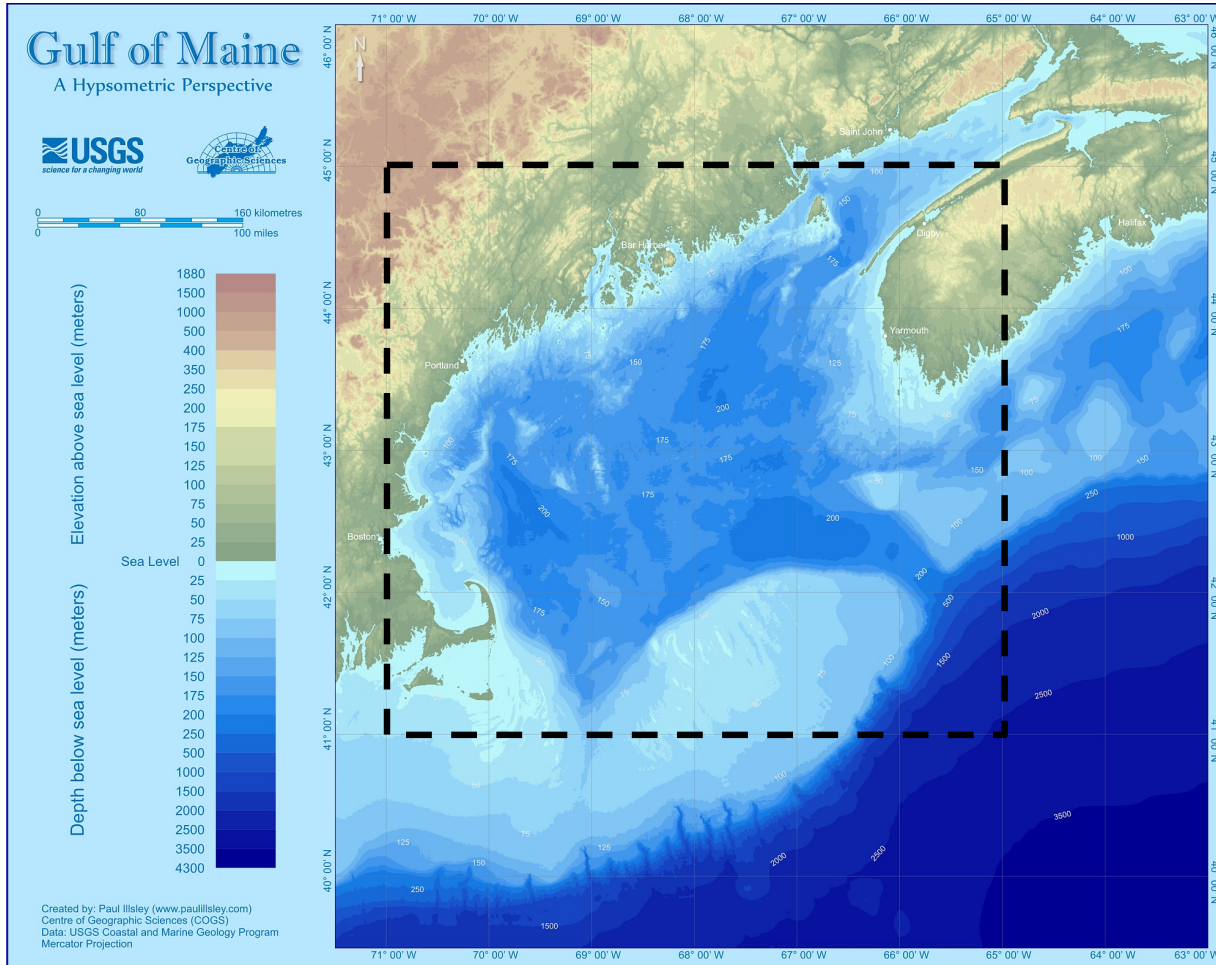
NOAA Eastern Region Climate Services webinar



**Gulf of Maine
Research Institute**

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Setting the Scene



Data Source

- [NOAA High Resolution SST data](#) provided by the NOAA/OAR/ESRL PSL, Boulder, CO.

Contributors

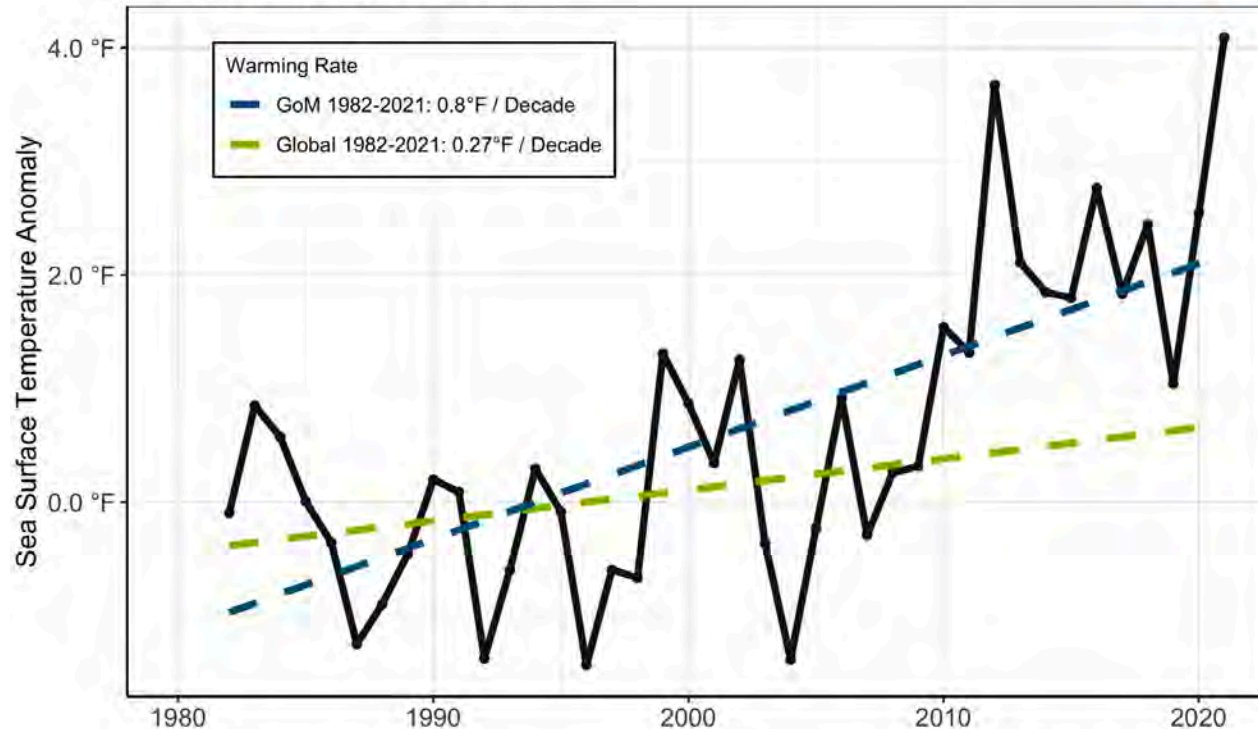


Adam Kemberling
*Quantitative Research
Technician*



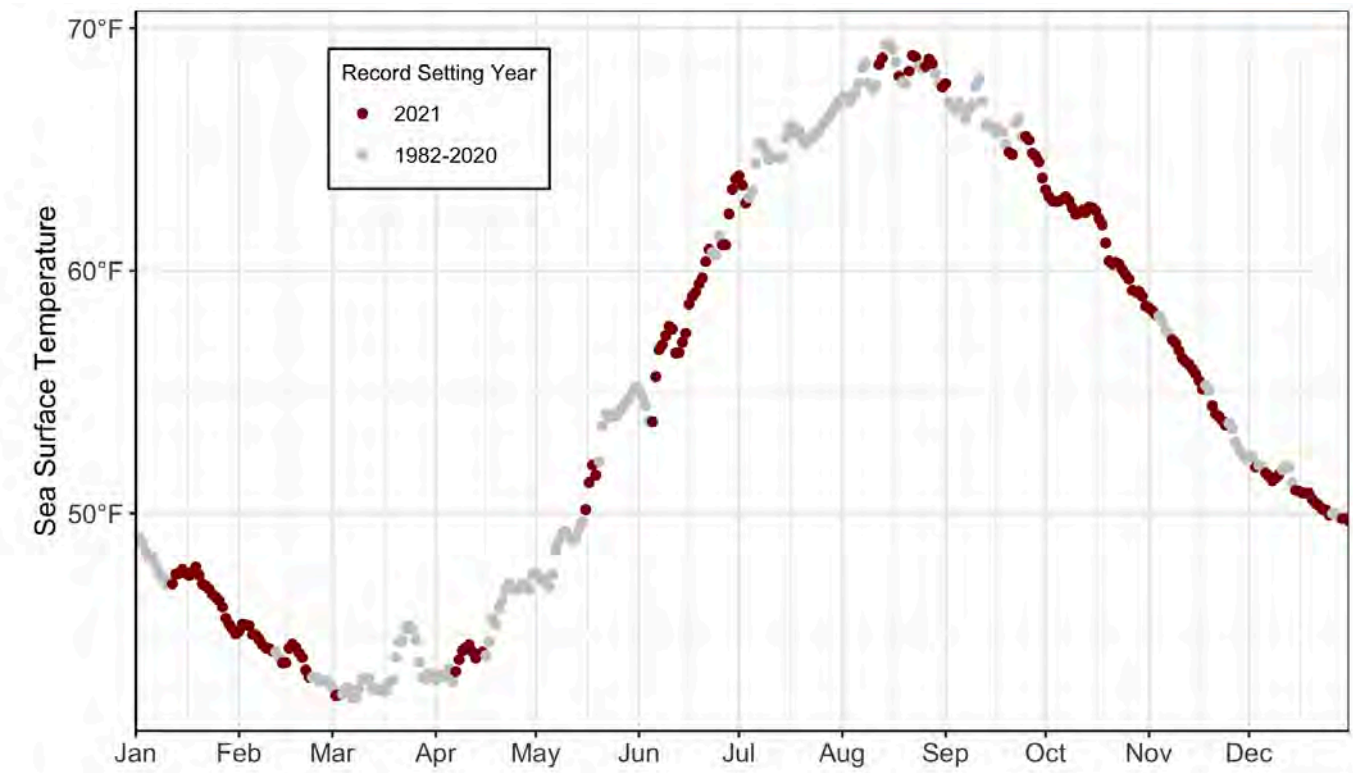
Dr. Kathy Mills
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What's Happening: *Rapid Warming in the Gulf of Maine*

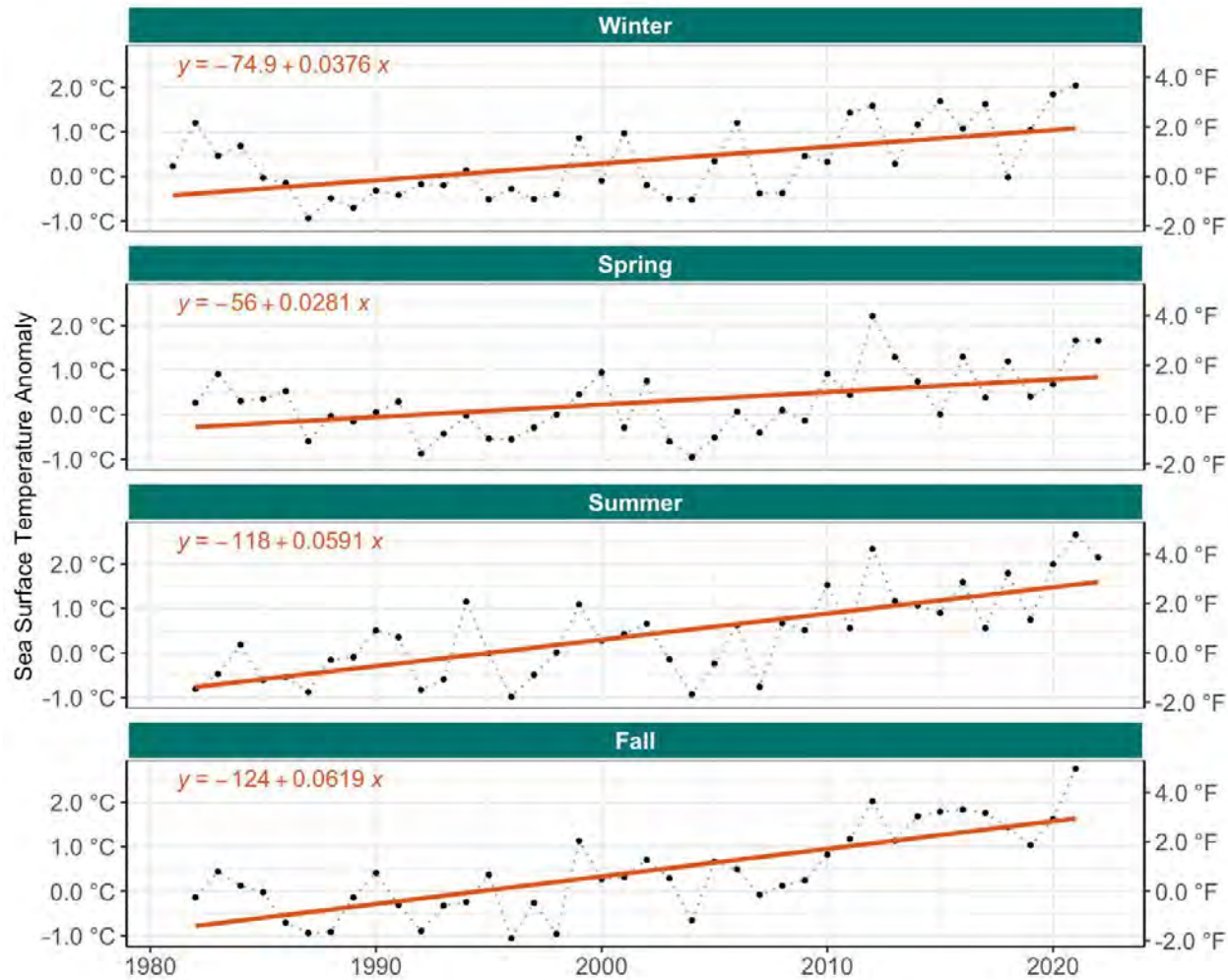


- Annual average SST in the Gulf of Maine was 54.1°F in 2021 (>4 °F above the long-term average)
- The Gulf of Maine is warming ~3x faster than the global ocean average

Record Hot Days in 2021



Seasonal Differences?



DJF = 0.038 °C/yr

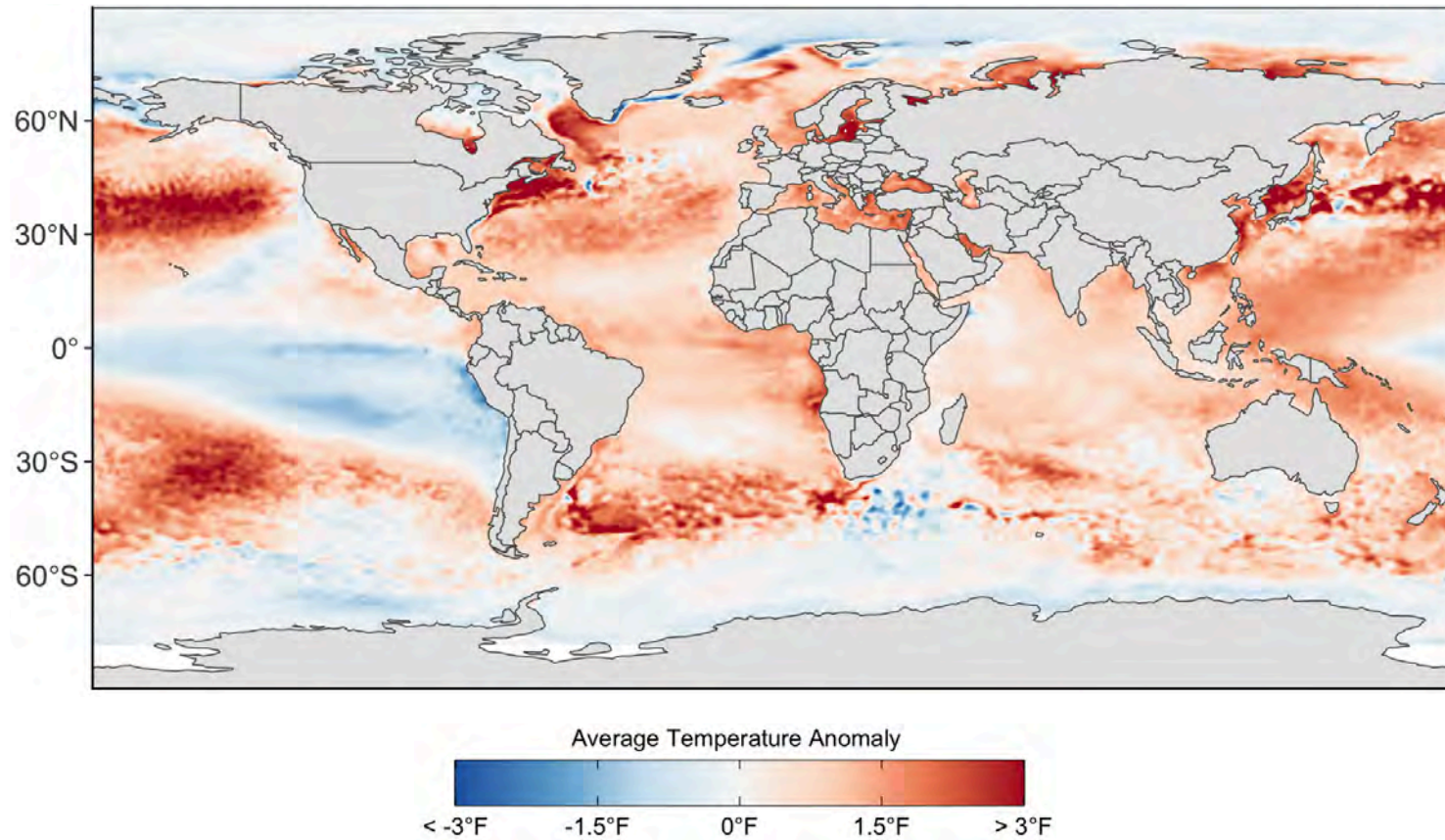
MAM = 0.028 °C/yr

JJA = 0.059 °C/yr

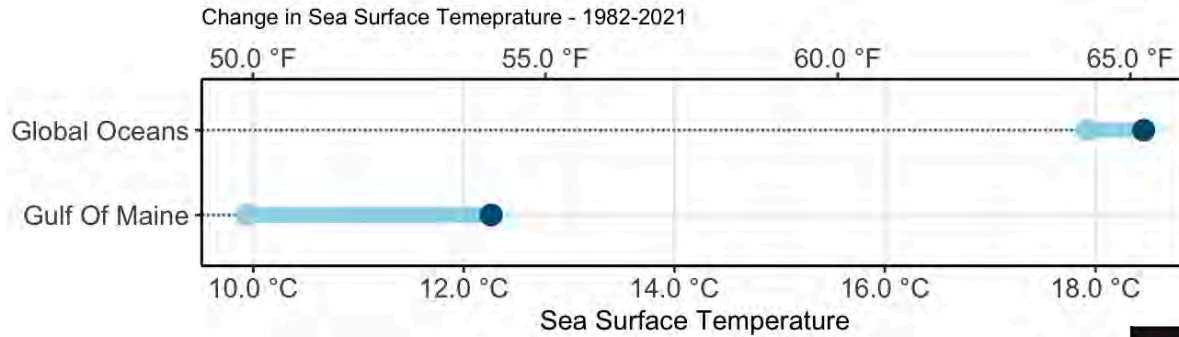
SON = 0.062 °C/yr

Summer & Fall trends are 50-100%
larger than Winter & Spring

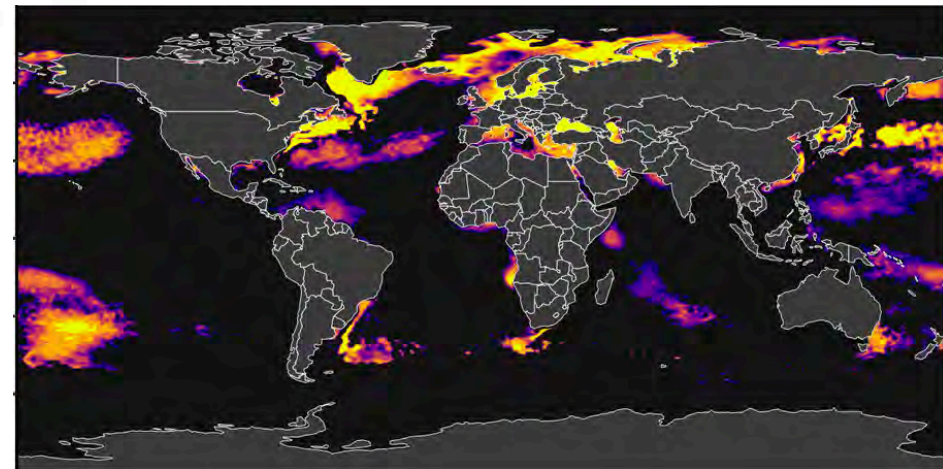
2021 in a Global Context



Rate of Warming in a Global Context



The Gulf of Maine is warming faster than >95% of the world's ocean



Warming Rate Percentile: 1982-2021

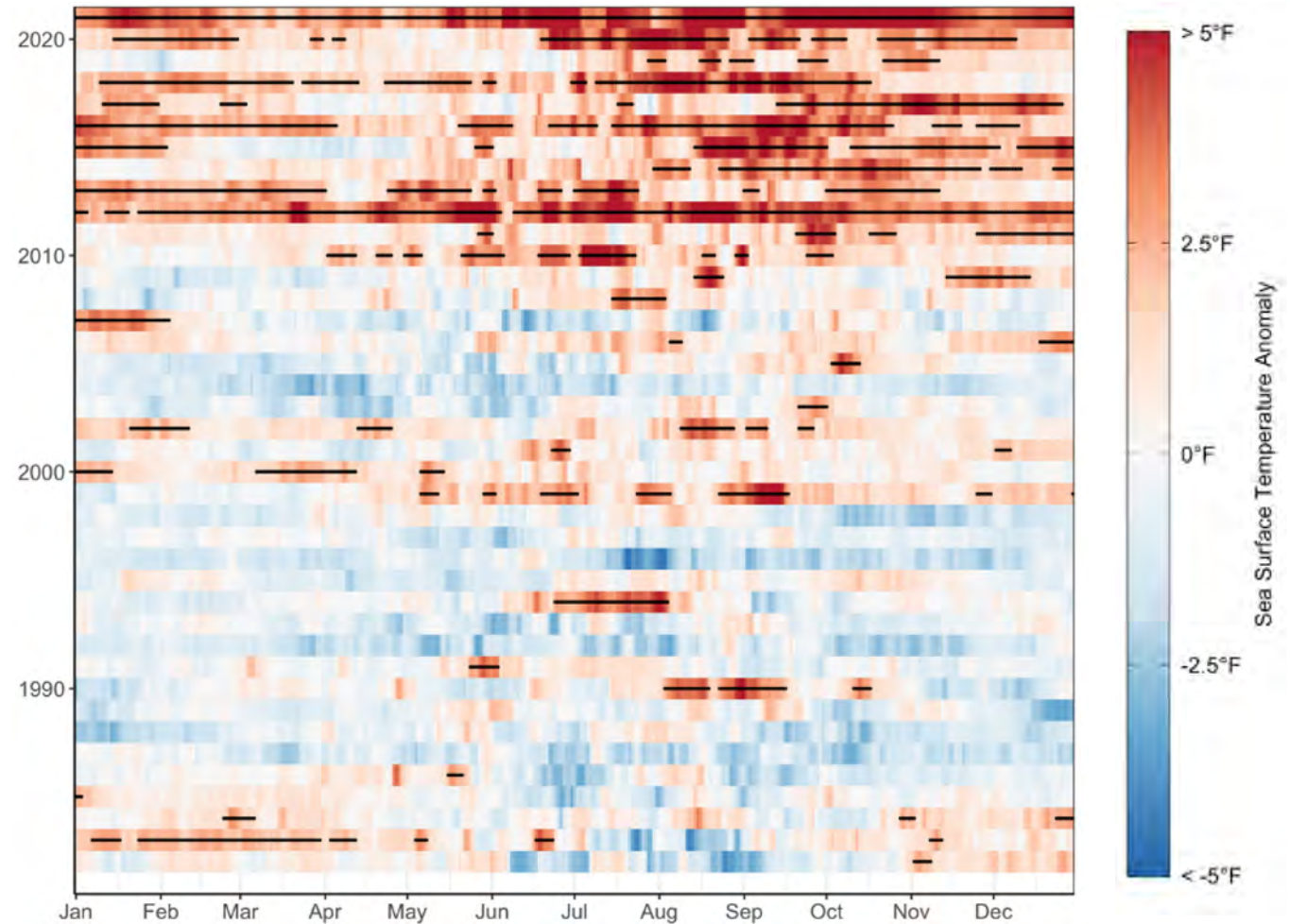


0.825 0.850 0.875 0.900 0.925 0.950 0.975

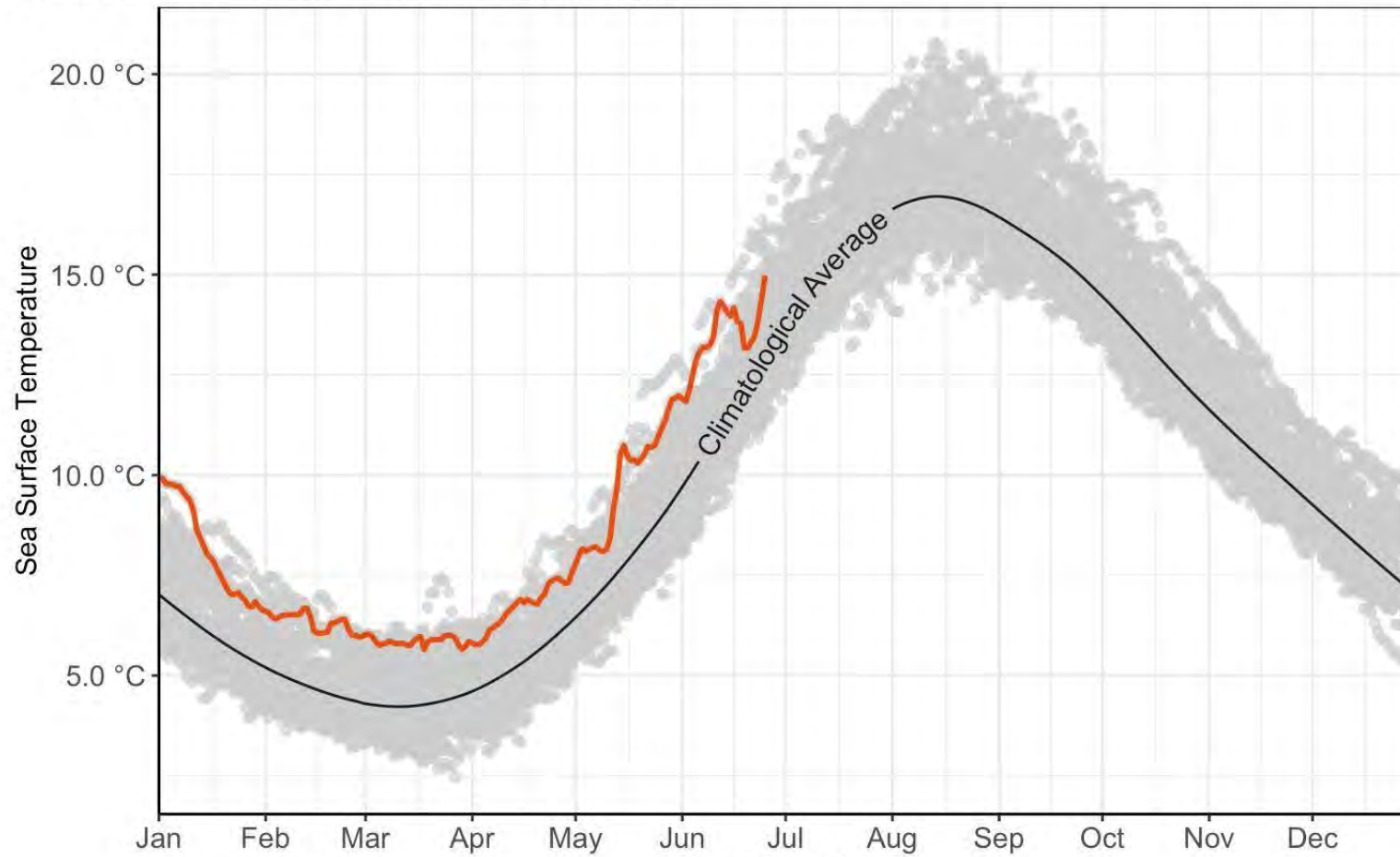
Persistent Marine Heatwave = Thermal Regime Shift?

MHW = 5+ days w/
SST >90th percentile
of 30-yr avg

— = Heatwave events



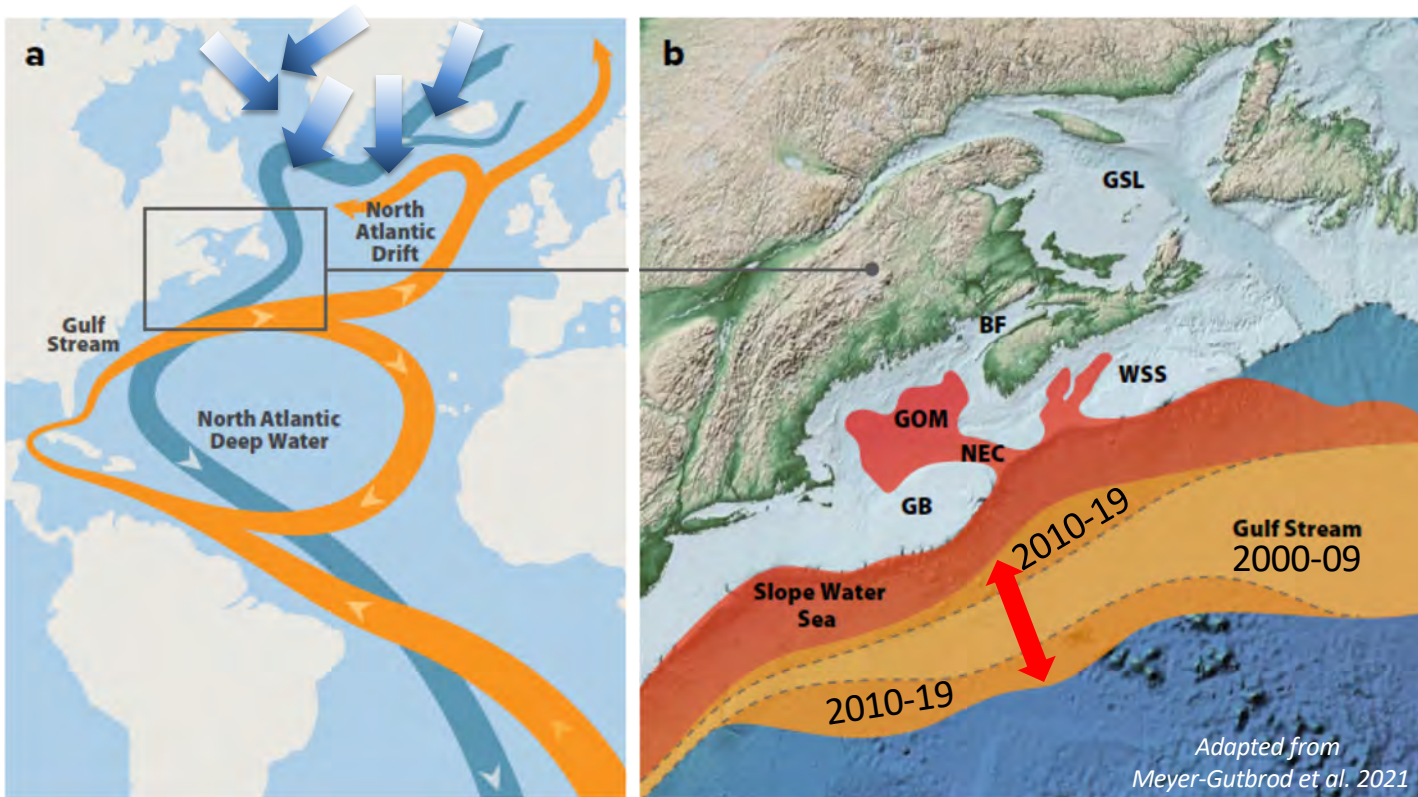
... and what about 2022 so far?



Primer in Physical Oceanography of NW Atlantic



Why is This Happening: *Natural & Anthropogenic Causes*



Leading Hypotheses

- Widening of the Gulf Stream ocean current
 - Role of Greenland Ice Sheet & Arctic glacier melt
- More persistent (+) phase of the North Atlantic Oscillation
- Anthropogenic forcing of the midlatitude jet stream

Why is This Happening: Natural & Anthropogenic Causes

Observation-based early-warning signals for a collapse of the Atlantic Meridional Overturning Circulation

Niklas Boers^{1,2,3,5}

An Observed Regime Shift in the Formation of Warm Core Rings from the Gulf Stream

Avijit Gangopadhyay¹, Glen Gawarkiewicz², E. Nishchitha S. Silva¹, M. Monim³ & Jenifer Clark⁴

Drivers of exceptional coastal warming in the northeastern United States

Ambarish V. Karmalkar^{1,2,3} and Radley M. Horton³

Natural variability has dominated Atlantic Meridional Overturning Circulation since 1900

Mojib Latif^{1,2,3}, Jing Sun^{1,5}, Martin Visbeck^{1,2} and M. Hadi Bordbar³

Change in the Gulf Stream preceded rapid warming of the North West Atlantic Shelf

Afonso Gonçalves Neto^{1,3}, Joseph A. Langan¹ & Jaime B. Palter¹

Distinct sources of interannual subtropical and subpolar Atlantic overturning variability

Yavor Kostov^{1,2,3}, Heide C. Josey¹, L. Paul van de Wal³, Astrid Heimbach^{4,5,6}, Gael Forget⁷, N. Penny Holliday⁸, M. Susan Lozier⁹, Li Li¹⁰, Elen R. ...¹¹

It's an Area of Active Research

Labrador Sea freshening linked to Beaufort Gyre freshwater release

Jiaxu Zhang^{1,2,3,4,5}, Wilbert Weijer¹, Michael Steele⁵, Wei Cheng^{3,4}, Tarun Verma¹ & Milena Veneziani⁶

Current Atlantic Meridional Overturning Circulation weakest in last millennium

L. Caesar^{1,2,3}, G. D. McCarthy¹, D. J. R. Thornalley¹, N. Cahill⁴ and S. Rahmstorf^{2,5}

Recent warming and decadal variability of Gulf of Maine and Slope Water

Dan Seidov^{1*}, Alexey Mishonov², Rost Parsons³

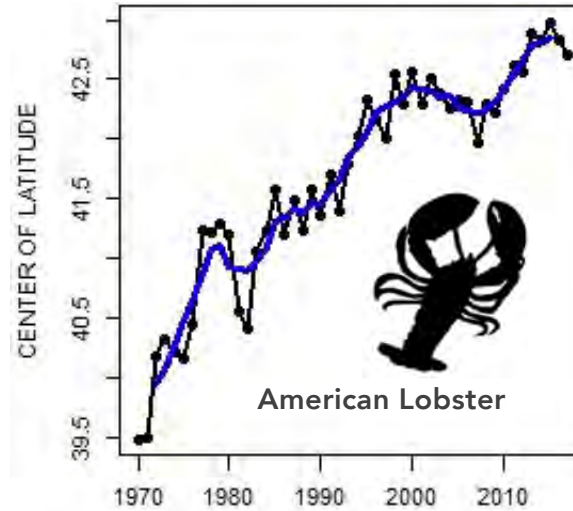
A shift in the ocean circulation has warmed the subpolar North Atlantic Ocean since 2016

Damien Desbruyères^{1,2}, Léon Chafik² & Guillaume Maze¹

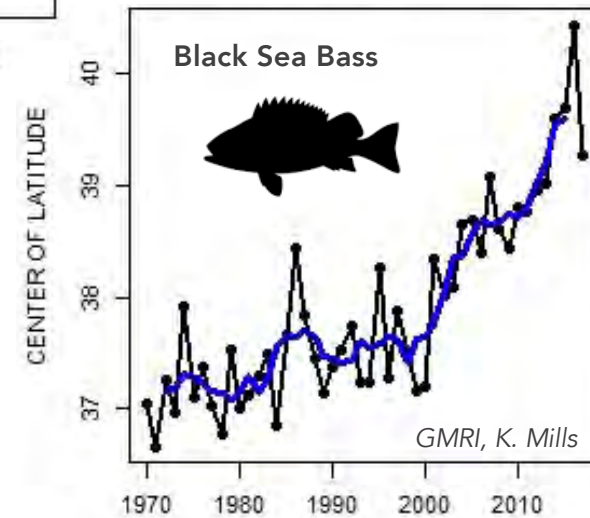
Why Does It Matter: Productivity Declines & Shifting Species



Decreases in cod and lobster productivity have been linked to increases in temperature

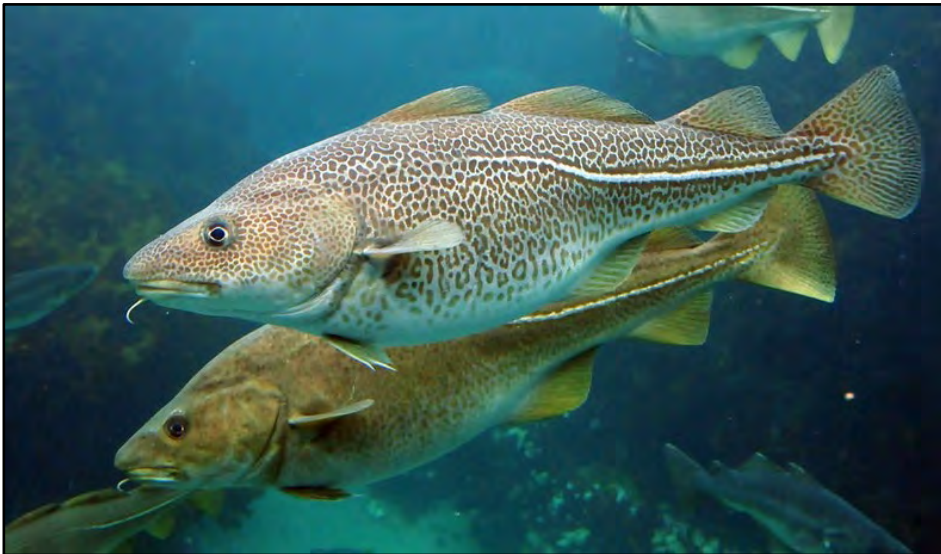


The hospitability of this region to various species (farmed and wild harvest) is changing



Why Does It Matter: Supply Chain Disruptions

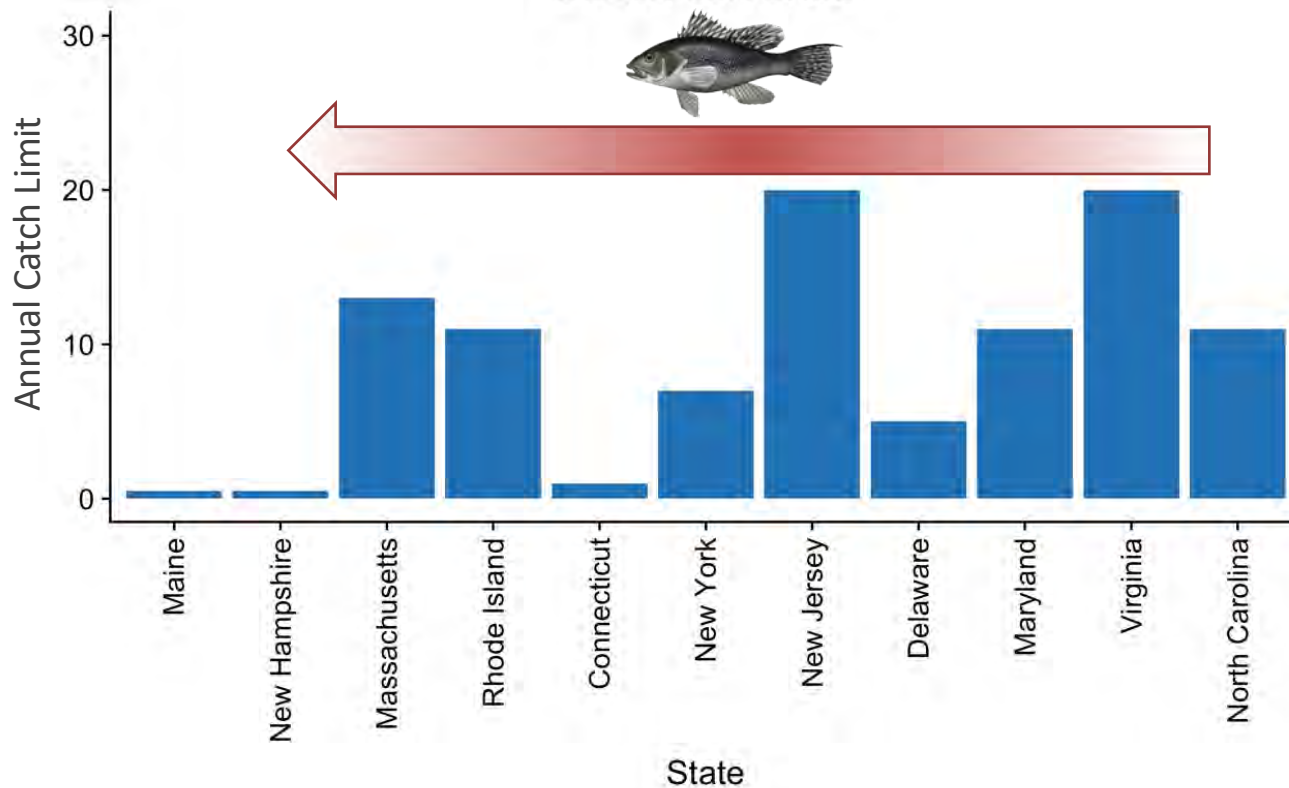
- Fluctuations in supply
- More frequent surprise events
- Loss of certifications (temporary or long-term)



- Additional Costs (e.g., risk / insurance)
- Increased competition for ocean space (wind, cargo, fisheries, etc.)

Responding to (Capitalizing Upon?) Change

BLACK SEA BASS



There's a need for a more dynamic regulatory & management regime



Thank You!

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gmri.org/climate



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Climate Action Strategies for Seafood Businesses



- Measure and reduce GHG emissions throughout supply chain
- Pursue vulnerability assessments and implement risk reduction strategies (diversify sources, create new markets, etc.)
- Support, fund, and partner on research and information development
- Advocate for climate considerations in aquaculture management
- Participate in networks and collaborations to integrate climate change into seafood sustainability efforts

Hiddenfjord slashes its carbon emissions by ceasing air freight use

Faroe Is.-based Atlantic salmon farming firm reduces CO₂ emissions from exporting activity by 94% by switching to sea freight

