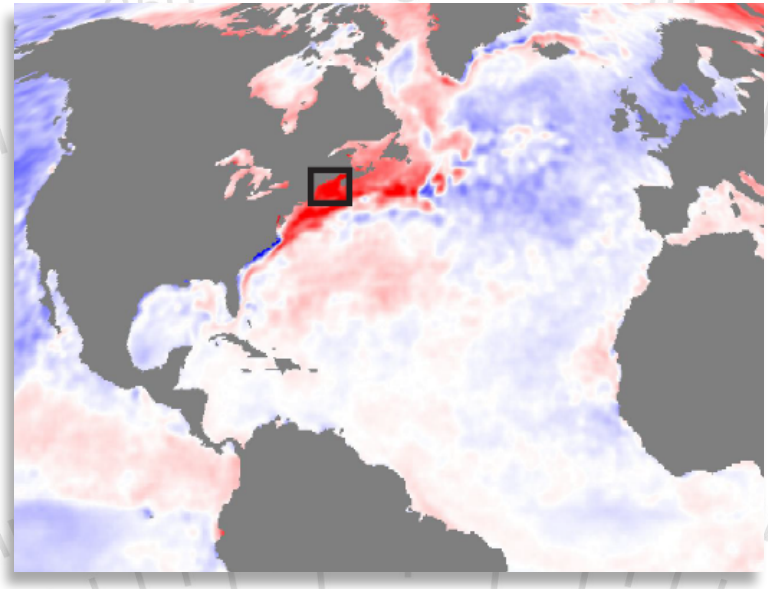
Warming Trends & Impacts in the Gulf of Maine



Andrew J. Pershing

Gulf of Maine Research Institute
Science. Education. Community.

Outline

- Temperature trends in the Gulf of Maine
- Temperature & lobsters
- Temperature & cod

Acknowledgements:

Kathy Mills, Arnault Le Bris, Janet Nye, Lisa Kerr, Graham Sherwood, Rick Wahle, Andy Thomas

Climatology Viewer

Gulf of Maine Research Institute

For a list of Northeast Ocean Climate Data Sources, click here.

Buoy Location	Data Type	Averaging Time Period
E01, Central Maine Shelf - UMaine	Water Temperature 1m	Daily

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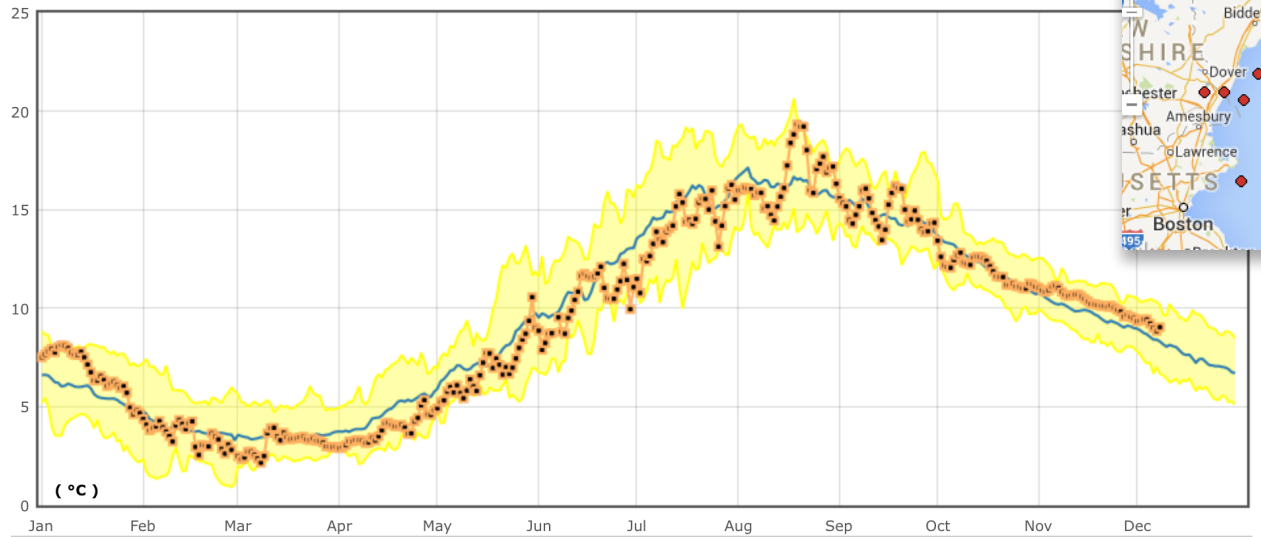
Mean Water Temperature 1 meter depth at E01 for 2001 thru 2015

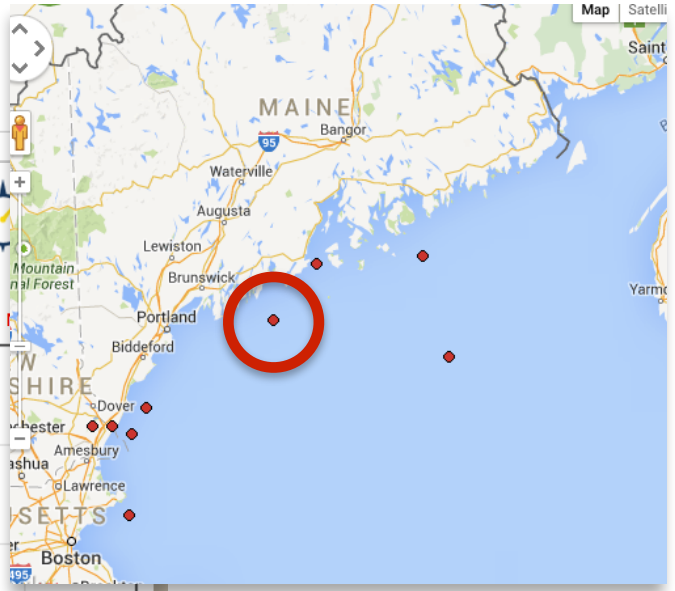
Daily



2015

Range of Daily Means 2001 thru 2014
Mean 2001 thru 2014
Daily Means By Year

View Climatology Data Table



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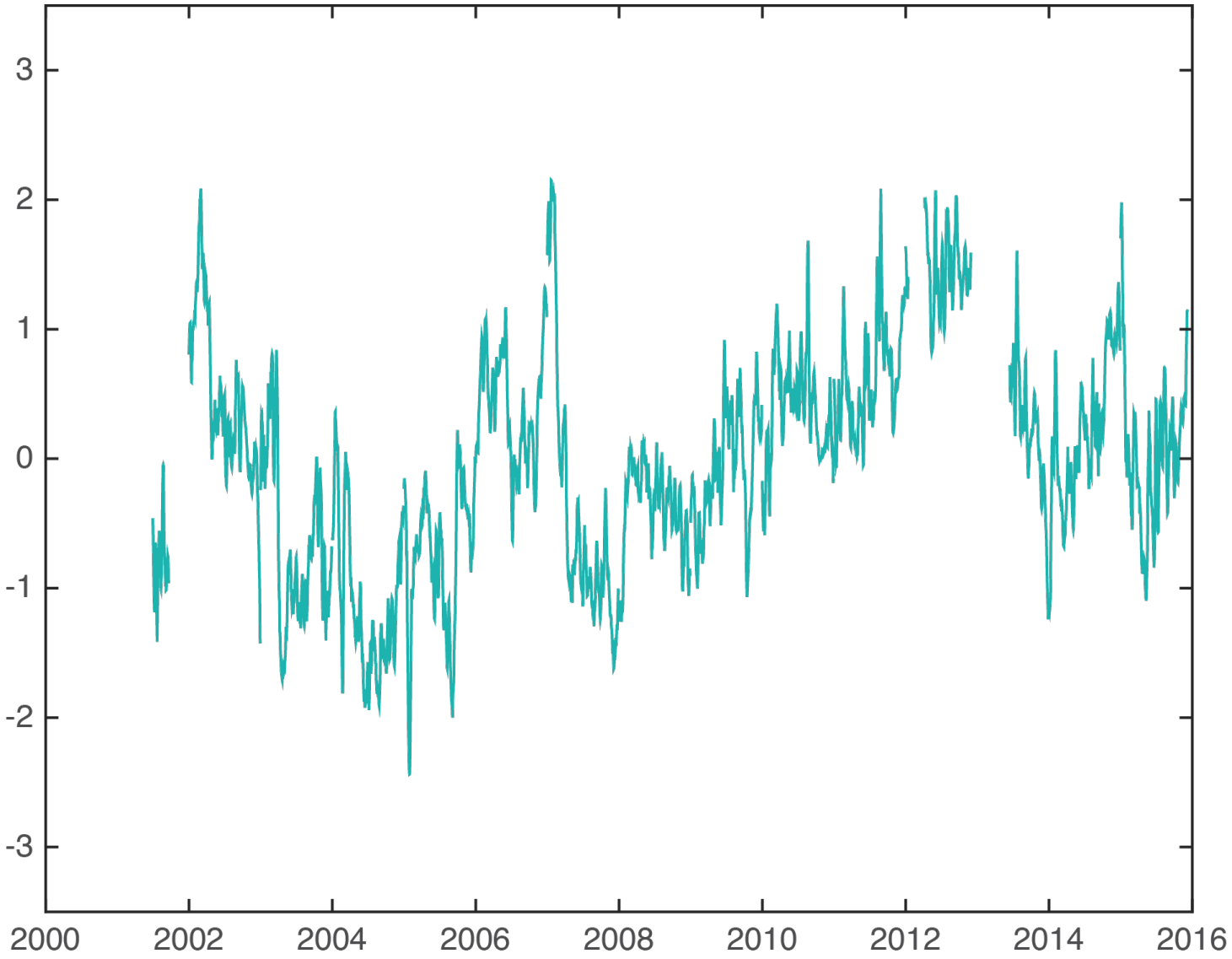
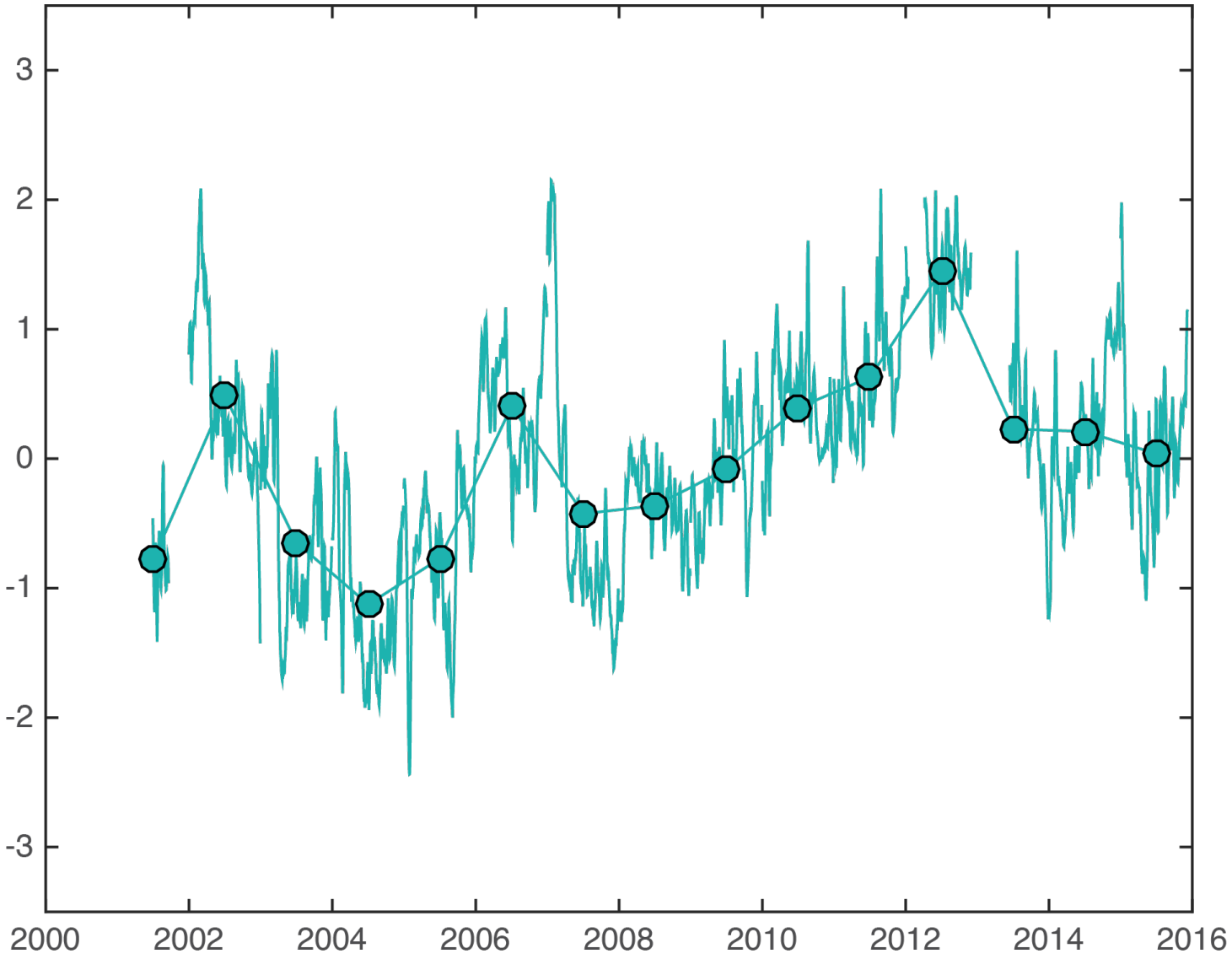
Buoy E Time Series



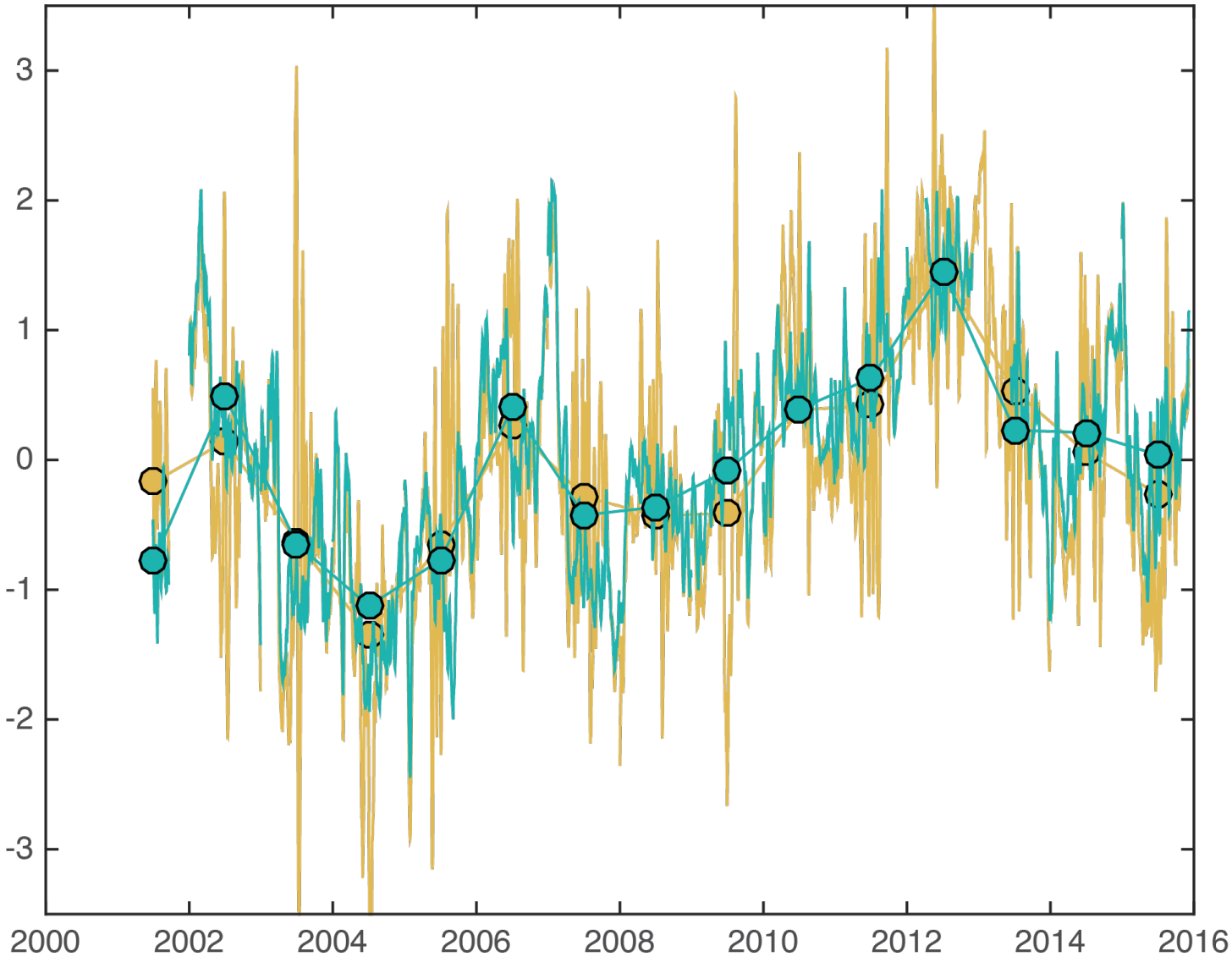
20m

Buoy E Time Series



20m

Buoy E Time Series



Buoy E Time Series

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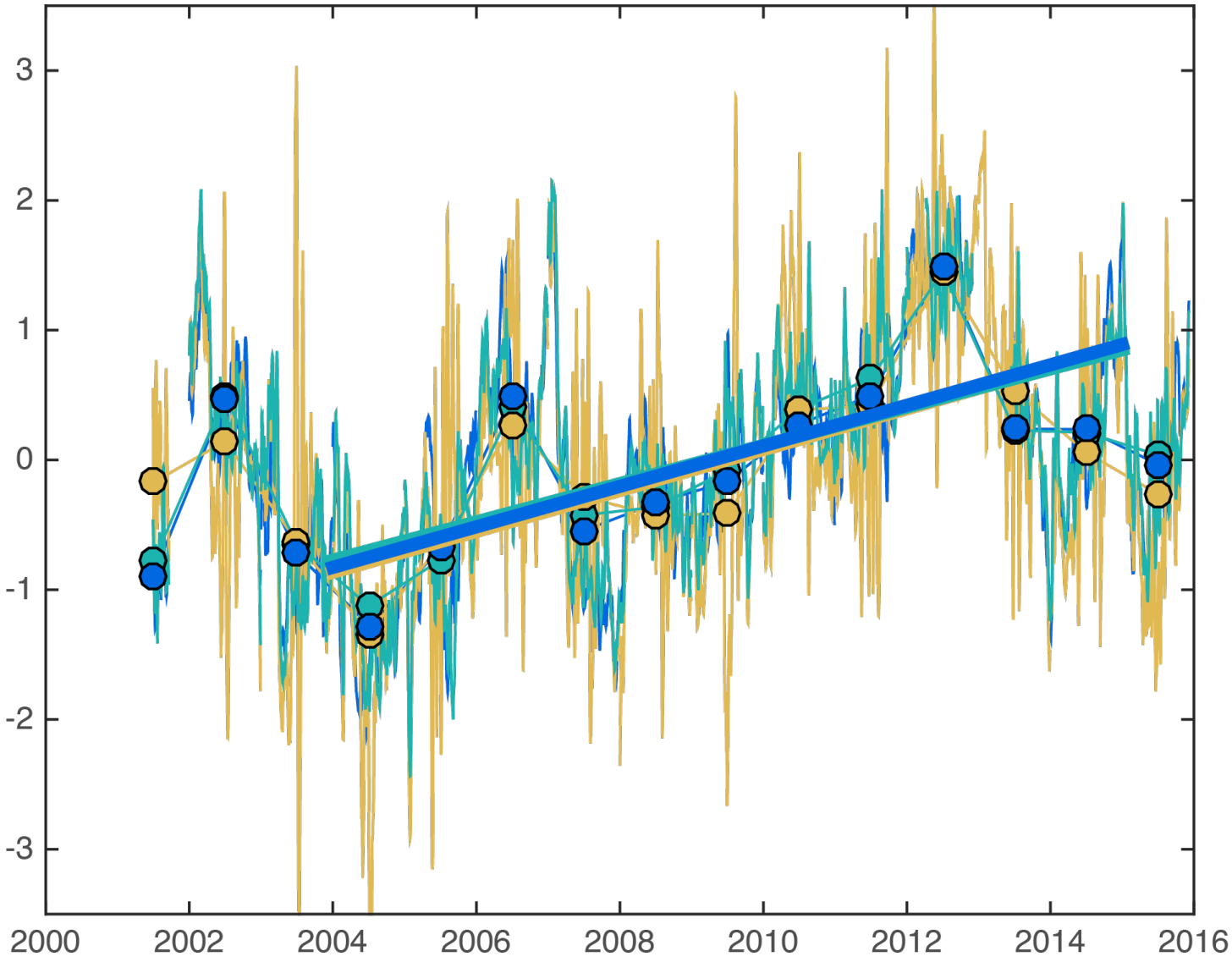


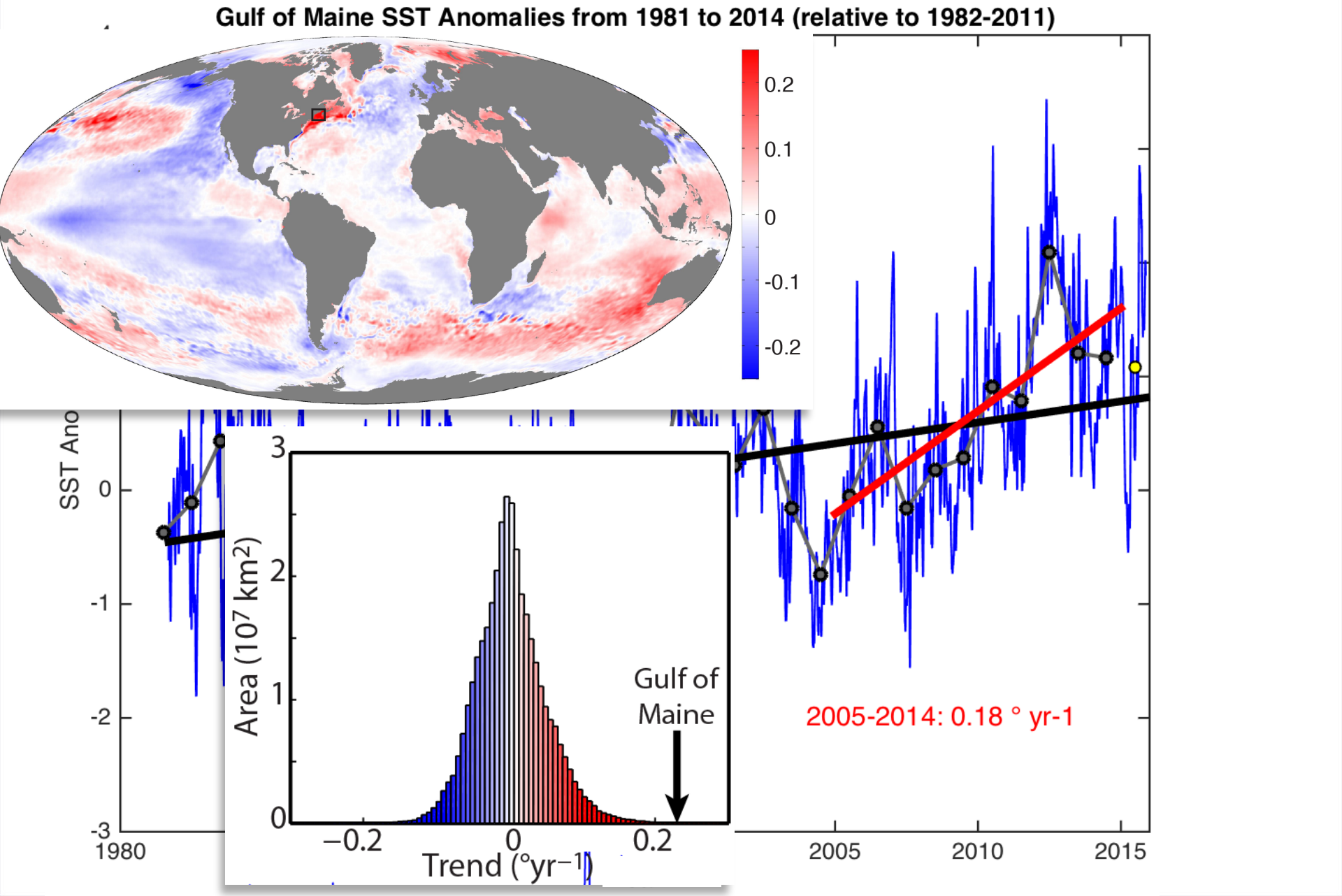
10m

20m

50m

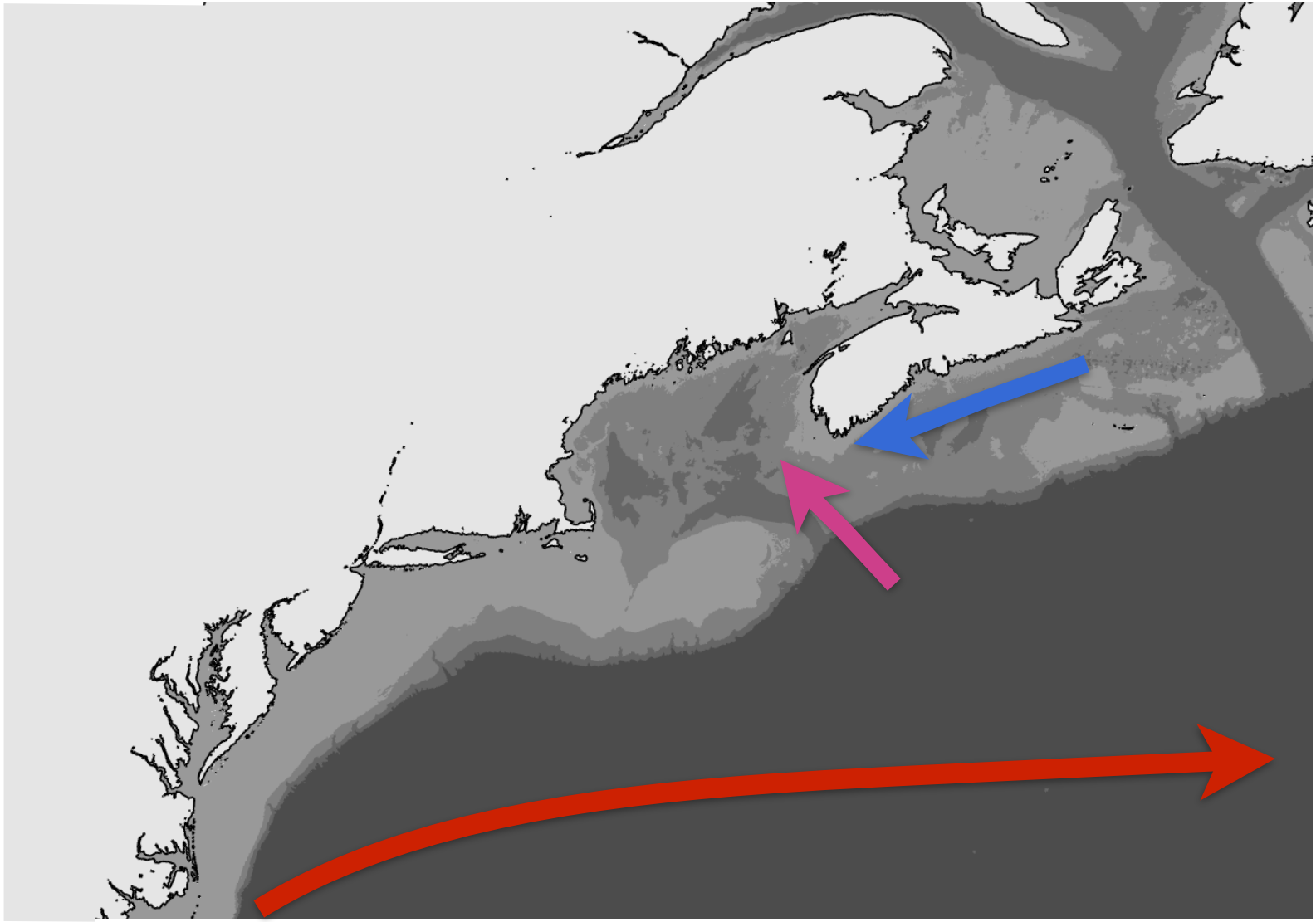
0.15° yr^{-1}

Gulf of Maine SST



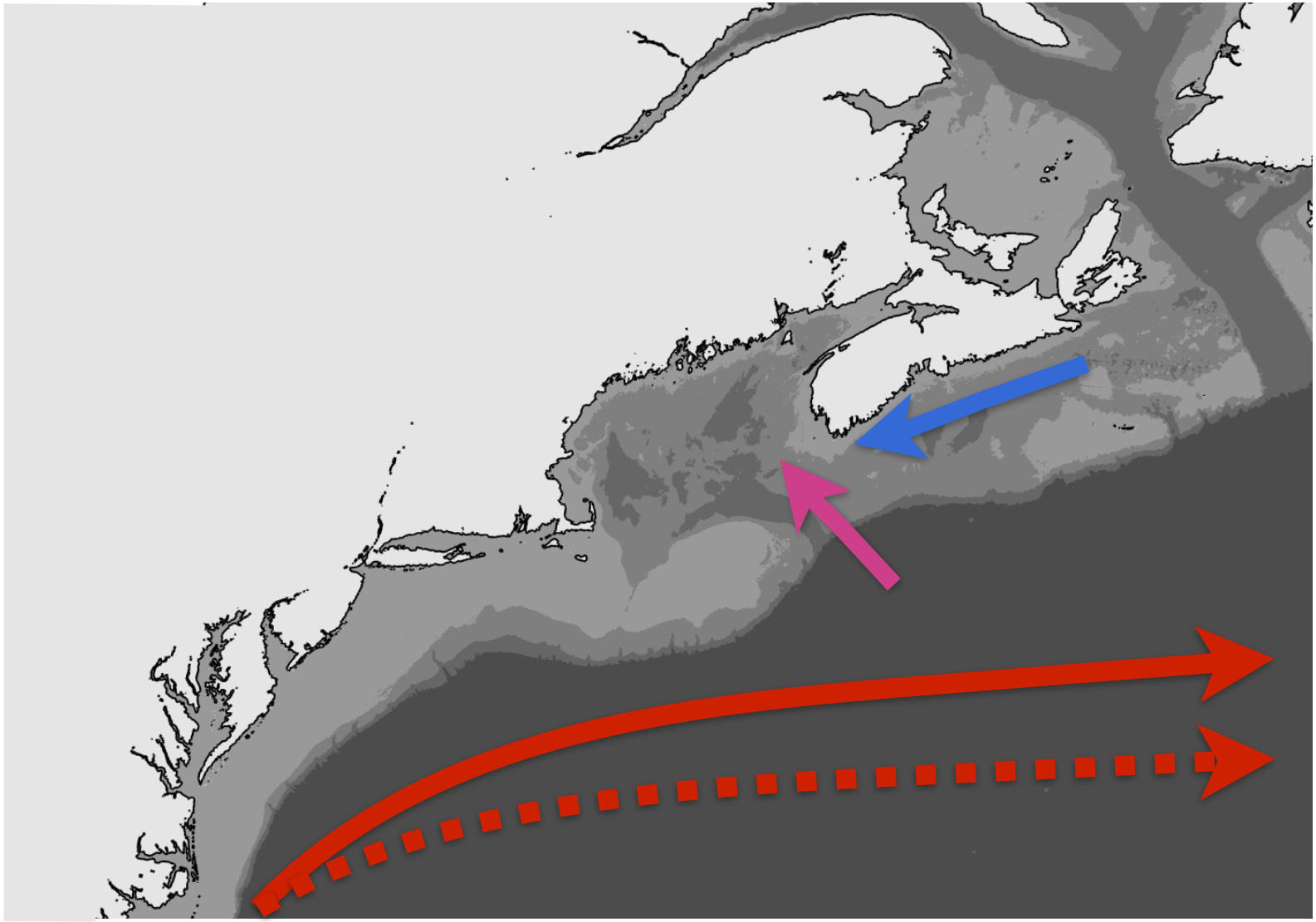
Gulf of Maine Warming

Gulf of Maine Research Institute



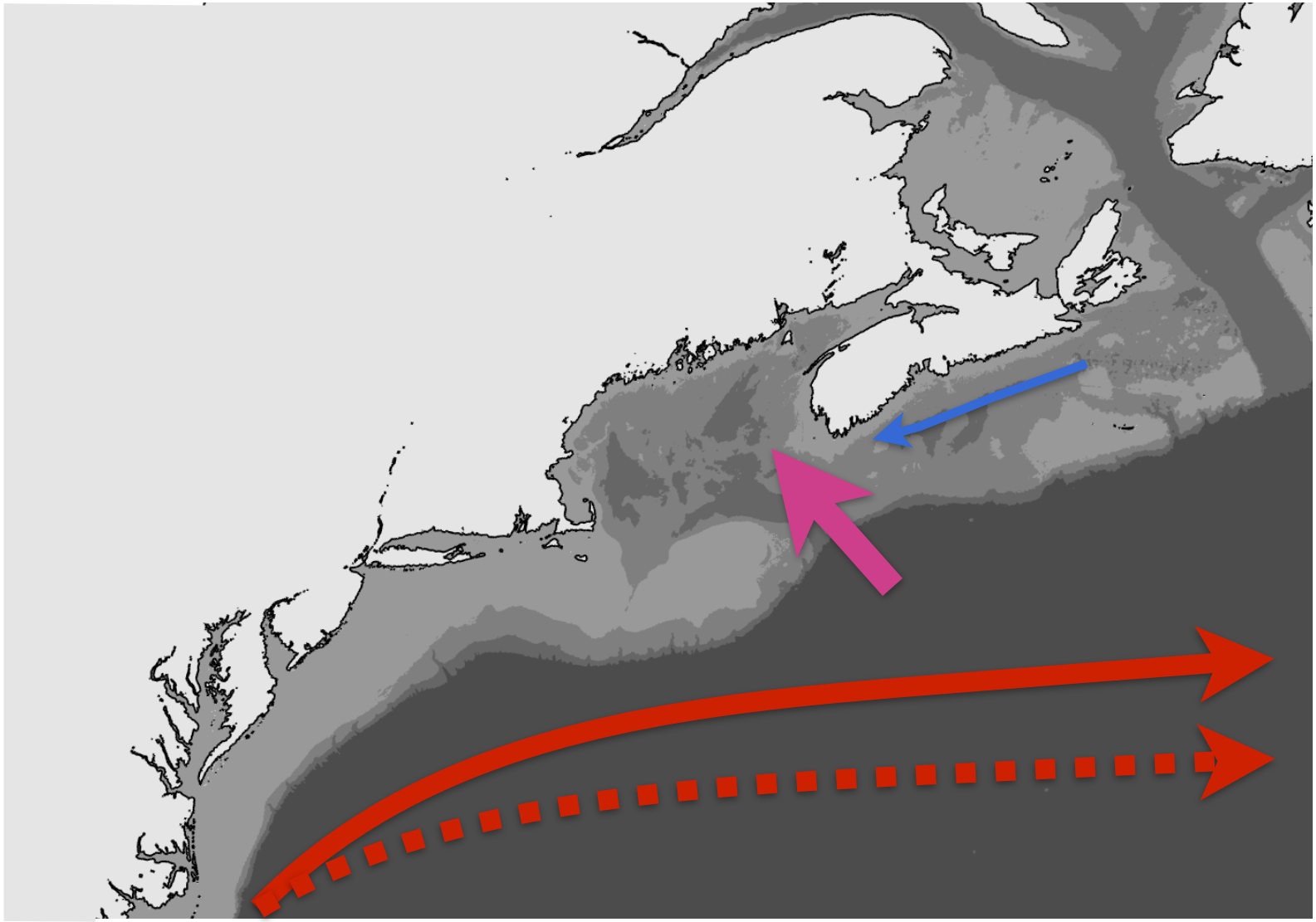
Gulf of Maine Warming

Gulf of Maine Research Institute



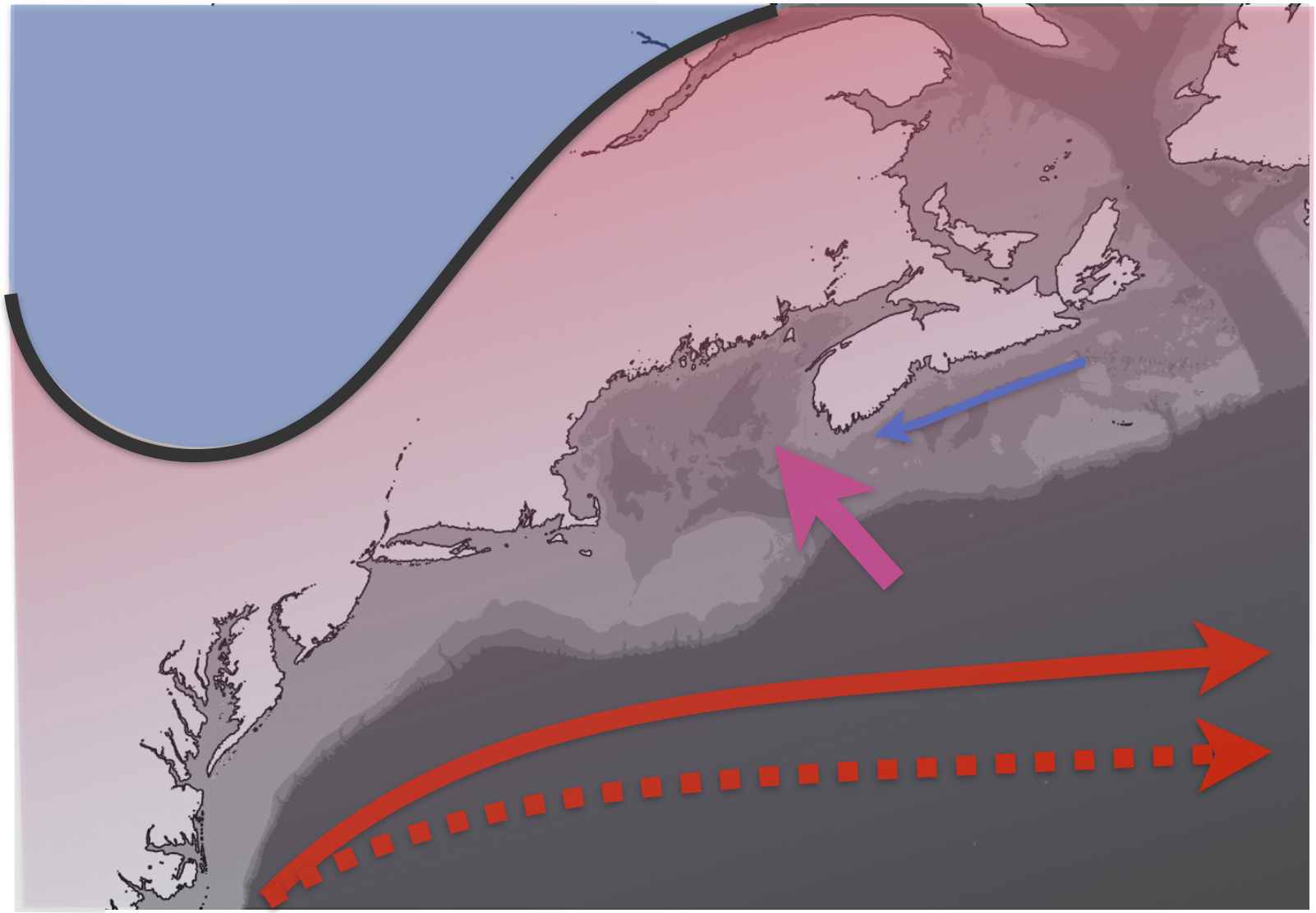
Gulf of Maine Warming

Gulf of Maine Research Institute

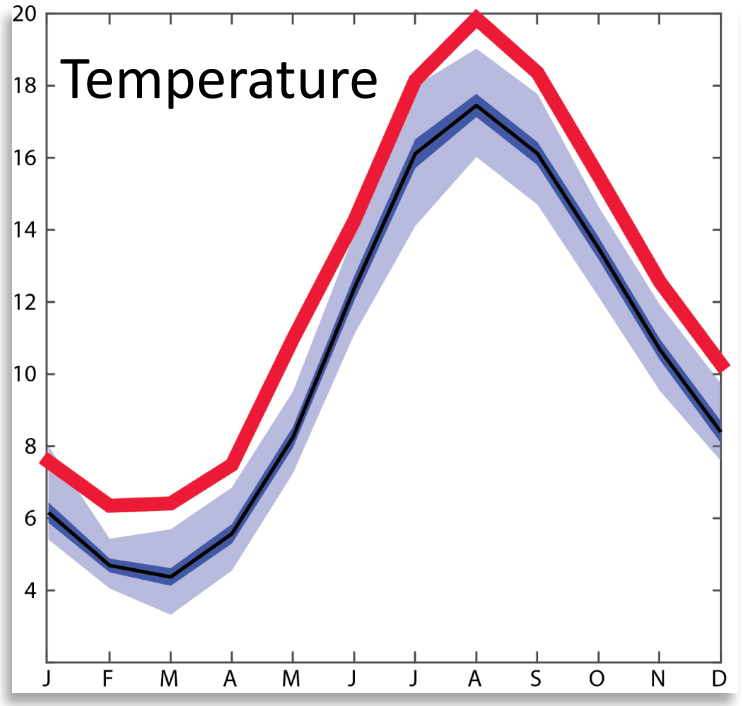


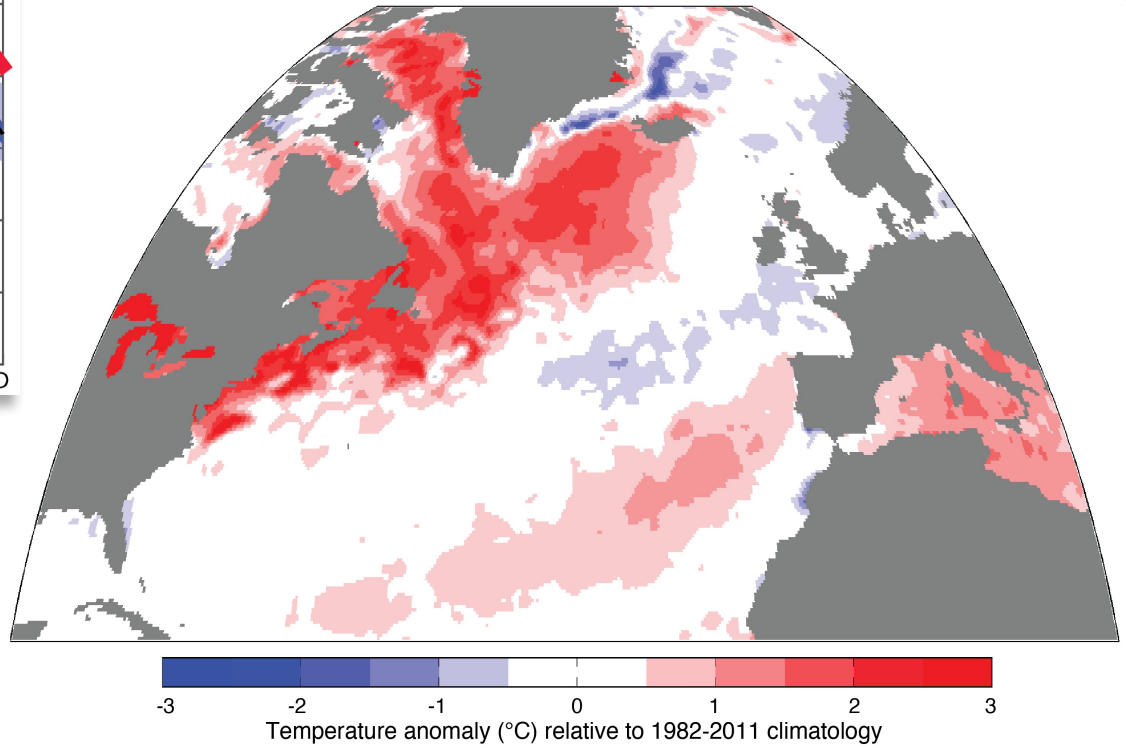
Gulf of Maine Warming

Gulf of Maine Research Institute

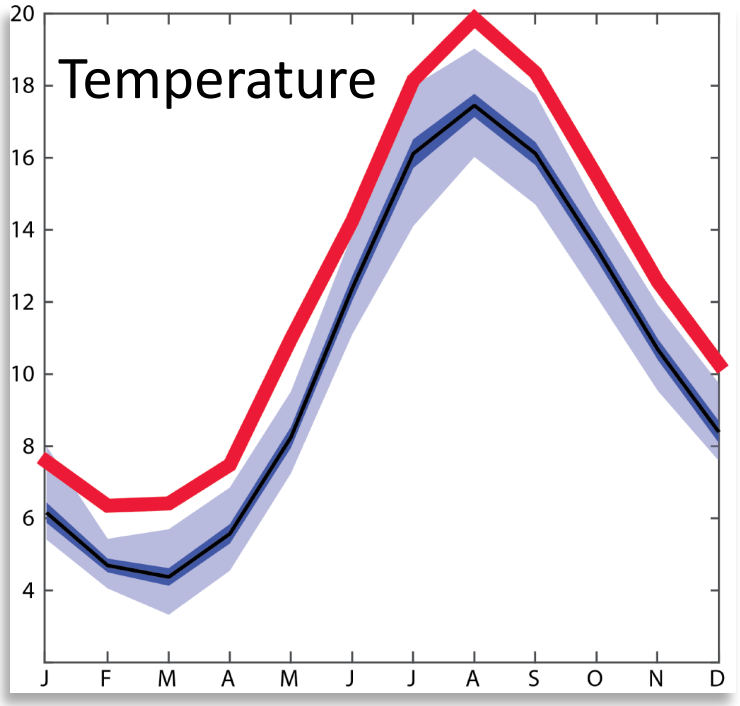


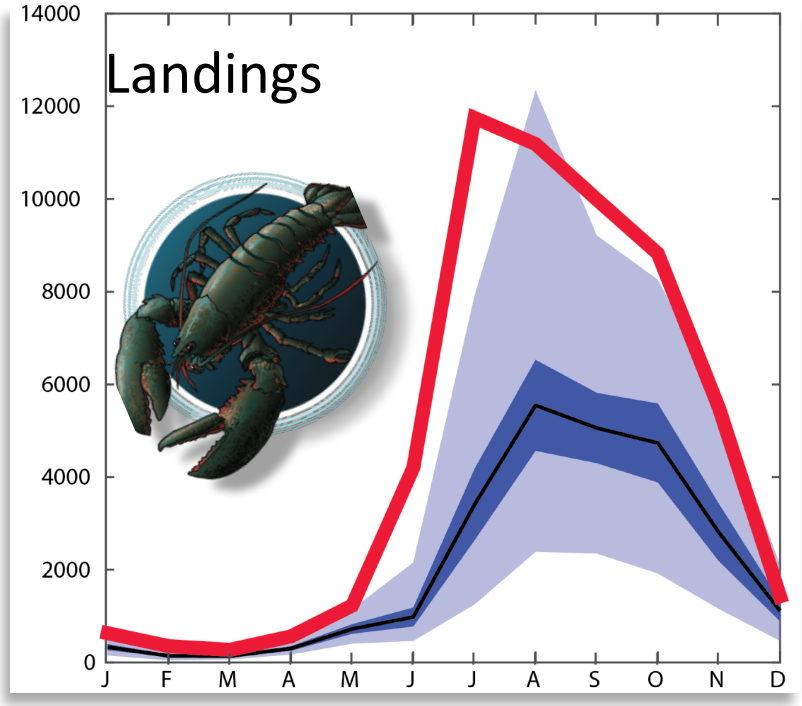
Impacts of 2012 heat wave





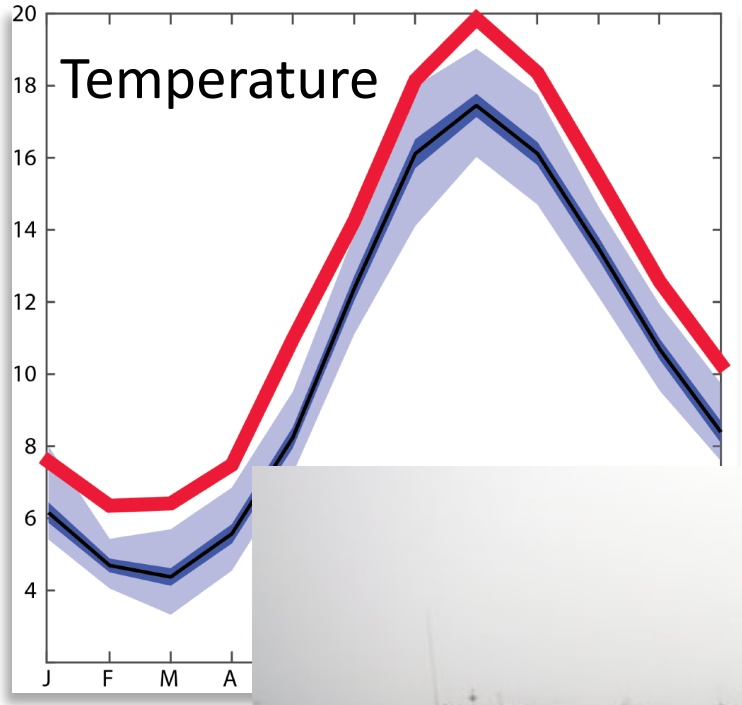
Impacts of 2012 heat wave

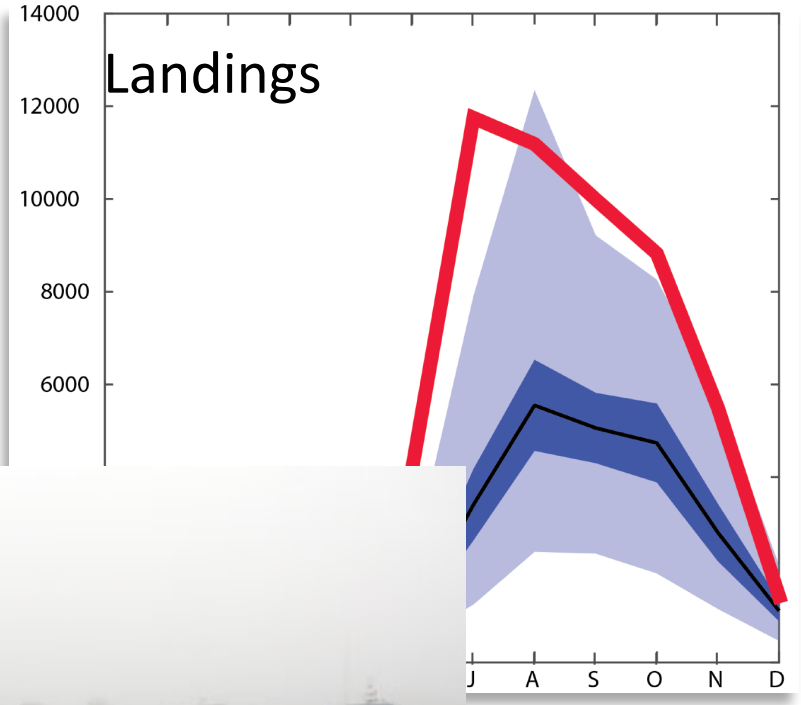




Impacts of 2012 heat wave

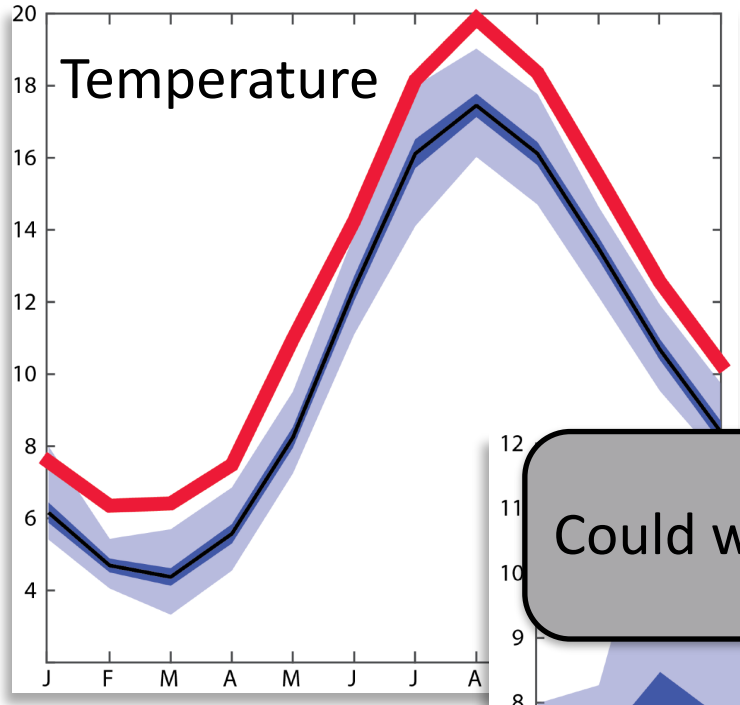
Gulf of Maine Research Institute

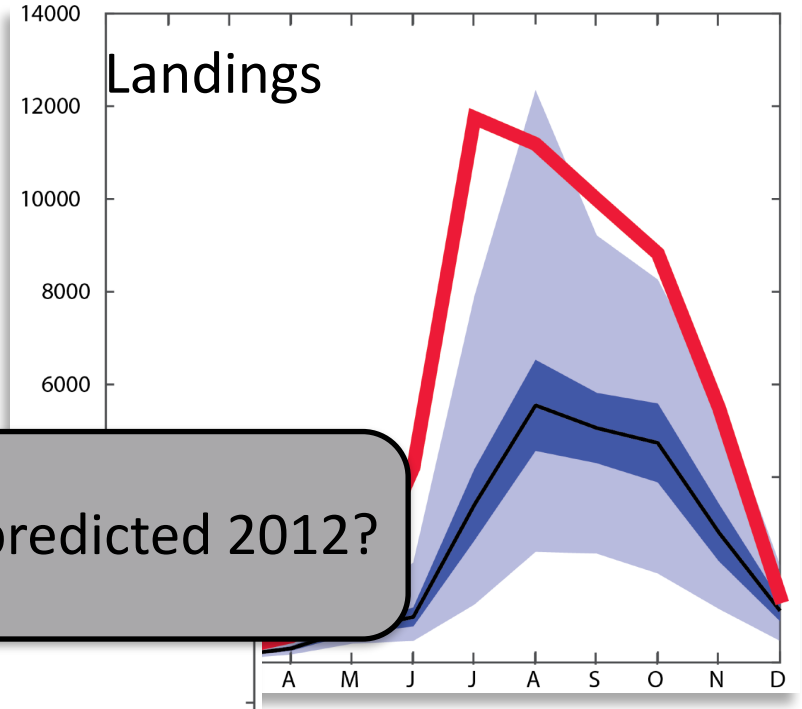


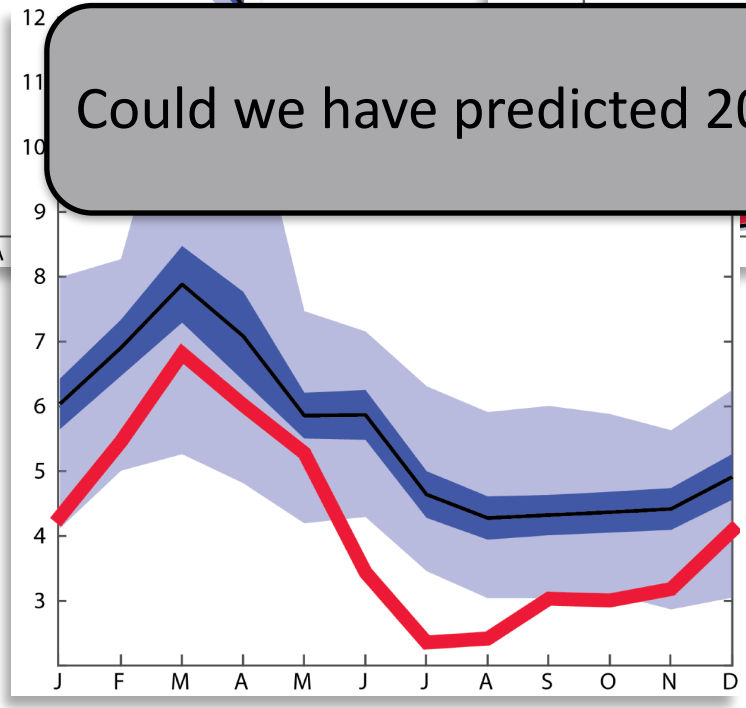


Impacts of 2012 heat wave

Gulf of Maine Research Institute

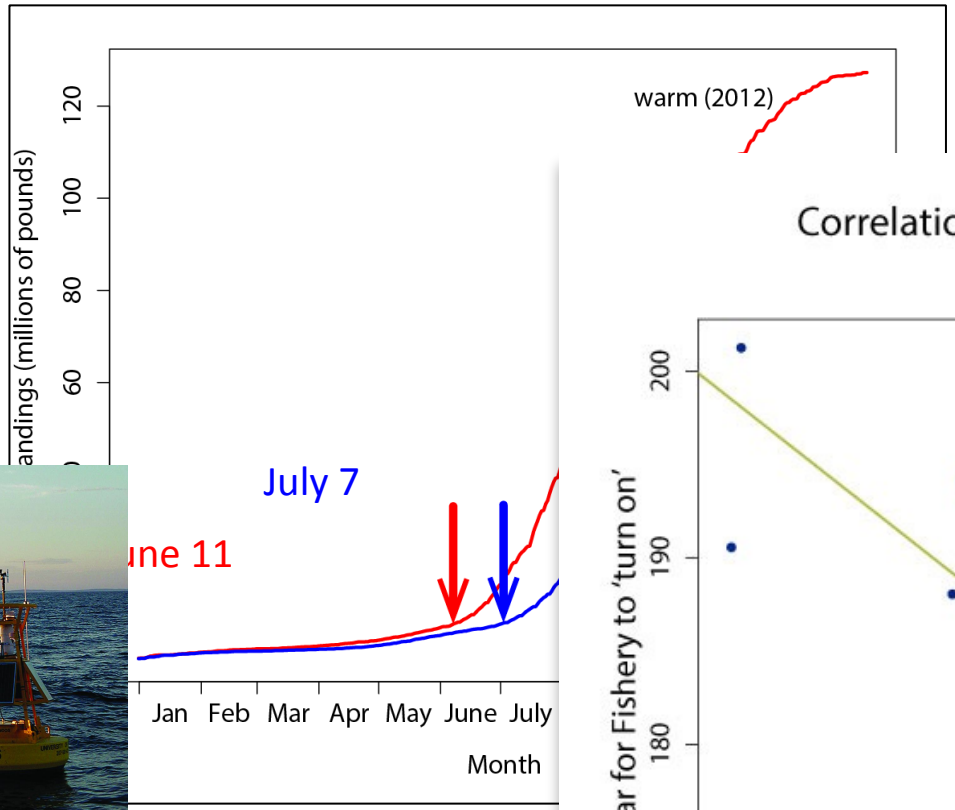


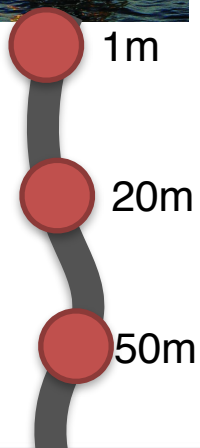


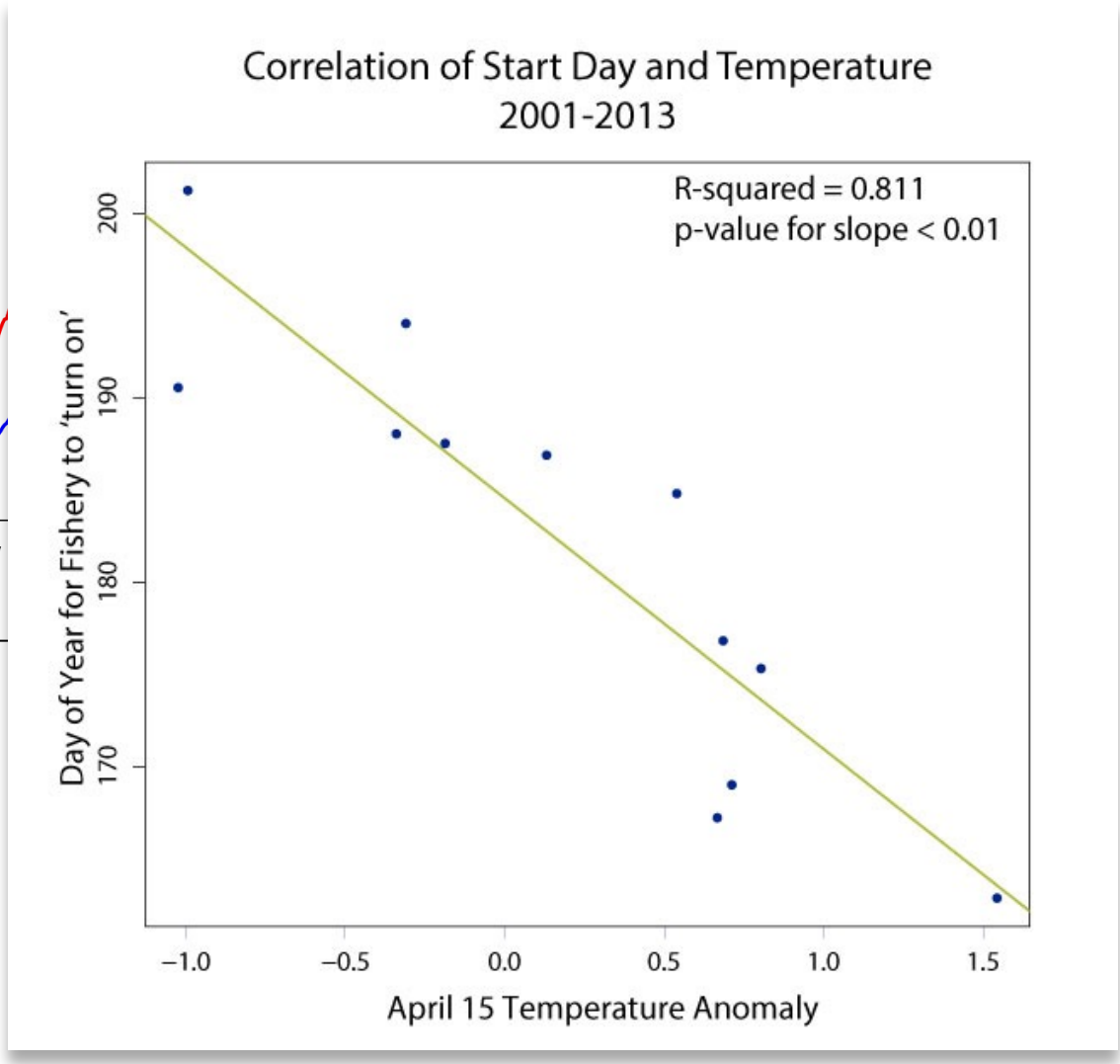


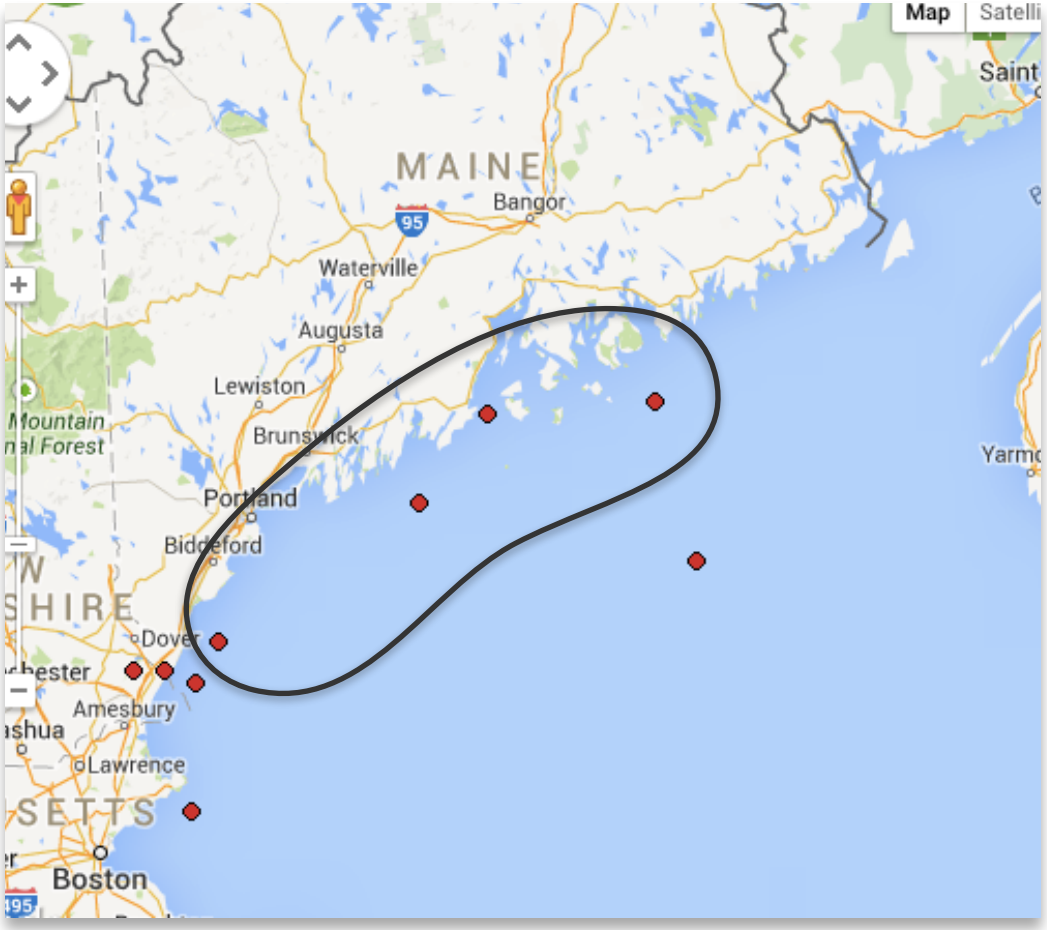
Could we have predicted 2012?

Temperature and Landings









- linear models for 4 buoys + average
- randomly draw model coefficients and apply
- yields probability of start date in a time window

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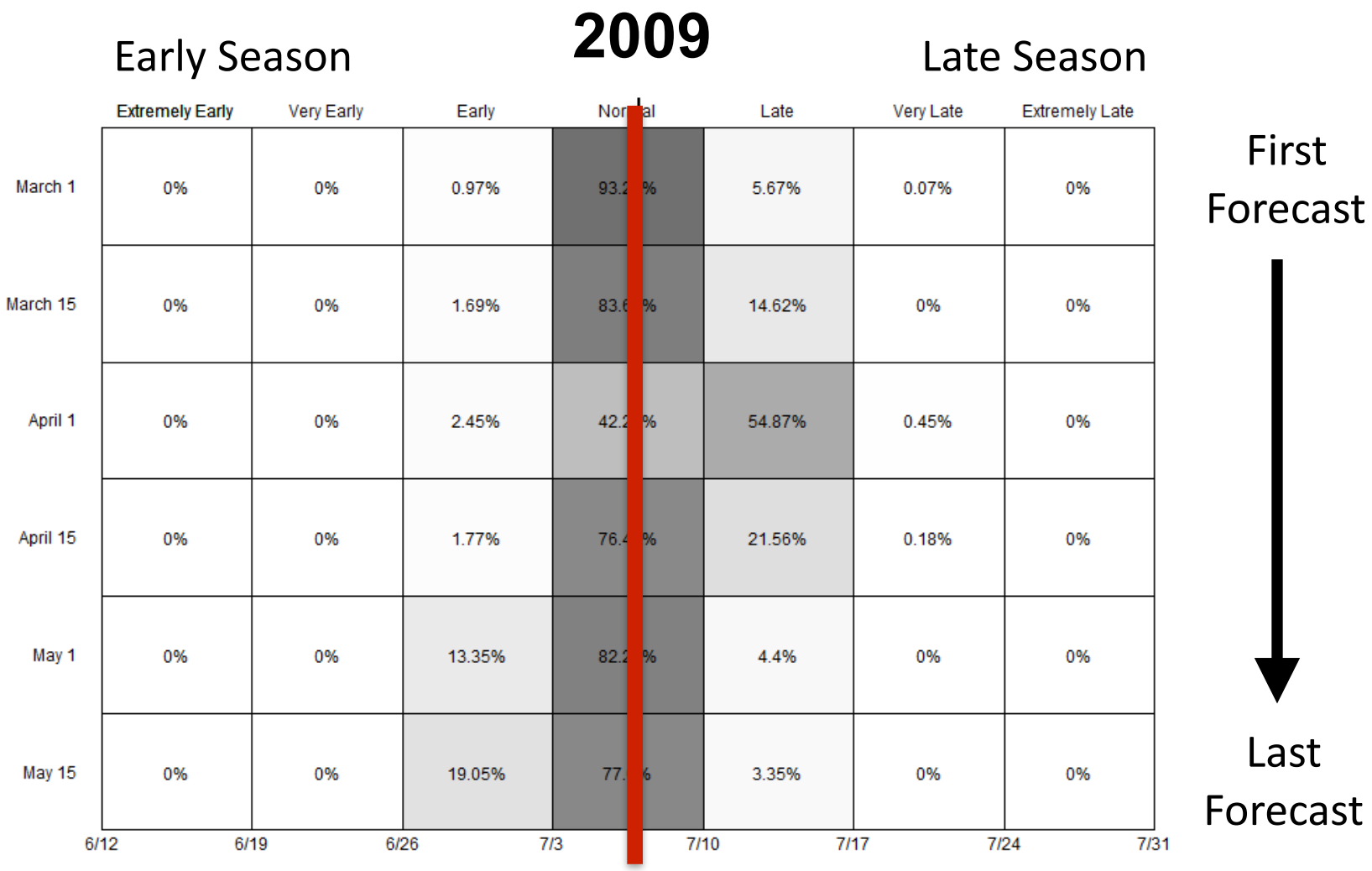
Hindcasts


2009
Early Season
Late Season
Extremely Early
Very Early
Early
Normal
Late
Very Late
Extremely Late
March 1
March 15
April 1
April 15
May 1
May 15
0%
0%
0.97%
5.67%
0.07%
0%
0%
0%
1.69%
14.62%
0%
0%
0%
0%
2.45%
54.87%
0.45%
0%
0%
0%
1.77%
21.56%
0.18%
0%
0%
0%
13.35%
4.4%
0%
0%
0%
0%
19.05%
3.35%
0%
0%
6/12
6/19
6/26
7/3
7/10
7/17
7/24
7/31
First Forecast
Last Forecast

Hindcasts

Gulf of Maine Research Institute

2012

Early Season

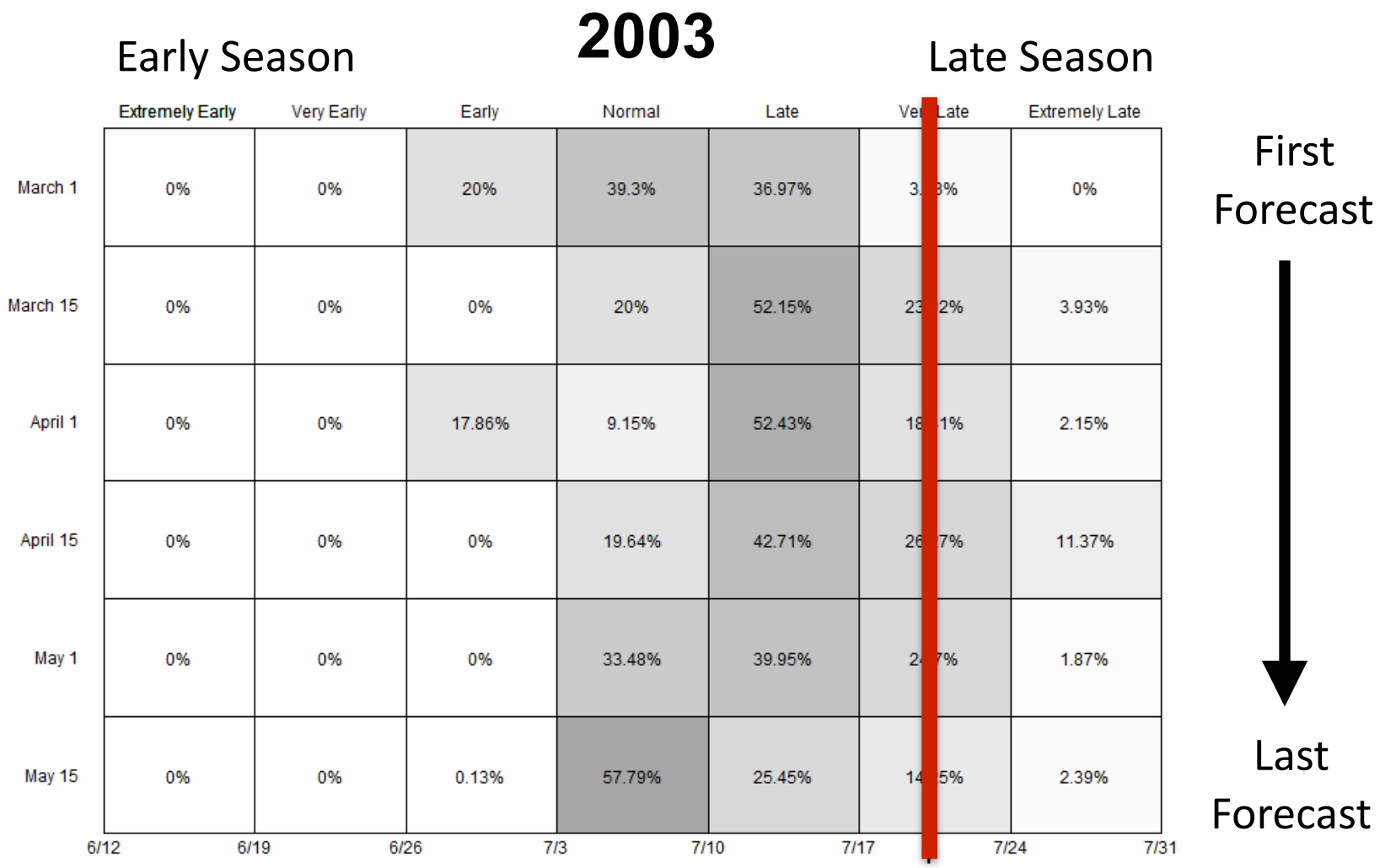
Late Season

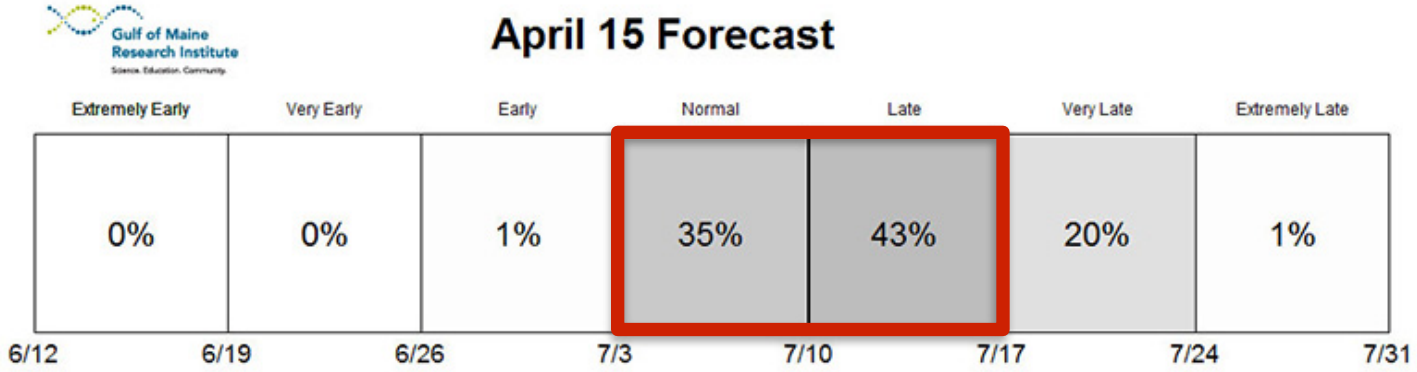
	Extremely Early	Very Early	Early	Normal	Late	Very Late	Extremely Late
March 1	47.74%	51.4%	0.85%	0%	0%	0%	0%
March 15	81.74%	17.92%	0.34%	0%	0%	0%	0%
April 1	73.61%	26.27%	0.13%	0%	0%	0%	0%
April 15	88.34%	11.45%	0.21%	0%	0%	0%	0%
May 1	77.3%	21.57%	1.13%	0%	0%	0%	0%
May 15	19.72%	70.65%	9.63%	0%	0%	0%	0%

First Forecast

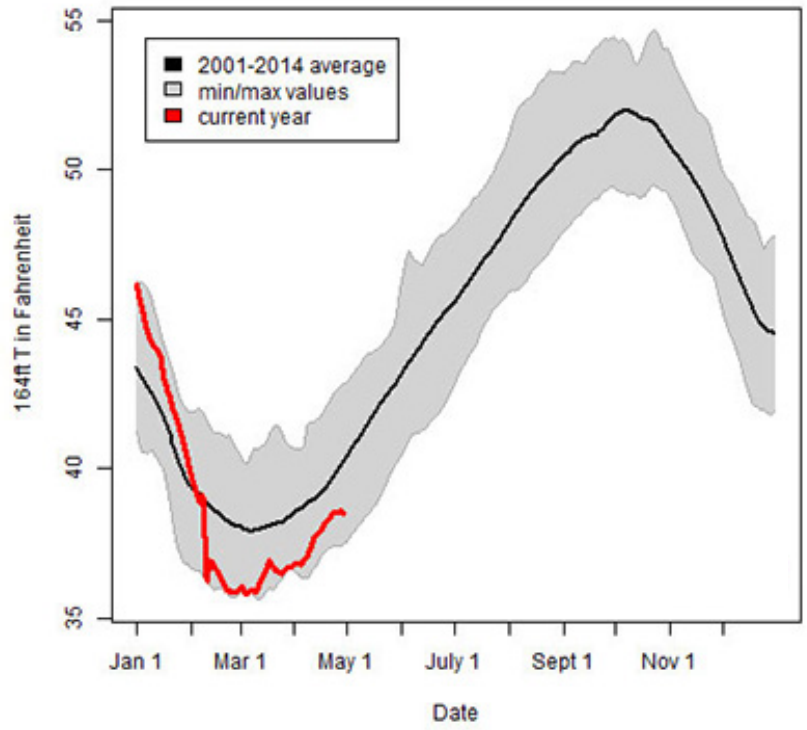
Last Forecast

Hindcasts


2003
Early Season
Late Season
Extremely Early
Very Early
Early
Normal
Late
Very Late
Extremely Late
March 1
March 15
April 1
April 15
May 1
May 15
0%
0%
20%
39.3%
36.97%
0%
0%
0%
0%
20%
52.15%
3.93%
0%
0%
17.86%
9.15%
52.43%
2.15%
0%
0%
0%
19.64%
42.71%
11.37%
0%
0%
0%
33.48%
39.95%
1.87%
0%
0%
0.13%
57.79%
25.45%
2.39%
6/12
6/19
6/26
7/3
7/10
7/17
7/24
7/31
First Forecast
Last Forecast



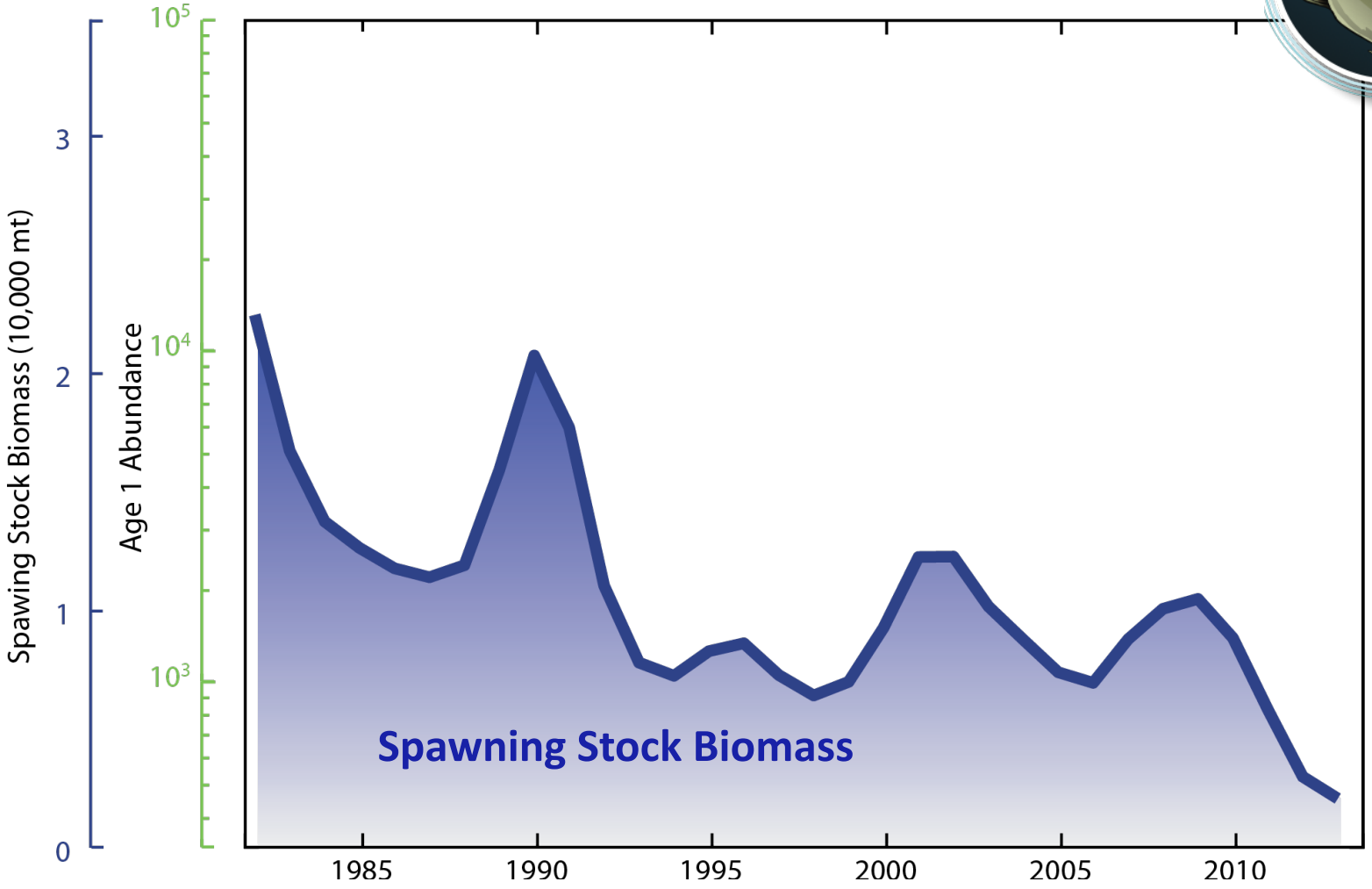
www.gmri.org/lobster-forecast



- 4/15—warming
- still cold
- late season, with a chance of very late

Gulf of Maine Cod

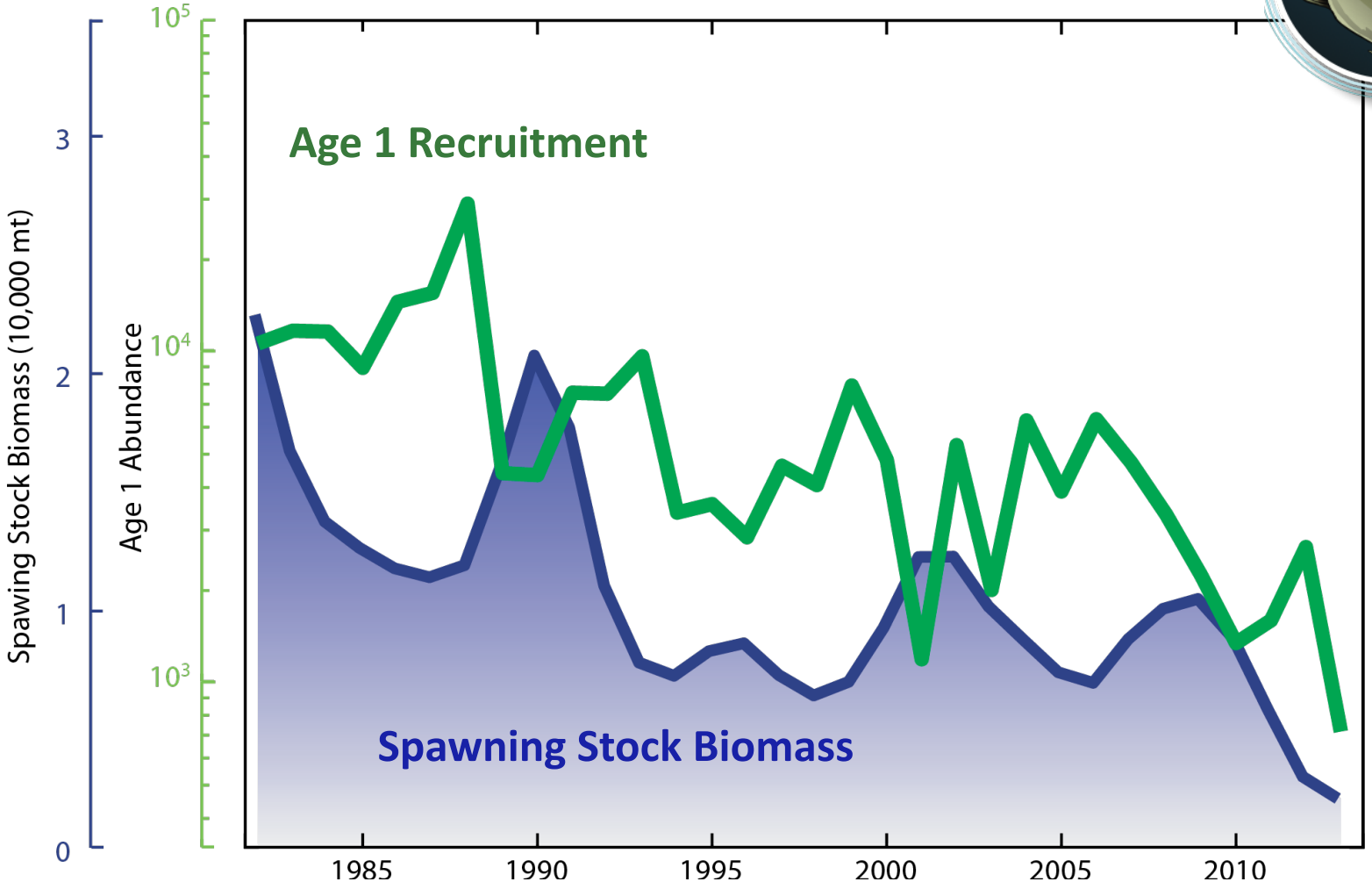
Gulf of Maine Research Institute



Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod

Gulf of Maine Research Institute



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Gulf of Maine Cod

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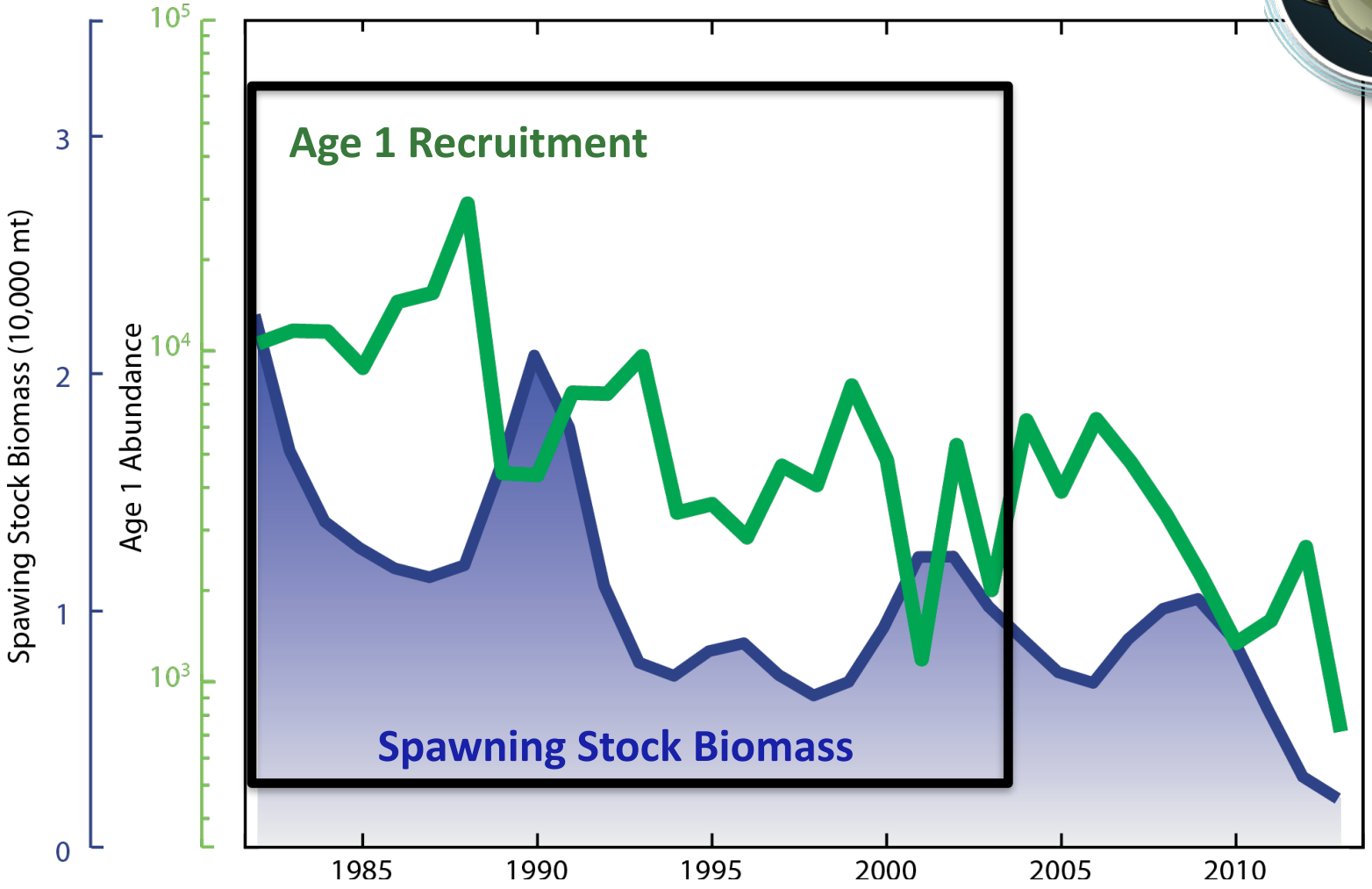
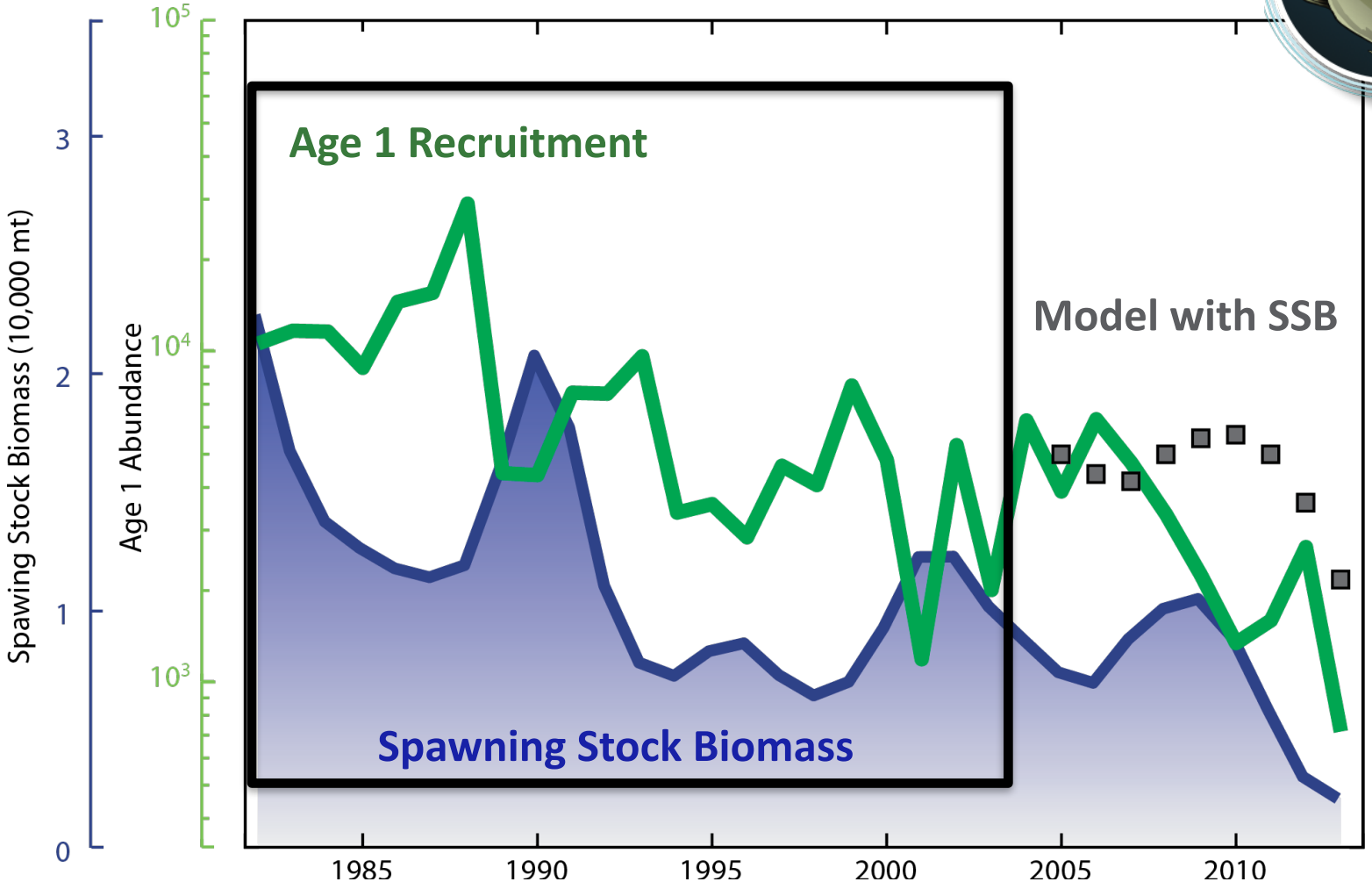


Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod

Gulf of Maine Research Institute



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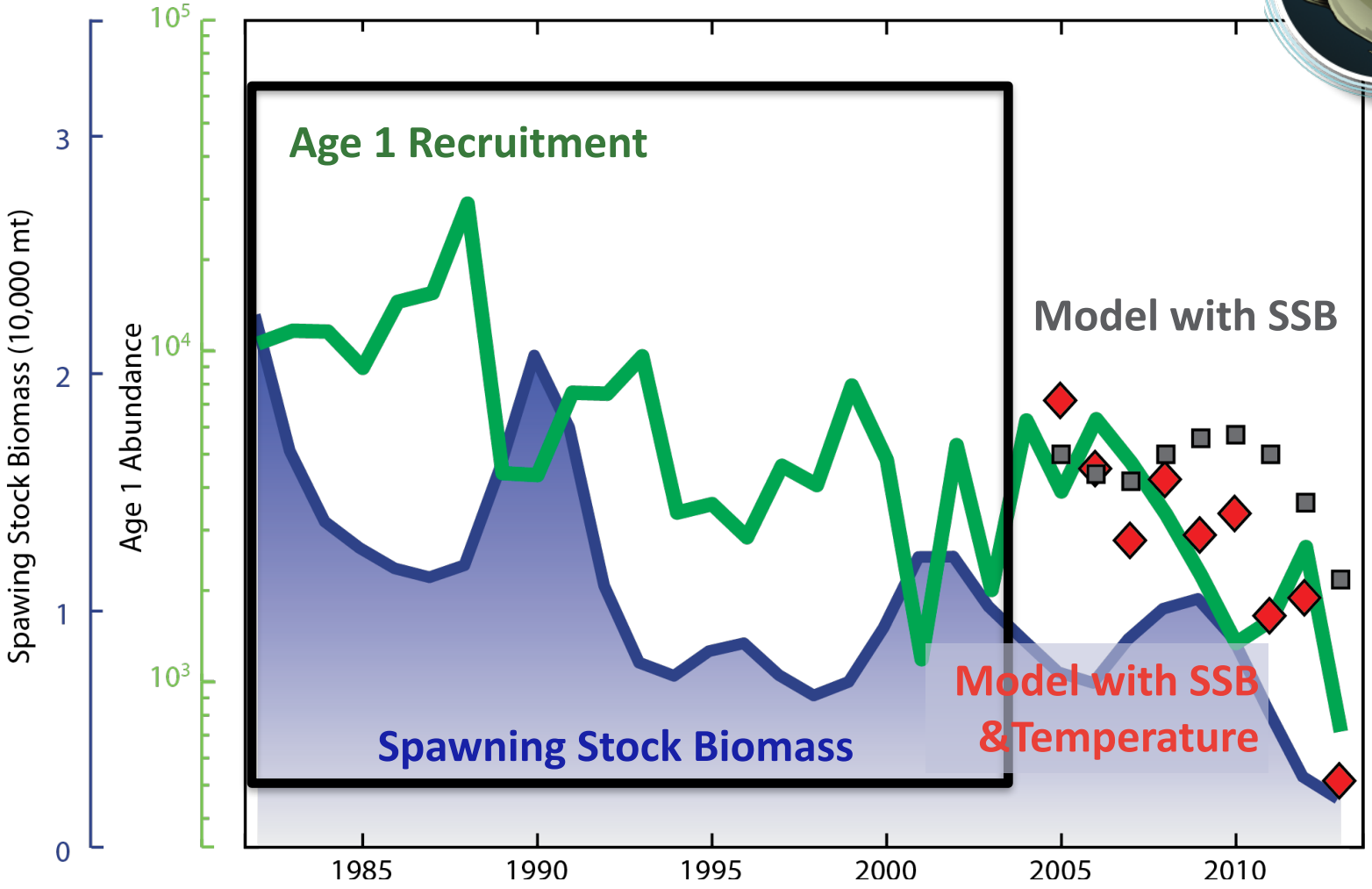
Gulf of Maine Cod

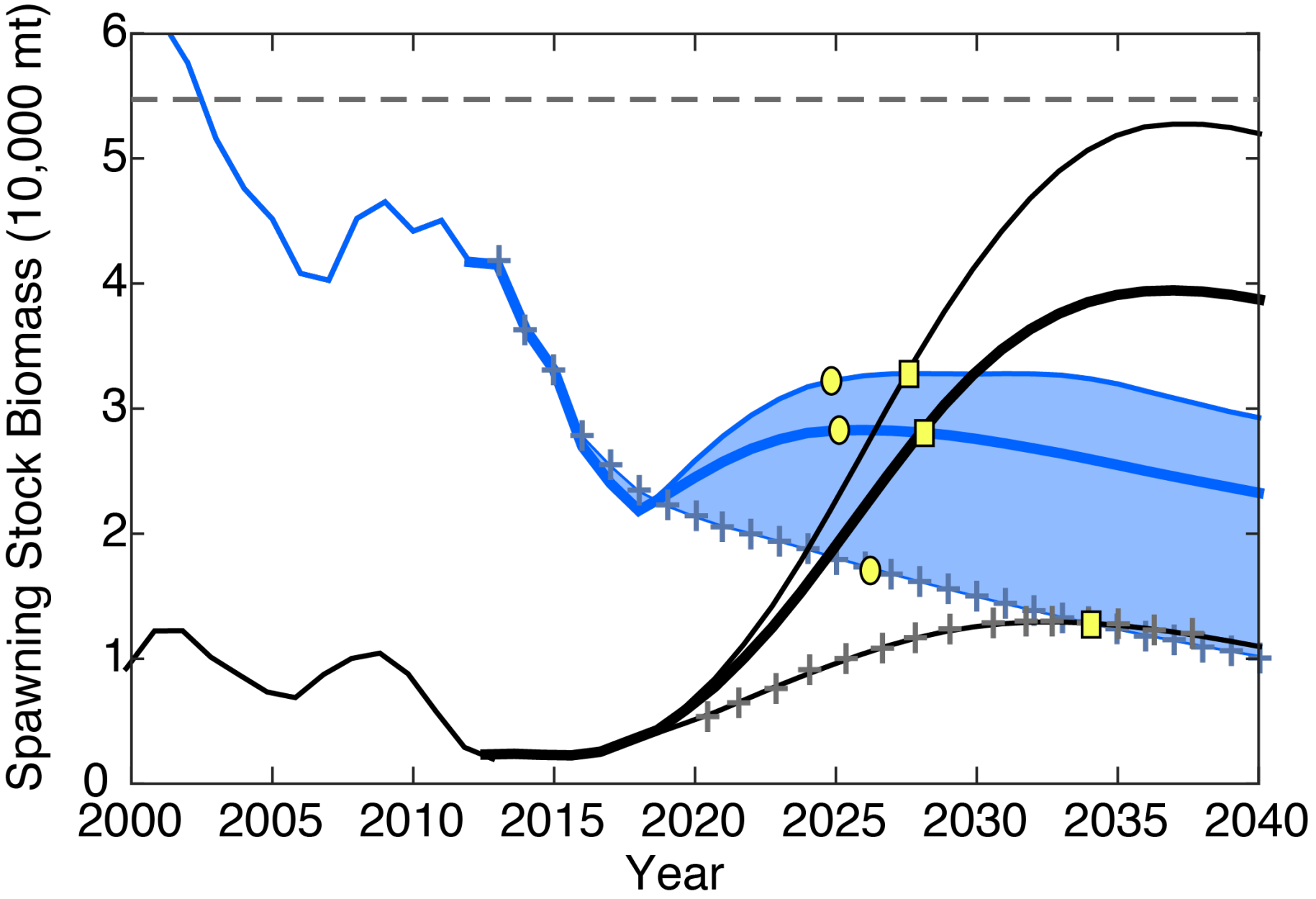
Gulf of Maine Research Institute



Data from 2014 stock assessment (Palmer, 2014)

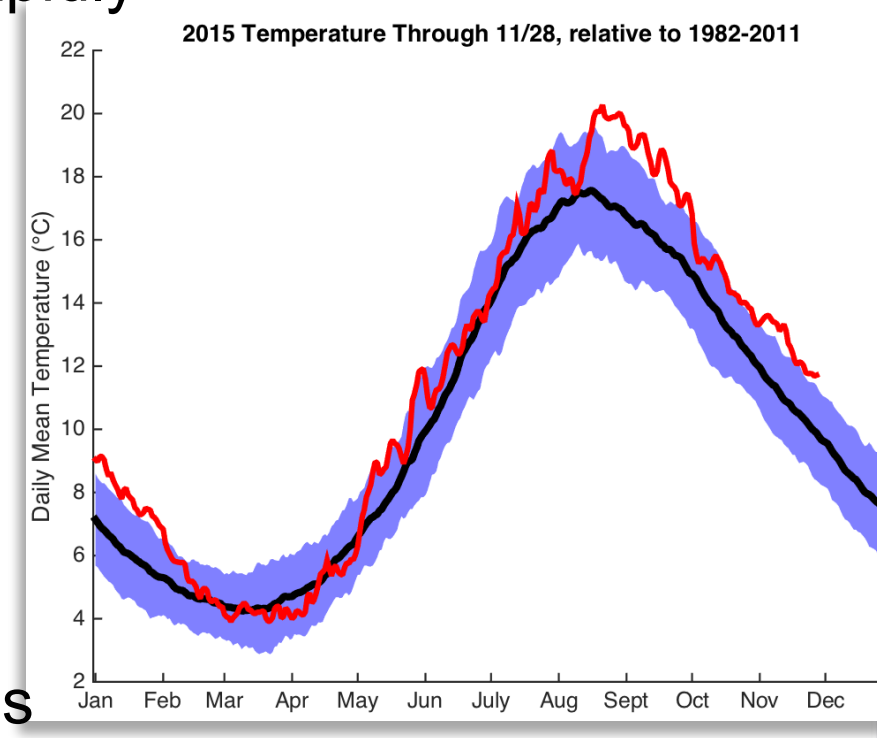
Future of Cod

Gulf of Maine Research Institute



Conclusion

- The Gulf of Maine is warming rapidly
- Warming has impacted
  - fish distributions
  - fisheries management
  - fishermen
- Climate adaptation
  - incorporate environmental factors in decision-making
  - information and forecast tools
  - understand how humans make decisions



Pershing et al. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science, 350: 809-812.

Mills et al. 2013. Fisheries management in a changing climate: lessons from the 2012 ocean heat wave. Oceanography, 26: 191-195.