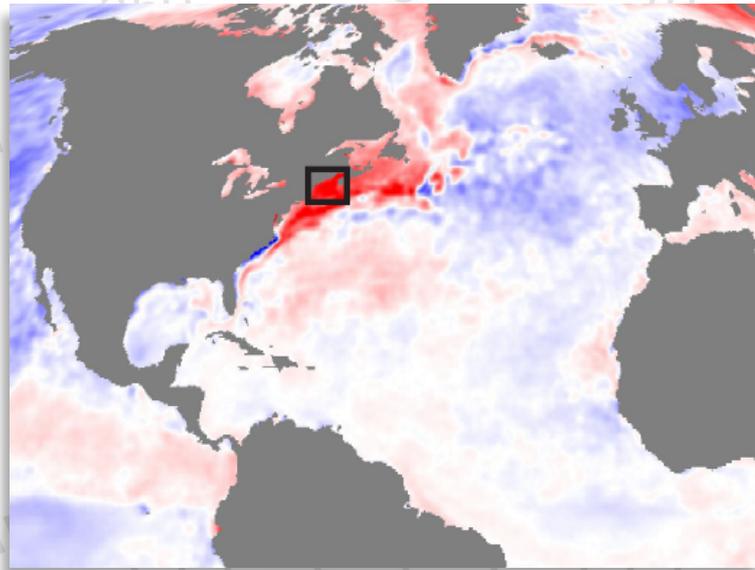


Warming Trends & Impacts in the Gulf of Maine



Andrew J. Pershing



Gulf of Maine
Research Institute

Science. Education. Community.

Outline

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

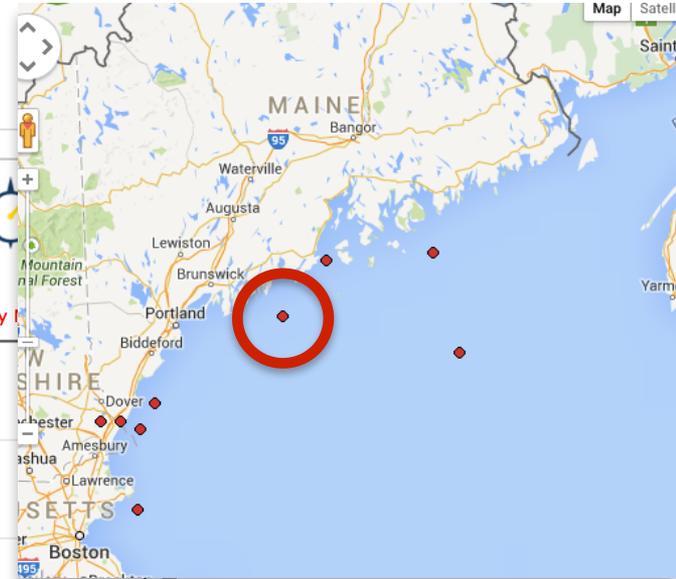
Acknowledgements:

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



LENFEST
OCEAN
PROGRAM

Climatology Viewer

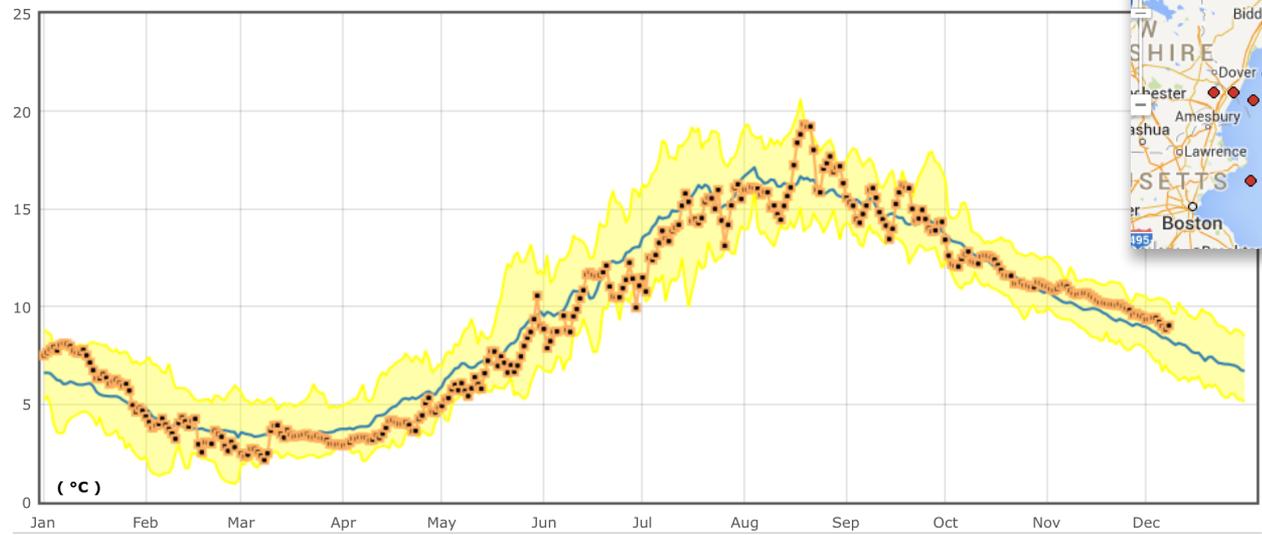


For a list of Northeast Ocean Climate Data Sources, [click here](#).

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

NERACOOS

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



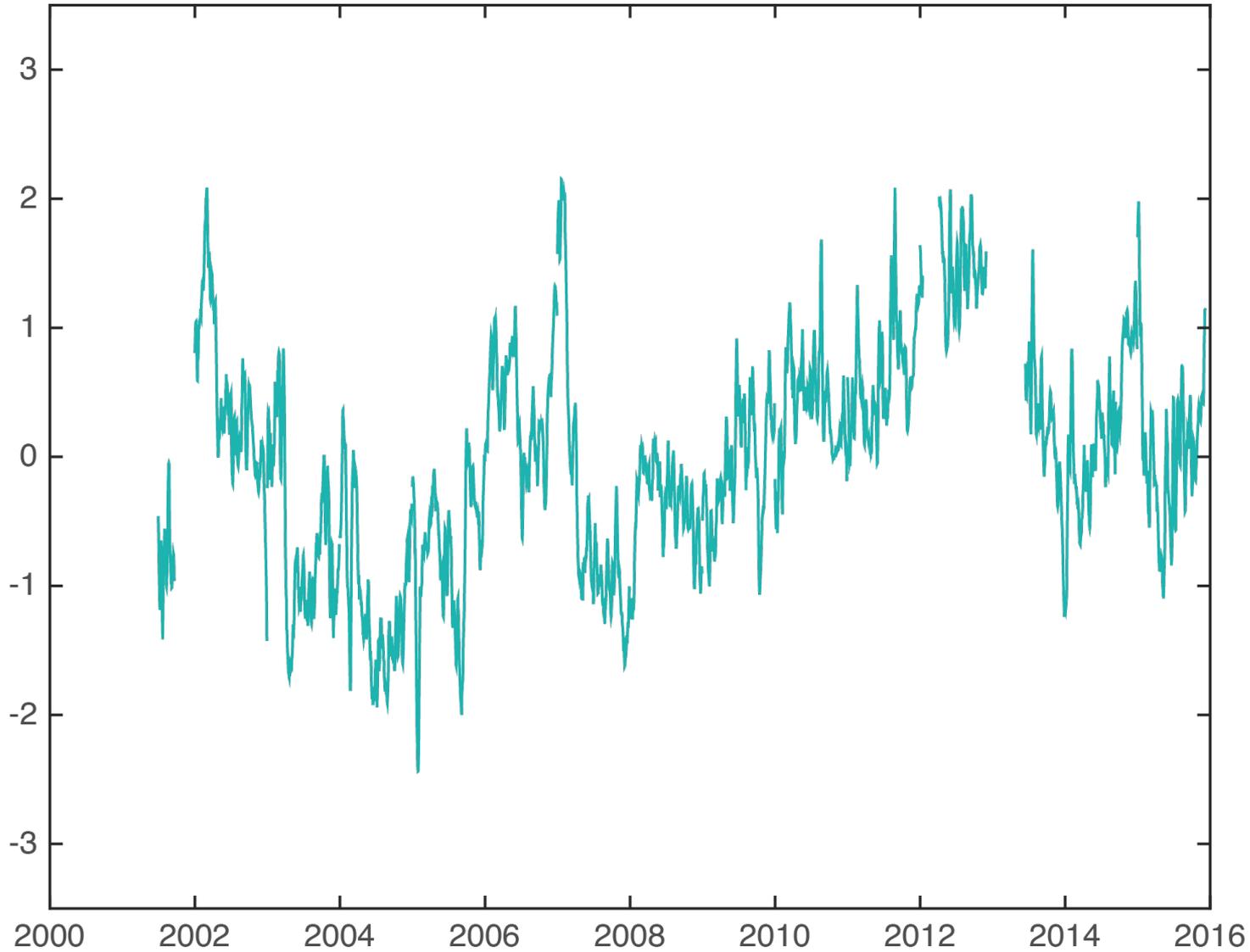
2015

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

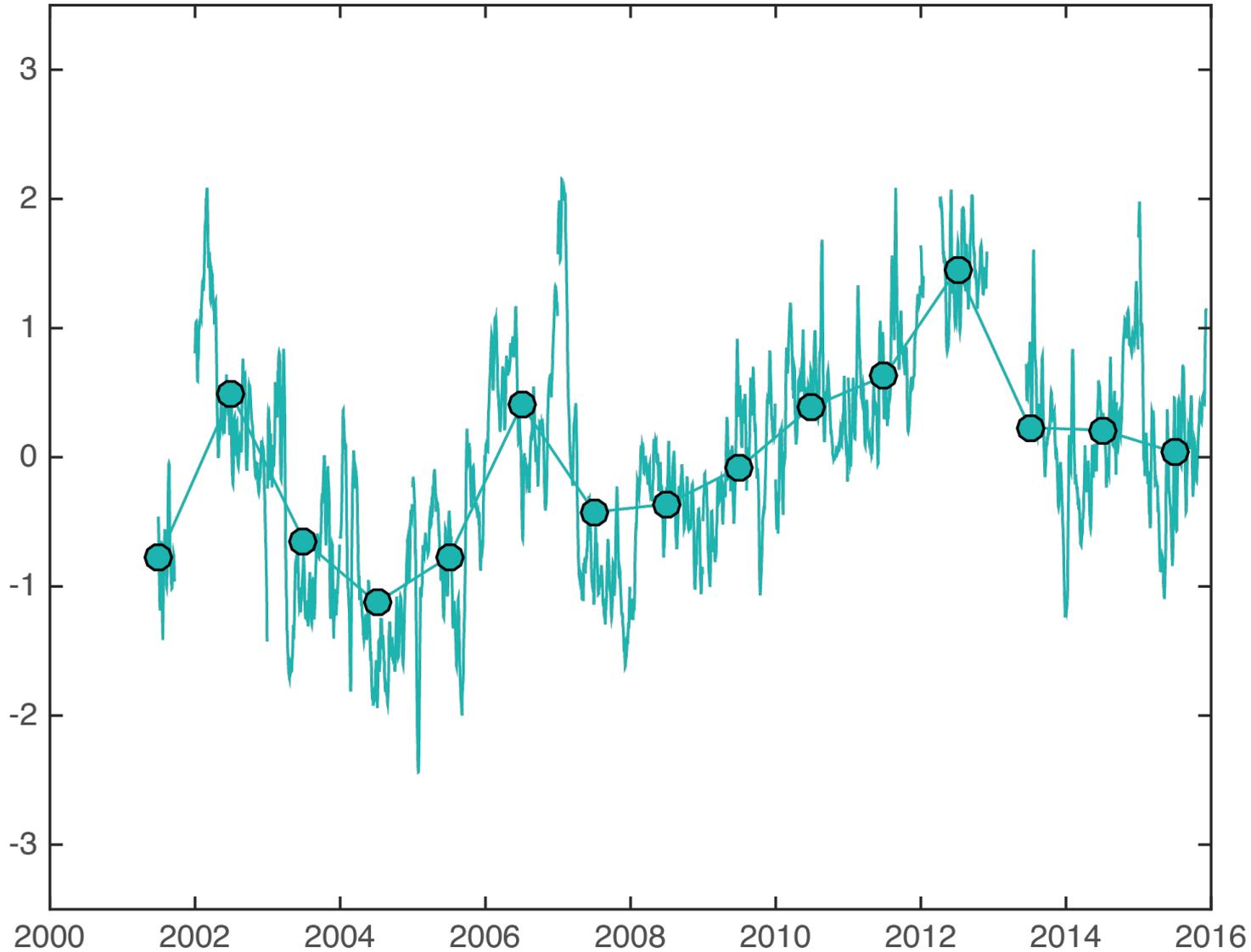
View Climatology Data Table



Buoy E Time Series

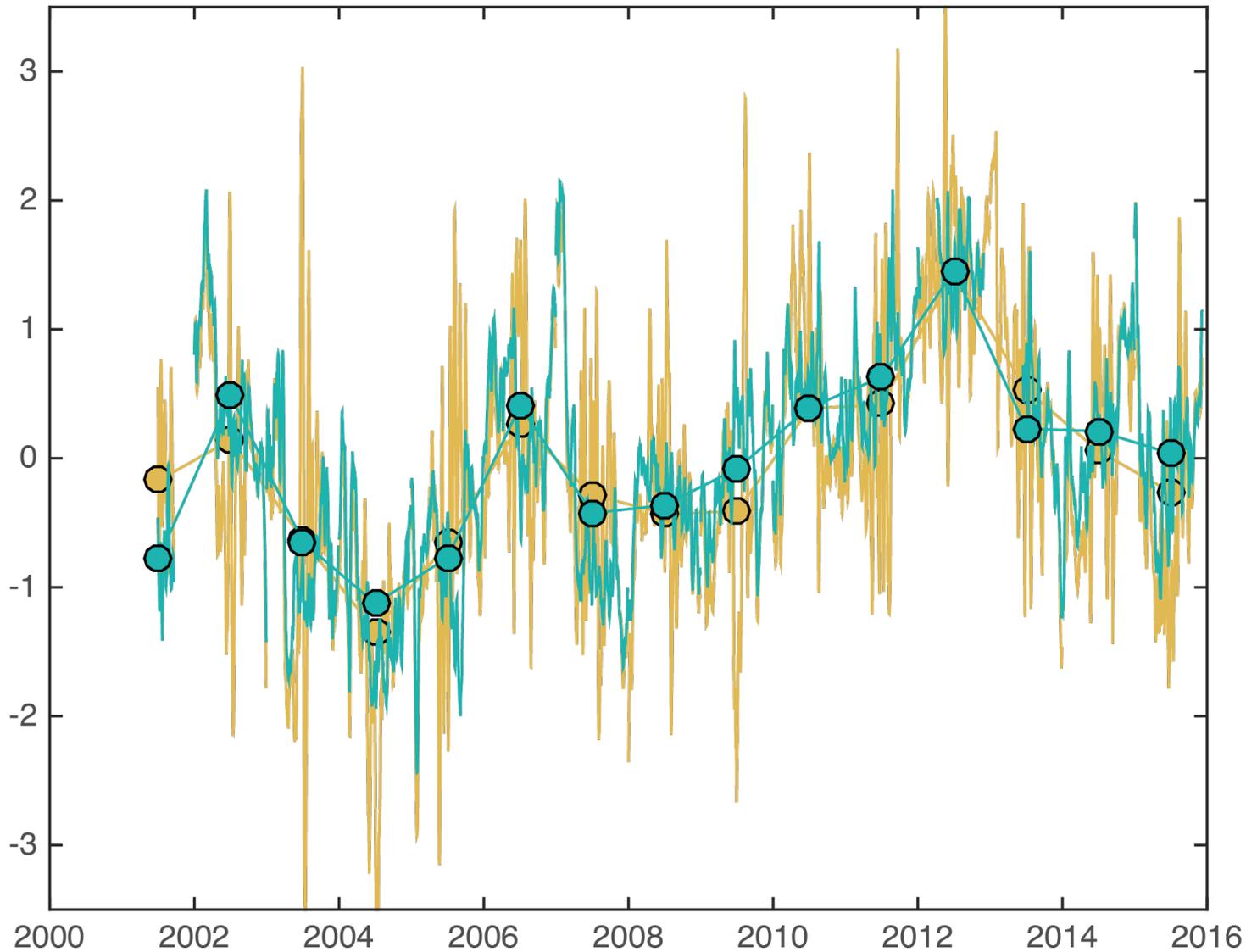


Buoy E Time Series



20m

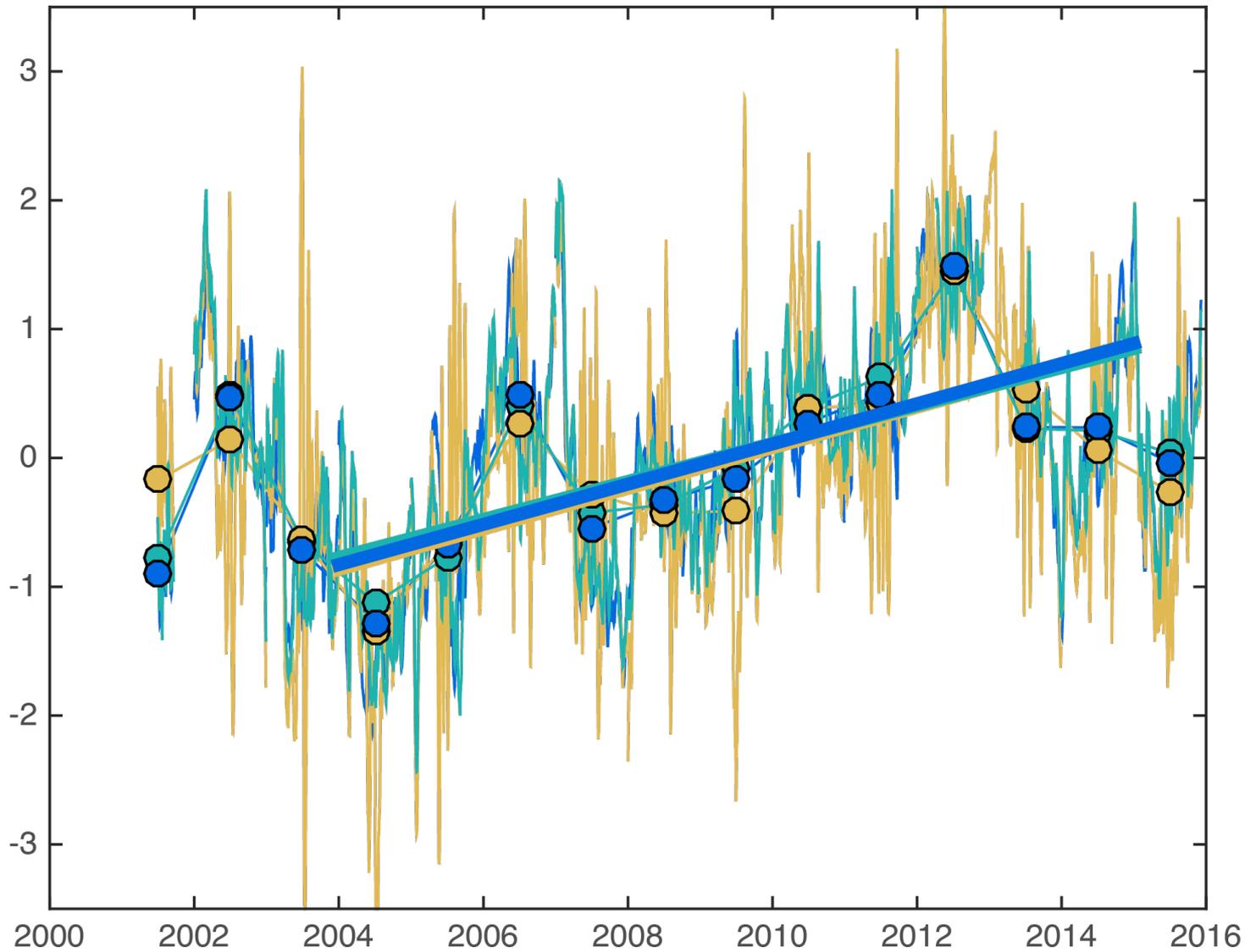
Buoy E Time Series



10m

20m

Buoy E Time Series



10m

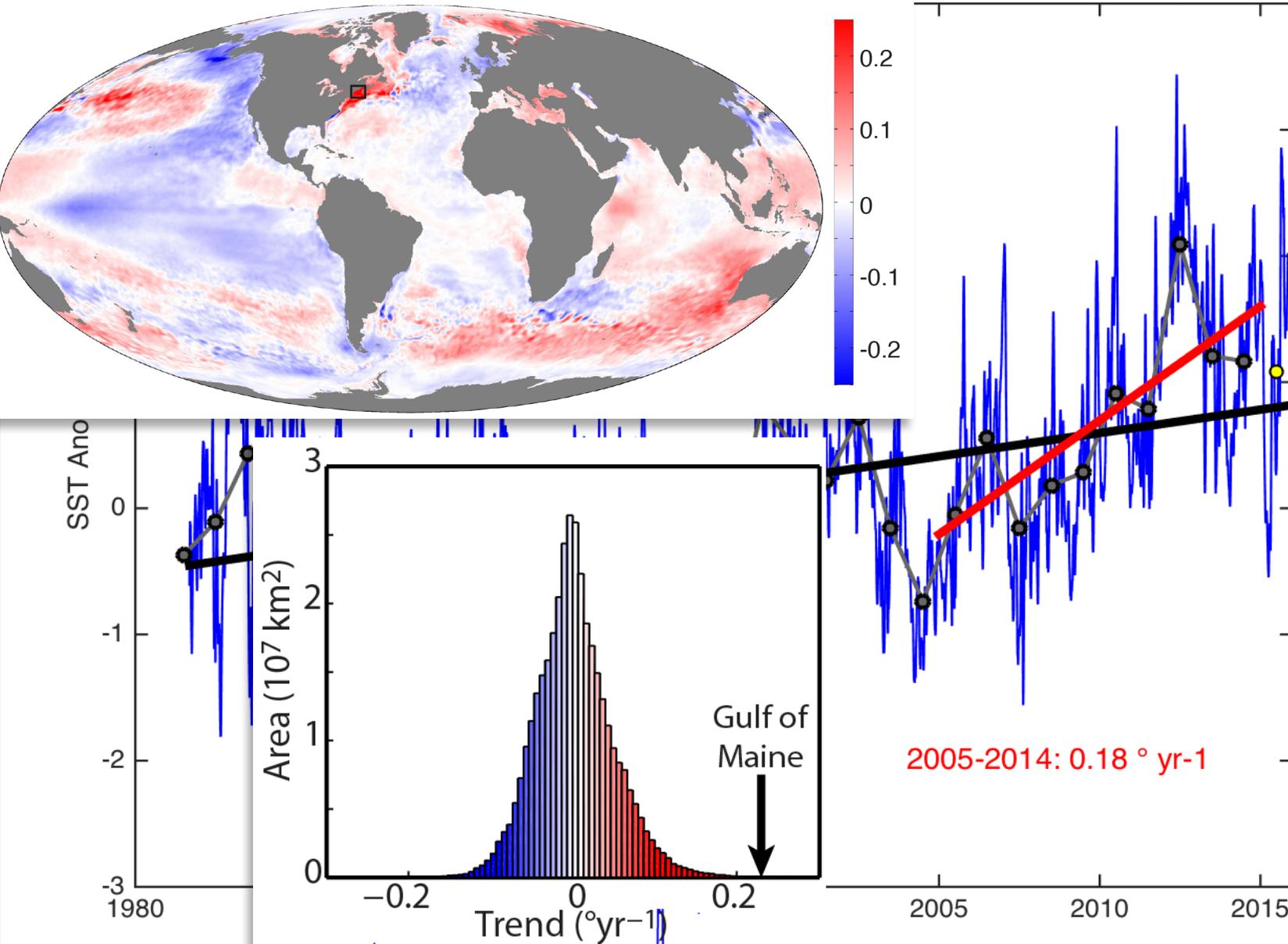
20m

50m

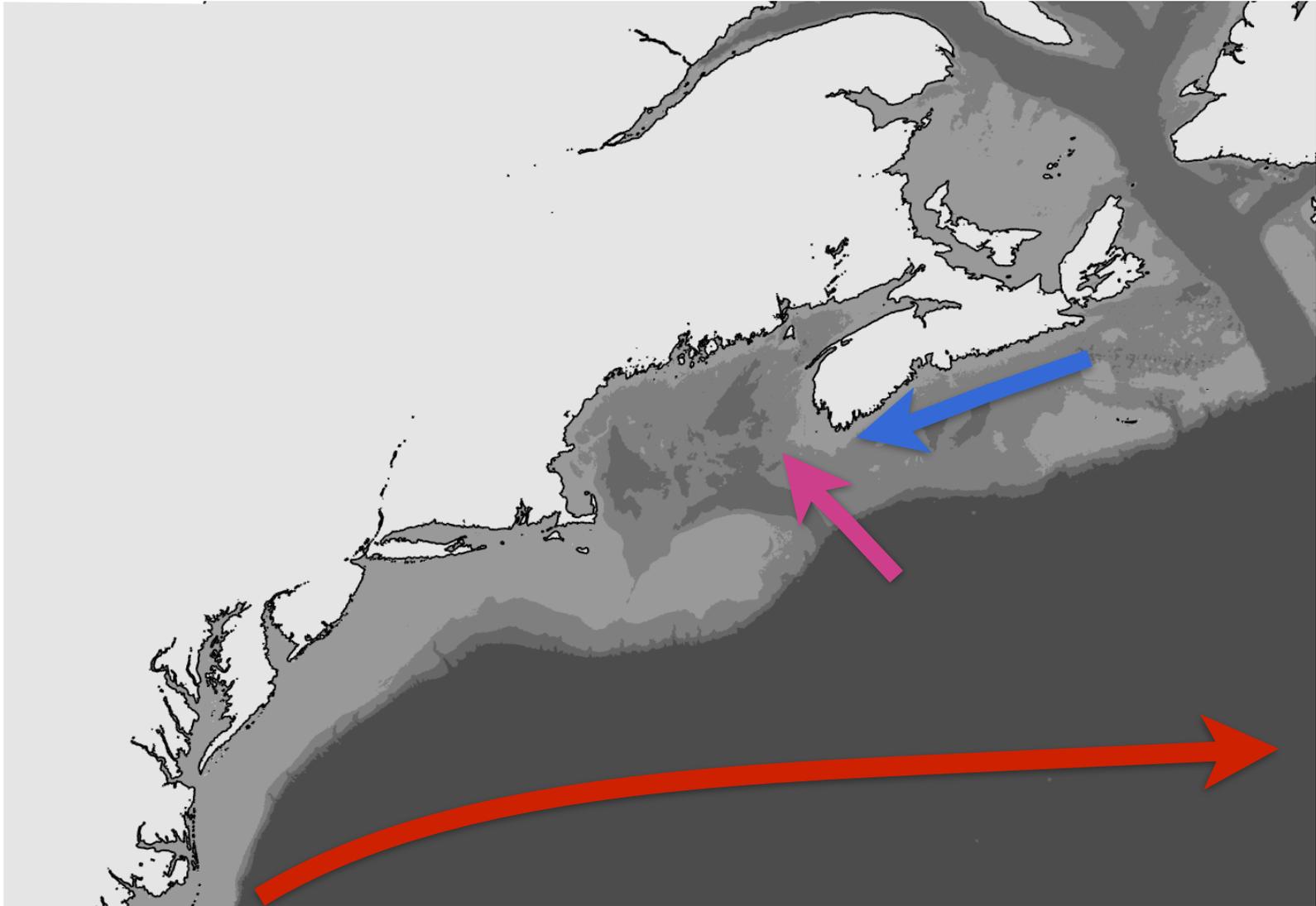
$0.15^\circ \text{ yr}^{-1}$

Gulf of Maine SST

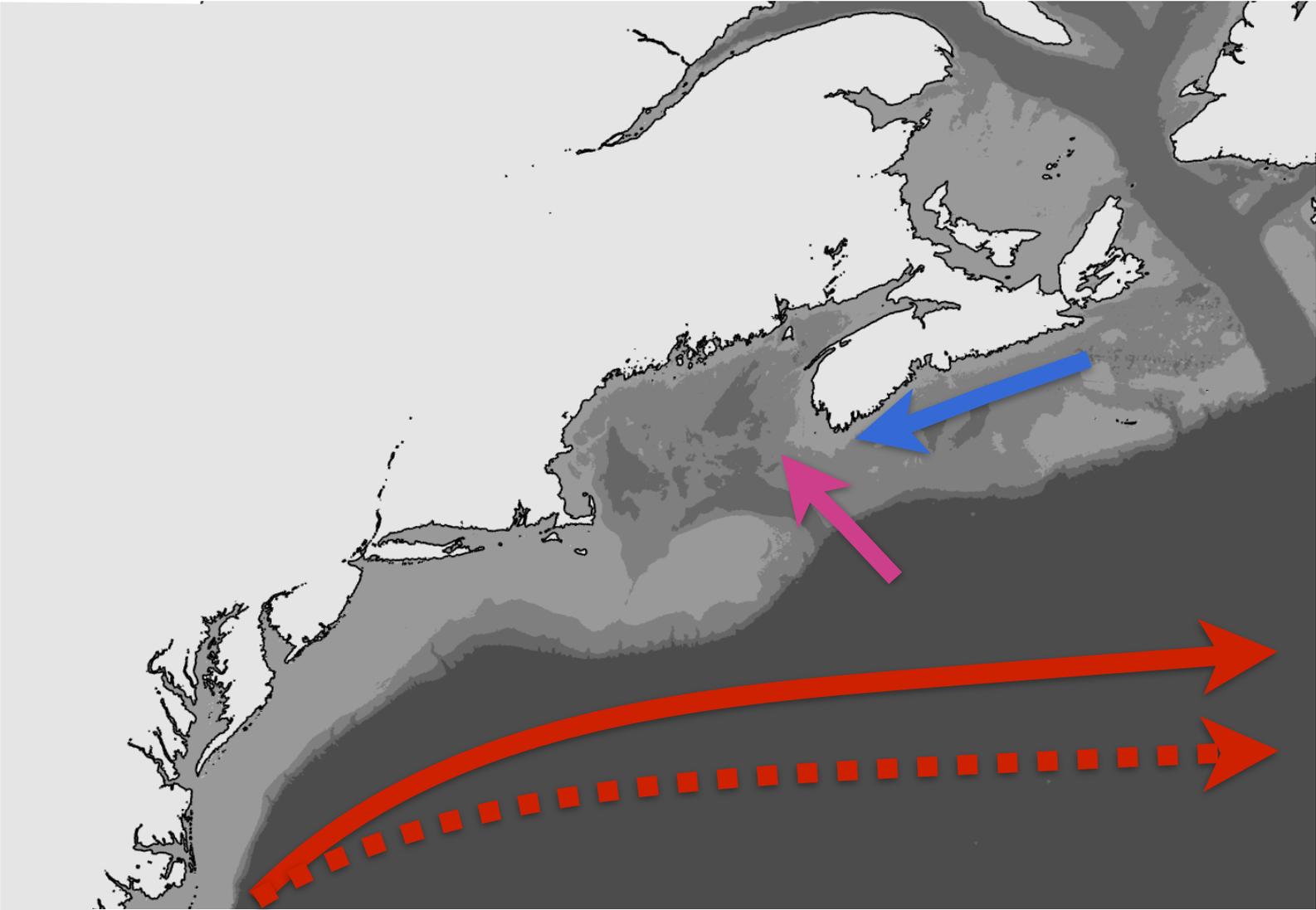
Gulf of Maine SST Anomalies from 1981 to 2014 (relative to 1982-2011)



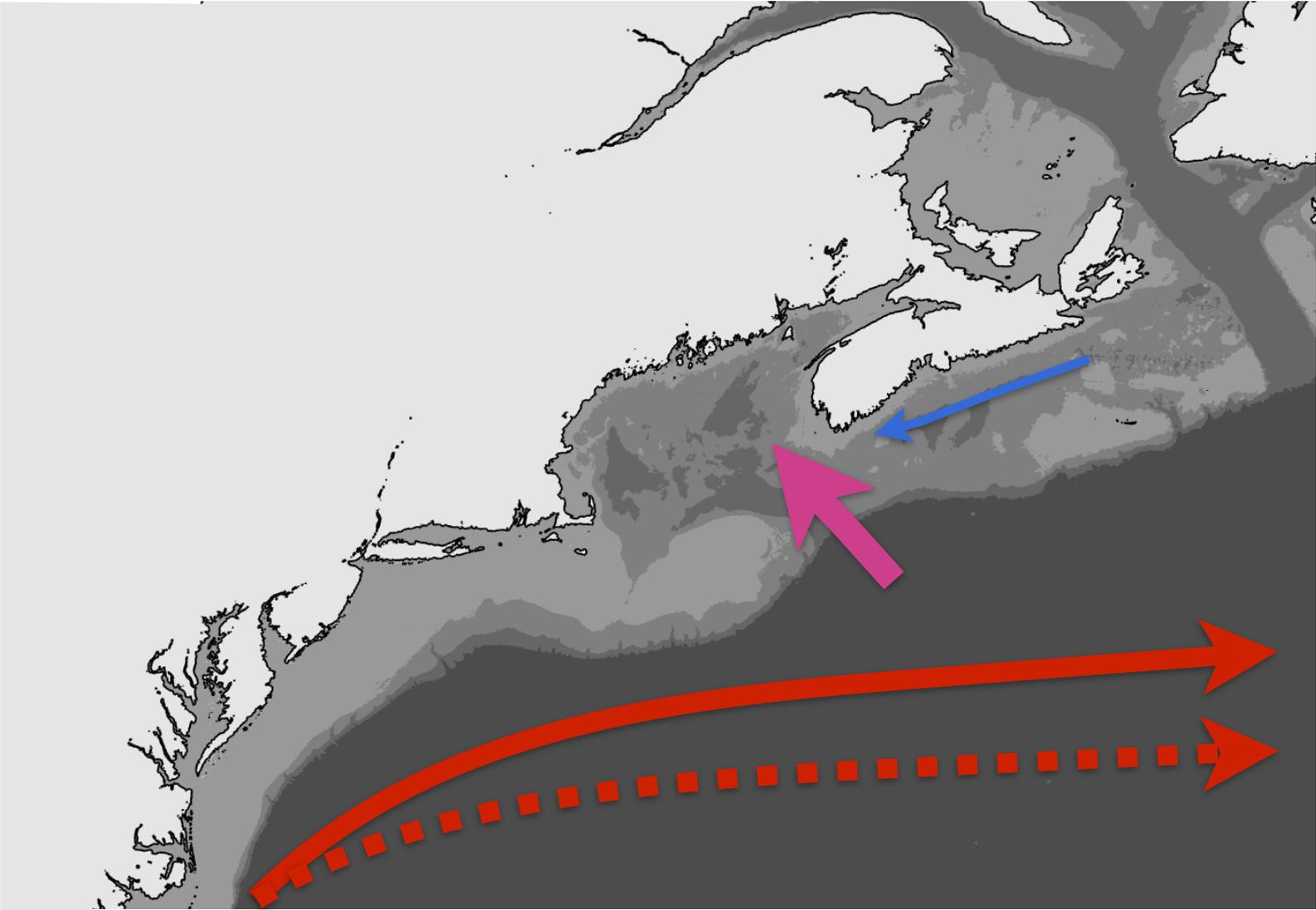
Gulf of Maine Warming



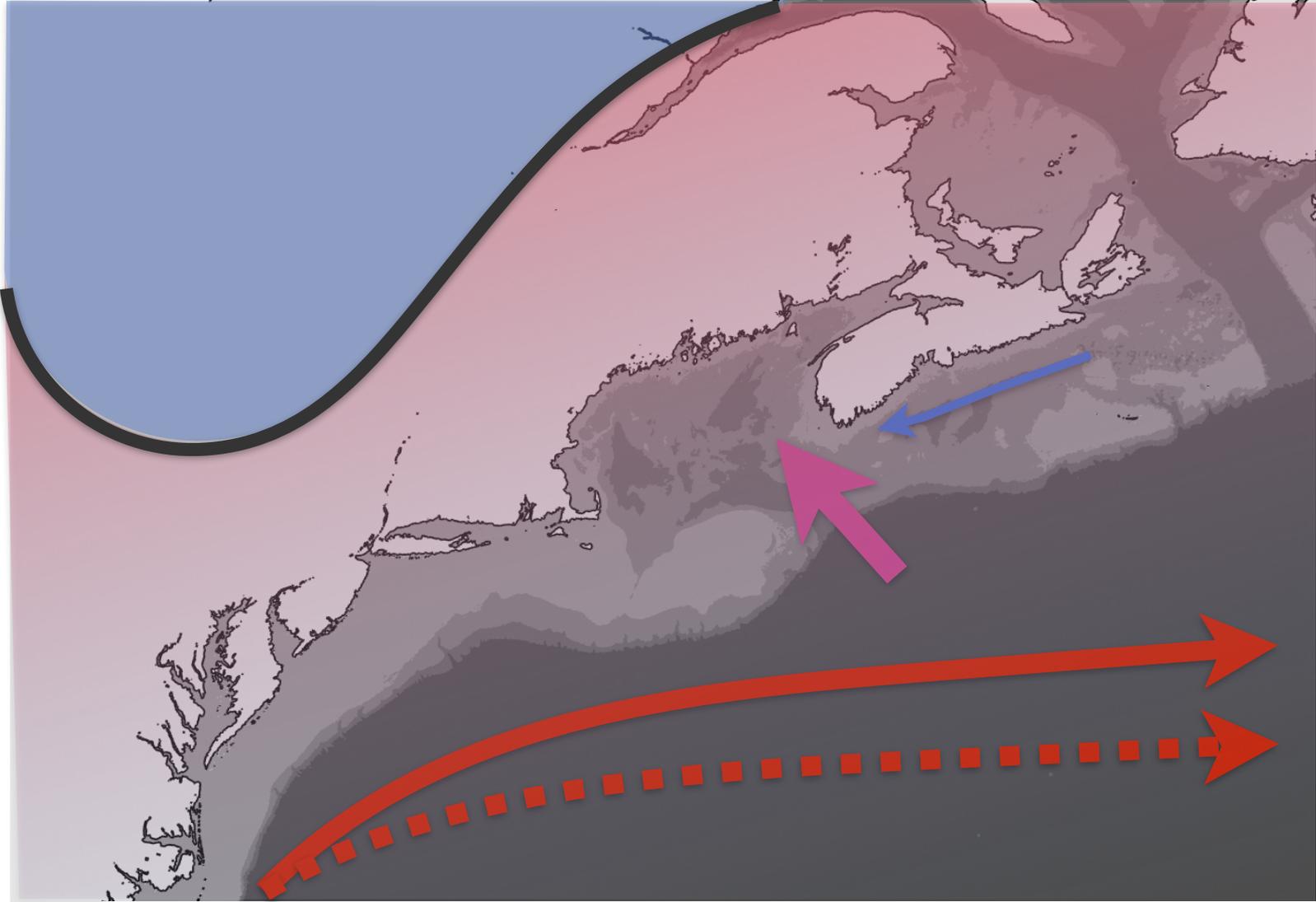
Gulf of Maine Warming



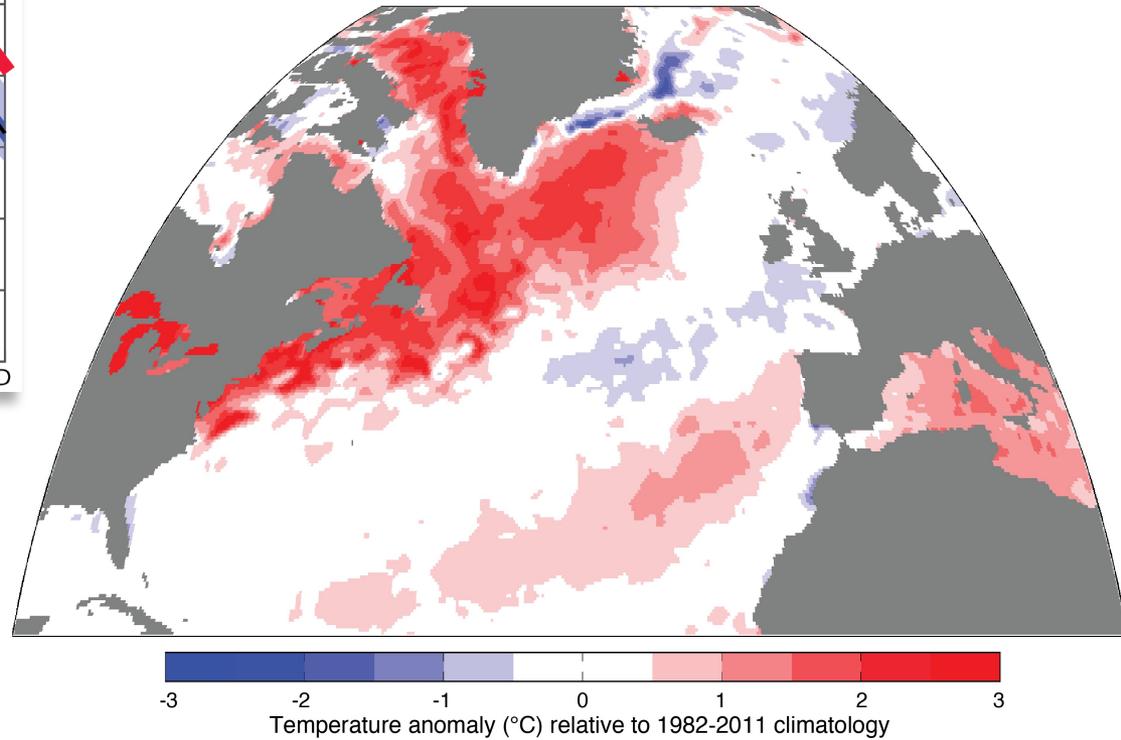
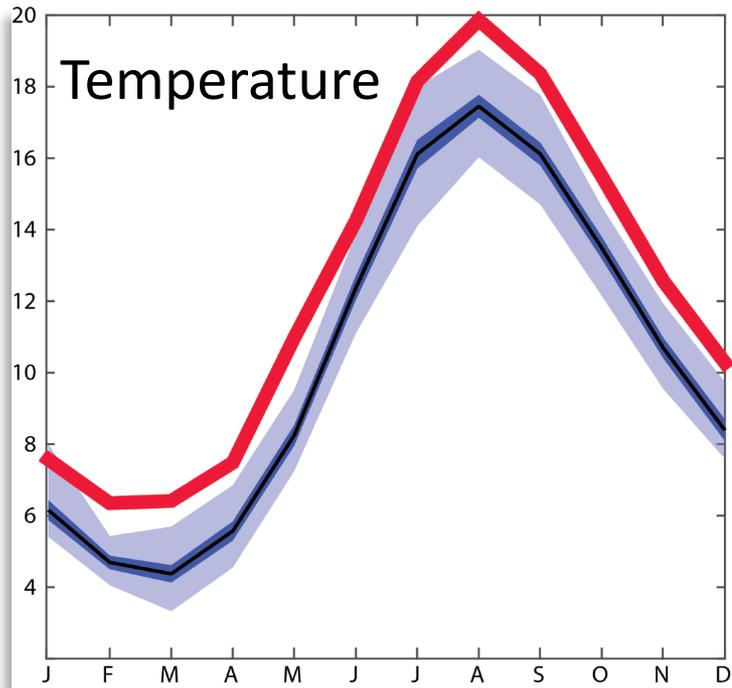
Gulf of Maine Warming



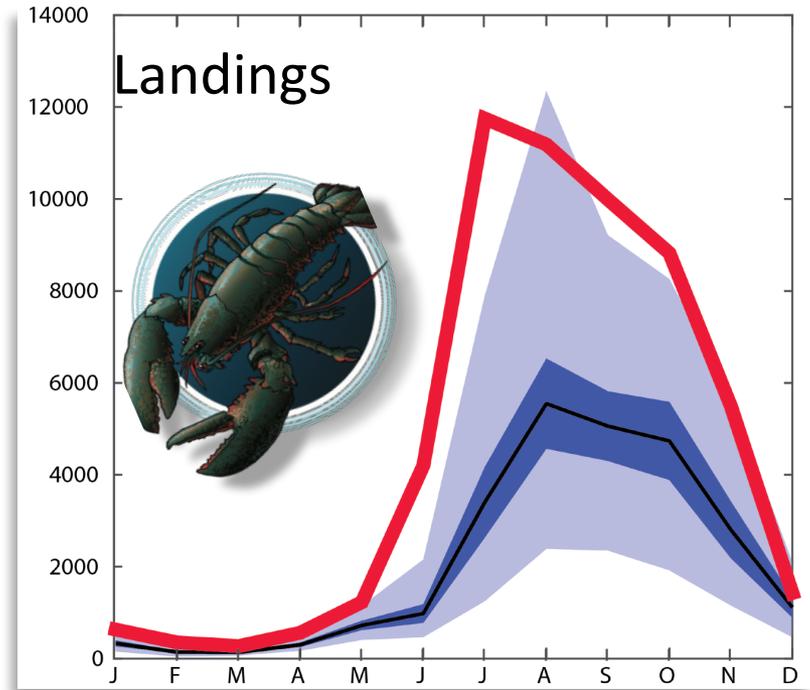
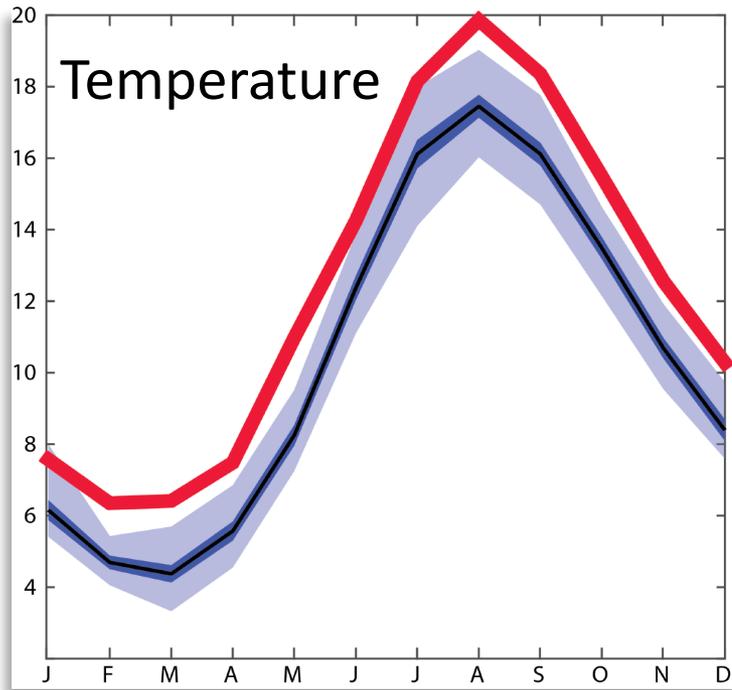
Gulf of Maine Warming



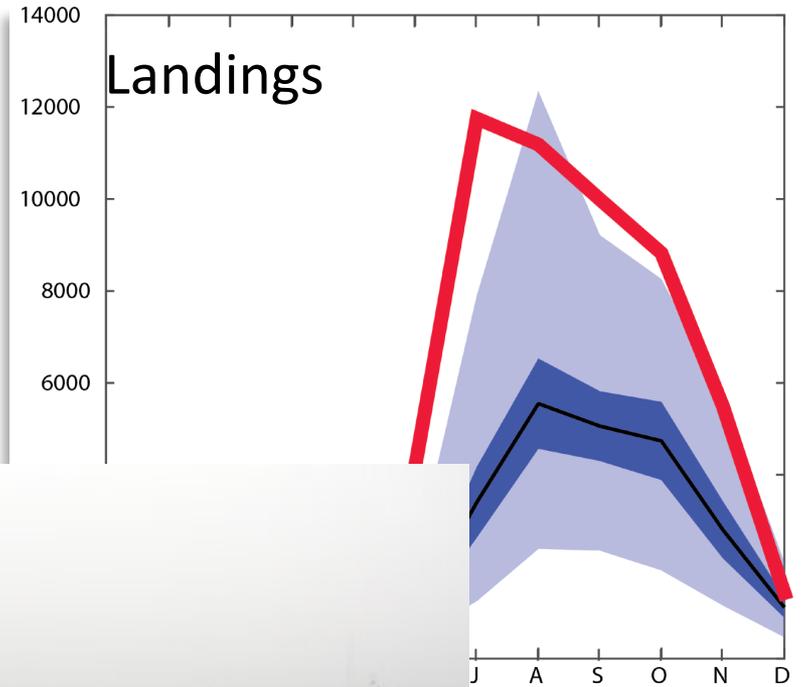
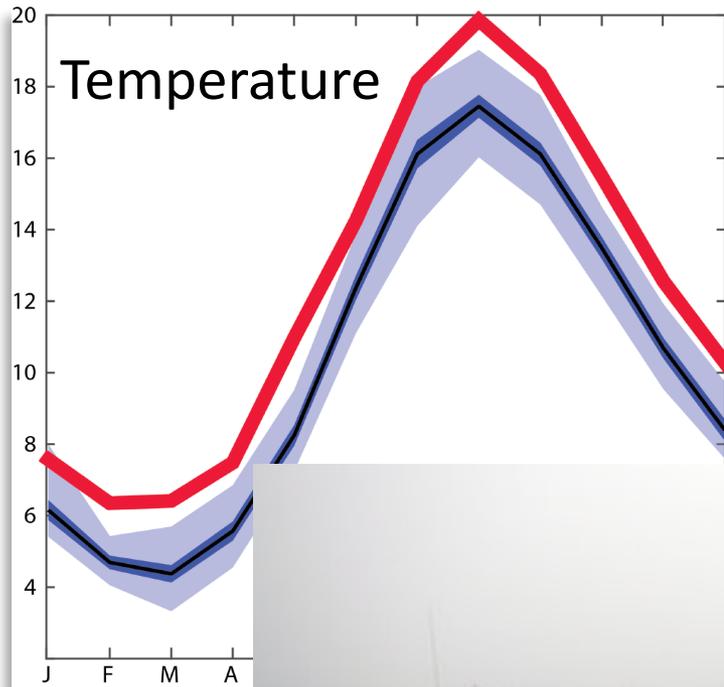
Impacts of 2012 heat wave



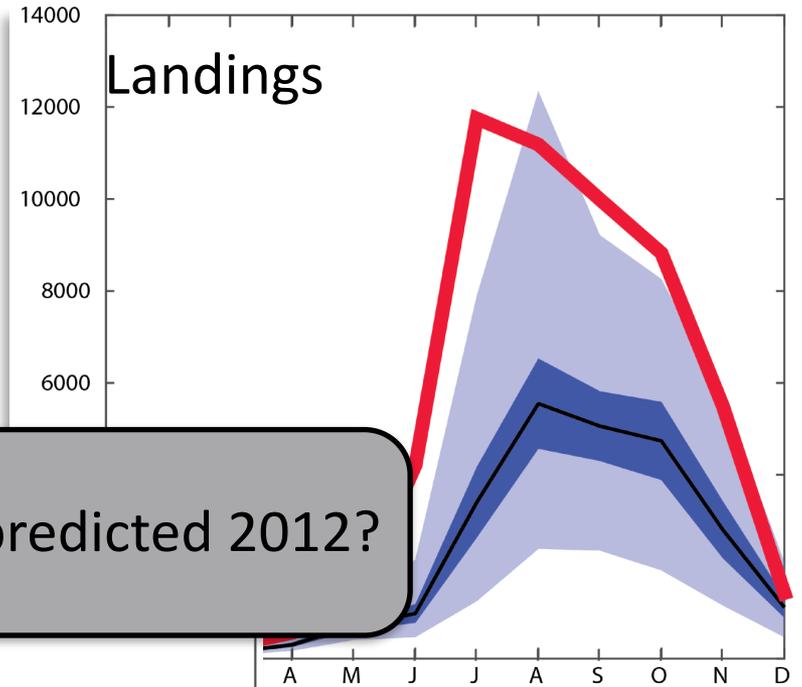
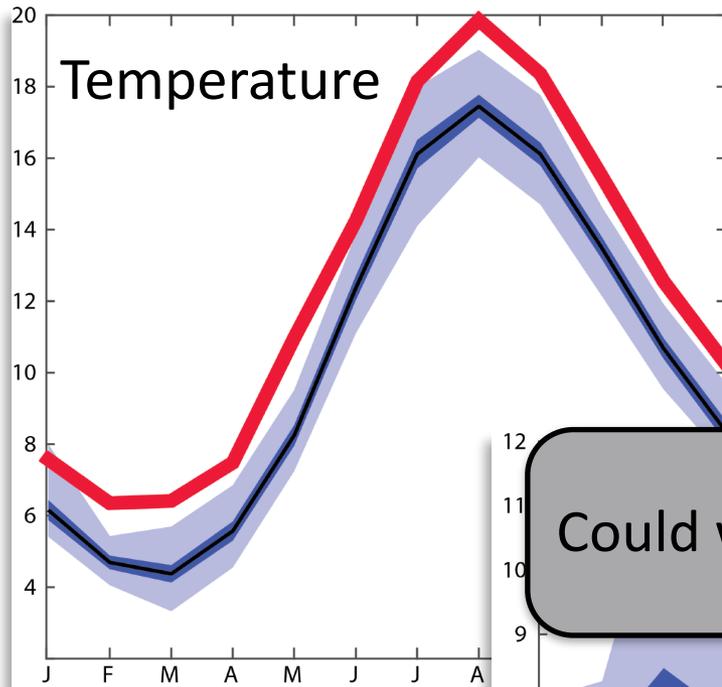
Impacts of 2012 heat wave



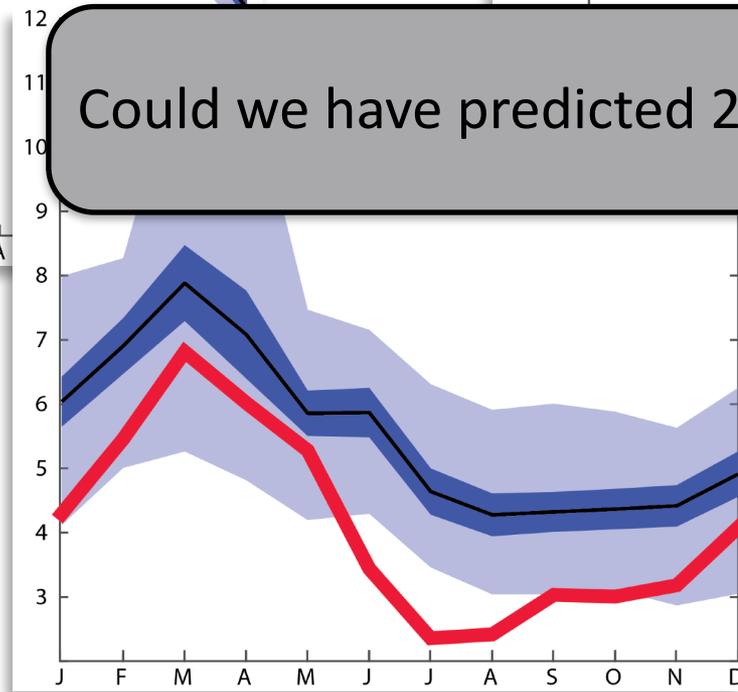
Impacts of 2012 heat wave



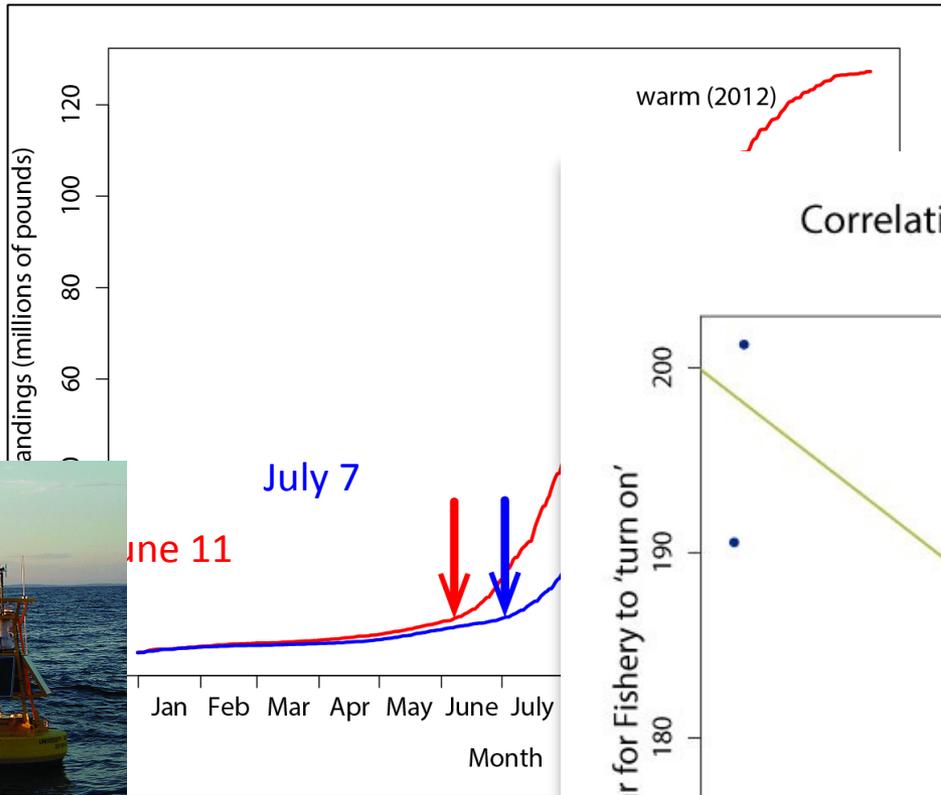
Impacts of 2012 heat wave



Could we have predicted 2012?

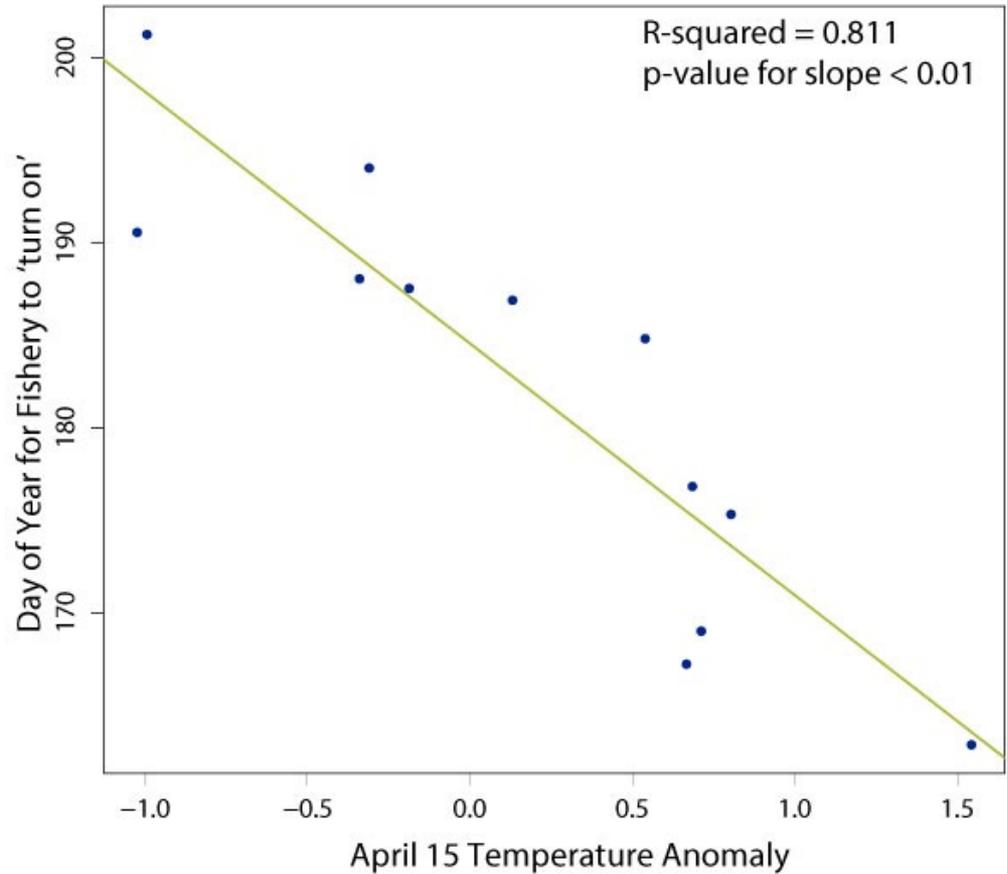


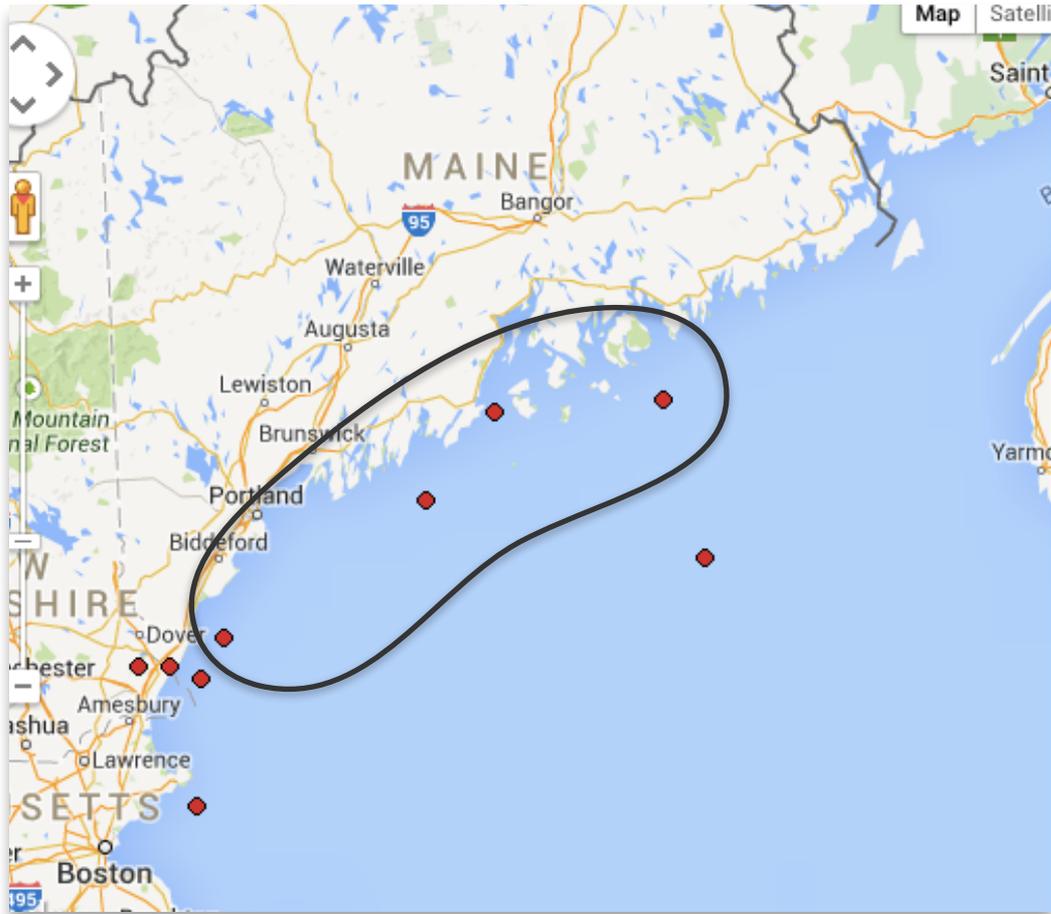
Temperature and Landings



- 1m
- 20m
- 50m

Correlation of Start Day and Temperature 2001-2013





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

2009

Early Season

Late Season

	Extremely Early	Very Early	Early	Normal	Late	Very Late	Extremely Late	
March 1	0%	0%	0.97%	93.21%	5.67%	0.07%	0%	
March 15	0%	0%	1.69%	83.61%	14.62%	0%	0%	
April 1	0%	0%	2.45%	42.21%	54.87%	0.45%	0%	
April 15	0%	0%	1.77%	76.41%	21.56%	0.18%	0%	
May 1	0%	0%	13.35%	82.21%	4.4%	0%	0%	
May 15	0%	0%	19.05%	77.11%	3.35%	0%	0%	
	6/12	6/19	6/26	7/3	7/10	7/17	7/24	7/31

First
Forecast



Last
Forecast

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%	
	6/12	6/19	6/26	7/3	7/10	7/17	7/24	7/31

First
Forecast



Last
Forecast

2003

Early Season

Late Season

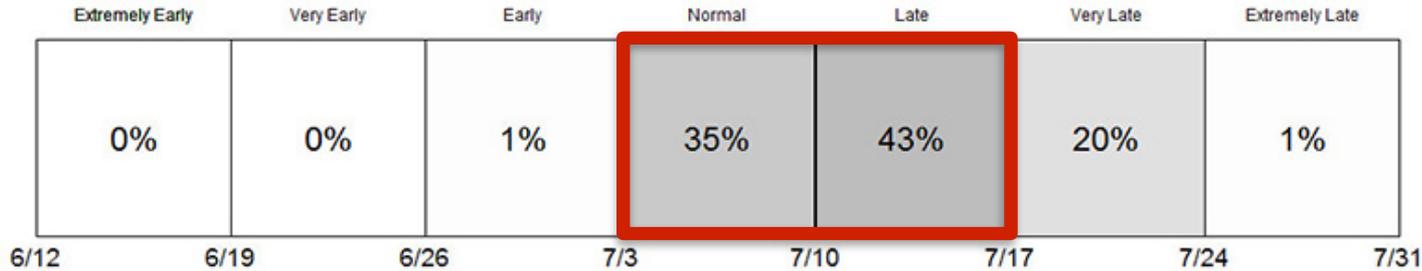
	Extremely Early	Very Early	Early	Normal	Late	Very Late	Extremely Late	
March 1	0%	0%	20%	39.3%	36.97%	3.8%	0%	
March 15	0%	0%	0%	20%	52.15%	23.2%	3.93%	
April 1	0%	0%	17.86%	9.15%	52.43%	18.1%	2.15%	
April 15	0%	0%	0%	19.64%	42.71%	26.7%	11.37%	
May 1	0%	0%	0%	33.48%	39.95%	24.7%	1.87%	
May 15	0%	0%	0.13%	57.79%	25.45%	14.5%	2.39%	
	6/12	6/19	6/26	7/3	7/10	7/17	7/24	7/31

First
Forecast

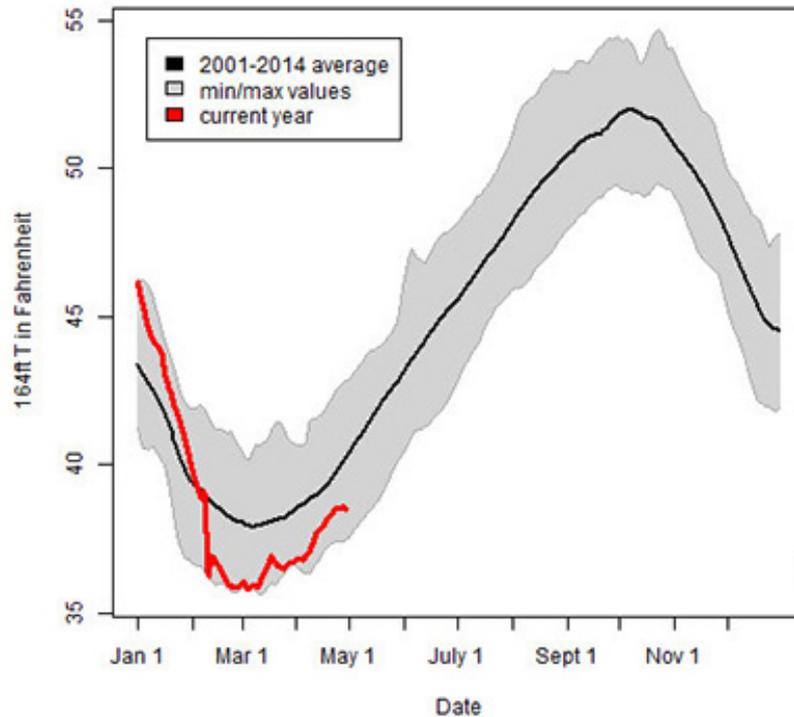


Last
Forecast

April 15 Forecast

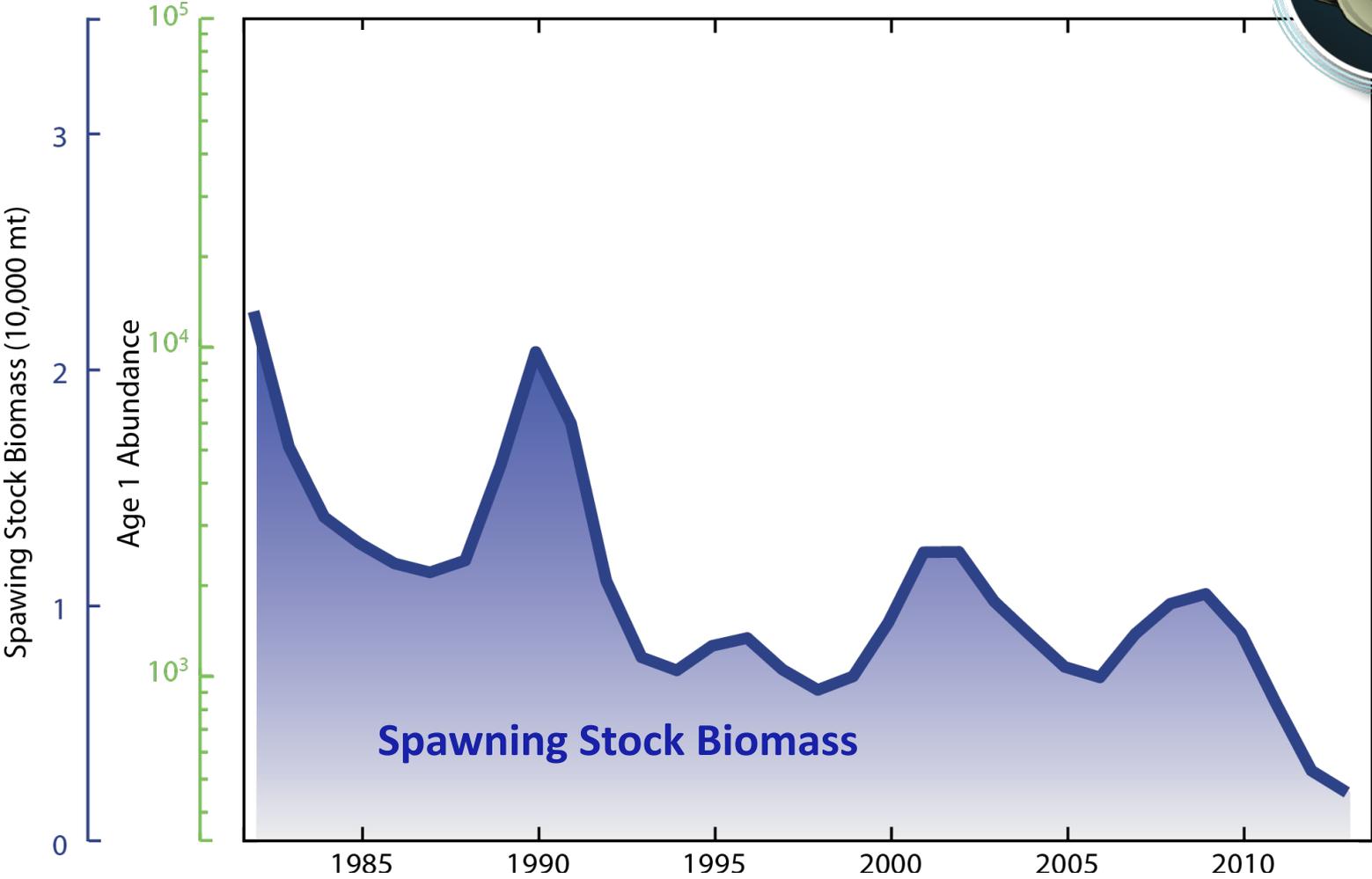


www.gmri.org/lobster-forecast



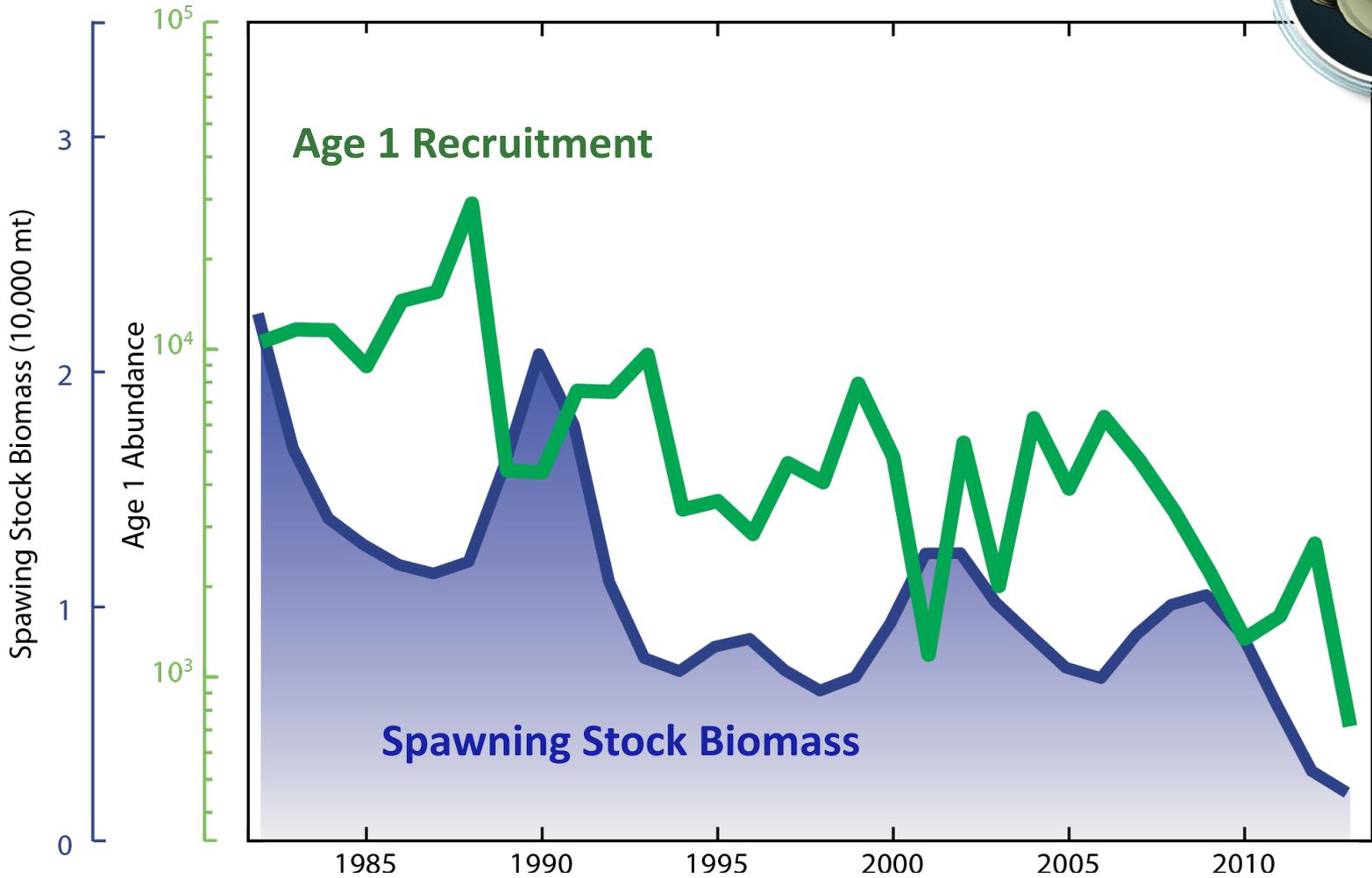
- 4/15—warming
- still cold
- late season, with a chance of very late

Gulf of Maine Cod



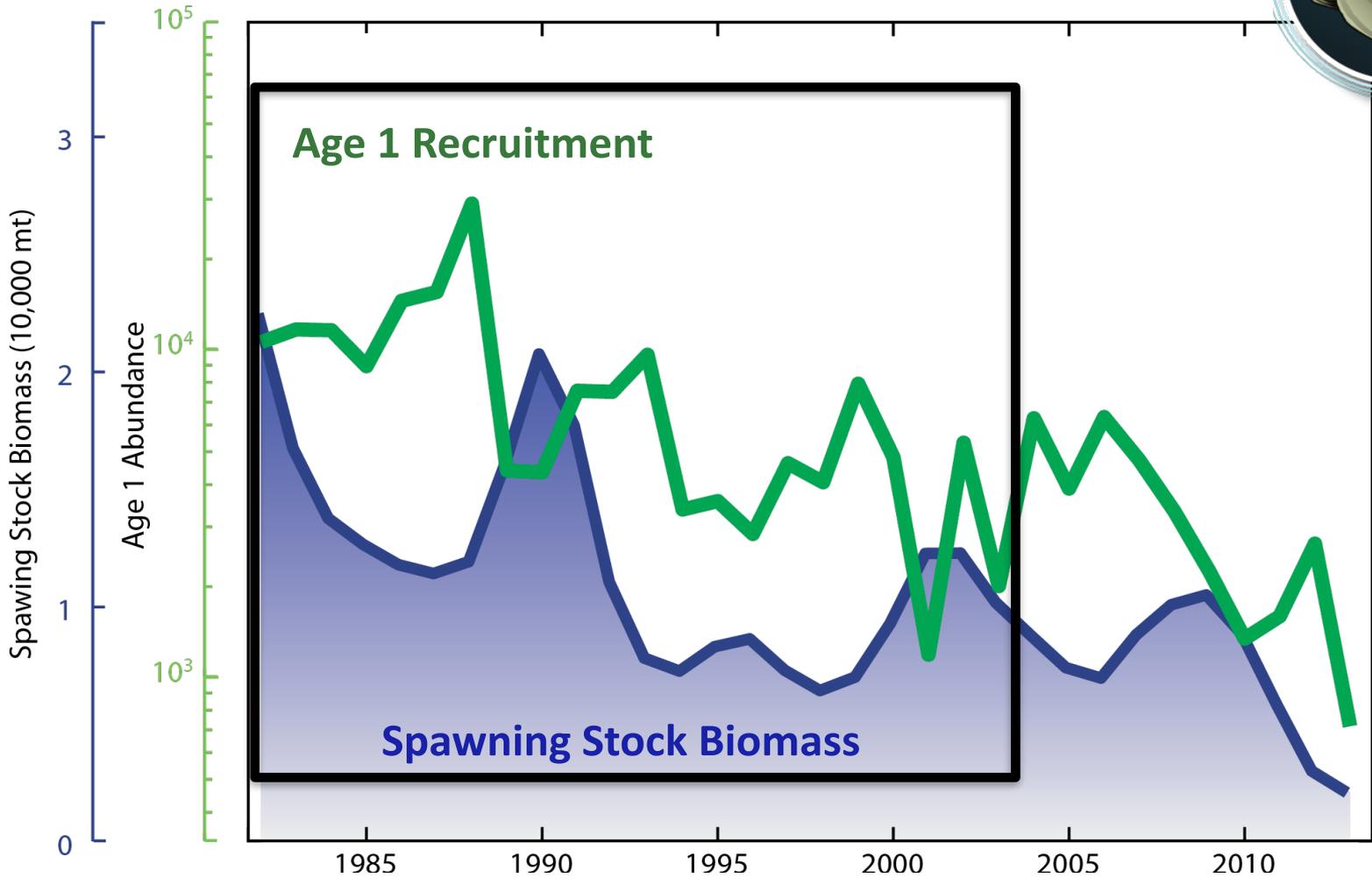
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



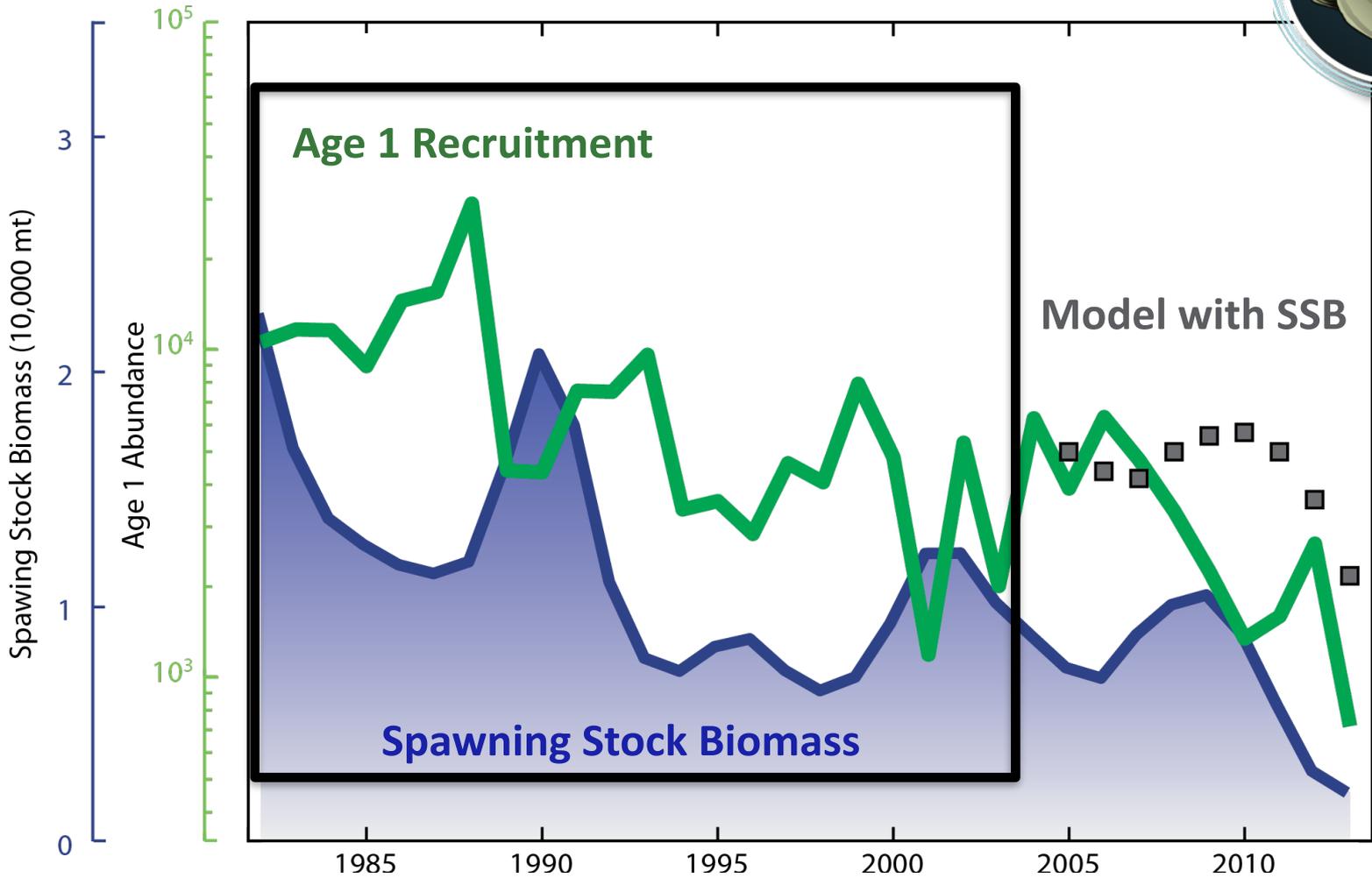
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



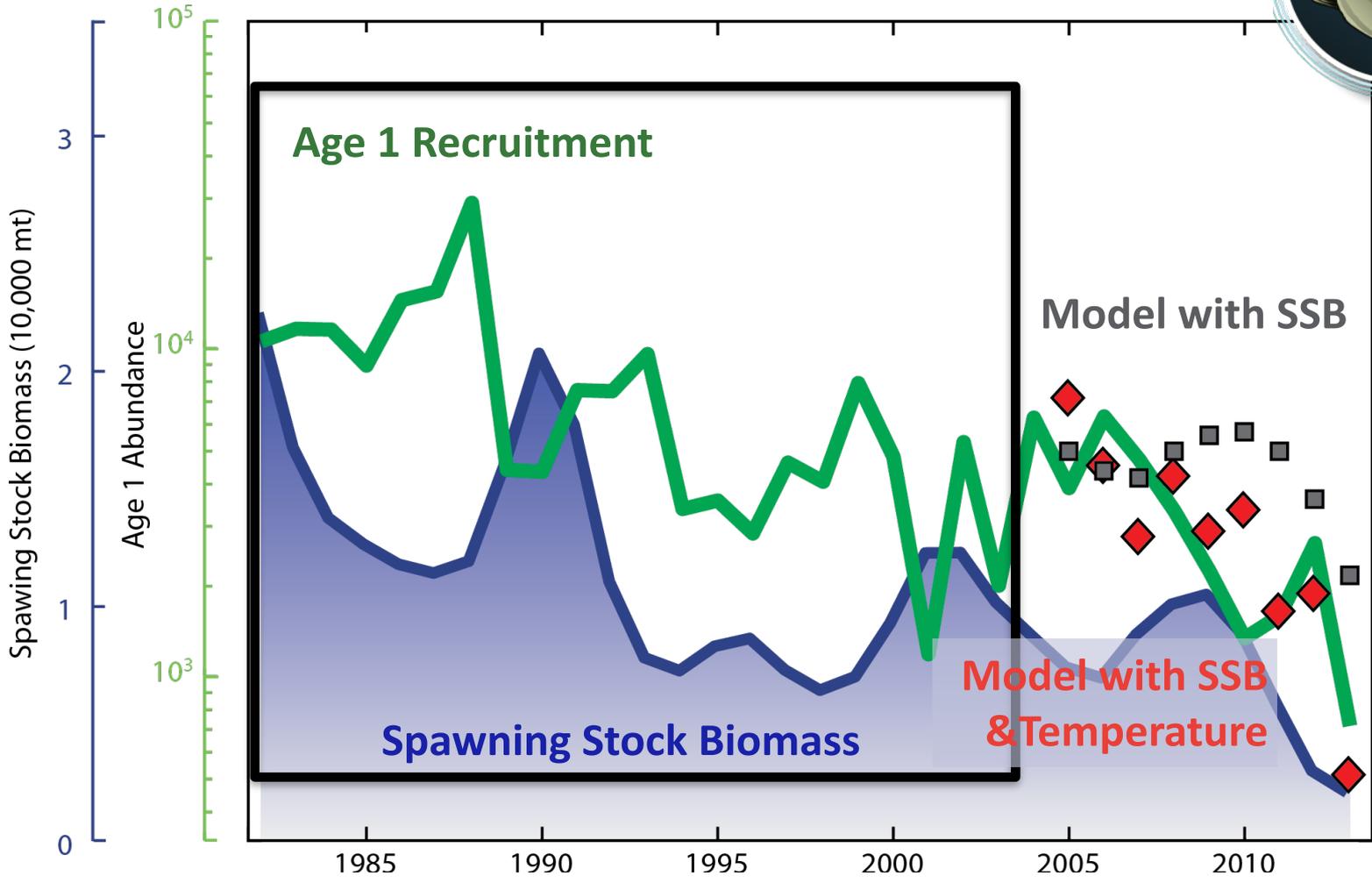
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



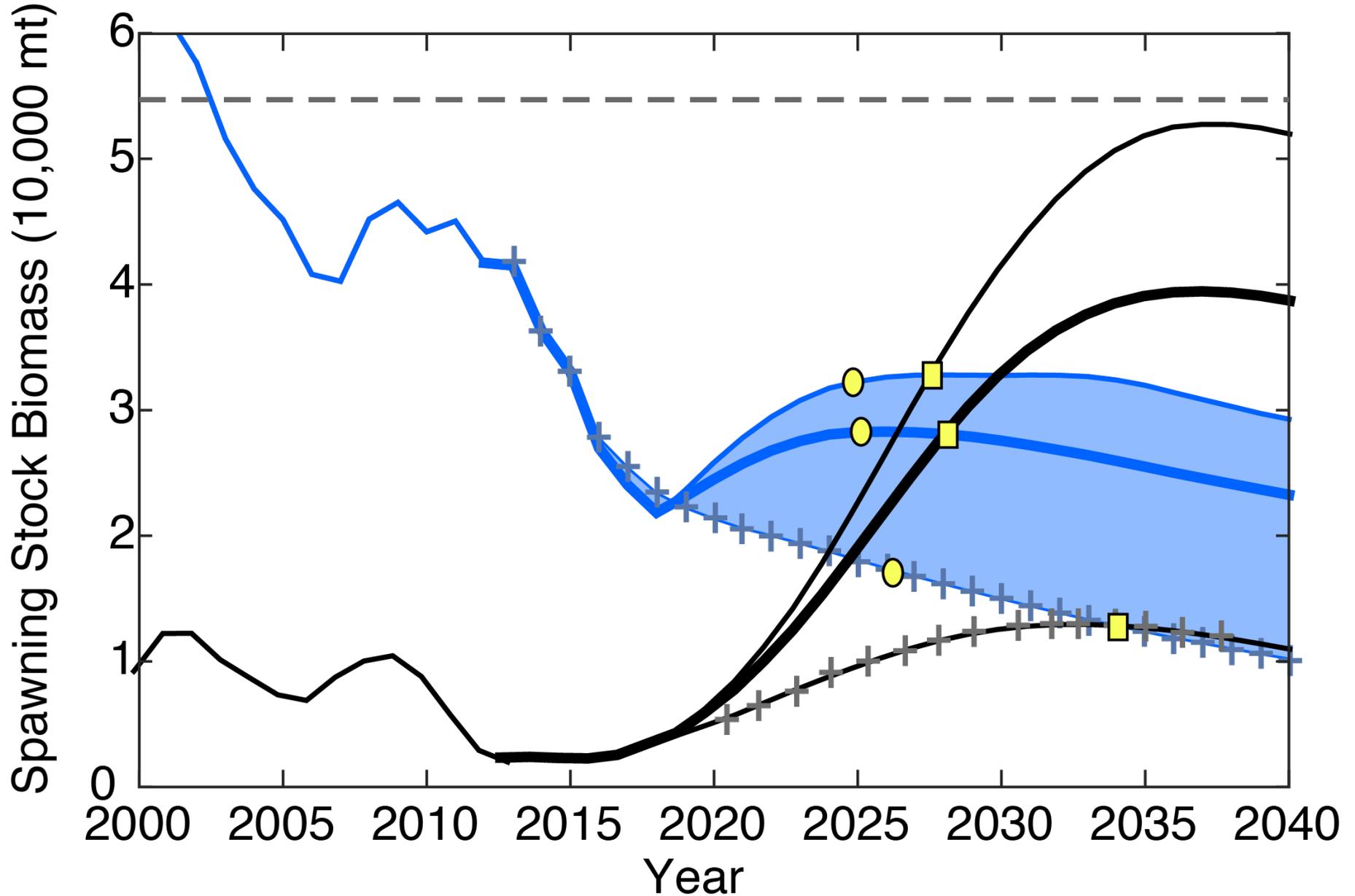
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



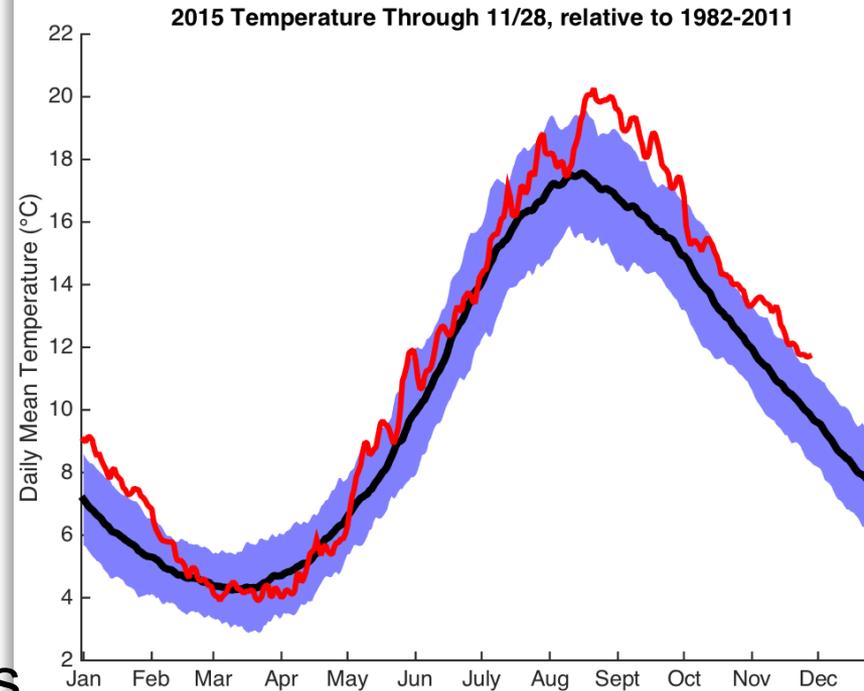
Data from 2014 stock assessment (Palmer, 2014)

Future of Cod



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.