draft working paper for peer review only

Gulf of Maine Atlantic cod

2015 Assessment Update Report

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

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This assessment of the Gulf of Maine Atlantic cod (Gadus morhua) stock is an update of the existing 2014 update assessment (Palmer 2014). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical assessment models through 2014. Additionally, stock projections have been updated through 2018. In what follows, there are two population assessment models brought forward from the 2014 benchmark assessment, the M=0.2 (natural mortality = 0.2) and the M-ramp (M ramps from 0.2 to 0.4) assessment models (see NEFSC 2013 for a full description of the model formulations).

State of Stock: The Gulf of Maine Atlantic cod (*Gadus morhua*) stock is overfished and overfishing is occurring (Figures 1-2). Spawning stock biomass (SSB) in 2014 was estimated to be 2,225 (mt) under the M=0.2 model and 2,536 (mt) under the M-ramp model scenario (Table 1) which is 6 and 4% (respectively) of the SSB_{MSY} proxy (40,187 (mt) and 59,045 (mt); Figure 1). The 2014 fully selected fishing mortality was estimated to be 0.956 and 0.932 which is 517 and 498% of the F_{MSY} proxy (0.185 and 0.187; Figure 2).

Table 1: Catch and status table for Gulf of Maine Atlantic cod. All weights are in (mt) recruitment is in (000s) and F_{Full} is the fishing mortality on fully selected ages.

	2007	2008	2009	2010	2011	2012	2013	2014
Data								
Recreational discards	154	153	142	188	164	48	69	85
Recreational landings	1,162	1,240	1,399	1,803	1,813	571	705	528
Commercial discards	178	349	752	171	99	93	52	26
Commercial landings	3,990	5,444	5,953	5,356	4,598	2,759	951	832
Catch for Assessment	5,485	7,186	8,247	7,517	6,673	3,472	1,777	1,471
Model Results (M=0.2)								
Spawning Stock Biomass	8608	9716	10088	8638	5617	2954	2064	2225
F_{Full}	0.716	0.926	1.043	1.073	1.563	1.778	1.334	0.956
Recruits $age1$	4407	3087	2035	1281	1615	2269	1030	2042
Model Results (M-ramp)								
Spawning Stock Biomass	11583	12649	12871	10645	6727	3599	2526	2536
F_{Full}	0.564	0.751	0.859	0.908	1.347	1.528	1.185	0.932
Recruits $age1$	9368	6307	4024	2486	3066	4114	1738	3211

Table 2: An $F_{40\%}$ proxy was used for the overfishing threshold. Intervals shown are 5^{th} and 95^{th} percentiles.

	2014 M=0.2	2014 M-ramp	M=0.2	M-ramp
F_{MSY}	0.18	0.18	0.185	0.187
SSB_{MSY} (mt)	47,184 (32,903 - 67,045)	69,621 (53,349 - 89,302)	40,187 (27,551 - 58,228)	59,045 (44,976 - 76,525)
MSY (mt)	7,753 (5,355 - 11,162)	11,388 (8,624 - 14,750)	6,797 (4,608 - 9,990)	10,043 (7,560 - 13,130)
Median recruits (age 1) (000s)	4,551	8,804	4,388	8,528
Overfishing	Yes	Yes	Yes	Yes
Overfished	Yes	Yes	Yes	Yes

Projections: Short term projections of median total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod were conducted based on a harvest scenario of fishing at the FMSY proxy between 2016 and 2018. Catch in 2015 was estimated at 279 mt. Recruitment was sampled from a cumulative distribution function derived from ASAP estimated age 1 recruitment between 1982 and 2012. The projection recruitment model declines linearly to zero when SSB is below 6.3 kmt under the M=0.2 and 7.9 kmt under the M-ramp model. The 2015 age-1 recruitment was estimated from the geometric mean of the 2010-2014 ASAP recruitment estimates. No retrospective adjustments were applied in the projections as the retrospective patterns are similar to the 2014 update for which no retrospective adjustments were made. Assumed weights are based on an average of the most recent three years. For the M-ramp model, projections are shown under two assumptions of short-term natural mortality: M=0.2 and M=0.4.

Table 3: Short term projections of total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod based on a harvest scenario of fishing at the F_{MSY} proxy between 2016 and 2018. Catch in 2015 has been estimated at 279 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
	M=0.2			*M-ramp(M=0.2)*			*M-ramp(M=0.4)*		
2015	279	3045	0.111	279	3219	0.112	279	3057	0.123
2016	697	4400	0.185	748	4950	0.187	555	3841	0.187
2017	939	5852	0.185	1085	7062	0.187	662	4536	0.187
2018	1211	7601	0.185	1507	9674	0.187	765	5220	0.187

Special Comments:

- What are the most important sources of uncertainty in this stock assessment? Explain, and describe qualitatively how they affect the assessment results (such as estimates of biomass, F, recruitment, and population projections).

  The largest source of uncertainty is the estimate of natural mortality. Past investigations into changes in natural mortality over time have been inconclusive (NEFSC 2013). Different assumptions about natural mortality affects the scale of the biomass and fishing mortality estimates.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major?

  The M=0.2 model has a major retrospective pattern (Mohn's rho SSB=0.54, F=-0.31) and the M-ramp model has a minor retrospective pattern (Mohn's rho SSB=0.20, F=-0.08). No retrospective adjustment was made to either model per the recommendations of the 2014 assessment review panel. Should the retrospective patterns continue then the models may have overestimated spawning stock size and underestimated fishing mortality.

- Based on this stock assessment, are population projections well determined or uncertain?

  Population projections for Gulf of Maine Atlantic cod are reasonably well determined and projected boimass from the last assessment was within the confidence bounds of the biomass estimated in the current assessment.

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the affect these changes had on the assessment and stock status.

  This update included re-estimation of recreational catch from 2004-2014 to account for recent updates to the MRIP data as well as a revised assumption on recreational discard mortality from 30% to 15% following a Capizzano et al. 2015 study (unpublished). Additionally, the 2009-2014 survey times series was re-estimated using the TOGA station acceptance criterion. All of these changes had minimal impacts on model results.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.

  There has been no change in stock status since the 2014 udpate assessment.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.

  The Gulf of Maine Atlantic cod assessment could be improved with additional studies on natural mortality and stock structure.

- Are there other important issues?

  Careful attention should be given as to whether to apply retrospective adjustments, particularly for the M=0.2 model. Additionally, it is unclear as to which level of natural mortality (M=0.2 or 0.4) to assume for the short-term projections.

References:

Northeast Fisheries Science Center. 2013. 55^{th} Northeast Regional Stock Assessment Workshop (55^{th} SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-01; 41 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026

Palmer MC. 2014. 2014 Assessment update report of the Gulf of Maine Atlantic cod stock. US Dept Commer,Northeast Fish Sci Cent Ref Doc. 14-14; 119 p. Available from: National Marine Fisheries Service,166 Water Street, Woods Hole, MA 02543-1026

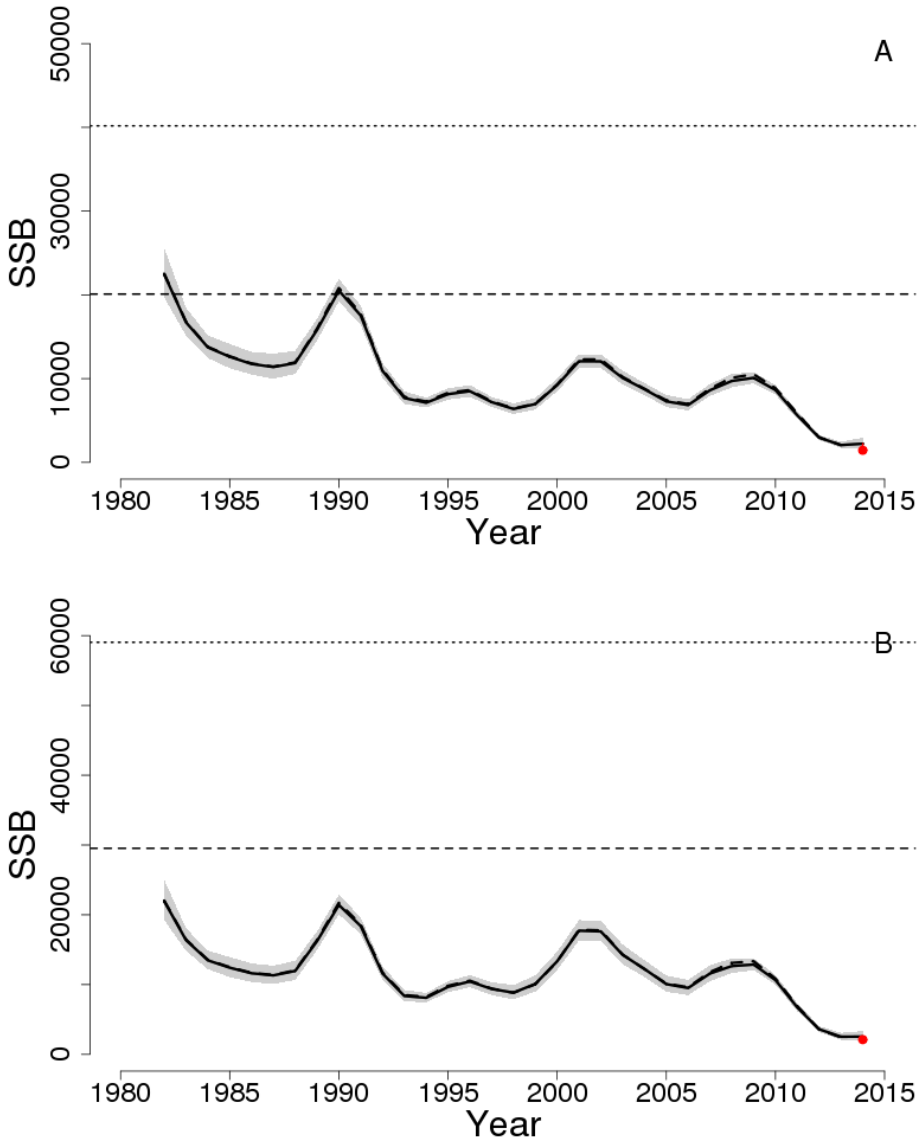

Figure 1: Estimated trends in the spawning stock biomass of Gulf of Maine Atlantic cod between 1982 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY}; horizontal dashed line) as well as SSB_{Target} SSB_{MSY}; horizontal dotted line) based on the 2015 M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown.

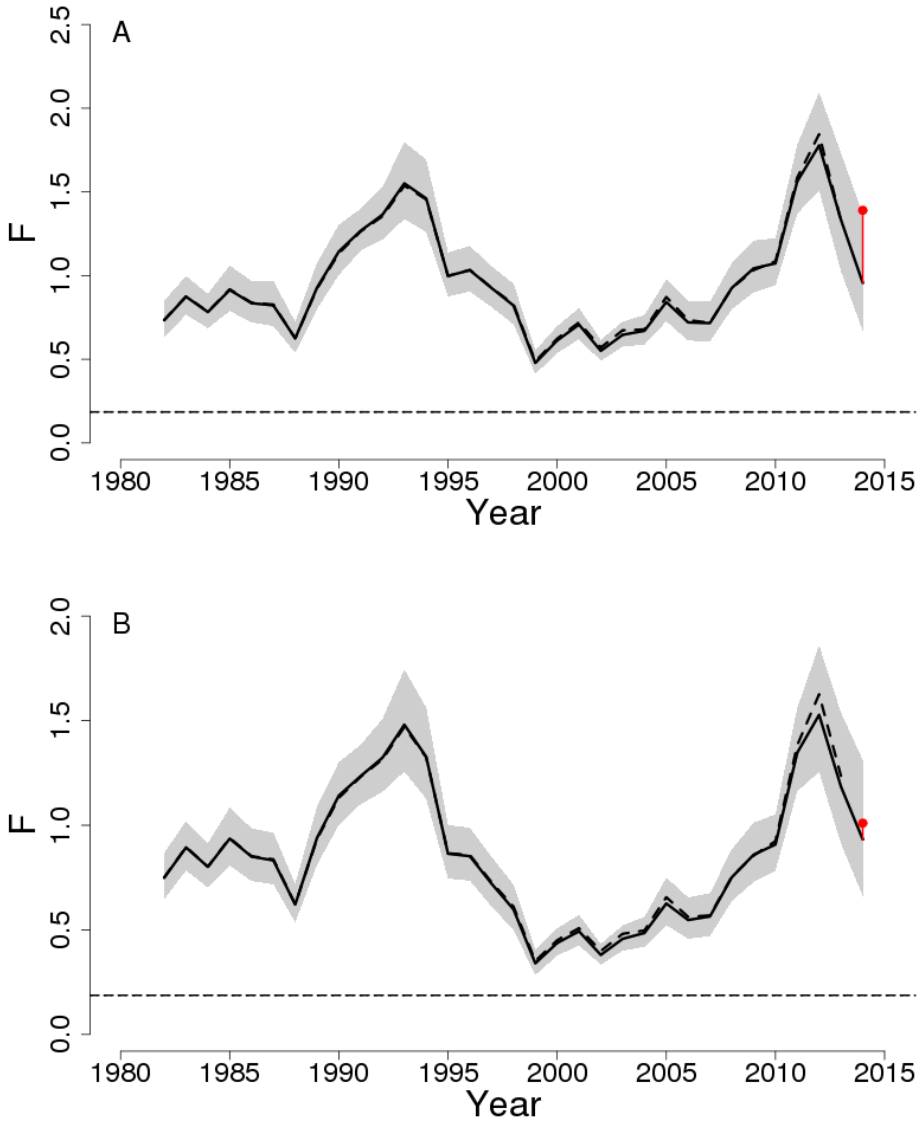

Figure 2: Estimated trends in the fully selected fishing mortality (F_{Full}) of Gulf of Maine Atlantic cod between 1982 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (0.185; dashed line) based on the 2015 M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown.

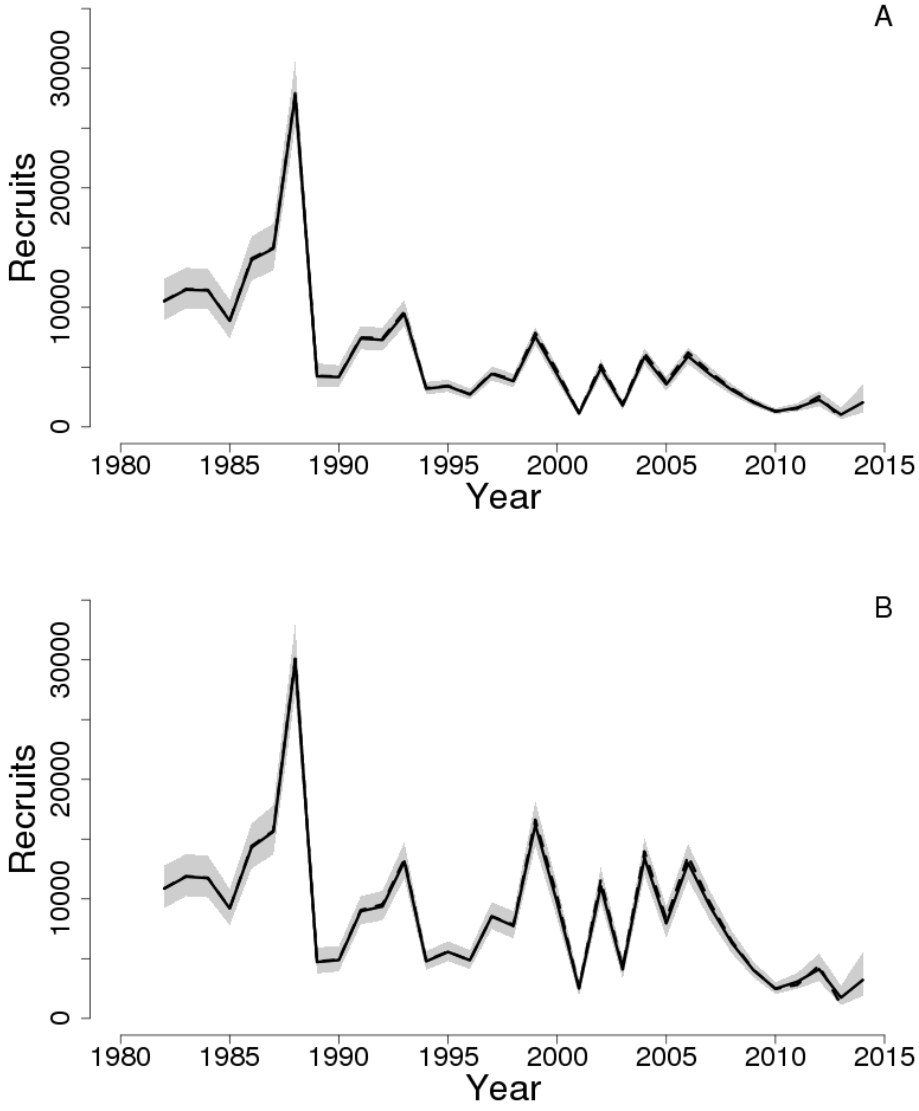

Figure 3: Estimated trends in age 1 recruitment (000s) of Gulf of Maine Atlantic cod between 1982 and 2014 from the current (solid line) and previous (dashed line) M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown.

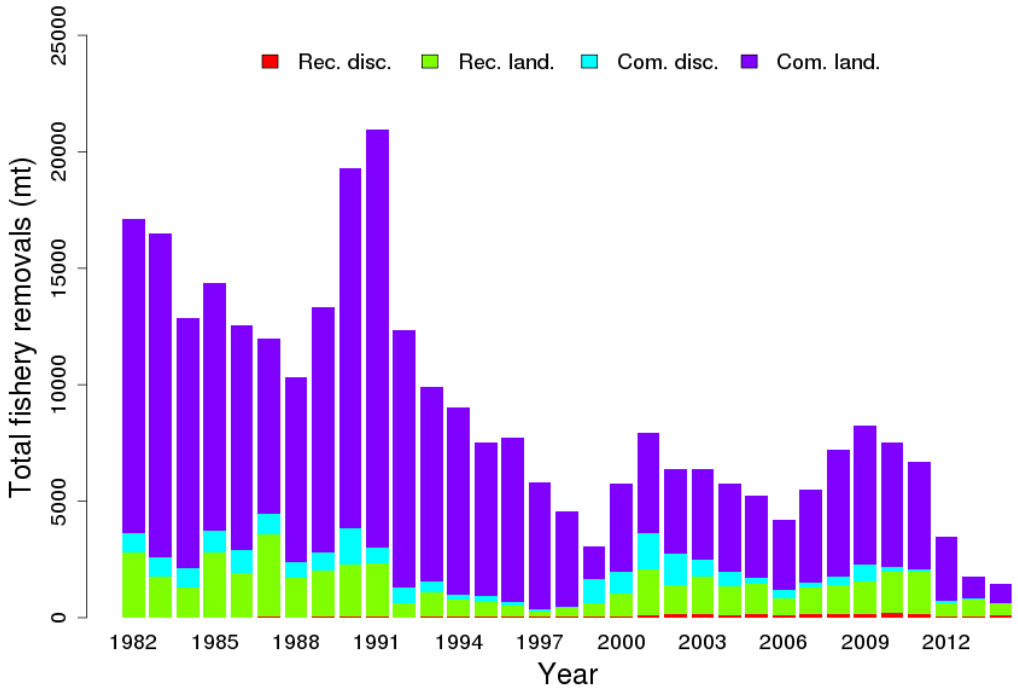

Figure 4: Total catch of Gulf of Maine Atlantic cod between 1982 and 2014 by fleet (commercial and recreational) and disposition (landings and discards).

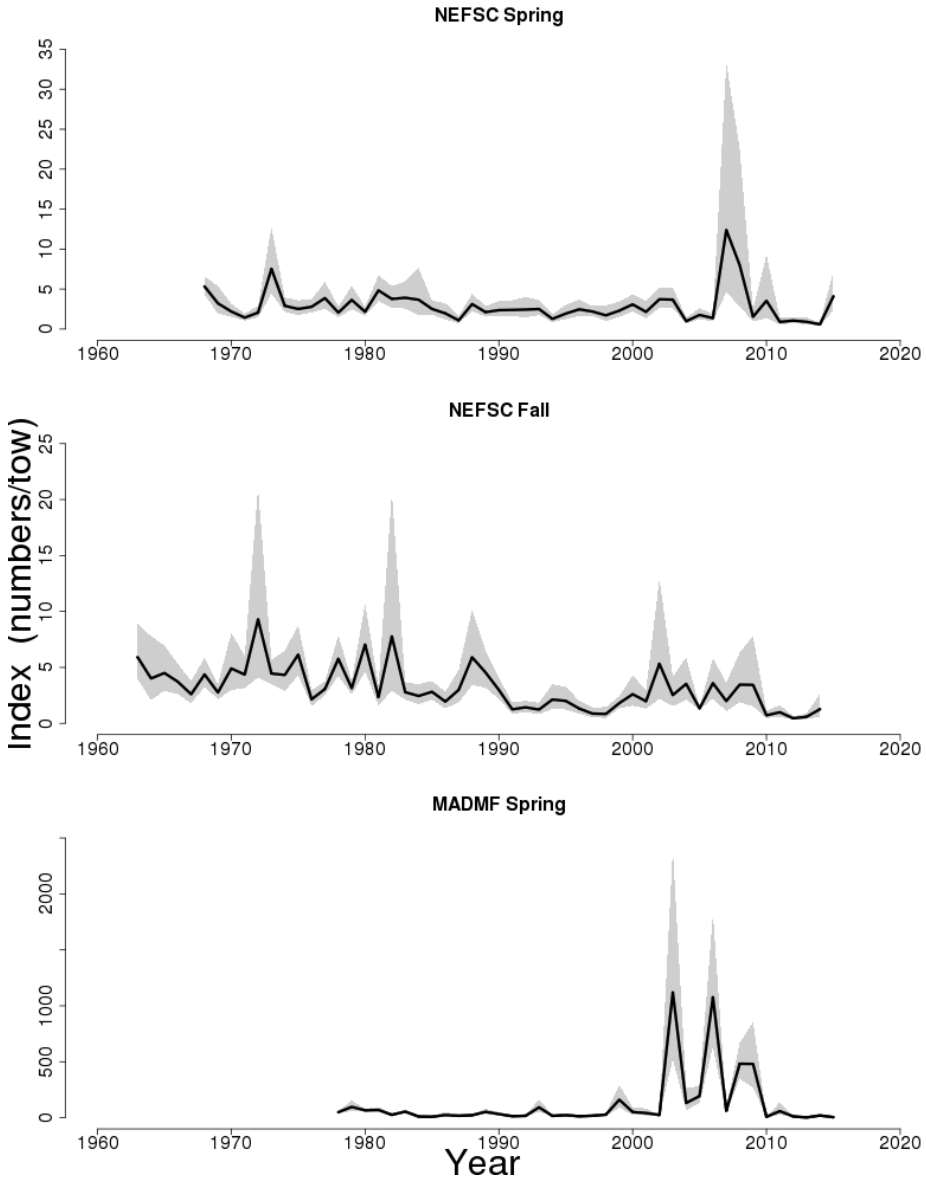

Figure 5: Indices of biomass for the Gulf of Maine Atlantic cod between 1963 and 2015 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and Massachusetts Department of Marine Fisheries (MADMF) spring bottom trawl survey. The 90% lognormal confidence intervals are shown.