4 Georges Bank haddock

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This assessment of the Georges Bank haddock (Melanogrammus aeglefinus) stock is an operational assessment of the existing 2012 update VPA assessment (Brooks et al., 2012). The last benchmark for this stock was in 2008 (Brooks et al., 2008). Based on the previous assessment in 2012, the stock was not overfished, and overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices of abundance, weights and maturity at age, and the analytical VPA assessment model and reference points through 2014. Additionally, stock projections have been updated through 2018.

State of Stock: Based on this updated assessment, the Georges Bank haddock (*Melanogrammus aeglefinus*) stock is not overfished and overfishing is not occurring (Figures 21-22). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2014 was estimated to be 150,053 (mt) which is 139% of the biomass target (SSB_{MSY} *proxy* = 108,300; Figure 21). The 2014 fully selected fishing mortality was estimated to be 0.241 which is 62% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.39; Figure 22).

Table 15: Catch and status table for Georges Bank haddock. All weights are in (mt), recruitment is in (000s), and F_{Full} is the average fishing mortality on ages 5 to 7. Model results are from the current updated VPA assessment. A rho adjustment was not applied to values in this Table.

	2007	2008	2009	2010	2011	2012	2013	2014
				Data				
US Commercial discards	1,968	389	196	144	212	321	538	1,409
US Commercial landings	14,837	20,632	22,930	25,759	5,210	1,550	1,659	4,240
Canadian Catch	10	0	0	0	11,248	5,064	4,631	12,953
Catch for Assessment	16,815	21,021	23,126	25,903	16,670	6,935	6,828	18,601
				Model Results				
Spawning Stock Biomass	182,528	166,726	140,278	103,889	71,076	65,848	162,078	225,080
F_{Full}	0.241	0.183	0.195	0.308	0.266	0.258	0.16	0.159
Recruits *age*1	5,826	6,488	3,574	7,696	399,497	70,916	29,655	3,406,466

Table 16: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold. The medians and 90% probability intervals are reported for MSY, SSBMSY, and RMSY, based on long-term stochastic projections with fishing mortality fixed at $F_{40\%}$.

	2012	Current
F_{MSY} *proxy*	0.39	0.39
SSB_{MSY} (mt)	124,900	108,300 (58,200 - 167,900)
MSY (mt)	28,000	24,900 (13,600 - 38,400)
Median recruits (age 1) (000s)	54,200	53,400 (3,500 - 130,000
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of biomass were derived by sampling from a cumulative distribution function of recruitment estimates from ADAPT VPA (corresponding to SSB>75,000 mt and dropping the extremely large 1963, 2003, and 2010 year classes, as well as the two final year class estimates for 2013 and 2014). The annual fishery selectivity, maturity ogive, and mean weights at age used in this projection are the most recent 5 year averages; retrospective adjustments were applied to the starting numbers at age (2015) in the projections.

Table 17: Short term projections of total fishery catch and spawning stock biomass for Georges Bank haddock based on a harvest scenario of fishing at F_{MSY} *proxy* between 2016 and 2018. Catch in 2015 was assumed to be 20,686 mt.

Year	Catch (mt)	SSB (mt)	F_{Full}
2015	20,686	450,644 (295,863 - 677,103)	0.100 (0.073 - 0.139)
2016	160,385 (98,994 - 255,087)	1,171,481 (636,247 - 1,997,691)	0.390
2017	242,187 (132,381 - 414,260)	1,226,513 (655,530 - 2,109,738)	0.390
2018	293,033 (155,255 - 506,597)	962,959 (525,327 - 1,647,905)	0.390

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 2013 recruitment, which accounts for a substantial portion of catch and SSB in projections. The rho adjusted projections reduce all starting numbers at age to 67% of unadjusted values (i.e., all 2015 numbers at age are multiplied by 0.667). Two other exceptionally large year classes were observed in 2003 and 2010. The 2003 year class is now estimated to be only 28% of its initial model estimate, while the 2010 year class is now estimated to be 63% of its initial estimate. Given that only 5 years of data are available to estimate the 2010 year class, it is possible that there may be further revisions to the magnitude of this year class estimate with more years of data.

Therefore, it remains uncertain if the scalar applied to all age classes in these projections (0.667, based on Mohn's rho for SSB) is sufficient to account for future revisions to the 2013 year class estimate. In addition, the median recruitment in the projections (the proxy for recruitment at MSY) is 53.4 million, which is greater than 7 of the last 10 recruitments even though SSB is above the SSBMSY proxy (Table 1). While projections of catch and SSB in the near-term are mostly driven by the 2013 year class, it is worth noting the magnitude of median projected recruitment relative to recent recruitment observations.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or F_{Full} lies outside of the approximate joint confidence region for SSB and F_{Full}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.20 in the 2012 assessment and was 0.50 in 2014. The 7-year Mohn's ρ, relative to F, was -0.15 in the 2012 assessment and was -0.34 in 2014. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2014 SSB (SSB_{ρ}=150,053) and 2014 F (F_{ρ}=0.241) were outside the approximate 90% confidence region around SSB (171,911 - 301,282) and F (0.13 - 0.203). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2016. The retrospective adjustment changed the 2014 SSB from 225,080 to 150,053 and the 2014 F_{Full} from 0.159 to 0.241.

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

  As noted above, population projections for Georges Bank haddock are uncertain due to uncertainty about the size of the 2013 year class. Two sensitivity projections were conducted. The first sensitivity used biological parameters and fishery selectivity values from the 2010 year class for the 2013 year class. A second sensitivity projection was made that used the same biological and selectivity parameters as the first sensitivity, and in addition it doubled the rho-adjustment on the 2013 year class (age 2 at the start of 2015) by multiplying it by 0.33. These sensitivity runs are available on the Stock Assessment Supplementary Information website (SASINF), in the sensitivity slides appended to the end of the background presentation.

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

  No changes, other than the incorporation of new data, were made to the Georges Bank haddock assessment for this update. However, the criterion for determining acceptable tows on NEFSC surveys used the TOGA protocol rather than the SHG protocol (TOGA=132x).

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

  The stock status of Georges Bank haddock has not changed.

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

  Projection advice and reference points for Georges Bank haddock are strongly dependent on recruitment. A decade ago, extremely large year classes were considered anomalies (e.g., 1963 and 2003). However, since 2003, there have been two more extremely large (2010 and 2013) and one very large (2012) year classes. Future work could focus on recruitment forecasting and providing robust catch advice.

- Are there other important issues?

  The Georges Bank haddock assessment has recently developed a major retrospective pattern. This stock assessment has historically performed very consistently. This should continue to be monitored. Density-dependent responses in growth should also continue to be monitored. The switch from SHG to TOGA was ruled out as the cause of the retrospective pattern.

4.1 Reviewer Comments: Georges Bank haddock

Recommendation: The Panel concluded that the updated assessment with retrospective adjustment was acceptable as a scientific basis for management advice. The minor revisions of survey data and maturity schedule were acceptable. The Assessment Oversight Panel decided that the base case projection excluded the few dominant year classes from the recruitment distribution, but a sensitivity analysis provided to the PDT included them.

Alternative Assessment Approach: Not applicable

Sources of Uncertainty: The major sources of uncertainty are the retrospective pattern, estimation of recent recruitment, and the expectation of density-dependent effects. The 2013 year class is not well estimated, and estimates of previous dominant year classes changed substantially as assessments were updated. Based on recent observations from dominant year classes in the fishery and surveys, density dependent growth should be expected. However, the expected changes in growth and selectivity are not accounted for in projections.

Research Needs: The Panel recommends that the sources of the retrospective pattern need to be addressed. Considering that retrospective patterns are a common problem, the generic problem may be most appropriately addressed in a research track topic, and all possible sources of the retrospective problem should be investigated (mis-specified natural mortality, changes in natural mortality, under-reported catch, changes in survey catchability and mis-specified selectivity, etc.). Specific research recommendations include monitoring of abundance and growth of the 2013 year class, investigation of recruitment processes to help improve recruitment forecasting, and methods to estimate MSY reference points for a stock with episodic recruitment.

References:

Brooks, E.N, M.L. Traver, S.J. Sutherland, L. Van Eeckhaute, and L. Col. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. CRD08-15

Brooks, E.N, S.J. Sutherland, L. Van Eeckhaute, and M. Palmer. 2012. In. Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 12-06.; 789 p. CRD12-06

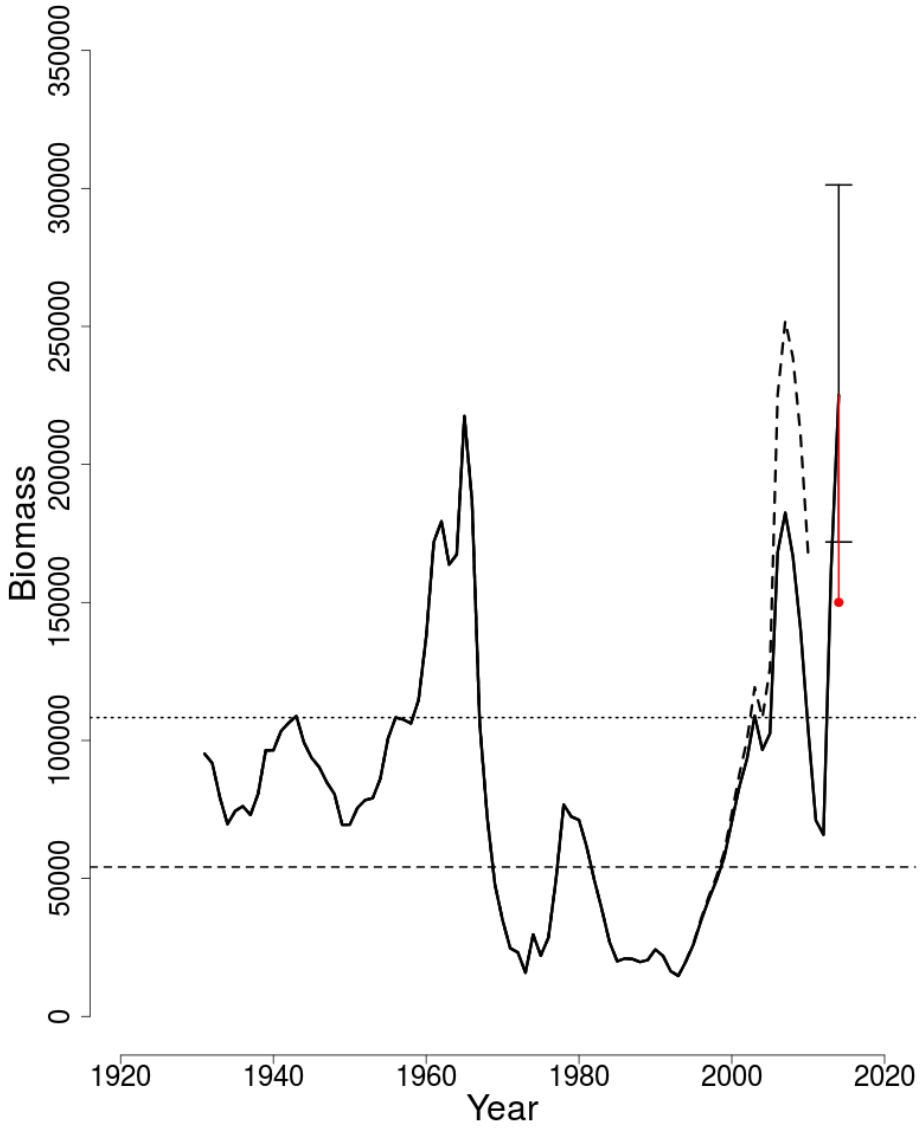

Figure 21: Trends in spawning stock biomass of Georges Bank haddock between 1931 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2015 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

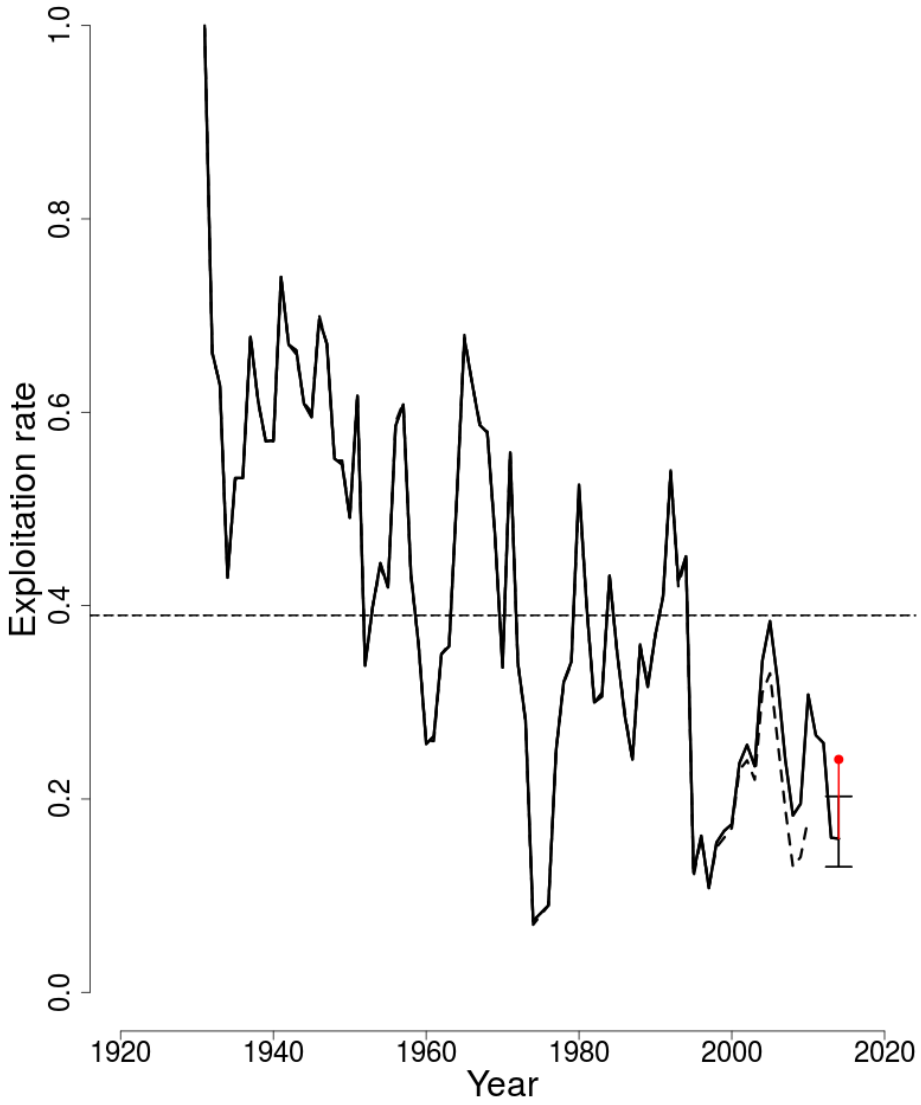

Figure 22: Trends in the fully selected fishing mortality (F_{Full}) of Georges Bank haddock between 1931 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.39; horizontal dashed line) based on the 2015 assessment. F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

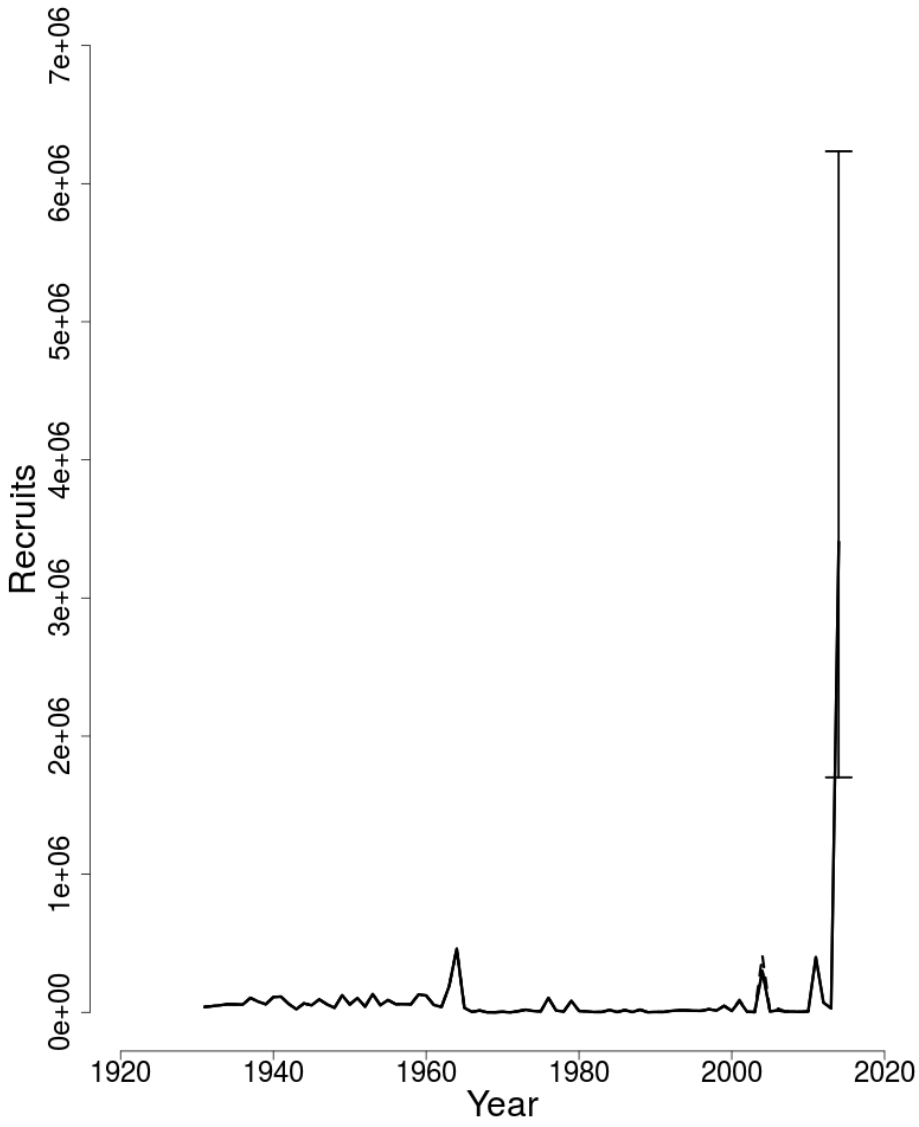

Figure 23: Trends in Recruits (age 1) (000s) of Georges Bank haddock between 1931 and 2014 from the current (solid line) and previous (dashed line) assessment. The 90% bootstrap probability intervals are shown.

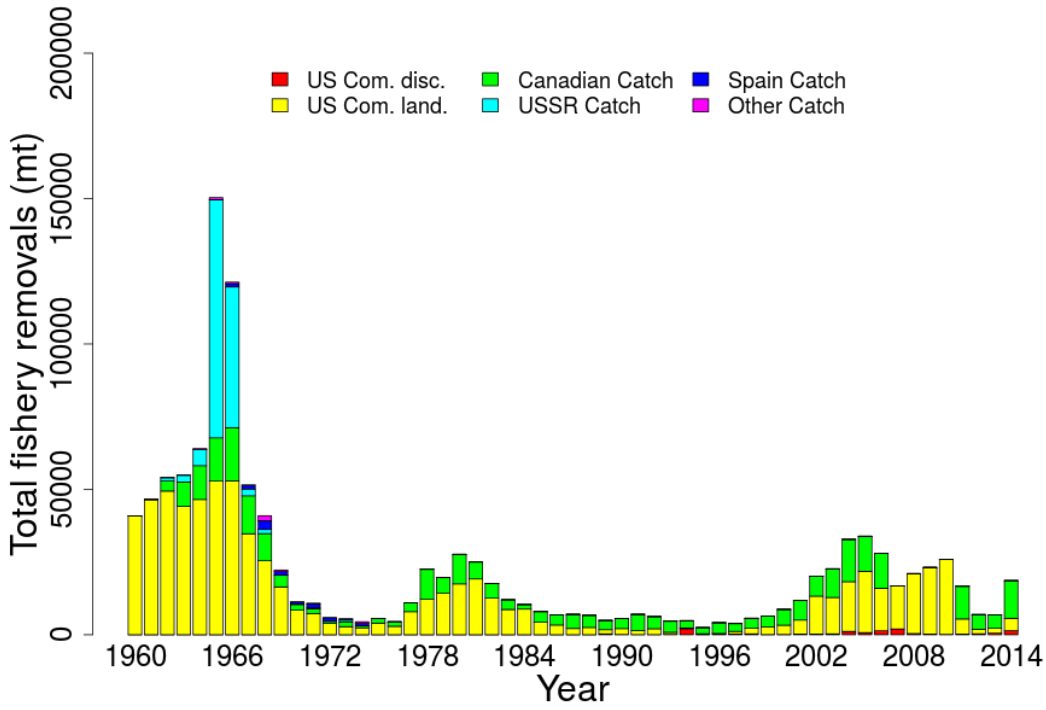

Figure 24: Total catch of Georges Bank haddock between 1931 and 2014 by fleet (US Commercial, Canadian, or foreign fleet) and disposition (landings and discards).

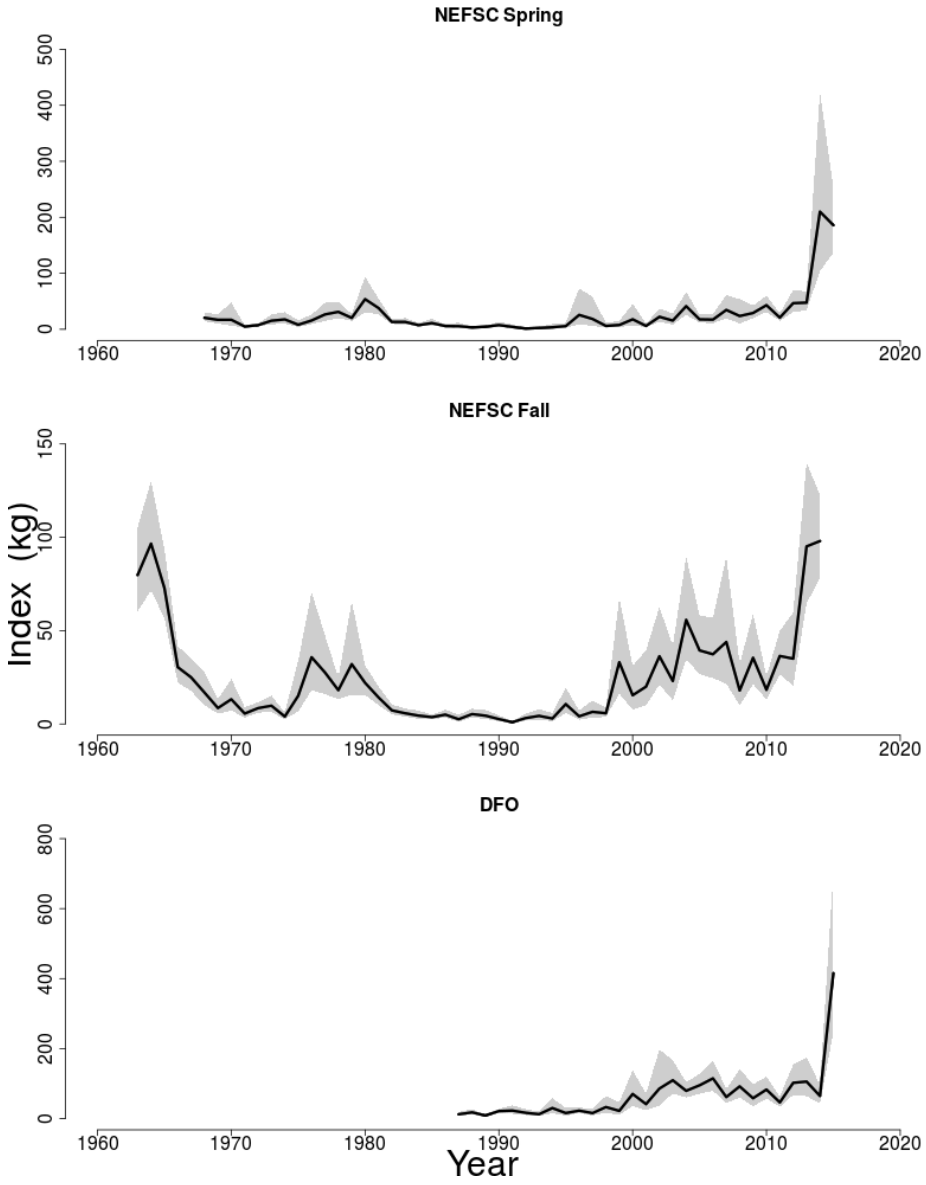

Figure 25: Indices of biomass (Mean kg/tow) for the Georges Bank haddock stock between 1963 and 2015 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and the DFO winter bottom trawl survey. The approximate 90% lognormal confidence intervals are shown.