draft working paper for peer review only

Georges Bank 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 Georges Bank Atlantic Cod (Gadus morhua) stock is an operational update of the existing 2012 benchmark assessment (NEFSC 2013). Based on the previous assessment the stock was overfished, and overfishing was ocurring. This 2015 assessment updates commercial fishery catch data, research survey indices of abundance, the analytical ASAP 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 Atlantic Cod (*Gadus morhua*) stock is overfished and overfishing is occurring (Figures 1-2). Spawning stock biomass (SSB) in 2014 was estimated to be 5,853 (mt) which is 3% of the biomass target for this stock (SSB_{MSY} *proxy* = 201,466; Figure 1). Adjusting for retrospective bias, SSB in 2014 is estimated to be 1,966 (mt) which is 1% of the biomass target for this stock. The 2014 fully selected fishing mortality was estimated to be 0.49 which is 290% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.169; Figure 2). Adjusting for retrospective bias, F in 2014 is estimated to be 1.61 which is 953% of the overfishing threshold for this stock.

Table 1: Catch and model results for Georges Bank Atlantic Cod. All weights are in (mt), recruitment is in (000s), and F_{Full} is the fishing mortality on fully selected ages (ages 5-8). Model results are from the current updated ASAP assessment.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
				Data						
Commercial landings	2,754	2,700	3,699	3,255	2,999	2,688	3,387	2,007	1,312	1,514
Commercial discards	394	232	728	309	385	253	122	120	83	19
Recreational landings	966	59	11	69	48	153	177	56	6	88
Recreational discards	101	4	3	1	5	23	17	1	1	2
CA landings	630	1,097	1,107	1,390	1,003	748	702	395	384	430
CA discards	226	350	117	140	206	94	43	75	39	28
Catch for Assessment	5,072	4,441	5,665	5,164	4,646	3,959	4,449	2,653	1,824	2,081
				Model Results						
Spawning Stock Biomass	9,435	9,358	9,197	7,968	7,652	6,076	5,166	3,953	4,986	5,853
F_{Full}	0.7	0.58	0.83	0.91	0.9	0.92	1.35	1.04	0.51	0.49
Recruits $age1$	1,297	2,932	3,404	2,204	2,382	1,874	3,151	2,023	889	1,099

Table 2: Comparison of reference points estimated in the previous assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on long-term stochastic projections.

	2012	Current
F_{MSY} *proxy*	0.177	0.169
SSB_{MSY} (mt)	186,535	201,466 (158,307 - 247,902)
MSY (mt)	30,622	30,570 (23,920 - 37,714
Median recruits (age 1) (000s)	8,765	7,119

Overfishing	Yes	Yes
Overfished	Yes	Yes

Projections: Short term projections of biomass were derived by sampling from a two-stage cumulative distribution function of recruitment estimates from ASAP model results, using a 50,000 mt cutpoint. The annual fishery selectivity, maturity ogive, and mean weights at age used in projections are the most recent 5 year averages; retrospective adjustments were applied in the projections.

Table 3: Short term projections of total fishery catch and spawning stock biomass for Georges Bank Atlantic Cod based on a harvest scenario of fishing at F_{MSY} *proxy* between 2016 and 2018. Catch in 2015 was assumed to be 1,784 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2015	1,784	1,653 (702 - 3,338)	1.510
2016	158	1,154 (311 - 2,819)	0.169
2017	332	2,754 (1,428 - 4,868)	0.169
2018	831	6,953 (3,743 - 14,451)	0.169

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 major source of uncertainty is presumbaly the estimate of catch or of natural mortality, considering the magnitude of the retrospective bias. These both affect the scale of the biomass, fishing mortality estimates, and the reference point estimates. The catch estimates do not include all discards (e.g.,lobster gear) and includes uncertain estimates of recreational landings and discards, and of some commercial discards (e.g., small mesh). Natural mortality (M) of Georges Bank Atlantic Cod is not well understood and is assumed constant over time in the model. Other sources of uncertainty include possible changes in growth parameters in recent years and how this affects fecundity, the viability of eggs/sperm, and the success rate of hatching - all influencing recruitment survival and year class strength.

- Does this assessment model have a retrospective pattern? If so, is the pattern strong, moderate, or mild?

  This assessment has a relatively strong retrospective pattern and high values of Mohn's rho of 1.98 for SSB and of -0.69 for fishing mortality.

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

  Population projections for Georges Bank Atlantic Cod are uncertain and likely optimistic. The projections are based on a biomass cutpoint of 50,000 mt, which has not been produced since 1992. The average recruitment since 1992 has been 4.3 million age 1

fish, whereas during the last 10 years, average recruitment has been about 2.1 million age 1 fish. A sensistivity projection using the most recent 10 years of recruitment was conducted and results presented in the SASINF database.

- 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 major changes, other than the addition of recent years of data, were made to the Georges Bank Atlantic Cod assessment for this update. However, recreational catch and commercial discard estimates were revised slightly due to minor changes in the databases, and the application of length frequencies (annual instead of half year) in one instance. The DFO survey estimates changed slightly after exclusion of surveys that did not consistently sample Georges Bank. A sensitivity run indicated minimal differences in model results for these changes compared to the previous assessment.

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

  As in recent assessments for Georges Bank Atlantic Cod the stock remains in an overfishing and overfished status

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

  The Georges Bank Atlantic Cod assessment could be improved with additional studies on natural mortality, growth, and fecundity. Additionally, more precise estimates of recreational landings and discards, sampling of fish caught by individual recreational anglers, and incorporation of discards in the lobster fishery would decrease uncertainty in the discard esimates.

- Are there other important issues?

  The differences in model assumptions of natural mortality between the SARC GB cod and the TRAC eGB cod assessment is problematic for the recovery of the entire GB cod stock. Model results of the TRAC VPA M=0.8 model are used to determine quota for the eGB management unit, so by default, proportionally more cod are being removed from eastern GB than what the GB cod ASAP model would predict.

References:

Northeast Fisheries Science Center. 2013. 55th Northeast Regional Stock AssessmentWorkshop (55th SAW) Assessment Summary Report. Northeast Fisheries Science CenterReference Document 13-01:43.

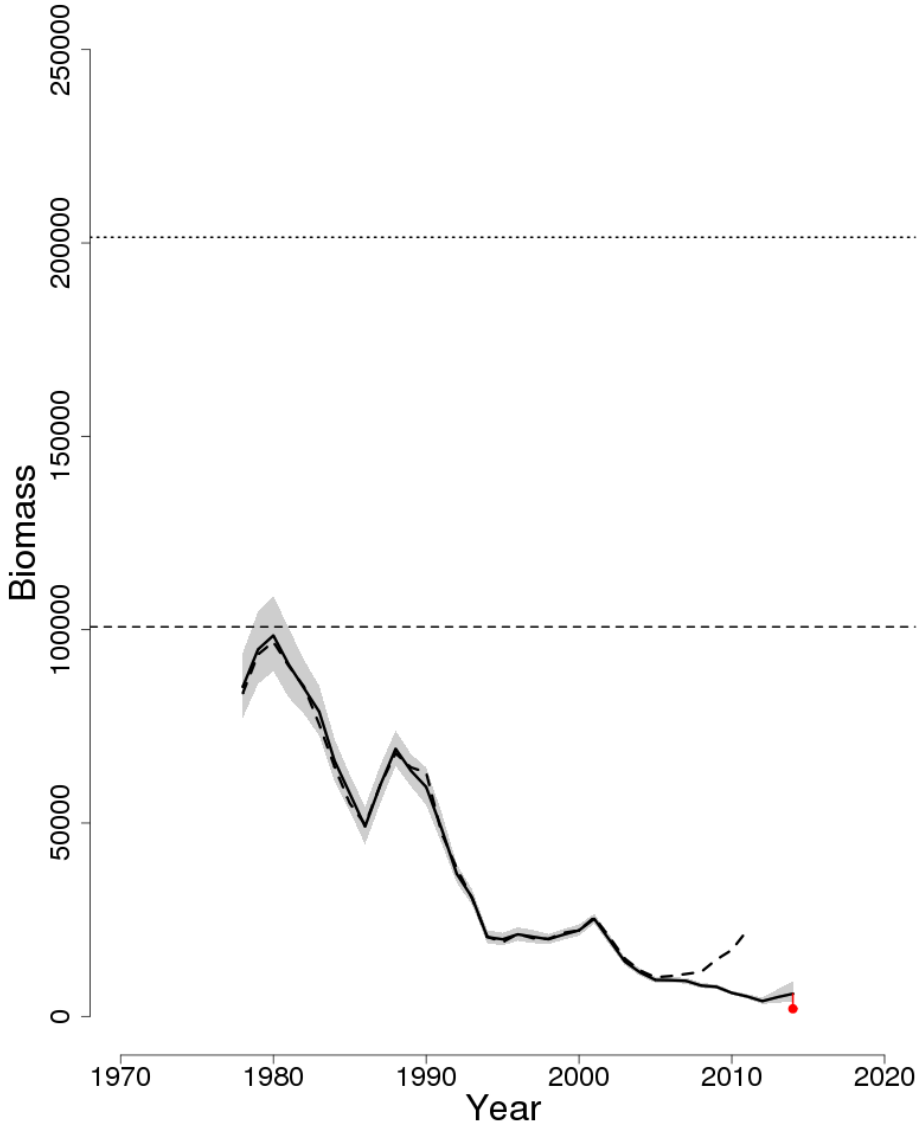

Figure 1: Trends in spawning stock biomass of Georges Bank Atlantic Cod between 1978 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2015 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

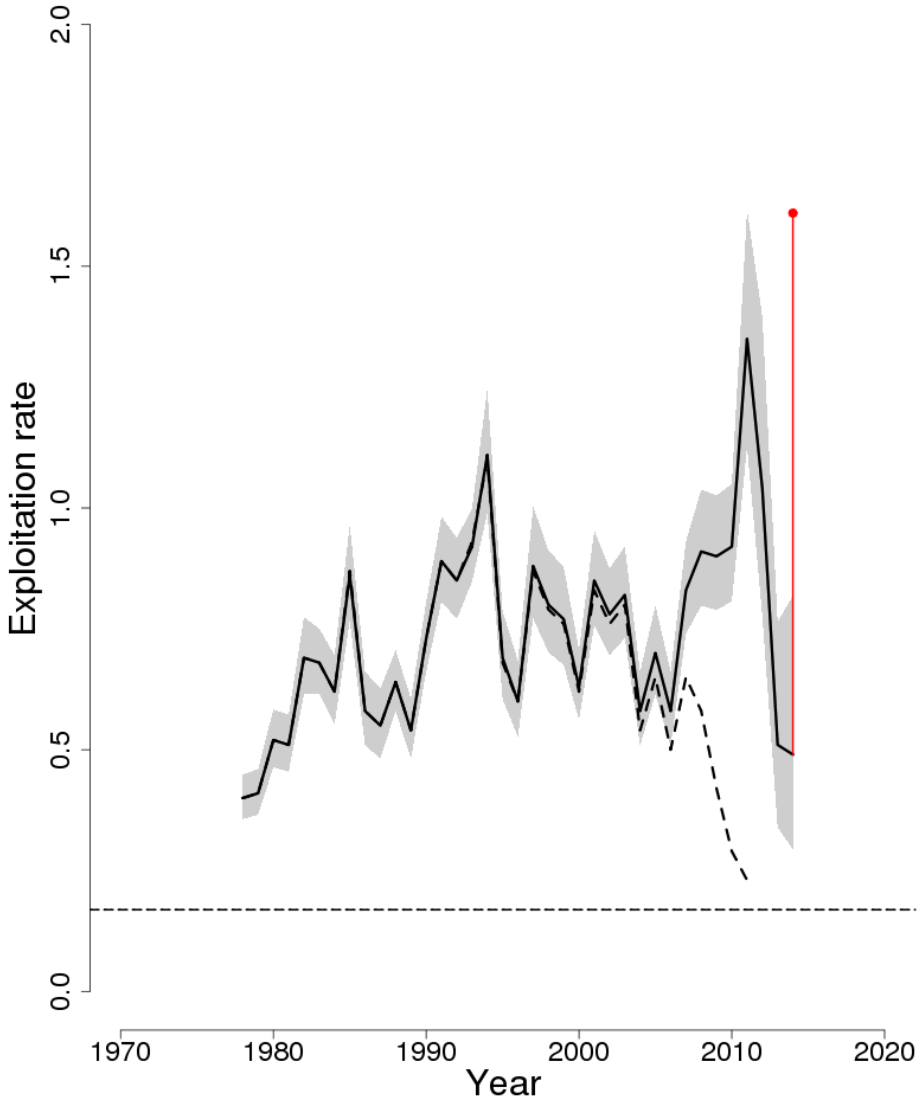

Figure 2: Trends in the fully selected fishing mortality (F_{Full}) of Georges Bank Atlantic Cod between 1978 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.169; horizontal dashed line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red, based on the 2015 assessment. The approximate 90% lognormal confidence intervals are shown.

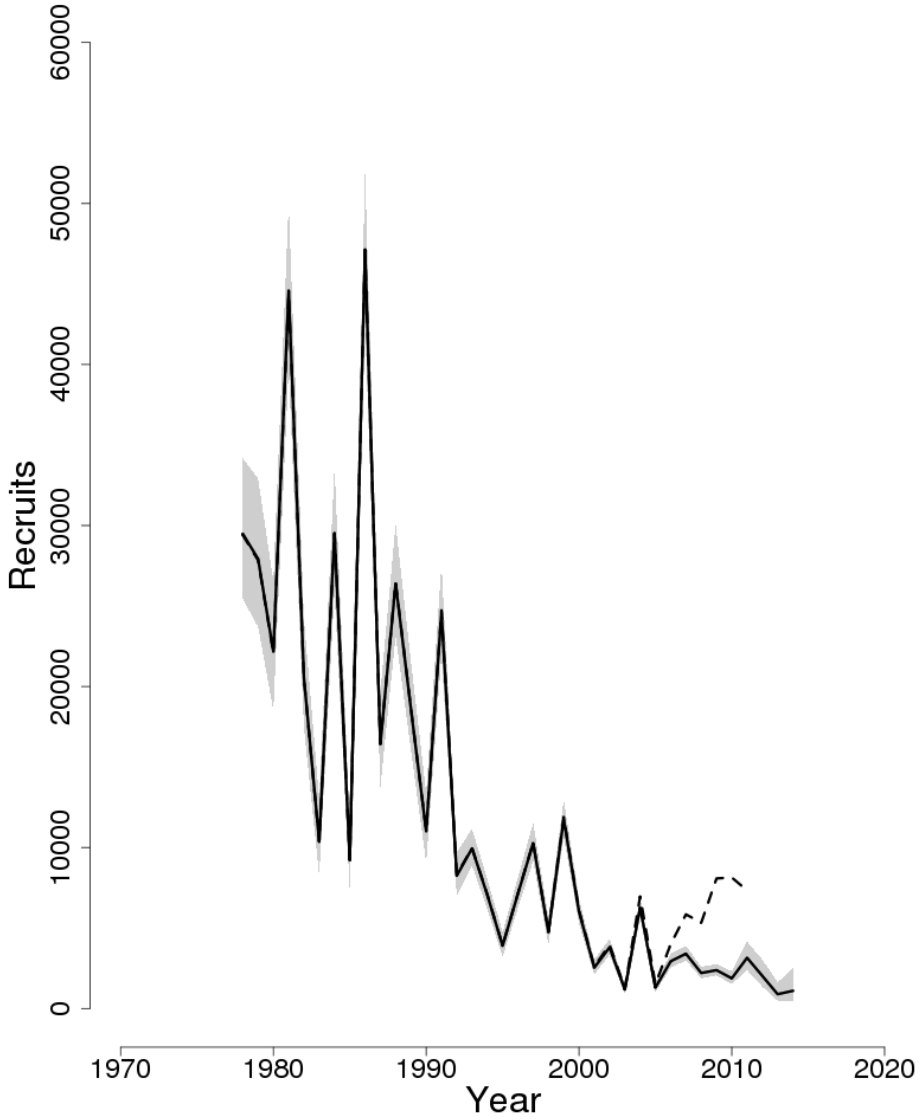

Figure 3: Trends in Recruits (age 1) (000s) of Georges Bank Atlantic Cod between 1978 and 2014 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

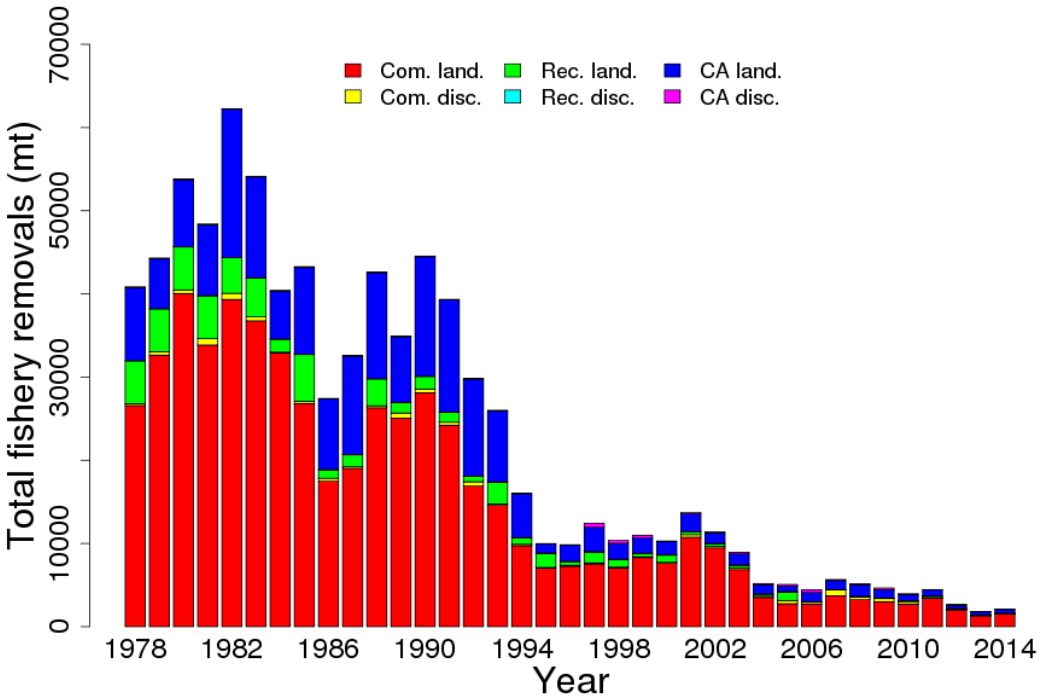

Figure 4: Total catch of Georges Bank Atlantic Cod between 1978 and 2014 by fleet (US commercial, US recreational, or Canadian) and disposition (landings and discards).

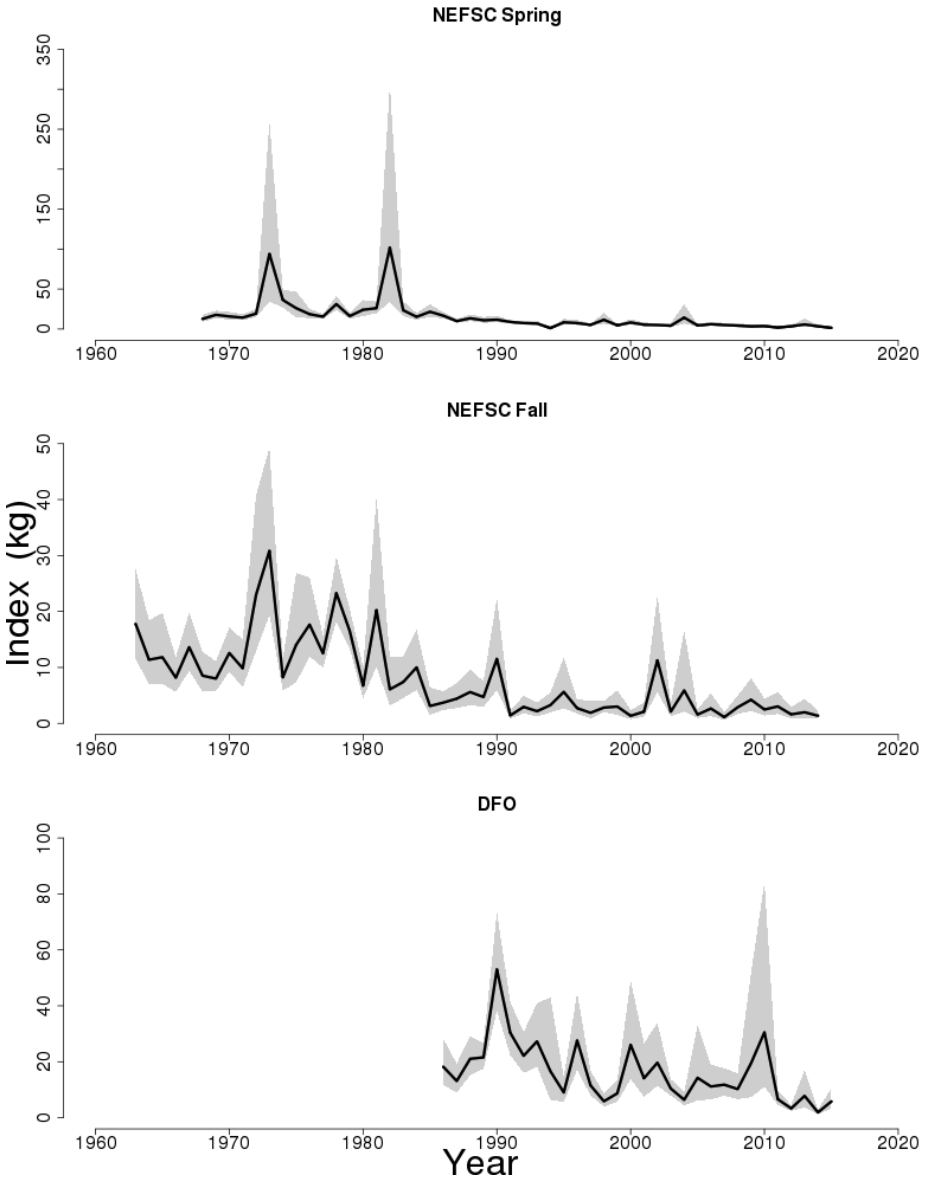

Figure 5: Indices of biomass for the Georges Bank Atlantic Cod between NA and NA for the Northeast Fisheries Science Center (NEFSC) spring and fall, and the DFO research bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.