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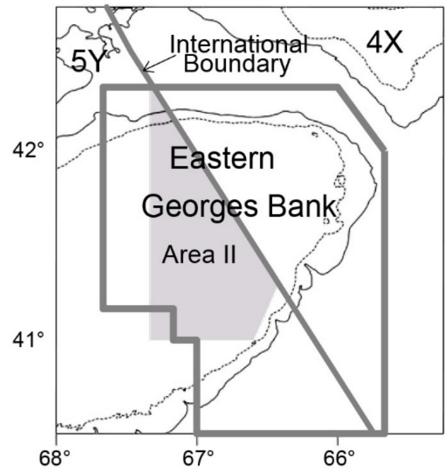
NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee
Status Report 2017/02

EASTERN GEORGES BANK HADDOCK

[5Zjm; 551,552,561,562]



Summary

- Combined Canada and USA catches in 2016 were 12,409 mt.

- At the beginning of 2017, adult biomass was 274,482 mt.

- A preliminary estimate for the 2016 year class is 111 million age 1 fish. The current estimate for the 2013 year class is 885 million age 1 fish, which would make it the largest cohort in the assessment time series, followed by the 2010 year class at 243 million. Except for the recent strong year classes, recruitment has fluctuated between 1.8 and 26.1 million since 1990.

- Fishing mortality (F) was below F_{ref} = 0.26 during 1995 to 2003, fluctuated around 0.35 in 2004 to 2006, then declined to 0.15 in 2008. Fishing mortality increased to levels above F_{ref} from 2010 to 2014 before dropping off again in 2015. In 2016, F was estimated at 0.10 (80% confidence interval: 0.08-0.14), well below F_{ref}.

- Recruitment, as well as age structure, spatial distribution, and fish growth reflect changes in the productive potential. Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt, and the stock has produced several exceptionally strong year classes in the last 16 years.

  - There has been a general decline in weights at age since the late 1990s. As biomass has increased growth rates and asymptotic length have declined. This decline in size at age appears to be exacerbated for the 2013 year class. Fish condition has generally been below the time series average since 2004 for all three surveys and was the lowest in the time series for both the DFO and NMFS spring surveys in 2017.

Ce document est disponible sur l'Internet a: This document can be found on the internet at:
https://www.nefsc.noaa.gov/saw/trac/

July 2017

- A combined Canada/USA catch of 86,000 mt in 2018 results in a neutral risk (50%) that the 2018 fishing mortality rate would exceed F_{ref}, assuming a 2017 catch equal to the 50,000 mt total quota. Biomass at the beginning of 2019 is projected to be 242,883 mt fishing at F_{ref}.

- A combined Canada/USA catch of 53,000 mt in 2019 results in a neutral risk (50%) that the 2019 fishing mortality rate would exceed F_{ref}, assuming a 2017 catch equal to the 50,000 mt total quota. Biomass at the beginning of 2020 is projected to be 195,716 mt fishing at F_{ref}.

- A retrospective bias was first noted in the 2014 assessment. The current assessment continues to exhibit retrospective bias in adult biomass, recruitment, and age 5-8 F, which results in overestimates of adult biomass and recruitment, and underestimates of F.

- A sensitivity analysis to account for retrospective bias on spawning stock biomass (SSB) and F for haddock was conducted. Assuming a 2017 catch equal to the 50,000 mt total quota, a combined Canada/USA catch of 44,000 mt in 2018 results in a neutral risk (50%) that the 2018 fishing mortality rate would exceed F_{ref} and a combined Canada/USA catch of 27,500 mt in 2019 results in a neutral risk (50%) that the 2019 fishing mortality rate would exceed F_{ref}.

- There was consensus among all TRAC participants that catch should be lower than the standard projections due to the poor model performance and uncertainty about growth patterns and abundance for the 2013 year class. A sensitivity projection using rho adjustment was proposed as a method to reduce catch advice from the standard projection. However, there was no consensus on the appropriate magnitude for reducing catch advice, or how it should be derived. The external reviewers were in favour of applying the rho adjustment and following the sensitivity catch advice.

- Performance of the VPA for EGB Haddock was poor and seems to be getting worse with time. Some of the diagnostic issues were poor fits to the survey data and significant retrospective patterns in biomass, fishing mortality, and recruitment, indicating an undiagnosed misspecification in the model. The VPA modeling approach is becoming increasingly unreliable for providing management advice.

TRAC Review Process

In the interest of transparency and in order to avoid any perceived conflict of interest, in 2017 TRAC introduced a new process of review for Eastern Georges Bank Cod and Haddock and Georges Bank Yellowtail Flounder. An overview of the entire process is available at https://www.nefsc.noaa.gov/saw/trac/trac-process-overview-2017.pdf. After the presentation of each assessment by the lead authors, there was initial scientific and technical review by the invited external reviewers (referred to as **external reviewers** in this document), followed by scientific and technical review by the science assessment staff and a U.S.A. and Canadian resource manager (referred to as **science** in this document) and then review and contributions by all meeting participants, including stakeholders, external non-government organizations and the general public (referred to as the **broader TRAC** in this document). At the completion of each level of review, consensus was sought and there was discussion as to whether or not revisions to the initial conclusions were warranted. In the absence of consensus the advice from the science group will be provided along with the perspective from the broader TRAC.

Table 1. Catches and Biomass (thousands mt); Recruits (millions)

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Avg[1]	Min[1]	Max[1]
Canada[2]	**Quota**	14.5	12.7	15.0	18.9	17.6	12.5	9.1	6.4	16.5	19.2	21.8	20.5			
	Landed	12.0	11.9	14.8	17.6	16.6	11.2	5.0	4.6	13.0	14.6	11.9		6.1	0.5	17.6
	Discard	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		0.1	<0.1	0.2
USA[2]	**Quota[3]**	7.5	6.3	8.1	11.1	12.0	9.5	6.9	4.0	10.5	17.8	15.2	29.5			
	Catch[3]	0.7	0.3	1.6	1.6	1.8	1.1	0.4	0.6[4]	1.3	1.9	0.5				
	Landed	0.3	0.3	1.1	2.2	2.2	1.3	0.4	0.3	1.2	1.5	0.3		1.9	<0.1	9.1
	Discard	0.3	0.3	0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.4	0.1		0.5	0.0	7.6
Total[2]	**Quota[3]**	22.0	19.0	23.0	30.0	29.6	22.0	16.0	10.4	27.0	37.0	37.0	50.0			
	Catch[5,6]	12.7	12.3	16.5	19.2	18.4	12.3	5.5	5.2	14.3	16.5	12.4				
	Catch	12.6	12.5	16.0	19.9	18.8	12.7	5.6	5.1	14.2	16.1	12.4		8.7	2.1	23.3
Adult Biomass[7]		83.3	96.8	93.0	92.8	66.2	40.4	23.9	85.0	105.0	95.6	293.3	274.5	45.8[8]	4.9[8]	293.3[8]
Age 1 Recruits		9.0	3.1	4.5	1.8	4.0	243.5	20.8	9.9	884.9	10.6	45.9	111.6	39.6[8]	0.2[8]	884.9[8]
Fishing mortality[9]		0.37	0.21	0.15	0.25	0.36	0.41	0.47	0.36	0.41	0.12	0.10		0.32	0.10	0.57
Exploitation Rate[9]		28%	17%	12%	20%	28%	30%	34%	28%	31%	10%	9%		24%	9%	40%

[1]1969 – 2016
[2] unless otherwise noted, all values reported are for calendar year
[3]for fishing year from May 1st – April 30th
[4]preliminary estimate
[5]for Canadian calendar year and USA fishing year May 1st – April 30th
[6]sum of Canadian landed, Canadian discard, and USA catch (includes discards)
[7]January 1st ages 3+
[8]1969 – 2017
[9]ages 4-8 for 1969 – 2002; ages 5-8 for 2003 – 2016

Fishery

Combined Canada and USA catches for Eastern Georges Bank (EGB) Haddock declined from 6,504 mt in 1991 to a low of 2,150 mt in 1995, varied between about 3,000 mt and 4,000 mt until 1999, and increased to 15,257 mt in 2005 (Figure 1). Combined catches then decreased to 12,510 mt in 2007, increased to 19,855 mt in 2009, decreased from 2010 to 2013 with higher catches from 2014 to 2016 and a total catch of 12,409 mt in 2016 (Table 1).

The **Canadian catch** decreased from 14,648 mt in 2015 to 11,943 mt in 2016. Discards in the groundfish fishery are considered to be negligible. Discards of haddock by the Canadian sea scallop fishery were 8 mt in 2016 but ranged between 8 mt and 186 mt over the time series.

USA catches decreased from 1921 mt in 2015 to 466 mt in 2016. Landings in 2016 were 341 mt and discards were estimated to be 125 mt, primarily from the otter trawl fishery with a small amount from the scallop dredge fishery (0.3 mt).

The combined Canada and USA **fishery age composition** (landings + discards) in 2016 was dominated by the 2010 (age 6) and 2013 (age 3) year classes by numbers and weight. Both the Canadian and the USA fisheries were adequately sampled to determine length composition of the catch.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee (TMGC) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality reference, F_{ref} = 0.26 (established in 2002 by the TMGC). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. In recent years, substantial fish growth changes and changes in fishery management measures led to concerns whether the F_{ref} is still reflective of the current fishery and was explored further in the appendix of the reference document.

State of Resource

The 2016 DFO survey index was the highest value for the time series (1986-2016), but decreased by 48% in 2017. A similar decrease occurred for the 2016 NMFS fall survey from 2015 to 2016 (53%), but index values increased by 16% from 2016 to 2017 for the NMFS spring survey (Figure 2).

Evaluation of the state of the resource was based on results from an age structured analytical assessment (Virtual Population Analysis, VPA) that used fishery catch statistics and sampling for size and age composition of the catch for 1969 to 2016 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series: DFO, NMFS spring, and NMFS fall.

Several large **recruitment** events since 1990 and reduced capture of small fish in the fisheries allowed the **adult population biomass** (ages 3+) to increase from near a historical low of 10,208 mt in 1993 to a historical high of 293,317 mt in 2016. At the beginning of 2017, adult biomass was 274,482 mt (80% confidence interval: 208,936 mt – 359,157 mt) (Figure 3). The more than doubling of the adult biomass after 2005 was due to the exceptionally strong 2003 year class, estimated at 196 million age 1 fish. A preliminary estimate for the 2016 year class is 111 million age 1 fish. The current estimate for the 2013 year class at age 1 is 885 million fish, which would make it the largest cohort in the assessment time series, followed by the 2010 year class at 243 million age 1 fish. Except for the recent strong year classes, recruitment has fluctuated between 1.8 and 26.1 million age 1 fish since 1990.

Fishing mortality (population weighted for ages 4-8 prior to 2003 and ages 5-8 for 2003-2013) fluctuated between 0.26 and 0.47 during the 1980s, and increased in 1992 to 1994 to about 0.55, the highest observed since 1971. After 2002, the age at full recruitment to the fishery has been at age 5 (previously age 4) due to a decline in size at age of haddock. Fishing was below F_{ref} = 0.26 during 1995 to 2003, fluctuated around 0.35 in 2004 to 2006, then declined to 0.15 in 2008. Fishing mortality increased to levels above F_{ref} from 2010 to 2014 before dropping off again in 2015. In 2016, F was estimated at 0.10 (80% confidence interval: 0.08-0.14), well below F_{ref} (Figure 1).

A retrospective bias was first noted in the 2014 assessment. In 2017, retrospective analyses were conducted to detect any tendency to consistently overestimate or underestimate fishing mortality, biomass, and recruitment relative to the terminal year estimates. The current assessment continues to exhibit a retrospective bias in adult (3+) biomass, recruitment and age 5-8 F, which results in decreased estimates of biomass and recruitment, and increased estimates of F when current estimates are compared to the results of previous assessments. A retrospective adjustment (denoted rho adjustment) based on the observed retrospective bias was applied to the terminal year estimates for comparisons of status determination following the methodology in Legault et al. (2010) (Table 2). The adjusted 2016 recruitment is 57.36 million which is about half of the unadjusted estimate. The adjusted 2016 5-8 F is 0.19, which is below F_{ref}. The adjusted 2017 3+ biomass is 154,877 mt, which is above the threshold of 40,000 mt where recruitment has generally been higher.

Table 2. Estimated and rho adjusted values for age 5-8 F, age 1 recruitment (R) in millions of fish and 3+ biomass (B) in metric tonnes from the Eastern Georges Bank (EGB) haddock framework VPA model.

Parameter	Estimate	rho Adjusted
2016 5-8 F	0.10	0.19
2016 R (millions)	111.58	57.36
2017 3+ B (mt)	274,482	154,877

Productivity

Recruitment, as well as age structure, spatial distribution, and fish growth reflect changes in the productive potential. Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt, and the stock has produced several exceptionally strong year classes in the last 16 years. The **population age structure** displays a broad representation of age groups, reflecting improving recruitment since 1995. The **spatial distribution** patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years.

There has been a general decline in weights at age since the late 1990s. As biomass has increased growth rates and asymptotic length have declined. This decline in size at age appears to be exacerbated for the 2013 year class (Figure 4). Fish condition, as measured by Fulton's K, has generally been below the time series average since 2004 for all three surveys and was the lowest in the time series for both the DFO and NMFS spring surveys in 2017.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2018 and 2019. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding $F_{ref} = 0.26$ in 2018 and 2019 and change in adult biomass from 2018 to 2019 and 2019 to 2020. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, the risk calculations are dependent on the data and model assumptions, and do not account for uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting, or the possibility that the model may not reflect stock dynamics closely enough.

Standard Projections

For projections, the weights at age for the 2013 year class were assumed to continue at a reduced growth rate at ages 5 through 7; these assumed values are below the lowest in the time series. For the 2010 year class, minimum values in the time series were used for weights at age. The fishery partial recruitment for the 2010 year class was assumed for the 2013 year class.

A combined Canada/USA catch of 86,000 mt in 2018 results in a neutral risk (50%) that the 2018 fishing mortality rate would exceed F_{ref} = 0.26, assuming a 2017 catch equal to the 50,000 mt total quota (Figure 5). The 2010 and 2013 year classes are expected to constitute the majority of the 2018 catch biomass at 11% and 86%, respectively. A catch of 71,000 mt in 2018 results in a low risk (25%) that the 2018 fishing mortality rate will exceed F_{ref}. A catch of 17,000 mt in 2018 results in a neutral risk (50%) that the 2018 biomass will not increase by 10%; a catch of 57,000 mt in 2018 results in a neutral risk that biomass will remain the same. Thus, both the low and neutral catch associated with not exceeding F_{ref} will produce a decline in biomass. Biomass at the beginning of 2019 is projected to be 242,883 mt fishing at F_{ref}.

A combined Canada/USA catch of 53,000 mt in 2019 results in a neutral risk (50%) that the 2019 fishing mortality rate would exceed F_{ref} = 0.26, assuming a 2017 catch equal to the 50,000 mt total quota (Figure 6). The 2010 and 2013 year classes are expected to constitute the majority of the 2019 catch biomass at 5% and 86%, respectively. A catch of 44,500 mt in 2019 results in a low risk (25%) that the 2019 fishing mortality rate will exceed F_{ref}. Even if no catch was taken in 2019, biomass is projected to decline because of the 2013 year class decrease in numbers and assumed weight at age. Biomass at the beginning of 2020 is projected to be 195,716 mt fishing at F_{ref}.

Sensitivity Projections

A sensitivity analysis to account for retrospective bias on spawning stock biomass (SSB) and F for haddock was conducted. Population numbers in 2017 (ages 0-9+) were scaled downwards to account for the retrospective pattern (rho adjusted) for deterministic projections and a risk assessment was conducted for years 2018-2020.

Assuming a 2017 catch equal to the 50,000 mt total quota, a combined Canada/USA catch of 44,000 mt in 2018 results in a neutral risk (50%) that the 2018 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 7). A catch of 35,000 mt in 2018 results in a low risk (25%) that the 2018 fishing mortality rate will exceed F_{ref} (Table 3). The 2010 year class at age 8 is expected to contribute 9% of the catch biomass and the 2013 year class at age 5 is expected to contribute 88%. A catch of 11,000 mt in 2018 results in a neutral risk (50%) that the 2018 biomass will not increase by 10%; a catch of 32,000 mt in 2018 results in a neutral risk that biomass will remain the same. Thus, the catch advice at both low and neutral risk associated with not exceeding F_{ref} in 2018 will produce a decline in biomass. Adult biomass is projected to be 126,137 mt, at the beginning of 2019 at the F_{ref} catch level.

A combined Canada/USA catch of 27,500 mt in 2019 results in a neutral risk (50%) that the 2019 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 8). A catch of 23,000 mt in 2019 results in a low risk (25%) that the 2019 fishing mortality rate will exceed F_{ref} (Table 3). The 2010 year class at age 9 is expected to contribute 4% of the catch biomass and the 2013 year class at age 6 is expected to contribute 86%. Even if no catch were taken in 2019, biomass is projected to decline. Adult biomass is projected to be 102,058 mt at the beginning of 2020 at the F_{ref} catch level.

The catch advice at F_{ref} from the sensitivity projections produces catches that are considerably lower than from standard projections.

Table 3. The levels of catch for which there is a 25%, 50% and 75% risk of the fishing mortality in 2018 and 2019 exceeding F_{ref} = 0.26 for both the standard and the rho adjusted projections.

Probability of exceeding F_{ref}	25%	50%	75%
2018 catch	71,000 mt	86,000 mt	102,000 mt
2018 catch (rho adjusted)	35,000 mt	44,000 mt	53,000 mt
2019 catch	44,500 mt	53,000 mt	63,000 mt
2019 catch (rho adjusted)	23,000 mt	27,500 mt	33,000 mt

TRAC Advice

There was consensus among all TRAC participants that catch should be lower than the standard projections due to the poor model performance and uncertainty about growth patterns and abundance for the 2013 year class. A sensitivity projection using rho adjustment was proposed as a method to reduce catch advice from the standard projection. However, there was no consensus on the appropriate magnitude for reducing catch advice, or how it should be derived. The **external reviewers** were in favour of applying the rho adjustment and following the sensitivity catch advice.

All TRAC participants agreed to provide both the standard and sensitivity (rho adjusted) projections for TMGC's consideration. There are several positive indicators for the stock, including the survey biomass being near historic highs, recent recruitment (2010 and 2013) estimated to be the highest in the time series, and expanded age structure. However, performance of the VPA model has degraded, as evidenced by the overestimation of SSB and underestimation of F in the last four assessments, the observation that terminal year biomass is lower than projected even though only about half of the quota was caught, and previous experience with assessments of other fish stocks of not accounting for retrospective bias leading to overfishing and further changes in perception of the stock status.

Special Considerations

Performance of the VPA for EGB Haddock was poor and seems to be getting worse with time. Some of the diagnostic issues were poor fits to the survey data and significant retrospective patterns in biomass, fishing mortality, and recruitment, indicating an undiagnosed misspecification in the model. The VPA modeling approach is becoming increasingly unreliable for providing management advice.

If the 2017 quota is caught, the 2017 F will be above F_{ref} due to the revision of the size of the 2013 year class in the 2017 assessment.

Source Documents

Barrett, M.A., E.N. Brooks, and Y. Wang. 2017. Assessment of Haddock on Eastern Georges Bank for 2017. TRAC Reference Document 2017/02.

Clark, K., and E.N. Brooks, editors. 2017. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder: Report of Meeting held 11-14 July 2017. TRAC Proceedings 2017/01.

Legault, C.M., L. Alade, and H.H. Stone. 2010. Stock Assessment of Georges Bank (5Zjmnh) Yellowtail Flounder for 2010. TRAC Reference Document 2010/06.

Correct Citation

TRAC. 2017. Eastern Georges Bank Haddock. TRAC Status Report 2017/02.

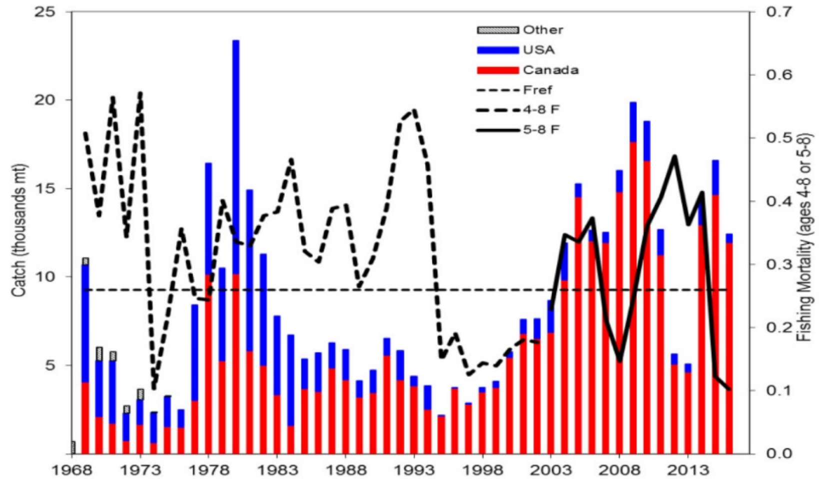


Figure 1. Catches and fishing mortality (F for ages 4-8 for 1969-2002 and ages 5-8 for 2003-2016) for Eastern Georges Bank (EGB) haddock. The asterisk (*) represents the rho adjusted value for fishing mortality in the terminal year.

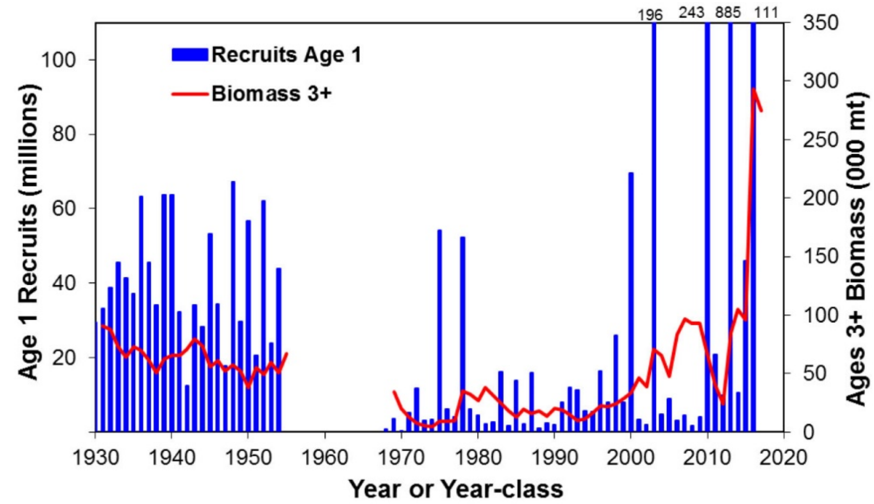


Figure 3. Biomass and recruitment for EGB haddock. The asterisk (*) represents the rho adjusted value for biomass (red) and recruits (blue) in the terminal year.

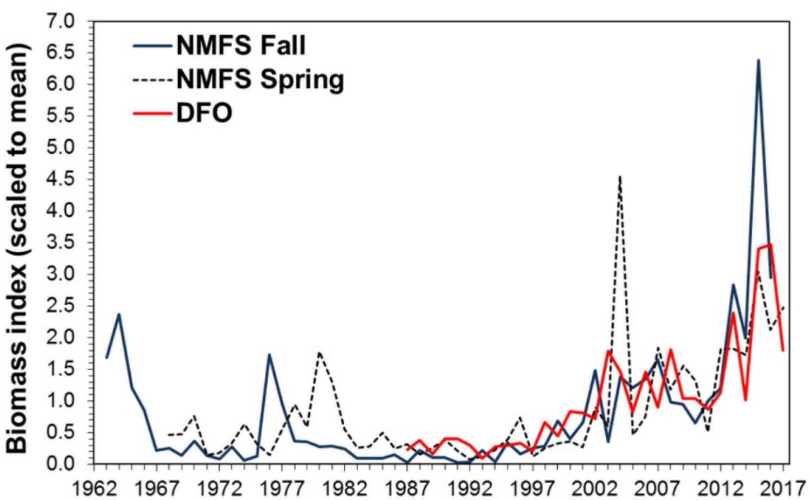


Figure 2. Scaled total biomass indices from research surveys for EGB haddock.

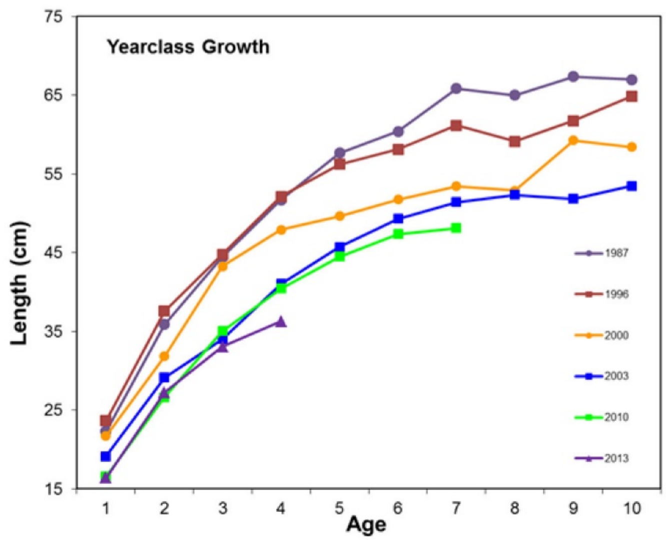


Figure 4. Mean length at age for selected year classes of EGB haddock sampled from the DFO survey.

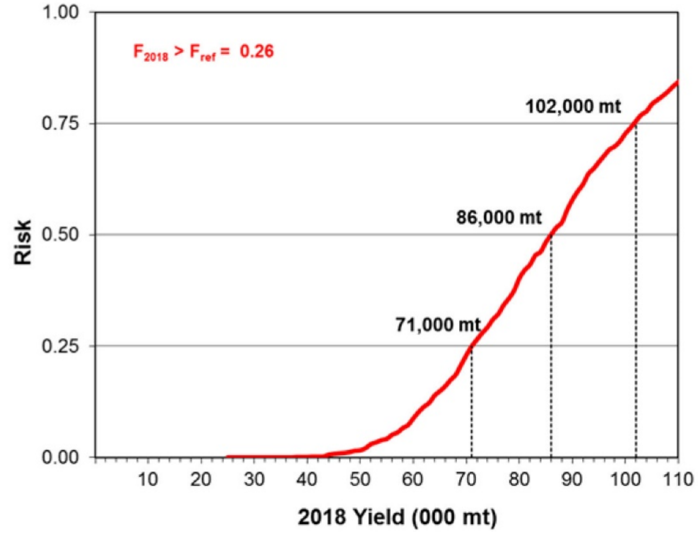


Figure 5. 2018 yield projection risks for EGB haddock.

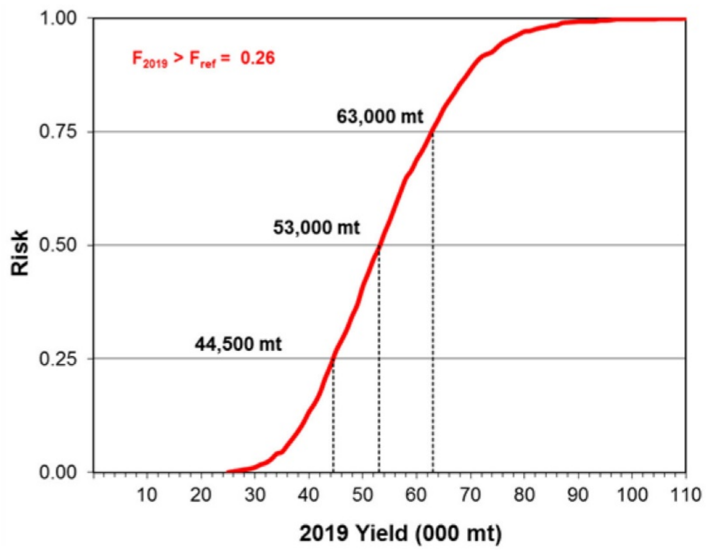


Figure 6. 2019 yield projection risks for EGB haddock assuming 2018 catch at F_{ref}.

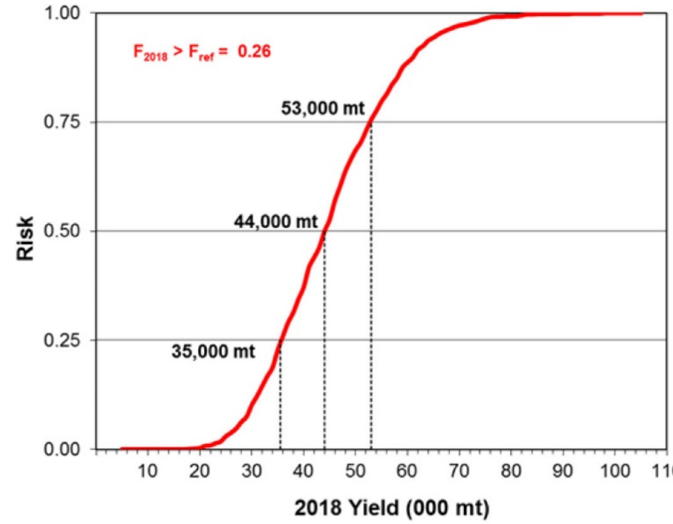


Figure 7. 2018 sensitivity (rho adjusted) yield projection risks for EGB haddock.

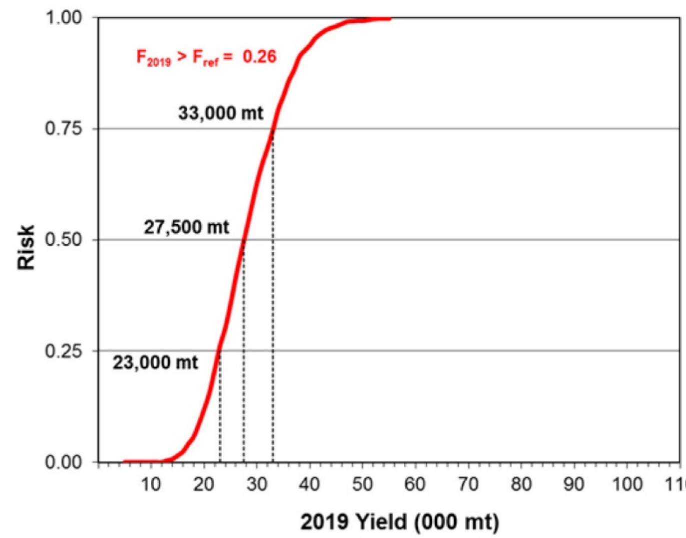


Figure 8. 2019 sensitivity (rho adjusted) yield projection risks for EGB haddock assuming 2018 catch at F_{ref}.