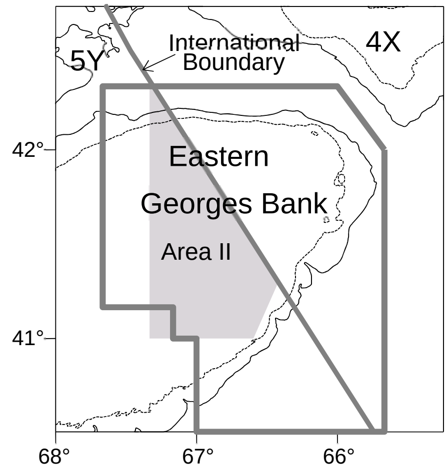
Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans
NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

Status Report 2015/02 (Revised)

EASTERN GEORGES BANK HADDOCK

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



Summary

- Combined Canada and USA catches in 2014 were 14,243 mt.

- At the beginning of 2015, adult biomass was 117,000 mt.

- A preliminary estimate for the 2014 year class is 12.9 million age 1 fish. The current estimate for the 2013 year class is 1,300 million age 1 fish, which would make it the largest cohort in the assessment time series, followed by the 2010 year class at 275 million. Except for the strong 2000 and 2011 year classes and the exceptionally strong 2003, 2010 and 2013 year classes, recruitment has fluctuated between 2.1 and 27.3 million since 1990.

- Fishing mortality (F) was below F_{ref} = 0.26 during 1995 to 2003, fluctuated around 0.33 in 2004 to 2006, then declined to 0.13 in 2008. Fishing mortality increased to levels above F_{ref} from 2010-2012 before dropping off again in 2013. In 2014, F was estimated at 0.23 (80% confidence interval: 0.20-0.30), just below $F_{ref.}$

- This stock exhibits a number of positive features. It has produced three exceptionally strong and two strong year classes in the last 13 years. The population age structure displays a broad representation of age groups. The spatial distribution patterns were similar to the average patterns over the previous ten years. However, there has been a general decline in weights at age since the late 1990s and fish condition derived from DFO survey data has generally been below the time series average since 2004.

Ce document est disponible sur l'Internet à : This document is available on the Internet at :
http://www.bio.gc.ca/info/intercol/trac-cert/index-en.php

July 2015
(Revised: July 27, 2015)

- Assuming a 2015 catch equal to the 37,000 mt total quota, a combined Canada/USA catch of 37,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} = 0.26. The probability that the biomass will not increase from 2016 to 2017 by 10% is negligible. Biomass at the beginning of 2017 is projected to be 522,000 mt fishing at F_{ref}.

- Assuming a 2015 catch equal to the 37,000 mt total quota and a 2016 catch at F_{ref} = 0.26, a combined Canada/USA catch of 81,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26. The probability that the biomass will not increase from 2017 to 2018 is high; population biomass in 2018 is expected to decline even at low levels of fishing. Biomass at the beginning of 2018 is projected to be 463,800 mt fishing at F_{ref}.

- A retrospective bias was first noted in the 2014 assessment. The current assessment exhibits retrospective bias in adult biomass and age 5-8 F which results in decreases in adult biomass and increases in F compared to the results of previous assessments.

- To account for the retrospective bias, a sensitivity projection using the rho adjusted 2015 population numbers was conducted. Assuming a 2015 catch equal to the 37,000 mt total quota, the rho adjusted projection indicates that a combined Canada/USA catch of 19,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} = 0.26 and that a combined Canada/USA catch of 45,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26.

- The Transboundary Resources Assessment Committee (TRAC) acknowledges that there are several reasons for considering both the standard projection and the sensitivity projection (rho adjusted) for catch advice. Given this, the TRAC has agreed to provide both projections for Transboundary Management Guidance Committee's (TMGC) consideration.

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

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	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			
	Landed	12.0	11.9	14.8	17.6	16.6	11.2	5.0	4.6	13.0		5.6	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	0.2
USA[2]	**Quota[3]**	7.5	6.3	8.1	11.1	12.0	9.5	6.9	4.0	10.5	17.8			
	Catch[3]	0.7	0.3	1.6	1.6	1.8	1.1	0.4	0.6[4]	1.3				
	Landed	0.3	0.3	1.1	2.2	2.2	1.3	0.4	0.3	1.2		2.0	<0.1	9.1
	Discard	0.3	0.3	0.1	0.1	<0.1	0.1	0.1	0.1	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			
	Catch[5,6]	12.7	12.3	16.5	19.2	18.4	12.3	5.5	5.2	14.6				
	Catch	12.6	12.5	16.0	19.9	18.8	12.7	5.6	5.1	14.2		8.2	2.1	23.3
Adult Biomass[7]		88.8	104.2	101.0	102.0	74.3	47.5	29.9	99.5	125.7	117.0	38.1[8]	4.9[8]	125.7[8]
Age 1 Recruits		9.8	3.6	4.8	3.1	5.4	274.7	33.9	14.5	1,300.0	12.9	48.4[8]	0.2[8]	1,300.0[8]
Fishing mortality[9]		0.35	0.20	0.13	0.22	0.31	0.33	0.37	0.22	0.23		0.31	0.08	0.57
Exploitation Rate[9]		27%	16%	11%	18%	24%	26%	28%	18%	19%		24%	9%	40%

[1]1969 – 2014
[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 – 2015
[9]ages 4-8 for 1969 – 2002; ages 5-8 for 2003 – 2014

Fishery

Combined Canada/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 but increased to 19,855 mt in 2009, decreased the following years, and were 14,243 mt in 2014 (Table 1).

The **Canadian catch** increased from 4,631 mt in 2013 to 12,953 mt in 2014. Discards in the groundfish fishery are considered to be negligible. Discards of haddock by the Canadian sea scallop fishery ranged between 10 mt and 186 mt from 1969 to 2014 and were 17 mt in 2014.

USA catches increased from 435 mt in 2013 to 1,290 mt in 2014. Landings were 1,182 mt and discards were estimated to be 108 mt, primarily from the otter trawl fishery with a small amount from the scallop dredge fishery (3 mt).

The combined Canada/USA **fishery age composition** (landings + discards) in 2014 was dominated by the 2010 year class (age 4) 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 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.

State of Resource

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 2014 (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, lower exploitation, and reduced capture of small fish in the fisheries allowed the **adult population biomass** (ages 3+) to increase from near a historical low of 10,300 mt in 1993 to a historical high of 125,700 mt in 2014. The beginning of year biomass estimate for 2015 is slightly lower at 117,000 mt (80% confidence interval: 92,500 mt – 153,000 mt) (Figure 2). The more than doubling of the adult biomass after 2005 was due to the exceptionally strong 2003 year class, estimated at 211 million age 1 fish. A preliminary estimate for the 2014 year class is 12.9 million age 1 fish. The current estimate for the exceptional 2013 year class is 1,300 million age 1 fish, which would make it the largest cohort in the assessment time series, followed by the 2010 year class at 275 million. Except for the strong 2000 and 2011 year classes and the exceptionally strong 2003, 2010 and 2013 year classes, recruitment has fluctuated between 2.1 and 27.3 million since 1990.

Fishing mortality (population weighted for ages 4-8) fluctuated between 0.28 and 0.50 during the 1980s, and increased in 1992-1994 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 mortality (population weighted for ages 4-8 prior to 2003 and ages 5-8 for 2003-2013) was below F_{ref} = 0.26 during 1995 to 2003, fluctuated around 0.33 in 2004 to 2006, then declined to 0.13 in 2008. Fishing mortality increased to levels above F_{ref} from 2010-2012 before dropping off again in 2013. In 2014, F was estimated at 0.23 (80% confidence interval: 0.20-0.30), just below F_{ref} (Figure 1).

A retrospective bias was first noted in the 2014 assessment. In 2015, 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 exhibits a retrospective bias in adult (3+) biomass and age 5-8 F, which results in decreases in biomass and increases in F 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 2014 5-8 F is 0.39, which is above F_{ref} = 0.26. The adjusted 2015 3+ biomass is 62,871 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
2014 5-8 F	0.23	0.39
2014 R (millions)	12.945	7.637
2015 3+ B (mt)	117,000	62,871

Productivity

This stock exhibits a number of positive features. It has produced three exceptionally strong and two strong year classes in the last 13 years. 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, which has been the case since 2001 (Figure 3). The **population age structure** displays a broad representation of age groups, reflecting improving recruitment and lower exploitation 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. However, there has been a general decline in weights at age since the late 1990s. The 2003 year class reached its maximum growth potential at a smaller average size than year classes from the 1990s. The 2010 and 2013 year classes are both showing similar growth to the 2003 year class. Fish condition, as measured by Fulton's K derived from DFO survey data, has generally been below the time series average since 2004.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2016 and 2017. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding $F_{ref} = 0.26$ and change in adult biomass from 2016 to 2017 and 2017 to 2018. 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 2015 survey weights were used for the 2015 beginning of year population. The most recent 3-year survey (2012-2015) weights at age were used for the 2016 to 2018 beginning of year populations, with the exception of the slow growing 2013 year class at ages 3, 4 and 5 for which the average weights at corresponding ages of the equally slow growing 2010 year class were used. The lowest fishery average weights at age (for 1969-2014) were used for beginning year fishery weights at age. Fishery partial recruitment (PR) was based on the 2005 to 2014 population weighted average. The PR on the age 9+ group was 0.26, which was consistent with the model. The 2010 year class values were used for the 2013 year class for population weights due to similarity in growth.

Assuming a 2015 catch equal to the 37,000 mt total quota, a combined Canada/USA catch of 37,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 4). The 2010 and 2013 year classes are expected to constitute the majority of the 2016 catch biomass at 46% and 41%, respectively. A catch of 32,000 mt in 2016 results in a low risk (25%) that the 2016 fishing mortality rate will exceed F_{ref}. A catch of 43,500 mt in 2016 results in a high risk (75%) that the 2016 fishing mortality rate will exceed F_{ref}

(Table 3). The probability that the biomass will not increase from 2016 to 2017 by 10% is negligible. Biomass at the beginning of 2017 is projected to be 522,300 mt fishing at F_{ref}.

Assuming a 2015 catch equal to the 37,000 mt total quota and a 2016 catch at $F_{ref} = 0.26$, a combined Canada/USA catch of 81,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 5). The 2010 and 2013 year classes are expected to constitute the majority of the 2017 catch biomass at 16% and 78%, respectively. A catch of 66,000 mt in 2017 results in a low risk (25%) that the 2017 fishing mortality rate will exceed F_{ref}. A catch of 97,000 mt in 2017 results in a high risk (75%) that the 2017 fishing mortality rate will exceed F_{ref} (Table 3). The probability that the biomass will not increase from 2017 to 2018 is high; population biomass in 2018 is expected to decline even at low levels of fishing. Biomass at the beginning of 2018 is projected to be 463,800 mt fishing at F_{ref}.

Table 3. The levels of catch for which there is a 25%, 50% and 75% percent risk of the fishing mortality in 2016 and 2017 exceeding $F_{ref} = 0.26$ for both the standard and the rho adjusted projections.

Probability of exceeding F_{ref}	25%	50%	75%
2016 catch	32,000 mt	37,500 mt	43,500 mt
2016 catch (rho adjusted)	16,000 mt	19,500 mt	22,500 mt
2017 catch	66,000 mt	81,000 mt	97,000 mt
2017 catch (rho adjusted)	37,000 mt	45,000 mt	55,000 mt

Sensitivity Projections

A sensitivity analysis to account for retrospective bias on spawning stock biomass (SSB) and F for haddock was conducted. Population numbers in 2015 (ages 0-9+) were rho adjusted for deterministic projections and a risk assessment was conducted for years 2016-2018. Assuming a 2015 catch equal to the 37,000 mt total quota, a combined Canada/USA catch of 19,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 6). A catch of 16,000 mt in 2016 results in a low risk (25%) that the 2016 fishing mortality rate will exceed $F_{ref.}$ A catch of 22,500 mt in 2016 results in a high risk (75%) that the 2016 fishing mortality rate will exceed F_{ref} (Table 3). The 2010 year class at age 6 is expected to contribute 40% of the catch biomass and the 2013 year class at age 3 is expected to contribute 47%. The probability that the 2017 biomass will not increase by 10% is negligible. Adult biomass is projected to be 299,000 mt, at the beginning of 2017 at the F_{ref} catch level.

A combined Canada/USA catch of 45,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 7). A catch of 37,000 mt in 2017 results in a low risk (25%) that the 2017 fishing mortality rate will exceed $F_{ref.}$ A catch of 55,000 mt in 2017 results in a high risk (75%) that the 2017 fishing mortality rate will exceed F_{ref} (Table 3). The 2010 year class at age 7 is expected to contribute 13% of the catch biomass and the 2013 year class at age 4 is expected to contribute 82%. The probability that the 2018 biomass will not increase by 10% is high because population biomass is expected to decline from 2017 to 2018. Adult biomass is projected to be 268,000 mt at the beginning of 2018 at the F_{ref} catch level.

The F_{ref} catches from the sensitivity projections are considerably lower than the catches from standard projections but they do take into account the emerging retrospective pattern which has occurred over the past two years in this assessment.

TRAC Advice

The TRAC acknowledges that there are reasons for considering both the standard projection and the sensitivity projection (rho adjusted) for catch advice. Reasons for using the standard projection include the survey biomass being at or near historic highs, recent recruitment (2010 and 2013) estimated to be the highest in the time series, expanded age structure, and success at projecting age composition of the fishery catch. Reasons for using the sensitivity projection include the overestimation of SSB and underestimation of F in the last two assessments, the observation that terminal year biomass is lower than projected even though only about half[1] 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. For these reasons, the TRAC has agreed to provide both projections for TMGC's consideration.

Special Considerations

The 2015 DFO survey index is the highest value for the time series (1986-2015), while the 2014 NMFS fall and the 2015 NMFS spring survey values are the second highest values for their respective time series.

Although the fishing mortality reference is based on a PR of 1 for older ages, the benchmark model indicates a PR of 0.26 for the 9+ age group. Several corroborating factors influenced the decision to use the lower PR produced by the model in the projections; for example, the predicted versus observed 2014 catch at age values support the use of the lower PR.

If the 2015 quota is caught, the 2015 F will be above F_{ref} due to the revision of the size of the 2010 year class in the 2015 assessment.

The TRAC examined the uncertainty in terminal year estimates (bootstrap results) relative to uncertainty indicated by the retrospective bias. The terminal year rho adjusted SSB and rho adjusted F were well outside of both the 80% and 95% confidence intervals of the point estimates. This result indicates there is substantial unmeasured uncertainty, which has increased since last year's assessment.

Source Documents

Curran, K.J., and E.N. Brooks, editors. 2015. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder: Report of Meeting held 7-9 July 2015. TRAC Proceedings 2015/01.

[1] Revision (July 27, 2015): Sentence corrected by deleting "less than half" and replacing with "only about half".

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.

Stone, H.H, E.N. Brooks, D. Busawon, and Y. Wang. 2015. Assessment of Haddock on Eastern Georges Bank for 2015. TRAC Reference Document 2015/02.

Correct Citation

TRAC. 2015. Eastern Georges Bank Haddock. TRAC Status Report 2015/02.

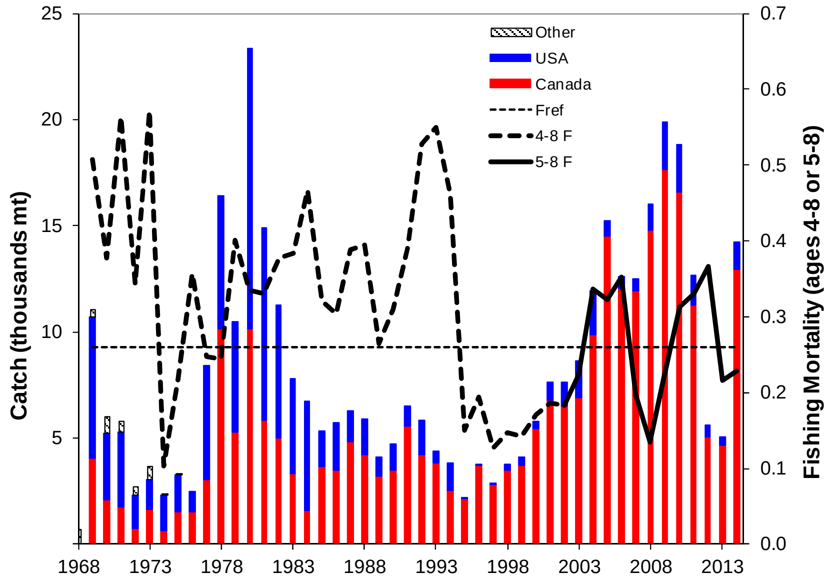


Figure 1. Catches and fishing mortality (F for ages 4-8 for 1969-2002 and ages 5-8 for 2003-2014) for Eastern Georges Bank (EGB) haddock.

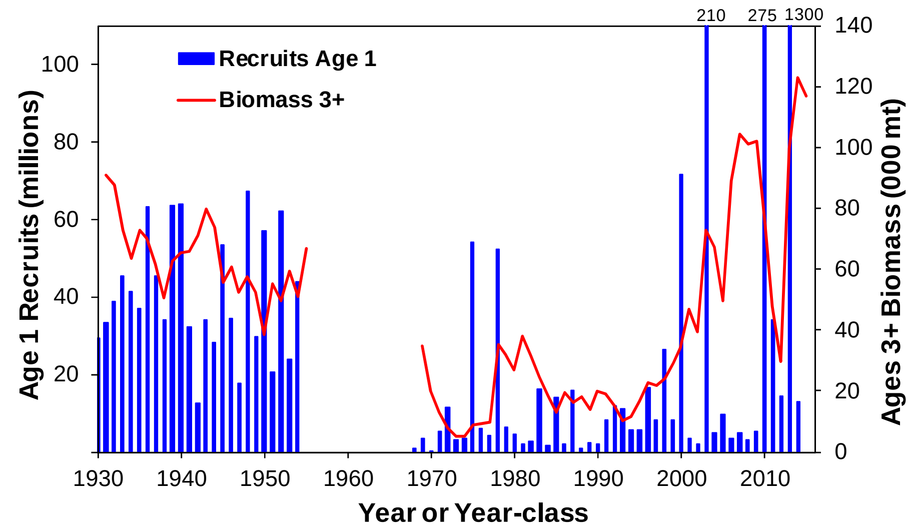


Figure 2. Biomass and recruitment for EGB haddock.

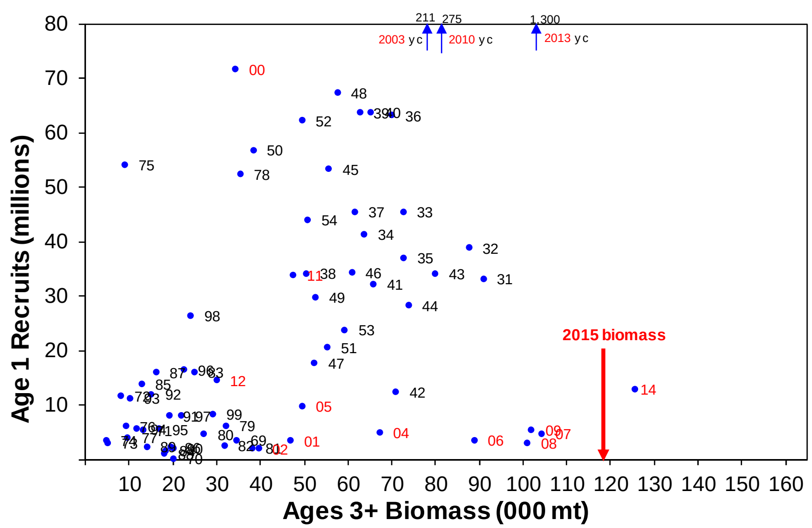


Figure 3. Stock recruitment patterns for EGB haddock.

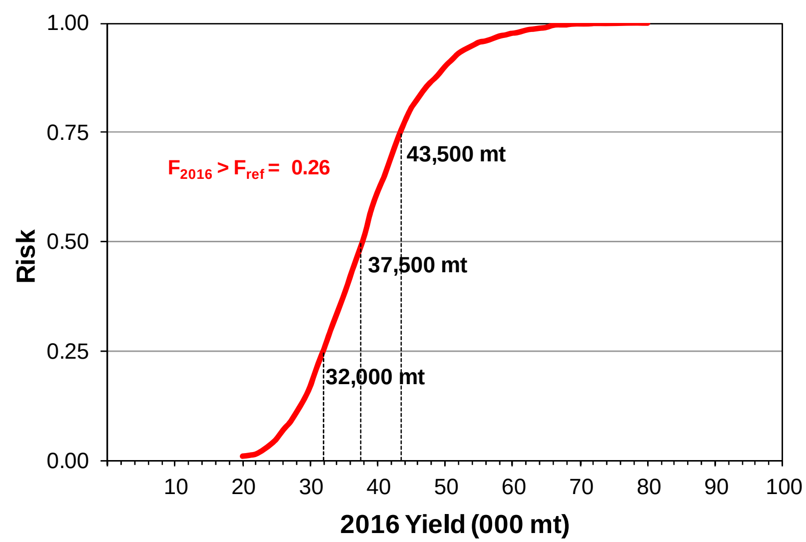


Figure 4. 2016 yield projection risks for EGB haddock.

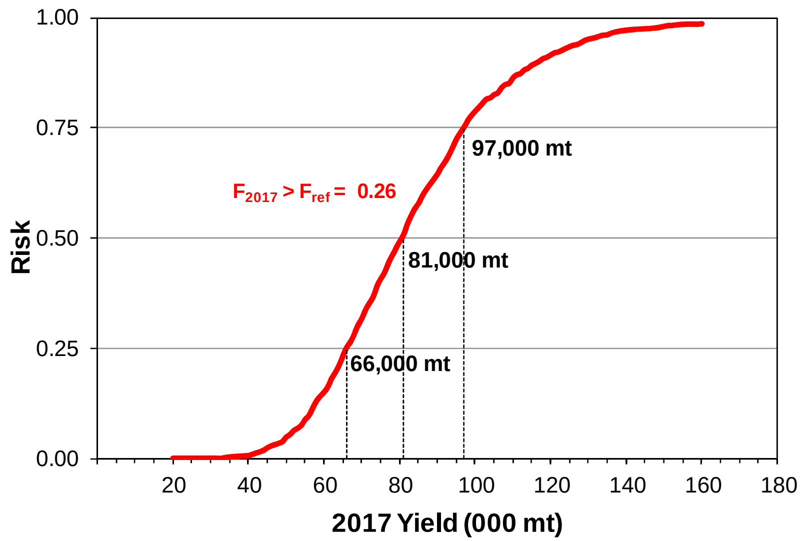


Figure 5. 2017 yield projection risks for EGB haddock.

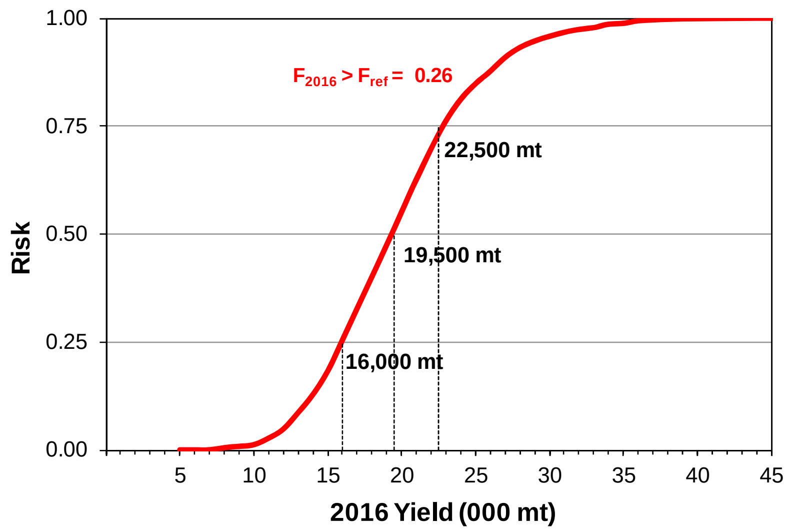


Figure 6. 2016 sensitivity (rho adjusted) yield projection risks for EGB haddock.

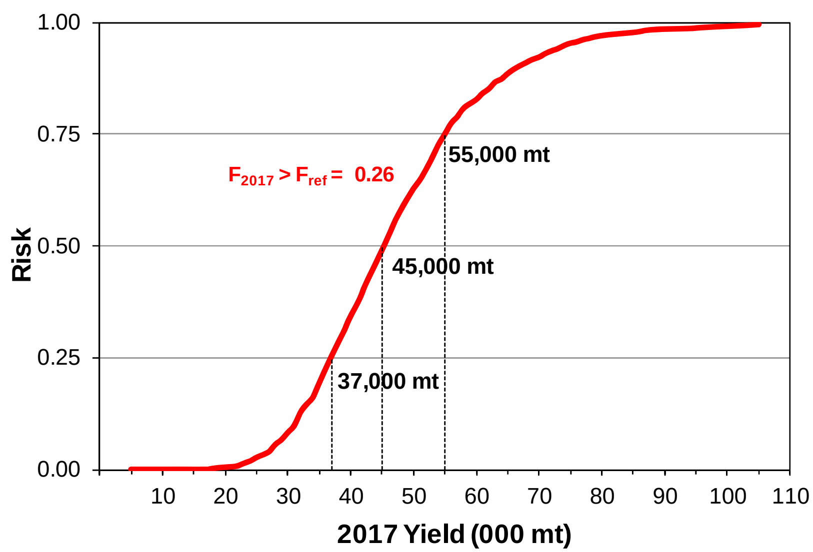


Figure 7. 2017 senstivity (rho adjusted) yield projection risks for EGB haddock