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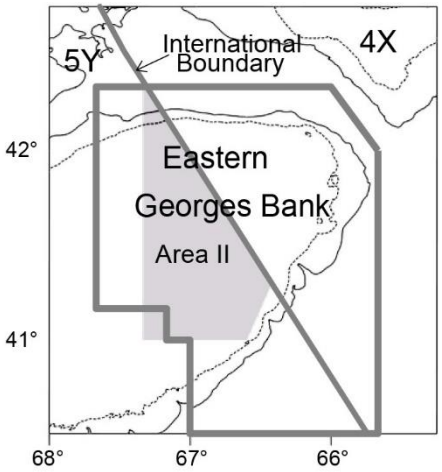
NOAA FISHERIES NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

Status Report 2015/01

EASTERN GEORGES BANK COD

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



Summary

- Combined Canada/USA catches were 574 mt, including 30 mt of discards in 2014.
- The Virtual Population Analysis (VPA) "M 0.8" model from the 2013 benchmark was used to provide catch advice. Natural mortality (M) was fixed at 0.2 for all ages in all years, except for ages 6+ in years from 1994 onward, where M = 0.8.
- Since 1995, adult population biomass (ages 3+) has fluctuated between 5,900 mt and 18,800 mt. The estimated adult population biomass at the beginning of 2015 from the VPA "M 0.8" model was 10,048 mt.
- Recruitment at age 1 has been low in recent years. The 2003 and 2010 year classes are estimated to be the highest recruitments since 1998. The current estimate of the 2013 year class is about two-thirds of the 2003 and 2010 year class based on the 2015 assessment. The 2012 year class is the lowest on record.
- Fishing mortality (F) has been declining since 2007 and has been at or below F = 0.11 since 2011. F in 2014 was estimated to be 0.04.
- Average weight at length, used to reflect condition, has been stable in the past, but has started to decline in recent years. Lower weights at age in the population in recent years and poor recruitment have contributed to the lack of rebuilding.
- In 2016, a 50% probability of not exceeding F = 0.11 corresponds to catches less than 675 mt. However, given the extremely low spawning stock biomass (SSB), the Transboundary

Resources Assessment Committee (TRAC) advises that management aim to rebuild SSB. Even with no fishing in 2016 there is a greater than 50% risk of a decrease in adult biomass from 2016 to 2017, and a catch of 475 mt would result in at least a 75% risk that 2017 adult biomass would decrease.

- In 2017, a 50% probability of not exceeding F = 0.11 corresponds to catches less than 725 mt. A catch of 625 mt will result in a neutral risk (50%) risk that 2018 age 3+ biomass will be lower than 2017, whereas a catch of 225 mt has a lower (25%) risk.

- A sensitivity risk analysis was conducted with an assumed 2016 catch equal to 600 mt, which has a 25% risk of exceeding F = 0.11. In 2017, a 50% risk of not exceeding F = 0.11 corresponds to catches less than 750 mt. A catch of 575 mt will result in a neutral (50%) risk that 2018 age 3+ biomass will be lower than 2017, whereas a catch of 175 mt has a lower (25%) risk.

- A consequence analysis to understand the risks associated with assumptions of the VPA "M 0.8" and ASAP "M 0.2" models was examined.

- Discovery that the risk analysis for the VPA results did not account for the differences in natural mortality rate between young ages and ages 6+ could have impacted catch advice since 2009.

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[9]	Quota	1.3	1.4	1.6	1.2	1	0.9	0.5	0.5	0.5	*0.5*			
	Catch	1.4	1.2	1.5	1.2	0.8	0.7	0.5	0.4	0.5		5.4	0.4	17.9
	Landed	1.1	1.1	1.4	1	0.7	0.7	0.4	0.4	0.4		5.3	0.4	17.8
	Discard	0.3	0.1	0.1	0.2	0.1	<0.1	0.1	<0.1	<0.1		0.2	<0.1	0.5
USA[9]	Quota[2]	0.4	0.5	0.7	0.5	0.3	0.2	0.2	0.1	0.2	0.1			
	Catch[2]	0.3	0.3	0.5	0.5	0.3	0.2	<0.1	<0.1	<0.1[10]				
	Landed	0.1	0.2	0.2	0.4	0.4	0.3	0.1	<0.1	0.1		3.3	<0.1	10.6
	Discard	0.1	0.3	<0.1	0.2	0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	0.3
Total[9]	Quota	1.7	1.9	2.3	1.7	1.3	1.1	0.7	0.6	0.7	0.65			
	Catch[3,4]	1.7	1.5	2.0	1.7	1.1	0.9	0.5	0.4	0.5[10]		9	0.5	26
	Catch	1.6	1.7	1.7	1.8	1.3	1.0	0.6	0.4	0.6				
From "M 0.8" model														
Adult Biomass[5]		7.5	7.5	9.0	11.4	10.3	8.7	7.9	9.1	9.9	10.0	25.7	5.9	59.7
Age 1 Recruits		3.7	2.5	1.4	0.9	1.4	4.4	1.5	0.4	3.1		5.7	0.5	24.1
Fishing mortality[6]		0.35	0.26	0.23	0.15	0.13	0.11	0.07	0.05	0.04		0.34	0.04	0.66
Exploitation Rate[7]		27%	21%	18%	15%	11%	14%	9%	6%	5%		25%	5%	44%
Exploitation Rate[8]		21%	21%	21%	22%	20%	12%	4%	1%	1%		23%	1%	46%

[1]1978 – 2014
[2]for fishing year from May 1 – April 30
[3]for Canadian calendar year and USA fishing year May 1-April 30
[4]sum of Canadian landed, Canadian discard, and USA catch (includes discards)
[5]Jan 1 ages 3+
[6]ages 4-9
[7]ages 4-5; M = 0.2
[8]ages 6-9; M = 0.8
[9] unless otherwise noted, all values reported are for calendar year
[10] preliminary estimate

Fishery

Combined Canada/USA catches in 2014 were 574 mt which included 30 mt of discards, with a quota of 700 mt (Table 1). Historically, catches averaged 17,198 mt between 1978 and 1993, peaking at 26,463 mt in 1982. Catches declined to 1,683 mt in 1995, then fluctuated at about 3,000 mt until 2004 and have subsequently declined (Figure 1).

Canadian catches increased from 424 mt in 2013 to 458 mt in 2014. Discards were estimated at 13 mt from the mobile gear and fixed gear fleets. Since 1996, the Canadian scallop fishery has not been permitted to land cod. Estimated discards of cod by the Canadian scallop fishery were 15 mt in 2014.

USA catches increased from 40 mt in 2013 to 116 mt in 2014. Estimated discards of cod for 2014 were 2 mt, almost entirely from the otter trawl groundfish fishery.

The combined Canada/USA 2014 **fishery age composition** (landings + discards) was dominated by the 2010 year class at age 4, followed by the 2011 year class at age 3 and the 2009 year class at age 5. The contribution to the catch of fish older than age 7 continued to be small in recent years: 0.2% by number and 1% by weight in 2014. 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}. At the 2013 Eastern Georges Bank Cod benchmark meeting, it was agreed that $F_{ref} = 0.18$ is not consistent with the VPA "M 0.8" model. At the 2014 TRAC, it was agreed that $F = 0.11$ was a more appropriate fishing mortality reference point for the VPA "M 0.8" model than F_{ref}. 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 (i.e., VPA), which used fishery catch statistics and sampling for size and age composition of the catch for 1978 to 2014 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series: DFO, NMFS spring, and NMFS fall.

The agreement at the benchmark assessment review in 2013 was to provide catch advice based on a VPA "M 0.8" model (Claytor and O'Brien, 2013). Natural mortality (M) was fixed at 0.2 for all the ages in all years, except for ages 6+ in years from 1994 onward, where M = 0.8.

Since 1995, **adult population biomass** (ages 3+) has fluctuated between 5,900 mt and 18,800 mt (Figure 2). The estimated adult population biomass at the beginning of 2015 from the VPA "M 0.8" model was 10,048 mt, which was about 20% of the adult biomass at the start of the time series in 1978 (Figure 2). The increase since 2005 was largely due to recruitment and growth of the 2003 and 2010 year class.

Recruitment at age 1 has been low in recent years (Figure 2). The 2003 and 2010 year classes are estimated to be the highest since 1998. The current estimate of the 2013 year class is about two-thirds of the 2003 and 2010 year classes based on the 2015 assessment. The other year classes are weak, and the 2012 year class is the lowest on record.

Fishing mortality (population weighted average of ages 4-9) has been declining since 2007 and has been at or below F= 0.11 since 2011. F in 2014 was estimated to be 0.04 from the VPA "M 0.8" model (Figure 1).

Productivity

Recruitment, age structure, fish growth, and spatial distribution typically reflect changes in the productive potential. The current biomass is well below 25,000 mt. When biomass is above this threshold, there is a better chance for higher recruitment (Figure 3). The **population age structure** displays a low proportion of ages 7+ compared to the 1980s. Average weight at length, used to reflect condition, has been stable in the past, but has started to decline in recent years. Lower weights at age in the population in recent years and poor recruitment have contributed to the lack of rebuilding. **Size at age** in the 2014 fishery remained at low levels. The research survey **spatial distribution** patterns of adult (3+) cod have not changed over the past decade.

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 = 0.11 and change in adult (ages 3+) biomass from 2016 to 2017 and from 2017 to 2018. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, 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 (PR) to the fishery, natural mortality, systematic errors in data reporting, the possibility that the model may not reflect stock dynamics closely enough, and retrospective bias.

For **projections**, the average of the most recent three years of fishery and survey weight data were used for fishery weights and beginning year population weights, respectively, for 2016- 2018. The 2015-2017 PR pattern was based on the most recent five years of estimated PR. The 2009-2013 average of recruitment at age 1 was used for 2016-2018 projections. The projection could be optimistic if the 2014 and 2015 year classes are lower. Catch in 2015 was assumed to be equal to the 650 mt quota, and F = 0.11 in 2016 and 2017.

During the TRAC, it was discovered that the age specific difference in natural mortality (M = 0.2, except M = 0.8 for ages 6+) was not accounted for in calculations of reference exploitation rate in the stochastic projections (i.e., Table 2a) for the VPA "M = 0.8" model. Although the specific implications of this could not be evaluated at TRAC, it was noted that the deterministic projection (with the correct calculation that accounted for the age differences in M) produced a 2016 catch of 842 mt. Generally, deterministic and stochastic projections result in very similar estimates of catch. On this basis, the TRAC agrees that a revised stochastic risk

analysis would likely result in an increase in the calculated catch on the order of 100-200 mt. Given this uncertainty and due to the current status of the stock, the TRAC recommends that the risk calculations provided remain appropriate despite the unaccounted for age specific difference in the stochastic projections.

Table 2a. Risk of fishery catch exceeding F reference point 0.11 in 2016 and 2017.

Probability	0.25	0.5	0.75
2016	600 mt	675 mt	775 mt
2017(if F_{2016} = 0.11)	640 mt	725 mt	850 mt
2017(if 2016 catch = 600mt)	650 mt	750 mt	875 mt

Table 2b. Risk that ages 3+ biomass will not increase from 2016 to 2017 and from 2017 to 2018.

Probability	0.25	0.5	0.75
2016 to 2017	0 mt	0 mt	475 mt
2017 to 2018 (if F_{2016} = 0.11)	225 mt	625 mt	1,025 mt
2017 to 2018 (if 2016 catch = 600mt)	175 mt	575 mt	1,025 mt

In 2016, a 50% risk of not exceeding F = 0.11 corresponds to catches less than 675 mt, and catches less than 600 mt correspond to a lower (25%) risk (Table 2a, Figure 4). Even with no fishing in 2016 there is a greater than 50% risk of a decrease in adult biomass from 2016 to 2017, and a catch of 475 mt would result in at least a 75% risk that 2017 adult biomass would decrease (Table 2b, Figure 4).

In 2017, a 50% risk of not exceeding F =0.11 corresponds to catches less than 725 mt, and catches less than 640 mt correspond to a lower (25%) risk (Table 2a, Figure 5). A catch of 625 mt will result in a neutral risk (50%) risk that 2018 age 3+ biomass will be lower than 2017, whereas a catch of 225 mt has a lower (25%) risk (Table 2b, Figure 5).

A sensitivity risk analysis was conducted with an assumed 2016 catch equal to 600 mt, which has a 25% risk of exceeding F = 0.11, as shown in Tables 2a and 2b. In 2017, a 50% risk of not exceeding F = 0.11 corresponds to catches less than 750 mt, and catches less than 650 mt corresponds to a lower (25%) risk (Table 2a, Figure 6). A catch of 575 mt will result in a neutral (50%) risk that 2018 age 3+ biomass will be lower than 2017, whereas a catch of 175 mt has a lower (25%) risk (Table 2b, Figure 6).

TRAC Advice

While management measures have resulted in a decreased exploitation rate since 1995, total mortality has remained high and adult biomass has fluctuated at a low level. The continuing poor recruitment since the early 1990s and the assumed high natural mortality on ages 6+ since 1995 are important factors for this lower productivity. Rebuilding will not occur without improved

recruitment. Given the extremely low spawning stock biomass (SSB), TRAC advises that management aim to rebuild SSB.

Consequence Analysis

Two models were examined at the benchmark. Natural mortality is assumed to be higher for age 6+ in the VPA (M = 0.8) compared to M = 0.2 for all ages in the ASAP model. Comparison of the 2015 assessment results of the two models indicates that biomass (ages 3+) is estimated to be higher in the VPA, in contrast to the ASAP model that estimated lower biomass (ages 3+). A consequence analysis to understand the risks associated with assumptions of the VPA "M 0.8" and ASAP "M 0.2" models was examined. This consequence analysis shows: 1) the projected catch (ages 1+) at F_{ref} = 0.18 and F = 0.11 and percent change in biomass, as if each model represented the "true state" of the resource; and 2) the consequences to fishing mortality and expected biomass (ages 3+) when 'true state' catch levels are removed under the assumptions of the other "alternate state" model.

In 2016, a catch of 675 mt at F = 0.11 would result in a decrease in the 2017 biomass for both models (6% in the VPA "true state" and 2% in the ASAP "alternate state"). A catch of 223 mt at F_{ref} = 0.18 would result in a 26% increase in the 2017 biomass based on the ASAP "true state", but a decrease of 3% based on the VPA "alternate state".

In 2017, a catch of 725 mt at F = 0.11 would result in a decrease in the 2017 biomass of 1% in the VPA "true state" and an increase of 31% in the ASAP "alternate state". A catch of 304 mt at F_{ref} = 0.18 would result in a 58% increase in the 2017 biomass based on the ASAP "true state", but a decrease of 1% based on the VPA "alternate state".

CONSEQUENCE ANALYSIS

Catch 2014		574 mt	
Quota 2015		650 mt	
		VPA 0.8	**ASAP 0.2**
2014 biomass (3+)		9,932 mt	2,422 mt
2015 biomass (3+)		10,048 mt	*1,521 mt*[1]
Projected catch(mt)			
VPA F=0.11		"true state"	"alternate state"
2016 catch = 675	2016 F	0.11	0.65
	2017 Biomass (mt)	9,425	1,610
	% B from 2016	-6%	-2%
2017 catch = 725	2017 F	0.11	0.66
	2018 Biomass (mt)	9,368	2,399
	% B from 2017	-1%	31%
ASAP F=0.18		"alternate state"	"true state"
2016 catch = 223	2016 F	0.028	0.18
	2017 Biomass (mt)	9,767	2,058
	% B from 2016	-3%	26%
2017 catch = 304	2017 F	0.034	0.18
	2018 Biomass (mt)	9,679	3,249
	% B from 2017	-1%	58%

	F<=F ref.pt. & biomass increase > 10%
	F<=F ref.pt. & biomass increase < 10%
	F> F ref.pt. & biomass increase < 10%
	F> F ref.pt. & biomass increase >10%

[1] derived from ASAP bootstrapped beginning year 2015 population numbers

Special Considerations

The consequence analysis reflects the uncertainties in the assessment model assumptions. Considering the current poor stock conditions, despite these uncertainties, all assessment results indicate that low catches are needed to promote rebuilding.

The discovery that the calculation being made in the risk analysis for the VPA results did not account for the differences in natural mortality rate between young ages and ages 6+ could have impacted catch advice since 2009 (see Outlook section). The TRAC compared deterministic and stochastic projections results for assessments since 2009 and found that the differences were minimal (-11% to 7%) until 2015 (20%).

Source Documents

Claytor R., and L. O'Brien, editors. 2013. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Transboundary Resources Assessment Committee Eastern Georges Bank Cod Benchmark Assessment. TRAC Proceedings 2013/01.

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 Jul. 2015. TRAC Proceedings 2015/01.

Wang, Y., L. O'Brien, and I. Andrushchenko. 2015. Assessment of Eastern Georges Bank Atlantic Cod for 2015. TRAC Reference Document 2015/03.

Correct Citation

TRAC. 2015. Eastern Georges Bank Cod. TRAC Status Report 2015/01.

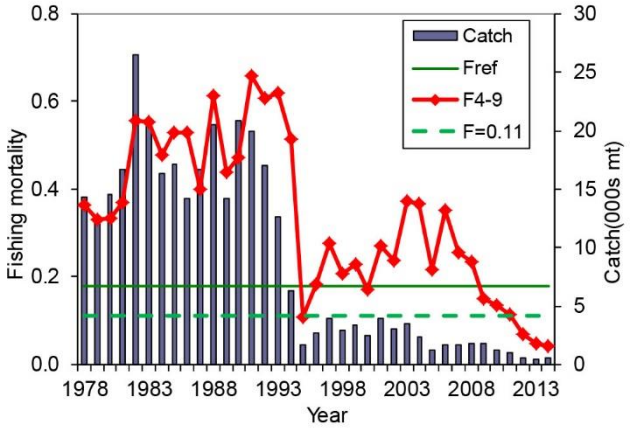


Figure 1. Catches and fishing mortality (F) for EGB cod.

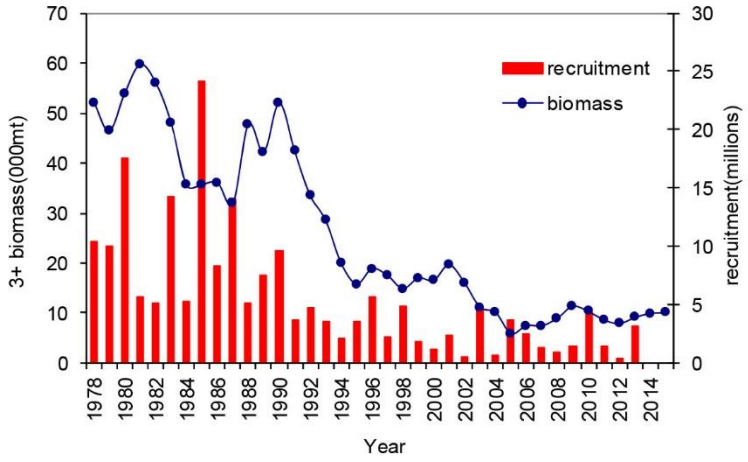


Figure 2. Biomass and recruitment for EGB cod.

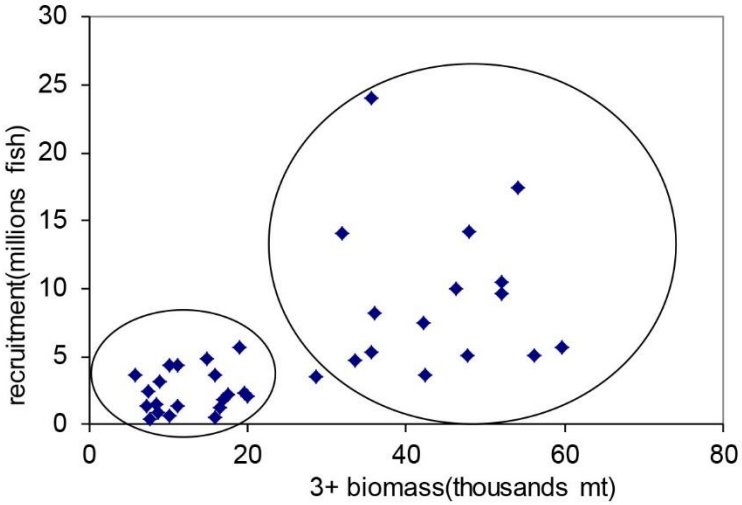


Figure 3. Stock recruitment patterns for EGB cod.

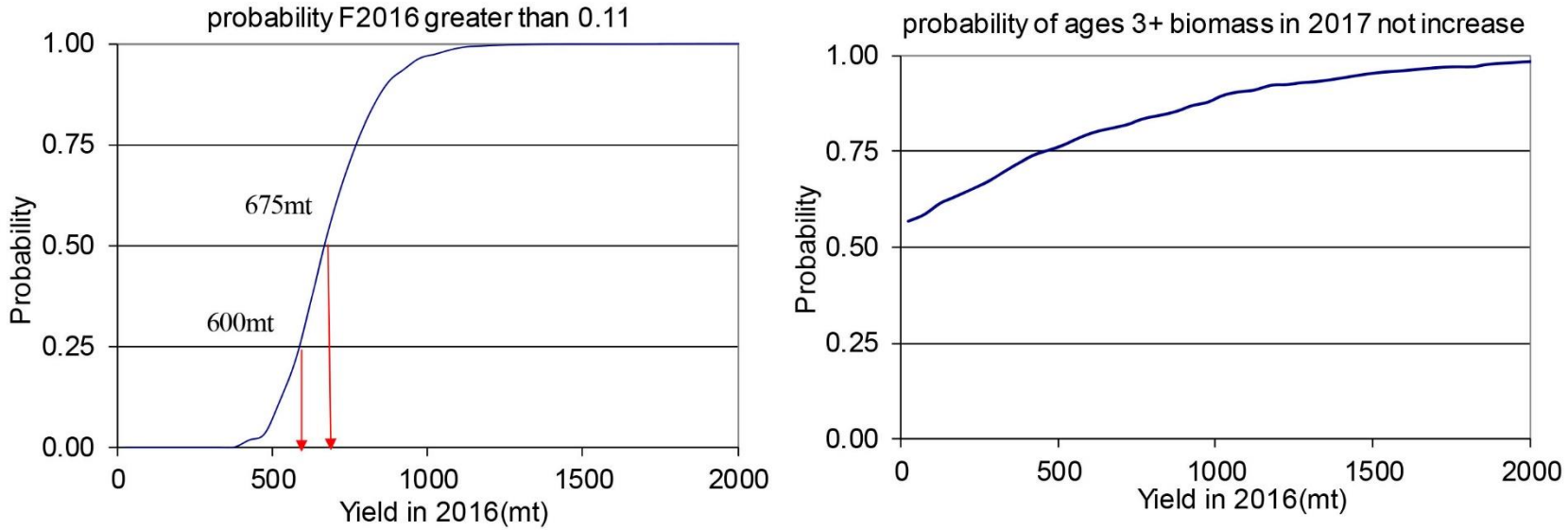


Figure 4. 2016 Projections and risks from VPA "M 0.8" results for EGB cod assuming 2015 catch of 650 mt.

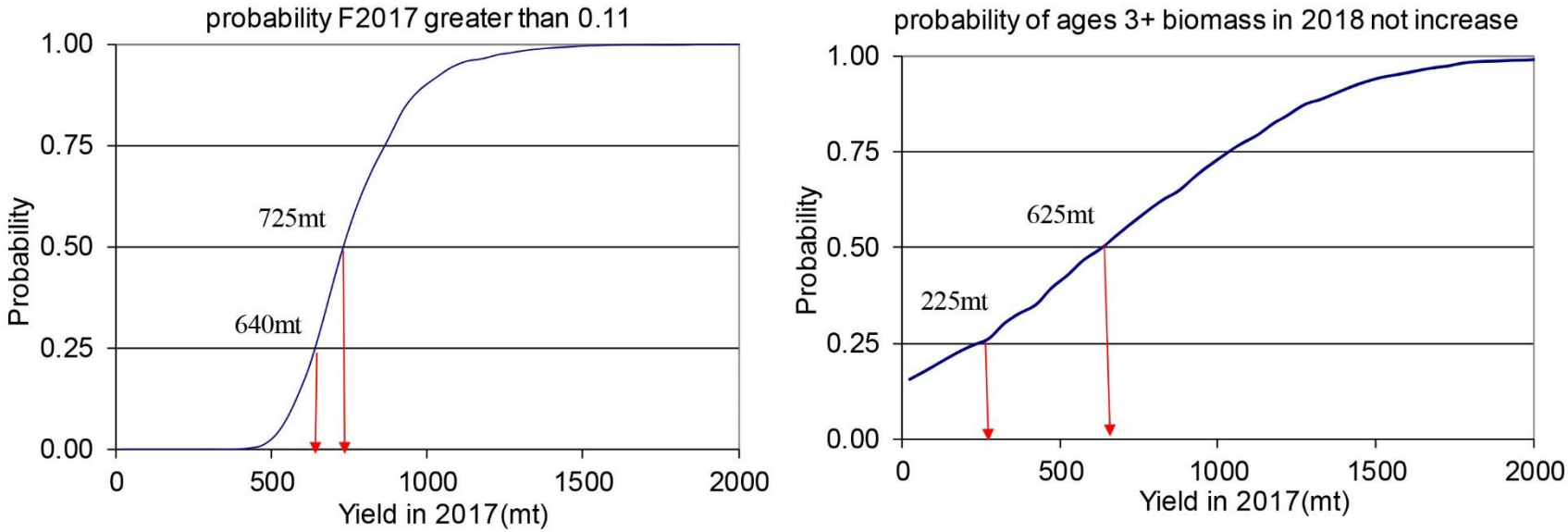


Figure 5. 2017 Projections and risks from VPA "M 0.8" results for EGB cod assuming 2016 catch at F = 0.11.

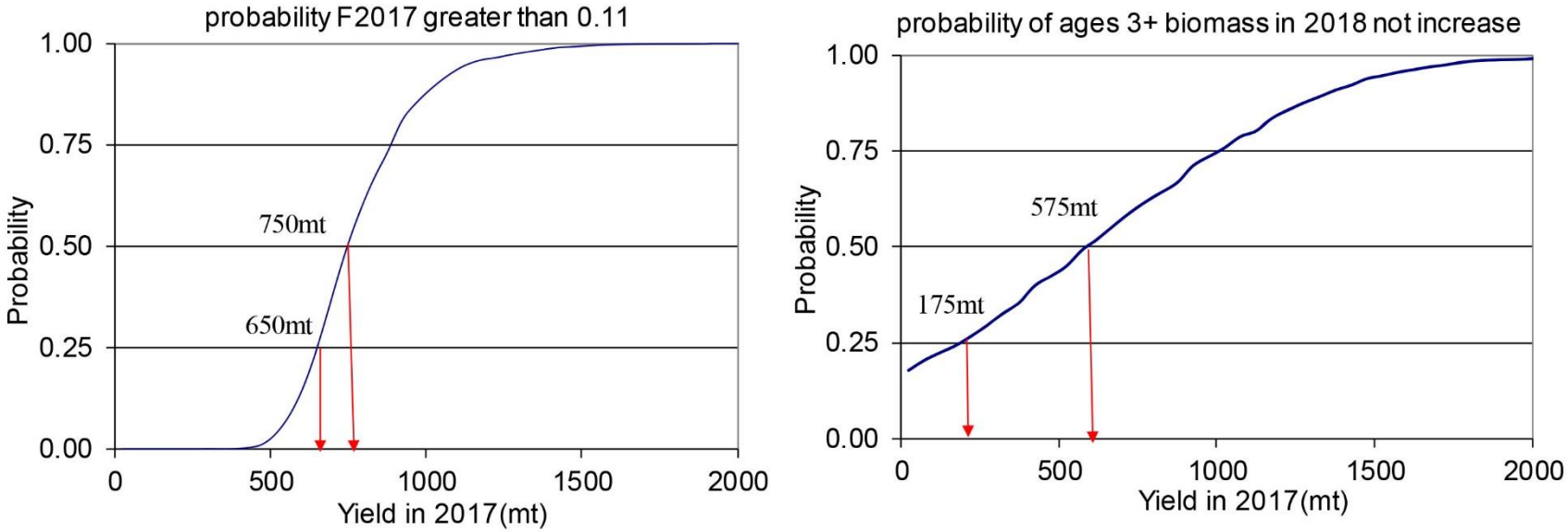


Figure 6. 2017 Projections and risks from VPA "M 0.8" results for EGB cod assuming 2016 catch = 600 mt.