

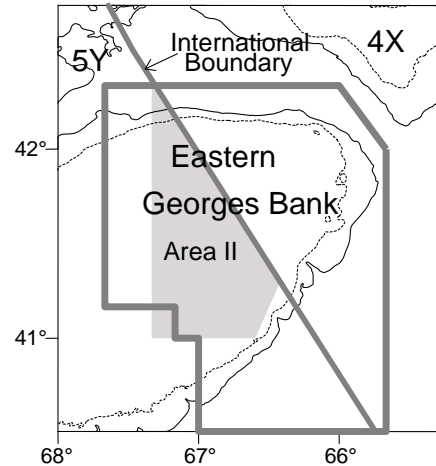


Transboundary Resources Assessment Committee

Status Report 2012/02 (Revised)

**EASTERN
GEORGES BANK
COD**

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



Summary

- Combined Canada/USA catches were 1,037 mt, including 69 mt of discards in the 2011 calendar year.
- Two alternative model formulations were used to provide status determination in the bullets below, but rho adjusted projections were used to provide catch advice. Both formulations assumed a split in the survey indices in 1994 but one assumed $M=0.2$, whilst the other assumed $M=0.5$ for ages 6+ from 1994 to 2011.
- Since 1995, adult population biomass (ages 3+) from the “split M 0.2” model has fluctuated between 3,000 mt and 10,100 mt. Biomass was 2,845 mt at the beginning of 2012. Since 1995, adult population biomass from the “split M 0.5” model has fluctuated between 4,000 mt and 12,600 mt. Biomass was 4,192 mt at the beginning of 2012. Biomass in 2012 is the second lowest in the time series from both models.
- Since 2000, the 2003 year class is the highest recruitment estimated by either model (excluding 2010). The initial estimates of the 2010 year class at 4.0 million from the “split M 0.2” model and 4.8 million from the “split M 0.5” model. However, the uncertainties on the 2010 year class are high. Both the 2003 and 2010 year classes are less than half of the average (about 10 million) during 1978-1990, when the productivity was considered to be higher. Recruitment for other recent year classes is low. Recruitment indices for the 2011 year class from the bottom trawl surveys are also low.
- Fishing mortality (F) in 2011 was estimated to be 0.49 from the “split M 0.2” model and 0.28 from the “split M 0.5” model. F has consistently remained above $F_{ref} = 0.18$.



- Resource productivity is currently very poor because of low recent recruitment and low weights at age.
- In recent years, catches based on the “split M 0.2” and “split M 0.5” unadjusted formulations have not reduced fishing mortality below F_{ref} and have not had the expected effect on age 3+ biomass or spawning stock biomass (SSB). TRAC recommends not basing 2013 catches on these unadjusted model projection results, but rather on the rho adjusted projection results.
- Considering both models, under the rho adjusted “split M 0.2” assumption, a 50% probability of not exceeding F_{ref} implies catches less than 400 mt, and of less than 775 mt under the rho adjusted “split M 0.5” assumption. Achieving a 20% increase in SSB between 2013 and 2014 implies catches less than 575 mt under the rho adjusted “split M 0.2” scenario, and of less than 400 mt under the rho adjusted “split M 0.5” scenario. Not exceeding F_{ref} and achieving a 20% increase in biomass, therefore, implies catches of less than 400 mt.

Catches and Biomass (thousands mt); Recruits (millions)[♦]

		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg ¹	Min ¹	Max ¹
Canada ⁹	Quota	1.3	1.0	0.7	1.3	1.4	1.6	1.2	1.0	0.9	0.5			
	Catch	1.5	1.3	0.9	1.4	1.2	1.5	1.2	0.8	0.7		5.9	0.7	17.9
	Landed	1.3	1.1	0.6	1.1	1.1	1.4	1.0	0.7	0.7		5.8	0.6	17.8
	Discard	0.2	0.1	0.2	0.3	0.1	0.1	0.2	0.1	<0.1		0.1	<0.1	0.5
USA ⁹	Quota ²		0.3	0.3	0.4	0.5	0.7	0.5	0.3	0.2	0.2			
	Catch ²		0.2	0.2	0.3	0.3	0.5	0.5	0.3	0.2				
	Landed	1.9	1.0	0.2	0.1	0.2	0.2	0.4	0.4	0.3		3.5	0.1	10.6
	Discard	0.1	0.1	0.3	0.1	0.4	<0.1	0.2	0.1	<0.1		<0.1	<0.1	0.4
Total ⁹	Quota		1.3	1.0	1.7	1.9	2.3	1.7	1.3	1.1	0.7			
	Catch	3.5	2.3	1.3	1.7	1.8	1.8	1.9	1.3	1.0		9.5	1.0	26
	Catch ^{3,4}		1.5	1.1	1.7	1.5	2.0	1.7	1.1	0.9				
From "split M 0.2" model														
	Adult Biomass ⁵	5.9	5.1	3.0	4.2	3.9	3.4	3.7	3.3	2.7	2.8	22.3	2.7	59.6
	Age 1 Recruits	0.4	2.8	0.5	0.9	1.4	0.9	0.9	1.0	4.0		5.1	0.4	23.6
	Fishing mortality ⁶	0.80	0.86	0.43	0.74	0.50	0.55	0.65	0.58	0.49		0.6	0.33	1.29
	Exploitation Rate ⁶	50%	53%	32%	48%	36%	38%	44%	40%	35%		40%	26%	67%
From "split M 0.5" model														
	Adult Biomass ⁵	7.3	6.6	4.0	6.1	6.2	5.7	6.4	5.2	4.2	4.2	23.6	4.0	59.6
	Age 1 Recruits	0.5	4.4	0.6	1.0	1.7	1.0	1.0	1.2	4.8		5.3	0.5	23.7
	Fishing mortality ⁶	0.60	0.61	0.31	0.50	0.27	0.25	0.31	0.33	0.28		0.48	0.24	1.05
	Exploitation Rate ⁷	41%	42%	24%	36%	22%	20%	25%	26%	22%		34%	20%	60%
	Exploitation Rate ⁸	36%	37%	21%	31%	19%	18%	21%	22%	19%		31%	14%	53%

¹1978 – 2011

²for fishing year from May 1 – April 30

³for Canadian calendar year and USA fishing year May 1-April 30

⁴sum of Canadian landed, Canadian Discard, and USA Catch (includes discards)

⁵Jan 1 ages 3+

⁶ages 4-9

⁷ages 4-5

⁸ages 6-9

⁹unless otherwise noted, all values reported are for calendar year

[♦] Last three columns of the table have been revised.

Fishery

Combined Canada/USA catches averaged 17,208 mt between 1978 and 1992, peaking at 26,464 mt in 1982. Catches declined to 1,683 mt in 1995, then fluctuated at about 3,000 mt until 2004, subsequently declining. Catches in 2011 were 1,037 mt, including 69 mt of discards (Figure 1).

Canadian catches decreased to 702 mt in 2011 from 840 mt in 2010. Since 1995, with reduction in cod quotas, the fishery has reduced targeting for cod through changes in fishing gear and practices. Discards were estimated at 13 mt from the mobile gear fleet and at 0 mt from the fixed gear fleet. Since 1996, the Canadian scallop fishery has not been permitted to land cod. Estimated discards of cod by the Canadian scallop fishery were 29 mt in 2011.

USA catches decreased to 294 mt in 2011 from 486 mt in 2010. Since December 1994, a year-round closure of Area II has been in effect, with the exception of Special Access Programs in 2004 and since 2010. With the implementation of a catch share system in 2010 most of the fleets are now managed by quotas. Estimated discards of cod for 2011 were 27 mt, almost entirely from the otter trawl groundfish fishery.

The combined Canada/USA 2011 **fishery age composition** (landings + discards) was dominated by the 2006 year class at age 5 (30% by number, 39% by weight), followed by the 2007 year class at age 4 (24% by number, 23% by weight) and the 2008 year class at age 3 (20% by number, 13% by weight). The 2003 year class at age 8 made little contribution to the 2011 catch (2% by number, 4% by weight). The contribution to the catch of fish older than age 7 continued to be small in recent years: 5% by number and 10% by weight in 2011. 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 limit reference, $F_{ref} = 0.18$ (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), which used fishery catch statistics and sampling for size and age composition of the catch for 1978 to 2011 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series: NMFS spring, NMFS fall, and DFO.

Two VPA model formulations were established during the benchmark assessment meeting in 2009. These model formulations will be referred to as the “split M 0.2” and “split M 0.5” model. The survey abundance indices were split in 1993-1994 for both model formulations. Natural mortality (M) was fixed at 0.2 for all the ages in all years for the “split M 0.2” model and was fixed at 0.5 for ages 6+ in years after 1994 for the “split M 0.5” model. It was recommended at

the 2009 benchmark meeting to consider both model formulations; this will be reconsidered at the next benchmark. Retrospective analyses were conducted to detect any tendency to consistently overestimate or underestimate fishing mortality (F), biomass (B), and recruitment relative to the terminal year estimates. The current stock assessments exhibit retrospective bias in B and F, which results in decreases in B and increases in F compared to the results of last year's assessment.

Given the strong retrospective bias, alternative approaches were considered to address the retrospective pattern to characterize uncertainty and risk in catch advice. The adult biomass, recruitment, and fishing mortality estimates presented below are from the unadjusted benchmark model formulations.

Since 1995, **adult population biomass** (ages 3+) from the “split M 0.2” model has fluctuated between 3,000 mt and 10,100 mt. Biomass was 2,845 mt (80% confidence interval: 2,409 mt – 3,705 mt) at the beginning of 2012 (Figure 2). Since 1995, adult population biomass from the “split M 0.5” model has fluctuated between 4,000 mt and 12,600 mt. Biomass was 4,192 mt (80% confidence interval: 3,586 mt – 5,474 mt) at the beginning of 2012 (Figure 2). In both models, the increase since 2005 was largely due to recruitment and growth of the 2003 year class. Lower weights at age in the population in recent years and generally poor recruitment have contributed to the lack of sustained rebuilding. Survey biomass indices have been lower since the mid-1990s. Survey biomasses for the spring 2012 NEFSC surveys and for the 2012 DFO survey were among the lowest in their time series. The estimated adult population biomass at the beginning of 2012 from the VPA was only 5.5% (“split M 0.2” model) and 8% (“split M 0.5” model) of the 1978 biomass. The 2012 adult population biomass estimates are the second lowest in the time series according to both models (Figure 3).

Recruitment at age 1 has been low in recent years (Figure 2). Since 2000, the 2003 year class (2.8 million fish from the “split M 0.2” model and 4.4 million fish from the “split M 0.5” model) is the highest recruitment estimated by either model (excluding 2010). The initial estimates of the 2010 year class at 4.0 million from the “split M 0.2” model and 4.8 million from the “split M 0.5” model are stronger than the 2003 year class based on the 2012 assessment. However, the uncertainties on the 2010 year class are high, with a 46% relative standard error on age 2 from both models. Both the 2003 and 2010 year classes are less than half of the average (about 10 million) during 1978-1990, when the productivity was considered to be higher. Recruitment for the 2002 and 2004 year classes was the lowest on record in both models. The 2006 year class at age 1 was 1.4 million from the “split M 0.2” model and at 1.7 million from the “split M 0.5” model. The 2007, 2008, and 2009 year classes were similar in strength to the 2000 year class, which was only about 10% of the 1978-1990 average recruitment in both models. The current biomass is well below 25,000 mt, above which there is a better chance to get a higher recruitment (Figure 4). Recruitment indices for the 2011 year class from the bottom trawl surveys are low.

Fishing mortality (population weighted average of ages 4-9) was high prior to 1994. F declined in 1995 to $F=0.36$ for the “split M 0.2” model and to 0.24 for the “split M 0.5” model due to restrictive management measures. F in 2011 was estimated to be 0.49 (80% confidence interval: 0.40-0.65) from the “split M 0.2” model and 0.28 (80% confidence interval: 0.24-0.38) from the “split M 0.5” model. Both models show recent reductions in F, but fishing mortality has consistently remained above the F_{ref} of 0.18 (Figure 1).

If the retrospective bias observed in this assessment continues, the 2011 fishing mortality rate estimate is expected to increase in future assessments from 0.49 to 0.89 (“split M 0.2” model) and from 0.28 to 0.45 (“split M=0.5” model), while the 2012 spawning stock biomass estimate is expected to decrease from 2,845 mt to 1,395 mt (“split M 0.2” model) and from 4,192 mt to 2,382 mt (“split M=0.5” model). These changes are based on the retrospective rho adjustments used in the projections.

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, above which there is a better chance to get a higher **recruitment** (Figure 4). In absolute numbers, 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. Length and weight at age has also declined in recent years, which could hamper biomass rebuilding due to potential changes in fecundity. In the 2011 fishery, **size at age** remains low. Research survey **spatial distribution** patterns of adult (3+) cod have not changed over the past decade. Resource productivity is currently very poor because of low recent recruitment and low weights at age compared to the 1980s.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2013. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding $F_{ref}=0.18$ and change in adult biomass from 2013 to 2014. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting, the possibility that the model may not reflect stock dynamics closely enough, and/or retrospective bias.

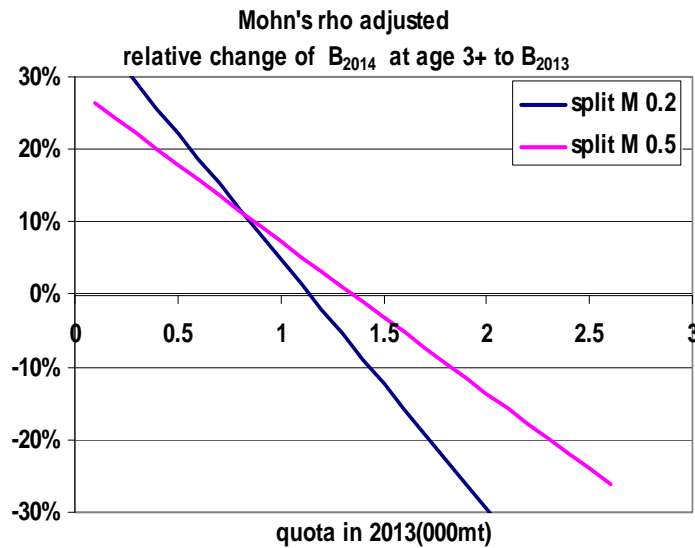
For **projections**, the 2009-2011 fishery average weights at age and the 2010-2012 survey average weights at age were assumed for the fishery and population weights at age in 2013-2014, respectively. However, for the slower growing 2003 year class, fishery weight at age 9 in 2012 was based on a cohort regression. The 2007-2011 average partial recruitment was assumed for the partial recruitment pattern in 2012 and 2013. The 2007-2011 geometric mean of recruitment at age 1 from each model was used for 2012-2014 projections. Catch in 2012 was assumed to be equal to the 675 mt quota, and $F=0.18$ in 2013. Deterministic projection and stochastic projections are provided from each of the model results.

Considering the strong retrospective bias exhibited by both models, the Mohn’s rho adjusted deterministic projection and stochastic projections are also provided. In both cases, the rho adjustments were computed as the average Mohn’s rho from seven year peels for the 3⁺ biomass (SSB) applied to all ages. The results are shown below and in Figures 5-6.

2013 Catch (mt)

Probability of exceeding F_{ref} in 2013	0.25	0.5	0.75
“Split M 0.2”	750 mt	875 mt	1,025mt
“Split M 0.5”	1,175 mt	1,400 mt	1,625 mt
“Split M 0.2”: Mohn’s rho adjusted	325 mt	400 mt	475 mt
“Split M 0.5”: Mohn’s rho adjusted	625 mt	775 mt	875 mt

Neutral risk (50%) that biomass will not increase by:	0%	10%	20%
“Split M 0.2”	2,475 mt	1,775 mt	1,050 mt
“Split M 0.5”	2,475 mt	1,525 mt	575 mt
“Split M 0.2”: Mohn’s rho adjusted	1,175 mt	900 mt	575 mt
“Split M 0.5”: Mohn’s rho adjusted	1,450 mt	900 mt	400 mt



In recent years, catches based on the “split M 0.2” and “split M 0.5” unadjusted formulations have not reduced fishing mortality below F_{ref} and have not had the expected effect on SSB. If the 2013 quota is set based on these models, this pattern of failing to achieve management objectives seems likely to continue given the models’ retrospective patterns. Sensitivity analysis conducted during the TRAC meeting demonstrated that had the rho adjusted catch advice been followed last year, the resulting fishing mortality rate would have been closer to the F_{ref} than using the unadjusted projections. TRAC recommends not basing 2013 catches on these unadjusted model projection results (shown in grey font in Table 1 and the text table above), but rather on the rho adjusted projection results.

Considering both models, under the rho adjusted “split M 0.2” assumption, a 50% probability of not exceeding F_{ref} implies catches less than 400 mt, and of less than 775 mt under the rho

adjusted “split M 0.5” assumption. However, given the extremely low SSB, TRAC considers that management should try to harness the growth potential from the 2010 year class to rebuild the spawning stock biomass. Achieving a 20% increase in SSB between 2013 and 2014 implies catches less than 575 mt under the rho adjusted “split M 0.2” scenario, and of less than 400 mt under the rho adjusted “split M 0.5” scenario. Not exceeding F_{ref} and achieving a 20% increase in biomass, therefore, implies catches of less than 400 mt (see text tables above and Table 1). No fishing in 2013 implies an increase in adult biomass from 2013 to 2014 of about 30-40%.

While management measures have resulted in decreased exploitation rate since 1995, fishing mortality has remained above F_{ref} and adult biomass has fluctuated at a low level. The continuing poor recruitment since the early 1990s is an important factor for this lower productivity. The initial estimate of the 2010 year class is higher than adjacent year classes, but is still well below the average of 1978-1990, when the productivity is considered to have been higher. Rebuilding will not occur without improved recruitment.

Special Considerations

Although the VPA used in both models for management advice assumes a split in the survey indices, the mechanisms for the large changes in survey catchability are not easily explained. These changes in survey catchability are assumed to alias an unknown mechanism that produces a better fitting model. The inability to plausibly explain these survey catchability changes causes increased uncertainty in this assessment.

The range of stock perceptions and outlooks from the two rho adjusted projections reflect the substantial uncertainty in the assessment. Despite these uncertainties, all assessment results indicate that low catches are needed to promote rebuilding.

Source Documents

Wang, Y., and L. O’Brien. 2012. Assessment of Eastern Georges Bank Atlantic Cod for 2012. TRAC Reference Document 2012/02.

O’Brien, L., and T. Worcester, editors. 2009. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Transboundary Resources Assessment Committee Eastern Georges Bank Cod Benchmark Assessment. TRAC Proceedings 2009/02.

O’Brien, L., and T. Worcester, editors. 2012. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. Report of Meeting held 26-29 June 2012. TRAC Proceedings 2012/01.

Correct Citation

TRAC. 2012. Eastern Georges Bank Cod. TRAC Status Report 2012/02.

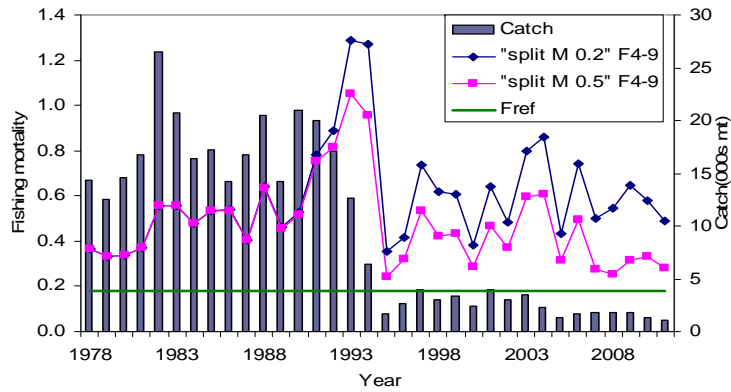


Figure 1. Catches and fishing mortality (F).

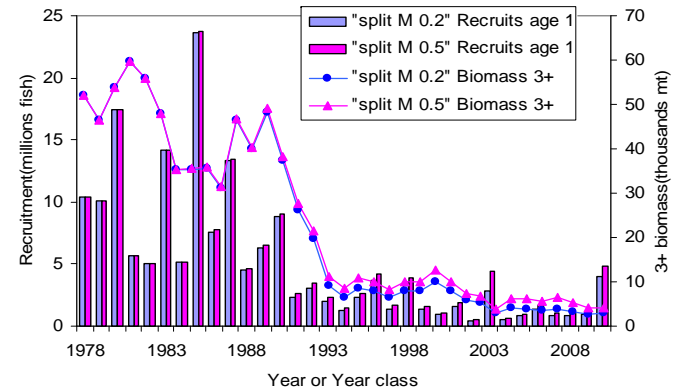


Figure 2. Biomass and recruitment.

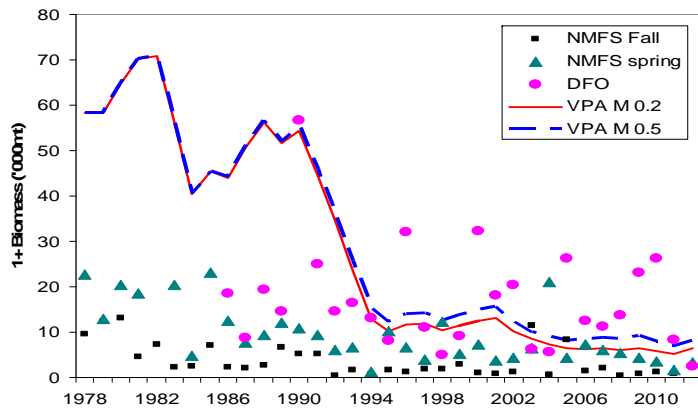


Figure 3. Age 1+ biomass from the surveys and assessments. The survey biomasses are not adjusted by survey catchability.

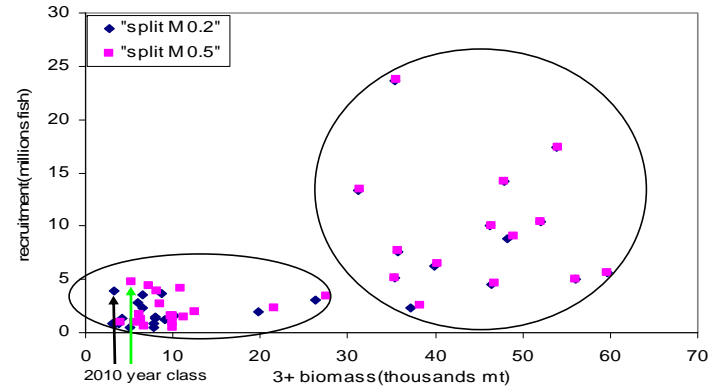


Figure 4. Stock recruitment patterns. Black and green arrows indicate 2010 year class at age 1 for from “split M 0.2” model and “split M 0.5” model, respectively.

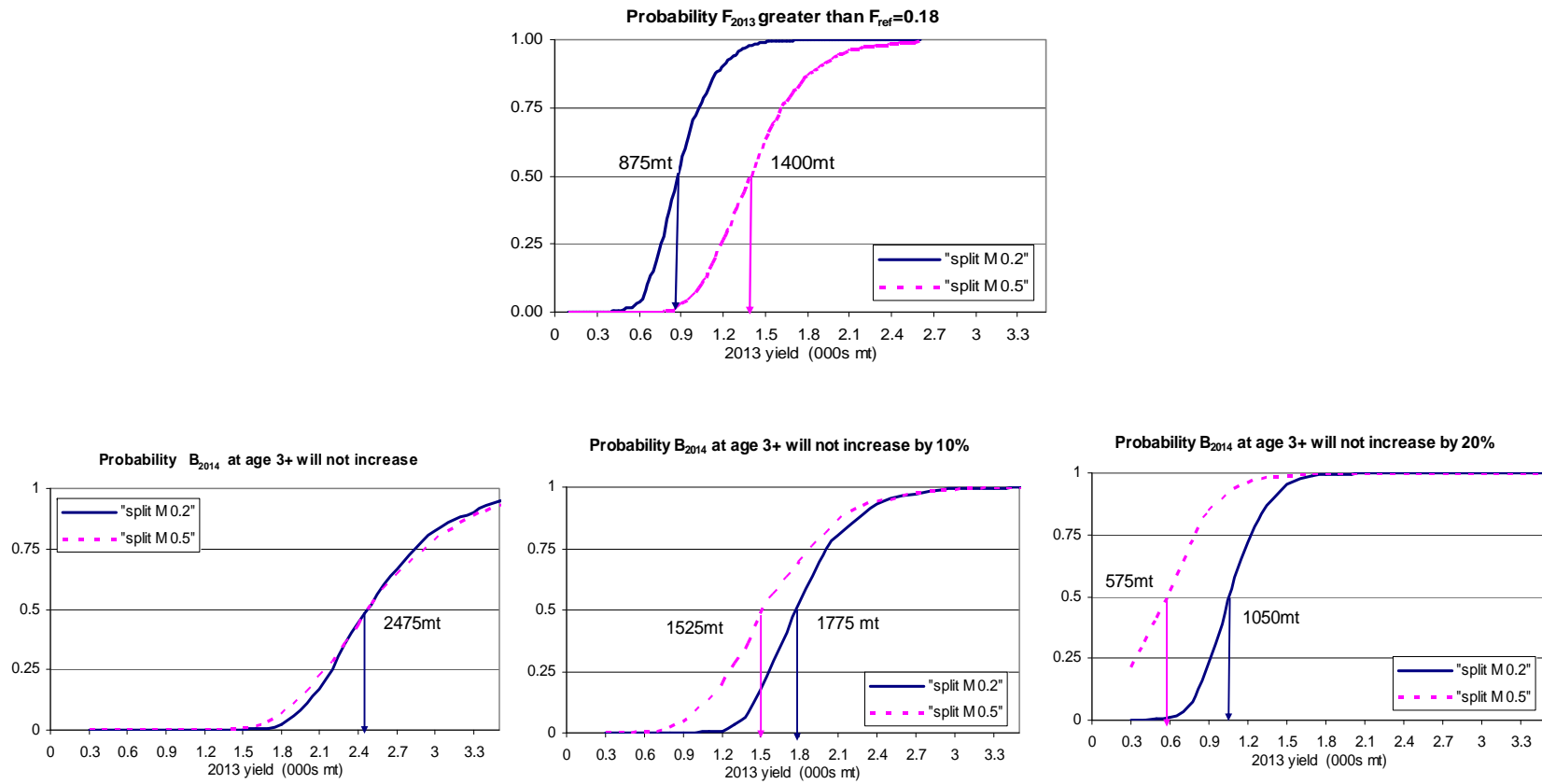


Figure 5. Projections and risks.

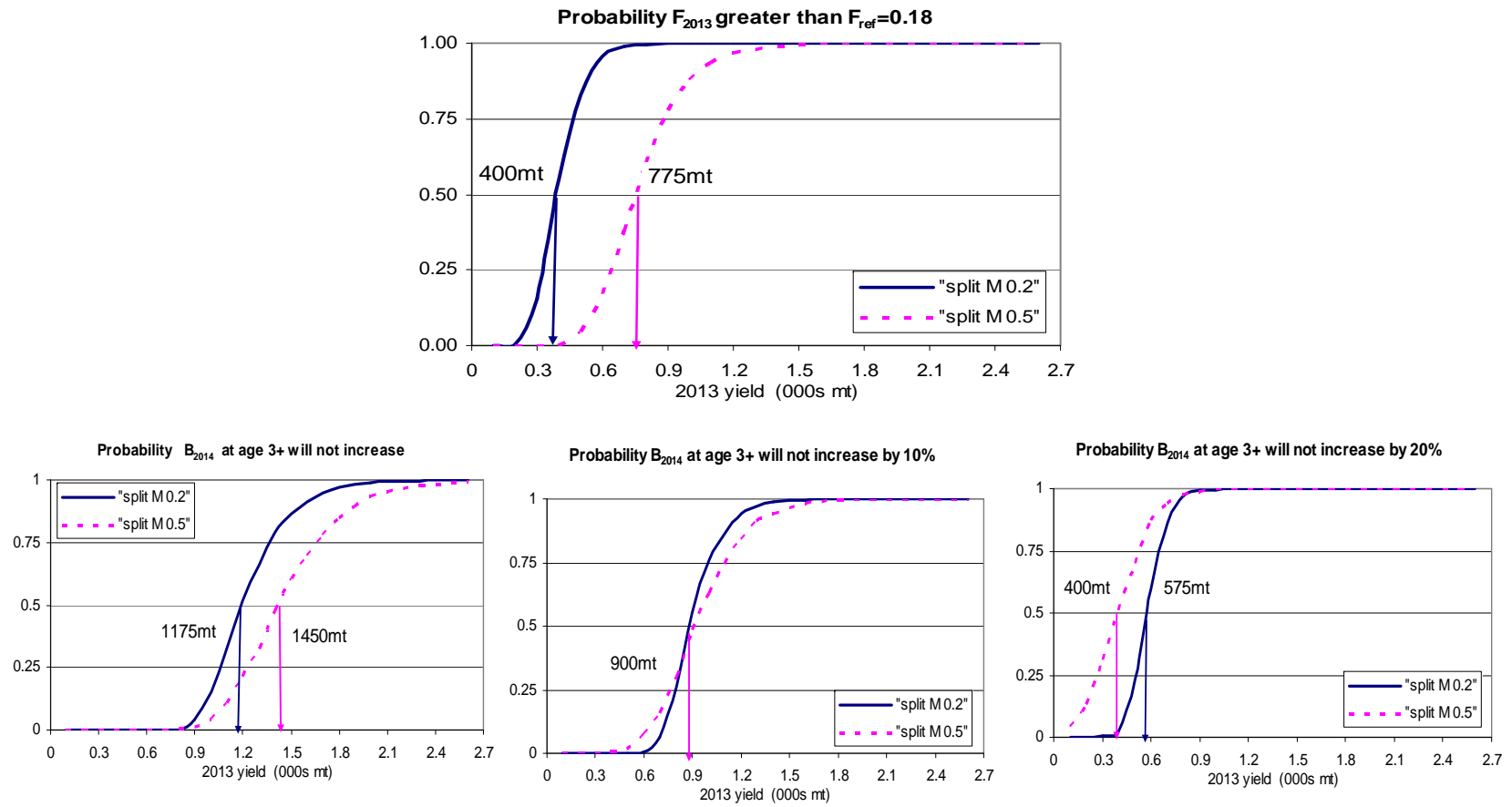


Figure 6. Mohn's rho adjusted projection and risks.

Table 1. Anticipated effects of different catch in 2013: comparison of probability of exceeding F_{ref} and neutral risk that stock size will not increase beyond the specified percentage for different projections analyses. The model options in gray font have strong retrospective bias that prevent their use for setting catch advice. The spawning biomass in 2013 will be 6,438 mt (“split M 0.2” model) and 8,461 mt (“split M 0.5” model). The Mohn’s rho adjusted spawning biomass in 2013 will be 2,806 mt (“split M 0.2” model) and 4,539 mt (“split M 0.5” model).

Catch 2013	Probability of exceeding F_{ref} in 2013				Neutral risk that spawning stock increase in 2014 will not exceed:			
			Rho Adj.				Rho Adj.	
	Split M=0.2	Split M=0.5	Split M=0.2	Split M=0.5	Split M=0.2	Split M=0.5	Split M=0.2	Split M=0.5
325	25% or less	25% or less	25%	25% or less	25% or more	20% or more	30%	20% or more
400			50%					
475			75%					
575								
625								
750								
775	50% or less	25% or less		50% or less	20% or more	10% or more	10% to 20%	10% to 20%
875				75%				
900	75% or less	25% or less			20% or more	10% or more	5% to 10%	5% to 10%
1025								
1050		50%			10% or more	10% or more	0%	0%
1175								
1400		75% or less			10% or more	10% or more	-10% to -15%	-5% to -10%
1450								
1525		75% or less			10% or more	10% or more	-15% to -25%	-5% to -10%
1625								
1775					0% or more	0% or more	-25%	-10%
2475							0%	<-30%