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NOAA FISHERIES NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

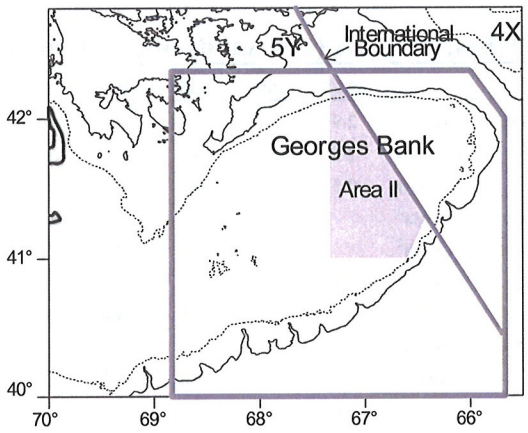
Status Report 2011/01

GEORGES BANK

YELLOWTAIL

FLOUNDER

[5Zhjmn; 522,525,551,552,561,562]



Summary

- Combined Canada and USA catches in 2010 were 1,160 mt.
- Adult population biomass (age 3+) increased from a low of 2,100 mt in 1995 to 10,900 mt in 2003, declined to about 2,700 mt in 2006, and increased to 9,300 mt at the beginning of 2011. Spawning stock biomass in 2010 was estimated to be 8,800 mt.
- During 1998-2001, recruitment averaged 22.2 million fish at age 1 but has since been below 20 million fish, including the 2005 and 2006 year classes estimated at 16.8 million and 17.2 million, respectively. The 2007 and 2008 year classes are well below average, and the 2009 year class is estimated to be the lowest in the time series at 0.9 million age-1 fish. The 2005 year class had been estimated as strong in previous assessments, but is now estimated as slightly below average.
- Fishing mortality for fully recruited ages 4+ was close to or above 1.0 between 1973 and 1995, fluctuated between 0.51 and 0.97 during 1996-2003, increased in 2004 to 1.93, and then declined to about 0.27 in both 2008 and 2009, and 0.13 in 2010, below the reference point of $F_{ref} = 0.25$.
- Assuming a catch in 2011 equal to the quota of 2,650 mt, a combined Canada/USA catch of about 1,700 mt in 2012 would result in a neutral risk (~50%) that the fishing mortality rate will exceed F_{ref}. A catch in 2012 of 2,300 mt will result in no change in median adult biomass from 2012 to 2013.

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Canada

June 2011

- With the reemergence of a retrospective pattern, despite using a split survey series formulation, alternative projection assumptions were explored to examine the sensitivity of this uncertainty on catch advice and stock rebuilding.

Catches, Biomass (thousands mt); Recruits (millions)

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg[1]	Min[1]	Max[1]
Canada	Quota	2.9	2.3	1.9	1.7	0.9	0.4	0.6	0.5	0.8[8]	1.2			
	Landed	2.6	2.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		0.5	<0.1	2.9
	Discard	0.5	0.8	0.4	0.2	0.5	0.1	0.1	0.1	0.2		0.5	0.1	0.8
USA	Quota[2]			6.0	4.3	2.1	0.9	1.9	1.6	1.2[8]	1.5			
	Catch[2]			5.9	3.8	1.9	1.0	1.6	1.8	1.1				
	Landed	2.5	3.2	5.8	3.2	1.2	1.1	1.0	1.0	0.7		4.4	0.4	15.9
	Discard	0.1	0.4	0.5	0.4	0.4	0.5	0.4	0.8	0.3		0.6	<0.1	3.0
Total	Quota[3]			7.9	6.0	3.0	1.3	2.5	2.1	2.0[8]	2.7			
	Catch[3,4]			6.4	4.1	2.5	1.1	1.7	1.9	1.3				
	Catch	5.7	6.6	6.8	3.9	2.1	1.7	1.5	1.8	1.2		6.1	1.1	17.2
Adult Biomass[5]		9.1	10.9	8.6	4.1	2.7	3.3	5.6	8.7	8.7	9.3	7.4[6]	2.0[6]	26.2[6]
SSB		10.1	10.1	5.5	3.3	2.9	4.4	7.1	9.3	8.8		7.2	2.2	22.2
Age 1 Recruits		15.2	10.7	7.4	11.6	16.8	17.2	8.0	4.7	0.9		20.3	0.9	70.6
Fishing mortality[7]		0.65	0.61	1.93	1.35	1.35	0.72	0.28	0.27	0.13		1.00	0.13	1.93
Exploitation Rate[7]		44%	42%	80%	69%	69%	47%	22%	22%	11%		58%	11%	80%

[1]1973 – 2010
[2]for fishing year 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 age 3+
[6]1973 - 2011
[7]age 4+ for calendar year
[8]quotas not jointly determined; established individually by each country

Fishery

Total catches of Georges Bank yellowtail flounder peaked at about 21,000 mt in both 1969 and 1970 (Figure 1). Prior to the mid-1990s, the USA fishery accounted for most of the annual catches. The combined Canada/USA catch increased from 1995 through 2001, averaged 6,300 mt during 2002-2004, but declined to 1,160 mt in 2010 due to restrictive management measures.

The 2010 **Canadian catch** of 217 mt was well below the Canadian quota of 756 mt, with landings of only 17 mt and estimated discards of 200 mt. Since there was no directed Canadian fishery for yellowtail in 2010, landings were incidental to cod and haddock fishing. Discards were due to the sea scallop dredge fishery.

USA catches in 2010 were 943 mt, with landings of 654 mt and discards of 289 mt. The USA landings in 2010 were predominantly from the trawl fishery while discards came from both the trawl and sea scallop dredge fisheries. Preliminary estimates of the USA catches for fishing year 2010-2011 were 93% of the 1,200 mt quota.

Ages 3-5 accounted for most of the **combined Canada/USA fishery** catch in 2010 by number. Both the Canadian and the USA fisheries were well sampled to determine length composition of the catch.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, $F_{ref} = 0.25$ (established during the 2005 TRAC benchmark). 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 1973 to 2010. The VPA was calibrated to trends in abundance from three bottom trawl survey series (NMFS spring, NMFS fall and DFO) and a recruitment index from the NMFS summer sea scallop survey. The VPA formulation down-weights the DFO surveys in 2008 and 2009 to account for the higher uncertainty in these years due to large tows, as recommended by the TRAC previously. This formulation is denoted Split Series and is most similar to the Major Change model of the benchmark assessment. 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 stock assessment exhibits retrospective patterns in SSB and F which results in decreases in SSB and increases in F compared to the results of last year's assessment.

In light of the re-emergence of the retrospective pattern in the Split Series VPA, two additional approaches were considered to address the retrospective pattern. Firstly, since the Split Series VPA no longer eliminates the retrospective, a rho adjustment was applied to this model. Secondly, a rho adjustment was applied to the Single Series VPA (formerly known as the Base Case formulation during the 2005 benchmark assessment, but not used in recent years). The Split Series with the rho adjustment applies two approaches in combination (splitting the survey time series and applying a rho adjustment) to address the retrospective pattern, whereas the Single Series with the rho adjustment applies a single adjustment with a larger rho.

The perception of the stock has changed from last year to this year primarily due to the retrospective pattern. If the retrospective pattern persists the state of the resource will be more pessimistic than described below.

Adult population biomass (age 3+) increased from a low of 2,100 mt in 1995 to 10,900 mt in 2003, declined to about 2,700 mt in 2006, and increased to 9,300 mt at the beginning of 2011. Total population biomass (age 1+) has generally tracked the three groundfish surveys, although splitting the series implies high catchability of the surveys in recent years (Figure 2). Spawning stock biomass in 2010 was estimated to be 8,800 mt (80% confidence interval: 7,300-10,800 mt) (Figure 3).

During 1973-2010 **recruitment** averaged 20.3 million fish at age 1 but has been below this average since 2002 (Figure 3). The 2005 and 2006 year classes are estimated at 16.8 million and 17.2 million, respectively. The 2007 and 2008 year classes are well below average, and the 2009 year class is estimated to be 0.9 million age-1 fish, which although estimated with high

uncertainty is by far the lowest in the time series. The 2005 year class had been estimated as strong in previous assessments, but is now estimated as below average.

Fishing mortality for fully recruited ages 4+ was close to or above 1.0 between 1973 and 1995, fluctuated between 0.51 and 0.97 during 1996-2003, increased in 2004 to 1.93, and then declined to about 0.27 in both 2008 and 2009, and 0.13 in 2010 (80% confidence interval: 0.10-0.17), below the reference point of $F_{ref} = 0.25$ (Figure 1).

Productivity

Age structure, spatial distribution, and fish growth typically reflect changes in the productive potential. In both absolute numbers and percent composition, the **population age structure** estimated by the VPA displays a truncated pattern with few old fish. **Spatial distribution patterns** from the three groundfish surveys generally follow historical averages. **Growth** has been variable without strong trends, but weights at age in recent years have trended down. Truncated age structure and lower weights at age indicate current resource productivity is lower than historical levels.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2012. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding $F_{ref} = 0.25$. 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 the reemergence of a retrospective pattern.

Projections were made using 2008-2010 average fishery partial recruitment and survey and fishery weights at age for the Split Series benchmark model, Single Series rho adjusted model, and the Split Series rho adjusted model. Results from all three models are given in the tables below.

For the Split Series model, assuming a catch in 2011 equal to the quota of 2,650 mt, a combined Canada/USA catch of about 1,700 mt in 2012 would result in a neutral risk (~50%) that the fishing mortality rate will exceed F_{ref}. Catches of 1,400 mt and 1,900 mt in 2012 would result in 25% and 75% risk that fishing mortality rate will exceed F_{ref}, respectively (Figure 4). A catch in 2012 of 2,300 mt will result in no change in median biomass from 2012 to 2013, while catches in 2012 of 1,500 mt and 700 mt will result in 10% and 20% increases in median biomass from 2012 to 2013, respectively (Figure 4).

2012 Catch (mt)

Probability of exceeding F_{ref}	25%	50%	75%
Split Series	1,400	1,700	1,900
Split Series rho adjusted	600	750	900
Single Series rho adjusted	1,400	1,700	1,900

Relative Change in Median Biomass 2012 to 2013

2012 Catch (mt)	Split Series	Split Series rho adjusted	Single Series rho adjusted
600	+22%	+25%	0%
750	+20%	+20%	-2%
900	+18%	+16%	-3%
1,400	+12%	+1%	-9%
1,700	+8%	-8%	-13%
1,900	+5%	-14%	-15%

In the USA, there is a requirement to provide rebuilding projections when stocks are overfished. The current rebuilding scenario for Georges Bank yellowtail flounder requires solving for a value of F (F_{reb50}) that, when applied in years 2012 onwards, results in a 50% probability that SSB is greater than SSB_{msy} (43,200 mt). Using the same starting conditions as the projection described above, the rebuilding target cannot be achieved by 2016 even under no fishing. There is a 50% probability that the rebuilding target will be achieved in 2017 at a fishing mortality rate of 0.08, which has an associated median 2012 catch of 600 mt.

Alternative projection assumptions were explored to examine the sensitivity of catch advice. The population abundance at age in 2011 was adjusted to account for the retrospective pattern by adjusting all ages by the same amount based on the SSB retrospective rho. This Split Series rho adjusted projection formulation resulted in much lower 2012 catch advice for a given probability of exceeding F_{ref} than the unadjusted Split Series projections (Figure 4). Another alternative projection used the Single Series VPA formulation (which was most similar to the benchmark Base Case formulation) and adjusted that population abundance at age in 2011 to account for the much larger retrospective pattern in SSB. This Single Series rho adjusted projection formulation resulted in nearly identical 2012 catch advice for a given probability of exceeding F_{ref} as the unadjusted Split Series projections. However, the Single Series rho adjusted projection formulation predicts decreases in median adult biomass from 2012 to 2013 under catches that are predicted to produce increases in this median biomass under the Split Series projections (Figure 4).

In light of the implications of the alternative models, if managers wish to base the 2012 catch on consideration of both F_{ref} and a desire to maintain stock biomass, a catch in the range of 900-1,400 mt is indicated.

Special Considerations

Although the Split Series VPA is used for management advice, the mechanisms for the large changes in survey catchability are not easily explained. These changes in survey catchability are

most appropriately thought of as aliasing an unknown mechanism that produces a better fitting model. The inability to plausibly explain these survey catchability changes causes increased uncertainty in this assessment relative to other assessments. Although the intention of the Split Series VPA was to eliminate the retrospective pattern, the pattern has re-emerged but at a lower magnitude. This additional source of uncertainty should be considered when setting the 2012 quota and indicates lower catch advice than the projections from the Split Series VPA.

In 2001 the US extended the Georges Bank yellowtail flounder rebuilding period to 2016. This assessment suggests the probability of rebuilding by that date is less than 50%. The rebuilding strategy may be revised again by May 2012 as authorized by the International Fisheries Agreement Clarification Act.

Source Documents

Gavaris S, O'Boyle R, Overholtz W, editors. 2005. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Benchmark Review of Stock Assessment Models for the Georges Bank Yellowtail Flounder Stock; 25 – 26 January 2005 and 26 – 29 April 2005. TRAC Proceedings 2005/01.

Legault CM, Alade L, Stone HH. 2011. Assessment of Georges Bank Yellowtail Flounder for 2011. TRAC Reference Document 2011/01.

Legault C, Alade L, Stone H, Gavaris S, Waters C. 2008. Georges Bank Yellowtail Flounder. *In* Northeast Fisheries Science Center. 2008. Assessment of 19th Northeast groundfish stocks through 2007: a report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. Northeast Fish Sci Cent Ref Doc. 08-15. [available at http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0815/]

Porter JM, O'Brien L, editors. 2011. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. Report of Meeting held 20-24 June 2011. TRAC Proceedings 2011/01.

Correct Citation

TRAC. 2011. Georges Bank Yellowtail Flounder. TRAC Status Report 2011/01.

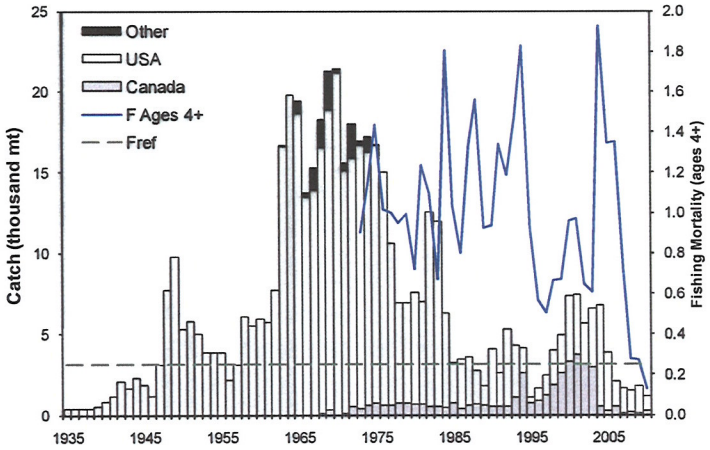


Figure 1. Catches and fishing mortality (F).

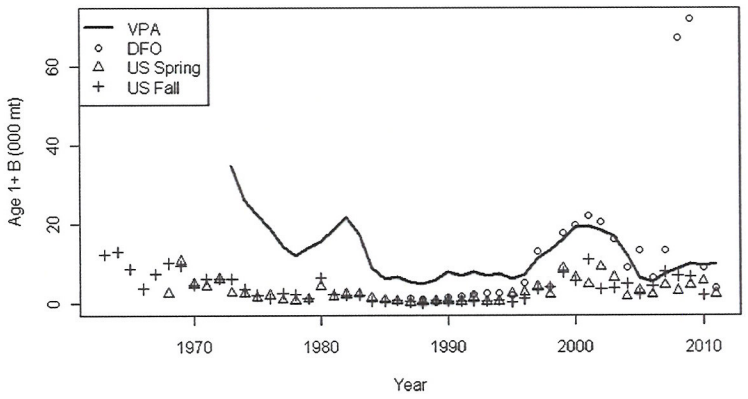


Figure 2. Ages 1+ biomasses (B).

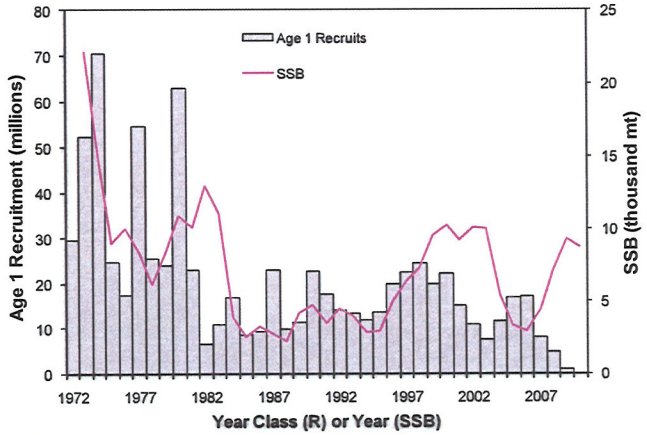


Figure 3. Recruitment and spawning stock biomass (SSB).

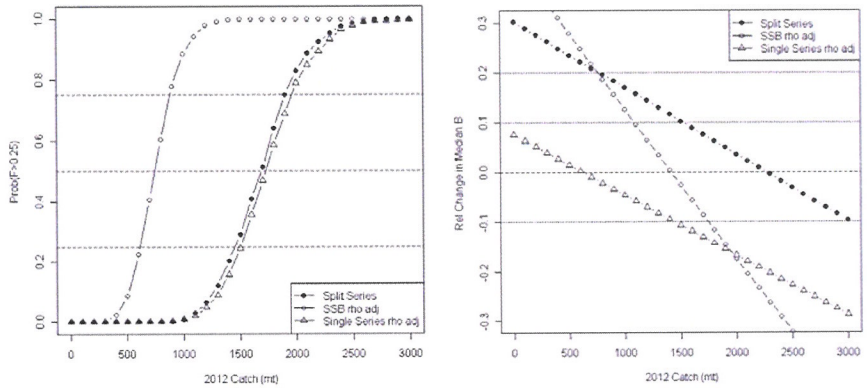


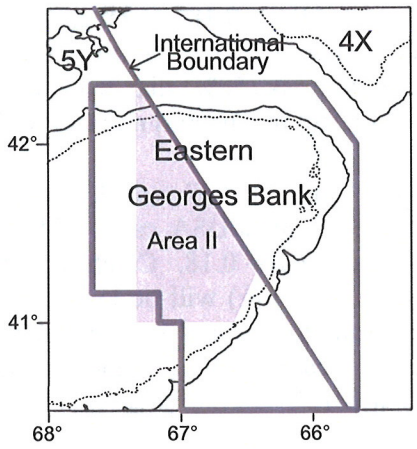
Figure 4. Risk of exceeding F_{ref}=0.25 and relative change in median biomass.

Transboundary Resources Assessment Committee

Status Report 2011/02

EASTERN GEORGES BANK COD

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



Summary

- Combined Canada/USA catches were 1,326 mt, including 221 mt of discards in the 2010 calendar year.

- Two alternative model formulations were used. Both assumed a split in the survey indices in 1994 but one assumed M=0.2, whilst the other assumed M=0.2 for all ages and years, except for ages 6+ where M=0.5 from 1994 to 2011.

- Since 1995 adult population biomass (ages 3+) from the "split M 0.2" model has fluctuated between 3,100 mt and 10,100 mt. Biomass was 3,288 mt at the beginning of 2011. Since 1995 adult population biomass from the "split M 0.5" model has fluctuated between 4,200 mt and 12,600 mt. Biomass was 5,088 mt at the beginning of 2011. Biomass in 2011 is the second lowest in the time series from both models.

- Fishing mortality (F) in 2010 was estimated to be 0.41 from the "split M 0.2" model and 0.25 from the "split M 0.5" model. F has been consistently above $F_{ref} = 0.18$.

- Since 2000, the 2003 year class was the highest recruitment observed by either model, but was less than half of the average (about 10 million) during 1978-1990, when productivity was considered to be higher. The 2002 and 2004 year classes were the lowest on record in both models. Initial indications were that the 2007, 2008, and 2009 year classes were less than 2 million. Recruitment indices from the bottom trawl surveys for the 2010 year class were higher than those for recent year classes although they were not estimated in the VPA.

- Resource productivity is currently very poor due to low recent recruitment and low weights-at-age.

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http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

June 2011
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Canada

- For the "split M 0.2" model, assuming a 2011 catch equal to the 1,050 mt total quota a combined Canada/USA catch of 600 mt corresponds to a neutral (50%) probability that F will exceed $F_{ref} = 0.18$. Catches of 1,350 mt will result in a neutral risk (50%) that the 2013[1] adult biomass (4+) will be lower than the 2012 adult biomass, a catch of 1,000 mt will result in a neutral risk (50%) that 2013[1] adult biomass will not increase by 10% and a catch of 650 mt will result in a neutral risk (50%) that 2013[1] adult biomass will not increase by 20%.

- For the "split M 0.5" model, assuming a 2011 catch equal to the 1,050 mt total quota a combined Canada/USA catch of 925 mt corresponds to a neutral (50%) probability that F will exceed $F_{ref} = 0.18$. Catches of 900 mt will result in a neutral risk (50%) that the 2013[1] adult biomass (4+) will be lower than the 2012 adult biomass and a catch of about 300 mt will result in a neutral risk (50%) that the 2013[1] adult biomass will not increase by 10%. Even at 0 catch, there is a more than 50% probability that 4+ biomass will not increase by 20% in 2013[1].

Catches, Biomass (thousands mt); Recruits (millions)

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg[1]	Min[1]	Max[1]
Canada	Quota	1.2	1.3	1.0	0.7	1.3	1.4	1.6	1.2	1.0	0.9			
	Catch	1.4	1.5	1.3	0.9	1.4	1.2	1.5	1.2	0.8				
	Landed	1.3	1.3	1.1	0.6	1.1	1.1	1.4	1.0	0.7		5.9	0.6	17.8
	Discard	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.2	0.1		0.1	<0.1	0.5
USA	Quota[2]			0.3	0.3	0.4	0.5	0.7	0.5	0.3	0.2			
	Catch[2]			0.2	0.2	0.3	0.3	0.5	0.5	0.3				
	Landed	1.7	1.9	1.0	0.2	0.1	0.2	0.2	0.4	0.4		3.8	0.1	10.6
	Discard	<0.1	0.1	0.1	0.3	0.1	0.4	<0.1	0.2	0.1		0.1	<0.1	0.4
Total	Quota			1.3	1.0	1.7	1.9	2.3	1.7	1.3	1.1			
	Catch[3,4]			1.5	1.1	1.7	1.5	2.0	1.7	1.1				
	Catch	3.1	3.5	2.3	1.3	1.7	1.8	1.8	1.8	1.3		10.0	1.3	26.5
From "split M 0.2" model														
	Adult Biomass[5]	7.9	5.9	5.1	3.1	4.2	3.9	3.6	4.2	3.9	3.3	22.1	3.1	59.2
	Age 1 Recruits	1.6	0.5	2.8	0.5	1.0	1.6	1.0	0.9	0.8		5.4	0.5	23.6
	Fishing mortality[6]	0.48	0.80	0.85	0.43	0.69	0.49	0.53	0.54	0.41		0.6	0.3	1.3
	Exploitation Rate[6]	35%	50%	53%	32%	45%	36%	38%	38%	31%		39%	26%	67%
From "split M 0.5" model														
	Adult Biomass[5]	10.1	7.4	6.7	4.2	6.2	6.3	6.0	7.0	6.1	5.1	24.1	4.2	59.2
	Age 1 Recruits	1.9	0.7	4.1	0.6	1.3	1.9	1.2	1.1	1.0		5.6	0.6	23.8
	Fishing mortality[6]	0.37	0.59	0.58	0.31	0.43	0.28	0.26	0.27	0.25		0.5	0.2	1.1
	Exploitation Rate[7]	27%	40%	41%	23%	28%	18%	21%	25%	24%		33%	18%	60%
	Exploitation Rate[8]	32%	43%	46%	35%	37%	34%	27%	20%	11%		35%	11%	60%

[1]1978 – 2010
[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
[8]ages 6-9

[1] Revised July 27, 2011 – 2012 corrected to 2013.

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 2010 were 1,326 mt, including 211 mt of discards (Figure 1).

Canadian catches decreased to 840 mt in 2010 from 1,209 mt in 2009. Since 1995, with reduction in cod quotas, the fishery has reduced targeting for cod through changes in fishing practices. All 2010 landings were subject to dockside monitoring, and at sea observers monitored close to 18% by weight of the mobile gear fleet landings, 6% by weight of the fixed gear landings and 10% by weight of the gillnet fleet landings. Discards were estimated at 48 mt from the mobile 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 44 mt in 2010.

USA catches decreased to 486 mt in 2010 from 628 mt in 2009. Since December 1994, a year-round closure of Area II has been in effect, with the exception of Special Access Programs in 2004 and 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 2010 were 129 mt, almost entirely from the otter trawl groundfish fishery.

The combined Canada/USA 2010 **fishery age composition** (landings + discards) was dominated by the 2006 year class at age 4 (44% by number, 41% by weight), followed by the 2007 at age 3 (23% by number, 17% by weight) and the 2005 year class at age 5 (15% by number, 19% by weight). The contribution to the catch of fish older than age 7 continued to be small in recent years: 8% by number and 17% by weight in 2010, although the stronger 2003 year class turned to age 7 in this year.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee 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 2010 (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 benchmark meeting to consider both model formulations until the fate of the 2003 year class provides information on natural mortality at older ages.

Since 1995 **adult population biomass** (ages 3+) from the "split M 0.2" model has fluctuated between 3,100 mt and 10,100 mt. Biomass was 3,288 mt (80% confidence interval: 2,769 mt – 4,217 mt) at the beginning of 2011 (Figure 2). Since 1995 adult population biomass from the "split M 0.5" model has fluctuated between 4,200 mt and 12,600 mt. Biomass was 5,088 mt (80% confidence interval: 4,274 mt – 6,291 mt) at the beginning of 2011 (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. In 2011, the survey biomass for all the 3 surveys was lower than 2010, and the NMFS spring survey index was the second lowest in the time series. The estimated biomass at the beginning of 2011 from VPA was only 6.4% ("split M 0.2" model) and 10% ("split M 0.5" model) of the 1978 biomass. The 2011 estimates are the second lowest in the time series according to both models (Figure 3).

Both assessment models exhibit a retrospective pattern in which perceptions of stock size were revised downward. The retrospective inconsistency in the 3+ biomass was approximately 88% for the "split M 0.2" model and approximately 62% for the "split M 0.5" model.

Recruitment at age 1 has been low in recent years. Since 2000, the 2003 year class (2.8 million fish – "split M 0.2" model and 4.1 million fish - "split M 0.5" model) was the highest recruitment observed by either model, but was less than half of the average (about 10 million) during 1978-1990, when the productivity was considered to be higher. The 2002 and 2004 year classes were the lowest on record in both models. The 2006 year class at age 1 at 1.6 million from the "split M 0.2" model and at 1.9 million from the "split M 0.5" model was closer to half the strength of the 2003 year class. Initial indications were that 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 30,000 mt where recruitment has historically been poor (Figure 4). Recruitment indices from the bottom trawl surveys for the 2010 year class were higher than those for recent year classes although they were not estimated in the VPA.

Fishing mortality (population weighted average of ages 4-9) was high prior to 1994. F declined in 1995 to 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 2010 was estimated to be 0.41 (80% confidence interval: 0.34-0.58) from the "split M 0.2" model and 0.25 (80% confidence interval: 0.21-0.34) from the "split M 0.5" model. F has been consistently above $F_{ref} = 0.18$ (Figure 1).

Both assessment models exhibit a retrospective pattern in which perceptions of fishing mortality were revised upward. If the retrospective pattern persists, the F in 2010 will be 39% higher than estimated above.

Productivity

Recruitment, age structure, fish growth and spatial distribution typically reflect changes in the productive potential. Although there is high **recruitment** variability at any given biomass, the

recruit per spawner has not increased when the biomass has been low. This hampers stock rebuilding. 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. The declines in length and weight at age from the early 1990s have hampered biomass rebuilding. **Size at age** in the 2010 fishery continued to decline for all the ages except for age 3. The research survey **spatial distribution** patterns of adult (3+) cod have not changed over the past decade. Resource productivity is currently very poor due to 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 2012. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding F_{ref} =0.18. 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 patterns.

For **projections**, the 2008-2010 average values were assumed for the fishery weight at age. The 2009-2011 survey average values were assumed for beginning of year population weights at age in 2012-2013. However, for the slower grow 2003 year class, fishery weights at age 8 in 2011 and age 9 in 2012 and beginning of year weights at age 9 in 2012 and at age 10 in 2013 were based on cohort regressed values. The 2006-2010 average values were assumed for the partial recruitment pattern in 2011-2012. Catch in 2011 was assumed to be equal to the 1,050 mt quota. Projections are provided from each of the model results.

A. "split M 0.2" model

A combined Canada/USA catch of 525 mt corresponds to a low (25%) probability that F will exceed F_{ref}=0.18, whereas catches of 600 mt correspond to a neutral (50%) probability and catches of 700 mt correspond to a high (75%) probability that F will exceed F_{ref}. Catches of 1,350 mt will result in a neutral risk (50%) that the 2013[1] adult biomass (4+) will be lower than the 2012 adult biomass, a catch of 1,000 mt will result in a neutral risk (50%) that 2013[1] adult biomass will not increase by 10% and a catch of 650 mt will result in a neutral risk (50%) that 2013[1] adult biomass will not increase by 20% (Figure 5).

B. "split M 0.5" model

A combined Canada/USA catch of 825 mt corresponds to a low (25%) probability that F will exceed F_{ref}=0.18, whereas catches of 925 mt correspond to a neutral (50%) probability and catches of 1,025 mt correspond to a high (75%) probability that F will exceed F_{ref}. Catches of 900 mt will result in a neutral risk (50%) that the 2013[1] adult biomass (4+) will be lower than the 2012 adult biomass (Figure 5) and a catch of about 300 mt will result in a neutral risk (50%) that

[1] Revised July 27, 2011 – 2012 corrected to 2013.

the 2013[1] adult biomass will not increase by 10%. Even at 0 catch there is a more than 50% probability that 4+ biomass will not increase by 20%.

2012 Catch (mt)

Probability of Exceeding F_{ref}	**25%**	**50%**	**75%**
Split M 0.2	525 mt	600 mt	700mt
Split M 0.5	825 mt	925 mt	1,025 mt

The benchmark methods do not account for the retrospective pattern in projections. If the magnitude of the retrospective pattern was accounted for, short term projections for catch would be decreased for both models.

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 2003 year class made a substantial contribution to the fishery and population biomass. It is projected to be only a small component in the population biomass and fishery catch biomass in 2011 (10% from "split M 0.2" model and 16% from "split M 0.5" model) and to a lesser extent in 2012 (less than 10% from both models). With the passing of the 2003 year class through the population, 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 most appropriately thought of as aliasing an unknown mechanism that produces a better fitting model. The inability to plausibly explain these survey catchability changes causes increased uncertainty in this assessment. This additional source of uncertainty should be considered when setting the 2012 quota and indicates lower catch advice than the projections from the two VPAs that assumed a split in the survey indices.

There is no strong evidence to determine which of the two benchmark methods provides a better scientific basis for fishery management; both models should be considered when setting catch levels. The range of stock perceptions and outlooks from the two models reflect the substantial uncertainty in the assessment. Despite these uncertainties, all assessment results indicate that low catches are needed to promote rebuilding and/or prevent further decline.

Source Documents

Wang Y, O'Brien L, Clark K, Hatt B. 2011. Assessment of Eastern Georges Bank Atlantic Cod for 2011. TRAC Reference Document 2011/02.

[1] Revised July 27, 2011 – 2012 corrected to 2013.

O'Brien L, Worcester T, editors. 2009. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Transboundary Resources Assessment Committee Eastern Georges Bank cod benchmark assessment. TRAC Proceedings 2009/02.

Porter JM, O'Brien L, editors. 2011. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. Report of Meeting held 20-24 June 2011. TRAC Proceedings 2011/01.

Correct Citation

TRAC. 2011. Eastern Georges Bank Cod. TRAC Status Report 2011/02.

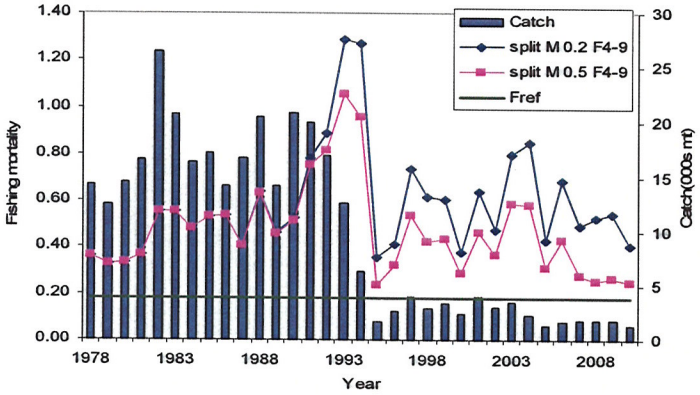

Figure 1. Catches and fishing mortality (F).

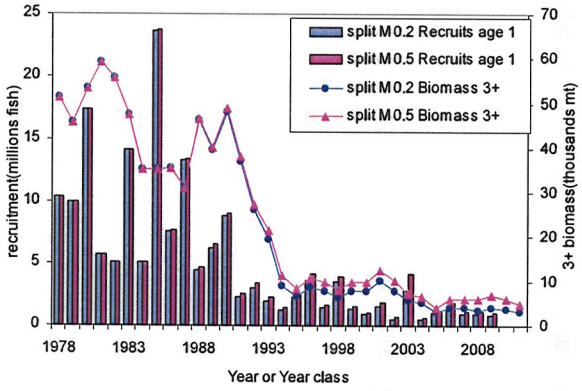

Figure 2. Biomass and recruitment.

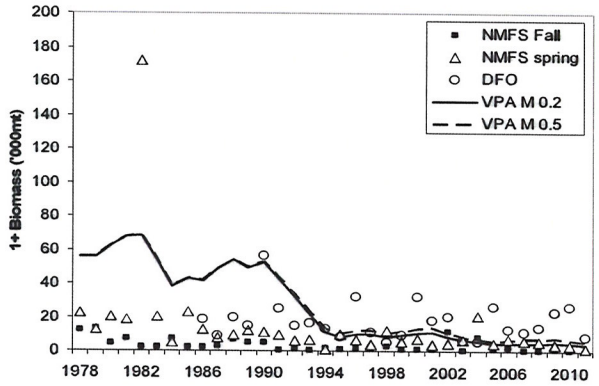

Figure 3. Age 1+ biomass from the surveys and assessments. The survey biomasses are not adjusted by survey catchablility.

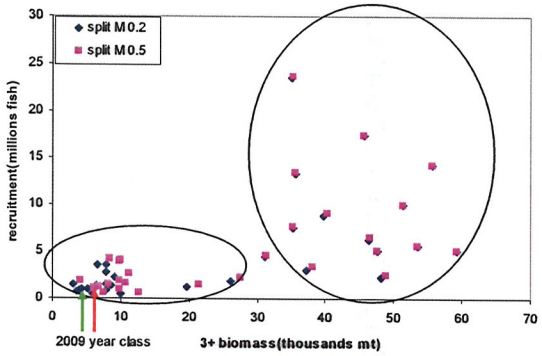

Figure 4. Stock recruitment patterns. Green and red arrows indicate 2009 year class at age 1 for from "split M 0.2" model and "split M 0.5" model, respectively.

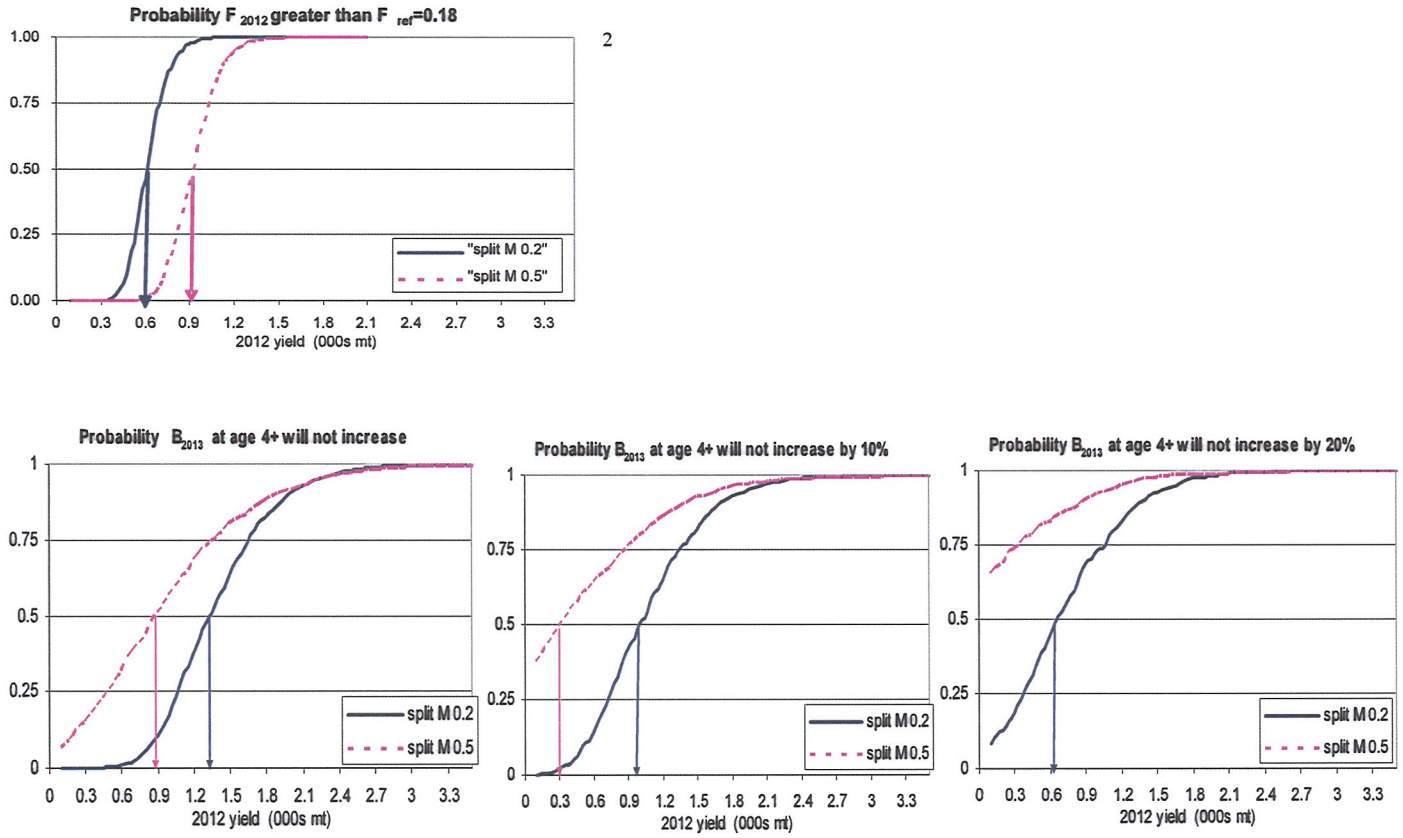

Figure 5. Projection and Risks.

[2] Revised July 27, 2011 – Figure added.

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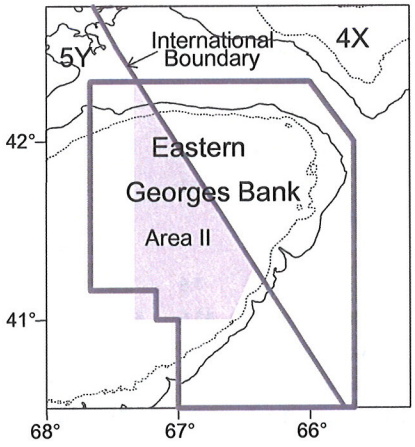
Transboundary Resources Assessment Committee

Status Report 2011/03

EASTERN GEORGES BANK HADDOCK

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



Summary

- Combined Canada and USA catches in 2010 were 18,794 mt.
- Adult biomass decreased to 59,700 mt in 2005 and subsequently increased to 162,800 mt in 2009. In 2011 the adult biomass decreased to 93,400 mt.
- The preliminary estimate for the 2010 year class is outstanding at 557 million age 1 fish which would make it the largest in the assessment time series. Except for the strong 2000 year class and the exceptional 2003 and 2010 year classes, recruitment has fluctuated around an average of 9 million since 1990.
- Fishing mortality was below $F_{ref} = 0.26$ during 1995 to 2003, above or near F_{ref} in 2004 to 2006, but declined since then and was 0.15 in 2010.
- This stock exhibits some positive features such as an expanding age structure, broad spatial distribution and has produced 2 exceptional year classes in the last 8 years.
- Assuming a 2010 catch equal to the 22,000 mt total quota, a combined Canada/USA catch of 16,000 mt in 2012 results in a neutral risk (50%) that the 2012 fishing mortality rate would exceed $F_{ref} = 0.26$. Due to the 2010 year class' entry into the 3+ group in 2013, the estimated probability that the adult biomass will decline from 2012 to 2013 is virtually 0%. Adult biomass is projected to be 124,600 mt at the beginning of 2013.

Ce document est disponible sur l'Internet à : This document is available on the Internet at :
http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

Canada

June 2011

Catches, Biomass (thousands mt); Recruits (millions)

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg	Min	Max
Canada	**Quota**	6.7	6.9	9.9	15.4	14.5	12.7	15.0	18.9	17.6	12.5			
	Landed	6.5	6.8	9.7	14.5	12.0	11.9	14.8	17.6	16.6		5.5	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
USA	**Quota**[2]			5.1	7.6	7.5	6.3	8.1	11.1	12.0	9.5			
	Catch[2]			1.1	0.6	0.7	0.3	1.6	1.6	1.8				
	Landed	1.1	1.7	1.8	0.6	0.3	0.3	1.1	2.2	2.2		2.1	<0.1	9.1
	Discard	<0.1	0.1	0.2	0.1	0.3	0.3	0.1	0.1	<0.1		0.6	<0.1	7.6
Total	**Quota**[3]			15.0	23.0	22.0	19.0	23.0	30.0	29.6	22.0			
	Catch[3,4]			10.9	15.1	12.7	12.3	17.1	17.6	18.4				
	Catch	7.6	8.6	11.9	15.3	12.6	12.5	16.0	19.9	18.8		8.2	2.1	23.3
	Adult Biomass[5]	43.6	83.6	78.7	59.7	122.5	149.5	152.6	162.8	129.4	93.4	49.2[6]	4.9[6]	162.8[6]
	Age 1 Recruits	4.1	2.6	304.4	6.1	23.6	6.4	9.8	5.1	5.9	557.1	34.5[6]	0.2[6]	557.1[6]
	Fishing mortality[7]	0.16	0.19	0.27	0.25	0.25	0.12	0.09	0.13	0.15		0.28	0.09	0.58
	Exploitation Rate[7]	14%	16%	21%	20%	20%	10%	7%	11%	13%		22%	7%	40%

[1]1969 - 2010
[2]for fishing year from May 1st – April 30th
[3]for Canadian calendar year and USA fishing year May 1st – April 30th
[4]sum of Canadian Landed, Canadian discard, and USA Catch (includes discards)
[5]January 1st ages 3+
[6]1931 - 1955, 1969 – 2011
[7]ages 4+ for 1969 - 2002; ages 5+ for 2003 - 2010

Fishery

Under restrictive management measures, **combined Canada/USA catches** 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 15,256 mt in 2005 (Figure 1). Combined catches then decreased to 12,508 mt in 2007 but increased to 19,856 in 2009 and then decreased to 18,794 mt in 2010.

The **Canadian catch** in 2010 decreased to 16,592 mt from 17,648 mt in 2009. The weight of all Canadian landings was monitored at dockside. At-sea observers monitored 12% of the total haddock landed, by weight, in 2010. Discarding and misreporting by the groundfish fishery have been negligible since 1992. Discards of haddock by the Canadian sea scallop fishery ranged between 29 mt and 186 mt since 1969 and were 14 mt in 2010.

USA catches in 2010 decreased to 2,201 mt from 2,208 mt in 2009. Landings were 2,167 mt and discards were estimated to be 34 mt, primarily from the otter trawl fishery, but discards also occurred in the longline fleet. Landings are reported by dealers and discards are estimated from at-sea observer data.

The **combined Canada/USA fishery catch** (landings + discards) in 2010 was dominated by the 2003 year class (age 7) by numbers and weight.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee 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 2010 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series: NMFS spring, NMFS fall and DFO. Data to approximate the age composition of the catch during 1931 to 1955 were used to reconstruct a population analysis of eastern Georges Bank haddock suitable for comparison of productivity to recent years. 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 stock assessment does not display a retrospective pattern.

Improved **recruitment** since 1990, lower exploitation, and reduced capture of small fish in the fisheries allowed the **adult population biomass** (ages 3+) to increase from near an historical low of 10,300 mt in 1993 to 83,600 mt in 2003 (Figure 2). Adult biomass decreased to 59,700 mt in 2005 and subsequently increased to 162,800 mt in 2009, higher than the 1931-1955 maximum biomass of about 90,000 mt. In 2011 the adult biomass decreased to 93,400 mt (80% confidence interval: 74,300 mt – 111,300 mt). The tripling of the adult biomass after 2005 was due to the exceptional 2003 year class, currently estimated at 304 million age 1 fish. The preliminary estimate for the 2010 year class is outstanding at 557 million age 1 fish which would make it the largest in the assessment time series: 1931-1955 and 1969-2010. Except for the strong 2000 year class and the exceptional 2003 and 2010 year classes, recruitment has fluctuated around an average of 9 million since 1990.

Fishing mortality (population weighted for ages 4+) fluctuated between 0.2 and 0.4 during the 1980s, and markedly increased in 1992 and 1993 to about 0.5, the highest observed. From 2003 to the present, the age at full recruitment to the fishery has been at age 5 (rather than age 4, previously) due to a decline in size at age of haddock. Fishing mortality (population weighted for ages 4+ prior to 2003 and ages 5+ for 2003-2010) was below $F_{ref} = 0.26$ during 1995 to 2003, above or near F_{ref} in 2004 to 2006, but declined since then and was 0.15 in 2010 (80% confidence interval: 0.13 – 0.19, Figure 1).

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 (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. There has been a general decline in weights at age since the late 1990s. The size at age for the 2003 year class is smaller than previous year classes, but its rate of growth at length has been similar to previous year classes. Growth of the 2003 year class now appears to have slowed substantially. DFO survey average weights at length, used to reflect fish **condition,** exhibit a declining trend since about 2001 and

declined in 2011 to well below each length's average and are at the lowest level for most lengths examined.

Outlook

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2011. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the probability of exceeding F_{ref}=0.26. 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 or the possibility that the model may not reflect stock dynamics closely enough.

For projections, the 2011 survey and 2010 fishery weights at age were used for inputs, unless it was considered appropriate to use the 3-year averages, i.e., to avoid using the lower weights at age of the 2003 year class and when weights at age had dropped within a cohort. Fishery partial recruitment was based on the most recent five years, however, a value of 1 was used for ages 9+ partial recruitment, higher than the assessment results indicated (0.5) but consistent with F_{ref}. Inputs for the 2003, 2005 and 2010 year classes were derived by accounting for recent trends in reduced size at age. Assuming a 2010 catch equal to the 22,000 mt total quota, a combined Canada/USA catch of 16,000 mt in 2012 results in a neutral risk (50%) that the 2012 fishing mortality rate would exceed $F_{ref} = 0.26$ (Figure 4). The 9+ age group, of which the 2003 year class is the main component, is expected to constitute 72% of the 2012 catch biomass. A catch of 13,900 mt in 2012 results in a low risk (25%) that the 2012 fishing mortality rate will exceed F_{ref}. A catch of 17,800 mt in 2012 results in a high risk (75%) that the 2012 fishing mortality rate will exceed F_{ref}. Due to the 2010 year class' entry into the 3+ group in 2013, the estimated probability that the adult biomass will decline from 2012 to 2013 is virtually 0%. Adult biomass is projected to be 124,600 mt at the beginning of 2013.

Probability of exceeding F_{ref}	**25%**	**50%**	**75%**
2012 catch	13,900 mt	16,000 mt	17,800 mt
2013 catch	13,700 mt	15,700 mt	18,100 mt

Special Considerations

The 2003 year class will enter the 9+ group in 2012. The reference catch will be highly influenced by the partial recruitment that is used for the 9+ age group in the projections.

The medium term outlook for stock biomass is strongly influenced by the outstanding 2003 and 2010 year classes. As the importance of the 2003 year class diminishes, the 3+ stock biomass will decline in 2012 even for relatively low catch, and it will then increase beginning in 2013 as the 2010 year class recruits. While the assessment indicates that the 2012 TAC should be less than the 2011 TAC to prevent the fishing mortality rate from exceeding the F_{ref}, the adult biomass would be expected to increase in 2013 and 2014 compared to the current level (2011),

even if the current TAC was maintained. However, if the 2010 year class turns out to be much smaller than currently estimated (i.e., half the size), a catch equal to the current TAC is likely to result in some decrease in adult biomass in 2014 compared to 2011.

Source Documents

Porter JM, O'Brien L, editors. 2011. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder: Report of Meeting held 21-24 June 2011. TRAC Proceedings 2011/01.

Van Eeckhaute L, Brooks E. 2011. Assessment of Haddock on Eastern Georges Bank for 2011. TRAC Reference Document 2011/03.

Correct Citation

TRAC. 2011. Eastern Georges Bank Haddock. TRAC Status Report 2011/03.

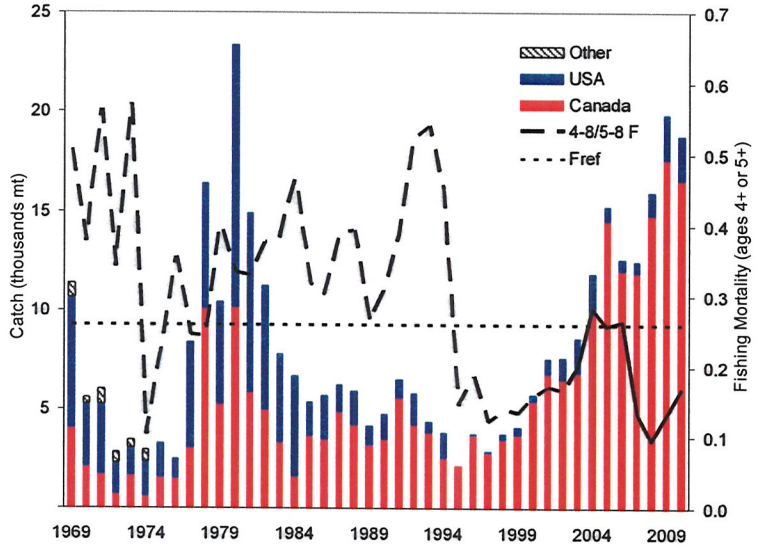


Figure 1. Catches (bars) and fishing mortality (line); (F=4-8 for 1969-2002 and 5-8 for 2003-2010).

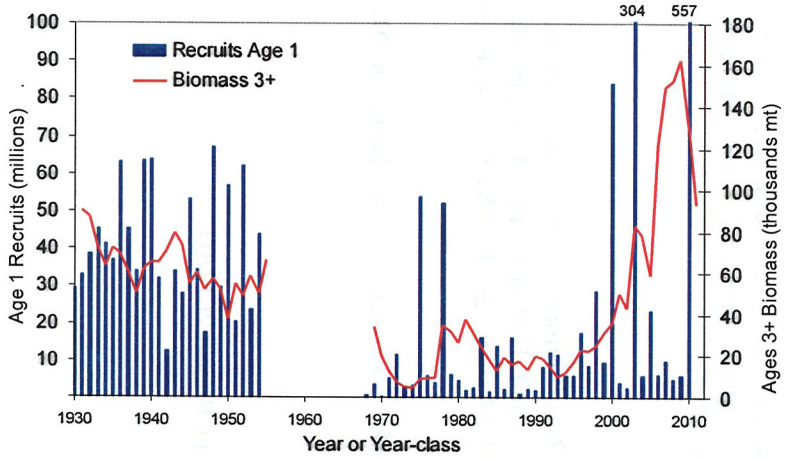


Figure 2. Biomass (line) and recruitment (bars).

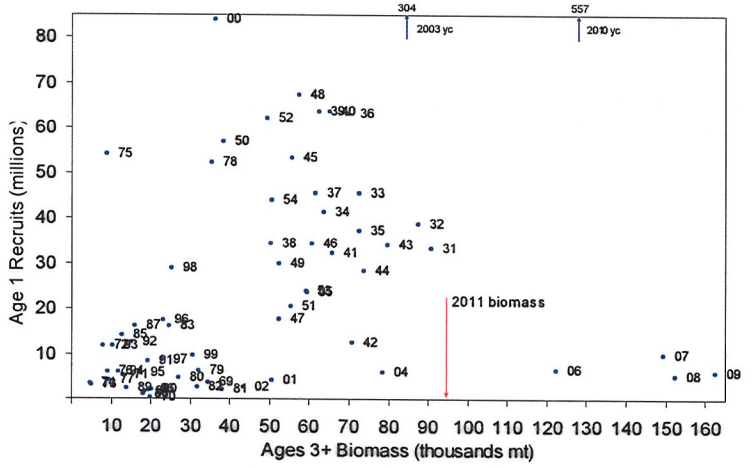


Figure 3. Stock recruitment patterns.

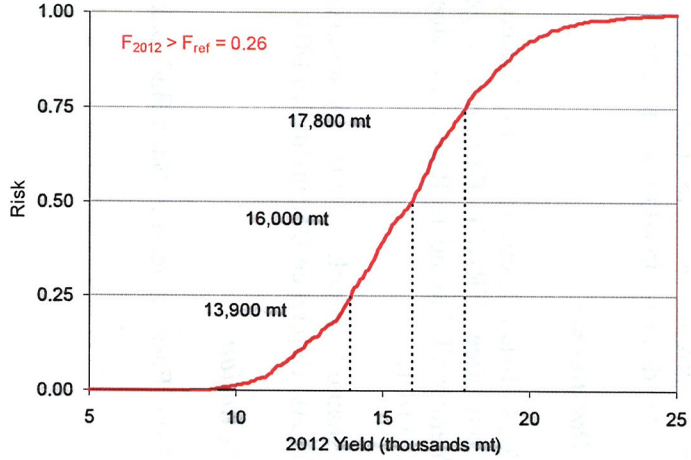


Figure 4. Projection risks.