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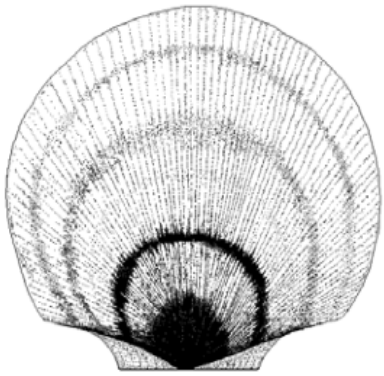
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2011/059

ASSESSMENT OF GEORGES BANK SCALLOPS (*PLACOPECTEN MAGELLANICUS*)



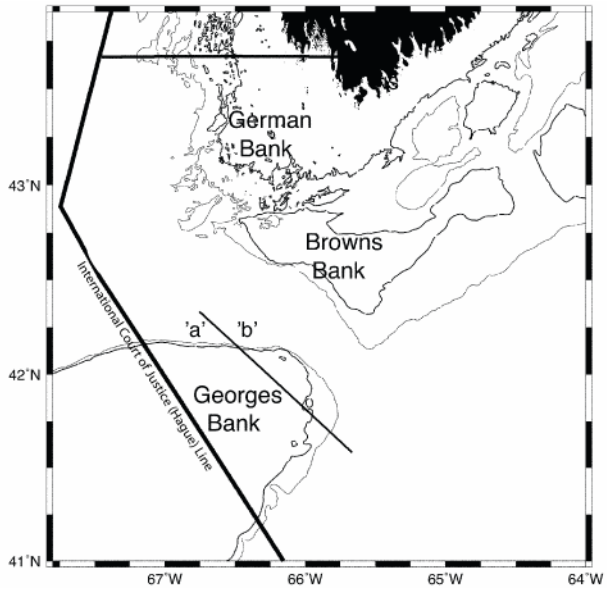


Figure 1. Location of Georges Bank 'a' and 'b'.

Context:

The sea scallop, Placopecten magellanicus, is found only in the Northwest Atlantic, from Cape Hatteras to Labrador. Scallops are aggregated in patches and harvestable concentrations are called beds. Major areas of offshore fishing activity are Georges Bank, Browns Bank, German Bank, the Eastern Scotian Shelf (Banquereau, Middle Bank, Sable and Western banks), and St. Pierre Bank (south of Newfoundland). Scallops prefer a sandy, gravel bottom and occur in depths of 35 to 120 m on the offshore banks.

The offshore scallop fleet consists of wet fish vessels and freezer-trawlers. Generally, these vessels simultaneously fish two New Bedford offshore rakes, 4 to 6.1 m width, one on each side of the vessel.

Annual assessments of the status of the offshore scallop resource take into account the annual survey findings, meat size distribution in the catch, and fishery performance. The management of the main scallop fishery on Georges Bank refers to zone 'a'. Georges Bank zone 'b' is a marginal growth area for scallops and has separate management measures. The assessment and advice presented in this document use the assessment framework established in 2009 and are for Georges Bank zone 'a' only; some elements of the fishery in zone 'b' are also presented for historical purposes.

In support of management of the Georges Bank 2011 scallop fishery, a meeting of the Science Advisory Process was held 5 May 2011 at the Bedford Institute of Oceanography in Dartmouth, N.S., to: (1) assess the status of the resource; (2) provide harvest advice for the 2011 fishery; and (3) document by-catch in the fishery.

SUMMARY

- The 2010 total allowable catch (TAC) was 5,500 t[1] for zone 'a' and 200 t for zone 'b'. Total reported landings were 5,300 t for zone 'a' and 66 t for zone 'b'.

- The commercial catch rate for zone 'a' declined slightly from 17.43 kg/hm in 2009 to 15.17 kg/hm 2010 but remains above the long-term median (10.15 kg/hm).

- By-catch estimates of yellowtail flounder have increased from 84 t in 2009 to 200 t in 2010. Estimated discards of cod declined from 69 t in 2009 to 44 t in 2010, and estimated discards of haddock declined from 54 t in 2009 to 14 t in 2010.

- In 2010, survey catch rates of recruit (75-94 mm) and fully recruited (≥95 mm) scallops were above their respective 29-year median levels while catch rates for pre-recruits (<75 mm) were at the 29-year median level. The 2010 estimate of recruits remains high, although overall abundance of the 2006 year class has continued to decline since it was first fully observed in 2008.

- Fully recruited biomass, estimated to be 20,785 t in 2010, increased from the 2009 estimate (16,610 t) and is above the 25-year median biomass of 12,745 t. Recruit biomass, estimated to be 14,040 t in 2010 declined from the 2009 estimate (18,890 t), but is still the third highest estimated biomass since 1986.

- The 2011 interim TAC of 4,500 t for zone 'a' results in an exploitation rate of 0.16, and incoming recruitment is expected to be among the highest in the time series. Harvest scenarios ranging from 1,000 to 9,000 t are all predicted to yield increases in commercial biomass for 2011.

- Harvest scenarios depend on the continued recruitment of the large 2006 year-class to the fishery in 2011. They assume a natural mortality of 0.1 for the recruit biomass and no fishing mortality of scallops below 95 mm.

BACKGROUND

Rationale for Assessment

A meeting of the Science Advisory Process was held 5 May 2011 at the Bedford Institute of Oceanography (BIO), in Dartmouth, Nova Scotia to review the 2010 fishery and assess the status of the scallop stock on Georges Bank in support of the management of the 2011 fishery. Participants included DFO scientists, fishery managers, representatives of the provincial government, and representatives of the industry and First Nations.

An assessment framework for Georges Bank scallops was reviewed at a framework meeting in February 2009 (Jonsen et al. 2009). Therefore, it was determined that the assessment approach would not be reviewed this year; only the assessment results and projections were reviewed.

[1] Throughout this report, 't' refers to tonnes of scallop meats.

ASSESSMENT

Fishery

The 2010 Total Allowable Catch (TAC) was 5,500 t for zone ‘a’ and 200 t for zone ‘b’ (Table 1). Total reported landings were 5,300 t for zone ‘a’ and 66 t for zone ‘b’. Based upon preliminary analysis of the 2010 fishery data and the annual stock survey data, an interim TAC of 4,500 t was set for the 2011 Georges Bank zone ‘a’ fishery and 0 t for zone ‘b’. Effort measured on Georges ‘a’ in hours fished multiplied by gear width in metres (hm) increased slightly from 316,862 hm in 2009 to 349,298 hm 2010. The commercial catch rate declined slightly from 17.43 kg/hm in 2009 to 15.17 kg/hm 2010 but remains above the long-term median of 10.15 kg/hm (Figure 2).

Table 1. Canadian landings of sea scallop meats from Georges Bank and total allowable catch (TAC), in metric tons. Since 1998, Georges Bank has been divided into zones ‘a’ and ‘b’.

Year	Catch (t)	TAC (t)
1981	7612	--
1982	3918	--
1983	2418	--
1984	1945	--
1985	3812	--
1986	4900	4300
1987	6793	6850
1988	4336	5400
1989	4676	4700
1990	5218	5200
1991	5805	5800
1992	6151	6200
1993	6183	6200
1994	5003	5000
1995	1984	2000
1996	2996	3000
1997	4259	4250

Year	Catch (t)		TAC (t)	
	zone ‘a’	zone ‘b’	zone ‘a’	zone ‘b’
1998	3191	800	3200	800
1999	2503	1196	2500	1200
2000	6212	601	6200	600
2001	6480	395	6500	400
2002	6469	192	6500	200
2003	5985	199	6000	200
2004	3518	200	3500	200
2005	2484	201	2500	200
2006	3932	162	4000	200
2007	4000	401	4000	400
2008	5498	358	5500	400
2009	5524	261	5500	350
2010	5300	66	5500	200

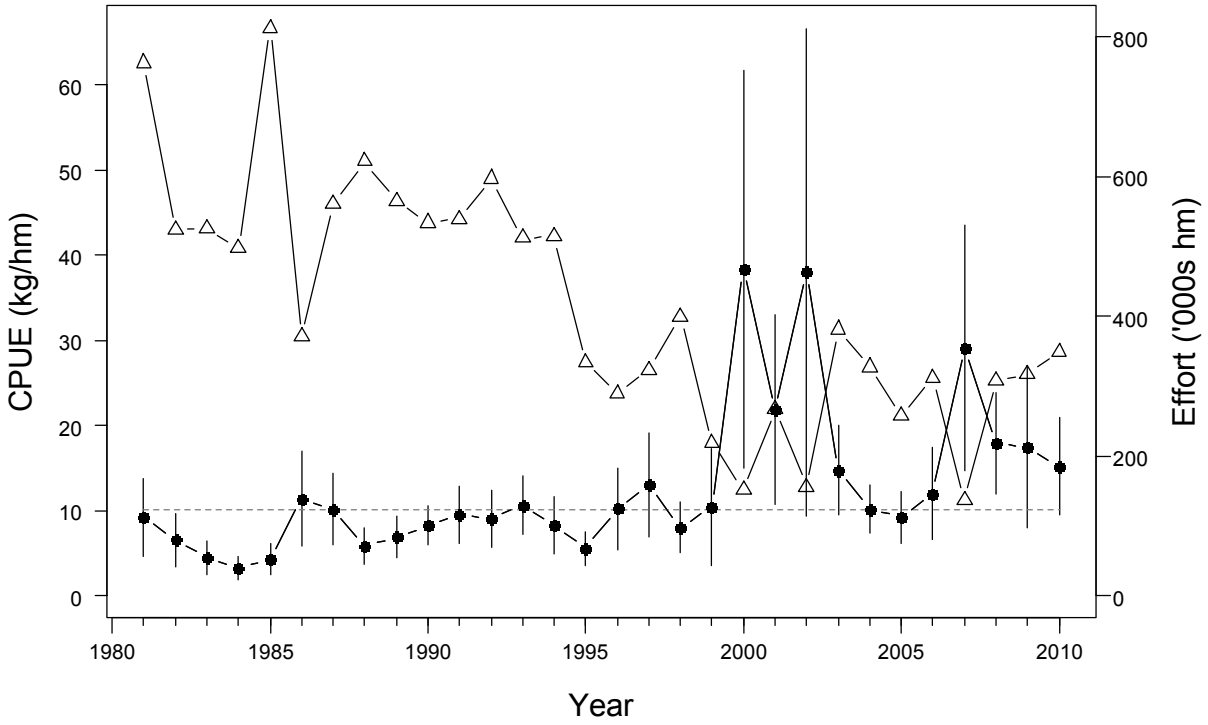


Figure 2. Annual catch per unit effort (CPUE, kg/hm, with jackknifed standard deviations) (●) and effort (hm) (Δ), wetfish and freezer trawler fleets combined, for Georges Bank 'a'. The dashed line is the 29-year median CPUE value.

By-catch

By-catch of yellowtail flounder, cod and haddock were estimated using the method described in Gavaris et al. (2009). Estimated discards of yellowtail flounder have increased from 84 t in 2009 to 200 t in 2010 (Table 2). Estimated discards of cod declined from 69 t in 2009 to 44 t in 2010, and estimated discards of haddock declined from 54 t in 2009 to 14 t in 2010. Fishing effort increased by over 100% from 2007 to 2008 and has been relatively constant from 2008 to 2009. Effort increased slightly from 2009 to 34,617 hours (h) in 2010 (Table 2). The target for observer coverage is 2 trips per month. In 2010, this represented approximately 11% of the total hours fished.

Table 2. Estimated effort (h) and discards (t) of yellowtail flounder (ytf), cod, and haddock (had) caught as by-catch in the scallop fishery on Georges Bank 'a' and 'b' during the years 2007 – 2010.

Year	Observed Effort (h)	Total Effort (h)	Species	Total Estimated Discards (t)
2007	1565	14,394	ytf	**96**
			cod	**114**
			had	**56**
2008	3325	31,885	ytf	**117**
			cod	**37***
			had	**33**
2009	3431	32,556	ytf	**84**
			cod	**69**
			had	**54**
2010	3825	34,617	ytf	**200**
			cod	**44**
			had	**14**

*Discards from the Canadian scallop fishery on Georges Bank for 2007 and 2008 were adjusted for minor changes in input data from two 2007 trips and two 2008 trips. For 2007, this did not result in any change in the total estimated discards, however, for 2008, this update resulted in an increase of 1t for cod.

Survey

Survey catch rates on Georges Bank 'a' for recruits (75-94 mm) and fully recruited (≥95 mm) scallops were above their respective 29-year median levels in 2010 (Figure 3) while catch rates for pre-recruits (<75 mm) were at the 29-year median level. The growth of the large cohort (2006 year-class) observed in the 70 to 95 mm range in 2009 appears slower than expected. While this year class has partly recruited to the fishery it remains largely within the recruit size range in 2010 (Figure 4). The overall abundance of this cohort has continued to decline since it was first fully observed in 2008. Investigations of this decline indicate that this could not be attributed to landings from the fishery. The 2010 estimate of recruits remains among the highest in the survey series to date (256 scallops/tow). The abundance of fully recruited scallops has increased from 2009 to 178 scallops/tow, levels similar to what was observed in 2000-02 and 2008 (Figure 3).

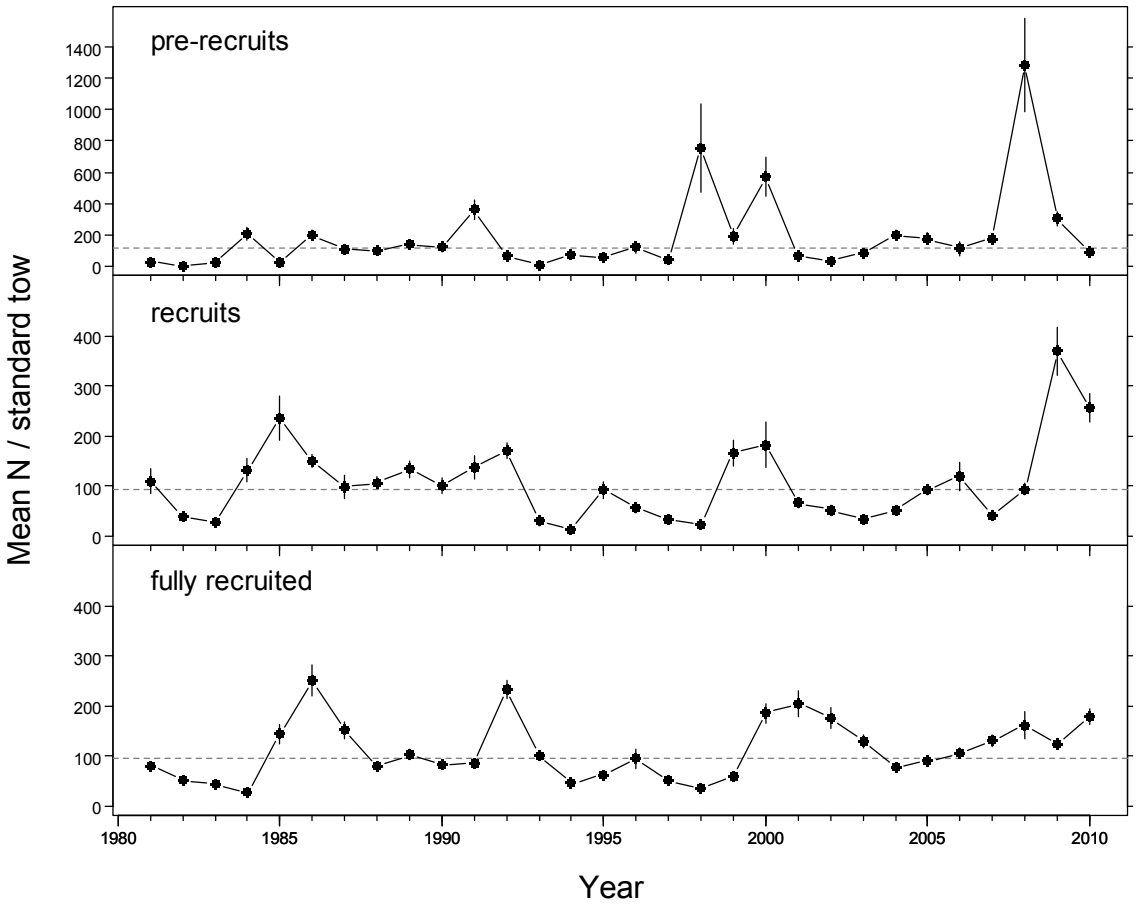


Figure 3. Survey abundance indices (mean number/standard tow) for pre-recruit (<75 mm since 1996, <60 mm from 1986-1995 and <45 mm before 1986), recruit (75-94 mm since 1996, 60-85 mm from 1986-1995 and 45-75 mm before 1986) and fully recruited (≥95 mm since 1996, ≥85 mm from 1986-1995 and ≥75 mm before 1986) scallops. The dashed lines are the 29-year median value for each size class.

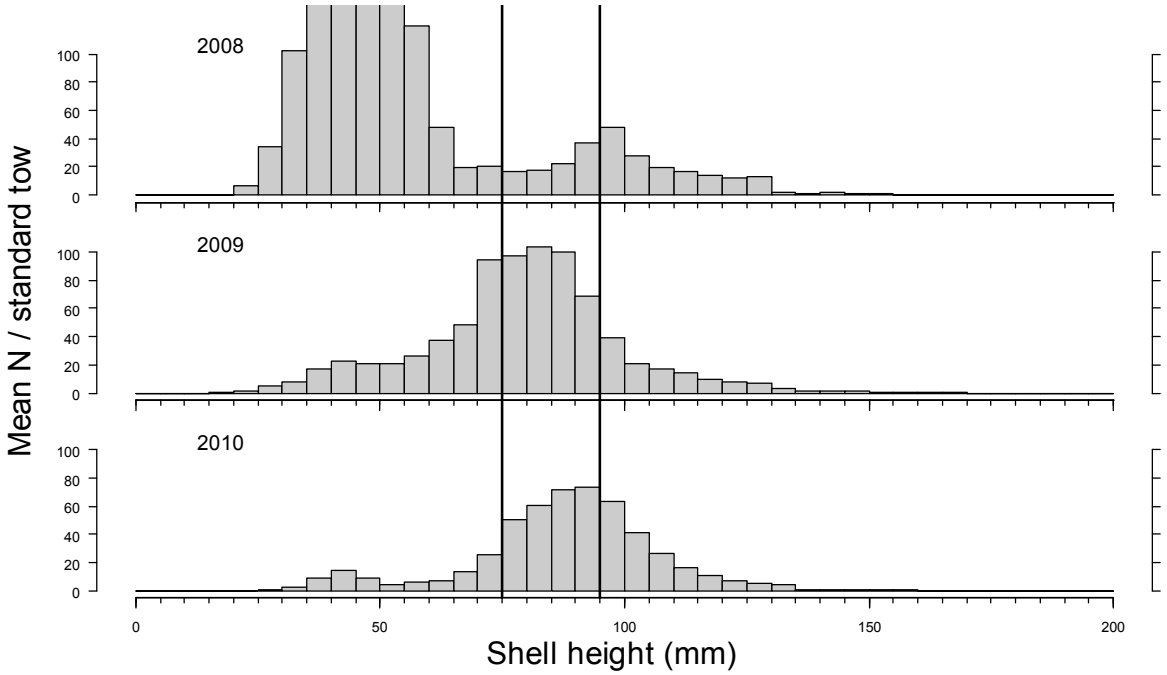


Figure 4. Mean number of scallops at shell height (mean number/standard tow) from the Georges Bank 'a' survey. The vertical lines indicate the divisions between pre-recruit, recruit and fully recruited size classes. The peak value in 2008 was 261 scallops per tow between 45-50 mm.

Shell height and meat weight data from the survey were analyzed to see how the condition varies over time. Condition refers to the meat weight relative to shell height and fluctuates depending on environmental variables that vary annually and spatially. The assessment model accounts for spatial variability using depth as a proxy. The overall condition factor for Georges Bank 'a' in August 2010 was 13.06 g/dm^3 (meaning that on average a scallop with a 100 mm shell would have an 13.06 g meat). This was well below the long term mean of 15.05 g/dm^3 (Figure 5).

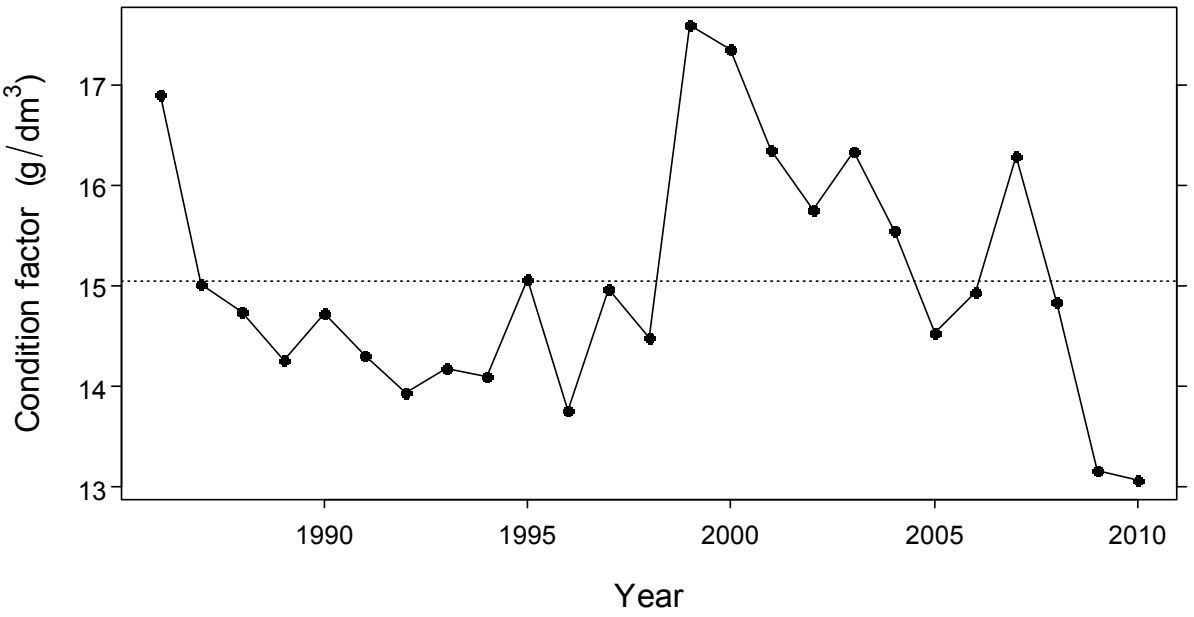


Figure 5. Overall annual condition factor calculated from shell height and meat weight data collected from the August survey. The horizontal dashed line is the 25-year mean value.

Population Model

The delay-difference model, described in Jonsen et al. (2009), was fit to the annual survey and commercial catch rate indices on Georges Bank 'a' from 1986 to 2010 to estimate commercial biomass and exploitation, as well as to provide 2011 biomass projections and harvest scenarios. Minor changes to the model included considering fishery data between surveys (September in year t to August in year t+1) and including annual condition in the growth estimates. The model was also fit to the time series beginning in 1986 to avoid the complications associated with the unregulated fishery in the early 1980s.

Fully recruited biomass, estimated to be 20,785 t in 2010, increased from the 2009 estimate (16,610 t) and is above the 25-year median biomass of 12,745 t (Figure 6). This estimate was lower than the median projection from 2009 (32,615 t) but within the 80% credible limit (18,449, 57,292 t). Recruit biomass, estimated to be 14,040 t in 2010 declined from the 2009 estimate (18,890 t), but is still the third highest estimated biomass since 1986. The model's forecast for 2011 biomass is 31,430 t, assuming a catch of 4,500 t (the interim TAC), no change in condition and a natural mortality rate for recruits of 0.1. This represents an estimated 52 % increase in biomass from 2010. Harvest scenarios ranging from 1,000 t to 9,000 t are predicted to yield increases in commercial biomass with a probability of decline ranging from 0.05 to 0.26 (Table 3).

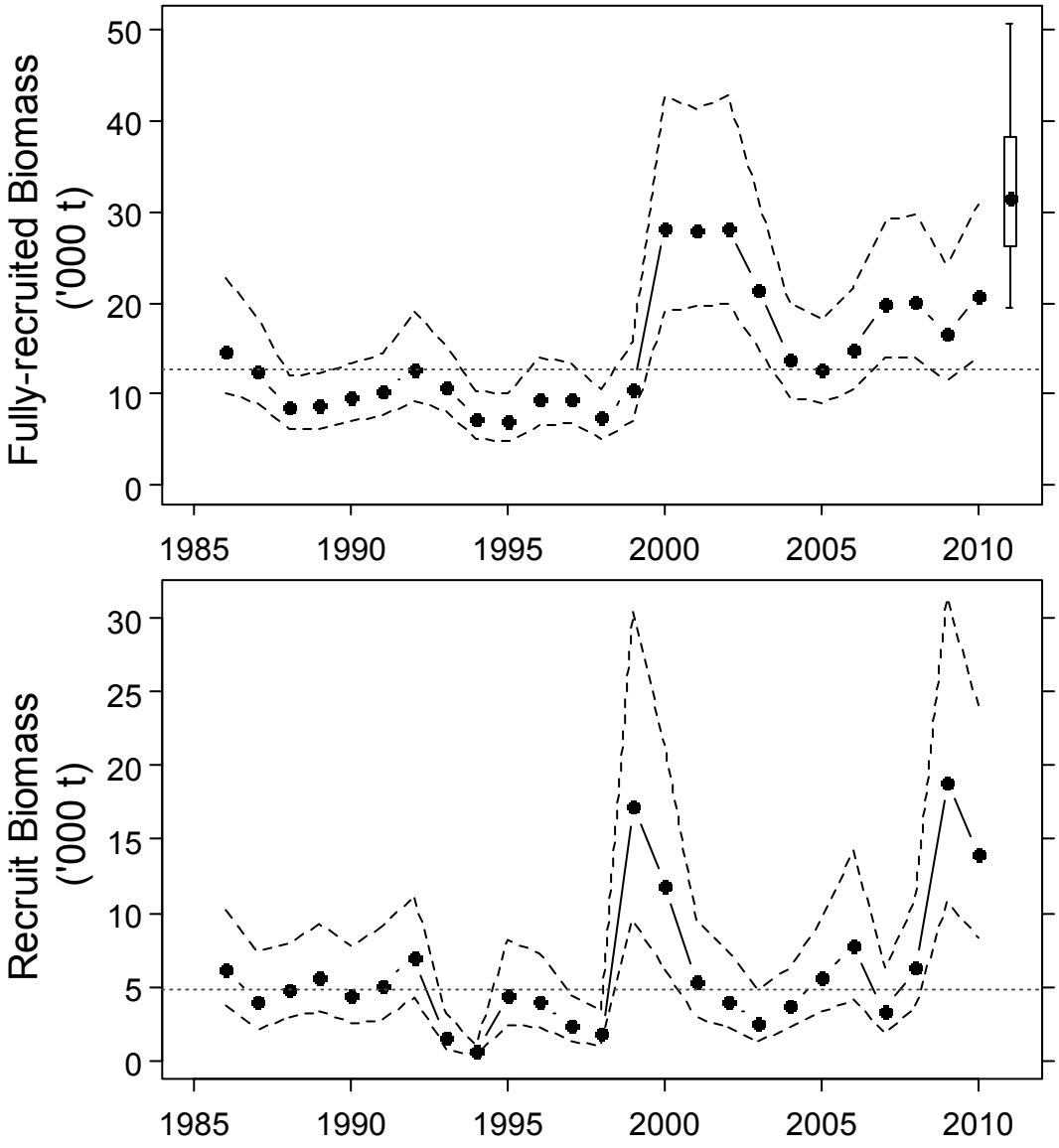


Figure 6. Biomass estimates for fully recruited scallops from the delay-difference model fit to the Georges Bank 'a' survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates and the dotted line represents the 25 year median. The forecasted fully recruited biomass for 2011, assuming a catch of 4,500 t, is displayed as a box plot with median (●), 50% credible limits (box) and 80% credible limits (whiskers).

Sources of Uncertainty

The delay-difference model assumes knife-edged recruitment and that natural mortality is 0.1 for both fully-recruited and recruit size classes. In effect, the model assumes that all scallops smaller than 95 mm shell height are not retained and there is no discard or incidental fishing mortality that results from fishing activity. The decline in the abundance of the 2006 year class from 2009 which was expected to recruit to the fishery in 2010 cannot be accounted for in the catch (Figure 3). As well higher proportions of clappers in high density areas, suggests that mortality of scallops smaller than 95 mm shell height was greater than 0.1 in 2010. Alternate

projection scenarios that considered natural mortality of recruits as high as 0.5 still resulted in increased commercial biomass when harvests ranged from 1,000 t to 9,000 t.

There is spatial heterogeneity in the distribution of age groups. The fishing fleet targets particular scallop size classes that can result in spatial aggregation of fishing effort. This aggregation suggests that the commercial catch rate index may not be proportional to abundance or biomass. This non-proportionality could be exacerbated in the future with continued use of voluntary closure areas.

In the past the delay-difference model has tended to under predict biomass as biomass increases and over predict as it declines and this pattern is typical of many stock assessment models. However, biomass is currently increasing and yet last year's projection was an overestimate. This could be the result of overestimating growth, underestimating natural mortality rate or some combination of both causes.

CONCLUSIONS AND ADVICE

Fully recruited (commercial) biomass has been above 10,000 t since 2000. This was due to a combination of two very large recruit cohorts in 1999 and 2000 (Figure 6), a shift by industry to generally lower exploitation rates, and the adoption of an industry-implemented protocol on a minimum landed scallop size from 1995 onward.

The 2011 interim TAC of 4,500 t results in an exploitation rate of 0.16, and incoming recruitment is expected to be among the highest in the time series. Harvest scenarios ranging from 1,000 to 9,000 t are all predicted to yield increases in commercial biomass for 2011 (Table 3). These scenarios depend on continued recruitment of the large 2006 year-class to the fishery in 2011. They assume a natural mortality of 0.1 for the recruit biomass and no fishing mortality of scallops below 95 mm.

Table 3. Harvest scenarios for 2011 in terms of exploitation and expected changes in biomass. Potential catches in 2011 are evaluated in terms of the probability of a decline in biomass. These probabilities account for uncertainty in the biomass forecasts. In this year, all changes in biomass are predicted to be positive.

Catch (t)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)
1000	0.06	0.05	74.24
2000	0.09	0.07	67.74
3000	0.12	0.07	60.80
4000	0.15	0.09	55.58
5000	0.17	0.12	48.44
6000	0.20	0.13	42.61
7000	0.23	0.17	36.18
8000	0.26	0.21	29.38
9000	0.29	0.26	23.02

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of 5 May 2011 on Georges Bank Scallop Assessment Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Gavaris, S., J. Sameoto, A. Glass, and I. Jonsen. 2009. Discards of Atlantic Cod, Haddock, and Yellowtail Flounder from the 2008 Canadian Scallop Fishery on Georges Bank. TRAC Ref. Doc. 2009/06.

Hubley, P.B., Glass, A., Reeves, A., Sameoto, J., and Smith S.J. 2011. Browns Bank North Scallop (Placopecten magellanicus) Stock Assessment. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/042: iv + 63p.

Jonsen, I.D., A. Glass, B. Hubley, and J. Sameoto. 2009. Georges Bank 'a' Scallop Framework Assessment: Data Inputs and Population Models. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/034.

FOR MORE INFORMATION

Contact: Brad Hubley
Population Ecology Division
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Box 1006, 1 Challenger Drive
Dartmouth, Nova Scotia B2Y 4A2 Canada

Tel: (902) 426-9760
Fax: (902) 426-1862
E-Mail: Brad.Hubley@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice,
Maritimes Region
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Phone number: 902-426-7070
Fax: 902-426-5435
e-mail address: XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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