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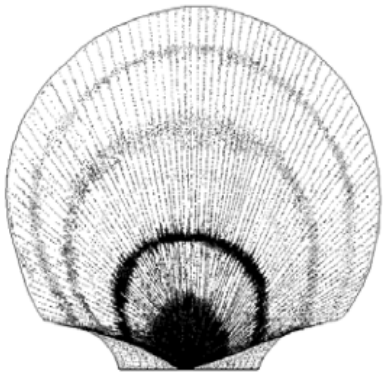
Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2009/038

ASSESSMENT OF GEORGES BANK SCALLOPS (*PLACOPECTEN MAGELLANICUS*)



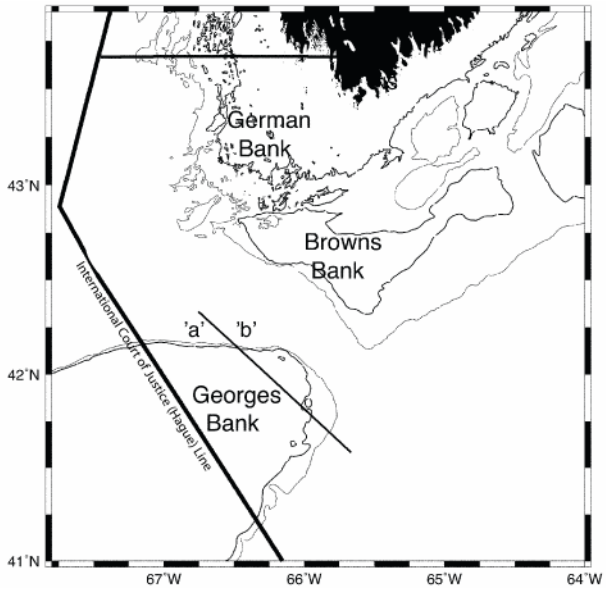


Figure 1. Location of Georges Bank 'a' and 'b'.

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, the Eastern Scotian Shelf (Banquereau, Middle Bank, Sable and Western banks), Browns Bank, German Bank, and St. Pierre Bank (south of Newfoundland). Scallops prefer a sandy, gravel bottom and occur in depths of 35 to 120m 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 a separate management plan. The assessment and advice presented in this document use the new 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 2009 scallop fishery, a meeting of the Regional Advisory Process was held 24 April 2009 at the Bedford Institute of Oceanography, in Dartmouth N.S. to: (1) assess the status of the resource; (2) provide harvest advice for the 2009 fishery; and (3) document bycatch in the fishery. Participants included DFO scientists, fishery managers and representatives of the industry and provincial government.

SUMMARY

- The 2008 total allowable catch (TAC) was 5,500 t for zone ‘a’ and 400 t for zone ‘b’. Total reported landings were 5,498 t for zone ‘a’ and 358 t for zone ‘b’.

- The offshore scallop fleet fished primarily fresh scallop products until 2002, when freezer trawlers were incorporated into the fleet. In the first year of fishing, the freezer trawlers landed 775 t or 12% of the total landings. In 2008, the freezer trawlers landed 3,776 t or 69% of the total landings from zone ‘a’ and 265 t or 74% of the total landings from zone ‘b’.

- The commercial catch rates declined from 2007 to 2008 but were still above the long-term average.

- Bycatch of yellowtail flounder in 2008 was similar to that in 2007, whereas bycatch of cod and haddock declined, despite a two-fold increase in fishing effort. The target for observer coverage is 2 trips per month. In 2008, this represented 10% of the total hours fished.

- In 2008, indices of pre-recruit, recruit and fully recruited scallop abundance were at or above their respective 27-year median levels. Abundance of pre-recruit scallops was at the highest level observed since 1981, approximately 400 scallops/tow higher than the previous high in 1998.

- Fully recruited biomass, estimated to be 22,540 t (meats) in 2008, declined very slightly from the 2007 estimate (22,680 t) but was well above both the 27-year median biomass of 9,960 t and the recent lows in 2004 to 2006.

- The 2009 interim TAC is 5,500 t and harvest scenarios evaluated in the historical range of 1,500 t to 7,000 t are all predicted to yield increases in commercial biomass. For 2009, a harvest of 7,673 t, representing an exploitation rate of 0.25, is predicted to result in no change in biomass. The extremely large cohort of pre-recruits observed in the 2008 survey will recruit to the fishery in 2010-11, with an expectation of much higher commercial biomass levels at that time.

BACKGROUND

Species Biology

Scallops may reach sexual maturity as early as age 2 and have separate sexes. The female gonad is red in colour and the male gonad is creamy white. The major spawning period is from August to October; eggs and sperm are released into the sea and fertilization is external. Fertilized eggs develop into the larval stage (veliger) in a few days, and will continue to develop while swimming in the water column for 30 to 60 days before settling to the bottom. Newly settled larvae undergo a series of morphological changes before becoming a juvenile scallop.

Scallop growth is estimated from the position of annual rings on the shell. The growth rates vary from one fishing area to another and are influenced by season, depth and temperature.

ASSESSMENT

Fishery

Georges Bank is one of the main sea scallop stocks fished by the offshore scallop fleet. Since 1986, the offshore scallop fleet has fished Georges Bank year round under an Enterprise Allocation management regime. Prior to 1998, this area was managed as one unit, but since then it has been managed as two zones. Zone 'a' is the traditional scallop fishing ground and a more productive area than zone 'b', which is marginal scallop habitat (Table 1, Figure 1).

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

A total allowable catch (TAC) and a meat count of 33 meats per 500 grams are used to manage Georges Bank 'a'. Until 2008, Georges Bank 'b' was managed with a meat count of 40 meats per 500 g and a rolling TAC allocated in 200 t increments for a specified fishing period (typically 6 weeks). As of 1 January 2008, Georges Bank 'b' is managed with a conventional TAC and a meat count of 40 meats per 500 g.

Since November 2004, the offshore scallop industry has implemented voluntary fishery closure areas on Georges Bank to improve commercial yield of large aggregations of juvenile scallops. Three voluntary closures were put in place by the industry in December 2007. The voluntary closure coordinates were modified in October 2008 as a result of available information on size distribution of scallops in the voluntary closed areas and surrounding areas.

The 2008 TAC was 5,500 t for zone ‘a’ and 400 t for zone ‘b’. Total reported landings were 5,498 t for zone ‘a’ and 358 t for zone ‘b’. Based upon preliminary analysis of the 2008 fishery data and the annual stock survey data, an interim TAC of 5,500 t was set for the 2009 Georges Bank zone ‘a’ fishery and 400 t for zone ‘b’.

In 2008, there were 10 wetfish and 6 freezer trawler vessels fishing at least a portion of the season. The offshore scallop fleet fished primarily fresh scallop products until 2002, when freezer trawlers were incorporated into the fleet. In the first year of fishing, the freezer trawlers landed 775 t or 12% of the total landings. In 2008, the freezer trawlers landed 3,776 t or 69% of the total landings from zone ‘a’ and 265 t or 74% of the total landings from zone ‘b’, compared to 68% and 55% of 2007 landings in zones ‘a’ and ‘b’, respectively.

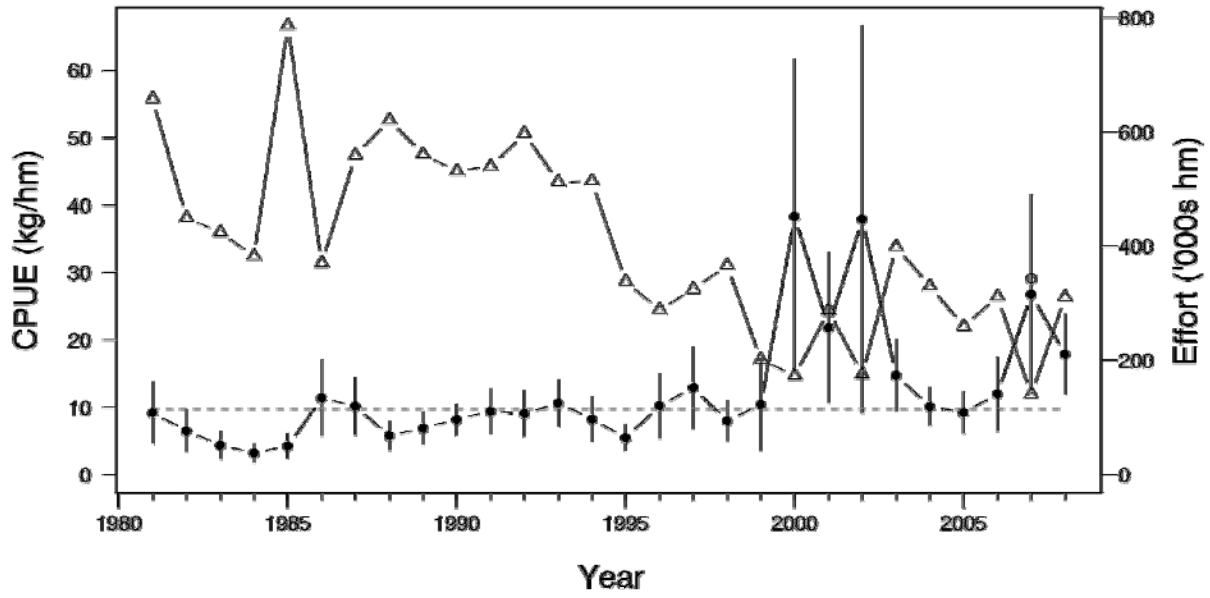


Figure 2. Annual catch per unit effort (CPUE, kg/hm, effort units are hour-metre, with jackknifed standard deviations) (●) and effort (hm) (Δ), wetfish and freezer trawler fleets combined, for Georges Bank 'a'. In 2007, the CPUE was calculated including (○) and not including catch reported from within the 2005 voluntary closure area. The dashed line is the 27-year median value.

A standardization distinguishing between wetfish and freezer trawler vessels indicated that catch rates are similar for both fleets once the rake size is taken into account (Jonsen et al. 2009). Therefore, catch rates are presented for both fleets combined. The commercial catch rate declined from 2007 to 2008 but was still above the long-term average (Figure 2). The catch rate in 2007is presented with and without fishing in the 2004 voluntary closure that was opened in 2007.

On average, the fishery landed smaller meats in 2008 (17 g mode) than in 2007 (21 g mode) (Figure 3). The meat weight mode in the 2008 catch was 2 g smaller than that of the 6-year mean distribution (19 g). This is consistent with the decline in average meat weights observed in the survey and within the expected range. Meats greater than 17 g were landed less frequently in 2008 than on average over the previous 6 years.

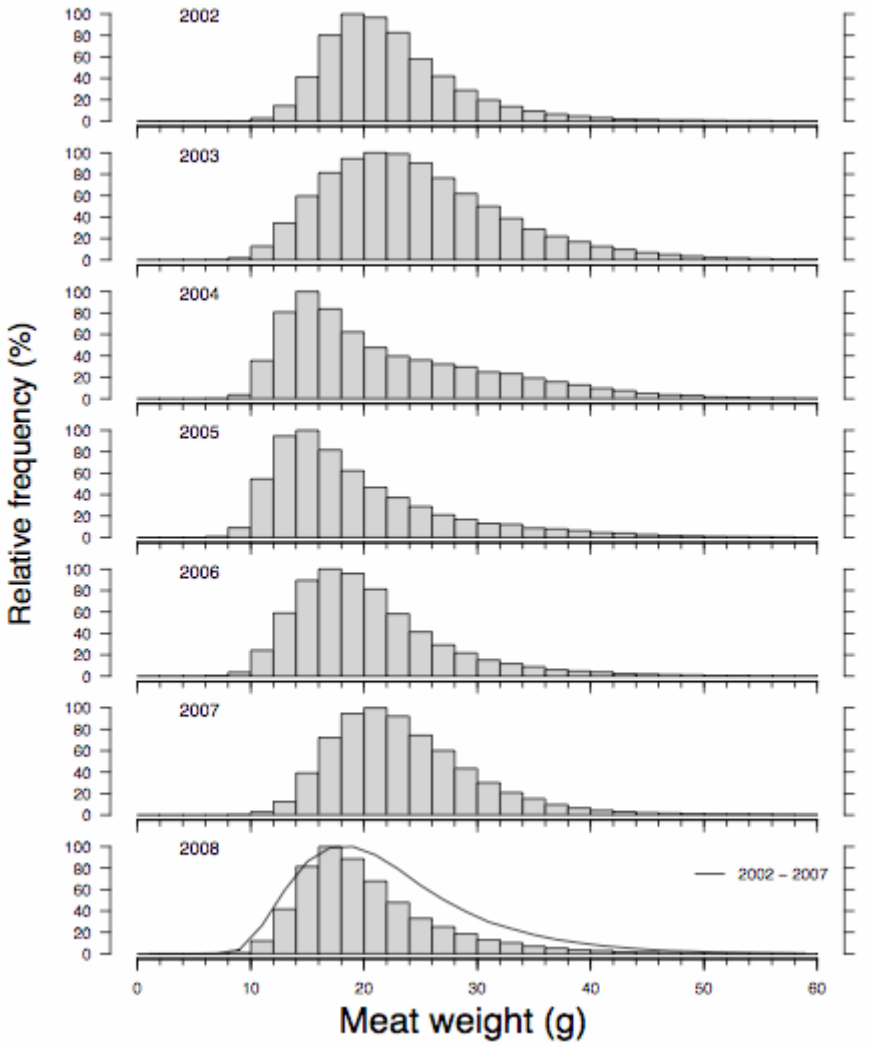


Figure 3. Meat weight distributions by 2-g increments sampled from Georges Bank 'a' landings (2002 to 2008). The solid line (bottom panel) is the 6-year mean distribution.

Bycatch

Discards in the scallop fishery on Georges Bank are recorded by independent observers. One scallop trip per month has been observed since 2005 and this coverage was increased to two trips per month in July 2007. Discards from observed trips were prorated to the entire scallop fleet via the observed discard rate (kg/h) (Gavaris et al. 2008). Discards of all identifiable species were recorded, but only three commercial groundfish species (yellowtail flounder, cod and haddock) are reported in detail here.

Bycatch of yellowtail flounder in 2008 was similar to that in 2007. Estimated discards of yellowtail flounder increased from 255 t in 2005 to 565 t in 2006 and then declined sharply, due to industry-implemented changes in fishing practices, to 105 t in 2007 and 117 t in 2008 (Table 2). Bycatch of cod and haddock declined, despite a two-fold increase in fishing effort. Estimated discards of cod declined from a high of 124 t in 2007 to 36 t in 2008. Estimated discards of haddock were highest at 67 t in 2006 and declined to 33 t in 2008. Fishing effort during this period peaked at 36,992 h in 2006, declined by more than half in 2007 and increased

to 36,109 h in 2008. The target for observer coverage is 2 trips per month. In 2008, this represented 10% of the total hours fished.

Table 2. Estimated discards of yellowtail flounder (ytf), cod, and haddock (had) caught as bycatch in the scallop fishery on Georges Bank 'a' and 'b' during the years 2005 – 2008.

Year	Observed Effort (h)	Total Effort (h)	Species	Total Estimated Discards (t)
2005	2005	31,681	ytf	**255**
			cod	**87**
			had	**50**
2006	2238	36,992	ytf	**565**
			cod	**117**
			had	**67**
2007	1726	16,614	ytf	**105**
			cod	**124**
			had	**61**
2008	3646	36,109	ytf	**117**
			cod	**36**
			had	**33**

Survey

A joint DFO – industry survey takes place annually on Georges Bank, covering both zones, but this assessment is only conducted on data from zone 'a'. Information is gathered to assess the abundance and composition of the scallop stock. Meat weight and shell height data obtained from scallop samples collected on the survey are used to convert from scallop numbers observed on the survey to scallop biomass.

Based on work presented in Hubley et al. (2009), a new stratification scheme was adopted based on a history survey index design. The survey data from 1981 to 2008 were re-stratified using this new design.

Survey catch rates on Georges Bank 'a' for pre-recruits (< 75 mm), recruits (75-94 mm) and fully recruited (≥ 95 mm) scallops fluctuated with three dominant peaks occurring since 1981. In 2008, all three indices were at or above their respective 27-year median levels. Abundance of pre-recruit scallops is at the highest level observed since 1981, approximately 400 scallops/tow higher than the previous high in 1998 (Figure 4). This large increase is due to a large cohort (2006 year-class) in the 25 to 65 mm range (Figure 5), which is primarily in the northwest region of the bank (Figure 6a). Moderately high densities (300-1,000 per tow) of pre-recruits were also found in the extreme southern region.

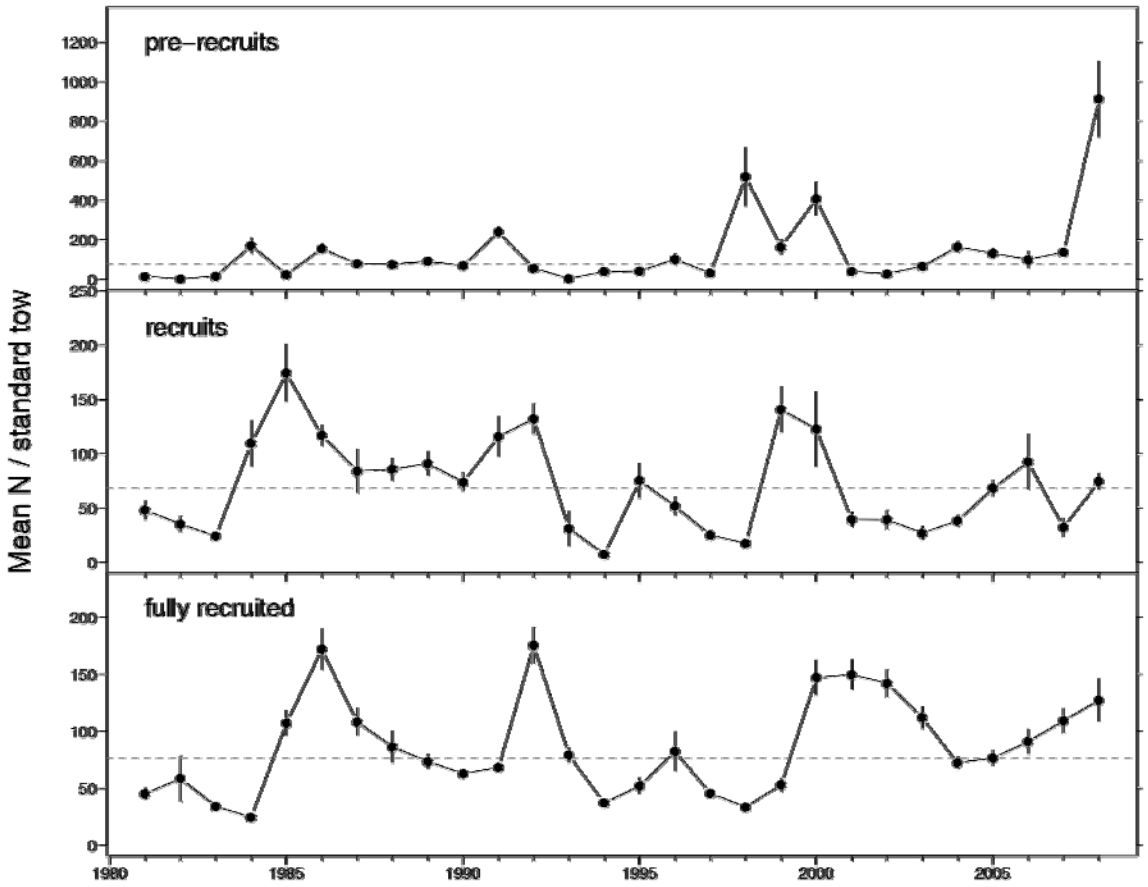


Figure 4. Survey abundance indices (mean number/standard tow) for pre-recruit (< 75 mm), recruit (75-94 mm) and fully recruited (≥ 95mm) scallops. The dashed lines are the 27-year median value for each size class.

Recruit size scallops increased from 2007 and are now at the 27-year median level (Figure 4). Most of these scallops are in the 90 to 94 mm range (Figure 5) with the highest densities primarily in the northwest and eastern regions of the bank (Figure 6b).

Fully recruited scallops increased steadily from 2005 and are now nearing the peak observed between 2000 and 2002 (Figure 4). Relatively few scallops above 130 mm were observed (Figure 5). The highest densities of fully recruited scallops were observed in the mid-northern region and straddling the division between zones ‘a’ and ‘b’ (Figure 6c). The average meat weight of fully recruited scallops in the 2008 survey decreased from 2007, but at 21.1 g it is still well above the 27-year mean of 18 g (Figure 7).

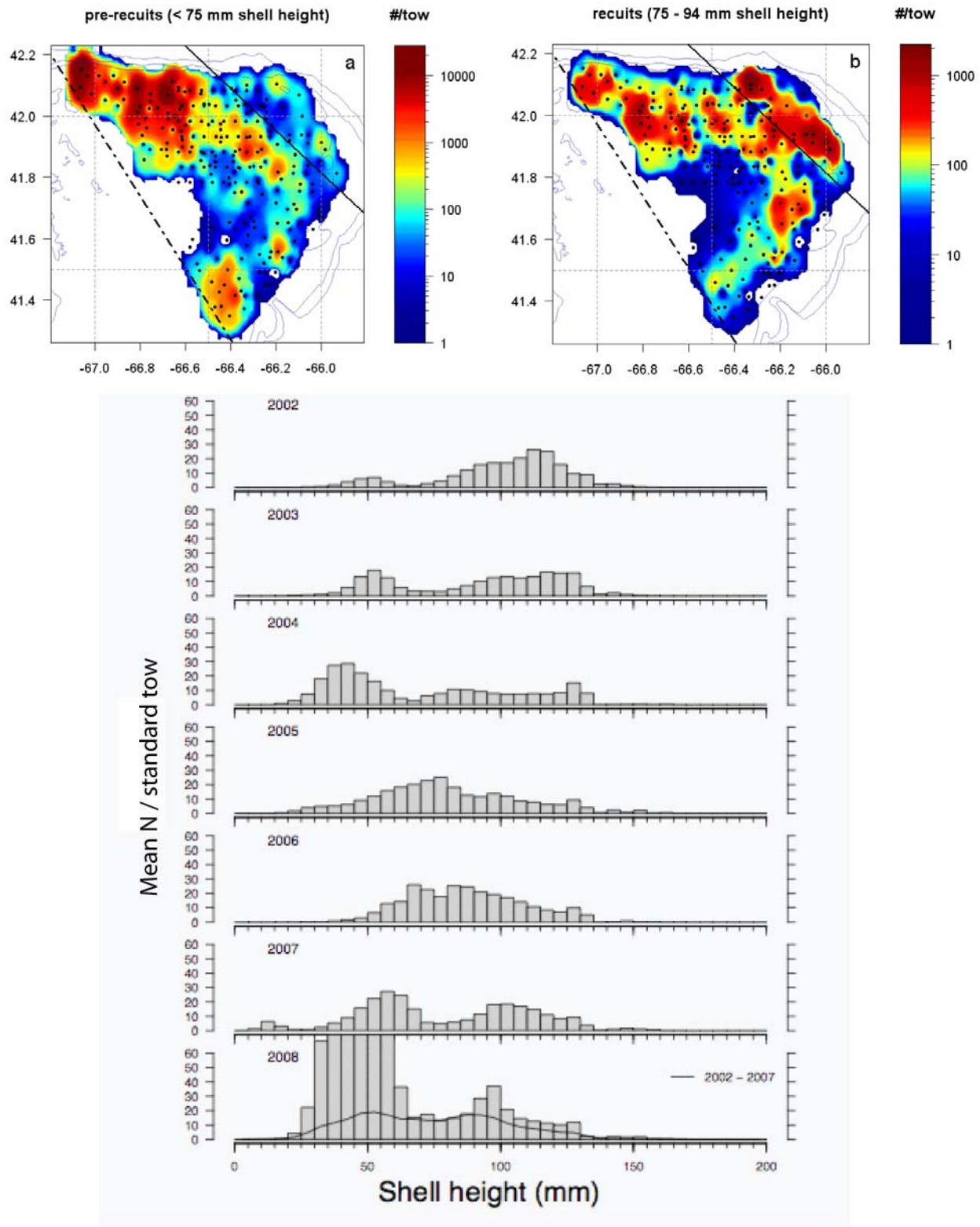


Figure 5. Mean number of scallops at shell height (mean number/standard tow) from the Georges Bank 'a' survey. The solid line (bottom panel) is the 6-year mean.

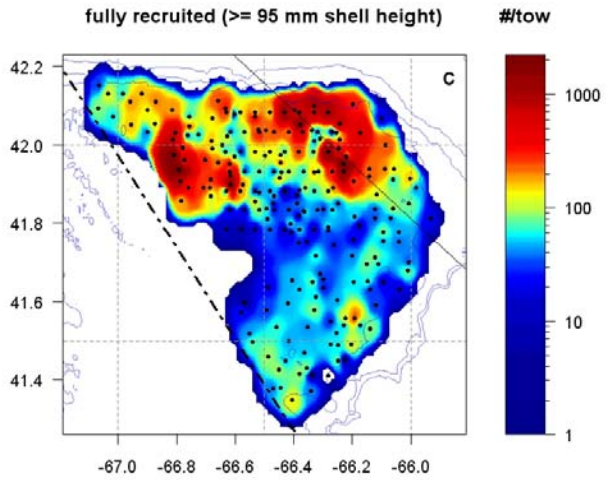


Figure 6. Spatial distribution of (a) pre-recruit, (b) recruit and (c) commercial size scallop catches from the 2008 Georges Bank survey. Tow positions are indicated.

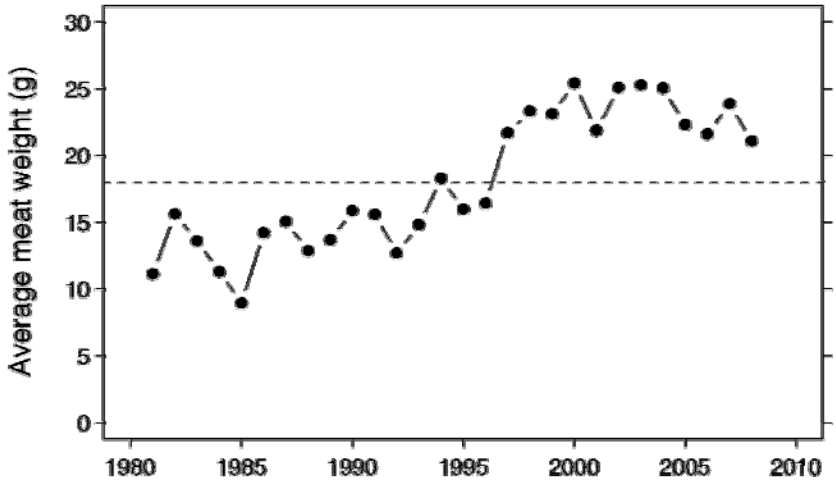


Figure 7. Average meat weight of fully recruited scallops from the survey of Georges Bank 'a'. The dashed line displays the 27-year mean.

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' to estimate commercial biomass and exploitation, as well as to provide 2009 biomass projections and harvest scenarios. This model has three key assumptions. First, increases in mean body size with age are linear. Second, selection to the fishery is knife-edged; that is, all scallops larger than the size at recruitment to the fishery have the same probability of being caught. Third, all fully selected scallops experience the same natural mortality rate. In general, these assumptions seem reasonable given our understanding of scallop biology and the fishery on Georges Bank.

Fully recruited biomass, estimated to be 22,540 t (meats) in 2008, declined very slightly from the 2007 estimate (22,680 t) but is well above both the 27-year median biomass of 9,960 t and the recent lows in 2004 to 2006 (Figure 8). The model's forecast for 2009 biomass is 25,320 t, assuming a catch of 5,500 t (the interim TAC). This represents an estimated 12% increase in

biomass from 2008 (Table 3). Harvest scenarios ranging between 1,500 t and 7,000 t are all predicted to yield increases in commercial biomass.

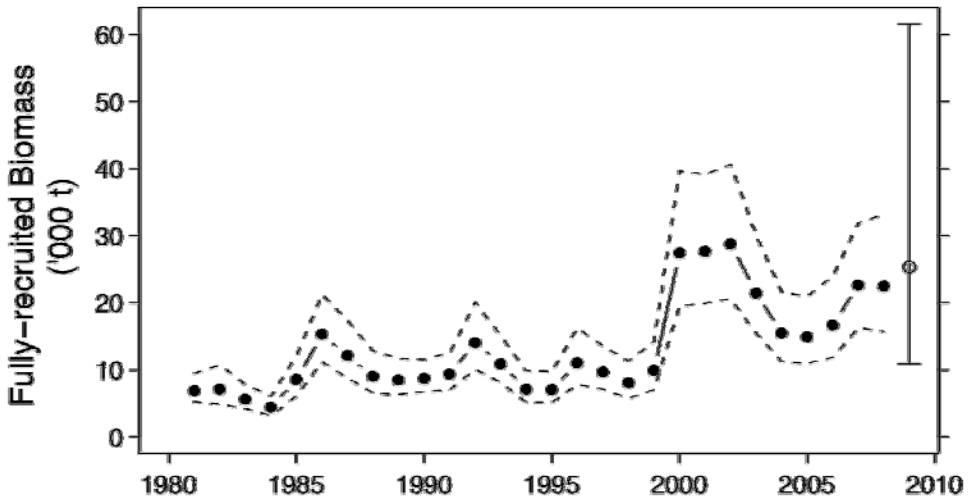


Figure 8. Biomass estimates for fully recruited scallops from the delay-difference model fit to the Georges Bank 'a' survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The forecasted fully recruited biomass for 2009, assuming a catch of 5,500 t, is displayed as the open symbol with 95% credible limits.

Sources of Uncertainty

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.

The delay-difference model tends to under predict biomass as biomass increases and over predict as it declines. This pattern is typical of many stock assessment models, but the magnitudes of over and under prediction by this model must be heeded when considering the harvest advice.

A lack of recent aging data for Georges Bank scallops limits confidence in the growth rate parameters used in the delay-difference model and could bias biomass estimates up or down. Unobserved changes in growth rate over time would affect the estimated biomass trajectory.

CONCLUSIONS AND ADVICE

Fully recruited (commercial) biomass has been above 10,000 t since 2000. This is due to a combination of two very large recruit cohorts in 1999 and 2000 (Figure 8), a shift by industry to generally lower exploitation rates (Figure 9), and adoption of an industry-implemented protocol on a minimum landed scallop size from 1995 onward. The exploitation rates are generally higher than the levels expected due to growth discounted for natural mortality (replacement line in Figure 9), suggesting that recruitment was able to compensate in years when biomass increased (e.g., 2007) but not in years when biomass decreased (e.g., 2005).

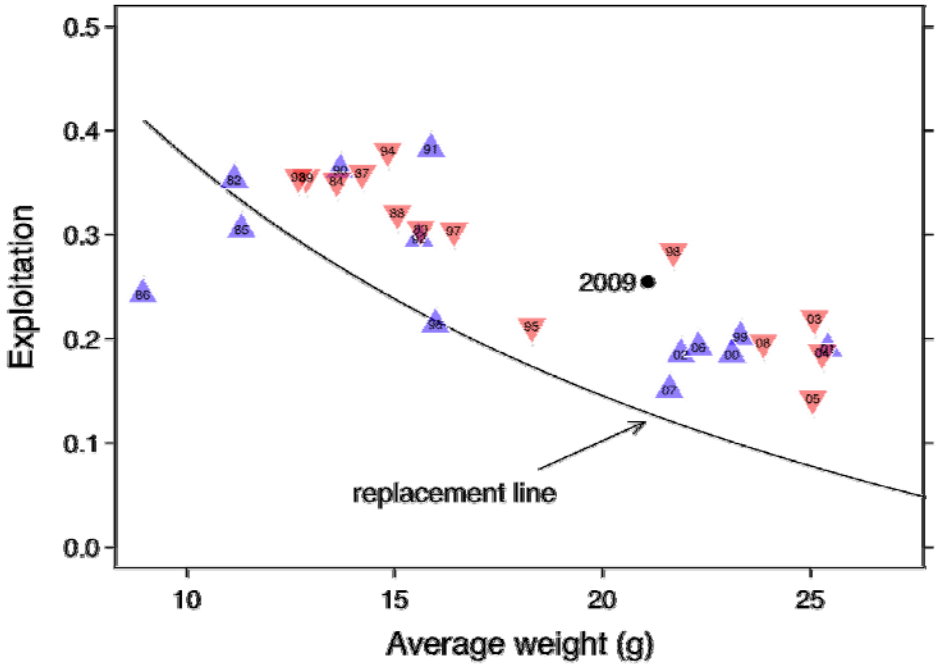


Figure 9. Exploitation versus average meat weight of fully recruited scallops on Georges Bank 'a'. Triangle symbols indicated whether a decrease (red, down) or increase (blue, up) in biomass from the previous year occurred. The replacement line refers to the expected increase in biomass due to growth discounted for natural mortality. The 2009 data point shows the estimated exploitation level that implies no change in fully recruited biomass from 2008 to 2009.

The 2009 interim TAC of 5,500 t results in an exploitation rate of 0.18, which is above the replacement line in Figure 9; however, incoming recruitment is expected to be near average and compensate for this level of exploitation. Harvest scenarios evaluated in the historical range of 1,500 to 7,000 t are all predicted to yield increases in commercial biomass for 2009 (Table 3). A harvest of 7,673 t, representing an exploitation rate of 0.25, is predicted to result in no change in biomass. The extremely large cohort of pre-recruits observed in the 2008 survey (Figure 4) will recruit to the fishery in 2010-11. Should this cohort recruit successfully, higher commercial biomass levels would be expected than at present.

Table 3. Harvest scenarios for 2009 in terms of exploitation and expected changes in biomass. Potential catches in 2009 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	Change in Biomass (%)
1,500	0.05	0.22	32.2
2,000	0.06	0.22	30.2
2,500	0.08	0.26	26.7
3,000	0.10	0.27	24.3
3,500	0.11	0.29	21.7
4,000	0.13	0.31	18.6
4,500	0.15	0.34	16.1
5,000	0.16	0.35	14.4
5,500	0.18	0.38	11.8
6,000	0.20	0.41	8.9
6,500	0.22	0.43	6.3
7,000	0.23	0.46	3.7

SOURCES OF INFORMATION

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ISSN 1919-5079 (Printed)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2009. Assessment of Georges Bank Scallops (*Placopecten magellanicus*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/038.