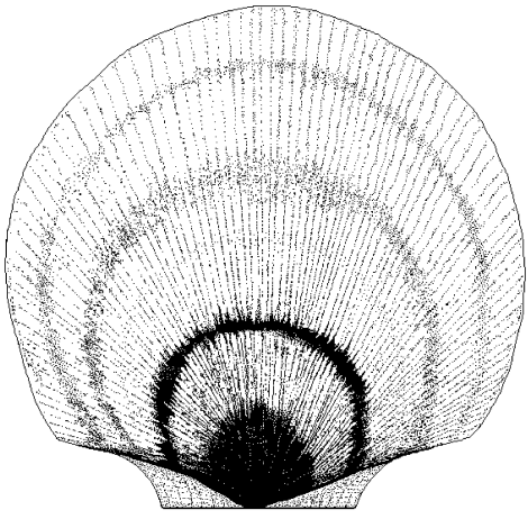
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2009/012

# ASSESSMENT OF SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY



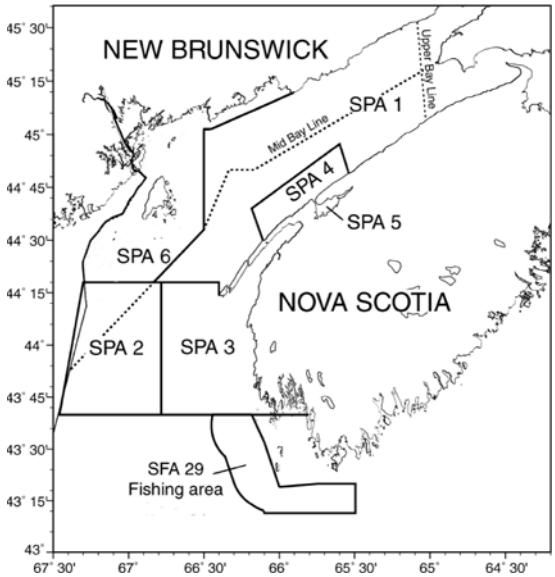



*Figure 1. Scallop Production Areas in the Bay of Fundy. Refer to full detail map in Figure 39 (last page) for place names.*

## Context

*The Bay of Fundy area is fished by three scallop fleets: the Full Bay Fleet, the Mid Bay Fleet, and the Upper Bay Fleet. Full Bay vessels are 45' to 65' while Mid Bay and Upper Bay vessels are generally between 30' to 45'. Full Bay licensed vessels are permitted to fish throughout the Bay of Fundy. The Mid Bay license holders have access to all areas north of the Mid Bay line. The Upper Bay licence holders are restricted to the upper reaches of the bay. The fishery has been managed using limited entry, gear size limits, seasonal closures, minimum shell height, meat count, and individual meat weight restrictions. The gear width limit is 5.5 m with a ring size of not less than 82 mm inside diameter. Quotas were introduced in 1997. The Full Bay Fleet operates under an Individual Transferable Quota (ITQ) system while the Mid and Upper Fleets fish with competitive quotas. Total Allowable Catches (TACs) are set and landings are reported in terms of meat weights (adductor muscles).*

*Scallops in Scallop Production Areas 1 to 6 in the Bay of Fundy are assessed annually according to a framework conducted in 2002.*

# SUMMARY

## General

- Some observer coverage was funded by DFO in 2008 for exploration of bycatch. No information from this program was available in time to be included in this assessment.
- The determination of stock status for scallops in all of the areas in the Bay of Fundy is highly dependent upon the estimates from the annual drag survey. The total number of survey stations covered in the Bay of Fundy and Approaches in 2008 was 754 (including 25 stations funded by the Petiticodiac Monitoring Program), less than the 855 stations in 2006 but still above the number of stations in recent previous years (520 to 702).

## SPA 1A

- Landings were 225 t for the Full Bay Fleet during the 2007/2008 fishing year against a quota of 216 t. An interim TAC of 120 t was set for the 2008/2009 season based on the 2007 assessment advice. Recent commercial catch rates have been stable around the median.
- The research survey boundaries have been revised since 2007, which has resulted in the increase of survey area within 1A (with a corresponding reduction in 1B). As a result, biomass calculations are now higher for this area than seen in previous assessments (reduced for 1B).
- Since the above average 1998 year-class recruited to the fishery in this area, recruitment has been lower and the abundance of commercial size scallops has been fished down.
- The only sign of above average recruitment is in the 8 to 16 mile area. While the densities of scallops in the 50 to 70 mm size range appear higher than observed in recent years, they are much lower than observed for the 1998 year-class at the same size.
- Population biomass estimated to be 1426 t (meats) in 2008, has increased over the estimate for 2007 (1408 t) and is above the median biomass of 1246 t (1997 to 2007).
- Catches of 196 to 265 t for 2008/2009 should result in a small increase in biomass for 2009. However, the model has a tendency to overestimate the commercial size population when forecasting ahead and catches in the upper part of this range may actually result in a small decrease in biomass.

## SPA 1B

- The Full Bay Fleet landed 210 t against a total quota of 206.25 t over all three subareas. Landings for the Mid Bay fleet were 120 t in total against a TAC of 148.28 t for SFA 28B and SFA 28C. The TAC for SFA 28C and 28D was 85.47 t for the Upper Bay fleet and they landed 87 t in total for 2008. An interim TAC for 2008/2009 was set at 100 t for the Full Bay fleet.
- Commercial catch rates have been increasing for all three fleets since 2006 mainly due to better than average recruitment in the Cape Spencer, Middle Bay North (Quaco Ledge) and SFA 28C area. The increase for the Upper Bay Fleet in 2008 was partly due to fishing in the small but very productive Advocate area of SFA 28D.
- The research survey boundaries have been revised since 2007, which has resulted in the decrease of survey area within 1B (with a corresponding increase in 1A). As a result, biomass calculations are now lower for this area than seen in previous assessments (increased for 1A).
- Survey estimates in the SFA 28B, 28C and Advocate Harbour areas (28D) indicate above average densities of scallops in the 40 to 64 mm size range in 2008.

- Population biomass estimated to be 1890 t (meats) in 2008 has increased slightly over the estimate for 2007 (1864 t) and is above the median biomass of 1638 t (1997 to 2007).
- Catches for 2008/2009 of 290 t or less should not result in a decline in biomass for 2009. Recruitment prospects look much better for 2009/2010 and the incoming year-class will be commercial size for the 2010/2011 fishery.

## SPA 2

- This area is considered to be marginal habitat for scallops and is not monitored regularly. SPA 2 was last assessed in 2006 (DFO 2007).

## SPA 3

- Total landings for the 2007/2008 fishing year were 80 t against a TAC of 70 t. An interim TAC of 50 t was set for October of the 2008/2009 fishing season.
- Commercial catch rate has been stable and close to the median over the time series since 2006.
- A voluntary closure to protect areas of high densities of scallops in the 10 to 40 mm size range observed in the 2007 survey was instituted at the request of the Full Bay fleet. While the 2008 survey found high densities of scallops in the 10 to 40 mm range, there was no evidence that the high densities from 2007 had resulted in similar higher than average densities in the next age class (40 to 70 mm) in 2008.
- Comparison of differences between survey estimates from the 2007 and 2008 surveys indicated significant decreases in mean numbers per tow of recruits and mean weights per tow of commercial size scallops and recruits.
- Population biomass estimated to be 463 t in 2008 has decreased over the estimate for 2007 (531 t) and is below the median biomass of 655 t (1996–2007).
- The commercial size biomass is predicted to decrease from 2008 to 2009 if the interim quota of 50 t was caught. Catches as low as 35 t in 2008/2009 will also result in a decline. Recruitment is expected to be low for at least the next two years.

## SPA 4

- Total landings in 2007/2008 were 79 t against a TAC of 100 t. An interim TAC of 100 t was set for the 2008/2009 season was based on last year's assessment.
- Commercial catch rates declined after the above average 1998 year class recruited to the fishery but have been either relatively stable or slightly increasing since 2005/2006.
- A voluntary closure to protect areas of high densities of scallops in the 10 to 40 mm size range observed in the 2007 survey was instituted at the request of the Full Bay fleet. There was no evidence of similar high densities in the next size class (50 to 80 mm) in the 2008 survey.
- Overall, the survey indices indicate that the population has been stable since 2006 with low levels of recruitment, pre-recruits and clappers. Given the trends in the pre-recruit estimates, low levels of recruitment will probably continue for the next two years.
- Population biomass estimated to be 779 t (meats) in 2008 has increased over the estimate for 2007 (760 t) and is just below the long-term median biomass of 792 t (1983 to 2007).
- A TAC of 100 t for 2008/2009 should result in little change in the population biomass of commercial size scallops for 2009.

## SPA 5

- Landings in 2008 were 7 t against a TAC of 10 t.
- Commercial catch rates in 2008 increased over 2007 and were close to the long-term median levels (1977–2007).
- Survey shell height frequencies indicate that the 2007 year-class may be the strongest seen since the 1999 and 2000 year-classes. Currently, the mean catch per tow for commercial size scallops is below the long-term median and close to the lowest seen in this series.
- The TAC for 2009 should not exceed the average catch of 9 t over the period 1997 to 2008 excluding the high catch in 2004. Good recruitment prospects may improve the stock status in 2010.

## SPA 6

- Landings in 2008 were 68 t against a TAC of 140 t.
- Both catch and catch rates for both fleets have been relatively stable over the last four years.
- Comparison of survey estimates from 2007 and 2008 suggests there has been little change in mean numbers per tow of commercial size scallops in 6A, 6B or 6C.
- Recent levels of catch do not appear to result in a decrease in the population abundance of scallops in the SPA 6 area as a whole.

# BACKGROUND

## Species Biology

The sea scallop (*Placopecten magellanicus*) occurs only in the northwest Atlantic from Virginia north to Labrador. Within this area, scallops are concentrated in persistent, geographically discrete aggregates or "beds", many of which support valuable commercial fisheries. The larger beds are found offshore and in the Bay of Fundy. Scallops exhibit varying growth rates and meat yields in different beds and in different areas of large beds.

Unlike many commercial scallop species, the sea scallop has separate sexes. Male scallops develop a white gonad in the summer months, while female gonads are bright red. Eggs and sperm are released into the water where fertilization takes place. Spawning begins in late August to early September, and the larvae drift in the water column for almost a month before settling to the bottom.

## Rationale for Assessment

A meeting of the Regional Advisory Process was held 11–12 December 2008 at the Bedford Institute of Oceanography in Dartmouth, N.S., to review the 2008 scallop fishery and assess the status of the scallop stocks in Scallop Production Areas 1 to 6 in the Bay of Fundy, as well as to provide the scientific advice for the 2009 fishery.

In 2008, a review of the survey database led to a number of tows being reassigned to different strata. As a result, there have been changes to some of the survey series, in particular Middle Bay South and Middle Bay North. Strata boundaries were also redefined to exactly coincide with the management boundaries for SPA 1A, 1B and 4.

In previous assessments, exploitation rate (e) was estimated as the ratio of catch and start of fishing year biomass, with an upper limit reference point of 0.2 based on empirical evidence from earlier work (DFO 2004). In this assessment, exploitation rates are estimated as the ratio of catch to the sum of catch and the end of fishing year biomass to account for annual productivity. Given that catch is being divided by a larger denominator, the reference level of 0.2 is no longer appropriate. In 2008, exploitation rates are compared with rate of growth (discounted for natural mortality) of the population as a function of mean meat weight in the commercial size portion of the population (i.e., the replacement line in figures 7, 13, 20, and 26). Biomass of the commercial size portion will increase due to growth and recruitment when exploitation rates are below this line, increase by recruitment only when exploitation rates are equal to the line, and increase only if recruitment plus growth exceeds catch if exploitation rates are above this line. As the age and average meat weight of the commercial size portion of the population increases, the reliance on recruitment to offset the impact of fishing also increases.

Projections ahead to 2009/2010 still use the beginning of fishing year biomass to calculate exploitation since the average meat weight or expected recruitment for 2009/2010 is not known at this time. These quantities can only be estimated from the survey data in 2009. Therefore, the estimated catch levels for 2009/2010 are conservative and are meant to provide guidance for interim TACs to be set for 1 October 2009. These catch levels will be refined when the 2009 surveys are analysed in next year's stock assessment.

# ASSESSMENT, CONCLUSION AND ADVICE

## SPA 1 - Inner/Upper Bay of Fundy

SPA 1 covers most of the mid to inner Bay of Fundy. Since 2002, it has been managed as two separate areas: SPA 1A and SPA 1B (refer to detailed map on last page, Figure 39). The Full Bay Fleet can fish throughout all of SPA 1A and 1B. However, the other fleets are restricted to SPA 1B, the Mid Bay Fleet fishing only north of the Mid Bay line, and the Upper Bay Fleet fishing only east of the Upper Bay line.

## SPA 1A - Southwest Bay of Fundy

### Fishery

Landings were 225 t for the Full Bay Fleet during the 2007/2008 fishing year against a quota of 216 t (Figure 2). The quota had been originally set to 190 t but the industry requested a re-evaluation of the quota in the summer of 2008 based upon recent catch rates. Review of catch rates did not indicate a substantial change in stock status; however, there was still some flexibility in increasing the TAC based on the decision table from last year's stock assessment and an increase to 216 t was implemented.

An interim TAC of 120 t was set for the 2008/2009 season based on the 2007 assessment advice. As of the Quota Cap report of 26 November 2008, 6 t had been landed from SPA 1A against this interim TAC.

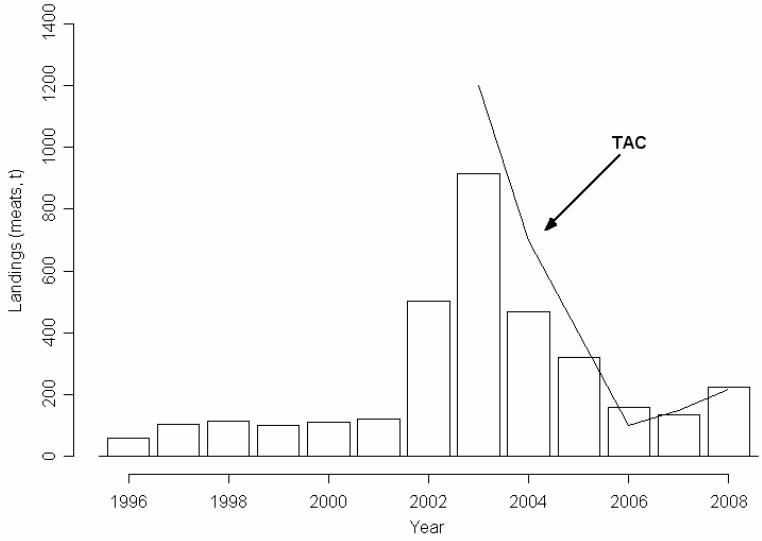



*Figure 2. Scallop landings and TAC (meats, t) in SPA 1A.*

## Assessment

Catch rates declined from 2001/02 to 2005/06 as the strong 1998 year-class, which was mainly located in the 8 to 16 mile area, was fished out (Figure 3). Recent catch rates have been stable around the median catch rate over the 1995/96 to 2006/07 period.

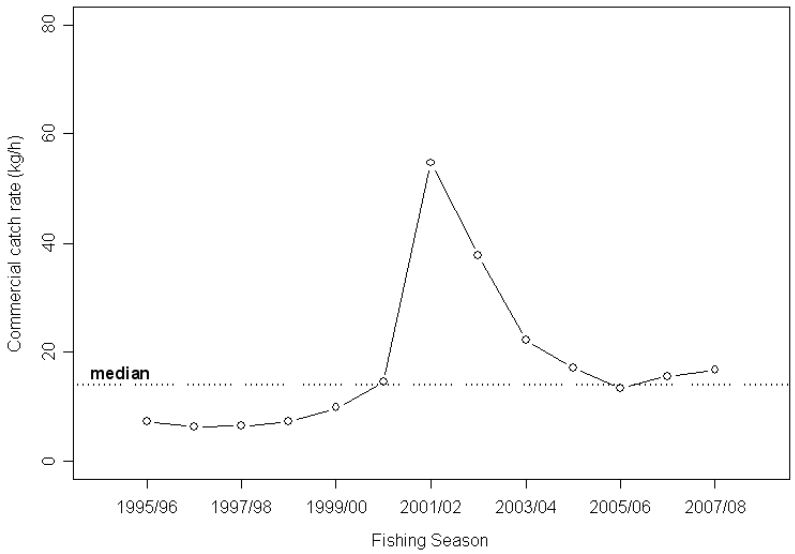



*Figure 3. Commercial catch rate (kg/h) from the Full Bay Fleet for scallops in SPA 1A.*

Since the 1998 year-class recruited to the fishery in this area, recruitment has been lower and the abundance of commercial size scallops has been fished down (Figure 4). Higher than average densities of scallops in the 20 to 40 mm range (mainly along the SPA 4 border with the 8 to 16 mile area) observed in last year's survey did result in a similar increase in 50 to 70 mm scallops in 2008. While the densities of scallops in this size range appear higher than observed in recent years, they are much lower than observed for the 1998 year-class at the same size.

Annual trends for commercial size scallops indicate that mean numbers/tow have been increasing in the 8 to 16 mile area since 2005, while declining in the other two areas (until 2008

for the 2 to 8 mile area, Figure 5). Average meat weight-at-shell height in the 2008 survey have decreased in all areas of SPA 1A from 2007, but are still above the recent lows in 2005 and 2006.

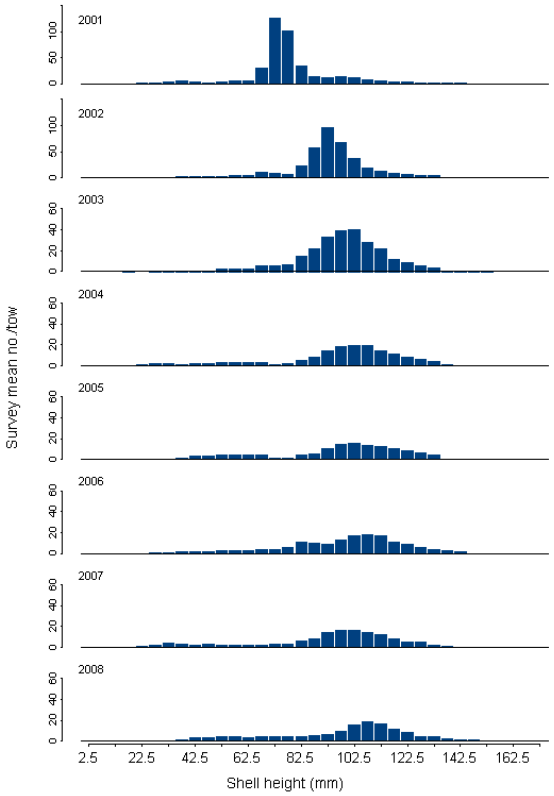



*Figure 4. Scallop shell height frequencies (mean no./tow) for SPA 1A. Surveys were conducted in June during 2001–2003 and in September during 2004–2008. Note change in scale after 2002.*

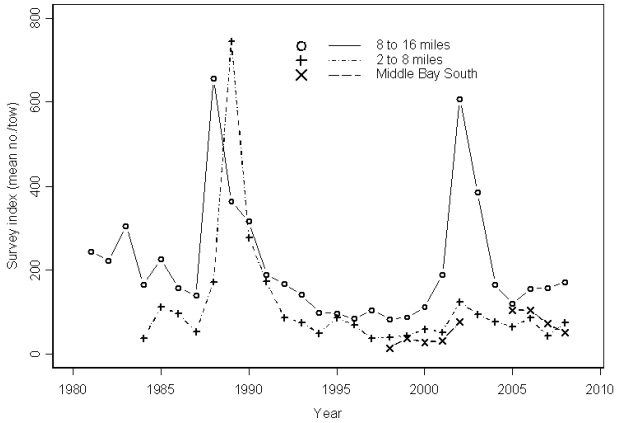



*Figure 5. Survey index (mean no./tow) for commercial size (≥80 mm shell height scallops in the 8 to 16 mile area, 2 to 8 mile area and Middle Bay South area of SPA 1A.*

The population model described in Smith and Lundy (2002) was applied to the combined survey biomass data for the three surveys in this area along with the catch data over the 1997–2007 period. Population biomass estimated to be 1426 t (meats) in 2008, has increased over the estimate for 2007 (1408 t) and is above the median biomass of 1246 t (1997 to 2007).

Evaluation of the model's forecasting ability indicated that the model tends to overestimate biomass for recent years but appears to have captured the dynamics of this population in the short-term (12 years, Figure 6). The forecast for 2009 was made assuming a catch of 120 t in 2008/2009 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2008.

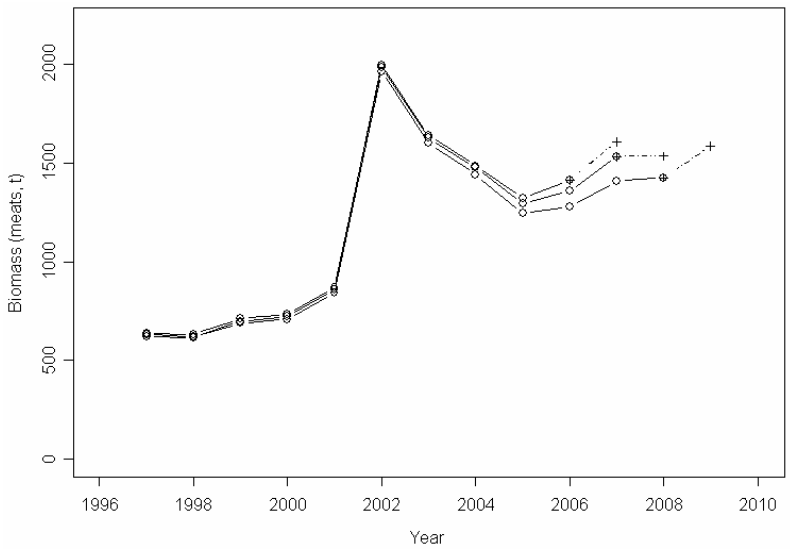



*Figure 6. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) from the delay-difference population model for data up to 2006, 2007, and 2008, respectively for SPA 1A. Predictions from the model for 2007, 2008, and 2009 indicated by dashed lines and crosses.*

## Conclusions and Advice

Commercial size biomass has been increasing since 2005 with moderate to low recruitment (Figure 6). The main reason for this increase appears to be exploitation rates less than or close to the expected levels due to growth discounted for natural mortality (designated as the replacement line in Figure 7). Note that the biomass declined for 1998 even though the exploitation rate was below the replacement line and a biomass increase was indicated for 2002 when the exploitation rate was above the line. In the former case, the decrease from 1997 to 1998 was extremely small and probably within the range of variation of the population estimates. The 2002 population increased despite the higher exploitation rate because of the recruitment of the larger than average 1998 year-class plus a stronger than expected growth rate (Smith et al. 2003).

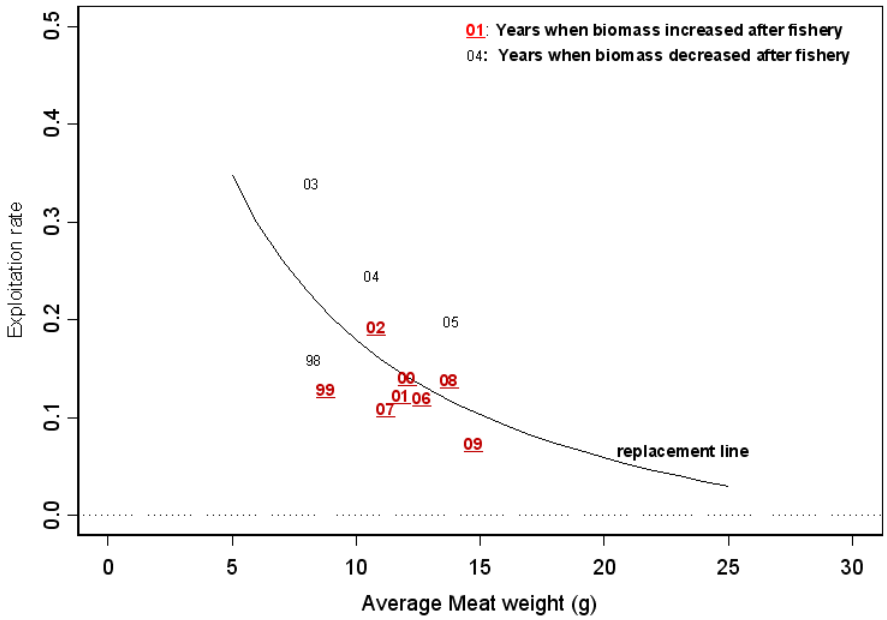



Figure 7. *Exploitation rate (catch/commercial size biomass) versus average meat weight of the commercial size scallops in SPA 1A. The replacement line refers to the expected increase in biomass due to growth discounted for natural mortality (see Rationale for Assessment section for further explanation).*

The interim TAC of 120 t results in an exploitation level below the replacement line and an increase in population biomass for 2009 is indicated. The average meat weight of the commercial size biomass has been increasing since 2007 as the average age of this portion of the biomass increases and the relatively low levels of recruitment continue.

Catches of 196 to 265 t for 2008/2009 should result in a small increase in biomass for 2009 (Table 1). However, the model has a tendency to overestimate the commercial size population when forecasting ahead, and catches in the upper part of this range may actually result in small decreases in biomass.

*Table 1. Decision table to evaluate catch levels for 2008/2009 in terms of expected changes in biomass. Potential catches in 2009/2010 are evaluated in terms of the posterior probability of exceeding exploitation rate of 0.2 (see Rationale for Assessment section for further explanation).*

| 2008/09 | | Catches in 2009/2010 | | | | |
|---|---|---|---|---|---|---|
| Catch (t) | % Change | Pr(e≥0.2) | | | | |
| (exploitation) | Biomass | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
| 196 (0.13) | 4.9 | 163 | 189 | 211 | 234 | 260 |
| 222 (0.15) | 3.2 | 158 | 185 | 206 | 229 | 255 |
| 243 (0.16) | 1.8 | 154 | 181 | 202 | 225 | 251 |
| 265 (0.18) | 0.4 | 150 | 176 | 198 | 221 | 247 |
| 291 (0.19) | -1.4 | 145 | 171 | 193 | 216 | 242 |

## SPA 1B - Northern/Upper Bay of Fundy

### Fishery

In 2007/2008, a TAC sharing formula for the three fleets in SPA 1B was implemented that allocated shares by the three subareas SFA 28B (excluding SPA 6), SFA 28C and SFA 28D

(Figure 39). In the 2008 season, the Full Bay Fleet landed 210 t against a total quota of 206.25 t over all three subareas (Figure 8). Landings for the Mid Bay fleet were 148.28 t in total for SPA 28B and SFA 28C. The TAC for SFA 28C and 28D was 85.47 t for the Upper Bay fleet and they landed 87 t in total for 2008.

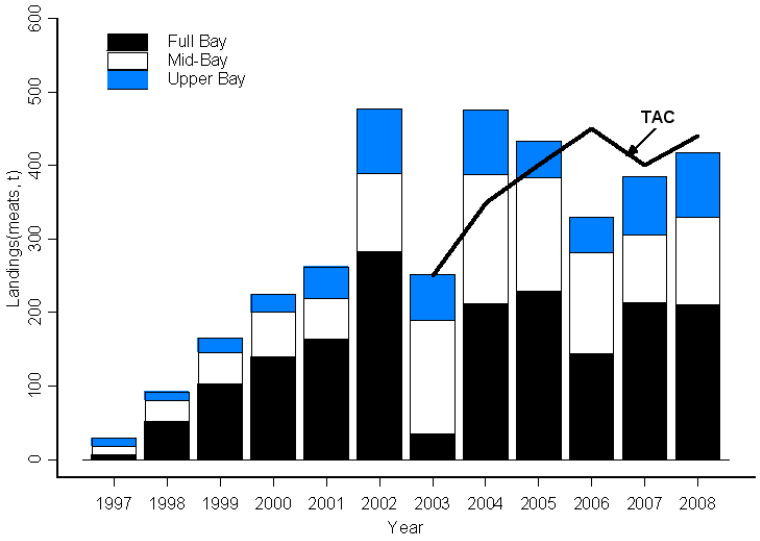



*Figure 8. Scallop landings and TAC (meats, t) in SPA 1B (for all fleets). TAC for SPA 1B introduced in 2002.*

## Assessment

Commercial catch rates have been increasing for all three fleets since 2006 mainly due to better than average recruitment in the Cape Spencer, Middle Bay North (Quaco Ledge) and SFA 28C area (Figure 9). The increase for the Upper Bay Fleet in 2008 was partly due to fishing in the small but very productive Advocate area of SFA 28D.

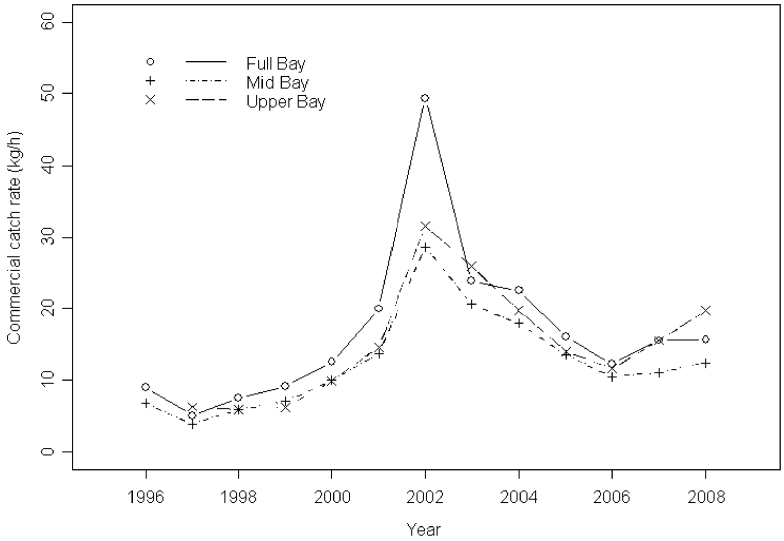



*Figure 9. Commercial catch rate (kg/h) for scallops in SPA 1B.*

Revisions to the research survey database have resulted in changes to survey trends in Middle Bay North (as compared to previous assessments).

The shell height distributions in SPA 1B have exhibited moderate and regular recruitment over time sufficient to maintain a stable abundance of commercial size scallops (Figure 10). While recruitment has declined over the last two years, there appears to be a larger than average abundance of scallops in the 40 to 64 mm range in 2008 that should recruit to the fishery in 2010.

The 2008 survey mean catch per tow for commercial size scallops indicates a decline from 2007 for all areas, except for Minas/Scots Bay (Figure 11). However, recruitment prospects should improve for 2010 in Cape Spencer, Middle Bay North, SFA 28C and the Advocate area for SFA 28D. Average meat weight-at-shell height in 2008 has decreased from 2007 in all survey areas, except for Cape Spencer.

The population model described in Smith and Lundy (2002) was applied to the combined survey biomass data and the catch data over the 1997–2007 period. Population biomass estimated to be 1890 t (meats) in 2008 has increased slightly over the estimate for 2007 (1864 t) and is above the median biomass of 1638 t (1997 to 2007).

Evaluation of the model's forecasting ability indicates that the forecast for 2008 was an overestimate (Figure 12). The forecast for 2009 was made assuming a catch of 100 t in 2008/2009 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2008.

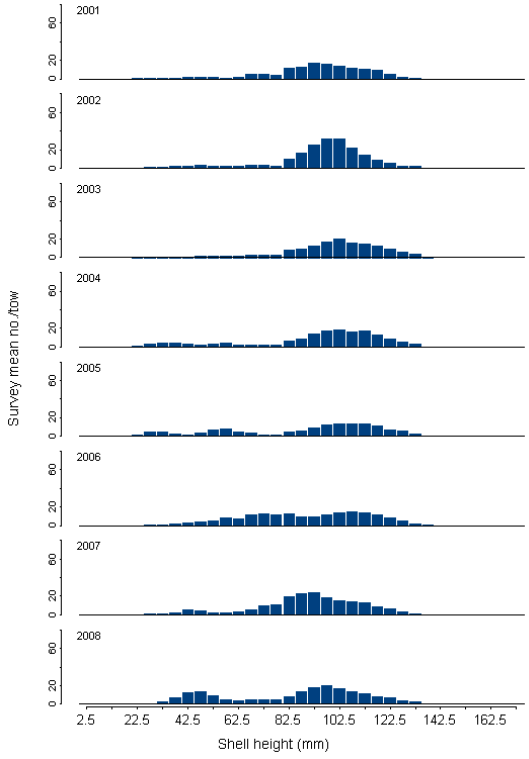



*Figure 10. Scallop shell height frequencies (mean no./tow) from surveys of SPA 1B. Surveys were conducted in June during 2001–2003 and in September during 2004–2008. .*

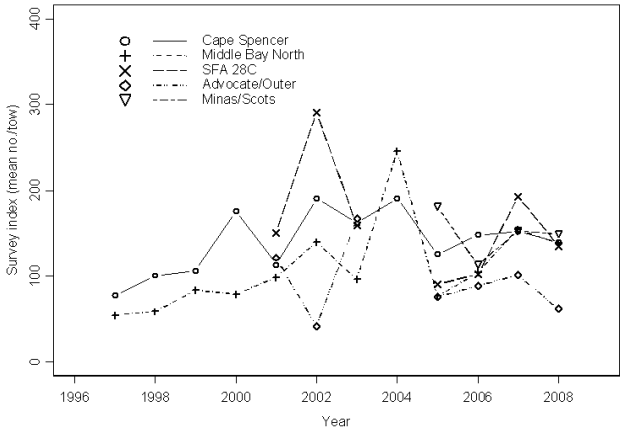



*Figure 11. Survey abundance index (no./tow) for commercial size (≥80 mm shell height) scallops in the Cape Spencer area, Middle Bay North area, and Upper Bay areas of SPA 1B.*

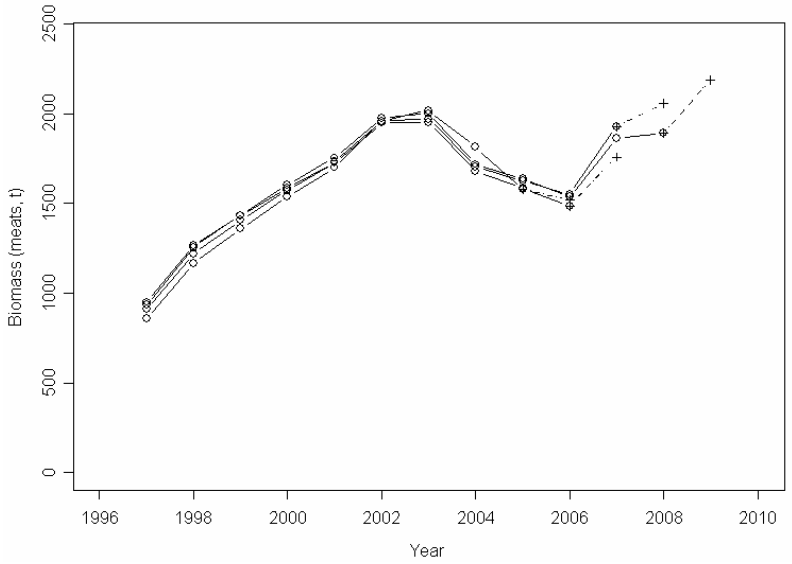



*Figure 12. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) in SPA 1B from the delay-difference population model for data up to 2006, 2007 and 2008, respectively. Predictions from the model for 2007, 2008 and 2009 indicated by dashed lines and crosses. Prediction for 2009 was made assuming a 2008/2009 catch of 100 t.*

## Conclusions and Advice

Natural mortality is higher in SPA 1B than in SPA 1A based on the clapper data from the surveys. As a result, the replacement line in SPA 1B is steeper than for SPA 1A, indicating a lower compensation for fishing by growth alone in the former area as the average meat weight of the commercial size biomass increases (Figure 13).

The commercial size biomass in SPA 1B increased from 1997 to 2003 and then declined until after 2006 when stronger than average recruitment entered the fishery in the Cape Spencer, Middle Bay North and SFA 28C areas over the next two years (Figure 10). From 1997 to 2003, the increases appear to be mainly due to biomass growth as the exploitation rates were very close to the replacement line (Figure 13). Exploitation rates higher than 0.15 resulted in declines in 2004, 2005 and 2006, while in 2007 and 2008 higher levels of recruitment offset the higher levels of exploitation in those years. The prediction for the interim TAC for 2009 is an exploitation rate below the replacement line with resultant increase in biomass from 2008 to 2009.

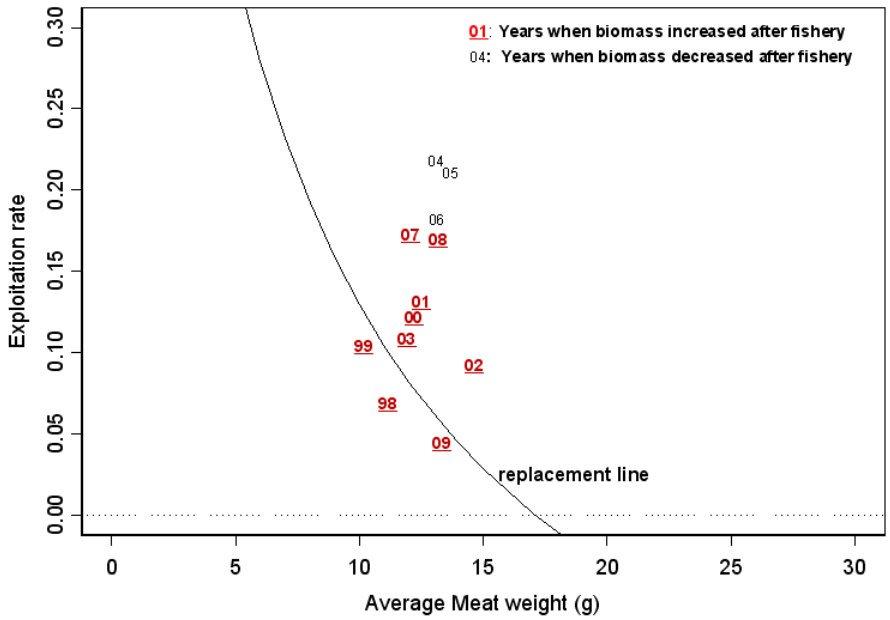



*Figure 13. Exploitation rate (catch/commercial size biomass) versus average meat weight of the commercial size scallops in SPA 1B. The replacement line refers to the expected increase in biomass due to growth discounted for natural mortality (see Rationale for Assessment section for further explanation.)*

Catches for 2008/2009 of 290 t or less should not result in a decline in biomass for 2009 (Table 2). As noted above, recruitment prospects look much better for 2009/2010 and this year-class will be commercial size for the 2010/2011 fishery.

*Table 2. Decision table to evaluate catch levels for 2008/2009 in terms of expected changes in biomass. Potential catches in 2009/2010 are evaluated in terms of the posterior probability of exceeding an exploitation rate of 0.2 (see Rationale for Assessment section for further explanation).*

| 2008/09 | | Catches in 2009/2010 | | | | |
|---|---|---|---|---|---|---|
| Catch (t) | % Change | Pr(e≥0.2) (exploitation) | | | | |
| (exploitation) | Biomass | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
| 261 (0.13) | 1.4 | 217 | 253 | 282 | 312 | 343 |
| 296 (0.15) | -0.3 | 211 | 246 | 276 | 305 | 337 |
| 325 (0.16) | -1.7 | 206 | 241 | 271 | 300 | 331 |
| 354 (0.18) | -3.1 | 201 | 236 | 265 | 295 | 326 |
| 385 (0.19) | -4.5 | 196 | 230 | 260 | 289 | 320 |

## SPA 3 - Brier Island, Lurcher Shoal, and St. Mary's Bay

### Fishery

Although scallops can be found throughout most of this area, there are three main beds; those around Lurcher Shoal, below Brier Island, and in St. Mary's Bay. St. Mary's Bay (formerly SPA 7) was combined with SPA 3 for a combined TAC starting in 1999.

Originally the TAC for 2007/2008 was set to 50 t. Based upon the wide distribution of high densities of small scallops observed during the 2007 survey, the Full Bay fleet recommended that a large portion of the Brier/Lurcher area be closed pending analysis of the June 2008 survey data. Analysis of the survey data in June 2008 indicated that closing the area had not

resulted in large numbers of the scallops in the next age class and DFO Science recommended removal of the closed area for the remainder of the 2007/2008 fishery. The TAC was increased to 70 t based on the decision table from last year's assessment (Figure 14).

Total landings for the 2007/2008 fishing year were 80.2 t. Based upon positions in the commercial fishing logs, none of the catch came from the closed area. An interim TAC of 50 t was set for October of the 2008/2009 fishing season, and 11 t have been landed as of the Quota Cap report of 26 November 2008.

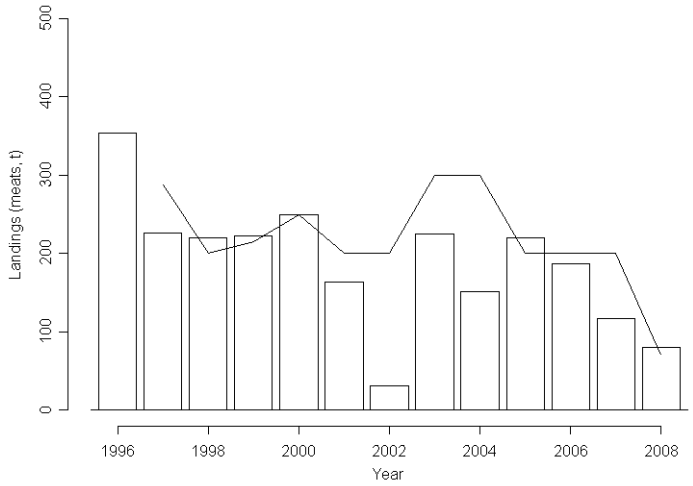



*Figure 14. Scallop landings and TAC (meats, t) in SPA 3.*

## Assessment

Commercial catch rate has been stable and close to the median over the time series since 2006 (Figure 15) while effort has been declining since 2006. Given that the fishery was concentrated in the eastern nearshore areas of SPA 3 where meat weights tend to be larger for a given shell height, it is possible that the 2008 catch rate would have been lower than observed had fishing occurred over the whole area.

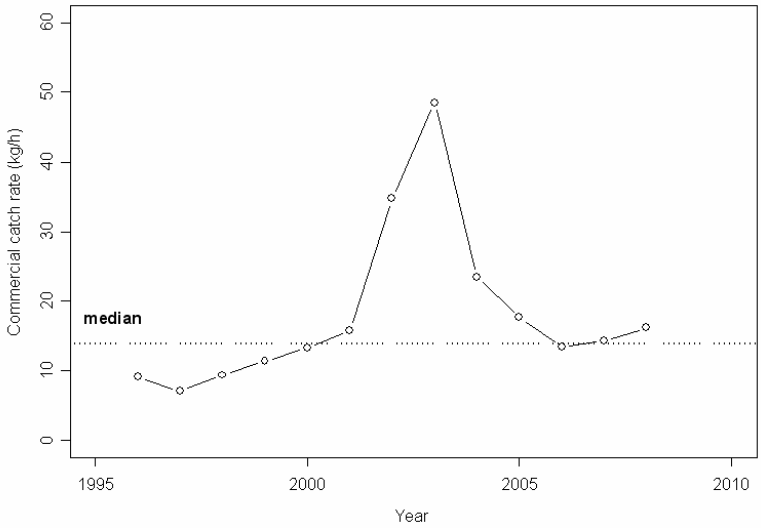



*Figure 15. Commercial catch rate (kg/h) for scallops in SPA 3.*

The 2007 survey estimated higher than average abundances of scallops in the 10 to 40 mm size range in SPA 3 (Figure 16). Estimates of scallops in this size range are usually interpreted as being more indicative than quantitative because of the 38 mm liner used in the lined gear. In the past, signs of above average abundance of pre-recruits have not always developed into actual above average recruitment in subsequent years (e.g., estimates in 2000 and 2004). The important difference with the catches of pre-recruits in the 2007 survey was that the high catches were found closer inshore and over a wider area than usual. While the survey found high densities of scallops in 10 to 40 mm range again in 2008, there was no evidence that the high densities from 2007 had resulted in higher than average densities in the next age class (40 to 70 mm) in 2008.

Comparison of differences between survey estimates from the 2007 and 2008 surveys indicated significant decreases in mean numbers per tow of recruits and mean weights per tow of commercial size scallops and recruits (Figure 17). Similar to many areas in the Bay of Fundy, meat weight-at-shell height in 2008 decreased in SPA 3 over that observed in 2007.

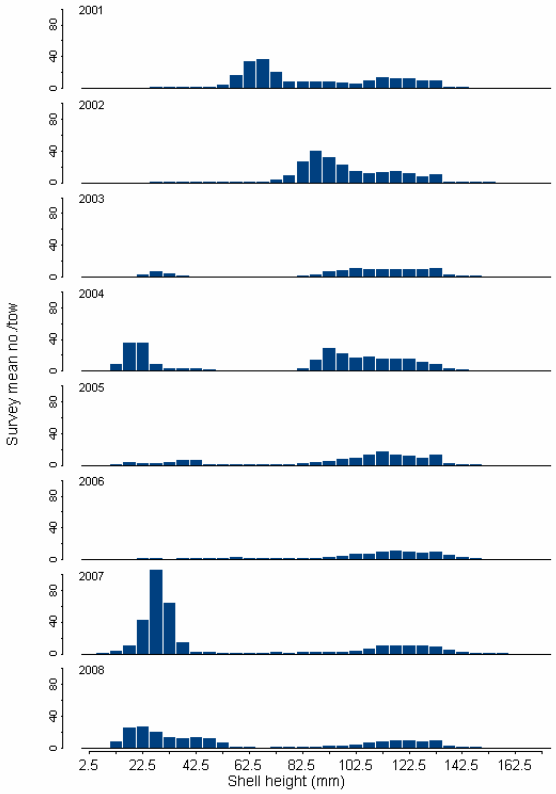



*Figure 16. Scallop shell height frequencies (mean no./tow) from surveys of SPA 3.*

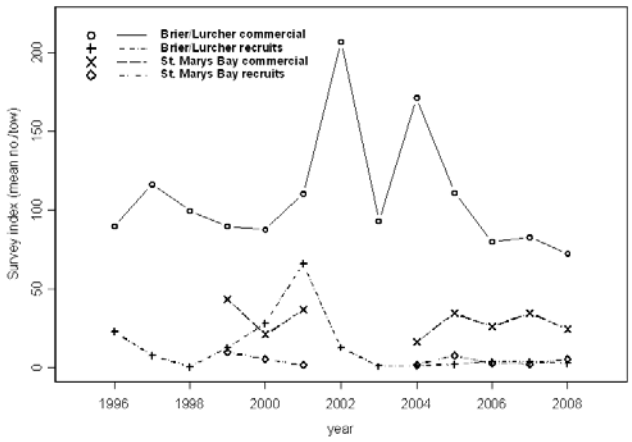



*Figure 17. Survey index (mean no./tow) for commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops in the Brier/Lurcher and St. Mary's Bay portions of SPA 3. Surveys were conducted in August until 2004 when the survey was changed to June.*

A delay-difference model (Smith and Lundy 2002) was fit to the survey data and commercial catch in SPA 3. Population biomass estimated to be 463 t in 2008 has decreased over the estimate for 2007 (531 t) and is below the median biomass of 655 t (1996–2007).

Evaluation of the model's forecasting ability indicated that the model tends to underestimate biomass (Figure 18). The population model predicts the biomass to October 2009 assuming a 2008/2009 catch of 50 t.

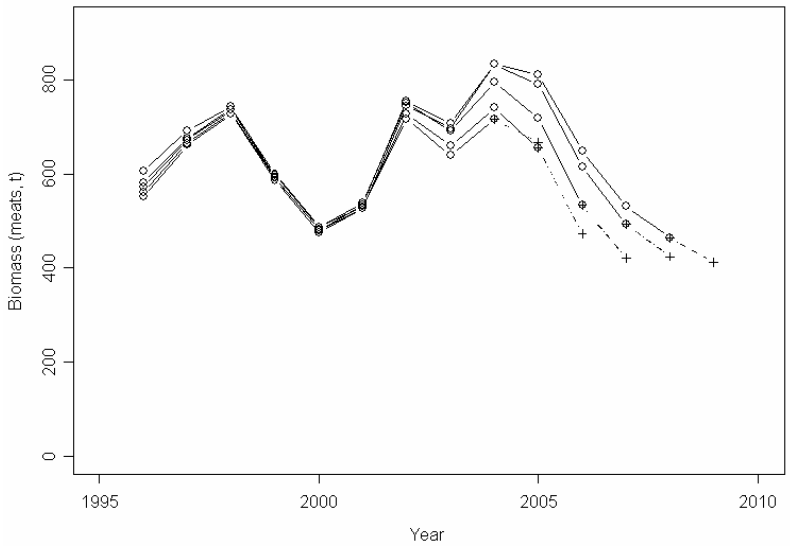



*Figure 18. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) from the delay-difference population model for data up to 2005, 2006, 20076 and 2008, respectively for SPA 3. Predictions from the model for 2006, 2007, 2008 and 2009 indicated by dashed lines and crosses. Prediction for 2009 was made assuming a 2008/2009 catch of 50 t.*

The biomass estimates in Figure 18 represent conditions at the time of the survey each year but the relative timing of the survey and fishery has changed over time. From 1996 to 2003 the survey was conducted in August and the bulk of the fishery occurred before the survey. Since 2004, the survey has been conducted in June and the major portion of the fishery occurs after the survey. Biomass estimates adjusted to the amount available to the fishery each year are presented in Figure 19 along with the recruitment estimates. As in Figure 18, the prediction for 2009 was made assuming a catch of 50 t in 2008/2009.

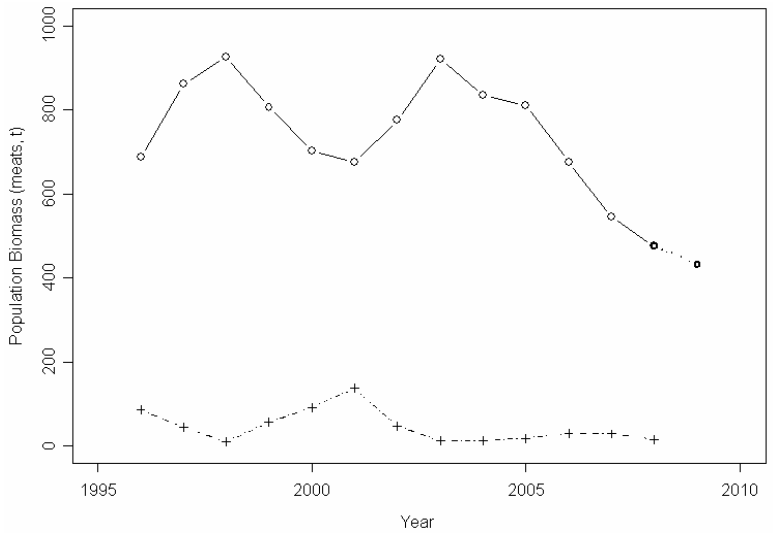



*Figure 19. Estimated population biomass for commercial and recruit size scallops in Scallop Production Area 3. The predicted biomass for 2009 was made assuming a catch of 50 t in 2008/2009.*

### Conclusions and Advice

Exploitation over the 1996 to 2008 period has been high in this fishery, generally exceeding 0.2 (Figure 20). There have only been four years (1997, 1998, 2002, and 2003) when biomass has increased and all four increases were due to incoming recruitment (Figure 19). In addition, there was an increase in biomass due to growth from 2002 to 2003 when only 34 t was landed in the 2002 fishery. The Full Bay fleet directed its attention to SFA 29 and other areas in the Bay in 2002.

The commercial size biomass is predicted to decrease from 2008 to 2009 if the interim quota of 50 t was caught (Figure 19, Table 3). Catches as low as 35 t in 2008/2009 will also result in a decline in biomass. Recruitment is expected to be low for at least the next two years.

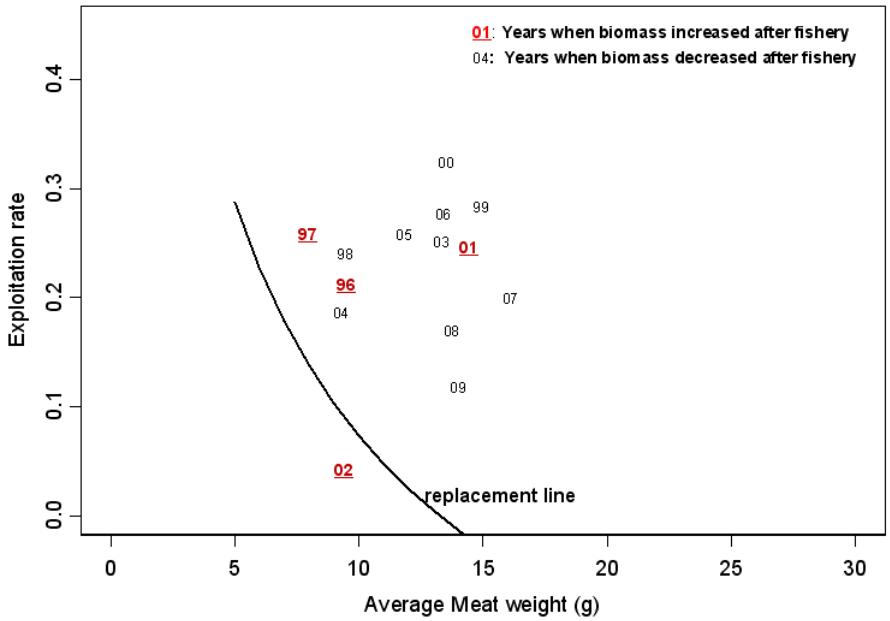



*Figure 20. Exploitation rate (catch/commercial size biomass) versus average meat weight of the commercial size scallops in SPA 3. The replacement line refers to the expected increase in biomass due to growth discounted for natural mortality (see Rationale for Assessment section for further explanation).*

*Table 3. Decision table to evaluate catch levels for 2008/2009 with respect to the expected changes in biomass (see Rationale for Assessment section for further explanation).*

| Catch (t) | Exploitation | Expected change in biomass (%) |
|---|---|---|
| 35 | 0.05 | -14.19 |
| 45 | 0.09 | -16.34 |
| 54 | 0.12 | -18.28 |
| 64 | 0.16 | -20.44 |
| 76 | 0.20 | -23.03 |

## SPA 4 - Digby

### Fishery

The SPA 4 fishing season extends from October 1st to April 30th. Total landings in 2007/2008 were 79 t against a TAC of 100 t (Figure 21). An interim TAC of 100 t was set for the 2008/2009

season based on last year's assessment. As of the 2008/2009 Quota Cap report of 26 November 2008, 46 t had been landed from SPA 4 against this interim TAC.

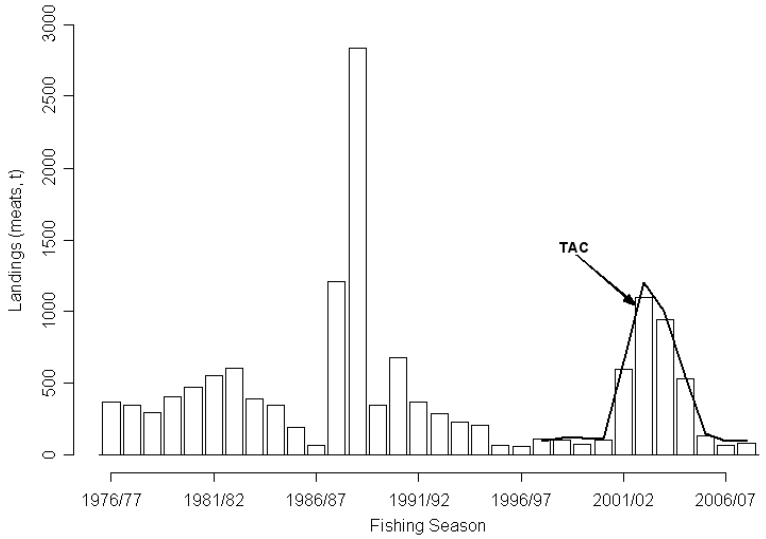



*Figure 21. Scallop landings and TAC (meats, t) in SPA 4.*

## Assessment

Effort has been declining in SPA 4 since the above average 1998 year-class was fished out. Commercial catch rates declined after the above average 1998 year-class recruited to the fishery, but have been either relatively stable or slightly increasing since 2005/2006 (Figure 22).

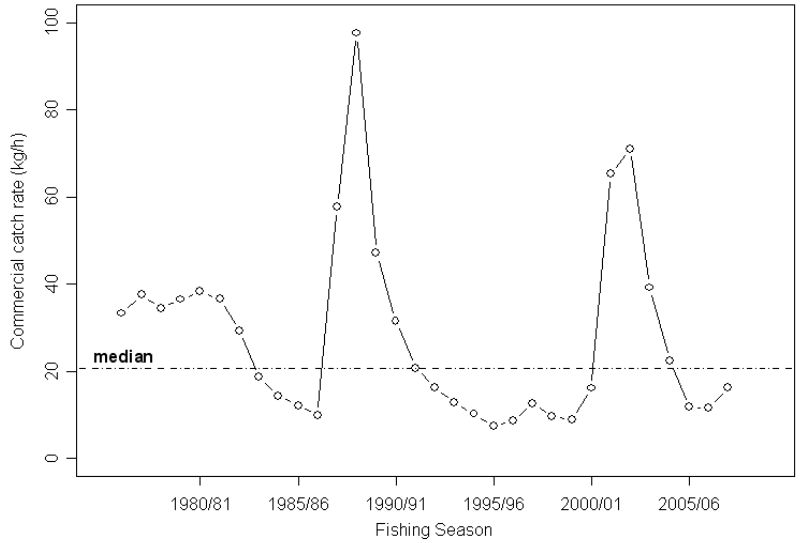



*Figure 22. Commercial catch rate (kg/h) for scallops in SPA 4.*

Areas of high densities of scallops less than 65 mm shell height were identified in SPA 4 and 1A in the 2007 survey. The Full Bay fleet recommended a closed area to DFO encompassing the distribution of the small scallops in SPA 4 and the adjoining area in SPA 1 (8 to 16 mile area). This close area went into effect 2 October 2007 (Maritimes Region Close Time Variation Order, 2007-123). While the fishery did avoid this closed area, there was no evidence of similar high densities in the next size class (50 to 80 mm) in the 2008 survey for SPA 4 (Figure 23).

Overall, the survey indices indicate that the population has been stable since 2006 with low levels of recruitment, pre-recruits and clappers (Figure 24). Given the trends in the pre-recruit estimates, low levels of recruitment will probably continue for the next two years.

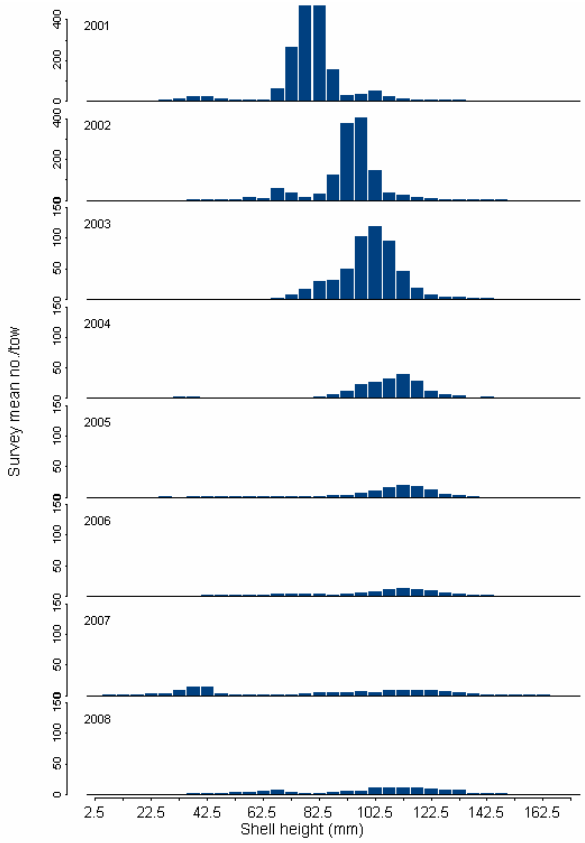



*Figure 23. Scallop shell height frequencies (mean no./tow) from surveys of SPA 4. Surveys were conducted in June during 1981–2003 and in August/September during 2004–2008.*

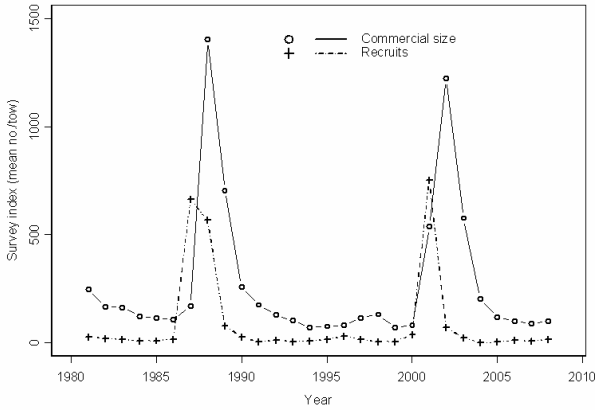



*Figure 24. Trends in survey biomass estimates (meats, t) of commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops from SPA 4.*

As in previous years, a delay-difference model was used to model the dynamics of the SPA 4 scallop population. Population biomass estimated to be 779 t (meats) in 2008 has increased over the estimate for 2007 (760 t) and is just below the long-term median biomass of 792 t (1983 to 2007).

Similar to the performance of the model in the other areas, there is a tendency to overestimate biomass to a small degree in recent years (Figure 25). The prediction for 2009 assumes a catch of 100 t in 2008/2009 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2008.

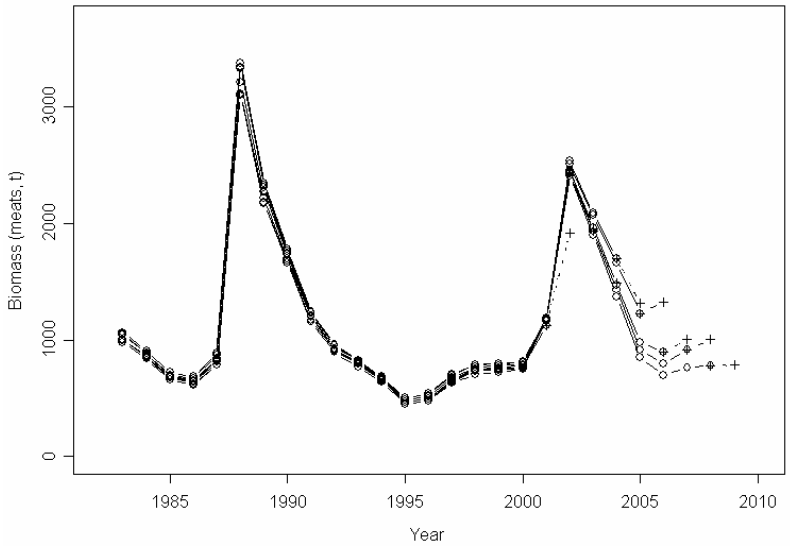



*Figure 25. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size (≥80 mm shell height) scallops in the current year for SPA 4. Prediction for 2009 was made assuming a 2008/2009 catch of 100 t.*

## Conclusions and Advice

Population biomass has been stable since 2005/2006 (Figure 25) and landings have been at their lowest in years. Recruitment is in the range of previous levels excluding the peak years of 1987/1988 and 2001. The exploitation rates for most years in which biomass had increased after the fishery were less than 0.16 and close to the replacement line (Figure 26). Increases in biomass in 1988 and 2002 were both due to the two strongest year-classes in the series. The high natural mortality experienced by the scallops in 1989 and 1990 resulted in declining populations despite the high levels of recruitment in 1988/1989.

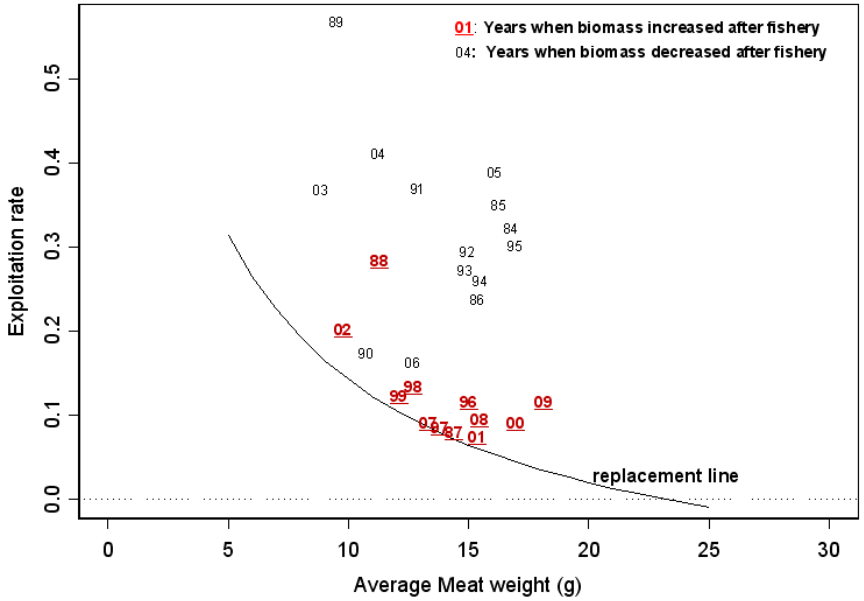



*Figure 26. Exploitation rate (catch/commercial size biomass) versus average meat weight of the commercial size scallops in SPA 4. The replacement line refers to the expected increase in biomass due to growth discounted for natural mortality (see Rationale for Assessment section for further explanation).*

A TAC of 100 t for 2008/2009 should result in little change in the population biomass of commercial size scallops for 2009 (Table 4).

*Table 4. Decision table to evaluate catch levels for 2008/2009 in terms of expected changes in biomass. Potential catches in 2009/2010 are evaluated in terms of the posterior probability of exceeding an exploitation rate of 0.2 (see Rationale for Assessment section for further explanation).*

| 2008/09 | | Catches in 2009/2010 | | | | |
|---|---|---|---|---|---|---|
| Catch (t) | % Change | Pr(e≥0.2) (exploitation) | | | | |
| (exploitation) | Biomass | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
| 75 (0.11) | 3.4 | 61 | 74 | 87 | 102 | 121 |
| 87 (0.13) | 1.9 | 59 | 72 | 85 | 100 | 118 |
| 100 (0.15) | 0.4 | 57 | 69 | 82 | 97 | 116 |
| 115 (0.17) | -1.4 | 54 | 67 | 80 | 95 | 113 |
| 133 (0.23) | -3.6 | 51 | 63 | 76 | 91 | 110 |

## SPA 5 - Annapolis Basin

### Fishery

The fishery in the Annapolis Basin (SPA 5) is only open to the Full Bay Fleet with the fishing season between January 1st and March 31st. In recent years, landings have varied between 2 and 20 t (Figure 27). Landings in 2008 were 7 t against a TAC of 10 t.

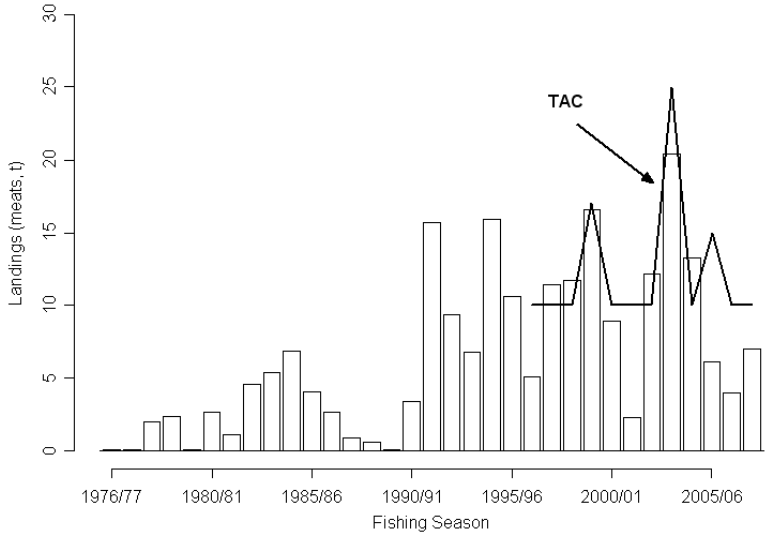



*Figure 27. Scallop landings and TAC (meats, t) in SPA 5.*

### Assessment

Commercial catch rates in 2008 increased over 2007 and were close to the long-term median levels (1977–2007; Figure 28).

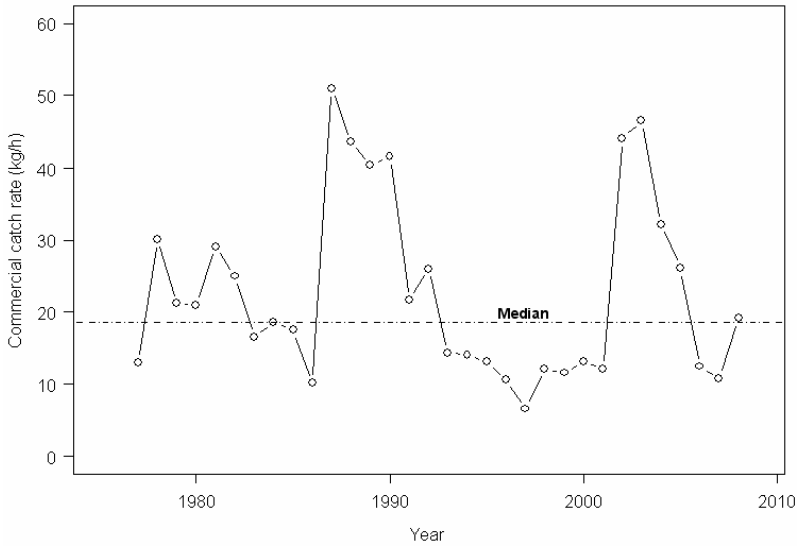



*Figure 28. Commercial catch rate (kg/h) for scallops in SPA 5.*

Survey shell height frequencies indicate that the 2007 year-class may be the strongest seen since the 1999 and 2000 year-classes (Figure 29). Currently, the mean catch per tow for commercial size scallops is below the long-term median and close to the lowest seen in this series (Figure 30).

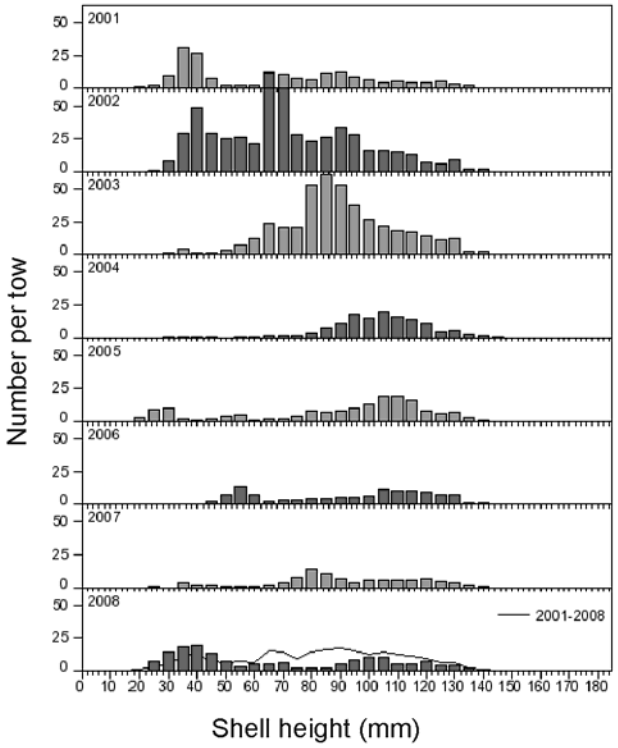



*Figure 29. Scallop shell height frequencies (mean no./tow) from surveys of SPA 5.*

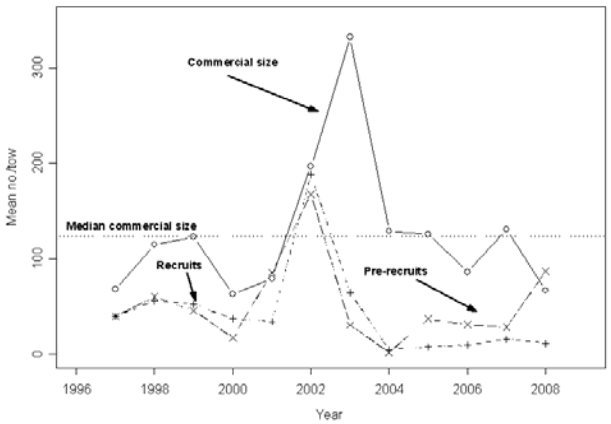



*Figure 30. Survey abundance index (mean no./tow) for commercial size (≥80 mm shell height), recruit (65–79 mm shell height), and pre-recruit (< 65 mm shell height) scallops in SPA 5.*

### Conclusions and Advice

Based on the survey, the abundance of commercial size scallops has declined and is currently close to the lowest seen in the series. Good recruitment prospects may improve the stock status in 2010. The TAC for 2008 should not exceed the average catch of 9 t over the period 1997 to 2008 excluding the high catch in 2004.

## SPA 6 - Grand Manan and Southwest New Brunswick

### Fishery

The areas around Grand Manan and off southwest New Brunswick are designated SPA 6. This area is further divided into 6A, 6B, 6C, and 6D (see detailed map on last page, Figure 39). Landings to 26 November 2008 were 68 t against a TAC of 140 t (Figure 31).

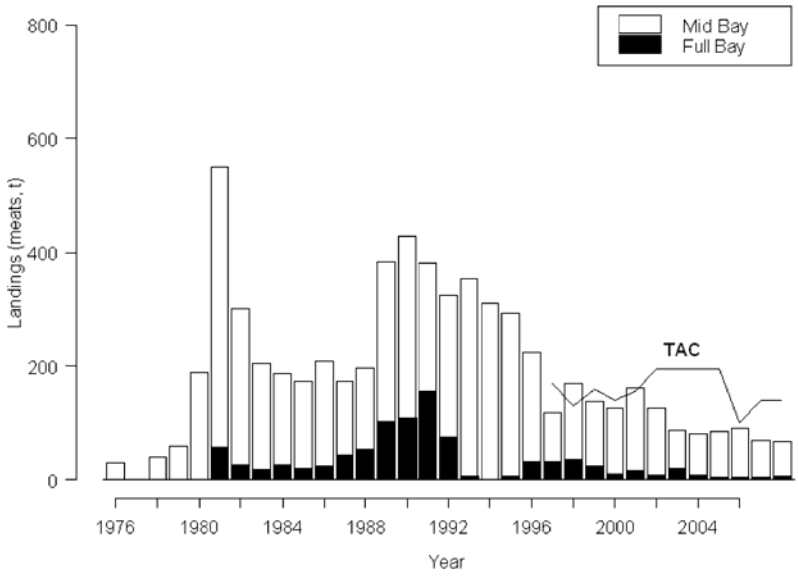



*Figure 31. Scallop landings by fleet and TAC (meats, t) in SPA 6.*

Landings by area for 2008 for the Full Bay Fleet were 1.7, 1.9, 2.7, and 1.1 t for SPA 6 A, B, C, and D (Figure 39), respectively, against a TAC of 21 t. This fleet has not caught its quota for the last 6 years as it has directed its effort to the other scallop fishing areas.

The 2008 quota for the Mid Bay fleet was 119 t. Mid Bay landings for 2008 by area were 15.8 t, 10.8 t, 27.6 t, and 6.3 t for SPA 6A, B, C, and D, respectively.

### Assessment

Both catch and catch rates for both fleets have been relatively stable over the last four years (Figure 32). Meat weight samples indicate that the commercial size portion of the population continues to get older on the average implying low recruitment over the last few years.

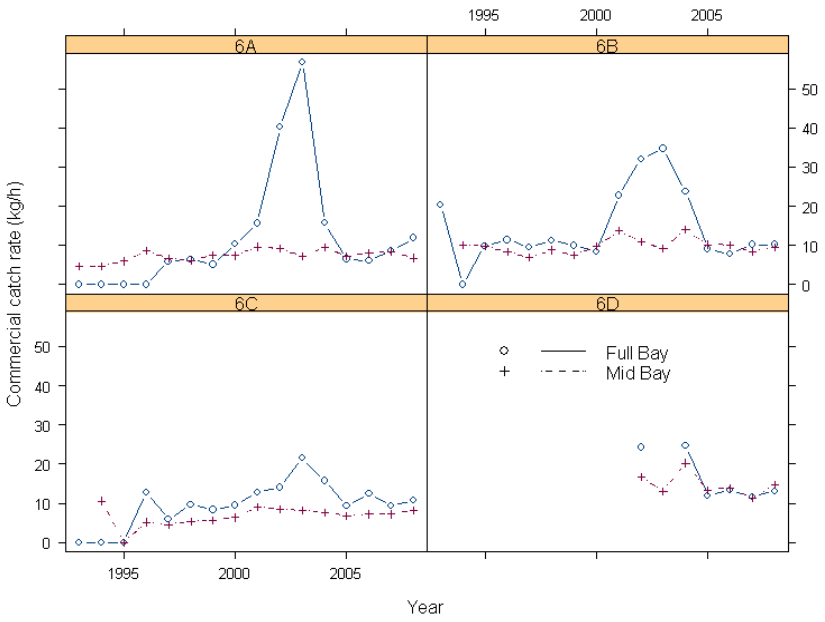



*Figure 32. Commercial catch rate (kg/h) for scallops in SPA 6A, 6B, 6C, and 6D.*

In 2008, research survey sampling in 6C did not extend along the New Brunswick shore to Mace's Bay.

Pre-recruits (40 to 64 mm) were more widely distributed in 2008 compared to 2007, with high concentrations in Passamaquoddy Bay and around the Wolves. Two exploratory tows in the Wolves area caught more than 23,000 scallops mainly in the 20 to 55 mm shell height size range. In the 2007 survey the main concentration of recruits (65–79 mm) were in the Campobello Island area (6A). This year pre-recruit scallops seen in the Duck Island Sound area in 2007 did appear as recruits in the 2008 survey. Mean catch per tow for commercial size scallops declined in the Duck Island Sound area in 2008, but the higher abundance of recruits in the survey should result in an increase in the abundance of commercial size scallops for 2009 in this small area.

Shell height frequency for each of subareas 6A, 6B, and 6C indicate small increases in scallops less than 80 mm in shell height in 2008 relative to the last four or more years (figures 33 to 35).

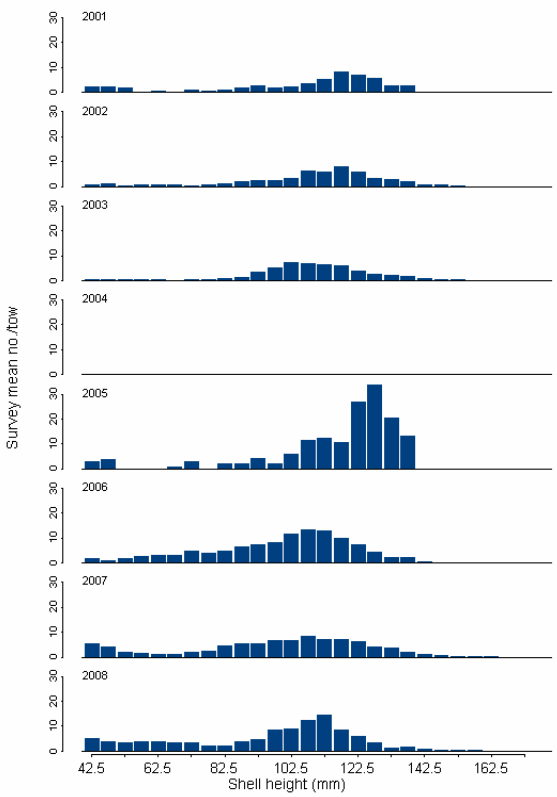



*Figure 33. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6A. No survey was conducted in 2004 and the 2005 survey consisted of only 2 tows.*

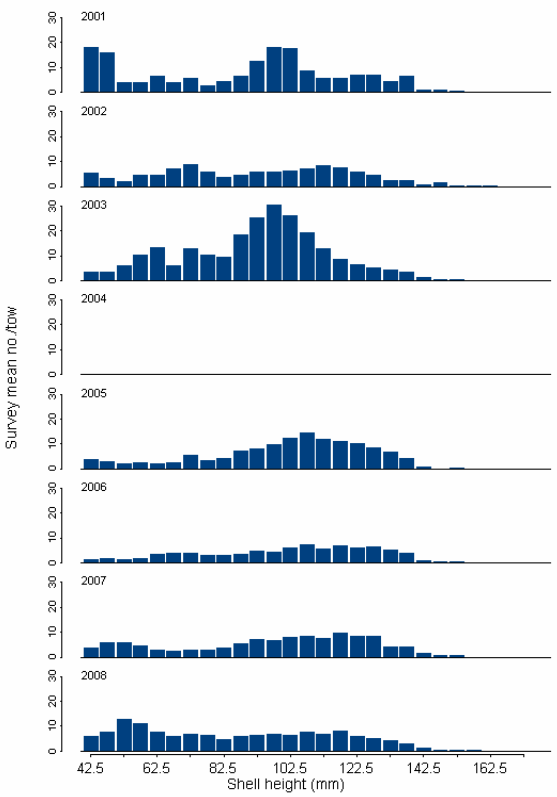



*Figure 34. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6B (includes 6D). No survey was conducted in 2004.*

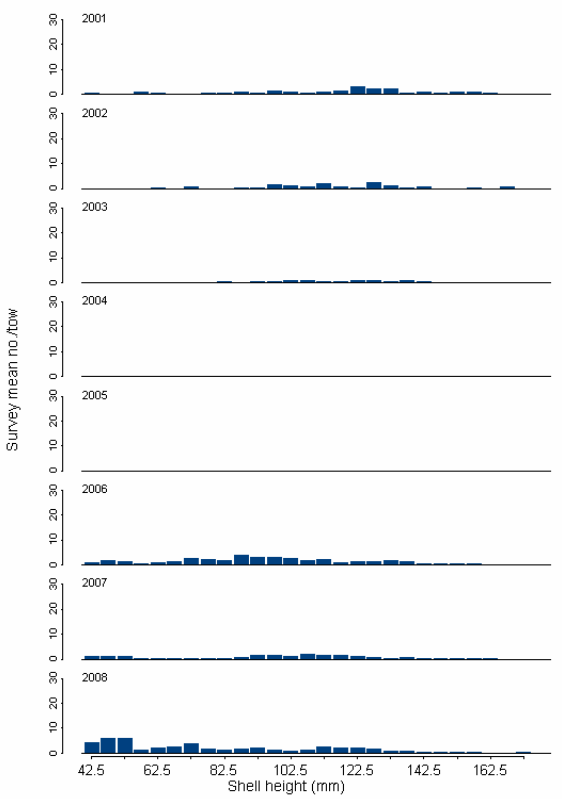



*Figure 35. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6C. No survey was conducted in 1998, 1999, 2004, and 2005.*

Annual trends for commercial size scallops and recruits are presented for each subarea in figures 36 to 38. The overlap in confidence intervals from 2007 to 2008 suggests that there has been little change in mean numbers per tow of commercial size scallops in 6A, 6B (includes 6D), or 6C. Statistical tests between mean number per tow for 2007 and 2008 using the double sampling estimates did not find any significant differences between the two years.

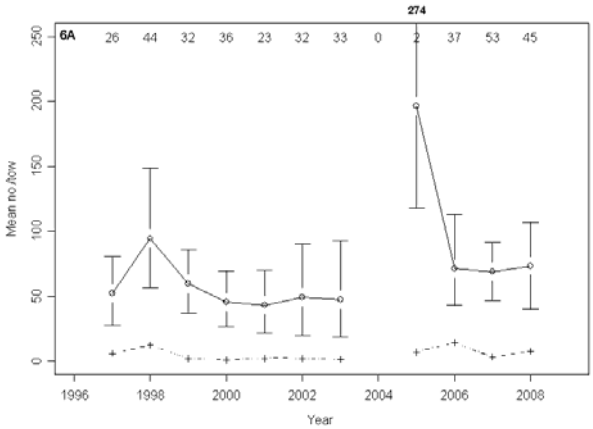



*Figure 36. Survey abundance index (mean no./tow) for commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6A. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.*

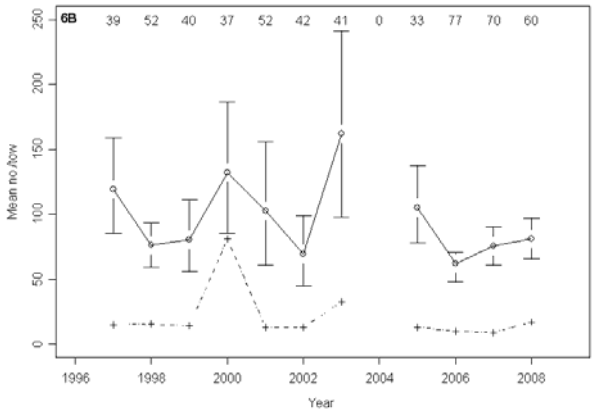



*Figure 37. Survey abundance index (mean no./tow) for commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6B. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.*

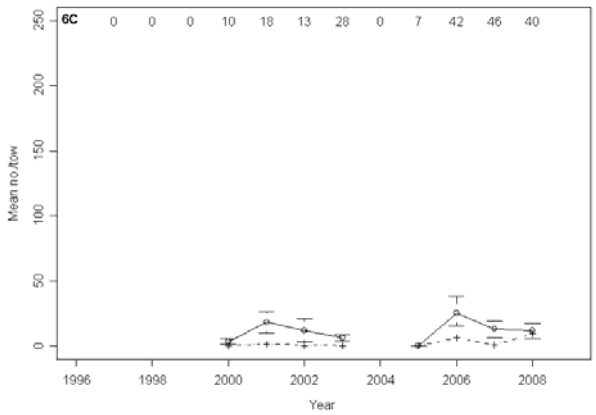



*Figure 38. Survey abundance index (mean no./tow) for commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6C. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.*

### Conclusions and Advice

Evidence from the Mid Bay commercial catch rates and the surveys suggest that the abundance of commercial size scallops remains unchanged from 2007 in SPA 6A and 6B and 6C. Recent levels of catch do not appear to result in a decrease in the population abundance of scallops in the SPA 6 area as a whole.

## OTHER CONSIDERATIONS

Some observer coverage was funded by DFO for 2008 for investigation of bycatch. No information from this program was available in time to be included in this assessment.

The determination of stock status for scallops in all of the areas in the Bay of Fundy is highly dependent upon the estimates from the annual drag survey. The total number of survey stations covered in the Bay of Fundy and Approaches in 2008 was 754 (including 25 stations funded by the Petiticodiac Monitoring Program), less than the 855 stations in 2006 but still above the number of stations in recent previous years (520 to 702). Fishing industry representatives agreed to help fund DFO overtime shortfalls in 2008 to maintain the survey coverage to be close to the 2007 level for SPA 1A, 1B, 3 and 4. Continuing support in future years by industry will be contingent upon evaluation of the results, further discussion about the purpose of the survey and the development of an equitable method of sharing the costs amongst industry participants.

## SOURCES OF INFORMATION

DFO, 2004. Proceedings of the Maritimes Regional Advisory Process Stock Assessment Update of SPA 1,3,4,5 and 6 Scallop Stocks; 8–9 December 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/049.

DFO, 2007. Stock Assessment Report on Scallops (*Placopecten magellanicus*) in Scallop Production Areas 1 to 6 in the Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/013.

Smith, S.J., and M.J. Lundy. 2002. Scallop Production Area 4 in the Bay of Fundy: Stock Status and Forecast. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/018.

Smith, S.J., M.J. Lundy, J. Sameoto, and B. Hubley. 2009. Scallop Production Areas in the Bay of Fundy: Stock Status for 2008 and Forecast for 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/004.

Smith, S.J., M.J. Lundy, D. Roddick, D. Pezzack, and C. Frail. 2003. Scallop Production Areas in the Bay of Fundy and Scallop Fishing Area 29 in 2002: Stock Status and Forecast. DFO Can Sci. Advis. Sec. Res. Doc. 2003/010.

## FOR MORE INFORMATION

Contact: Stephen Smith and Mark Lundy
Population Ecology Division
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia B2Y 4A2

Tel: (902) 426-3317 / 426-3733
Fax: (902) 426-1862
E-Mail: smithsj@mar.dfo-mpo.gc.ca
lundym@mar.dfo-mpo.gc.ca

This report is available from the:

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

Telephone: 902-426-7070
Fax: 902-426-5435
E-Mail:XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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 Scallops (*Placopecten magellanicus*) in Scallop Production Areas 1 to 6 in the Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/012.

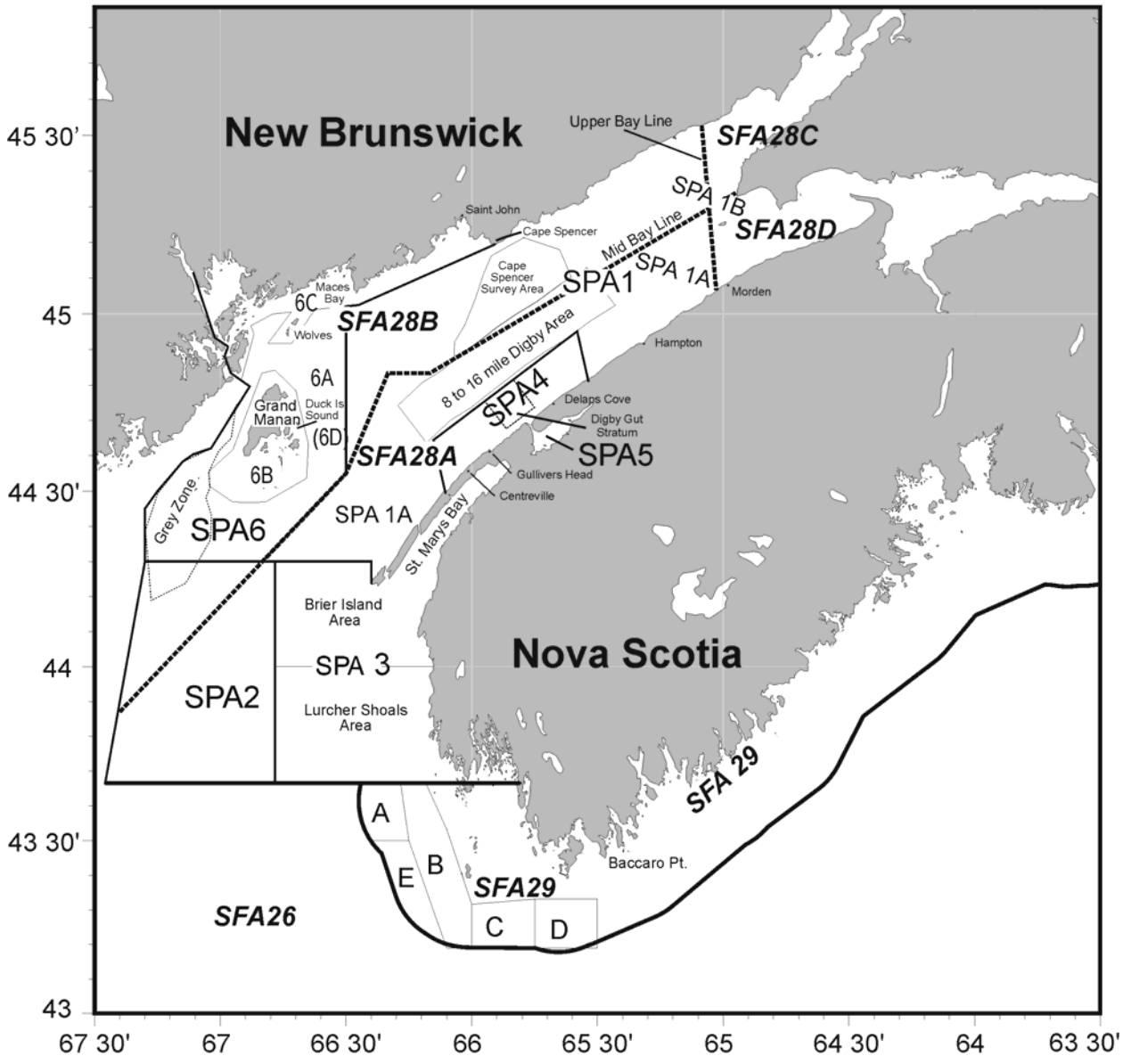



*Figure 39. Locations and place names for inshore scallop grounds.*