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Scallop Production Areas in the Bay of Fundy: Stock Status for 2005 and Forecast for 2006

Zones de production de pétoncle dans la baie de Fundy : état des stocks en 2005 et prévisions pour 2006

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Abstract

This document reviews the status of scallop stocks in Scallop Production Areas (SPA) 1, 3, 4, 5, and 6 (Bay of Fundy and Approaches) for 2004–2005 with advice for 2005–2006.

Commercial catch rate in SPA 1A has been declining from a peak observed in 2002. Survey estimates for this area indicate that the larger than average 1998 year-class has been fished down with no sign of strong recruitment for the upcoming years. A fishing strategy of 100 t in SPA 1A for 2005/2006 and 2006/2007 has a greater than 50 percent probability of resulting in median exploitation rates at or below 0.2 which could allow the population biomass to increase slightly. Lower removals would increase the probability of population biomass increase while higher removals would decrease this probability.

Commercial catch rate in SPA 1B has declined during the last two years but is still above the median level observed in 1982–2005. Survey estimates indicate there are two above average pre-recruit year-classes, however the pre-recruit year-class that appeared above average last year appears about average this year. The present quota of 400 t for SPA 1B should be maintained until the contribution of these year-classes is better defined.

Commercial catch rate in SPA 3 averaged 16.7 kg/h in 2005, compared to 22.1 kg/h in 2004 and was slightly above the median catch rate for 1996–2005 (14.5 kg/h). The 2005 survey index (1.4 kg/tow) indicated that the biomass of commercial size scallops declined after 2002, but remains just above the median (1.3 kg/tow) for the ten-year survey series. There appears to be little sign of recruitment for 2006. Based upon the survey trends in SPA 3, the population appears to be stable at the 150 to 200 t catch level with the possibility of an above average 2004 year-class that could recruit to the fishery within St. Mary's Bay in 2008.

Commercial catch rates in SPA 4 during 2004/2005 (21.8 kg/h) declined from 2003/2004 (38.6 kg/h) and were near the median for the time-series (21.3 kg/h). Mean catch rates in October 2005 (12.2 kg/h) were less than half the mean for October 2004 (27.0 kg/h). Survey numbers indicate that the stronger than average 1998 year-class has been fished down and there are no indications of any substantial recruitment for the next two to three years. An interim TAC of 200 t was set for the 2005/2006 season in SPA 4 which opened 1 October 2005. Our population model predicts that a TAC of 200 t will result in a median exploitation rate of 0.26 and a decline in population biomass. Meanwhile, a fishing strategy of 150 t in 2005/2006 and in 2006/2007 has a 0.50 probability of resulting in exploitation rates which could allow the population biomass in SPA 4 to increase slightly. Lower removals would increase the probability of population biomass increase while higher removals would decrease this probability.

Commercial catch rate in SPA 5 during 2005 (26.1 kg/h) was lower than in 2004 (32.1 kg/h) but still above the median for 1977–2005 (21.0 kg/h). Survey estimates indicate that the population abundance for commercial size scallops (126/tow) is just above the median for the time series (1997–2005; 123/tow) but little recruitment is expected for the next two years. The TAC for SPA 5 in 2006 should not exceed the average over the low abundance periods (1997–1999) of 10 t.

Landings in SPA 6 have been approximately 80–90 t per year for the last three years under a TAC of 195 t. Commercial catch rates in this area have been variable with low effort. Due to vessel problems, there was no DFO survey in SPA 6 in 2004. A survey with a commercial vessel in 2005 only covered part of SPA 6B due to time constraints. Most stock indicators show no sign of good

recruitment, and a stock of fully recruited scallops that is being fished down. The TAC in SPA 6 should not exceed 80 t in 2006.

Resumé

Le présent document porte sur l'état des stocks de pétoncle dans la zone de production de pétoncles (ZPP) 1, 3, 4, 5 et 6 (baie de Fundy et environs) pour 2004–2005 et contient des conseils pour 2005–2006.

Les taux de prises commerciales dans la ZPP 1A ont diminué par rapport au sommet observé en 2002. Selon le relevé réalisé dans cette zone, la classe d'âge de 1998, supérieure à la moyenne, a été entièrement exploitée et on ne constate aucun signe de fort recrutement pour les années à venir. Une stratégie de pêche de 100 t dans la ZPP 1A pour 2005-2006 et 2006–2007 a une probabilité de plus de 50 % d'entraîner un taux d'exploitation médian égal ou inférieur à 0,2, ce qui pourrait permettre à la biomasse de la population d'augmenter légèrement. Des taux de prises inférieurs feraient grimper la probabilité d'augmentation de la biomasse, tandis que des prélèvements supérieurs diminueraient cette probabilité.

Les taux de prises commerciales dans la ZPP 1B ont diminué au cours des deux dernières années, mais demeurent supérieurs à la valeur médiane observée entre 1982 et 2005. Les estimations établies à partir du relevé indiquent la présence de deux classes d'âge de prérecrues supérieures à la moyenne; toutefois, la classe d'âge qui paraissait supérieure à la moyenne l'année dernière semble plutôt moyenne cette année. Le quota actuel de 400 t pour la ZPP 1B devrait être maintenu jusqu'à ce que la contribution de ces classes d'âge soit mieux définie.

Les taux de prises commerciales dans la ZPP 3 étaient en moyenne de 16,7 kg/h en 2005, comparativement à 22,1 kg/h en 2004, et légèrement supérieurs à la valeur médiane pour 1996 à 2005 (14,5 kg/h). L'indice du relevé de 2005 (1,4 kg/trait) révélait que la biomasse de pétoncles de taille commerciale avait diminué après 2002, mais demeurait au-dessus de la valeur médiane (1,3 kg/trait) de la série chronologique de dix ans des relevés. On observe peu de signes de recrutement pour 2006. D'après les tendances des relevés dans la ZPP 3, la population paraît stable à un niveau de prises de 150 à 200 t; de plus, il est possible que la classe d'âge de 2004 soit supérieure à la moyenne et puisse être recrutée au sein de la population exploitable dans la baie Ste Marie en 2008.

Les taux de prises commerciales dans la ZPP 4 en 2004–2005 (21,8 kg/h) ont diminué par rapport à 2003-2004 (38,6 kg/h) et se situaient près de la valeur médiane de la série chronologique (21,3 kg/h). Les taux de prises moyens d'octobre 2005 (12,2 kg/h) étaient inférieurs à la moitié de la moyenne d'octobre 2004 (27,0 kg/h). Les données tirées du relevé montrent que la classe d'âge supérieure à la moyenne de 1998 a été entièrement exploitée et on n'observe aucun signe de recrutement substantiel pour les deux ou trois prochaines années. Un TAC provisoire de 200 t a été fixé pour la saison de 2005–2006 dans la ZPP 4 où la pêche a été ouverte le 1er octobre 2005. Selon notre modèle de population, un TAC de 200 t entraînera un taux d'exploitation médian de 0,26 et une baisse de la biomasse de la population. Par ailleurs, une stratégie de pêche de 150 t en 2005–2006 et en 2006–2007 a une probabilité de 50 % de résulter a un taux d'exploitation qui permettraient à la biomasse de la population de la ZPP 4 d'augmenter légèrement. Des captures inférieures hausseraient probablement la possibilité d'accroissement de la biomasse de la population, tandis que des captures supérieures diminueraient cette possibilité.

Les taux de prises commerciales dans la ZPP 5 en 2005 (26,1 kg/h) étaient inférieurs à ceux de 2004 (32,1 kg/h), mais supérieurs à la valeur médiane pour 1977 à 2005 (21,0 kg/h). D'après les estimations du relevé, l'abondance de la population de pétoncles de taille commerciale (126/trait) est tout juste supérieure à la valeur médiane pour la série chronologique (1997–2005; 123/trait),

mais on s'attend à un recrutement faible pour les deux prochaines années. Le TAC de la ZPP 5 pour 2006 ne devrait pas dépasser la moyenne de 10 t des périodes de faible abondance (1997–1999).

Les débarquements dans la ZPP 6 se chiffrent à environ 80 à 90 t par année depuis trois ans, avec un TAC de 195 t. Les taux de prises commerciales dans cette zone ont fluctué mais l'effort est demeuré faible. À cause de problèmes du navire scientifique, le MPO n'a pas entrepris de relevé dans la ZPP 6 en 2004. Un relevé réalisé par un bateau de pêche commerciale en 2005 s'étendait sur certaines parties seulement de la ZPP 6B à cause de contraintes de temps. La plupart des indices du stock ne donnent aucun signe de bon recrutement et révèlent plutôt un stock entièrement recruté et actuellement exploité. Le TAC de la ZPP 6 ne devrait pas dépasser 80 t en 2006.

Introduction

The Bay of Fundy is fished by three different categories of scallop licenses. Full Bay scallop license holders are able to fish scallops anywhere in the Bay of Fundy, Mid Bay license holders can fish for scallops on the northern side of the Mid Bay line (Fig. 1) and Upper Bay license holders fish east of the Upper Bay line. The Full Bay fleet has traditionally been based in Digby with larger vessels (>14.5 m and <19.8 m Length Over All (LOA)) fishing only scallops, the Mid Bay fleet consists mainly of New Brunswick based, smaller (<14.5 m LOA) vessels with multiple licenses for different species, and the Upper Bay fleet are Nova Scotian and New Brunswick based smaller, multi-species vessels. These distinctions are diminishing as the Mid and Upper Bay fleets become more specialized, and smaller boats are replaced with larger ones. The Full Bay fleet fishes under Individual Transferable Quotas (ITQs) with a 1 October to 30 September season while the Mid and Upper Bay fleets fish a competitive quota with a 1 January to 31 December season.

In this document, we present the scientific basis for advice given in December 2005 during the review of stock status for scallops in the Bay of Fundy and Approaches. Data used for the analyses came from commercial fishing logs and dockside monitoring documents, samples of meat weights in the catch, and independent research vessel surveys. Details on these sources of data, survey protocols, and their analyses are available in Roddick (2002), Roddick and Butler (2002), Smith and Lundy (2002*a*), and Smith and Lundy (2002*b*).

The Canadian Coast Guard vessel J.L. Hart which has been used to conduct the surveys since 1989 was unexpectedly retired from service in late 2004/early 2005 due to structural problems leaving the program without a survey vessel. A tender was put out for an industry vessel to replace the CCGC J.L. Hart and the fishing vessel Royal Fundy was awarded the contract to continue the survey program. No comparative tows were conducted between the FV Royal Fundy and CCGC J.L. Hart, because of the sudden departure of the CCGC J.L. Hart. The standard survey 4-gang Digby drags were used on the FV Royal Fundy and all survey protocols followed on the CCGC J.L. Hart remained the same. Analysis of data from SPA 4 suggested that the indices from the FV Royal Fundy survey were comparable to those from the CCGC J.L. Hart surveys.

In recent assessments of the scallop stocks in Scallop Production Areas 1 (8–16 miles off of Digby) and 4, delay-difference models were used to model population biomass trends over time (Smith and Lundy 2000, Smith and Lundy 2002*b*, Smith et al. 2003). These models use survey biomass estimates to model the trends in the population and estimate population biomass by assuming that there is a proportional relationship between the survey biomass estimate and the population biomass estimate. That is, $I_t = q_I * B_t$, where I_t is the survey biomass estimate at time t, q_I is the proportionality constant, often referred to as the catchability coefficient and B_t is the population biomass. In these earlier assessments, the catchability coefficient which is estimated from the model was assumed to be constant over time, reflecting the belief that the survey biomass estimates have a constant relation to the population biomass over time. While these models had fit the survey and catch data quite well, their ability to predict next year's biomass for different levels of catch in the upcoming season had been steadily declining.

The population models were modified for the 2004 assessment to allow for time-varying catchability (Lavoie 2004). This revision resulted in marked improvements in model predictions and time-varying catchabilities are used in this year's assessments as well.

SPA 1

SPA 1 covers most of the mid to inner Bay of Fundy (Fig. 1). It is fished under three classes of scallop licences: Full Bay licences, which can fish anywhere in the Bay of Fundy; Mid Bay licences which can fish North of the Mid Bay line; and Upper Bay licences, which can fish East of the Upper Bay line.

In 2001, the Full Bay fleet changed the quota year for SPA 1. It now runs from 1 October to 30 September. The Mid and Upper Bay fleets remain on a calendar year, but split their quota into two seasons, January to April, and August to December.

In 2002, SPA 1 was split into SPA 1A and SPA 1B to accommodate a recruitment pulse that was located in SPA 1A that was only accessible to the Full Bay fleet.

SPA 1A

Commercial Fishery

The 2004/2005 quota for Full Bay licence holders in SPA 1A was 400 t. This was down from the 1200 t level in 2002/2003, but still above the long term average. The fleet did not, however, reach this quota.

Landings to 7 November 2005 were 322 t for the Full Bay licence holders (2004/2005 fishing year).

Year	Avg. 97–01	2001–2002[1]	2002–2003[2]	2003–2004	2004–2005	2005–2006[3]
TAC (t)	240	700	A:1200	A:700	A:400	A:50
Landing (t)	210	745	A:913	A:464	A:322	A:1

[1] Starting 1 October 2001, the Full Bay Fleet fishing season changed from a calendar year to 1 October to 30 September.

[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/2003. Quotas and landings for 1997–2001/2002 are for all SPA 1; those for 2002/2003 to 2005/2006 are for SPA 1A only.

[3] Interim TAC, landings to 7 November 2005.

Landings in SPA 1A have shown two large peaks; one in 1990 and a recent one in 2003 with landings currently declining (Fig. 2). The 1990 peak was seen throughout the Bay while the recent one was confined to SPA 1A. Landings declined to low levels between these peaks.

Catch per unit effort (CPUE) in SPA 1A declined from a high in the late 1980's to a low in 1997. With the large 1998 year-class recruiting to SPA 1A, it peaked again in 2002, and is now declining (Fig. 3).

Survey

In SPA 1A, resource surveys have been conducted annually since 1981 in the 8 to 16 mile area off Nova Scotia. Up to 2003 the surveys were conducted in May-June, but the expanding distribution

of lobster traps in the area necessitated rescheduling the survey to August-September. The survey vessel had mechanical problems in 2004, resulting in a shortened survey in September–October.

The 2005 survey had the most complete coverage of any of the modern surveys in this area (Fig. 4).

The mean catch per standard tow in this area is still declining from the recent peak (Fig. 5), with no strong year-classes evident in the survey size frequencies.

The size frequency distributions from the surveys show the 1998 year-class in the 2000–2005 surveys as it recruited to the fishery and was fished down (Fig. 6). This year-class has supported the fishery in SPA 1A since it started to recruit to the fishery in late 2001. It has been fished heavily and the abundance of scallops $\geq$ 80 mm shell height has now declined close to the low levels observed in the 1994 to 2000 period.

Stock Status and Forecast

The population model described in Smith et al. (2003) was used to analyze the survey and commercial catch data and estimate natural mortality and population biomass. The model was revised in 2004 to improve its ability to forecast population size for the following year. Differences between predicted and estimated biomass in 2002 partly reflect the increase in growth rate noted in 2001, as a constant growth function was assumed for this model. The other reason for the difference between the two sets of estimates for this time period may be due to imperfect corrections for the changing relative behaviour of the lined and unlined survey gear when densities are high. Further analysis of the relative selectivity of the survey gear will have to be conducted to solve this issue. The predicted mean biomass for the start of the 2006/2007 season was based on a catch of 100 t for 2005/2006 (Fig. 7).

In last year's assessment, exploitation rate was suggested as a fishery indicator with an upper limit reference point of 0.2 based on empirical evidence from previous assessments (Lavoie 2004). Given the boom-and-bust cycles observed for this fishery, this indicator was recommended for periods of weak recruitment and low stock biomass. In Table 1, a catch of 100 t in 2005/2006 is expected to result in an exploitation rate of 0.18. With all of the uncertainties contained in the model, a catch of 100 t has a probability of 0.42 of exceeding 0.2. For 2006/2007 a catch of approximately 100 t would result in a median exploitation rate of 0.18 with about a 0.45 chance of exceeding 0.20. The model predicts that a fishing strategy of 100 t catch for this season and next season would result in a modest increase in population biomass after this year's fishery and next year's fishery. All catches below these levels should result in small increases in population biomass.

A fishing strategy of 100 t in SPA 1A for 2005/2006 and 2006/2007 will likely result in exploitation rates (0.18 and 0.18) at or below 0.2 which could allow the population biomass to increase slightly.

There are no signs of above average recruitment for the next few years, so fishing above this level will decrease the biomass.

SPA 1B

Commercial Fishery

The Full Bay quota in SPA 1B for 2004/2005 was 200 t which was the same as in 2003/2004. The Mid and Upper Bay fleets also had a quota of 200 t in 2005, a 50 t increase from the last 2 years. The quotas were exceeded in SPA 1B.

In SPA 1B the landings were 228 t for the Full Bay (2004/2005 fishing year), 157 t for the Mid Bay and 50 t for the Upper Bay fishers (2005 fishing year). Landings by all fleets remain above long term median levels.

In 2004 the remaining quotas for SPA 1B and 6 were combined in August, with most of the combined quota taken in SPA 1B; this resulted in 2004 landings higher than the initial SPA 1B quota. The quotas remained separate in 2005.

Full Bay

Year	Avg. 97–01	2001–2002[1]	2002–2003[2]	2003–2004	2004–2005	2005–2006[3]
TAC (t)	240	700	B:100	B:200	B:200	B:50
Landing (t)	210	745	B:33	B:210	B:228	B:2

[1] Starting 1 October 2001, the Full Bay Fleet fishing season changed from a calendar year to 1 October to 30 September.

[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/2003. Quotas and landings for 1997 to 2001/2002 are for all SPA 1; those for 2002/2003 to 2005/2006 are for SPA 1B only.

[3] Interim TAC, landings to 7 November 2005.

Mid and Upper Bay

Year	Avg. 97–01	2002	2003	2004	2005
TAC (t)	66	100	150	150	200
Landing (t)	66	186	212	261[1]	206

[1] Remaining quotas in SPA 1 and 6 combined 2 August 2004 with most of the combined quota coming from SPA 1.

The Mid Bay and Upper Bay vessels were not required to keep logbooks until 1996, so their earlier catches cannot be broken down by SPA. Landings by Statistical District for Districts 24, 40, 43, 44, 48 and 79, (coast of Bay of Fundy from St. John, N.B. to Morden, Nova Scotia) were used to estimate Mid and Upper Bay landings from Area 1B prior to 1997 (Fig. 8).

In SPA 1B, the Full Bay log records do not contain complete data (location, catch and effort) until 1982. For the Mid Bay fleet, CPUE can only be calculated for the period since 1992, and for the Upper Bay fleet since 1997.

Commercial catch rates show an increasing trend from the low in 1997 (Fig. 9), but not the large peak observed in 2002 in SPA 1A (Fig. 3). Commercial catch rate has declined the last two years, but is still above the median level.

Survey

In SPA 1B, resource surveys have not consistently covered the whole area. The surveys off Digby were expanded to the Cape Spencer grounds in 1996, and the Upper Bay area was added after industry surveys in 1998 and 1999. Other areas in SPA 1B are covered as time is available during these surveys. Due to research vessel problems, the 2004 survey only covered the Cape Spencer grounds. The 2005 survey, using a commercial vessel, had more extensive coverage in SPA 1B than in previous years (Fig. 4).

Mean numbers per tow of commercial-sized scallops in the Cape Spencer Area showed an increasing trend to 2004 as moderate year-classes (1996, 1997) entered the fishery (Fig. 10). Recruitment in this area has remained relatively constant, with little sign of the 1998 year-class observed in the 8-16 mile area of SPA 1A. The 2005 survey found lower numbers of commercial sized scallops than the previous three years, but above the levels seen in 1997-1999.

The height frequencies show the moderate strength year-class that recruited to the fishery in 2000 (Fig. 11). Recruitment and growth have kept up with removals from the stock, resulting in an increasing trend in the abundance of commercial-sized scallops. The 2004 survey showed a mode of small (approximately 35 mm shell height) scallops located in a band along the New Brunswick side of the Mid Bay line. This mode appears much smaller at approximately 55 mm, in the 2005 survey and will have less of an impact than originally anticipated when it recruits to the fishery in 2006.

Surveys have been conducted in the Upper Bay area at varying times of year since 1998.

The 2005 survey shows a large decline in the abundance of commercial-sized ($\geq$ 80 mm shell height) scallops, but an increase in scallops $<$ 65 mm shell height since 2003 (Fig. 12).

The survey shell height frequency data show that the increase in pre-recruits is made up of two modes, one at 30 and another at 55 mm shell height (Fig. 13). These year-classes were found in only a few tows during the survey and so may not be widespread.

Stock Status and Forecast

In SPA 1B there are signs of two above average year-classes evident in this year's survey. However the year-class that appeared to be above average in last year's survey appears to be average in this year's survey. In light of the possibility these year-classes may be overestimated, the advice is to take a cautious approach and not change the allowable catch until the sizes of these year-classes are better defined.

SPA 3

Commercial Fishery

Although scallops can be found throughout most of the 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 in 1999 for management purposes with a single TAC. The lobster fishery influences the scallop-fishing season throughout this area.

In the 1950's and 1960's, this area was heavily exploited but subsequently, fishing was minimal until 1980, when both the inshore and offshore fleets fished the area until 1986. In 1986, an

agreement was reached between the two fleet sectors to establish separate inshore and offshore grounds, north and south of latitude 43°40'N, respectively. This agreement excluded the offshore fleet sector from the area now defined as SPA 3.

Landings in SPA 3 increased each year from 1991 to 1994, reaching a high of 1439 t (Fig 14). Landings declined from 1995 until 1998. However, there is uncertainty about the landings from 1991 to 1996, due to misreporting.

The landings for SPA 3 and 7 have been combined since 1999. There were serious doubts raised about whether all of the landings reported in 1999 for SPA 3 came from this area. There does not appear to be any reason to suspect that landings reported to SPA 3 in subsequent years were from other areas. In recent years (2001–2004) effort has been redirected from SPA 3 to other areas.

Year	Avg. 95–99	2000	2001	2002	2003	2004	2005	2005–2006
TAC (t)	234[1]	200+50	200	200	300	300	200	50
Landing (t)	388	244	163	31	225	151	208	12[2]

[1] TACs have only been in effect since 1997, so average TAC is for 1997–99.

[2] reported as of 14 November 2005.

Landings for the 2004/2005 fishing year were 208 t against a TAC of 200 t (Fig 14). Of this total amount 134 t were landed from Brier/Lurcher while 74 t came from St. Mary's Bay. These landings are the second highest of those reported since 2000 but below the average landings from 1995–1999. An interim TAC of 50 t was granted for October/November of the 2005/2006 fishing season and the most recent record of landings against the TAC was 12 t.

Commercial catch rate in 2005 (16.7 kg/h) declined from that observed over the previous three years (Fig. 15) while effort has increased over the same period of time (Fig. 16). Nonetheless, catch rate in 2005 was just above the median catch rate for the series (1991–2005: 14.5kg/h) and effort was below the long term median.

Meat counts for 2005 were similar to those reported for 2003 and 2004 in all three areas (St. Mary's Bay, Brier Island, and Lurcher Shoal; Table 2). Meat weights tend to be smaller in the Lurcher Shoal area partly due to the slower growth in the deeper depths there.

Survey

Annual research vessel surveys have been conducted around Brier Island and Lurcher Shoal each August from 1991 to 2003. Surveys in SPAs 1 and 4 were re-scheduled to August in 2004 and 2005 to avoid problems with lobster gear in June. As a result, the survey in SPA 3 was conducted in June during 2004 and 2005. Sampling intensity was increased in 2005 by 47 tows in the Brier/Lurcher area. Due to coverage and design, only the results from the 1996 to 2005 surveys are comparable.

The largest concentrations of commercial-size scallops (shell height $\geq$ 80 mm) continue to be mainly in the southwest portion of Lurcher Shoal (Fig. 17, upper left panel). The scallops in this area usually have smaller meat weight-at-shell height than those caught elsewhere in SPA 3 due to lower growth rates in the deeper water. The distribution of recruits (shell height 65–79 mm) was patchy and mainly in the eastern part of the area (Fig. 17, upper right panel). Pre-recruits (shell height $<$ 65 mm) occurred in relatively high densities in the Lurcher Shoal area (Fig. 17, lower left panel) however, based upon past experience, indices for this size range are not very reliable

indicators of year-class strength. Three tows with a relatively large number of clappers were made near the western boundary of the survey area but otherwise clappers were of low density and patchy in distribution (Fig. 17, lower right panel).

The pulse of pre-recruits evident in 2004 (shell heights 15–25 mm) was not observed in 2005. In areas where we had observed large numbers of pre-recruits in 2004, we found single valves in the 35–45 mm range. During 2005, individuals in the population were distributed over a broad range of size classes at relatively low densities (Fig. 18).

Mean numbers of commercial-size scallops per tow declined in 2005 in the Brier and Lurcher areas (Table 3) but were similar to the long term average (1996–2005; Fig. 19). Mean weight per tow (1.4 kg/tow) indicated that the biomass of commercial-size scallops declined after 2002, but remained just above the median for the ten-year series ((1.3 kg/tow); Fig. 20). There appears to be little recruitment for 2006 in the Brier/Lurcher area (Figs. 19–20).

Surveys of St. Mary's Bay have been conducted from 1999 to 2001, inclusive. No surveys were conducted for St. Mary's Bay in 2002 and 2003 due to limited research vessel time. Eighteen and 24 stations were completed in St. Mary's Bay in 2004 and 2005, respectively.

The largest concentrations of commercial-size scallops (shell height $\geq$ 80 mm) were found off of Long Island with smaller patches in the upper part of the Bay (Fig. 21, upper left panel). The distribution of recruits (shell height 65–79 mm) was widespread but they were at low densities everywhere (Fig. 21, upper right panel). Pre-recruits (shell height $<$ 65 mm) were widespread but occurred in relatively high densities near Long Island (Fig. 21, lower left panel). Two tows with relatively large numbers of clappers were made off of Long Island and one further up the Bay; there were low densities of clappers elsewhere (Fig. 21, lower right panel).

In St. Mary's Bay, individuals were present over a broad range of size classes and there was a particularly high number of pre-recruits (shell height 15–40 mm) in 2005 relative to that observed since 2000 (Fig. 22), but as noted above these small animals mainly occurred in one tow off of Long Island.

Stock Status and Forecast

There are no reference points for this fishery. Based upon the survey trends, the population appears to be stable at the 150 to 200 t catch level with the possibility of an above average 2004 year-class that could recruit to the fishery within St. Mary's Bay in 2008.

SPA 4

Commercial Fishery

Landing data in what is now SPA 4 are available from 1976 to 2005 (Fig. 23). The season extends from 1 October to 30 April. In 2005, the season was extended to May 6th.

Landings steadily declined from 1991 to 1995 as the remnants of large year-classes (1984, 1985) were fished down. Portions of what is now SPA 4 were closed in 1995 and 1996 because of low stock levels. The increase in landings starting in 2001 was due to the strong 1998 year-class recruiting to the fishery. In October 2001 fishing was restricted to the Digby Gut up the Bay to

Parkers Cove to protect the abundant 1998 year-class. As this year-class grew and recruited to the fishery, fishing occurred throughout area 4.

A total of 945 t was landed against a TAC of 1000 t in 2003/2004. Reasons for the total TAC not being caught include unallocated quota due to ongoing negotiations with First Nations. Landings in 2004/2005 were 535 t against a TAC of 550 t (Fig. 23). An interim TAC of 200 t has been set for the 2005/2006 season which opened 1 October 2005. As of the quota report of 14 November 2005, 60.0 t had been landed from SPA 4.

Year	Avg. 95–99	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
TAC (t)	107[1]	110	650	1200	1000	550	200[2]
Landing (t)	85	102	598	1097	945	535	60.0[3]

[1] TACs have only been in effect since 1997, so average TAC is for 1997–99.

[2] Interim TAC.

[3] as of November 14, 2005.

Total effort (hours) was low in 1995/96 and 1996/97, due to the closures in part of SPA 4, but effort increased thereafter until 1998/1999 (Fig. 24). In 2000/01, effort was at its lowest level in 26 years. Current levels of effort are at the second highest in the series.

Commercial catch rates in 2004/2005 (21.8 kg/h) declined over those from the previous three years (Fig. 25) and was near the median for the time-series of 21.3 kg/h. Average catch rates from October 2005 (12.2 kg/h) are less than half the average for the same time in 2004 (27.0 kg/h).

In general, the fishery is concentrating on older scallops as indicated by the large meat weights in the fall of 2004 (Table 4). The lower meat weights in October each year are expected as the animals recover from spawning in August/September. Lower meat weights in the spring reflect incoming recruitment and weight loss from low food conditions in the winter.

Survey

Research vessel surveys, using a consistent stratified random design, have been conducted since 1991. Prior to 1991, surveys were stratified according to the spatial pattern of the preceding year's commercial catch rate. Up to 2003 the surveys have been conducted in June every year, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August in 2004. However, survey vessel mechanical problems resulted in the 2004 survey being conducted in September. The 2005 survey of SPA 4 was completed in August as planned.

In 2005, the main concentration of commercial size scallops (shell height $\geq$ 80 mm) continued to be found in the Centreville to Digby gut area (Table 5, Fig. 26, upper left panel). Overall, numbers of commercial size scallops have declined by 45 percent from 2004 with the largest decrease (74%) being observed in the areas shallower than 90 m. Scallops that will recruit in 2005/2006 (shell height 65–79 mm) were marginally higher than in 2004 but were absent from many of the shallower areas (Fig. 26, upper right panel). For scallops of less than 65 mm, mean numbers in 2005 are slightly higher than in 2004, but still low compared to recent years (Fig. 26, lower left panel). Shell height frequencies indicate that the stronger than average 1998 yearclass has been fished down and there are no indications of any substantial recruitment for the next two to three years (Fig. 27). The distribution of clappers was patchy and at very low densities (Fig. 26, lower right panel).

Survey biomass declined in 2005 relative to 2002 similar to the trend in survey numbers (Fig. 28, 29).

The delay-difference population model described in Smith et al. (2003) and updated in Lavoie (2004) was used to quantify the impact of the fishery on the population and to evaluate various proposed catch levels for 2005/2006 season. The major modification introduced in Lavoie (2004) was the incorporation of annual estimates of catchability of the commercial size scallops to the survey gear. These were introduced to compensate for the observed trend of decreasing relative efficiency for the lined gear when scallop densities were high. This change in efficiency was measured as the ratio of the estimates of the mean number of commercial size scallops from the lined and unlined gear (Fig. 30). Scallops of shell height 80 mm and higher are considered to be fully selected by both the lined and unlined survey gear. In the original model presented in Smith et al. (2003) the relative efficiency between the lined and unlined gear was assumed to be constant over time. However as the 1998 year-class recruited to the survey gear the efficiency of the lined gear decreased (2001 and 2002). The model compensated by decreasing the estimated catchability of the commercial size scallops to the unlined gear resulting in the population model overestimating the number and biomass of the commercial size scallops. In particular, the population model overestimated the predicted population size for the following year which was used to set catch levels. Removing the constant relative efficiency assumption and allowing for annual changes in catchability reduced the overestimation problem.

As noted above, the unexpected retirement of the CCGC J.L. Hart did not allow for comparative survey work to calibrate the survey results from the FV Royal Fundy. Size compositions from the FV Royal Fundy survey tows did not seem to indicate any unexpected deviations from the compositions expected based upon previous surveys (Fig. 27).

Previous assessments have reported a significant linear relationship between survey biomass estimates of commercial size scallops in the current year and the commercial fishery catch rate in the following season. Indeed, this relationship holds for the survey estimates and the commercial catch rate from the following October, the start of the season and the time at which the highest catch rates are achieved (Fig. 31). Using a linear relationship based on CCGC J.L. Hart points only (1996 to 2004) the predicted commercial catch rate for October 2005 based on the FV Royal Fundy estimate was 10.2 kg/h and the observed catch rate was 12.2 kg/h which was within the 95 percent confidence limits of 6.8 kg/h and 13.7 kg/h (Fig. 31). Based upon these results it was assumed that the 2005 survey estimate was comparable to previous years' survey estimates using the CCGC J.L. Hart.

Stock Status and Forecast

In previous stock assessments for SPA 4, the model prediction of the following year's survey was compared against the actual survey estimate as a diagnostic tool of the reliability of catch level decisions for the following year from the model. This approach made sense when we assumed constant relative efficiency between the lined and unlined gear. This year, we use the comparison between the predicted and estimated population biomass of commercial size scallops as a diagnostic tool (Fig. 32). The predicted biomass uses all of the information up to year t to predict the biomass in year $t+1$ while the estimated biomass for year $t+1$ is based on the data up to and including year $t+1$. A constant growth model was assumed and the differences between the two sets of

estimates from 2001 to 2003 (maybe 2004) are partly due to the changing growth rates observed during that period. Once we have been able to fully analyze the bimonthly sampling data annual growth changes can be incorporated into the model. However, growth changes in the following year can not be anticipated and these will continue to add uncertainty to predictions. The other reason for the difference between the two sets of estimates for this time period may also be due to imperfect corrections for the changing relative behaviour of the lined and unlined survey gear when densities are high. Further analysis of the relative selectivity of the survey gear will have to be conducted to solve this issue. Overall, the delay-difference model seems to track the population quite well and provide a means for evaluating future fishing. The predicted biomass (posterior mean) for 2006 was based on a catch of 200 t for 2005/2006.

In last year's assessment, exploitation rate was suggested as a fishery indicator with an upper reference point of 0.2 set based on empirical evidence from previous assessments (Lavoie 2004). Given the boom-and-bust cycles observed for this fishery, this indicator was recommended for periods of weak recruitment and low stock biomass. In Table 6, the current TAC of 200 t for 2005/2006 is expected to result in an exploitation rate of 0.26. With all of the uncertainties contained in the model, a catch of 200 t has a probability of 0.63 of exceeding 0.2. For 2006/2007 a catch of approximately 125 t would result in a median exploitation rate of 0.20 with about a 0.50 chance of exceeding 0.20. The 0.2 exploitation strategy would be 150 t for the current year and no more than 150 t next year. The model predicts that this strategy would result in a modest increase in population biomass after this year's fishery and next year's fishery. All catches below these levels should result in increases in population biomass.

SPA 5

Commercial Fishery

The fishery in SPA 5, which is only open to the Full Bay fleet, has been quite small with a season running from 1 January to 31 March. In recent years, landings have varied between 2 and 20 t (Fig. 33).

Landings dropped to 2.3 t in 2002 mainly due to increased effort directed towards SPA 4 in the winter. Increased landings in 2003 and 2004 were due to strong recruitment of 1999 and 2000 year-classes. Landings in 2005 were 13.3 t against a TAC of 10 t.

Year	Avg. 95–99	2000	2001	2002	2003	2004	2005
TAC (t)	10[1]	17	10	10	10	25	10
Landing (t)	10.9	16.6	8.9	2.3	12.2	20.4	13.3

[1] TACs have only been in effect since 1997, so average TAC is for 1997–99.

Commercial catch rate in 2005 (26.1 kg/h) was lower than that observed during the past three years but was still above the long term median of 21 kg/h (1977–2005; Fig. 34). Effort declined in 2005 over 2004 but is higher than in 2002 and 2003 (Fig. 35). Over the long term, effort in 2005 is still at a lower level than the 1995 to 2000 period.

Meat counts for 2005 were similar to those reported for 2002 and 2003 (Table 7). No samples were collected during 2004.

Survey

Research vessel surveys have been conducted on a regular basis in Annapolis Basin every June since 1997 in conjunction with the SPA 1 and 4 surveys. The rescheduling of these surveys in 2004 to August and then to September resulted in the 2004 SPA 5 survey also being conducted in September. In 2005, the SPA 5 survey was completed in June.

For the 2005 survey, 11 of the 20 tows had catches exceeding 100 commercial-size scallops (shell height $\geq$ 80 mm) and these were widespread in distribution (Fig. 36, upper left panel). Recruits (shell height 65–79 mm; Fig. 36, upper right panel) and pre-recruits (shell height $<$ 65 mm; Fig.36, lower left panel) were also relatively widespread but at lower densities. All of the tows had $<$ 35 recruits while only 2 tows had greater than 100 pre-recruits.

Clappers were observed at low densities (19 out of 20 tows $<$ 20 clappers) throughout most of the area (Fig. 36, lower right panel).

Strong 1999 and 2000 year-classes are evident in the shell height frequencies from the annual survey (Fig. 37). These year-classes have been fished down and recruits from the 2001 and 2002 year-classes appear to be at very low abundance.

Mean number of commercial-size scallops per tow in 2005 was unchanged from 2004 (Fig. 38). The mean number of recruits and pre-recruits per tow in 2005 were similar to those observed during most of the time series (the exception being 2002 — a year of particularly high abundance).

Stock Status and Forecast

A population model has yet to be developed for this SPA. Based on the survey, the stock status of commercial size scallops has remained virtually unchanged after a 2005 fishery of 13 t.

Survey estimates indicate that the commercial size portion of the population (126/tow) is just above the 1997-2005 median (123/tow) but little recruitment is expected for the next two years. The TAC for 2006 should not exceed the average over the low abundance periods (1997 to 1999) of 10 t.

SPA 6

The areas around Grand Manan and off southwest New Brunswick are designated SPA 6. This area is further divided into the Grand Manan Island inside zone (SPA 6B), the New Brunswick inside zone including the Wolves and Campobello Island (SPA 6C), and the outside zone (SPA 6A) (Fig. 1).

Commercial Fishery

Year	Avg. 97–01	2002	2003	2004	2005
TAC (t)	151	195	195	195	195
Landing (t)	143[1]	128	89	82	83

[1] Landings not available by SPA prior to 1997.

The 2005 SPA 6 quota for the Full Bay fleet was 50 t with a maximum of 30 t from the inside zones (SPA 6B+C) the same as in 2004 (Fig. 39). Full Bay landings by area for 2005 were 0.5 t, 8.8 t and 0.5 t for SPA 6 A, B and C respectively. This fleet has not caught it's quota for the last 4 years as it has directed it's effort to the other areas.

The 2005 quota for the Mid Bay fleet was 145 t. This was split 105 t for the inside winter fisheries in 6B and 6C, and 40 t for the summer fishery in 6A. Mid Bay landings for 2005 by area were 35.4 t, 26.1 t and 16.7 t for SPA 6A, B and C respectively. Although the situation is improving, there are still problems with late submissions of monitoring documents.

Commercial catch rates for the Full Bay fleet have been fluctuating with low effort in SPA 6. The Mid Bay fleet catch per unit effort (CPUE) is fluctuating at a lower rate at or above the 1993-2005 median (Fig. 40). Effort for the Mid Bay fleet has declined dramatically from 1993 (Fig. 41) and that of the Full Bay fleet remains at low levels (Fig. 41).

Meat weight sampling provides information on the sizes of scallops being landed, and is used to monitor the proportion of meats less than 8 and 11 g in the catch (Fig. 42). Samples in 2005 indicated that the fishery in SPA 6 has been relying more on smaller scallops than it did in 2004 during Jan-Mar (Fig. 43). One sample in SPA 6C indicated that the majority of the catch consisted of scallop meats less than 11 grams. Only one sample was taken in September, but was made up of larger scallops. The meat weight samples do not indicate that a strong year-class recruited to the fishery in 2005.

Survey

Research vessel (RV) surveys were conducted annually from 1979 to 1991. A new survey series with a different design was initiated in 1996. From 1997 to 1999, SPA 6C was not covered by the survey. There was no RV survey in 2004 due to vessel problems, and a survey with a commercial vessel in 2005 was incomplete (Fig. 44).

Comparing the survey catch rates through time for SPA 6B in the area where the 2005 survey coverage occurred, shows the abundance of commercial-sized (shell height $\geq$ 80 mm) scallops has remained steady, but the abundance of smaller scallops is low (Fig. 45). This decline in the number of small scallops in 2005 is supported by the size frequency data with the lowest numbers of scallops less than 80 mm observed since the start of the survey series in 1997 (Fig. 46).

Stock Status and Forecast

Most of the stock indicators show no signs of good recruitment, and a stock of fully recruited scallops that is being fished down. The lack of effort by the Mid Bay fleet in 2005 suggests that there was no strong recruitment to the SPA 6 fishery during 2005 in the portions not covered by the survey.

The population has appeared stable with removals in the range of 80 to 90 t per year for the last three years. The survey coverage of part of SPA 6B shows no sign of recruitment. The advice is that catch should not exceed 80 t in 2006.

Summary

The most significant event in Bay of Fundy scallop fishery in recent years was the appearance of a strong 1998 year-class off Digby which began to recruit to the fishery in 2001. This year-class has been fished down and total landings for the Bay of Fundy have been in decline since the 2002/2003 season. Overall, there are no strong signs of recruitment in the Bay of Fundy for the next two to three years.

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Table 1. Posterior probabilities for the exploitation rate exceeding the provisional reference exploitation level (0.20) for Scallop Production Area 1 (8–16 mile). Posterior median exploitation rate given in brackets.

Catches in 2005/2006		$\Pr(e_{2006} \geq 0.2)$ for Catches in 2006/2007				
(meats, t)	$\Pr(e_{2005} \geq 0.2)$	50	100	150	200	250
100	0.42 (0.18)	0.16 (0.09)	0.45 (0.18)	0.77 (0.36)	0.89 (0.54)	0.95 (0.73)
200	0.81 (0.35)	0.30 (0.11)	0.55 (0.23)	0.81 (0.46)	0.90 (0.69)	0.96 (0.92)
300	0.93 (0.53)	0.43 (0.16)	0.64 (0.31)	0.84 (0.63)	0.93 (0.94)	0.97 (—)

Table 2. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 3 for the 2003, 2004 and 2005 fishing seasons. All samples collected by industry supported dockside monitoring program. Statistics on the percentage by number of meats in the sample that were less than 8 g are also given.

		Meat Weight (g)			Count	Number of	Percent < 8 g		
Month	N	Mean	Min.	Max.	per 500 g.	Samples	Mean	Min.	Max.
					St. Marys Bay				
2003 Season									
June	111	28.4	10.2	61.2	18.1	3	0.0	0.0	0.0
July	41	34.8	21.4	53.6	14.4	1	0.0	0.0	0.0
2004 Season									
June	130	34.5	12.7	81.4	15.6	4	0.0	0.0	0.0
July	40	26.3	16.4	41.5	19.0	1	0.0	0.0	0.0
2005 Season									
June	186	28.0	8.2	56.9	18.9	5	0	0	
July	68	30.2	13.8	74.4	16.6	2	0	0	
					Brier Island				
2003 Season									
June	47	20.5	8.9	34.1	24.4	1	0.0	0.0	0.0
2004 Season									
June	239	22.1	9.7	42.9	23.2	5	0.0	0.0	0.0
July	60	16.0	8.9	32.7	31.3	1	0.0	0.0	0.0
August	112	17.9	8.3	31.2	28.0	2	0.0	0.0	0.0
2005 Season									
June	47	21.7	14.1	43.6	23.0	1	0.0	0	0.0
July	199	21.6	6.9	56.8	23.8	4	0.4	0	1.7
August	235	17.6	4.8	37.4	28.8	4	3.9	0	10.3
					Lurcher Shoal				
2003 Season									
June	1253	13.7	5.4	57.8	38.4	16	3.9	0.0	38.0
July	84	12.3	7.7	23.1	40.8	1	3.0	3.0	3.0
August	0					0			
September	63	16.0	9.4	27.2	31.2	1	0.0	0.0	0.0
2004 Season									
July	96	20.2	10.1	38.6	25.1	2	0.0	0.0	0.0
August	443	15.7	3.2	35.1	32.7	7	2.6	8.6	0.0
September	64	16.0	6.5	33.9	31.3	1	1.6	1.6	1.6
2005 Season									
June	72	14.0	8.0	26.1	35.7	1	0	0	0
July	280	13.9	8.0	27.6	36.4	4	0	0	0
August	67	15.7	11.1	21.4	31.8	1	0	0	0

Table 3. Mean numbers per tow for the 1995–2005 scallop surveys in scallop production area 3. The percentages of clappers are shown in brackets. There was no survey in the St. Mary's Bay area in 2002 and 2003.

		Shell Height (mm)			
Subarea	Year	< 65	65–80	≥ 80	No. of tows
St. Mary's	1999	38.49 (2.6)	9.99 (1.8)	43.57 (1.5)	38
	2000	18.90 (1.2)	5.57 (1.9)	21.02 (3.4)	40
	2001	3.63 (0.0)	1.68 (0.0)	36.77 (0.7)	31
	2004	32.38 (0.0)	2.08 (0.0)	16.44 (6.9)	18
	2005	82.07 (5.7)	7.64 (3.2)	34.52 (3.8)	24
Brier Island	1995	14.22 (2.0)	3.52 (7.1)	64.59 (9.1)	43
	1996	12.46 (2.7)	3.69 (0.0)	56.73 (8.8)	43
	1997	57.92 (1.7)	4.12 (9.5)	70.48 (7.7)	47
	1998	38.32 (1.0)	1.19 (8.2)	76.25 (8.5)	31
	1999	14.64 (2.0)	4.63 (4.7)	63.30 (7.9)	52
	2000	430.43 (0.1)	2.17 (0.0)	51.95 (3.2)	48
	2001	30.50 (0.0)	16.75 (1.1)	78.28 (2.8)	41
	2002	2.82 (14.0)	1.97 (11.0)	76.20 (10.0)	32
	2003	3.52 (0.0)	0.51 (0.0)	38.24 (2.8)	36
	2004*	25.64 (0.0)	1.77 (0.0)	64.36 (2.8)	20
	2005	14.89 (4.6)	2.61 (3.3)	59.04 (9.0)	46
Subarea	Year	< 70	70–80	≥ 80	No. of tows
Lurcher	1995	29.99 (7.8)	21.23 (22.2)	151.90 (16.5)	65
	1996	9.44 (12.3)	36.34 (4.1)	112.70 (13.1)	62
	1997	43.66 (1.1)	10.00 (6.4)	133.40 (6.0)	84
	1998	32.05 (2.0)	0.60 (8.6)	110.10 (4.2)	69
	1999	130.17 (0.6)	19.60 (0.3)	111.60 (2.4)	62
	2000	539.10 (0.5)	45.03 (0.0)	110.70 (0.8)	75
	2001	81.02 (2.8)	92.45 (0.5)	127.80 (2.3)	76
	2002	7.42 (14.0)	15.65 (40.0)	259.80 (10.0)	79
	2003	21.15 (2.3)	1.04 (0.2)	115.70 (13.7)	87
	2004	121.59 (0.9)	0.49 (9.1)	142.78 (3.9)	71
	2005	40.87 (3.2)	2.08 (9.9)	136.84 (6.3)	92

*: Tow 102 with a catch of 4227 scallops all greater than 80 mm excluded. Additional tows were made within 1/2 mile of tow 102 did not catch appreciable numbers indicating that this was a very local high density area.

Table 4. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 4 for the 2002/2003, 2003/2004 and 2004/2005 fishing seasons. All samples collected by industry supported dockside monitoring program. Statistics on the percentage by number of meats in the sample that were less than 8 g are also given.

		Meat Weight (g)			Count	Number of	Percent < 8 g		
Month	N	Mean	Min.	Max.	per 500 g.	Samples	Mean	Min.	Max.
2002/2003 Season									
October	3680	11.2	1.2	38.5	45.0	40	6.6	0.0	29.4
November	2820	12.0	5.9	34.3	41.7	33	2.2	0.0	9.2
December	168	12.3	8.3	28.8	40.7	2	0.0	0.0	0.0
January	256	12.2	7.5	27.7	41.0	3	1.1	0.0	2.2
February	617	13.5	1.7	37.3	37.2	8	0.6	0.0	2.6
March	1513	13.2	6.3	32.0	38.7	19	2.5	0.0	15.0
April	2928	12.8	1.3	41.5	39.8	36	3.1	0.0	12.0
May	343	15.3	8.3	36.6	33.7	5	0	0.0	0
2003/2004 Season									
October	734	14.2	5.8	29.0	35.7	10	1.5	0.0	4.9
November	2077	16.5	5.8	43.0	30.8	33	0.7	0.0	6.1
December	312	13.2	6.5	28.9	38.0	4	2.8	1.5	4.8
January	0								
February	0								
March	1116	18.2	5.3	40.5	28.1	19	0.7	0.0	7.0
April	1244	17.3	8.0	42.6	29.8	20	2.0	0.0	0.0
May	0								
2004/2005 Season									
October	3892	19.1	6.8	47.1	27.1	70	0.1	0.0	1.7
November	215	24.5	10.0	49.3	21.0	5	0.0	0.0	0.0
December	75	27.2	10.0	49.3	18.4	2	0.0	0.0	0.0
January	275	23.0	9.7	46.2	22.1	6	0.0	0.0	0.0
February	449	22.5	8.2	49.4	22.8	10	0.0	0.0	0.0
March	752	21.4	5.6	50.1	24.2	16	0.2	0.0	2.1
April	1357	21.1	6.8	46.3	24.6	27	0.1	0.0	1.7
May	343	18.0	7.9	28.9	28.1	6	0.6	0.0	1.8

Table 5. Estimates from stratified research survey for scallops in Scallop Production Area 4, August 2005. Proportion of survey area in each stratum is given in the second column. Estimates of mean number are given for three shell height size classes corresponding to pre-recruit, recruits and fully-recruited animals.

			< 65 mm		65 to 79 mm		80+ mm	
Stratum Name	Propn. area in stratum	Number of Tows	Mean number	Standard error	Mean number	Standard error	Mean number	Standard error
Centreville	0.133	11	7.93	2.66	5.26	2.24	176.57	24.20
CV to GH	0.068	6	9.08	3.75	0.58	0.58	310.73	76.87
Gulliver's Head	0.133	11	7.70	4.39	1.60	0.56	141.45	33.69
GH to DG	0.100	7	7.51	2.99	2.00	1.03	130.07	34.98
Digby Gut	0.200	18	10.69	3.78	5.07	1.70	95.24	15.90
DG to DC	0.100	9	7.87	5.36	3.83	2.76	80.19	20.38
Delaps Cove	0.133	13	14.60	5.96	11.39	4.95	71.22	15.86
Parkers Cove	0.133	10	1.63	0.99	1.35	0.55	33.57	7.17
Stratified estimates	1.000	85	8.53	1.46	4.25	0.86	117.17	9.42
Depth $<$ 90 m		47	5.05	1.47	2.76	1.01	59.91	7.68
Depth $\geq$ 90 m		38	9.19	2.23	3.59	1.12	208.61	29.32

Table 6. Posterior probabilities for the exploitation rate exceeding the provisional reference exploitation level (0.20) for Scallop Production Area 4. Posterior median exploitation rate given in brackets.

Catches in 2005/2006		$\Pr(e_{2006} \geq 0.2)$ for Catches in 2006/2007				
(meats, t)	$\Pr(e_{2005} \geq 0.2)$	50	100	150	200	250
100	0.31 (0.13)	0.14 (0.06)	0.34 (0.13)	0.49 (0.19)	0.60 (0.26)	0.69 (0.32)
150	0.49 (0.20)	0.18 (0.07)	0.37 (0.14)	0.52 (0.21)	0.63 (0.28)	0.71 (0.35)
200	0.63 (0.26)	0.23 (0.08)	0.41 (0.15)	0.54 (0.23)	0.65 (0.30)	0.73 (0.38)
250	0.74 (0.36)	0.29 (0.08)	0.44 (0.17)	0.57 (0.25)	0.67 (0.33)	0.75 (0.42)

Table 7. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 5 for the 2002 and 2003 fishing seasons. No samples were collected from the 2004 fishery. All samples collected by industry supported dockside monitoring program. Statistics on the percentage by number of meats in the sample that were less than 8 g are also given.

		Meat Weight (g)			Count	Number of	Percent < 8 g		
Month	N	Mean	Min.	Max.	per 500 g.	Samples	Mean	Min.	Max.
2002 Season									
January	282	22.0	7.3	61.5	22.9	6	0.7	0.0	4.1
2003 Season									
January	80	26.2	9.9	84.8	19.2	2	0.0	0.0	0.0
February	49	21.2	10.4	51.2	23.6	1	0.0	0.0	0.0
2005 Season									
January	662	22.6	7.3	61.1	22.6	14	0.13	0	1.75

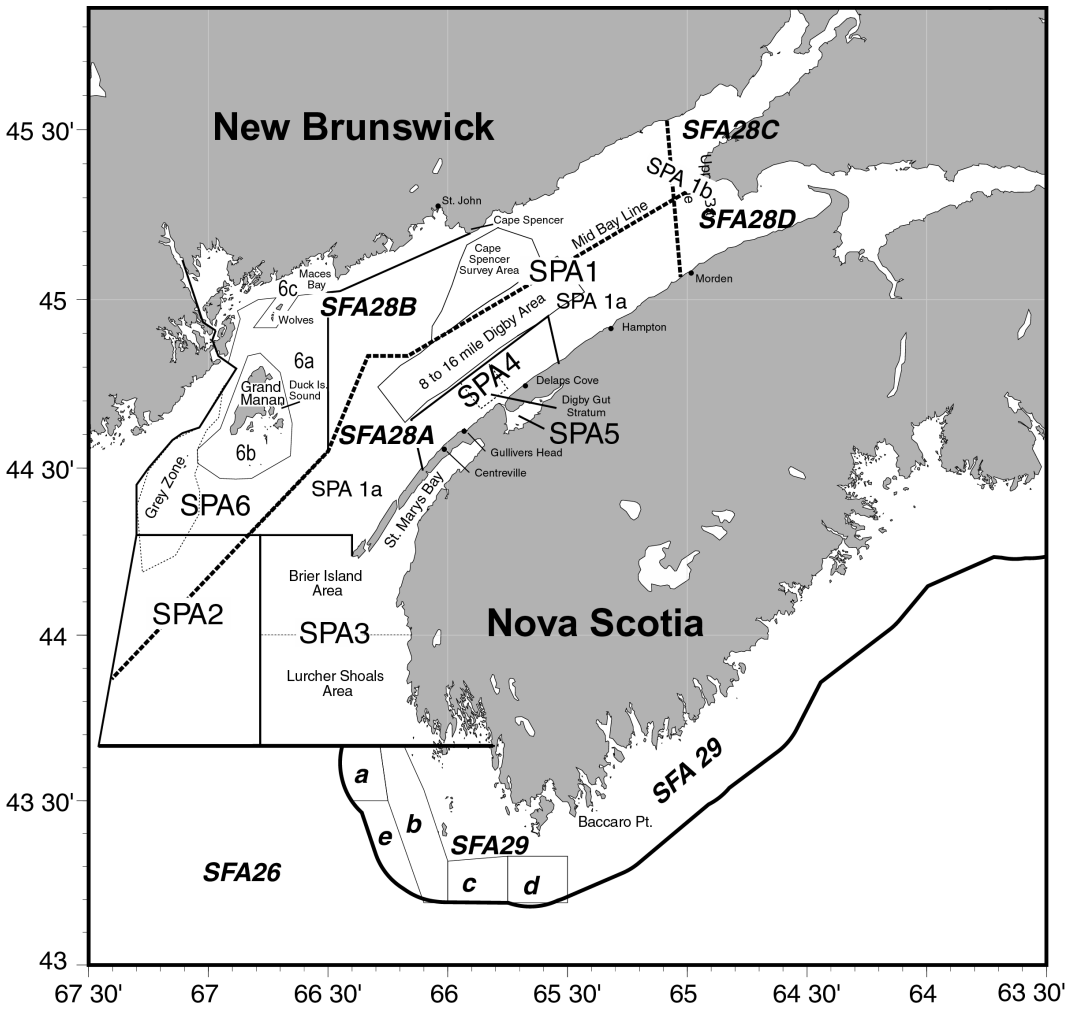

Fig. 1. Scallop Production Areas and Scallop Fishing Areas in the Bay of Fundy.

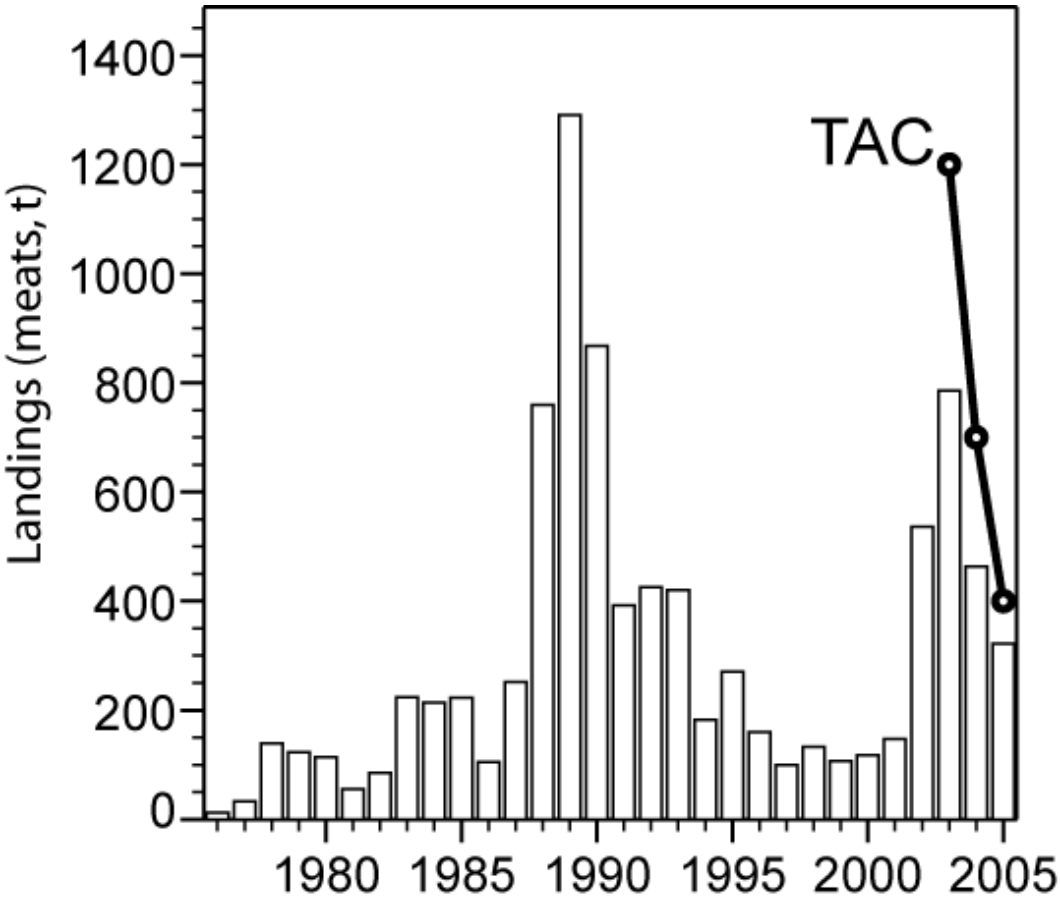

Fig. 2. Scallop landings (meats, t) in Scallop Production Area 1A.

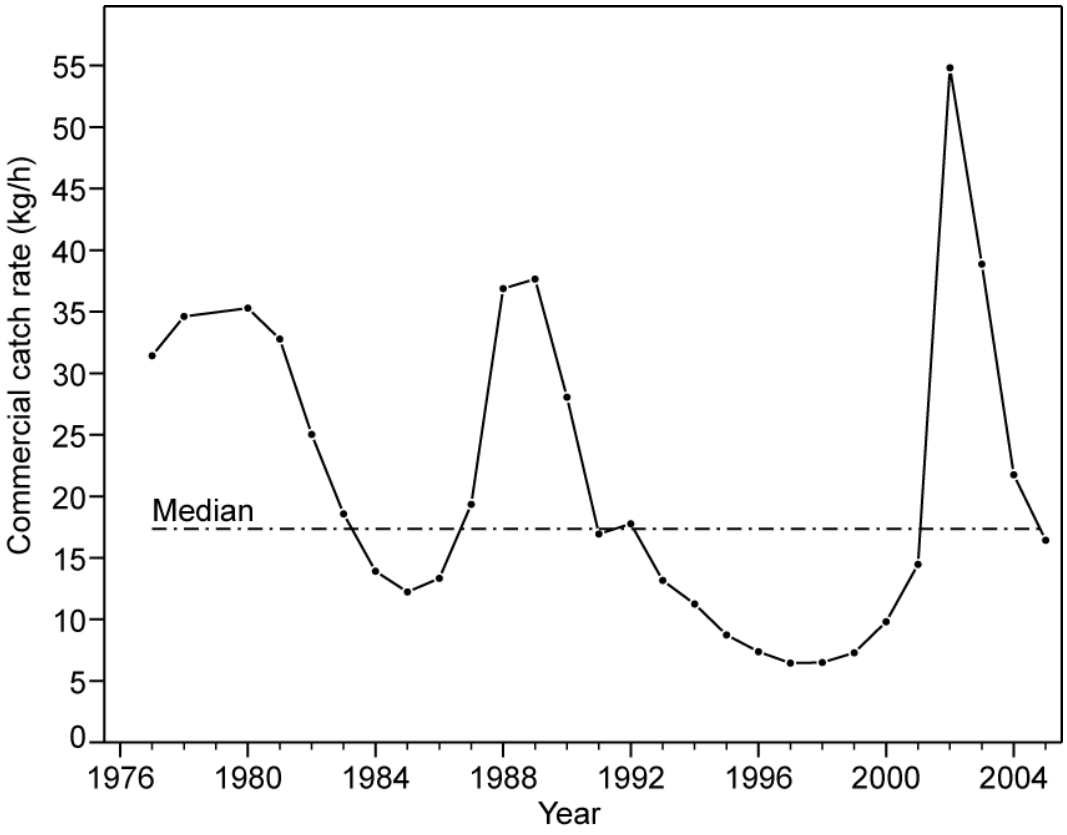

Fig. 3. Commercial catch rate (kg/h) for scallops in Scallop Production Area 1A.

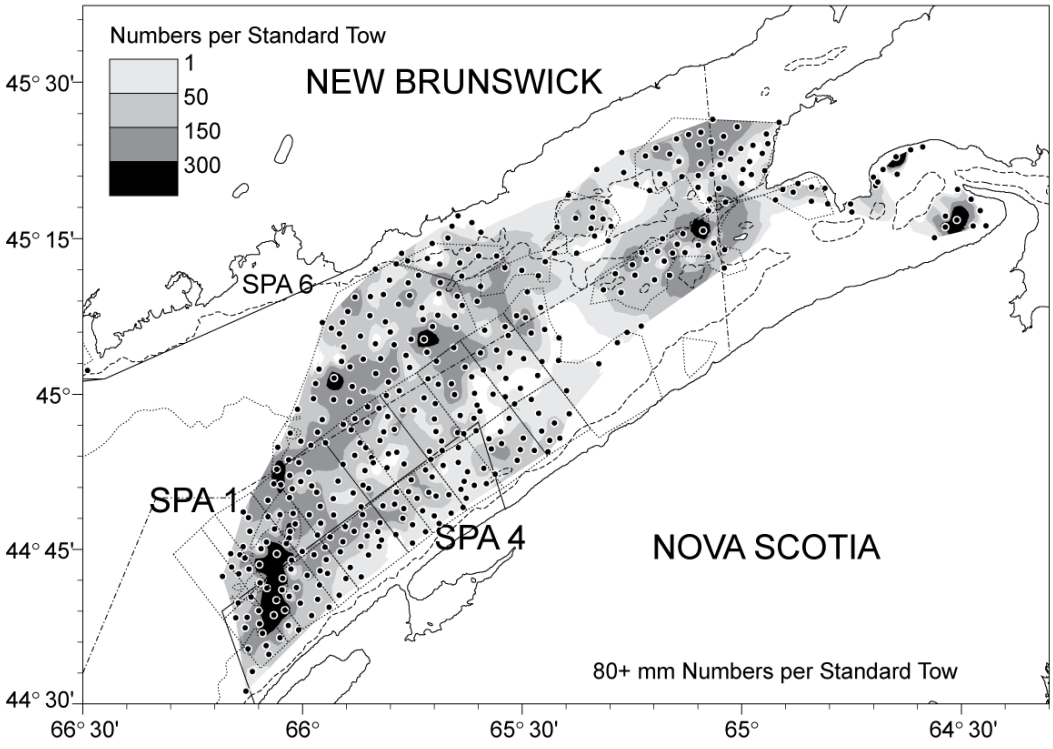

Fig. 4. Number of scallops $\geq$ 80 mm shell height and station locations for the 2005 survey in Scallop Production Areas 1 and 4.

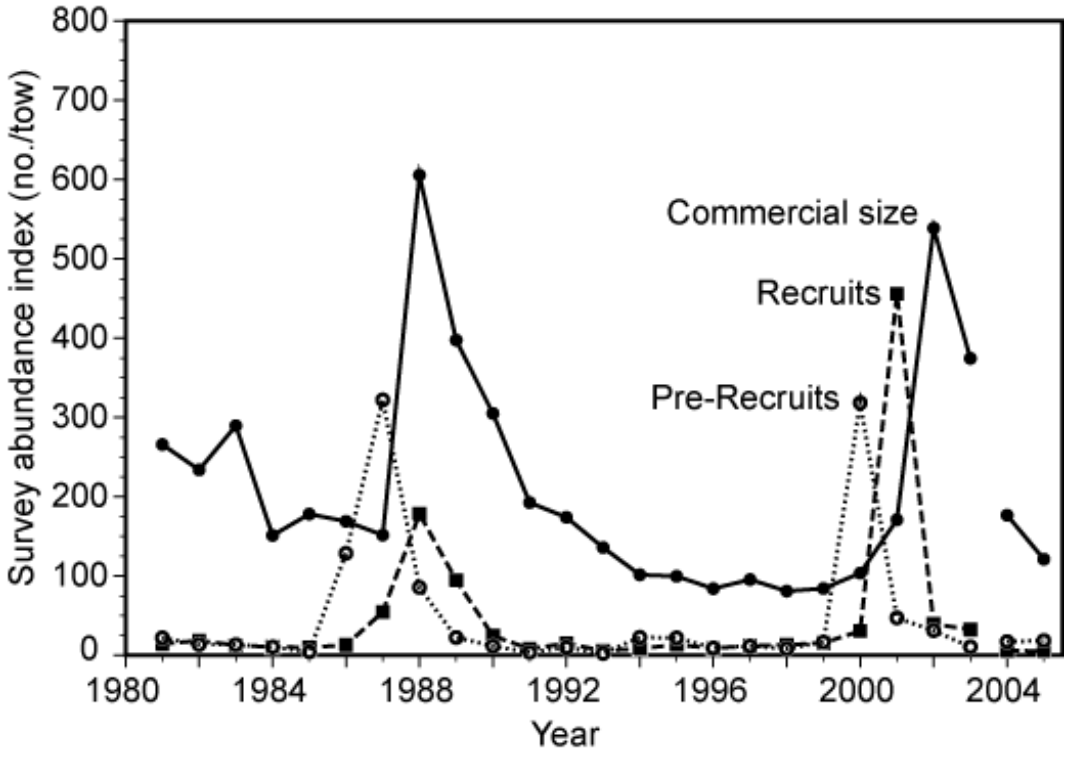

Fig. 5. Survey abundance index (mean number/tow) for commercial size scallops ($\geq$ 80 mm shell height), recruits (65–79 mm shell height), and pre-recruits ($<$ 65 mm shell height) in the 8–16 mile area of Scallop Production Area 1A. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

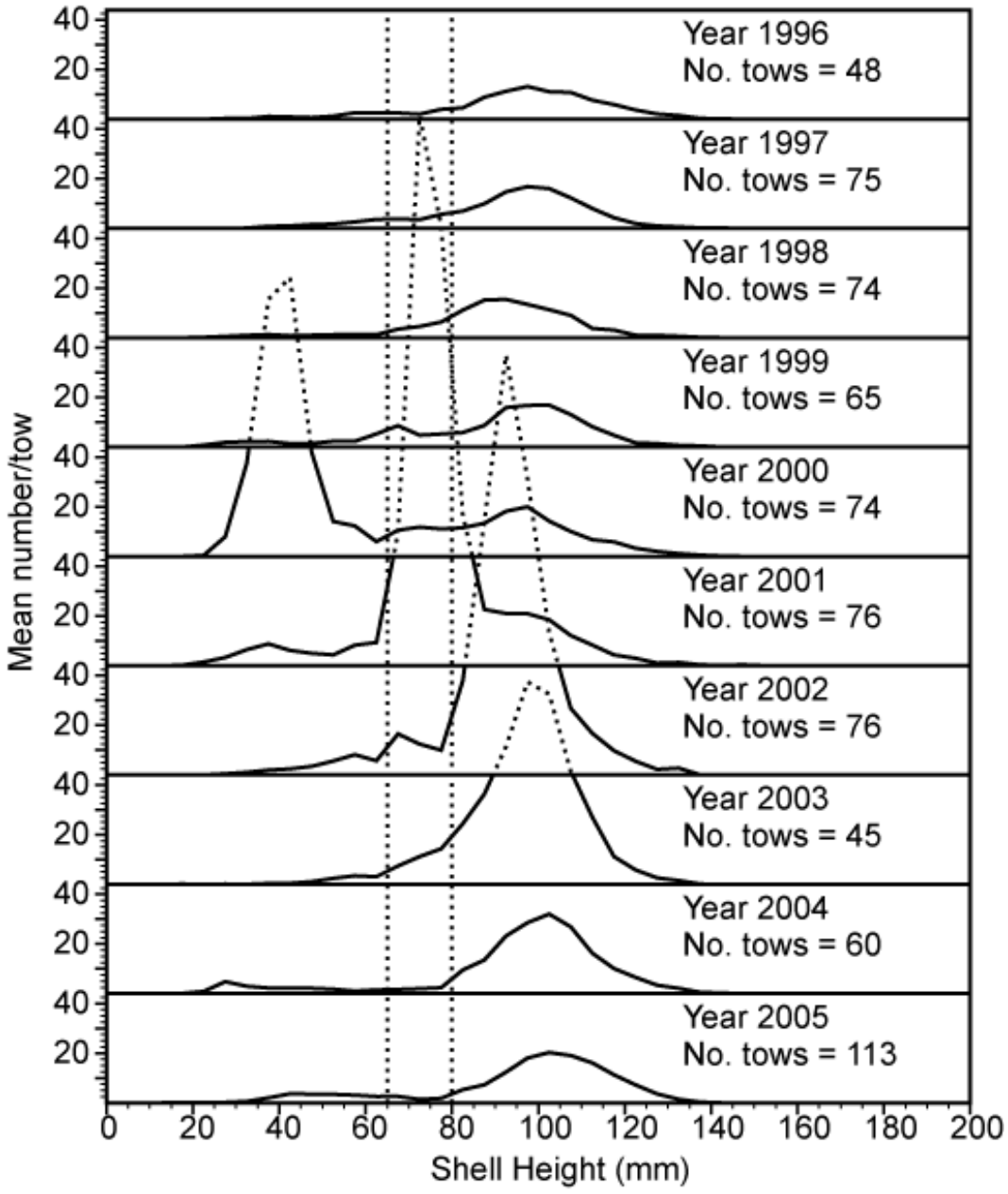

Fig. 6. Scallop shell height frequencies from the surveys of the 8–16 mile area of Scallop Production Area 1A. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

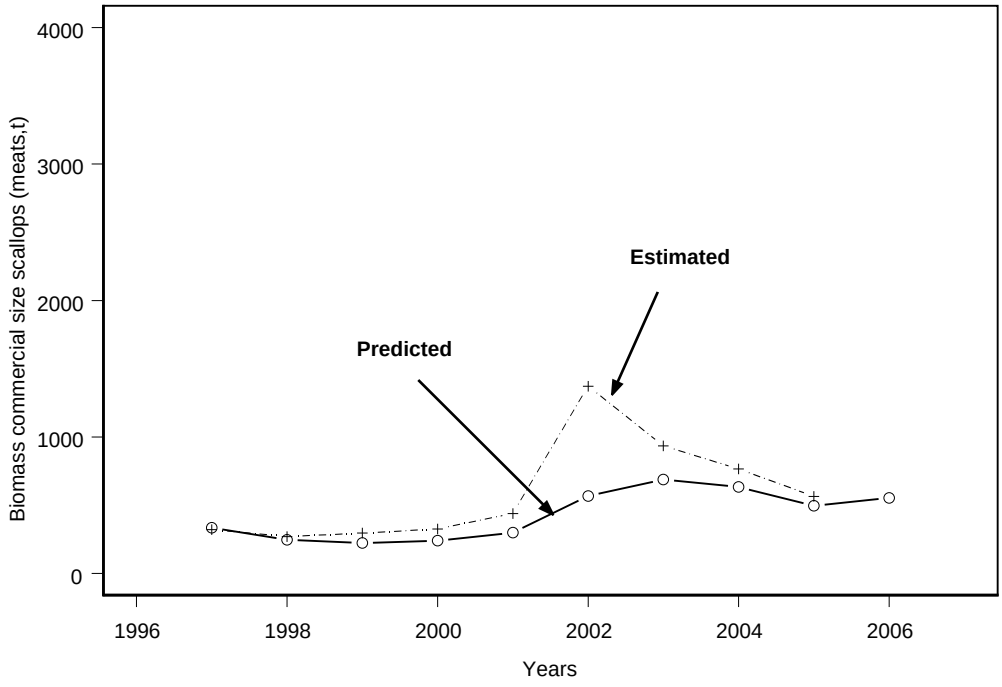

Fig. 7. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size scallops (shell height $\geq$ 80 mm) in the current year for the 8–16 mile area of Scallop Production Area 1A.

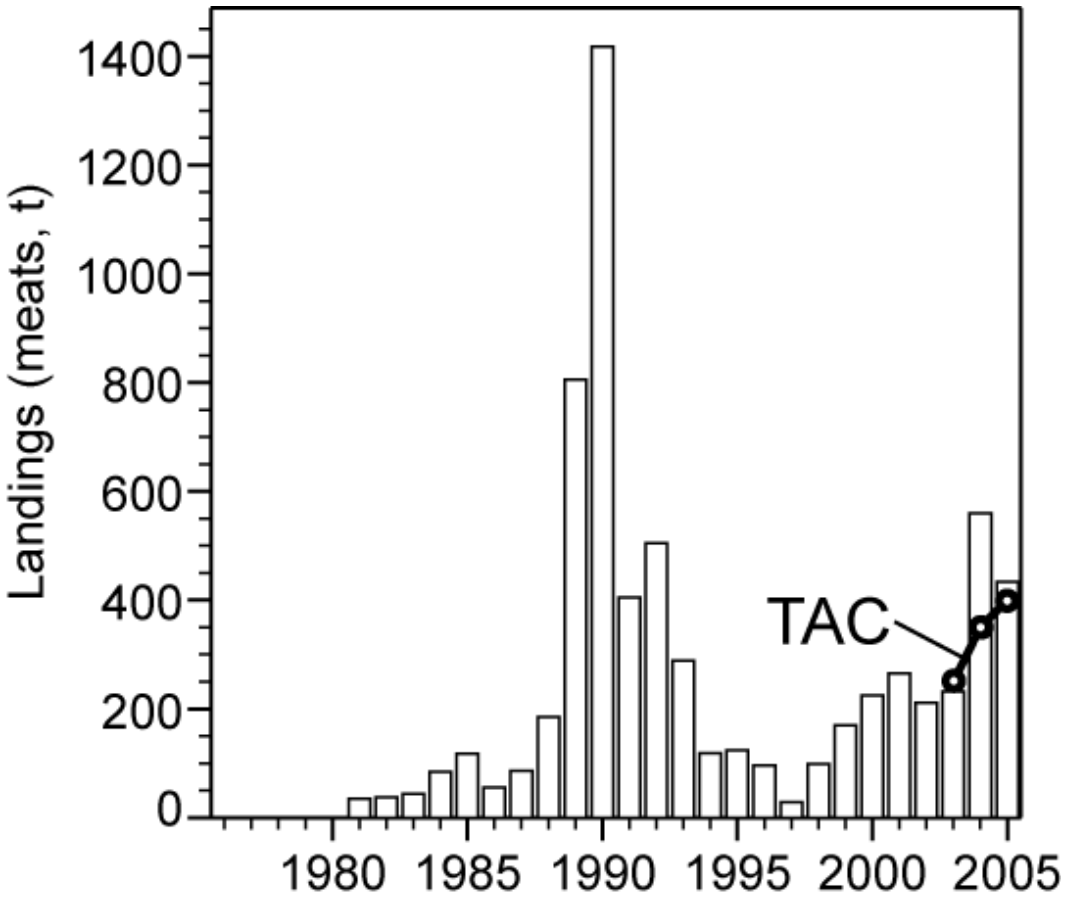

Fig. 8. Scallop landings (meats, t) in Scallop Production Area 1B.

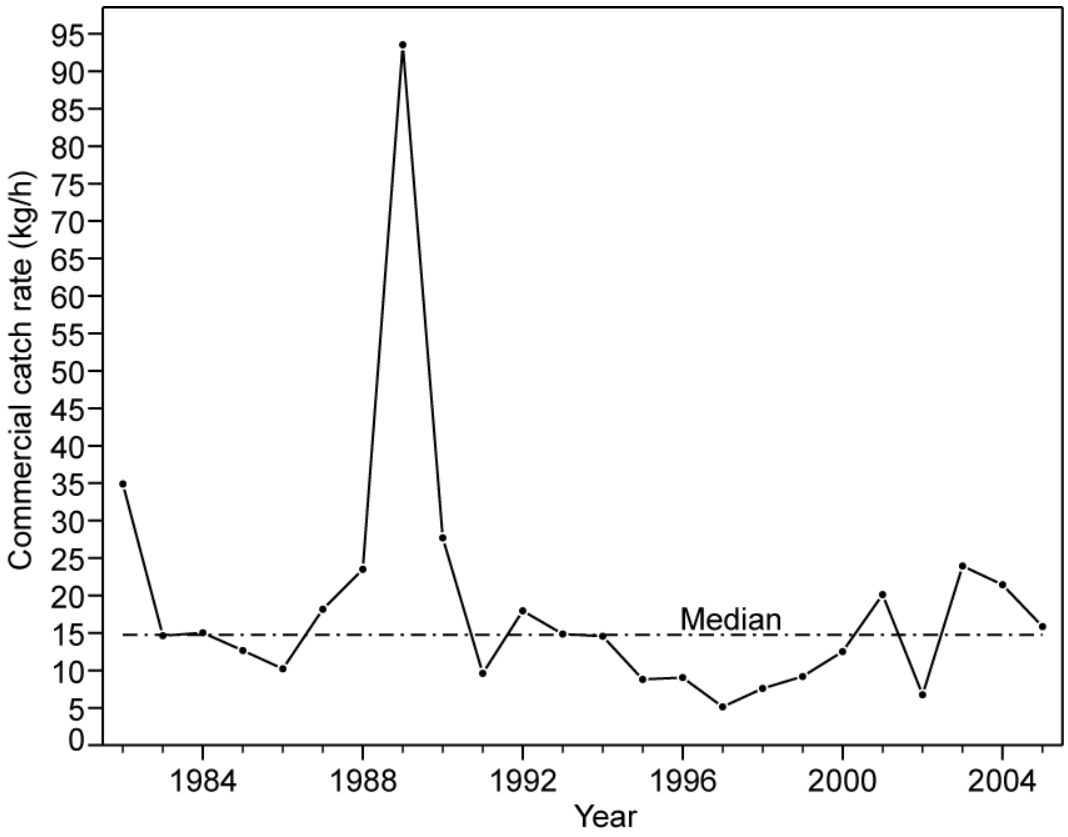

Fig. 9. Commercial catch rate (kg/h) for scallops in Scallop Production Area 1B.

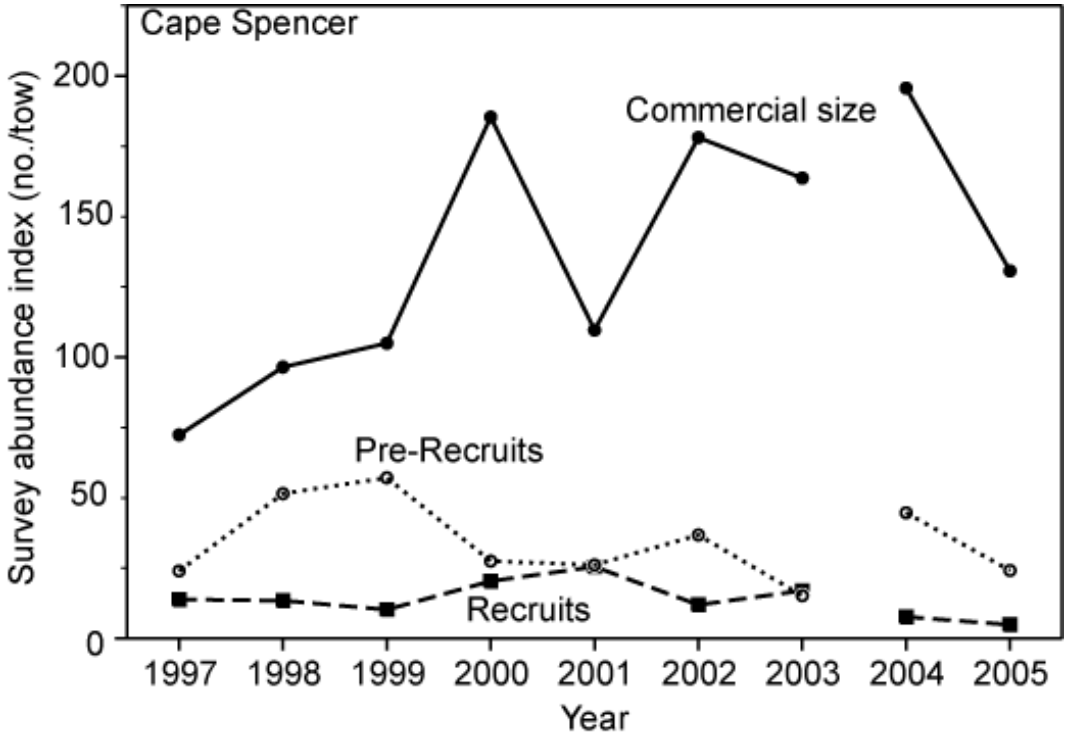

Fig. 10. Survey abundance index (mean number/tow) for commercial size scallops ($\geq$ 80 mm shell height), recruits (65–79 mm shell height), and pre-recruits ($<$ 65 mm shell height) in the Cape Spencer area of Scallop Production Area 1B. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

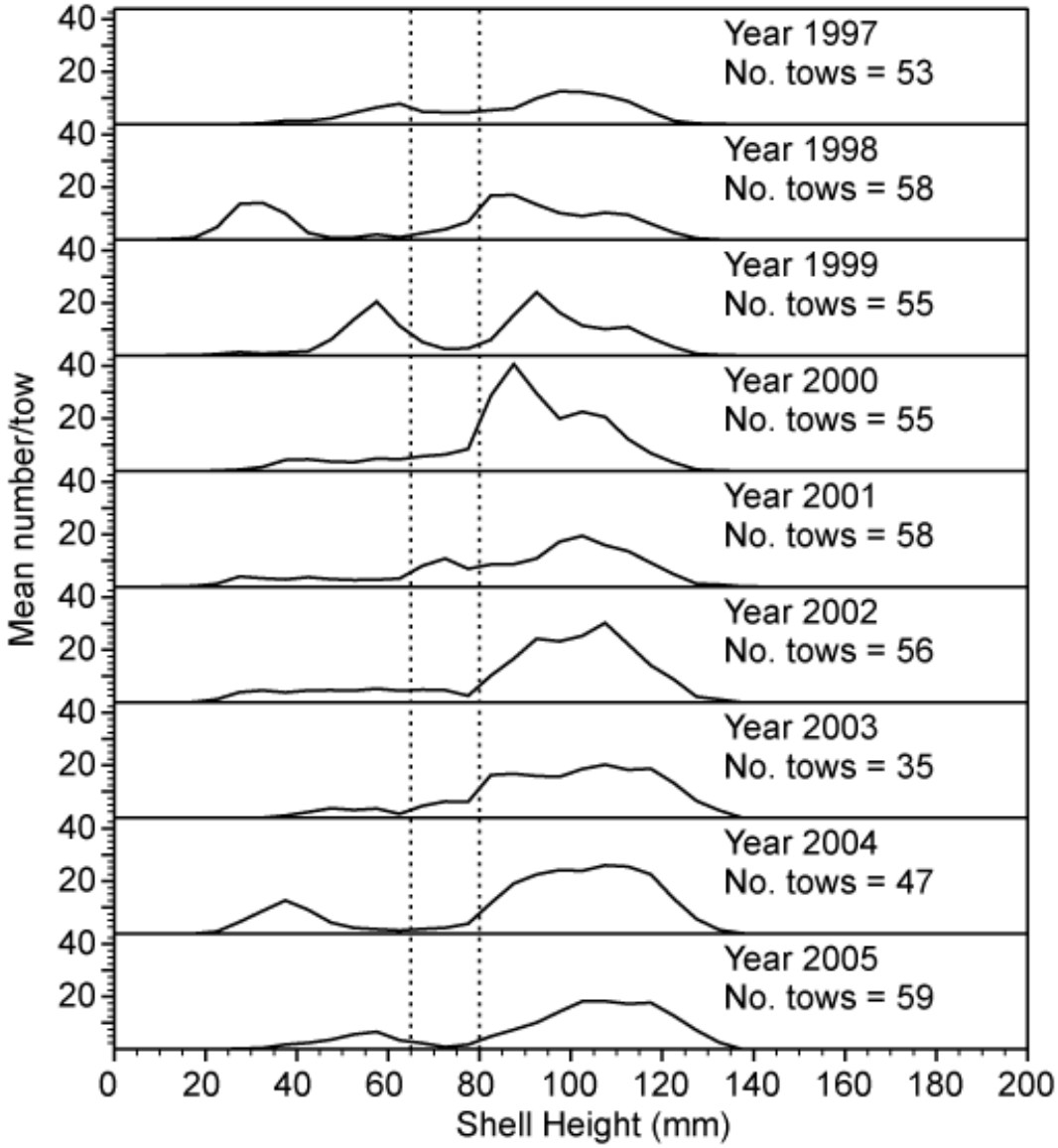

Fig. 11. Scallop shell height frequencies from the surveys of the Cape Spencer area of Scallop Production Area 1B. Surveys were conducted in May/June from 1981 to 2003 and in August/September in 2004 and 2005.

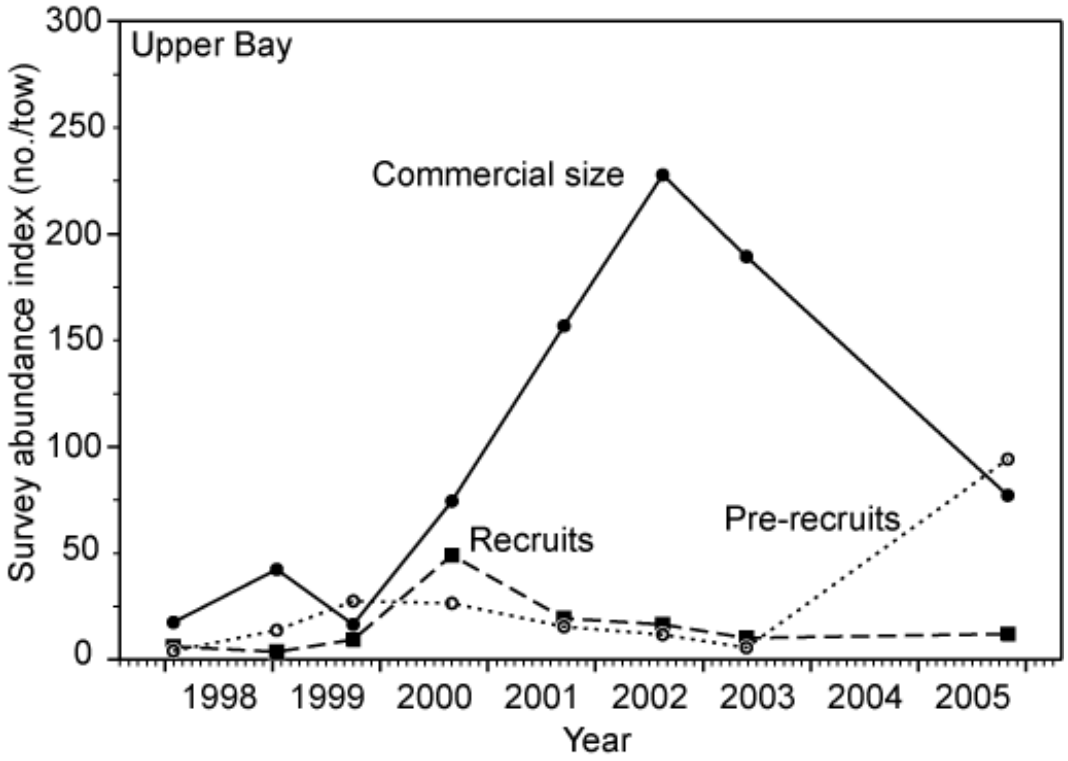

Fig. 12. Survey abundance index (mean number/tow) for commercial size scallops ($\geq$ 80 mm shell height), recruits (65–79 mm shell height), and pre-recruits ($<$ 65 mm shell height) in the Upper Bay area of Scallop Production Area 1B.

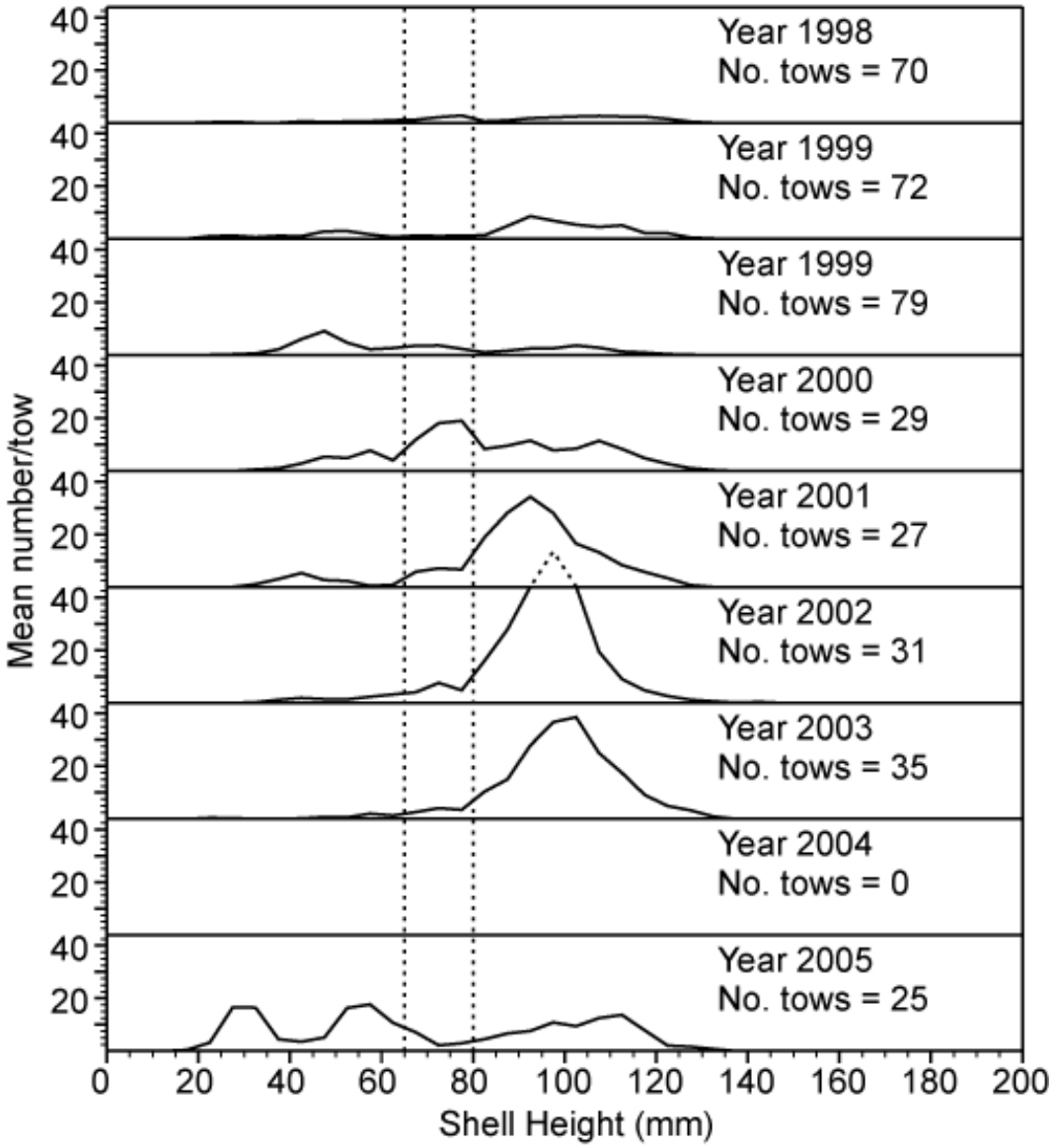

Fig. 13. Scallop shell height frequencies from the surveys of the Upper Bay area of Scallop Production Area 1B.

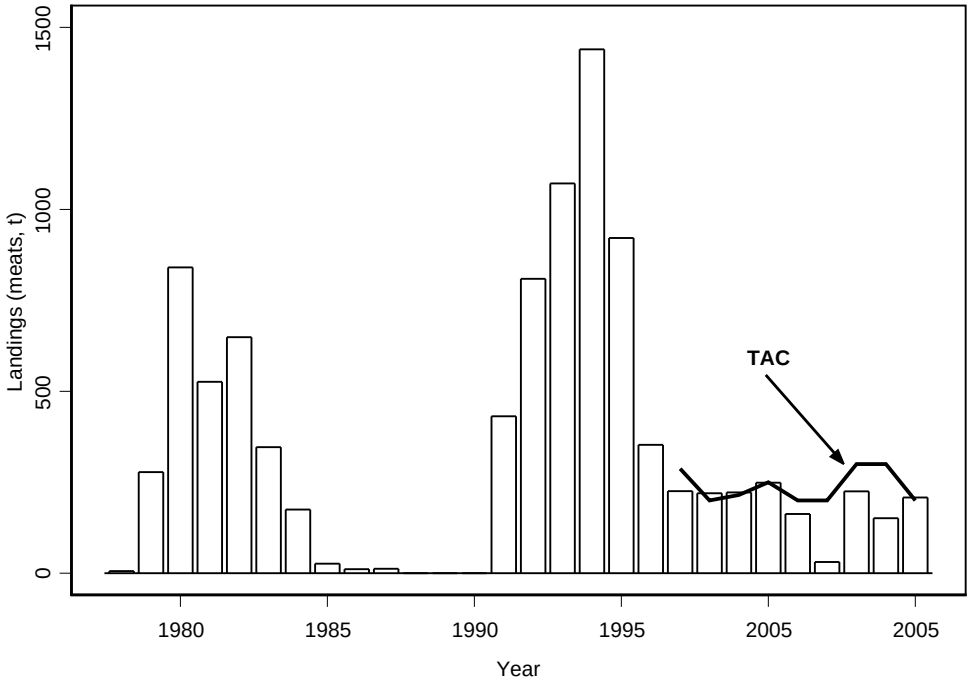

Fig. 14. Scallop landings (meats, t) in Scallop Production Area 3.

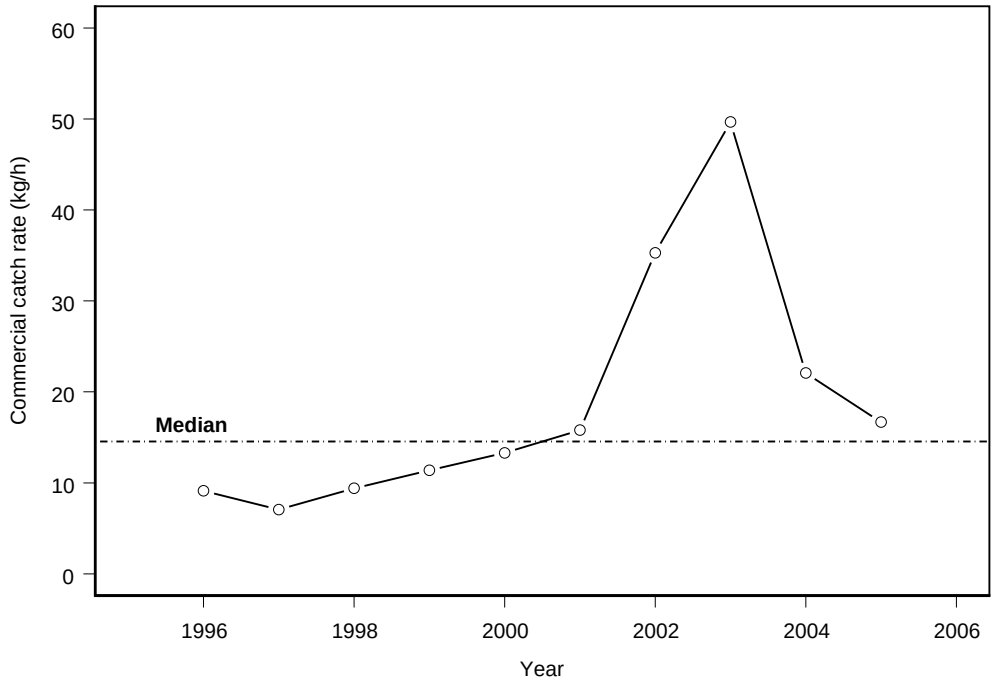

Fig. 15. Commercial catch rate (kg/h) for scallops in Scallop Production Area 3. Median catch rate over the 1996 to 2005 period indicated./

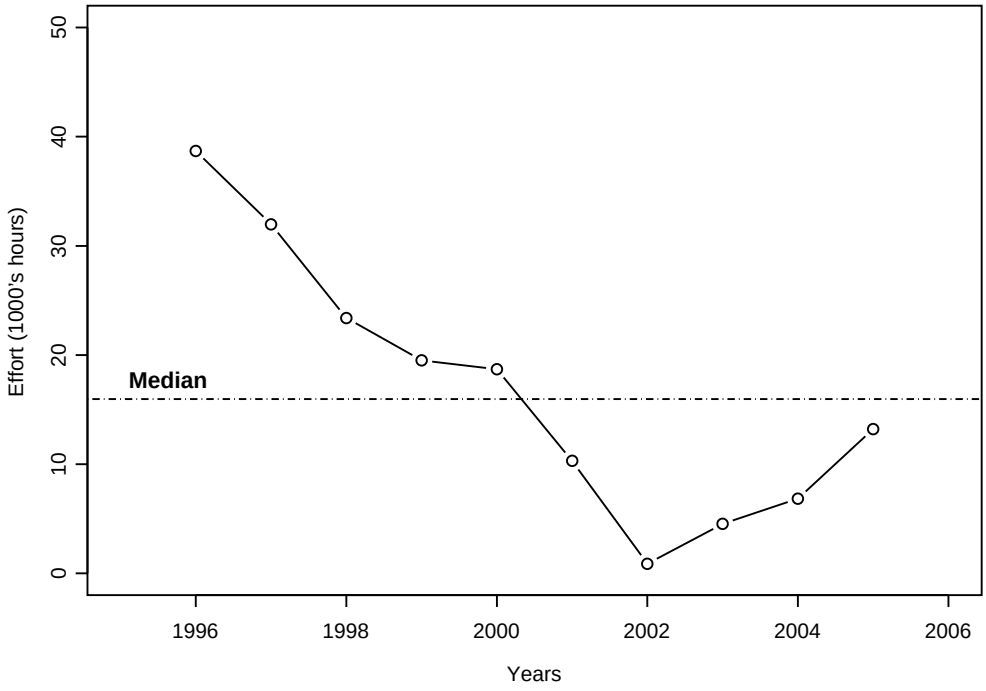

Fig. 16. Commercial fishing effort (hours) for scallops in Scallop Production Area 3. Median effort over the 1996 to 2005 period indicated./

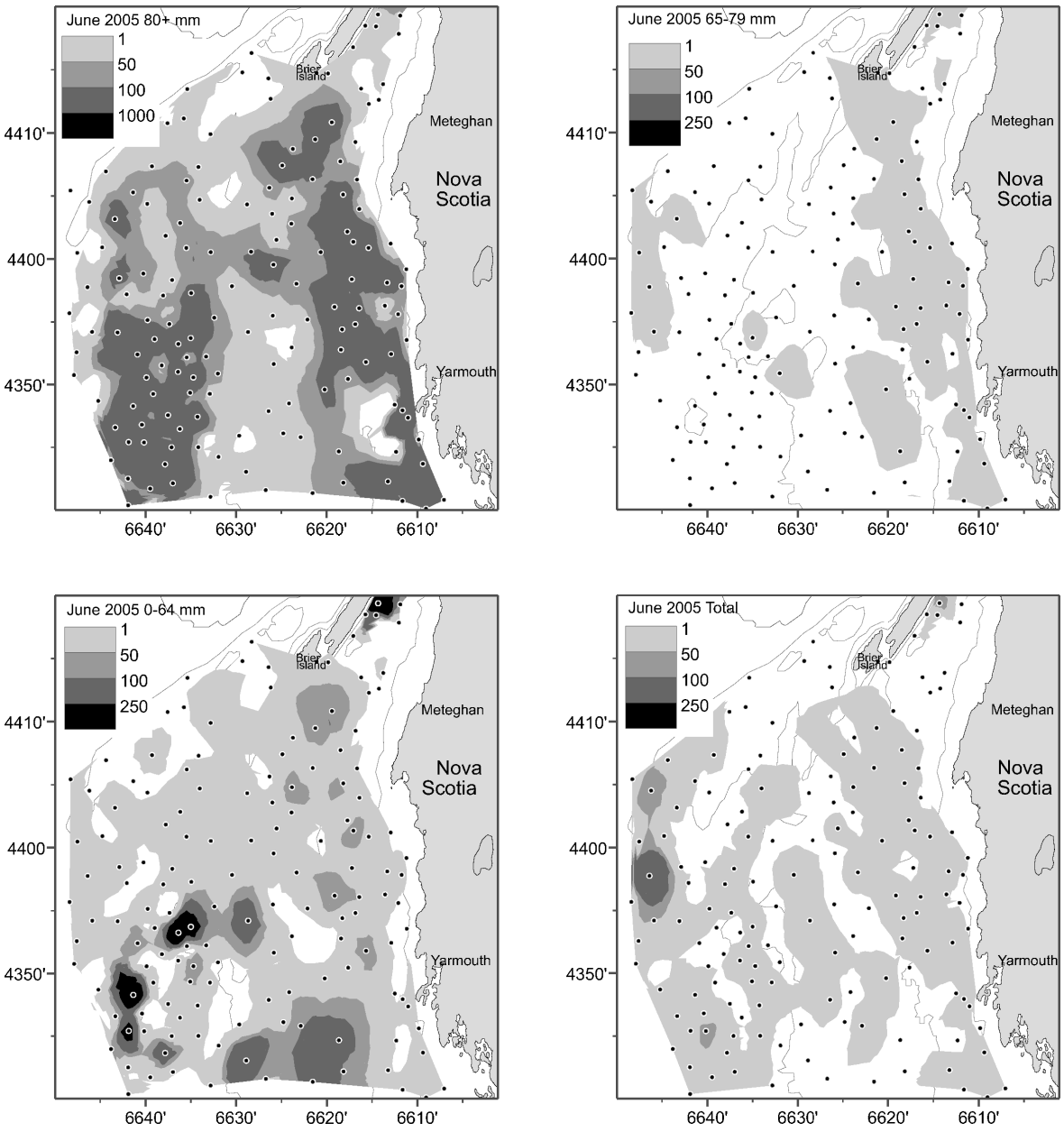

Fig. 17. Spatial distribution of scallop catches from the June 2005 survey of the Brier/Lurcher portion of Scallop Production Area 3. Upper left panel: scallops with shell heights equal to or greater than 80 mm. Upper right panel: scallops with shell heights 65 to 79 mm. Lower left panel: scallops with shell heights less than 65 mm. Lower right panel: catches of clappers for all shell sizes. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated on the map.

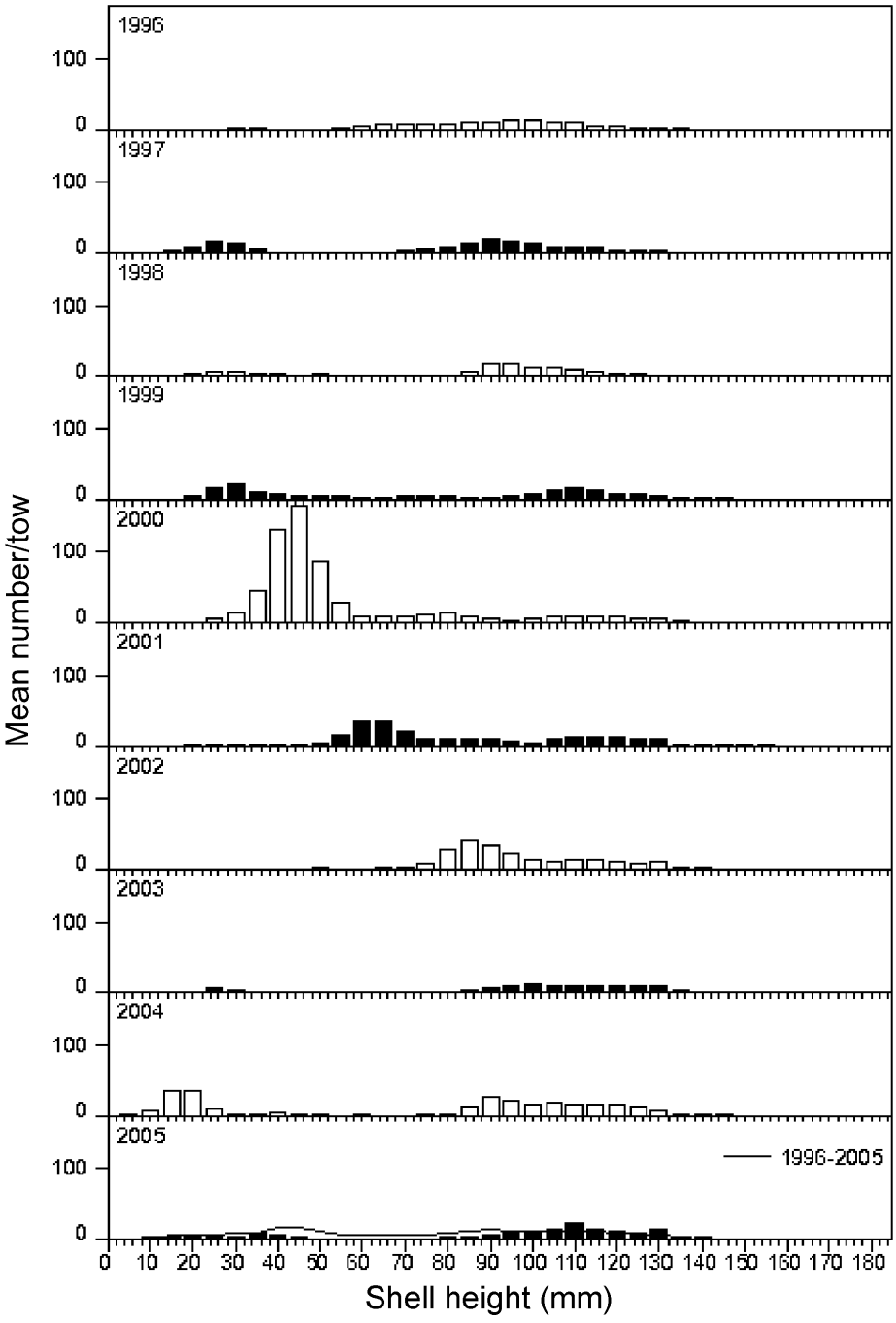

Fig. 18. Scallop shell height frequencies from the 1996 to 2005 surveys of the Brier/Lurcher portion of Scallop Production Area 3.

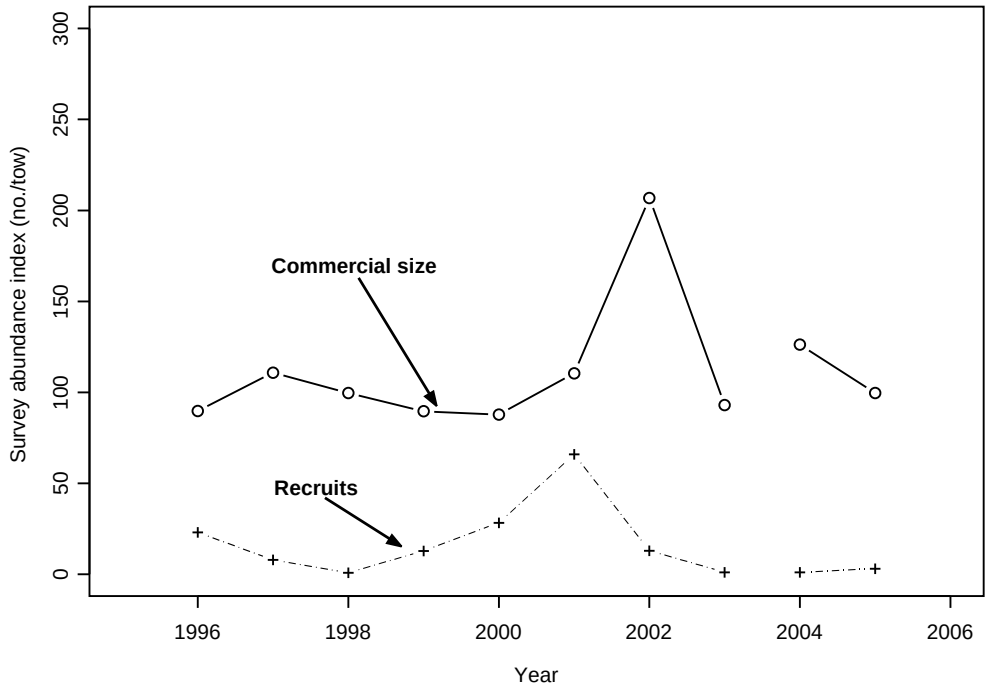

Fig. 19. Survey abundance index (mean number/tow) for commercial size scallops (≥ 80 mm shell height) and recruits (65–79 mm shell height) in the Brier/Lurcher portion of Scallop Production Area 3. Break in the series indicates the change from August surveys to June surveys starting in 2004.

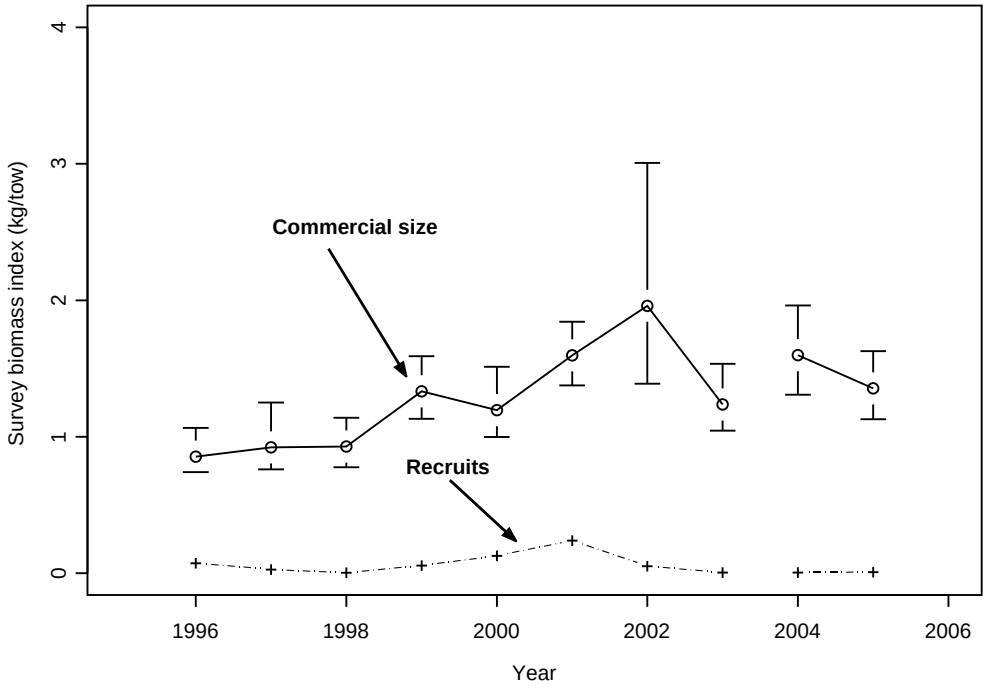

Fig. 20. Survey biomass index (kg/tow) for commercial size scallops ($\geq$ 80 mm shell height) and recruits (65–79 mm shell height) in the Brier/Lurcher portion of Scallop Production Area 3. Commercial biomass index has 95 percent confidence intervals included. Break in the series indicates the change from August surveys to June surveys starting in 2004.

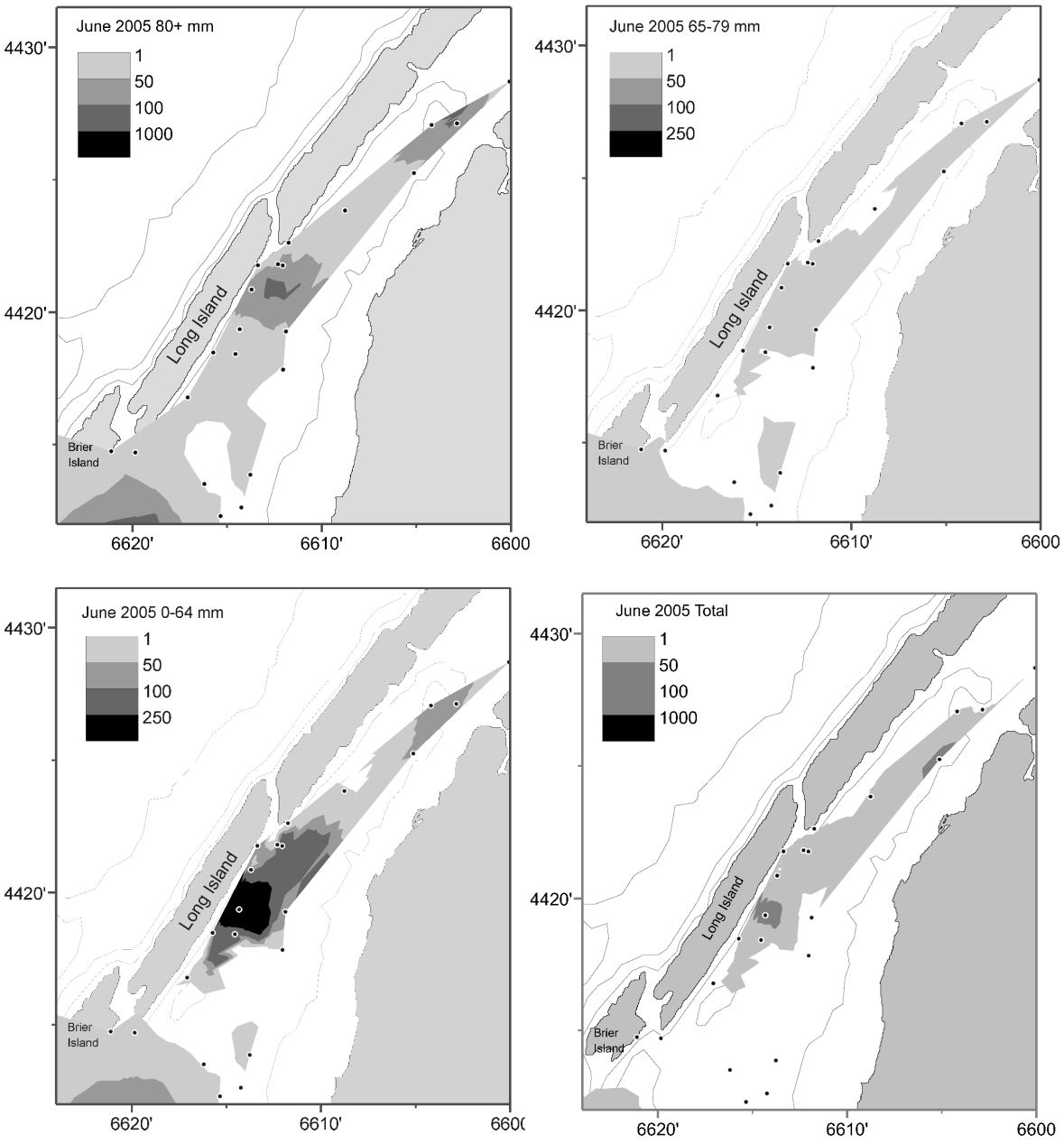

Fig. 21. Spatial distribution of scallop catches from the June 2005 survey of the St. Mary's Bay portion of Scallop Production Area 3. Upper left panel: scallops with shell heights equal to or greater than 80 mm. Upper right panel: scallops with shell heights 65 to 79 mm. Lower left panel: scallops with shell heights less than 65 mm. Lower right panel: catches of clappers for all shell sizes. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated on the map.

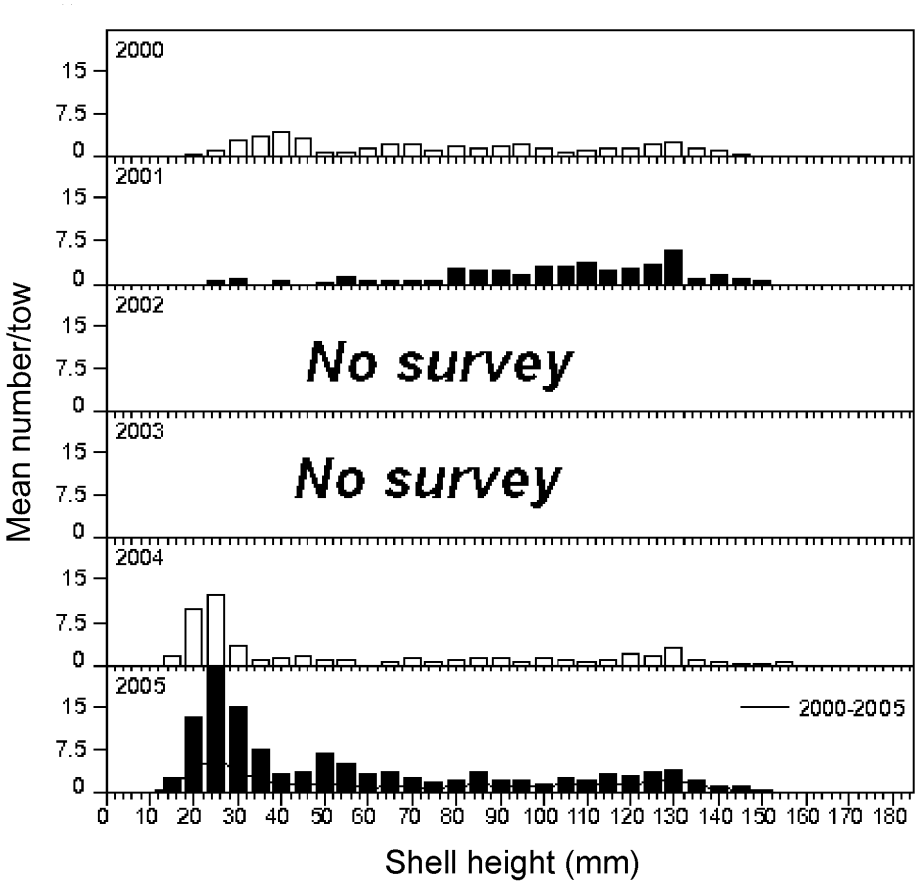

Fig. 22. Scallop shell height frequencies from the 2000 to 2005 surveys of the St. Mary's Bay portion of Scallop Production Area 3.

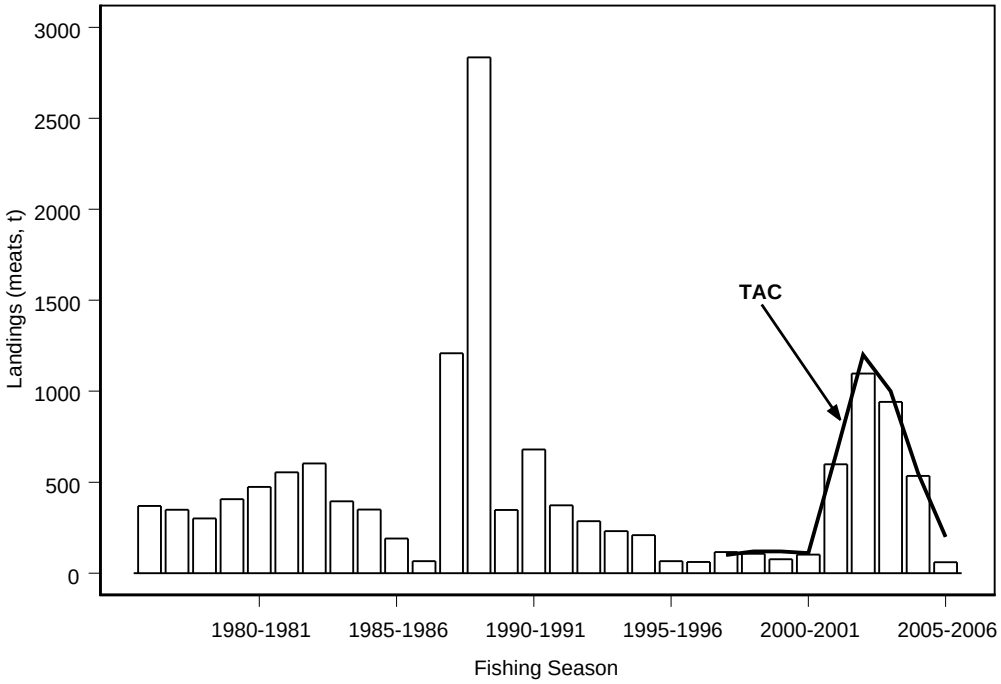

Fig. 23. Scallop landings (meats, t) in Scallop Production Area 4.

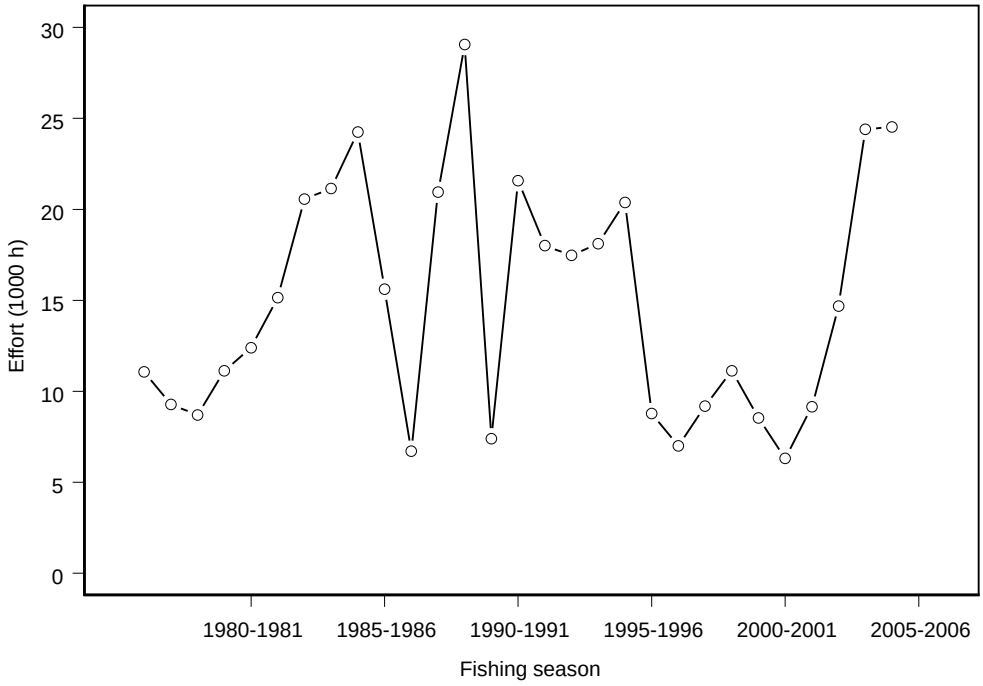

Fig. 24. Commercial fishing effort (1000's hours) for scallops in Scallop Production Area 4.

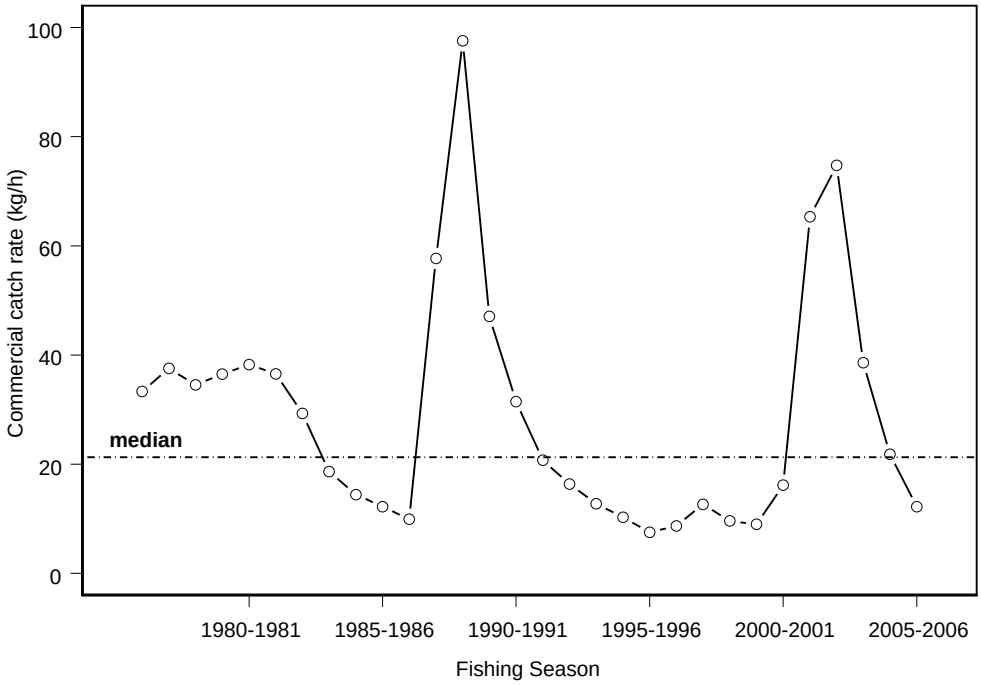

Fig. 25. Commercial catch rate (kg/h) for scallops in Scallop Production Area 4. Median catch rate over the 1976-1977 to 2004-2005 period indicated. Catch rate for 2005-2006 refers to October 2005 only.

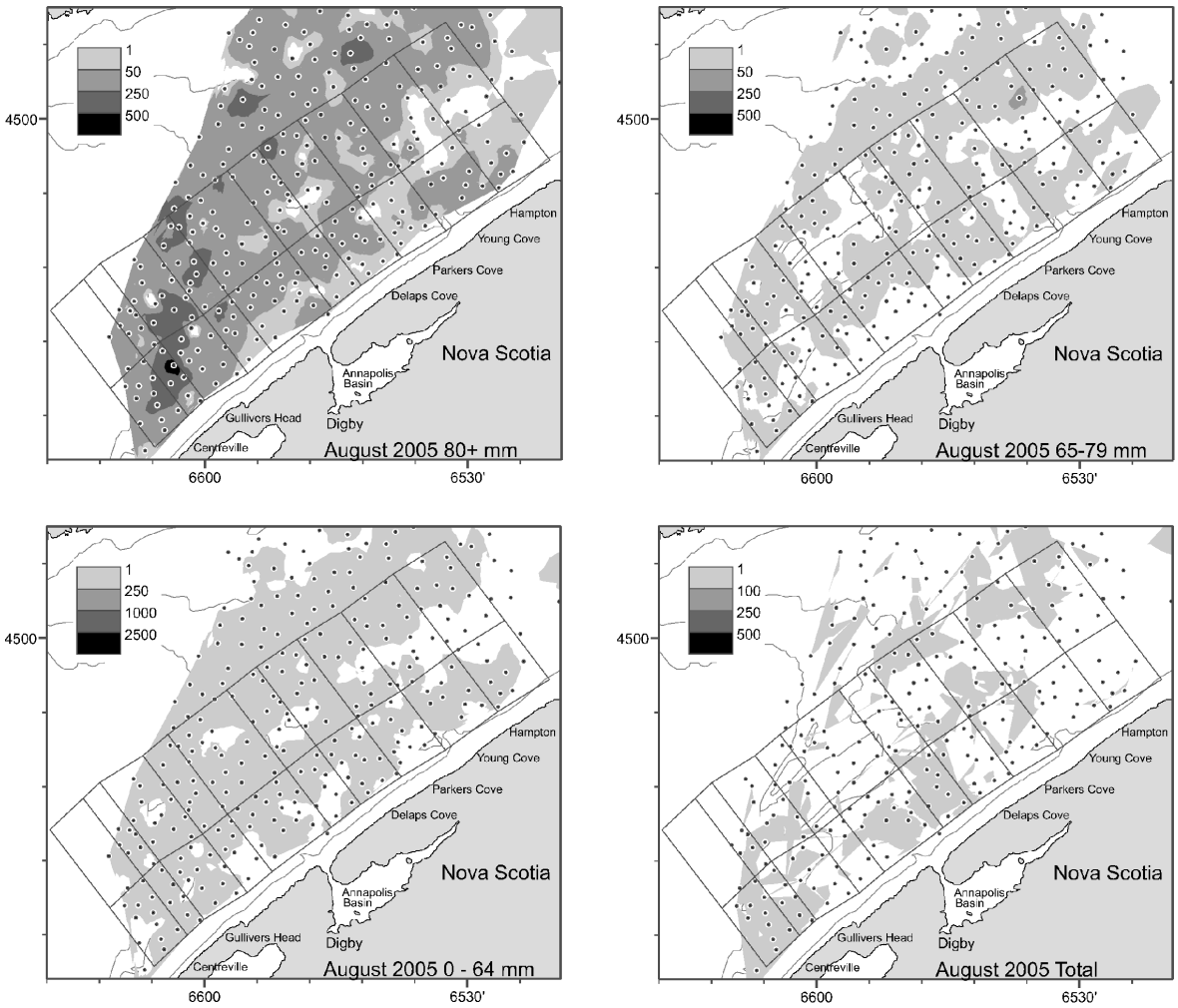

Fig. 26. Spatial distribution of scallop catches from the August 2005 survey of Scallop Production Area 4. Upper left panel: scallops with shell heights equal to or greater than 80 mm. Upper right panel: scallops with shell heights 65 to 79 mm. Lower left panel: scallops with shell heights less than 65 mm. Lower right panel: catches of clappers for all shell sizes. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations and the outer boundary of Scallop Production Area 4 (bold) are indicated on the map.

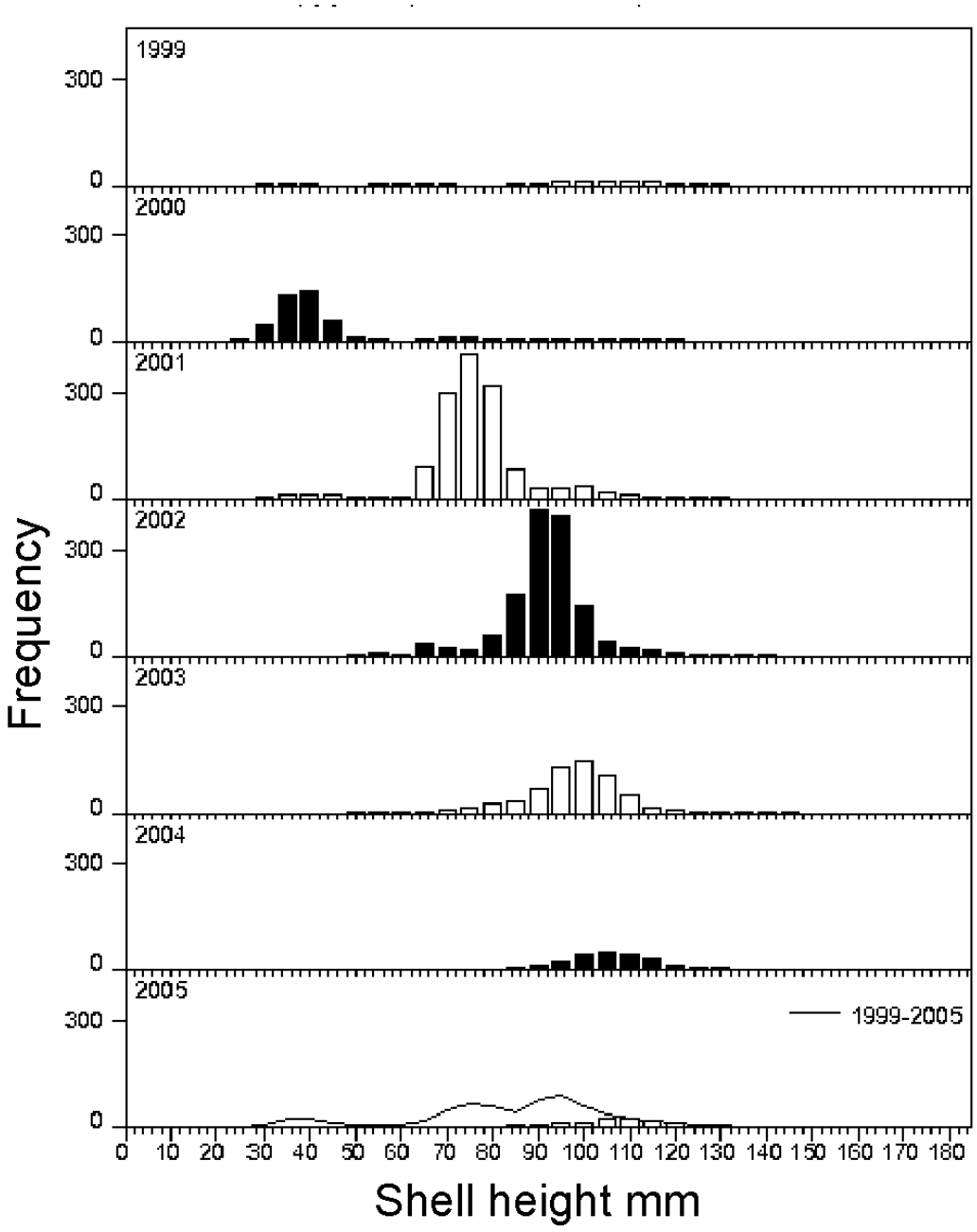

Fig. 27. Scallop shell height frequencies from the 1999 to 2005 surveys of Scallop Production Area 4. Note survey vessel changed in 2005.

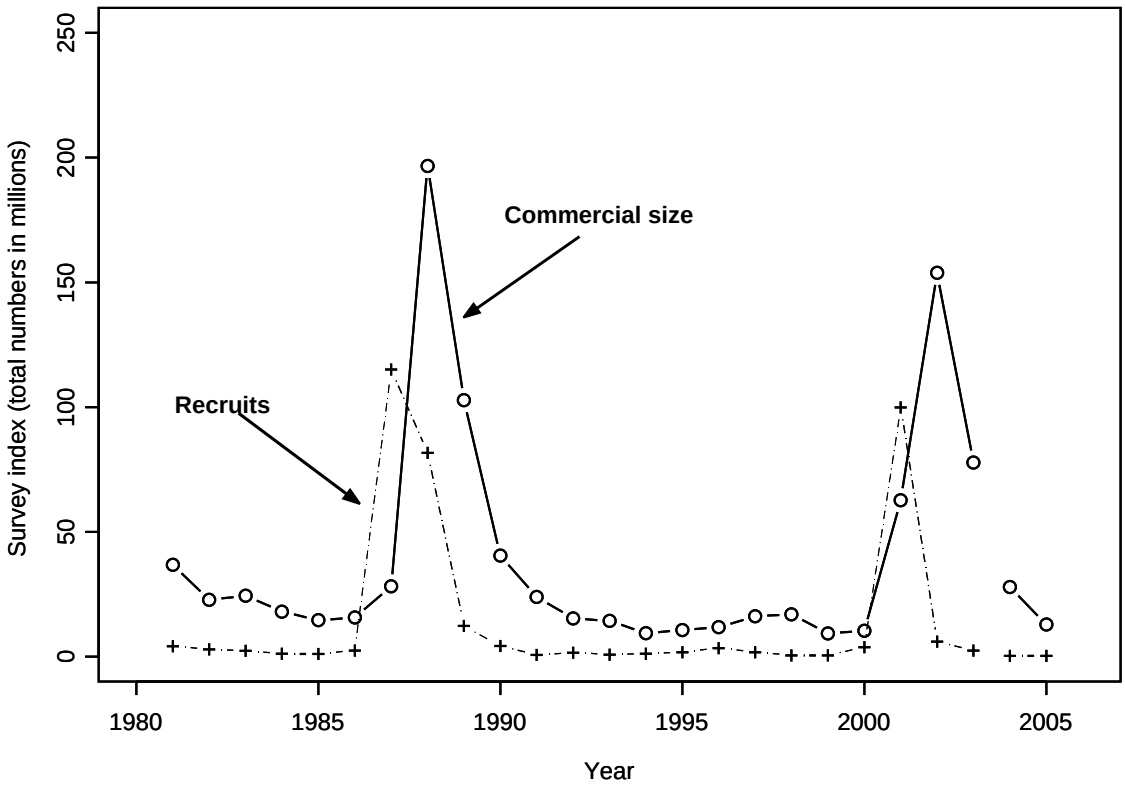

Fig. 28. Trends in survey estimates of numbers (millions) of commercial size scallops ($\geq$ 80 mm shell height) and recruits (65–79 mm shell height) from annual research vessel surveys of Scallop Production Area 4. Break in series indicates change from June surveys to August surveys starting in 2004.

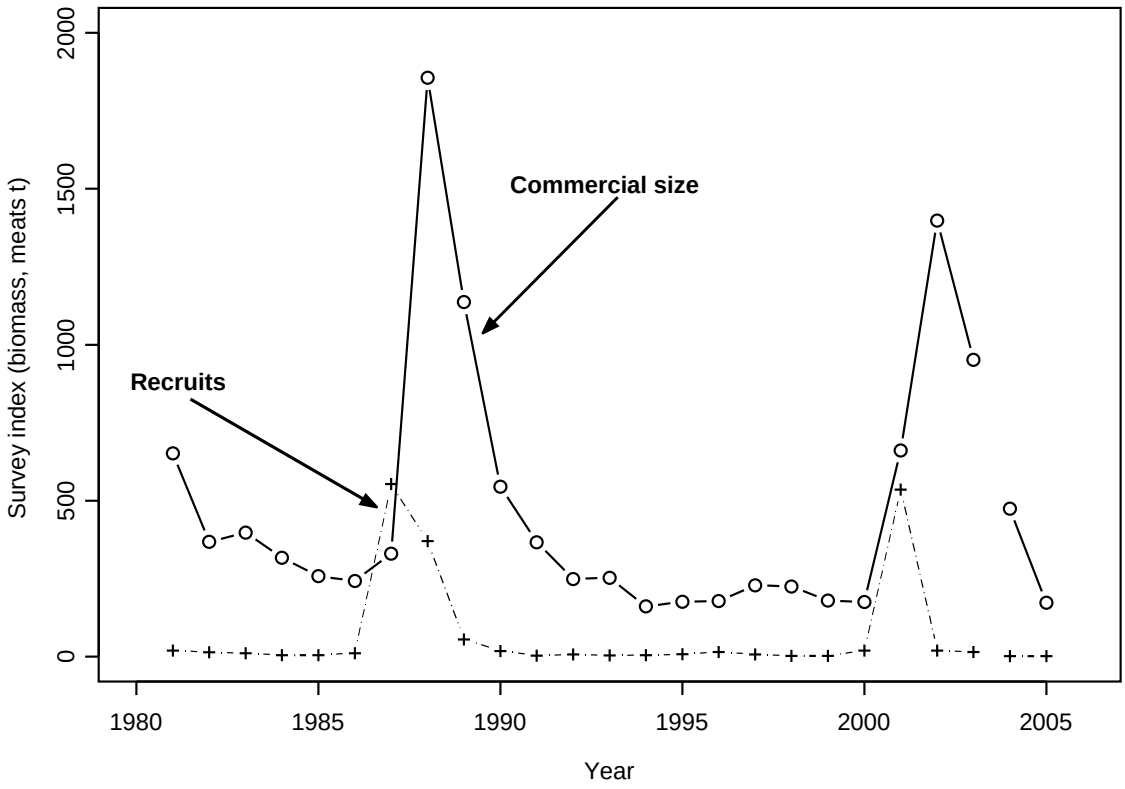

Fig. 29. Trends in survey estimates of biomass (t) of commercial size scallops (≥ 80 mm shell height) and recruits (65–79 mm shell height) from annual research vessel surveys of Scallop Production Area 4. Break in series indicates change from June surveys to August surveys starting in 2004.

Fig. 30. Ratio of the mean number per tow of commercial size scallops from the lined and unlined survey gear.

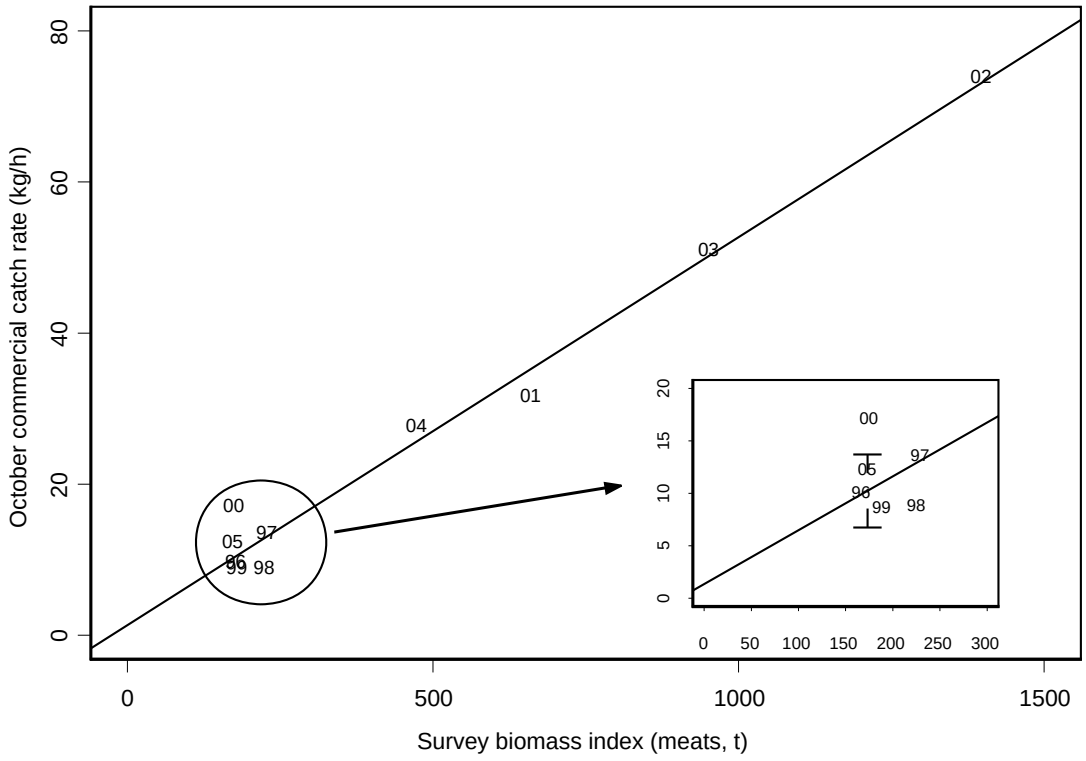

Fig. 31. Comparison between summer research survey biomass index for commercial size scallops ($\geq$ 80 mm shell height) with commercial catch rate in October of the same year for Scallop Production Area 4. Prediction for 2005 October catch rate based on relationship for 1996 to 2004 points. Inset shows 95 percent confidence interval for prediction of 2005 point.

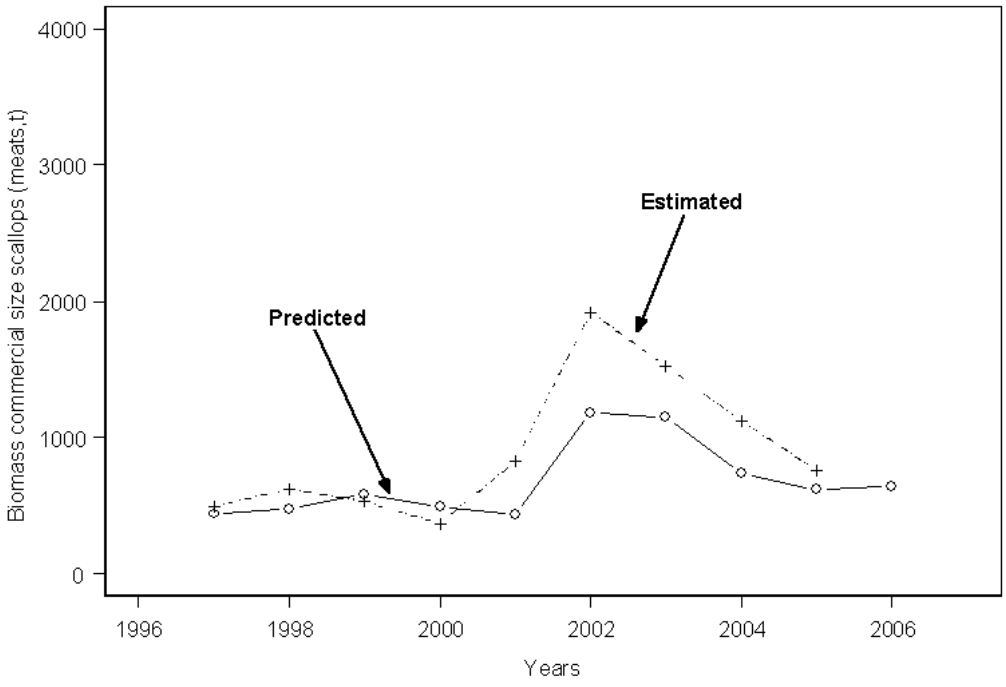

Fig. 32. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size scallops ($\geq$ 80 mm shell height) in the current year in Scallop Production Area 4. Predictions and current year estimates were produced from the delay-difference population model. Prediction for 2006 made assuming a 2005/2006 catch of 200 t.

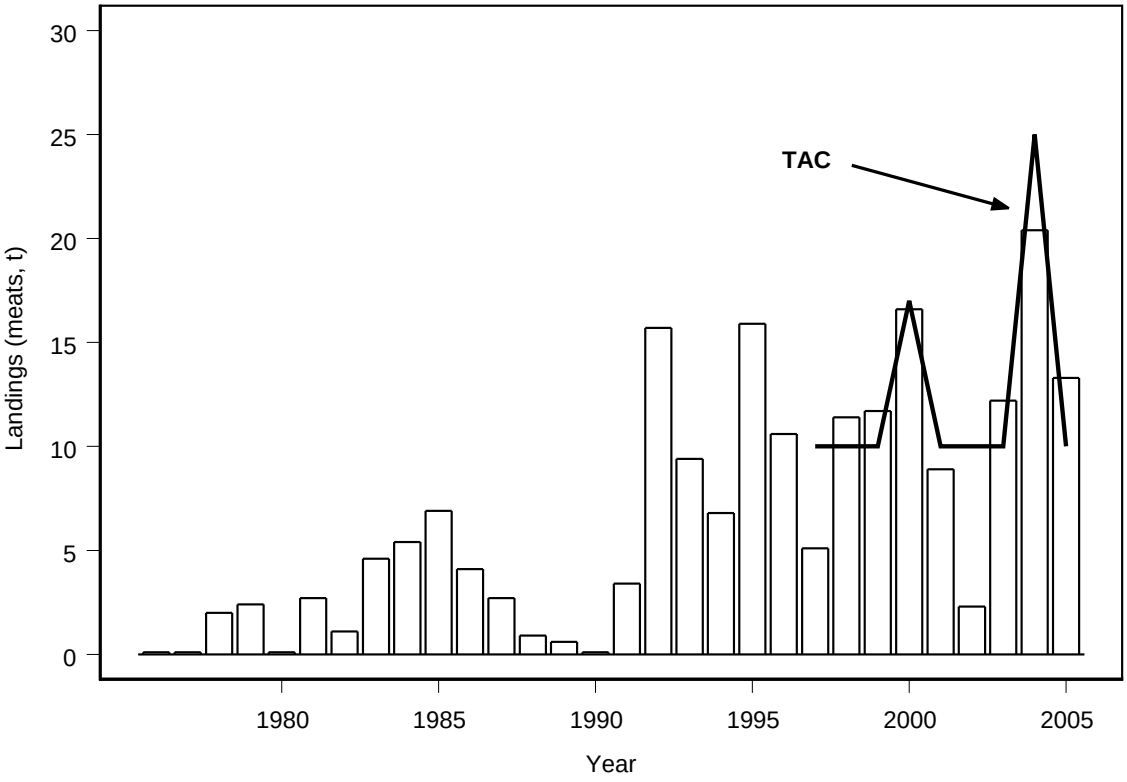

Fig. 33. Scallop landings (meats, t) in Scallop Production Area 5.

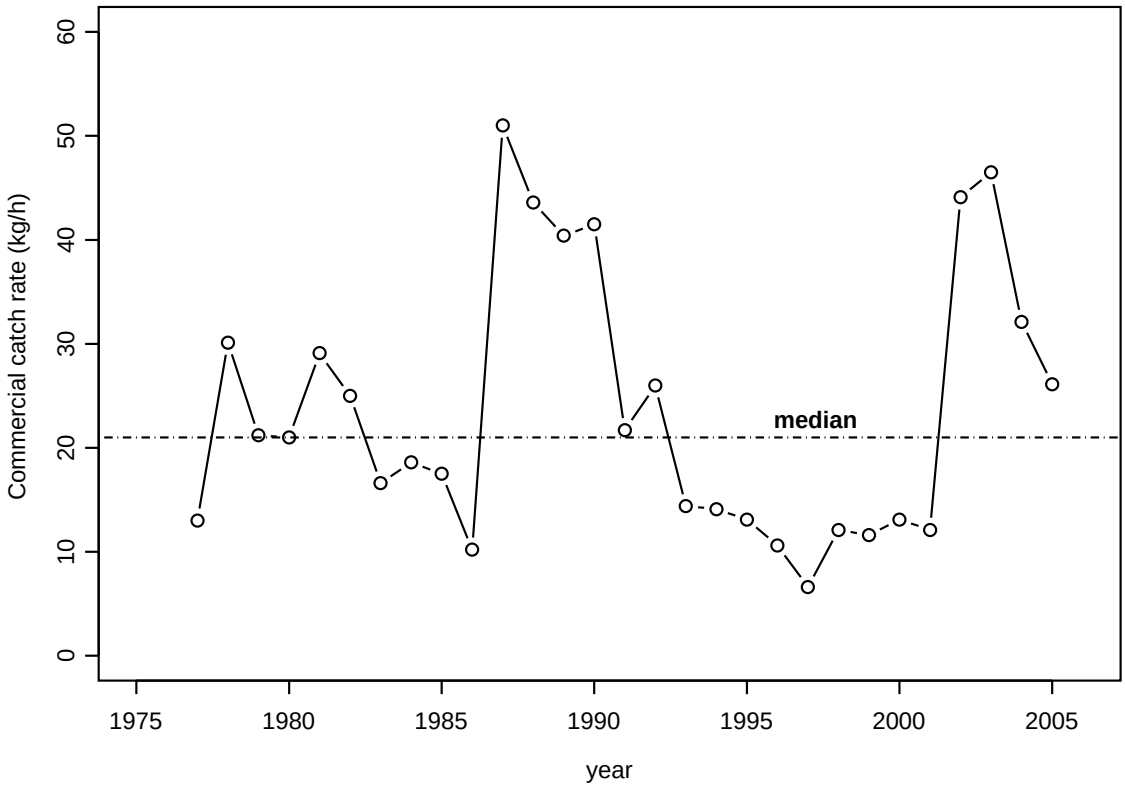

Fig. 34. Commercial catch rate (kg/h) for scallops in Scallop Production Area 5. Median catch rate over the 1976 to 2005 period indicated.

Fig. 35. Commercial fishing effort (hours) for scallops in Scallop Production Area 5.

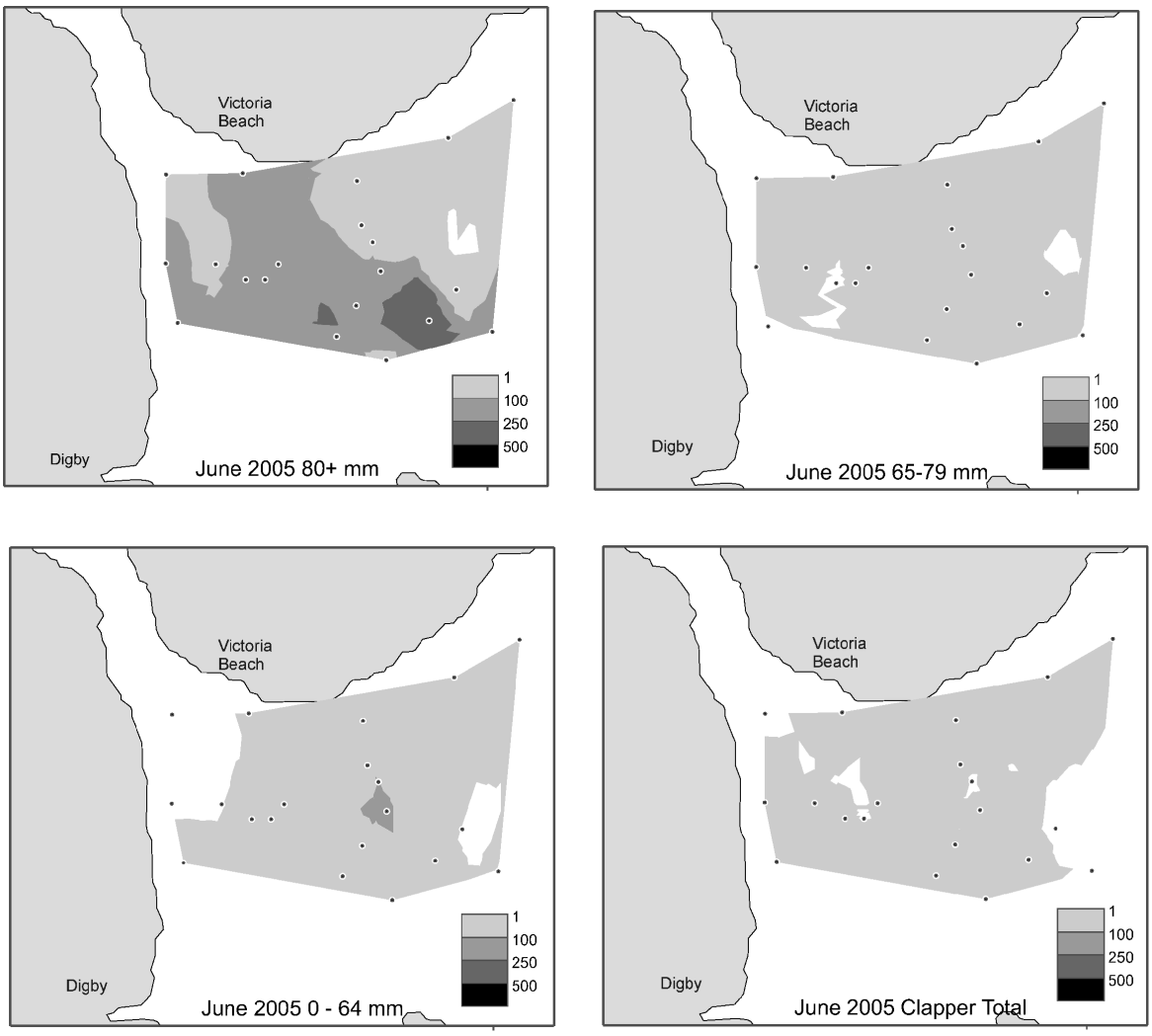

Fig. 36. Spatial distribution of scallop catches from the June 2005 survey of Scallop Production Area 5. Upper left panel: scallops with shell heights equal to or greater than 80 mm. Upper right panel: scallops with shell heights 65 to 79 mm. Lower left panel: scallops with shell heights less than 65 mm. Lower right panel: catches of clappers for all shell sizes. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated on the map.

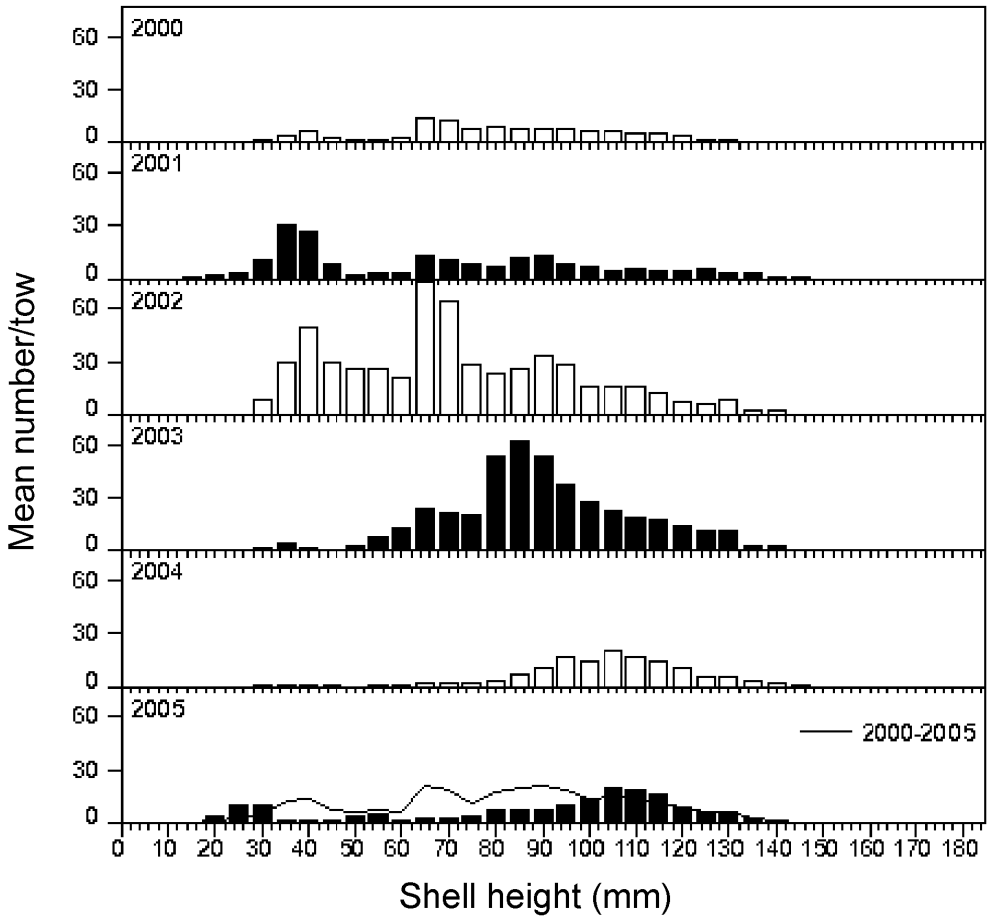

Fig. 37. Scallop shell height frequencies from the 2000 to 2005 surveys of Scallop Production Area 5.

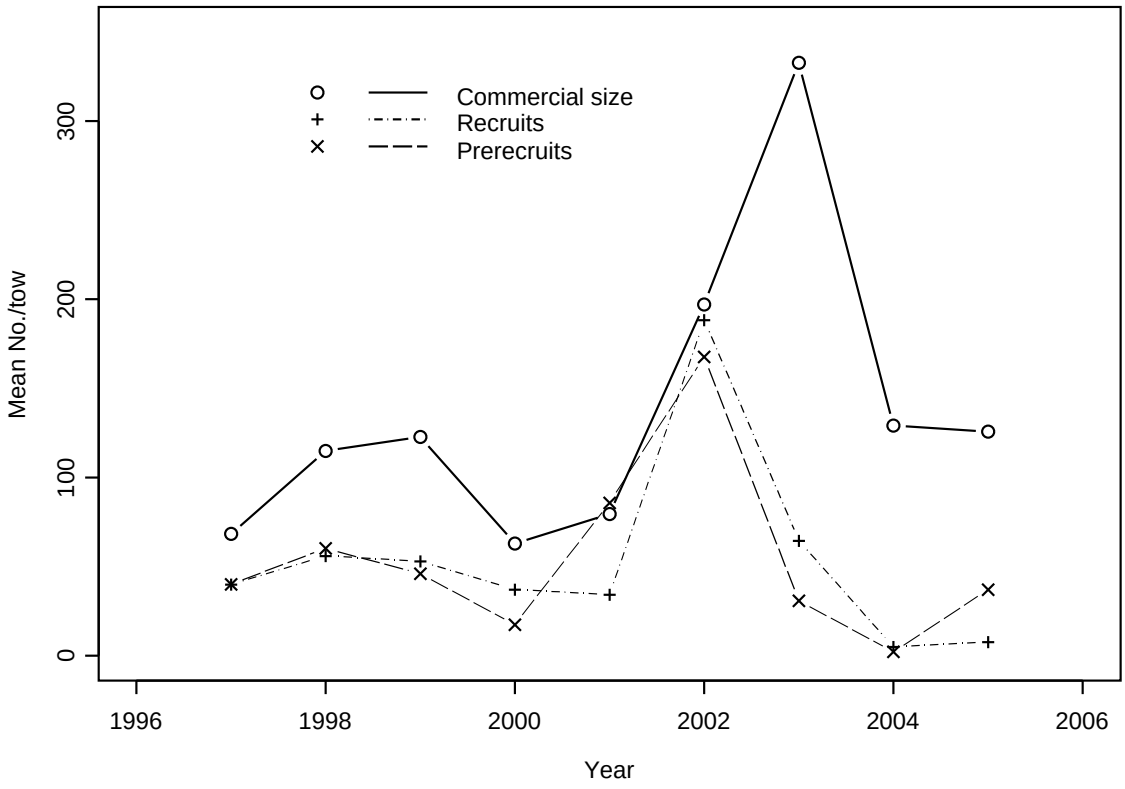

Fig. 38. Survey abundance index (mean number/tow) for commercial size scallops (≥ 80 mm shell height), recruits (65–79 mm shell height), and pre-recruits (< 65 mm shell height) in Scallop Production Area 5.

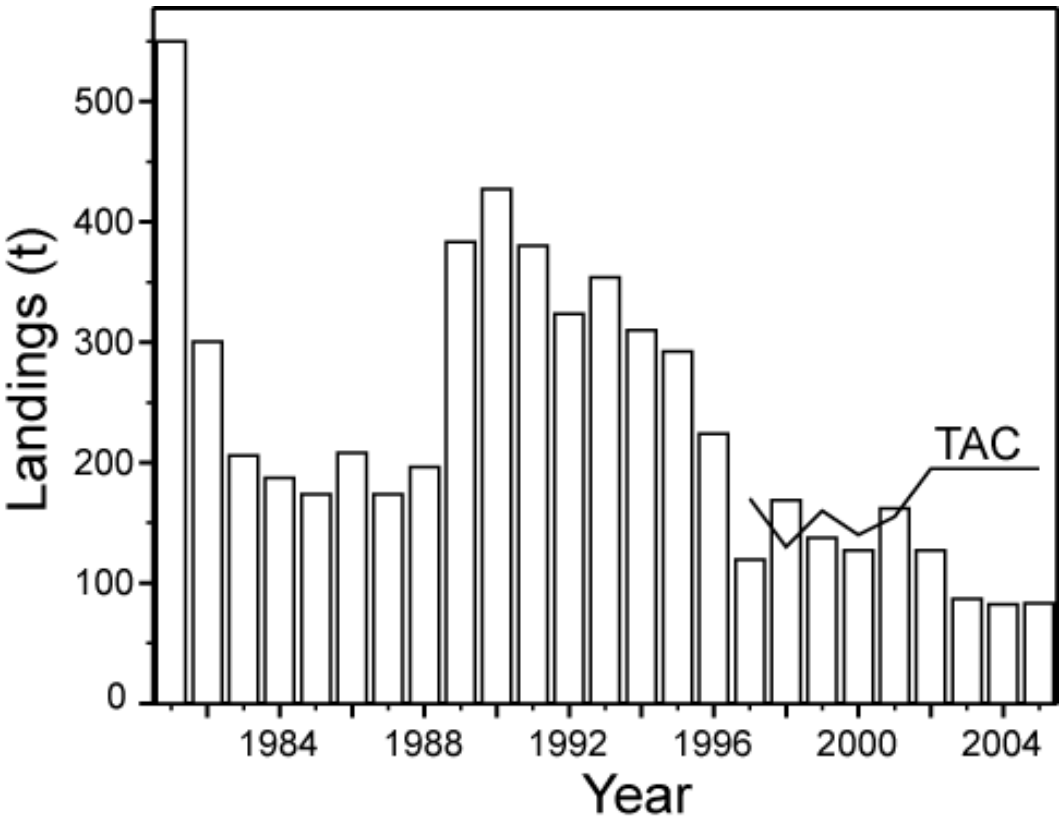

Fig. 39. Scallop landings (meats, t) in Scallop Production Area 6.

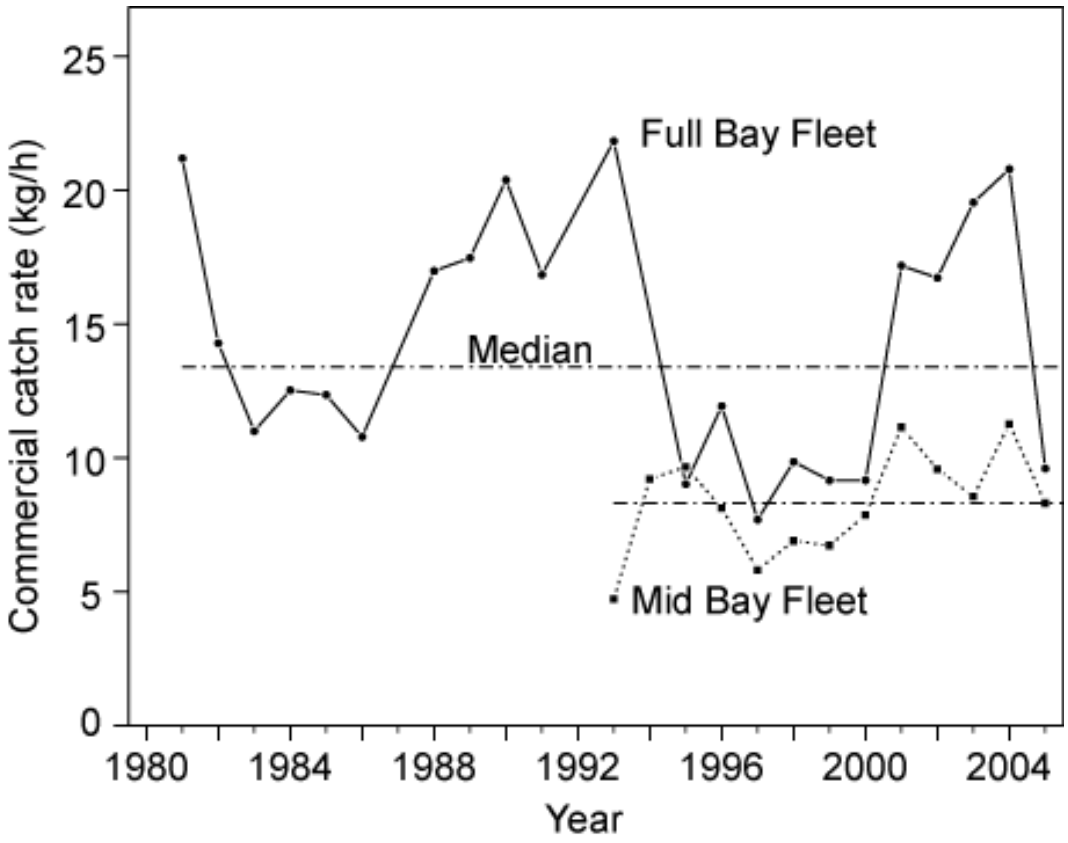

Fig. 40. Commercial catch rate (kg/h) by fleet for scallops in Scallop Production Area 6.

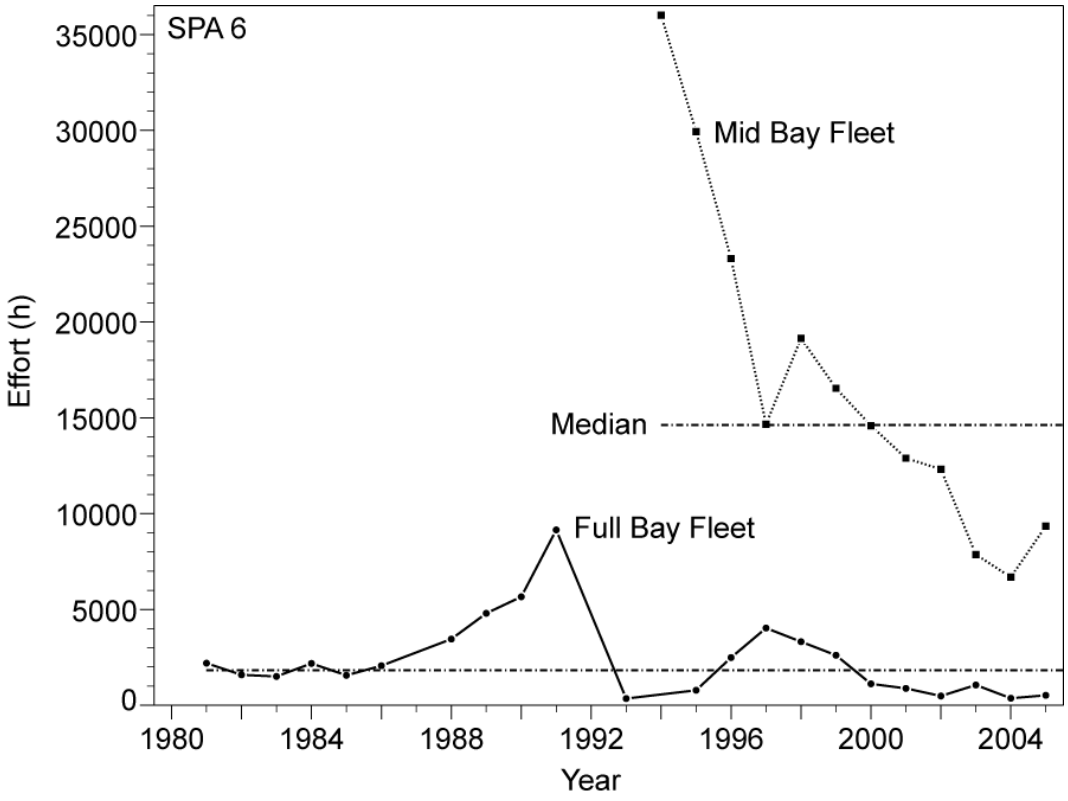

Fig. 41. Commercial fishing effort (hours) by fleet for scallops in Scallop Production Area 6.

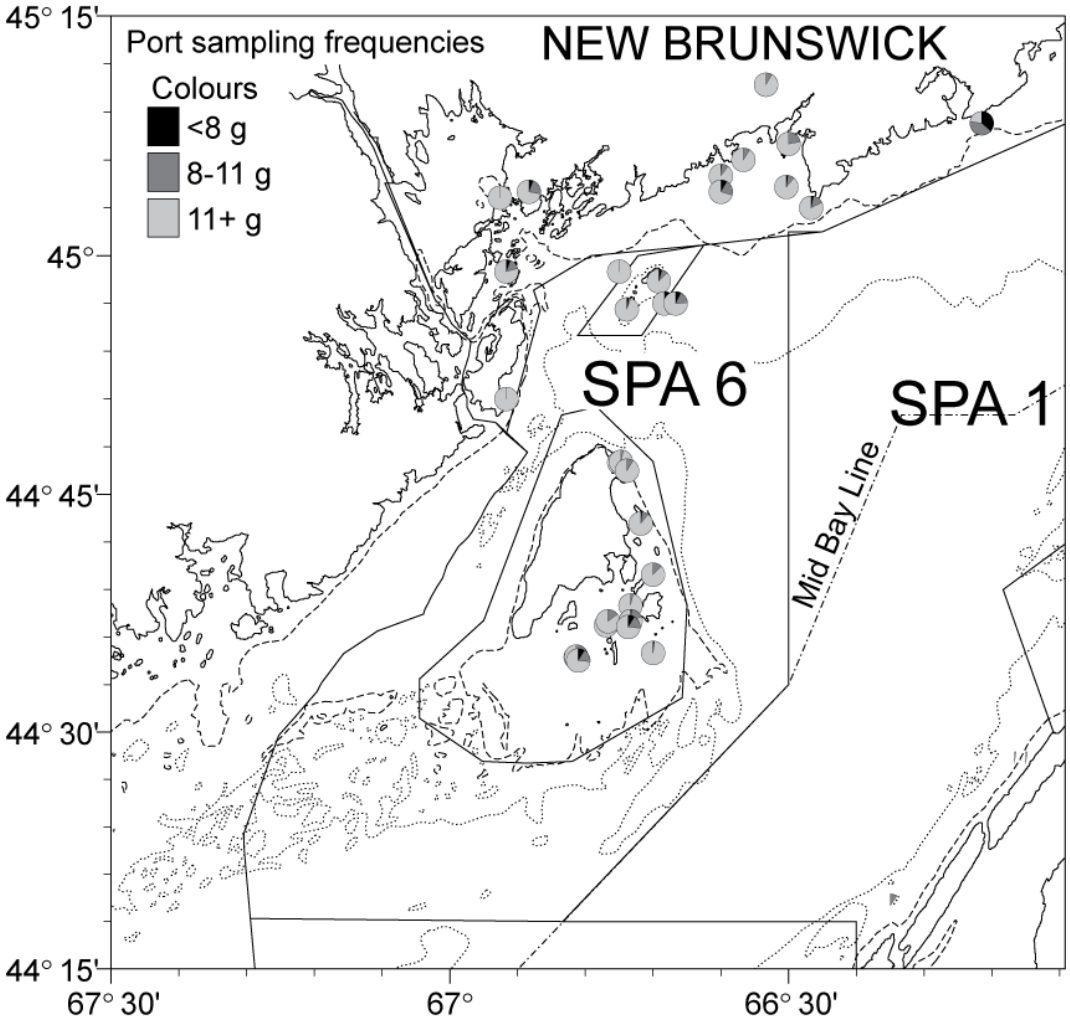

Fig. 42. Distribution of meat weight samples in 2005. Wedges show the proportion of meats in the size classes specified in the legend.

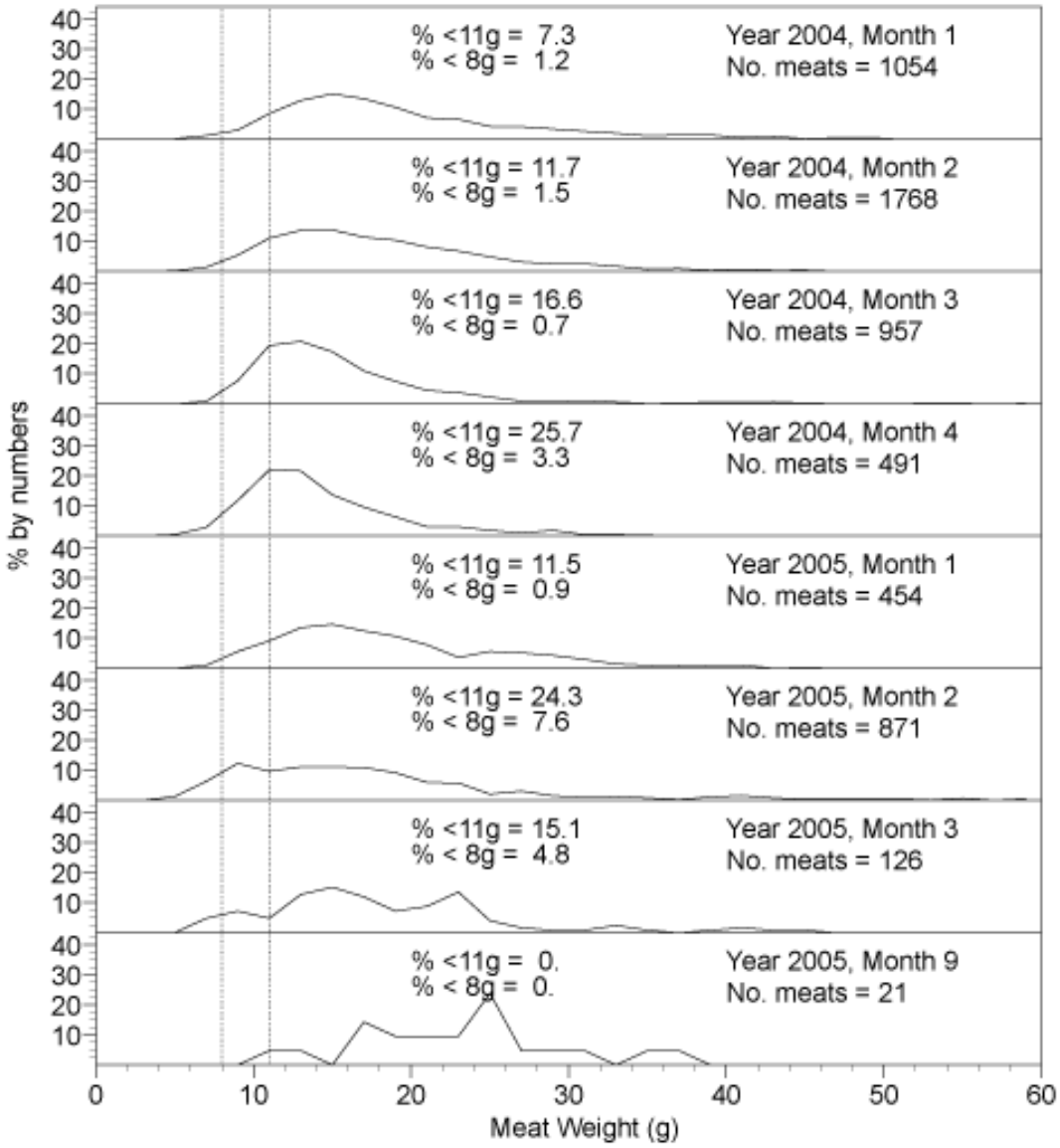

Fig. 43. Size frequencies for meat weight sampling in Scallop Production Area 6 for 2004 and 2005.

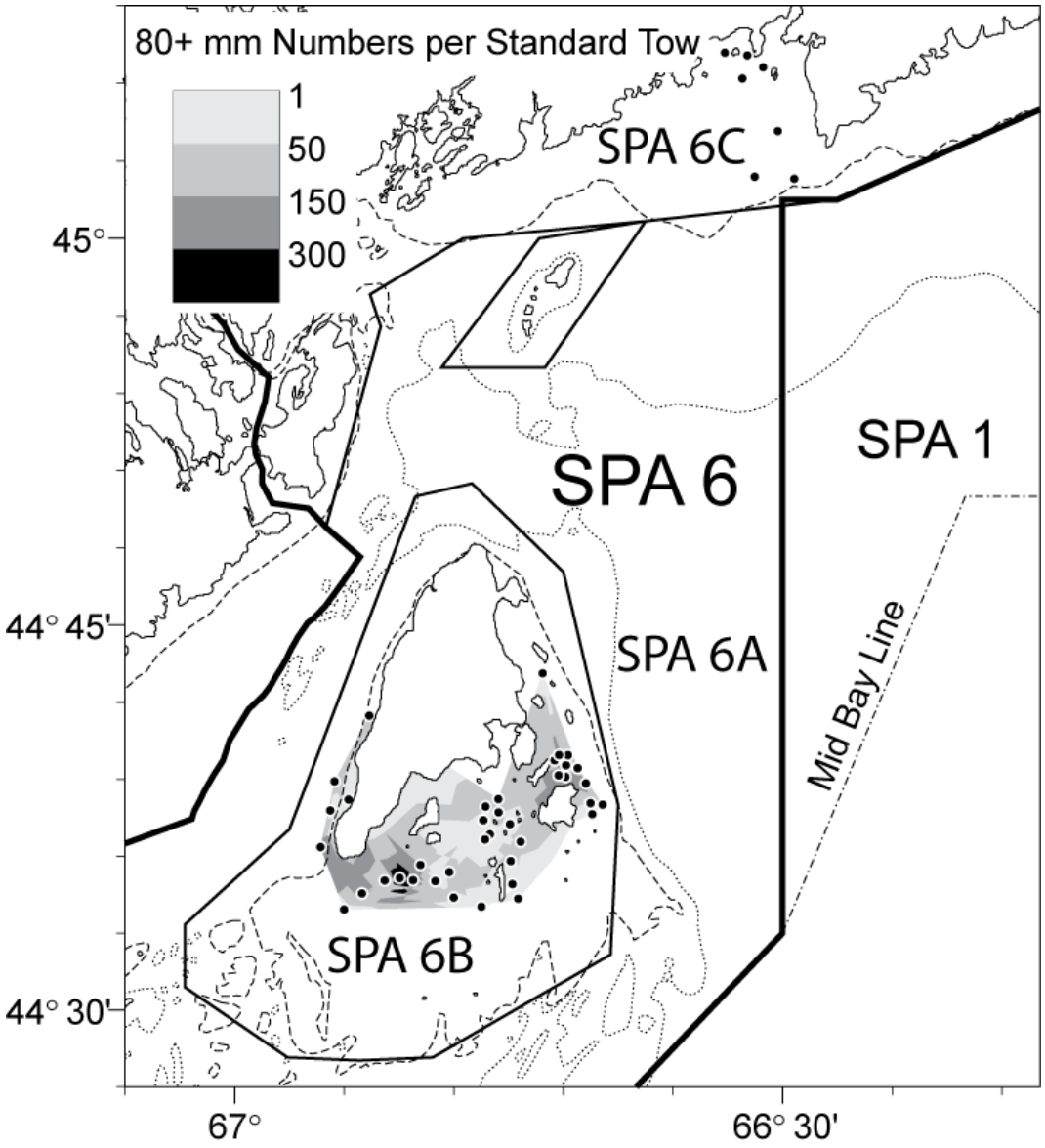

Fig. 44. Spatial distribution of scallop catches from the 2005 survey of Scallop Production Area 6 for scallops with shell heights equal to or greater than 80 mm. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated on the map. Survey was not completed due to time constraints.

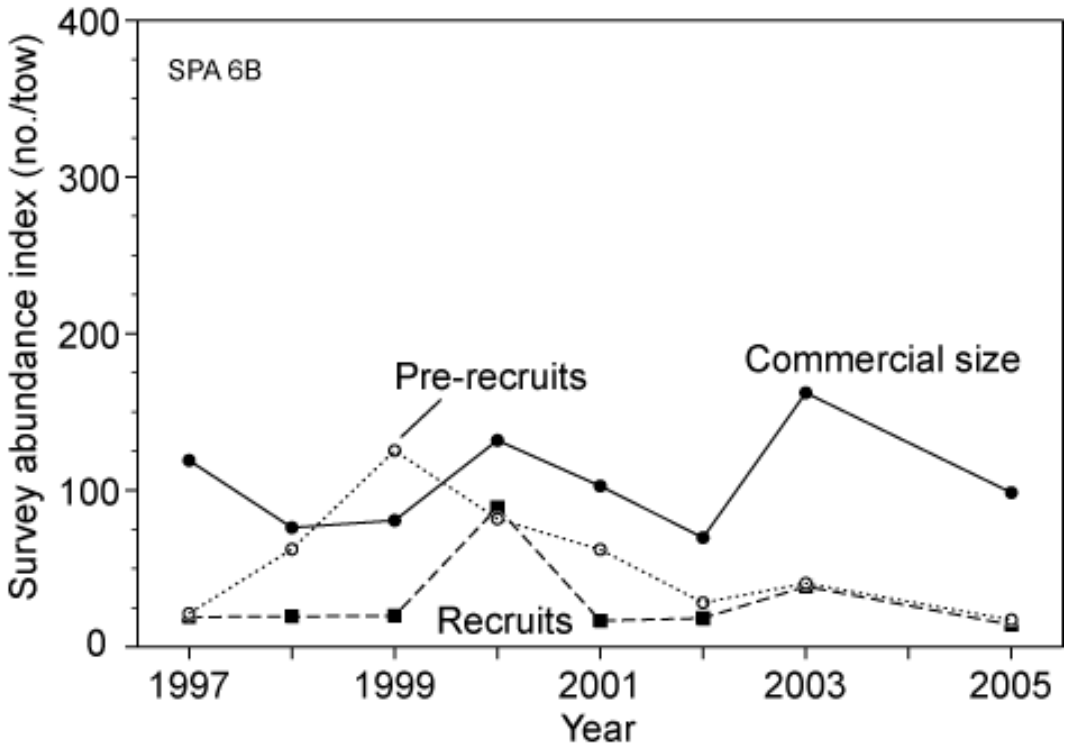

Fig. 45. Survey abundance index (mean number/tow) for commercial size scallops ($\geq$ 80 mm shell height), recruits (65–79 mm shell height), and pre-recruits ($<$ 65 mm shell height) in Scallop Production Area 6B.

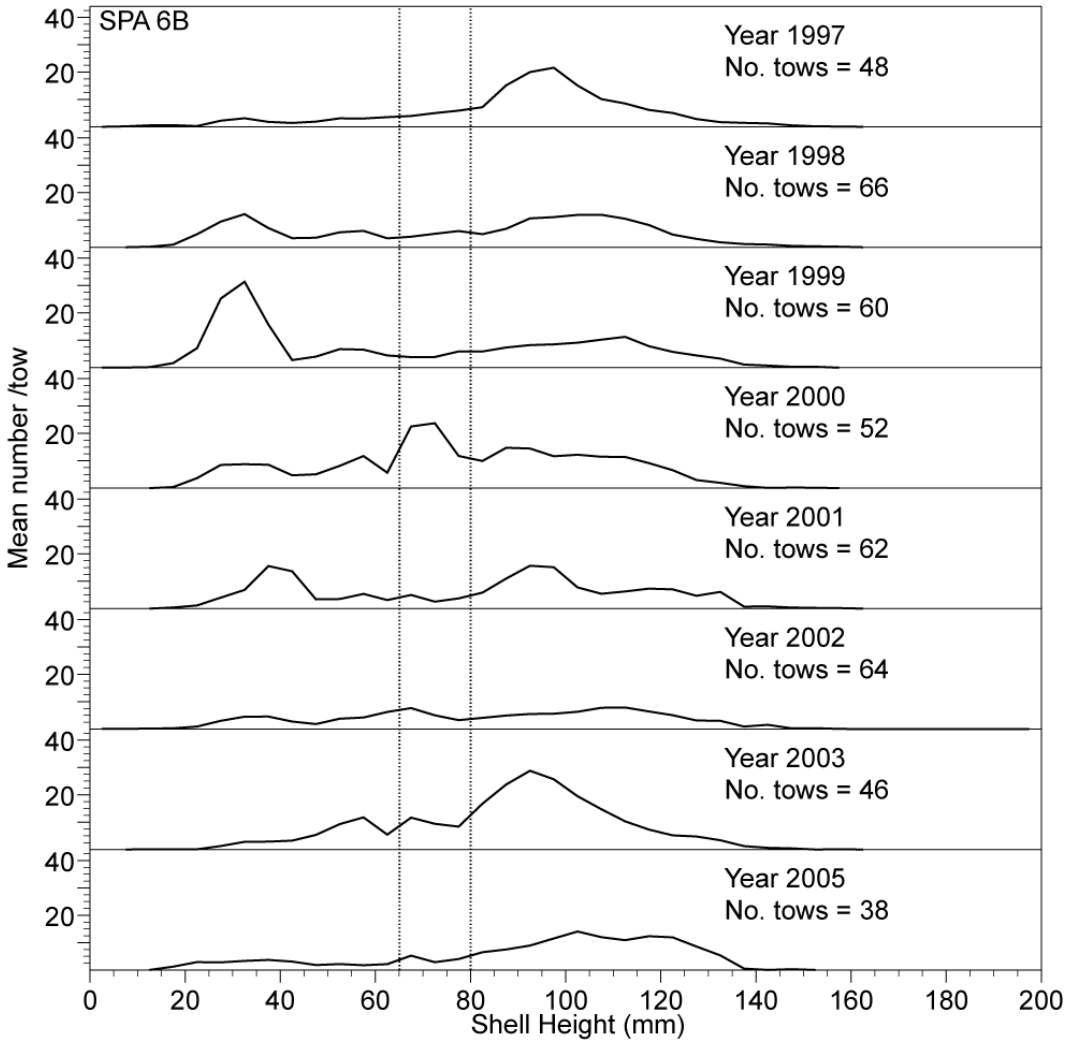

Fig. 46. Scallop shell height frequencies from the surveys of Scallop Production Area 6B.