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Scallop Production Areas in the Bay of Fundy: Stock Status for 2007 and Forecast for 2008

Zones de production du pétoncle dans la baie de Fundy: état du stock en 2007 et prévisions pour 2008

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Abstract

This document reviews the status of scallop stocks in Scallop Production Areas (SPAs) 1, 2, 3, 4, 5, and 6 (Bay of Fundy and Approaches) for 2006–2007 with advice for the fisheries in 2007–2008.

Landings in SPA 1A were 168t against a TAC of 150 t for the 2006/2007 season. Commercial catch rates have been declining from a recent peak in 2002. Since the 1998 year-class had recruited to the fishery in this area, recruitment has been minimal and the abundance of commercial size scallops has been fished down. There may be above average recruitment in the 8 to 16 mile area along its border with SPA 4 in two to three years, otherwise recruitment is expected to be below average in the SPA 1A area. Population biomass estimated to be 1245 t (meats) in 2007 has increased over the estimate for 2006 (1233 t) and is above the median biomass of 1080 t (1997 to 2006). A total catch of 150 t in 2007/2008 is expected to result in a probability of 0.16 that exploitation rates will be greater than 0.20. This catch level is expected to result in no change in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 150 t in 2007/2008, a total catch of 150 t in 2008/2009 should result in a probability of 0.30 that the exploitation rate will exceed 0.20.

For SPA 1B landings were 220 t against a TAC of 200 t for the Full Bay Fleet in the 2006/2007 season, and 173 t against a TAC of 200 t for the Mid and Upper Bay fleets in the 2007 season. Commercial catch rates have either increased slightly (Full Bay and Mid-Bay) or stayed the same (Upper Bay) in 2007 relative to last four years and all are above the low levels of the mid to late 1990s. Pre-recruits observed in the 2004 and 2005 survey near the Mid-Bay/Upper Bay line are now recruiting to the commercial fishery. There is no evidence of any above average recruitment for the next two to three years. Population biomass estimated to be 2380 t (meats) in 2007 has increased over the estimate for 2006 (1983 t) and is above the median biomass of 2006 t (1997 to 2006). A total catch of 400 t in 2007/2008 is expected to result in a probability of 0.38 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 400 t in 2007/2008, a total catch of 400 t in 2008/2009 should result in a probability of 0.39 that the exploitation rate will exceed 0.20. SPA 2 is considered to be marginal habitat for scallops and is not monitored regularly. Stock status in this area was last assessed in 2006.

Landings for SPA 3 in 2006/2007 were 119 t against a TAC of 200 t. Commercial catch rate has declined in this area since the high of 2003 and the 2007 estimate of 14.6 kg/h is just above the long-term median. The small increase in the 2007 survey biomass estimate for commercial size scallops over the 2006 biomass estimate was probably due to the increase in meat weight only, as mean numbers per tow stayed the same over the two years. The 2007 survey estimated higher than average abundances of scallops in the 10 to 40 mm size range in the Brier/Lurcher area. Better estimates of the strength of this year-class should be available from the 2008 survey. Population biomass estimated to be 449 t in 2007 has decreased over the estimate for 2006 (537 t) and is below the median biomass of 638t (1996-2006). A total catch of 50 t in 2007/2008 is expected to result in a probability of 0.29 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% decrease in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time.

Total landings for SPA 4 in 2006/2007 were 68 t against a TAC of 100 t. Commercial catch rate in 2006/2007 was unchanged from 2005/2006 at 11.38 kg/h. The increased catch rate observed in October 2007 (15.9 kg/h) may be due to increased meat weight at shell height. The survey biomass estimate indicates that there was little change in biomass in 2007 relative to 2006 and that the current population levels are similar to those in the mid-1990s with below average recruitment expected in the upcoming year. The mean numbers of scallops with 20–50 mm shell height in 2007

were three times greater than the mean number in 2006, but were well below the densities observed for the above average 1998 year-class at the same size. These scallops are probably two year-olds and will not recruit to the fishery until 2009/2010. Population biomass estimated to be 712 t (meats) in 2007 has increased over the estimate for 2006 (672 t) and is below the median biomass of 835 t (1983 to 2006). A total catch of 100 t in 2007/2008 is expected to result in a probability of 0.44 that exploitation rates will be greater than 0.20. This catch level is expected to result in an 8% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 100 t in 2007/2008, a total catch of 100 t in 2008/2009 should result in a probability of 0.46 that the exploitation rate will exceed 0.20.

A total of 3.8 t were landed in SPA 5 in 2007 against a TAC of 10 t. Commercial catch rate in 2007 (10.8 kg/h) was lower than that observed for 2006 (12.5 kg/h) and below the long term median of 19.8 kg/h (1977–2006). The mean number per tow of commercial size scallops in 2007 (131/tow) is above the 1997–2006 median (120/ tow) but little recruitment is expected for the next two years. The TAC for 2008 should not exceed the average catch of 10t over the period 1997 to 2007 (excluding the high catch in 2004).

For SPA 6 landings to 26 November 2007 were 68 t against a TAC of 140 t. The Mid-Bay catch rate may be a better refection of population trends than the Full Bay catch rate as it is based on somewhat higher levels of effort, however, this index does not indicate any large changes in the last 10 years. The abundance of commercial size scallops appears to remain unchanged from 2006 in SPA 6A and 6B and has possibly declined in SPA 6C. Above average recruitment was detected in SPA 6A and 6B; however, in the case of the latter, this recruitment appears to be confined to Duck Island Sound. There is no evidence to advise increasing the TAC over its current level.

Résumé

Le présent document porte sur l'état des stocks de pétoncles dans les zones de production de pétoncles (ZPP) 1, 2, 3, 4, 5 et 6 (baie de Fundy et environs) pour 2006-2007 et contient un avis pour les pêches de 2007-2008.

Dans la ZPP 1A, 168 t ont été débarquées en 2006-2007; le total autorisé des captures (TAC) était de 150 t. Les taux de prise de la pêche commerciale ont décliné depuis le récent sommet atteint en 2002. Depuis que la classe d'âge de 1998 a intégré la pêche dans cette zone, le recrutement a été minimal et l'effectif de pétoncles de taille commerciale a été entièrement exploité. Le recrutement peut être supérieur à la moyenne deux ans sur trois dans le secteur de 8-16 milles, le long de sa limite avec la ZPP 4; autrement, le recrutement devrait être inférieur à la moyenne dans la ZPP 1A. La biomasse de la population, estimée à 1245 t (chair) en 2007, est supérieure à l'estimation établie pour 2006 (1233 t) et est supérieure à la biomasse médiane de 1080 t (1997-2006). Des prises totales de 150 t en 2007-2008 devraient entraîner, dans une probabilité de 0,16, des taux d'exploitation supérieurs à 0,20. Ce taux de prise ne devrait pas entraîner de changement dans la biomasse entre 2007 et 2008, si le poids en chair selon la hauteur de la coquille demeure inchangé durant cette période. Étant donné des prises de 150 t en 2007-2008, des prises totales de 150 t en 2008-2009 devraient entraîner, dans une probabilité de 0,30, des taux d'exploitation supérieurs à 0,20.

Dans la ZPP 1b, 220 t ont été débarquées en 2006-2007 par la flottille exploitant toute la baie (TAC de 200 t) et 173 t ont été débarquées en 2007 par les flottilles exploitant le milieu et la partie supérieure de la baie (TAC de 200 t). Les taux de prise de la pêche commerciale ont légèrement augmenté (totalité et milieu de la baie) ou sont demeurés inchangés (partie supérieure de la baie) en 2007 comparativement aux quatre dernières années, et tous excèdent les faibles taux observés du milieu jusqu'à la fin des années 1990. Les prérecrues observées dans le relevé de 2004 et de 2005 mené près de la ligne de démarcation entre le milieu et la partie supérieure de la baie sont présentement recrutées par la pêche commerciale. Rien n'indique un recrutement supérieur à la moyenne pour les deux à trois prochaines années. La biomasse de la population, estimée à 2380 t (chair) en 2007, a dépassé l'estimation établie pour 2006 (1983 t) et est supérieure à la biomasse médiane de 2006 t (1997-2006). Des prises totales de 400 t en 2007-2008 devraient entraîner, dans une probabilité de 0,38, des taux d'exploitation supérieurs à 0,20. Ce taux de prise devrait entraîner une augmentation de 9 % de la biomasse entre 2007 et 2008, si le poids en chair selon la hauteur de la coquille demeure inchangé durant cette période. Étant donné des prises de 400 t en 2007-2008, des prises totales de 400 t en 2008-2009 devraient entraîner, dans une probabilité de 0,39, des taux d'exploitation supérieurs à 0,20. La ZPP 2 est considérée comme un habitat marginal pour les pétoncles et ne fait pas l'objet d'une surveillance régulière. La dernière évaluation de l'état des stocks dans cette zone remonte à 2006.

Dans la ZPP 3, 119 t ont été débarquées en 2006-2007; le TAC était de 200 t. Les taux de prise de la pêche commerciale ont décliné dans cette zone depuis le sommet atteint en 2003, et l'estimation pour 2007 de 14,6 kg/h est tout juste supérieure à la valeur médiane à long terme. La faible augmentation de l'estimation tirée du relevé de 2007 de la biomasse des pétoncles de taille commerciale, comparativement à l'estimation de la biomasse de 2006, était probablement due à l'augmentation du poids en chair uniquement étant donné que les prises moyennes par trait sont demeurées inchangées au cours de ces deux années. L'estimation de l'abondance des pétoncles dérivée du relevé de 2007 était supérieure à la moyenne pour la fourchette de tailles se situant entre 10 et 40 mm dans le secteur de Brier/Lurcher. De meilleures estimations de l'effectif de cette classe d'âge devraient être fournies par le relevé de 2008. La biomasse de la population, estimée à 449 t en 2007, est inférieure à l'estimation établie pour 2006 (537 t) et est inférieure à la biomasse médiane de 638 t (1996-2006). Des prises totales de 50 t en 2007-2008 devraient

entraîner, dans une probabilité de 0,29, des taux d'exploitation supérieurs à 0,20. Ce taux de prise devrait entraîner une diminution de 9 % de la biomasse entre 2007 et 2008, si le poids en chair selon la hauteur de la coquille demeure inchangé durant cette période.

Dans la ZPP 4, 68 t ont été débarquées en 2006-2007; le TAC était de 100 t. Les taux de prise de la pêche commerciale en 2006-2007 sont demeurés inchangés comparativement à 2005-2006, à 11,38 kg/h. Le taux de prise accru observé en octobre 2007 (15,9 kg/h) peut être dû à une augmentation du poids en chair selon la hauteur de la coquille. L'estimation dérivée du relevé indique que la biomasse a peu changé en 2007 comparativement à 2006 et que les effectifs actuels de la population sont similaires à ceux observés au milieu des années 1990, et un recrutement inférieur à la moyenne est prévu pour l'année à venir. Les effectifs moyens des pétoncles dont la hauteur de coquille oscille entre 20 et 50 mm en 2007 sont trois fois plus élevés que ceux de 2006, mais de beaucoup inférieurs aux densités observées pour la forte classe d'âge de 1998 à la même taille. Ces pétoncles ont probablement deux ans et ne seront pas recrutés par la pêche avant 2009-2010. La biomasse de la population, estimée à 712 t (chair) en 2007, est supérieure à l'estimation établie pour 2006 (672 t) et est inférieure à la biomasse médiane de 835 t (1983-2006). Des prises totales de 100 t en 2007-2008 devraient entraîner, dans une probabilité de 0,44, des taux d'exploitation supérieurs à 0,20. Ce taux de prises devrait entraîner une augmentation de 8 % de la biomasse entre 2007 et 2008, si le poids en chair selon la hauteur de la coquille demeure inchangé durant cette période. Étant donné des prises de 100 t en 2007-2008, des prises totales de 100 t en 2008-2009 devraient entraîner, dans une probabilité de 0,46, des taux d'exploitation supérieurs à 0,20.

Dans la ZPP 5, un total de 3,8 t ont été débarquées en 2007; le TAC était de 10 t. Les taux de prise de la pêche commerciale en 2007 (10,8 kg/h) sont inférieurs à ceux observés en 2006 (12,5 kg/h) et se situent sous la valeur médiane à long terme de 19,8 kg/h (1977-2006). Les prises moyennes par trait de pétoncles de taille commerciale en 2007 (131/trait) sont supérieures à la valeur médiane pour 1997-2006 (120/trait), mais le recrutement devrait être faible durant les deux prochaines années. Le TAC pour 2008 ne devrait pas dépasser la moyenne de 10 t de la période allant de 1997 à 2007 (si l'on exclut les prises élevées réalisées en 2004).

Dans la ZPP 6, 68 t avaient été débarquées au 26 novembre 2007; le TAC était de 140 t. Dans le milieu de la baie, le taux de prise peut mieux refléter les tendances de la population que le taux de prise pour la totalité de la baie puisque celui-ci est fondé sur des niveaux d'effort un peu plus élevés. Néanmoins, cet indice n'indique pas la survenue de changements substantiels au cours des dix dernières années. L'abondance des pétoncles de taille commerciale semble être demeurée inchangée en 2006 dans les ZPP 6A et 6B et a probablement décliné dans la ZPP 6C. Un recrutement supérieur à la moyenne a été détecté dans les ZPP 6A et 6B; toutefois, dans le cas de cette dernière, ce recrutement semble être confiné au détroit de Duck Island. Aucune donnée ne justifie une augmentation du TAC.

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.

Details on areas, fleet access, current TACs, landings and available datasets for stock assessment are given in the table below. No TAC has been set for SPA 2 and fishing can take place subject to special licence conditions. The Decision column indicates whether advice is provided in terms of a formal model or simply on the basis of trends in the abundance indices. The major change in this year's stock assessment is that the delay-difference model used since 2002 for SPA 4 and a portion of SPA 1 has now been applied to SPA 1A, 1B, and 3.

	TAC		Landings			
SPA	Fleets	(meats, t)	(meats, t)	Survey(strata)[1]	CPUE	Decision
1A	Full Bay	150.0	168	1981–2007 (8–16) 1984–2997 (2–8 mile) 1997–2002, 2004–2007 (MBS)	1976–2007	Model
1B	Full Bay	200.0	220	1997–2007 (Cape S., MBN)	1982–2007	Model
	Mid-Bay	200.0	93	2002–2003, 2005–2007 (UB)	1992–2007	
	Upper Bay		80		1997–2007	
2	Full Bay			2006		Marginal Area
	Mid-Bay					
3	Full Bay	200.0	118	1996–2007	1996–2007	Model
4	Full Bay	100.0	68	1981–2007	1976–2007	Model
5	Full Bay	10.0	4	1997–2007	1976–2007	Trends
6	Full Bay	35.0	5	1997–2003, 2004–2007	1976–2007	Trends
	Mid-Bay	105.0	65		1993–2007	
	All	1000	908			

1. Survey strata are given in Fig. 2

Currently, scientific advice is provided by scallop production areas (1 to 6; Fig. 1). Since 2002, scallop production area (SPA 1) has been divided into 1A where the Full Bay fleet has exclusive access and 1B where the TAC is shared by all three fleets within subareas there. Within SPA 1B there are two upper Bay areas referred to as scallop fishing area (SFA) 28C (access shared by all three fleets), SFA 28D (access shared by Full Bay and

Upper Bay fleets) and SFA 28B (excluding SPA 6) on the western side of the Bay of Fundy where access is shared between the Full Bay and Mid-Bay fleets.

In last year's research document (Smith et al. 2007), attention was focussed on the decline in meat weights seen across most of the areas in the Bay of Fundy and Approaches and the observation that in all areas the average meat was below the high recorded in 2001. This year, meat weights have increased and are now close to or in some cases higher to the 2001 means. Trends in meat weights are presented for each of the areas in this document.

The total number of stations covered in the Bay of Fundy and Approaches in 2007 was 702, less than the 875 stations in 2006 but still above the number of stations in recent previous years (520 to 645). The decrease in stations reflected budgetary restrictions in the science program. We still have to evaluate if we will be able to sustain 700 stations in 2008. Survey strata for the Bay of Fundy are presented in Fig. 2. The 2007 survey coverage and spatial distribution for the different size classes and clappers are presented in figures 3–6. Clappers were generally found in low densities throughout the bay.

In this document, we present the scientific basis for advice for the 2007/2008 Full Bay scallop fleet season and the 2008 season for the Mid-Bay and Upper Bay scallop fleets. Data used for the analyses came from commercial fishing logs and dockside monitoring documents, samples of meat weights in the catch, and fishery-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*).

Delay-Difference Model

The delay-difference population biomass model was fully described in Smith and Lundy (2002*b*) where it was first applied to survey and catch data from SPA 4 and the 8 to 16 mile survey in SPA 1. Here we present a brief review of the model for background to its use in SPA 1A, 1B, and 3. The basic delay-difference model with average weights known is defined as (Hilborn and Walters 1992),

$$B_{t+1} = s_t\left(\rho + \frac{\alpha}{\varpi_t}\right)B_t + R_t \qquad (1)$$

where B_t, $\overline{\omega}_t$, and s_t are the population biomass, average weight of the portion of the population recruited to the fishery and the survival from both fishing and natural mortality, respectively in year t. The term R_t denotes the biomass of the recruiting size classes in year t. The $\rho + \alpha/\overline{\omega}_t$ term is the annual growth increment and will decrease (increase) as the average size increases (decreases) representing an older slower growing (younger, faster growing) population. The parameters α

and ρ are obtained from a regression of the weights-at-age *a* on the weights-at-age *a* - 1.

$$\omega_a = \alpha + \rho\omega_{a-1} \tag{2}$$

This linear relationship is a consequence of using a von Bertalanfy growth curve for weight as a function of age (Quinn and Deriso 1999). The total survival rate is assumed to be the product of natural survival rate and the harvesting rate.

$$s_t = s_t^M s_t^F \tag{3}$$

With catch known the model in Equation 1 can be written as,

$$B_{t+1} = \left(\exp(m_t)\left(\rho + \frac{\alpha}{\varpi_t} \right)(B_t - C_t) + R_t \right)\mu_t \tag{4}$$

where m_t represents instantaneous natural mortality and C_t is the catch in year t. The μ_t denotes a random error associated with the model dynamics.

We do not directly observe B_t , R_t or m_t as they represent population states. Instead we observe survey estimates of commercial size biomass, recruiting size-classes and clappers (c_t, paired empty shells) as a proxy for natural mortality. We relate these observation level variables with the state variables as follows.

First we assume that there is a proportional relationship between the survey biomass I_t and the population biomass.

$$I_t = q_I B_t \varepsilon_t \tag{5}$$

The survey recruitment index $R_t^{'}$ is used for the biomass of recruits.

$$R_t^{'} = q_R R_t \nu_t \tag{6}$$

Finally, we used the so-called Popcorn model (Smith and Lundy 2002*b*) for natural mortality as,

$$c_t = \frac{S}{2} m_t \left[SL_{t-1} + (2 - S)L_t \right]\varepsilon_t \tag{7}$$

where *S* is the mean separation time of the hinge of a clapper. The observation model for the number of live scallops from the survey was modelled as,

$$L_t = (q_I B_t / \omega_t)\varphi_t \tag{8}$$

We assume that all of the error terms given above (i.e. μ_t , ε_t , ν_t , ϵ_t and φ_t) are independent log normal random variates with unknown means and unknown variances σ^2, σ_ε^2 , σ_ν^2 , σ_ε^2 and σ_φ^2, respectively. The means will be derived from the expected values of equations 4–7.

The parameters to be estimated are the variance terms given above, the proportionality constants q_I and q_R and the dissolution rate S, as well as the state variables B_t , R_t and m_t for all t in Equation 4.

The state model in Equation 4 and the observation equations in equations 5–8 are components of a non-linear state-space model. Bayesian methods are used to estimate the parameters following the approach in Meyer and Millar (1999) and using the WinBugs public domain software (Lunn et al. 2000).

Construction of prior distributions and the application of convergence tests are discussed in Smith and Lundy (2002*b*). Recent changes to the model are the replacement of q_R with a function of the ratio of the lined and unlined gear catches and q_I to give a time-varying catchability coefficient (see Smith et al. 2005) and the use of uniform distributions instead of gamma distributions for the priors of some of the scale parameters. In recent years the performance of the model has been evaluated by comparing projections of population biomass in year $t + 1$ from estimates in year t with estimates from year $t + 1$.

Decision Rules

Current practice within the Department of fisheries and Oceans is to define reference points for decision rules with respect to measures of stock status and removal or harvest rate (DFO 2006). Scientific advice on harvesting activities will be provided in terms of maintaining the stock size (biomass or numbers) above a specified stock limit reference point and keeping the removal or exploitation rate below a maximum acceptable exploitation rate. The stock limit reference point is generally defined as "…the stock level below which productivity is sufficiently impaired to cause serious harm but above the level where the risk of extinction becomes a concern". The maximum acceptable exploitation rate has been defined as the exploitation rate associated with maximum sustainable yield to comply with the provisions of the United Nations fish Stock Agreement (UNFSA, DFO 2006).

The issue of defining reference points for scallops stocks has been discussed before (DFO 2004, Smith and Rago 2004). The definition of the stock limit reference point above suggests that there is a minimum stock size below which the rate of reproduction and growth are so low that natural mortality alone would restrict population growth making the population vulnerable to extirpation or extinction. Scallop populations in the Bay of Fundy have experienced large variations in stock size even within the range of years covered by this stock assessment without any apparent evidence of long-term impairment to population reproduction or growth. In theory, calculation of the stock limit reference point requires some idea of how the population reproduction rate might change when the stock is at very low levels. There have been at least two large episodic recruitment events in the Bay of Fundy since 1981 and the potential of an additional event in SPA 3 in 2007, all apparently originating from stock sizes in the lower range of those observed during this period. The potential impact of environment and habitat suitability issues on recruitment dynamics have been discussed elsewhere (Caddy 1979, Smith and Rago 2004, Orensanz

et al. 2006) but to date there has been no demonstrable relationship between stock and recruitment for sea scallops (*Placopecten magellanicus*).

The definition of a maximum acceptable exploitation rate generally employs information of average growth, natural mortality and recruitment rate. All of these rates exhibit annual fluctuations and as a result annual changes in growth in terms of meat yield and natural mortality have been incorporated into the stock assessment over the last six years. Recruitment is modelled from the survey indices for those size classes expected to grow into the commercial size range in the following year. As noted above, the occurrence of episodic recruitment (and sometimes mortality) makes it difficult to interpret an average recruitment rate (or mortality rate) in terms of long-term population dynamics.

In 2004 an heuristic approach was proposed based upon the estimated exploitation rates (catch in year *t* divided by biomass in year *t*) and the associated changes in biomass for various stocks over the periods covered by the assessment model (DFO 2004). Excluding those years where episodic recruitment occurred, the general finding for SPA 4 and SPA 1 (based on 8–16 mile survey only) was that population biomass almost always increased following an exploitation rate of less than 0.2, while population biomass would almost always decrease following exploitation rates higher than 0.2.

Estimates of exploitation and subsequent biomass change for SPA 1A, 1B, 3 and 4 are presented in Figure 7. Regression lines were fit to the points for each area and the results indicated that an exploitation threshold of 0.2 during years of non-episodic recruitment was common for all areas except for SPA 1A (0.12). However, SPA 1A has seen high productivity in the past and it is likely that the scallop stock there can handle exploitation levels similar to the other areas.

SPA 1A: Southwest Bay of Fundy

Commercial Fishery

The 2006/2007 quota for the Full Bay Fleet in SPA 1A was 150t. This was down from 1200t in 2002/2003 and below the average (1997–2007) of recent landings (Fig. 8). Landings to 26 November 2007 were 168t for the Full Bay Fleet during the 2006/2007 fishing year. An interim TAC of 100t was for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice.

Year	Avg. 98–02	2002–2003[1]	2003–2004[2]	2004–2005	2005–2006	2006–2007	2007–2008[3]
TAC(t)	NA	1200	700	500	100	150	100
Landing (t)	182	814	462	304	180	168	42

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

[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/2003. Quotas prior to 2002 are not applicable here and landings for 1998–2001/2002 are for SPA 1A only.

[3] Interim TAC, landings to 26 November 2007.

Commercial catch rate in SPA 1A declined from a high in the late 1980s to a low in 1997. With the large 1998 year-class recruiting to SPA 1A, it peaked again in 2002, and has been declining since then (Fig. 9).

Average meat weights sampled from the catch during 2006/2007 were 10 to 15% higher than those sampled during the 2005/2006 fishing season and are consistent with fishing on an older population with little recruitment (Table 1).

Survey

In SPA 1A, resource surveys have been conducted annually since 1981 in the 8 to 16 mile area off of Digby, 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. Since 2005, survey coverage has been consistent in the 8 to 16 mile area.

Since the 1998 year-class recruited to the fishery 2001/2002 in the this survey area, recruitment has been minimal and the abundance of commercial size scallops has been fished down (Fig. 10). While there are higher than average densities of scallops in the 20 to 40 mm range (mainly along the SPA 4 border, Fig. 5), the strength of this year-class (possibly 2006) cannot be evaluated until next year's survey when these animals will be larger and more vulnerable to the survey gear.

Annual survey tows have also been conducted in the 2 to 8 mile Youngs Cove and Hampton strata (east of SPA 4) since 1984. This survey series indicates that the large 1984 and 1985 year-classes seen in the 8 to 16 mile survey and SPA 4 were also abundant in this area, although the 1998 year-class does not appear to have been as strong here as in those other survey areas (Fig. 12 and 13).

There has been an increasing amount of survey coverage in the parts of SPA 1A outside of the 8 to 16 mile area and the 2 to 8 mile Youngs Cove and Hampton strata in recent years (this 'outside' area will be referred to as the Middle Bay South area). During 1997–2006, a range of 2 to 41 survey tows have occurred annually in this area (an exception is 2003 during which no tows were conducted). The 1998 year-class was not picked up in the survey here but the commercial size index did increase in 2002 when this year-class was recruiting in the other areas of SPA 1A (figs. 14 and 15). There appears to have been an increase in 2005 and 2006 possibly due to recruits picked up in the 2005 survey. The survey index for 2007 indicates a decline in the abundance of commercial size scallops.

Average meat weights calculated from survey data have increased (8 to 16 mile and 2 to 8 mile) or stayed the same in the three survey areas of SPA 1A (Fig. 16).

The delay-difference model was fitted to a combined survey biomass estimate weighted by survey area and catches from SPA 1A from 1997 to 2007. This is the first time that this model has been applied to all of the surveys and catch data from SPA 1. The missing survey biomass estimate for 2003 in the Middle Bay South area was estimated using the average of the 2002 and 2004 estimates. While meat weight/shell height data was available in each area, growth information was confined to 1996 data for the 8 to 16 mile area only. The combined survey biomass estimates for commercial size scallops are presented in Figure 17 along with the posterior predicted values and associated 95

percent credible regions from the model fit. The posterior means are almost an exact fit to the observed survey estimates.

Commercial catch rate data (Fig. 9) were also included in the model and evaluated using the DIC method (Deviance Information Criterion, Spiegelhalter et al. 2002). The DIC measure for the model with the survey data alone was 958.274 compared with 1079.040 when both survey and commercial catch rate data were used. The criterion indicates that the model with the smaller DIC measure be preferred suggesting that after including the survey data, the commercial data did not add any significant information to the model.

Model diagnostics based on the posterior predictive distributions indicate that the model fits the data quite well as all of the probabilities of drawing a more extreme observation from the marginal posterior distributions are very close to 0.5 and do not exceed the 0.025 and 0.975 bounds for extreme values (Fig. 18).

An evaluation of the performance of the model with respect to estimating and forecasting biomass shows that there are little or no retrospective problems with the model and the forecasts of biomass in the following year (for 2005, 2006, and 2007 using data up to and including 2004, 2005, and 2006, respectively) are quite stable (Fig. 19).

Stock Status and Forecast

In previous documents (e.g., Smith et al. 2007) catch levels in the current and next year are evaluated in terms of the probability of the resultant exploitation rate exceeding 0.2 determined using the posterior distribution from the delay-difference model. For example, a catch of 150 t in 2007/2008 results in a median exploitation rate of 0.14 with a 0.16 probability of exceeding an exploitation rate 0.2 (column labelled “This year” in Table 2). The probability calculation incorporates all of the uncertainties built into the model with respect to estimation and process (model) error. Assuming that 150 t will be landed in 2007/2008, the right hand side of Table 2 evaluates potential catches for 2008/2009 in the same manner.

In this document we have included an additional column in the table labelled as “Last year” that provides the right hand of the table for last year’s actual catch (i.e., 2006/2007) as means of evaluating year-to-year variation in advice provided by this method. While, this kind of model was not for the same data that was used in last year’s stock assessment the calculations can be made as if this model was used. Our interpretation of this column for Table 2 is that using last year’s data, the model forecasts of expected exploitation rates for 2007/2008 were supported by this year’s data and model results, although the probabilities of exceeding 0.2 were in general somewhat more pessimistic using data previous to this year. Granted this is only one year’s comparison but it does suggest that given the tight relationship in Figure 19, the expected exploitation rates in the following year are likely to be very close to the realized estimates once the model is fitted to next year’s data.

Overall the table of posterior probabilities indicates that catches less than or equal to 150 t in 2007/2008 should result in exploitation rates less than 0.20 and no change in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change drastically over that time. Catches of 200 and higher are forecast to result in a decline in biomass. Catches of 150 t or less in 2008/2009 should result in a low probability of exceeding the exploitation rate of 0.2.

There appears to be the potential for limited recruitment in the 8 to 16 mile area along its border with SPA 4 in two to three years, otherwise recruitment is expected to be below average in the SPA 1A area.

SPA 1B: Northern/Upper Bay of Fundy

Commercial Fishery

In 2006/2007 the Full Bay fleet landed 220 t against a quota of 200 t. The Mid (MB) and Upper Bay (UB) fleets had a shared quota of 200 t and their combined landings were 173 t (Fig. 20).

Full Bay

Year	Avg. 98–02	2002–2003[1]	2003–2004[2]	2004–2005	2005–2006	2006–2007	2007–2008[3]
TAC(t)	NA	100	200	200	225	200	50
Landing (t)	210	33	210	228	145	220	15

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

[2] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/2003. Quotas prior to 2002 are not applicable here and landings for 1998–2001/2002 are for SPA 1B only.

[3] Interim TAC, landings to 26 November 2007.

Mid and Upper Bay

Year	Avg. 98-02	2003	2004	2005	2006	2007
TAC(t)	76	150	150	200	225	200
MB: Landing (t)	39	145	166	1531	137	93
UB: Landing (t)	13	61	85	51	49	80

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

In SPA 1B, the Full Bay Fleet log records do not contain complete data (location, catch, and effort) until 1982. For the Mid-Bay Fleet, catch rate can only be calculated for the period since 1992, and for the Upper Bay Fleet since 1997. Commercial catch rate have either increased slightly (Full Bay and Mid-Bay) or stayed the same (Upper Bay) in 2007 relative to last four years and all are above the low levels of the mid to late 1990s (Fig. 21).

Meat weights sampled from the Full Bay fleet indicate increased meat weights in 2007 compared to 2006 (Table 3). For Mid-Bay, and Upper Bay fleets meat weights during 2007 were similar to those reported for the previous year in all three areas (Cape Spencer, Middle Bay North, and Upper Bay; Tables 4–5).

Survey

In SPA 1B, resource surveys have not covered the whole area consistently. Surveys off of Digby were expanded to the Cape Spencer grounds in 1996, and the Upper Bay area was added after 2000. The part of SPA 1B that is within SFA 28B and outside of Cape Spencer (Middle Bay North area) has been covered as time permitted. Due to research vessel problems, the 2004 survey only covered the Cape Spencer grounds and 6 stations in the Middle Bay North area. Since 2005, the study has been conducted by a commercial vessel and coverage in SPA 1B has been more extensive than in previous years (Fig. 3).

In the Cape Spencer area, while there have been no especially strong year-classes recruiting to the fishery, recruitment has been generally sufficient to maintain the mean number per tow of commercial size scallops above 100 scallops per tow since 1999 (figs. 22 and 23).

In the remaining part of SPA 1B that is within SFA 28B (Middle Bay North area), a range of 6 to 69 survey tows have been conducted annually since 1997. Again, like the Cape Spencer area, there has been no indication of strong year-classes in the area (figs. 24 and 25) although there are areas of high density near the Upper Bay line (figs. 3–5).

DFO surveys have been conducted in the Upper Bay area since 2002 (only one tow was made in 2001), however, no stations were fished there in 2004. There appears to be consistent recruitment since 2005 mainly in the western portion of the Upper Bay area near the Middle Bay North survey area (figs. 26, 27, 4, and 5).

Average meat weights based on survey data have increased in all three survey areas in SPA 1B by between 20 and 30 percent (Fig. 28).

The delay-difference model was fitted to a combined survey biomass estimate weighted by survey area and catches from SPA 1B from 1997 to 2007. The survey biomass indices for Upper Bay and Middle Bay North appeared to be very similar in trend and magnitude and therefore the Middle Bay North survey estimates were used to fill in for missing survey years in the Upper Bay survey (Fig. 29).

While meat weight/shell height data was available in each area, growth information was confined to 1996 data for the 8 to 16 mile area only. The combined survey biomass estimates for commercial size scallops are presented in Figure 30 along with the posterior predicted values and associated 95 percent credible regions from the model fit. The posterior means are almost an exact fit to the observed survey estimates.

Model diagnostics based on the posterior predictive distributions indicate that the model fits the data quite well as all of the probabilities of drawing a more extreme observation from the marginal posterior distributions are close to 0.5 and do not exceed the 0.025 and 0.975 bounds for extreme values (Fig. 31).

Commercial catch rate data (Fig. 21) were also included in the model and evaluated using the DIC method (Deviance Information Criterion, Spiegelhalter et al. 2002). The DIC measure for the model with the survey data alone was 1000.690 compared with 1355.510 when both survey and commercial catch rate data were used. The criterion indicates that the model with the smaller DIC measure be preferred suggesting that after including the survey data, the commercial data did not add any significant information to the model.

Biomass forecasts for SPA 1B deviated from the in-year estimated biomass for 2007 (Fig. 32). The trend lines estimated for 2005 and 2007 were similar and after 2004 differ from the trend line calculated for the 2006 data. This deviation of 2006 from the other two may be due to the lower meat weight-at-shell height observed in 2006 in Cape Spencer. However, we are using a growth model particular to the 8 to 16 mile survey area and therefore may not be appropriate for scallops in SPA 1B. In addition, a constant growth curve is assumed in the model which will limit the model's ability to accommodate changes in growth over time.

Stock Status and Forecast

Potential catches for 2007/2008 and 2008/2009 are evaluated for SPA 1B in a manner similar to SPA 1A (Table 6). Comparing exploitation estimates and probabilities of exceeding 0.2 for 2007/2008 for data up to 2006 and 2007 shows that the results were not as close as they were for SPA 1A. The lower estimates of exploitation and higher probabilities using the 2007 may both reflect the much higher meat weights in 2007 relative to 2006. Assuming these higher meat weights continue catches of 400 t or less in 2007 and 2008 will likely result in exploitation rates less than 0.2. Again assuming that the higher meat weights continue, the population is expected to grow an average of 9 percent in biomass by next year's survey for a catch of 400 t.

SPA 3: Brier, Lurcher, and St. Mary's Bay

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 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, after which 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. 33). 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.

Commercial Fishery

Year	Avg. 98–02	2003	2004	2005	2005–2006	2006–2007	2007–2008
TAC(t)	213	200	300	300	200	200	50[1]
Landing (t)	177	225	151	208	174	119	13[2]

[1] interim beginning of season TAC.
[2] reported as of 26 November 2007

Landings for the 2006/2007 fishing year were 119 t against a TAC of 200 t (Fig. 33). An interim TAC of 50 t was granted for October/November of the 2007/2008 fishing season and the most recent record of landings against the TAC was 13 t.

Commercial catch rate has declined in this area since the high of 2003 and the 2007 estimate of 14.6 kg/h is just above the long-term median (1996–2006; Fig. 34). October catch rates are also just above the median. Effort declined in 2007 relative to recent years (Fig. 35).

Relatively few meat weight samples were collected in SPA 3 during 2006/2007. The available data suggest that average meat weights for 2006/2007 were higher than those reported for the previous fishing year in the Brier and Lurcher areas (Table 7).

Survey

Annual research vessel surveys have been conducted un the Brier Island and Lurcher Shoal areas 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 has been conducted in June since 2004. Due to coverage and design, only the results from the 1996 to 2006 surveys are comparable.

The survey for 2007 was redesigned as a repeated station or double sampling design similar to that used in SPA 6 in 2006 (Smith et al. 2007). A total of 150 tows were allocated to this survey of which 37 were randomly chosen from tows conducted in 2006 and the remainder were randomly chosen over the whole area. This survey design can potentially provide a number of benefits. If the mean number per tow in the repeated tows in 2007 are correlated with the mean number per tow in 2006, this relationship can be used to increase the precision of the mean of the random tows in 2007. In addition, the repeated tows allow one to test for significant change in mean number per tow between the two years without the need of a population dynamics model.

The mean number per tow for commercial size scallops in 2007 was significantly correlated with commercial size scallops with or without recruits in 2006 (Fig. 36, Table 8). While one tow (tow 100) was highly influential on the relationship, the correlation continued to be significant at the 0.05 level when the data from tow 100 were excluded.

Incorporation of the repeated tows reduced the variance of the mean number of commercial size scallops in 2007 by 36 percent when all of the data was used and 26 percent when tow 100 was excluded (Table 9). The expected decrease in variance for 150 random tows relative to the 113 used would be 25 percent and so using the repeated stations and the same total number of tows we gained an additional 11 percent decrease

in variance. However, when tow 100 is excluded the expected decrease for 149 random tows would have also been 25 percent, only one percent less than was obtained from using the repeated stations. Comparison of estimates between the two years suggest that there was no significant change in mean number per tow (Table 10).

The 2007 survey estimated higher than average abundances of scallops in the 10 to 40 mm size range in the Brier/Lurcher area (Fig. 37). 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. Signs of good recruitment in the past have not always panned out into actual recruitment (e.g., estimates in 2000 and 2004). High catches of pre-recruits have generally been found in the deeper waters of the Lurcher portion of the survey area where growth rates tend to be lower than areas closer inshore and to the north in the Brier portion of the survey (Fig. 38). These deeper areas may contain marginal scallop habitat and the pre-recruits may not survive in sufficient numbers to become higher than average recruiting year-classes. However, the important difference with the catches of pre-recruits in the 2007 survey was that the high catches were found over a broader area and closer inshore than usual. Better estimates of the strength of this year-class should be available from the 2008 survey once these scallops grow another year and become more vulnerable to the survey gear.

The mean numbers per tow of commercial size scallops in the Brier/Lurcher area have declined since 2004 and the 2007 estimate appears to be little changed from that in 2006 as noted earlier (Fig. 39).

The St. Mary's Bay portion of SPA 3 has been surveyed since 1999 with no survey for 2002–2003 due to vessel constraints. A number of strong year-classes have been detected in this survey but these year-classes have rarely panned out based on the densities of commercial size scallops (figs. 40 and 41). Densities in this area are less than one half those observed in the Brier/Lurcher area.

Similar to areas in the Bay of Fundy, meat weight-at-shell height in 2007 increased in SPA 3 by approximately 10 percent over 2006 (Fig. 42).

The survey biomass indices for commercial size and recruits are presented in Figure 43. An error in the calculations for the estimate of the indices for 2006 in last year's document was discovered and corrected, resulting in a much more pessimistic view of stock status in 2006.

The increase in the commercial index for 2007 over the 2006 biomass estimate was probably due to the increase in meat weight only, given that the mean numbers per tow stayed the same over the two years (see Fig. 39).

A delay-difference model was fit to the survey data and commercial catch. While formulations of this model had performed poorly in the past, this year close attention was paid to the timing of the survey and the fishery. Prior to 2004, the survey had occurred in August when 80 percent or more of the catch had been landed while starting in 2004 the survey was in June when 10 to 20 percent of the catch had been landed. A constant growth model over time was assumed based on parameter estimates from 1996 data from the Brier/Lurcher area.

The comparison of the survey estimates with the model fit from the posterior with associated credible regions indicated that the model followed the survey estimates quite closely (Fig. 44). The model generally estimated larger recruitment indices than were observed in the data but the probability of getting larger indices from the posterior estimates did not exceed the 0.025 and 0.975 bounds (Fig. 45).

Overall, the delay-difference model fit the data well, however there are discrepancies in the fit in the last 4 years between model fits with the data up to 2004, 2005 and 2006 and the data from 2007 (Fig. 46). These differences are probably due to the higher meat weight in 2007 along with the assumption of a constant growth model. The model also predicts a continued decline from 2006 to 2007 despite the survey predicting little change in numbers and a small increase in weight. Year specific catchability coefficients for the survey estimated in the model indicate an increase in catchability in the 2007 survey relative to 2006. This increase in the year specific rate may be due to the impact of large catches of the 10 to 40 mm scallops.

Commercial catch rate data (Fig. 34) were also included in the model and evaluated using the DIC method (Deviance Information Criterion, Spiegelhalter et al. 2002). The DIC measure for the model with the survey data alone was 923.752 compared with 1049.320 when both survey and commercial catch rate data were used. The criterion indicates that the model with the smaller DIC measure be preferred suggesting that after including the survey data, the commercial data did not add any significant information to the model.

Stock Status and Forecast

The model indicates that the 2006/2007 catch level resulted in a median exploitation of 0.36 with a probability of exceeding 0.2 of 0.83. In Figure 46 the delay-difference model used for SPA 3 predicts the biomass to June 2008 assuming that 20t are removed between October 1, 2007, and May 31, 2008. Evaluation of the impact of various catch levels on the population are conducted assuming the remainder of the catch (i.e., minus 20t) is removed starting in June through to the end of September (table below). A total catch of 50 t in 2007/2008 is expected to result in a probability of 0.29 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% decrease in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. The population biomass is expected to decline for all of the catch levels given below.

Catches in 2007/08 (meats, t)	Median Exploitation	$Pr(e_{2007/2008}) \geq 0.2$	Expected Decline in Biomass (%)
50	0.13	0.29	8.7
100	0.32	0.68	27.1
150	0.52	0.84	47.0
175	0.71	0.96	70.3

The 2008 survey should provide a better estimate of the strength of the recruitment for 2009. Measures to enhance protection of these pre-recruits should be considered.

SPA 4: Digby

Commercial Fishery

Landings data in what is now SPA 4 are available from 1976 to 2006 (Fig. 47). The season extends from 1 October to 30 April. Total landings were 68 t in 2006/2007 against a TAC of 100 t. An interim TAC of 100t was for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice. As of the Quota Cap report of 26 November 2007, 36 t had been landed from SPA 4 against this interim TAC.

Year	Avg. 98–02	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008
TAC(t)	250	1200	1000	550	150	100	100[1]
Landing (t)	221	1097	945	535	133	68	36[2]

[1] Interim TAC set in 2006 for Oct. 1, 2007.

[2] Landings as of 26 November, 2007.

Effort has been declining in SPA 4 over the last years after the above average 1998 year-class was fished out (Fig. 48). The commercial catch rate in 2006/2007 was unchanged from 2005/2006 at 11.38 (kg/h) (Fig. 49). The higher October catch rate (15.9 kg/h) may be mainly due to increases in meat weight at shell height in 2006.

In general, the fishery is continuing to concentrate on older scallops as indicated by the large meat weights in 2004/2005, 2005/2006, and 2006/2007 compared to 2003/2004 (Table 11).

Survey

Research vessel surveys, using a stratified random design, have been conducted since 1981. Prior to 1991, surveys were stratified according to the spatial pattern of the preceding year's commercial catch rate. Since 1991, the strata boundaries have been set to a fixed set of coordinates and remain unchanged since their original definition. 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. Since 2005, surveys of SPA 4 have been completed in August each year as planned.

Similar to last year (Smith et al. 2007), the higher densities of commercial scallops are found in the strata below Digby Gut and in the Digby Gut to Delap's Cove stratum (Table 12). Numbers per tow in the deeper areas have not changed appreciably since 2006. Densities of scallops with shell heights in the 20 to 50 mm range were four to five times higher in the Digby Gut to Gulliver's Head strata in 2007 compared to 2006 (Table 12, Fig. 50). Over all strata, the mean number of scallops in this size class in 2007 were three times the mean number in 2006 but still well below the densities observed for the 1998 year-class at the same size (Fig. 50). We have not determined the ages of these scallops yet but they are probably two year-olds and therefore will not recruit to the fishery until 2009/2010. The survey estimate of total numbers (uncorrected for catchability) indicate that the current population levels are at a level similar to that in the mid-1990s with below

average recruitment expected in the upcoming year (Fig. 51). Estimates of the mean number of clappers remain low in SPA 4 in 2007 (Fig. 52).

The 2007 survey estimates were presented to a meeting of the Full Bay Fleet on September 7, 2007 showing areas where we had found the small scallops (Fig. 5). In turn, 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 October 2, 2007 (Maritimes Region Close Time Variation Order, 2007-123, Fig. 53). This closed area will be re-evaluated after the 2008 survey.

The trend in survey biomass estimates mirrors that for survey numbers indicating that there was little change in biomass in 2007 relative to 2006 (Fig. 54). Similar to the other areas in the Bay of Fundy, average meat weight (measured during the survey) also had increased in SPA 4 in 2007 (Fig. 55).

As in previous years, the delay-difference model was fit to the survey and catch data. At present a growth model based on 1996 data is used for all years while work continues on evaluating changes in growth over time. The model fits the survey biomass indices quite closely (Fig. 56). On the other hand, the model generally tends toward smaller estimates of the number of clappers than was observed during the mass mortality event in 1989/1990 (Fig. 57). Overall, the model also tends toward higher recruitment estimates than were observed most years. However for both the clapper and recruitment estimates, the posterior probabilities were within the 95 percent bounds and therefore consistent with the model.

Model estimates of population biomass for commercial size and recruit scallops are given in Fig. 58. Last year's predicted biomass for 2007 (using the catch of 68 t) was very close to the biomass predicted for 2007 in this assessment (Fig. 59). The prediction for 2008 assumes a catch of 100 t in 2007/2008 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2007.

Commercial catch rate data (Fig. 49) were also included in the model and evaluated using the DIC method (Deviance Information Criterion, Spiegelhalter et al. 2002). The DIC measure for the model with the survey data alone was 2027.870 compared with 2317.130 when both survey and commercial catch rate data were used. The criterion indicates that the model with the smaller DIC measure be preferred suggesting that after including the survey data, the commercial data did not add any significant information to the model.

Stock Status and Forecast

The performance of using posterior probabilities for evaluating catch scenarios shows that last year's estimates of expected median exploitation rates as well as the probabilities of exceeding 0.2 for 2007/2008 were quite accurate (Table 13). This year's results support last year's recommendation of 100 t as being a catch corresponding to an exploitation rate less 0.2. A catch of 100 t in 2007/2008 is expected to result in an 8 percent increase in biomass for next year assuming that meat weights-at shell height do not change. Given a catch of 100 t in 2007/2008, a total catch of 100 t in 2008/2009 should result in a probability of 0.46 that the exploitation rate will exceed 0.20.

SPA 5: Annapolis Basin

Commercial Fishery

The fishery in the Annapolis Basin (SPA 5), is only open to the Full Bay fleet and 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. 60).

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 the 1999 and 2000 year-classes. Landings in 2007 were 3.8 t against a TAC of 10t.

Year	Avg. 98-02	2003	2004	2005	2006	2004
TAC(t)	11.4	10.0	25.0	10.0	15.0	10.0
Landing (t)	10.1	12.2	20.4	13.3	6.1	3.8

Commercial catch rate in 2007 (10.8 kg/h) was lower that observed for 2006 (12.5 kg/h) and below the long term median of 19.8 kg/h (1977–2006; Fig. 61). Effort declined in 2007 by about 32 percent over that in 2006 (Fig. 62).

There have been no meat weight samples collected from this fishery since 2005 probably because the fishery only lasts a few days in January.

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. Since 2005, the SPA 5 surveys have been completed in the June of each year.

Shell height frequencies indicate that the 2004 year-class has started to recruit to commercial size (Fig. 63). This year-class is much weaker than the 1999 and 2000 year-classes that contributed to the higher than average commercial size indices in 2002 and 2003 which in turn were reflected by the higher commercial catch rates in those same years (Fig. 61).

The largest concentration of scallops of commercial size were in the stations closest to the inner side of the basin (Fig. 64). The mean number per tow of commercial size scallops in 2007 exhibited an increase of 50 percent over 2006 and is now the third highest in the series albeit similar to estimates in 1999, 2004 and 2005 (Fig. 65). Pre-recruits and recruits were found in low densities throughout the survey area (Fig. 64). Recruitment appears to be below average for the next two years. Clappers were found in only 7 of the 20 tows (Fig. 65).

The meat weight-at-shell height has increased in this area similar to other areas in the Bay of Fundy (Fig. 66).

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 increased due the recruitment of the 2004 year class.

Survey estimates indicate that the commercial size portion of the population (131/tow) is above the 1997–2006 median (120/tow) but little recruitment is expected for the next two years. The commercial catch rate also indicates a decline in the population of commercial size scallops. The TAC for 2007 should not exceed the average catch of 10 t over the period 1997 to 2007 excluding the high catch in 2004.

SPA 6: Grand Manan and Southwest New Brunswick

Commercial Fishery

Year	Avg. 98-02	2003	2004	2005	2006	2007
TAC(t)	156	195	195	195	100	140
FB: Landing (t)	19	21	8	5	5	5[1]
MB: Landing (t)	125	66	74	81	86	65[1]

[1] Landings as of 26 November, 2007.

The 2007 SPA 6 quota for the Full Bay fleet was 35 t. Full Bay landings by area for 2007 were 2.3 t, 1.7 t, 0.1 t, and 0.8 t for SPA 6A, B, and D (Duck Island Sound; Fig. 67), respectively. This fleet has not caught its quota for the last 6 years as it has directed its effort to the other areas (Fig. 68).

The 2007 quota for the Mid-Bay fleet was 105 t. Mid-Bay landings for 2007 by area were 21.7 t, 11.4 t, 23.3 t and 6.6 t for SPA 6A, B, C and D, respectively.

The commercial catch rate for the Full Bay fleet increased from 2000 to 2004 but given the low levels of effort, this index may not be tracking changes in the population (Fig. 69). The Mid-Bay catch rate may be a better reflection population trends as it is based on somewhat higher levels of effort. As it is, this index does not indicate any large changes in the last 10 years.

Average meat weights sampled from the Mid-Bay Fleet catch in 2007 are similar to those reported for 2006 and are consistent with fishing on an older population with little recruitment (Table 14). No meat weight samples were collected from the Full Bay Fleet during 2007.

Survey

Research surveys in SPA 6 were initiated in 1979 but discontinued after 1991 until a new series was started in September 1997. This new series covered 6A and 6B and stations in 6C were included after 1999. In 2004, mechanical problems with the *CCGC J.L. Hart* resulted in cancelling the survey that year. The Bay of Fundy survey in 2005 was conducted on the *F/V Royal Fundy* and partial coverage of SPA 6 was completed. Only two random stations were made in 6A, with 33 stations in 6B and 7 stations in 6C. A

number of exploratory stations were also made to learn more about the spatial distribution of the scallop beds. In 2006, coverage was more extensive with a total of 180 stations allocated to 6A, 6B and 6C.

In 2006 a repeated or double sampling survey design was used to deal with the patchiness of the distribution of scallops in SPA 6B. In 2007 this survey design was extended to all areas with 124 survey stations chosen randomly and 45 stations randomly chosen from locations surveyed in 2006. The survey was conducted in July using the *F/V Royal Fundy*. Coverage was similar to last year (169) over 6A, 6B and 6C, however like last year the sampling in 6C did not extend along the New Brunswick shore to Mace's Bay (Fig. 70).

The survey showed similar distributions of scallops observed in the 2006 survey, however large catches of small scallops were limited to Duck Island Sound (6D) and Campobello Island (6A) (Fig. 70). The large numbers of scallops <65 mm found in the Seal Cove channel and Three Islands (6B) area in 2006 did not appear as 65–79 mm scallops in these areas in 2007.

The shell height frequency for SPA 6A in 2007 indicates that the recruitment detected in 2006 has entered the fishery but the numbers of potential recruits for 2008 are low relative to estimates in 2006 for 2007 (Fig. 71).

Scallops with shell heights between 35 and 50 mm appear to be above average in abundance in SPA 6B with most of these scallops located in Duck Island Sound (figs. 70 and 72).

Survey catches in 6C are generally small and the scale has been adjusted in Fig. 73 to range from 0 to 3.0 scallops (0 to 30 in figs. 71 and 72).

The repeated double sampling method was described in detail in Smith et al. (2007) and above for the SPA 3 survey. A total of 11, 26 and 8 stations from the 2006 survey in SPA 6A, 6B and 6C, respectively were retained for the 2007 survey. Additional random stations were chosen to estimate the variance of the mean (6A: 42, 6B: 44 and 6C: 38). Correlation coefficients were calculated between catches of commercial size scallops (≥80 mm shell height) in the two years as well as between numbers per tow of commercial size and recruits in 2006 with commercial size scallops in 2007 for each of the areas (figs. 74 and 75; Table 15).The correlations for 6A were the highest but were driven by one large tow in the two years. The correlation in 6B was based on the largest sample size and was the most stable. In 6C, the correlation coefficient was marginally significant probably due to the small sample size. For 6A and 6B there appeared to be little difference between using numbers of commercial size alone or commercial plus recruits from the 2006 survey.

Gains in precision from using the repeated design ranged from 47 percent for SPA 6A and 6B to 22 percent for 6C. Expected gains due to increased sample size were 21 percent for 6A, 38 percent for 6B and 18 percent for 6C. Overall, the method continues to be promising in providing gains in precision above those expected due to increased sample size when the sample size of the repeated stations is large enough to adequately estimate the correlation between the two years (i.e., 6B and possibly 6A).

The differences between the means for 2006 and 2007 for each of the three areas were evaluated in Table 17. Differences are generally considered significant if these differences

are 2 to 3 times the standard error (similar to a Students *t*-test). Only the differences for 6A when using commercial plus recruits in 2006 and for 6C for either measure from 2006 did the ratio of differences to standard error exceed 2.

Annual trends for commercial size and recruits are presented for each sub-area in figs. 76 to 78. For each annual estimate of commercial size scallops, except for 2007, 95 percent confidence intervals were calculated using the bootstrap method and empirical (percentile) limits. Confidence limits have not been defined for the repeated sample design estimates as of yet and the limits for 2007 are simply twice the standard error of the combined mean (see above and Table 16). Comparison across confidence intervals suggests that there has been little change in mean numbers per tow of commercial size scallops in 6A (Fig. 76). While the 2007 estimate for 6B is similar to 2006 both are significantly lower than 2003 (Fig. 77). The estimates for 6C may not be indicative of trends in this area due to the small sample sizes in the past and the incomplete coverage of the entire area (Fig. 78). However, the survey estimate indicates a decline in abundance in 6C from 2006.

Stock Status and Forecast

Evidence from the Mid-Bay commercial catch rates and the surveys suggest that the abundance of commercial size scallops remains unchanged from 2006 in SPA 6A and 6B and is possibly declining in SPA 6C. Above average recruitment was detected in SPA 6A and 6B, however in the case of the latter, this recruitment appears to be confined to Duck Island Sound.

There is no evidence to advise increasing the TAC over its current level.

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Table 1. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 1A for the 2005/2006, 2006/2007, and 2007/2008 fishing seasons. All samples collected by an 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 < 8g		
Month	N	Mean	Min.	Max.	per 500 g.	Samples	Mean	Min.	Max.
2005/2006 Season									
November	98	21.0	9.7	36.7	23.8	2	0.0	0.0	0.0
February	214	20.2	7.5	44.0	25.7	4	0.4	0.0	1.8
March	955	18.4	8.6	41.1	27.4	17	0.0	0.0	0.0
April	1093	21.5	5.4	45.0	24.5	22	1.4	0.0	17.8
May	1932	19.2	5.1	42.4	27.2	35	1.1	0.0	10.4
July	195	16.1	7.3	27.9	31.9	3	2.1	0.0	6.2
August	403	15.5	4.6	29.3	33.3	6	3.4	0.0	12.0
September	66	16.2	8.0	24.8	30.9	1	0.0	0.0	0.0
2006/2007 Season									
October	89	22.5	9.8	37.1	22.5	2	0.0	0.0	0.0
November	181	22.5	8.9	39.2	22.3	4	0.0	0.0	0.0
April	226	24.3	8.5	45.2	21.8	5	0.0	0.0	0.0
May	2002	21.6	1.6	51.9	23.8	41	0.7	0.0	6.9
June	241	21.5	10.6	35.5	23.3	5	0.0	0.0	0.0
August	288	18.0	7.5	36.4	28.0	5	0.3	0.0	1.7
September	114	17.7	8.0	32.2	28.3	2	0.0	0.0	0.0
2007/2008 Season									
October	108	28.6	11.6	46.1	17.9	3	0.0	0.0	0.0

Table 2. Posterior probabilities for the exploitation rate exceeding the provisional reference exploitation level (0.20) for Scallop Production Area 1A. Posterior median exploitation rate given in brackets. The column labelled “Last year” refers to the posterior probabilities calculated using data up to and including 2006 and the reported catch for 2006/2007.

Catches in 2007/2008			Pr ($e_{2008} \geq 0.2$) Catches (t) in 2008/2009			
	Last Year	This Year				
(meats, t)	Pr ($e_{2007} \geq 0.2$)		75	100	150	200
100	0.09 (0.09)	0.01 (0.09)	0.03 (0.07)	0.08 (0.09)	0.26 (0.14)	0.46 (0.19)
150	0.27 (0.14)	0.16 (0.14)	0.04 (0.07)	0.10 (0.10)	0.30 (0.15)	0.50 (0.20)
200	0.46 (0.19)	0.43 (0.19)	0.05 (0.08)	0.163 (0.11)	0.34 (0.16)	0.53 (0.21)
250	0.60 (0.23)	0.64 (0.24)	0.08 (0.09)	0.07 (0.11)	0.39 (0.17)	0.57 (0.22)

Table 3. Statistics from meat weight samples of the Full Bay fleet scallop vessels in Scallop Production Area 1B for the 2006 and 2007 fishing seasons. All samples collected by an 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 Per 500 g	Number of Samples	Pecent < 8 g		
Month	N	Mean	Min.	Max.			Mean	Min.	Max.
				CAPE SPENCER					
2005/2006 Season									
February	92	12.1	6.1	22.7	41.3	1	5.4	5.4	5.4
March	275	18.6	7.6	41.3	27.2	5	0.4	0.0	1.8
April	57	18.1	12.5	24.2	27.6	1	0.0	0.0	0.0
May	197	15.5	8.4	35.5	32.5	3	0.0	0.0	0.0
August	307	13.8	6.7	26.7	36.2	4	2.9	0.0	5.5
September	216	14.4	7.9	26.8	34.8	3	0.5	0.0	1.5
2006/2007 Season									
October	65	15.7	8.8	24.5	31.8	1	0.0	0.0	0.0
February	55	17.9	7.3	34.7	28.0	1	5.5	5.5	5.5
May	108	19.0	7.4	33.7	26.5	2	1.7	0.0	3.4
July	49	21.5	12.7	34.3	23.2	1	0.0	0.0	0.0
August	355	17.4	7.9	29.6	28.9	6	0.3	0.0	1.5
September	109	18.5	7.9	30.5	27.1	2	0.9	0.0	1.9
2007/2008 Season									
October	41	24.7	13.8	35.9	20.2	1	0.0	0.0	0.0
				MIDDLE BAY NORTH					
2005/2006 Season									
February	60	17.3	9.4	36.4	28.9	1	0.0	0.0	0.0
March	242	16.9	6.5	27.7	29.7	4	0.4	0.0	1.5
April	88	23.8	16.0	35.6	21.3	2	0.0	0.0	0.0
May	128	16.3	9.3	25.3	30.8	2	0.0	0.0	0.0
June	51	19.5	8.9	32.5	25.6	1	0.0	0.0	0.0
July	188	17.0	7.4	31.2	30.9	3	0.8	0.0	2.4
September	82	15.8	9.5	27.9	31.7	1	0.0	0.0	0.0
2006/2007 Season									
May	133	23.7	8.0	39.3	21.5	3	0.0	0.0	0.0
August	410	20.4	6.9	44.2	25.0	8	0.4	0.0	3.6
September	224	23.6	5.3	43.0	21.8	5	0.8	0.0	3.9
2007/2008 Season									
October	40	25.0	12.4	39.0	20.0	1	0.0	0.0	0.0
				UPPER BAY					
2005/2006 Season	105	19.6	10.9	34.4	25.6	2	0.0	0.0	0.0
April									
2006/2007 Season									
January	232	13.5	4.8	25.0	37.1	3	5.1	0.0	11.5
May	45	23.0	14.7	31.9	21.7	1	0.0	0.0	0.0
August	322	18.9	4.2	43.0	26.8	6	0.9	0.0	3.5
September	67	14.9	8.2	32.2	33.6	1	0.0	0.0	0.0

Table 4. Statistics from meat weight samples of the Mid-Bay fleet scallop vessels in Scallop Production Area 1B for the 2006 and 2007 fishing seasons. All samples collected by an 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.

Month	N	Meat Weight (g)			Count Per 500 g	Number of Samples	Pecent < 8 g		
		Mean	Min.	Max.			Mean	Min.	Max.
CAPE SPENCER									
2006 Season									
February	237	19.2	4.9	36.2	26.9	4	1.0	0.0	4.0
March	359	15.7	5.3	39.6	32.3	5	4.1	0.0	8.6
August	679	12.0	4.5	28.1	43.0	7	16.5	0.0	35.9
September	146	16.9	5.9	28.7	31.1	2	1.1	0.0	2.3
2007 Season									
January	75	15.9	6.9	31.1	31.5	1	5.3	5.3	5.3
February	53	17.2	5.9	31.5	29.1	1	1.9	1.9	1.9
March	143	14.5	7.2	23.1	34.6	2	1.4	0.0	2.9
April	62	21.1	8.0	31.6	23.7	1	0.0	0.0	0.0
August	41	21.8	9.3	38.8	22.9	1	0.0	0.0	0.0
September	259	18.3	9.1	33.4	27.5	5	0.0	0.0	0.0
MIDDLE BAY NORTH									
2006 Season									
February	395	15.0	5.7	33.8	34.9	5	3.9	0.0	11.2
March	335	20.3	5.8	38.8	25.2	6	1.8	0.0	5.3
April	48	21.7	10.3	38.9	23.1	1	0.0	0.0	0.0
August	347	17.1	7.3	33.2	29.4	5	0.8	0.0	2.6
September	62	18.0	9.7	28.4	27.8	1	0.0	0.0	0.0
2007 Season									
January	58	16.0	8.9	23.9	31.3	1	0.0	0.0	0.0
February	56	16.6	6.5	29.3	30.2	1	5.4	5.4	5.4
March	155	14.5	5.0	27.8	34.7	2	3.0	0.0	6.1
April	73	14.5	5.4	27.7	34.4	1	5.5	5.5	5.5
UPPER BAY									
2006 Season									
January	272	14.8	11.0	23.0	34.0	4	0.0	0.0	0.0
February	46	22.2	14.0	35.5	22.5	1	0.0	0.0	0.0

Table 5. Statistics from meat weight samples of the Upper Bay fleet scallop vessels in Scallop Production Area 1B for the 2006 and 2007 fishing seasons. All samples collected by an 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 < 8g		
Month	N	Mean	Min.	Max.	per 500 g.	Samples	Mean	Min.	Max.
				Upper Bay					
2006 Season									
January	208	14.6	9.3	23.1	34.2	3	0.0	0.0	0.0
February	132	15.3	10.6	21.2	32.6	2	0.0	0.0	0.0
March	130	16.5	12.1	23.7	30.2	2	0.0	0.0	0.0
September	179	17.0	12.0	24.9	29.3	3	0.0	0.0	0.0
2007 Season									
January	199	15.3	10.1	23.4	32.7	3	0.0	0.0	0.0
February	140	14.4	8.8	21.0	34.8	2	0.0	0.0	0.0
April	137	14.8	7.7	24.3	33.9	2	0.7	0.0	1.4
August	257	15.8	12.0	24.0	31.7	4	0.0	0.0	0.0
September	64	15.7	7.8	23.4	31.9	1	1.6	1.6	1.6

Table 6. Posterior probabilities for the exploitation rate exceeding the provisional reference exploitation level (0.20) for Scallop Production Area 1B. Posterior median exploitation rate given in brackets. The column labelled “Last year” refers to the posterior probabilities calculated using data up to and including 2006 and the reported catch for 2006/2007.

Catches in 2007/2008			Pr ($e_{2008} \geq 0.2$) Catches (t) in 2008/2009			
	Last Year	This Year				
(meats, t)	Pr ($e_{2007} \geq 0.2$)		300	400	500	600
300	0.38 (0.17)	0.08 (0.14)	0.17 (0.13)	0.36 (0.17)	0.54 (0.21)	0.68 (0.25)
400	0.59 (0.23)	0.38 (0.18)	0.20 (0.13)	0.39 (0.17)	0.57 (0.22)	0.70 (0.26)
450	0.65 (0.25)	0.55 (0.21)	0.22 (0.14)	0.42 (0.18)	0.59 (0.23)	0.72 (0.27)
500	0.72 (0.28)	0.66 (0.23)	0.23 (0.14)	1.43 (0.18)	0.61 (0.23)	0.73 (0.28)

Table 7. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 3 for the 2005 to 2007/2008 fishing seasons. All samples collected by an 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 Per 500 g	Number of Samples	Pecent < 8 g		
Month	N	Mean	Min.	Max.			Mean	Min.	Max.
				ST. MARYS BAY					
2005 Season									
June	186	28.0	8.2	56.9	18.9	5	0.0	0.0	0.0
July	68	30.2	13.8	74.4	16.6	2	0.0	0.0	0.0
2005/2006 Season									
June	163	26.1	5.5	51.3	20.2	4	1.7	0.0	2.9
2006/2007 Season									
June	92	22.8	9.5	66.0	23.0	2	0.0	0.0	0.0
August	50	21.0	7.9	33.8	23.8	1	2.0	2.0	2.0
				BRIER ISLAND					
2005 Season									
June	47	21.7	14.1	43.6	23.0	1	0.0	0.0	0.0
July	199	21.6	6.9	56.8	23.8	4	0.4	0.0	1.7
August	235	17.6	4.8	37.4	28.8	4	3.9	0.0	10.3
2005/2006 Season									
October	341	17.7	6.0	33.9	28.4	6	2.1	0.0	9.3
November	54	19.0	10.7	29.4	26.2	1	0.0	0.0	0.0
June	112	20.1	6.8	43.9	27.7	2	1.4	0.0	2.7
July	66	15.3	7.7	28.8	32.8	1	1.5	1.5	1.5
August	63	16.4	7.9	28.3	30.5	1	1.6	1.6	1.6
September	112	18.8	8.7	31.1	27.2	2	0.0	0.0	0.0
2006/2007 Season									
August	93	25.0	6.3	47.7	21.8	2	2.5	0.0	4.9
September	38	26.4	17.7	40.9	19.0	1	0.0	0.0	0.0
				LURCHER SHOAL					
2005 Season									
June	72	14.0	8.0	26.1	35.7	1	0.0	0.0	0.0
July	280	13.9	8.0	27.6	36.4	4	0.0	0.0	0.0
August	67	15.7	11.1	21.4	31.8	1	0.0	0.0	0.0
2005/2006 Season									
April	85	12.6	7.4	20.4	39.6	1	2.4	2.4	2.4
May	312	13.3	6.2	22.5	37.9	4	2.8	1.3	5.1
June	341	14.5	4.3	49.9	35.0	5	3.6	0.0	14.5
July	193	15.8	8.0	27.2	31.9	3	0.0	0.0	0.0
August	786	17.1	7.5	34.8	29.6	13	0.6	0.0	2.8
September	562	18.4	8.6	36.9	27.7	10	0.0	0.0	0.0
2006/2007 Season									
May	80	12.7	7.7	22.9	39.3	1	1.3	1.3	1.3
July	111	18.3	7.4	34.1	27.4	2	0.9	0.0	1.9
August	96	21.6	10.8	34.3	23.2	2	0.0	0.0	0.0
September	92	24.5	11.4	40.0	22.5	2	0.0	0.0	0.0
2007/2008 Season									
September	51	19.8	11.2	31.9	22.5	1	0.0	0.0	0.0

Table 8. Correlation between observations from tows in 2006 that were repeated in 2007 in SPA 3.

Case	2007	2006	$\hat{\rho}$	*p*-level
all tows	commercial size	commercial size	0.77	< 0.0001
		com+recruits	0.77	< 0.0001
drop tow 100	commercial size	commercial size	0.46	0.0122
		com+recruits	0.49	0.0076

Table 9. Double sample estimates of the mean number per tow using relationship between observations from tows in 2006 that were repeated in the 2007 survey of SPA 3.

Case	Components	Mean Estimate	Variance
Commercial size in 2006			
all tows	New stations	74.66	91.47
	Repeated stations in 2007	122.61	495.90
	Repeated (corrected for 2006)	97.54	160.06
	Combined	82.98	58.21
drop tow	New stations	74.66	71.28
100	Repeated stations in 2007	106.89	266.32
	Repeated (corrected for 2006)	95.81	195.77
	Combined	80.30	52.25
(Commercial+recruits) in 2006			
all tows	New stations	74.66	91.47
	Repeated stations in 2007	122.61	495.90
	Repeated (corrected for 2006)	96.36	159.88
	Combined	82.56	58.18
drop tow	New stations	74.66	71.28
100	Repeated stations in 2007	106.89	266.32
	Repeated (corrected for 2006)	95.02	191.36
	Combined	80.19	51.94

Table 10. Double sample estimates of the mean number per tow, difference between mean number per tow for 2006 and 2007 and standard error (SE) of the difference for SPA 3.

	Mean No./tow			
Case	2006	2007	Difference	SE(Diff)
Commercial size in 2006				
all tows	79.91	82.98	3.073	9.37
drop tow 100	75.60	80.30	4.701	9.67
(Commercial+recruits) in 2006				
all tows	82.47	82.56	0.085	9.37
drop tow 100	78.16	80.19	2.029	9.60

Table 11. Statistics from meat weight samples of Full Bay fleet scallop vessels in Scallop Production Area 4 for the 2003/2004, 2004/2005, 2005/2006, 2006/2007, and 2007/2008 fishing seasons. All samples collected by an 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 Per 500 g	Number of Samples	Pecent < 8 g		
Month	N	Mean	Min.	Max.			Mean	Min.	Max.
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
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
2005/2006 Season									
October	216	21.2	6.8	45.8	26.7	4	0.7	0.0	1.5
November	229	18.5	7.2	39.0	27.6	4	0.5	0.0	2.0
February	43	23.9	12.3	45.8	20.9	1	0.0	0.0	0.0
March	477	21.7	8.4	45.1	23.7	10	0.0	0.0	0.0
April	222	20.1	7.4	40.2	27.4	4	0.6	0.0	2.4
May	49	21.1	11.3	31.2	23.7	1	0.0	0.0	0.0
2006/2007 Season									
October	876	20.8	5.9	45.9	25.0	17	1.2	0.0	20.2
November	138	14.9	7.2	25.4	34.0	2	1.5	1.3	1.6
April	485	24.6	6.3	46.0	21.4	11	2.1	0.0	17.6
May	421	25.9	7.5	50.9	20.4	10	0.2	0.0	2.1
2007/2008 Season									
October	207	24.1	10.8	58.7	20.9	5	0.0	0.0	0.0

Table 12. Estimates from stratified research survey for scallops in Scallop Production Area 4, August 2007. Proportion of survey area in each stratum is given in the second column. Estimates of mean number per tow 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	12	4.97	1.50	1.27	0.54	136.55	11.05
CV to GH	0.068	6	15.07	4.83	10.10	3.70	150.82	26.70
Gulliver's Head	0.133	13	73.95	26.85	7.67	2.98	123.58	27.61
GH to DG	0.100	11	71.37	35.96	5.47	2.62	58.27	18.47
Digby Gut	0.200	21	61.22	24.41	3.65	1.05	60.33	11.26
DG to DC	0.100	13	17.00	5.91	2.57	1.45	120.94	21.98
Delaps Cove	0.133	10	86.50	18.83	22.01	5.81	60.52	12.37
Parkers Cove	0.133	13	17.35	5.73	4.17	1.57	47.58	10.24
Stratified estimates	1.000	99	46.46	7.54	6.89	1.00	91.15	6.27
Depth < 90 m		67	34.32	6.76	6.58	1.18	70.18	6.31
Depth ≥ 90 m		32	42.69	10.17	5.96	1.40	139.29	12.65

Table 13. 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. The column labelled "Last year" refers to the posterior probabilities calculated from the 2006 assessment using the reported catch for 2006/2007.

Catches in 2007/2008			Pr (e_{2008} ≥ 0.2) Catches (t) in 2008/2009				
	Last Year	This Year					
(meats, t)	Pr (e_{2007} ≥ 0.2)		50	75	100	125	150
50	0.15 (0.08)	0.08 (0.09)	0.12 (0.08)	0.27 (0.13)	0.41 (0.17)	0.52 (0.21)	0.61 (0.25)
75	0.30 (0.13)	0.26 (0.14)	0.15 (0.09)	0.30 (0.13)	0.44 (0.18)	0.55 (0.22)	0.63 (0.26)
100	0.42 (0.17)	0.44 (0.18)	0.18 (0.09)	0.33 (0.14)	0.46 (0.18)	0.57 (0.23)	0.65 (0.28)
125	0.52 (0.21)	0.57 (0.23)	0.21 (0.10)	0.36 (0.15)	0.49 (0.20)	0.59 (0.25)	0.67 (0.30)

Table 14. Statistics from meat weight samples of the Mid and Full Bay fleets scallop vessels in Scallop Production Area 6 for the 2006 and 2007 fishing seasons. All samples collected by an 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.

Month	N	Meat Weight (g)			Count Per 500 g	Number of Samples	Pecent < 8 g		
		Mean	Min.	Max.			Mean	Min.	Max.
				MID-BAY					
SPA 6A									
2006 Season									
January	761	20.1	4.3	68.0	29.0	17	1.9	0.0	11.4
February	621	16.6	5.0	56.6	37.0	12	13.6	0.0	75.0
2007 Season									
January	50	19.9	11.7	28.4	25.1	1	0.0	0.0	0.0
February	40	23.5	10.9	42.4	21.3	1	0.0	0.0	0.0
August	59	16.9	7.9	24.7	29.6	1	1.7	1.7	1.7
SPA 6B									
2006 Season									
January	654	21.0	5.2	56.5	25.2	16	1.1	0.0	8.5
February	877	21.8	5.9	65.9	24.3	23	2.2	0.0	27.9
March	105	18.3	6.9	30.8	27.4	2	0.9	0.0	1.8
2007 Season									
January	239	19.9	5.7	44.6	25.4	5	1.1	0.0	5.6
February	237	22.1	5.5	44.0	24.7	5	2.4	0.0	12.0
March	73	13.7	6.4	22.4	36.6	1	9.6	9.6	9.6
SPA 6C									
2006 Season									
January	242	30.2	10.0	81.0	18.3	7	0.0	0.0	0.0
February	825	17.5	3.7	52.8	31.5	14	4.1	0.0	33.6
March	127	16.1	8.3	30.9	31.0	2	0.0	0.0	0.0
2007 Season									
January	340	19.5	4.2	68.7	26.9	7	5.7	0.0	12.1
February	577	19.6	4.1	62.0	26.9	11	3.6	0.0	10.8
March	166	18.1	5.2	49.6	27.7	3	4.3	0.0	11.1
				FULL BAY					
SPA 6B									
2006 Season									
March	70	13.7	6.0	25.1	36.6	1	4.3	4.3	4.3

Table 15. Correlation between observations from tows in 2006 that were repeated in 2007 in SPA 6.

	2007	2006	$\hat{\rho}$	*p*-level
SPA 6A	commercial size	commercial size	0.94	< 0.0001
all tows		com+recruits	0.92	< 0.0001
drop tow	commercial size	commercial size	0.40	0.2560
5		com+recruits	0.42	0.2297
SPA 6B	commercial size	commercial size	0.68	0.0001
all tows		com+recruits	0.69	0.0001
SPA 6C	commercial size	commercial size	0.75	0.0326
all tows		com+recruits	0.55	0.1566

Table 16. Double sample estimates of the mean number per tow using relationship between observations from tows in 2006 that were repeated in the 2007 survey of SPA 6.

Case	Components	Mean Estimate	Variance
6A Commercial size in 2006			
all tows	New stations	50.14	238.57
	Repeated stations in 2007	119.57	2517.87
	Repeated (corrected for 2006)	78.22	273.23
	Combined	63.23	127.36
drop tow	New stations	50.14	110.67
5	Repeated stations in 2007	72.29	313.58
	Repeated (corrected for 2006)	67.49	405.64
	Combined	53.86	86.95
6A Commercial+recruits in 2006			
all tows	New stations	50.14	238.57
	Repeated stations in 2007	119.57	2517.87
	Repeated (corrected for 2006)	72.78	293.72
	Combined	60.29	131.64
drop tow	New stations	50.14	110.67
5	Repeated stations in 2007	72.29	313.58
	Repeated (corrected for 2006)	65.49	399.31
	Combined	53.47	86.65
6B Commercial size in 2006			
all tows	New stations	78.88	104.25
	Repeated stations in 2007	83.03	159.56
	Repeated (corrected for 2006)	71.66	114.30
	Combined	75.44	54.52
6B Commercial+recruits in 2006			
all tows	New stations	78.87	104.25
	Repeated stations in 2007	83.03	159.56
	Repeated (corrected for 2006)	72.32	123.70
	Combined	75.88	56.57
6C Commercial size in 2006			
all tows	New stations	11.44	14.27
	Repeated stations in 2007	25.35	82.10
	Repeated (corrected for 2006)	16.52	36.41
	Combined	12.87	10.25
6C Commercial+recruits in 2006			
all tows	New stations	11.45	14.27
	Repeated stations in 2007	25.35	82.10
	Repeated (corrected for 2006)	18.73	50.76
	Combined	13.05	11.14

Table 17. Double sample estimates of the mean number per tow, difference between mean number per tow for 2006 and 2007 and standard error (SE) of the difference for SPA 6.

	Mean No./tow			
Case	2006	2007	Difference	SE(Diff)
6A Commercial size in 2006				
all tows	71.45	63.23	−8.22	11.28
drop tow 5	55.43	53.86	−1.56	12.69
6A (Commercial+recruits) in 2006				
all tows	85.82	60.29	−25.53	12.06
drop tow 5	68.48	53.47	−15.01	12.64
6B Commercial size in 2006				
all tows	61.99	75.44	13.45	9.01
6B (Commercial+recruits) in 2006				
all tows	73.14	75.88	2.74	8.94
6C Commercial size in 2006				
all tows	25.30	12.87	−12.42	4.12
6C (Commercial+recruits) in 2006				
all tows	31.71	13.05	−18.66	4.48

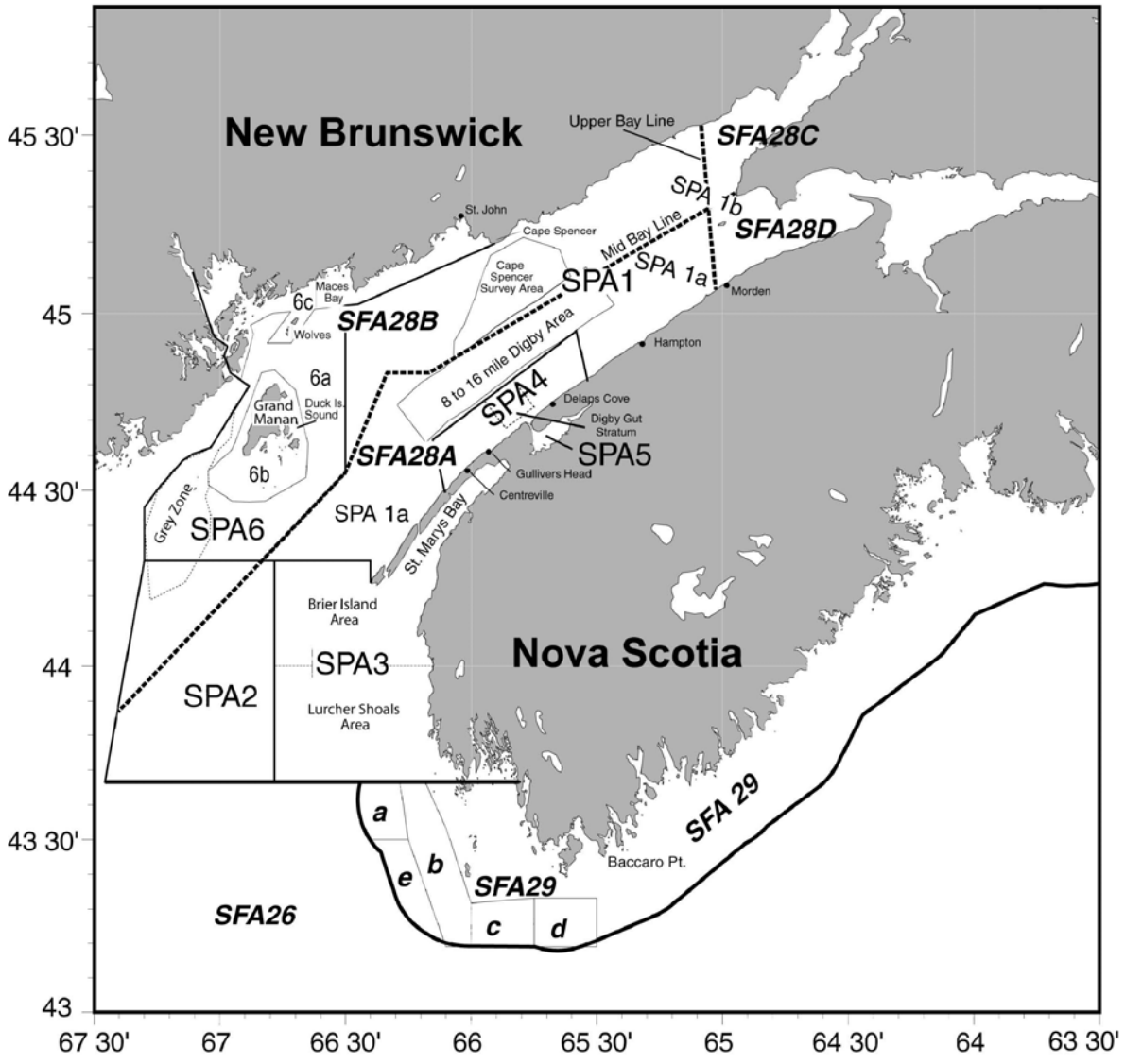

Fig. 1. Scallop Production Areas and Scallop Fishing Areas in the Bay of Fundy.

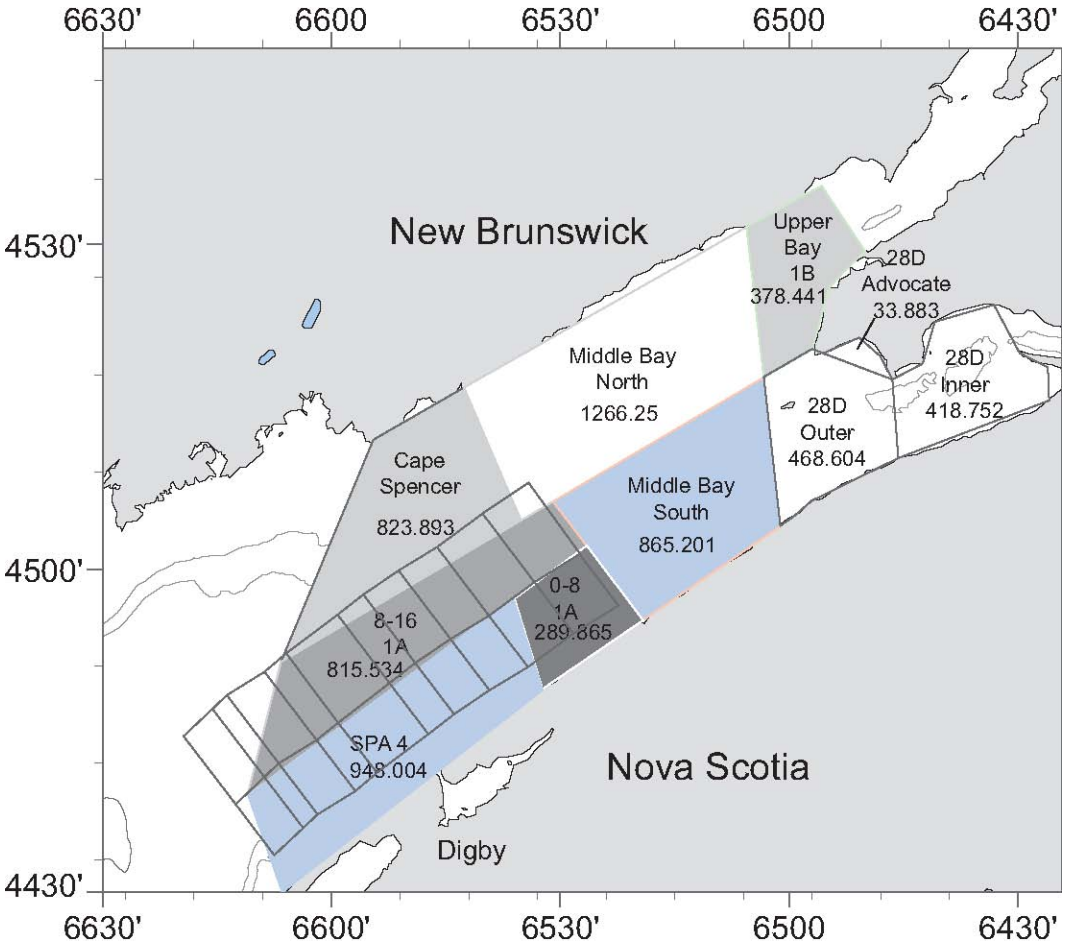

Fig. 2. Map of survey strata for the Bay of Fundy scallop survey. Area in square kilometers are given for each stratum.

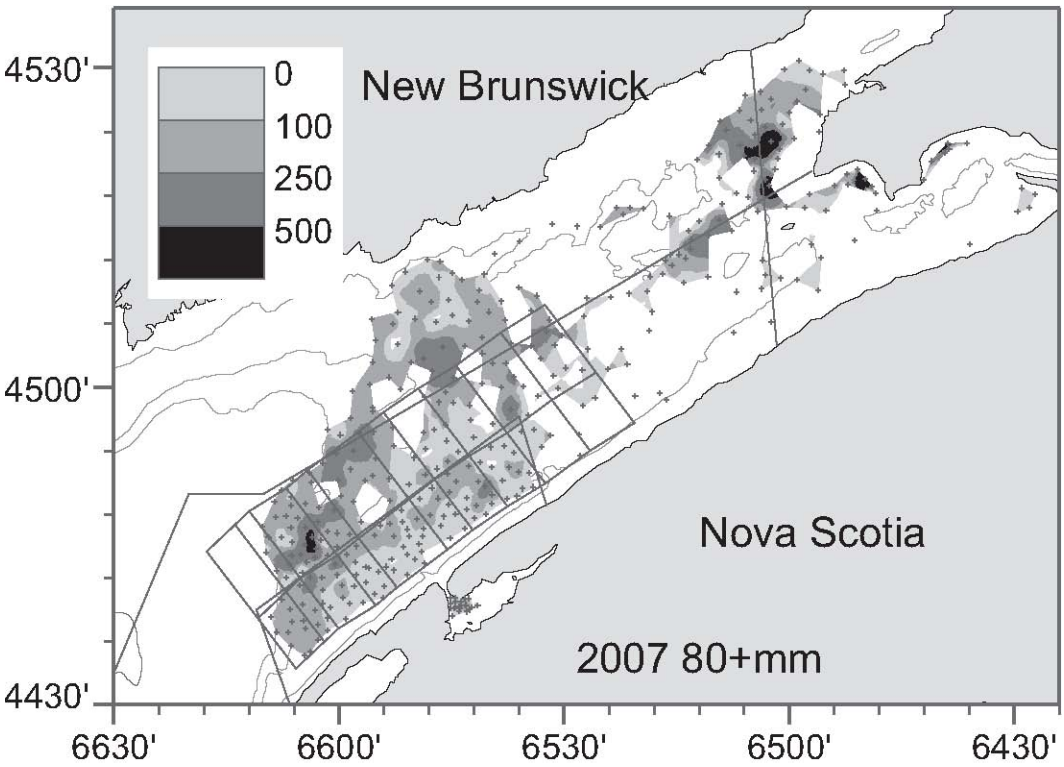

Fig. 3. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for commercial size (≥ 80 mm shell height) scallops. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated.

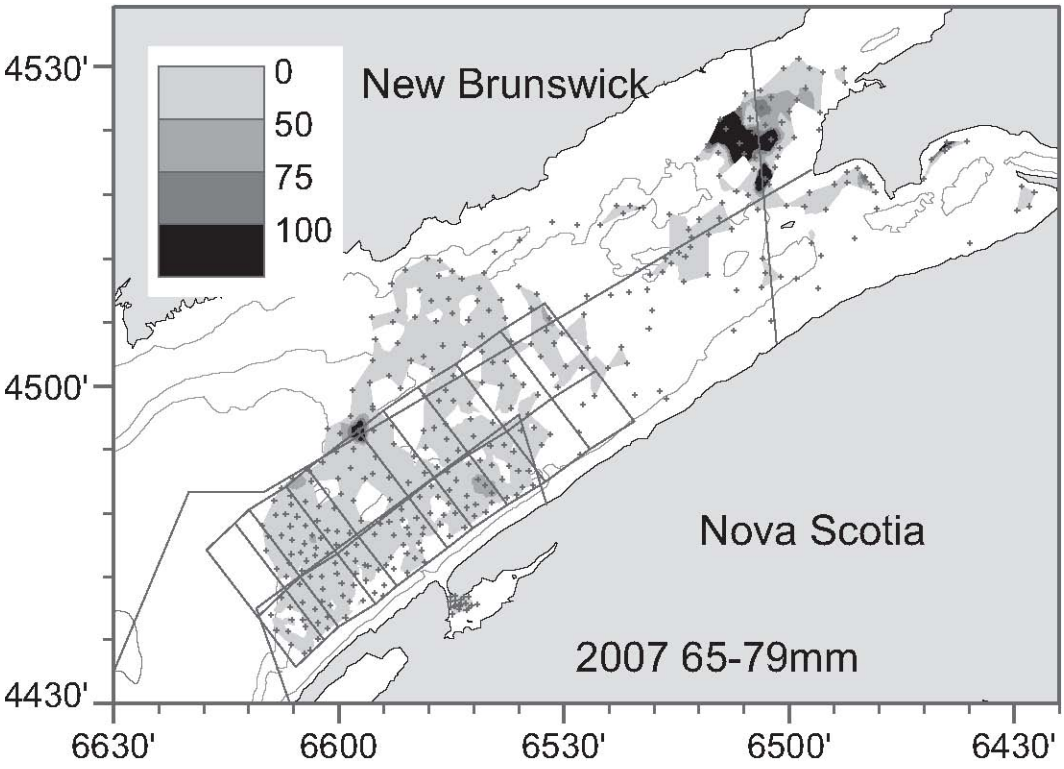

Fig. 4. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for recruit size (65 to 79 mm shell height) scallops. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated.

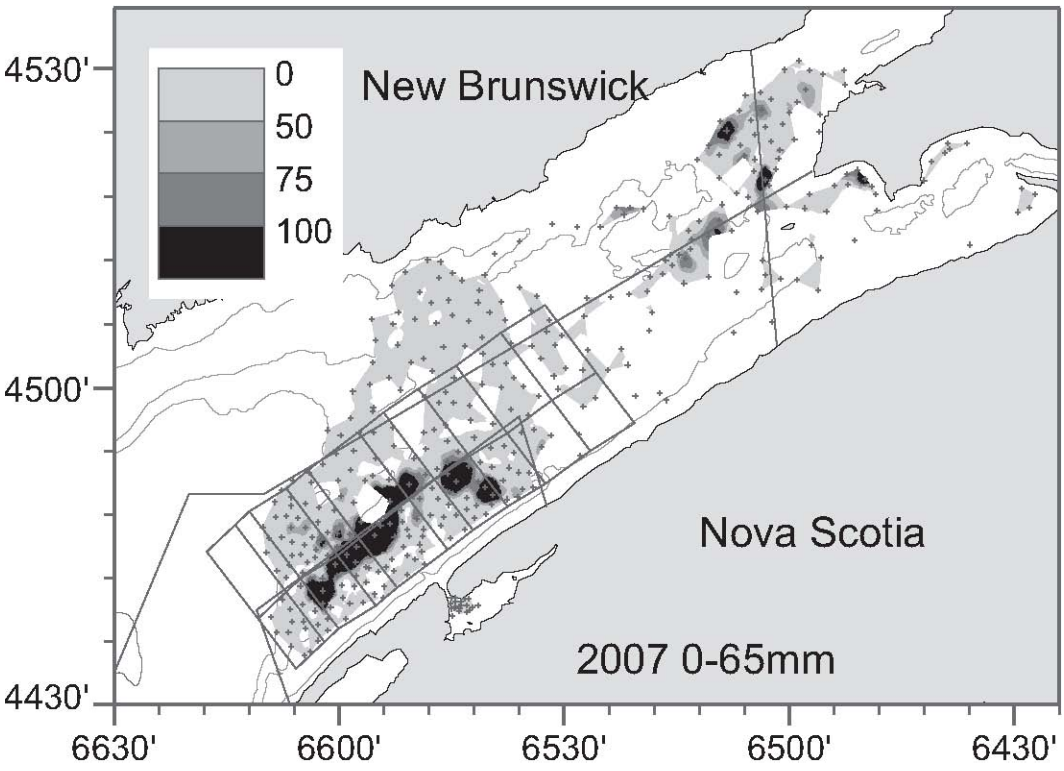

Fig. 5. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for pre-recruit size(<65 mm shell height) scallops. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated.

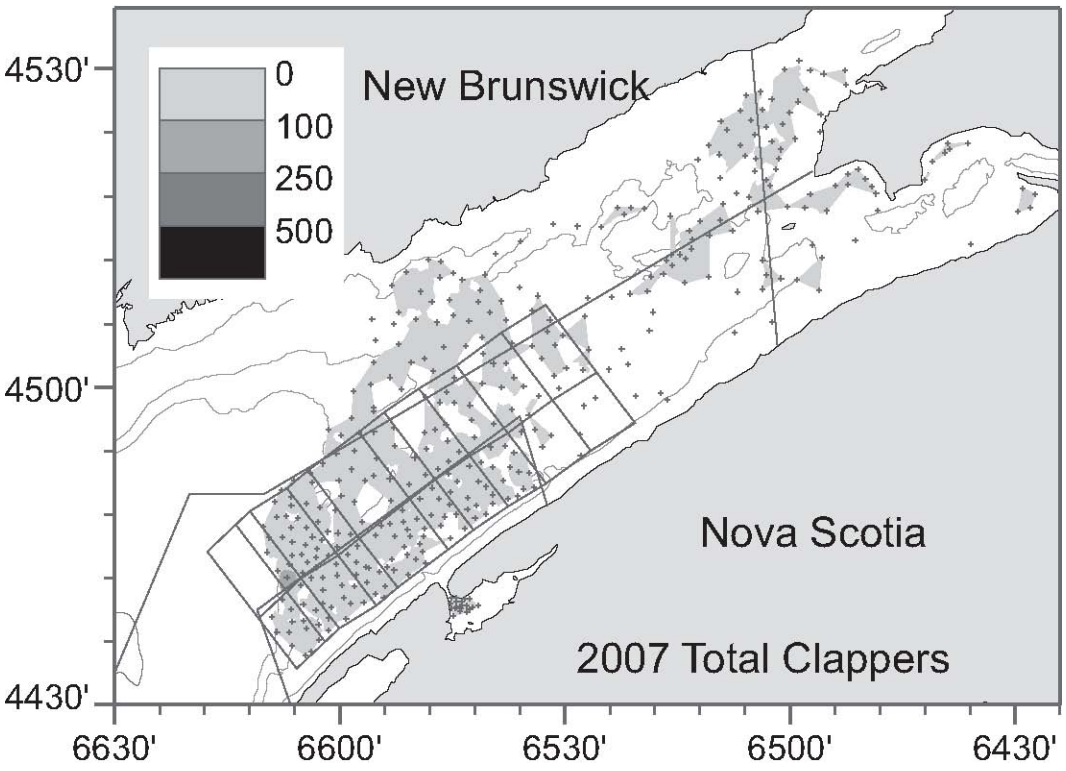

Fig. 6. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for all sizes of scallop clappers (paired empty shells). Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated.

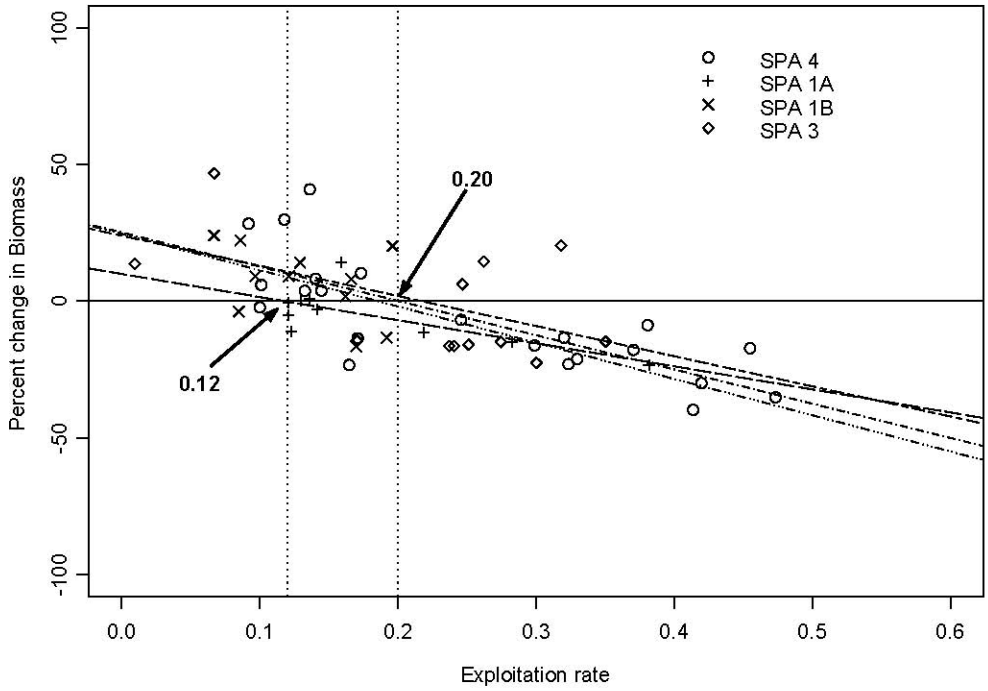

Fig. 7. Comparison of exploitation rate in year t versus percent change in biomass in year $t + 1$ for four SPAs. Lines represent regressions fit through the data for each SPA. Exploitation rate at zero biomass change based on regression lines indicated for SPA 1B, 3, and 4 (0.20) and SPA 1A (0.12).

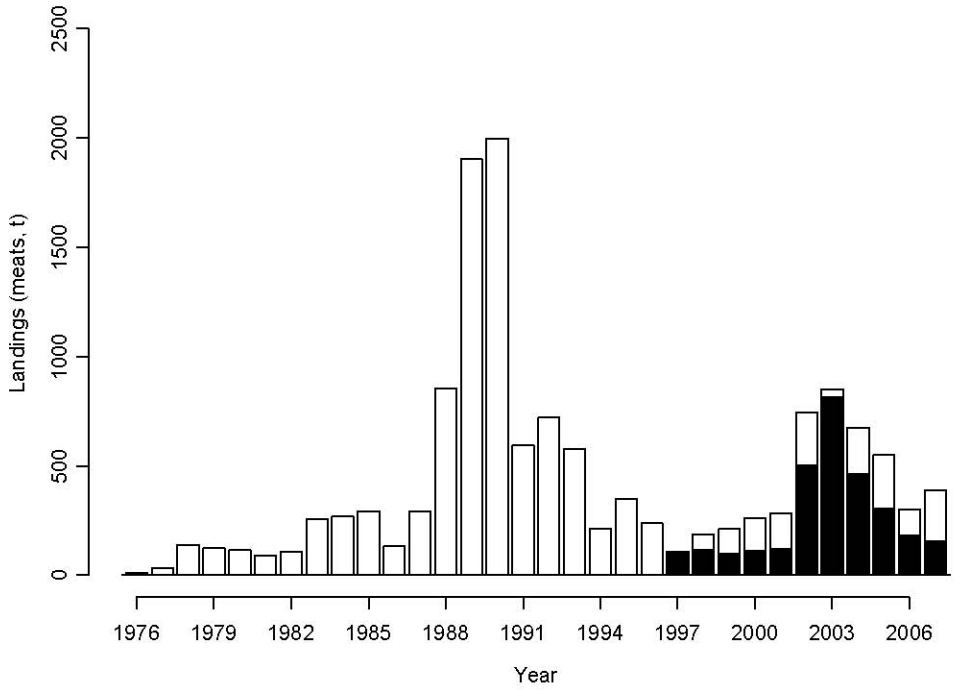

Fig. 8. Scallop landings (meats, t) in Scallop Production Area 1 by the Full Bay Fleet. Open bars represent all of SPA 1 while solid bars represent landings by the Full Bay fleet in SPA 1A.

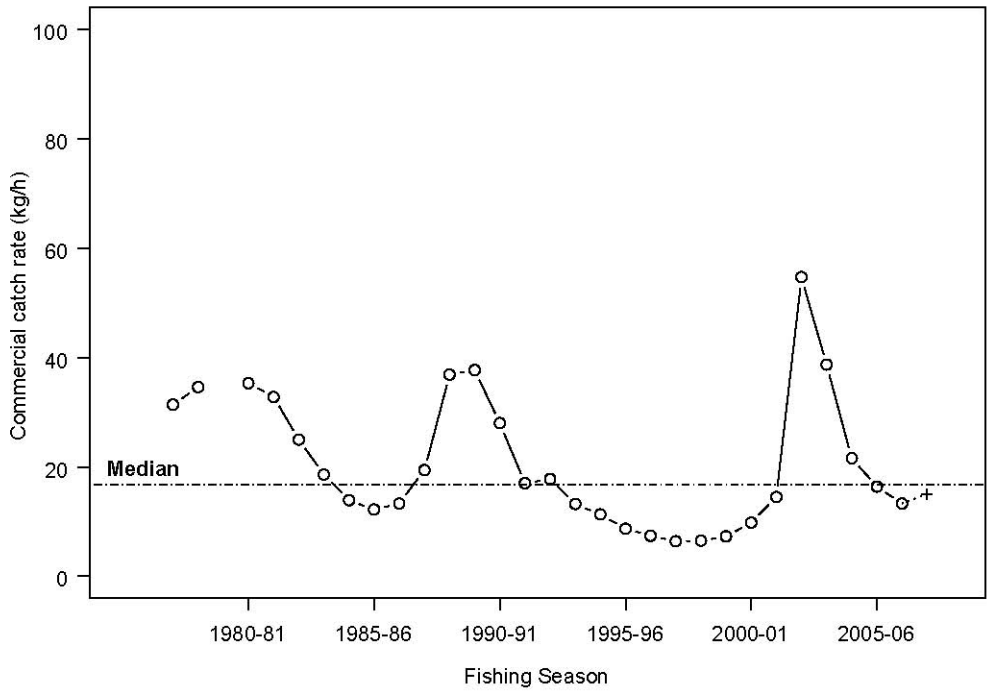

Fig. 9. Trends in scallop catch rate (kg/h) from SPA 1A. Median catch rate over the 1976–1977 to 2006–2007 period indicated. Catch rate for 2007–2008 indicated by + refers to data for October 2007 only.

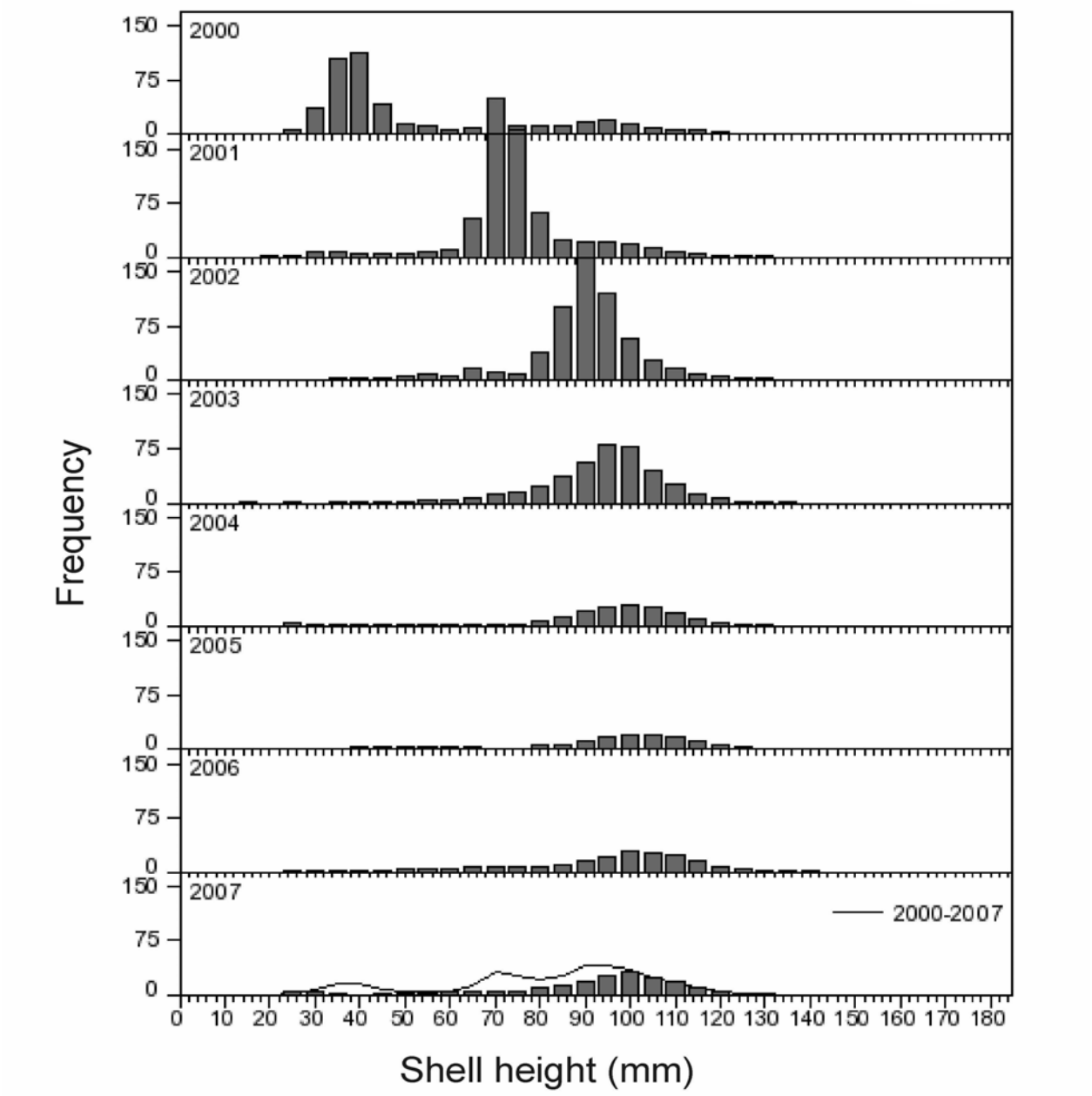

Fig. 10. Scallop shell height frequencies (mean number/tow) from the surveys of the 8-16 mile area of Scallop Production Area 1A. Surveys were conducted in June from 1981 to 2003 and in August/September from 2004 to 2007.

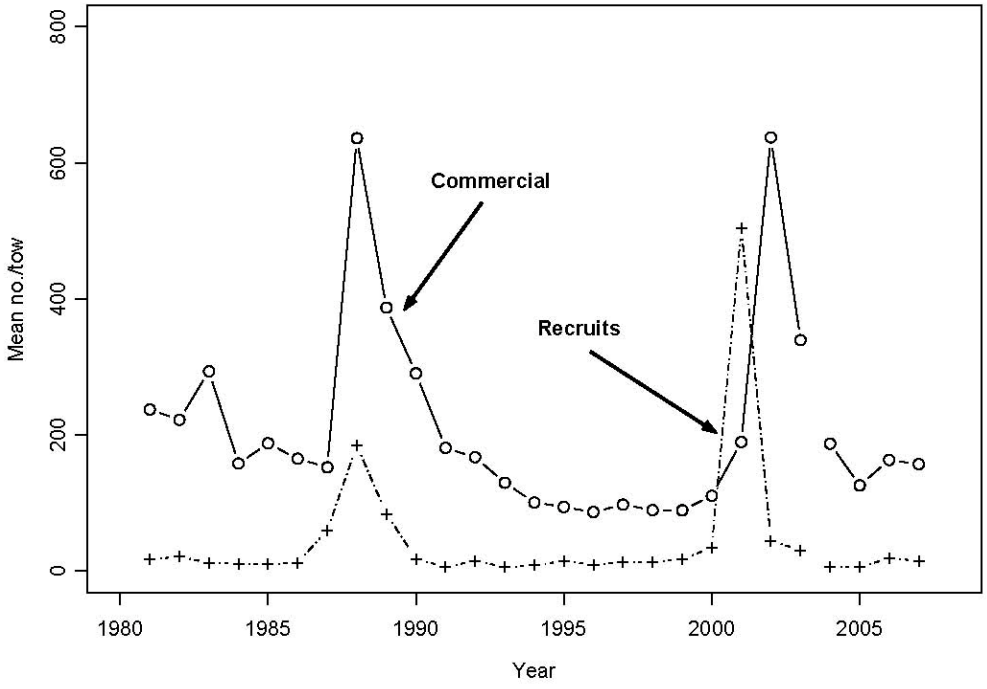

Fig. 11. Survey abundance index (mean number/tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in the 8–16 mile area of Scallop Production Area 1A. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June fro 1981 to 2003 and in August/September in 2004 to 2007.

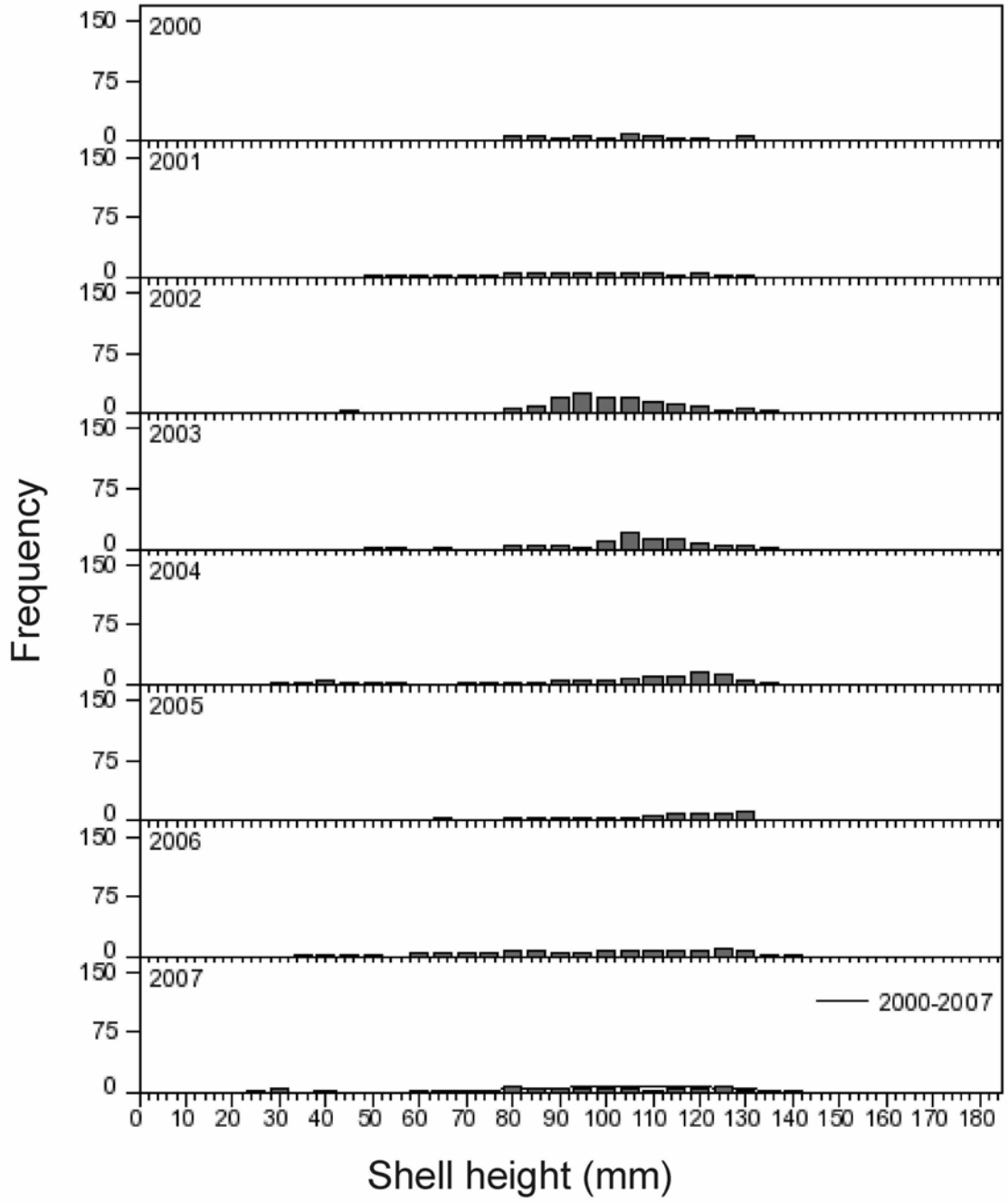

Fig. 12. Scallop shell height frequencies (mean number/tow) from the surveys of the 2–8 mile Youngs Cove and Hampton strata (Fig. 2: 0–8, 1A) of Scallop Production Area 1A.

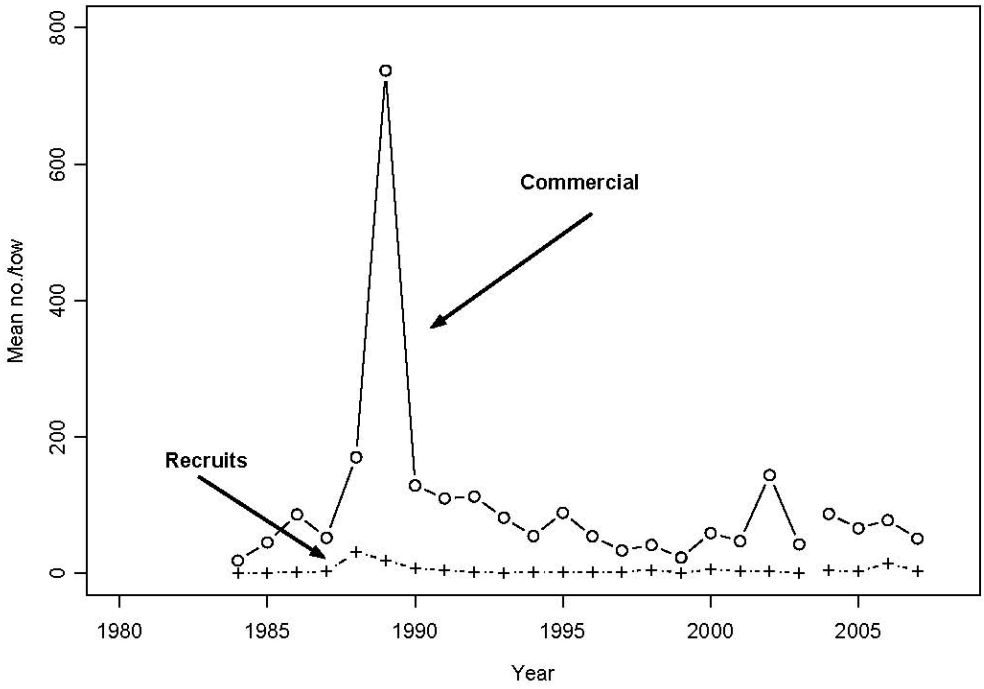

Fig. 13. Survey abundance index (mean number/tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in the 2–8 mile Youngs Cove and Hampton strata (Fig. 2: 0–8, 1A) of Scallop Production Area 1A. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 to 2007.

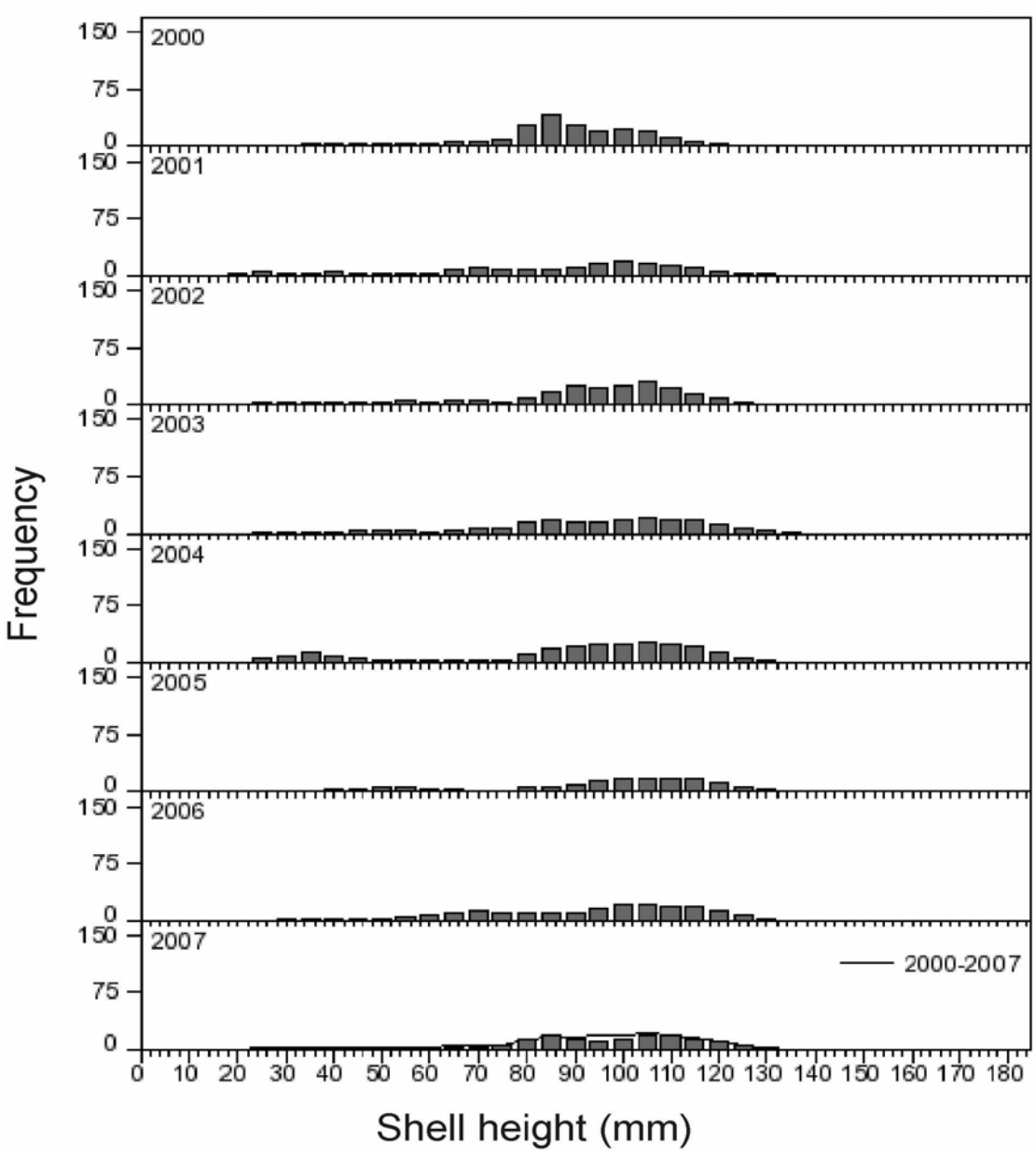

Fig. 14. Scallop shell height frequencies (mean number/tow) from the surveys of the Middle Bay South area of Scallop Production Area 1A.

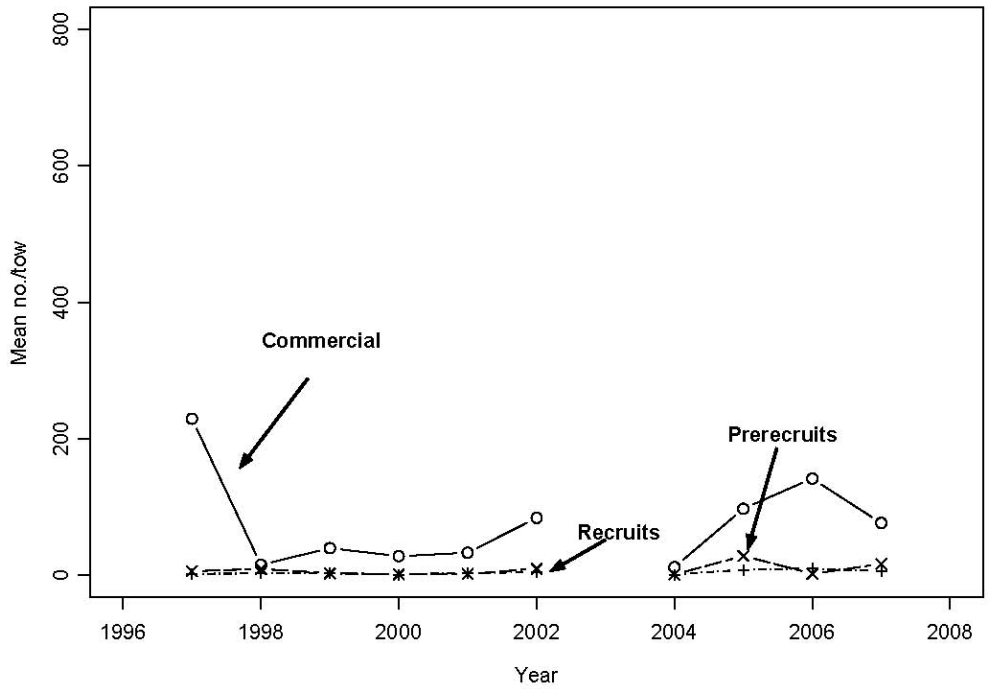

Fig. 15. Survey abundance index (mean number/tow) for commercial size (≥80 mm shell height) and recruit (65–79 mm shell height) scallops in the Middle Bay South area of Scallop Production Area 1A.

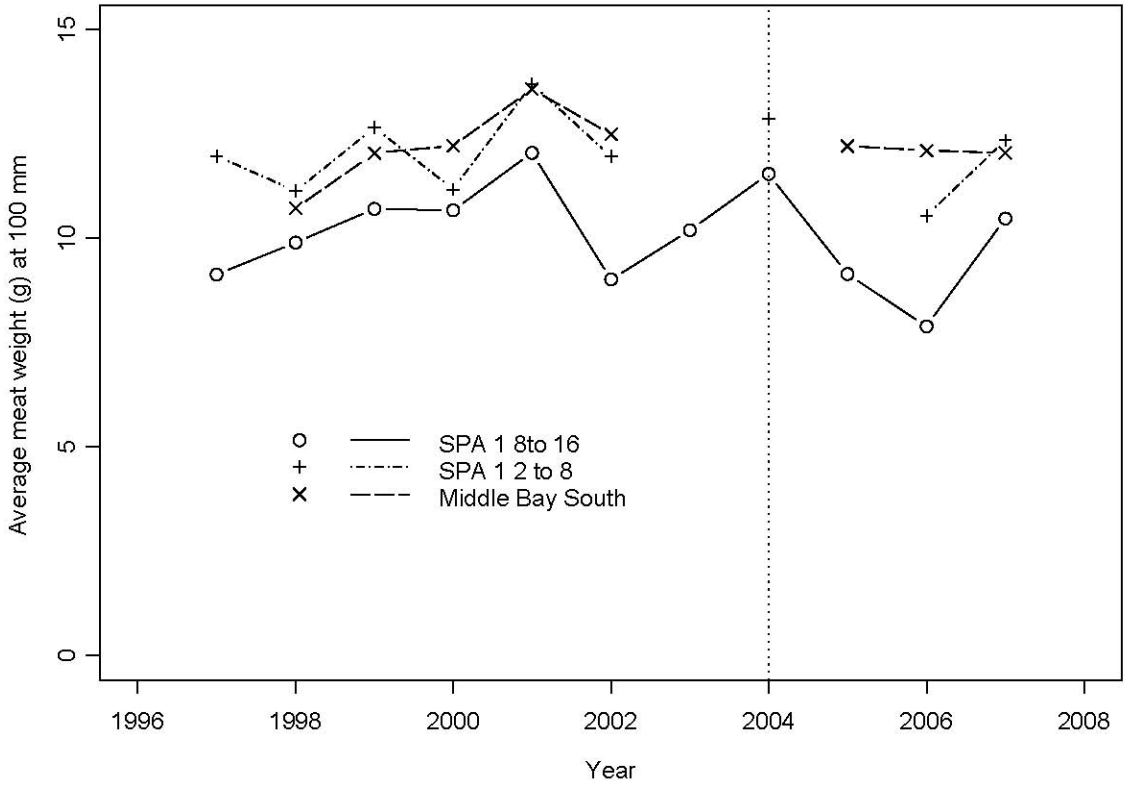

Fig. 16. Predicted meat weights for a scallop with shell height equal to 100 mm and depth equal to the mean depth for each of the survey areas in SPA 1A. Predictions come from a mixed effects model fitted to survey data with meat weight a function of shell height and depth.

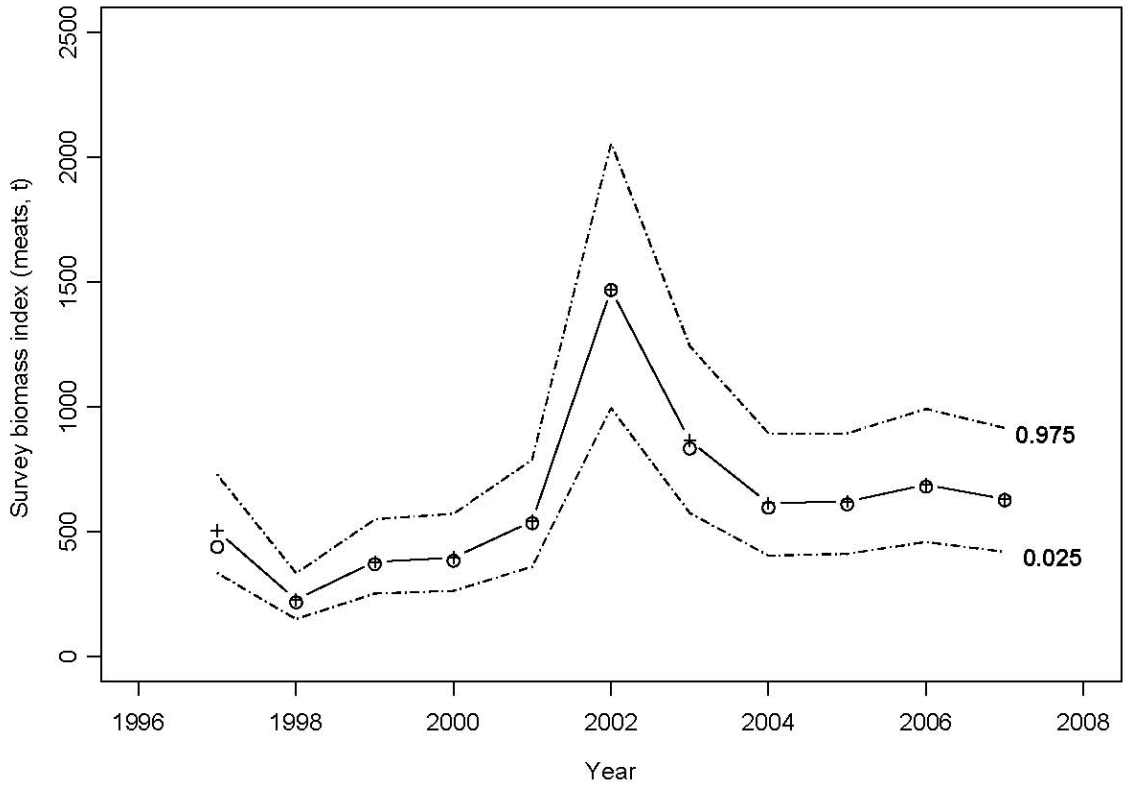

Fig. 17. Comparison of observed survey biomass estimates of commercial size scallops (+) for SPA 1A with posterior mean (o) and 95 percent credible regions (dash-dot lines) for fitted survey biomass.

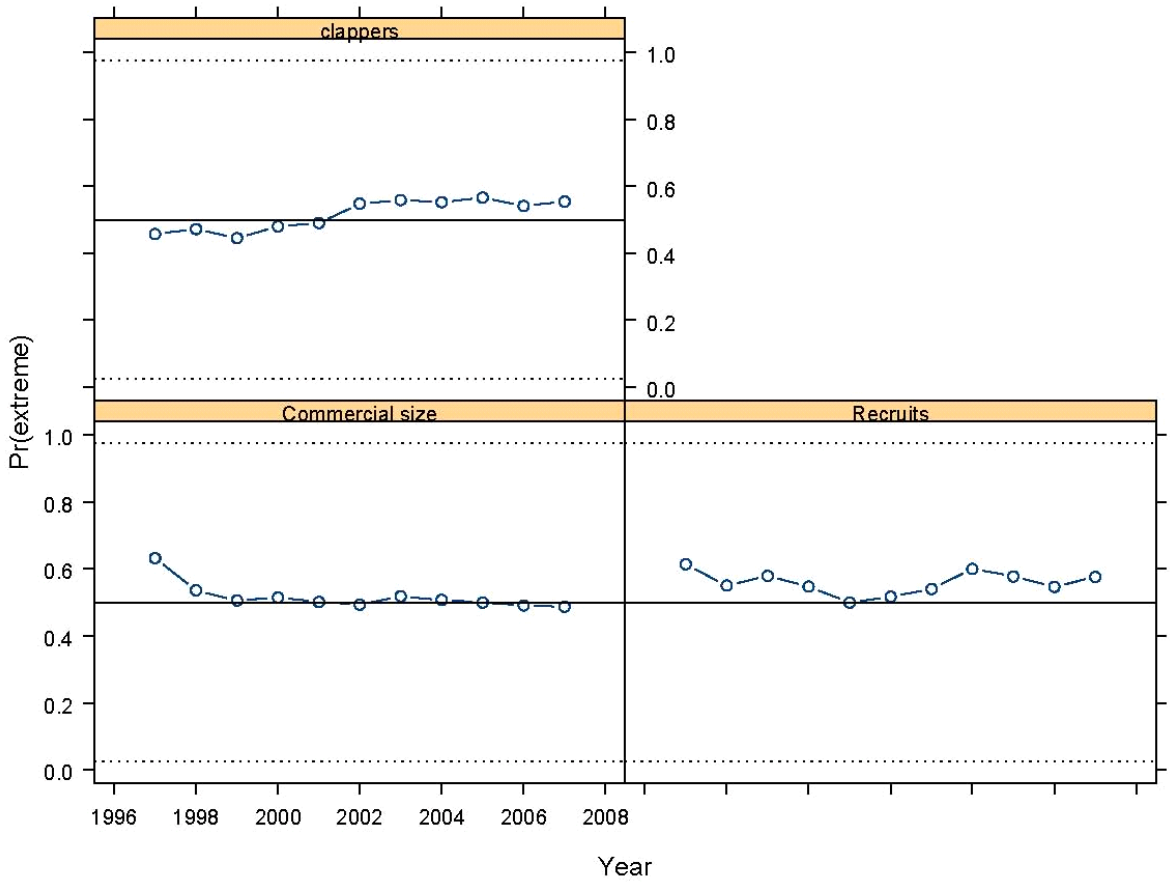

Fig. 18. Probabilities of getting larger observations then obtained for survey estimates of Biomass, recruits and clappers for the delay-difference model in SPA 1A. Dotted lines indicate probabilities of 0.025 and 0.975.

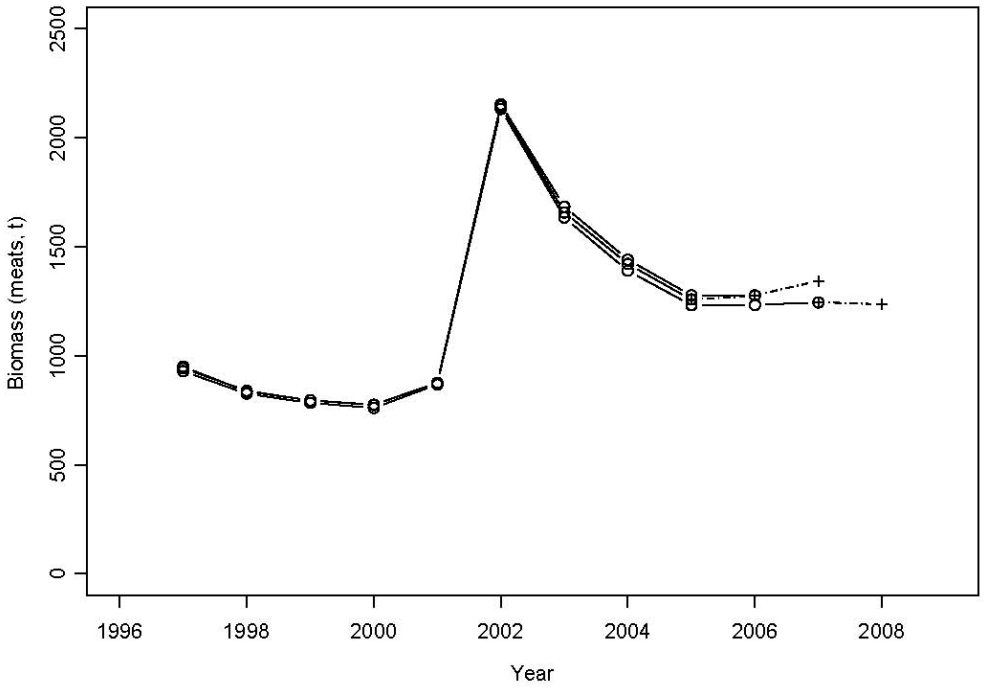

Fig. 19. Comparison of population biomass estimates of commercial size scallops (≥ 80 mm shell height) from the delay-difference population model for data up to 2005, 2006, and 2007, respectively for SPA 1A. Predictions from the model for 2006, 2007, and 2008 indicated by dashed lines and crosses. Prediction for 2008 made assuming a 2007/2008 catch of 150 t.

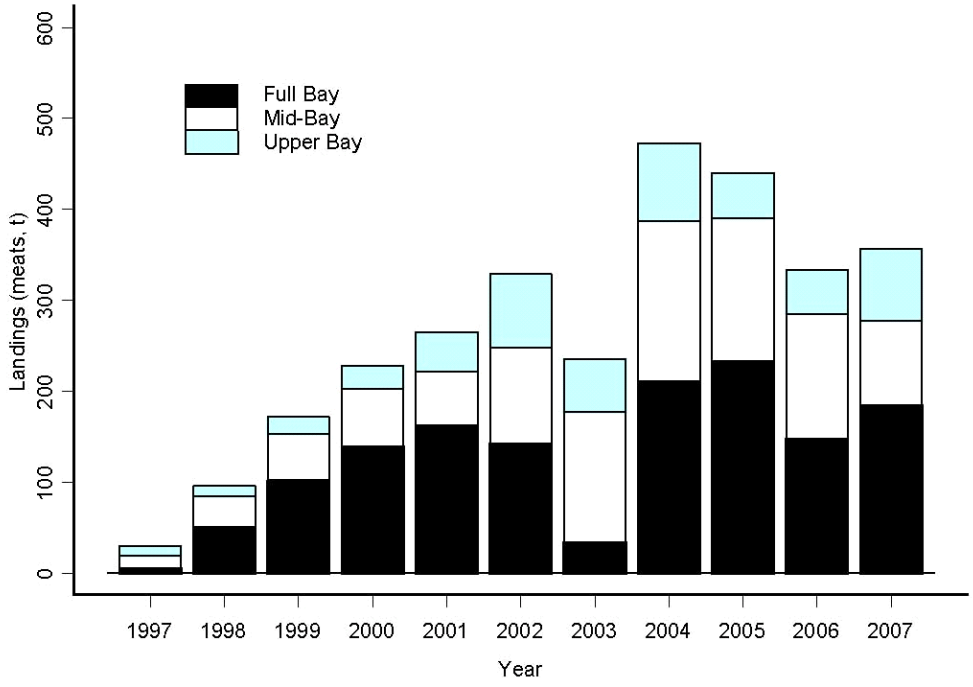

Fig. 20. Scallop landings (meats, t) in Scallop Production Area 1B by each fleet.

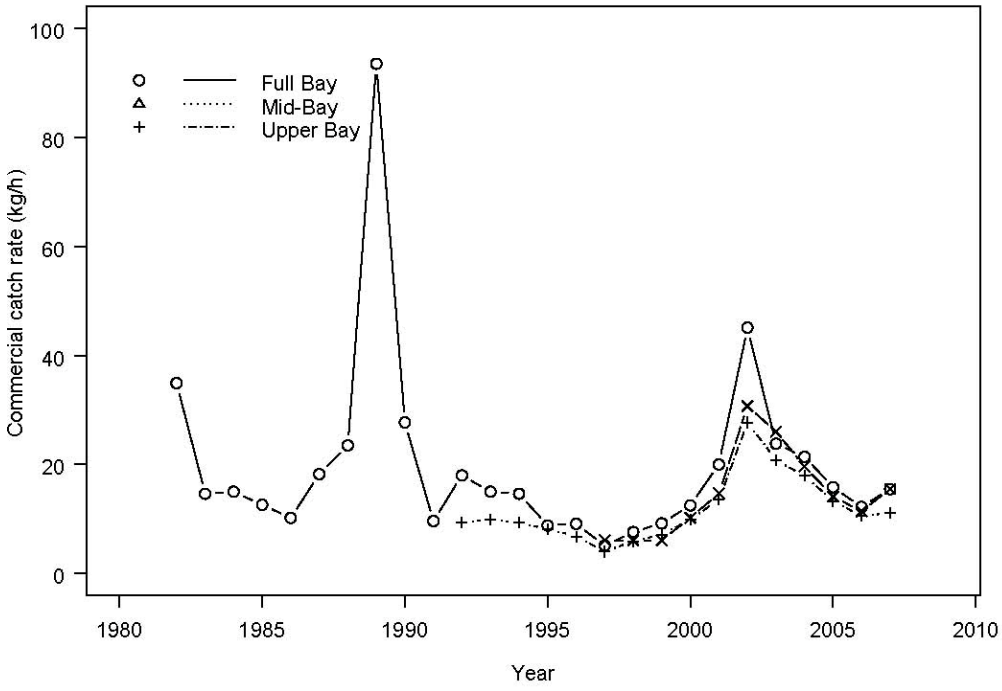

Fig. 21. Commercial catch rate (kg/h) for scallops in Scallop Production Area 1B.

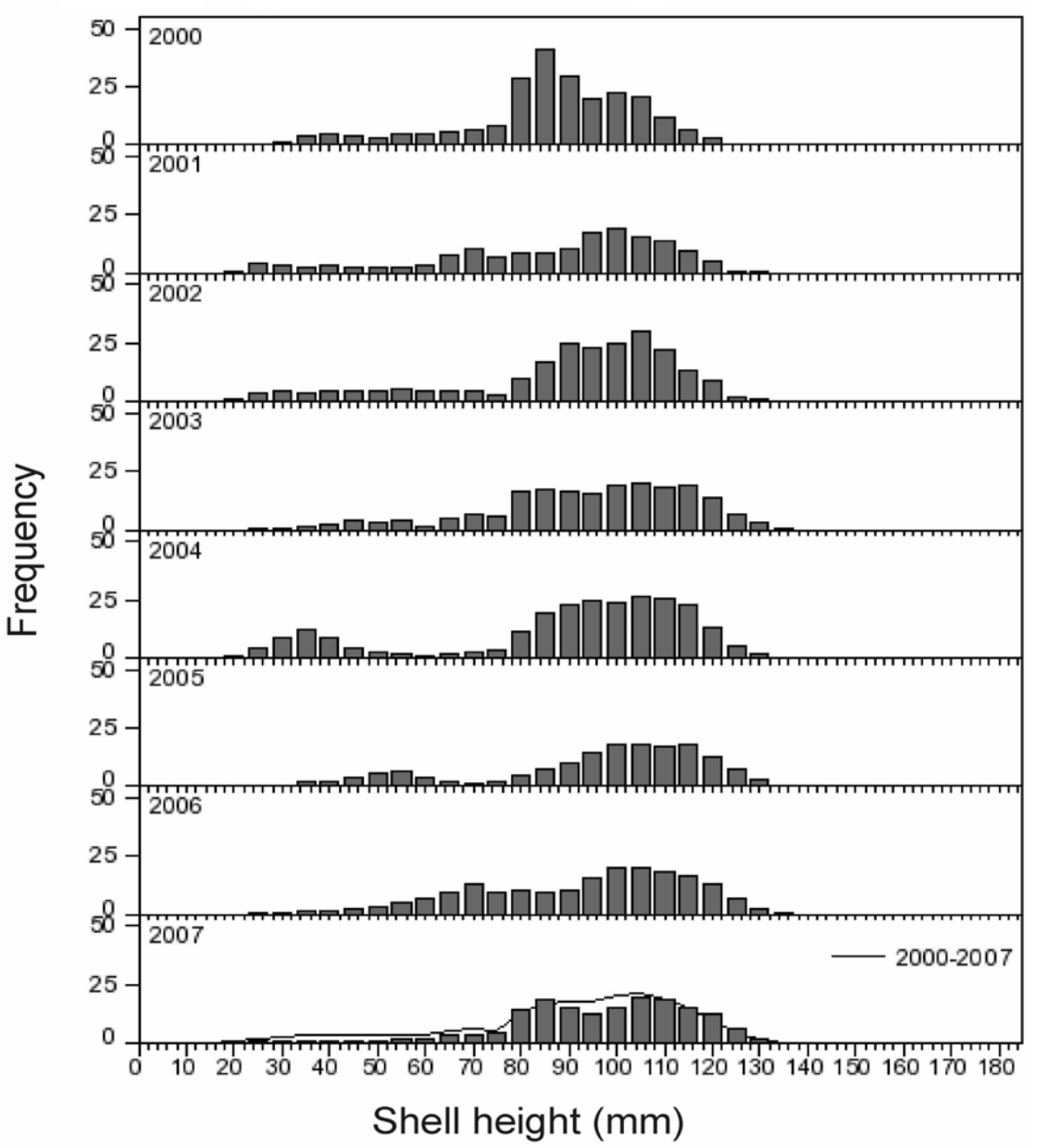

Fig. 22. Scallop shell height frequencies (mean number/tow) from the surveys of the Cape Spencer area of Scallop Production Area 1B.

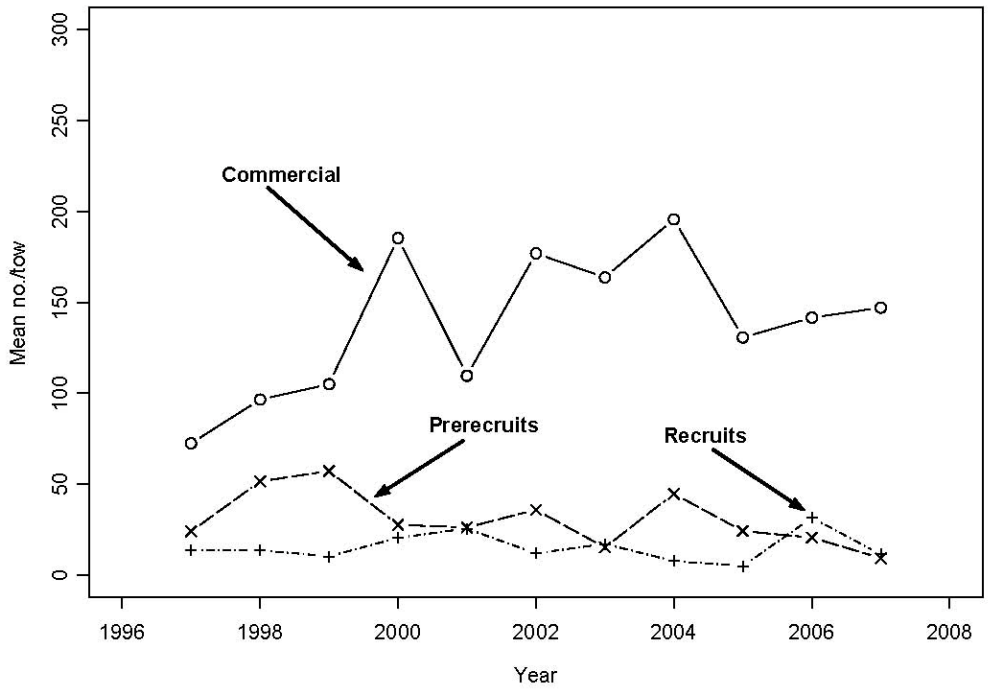

Fig. 23. Survey abundance index (mean number/tow) for commercial size (≥80 mm shell height), recruits (65–79 mm shell height) and pre-recruits (<65 mm shell height) scallops in the Cape Spencer area of Scallop Production Area 1B.

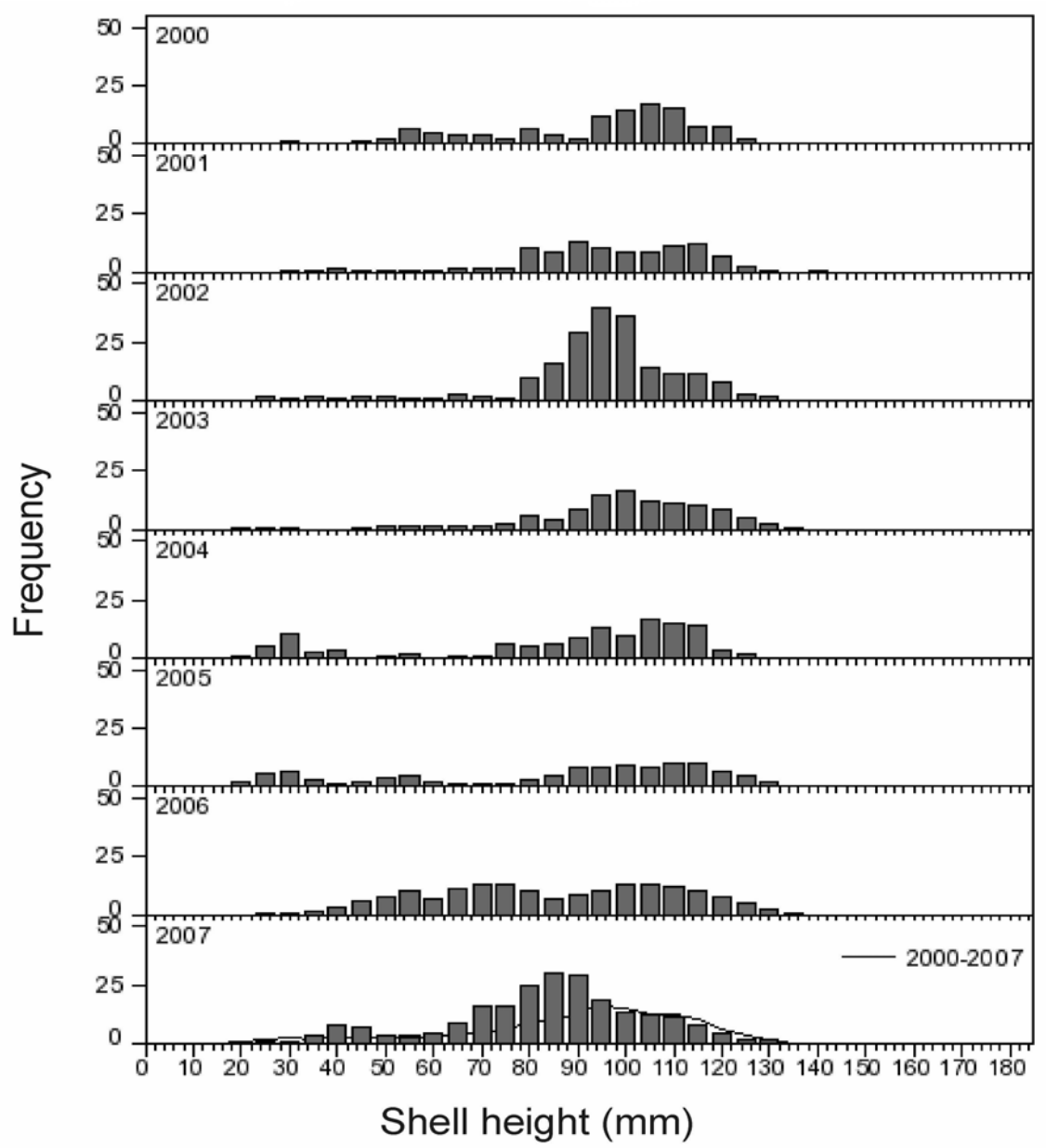

Fig. 24. Scallop shell height frequencies (mean number/tow) from the surveys of the Middle Bay North area of Scallop Production Area 1B.

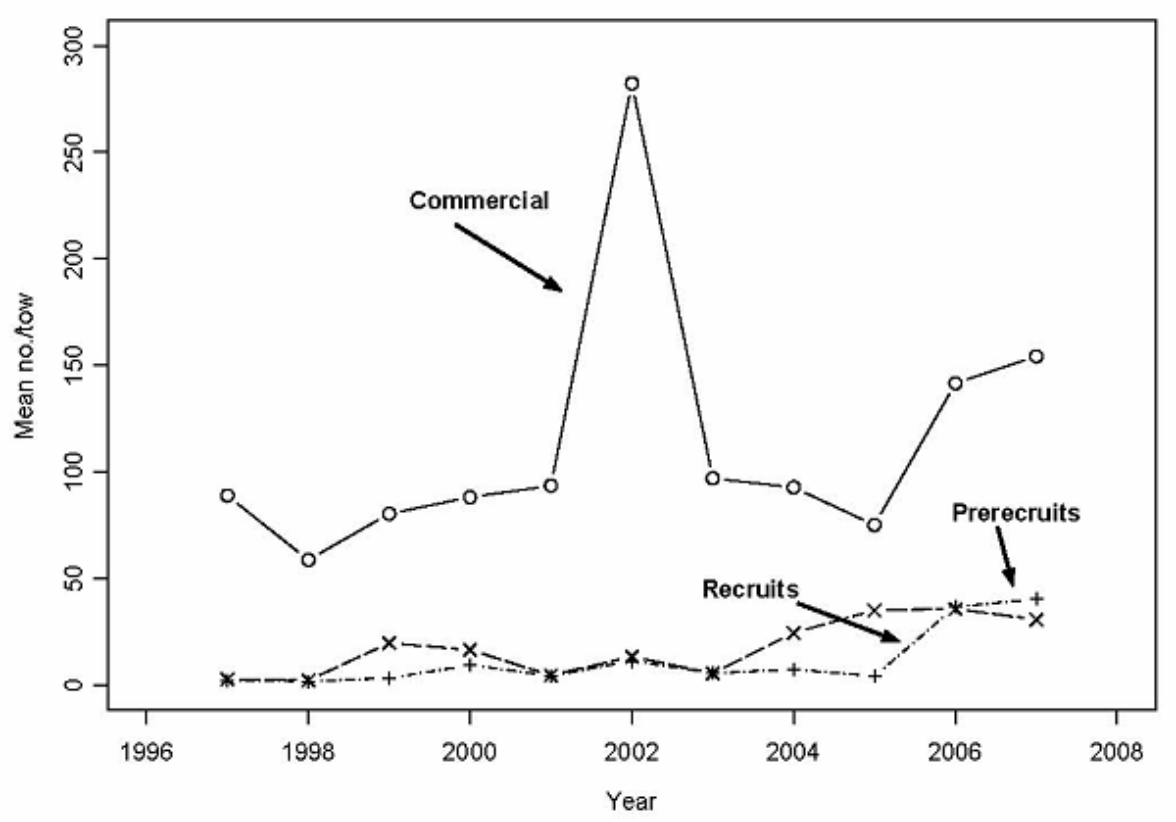

Fig. 25. Survey abundance index (mean number/tow) for commercial size (≥80 mm shell height), recruits (65–79 mm shell height) and pre-recruits (<65 mm shell height) scallops in the Middle Bay North area of Scallop Production Area 1B.

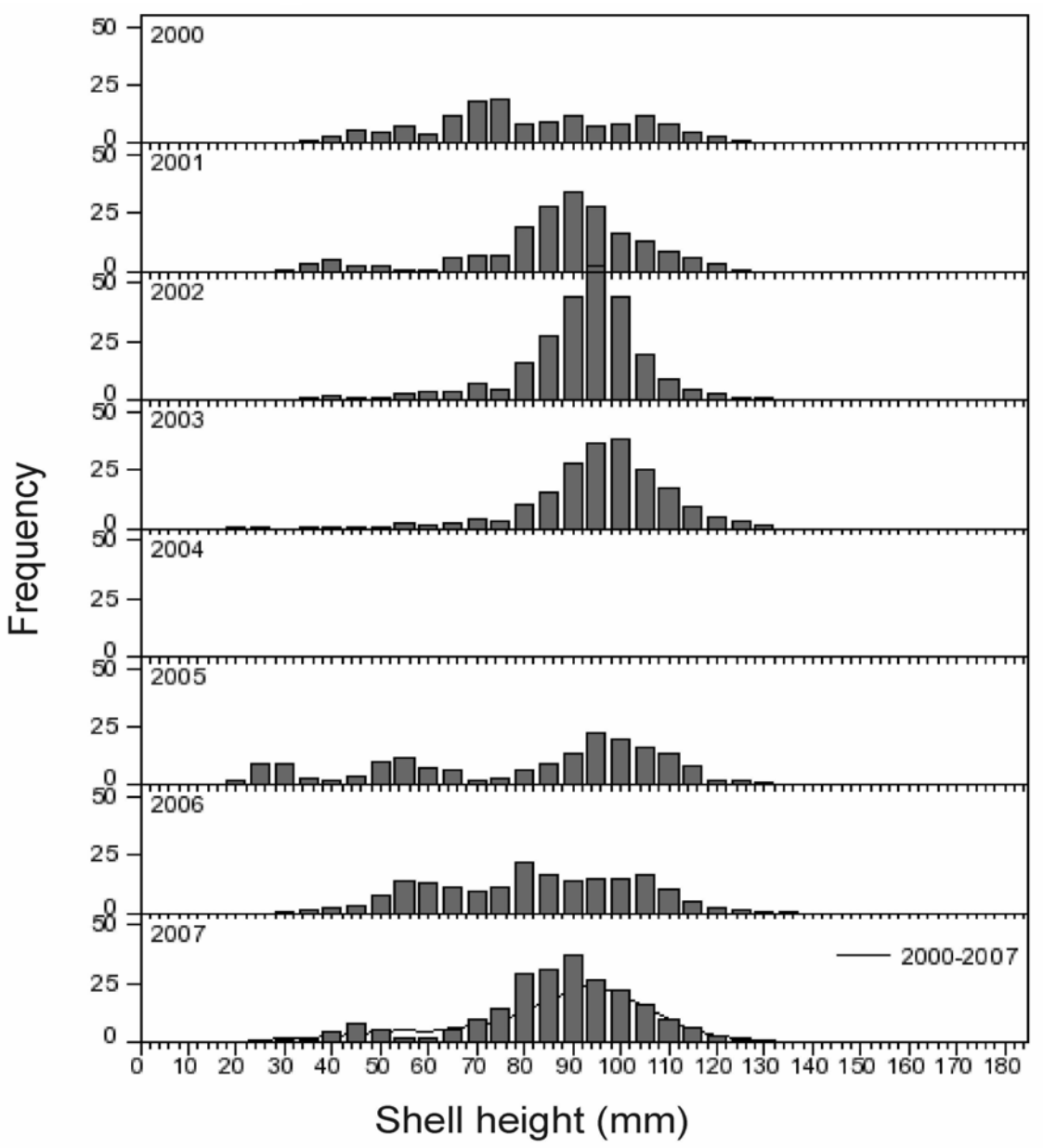

Fig. 26. Scallop shell height frequencies (mean number/tow) from the surveys of the Upper Bay area of Scallop Production Area 1B.

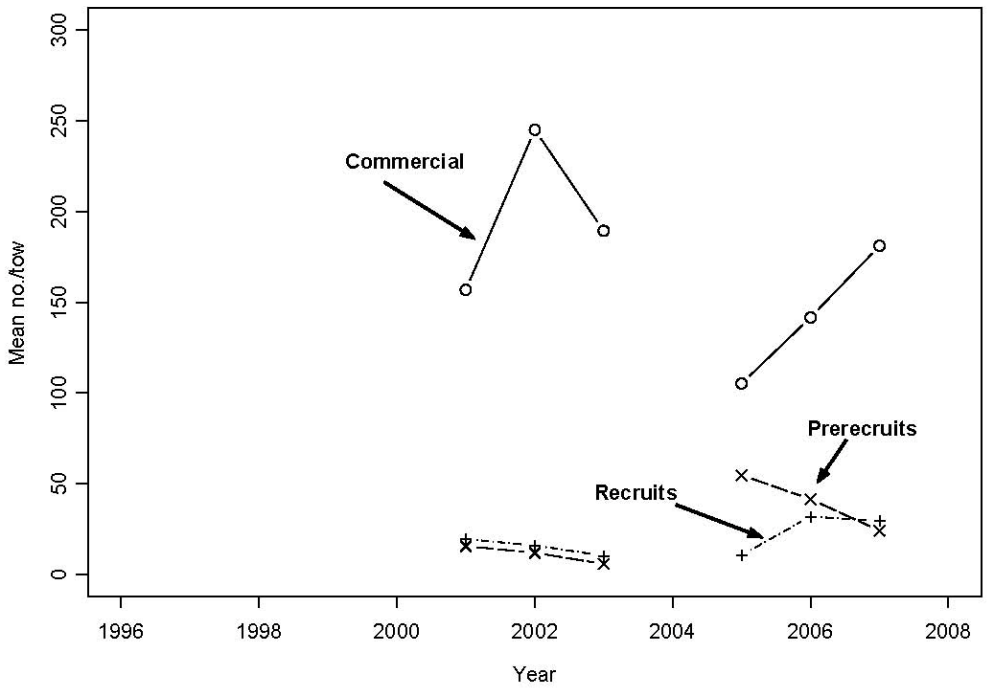

Fig. 27. Survey abundance index (mean number/tow) for commercial size (≥80 mm shell height), recruits (65–79 mm shell height) and pre-recruits (<65 mm shell height) scallops in the Upper Bay area of Scallop Production Area 1B.

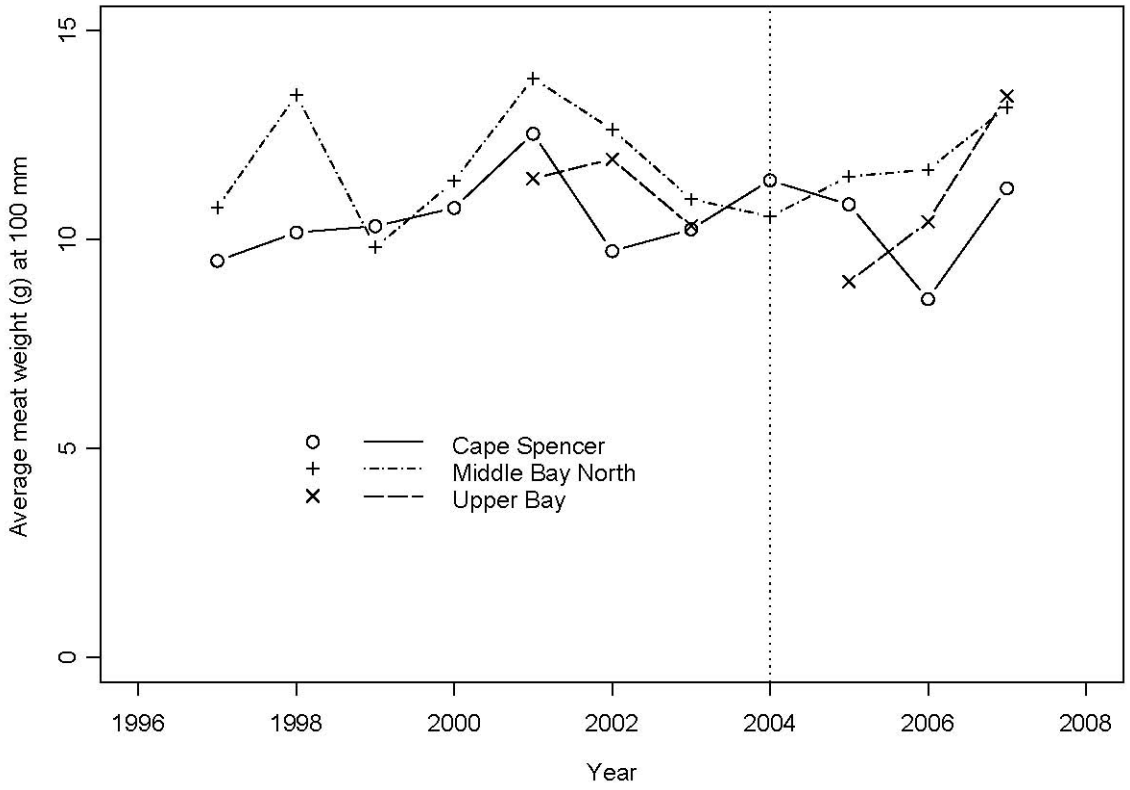

Fig. 28. Predicted meat weights for a scallop with shell height equal to 100 mm and depth equal to the mean depth for each of the survey areas in SPA 1B. Predictions come from a mixed effects model fitted to survey data with meat weight a function of shell height and depth.

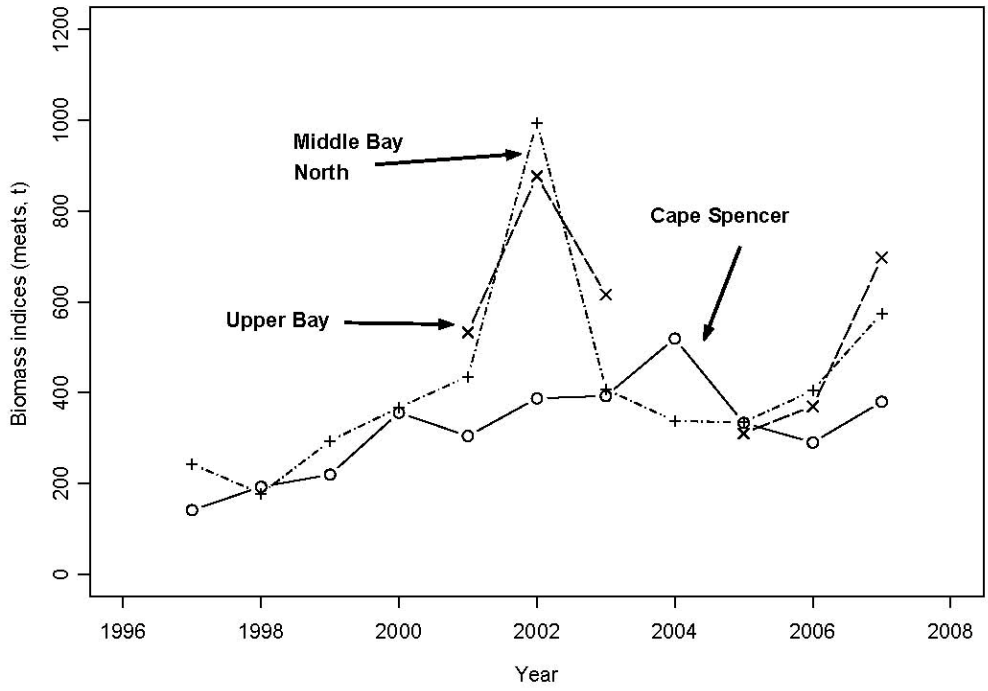

Fig. 29. Survey biomass index (kg/tow) for commercial size (≥80 mm shell height), recruits (65–79 mm shell height) and pre-recruits (<65 mm shell height) scallops in the survey areas of Scallop Production Area 1B.

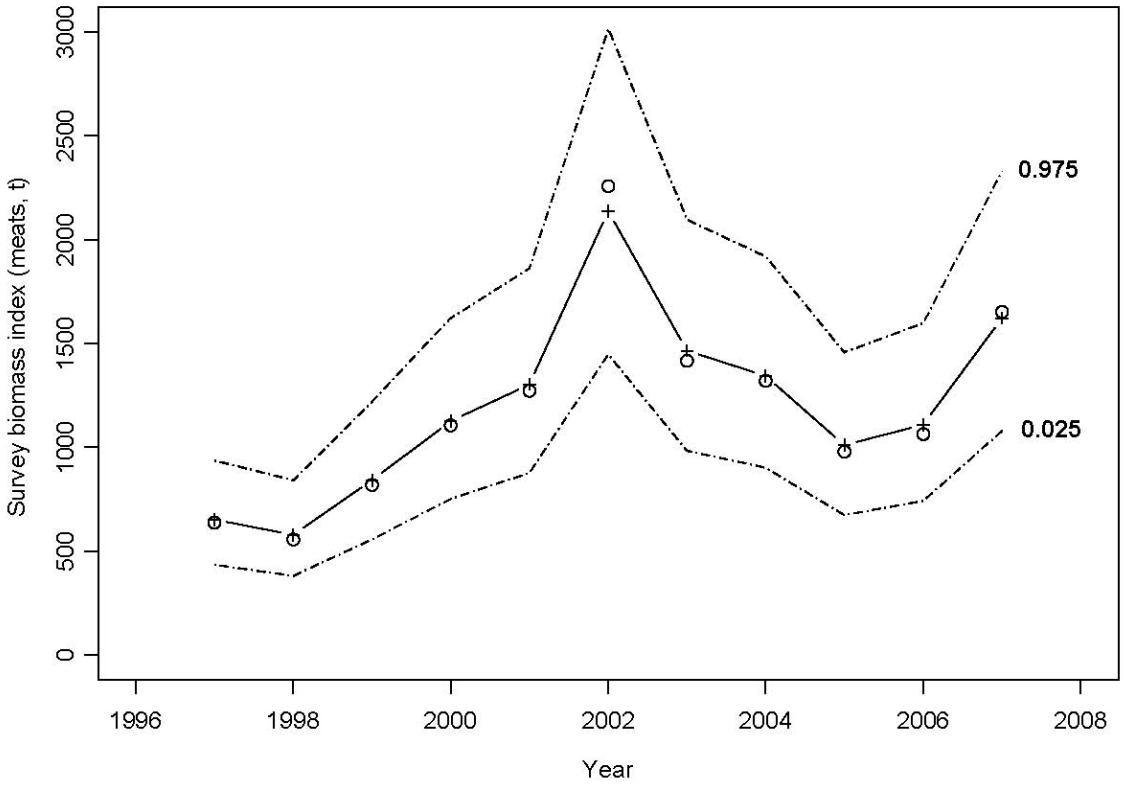

Fig. 30. Comparison of observed survey biomass estimates of commercial size scallops (+) for SPA 1B with posterior mean (o) and 95 percent credible regions (dash-dot lines) for fitted survey biomass.

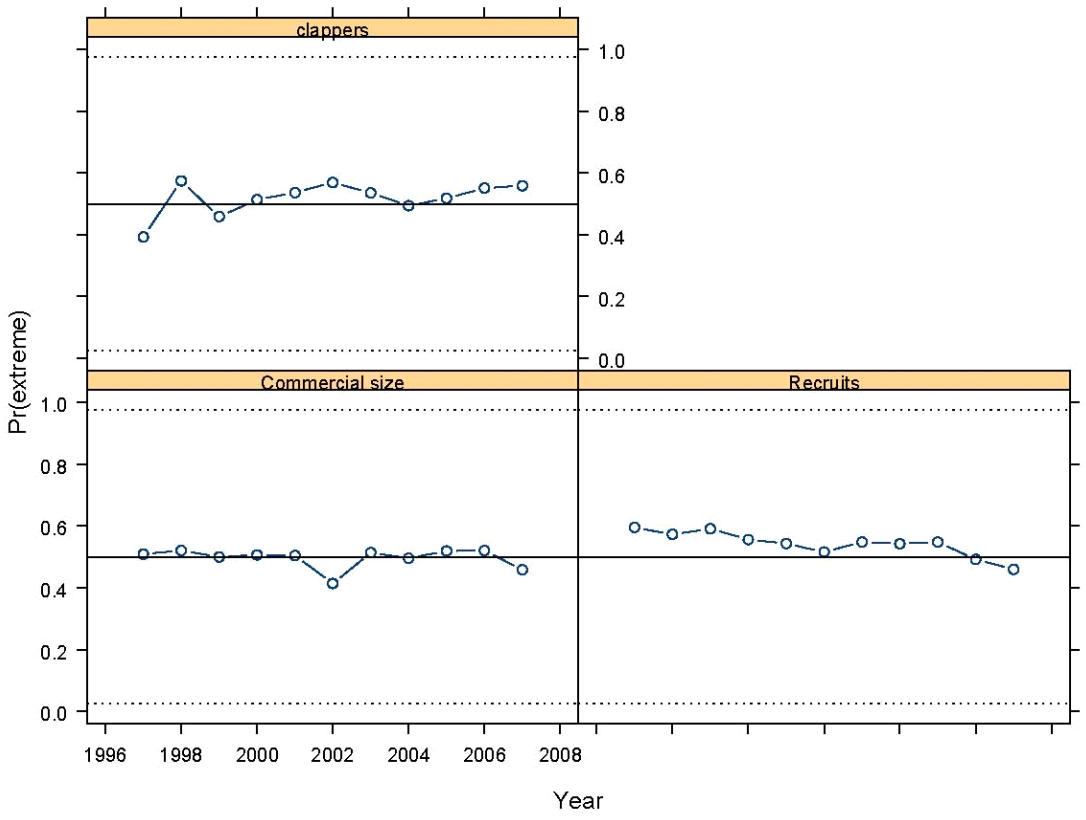

Fig. 31. Probabilities of getting larger observation than obtained for survey estimates of biomass, recruits, and clappers for the delay-difference model in SPA 1B. Dotted lines indicate probabilities of 0.025 and 0.975.

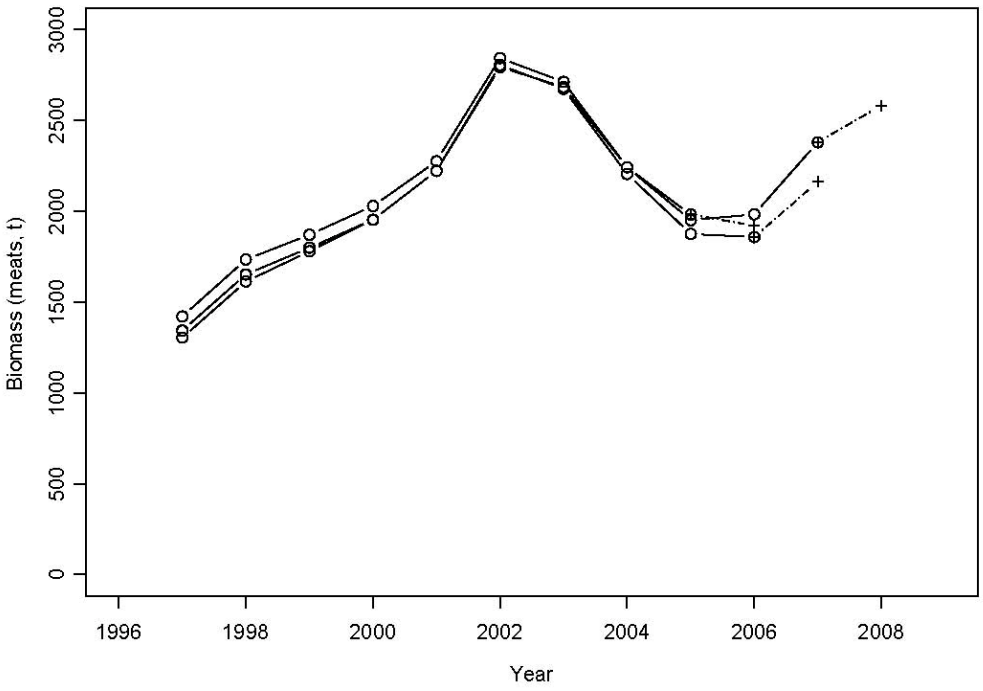

Fig. 32. Comparison of population biomass estimates of commercial size scallops (≥ 80 mm shell height) from the delay-difference population model for data up to 2005, 2006, and 2007, respectively, for SPA 1B. Predictions from the model for 2006, 2007, and 2008 indicated by dashed lines and crosses. Prediction for 2008 made assuming a 2007/2008 catch of 400 t.

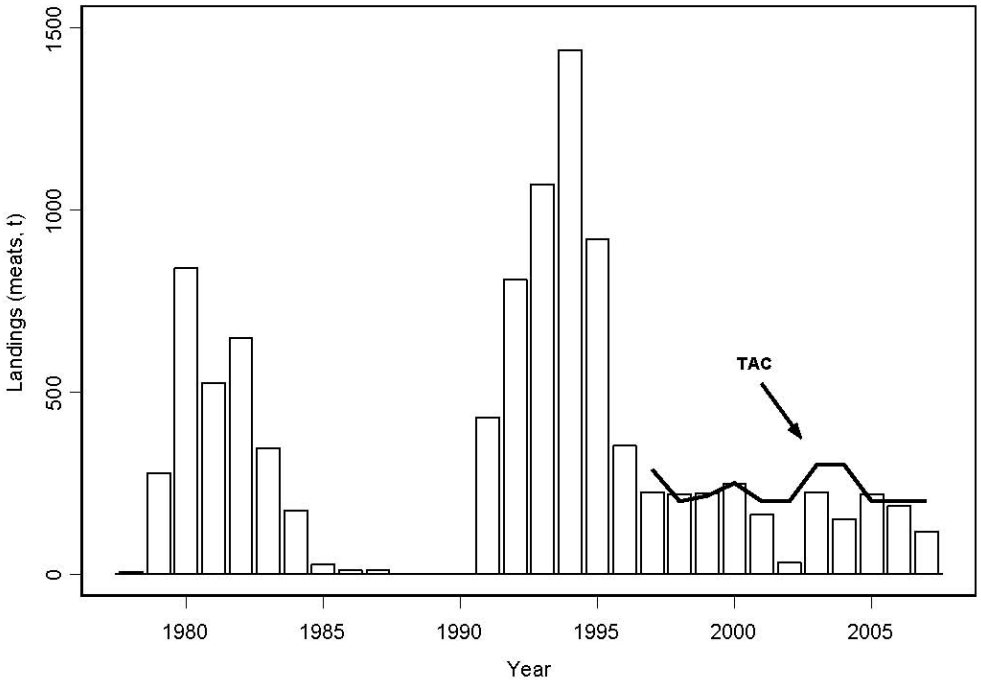

Fig. 33. Scallop landings (meats, t) in Scallop Production Area 3.

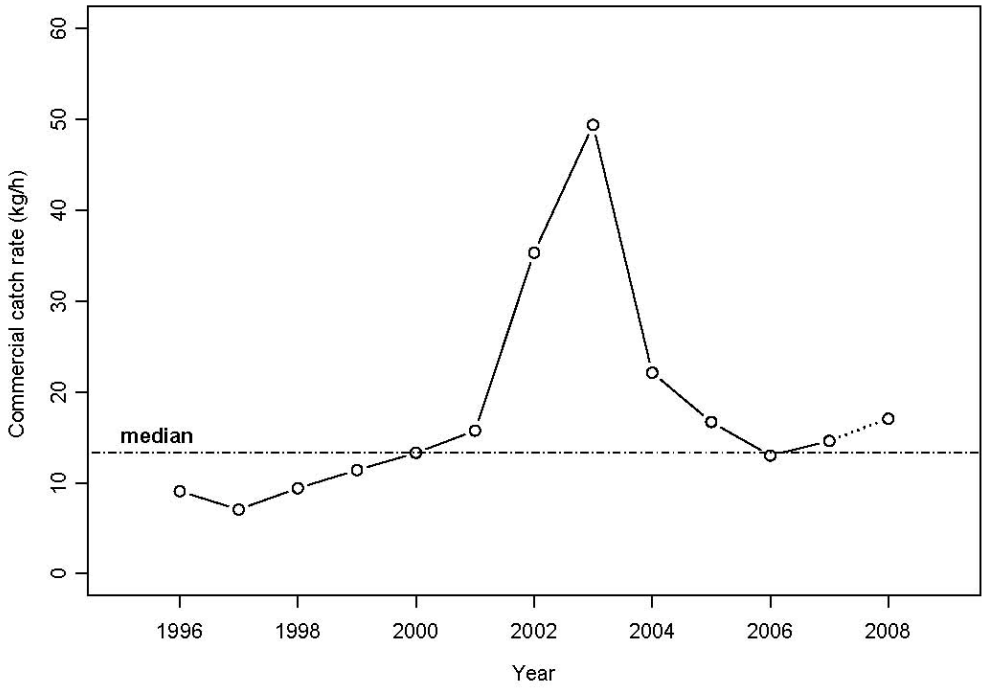

Fig. 34. Commercial catch rate (kg/h)for scallops in Scallop Production Area 3. Median catch rate over the 1996 to 2006 period indicated. Estimate for 2008 based on data for October 2007 catch rates only.

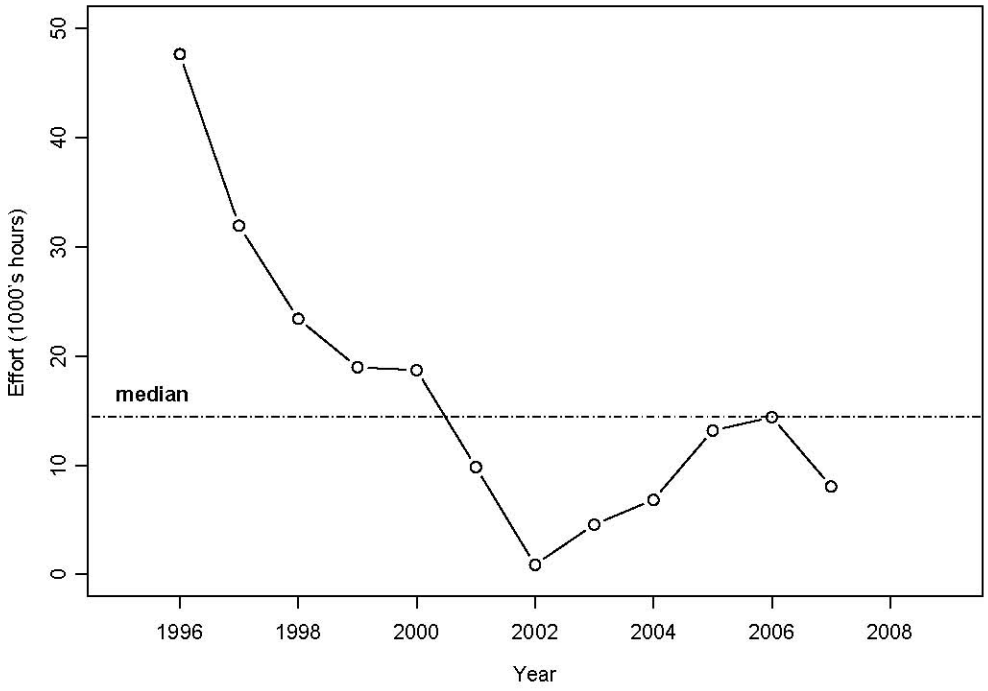

Fig. 35. Commercial fishing effort (hours)for scallops in Scallop Production Area 3. Median effort over the 1996 to 2006 period indicated.

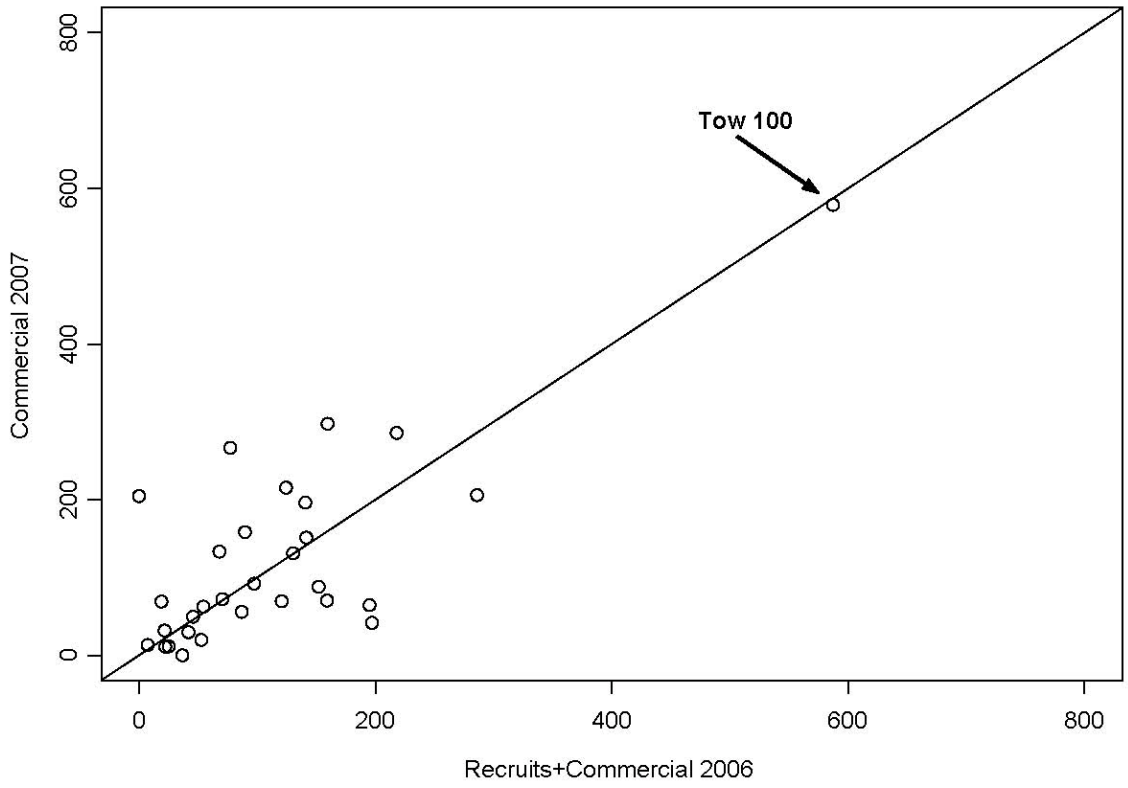

Fig. 36. Comparing numbers of commercial size scallops (≥80 mm shell height) and recruits (65–79 mm shell height) caught in 2006 and commercial size scallops in 2007 in the survey stations common to both of the surveys in SPA 3. Solid line indicates 1:1 line.

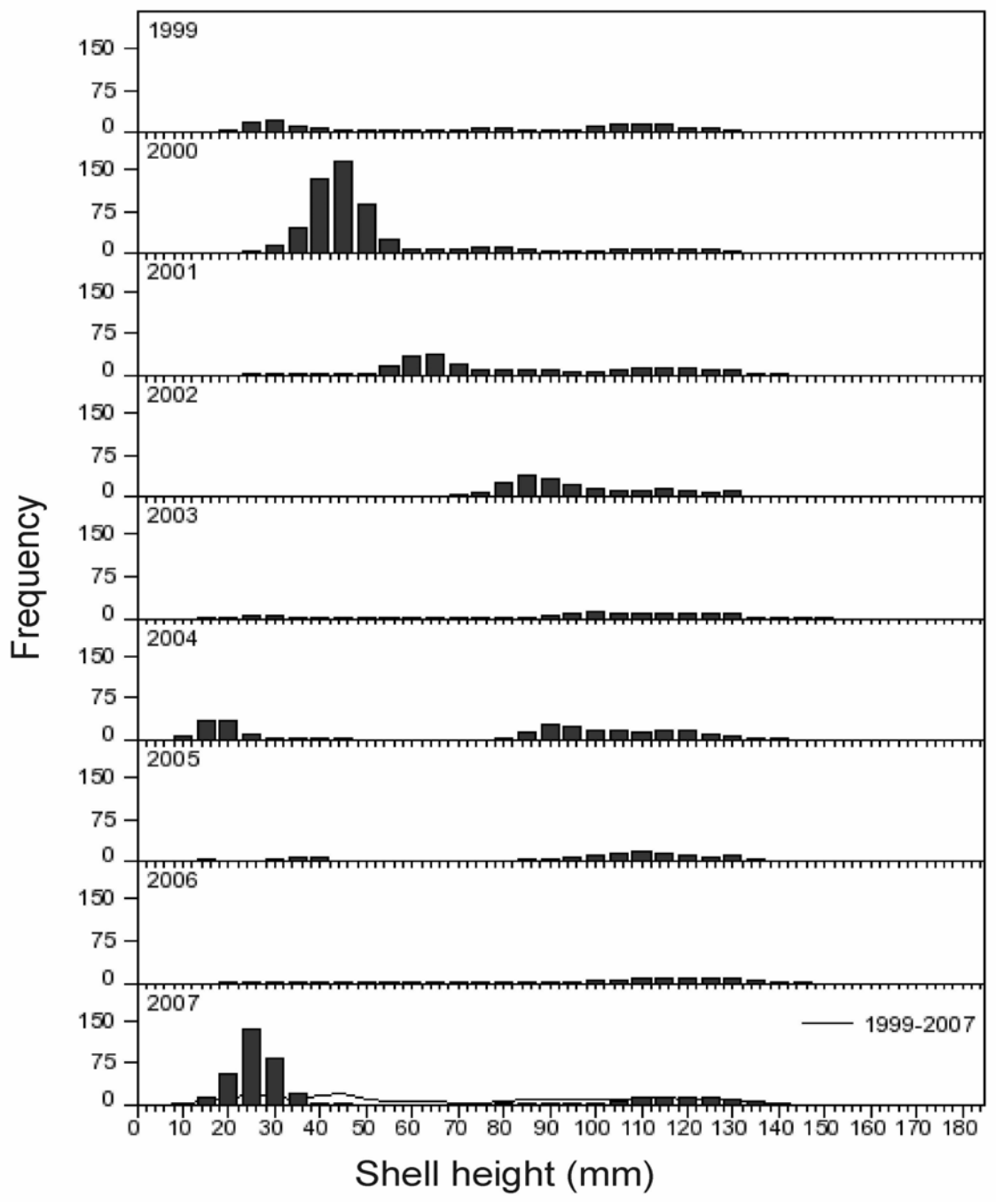

Fig. 37. Scallop shell height frequencies from the 1999 to 2007 surveys of the Brier/Lurcher portion of Scallop Production Area 3.

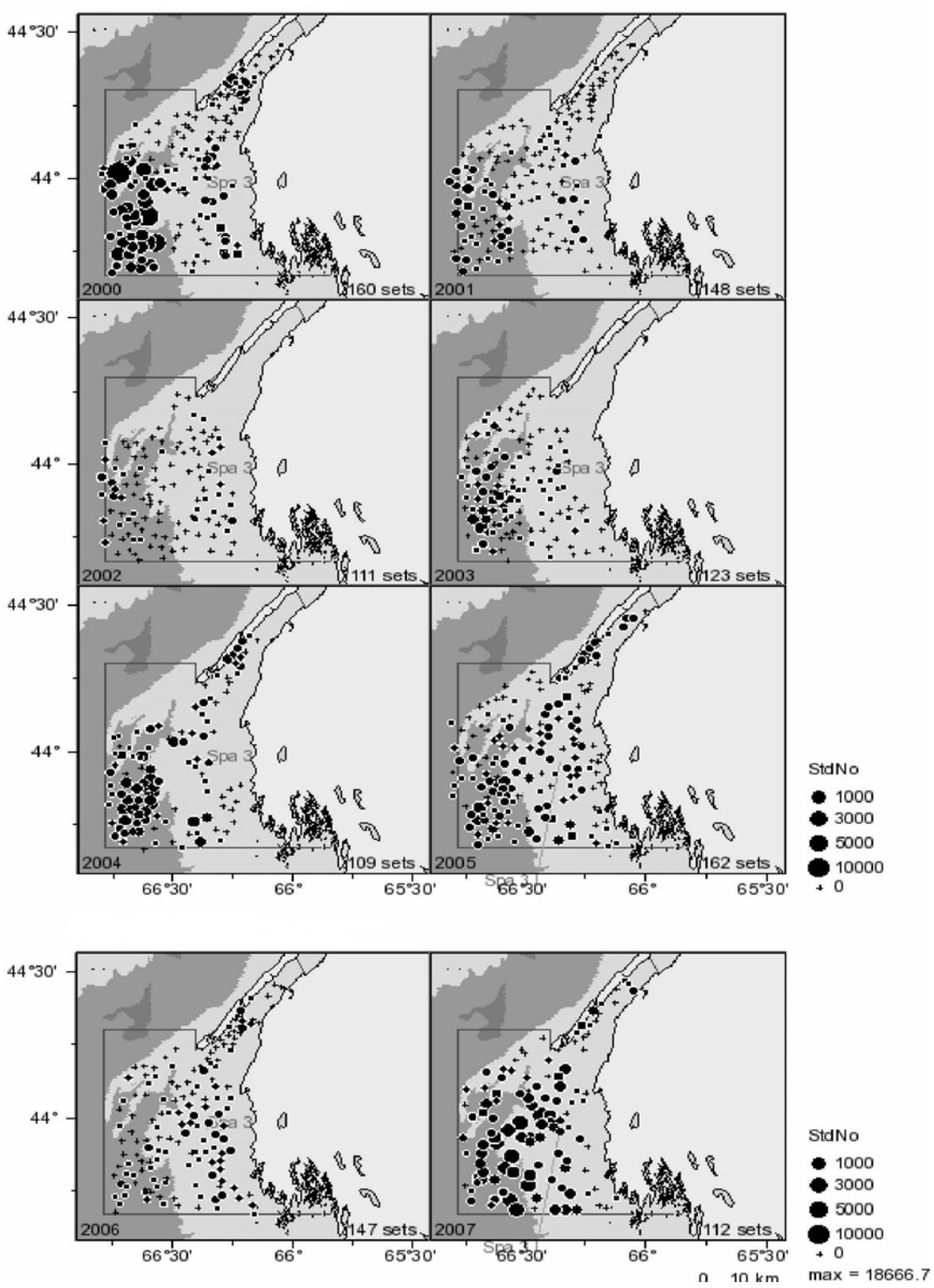

Fig. 38. Spatial distribution of scallop catches for shell height ≥50 mm from surveys of Scallop Production Area 3. Surveys conducted in August until 2005 when the survey was changed to June.

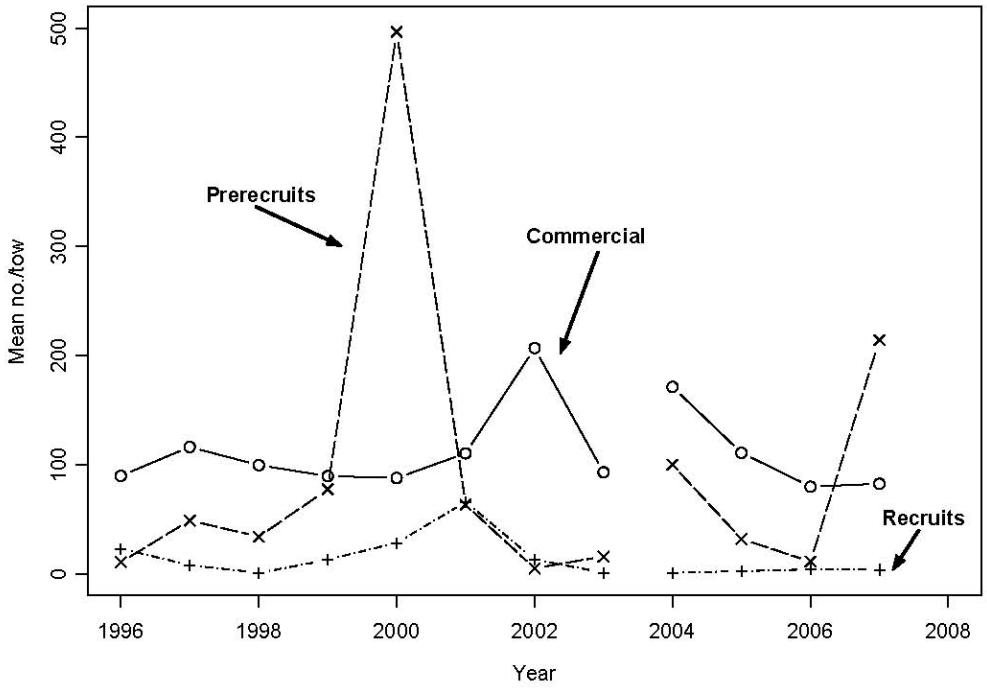

Fig. 39. Survey abundance index for commercial size scallops (≥80 mm shell height) and recruits (Brier: 65–79 mm and Lurcher: 70–79 mm shell height) in the Brier/Lurcher portion of Scallop Production Area 3. Break in the series indicates the change from August surveys to June surveys starting in 2004.

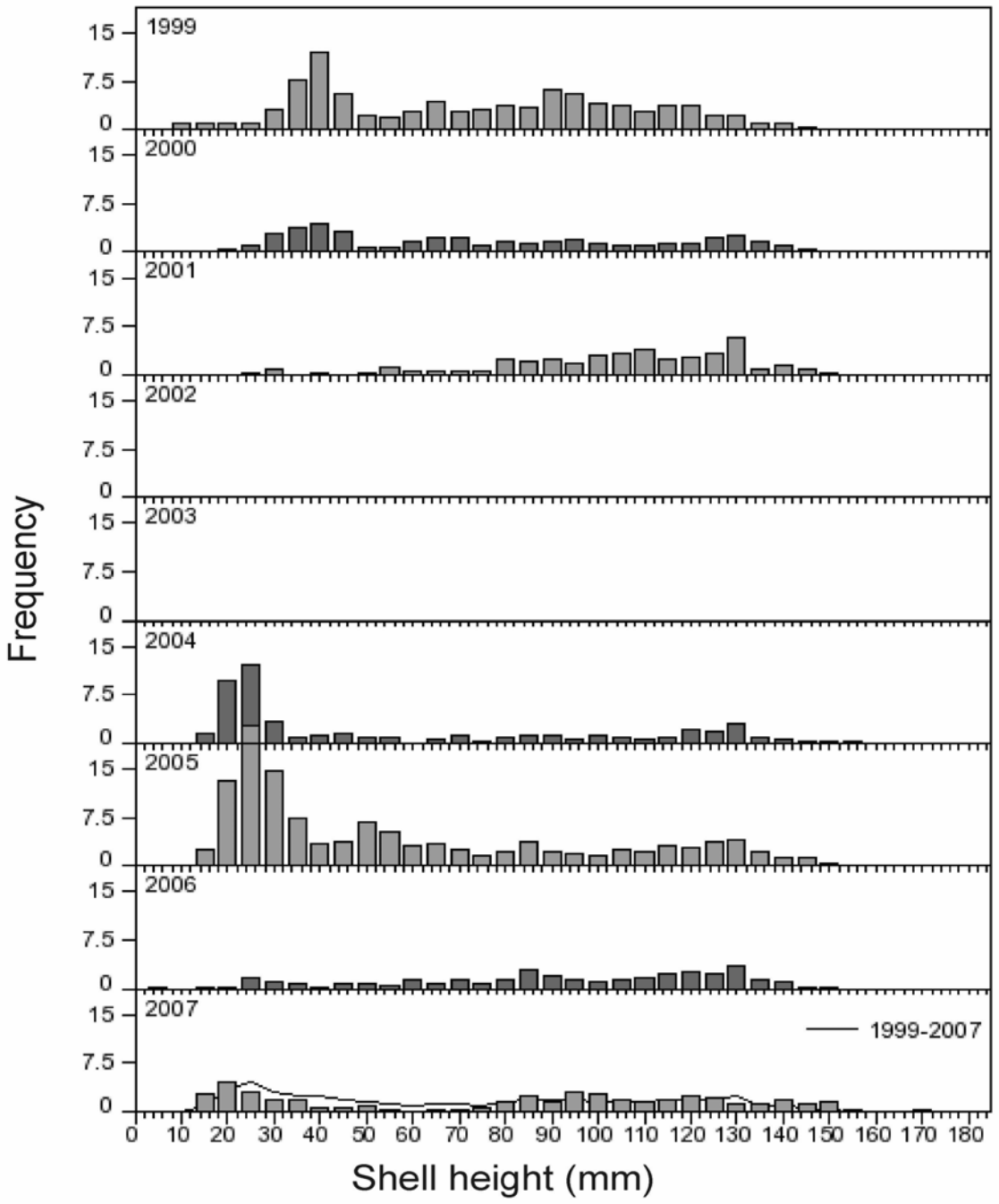

Fig. 40. Scallop shell height frequencies from the 1999 to 2007 surveys of the St. Mary's Bay portion of Scallop Production Area 3.

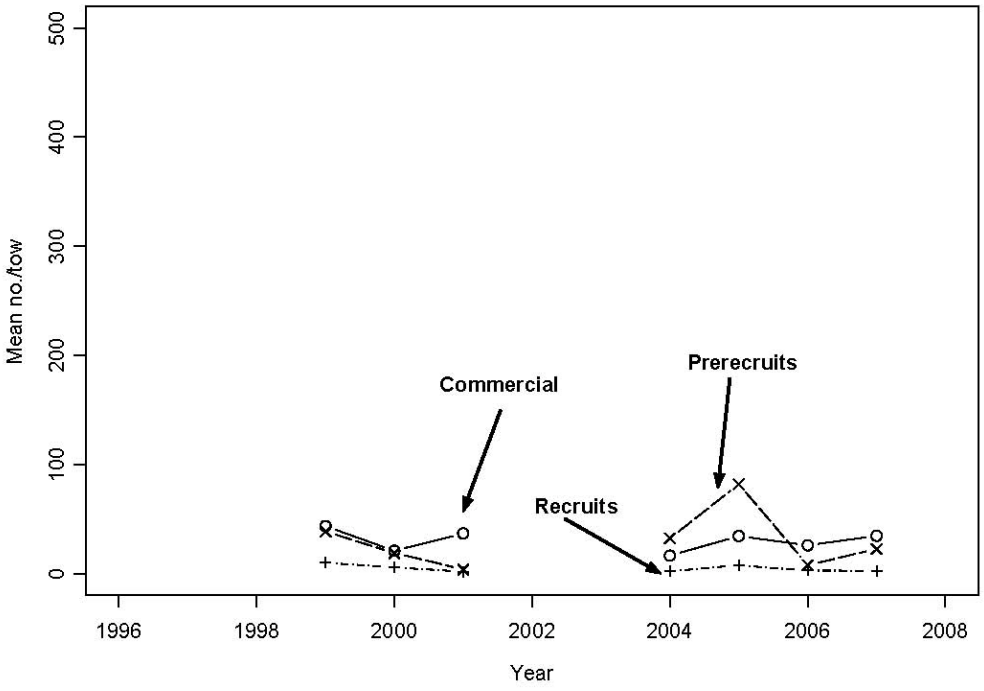

Fig. 41. survey abundance index for commercial size scallops (≥80 mm shell height) and recruits (65–79 mm) in the St. Mary's Bay portion of Scallop Production Area 3. Break in the series indicates the change from August surveys to June surveys starting in 2004.

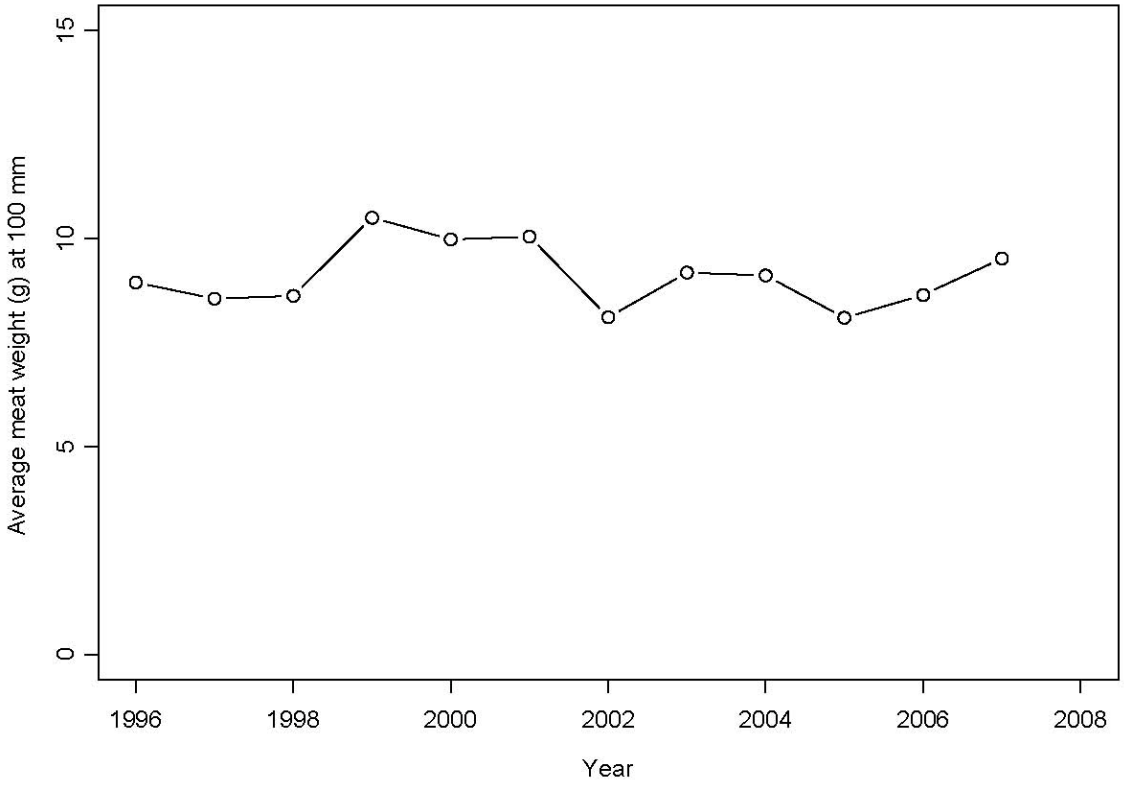

Fig. 42. Predicted meat weights for a scallop with shell height equal to 100 mm and depth equal to the mean depth in SPA 3. Predictions come from a mixed effects model fitted to survey data with meat weight a function of shell height and depth.

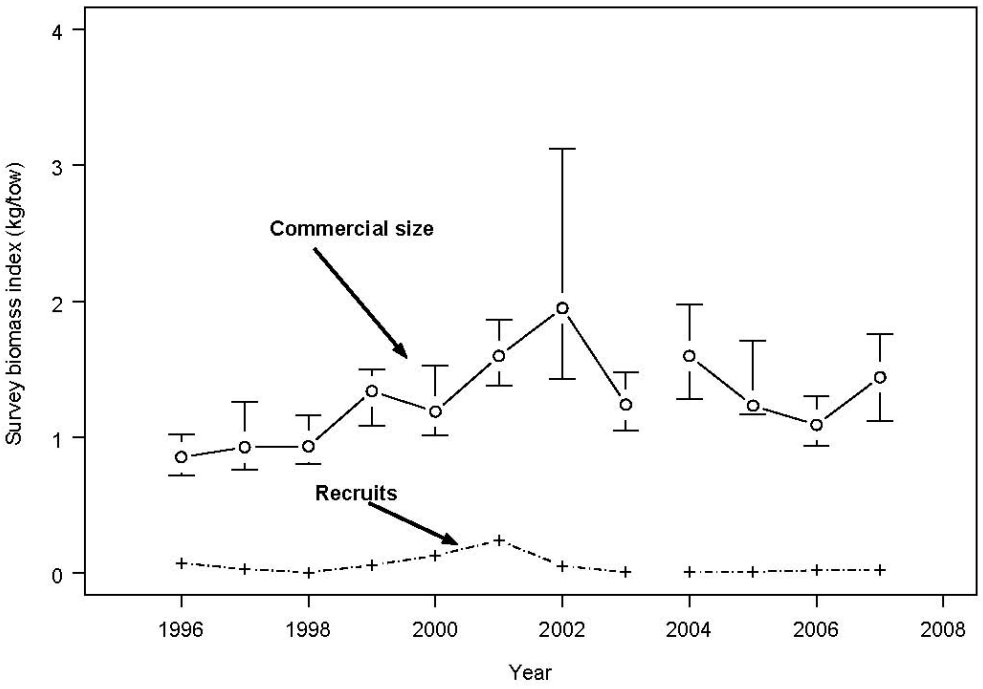

Fig. 43. Survey biomass index (kg/tow) for commercial size scallops (≥80 mm shell height) and recruits (Brier: 65–79 mm and Lurcher: 70–79 mm shell height) in the Brier/Lurcher portion of Scallop Production Area 3. Commercial biomass index for 1996 to 2006 has 95 percent bootstrap confidence intervals included. Upper and lower bounds for 2007 correspond to two times the standard error from the repeated survey design estimate. The break in the series indicates the change from August surveys to June surveys starting in 2004.

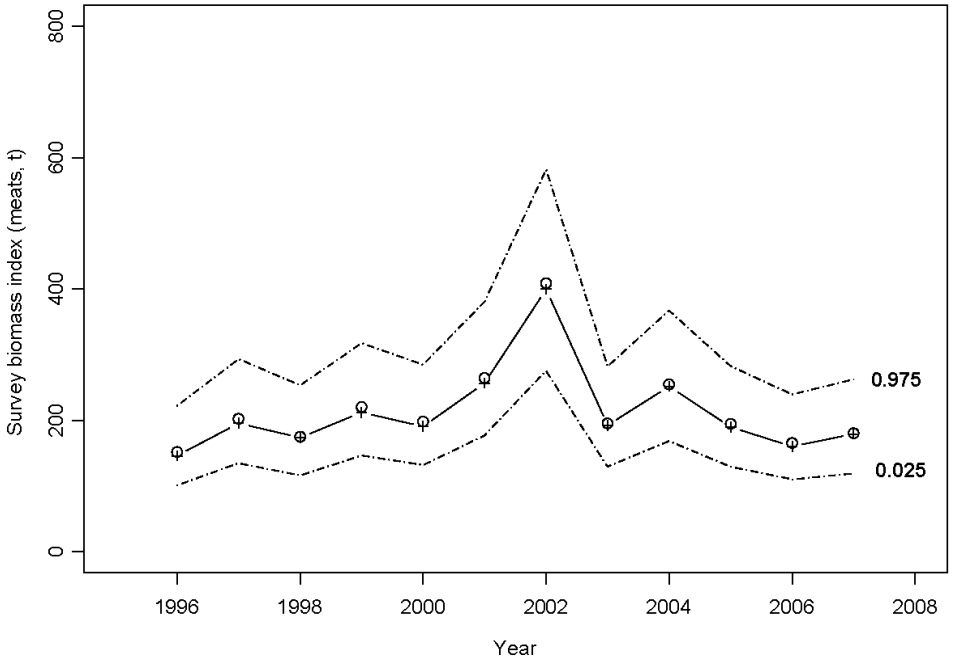

Fig. 44. Comparison of observed survey biomass estimates of commercial size scallops (+) for SPA 3 with posterior mean (o) and 95 percent credible regions (dash-dot lines) for fitted survey biomass.

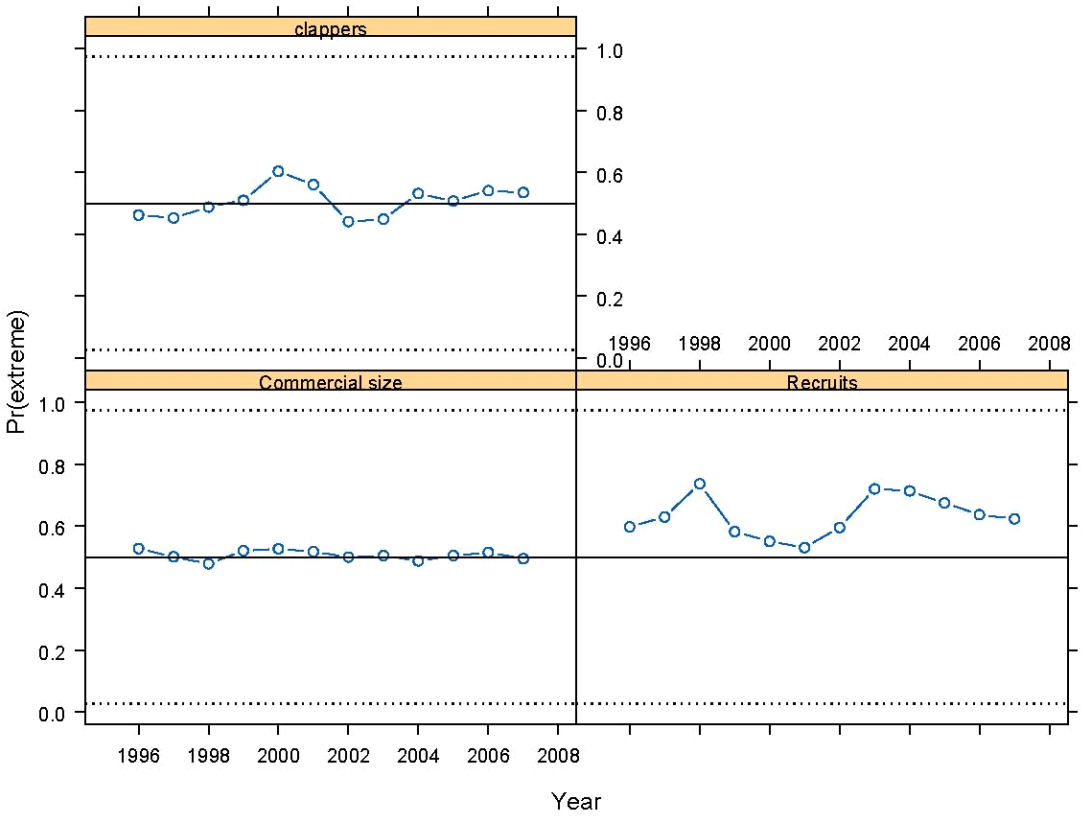

Fig. 45. Probabilities of getting larger observations than obtained for survey estimates of biomass, recruits, and clappers for the delay-difference model in SPA 3. Dotted lines indicate probabilities of 0.025 and 0.975.

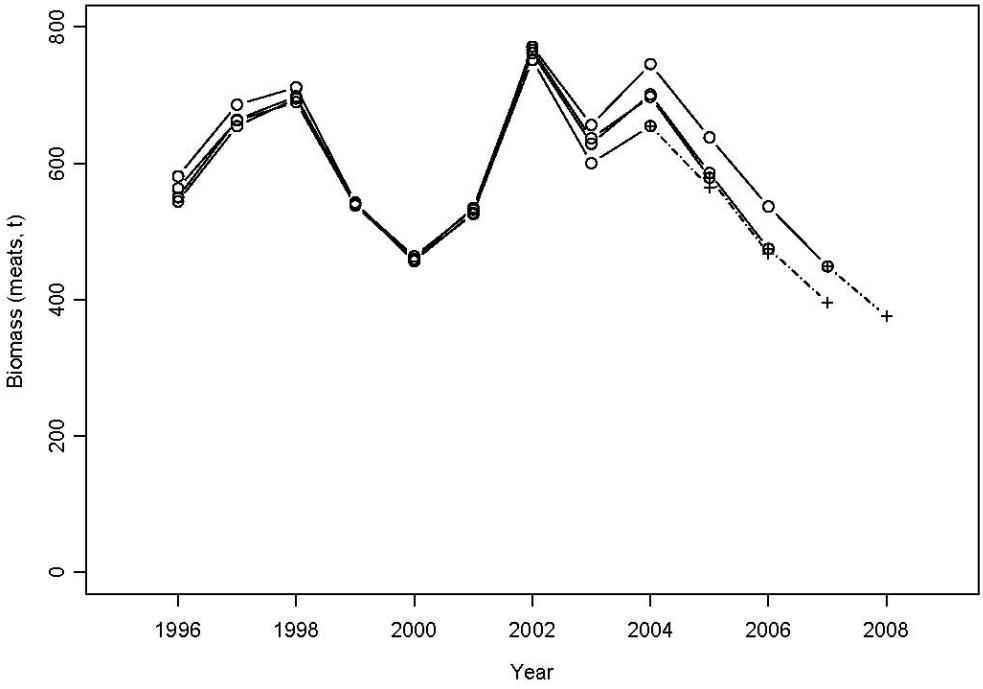

Fig. 46. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) from the delay-difference population model for data up to 2004, 2005, 2006, and 2007, respectively for SPA 1A. Predictions from the model for 2005, 2006, 2007, and 2008 indicated by dashed lines and crosses. Prediction for 2008 made assuming a 2007/2008 catch of 20 t up to June 2008.

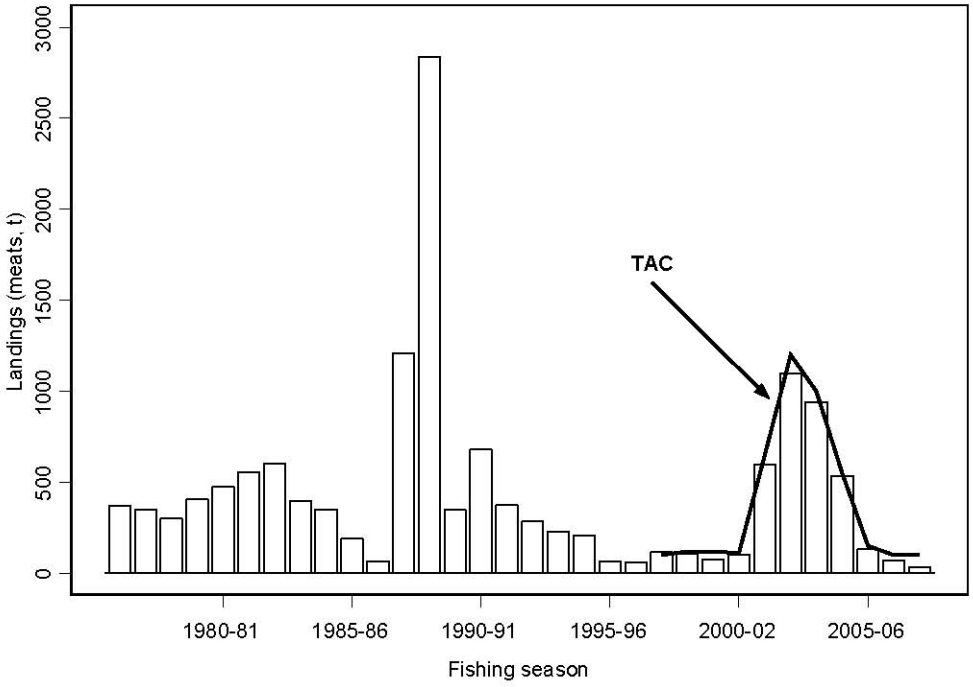

Fig. 47. Trends in scallop catch (meats, t) from SPA 4. TACs were initiated in 1997.

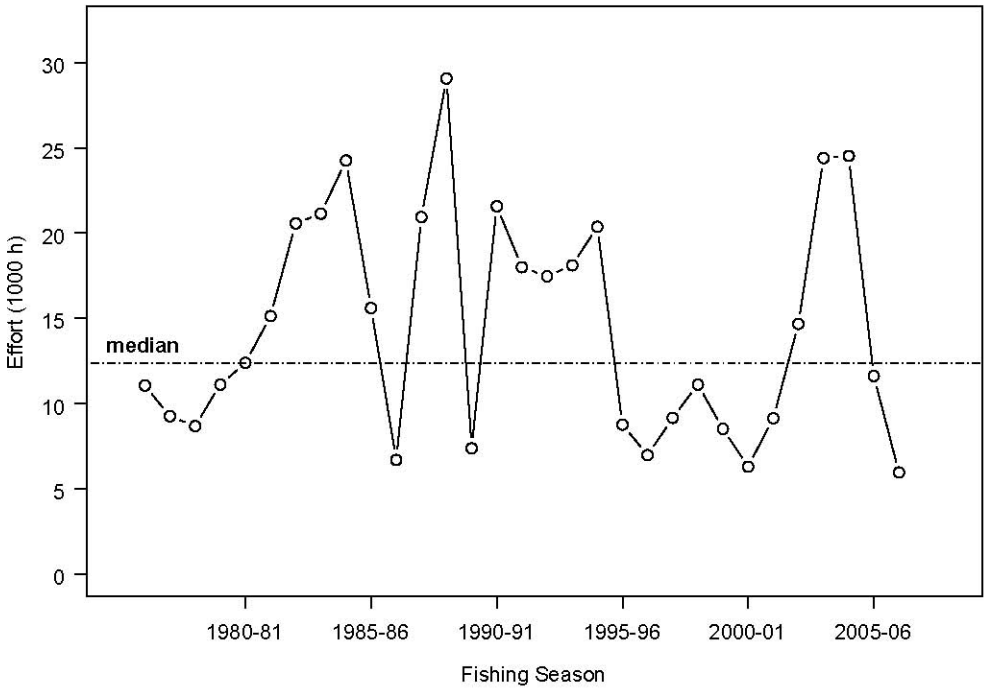

Fig. 48. Trends in scallop fishing effort (1000's hours) from SPA 4.

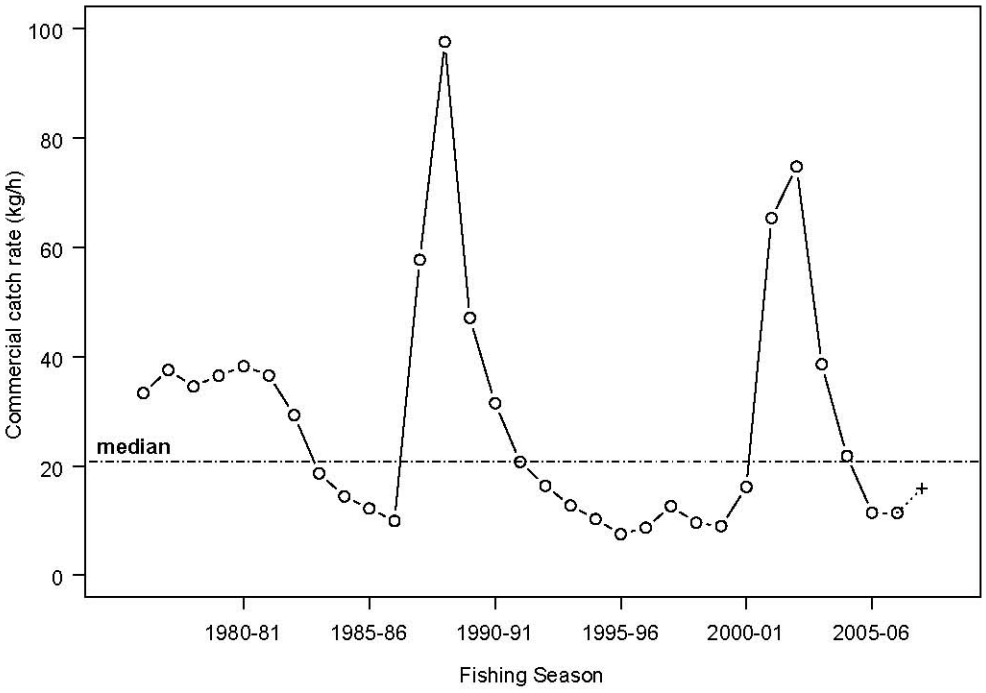

Fig. 49. Trends in scallop catch rate (kg/h) from SPA 4. Median catch rate over the 1976–1977 to 2006–2007 period indicated. Catch rate for 2007–2008 indicated by + refers to October 2007 only.

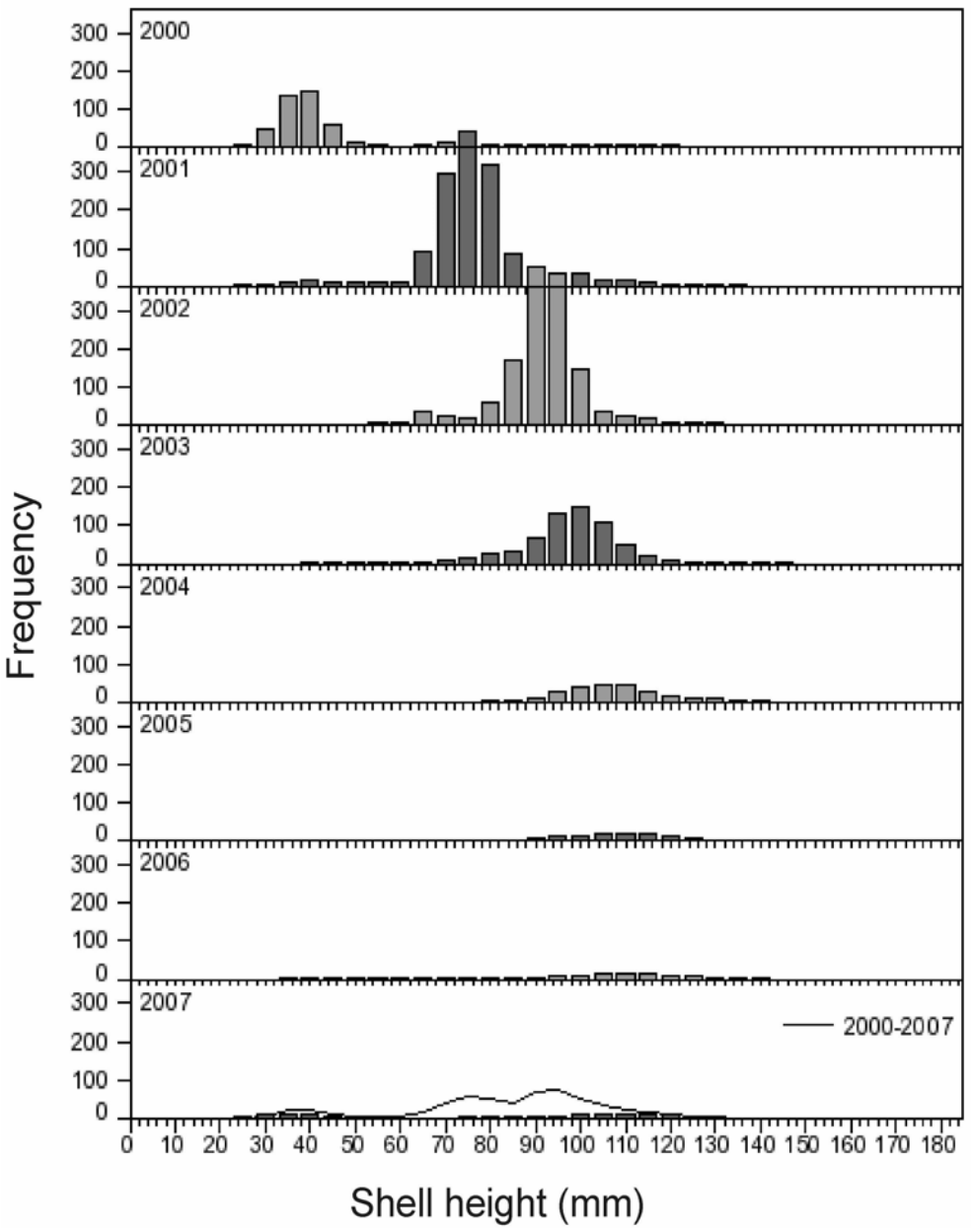

Fig. 50. Comparison of shell height frequencies from the 2000 to 2007 surveys of SPA 4.

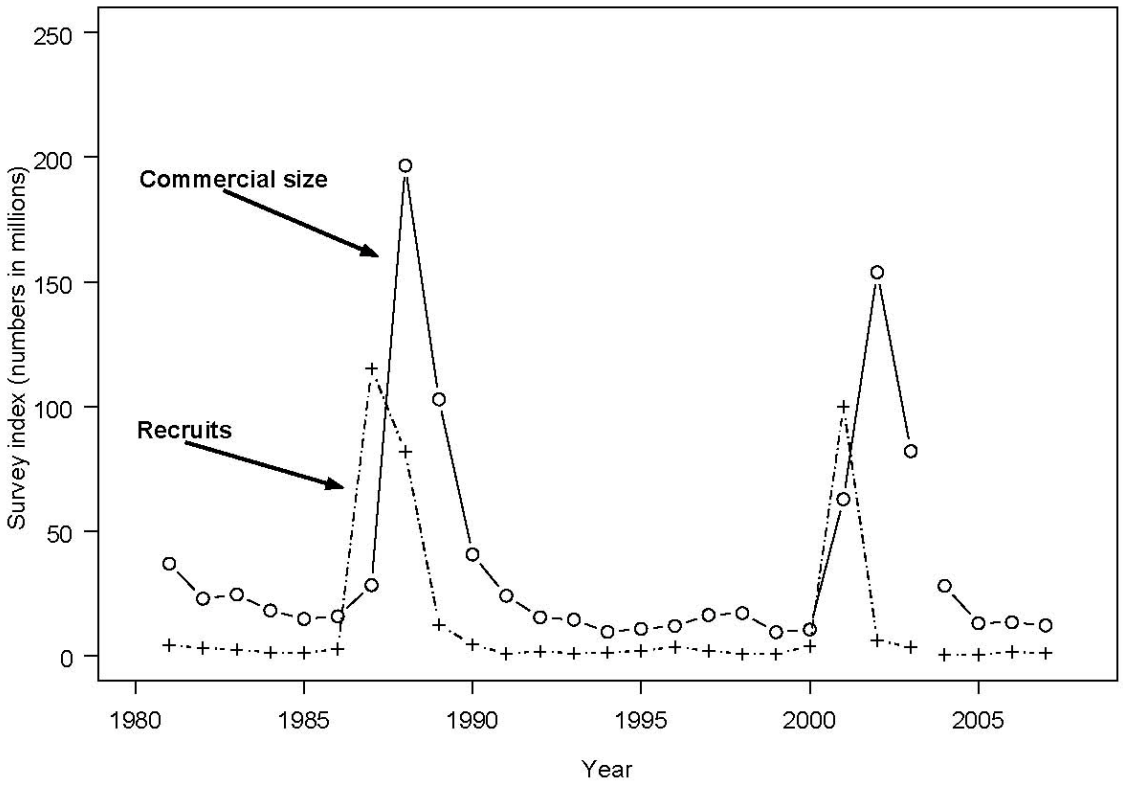

Fig. 51. Trends in survey estimates of numbers (millions) of commercial size scallops (shell height ≥80 mm) and recruits (see text for definition) from annual research vessel surveys of Scallop Production Area 4. Breaks in series indicates change from June surveys to August surveys starting in 2004.

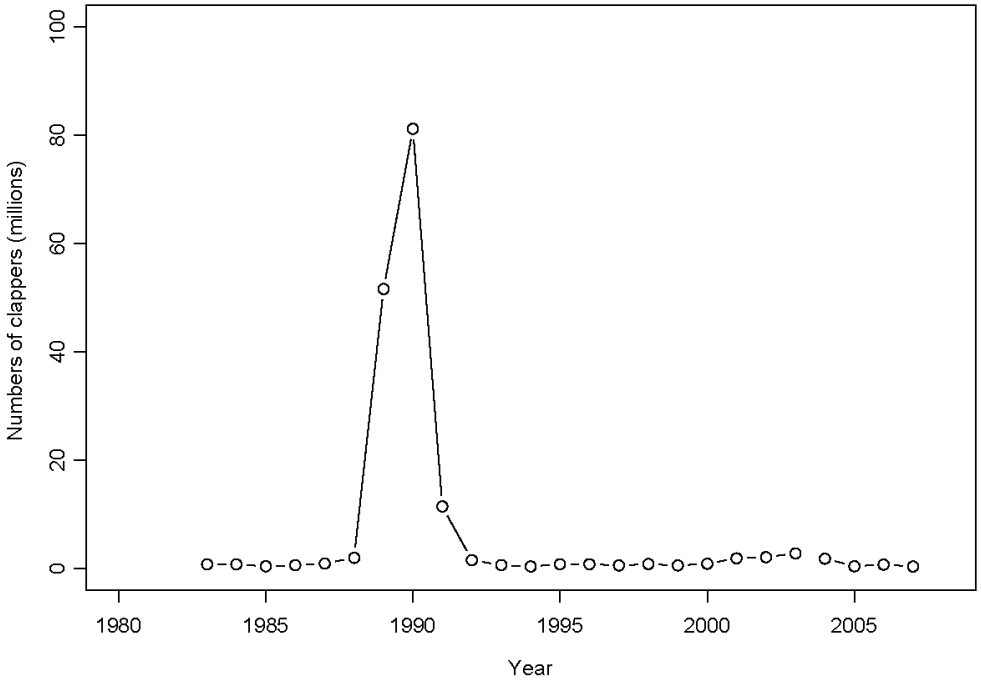

Fig. 52. Trends in survey estimates of clappers (paired empty shells, in millions) of commercial size scallops (shell height ≥80 mm) from annual research vessel surveys of Scallop Production Area 4. Breaks in series indicates change from June surveys to August surveys starting in 2004.

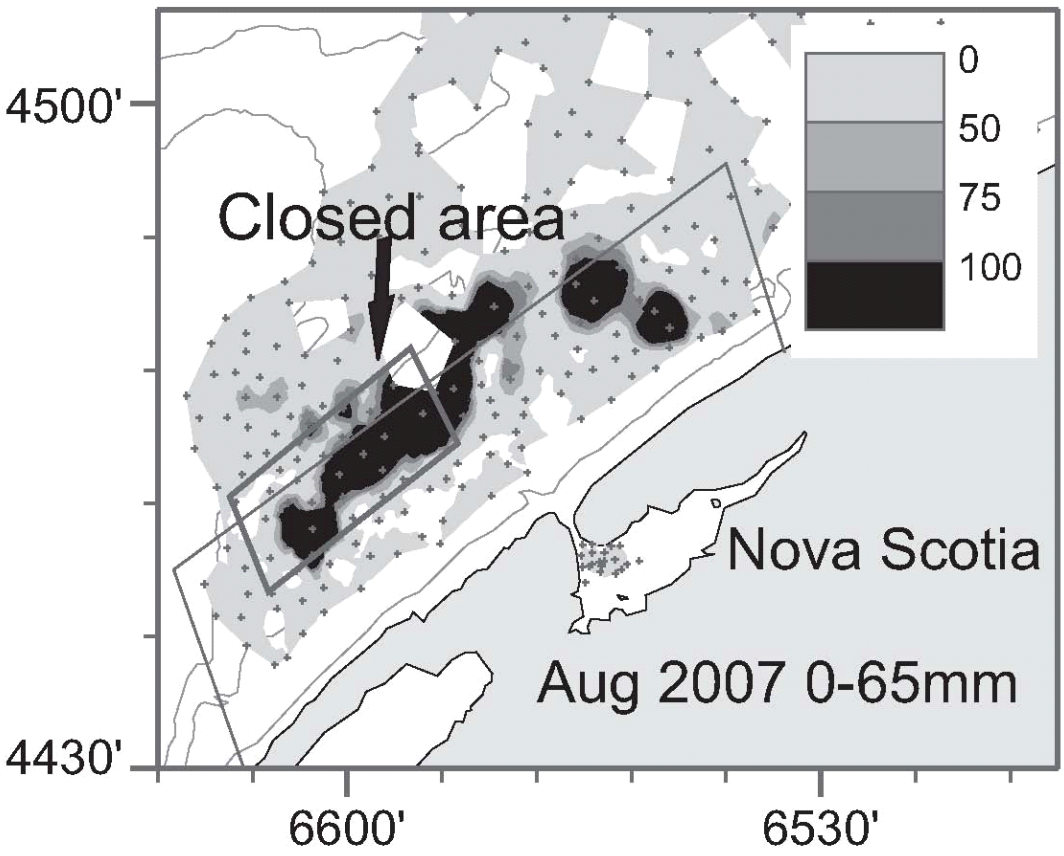

Fig. 53. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for pre-recruit size (<65 mm shell height) scallops. Closed area proposed by Full Bay Fleet to protect small scallops indicated. This closed area was implemented on October 2, 2007, as Variation Order 2007-123. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of tow locations are indicated.

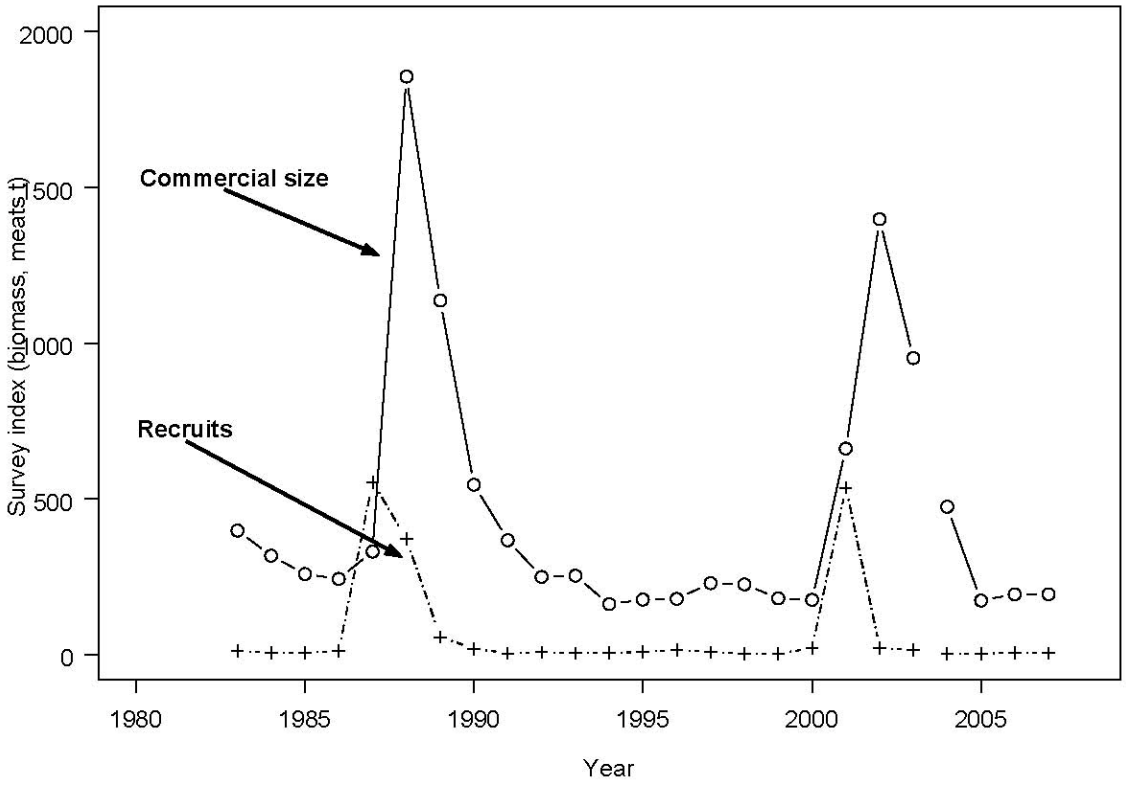

Fig. 54. Trends in survey estimates of biomass (t) of commercial size scallops (shell height ≥80 mm) and recruits (see text for definition) from annual research vessel surveys of Scallop Production Area 4. Breaks in series indicates change from June surveys to August surveys starting in 2004.

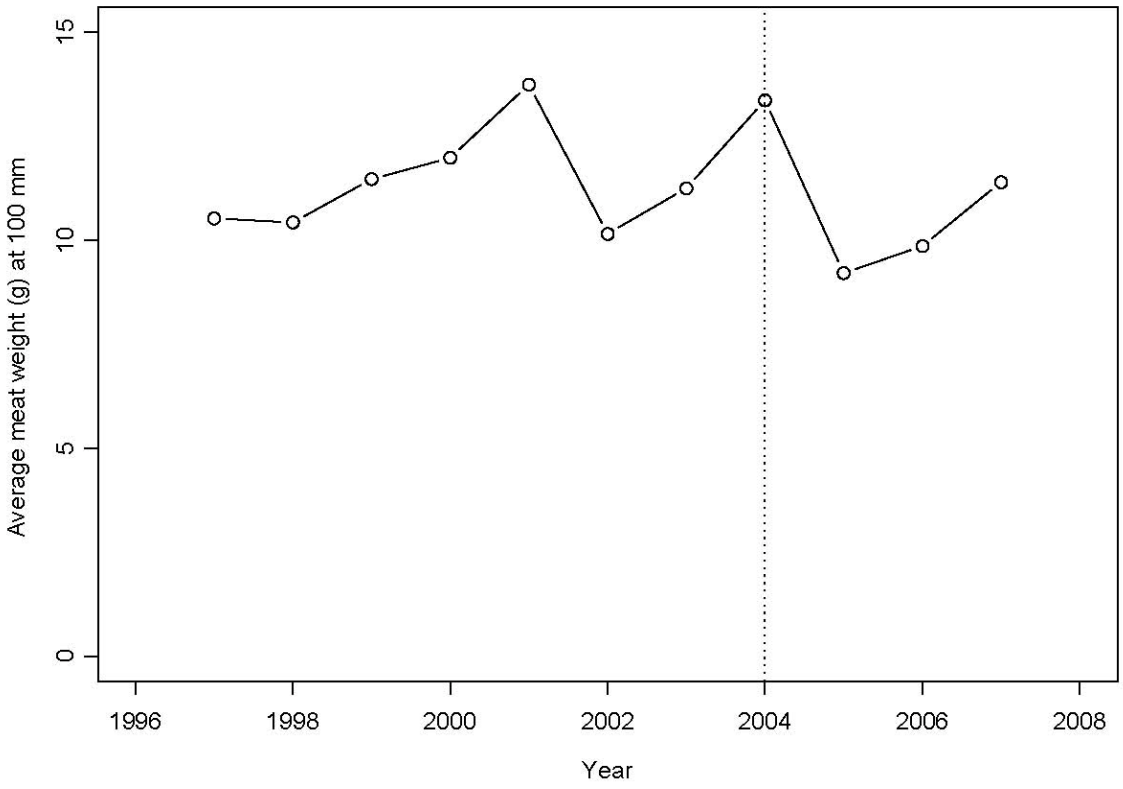

Fig. 55. Predicted meat weights for a scallop with shell height to 100 mm and depth equal to the mean depth of SPA 4. Predictions come from a mixed effects model fitted to survey data with meat weight a function of shell height and depth.

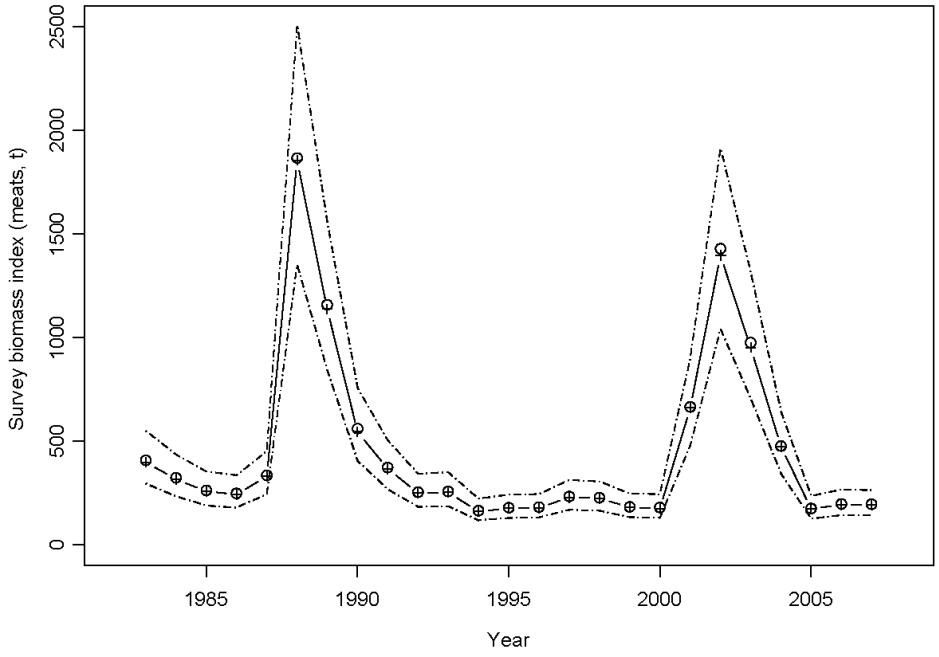

Fig. 56. Comparison of observed survey biomass estimates of commercial size scallops (+) for SPA 4 with posterior mean (o) and 95 percent credible regions (dash-dot lines) for fitted survey biomass.

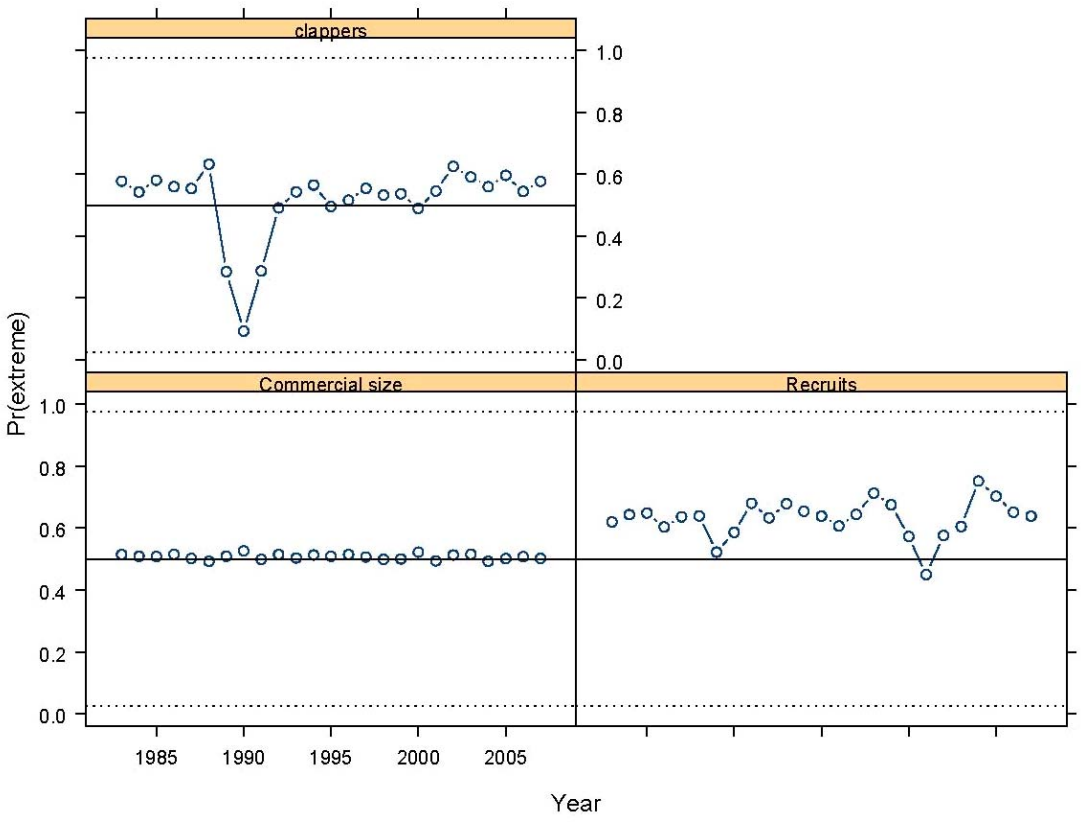

Fig. 57. Probabilities of getting larger observation than obtained for survey estimates of biomass, recruits, and clappers. Dotted lines indicate probabilities of 0.025 and 0.975.

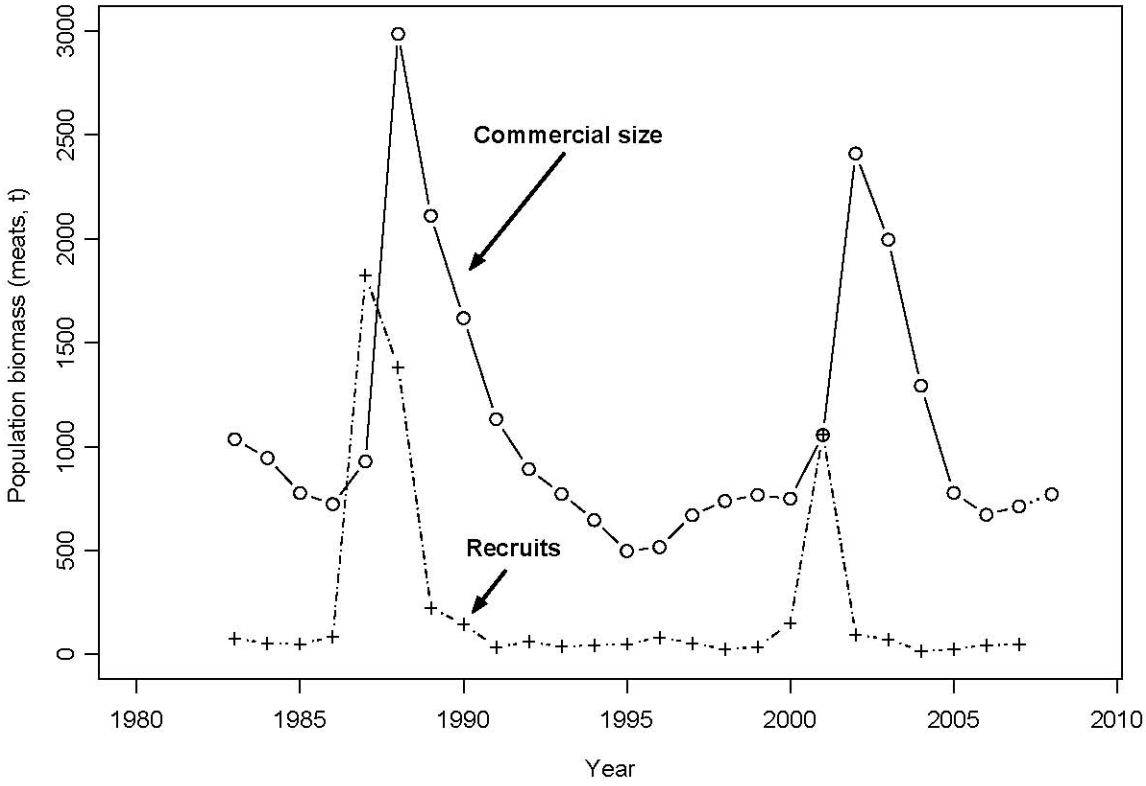

Fig. 58. Trends in model estimates of biomass (meats, t) of commercial size scallops (shell height ≥80 mm) and recruits for scallop fishing area 4. Forecast for 2008 based upon a catch of 100 t in the 2007–08 fishing season.

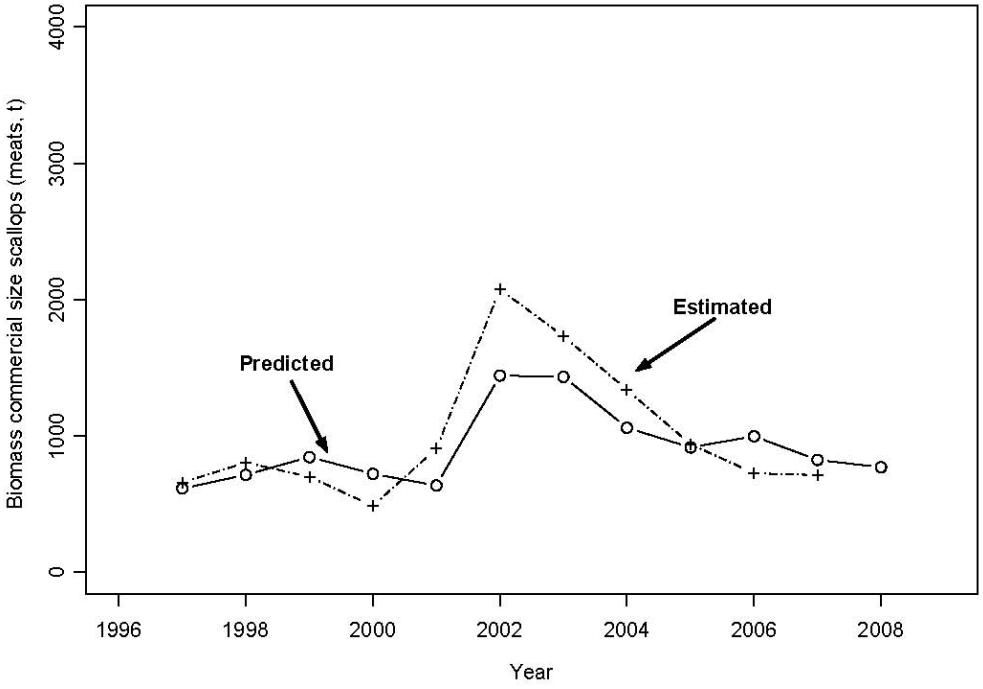

Fig. 59. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size scallops (≥80 mm shell height) in the current year in Scallop Production Area 4. Predictions and current year estimates were produced form the delay-difference population model. Prediction for 2008 made assuming a 2007/2008 catch of 100 t.

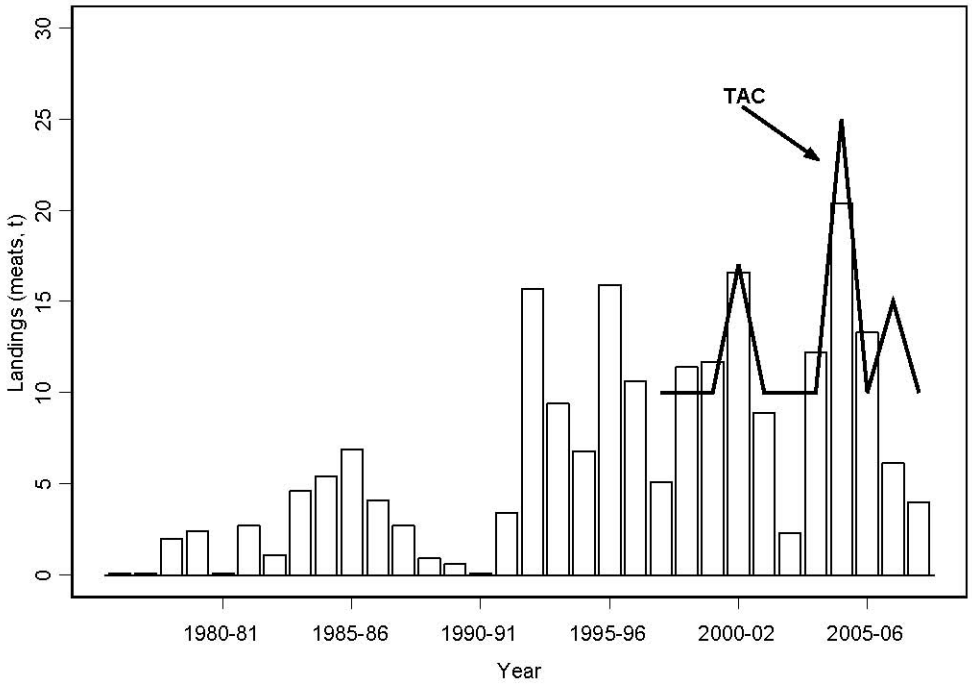

Fig. 60. Trends in scallop catch (meats, t) from SPA 5. TACs were initiated in 1997.

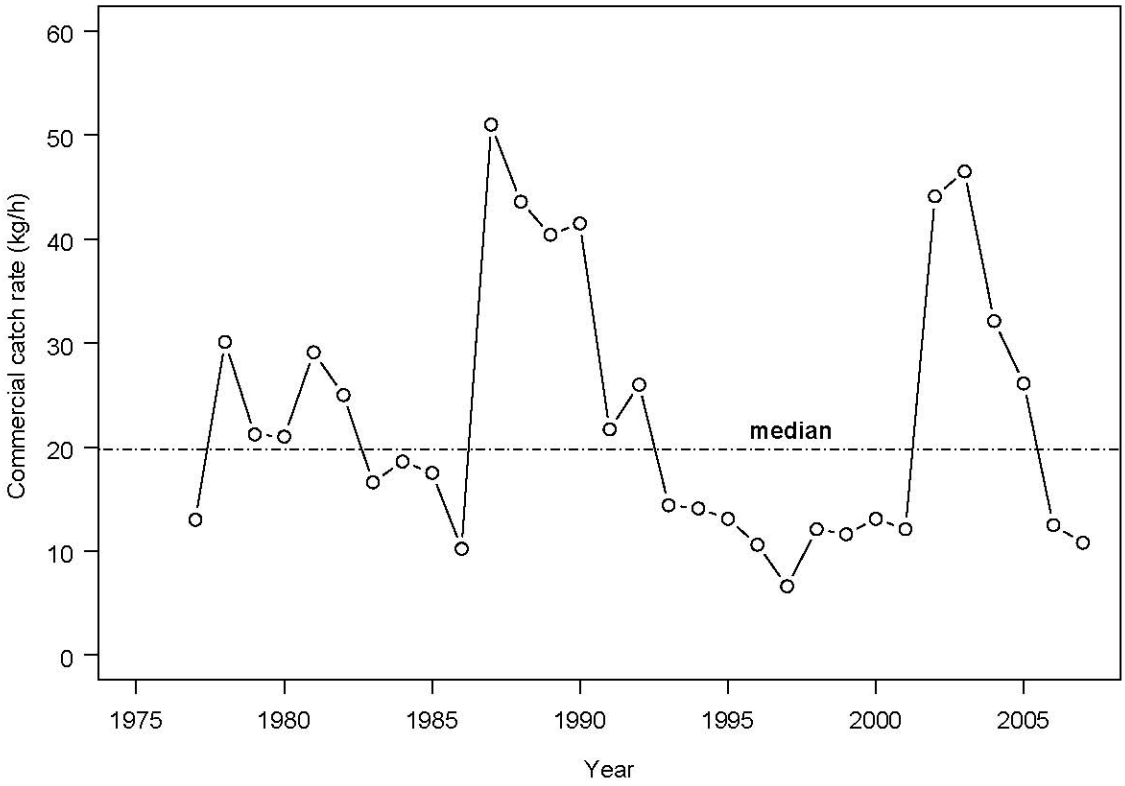

Fig. 61. Commercial catch rate (kg/h)for scallops in Scallop Production Area 5. Median catch rate over the 1976 to 2006 period indicated.

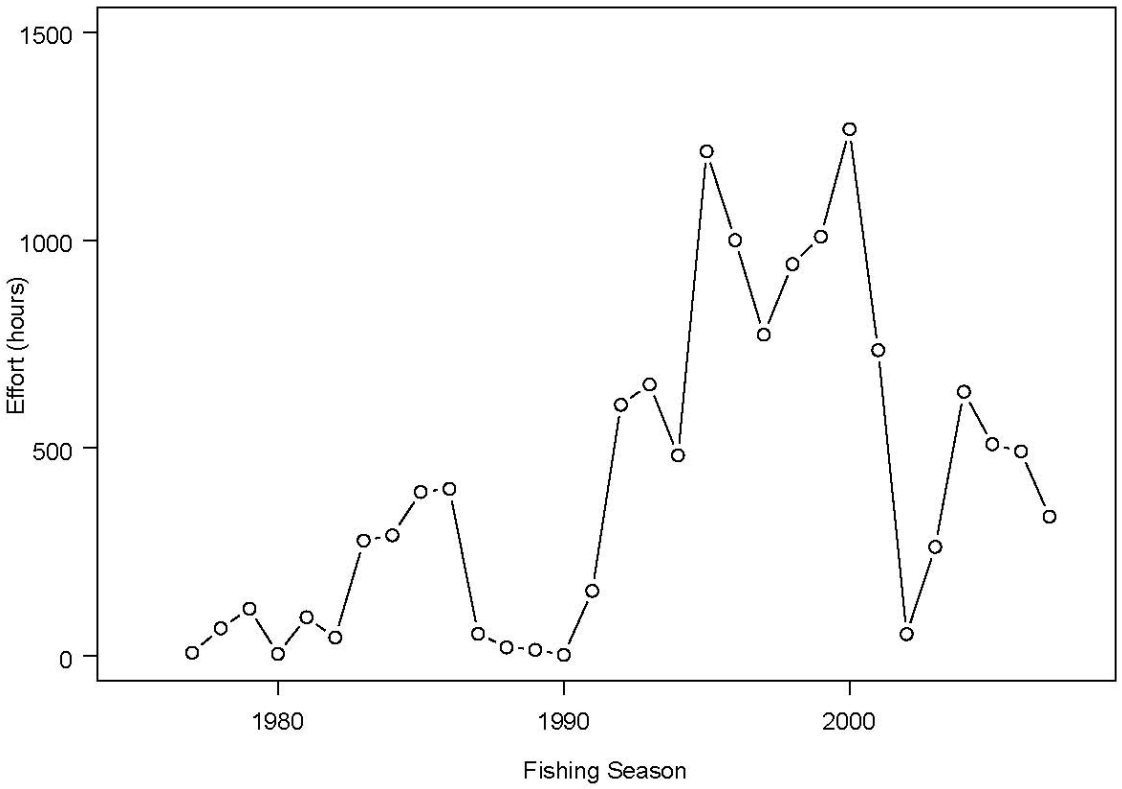

Fig. 62. Commercial fishing effort (hours) for scallops in Scallop Production Area 5.

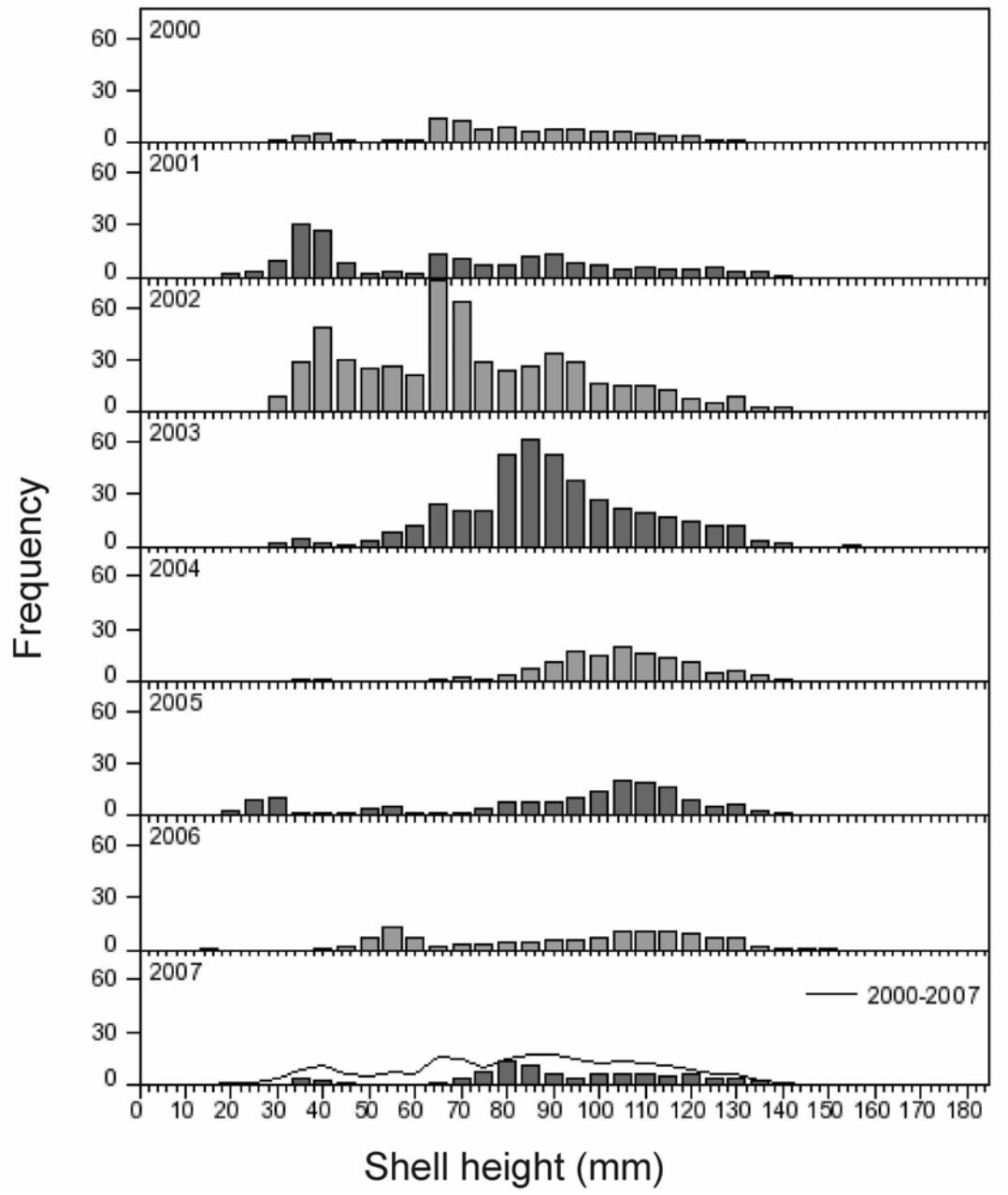

Fig. 63. Scallop shell height frequencies from the 2000 to 2007 surveys of Scallop Production Area 5.

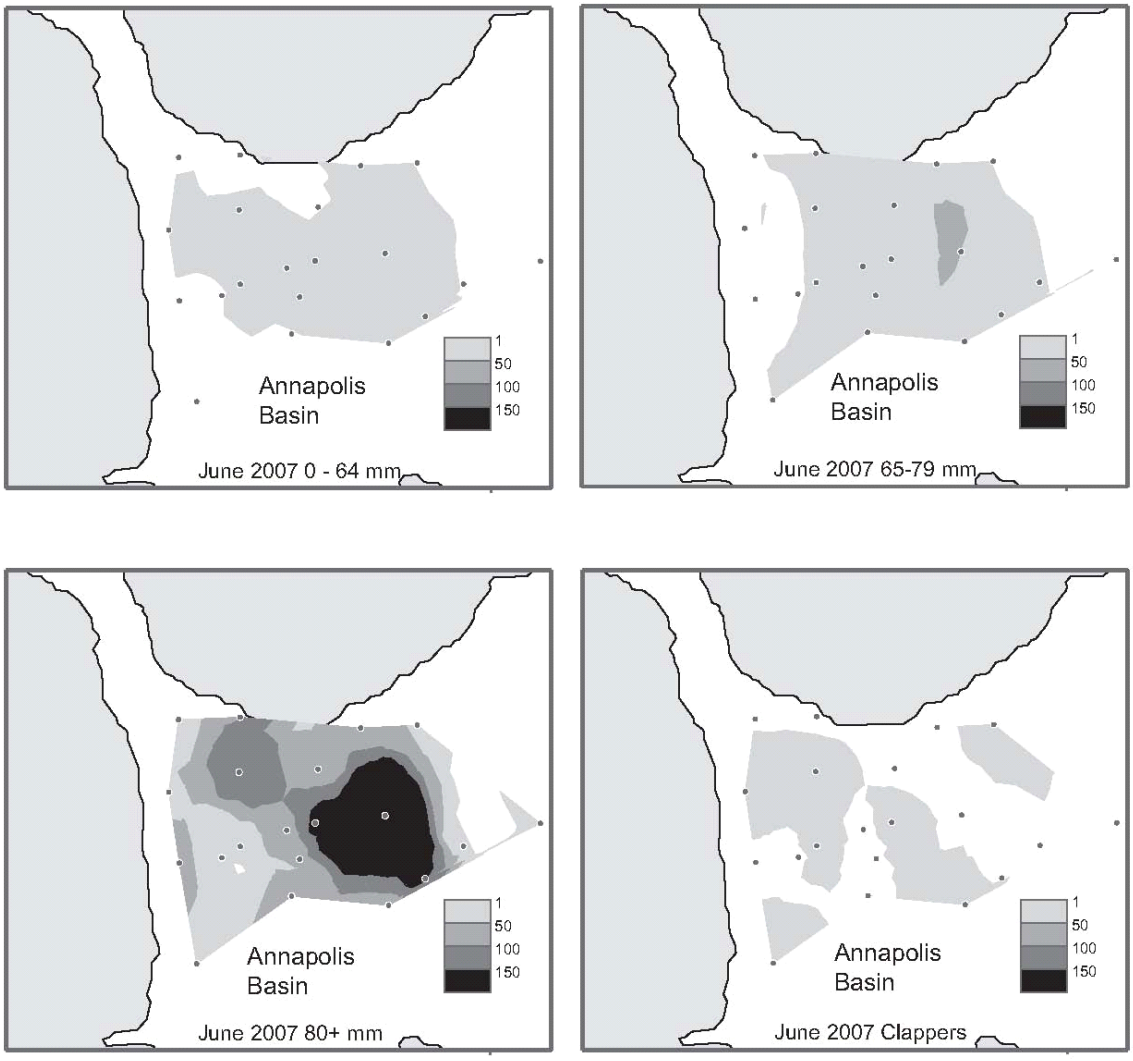

Fig. 64. Spatial distribution of scallop catches from the June 2007 survey of Scallop Production Area 5. Upper left panel: scallops with shell heights less than 65 mm. Upper right panel: scallops with shell heights 65 to 79 mm. Lower left panel: scallops with shell heights equal to or greater than 80 mm. Lower right panel: catches of clappers for all shell sizes. Contouring was derived using Delauney triangles and inverse distance weight interpolation. Positions of two locations are indicated on the map.

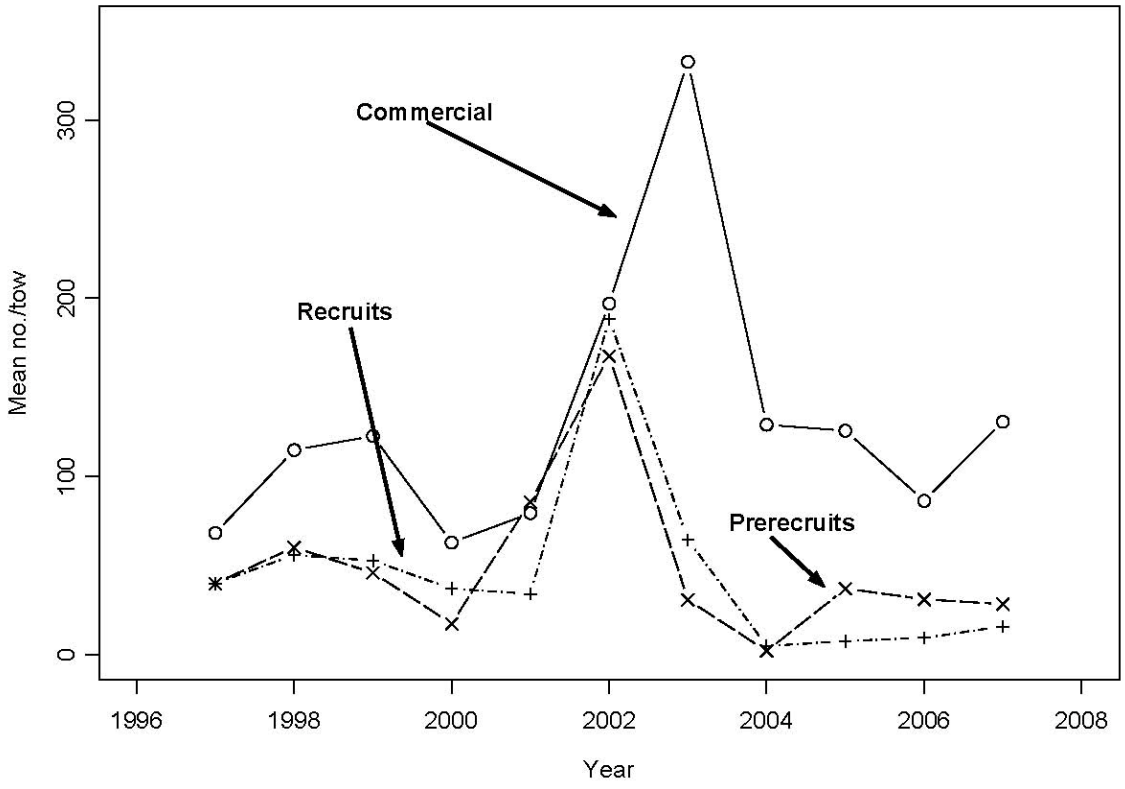

Fig. 65. Survey abundance index (mean number/tow) for commercial size scallops (≥80 mm shell height), recruits (65–79 mm shell height), and pre-recruits (<65 mm shell height) in Scallop Production Area 5.

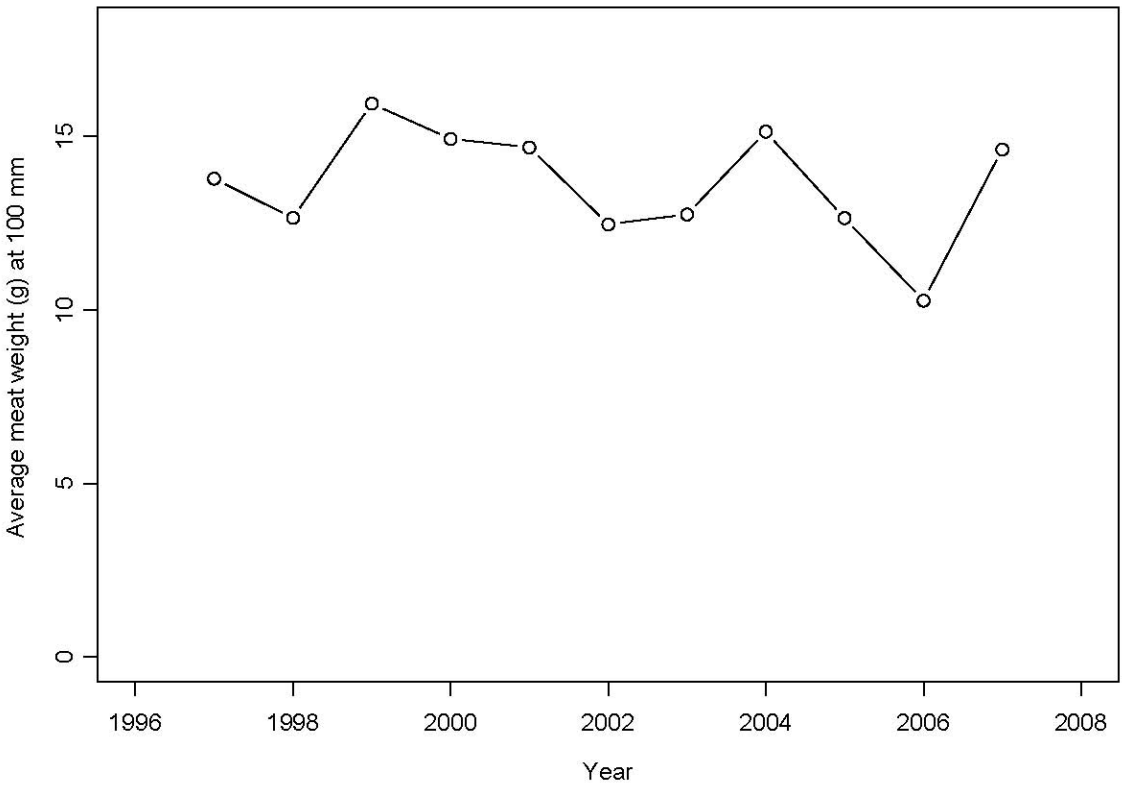

Fig. 66. Predicted meat weights for a scallop with shell height equal to 100 mm in SPA 5. Predictions come from a mixed effects model fitted to survey data with meat weight a function of shell height.

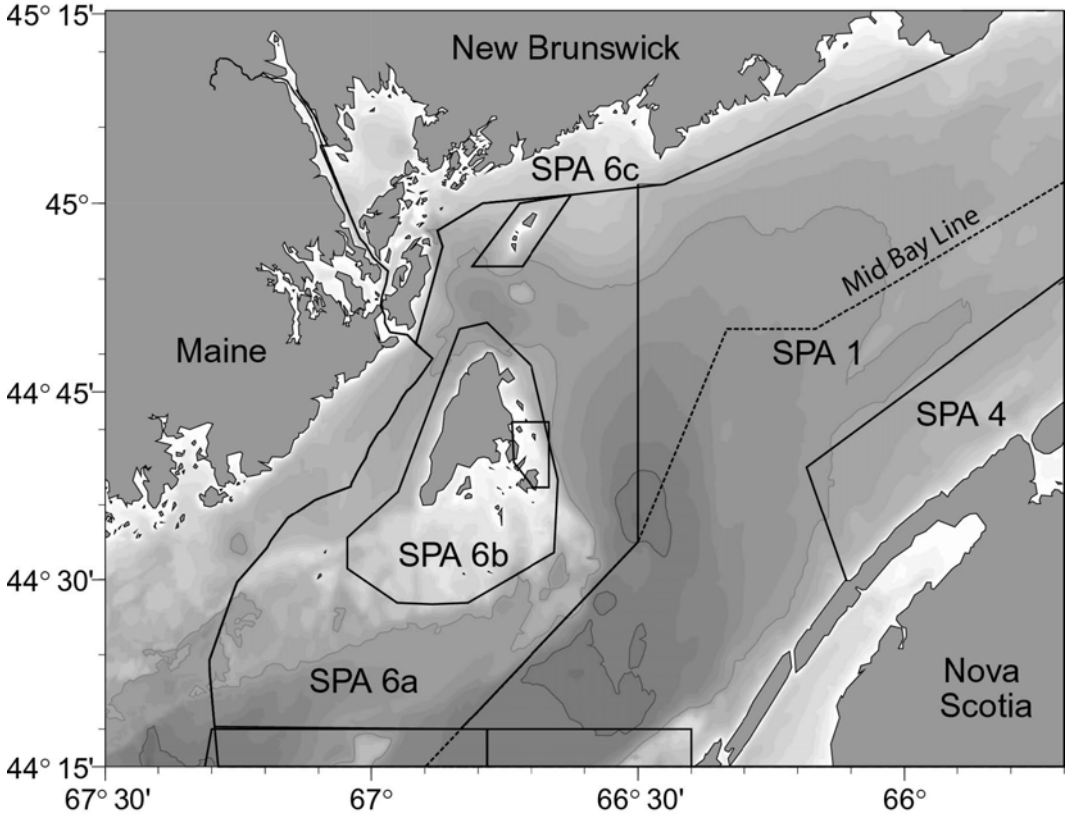

Fig. 67. Map of Scallop Production Area (SPA) 6 in the Bay of Fundy.

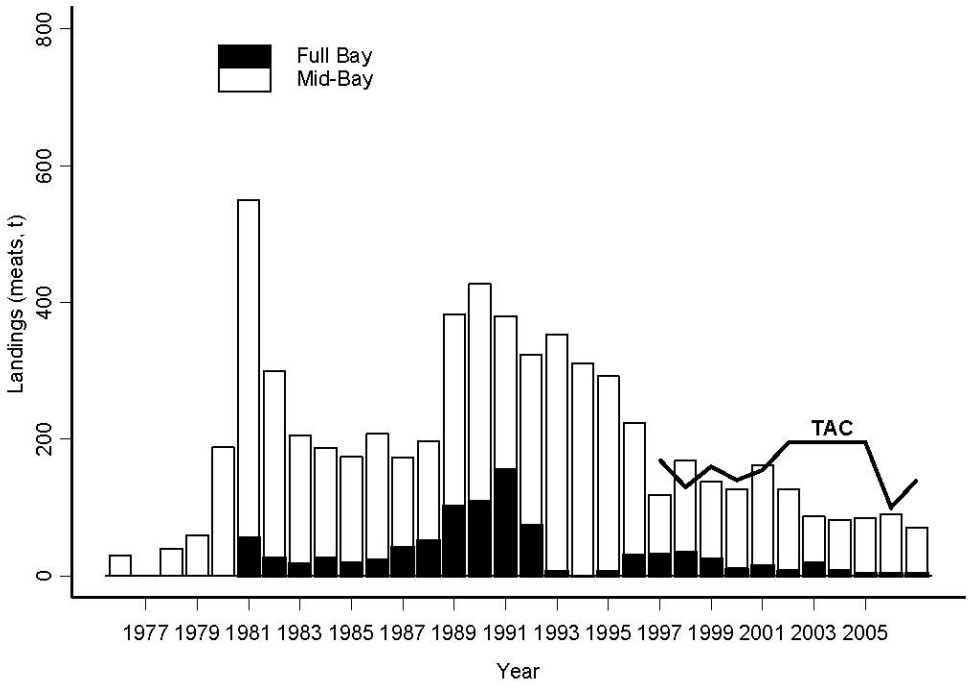

Fig. 68. Scallop landings (meats, t) in Scallop Production Area 6 by fleet.

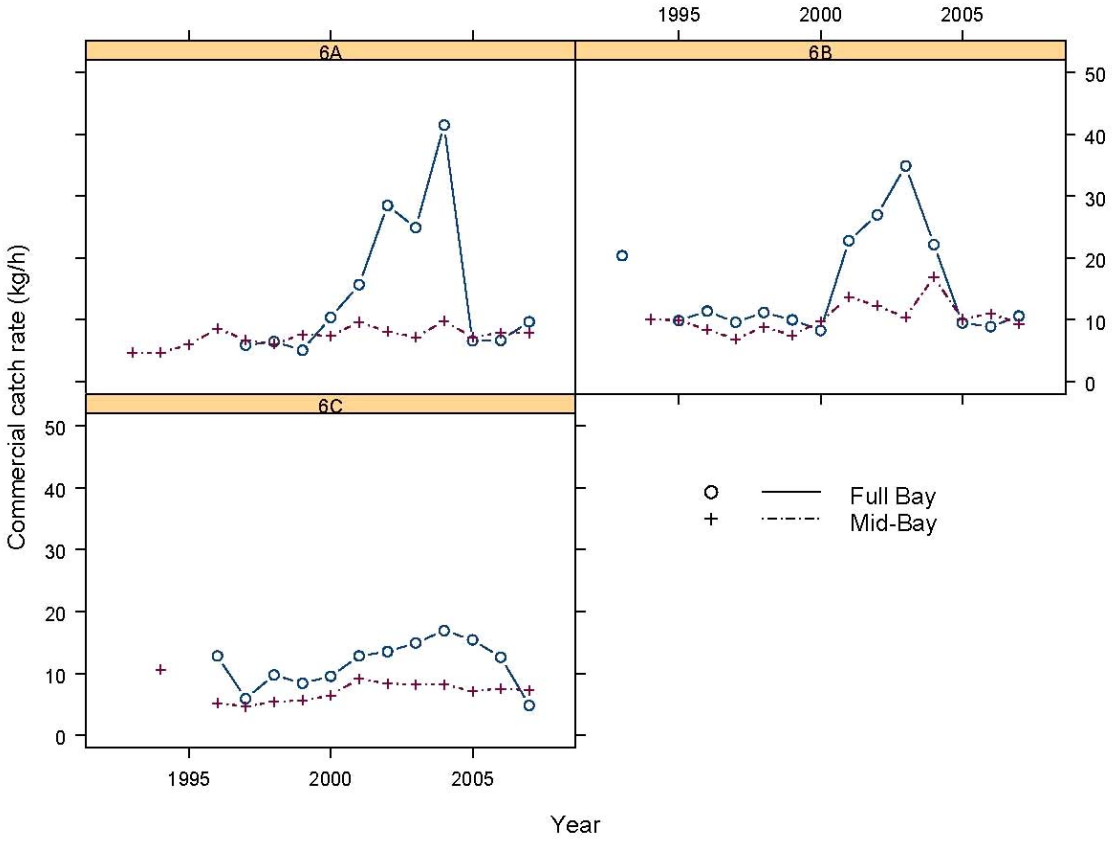

Fig. 69. Commercial catch rate (kg/h) for scallops in Scallop Production Area 6. Top left: SPA 6A, Top right: 6B, Bottom left: 6C.

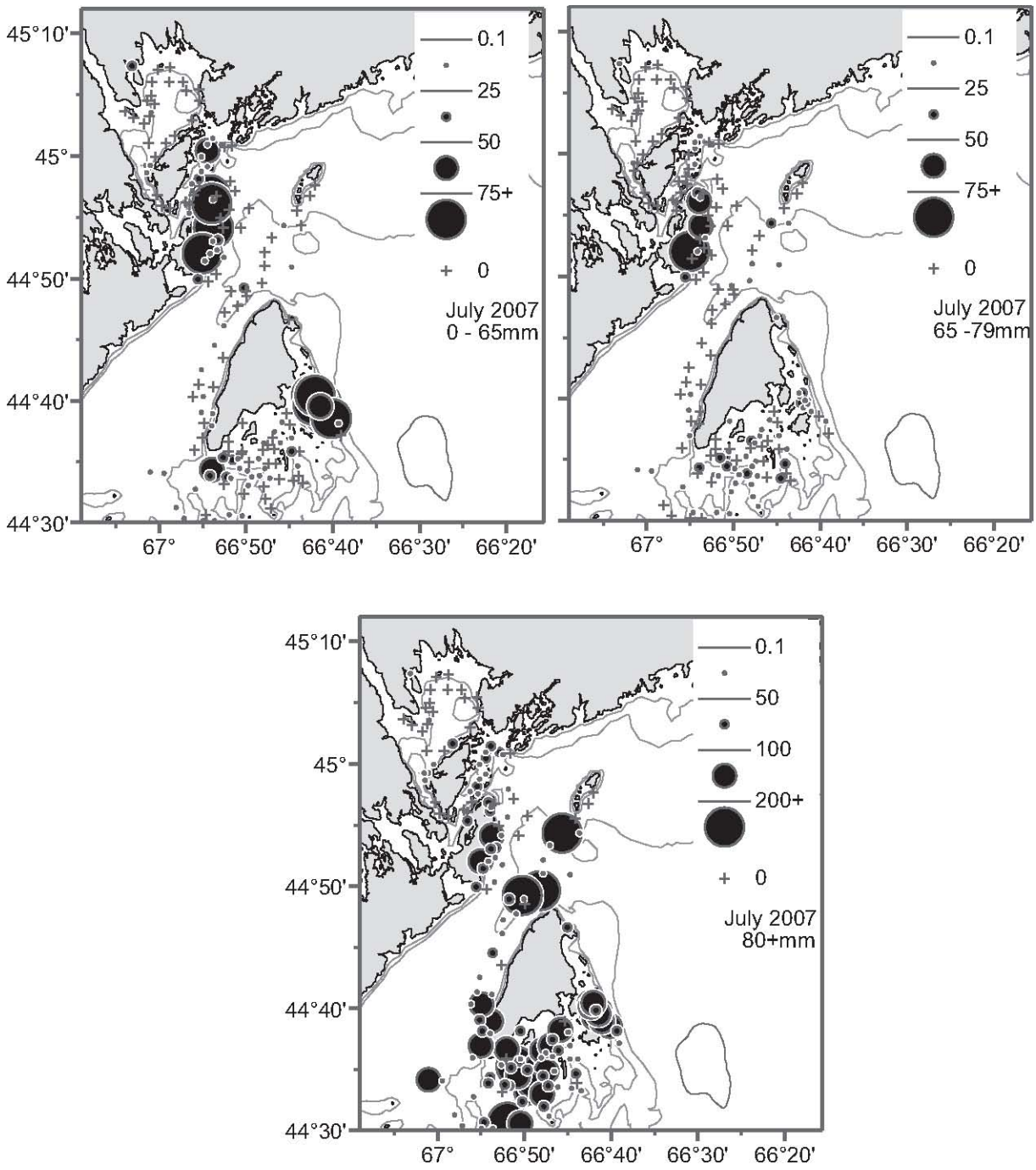

Fig. 70. Spatial distribution of scallop catches from the July 2007 survey of Scallop Production Area 6. Top left panel: 0–64 cm shell height; top right panel: 65–79; bottom panel: ≥80 mm.

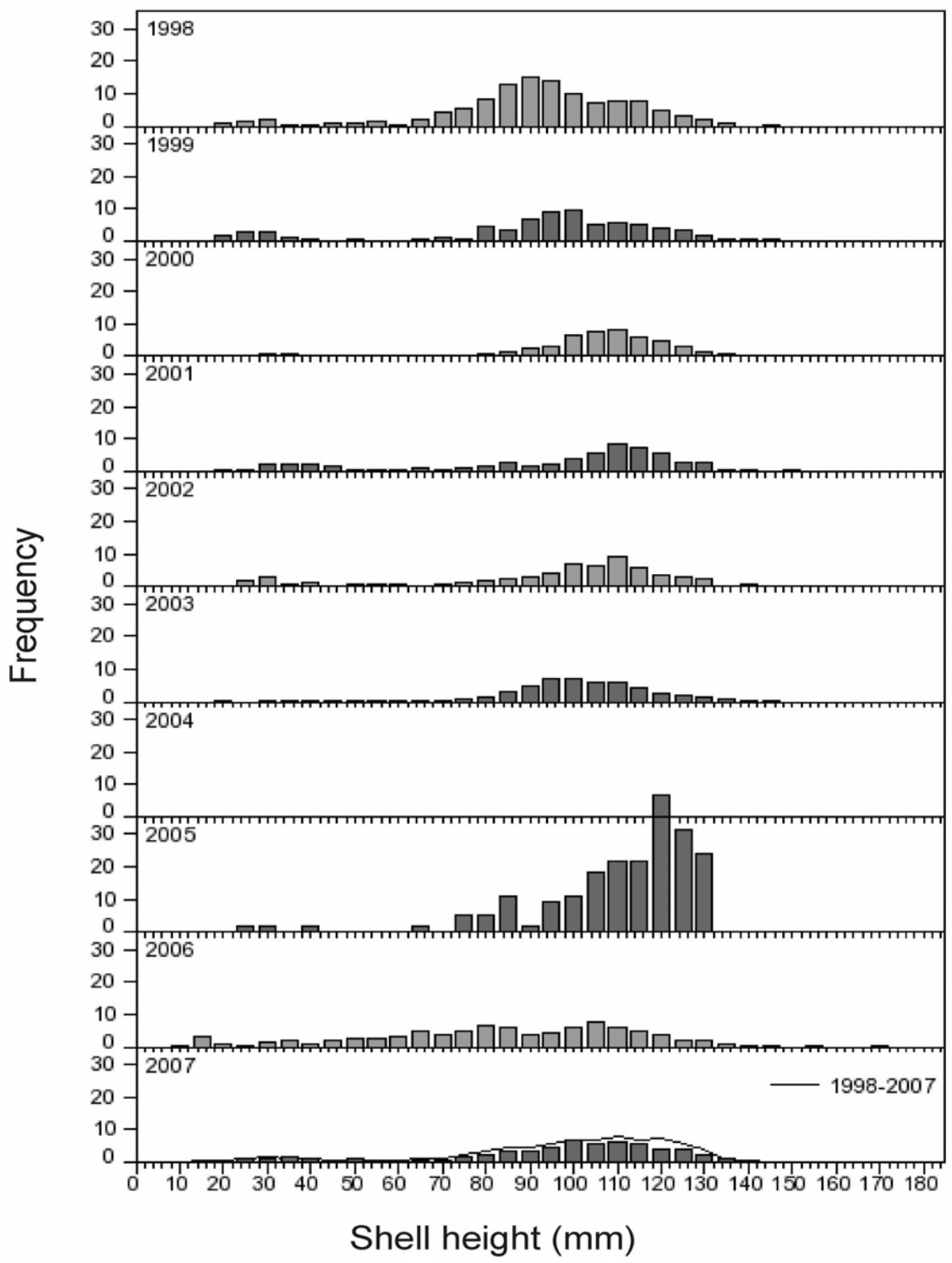

Fig. 71. Comparison of shell height frequencies from the 1997 to 2007 surveys of SPA 6A. No survey was conducted in 2004 and the 2005 survey consisted of only 2 tows.

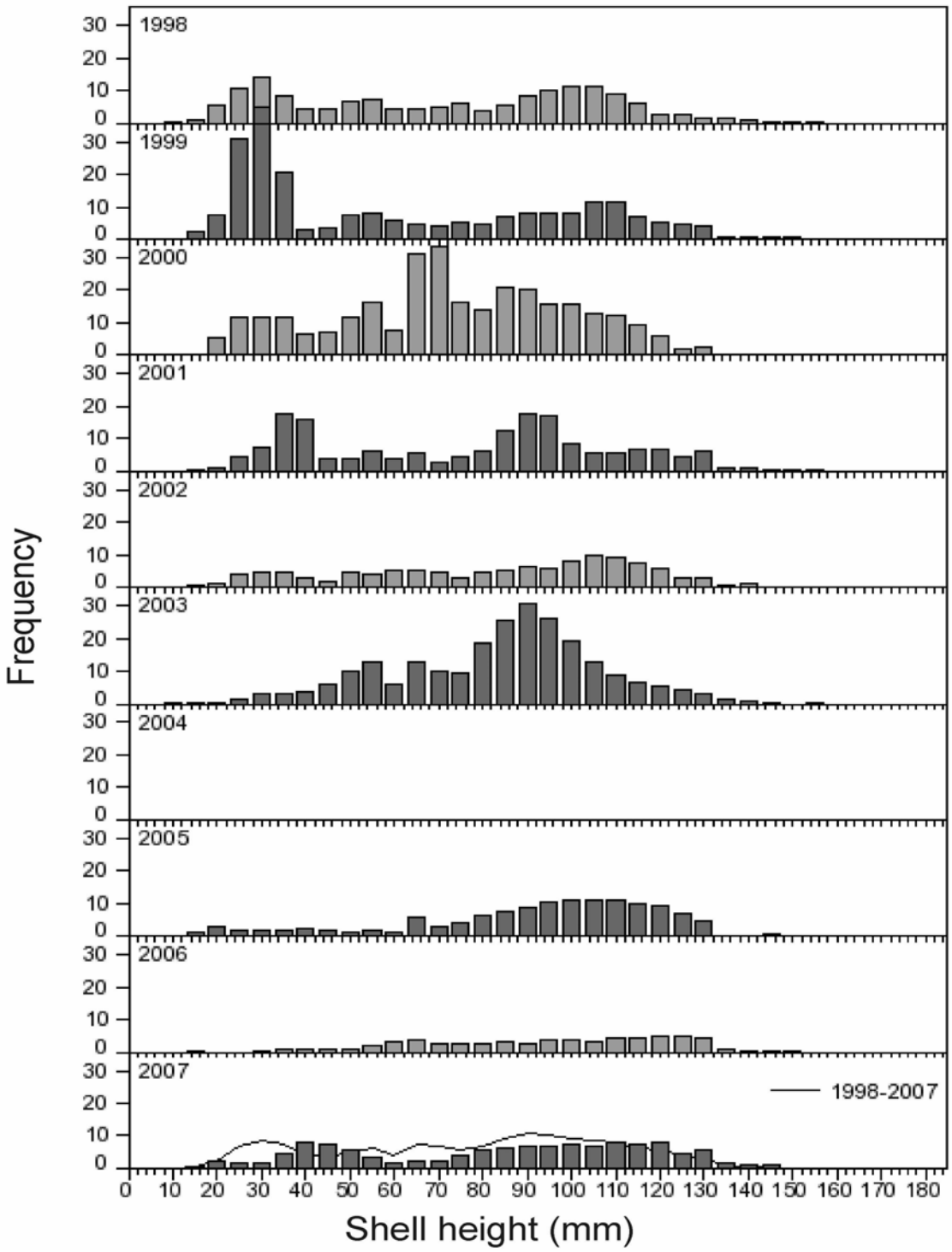

Fig. 72. Comparison of shell height frequencies from the 1997 to 2007 surveys of SPA 6B. No survey was conducted in 2004.

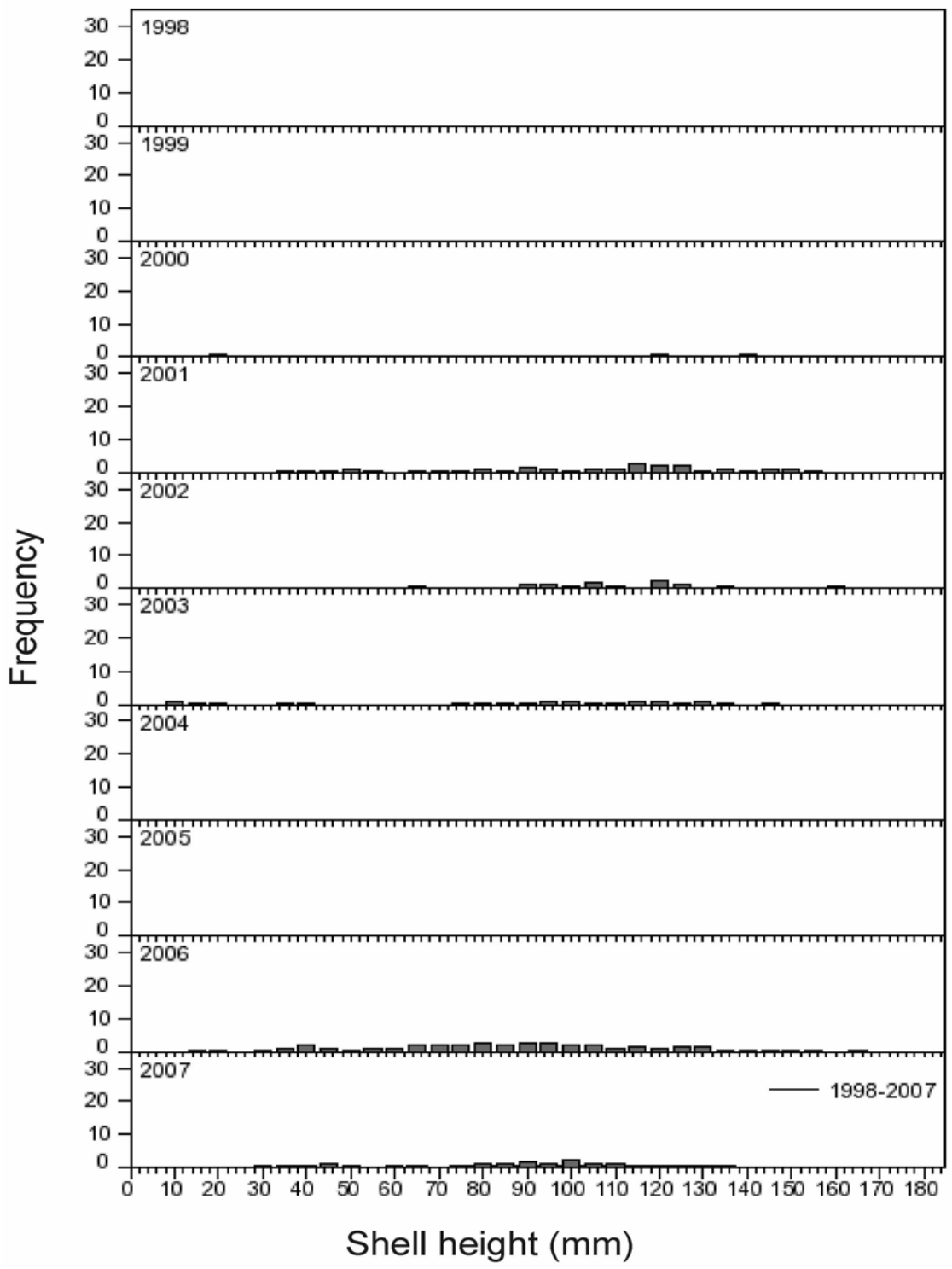

Fig. 73. Comparison of shell height frequencies from the 2000 to 2007 surveys of SPA 6C. No survey was conducted in 2004 or in 2005.

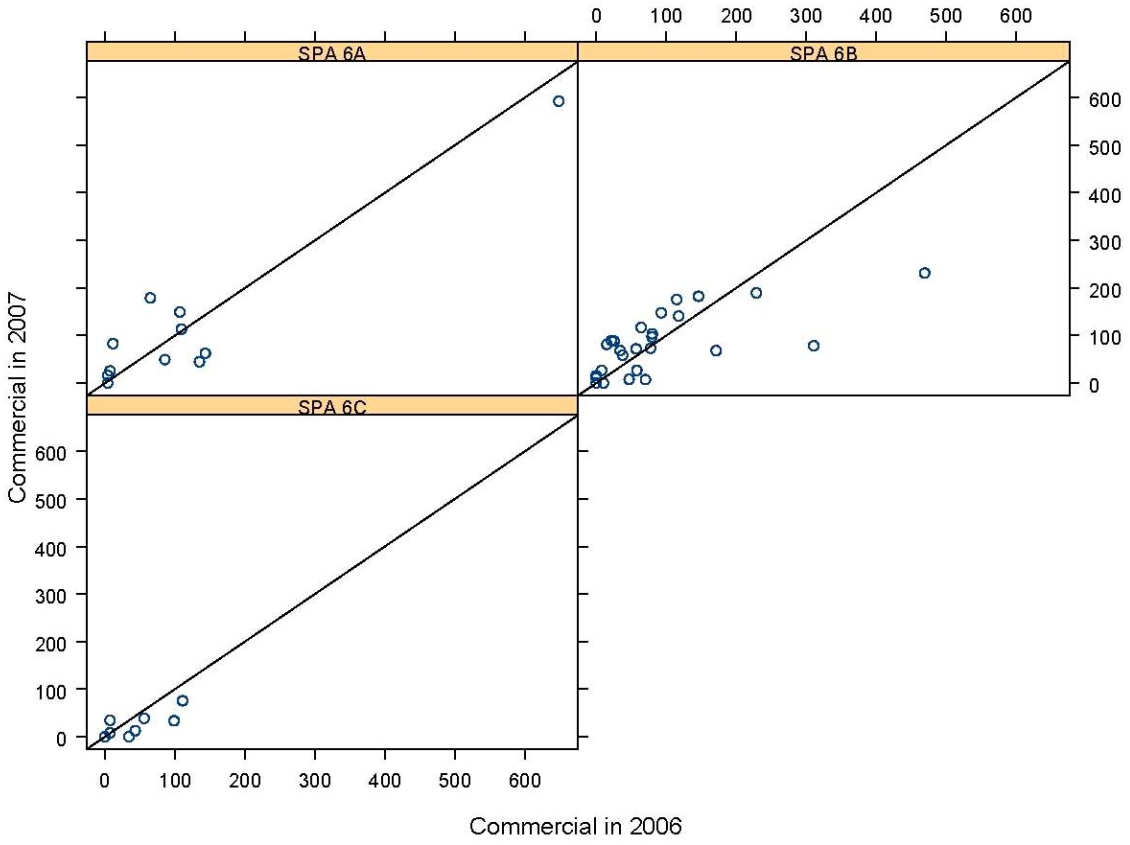

Fig. 74. Comparing numbers of commercial size scallops (≥80 mm shell height) caught in 2006 and 2007 in the survey stations common to both of the surveys in SPA 6. Solid line indicates 1:1 line.

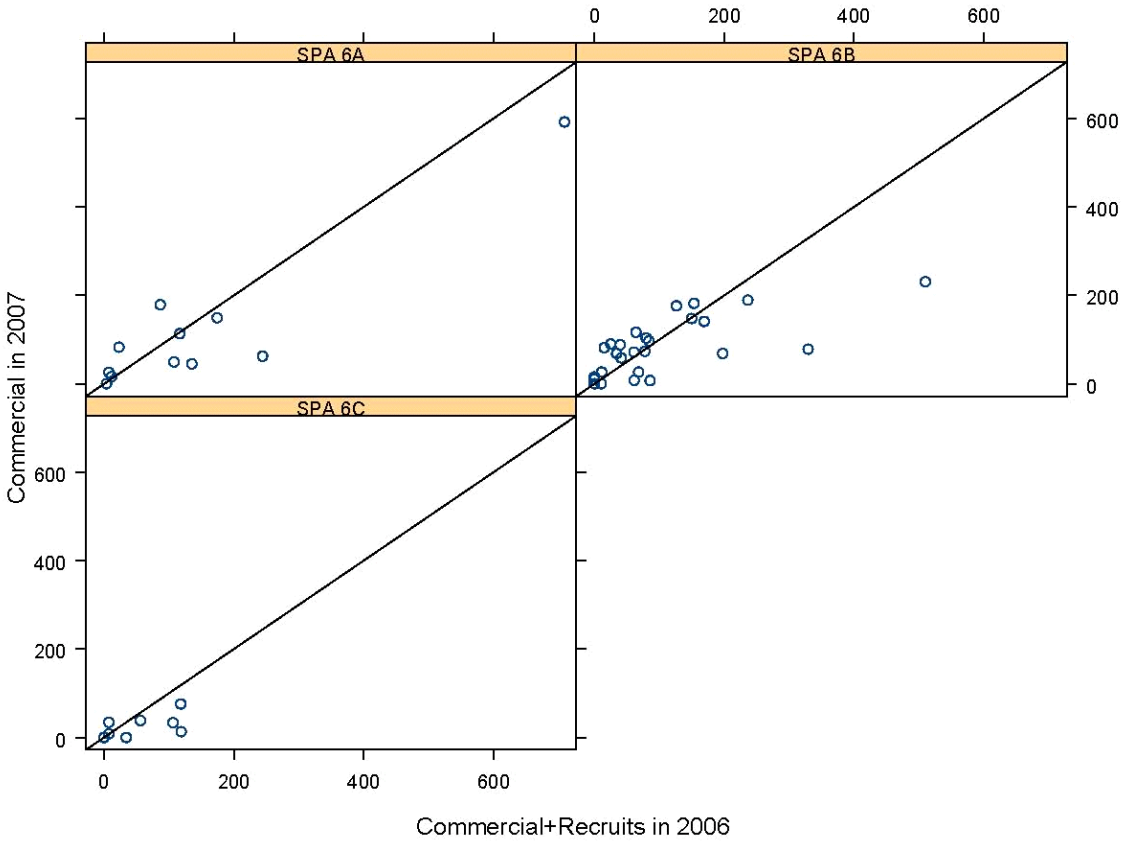

Fig. 75. Comparing numbers of commercial size scallops (≥80 mm shell height) and recruits (65 to 79 mm shell height) caught in 2006 and commercial size scallops 2007 in the survey stations common to both of the surveys in SPA 6. Solid line indicates 1:1 line.

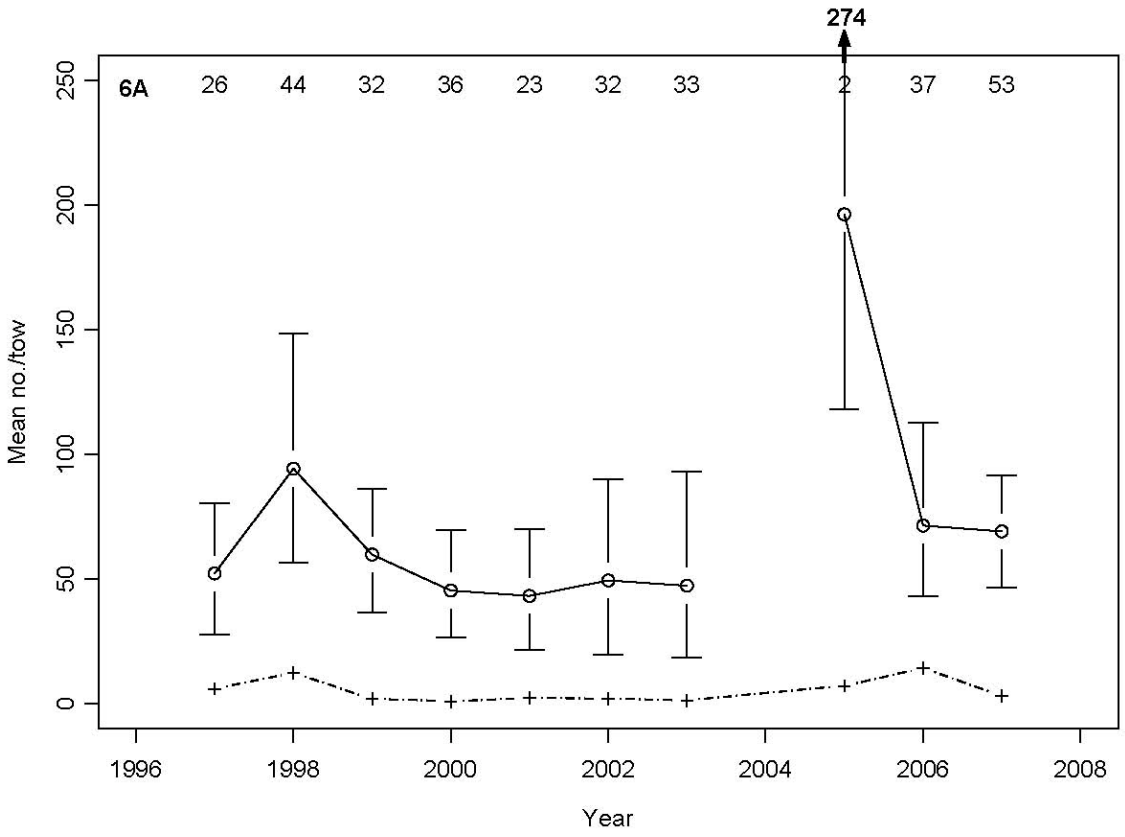

Fig. 76. Trends in survey estimates of mean number per tow of commercial size scallops (shell height ≥80 mm) and recruits (see text for definition) from research vessel surveys of Scallop Production Area 6A. Upper and lower limits refer to 95 percent bootstrap limits. The number of random tows complete each year are given across the top of the graph.

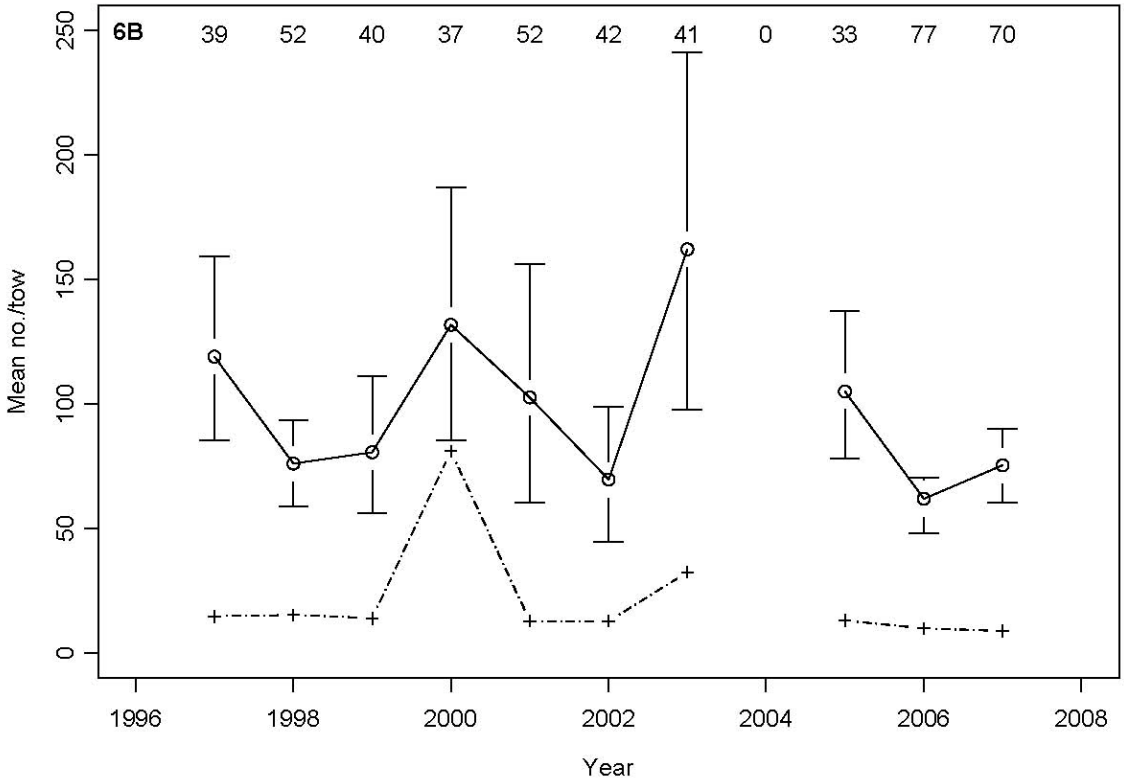

Fig. 77. Trends in survey estimates of mean number per tow of commercial size scallops (shell height ≥80 mm) and recruits (see text for definition) from research vessel surveys of Scallop Production Area 6B. Upper and lower limits refer to 95 percent bootstrap limits. The number of random tows complete each year are given across the top of the graph.

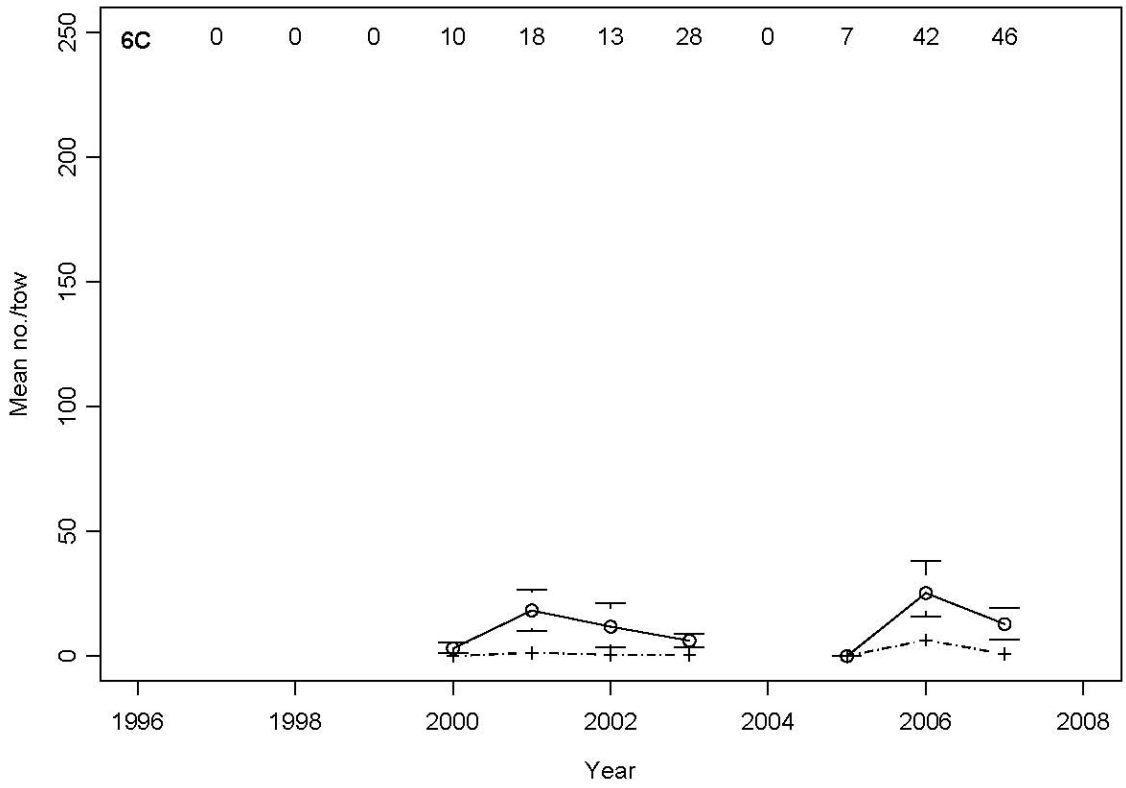

Fig. 78. Trends in survey estimates of mean number per tow of commercial size scallops (shell height ≥80 mm) and recruits (see text for definition) from research vessel surveys of Scallop Production Area 6C. Upper and lower limits refer to 95 percent bootstrap limits. The number of random tows complete each year are given across the top of the graph.