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# Scallop fishing area 29: Stock status and update for 2007

# Zone de pêche 29 du pétoncle : état du stock et mise à jour pour 2007

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## Abstract

For the sixth consecutive year, a fishery was conducted in the portion of Scallop Fishing Area (SFA) 29 west of longitude 65°30′W. Starting in 2002, the TAC was shared between the Full Bay Fleet and a limited number of inshore east of Baccaro licence holders who are eligible to fish in SFA 29 west of longitude 65°30′W (i.e., East of Baccaro Fleet). During 2006, a total of 406.1 t (307.7 t Full Bay; 98.4 t East of Baccaro) was landed against a TAC of 400 t. Average meat weights from the 2006 fishery ranged from 19.2 g to 23.8 g and were not appreciably different from those observed in 2005.

Average commercial catch rates have declined since the opening of the fishery in 2001 with the rate of decline being higher for the Full Bay Fleet compared to the East of Baccaro Fleet. Preliminary analysis of the spatial patterns of catch and effort from log books suggests that effort rather than catch rate is matching the density of scallops and as a result catch rate is becoming more similar throughout the areas and between vessels. Therefore, the decline in catch rates will in part reflect a decline in stock abundance but will also be confounded by fishing behaviour. These results match predictions from the Ideal Free Distribution predator-prey theory and are similar to those from studies of catch rates from other fisheries for a variety of species.

The annual survey indicates that biomass levels of commercial and recruit size scallop have declined appreciably since 2005 in all subareas and are at their lowest levels since 2002.

Large numbers of clappers (paired empty shells) were reported by fishermen during the 2006 fishery in subarea D. While it is acknowledged that clapper ratios are higher in subarea D for reasons unknown, there is no evidence to indicate that an epidemic was occurring during the fishery.

Very few scallops with shell heights less than 100 mm were found by the survey in subarea A. Continued fishing in subarea A in 2007 will probably be limited to scallops ages 6 and older due to limited recruitment.

The population model estimates have a high degree of uncertainty associated with them and may represent a lower bound for possible TACs (25 t in each of subareas B, C, and D). While commercial catch rates, which are not used in the model, have declined in SFA 29, they suggest a higher biomass than that estimated by the model. There was not enough survey information to recommend catch levels for subarea E. This subarea appears to offer marginal habitat for scallop. Continuing with a TAC at the 2006 level (400 t) for SFA 29 may not be sustainable in the future given that the survey indicates low recruitment for the next three or more years.

Bycatch of lobster by the SFA 29 scallop fishery in 2006 was estimated at approximately 0.12% of the number of lobsters landed by the Lobster Fishing Area (LFA) 34 lobster fishery in the SFA 29 area. Of this 0.12%, less than a third of lobsters were dead or injured.

# Résumé

Pour la sixième année de suite, une pêche a eu lieu dans la partie de la zone de pêche du pétoncle 29, située à l'ouest de 65°30′ de longitude Ouest. Depuis 2002, le TAC est partagé entre la flottille de la totalité de la baie et un nombre limité de titulaires de permis de pêche côtière pour l'est de Baccaro, autorisés à pêcher dans la ZPP 29 à l'ouest de 65°30′ O (soit à l'est de la zone de pêche de la flottille de Baccaro). En 2006, le total des débarquements s'est chiffré à 406,1 t (307,7 t pour la flottille de la totalité de la baie et 98,4 t pour les pêcheurs de l'est de Baccaro), par rapport à un TAC de 400 t. Le poids moyen des chairs des pétoncles pêchés en 2006 se situait entre 19,2 g et 23,8 g, ce qui ne différait pas sensiblement des poids observés en 2005.

Les taux de prises moyens de la pêche commerciale ont diminué depuis l'ouverture de la pêche, en 2001, le déclin étant plus grand au sein de la flottille de la totalité de la baie que parmi les pêcheurs de l'est de Baccaro. Une analyse préliminaire de la dynamique spatiale des prises et de l'effort à partir des journaux de bord semble indiquer que l'effort, plutôt que le taux de prise, correspond à la densité de pétoncles, de sorte que les taux de prise semblent se niveler de plus en plus dans les différentes zones et pour les différents bateaux. Par conséquent, la baisse des taux de prise correspondra en partie à une baisse de l'abondance, mais sera aussi influencée par les pratiques de pêche. Ces résultats sont en accord avec les prédictions faites selon la théorie de la répartition idéale libre et des prédateurs-proies et sont semblables à ceux des études des taux de prise d'autres pêches de diverses espèces.

Il ressort du relevé annuel que la biomasse des pétoncles de taille commerciale et des recrues a sensiblement diminué depuis 2005 dans toutes les sous-zones et qu'elle se situe maintenant à ses niveaux les plus bas depuis 2002.

Les pêcheurs ont signalé la présence de nombreuses claquettes (paires de coquilles vides) au cours de la pêche de 2006 dans la sous-zone D. Il est notoire que le taux de claquettes est plus élevé qu'ailleurs dans la sous-zone D, pour des raisons qu'on ignore, mais rien n'indique que le phénomène ait été épidémique dans l'ensemble de la zone de pêche.

On n'a capturé que très peu de pétoncles d'une hauteur de coquille inférieure à 100 mm dans la sous-zone A au cours du relevé. La pêche dans la sous-zone A en 2007 sera probablement limitée aux pétoncles d'au moins 6 ans, en raison du recrutement limité.

Les estimations découlant du modèle de population comportent un haut degré d'incertitude et peuvent représenter la limite inférieure des TAC possibles (25 t dans chaque sous-zone B, C et D). Quoique les taux de prises commerciales, qui ne sont pas utilisés dans le modèle, aient diminué dans la ZPP 29, ils donnent à penser que la biomasse est plus élevée que ne l'estimait le modèle. Il n'y avait pas suffisamment de données de relevé pour recommander un niveau de prises dans la sous-zone E. Cette sous-zone semble n'offrir qu'un habitat marginal pour le pétoncle. Le maintien du TAC à son niveau de 2006 (400 t) dans la ZPP 29 pourrait ne pas être viable à l'avenir, étant donné que le relevé dénote un faible recrutement pour les trois prochaines années, voire pour plus longtemps.

En 2006, les prises accessoires de homard par les pêcheurs de pétoncle de la ZPP 29 ont été évaluées à environ 0,12 % du nombre de homards débarqués par les homardiers de la zone de pêche du homard (ZPH) 34 dans la ZPP 29. De cette proportion de 0,12 %, moins du tiers des homards étaient morts ou blessés.

## Introduction

Scallop Fishing Area (SFA) 29 encompasses a very large inshore area inside the 12-mile territorial sea, from the south of Yarmouth (latitude 43° 40′N) to Cape North in Cape Breton (Fig. 1). This report refers to only that portion of SFA 29 west of longitude 65° 30′W continuing north to Scallop Production Area 3 at latitude 43° 40′N.

Prior to 1986, the Full Bay Scallop fleet had fished in this area. Following the 1986 inshore/offshore scallop fishing agreement, fishing by the Full Bay fleet was restricted to north of latitude 43°40′N. A limited fishery by the Full Bay fleet was granted from 1996–98 in the northern portion of SFA 29 as defined above. Access was again granted to this fleet in 2001 with a full at-sea monitoring program, and with a condition of a post-season industry-funded survey. Scallop fishers had consulted with lobster fishers in the area to deal with potential conflicts. Lobster by-catch was minimal in 2001 despite high scallop catch rates (for more details on the history of this fishery see Smith and Lundy 2002a). Lobster bycatch continues to be monitored in this fishery.

In 2002, the Minister approved access to SFA 29 by the Full Bay fleet and inshore east of Baccaro licence holders who are authorized to fish in SFA 29 west of longitude 65°30′W. SFA 29 inshore scallop licenses were historically restricted to east of Baccaro (east of longitude 65°30′W). Five areas within SFA 29 (A to E) were defined for the 2002 fishery based upon areas of similar densities of commercial size scallops in the 2001 survey (Fig. 1). These areas were designed to provide flexibility in the allocation of catch and fishing effort for the 2002 fishery and have been retained as part of the fishing plan since then (Smith and Lundy 2002a).

A three-year joint project agreement was signed in 2002 with the two fishing fleets, Natural Resources Canada, and Department of Fisheries and Oceans with all parties providing funds to conduct multi-beam acoustic mapping of the seafloor and other scientific work. A map showing bottom features for the entire area was prepared and distributed to the fishermen for the 2004 fishery (Fig. 2). This map was used in this assessment to interpret trends in commercial catch rate and survey estimates of abundance and biomass.

This report summarizes commercial fishery, research survey and observer data for the 2006 fishery and provides advice for the 2007 fishery. The scallop fishery in this area was last assessed in 2006 (Smith et al. 2006a).

Smith et al. (2006a) used a delay-difference model to evaluate the impact of the fishery on the population. These kinds of models are only as good as the abundance indices and the validity of associated assumptions underlying them. In this document, we evaluate the two available abundance indices: commercial catch rate (or CPUE) and survey estimates. While we only used the latter last year, the possibility of losing the survey series required us to evaluate the commercial series as well.

## Commercial fishery

The 2006 SFA 29 scallop fishery in subareas A, B, and E opened 0600h 19 June, while that in subarea C and subarea D opened at 0600h on 26 June and 4 July, respectively. The fishery continued until 18 August with the exceptions of subarea D which was closed at

0559h 7 July (reopened 17 July for a 12 hour period; Variation order 2006-070) and subareas A, C, and E which were closed 2 August. During 2006, a total of 406.1 t (307.7 t Full Bay; 98.4 t East of Baccaro) was landed against a TAC of 400 t (Table 1).

The fishery management plan sets a 100 mm minimum shell height for retained scallops and in this report, scallops with shell height $\geq$ 100 mm will be referred to as commercial size and 90–100 mm scallops will be referred to as recruits for the following year.

The number of meat weight samples from the commercial catch was down in 2006 (17 samples) relative to 2005 (35 samples) for the Full Bay Fleet and none were collected in 2006 for the East of Baccaro Fleet (compared to 4 samples in 2005; Table 2). Average meat weights in each subarea during 2006 were not appreciably different from those observed in 2005. Percentages of small meats (less than 8 g) continued to be extremely low.

Catch rate indices

Corrupted commercial log data was discovered in the database while preparing this assessment. The correct data have now been loaded to the database and the catch rate indices for both fleets have been recalculated for this document. As a result, the indices presented here will differ from those presented in previous documents, in particular, the estimates for 2002 will be higher than previously reported.

Average commercial catch rates (kg of meats/h) over the whole area have declined since the opening of the fishery in 2001 with the rate of decline being higher for the Full Bay fleet compared to the East of Baccaro fleet (Fig. 3). Trends for each of the subareas A to C were similar, however the changes between 2005 and 2006 for subarea D were very different for the two fleets (Fig. 4). Only the western half of D was opened in 2004 and while the whole area was opened briefly in 2005, all fishing by both fleets was concentrated in the eastern half of the subarea (Fig. 5). Many fishermen reported large catches of clappers (paired empty shells) during this fishery (see discussion of clappers as an index of natural mortality in Smith and Lundy 2002b). From previous surveys and fishing we know that this subarea has higher densities of clappers than the other subareas in SFA 29 but the reports from the 2006 fishery indicated that they were higher than 10 to 30% observed in earlier years and more widespread in distribution. Estimates obtained from fishermen during and after the fishery and as well as from onboard observers ranged from 30 to 70% of the catch being made up of clappers. The fishery in D was closed 7 July pending updates to the quota report. The fishery was reopened for a 12 hour period July 17 so that the two fleets could complete fishing their quotas; At the same time the F/V Royal Fundy agreed to go to survey the area with a DFO technician on board. An analysis was presented to representatives of both fleets at BIO on August 4 where a number of representatives asked that more quota be allocated in this subarea in anticipation of continued high mortality as indicated by the clappers. The Regional Director General did not support additional quota and the fishery in D remained closed. We will return to the clapper issue later in this document.

Final catch rates in D for the Full Bay fleet declined in 2006 after the high in 2005 to be below the estimate for 2004, while the East of Bacarro catch rates remained level over the three years subarea D has been open. However, the catch rates for this subarea continued to be higher than the other four subareas similar to last year (Table 3). In the past, catch rates tended to be higher at the beginning of the season, but this year saw catch rates peak in July for those subareas that opened in June (A, B and E). The catch rates for August only reflect between 2 and 6 days of fishing.

Catch rate estimates calculated by major bottom types in the area generally reflect trends for each of the subareas (Fig. 6). The thin sand areas are mainly found in subarea D while glacial till generally occurs in subarea C. The increase in the catch rate for till/silt mainly tracks subarea A and part of B. The increase in 2004 mirrors that for subarea A (Fig. 4).

Catch rate as an indicator of population abundance

The traditional interpretation of commercial catch rate (catch-per-unit effort or CPUE or $C/E$) is based on the following equation

$$\begin{aligned} C &= qEN \\ C/E &= qN \end{aligned} \tag{1}$$

where $C$ represents catch (numbers or weight), $q$ is catchability to the gear, $E$ is effort and $N$ is the population abundance or biomass. Assuming that catchability is constant over time, catch rate $C/E$ should track population abundance over time.

This is a very simplistic model and even if $q$ was constant over time, it does not take into account the spatial distribution of the animals being fished. Clark (1982) proposed four types of frequency distributions or "concentration" profiles that could describe all of the known distribution patterns of marine commercial species (see also Prince and Hilborn 1998). Scallops are known to be more abundant in specific habitats and a skewed concentration profile (e.g., Fig. 7) where conditions favouring high densities of scallops are relatively rare would seem to be appropriate.

Given this type of concentration profile, the expected trends for commercial catch rate over time will be a very rapid decline once the high abundance (density) areas have been located and fished out and then a much slower decline as areas of more moderate densities are fished. Over time, catch rates will diminish unless there is a substantial recruitment event. This pattern appears to explain the trends for subareas 29 B and C and possibly A. Density plots for Full Bay commercial catch rates for subareas A to C (Fig. 8) all show similar patterns of a few very high catch rates in the early years followed by a rapid decline in mean catch rate. Thereafter, there is a much slower decline in the maximum and mean catch rate and range of catch rates observed.

East of Baccaro commercial catch rates follow a similar pattern but this fleet did not experience the very high catch rates in the earlier years that the Full Bay fleet did possibly because they entered the fishery in its (2002; Fig. 9).

The pattern for Full Bay catch rates in subarea D was different than expected mainly because the area fished in 2004 and 2005 were almost completely different whereas the fishery in 2006 overlapped these two areas plus the area to the south (Figs. 5 and 8).

The spatial resolution of the commercial logbook data is only available to the one minute square on a trip basis. Preliminary comparison of the VMS and logbook data indicated that locations were very similar in both cases (Black and Smith 2006). Even at this resolution, Black and Smith (2006) observed that there were differences in locations fished for the three years that they examined (2003 to 2005). In general, the fishery concentrates on a higher proportion of new locations each year relative to repeating locations fished in the previous year (Table 4). The catch rates at the new locations were higher than those observed at the repeat locations from the previous year about half the time. For subarea D there is somewhat more overlap in Figure 5 than reported in Table 4 because the former was based on all daily log records while the latter only used class 1 logs (i.e., complete catch, effort and location data recorded for entire trip). It is interesting to note that all of the high density areas in subareas B and C as measured by catch rate were discovered in the first two years of the fishery despite the high degree of movement each year thereafter (with possible exception of one trip by Full Bay in C in 2004).

This interpretation of catch rates, referred to as exploitative by Gillis and Peterman (1998) suggests that the higher catch rates will be associated with the higher amounts of effort. However, the pattern for catch rates here is that more often than not the highest catch rates are associated with the lower levels of effort (Figs. 10 to 13).

There is an alternate interpretation of commercial catch data that borrows from predator-prey theory referred to as Ideal Free Distribution theory (Fretwell and Lucas 1970). This theory predicts that for predators hunting prey characterized by patchy distributions, the predators will distribute themselves so that their foraging activity will be proportional to the density of their prey and hunting success will be very similar everywhere irrespective of the prey density. This theory assumes that predators have freedom to move around, have a good knowledge of prey distribution and there is increasing interference between predators as predator density increases. This theory has been applied to commercial fishing by Gillis et al. (1993), Gillis and Peterman (1998) and Swain and Wade (2003), amongst others. In the case of SFA 29, we can assume that fishermen do have a good knowledge of scallop distribution at least after the first year or two of fishery in addition to receiving tow positions from the survey each year. The availability of the multibeam maps after 2002 may have also conferred some advantage. The subareas A to E are small enough that searching within these subareas should not be severely restricted by operating costs. Given the short season, interference in terms of spatial limitations on the number of boats in an area would be a reasonable assumption.

The main elements that this theory predicts for commercial catch rates are that effort rather than catch rate will be directly proportional to the density of scallops in any one area and that catch rates will tend to become more similar over the area and between vessels. In this context the expected pattern for the distribution of effort is that in the initial stages of the fishery, effort by location will exhibit a restricted range. This does not mean that high densities have not been identified only that knowledge of their location is not widespread through the fleet. Given the short season for SFA 29, this knowledge may take more than one season to disseminate but once these areas have been identified, the range of effort will increase with the higher effort locations being associated with the higher scallop density areas. New high density areas may be identified in time but will attract more effort at the time or in the future. As effort matches the density of scallops, catch rates become more similar over the area, extremely high catch rates are no longer observed and overall the catch rate in an area will decline but not necessarily in direct proportion to the decline in the resource.

While the comparison between catch rate and proportion of effort (Figs 10 to 13) may suggest that effort is matching the density of scallops the real test requires showing that catch rate is becoming more similar throughout the areas and between vessels. To test this we use the approach of Gillis et al. (1993) where the catch rate $C_i/E_i$ at any location $i$ are similar over all locations if,

$$C_/E_i = \frac{\sum_i C_i}{\sum_i E_i} \tag{2}$$

for all locations $i$. Rearranging this equation gives

$$\frac{C_i}{\sum_i C_i} = \frac{E_i}{\sum_i E_i} \tag{3}$$

which indicates that the proportion of catch at location $i$ will be equivalent to the proportion of effort at the same location. This relationship implies a linear relationship of the form $Y = X\beta$ so that linear regression methods can be used to test whether or not $\beta$ is equal to 1.0. In our case the relationship is more linear if we transform the above to

$$\log\left(\frac{C_i}{\sum_i C_i}\right) = \log\left(\frac{E_i}{\sum_i E_i}\right) \tag{4}$$

An arcsin transformation could also be used here. As long as the transformation is one-to-one the finding that $\beta = 1$ or $\beta \neq 1$ in the transformed scale implies the same finding in the original scale.

Standard regression methods were used to construct 95 percent confidence intervals for estimates of $\beta$. The null hypothesis of $\beta = 1$ cannot be rejected when 1.0 is contained within the interval while the alternate hypothesis is indicated when the interval did not contain 1.0. The analysis included grouping the data by location and by vessel.

The results suggest that for the Full Bay fleet, the assumption of equal catch rate among areas was rejected in B and marginal in C for the first two (B) to three (C) years, but could not be rejected for the remaining years in the series (Fig. 14). In 2001, the results imply that the larger portion of the total catch came from areas with lower catch rates for subareas B and C while in 2002 (B) and in 2002–2003 (C), the larger portions of the total catch came from the higher catch rate areas. Thereafter, catch rates by area appeared to be similar. For the most part the patterns for catch rates by vessel were similar to those by area. The results for subarea A were more variable given the smaller amount of effort and trips occurring there. In subarea D, it appears that effort matched the density of scallops in 2004 and marginally in 2006 while in 2005 the larger portions of the total catch tended to come from high catch rate areas. In 2006, more of the catch came from vessels with lower catch rates.

The East of Baccaro results suggest that effort matched the resource starting in 2002 for B and C but in subarea B in 2006, the larger portions of the catch tended to come from the lower catch rate areas (Fig. 15). In subarea D, effort did not match the density of the scallops until 2006. The results for subarea A were too variable to interpret. For the most part the results for vessels tended to follow those for areas.

Simulation results reported by Gillis and Peterman (1998) show that the correlation between stock size and catch rate decreases when ideal free theory is appropriate especially for medium and low density population levels. In our case, the decline in catch rates will in part reflect a decline in stock abundance but will be confounded by fishing behaviour. Therefore, while we know that there has been a decline in abundance we can not say for certain how much of a decline relative to other years. As of yet, there has been no development of catch rate indices that overcome this problem and papers on the subject tend to suggest relying on a survey index for monitoring stock size.

## Research survey

The annual research survey of SFA 29 has been conducted on industry vessels after the fishing season under joint project agreements since 2001. During this time there has been four vessels involved in the survey: F/V Julie Ann Joan (2001–2003,2005–2006), F/V Branntelle (2004), F/V Overton Bay (2005) and F/V Faith Alone (2006). No comparative towing was conducted between the F/V Julie Ann Joan and the F/V Branntelle. Comparative surveys between the other vessels is discussed below.

The F/V Julie Ann Joan used nine miracle drags with 75–78 mm inside diameter rings knitted together with steel washers and with offshore chafing rubbers. Note that steel washers were not used for the 2001 survey. Drag number 1 was lined with 38 mm polypropylene mesh to retain the smaller scallops. The catch in the two end drags (numbers 1 and 9) were sampled on each tow. Sampling and measurements were conducted as per standard scallop research survey protocols (Smith and Lundy 2002b).

Each year, one survey drag was lined with 38 mm polypropylene stretch mesh. Catch in the lined gear was used to estimate the abundance of scallops with shell height less than 80 mm while the catch from one unlined drag was used to estimate the abundance of scallops with shell heights greater than or equal to 80 mm. Catches of scallops with shell heights less than 40 mm are thought to give qualitative indications of abundance only, due to uncertainties about catchability of the small animals.

### Comparative survey

Comparative tows were conducted during the annual scallop stock surveys of 2005 (F/V Julie Ann Joan vs. Overton Bay) and 2006 (F/V Julie Ann Joan vs. Faith Alone). The gear used by each of the vessels was generally similar although there were minor differences. All vessels used 9 gang toothed Miracle gear, however the washers were different. The Julie Ann Joan gear was linked with steel washers with rubber chafing gear while the East of Baccaro gear was linked with rubber washers. The catches in the two end drags were measured, one lined with shrimp netting. In an attempt to make the gear comparable, the East of Baccaro unlined end drag was linked with steel washers with the remainder of the gear linked with rubber washers. Although the end lined gear had different links (steel versus rubber) this should not affect the catch due to the liner. It is unknown what effect different links have on how the gear fishes as a whole. It should also be noted that the Julie Ann Joan towed the gear from the starboard side while the East of Baccaro vessels towed from the stern using an A-frame, which may contribute to how the gear is towed on the bottom.

In 2005, ten comparative tows were completed between the F/V Julie Ann Joan and the F/V Overton Bay. Five of the tows were made on bedrock bottom, but the tow tracks were not lined up and the results were too variable to detect any differences. The remaining 5 tows were made on thin sand bottom and only three of the tows were close together. Preliminary results indicated that on thin sand the F/V Julie Ann Joan did catch more scallop than the F/V Overton Bay.

In 2006, 5 comparative tows were made between F/V Julie Ann Joan and F/V Faith Alone in each of two separate locations in subarea D. The original intent was that the two locations would represent different bottom types but in the end both locations were chosen based on the probability of getting significant scallop catches for comparison purposes. Based upon the surficial bottom type chart both locations had thin sand bottoms. Locations of tows by the two vessels were much closer together than for the experiment in 2005 and probably represent the best that can be done under the circumstances.

Sampling and measurements of the catch on the F/V Julie Ann Joan was handled by DFO staff while a Javitech observer was responsible for the sampling on the F/V Faith Alone. Although the same type of measuring board were used on the two vessels for shell height, the shell height frequencies from F/V Faith Alone were offset from the comparative frequencies from the F/V Julie Ann Joan by at least 5 mm (Fig. 16).

Analysis was restricted to looking at aggregate size classes (commercial and recruits) only because of the offset noted above. The data were analysed as is and with a 5 mm correction for the offset. Paired comparisons (t-test and Wilcoxon signed-rank tests) indicated that the both size classes were more similar between vessels when a 5 mm correction was used. However, this correction is rough at best and so similar to last year we will either present results of the F/V Julie Ann Joan alone or in comparison to using tows from both vessels.

## Survey trends

In 2001, the survey used a simple random sampling design over the whole area. From 2002 to 2004, subareas A–E were defined to be strata with random sampling within strata. Area E has not been consistently covered in the survey due to time limitations. This area has been considered to be marginal habitat for scallops based on previous survey results and has received less priority as a result. In 2005, stratification was based upon the bottom types identified in the bottom features map (Fig. 2) with allocation of tows to these surficial "strata" over the whole subarea. Therefore the surficial strata were the main survey design variables and indices by subarea (A to D) had to be estimated after the fact. The design was modified in 2006 so that allocation of tows was to surficial strata within subareas (A to D), which simplified the calculations.

In previous stock assessments for SFA 29, survey estimates for 2001 to 2004 were calculated using standard formula for stratified random surveys. In this document, these estimates have been recalculated as post-stratifed estimates based on surficial strata within subareas.

The 2005 estimates were calculated using domain estimators to overcome the problem allocating to bottom type and then grouping by subarea. In 2006, standard stratified random estimates were used for surficial strata within subareas. Details on these different estimating methods are presented in Smith et al. (2006b). The impact of these changes particularly for 2001 to 2004 are minimal for subareas A and B (Fig. 17). For C the trend remains the same for the two sets of estimates although those based on bottom type for 2001 to 2004 are lower overall. The major change in D is that the estimate for 2003 has been adjusted down to account for non-proportional sampling between the bedrock and the thin sand bottom (see Smith et al. 2006b). In an earlier assessment, the decline from 2003 to 2004 was seen as higher than expected given the size of the fishery that year.

Spatial plots of the size of survey catches over the six years of the survey indicate the high commercial size densities over most of the subareas in the first few years (Fig. 18). Recruits were mainly in the west portion of SFA 29 in the earlier years but thereafter the major area for recruitment was in subareas C and D (Fig 19). The spatial patterns for pre-recruits (80 to 89 mm) and younger (65–79 mm) mimic those for the recruits with the appropriate delay in time (Figs 20 and 21, respectively). At present, almost all recruits and pre-recruits are in C and D.

The shell height frequencies present similar information to the spatial plots (Figs. 22 to 25) but with two additional observations to note here. First, clappers (paired empty shells) tend to mirror the frequency distribution and abundance of the live commercial size animals. It is possible that there would have been similar distributions of clappers for the smaller animals but because of their size they were more prone to having the hinge broken or more quickly deteriorated than the larger scallop shells.

The second thing to note is that unlike shell height frequencies for surveys in the Bay of Fundy (Smith et al. 2006c) it is difficult to follow cohorts in SFA 29 survey data. Cohort signals are probably strongest in subarea C (Figs 24) and possibly in subarea D (Fig.25) but the changes in abundance between 2003 and 2006 in the latter subarea appear to be too abrupt to be explained by population dynamics or fishery impacts.

The difficulty in tracking cohorts is also obvious when survey estimates of total numbers by subarea are grouped into size groups corresponding to ages 3, 4, 5 and 6 plus (Table 6). Large increases in numbers of commercial size animals (e.g., subarea B in 2001 to 2002, subarea D in 2004 to 2005) do not seem to be preceded by large numbers of recruits.

Scallops in the different subareas exhibit different growth curves with those in subarea A having the lowest maximum meat weight size and scallops in subarea C having the highest (Fig. 26). Differences are less consistent over time between growth curves for the scallops in the four major bottom types (Table 7).

Numbers of scallops at shell height are converted to estimates of biomass of meat weights through subarea and location specific meat weight/shell height curves using linear mixed effects models to account for animals from the same tow having more similar meat weight/shell height relationships than those between tows. The model is of the following form for each subarea with $i$ indexing tow and $j$ observations within tow $i$.

$$\log(\text{meat weight})_{ij} = (\beta_0 - b_{0i}) + (\beta_1 - b_{1i}) \log(\text{shell height})_{ij} + \epsilon_{ij}$$

The $\beta$ parameters are the fixed effects representing population level parameters while the $b$ parameters are the random effects reflecting differences at the tow level. The random effects are assumed to be bivariate normal with mean 0 and variance/covariance matrix $\Sigma$. The error terms, $\epsilon_{ij}$ are assumed to be normal with mean zero with variance/covariance matrix $\sigma^2\mathbf{I}$.

Estimates of survey total biomass (meats, t) for each subarea for commercial size and recruit size scallops indicate that the biomasses for both of these size classes in 2006 have declined appreciably since 2005 (Fig. 27). The declines were similar for estimates calculated for the two East of Baccaro survey vessels.

Clappers

In response to the report of large numbers of clappers by fishermen during the 2006 fishery in subarea 29 D a total of 22 stations were chosen in subarea 29D based upon satellite vessel monitoring system (VMS) records of areas fished during July 3 to 5, 2006. Stations were either placed in areas where fishing was concentrated or just outside to bracket the area. The F/V Royal Fundy conducted the survey on July 18, 2006 with a DFO scallop technician onboard. Three additional stations were added by the captain of the F/V Royal Fundy to reflect stations fished by the F/V Julie Ann Joan where high clapper levels were observed.

At each station a 10 minute tow was made using nine miracle drags. The catch of live scallops and clappers in the two end drags (numbers 1 and 9) were sampled on each tow. Sampling and measurements were conducted as per standard scallop research survey protocols.

The main results of this survey was that the proportion of clappers in the tows ranged from 0 to 0.41 with a mean of 0.15. There did not seem to be an obvious spatial pattern for the proportion of clappers (Fig. 30). Shell height frequencies over all tows indicate that the mode for the clappers may be 5 to 10 mm below that for the live scallops (Fig. 31).

A sample of 60 live scallops were kept from the survey tow with the highest proportion of clappers and shipped to the University of Prince Edward Island when the vessel landed in Digby on July 19. A pathologist at the Atlantic Veterinary College was contracted to study the samples in terms of overall condition and for microscopic evidence of disease. The results of their study indicated that the scallops were in good condition with no evidence of significant morphologic changes, inflammation or infectious agents. A few free living protozoans were present within the gill tissues. Six representative scallops were examined histologically and in general the tissues were found to be in fair to good condition. Ovary and testes were near to ripe while the lumen of the digestive track in several of the scallops was void of food material.

The observer database contained reports from three vessels that had observers onboard in SFA 29D during 4 to 7 July. Shell height frequencies and counts were only available for a total of three positions for two of the boats. Clapper ratios were 0.10, 0.21 and 0.36 for these positions. These data are plotted along with the survey estimates on the surficial map (Fig. 32). Positions reported by scallop fisherman, K. Amero, during the fishery are also indicated on this map.

High catches of clappers have been common in survey tows in subarea D since at least 2002 (Fig. 28). As noted earlier, the abundance and size distribution of the clappers tends to mirror the same for the live scallops (see Fig. 25). In fact, the ratios of clappers to live scallops has been much higher in the past in all four subareas than they are now (Fig. 29). The ratio for subarea D is the highest overall for all six years of the survey. We do not know why the subareas differ in clapper ratios nor what process is underlying the annual trends in Fig. 29. Most of the clapper tows were found in thin sand areas which probably experience stronger currents (indicated by the barchan dunes that have been found in the area) than the other areas. It is possible that higher mortality rates may be associated with higher energy areas.

Can we determine if the high number of clappers observed by the fleet in subarea D in 2006 was indicative of an epidemic? A comparison of the positions in Fig. 32 with those in Fig. 5 indicates that many of the clapper positions are in the southern part of D much of which was fished for the first time in 2006. It is possible that the distribution appeared to be more widespread than observed previously because while clappers were found in this subarea by survey in previous years (Fig. 28), the fishermen had no experience with what to expect here. In October, we carried out three transects with our towed camera vehicle (TowCam) in the sand area in D with one of the transects intersecting the higher clapper density areas (Fig. 32) but did not observe large numbers of clappers among the live scallops there. While we acknowledge that clapper ratios are higher in D, we do not have any evidence that would indicate that there was an epidemic occurring.

## Bycatch

Lobster

Data sources for lobster bycatch come from both the scallop survey and the SFA 29 fishery, which has observer coverage. The regular monitoring of the SFA 29 fishery by onboard observers is unique relative to other scallop fisheries and was required for both fleets. In 2006, observer coverage consisted of 7.5% of trips.

As in most years of the survey, the mean numbers of lobsters per tow was highest in subarea B (Fig. 33; Fig. 34). In subarea B the catch rate increased to the highest level of the series (3.6 lobsters per tow). In subareas A, D and C the catch rate decreased to less than 1.3 lobsters per tow. In subarea C, there has been an increase in the proportion of sets with lobsters in the last 2 years (Fig. 34) The size range of lobsters captured in the survey was 23-87 mm Carapace Length (CL), with most lobsters between 50 and 120 mm CL (Fig. 35). In 2006 the size range was 23-157 mm CL, with a mode at 95-96 mm CL.

Most lobsters caught during observed fishing trips were in subarea B (Fig. 36). In subarea A, C and D most tows had zero lobsters. The size of lobsters captured as a bycatch ranged from 28 mm CL to 250 mm CL but most lobsters were between 50 and 120 mm CL (Fig. 37).

Data from observers on the number and condition of lobsters by subarea, year and fleet are shown in Tables 8 and 9. Regulations prohibit retention of lobsters caught as a bycatch, but the total number of lobsters caught by each fleet can be estimated with the assumption that the mean number of lobsters caught per tonne of scallop meats in the observed sets is representative of the fishery. The estimates for the fishery (both fleets) range from a low of 2777 lobsters in 2001 (Full Bay fleet only) to a high of 7339 lobsters in 2002 (Tables 10 and 11). The estimate for the 2006 fishery was 7107 lobsters (4641 lobsters by the Full Bay fleet and 2466 lobsters for East of Baccaro fleet).

Summing over all subareas and both fleets, the condition of the lobster bycatch observed in 2006 can be summarized as 73% uninjured, 19% injured and 8% dead (Tables 8 and 9). The number of lobsters killed or injured by the fishery can be estimated by assuming that the proportion seen in the observed sets is representative of the fishery as a whole. The estimates for the fishery (both fleets) range from a low of 452 lobsters in 2004 to a high of 2426 lobsters in 2002 (Tables 10 and 11). The estimate for the 2006 fishery was 2174 lobsters (1663 lobsters by the Full Bay fleet and 512 lobsters for East of Baccaro fleet). To put this 2174 lobsters in perspective, landings by the LFA 34 lobster fishery in the subareas corresponding to SFA 29 were 3468 mt in the 2005–06 season (Table 12), equivalent to approximately 5,780,000 lobsters with a carapace length of 90 mm CL (approximately 0.6 kg).

As far as the direct effects of the scallop fishery on the lobster stock, the only information available is the catch during the fishery and survey. There are no available data on what the bottom impacts are. To evaluate all potential impacts would be challenging and expensive.

Indirect information on the effect of the scallop fishery comes from trends in the lobster landings by the directed lobster fishery in LFA 34 (Table 12). Lobster catches by the lobster fishery in the SFA 29 area are not indicative of an area that has been adversely affected by the scallop fishery since 2001. Like landings in LFA 34 as a whole, lobster landings in the SFA 29 area peaked in 2001–2, declined to 2004–05, and then increased in 2005–06 (Fig. 38). Relative to the 2000–01 season, landings in 2005–06 in the SFA 29 area showed a larger increase than LFA 34 as a whole. While the landings trends are consistent with the idea that the scallop fishery has not had a negative effect on the lobster fishery, landings trends by themselves cannot confirm no effect.

Direct injury and mortality of lobsters due to the scallop fishery is likely greater in localized areas of high lobster density. Effort should be taken to avoid areas and times when lobsters are in high concentrations or are soft-shelled. This has been attempted with in Area B where an area was closed to scallop fishing unless an observer was onboard. Fisheries management has closed this area to all scallop fishery when the bycatch exceeded a pre-set level. The catch rate of lobsters in and out of the restricted or closed area box is shown in Table 13. In 2005, the catch of lobsters per tonne of scallops was particularly high in this area; in other years the catch of lobsters per tonne of scallops is actually higher outside the restricted area. The difference between years may be related to annual differences in the timing of the effort and the movement of lobsters. A better understanding of the timing of lobster movements and molting is important to avoid locations and times when lobsters are concentrated or less mobile due to molting. The molting period for lobsters is mainly July-October, so fishing in areas of known lobster concentrations should be avoided during this period.

Other species

In addition to lobsters all fish and invertebrate species are monitored by the observers. A preliminary analysis of the presence/absence of the different species in the observed catch was conducted for the data from 2001 to 2005. A multinomial logit model was used to relate the presence/absence of each species with bottom type, depth, associated catch of scallops and the amount of catch of stones and garbage, etc.

Likelihood ratio tests indicated that all of the covariates (except scallop catch and stones in 2001) were significantly related to the presence of many of the species. In particular, the probability of bycatch of monkfish (*Lophius americanus*) increased with depth, while yellowtail flounder (*Limanda ferruginea*) and winter flounder (*Pseudopleuronectes americanus*) decreased with depth.

The probability of bycatch of lobster showed the strongest relationship with bottom type with the lowest probability associated with till/silt (Figs. 39–42). Monkfish has the second highest probability of being present as bycatch. Yellowtail flounder was most likely to be caught in tows on till/silt while winter flounder was least likely to be caught on this bottom type but more likely to be caught on thin sand. Winter skate was also less likely to be caught on till/silt sediments[1].

## Stock status and advice for 2007

There are three indicators of stock size for SFA 29 scallop: commercial catch rates for the Full Bay fleet, the East of Baccaro fleet and the annual research survey. The two catch rate series provide similar trends for subareas SFA 29 A, B and C and indicate that population biomass is slowly declining in the last two years (Fig. 4). The two series differ for SFA 29 D where the Full Bay fleet series is indicating a large decline from 2005 to 2006 while the East of Baccaro series shows little change from 2004 through to 2006.

Analysis presented here on the spatial dynamics of the catch rate series suggests that effort rather than catch rate is matching the spatial density of the stock for the most recent three to four years. If this is true then the commercial catch rates are not directly measuring the change in stock biomass and are confounded by fishing behaviour. According to other studies on similar situations, this condition is particularly problematic for medium and low population densities. Therefore it is likely that the decline in population biomass in subareas B and C is more severe than the commercial catch rates indicate. Interpretation of the catch rate series in D is confounded by the differences in the portion of the area fished in each of the three years. On the one hand, the catch rates from the Full Bay fleet in 2004 and 2005 may be simply measuring local high densities in the western and then northeastern portion of subarea D, respectively. In 2006, more of the catch came from the lower density areas to the south of subarea D. However, the East of Baccaro vessels followed a similar pattern of fishing and their catch rates do not indicate any differences between the years and subareas.

The commercial catch rates are poorly correlated with the survey biomass estimates (Fig. 43), albeit there are very few data points in this analysis. The survey biomass estimates for all of the subareas indicate more rapid declines from 2005 to 2006 than indicated by the

[1]Skate species identification must be treated with caution.

commercial catch rates (Fig. 27). However, the lack of strong population dynamics signals in the survey data makes it difficult to model the population precisely. Comparing predicted population biomass for 2006 from the last assessment with the current estimate for 2006 shows that all subareas declined but these estimates (posterior distributions) have very large confidence intervals (Fig. 44). Last year's model predicted that for the catch levels chosen for the 2006 fishery, the probability of the population biomass declining for all subareas exceeded 50 to 60 percent. These estimates still stand despite the changes to survey series estimates. The expected decline was less than 10 percent but estimated declines from the current model are more in the order of 13 percent for subarea B and 31 percent for subareas C and D. The current model predicts that catches of 25 t in subareas B, C and D all result in a greater than 50 percent chance of the population declining. The expected decline is on the order of 10 percent or less.

## Acknowledgements

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Table 1. Scallop landings (meats, t) for Scallop Fishing Area 29. Landings by subarea in 2001 determined from log records. TAC for subareas A, B and E were combined in 2004. TAC for subarea A and E combined in 2006.

| | | Full Bay | | East of Baccaro | | Total | |
|---|---|---|---|---|---|---|---|
| Year | Area | TAC (t) | Landings (t) | TAC (t) | Landings (t) | TAC (t) | Landings (t) |
| 2001 | 29A | | (2) | | | | |
| | 29B | | (71) | | | | |
| | 29C | | (309) | | | | |
| | 29U | | (18) | | | | |
| | Total | 400 | 400 | | | 400 | 400 |
| 2002 | 29A | 75 | 1 | 25 | 4 | 100 | 5 |
| | 29B | 150 | 193 | 50 | 75 | 200 | 268 |
| | 29C | 375 | 334 | 125 | 106 | 500 | 440 |
| | Total | 600 | 528 | 200 | 185 | 800 | 713 |
| 2003 | 29A | | | | | | |
| | 29B | 150 | 114 | 51 | 38 | 201 | 152 |
| | 29C | 188 | 33 | 63 | 32 | 251 | 65 |
| | 29E | | 2 | | 2 | | 4 |
| | Total | 338 | 149 | 114 | 72 | 452 | 221 |
| 2004 | 29A | 150.0 | 70.2 | 50.0 | 9.9 | 200 | 80.1 |
| | 29B | | 33.1 | | 46.8 | | 79.9 |
| | 29E | | 0.2 | | 3.4 | | 3.6 |
| | 29C | 187.5 | 123.8 | 62.5 | 35.2 | 250 | 159.0 |
| | 29D | 112.5 | 148.6 | 37.5 | 40.0 | 150 | 188.6 |
| | Total | 450.0 | 375.9 | 150.0 | 135.3 | 600 | 511.2 |
| 2005 | 29A | 45.0 | 2.5 | 15.0 | 2.2 | 60 | 4.7 |
| | 29B | 30.0 | 22.7 | 10.0 | 26.3 | 40 | 48.9 |
| | 29C | 75.0 | 91.9 | 25.0 | 23.4 | 100 | 115.3 |
| | 29D | 41.25 | 63.2 | 13.75 | 10.7 | 55 | 73.9 |
| | 29E | | 8.8 | | 1.7 | | 10.5 |
| | Total | 191.25 | 189.1 | 63.1 | 64.3 | 255 | 253.3 |
| 2006 | 29A | 18.75 | 20.4 | 6.25 | 1.1 | 25 | 21.5 |
| | 29E | | 0.8 | | 1.0 | | 1.8 |
| | 29B | 93.75 | 87.8 | 31.25 | 27.8 | 125 | 115.6 |
| | 29C | 75.00 | 85.7 | 25.00 | 25.6 | 100 | 111.3 |
| | 29D | 112.50 | 113.0 | 37.50 | 42.9 | 150 | 155.9 |
| | Total | 300 | 307.7 | 100 | 98.4 | 400 | 406.1 |

Table 2. Statistics from meat weight samples of scallop vessels in Scallop Fishing Area 29 for the 2006 fishing season. 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 < 8 g | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | N | Mean | Min. | Max. | per 500 g. | Samples | Mean | Min. | Max. |
| **29A** | | | | | | | | | |
| | | | | | Full Bay | | | | |
| July | 165 | 19.2 | 9.6 | 32.1 | 26.1 | 3 | 0.0 | 0.0 | 0.0 |
| **29B** | | | | | | | | | |
| | | | | | Full Bay | | | | |
| June | 162 | 19.8 | 4.3 | 37.3 | 27.6 | 3 | 5.6 | 0.0 | 14.5 |
| July | 48 | 21.1 | 8.8 | 33.2 | 23.7 | 1 | 0.0 | 0.0 | 0.0 |
| **29C** | | | | | | | | | |
| | | | | | Full Bay | | | | |
| June | 172 | 23.4 | 7.7 | 49.2 | 21.7 | 4 | 0.5 | 0.0 | 2.0 |
| July | 131 | 23.8 | 8.2 | 45.5 | 21.4 | 3 | 0.0 | 0.0 | 0.0 |
| **29D** | | | | | | | | | |
| | | | | | Full Bay | | | | |
| July | 136 | 22.3 | 9.8 | 59.1 | 22.6 | 3 | 0.0 | 0.0 | 0.0 |

Table 3. Commercial catch rate of scallop meats (kg/h) by month, subarea and fleet for SFA 29 in 2006.

| Fleet | June | July | Aug | Sept | All |
|---|---|---|---|---|---|
| All Areas | | | | | |
| Full Bay | 26.4 | 35.4 | 21.1 | | 31.1 |
| E. Baccaro | 21.3 | 34.3 | 19.8 | | 27.5 |
| Area A | | | | | |
| Full Bay | 20.7 | 20.9 | 12.9 | | 19.3 |
| E. Baccaro | | 23.9 | 13.9 | | 16.2 |
| Area B | | | | | |
| Full Bay | 25.5 | 28.4 | 20.4 | | 25.9 |
| E. Baccaro | 20.1 | 21.5 | 16.0 | | 19.8 |
| Area C | | | | | |
| Full Bay | 29.1 | 28.7 | 15.5 | | 28.7 |
| E. Baccaro | 23.4 | 25.4 | 5.6 | | 24.4 |
| Area D | | | | | |
| Full Bay | | 48.1 | | | 48.1 |
| E. Baccaro | | 44.6 | | | 44.6 |
| Area E | | | | | |
| Full Bay | 14.6 | 22.2 | | | 14.7 |
| E. Baccaro | | | 11.8 | | 11.8 |

Table 4. Catch rate (CPUE, kg/h) broken down by fleet, subarea and one minute square. Prop. new refers to the proportion of one minute squares recorded in the fishing logs in year $t$ that were not recorded in year $t-1$. CPUE repeat refers to the catch rate in one minute squares during year $t$ that were also recorded in the logs in year $t-1$. CPUE new is the catch rate for those one minute squares recorded in the fishing logs in year $t$ that were not recorded in year $t-1$.

| Fleet | | East Baccaro | | | | Full Bay | | | |
|---|---|---|---|---|---|---|---|---|---|
| Area | | A | B | C | D | A | B | C | D |
| 2001 | CPUE | | | | | 78.48 | 85.59 | 120.73 | |
| 2002 | Prop. new | | | | | 1.00 | 0.79 | 0.69 | |
| | CPUE repeat | | | | | | 61.98 | 80.17 | |
| | CPUE new | 30.91 | 49.29 | 47.15 | | 15.07 | 70.69 | 77.99 | |
| 2003 | Prop. new | | 0.83 | 0.50 | | | 0.83 | 0.60 | |
| | CPUE repeat | | 44.64 | 33.58 | | | 47.93 | 44.08 | |
| | CPUE new | | 33.86 | 34.03 | | | 51.48 | 48.40 | |
| 2004 | Prop. new | 0.60 | 0.79 | 0.92 | | 0.91 | 0.79 | 0.76 | |
| | CPUE repeat | 53.90 | 27.55 | 22.32 | | 65.82 | 46.08 | 43.49 | |
| | CPUE new | 39.45 | 30.44 | 28.57 | 44.80 | 58.13 | 39.57 | 48.93 | 73.01 |
| 2005 | Prop. new | 1.00 | 1.00 | 0.65 | 1.00 | 0.60 | 0.77 | 0.57 | 1.00 |
| | CPUE repeat | | | 22.88 | | 36.13 | 22.82 | 41.83 | |
| | CPUE new | 25.58 | 18.93 | 32.26 | 43.88 | 16.09 | 24.25 | 38.57 | 82.81 |
| 2006 | Prop. new | 0.66 | 0.93 | 0.45 | 0.71 | 0.89 | 0.83 | 0.47 | 0.78 |
| | CPUE repeat | 11.36 | 15.27 | 19.21 | 52.26 | 19.48 | 26.52 | 26.94 | 54.31 |
| | CPUE new | 16.75 | 19.98 | 28.12 | 35.55 | 20.59 | 26.06 | 31.75 | 45.52 |

Table 5. P-levels for tests between numbers per tow for the comparative survey experiment between F/V Julie Ann Joan and Faith Alone in 2006.

| | | Faith Alone | |
|---|---|---|---|
| Julie Ann Joan | | 100+ mm | 95+ mm |
| 100+ mm | t-test | 0.19 | 0.92 |
| | Wilcoxon | 0.17 | 1.00 |
| | | 90–99 mm | 85 to 94 mm |
| 90–99 mm | t-test | 0.04 | 0.27 |
| | Wilcoxon | 0.05 | 0.28 |

Table 6. Survey total numbers index (thousands) in scallop fishing area 29 stratified by management subareas. Survey vessels: 2001–2003, 2005a, 2006a F/V Julie Ann Joan, 2004 F/V Branntelle, 2005b F/V Julie Ann Joan and F/V Overton Bay, and 2006 F/V Julie Ann Joan and F/V Faith Alone.

| | | Shell Height (mm) | | | | |
|---|---|---|---|---|---|---|
| Area | Year | 65–80 | 80–90 | 90–100 | $\geq$ 100 | No. of tows |
| 29A | 2001 | 85.6 | 343.0 | 2298.8 | 14086.2 | 18 |
| | 2002 | 0.0 | 131.4 | 339.3 | 7888.1 | 20 |
| | 2003 | 42.4 | 0.0 | 299.1 | 10236 | 12 |
| | 2004 | 0.0 | 0.0 | 0.0 | 8152.2 | 15 |
| | 2005a | 0.0 | 0.0 | 0.0 | 8298.2 | 13 |
| | 2006a | 0.0 | 0.0 | 0.0 | 4216.6 | 12 |
| 29B | 2001 | 1024.3 | 1671.0 | 3528.0 | 25220.6 | 46 |
| | 2002 | 2248.4 | 629.8 | 2069.1 | 50397.8 | 54 |
| | 2003 | 2592.6 | 966.3 | 2111.0 | 37539 | 34 |
| | 2004 | 953.8 | 474.3 | 601.1 | 18607.8 | 41 |
| | 2005a | 509.4 | 255.43 | 1660.5 | 25114 | 44 |
| | 2006a | 492.5 | 212.3 | 351.5 | 9863.8 | 40 |
| 29C | 2001 | 1555.8 | 312.2 | 744.1 | 26021.9 | 20 |
| | 2002 | 2113.4 | 1149.9 | 2275.0 | 9150.8 | 24 |
| | 2003 | 2354.6 | 5073.9 | 5053.6 | 13609 | 23 |
| | 2004 | 629.6 | 867.0 | 4934.9 | 10559.6 | 18 |
| | 2005a | 194.5 | 0 | 1243.6 | 13552 | 7 |
| | 2005b | 307.88 | 280.37 | 2107.1 | 12360 | 17 |
| | 2006a | 221.7 | 300.0 | 387.1 | 4584.3 | 17 |
| | 2006b | 199.8 | 265.4 | 371.6 | 3632.0 | 26 |
| 29D | 2001 | 587.2 | 87.9 | 64.5 | 2544.3 | 19 |
| | 2002 | 3460.5 | 826.9 | 923.6 | 8395.9 | 27 |
| | 2003 | 22688.4 | 9742.5 | 7474.8 | 10940 | 24 |
| | 2004 | 1760.5 | 2144.5 | 5845.6 | 9731.3 | 21 |
| | 2005a | 898.9 | 1249.7 | 4738.1 | 32918 | 30 |
| | 2005b | 782.5 | 1586.1 | 5718.9 | 28980 | 49 |
| | 2006a | 75.5 | 416.1 | 474.1 | 6447.7 | 20 |
| | 2006b | 279.8 | 496.2 | 146.1 | 9318.3 | 37 |

Table 7. Estimated growth parameters from a nonlinear mixed effects version of the Von Bertalanffy growth model of meat weight as a function of shell height. See Smith and Rago (2004) for details of growth model.

| Year | Group | $W_\infty$ | $K$ | $t_0$ |
|---|---|---|---|---|
| 2005 | 29 A | 20.67 | 0.29 | 2.88 |
| | 29 B | 34.45 | 0.12 | 1.59 |
| | 29 C | 67.13 | 0.06 | 1.06 |
| | 29 D | 35.54 | 0.14 | 1.63 |
| 2006 | 29 A | 27.31 | 0.14 | 1.24 |
| | 29 B | 38.99 | 0.15 | 1.95 |
| | 29 C | 53.15 | 0.11 | 1.50 |
| | 29 D | 32.76 | 0.16 | 1.53 |
| 2005 | Bedrock | 30.03 | 0.16 | 1.80 |
| | Thin sand | 35.05 | 0.14 | 1.63 |
| | Glacial till | 73.66 | 0.05 | 0.93 |
| | Till/silt | 31.79 | 0.10 | 1.72 |
| 2006 | Bedrock | 42.82 | 0.13 | 1.61 |
| | Thin sand | 33.06 | 0.17 | 1.61 |
| | Glacial till | 40.80 | 0.15 | 1.64 |
| | Till/silt | 24.14 | 0.29 | 3.08 |

Table 8. Numbers of lobsters recorded by observers for the Full Bay Scallop Fleet and notes on condition. Note that condition was not recorded for all lobsters caught. N/A refers to condition being recorded as unknown. NR is the number of lobsters for which condition was not recorded.

| | | Alive | | | | | Grand |
|---|---|---|---|---|---|---|---|
| Year | Area | No injury | Injured | Dead | N/A | NR | Total |
| 2001 | A | 28 | 2 | 4 | 0 | 1 | 35 |
| | B | 465 | 54 | 26 | 37 | 124 | 706 |
| | C | 56 | 9 | | 10 | 27 | 102 |
| | D | | | | | | |
| | E | | | | | | |
| | Total | 549 | 65 | 30 | 47 | 152 | 843 |
| 2002 | A | 0 | 0 | 0 | 0 | 0 | 0 |
| | B | 474 | 218 | 85 | 24 | 14 | 815 |
| | C | 34 | 17 | 5 | 0 | 34 | 90 |
| | D | 0 | 0 | 0 | 0 | 0 | 0 |
| | E | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 508 | 235 | 90 | 24 | 48 | 905 |
| 2003 | A | 0 | 0 | 0 | 0 | | 0 |
| | B | 769 | 301 | 172 | 21 | 34 | 1297 |
| | C | 21 | 13 | 1 | 1 | 2 | 38 |
| | D | 0 | 0 | 0 | 0 | 0 | 0 |
| | E | 4 | 2 | 0 | 0 | 72 | 78 |
| | Total | 794 | 316 | 173 | 22 | 108 | 1413 |
| 2004 | A | 7 | 3 | 0 | | 2 | 12 |
| | B | 76 | 9 | 4 | | 111 | 200 |
| | C | 38 | 5 | 1 | | 43 | 87 |
| | D | 2 | 0 | 1 | | 0 | 3 |
| | E | 16 | 4 | 0 | | 0 | 20 |
| | Total | 139 | 21 | 6 | | 156 | 322 |
| 2005 | A | 0 | 0 | 0 | | 0 | 0 |
| | B | 95 | 23 | 7 | | 26 | 151 |
| | C | 40 | 6 | 2 | | 2 | 50 |
| | D | 0 | 0 | 0 | | | 0 |
| | E | 74 | 12 | 5 | | 16 | 107 |
| | Total | 209 | 41 | 14 | | 44 | 308 |
| 2006 | A | 14 | 3 | | 0 | 0 | 17 |
| | B Triangle | 186 | 82 | 28 | 0 | 60 | 356 |
| | B Open | 173 | 89 | 16 | 1 | 5 | 284 |
| | C | 17 | 8 | 5 | 0 | 0 | 30 |
| | D | 8 | 1 | 0 | 0 | 0 | 9 |
| | E | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 398 | 183 | 49 | 1 | 65 | 696 |

Table 9. Numbers of lobsters recorded by observers for the East of Baccaro Scallop Fleet and notes on condition. Note that condition was not recorded for all lobsters caught. NR is the number of lobsters for which condition was not recorded.

| | | Alive | | | | | Grand |
|---|---|---|---|---|---|---|---|
| Year | Area | No injury | Injured | Dead | N/A | NR | Total |
| 2002 | A | 6 | 2 | 0 | | 0 | 8 |
| | B | 93 | 12 | 4 | | 1 | 110 |
| | C | 20 | 7 | 0 | | 12 | 39 |
| | D | 0 | 0 | 0 | | 0 | 0 |
| | E | 0 | 0 | 0 | | 0 | 0 |
| | Total | 119 | 21 | 4 | | 13 | 157 |
| 2003 | A | 0 | 0 | 0 | | 0 | 0 |
| | B | 35 | 14 | 0 | | 23 | 72 |
| | C | 7 | 1 | 0 | | 176 | 184 |
| | D | 0 | 0 | 0 | | 0 | 0 |
| | E | 8 | 0 | 0 | | 53 | 61 |
| | Total | 50 | 15 | 0 | | 252 | 317 |
| 2004 | A | 3 | 0 | 0 | | 0 | 3 |
| | B | 339 | 52 | 11 | | 19 | 421 |
| | C | 3 | 0 | 0 | | 0 | 3 |
| | D | 0 | 0 | 0 | | 0 | 0 |
| | E | 0 | 0 | 0 | | 0 | 0 |
| | Total | 345 | 52 | 11 | | 19 | 427 |
| 2005 | A | 0 | 0 | 0 | | 0 | 0 |
| | B | 367 | 75 | 34 | | 4 | 480 |
| | C | 2 | 2 | 0 | | 0 | 4 |
| | D | 0 | 0 | 0 | | 0 | 0 |
| | E | 22 | 3 | 0 | | 0 | 25 |
| | Total | 391 | 80 | 34 | | 4 | 509 |
| 2006 | A | 0 | 0 | 0 | 0 | 0 | 0 |
| | B Triangle | 514 | 57 | 53 | 4 | 77 | 705 |
| | B Open | 78 | 6 | 5 | 0 | 0 | 89 |
| | C | 26 | 11 | 4 | 0 | 5 | 46 |
| | D | 0 | 0 | 0 | 0 | 0 | 0 |
| | E | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 618 | 74 | 62 | 4 | 82 | 840 |

Table 10. Estimated total numbers of lobsters caught in the scallop fishery by Full Bay Scallop fleet for 2001–2006 based upon observer data. NA = observer did not record scallop catch. DI refers to dead or injured lobsters.

| | | Observer data | | | Fishery | Estimated | |
|---|---|---|---|---|---|---|---|
| Year | Area | No. Lobsters | DI (%) | Meats (t) | Meats (t) | No. Lobsters | DI |
| 2001 | A | 35 | | 0.4 | 2 | 183 | |
| | B | 706 | | 23.2 | 71 | 2158 | |
| | C | 102 | | 72.2 | 309 | 436 | |
| | Unknown | | | | 18 | | |
| | Total | 843 | | 95.8 | 400 | 2777 | |
| 2002 | A | 0 | 0 | 0.0 | 1 | 0 | |
| | B | 815 | 38 | 33.0 | 193 | 4773 | 1814 |
| | C | 90 | 39 | 43.6 | 334 | 690 | 369 |
| | D | 0 | 0 | 0.0 | | 0 | |
| | E | 0 | 0 | 0.0 | | 0 | |
| | Total | 905 | | 76.6 | 528 | 5463 | 2083 |
| 2003 | A | 0 | 0 | 0.0 | 0 | 0 | |
| | B | 1297 | 37 | 31.4 | 114 | 4713 | 1743 |
| | C | 38 | 39 | 9.1 | 33 | 138 | 54 |
| | D | 0 | 0 | 0.0 | 0 | 0 | |
| | E | 78 | 33 | NA | 2 | NA | |
| | Total | 1413 | | 80.5 | 149 | 4851 | 1797 |
| 2004 | A | 12 | 30 | 11.4 | 70.2 | 74 | 22 |
| | B | 200 | 15 | 12.6 | 33.1 | 527 | 79 |
| | C | 87 | 14 | 22.3 | 123.8 | 483 | 68 |
| | D | 3 | 33 | 9.6 | 148.6 | 46 | 15 |
| | E | 20 | 20 | 0.2 | 0.2 | 26 | 5 |
| | Total | 322 | | 56.1 | 375.9 | 1156 | 189 |
| 2005 | A | 0 | 0 | 0 | 2.5 | 0 | |
| | B | 151 | 24 | 3.3 | 22.7 | 1047 | 251 |
| | C | 50 | 17 | 12.3 | 91.9 | 375 | 64 |
| | D | 0 | 0 | 5.4 | 63.2 | 0 | |
| | E | 107 | 19 | 3.1 | 8.8 | 308 | 59 |
| | Total | 308 | | 24.1 | 189.1 | 1730 | 374 |
| 2006 | A | 17 | 18 | 1.1 | 20.4 | 309 | 56 |
| | B | 640 | 37 | 14.7 | 88.5 | 3861 | 1429 |
| | C | 30 | 43 | 6.6 | 86 | 393 | 169 |
| | D | 9 | 11 | 13.1 | 113.1 | 78 | 9 |
| | E | 0 | 0 | 0 | 0.01 | 0 | |
| | Total | 696 | | 35.4 | 308.0 | 4641 | 1663 |

Table 11. Estimated total numbers of lobsters caught in the scallop fishery by East of Baccaro fleet for 2001–2005 based upon observer data. NA = observer did not record scallop catch. DI refers to dead or injured lobsters.

| | | Observer data | | | Fishery | Estimated | |
|---|---|---|---|---|---|---|---|
| Year | Area | No. Lobsters | DI (%) | Meats (t) | Meats (t) | No. Lobsters | DI |
| 2002 | A | 8 | 25 | 0.1 | 4 | 460 | 115 |
| | B | 110 | 15 | 6.5 | 75 | 1268 | 190 |
| | C | 39 | 26 | 27.9 | 106 | 148 | 38 |
| | D | 0 | 0 | 0 | | 0 | |
| | E | 0 | 0 | 0 | | 0 | |
| | Total | 157 | | 34.5 | 185 | 1876 | 343 |
| 2003 | A | 0 | 0 | 0 | 0 | 0 | |
| | B | 72 | 29 | 39.2 | 38 | 579 | 168 |
| | C | 184 | 13 | 51.3 | 32 | 953 | 124 |
| | D | 0 | 0 | 0 | 0 | 0 | |
| | E | 61 | 0 | NA | 2 | NA | |
| | Total | 317 | | 90.5 | 72 | 1532 | 292 |
| 2004 | A | 3 | 0 | 1 | 9.9 | 29 | 0 |
| | B | 421 | 16 | 13.8 | 46.8 | 1426 | 228 |
| | C | 3 | 0 | 3 | 35.2 | 35 | 35 |
| | D | 0 | 0 | 1.4 | 40 | 0 | |
| | E | 0 | 0 | 0 | 3.4 | 0 | |
| | Total | 427 | | 19.2 | 135.3 | 1490 | 263 |
| 2005 | A | 0 | 0 | 0 | 0 | 0 | |
| | B | 480 | 23 | 43.2 | 26.3 | 2426 | 558 |
| | C | 4 | 50 | 4.8 | 23.4 | 163 | 82 |
| | D | 0 | 0 | 0 | 0 | 0 | |
| | E | 25 | 12 | 4.4 | 1.7 | 81 | 10 |
| | Total | 509 | | 52.4 | 51.4 | 2670 | 650 |
| 2006 | A | 0 | 0 | 0 | 8.8 | 0 | |
| | B | 794 | 17 | 11.1 | 27.9 | 2002 | 340 |
| | C | 46 | 37 | 2.5 | 25.3 | 464 | 172 |
| | D | 0 | 0 | 0.8 | 43.9 | 0 | |
| | E | 0 | 0 | 0 | 3.5 | 0 | |
| | Total | 840 | | 14.3 | 109.4 | 2466 | 512 |

Table 12. Lobster landings (t) in the LFA 34 lobster fishery in the lobster logbook $10 \times 10$ minute grids that correspond to the subareas of SFA29, grids immediately adjacent to SFA 29 and the total landings for LFA 34

| | Lobster landings (t) | | | | | |
|---|---|---|---|---|---|---|
| Area | 2000–01 | 2001–02 | 2002–03 | 2003–04 | 2004–05 | 2005–06 |
| A | 352 | 448 | 323 | 367 | 314 | 335 |
| B | 1343 | 1566 | 1239 | 1131 | 971 | 1120 |
| C | 432 | 565 | 632 | 649 | 714 | 937 |
| D | 348 | 294 | 432 | 387 | 493 | 596 |
| E | 538 | 631 | 499 | 484 | 363 | 479 |
| SFA 29 | 3013 | 3504 | 3125 | 3018 | 2855 | 3468 |
| Adjacent to SFA 29 | 3255 | 3920 | 3577 | 3779 | 2875 | 3209 |
| LFA 34 | 16503 | 19284 | 19000 | 18955 | 17007 | 16951 |

Table 13. Estimated numbers of lobsters caught per observed catch of scallops (meats, t) and observed set inside and outside the closed area in B.

| | | Full Bay | | | | East of Baccaro | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Observed | | Estimated | | Observed | | Estimated | |
| | Closed | Scallop | number | lobster | | Scallop | number | lobster | |
| Year | Area B | Catch (t) | of sets | No./mt | No./set | Catch (t) | of sets | No./mt | No./set |
| 2001 | inside | 0.5 | 21 | 16.0 | 0.38 | | | | |
| | outside | 22.7 | 635 | 30.7 | 1.10 | | | | |
| 2002 | inside | 8.1 | 223 | 35.1 | 1.27 | 3.5 | 141 | 8.6 | 0.21 |
| | outside | 24.9 | 983 | 21.3 | 0.54 | 3.0 | 172 | 26.7 | 0.47 |
| 2003 | inside | 16.0 | 434 | 19.6 | 0.72 | 4.0 | 183 | 13.3 | 0.29 |
| | outside | 15.4 | 608 | 63.9 | 1.62 | 0.7 | 44 | 27.1 | 0.43 |
| 2004 | inside | 0.8 | 54 | 118.8 | 1.76 | 2.8 | 190 | 77.5 | 1.14 |
| | outside | 11.7 | 758 | 9.0 | 0.14 | 11.0 | 723 | 18.5 | 0.28 |
| 2005 | inside | 0.0 | 0 | | | 0.1 | 4 | 410.0 | 10.25 |
| | outside | 3.3 | 287 | 45.8 | 0.53 | 5.1 | 412 | 86.1 | 1.07 |
| 2006 | inside | 10.6 | 820 | 33.6 | 0.4 | 10.2 | 501 | 69.1 | 1.4 |
| | outside | 4.1 | 288 | 69.3 | 1.0 | 0.84 | 71 | 106.0 | 1.3 |

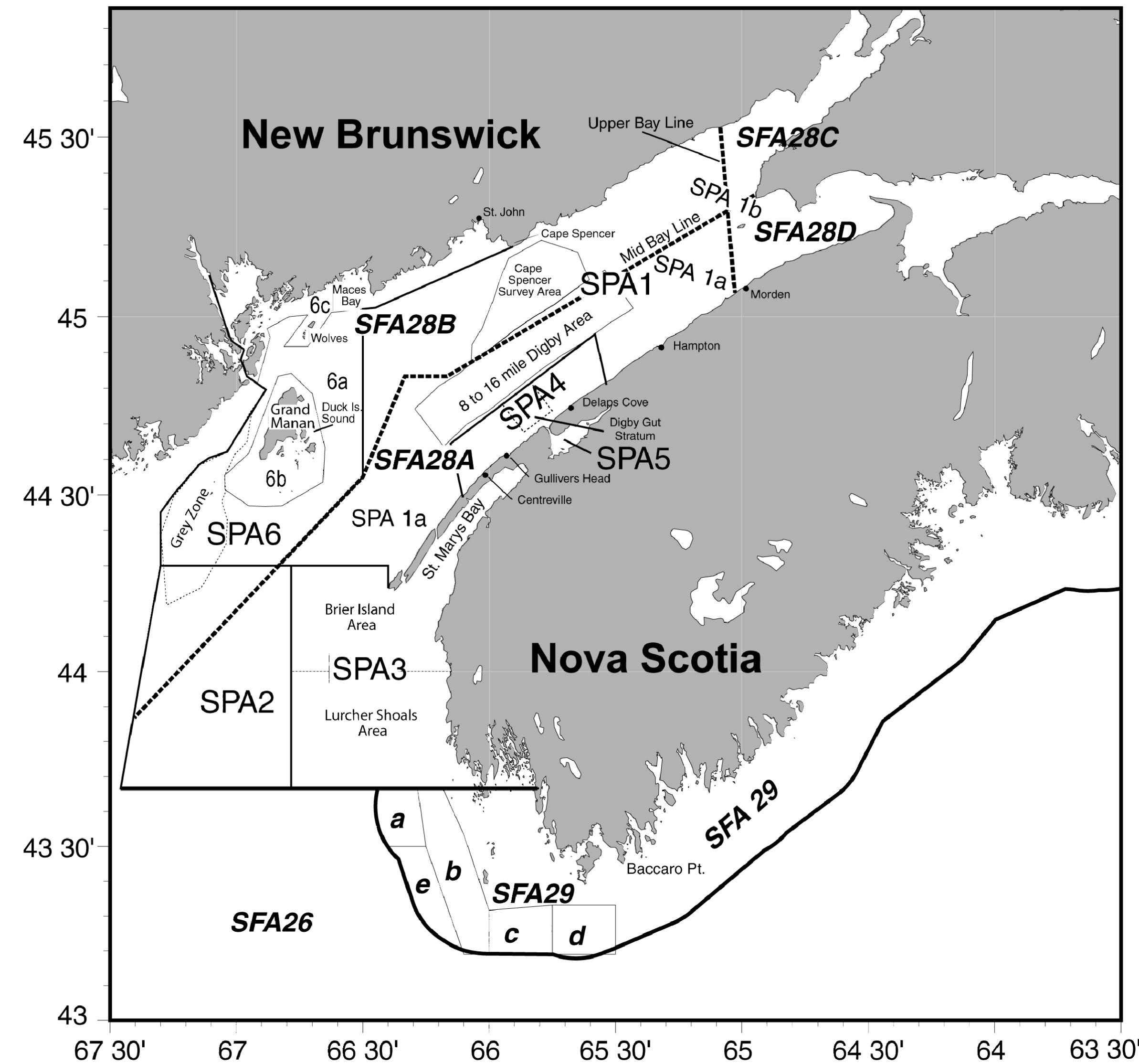



Fig. 1. Map of Scallop Fishing Areas (SFA) and Scallop Production Areas (SPA).

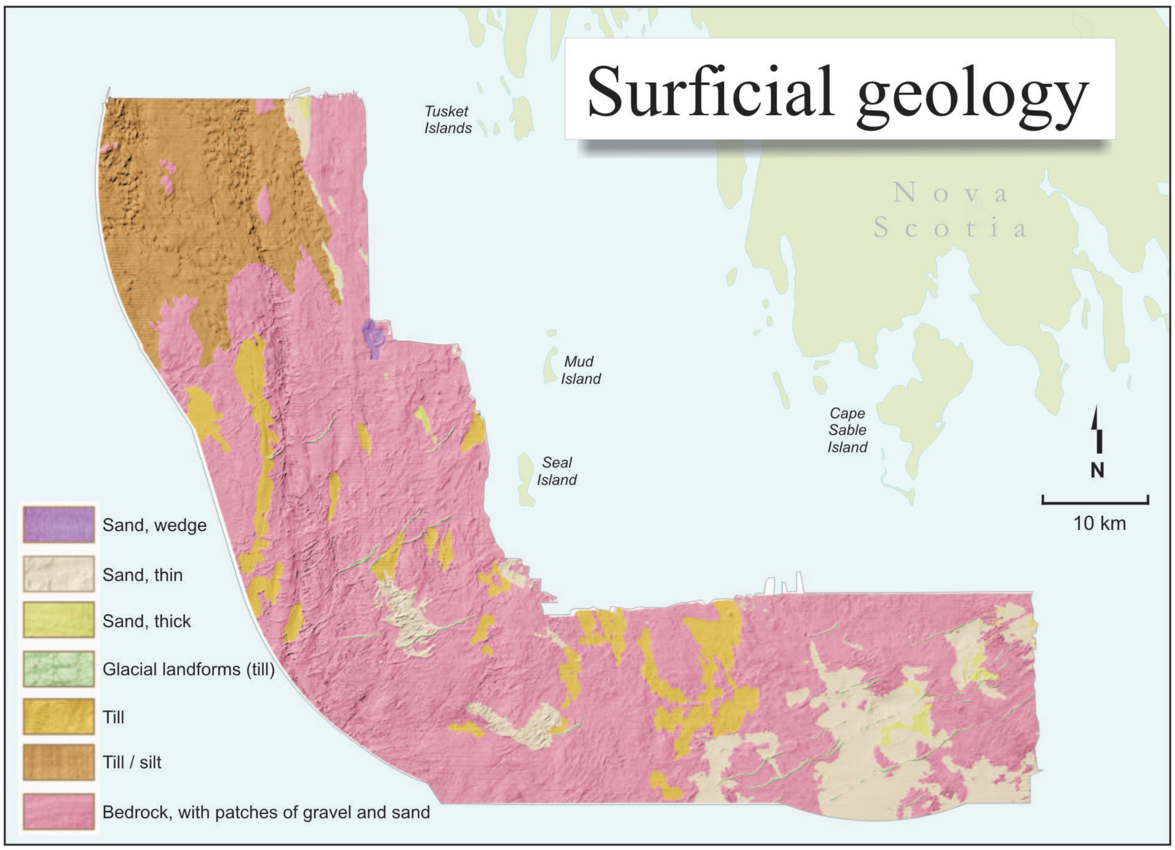



Fig. 2. Map of surficial geology of Scallop Fishing Area 29.

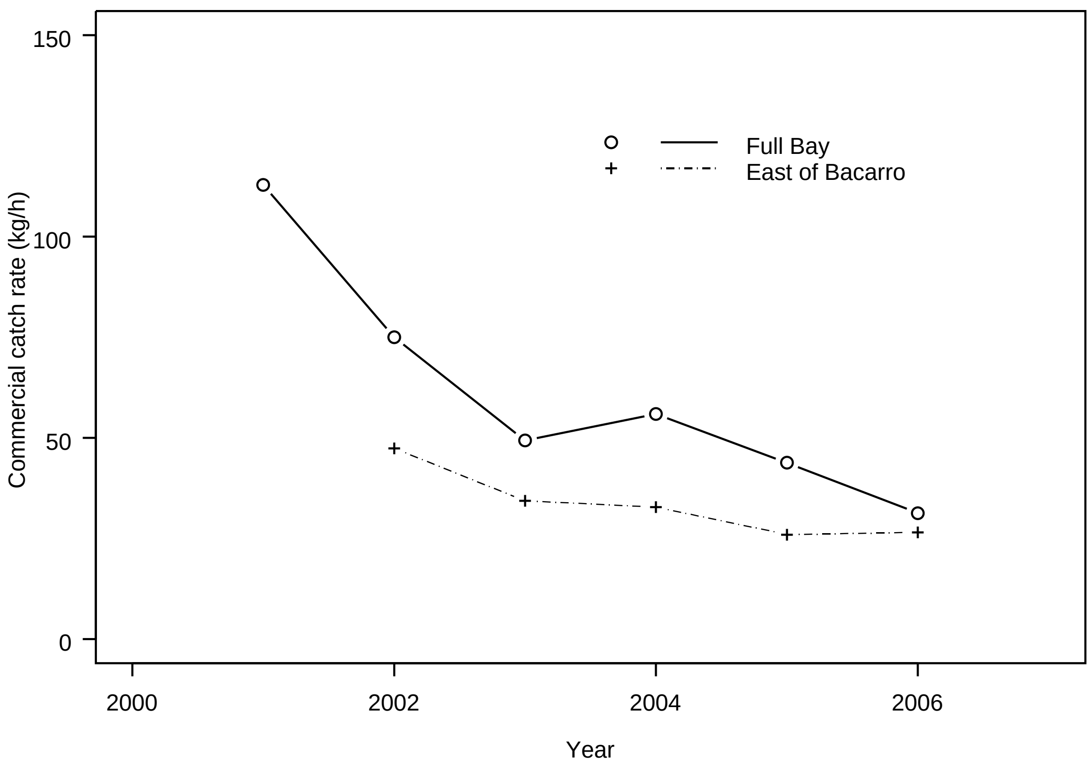



Fig. 3. Mean commercial catch rate (kg/h) trends for SFA 29 scallop fishery for all subareas by fleet.

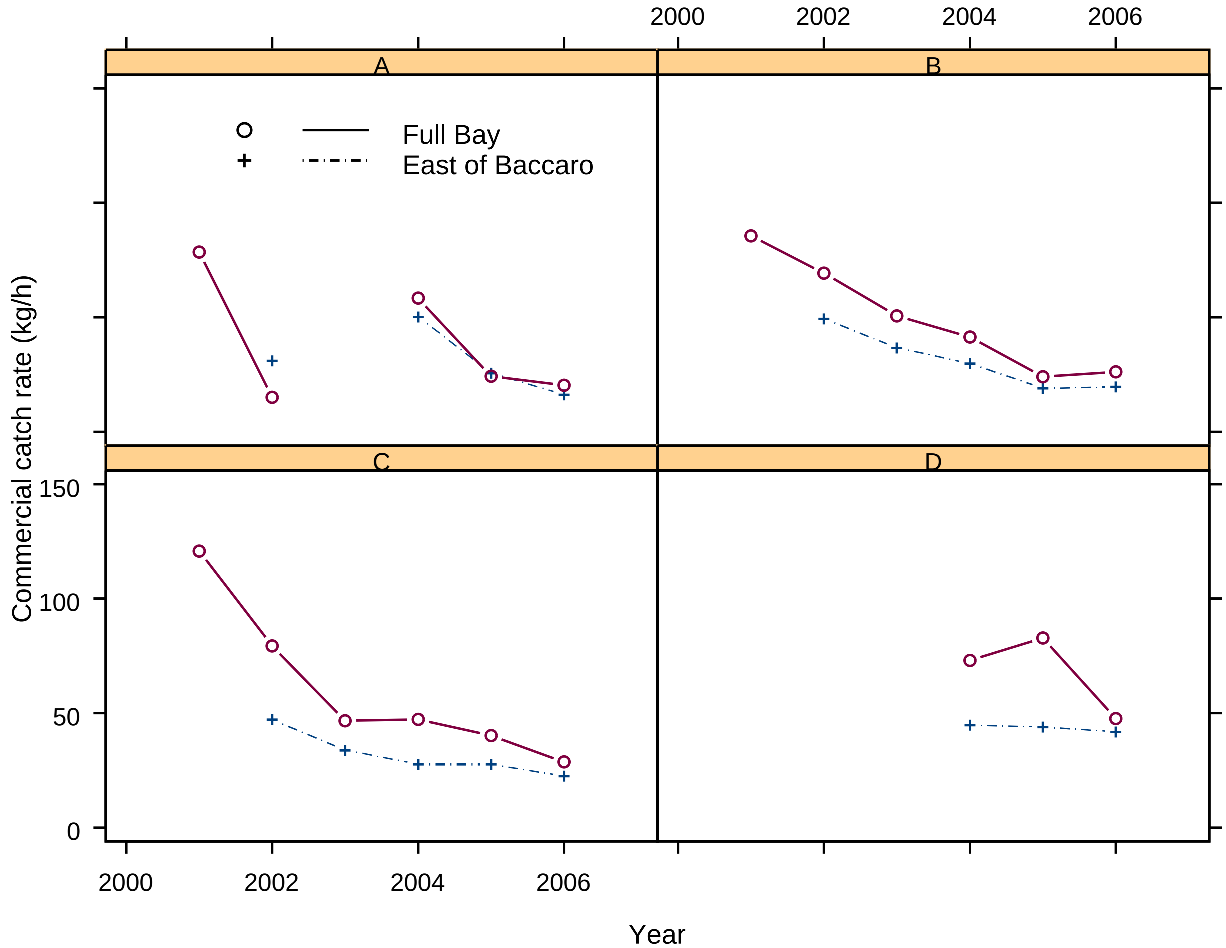



Fig. 4. Mean commercial catch rate (kg/h) trends for SFA 29 scallop fishery for each subarea by fleet.

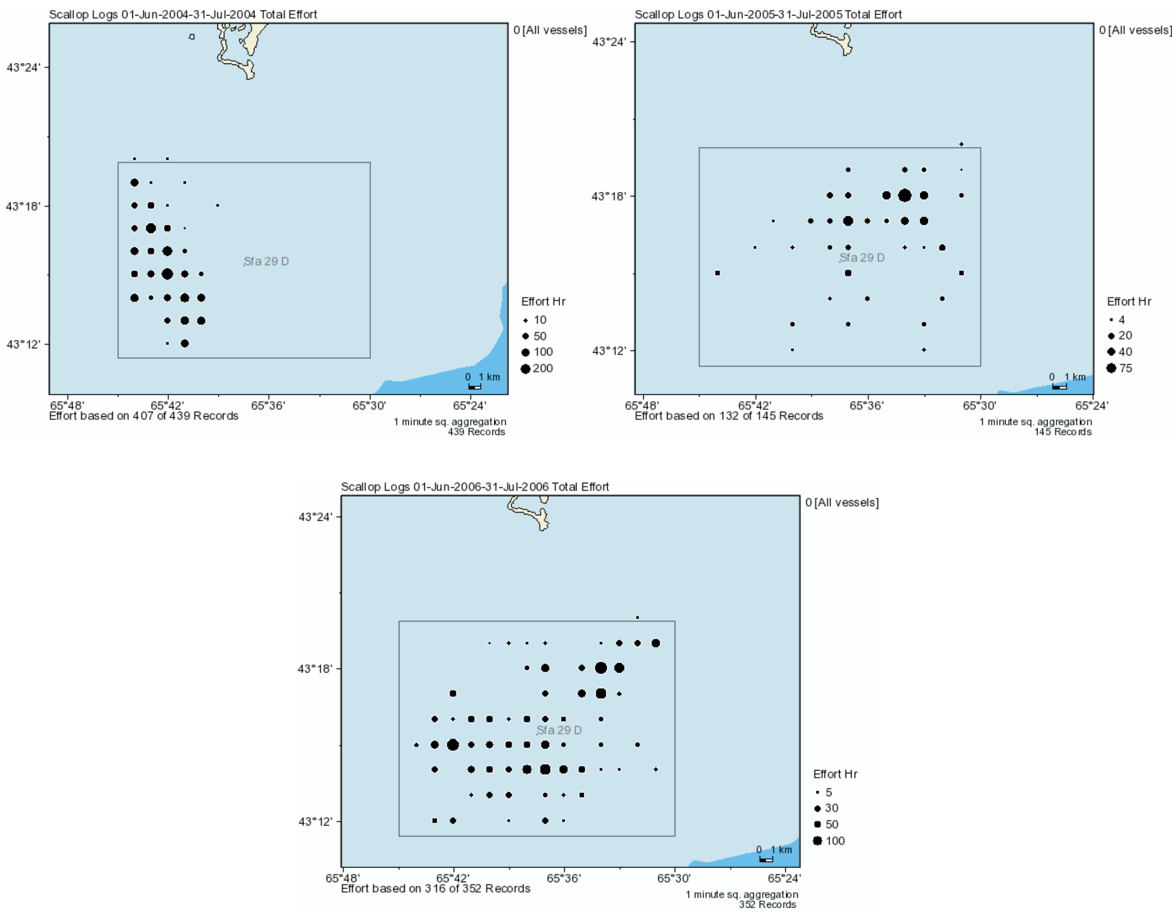



Fig. 5. Location of total effort (h) by one minute squares in SFA 29 D. Data is from log books for both fleets.

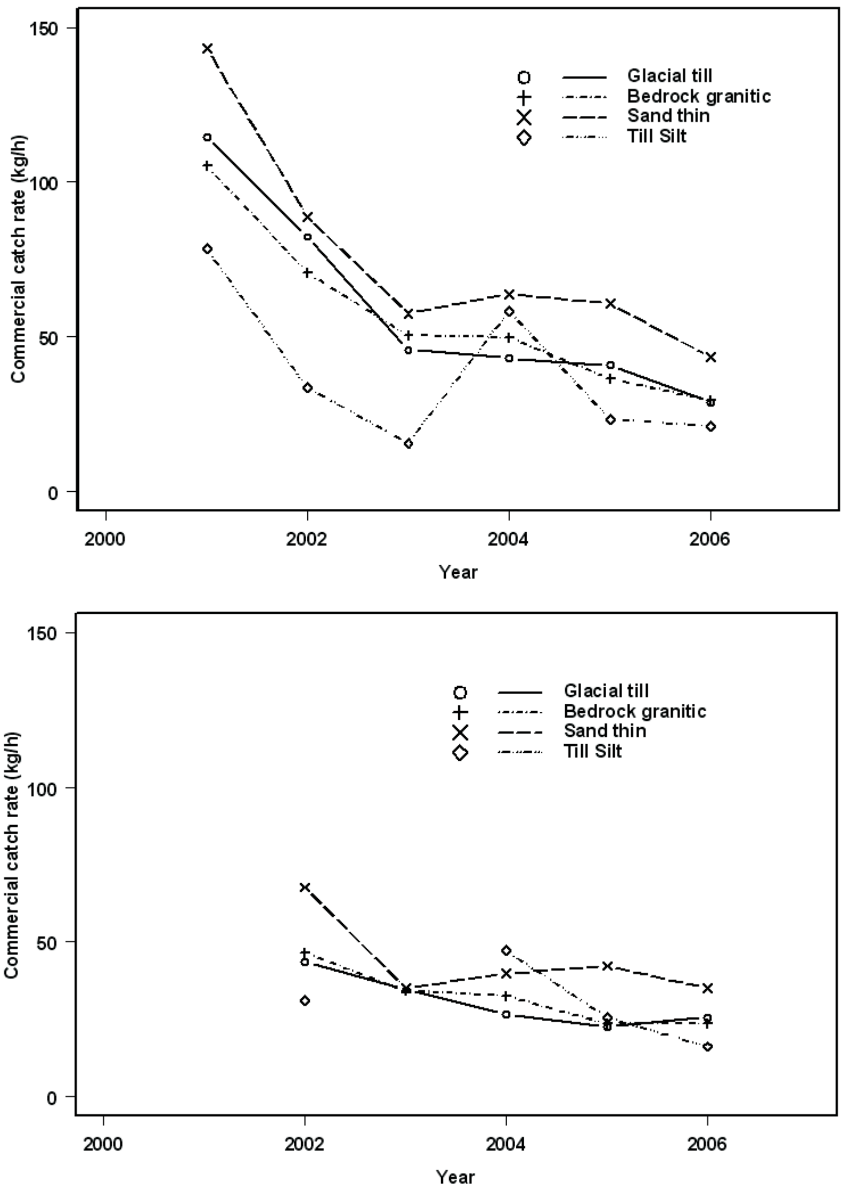



Fig. 6. Mean commercial catch rate (kg/h) trends for SFA 29 scallop fishery for each bottom type by fleet. Upper panel: Full Bay. Lower panel: East of Baccaro.

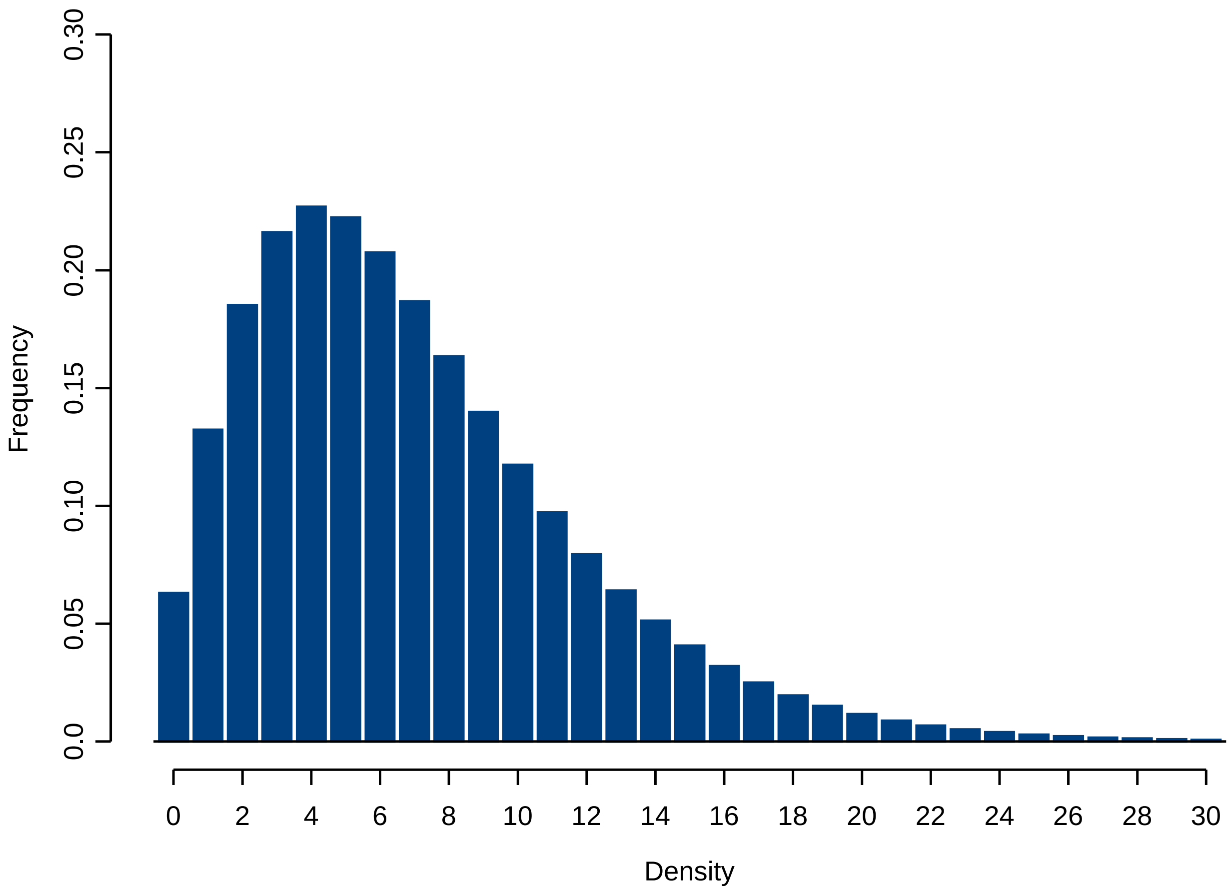



Fig. 7. Example of a type concentration profile for the expected density of species that is habitat limited.

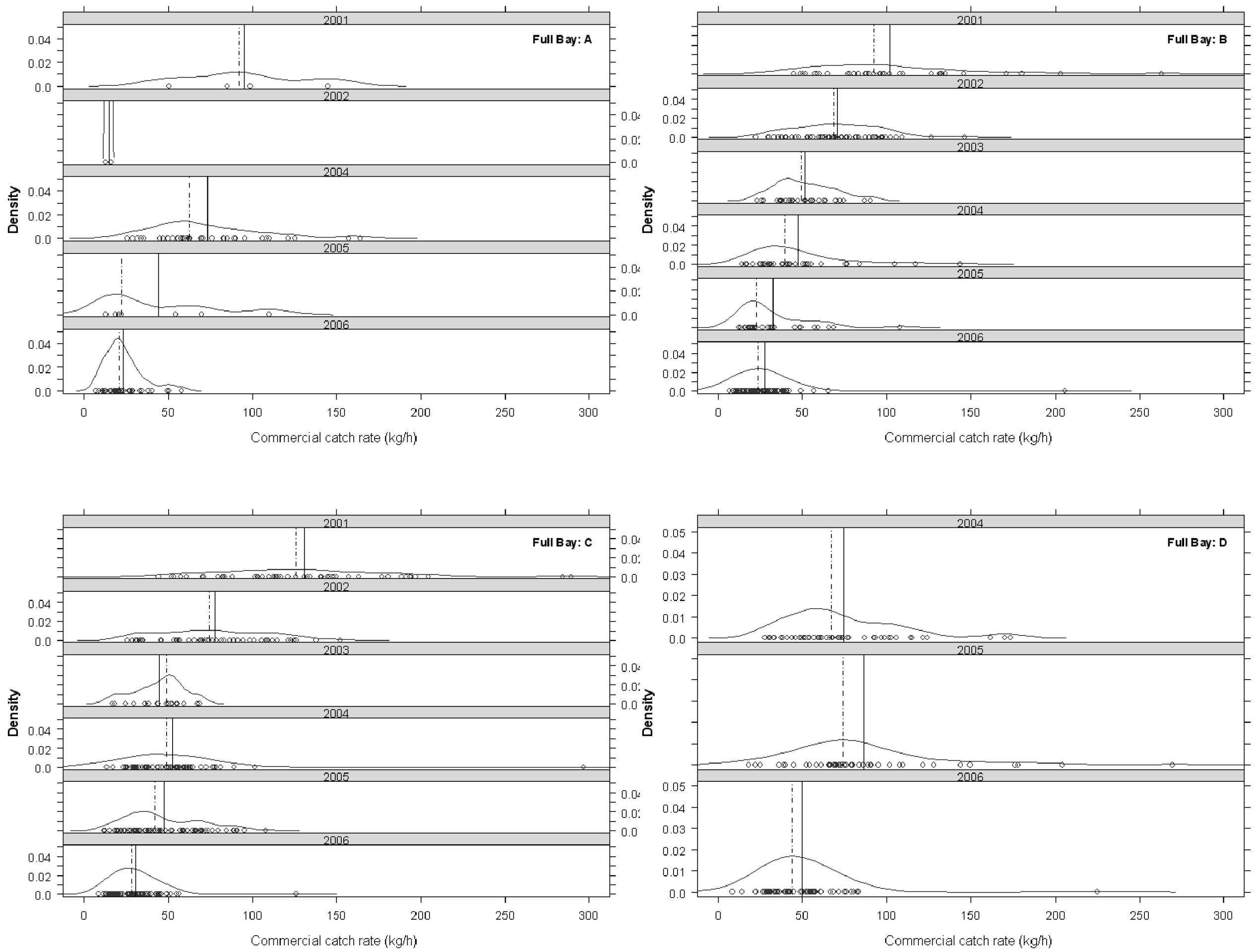



Fig. 8. Frequency plot of catch rates by trip from Full Bay log books for SFA 29. Top left panel: SFA 29 A; Top right panel: SFA 29 B; Bottom left panel: SFA 29 C; bottom right panel: SFA 29 D. The vertical solid line indicates the mean catch rate while the vertical dash-dot line indicates the median.

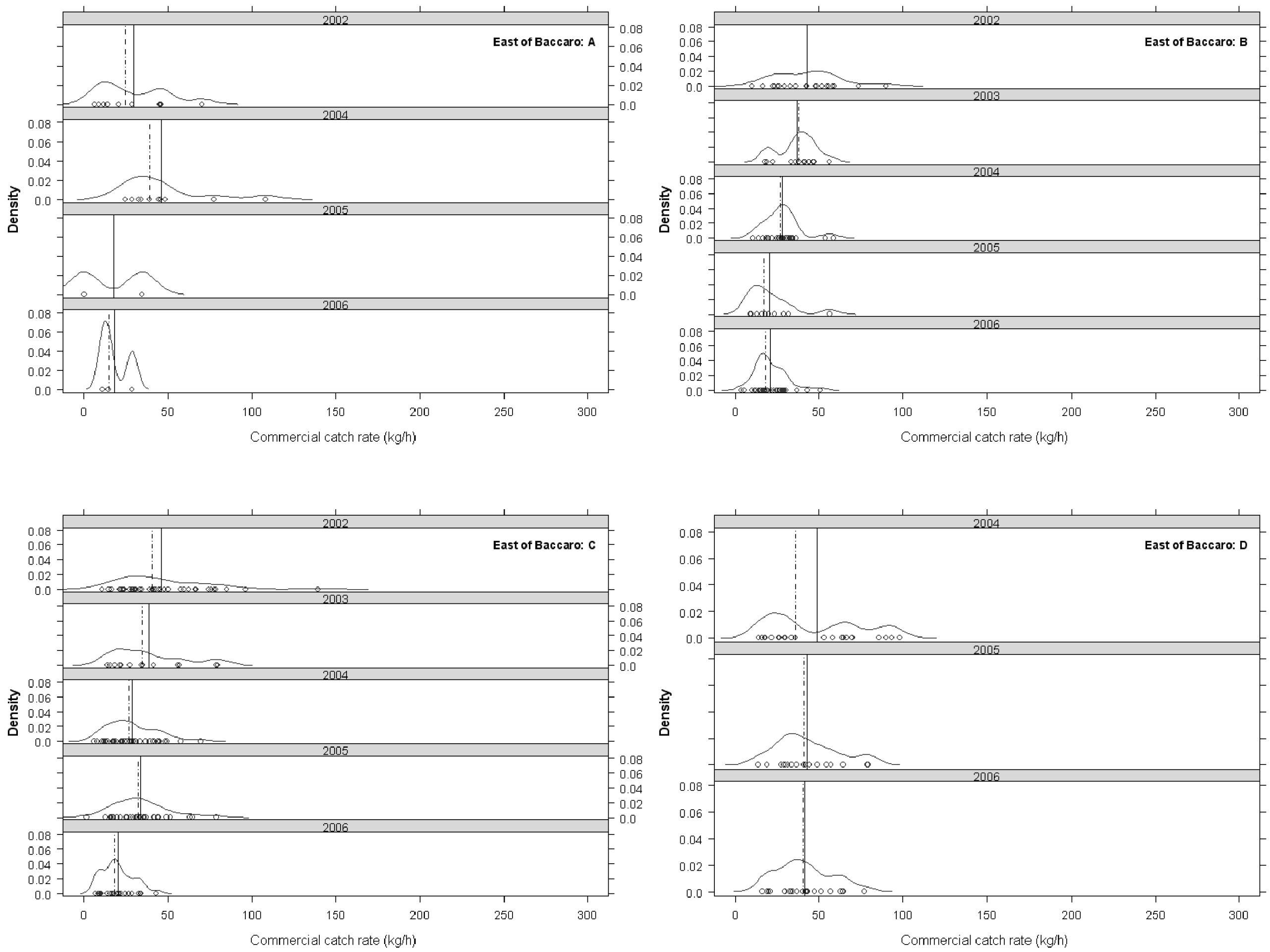
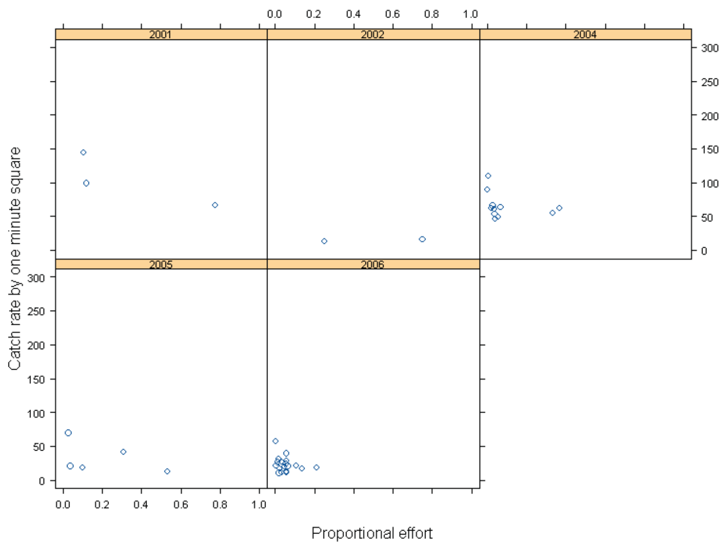



Fig. 9. Frequency plot of catch rates by trip from East of Baccaro log books for SFA 29. Top left panel: SFA 29 A; Top right panel: SFA 29 B; Bottom left panel: SFA 29 C; bottom right panel: SFA 29 D. The vertical solid line indicates the mean catch rate while the vertical dash-dot line indicates the median.



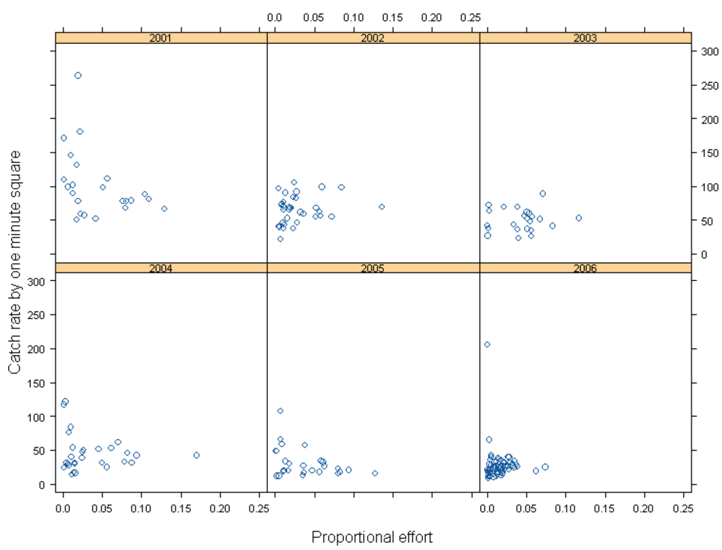




Fig. 10. Scatter plot of catch rates (kg/h) by subarea versus proportion of total effort by subarea from Full Bay log books for SFA 29. Top panel: SFA 29 A; Bottom panel: SFA 29 B.

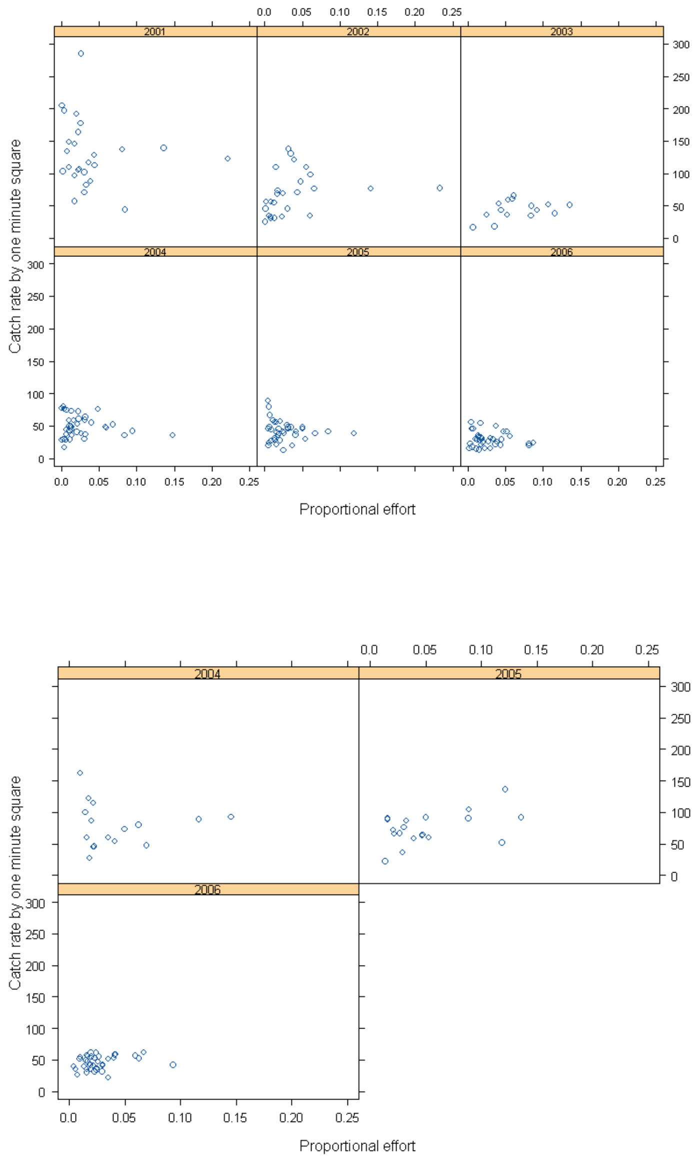
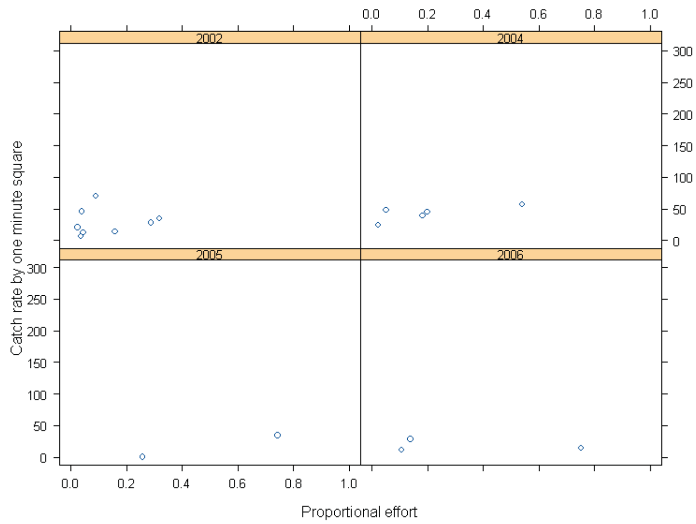



Fig. 11. Scatter plot of catch rates (kg/h) by subarea versus proportion of total effort by subarea from Full Bay log books for SFA 29. Top panel: SFA 29 C; Bottom panel: SFA 29 D.



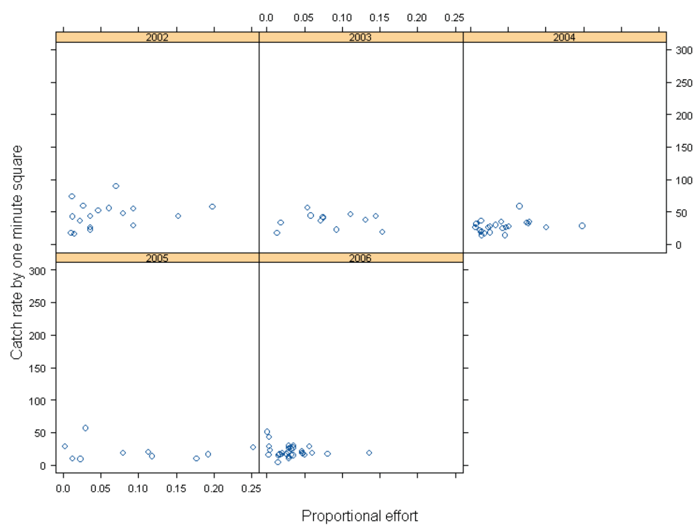
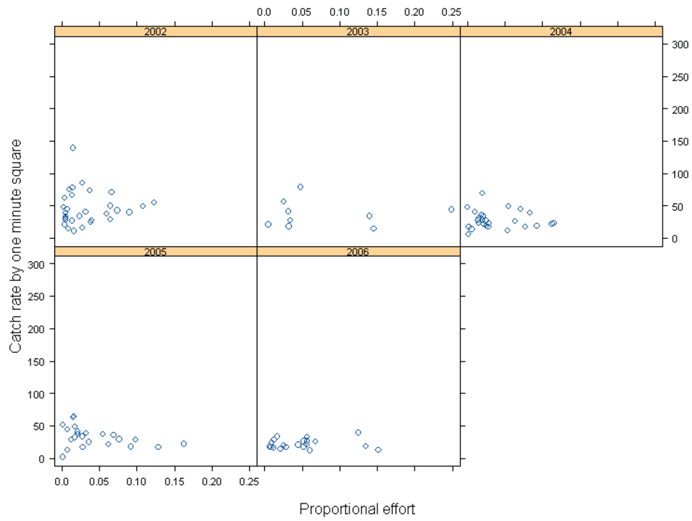




Fig. 12. Scatter plot of catch rates (kg/h) by subarea versus proportion of total effort by subarea from East of Baccaro log books for SFA 29. Top panel: SFA 29 A; Bottom panel: SFA 29 B.



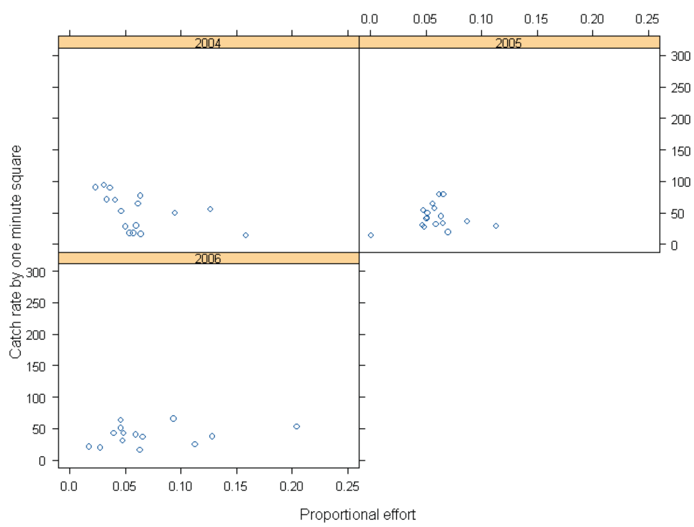




Fig. 13. Scatter plot of catch rates (kg/h) by subarea versus proportion of total effort by subarea from East of Baccaro log books for SFA 29. Top panel: SFA 29 C; Bottom panel: SFA 29 D.

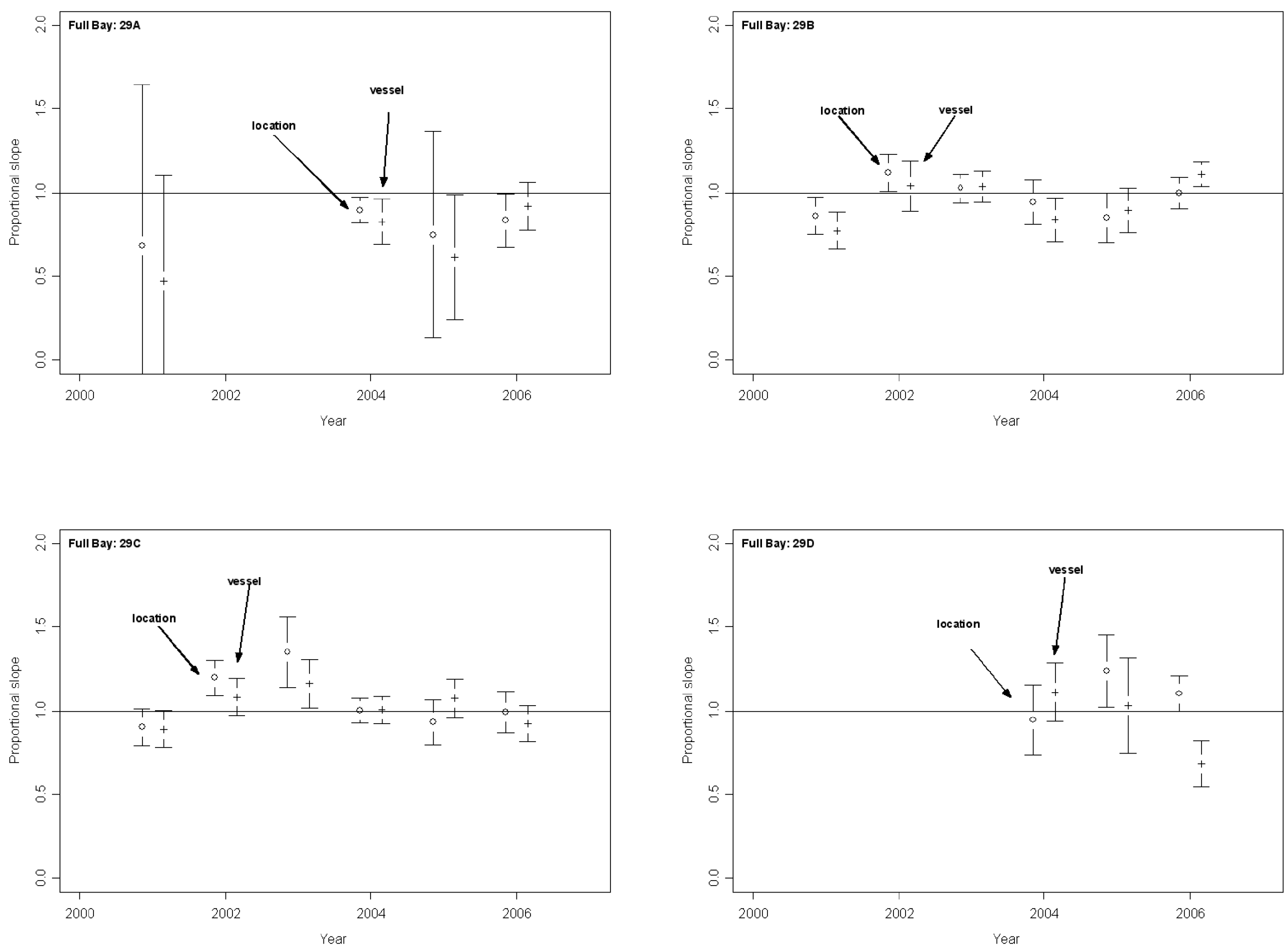



Fig. 14. Estimate of slope and 95 percent confidence intervals for relationship between proportion of catch and effort by year. Full Bay catches in SFA 29A. Top left panel: SFA 29 A; Top right panel: SFA 29 B; Bottom left panel: SFA 29 C; bottom right panel: SFA 29 D.

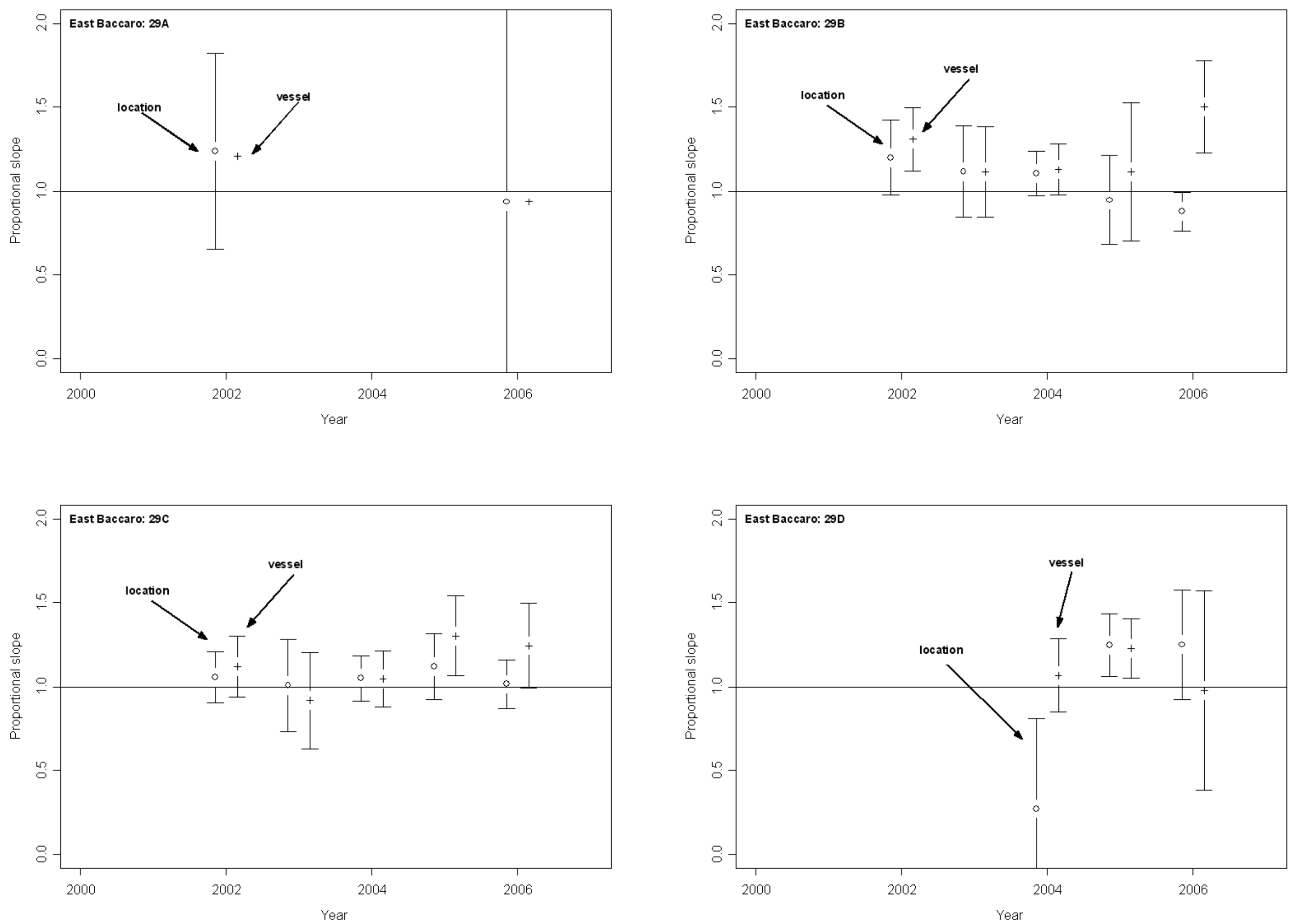



Fig. 15. Estimate of slope and 95 percent confidence intervals for relationship between proportion of catch and effort by year. East of Baccaro catches in SFA 29. Top left panel: SFA 29 A; Top right panel: SFA 29 B; Bottom left panel: SFA 29 C; bottom right panel: SFA 29 D.

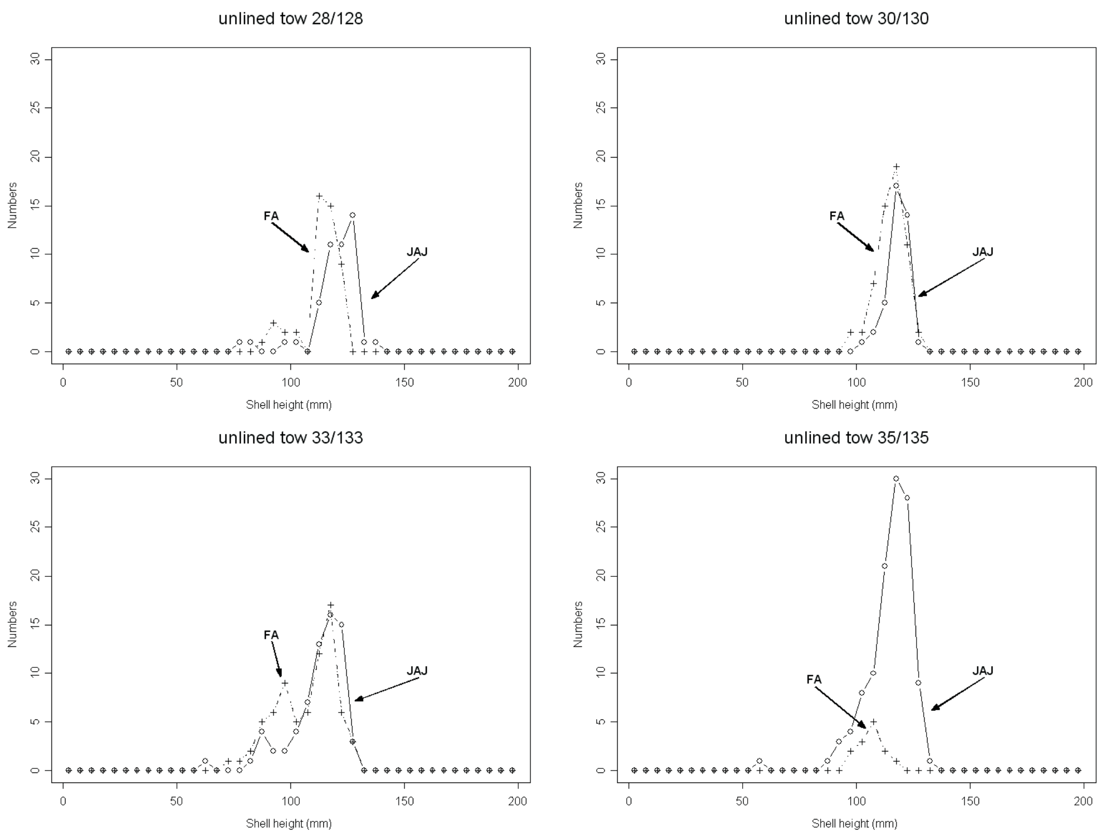



Fig. 16. Shell height frequencies from the unlined drag for four of the ten comparative tows between the F/V Julie Ann Joan (JAJ) and F/V Faith Alone (FA) during 2006 survey.

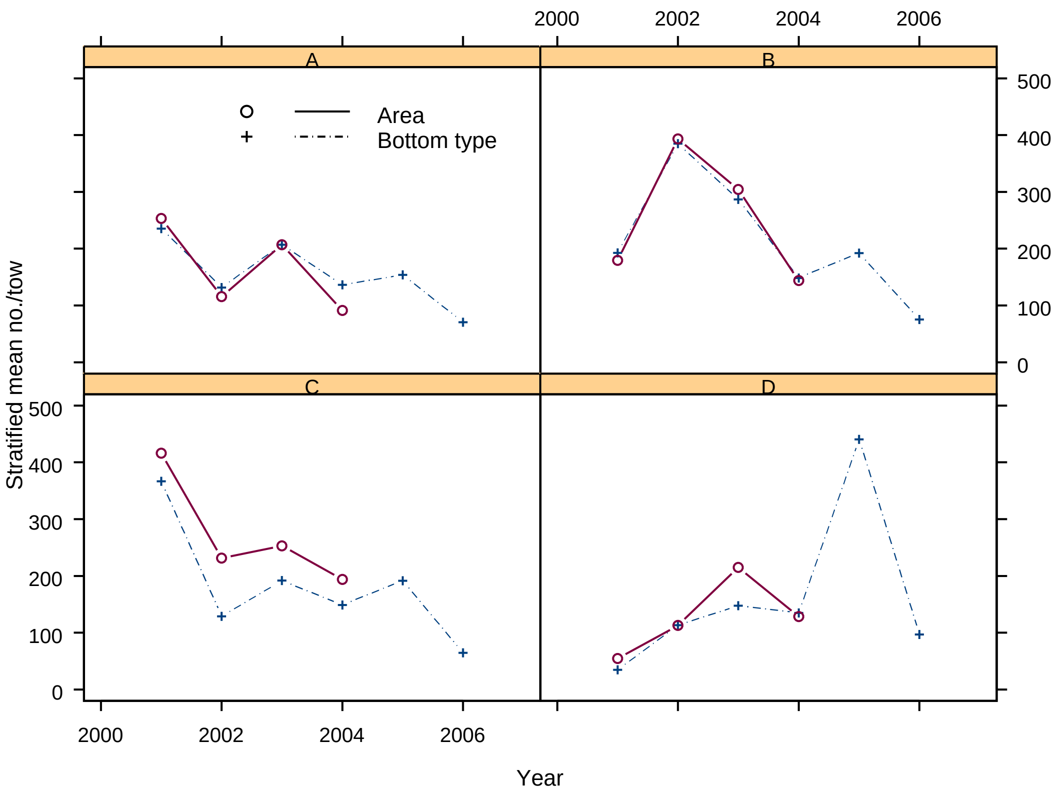



Fig. 17. Comparison of estimates of stratified mean number per tow of commercial size scallops (shell height $\geq$ 100 mm) using stratification by subarea or bottom type. Note estimates based on data from F/V Julie Ann Joan only for C and D in 2005 and 2006. (After Smith et al. 2006b).

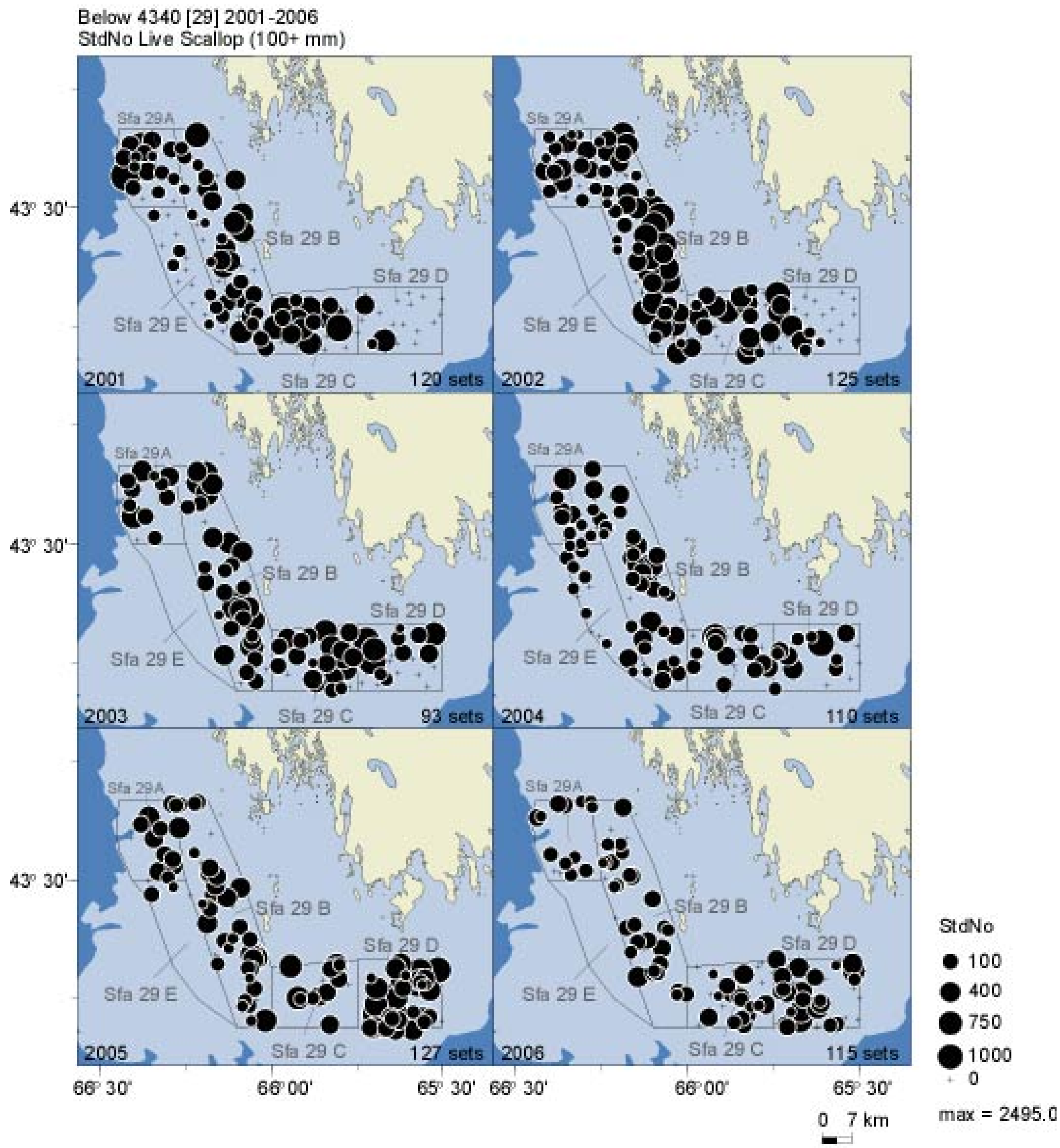



Fig. 18. Spatial distribution of scallops for shell heights 100 mm and larger (corresponding to approximately age 6+) caught during the 2001–2006 scallop research surveys in SFA 29.

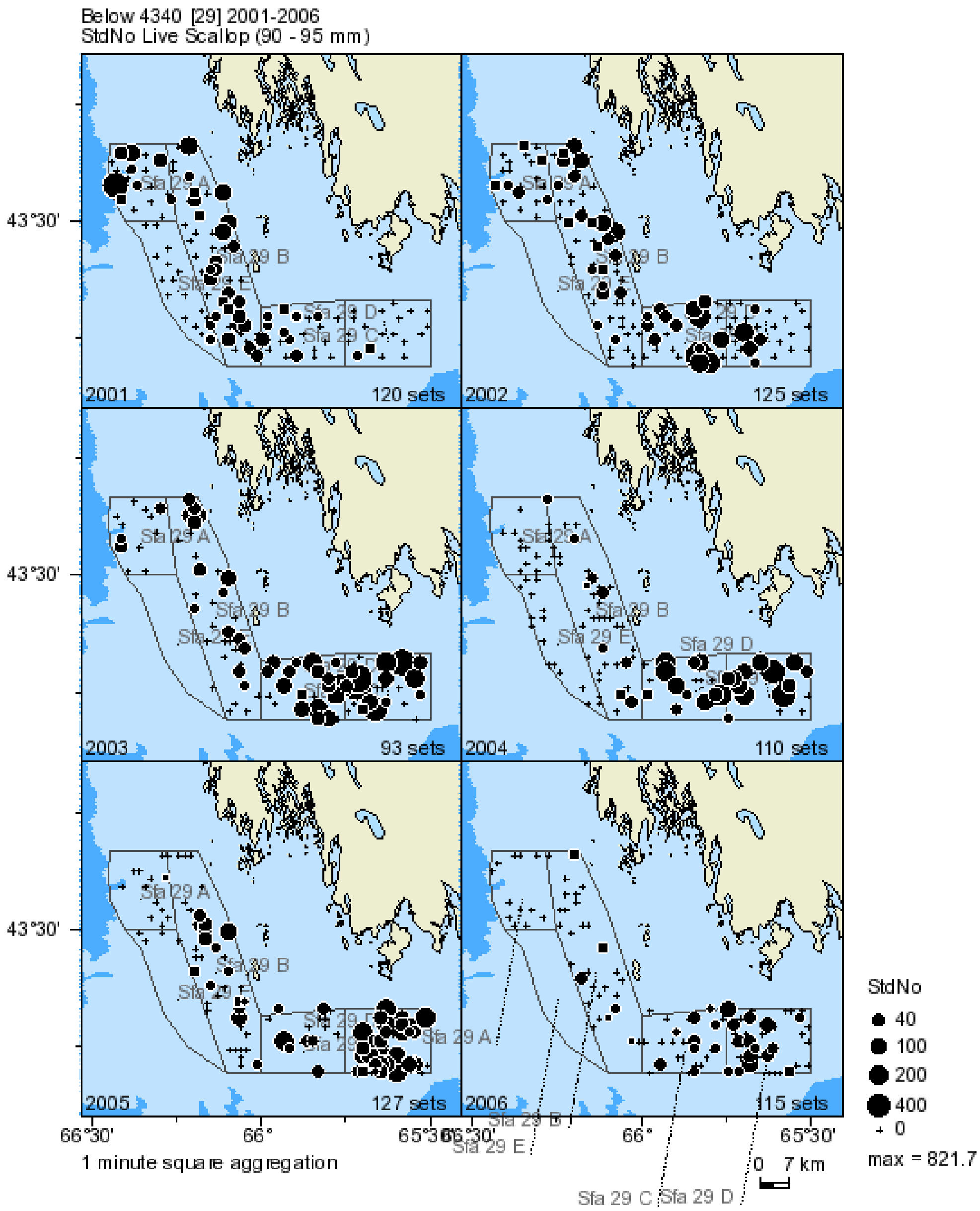



Fig. 19. Spatial distribution of scallops for shell heights from 90 to 99 mm (corresponding to approximately age 5) caught during the 2001–2006 scallop research surveys in SFA 29.

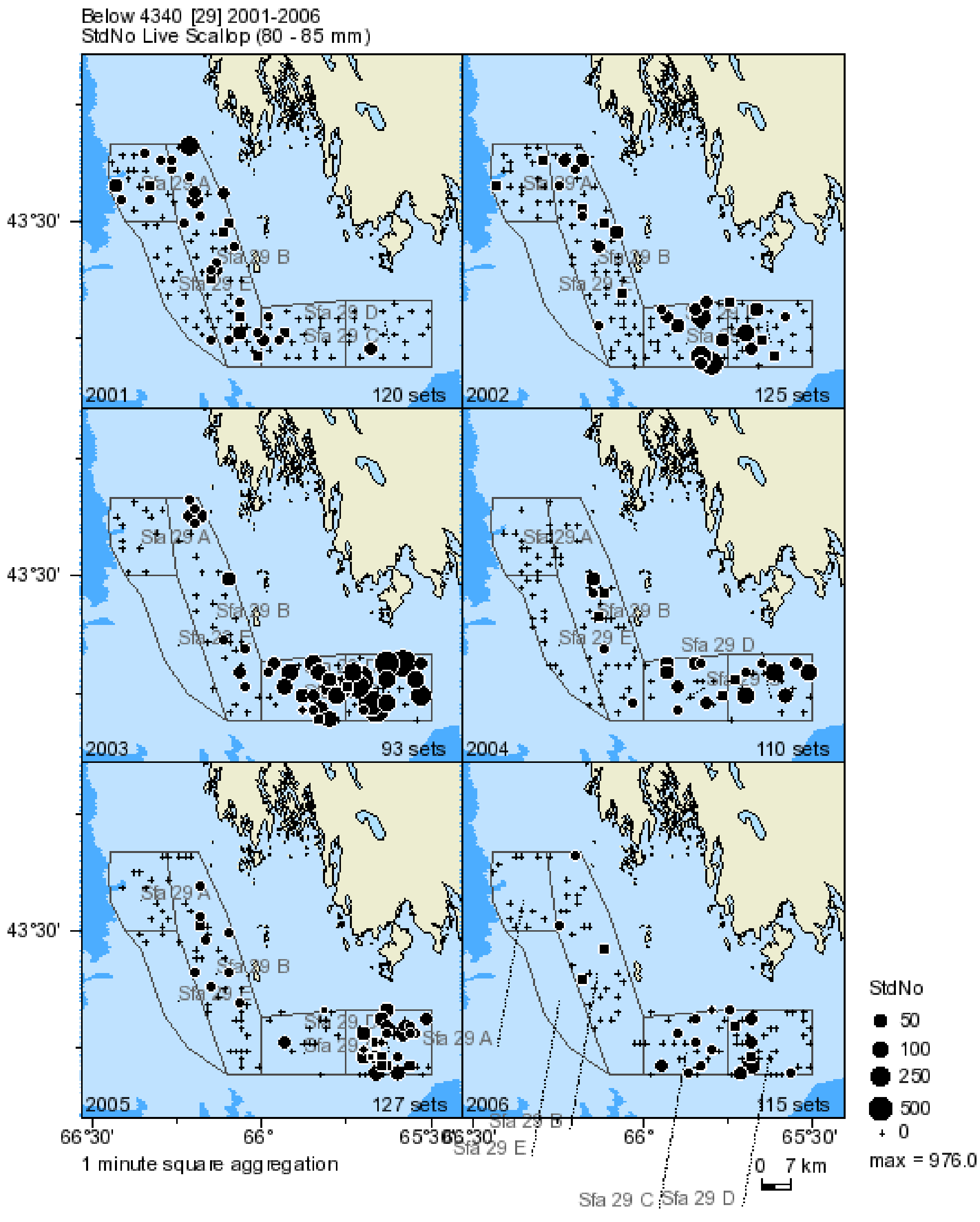



Fig. 20. Spatial distribution of scallops for shell heights from 80 to 89 mm (corresponding to approximately age 4) caught during the 2001–2006 scallop research surveys in SFA 29.

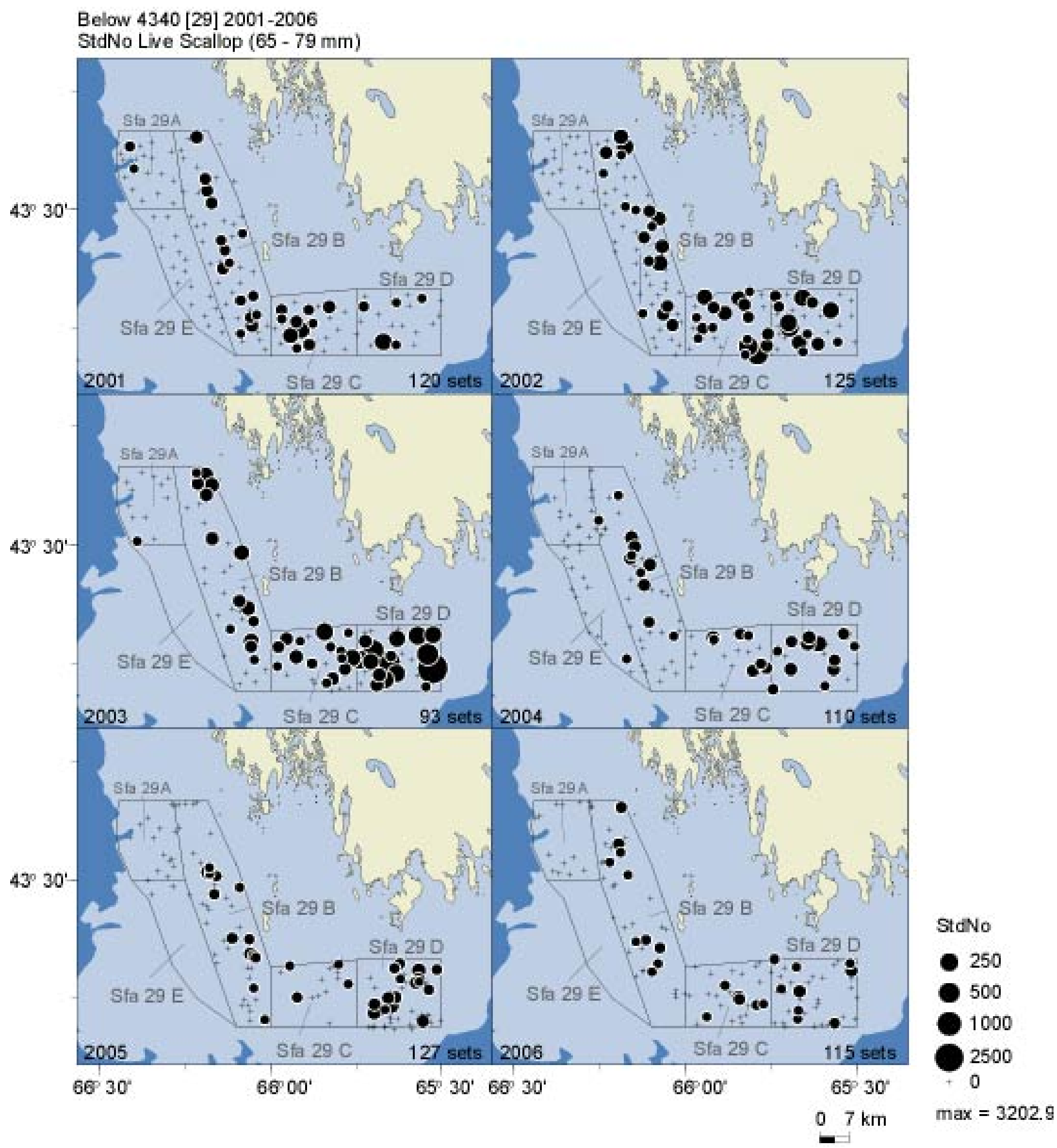



Fig. 21. Spatial distribution of scallops for shell heights from 65 to 79 mm (corresponding to approximately age 3) caught during the 2001–2006 scallop research surveys in SFA 29.

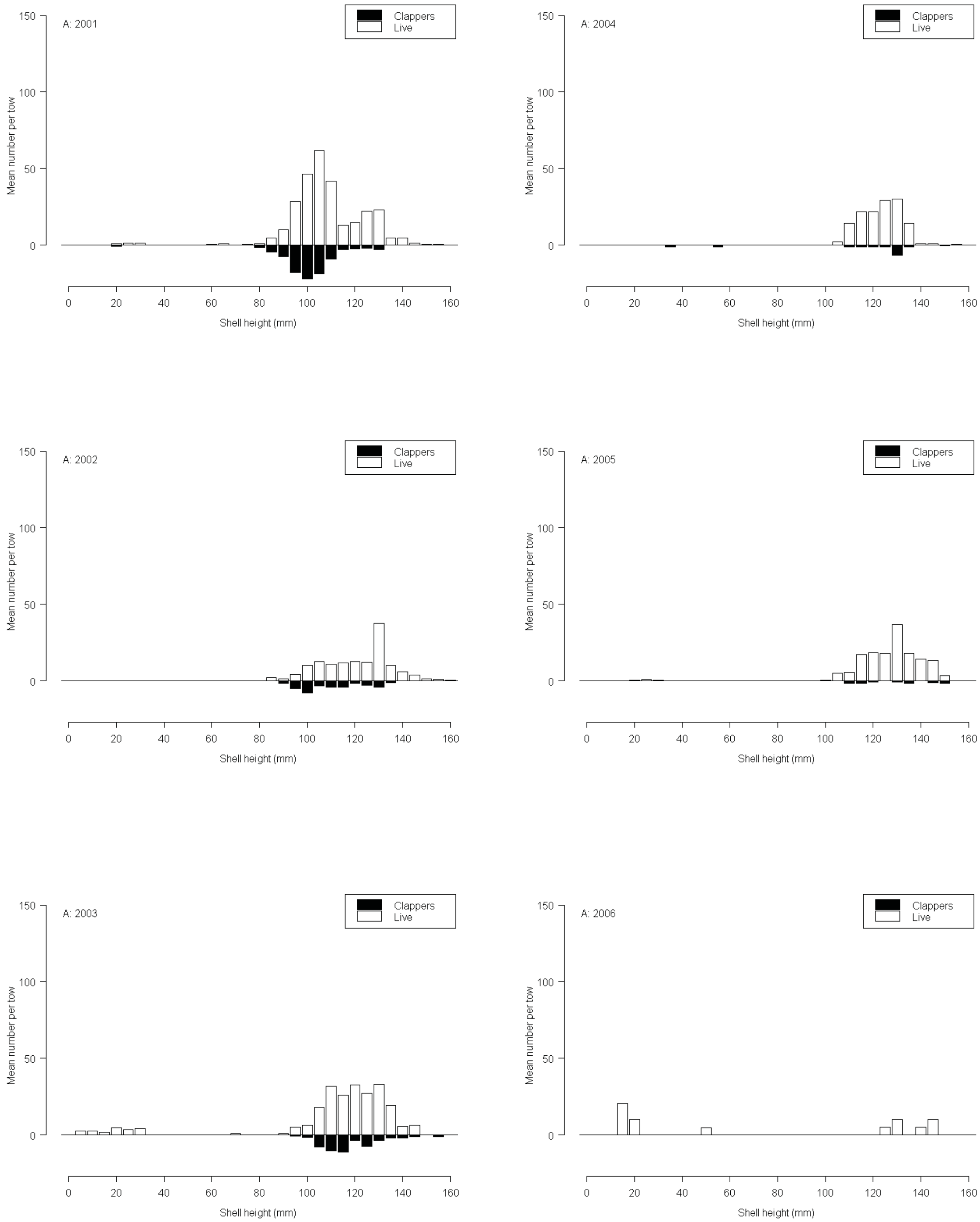



Fig. 22. Shell height frequencies for SFA 29A from survey data.

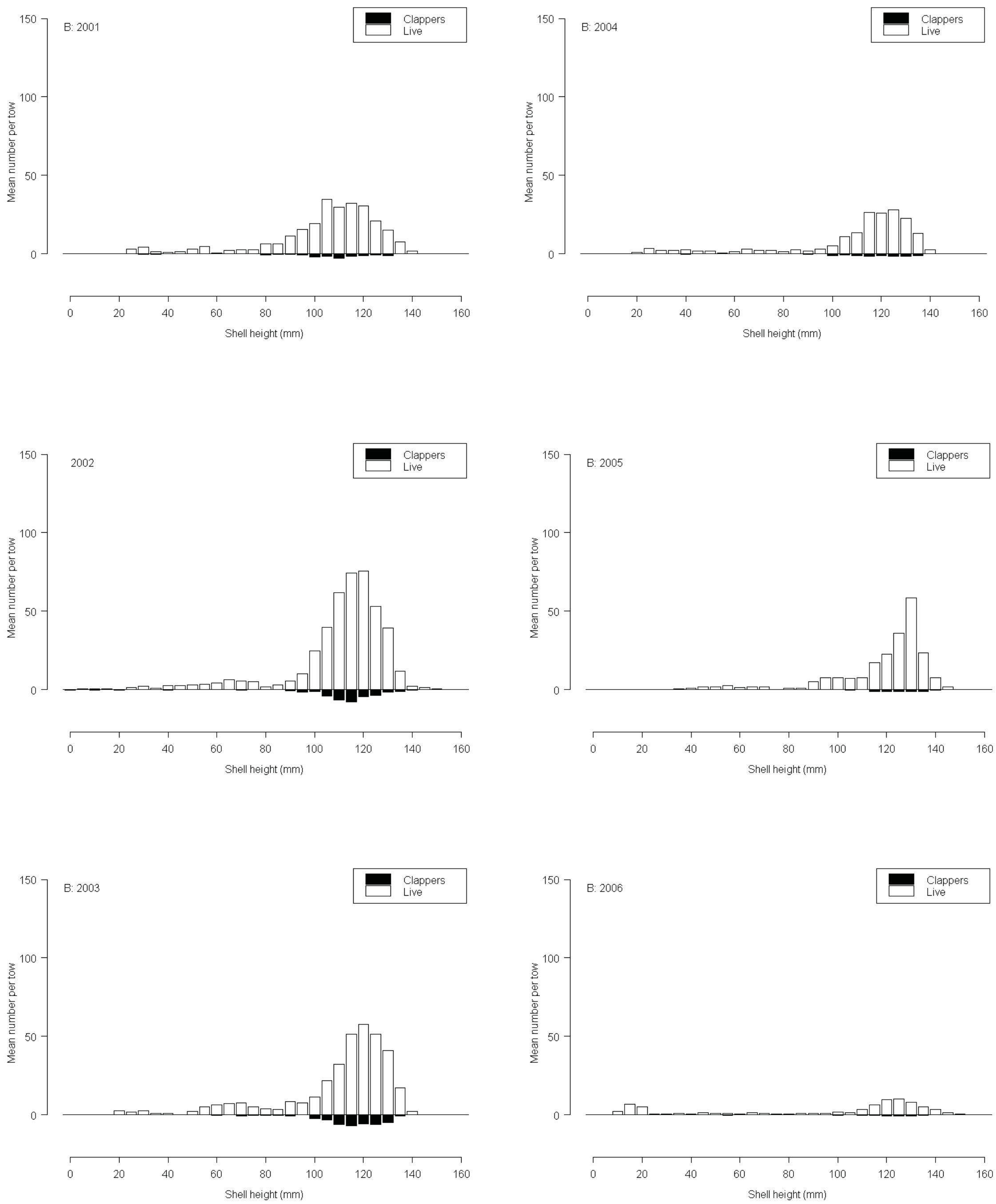



Fig. 23. Shell height frequencies for SFA 29B from survey data.

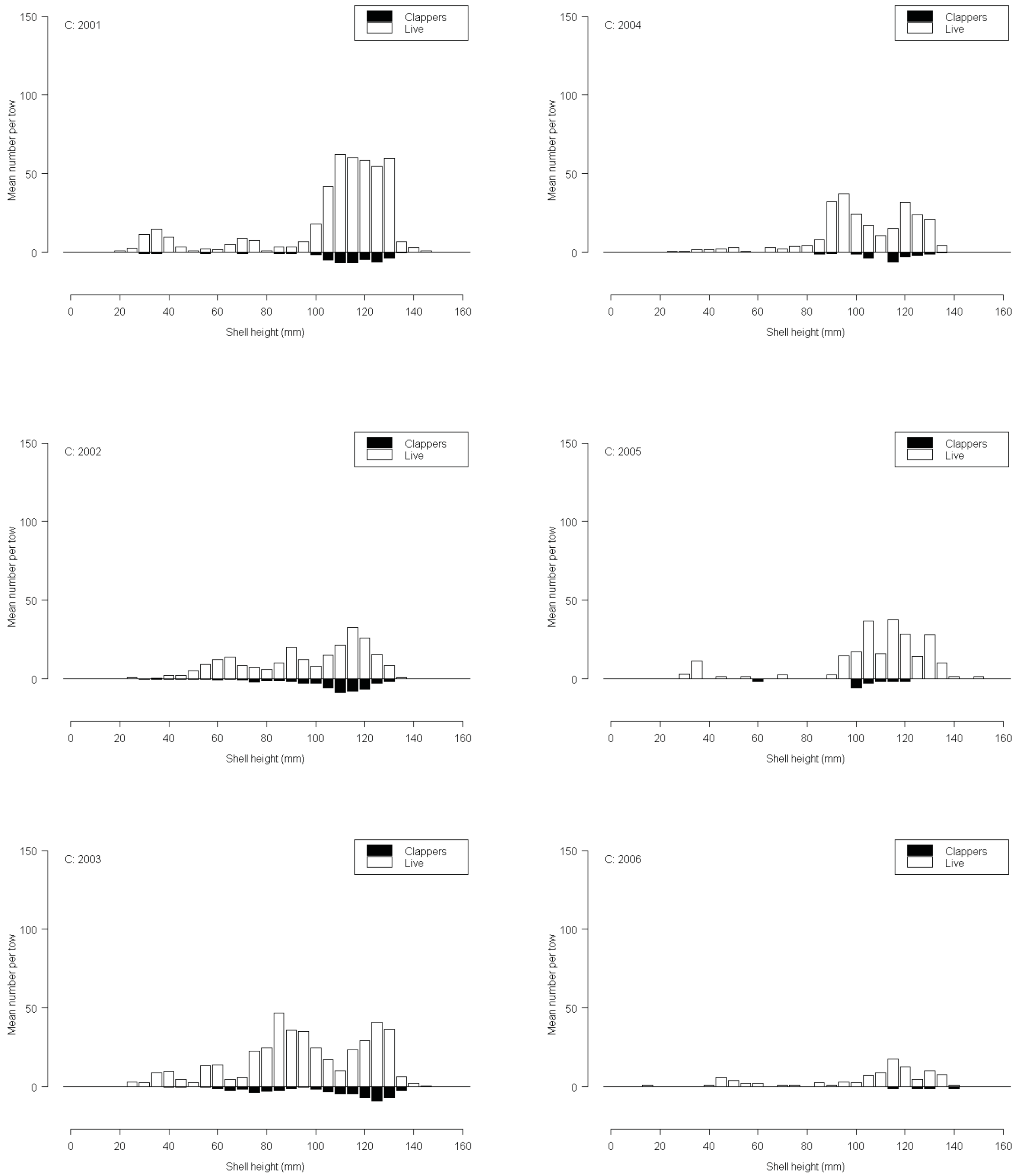



Fig. 24. Shell height frequencies for SFA 29C from survey data.

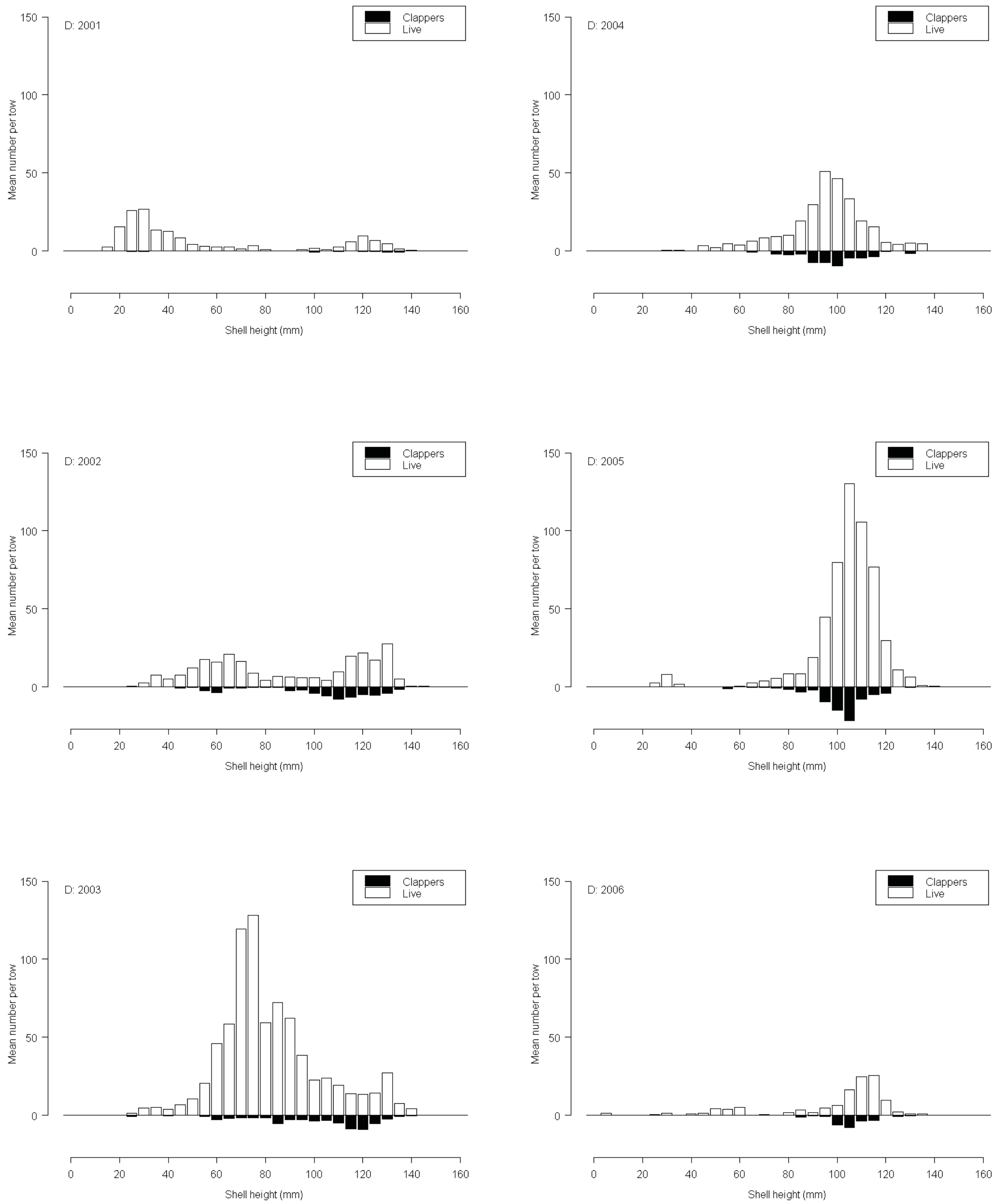



Fig. 25. Shell height frequencies for SFA 29D from survey data.

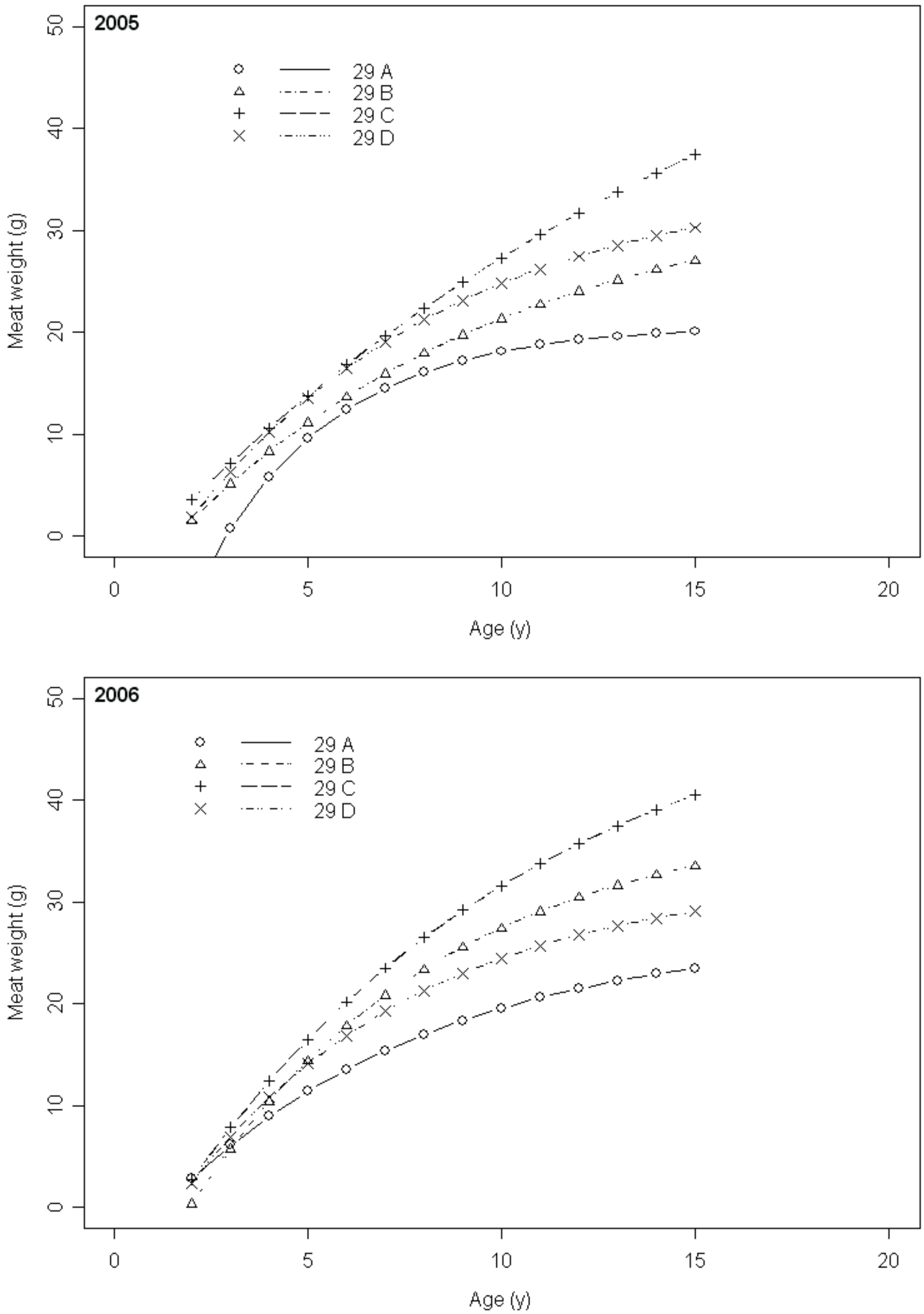



Fig. 26. Growth curves of meat weight as a function of age by subarea SFA 29 A, B, C and D for 2005 and 2006 survey data.

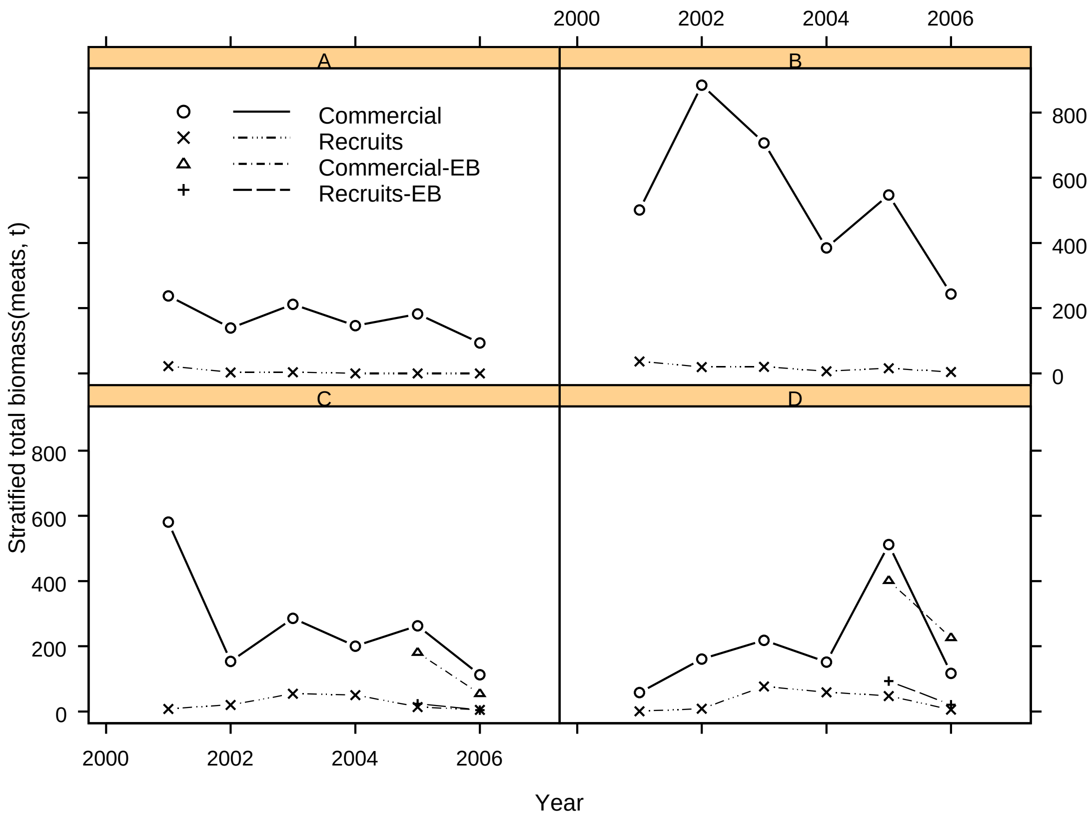



Fig. 27. Annual trends of fully recruited (100+ mm) and recruit (90-100 mm) size classes of estimates of total biomass of scallops (meats, t) from research surveys by subarea in SFA 29. Commercial and Recruits series estimated from F/V Julie Ann Joan (2001–2003, 2005–2006) and F/V Branntelle (2004) tows. Commercial-EB and Recruits-EB estimated from F/V Overton Bay (2005) and F/V Faith Alone (2006).

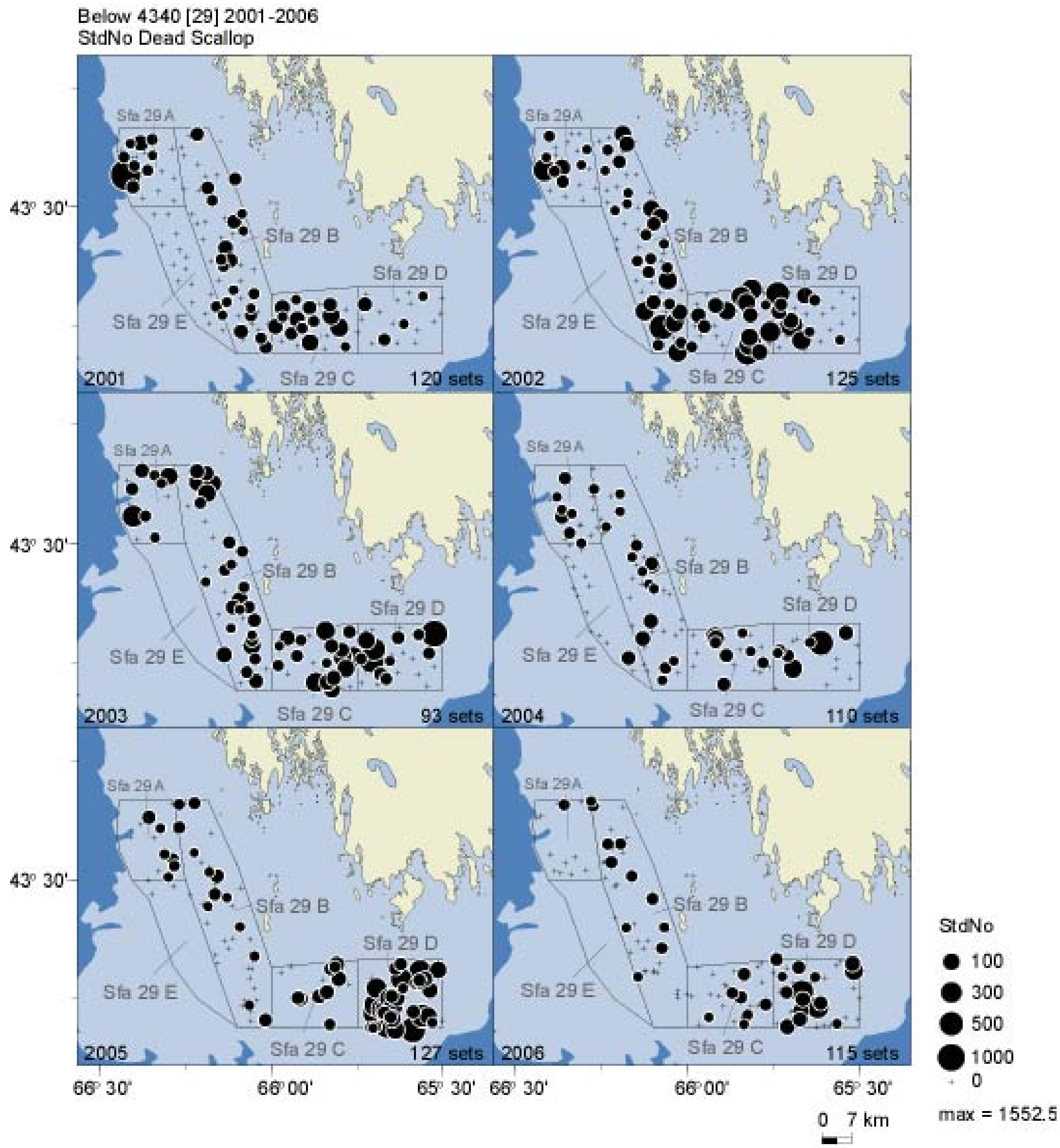



Fig. 28. Spatial distribution of clappers for all sizes caught during the 2001–2006 research surveys in Scallop Fishing Area 29.

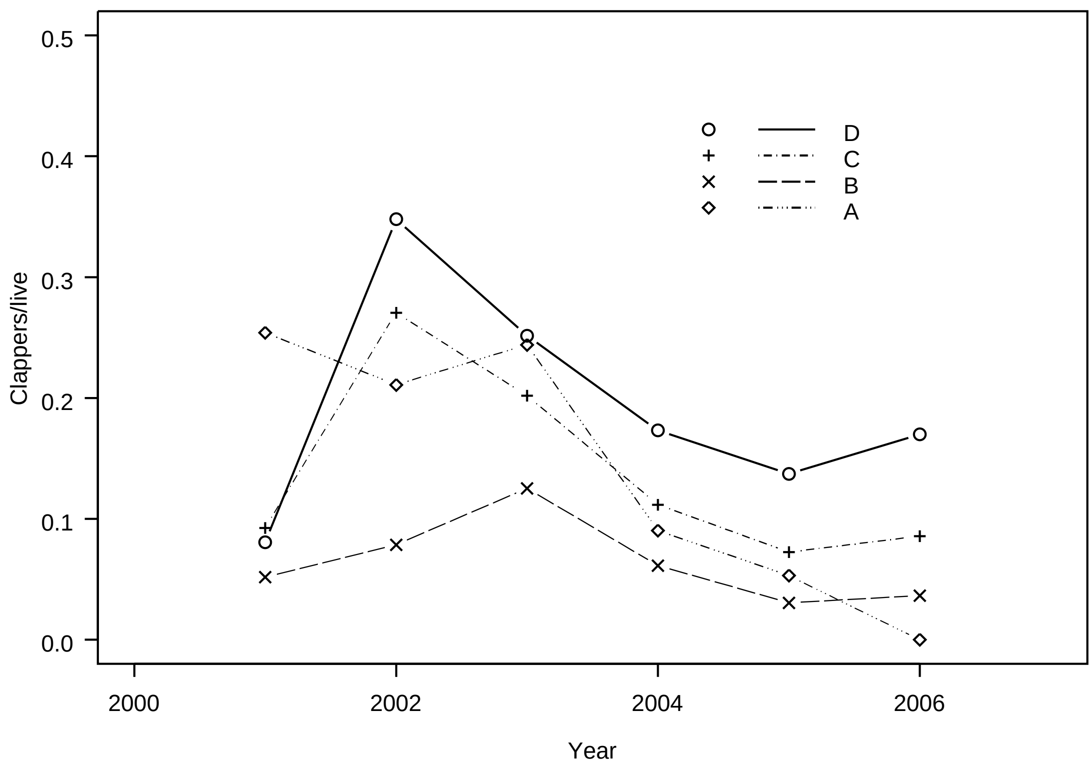



Fig. 29. Ratio of mean number of clappers to mean number of live scallops of commercial size from annual survey in SFA 29.

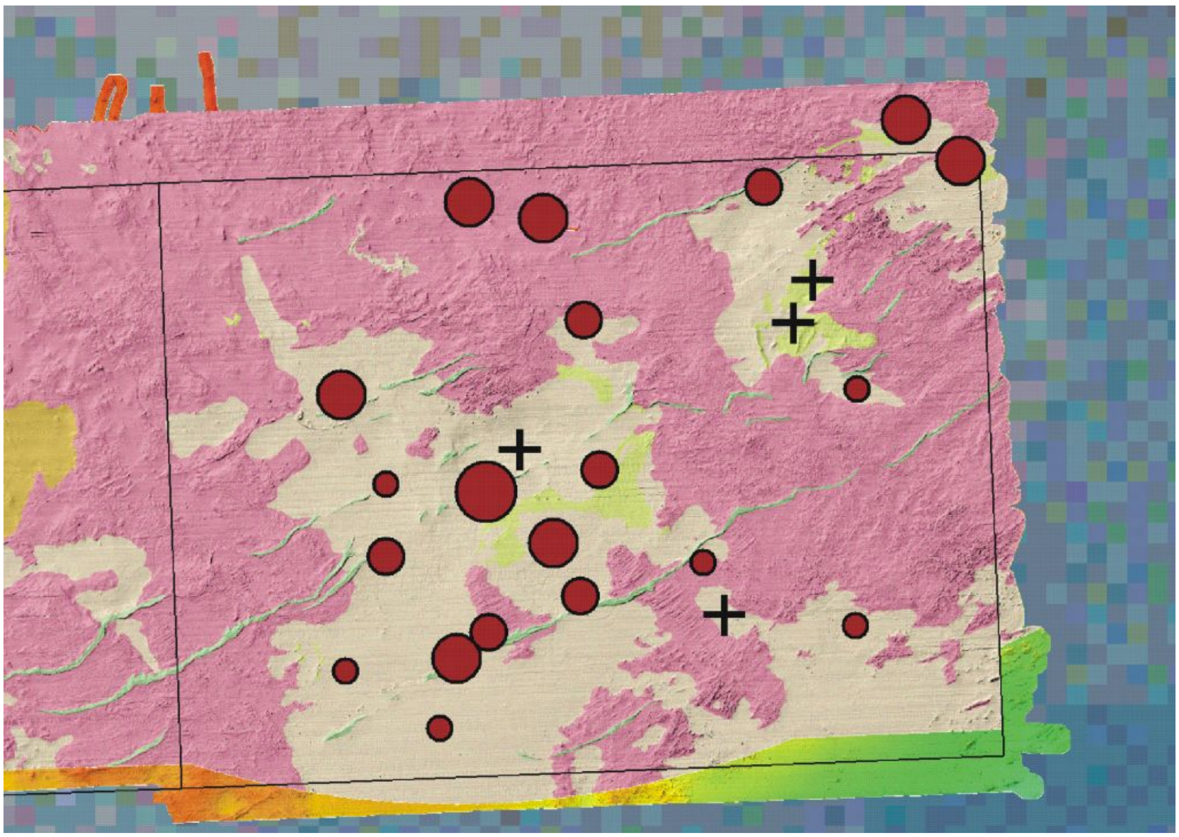


Fig. 30. Proportions of clappers in July 2006 SFA 29 survey catches. Positions with "+" indicate zero clappers.

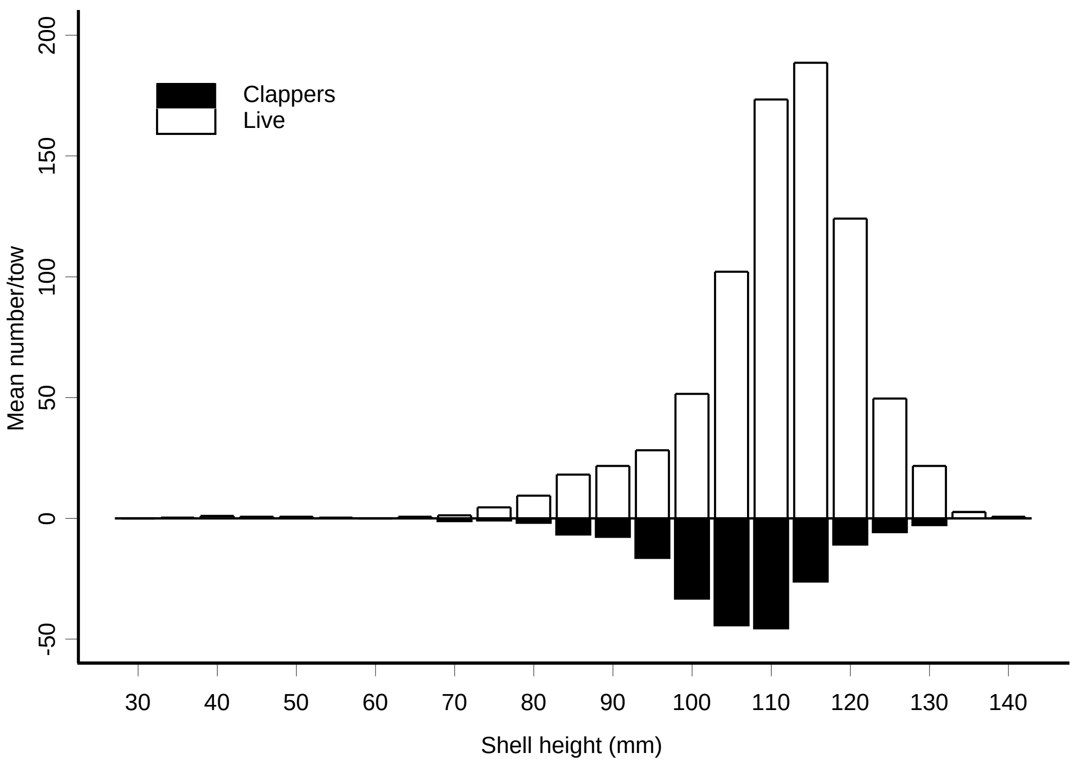



Fig. 31. Shell height frequencies for live scallops and clappers over all tows in the July 2006 survey of SFA 29 D.

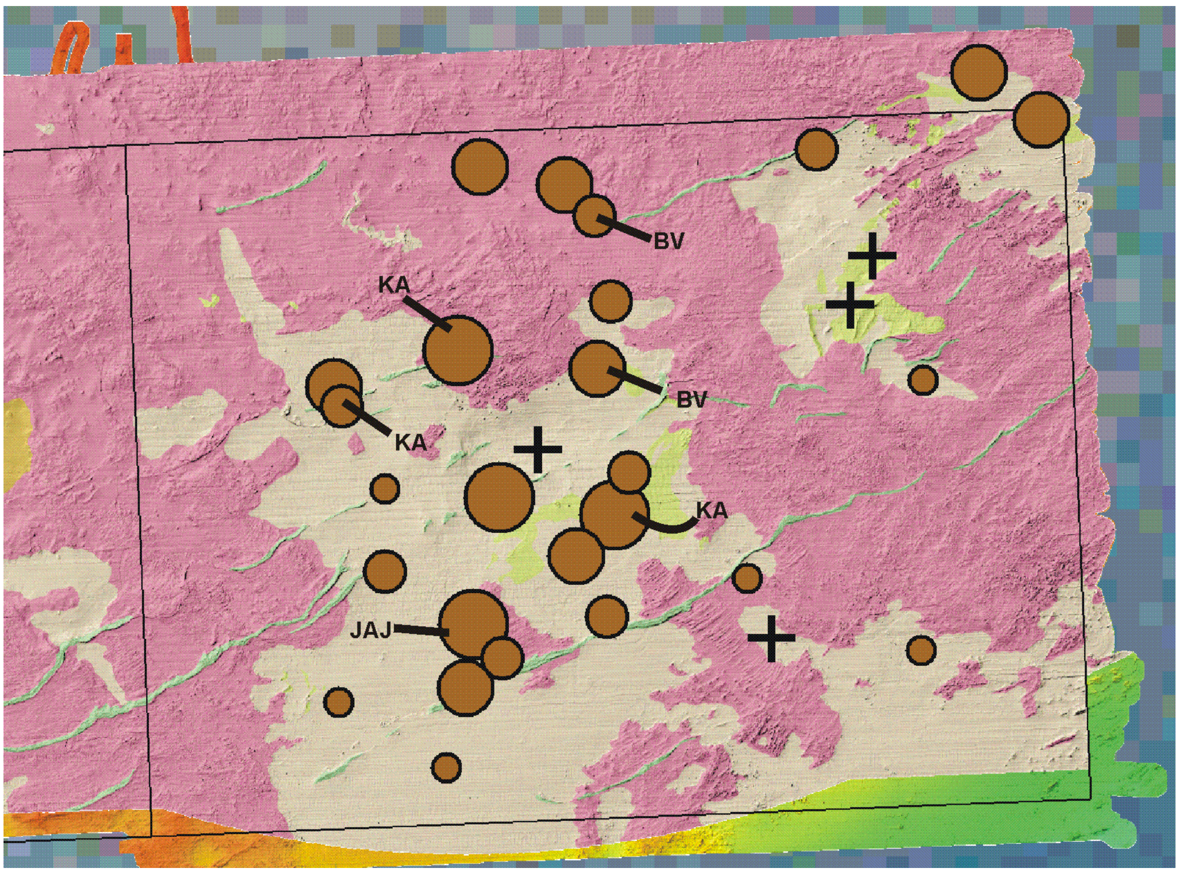



Fig. 32. Proportions of clappers in July 2006 survey catches and proportions from observer data and estimates from K. Amero. Positions with "+" indicate zero clappers.

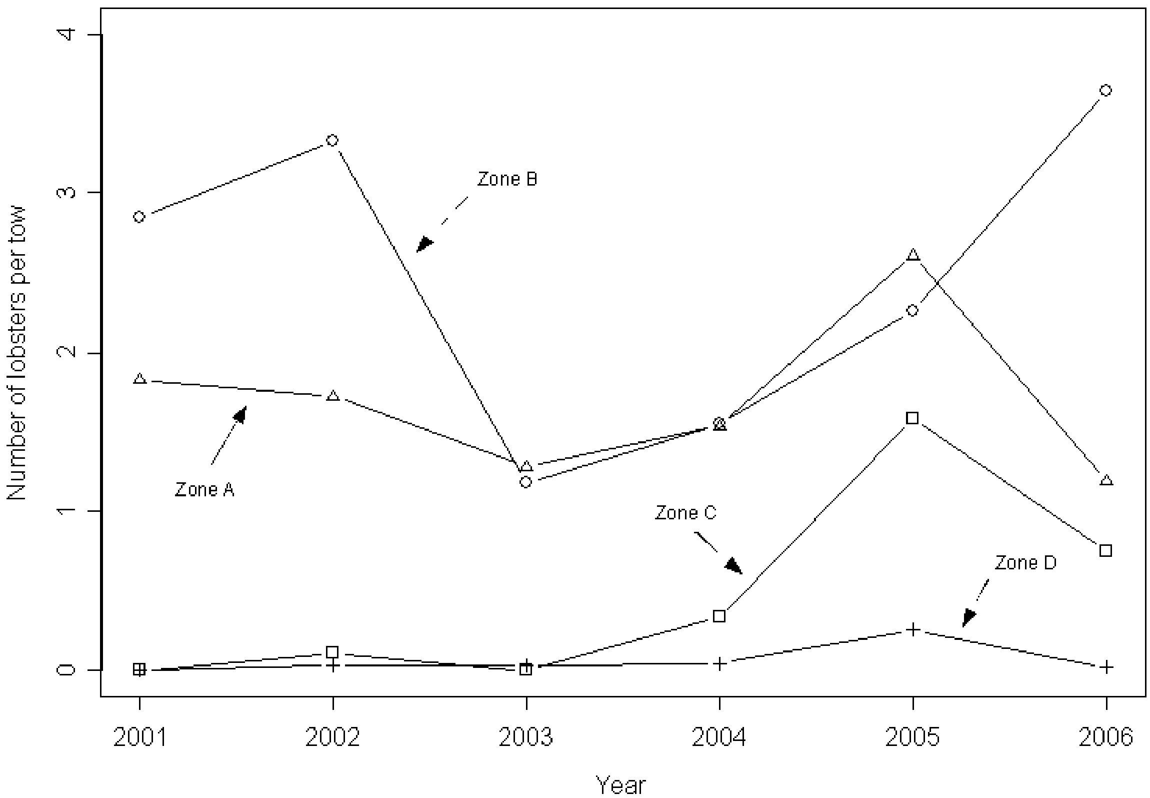



Fig. 33. Mean number of lobsters per tow from annual scallop survey in SFA 29.

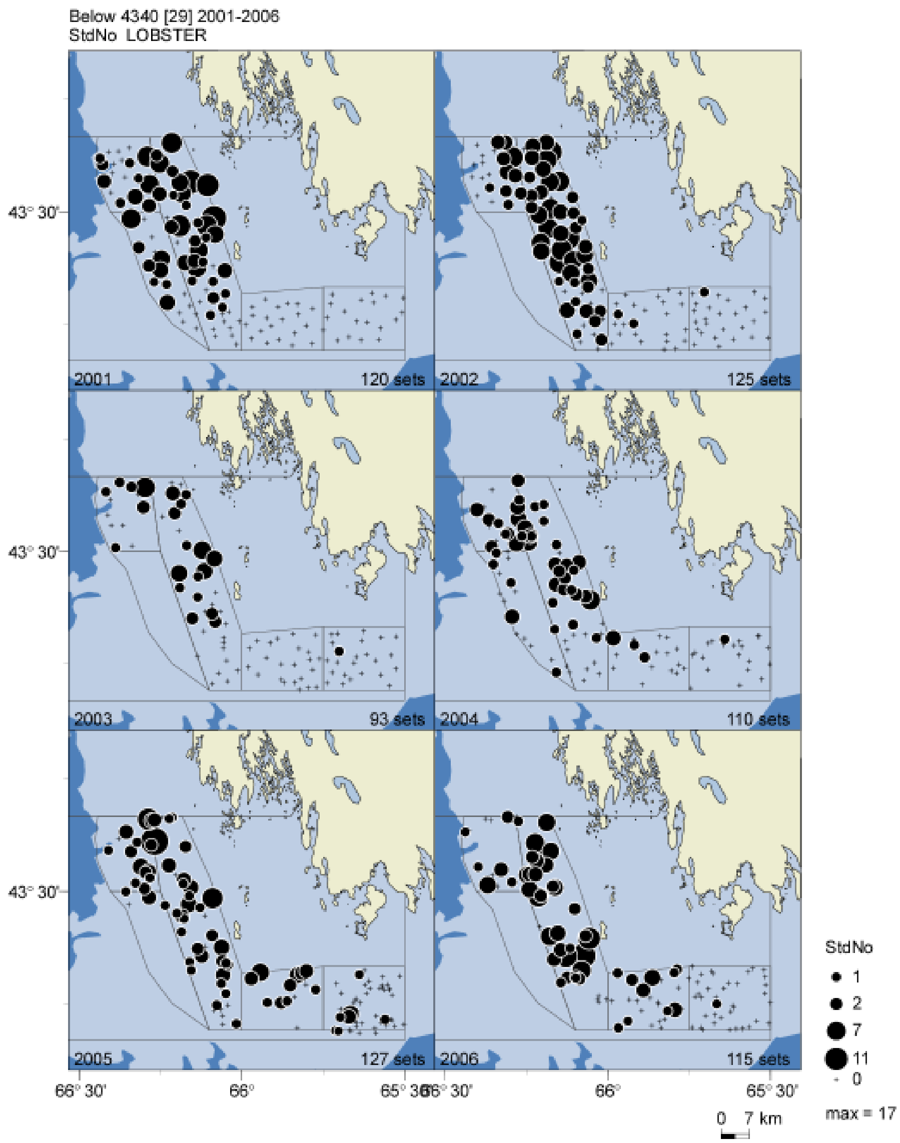



Fig. 34. Spatial distribution of lobsters caught during scallop survey in SFA 29, 2001–2006.

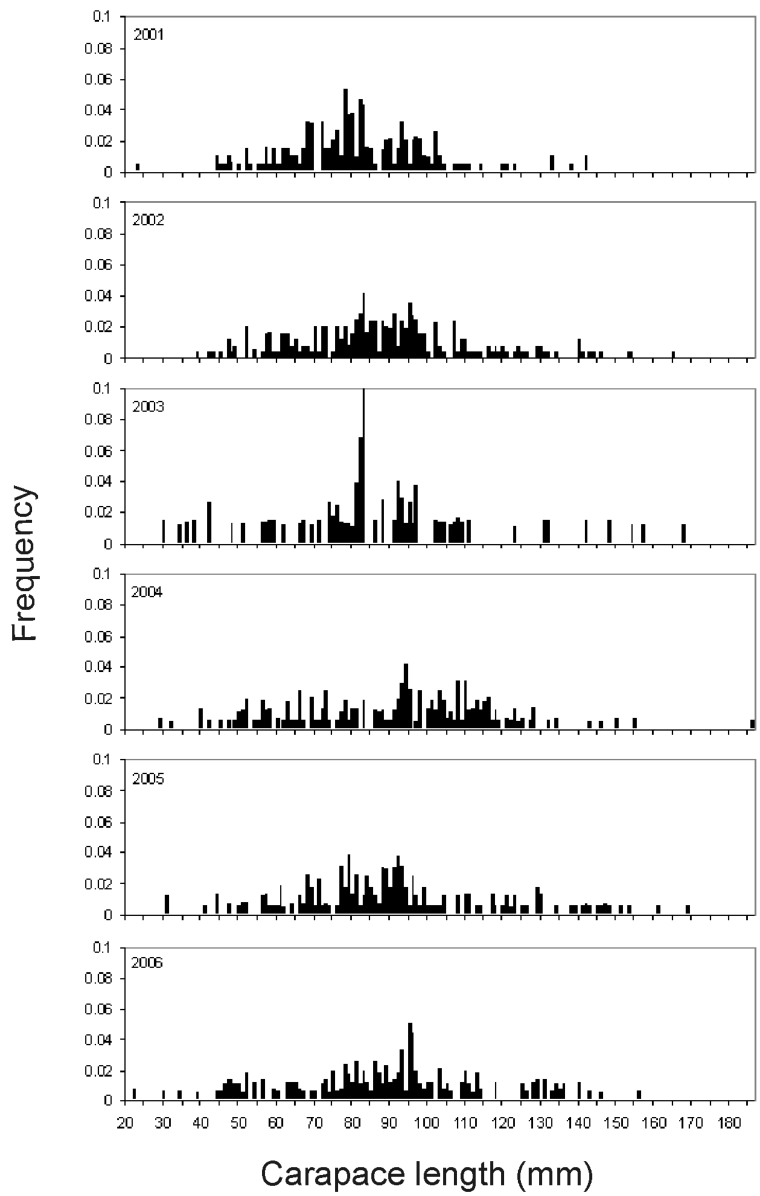



Fig. 35. Size frequency of lobsters measured during scallop survey in SFA 29 from 2001–2006. Numbers measured per year were 187 (2001), 248 (2002), 73(2003), 160 (2004), 158 (2005), and 158 (2006).

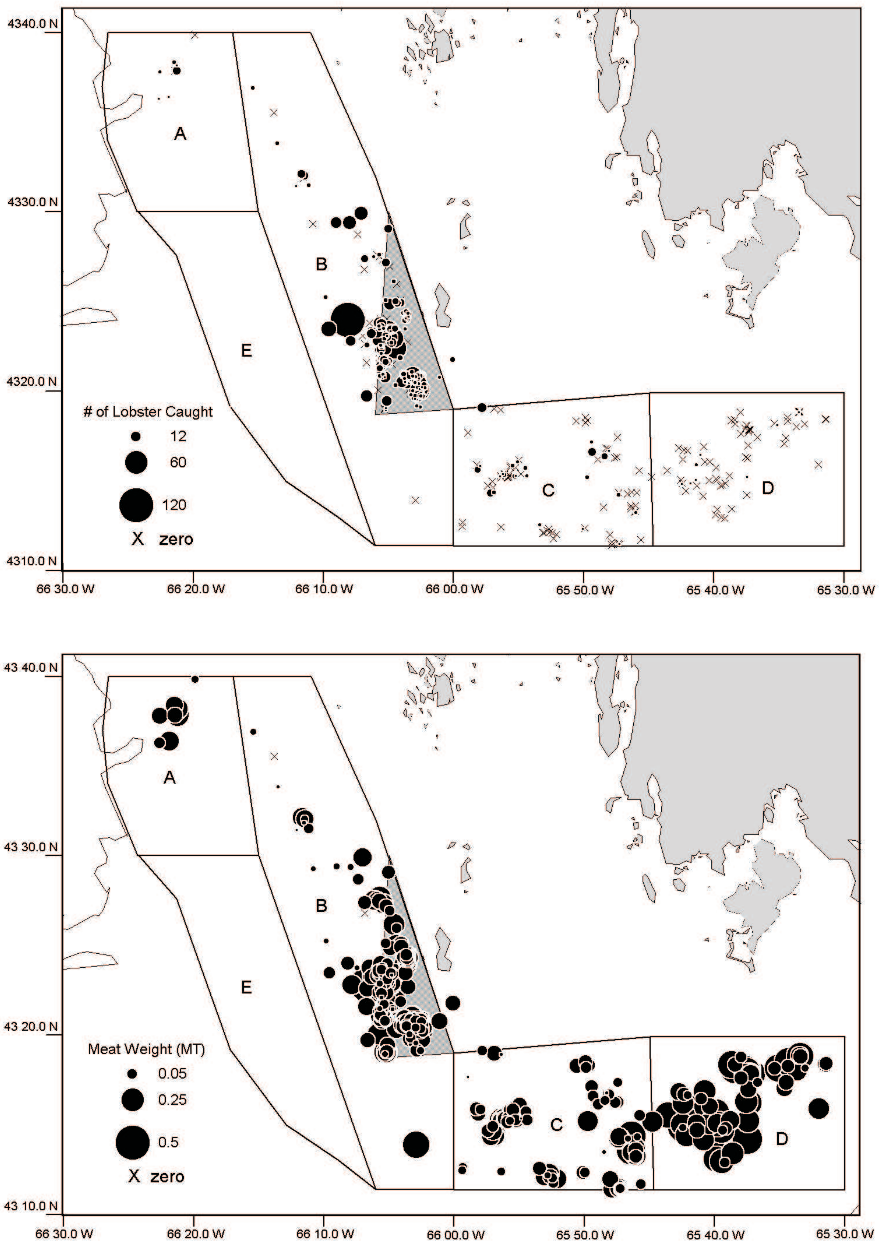



Fig. 36. Upper panel: Location and numbers of lobsters caught per set in SFA 29 in 2006 from observed scallop fishing trips. Lower panel: observed scallop catches from same tows. Shaded triangle indicates area closed during fishery for high bycatch of lobster.

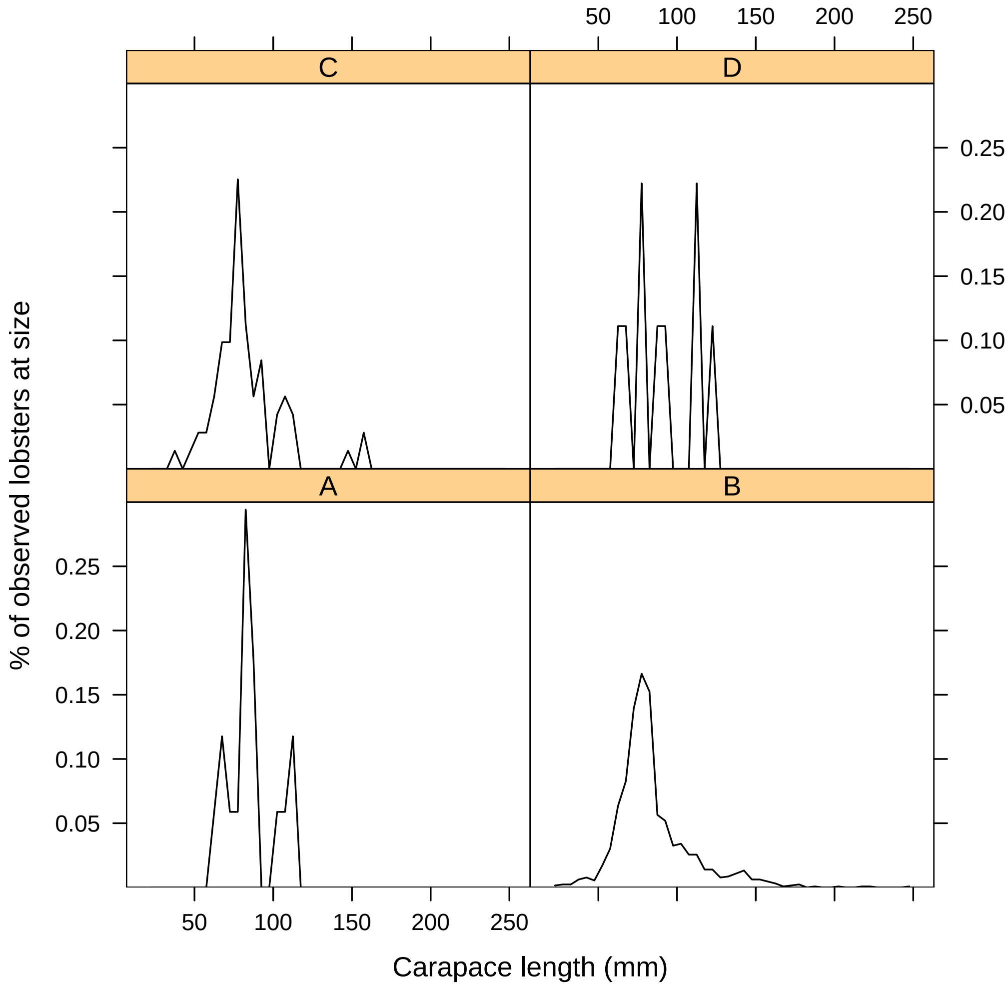



Fig. 37. Size frequency of lobsters measured by observers during SFA 29 fishery in 2006. Numbers measured by subarea were 17 (A), 1232 (B), 71 (C) and 9 (D).

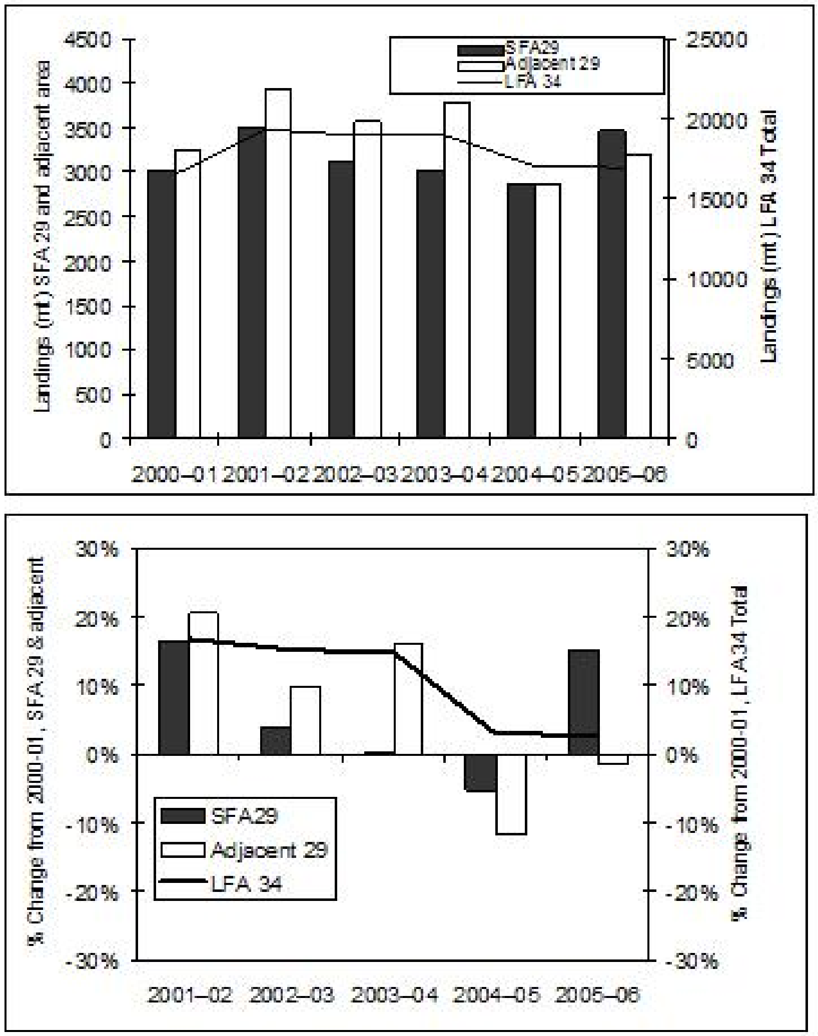



Fig. 38. Landings of lobster fishery in area corresponding to SFA 29, in the area adjacent to SFA 29, and in LFA 34 as a whole. Upper panel shows landings, lower panel shows the percent change relative to 2000–01.

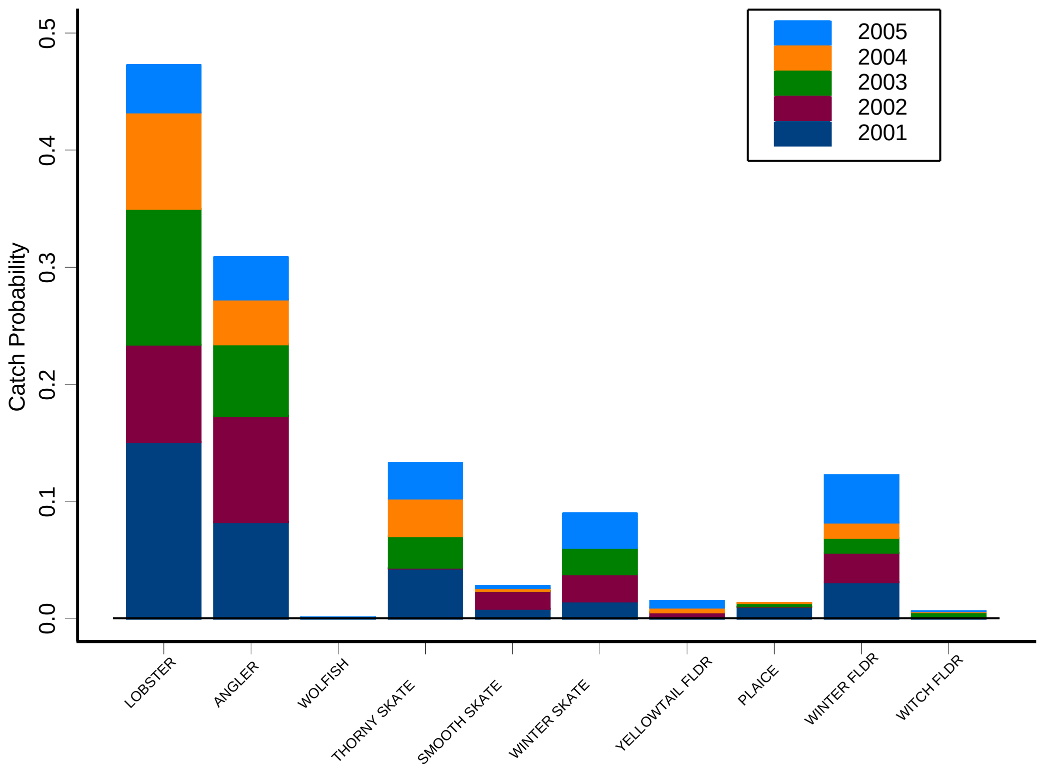



Fig. 39. Probability of bycatch species appearing in at least 10 percent of the observed catches on bedrock sediments in the SFA 29 scallop fishery.

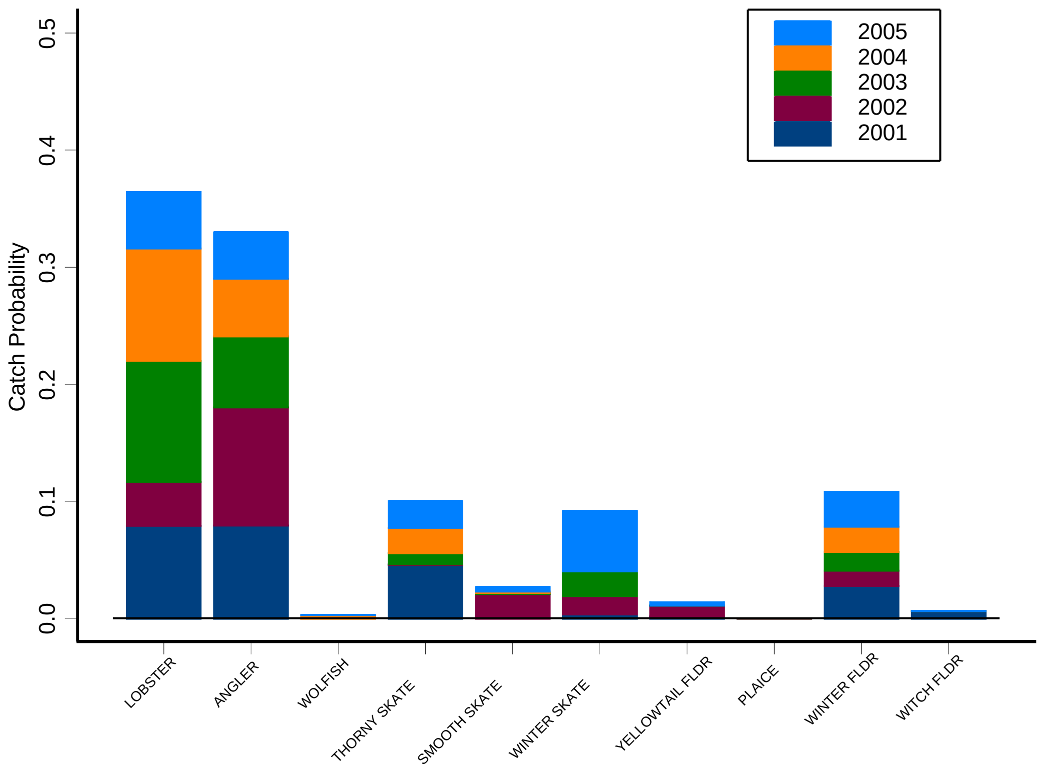



Fig. 40. Probability of bycatch species appearing in at least 10 percent of the observed catches on glacial till sediments in the SFA 29 scallop fishery.

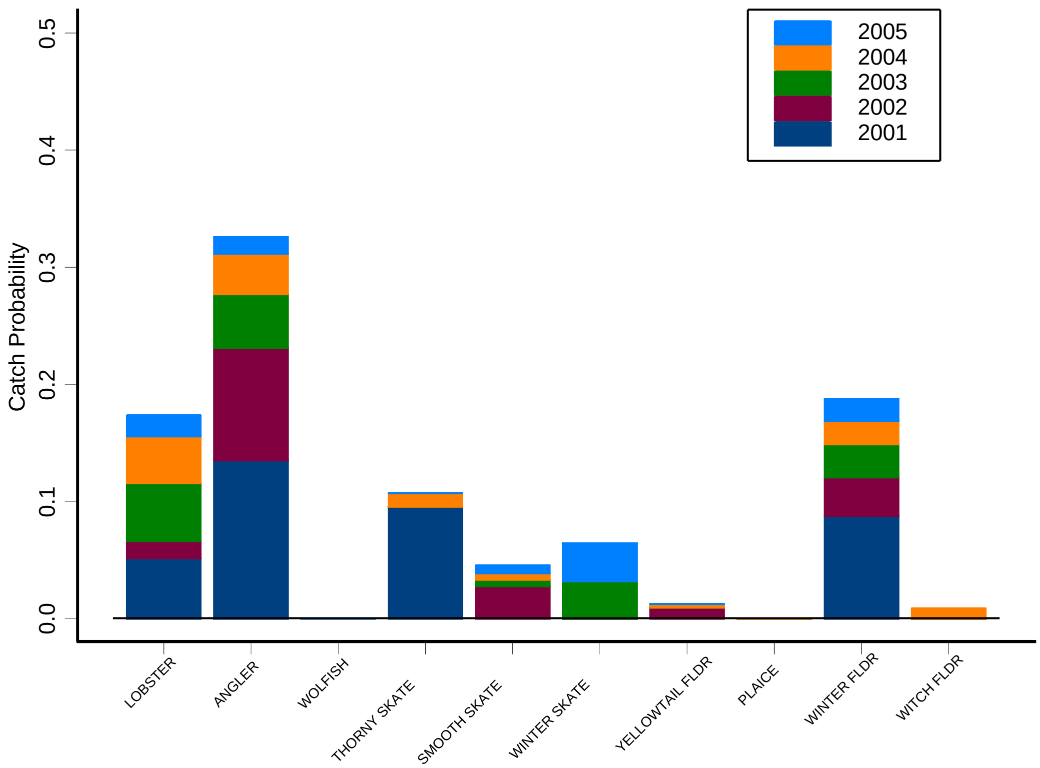



Fig. 41. Probability of bycatch species appearing in at least 10 percent of the observed catches on thin sand sediments in the SFA 29 scallop fishery.

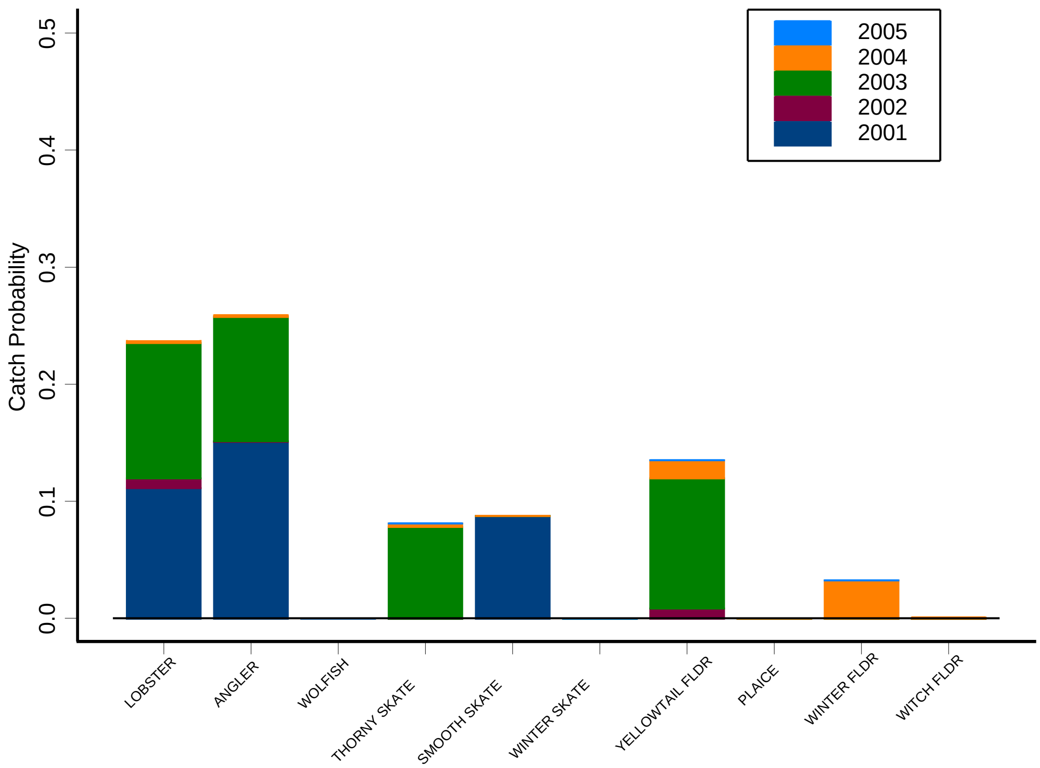



Fig. 42. Probability of bycatch species appearing in at least 10 percent of the observed catches on till and silt sediments in the SFA 29 scallop fishery.

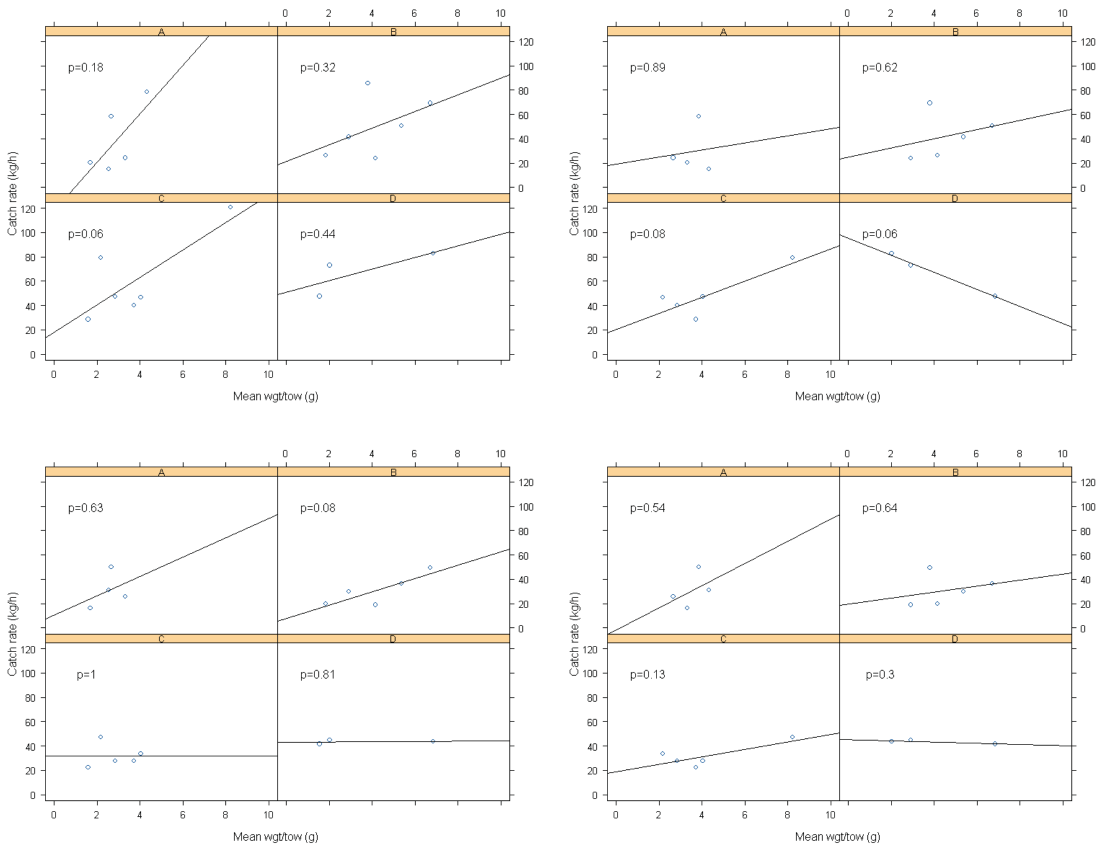



Fig. 43. Correlations between commercial catch rate and survey mean weight per tow for commercial size scallops. Each panel shows the linear regression line and the $p$-level for testing the correlation coefficient. Top left panel: Full Bay catch rate against survey mean in the same year, top right panel: Full Bay catch rate against survey mean in the previous year, bottom left panel: East of Baccaro catch rate against survey mean in the same year, bottom right panel: East of Baccaro catch rate against survey mean in the previous year.

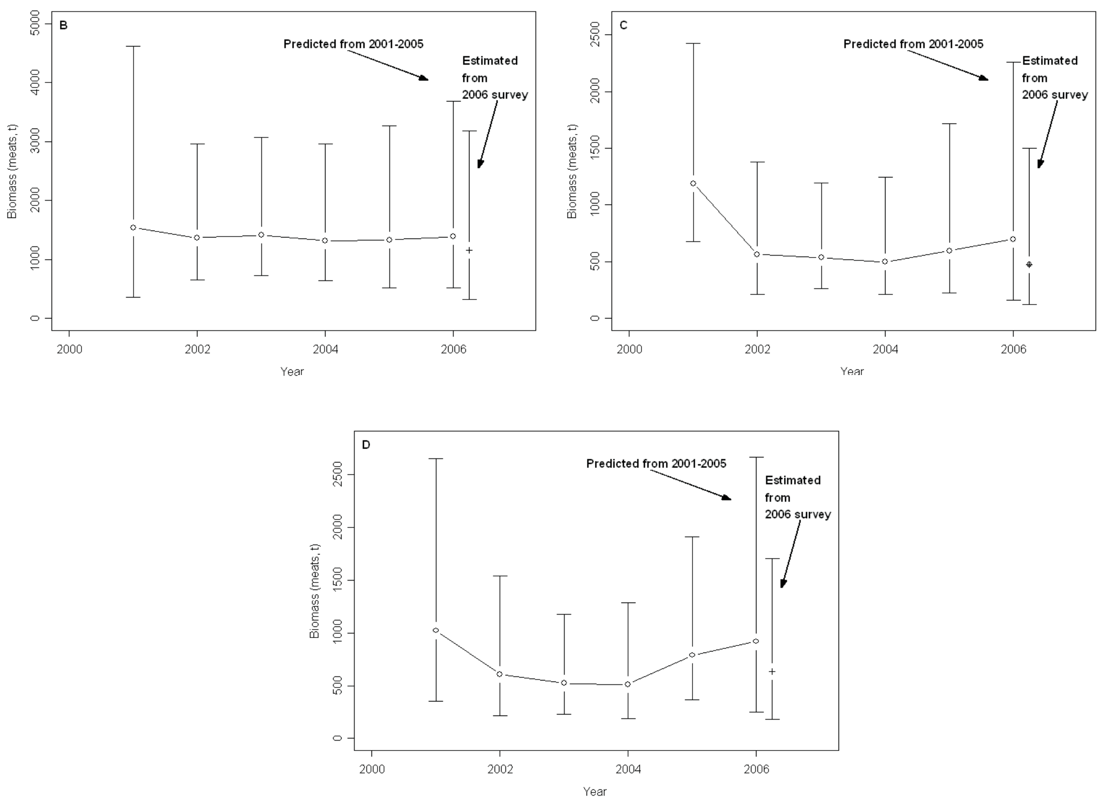



Fig. 44. Comparison of predicted biomass of commercial size scallops in 2006 from model used in 2005 assessment and estimate of 2006 biomass after survey and fishery in 2006. Top left panel: SFA 29 B, top right panel: SFA 29 C, bottom centre panel: SFA 29 D.