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Scallop Production Areas 2, 3 and 7 in the Bay of Fundy: Stock status update for 1999

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Abstract

This document reports on the stock status of scallops in three scallop production areas (SPA) at the approaches to the Bay of Fundy which were evaluated in the fall of 1999. Prior to 1997, the scallop beds in SPA 2 had not been heavily fished. In 1999, vessels could fish under special license with an at-sea observer required if fishing without restrictions on meat count or with no observer if fishing under a 45/500 g meat count. The landings in 1999 were unprecedented in the history of this area with the Full Bay fleet landing 93 t and Mid-Bay fleet 18.6 t. Based on historical fishing patterns and the magnitude of past removals in SPA 2 we can only conclude that most of the catch recorded as being from SPA 2 came from somewhere else.

In 1999 SPA 3 and SPA 7 (St. Mary's Bay) were combined for management purposes with a single TAC. Landings in 1999 are for SPA 3 and 7 combined and a comparison of the combined landings for the two areas for 1997 and 1998 indicate that overall landings have been unchanged at approximately 220 t. The fishing season was closed in SPA 3 on 22 July because the quota was overrun. This closing was earlier than normal and serious doubts have been raised about whether all of the landings reported to SPA 3 actually came from this area. The survey continues to show that the highest densities of scallops were in the southwest area of Lurcher Shoal. Large numbers of small scallops with a mode at 40 mm shell height were observed in the Lurcher Shoal area. These catches could indicate above average recruitment to the 2001 and 2002 fishery. There were also high densities of commercial-sized scallops located in the same areas and measures should be taken to protect these pre-recruits from incidental fishing mortality. It was recommended that 2000 TAC remain at the 1999 level of 200 t.

Résumé

Le présent document traite de l'état des stocks de pétoncle dans trois zones de production de pétoncle (ZPP) situées à l'entrée de la baie de Fundy qui ont fait l'objet d'une évaluation à l'automne de 1999. Les lits de pétoncles de la ZPP 2 n'ont pas fait l'objet d'une pêche intense avant 1997. En 1999, les bateaux pouvaient pêcher en vertu d'un permis spécial et la présence d'un observateur à bord était exigée en l'absence de limite imposée au nombre de chairs, mais aucun observateur n'était nécessaire si une limite de 45 chairs par 500 g était respectée. Les débarquements de 1999 en provenance de cette zone ont été sans précédent, les bateaux Full Bay ayant effectué des prises s'élevant à 93 t et ceux Mid-Bay des prises de 18.6 t. D'après la configuration historique de la pêche et l'importance des récoltes antérieures dans la ZPP 2, nous ne pouvons que conclure que la plupart des captures signalées comme provenant de la ZPP 2 provenaient en réalité d'ailleurs.

En 1999 la ZPP 3 et la ZPP 7 (baie St. Mary's) ont été combinées en un seul TAC à des fins de gestion. Les débarquements de 1999 proviennent de l'ensemble de ces deux zones et la comparaison des débarquements totaux pour les deux zones pour 1997 et 1998 sont demeurés inchangés à 220 t environ. La saison de pêche a été fermée le 22 juillet dans la ZPP 3 suite au dépassement du quota. Cette fermeture était plus hâtive que prévu et certains ont sérieusement mis en doute le fait que tous les débarquements signalés comme

provenant de la ZPP 3 provenaient vraiment de cette zone. Le relevé continu d'indiquer que les densités de pétoncles les plus importantes se situent dans la région sud-ouest du haut-fond Lurcher.

Des nombres élevés de petits pétoncles dont le mode de la hauteur de coquille est de 40 mm ont été observés dans la région du haut-fond Lurcher. De telles captures pourraient indiquer un recrutement supérieur à la moyenne aux pêches de 2001 et 2002. On a aussi noté des densités élevées de pétoncles de taille commerciale dans la même région et des mesures devraient être prises pour protéger ces pré-recrues d'une mortalité par pêche accidentelle. Il a été recommandé que le TAC de 200 t de 1999 soit maintenu pour l'an 2000.

Introduction

On 1 January 1997, an area-based management plan was implemented for the scallop fishery in the Bay of Fundy dividing the Bay into 7 Scallop Production Areas (SPAs; Fig. 1A). Historically, scallop fishing in SPA 3, which encompasses the outer reaches and approaches to the Bay of Fundy, has been sporadic and mainly supported by intermittent recruitment. This area was heavily exploited in the 1950's and 1960's but after that fishing was minimal until 1980 when both the inshore (LOA¹ under 19.8 m) and offshore (LOA over 19.8 m) fleets fished the area until 1986. In 1986 an agreement was reached between the two fleet sectors to separate fishing grounds as inshore grounds being north and offshore grounds being south of latitude 43°40' N. After 1986, the inshore fleet did not fish the area now known as SPA 3 until 1991 probably due the record catches being made on the Digby beds in the late 1980's. Since 1991, landings from the area south of Brier Island have made up a significant proportion of the total landings of the inshore fleet. The 1999 TAC had been set at 200 t for SPA 3 and 7 (St. Mary's Bay), which have been combined in 1999 for fisheries management purposes. The stock status for SPA 3 was recently reviewed by Lundy and Smith (1999) where it was judged that based on the population size structure for meat weights estimated from the survey, there was no reason to change the TAC for 1999.

Prior to 1997, the scallop beds in Area 2 had not been heavily exploited (annual log book landings less than 1 t from 1991 to 1994, and 3 t in 1995). A TAC of 20't was set for 1997. No catch limits were set for 1998 and 1999 but special license conditions were applied. As a result of the biological data reviewed in 1997 that showed poor growth and yield in this area (Kenchington et al. 1997), there were no size controls in this fishery in 1998. In 1999, vessels could fish under special license with an at-sea observer required if fishing without restrictions on meat count or with no observer if fishing under a 45/500 g meat count. A portion of this area within the Mid-Bay Line is open to fishing by the Mid-Bay fleet. The entire area is open to fishing by the Full Bay Fleet.

Commercial Fishery

SPA 3

A portion of SPA 3 was opened to the scallop fishery from 1 March to 31 May (Fig. 1B) after which the whole area was opened until closed on 22 July due to the quota being overrun. This closing was earlier than normal and serious doubts have been raised about whether all of the landings reported to SPA 3 actually came from this area.

Fishing in the former SPA 7 is influenced by the lobster season in the area and in 1999 scallop fishing took place between 1 June and 19 July.

¹Length Overall (LOA).

SPA 3 Landings (metric tons meats)

| Year | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|--------------------------|------|------|------|------|------|------|------|------|------------------|
| Total SPA 3 | 451 | 827 | 991 | 1382 | 767 | 200 | 190 | 162 | |
| TAC SPA 3 | | | | | | | 237 | 150 | |
| Total SPA 7 ² | | | | | | | 36 | 58 | |
| TAC SPA 7 | | | | | | | 237 | 150 | |
| Total SPA 3+7 | | | | | | | | | 222 ³ |
| TAC SPA 3+7 | | | | | | | | | 200 |

² Landings for SPA 7 not readily available prior to 1997.

³ Preliminary and includes 5.8 t from extended opening in Sept.–Oct., 1999.

A comparison of landings in SPA 3+7 in 1999 with the combination of the landings for each of the two areas for the last two years shows that since 1997 landings have been stable around 220 t. However, not knowing how much of the catch reported to SPA 3, came from elsewhere makes it difficult to interpret this trend.

Catch rate and effort are presented in Figs. 2 and 3, however potential misreporting make interpreting trends in these data difficult as well.

As noted earlier, landings in SPA 2 were minimal until recently when 29.7 t was removed in 1997 and 15.3 t in 1998. In 1999, an unprecedented 111.6 t (Full Bay: 93 t) was reported from this area.

Fishing locations by month from logbooks (Fig. 4) tend to show a reasonable pattern in SPA 2, and 3+7 from March to June in 1999 with fishing being limited to the shaded area in Fig. 1B until June when the rest of SPA 3 and all of SPA 7 opened up. Some fishing appears to have taken place on Southwest Bank in SPA 2 in May and June followed by more concentrated effort as the summer progresses (Fig. 5). However, there was also an unprecedented large amount of catch being reported on the SPA 2 side of the SPA 2–3 boundary after SPA 3 closed.

The trends in catch and CPUE by month in 1999 for SPA 2 and 3 are presented in Figs. 6 and 7, respectively. As landings in SPA 3 declined and the fishery was eventually closed in July, catches in SPA 2 increased and peaked well into September. Catch rates in SPA 2 were also well above expected for this area, registering even higher than the more productive SPA 3.

Based on historical fishing patterns and the magnitude of past removals in SPA 2 we can only conclude that most of the catch recorded as being from SPA 2 came from somewhere else.

Limited meat weight sampling data (DFO program) was available from the 1999 fishery with almost all samples coming from the Brier Island area near the SPA 7 border (Fig. 8). As is usually the case, meat weights are higher in the Brier Island subarea (North of 44°N) than in the Lurcher Shoal subarea (south of 44°N) [Table 1]. All of the samples from 1999 showed no meats less than 11 g which was quite atypical compared to previous years (Figs. 9 and 10).

Some meat weight sampling was also available from SPA 7 where, in general, meat weights are higher than in SPA 3, with the exception of 1999 (Table 2). Sampling intensity was very low and as a result it is difficult to interpret trends in these data. All of the meats in the

1999 sample were larger than 11 g which was comparable to samples in late 1997 and 1998 (Fig. 11).

There was only one meat weight sample from SPA 2 in 1999 and in it the average meat weight was twice that observed in 1998 but again sampling was very limited (Table 3)

At the spring Inshore Scallop Advisory Committee meeting this year, the fishing industry had requested access to the low yield scallops in the deeper water (western side) of SPA 3. Lundy and Smith (1999) had shown that the animals appeared to stop growing larger as they grew older in the deeper water west of 66°40' W. However, observations from the 1999 August survey indicated that meat weights had increased over the previous year (see Research Survey section). Therefore, a limited re-opening of SPA 3 was authorized for late September/early October which restricted fishing to the deep water portion of the SPA. The conditions of the fishery were:

- 15 t catch limit or three week fishing period, whichever occurs first.
- 50/500 blended meat count and 105 mm minimum shell height.
- 50 percent of all landings have to be sampled for meat size and meat count. Sampling to be paid for by Industry and sampling data provided to DFO Science electronically within 48 hours of landing.
- All trip logs provided to DFO Science within 12 hours of landing.
- 30 percent of all trips subject to at-sea observer coverage.

As noted above only 5.8 t was reported for this limited opening and in fact, the fishery was only officially closed on 14 November. A total of 11 meat weight samples were received representing 61 percent of the trips and meat counts were well under the regulated level (Table 1). An average of 88.9 percent of the meats were greater than 10 g (Fig 12). Seven vessels participated in this fishery and all submitted their logs in a timely fashion.

Research Surveys

Annual stock surveys have been conducted every August since 1991 using the research vessel J.L. Hart. The four-gang dredge gear configuration has remained unchanged throughout the survey series (Kenchington et al. 1997). However, the survey design and the amount of area covered have changed over time. The survey followed a grid pattern from 1991 to 1996 with area surveyed expanding each year (Kenchington and Lundy 1998). The survey used random locations for stations in 1997, 1998 and 1999. The area covered by the surveys has been comparable since 1995.

As in previous surveys, two of the four dredges were lined with 38 mm polypropylene stretch mesh. Catches in the lined gear were used to estimate the abundance of scallops with shell height less than 80 mm while the catches from the unlined gear were used to estimate the abundance of scallops with shell heights greater than 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. All catches were prorated to

the expected catch of a seven-gang gear rig and numbers were standardized to a tow distance of 800 m. Despite numerous vessel problems we were able to survey all of SPA 3 and do the first complete survey of SPA 7.

The spatial distribution for all scallops caught in the SPA 3 survey was similar to previous years (Lundy and Smith 1999) with the higher densities found in the southwest corner (Fig. 13). Large numbers of animals less than 80 mm in shell height were found mainly in the Lurcher Shoal subarea (Fig. 14) throughout the southwest area. Fully recruited animals (greater than or equal to 80 mm) were also in the southwest but there were also high densities in the inshore areas (Fig. 15). Historically, mean numbers per tow were higher in Lurcher than the Brier area and all estimates with the exception of animals less than 80 mm in Lurcher show a decline in 1999 over 1998 (Table 4). The large mean number per tow for the less than 80 mm scallops in Lurcher was mainly due to large catches of animals in the 30 to 40 mm size range. Large catches of animals in this size range have been observed in both Brier (Fig. 16) and Lurcher (Fig. 17) before but they do not always appear in similar numbers at older ages in later years. As we noted earlier, catches of 40 mm and smaller animals in the dredge are a qualitative indicator at best. If we limit pre-recruits to the 55–79 mm size range as was done in SPA 4 (Smith et al. 1999) then we see that the pre-recruit trend in Brier appears to be insignificant and unconnected to subsequent increases in the mean number per tow of recruited animals (Fig. 18). The trend for pre-recruits and subsequently for recruited animals in Lurcher Shoal subarea appears to follow as expected.

In general, scallops in SPA 3 tend to be smaller at age and have smaller meats-at-shell-height in the deeper water in the western part of the area (Lundy and Smith 1999). These patterns appear to be related to the current systems in the area (J. Loder, Ocean Sciences Division, BIO, pers. com.) but more work needs to be done on the oceanography and the growth of scallops in this area. However, Lundy and Smith (1999) noted that in general, scallops found west of 66°40'W appeared to stop growing after age 7. Kenchington and Lundy (1998) also identified this area as where scallops of low condition were routinely caught.

Estimates of meat weight and count in Table 5 demonstrate the decrease in weight going from east to west across SPA 3. These estimates also show that all areas appeared to have experienced an increase in meat weight over the previous two years. In fact the meat weights had increased enough that fishing could be conducted west of 66°40'W within a reasonable meat count (40 to 50/500 g). Based on these estimates and that a large amount of scallops were in this area we arranged for the limited re-opening of SPA 3 in September/October discussed in the previous section. The Industry meat weight samples taken during this fishery confirmed our observations from the survey that meats were large enough in the deeper water in 1999 for a fishery (Table 1, Fig. 12).

Lundy and Smith (1999) used the frequency of mean number per tow at meat weight from the 1996–1998 surveys to evaluate the effects of the 1998 fishery on the population. The 1999 results show that the peaks noted in both subareas in 1998 have been cropped down by the 1999 fishery but there still seems to a large proportion of the population with meat weights greater than 10 g in Lurcher (Fig. 19). The apparent increase in numbers of larger meats probably reflects the overall increase in weight noted earlier. The figure also shows the large numbers of pre-recruit scallops which were in the 2–5 g range in August in Lurcher.

The mean meat weight per tow indicates a slight decrease from 1998 to 1999 in the Brier Island area while there appears to be an increase in Lurcher Shoal (Fig. 20). However, the bootstrap confidence intervals (Efron and Tibshirani 1993) indicate that these estimates are highly variable and it may be difficult to show that these increases or decreases were significant from one year to the next.

The results for the survey in SPA 7 are presented here for information only (Table 4) — it is difficult to say anything about these results without a time series. The spatial distribution of the recruited scallops reflects what we know about the location of the commercial catch (Fig. 4). The shell height frequency also shows relatively large numbers of animals at 30 to 45 mm similar to SPA 3 (Fig. 22).

Exploitation Rate

Exploitation rate was estimated using a Leslie depletion estimator (See Smith et al. 1999). The model was fitted to data from SPA 3 and 7 separately and then to data from the areas combined. This method requires the following assumptions about the data.

1. Catchability of the fished population is constant over a fishing season.
2. Fishing effort is uniformly distributed over the area occupied by the stock.
3. The population is closed and has no movement in or out and no natural mortality during the fishery.
4. Landings and effort are reported accurately.

Catch and effort data used to estimate exploitation rate were derived from logbooks. Location of fishing was provided for the first tow of each day during a fishing trip. The data selected for analysis of SPA 3 and 7 consisted of all logbook reports fishing within the designated coordinates of the SPAs during the dates that corresponded to the fishing seasons.

Mean weights were estimated separately for each area according to the methods described for SPA 4 (Smith et al. 1999). The mean weights for each area were then combined for the SPA 3 + 7 analysis (Tables 6 and 7).

Data for the regression model used to estimate population numbers and exploitation rates were CPUE (numbers/hour) and catch by date of last trip (numbers). Influential data points were identified by large residuals. All regression procedures were done using SAS PROC REG (SAS 1999).

Significant relationships ($p < 0.05$) were found for SPA 3 and 7 in 1997 for the period when they were both open, 1 June to 15 July, but only if influential points were removed from SPA 7. The regression for the combined data for SPAs 3 and 7 in 1997 for 1 June to 15 July was not significant. Similarly, for the entire season 1 June to 11 December in both areas the relationship was not significant.

The relationship was significant for data from 3 June to 9 July in SPA 7, the period for which there were catch and effort logbook records (Fig. 23). None of the relationships that included data from SPA 3 were significant. These included the relationship for SPA 3 for

the 3 June to 9 July time period (both with and without SPA 7), and for the entire 1 June to 21 September season. The relationship between CPUE and cumulative catch for SPA 3 during the early opening of 20 April to 31 May was also not significant.

The exploitation rate for significant the relationship in SPA 7 was 32 percent, corresponding to an instantaneous fishing mortality (F) of 0.39 (Fig. 23, Table 8).

These results provide exploitation rates and F values that do not appear overly excessive for these fisheries. The difference in mean weights between the two areas (Table 8) and that the model fits for SPA 7 but not SPA 3 may indicate that these two areas need to be considered separately for management.

These areas would seem to be amenable to separate management and analysis where data were of sufficient quality to provide separate assessments. Most of the assumptions required by depletion analysis would seem to be met by these fisheries. They occur over a limited area but detecting fishery effects on the population require detailed knowledge of where all the sets during a day are made and not just the first set.

Summary

1. Reported landings in SPA 3+7 during the regular fishing season were 216 t, 16 t higher than the quota. Widespread reports of misreporting of illegal offshore scallop catches to SPA 3 (and SPA 2) makes our catch statistics questionable. It was difficult to interpret trends in landings and catch rates given the apparent large but unknown level of misreporting.
2. Sampling intensity for the departmental voluntary meat weight sampling program continues to be low and sample locations were limited to mainly one area of the fishery.
3. A limited re-opening in the deep water of SPA 3 with a TAC of 15 t resulted in landings of almost 6 t. Samples of meat weights and counts, supplied and paid for by the fishermen, confirmed the August 1999 survey findings that meat weights had significantly increased in 1999 over those recorded in previous years. The Industry meat weight sampling program provided a much higher sampling rate (11 out 18 trips sampled) than the departmental program.
4. Survey estimates of abundance indicate that mean numbers per tow for recruited animals have declined in both subareas of SPA 3. While there were some signs of good recruitment from animals in the 55 to 79 mm shell height range in Lurcher Shoal, there was little sign of recruitment in the Brier Island area. We recommend that 2000 TAC remain at the 1999 level of 200 t.
5. The survey did find good qualitative signs of recruitment in the southwest corner of Lurcher but these animals are around 40 mm in shell height and would not enter the fishery until at least 2001. Measures are needed to protect this recruitment pulse from incidental fishing mortality until at least 2001.

6. Given the difficulties of determining removals from all of the areas we also recommend that more intensive meat weight sampling and other measures be implemented to improve data quality including the area of capture data.

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Table 1: Meat weight statistics for the Full Bay licence holders in SPA 3 (Brier Island/Lurcher Shoal) by month and year calculated from samples of the commercial catch.

| Year | Month | Meat weight (g) | | | | Sample size (no. of meats) | Meat count per 500 g |
|------------------------------|-----------|-----------------|------|-------|------|-------------------------------|-------------------------|
| | | Mean | Min. | Max. | SD | | |
| Brier Island Fishing Grounds | | | | | | | |
| 1983 | May | 10.62 | 3.7 | 18.0 | 3.20 | 85 | 47.1 |
| | June | 9.00 | 4.0 | 27.2 | 4.19 | 106 | 55.6 |
| 1991 | May | 13.55 | 6.5 | 38.8 | 5.70 | 74 | 36.9 |
| | June | 20.23 | 4.5 | 37.6 | 6.93 | 50 | 24.7 |
| 1992 | June | 12.91 | 5.6 | 26.2 | 4.03 | 77 | 38.7 |
| | July | 13.36 | 2.8 | 59.2 | 8.86 | 434 | 37.4 |
| | Sept. | 8.64 | 3.8 | 17.0 | 2.12 | 583 | 57.9 |
| 1993 | April | 12.50 | 3.3 | 25.6 | 4.74 | 318 | 40.0 |
| | May | 10.59 | 3.4 | 29.6 | 5.99 | 280 | 47.2 |
| | June | 9.98 | 3.9 | 26.7 | 3.58 | 200 | 50.1 |
| | Sept. | 11.31 | 3.6 | 42.9 | 6.51 | 379 | 44.2 |
| | Nov. | 14.00 | 7.3 | 23.7 | 3.37 | 71 | 35.7 |
| 1994 | March | 20.91 | 9.3 | 37.0 | 6.75 | 53 | 23.9 |
| | April | 19.00 | 4.9 | 42.0 | 7.64 | 419 | 26.3 |
| | May | 13.64 | 5.5 | 22.0 | 3.20 | 292 | 36.7 |
| | June | 16.18 | 4.6 | 51.5 | 7.26 | 1055 | 30.9 |
| | July | 22.00 | 11.0 | 37.5 | 6.30 | 111 | 22.7 |
| 1996 | May | 10.80 | 2.9 | 25.9 | 4.33 | 155 | 46.3 |
| | July | 19.80 | 15.8 | 23.9 | 2.17 | 35 | 25.3 |
| | August | 15.48 | 11.1 | 24.1 | 3.19 | 37 | 32.3 |
| 1997 | May | 13.46 | 6.3 | 24.4 | 4.05 | 120 | 37.1 |
| | June | 12.50 | 3.2 | 38.8 | 4.64 | 726 | 40.0 |
| | July | 15.05 | 5.1 | 41.7 | 5.47 | 1102 | 33.2 |
| | August | 13.61 | 4.4 | 45.1 | 6.91 | 341 | 36.7 |
| | Sept. | 13.91 | 5.3 | 49.0 | 8.31 | 358 | 35.9 |
| | October | 17.58 | 8.2 | 32.4 | 6.51 | 53 | 28.4 |
| 1998 | June | 16.97 | 5.0 | 28.7 | 4.06 | 744 | 29.5 |
| | July | 13.98 | 4.1 | 43.8 | 5.77 | 650 | 35.8 |
| 1999 | June | 20.45 | 13.1 | 37.7 | 3.77 | 552 | 24.4 |
| | July | 21.90 | 15.0 | 92.0 | 6.21 | 536 | 22.8 |
| Re-Opening in Sept./Oct. | | | | | | | |
| 1999 | September | 16.81 | 3.56 | 25.90 | 9.7 | 62 | 29.7 |
| | October | 17.92 | 5.72 | 34.20 | 8.7 | 281 | 27.9 |

Table 1: SPA 3 (Brier Island/Lurcher Shoal) Meat weight statistics, cont'd.

| Lurcher Shoal Fishing Grounds | | | | | | | |
|-------------------------------|-----------|-------|------|-------|------|------|------|
| 1991 | June | 6.67 | 2.2 | 27.6 | 1.95 | 1210 | 75.0 |
| | July | 9.17 | 3.1 | 33.7 | 5.15 | 437 | 54.5 |
| | August | 7.73 | 3.7 | 25.5 | 3.09 | 134 | 64.7 |
| 1992 | June | 9.84 | 3.3 | 29.0 | 3.86 | 312 | 50.8 |
| | July | 10.88 | 2.5 | 38.4 | 4.59 | 907 | 46.0 |
| | August | 15.20 | 9.4 | 27.0 | 2.75 | 66 | 32.9 |
| | Sept. | 9.17 | 4.6 | 15.7 | 2.14 | 446 | 54.5 |
| 1993 | April | 8.89 | 3.0 | 23.8 | 3.79 | 225 | 56.2 |
| | May | 7.00 | 3.0 | 25.3 | 2.44 | 711 | 71.4 |
| | June | 8.21 | 3.1 | 17.0 | 2.02 | 122 | 60.9 |
| | Sept. | 10.04 | 3.5 | 27.8 | 3.96 | 597 | 49.8 |
| | Nov. | 14.06 | 6.1 | 30.4 | 4.77 | 142 | 35.6 |
| 1994 | April | 15.72 | 5.6 | 43.5 | 7.10 | 380 | 31.8 |
| | May | 14.40 | 3.6 | 32.3 | 3.80 | 851 | 34.7 |
| | July | 12.31 | 4.8 | 34.3 | 4.05 | 971 | 40.6 |
| 1995 | June | 16.64 | 5.5 | 26.7 | 4.69 | 59 | 30.0 |
| | July | 14.33 | 5.7 | 29.3 | 4.61 | 344 | 34.9 |
| | August | 14.16 | 5.8 | 24.8 | 4.37 | 78 | 35.3 |
| 1996 | June | 11.83 | 4.3 | 29.2 | 4.01 | 350 | 42.3 |
| | July | 13.30 | 4.0 | 37.1 | 6.89 | 279 | 37.6 |
| | August | 17.58 | 10.4 | 25.3 | 3.34 | 75 | 28.4 |
| | November | 12.40 | 5.1 | 28.0 | 4.30 | 243 | 40.3 |
| 1997 | May | 10.87 | 3.2 | 33.7 | 4.01 | 951 | 46.0 |
| | June | 13.11 | 3.5 | 40.9 | 5.74 | 874 | 38.1 |
| | July | 12.96 | 3.7 | 38.4 | 5.08 | 1015 | 38.6 |
| | August | 11.72 | 4.0 | 38.4 | 4.94 | 574 | 42.7 |
| | September | 14.03 | 3.3 | 33.5 | 6.29 | 312 | 35.6 |
| | October | 14.79 | 5.1 | 32.4 | 5.44 | 125 | 33.8 |
| 1998 | June | 11.84 | 3.6 | 47.60 | 6.10 | 455 | 42.2 |
| | July | 12.21 | 4.3 | 55.10 | 4.97 | 601 | 41.0 |
| | August | 12.58 | 5.1 | 25.40 | 4.81 | 221 | 39.7 |
| 1999 | May | 19.42 | 15.4 | 23.50 | 1.84 | 69 | 25.7 |
| Re-Opening in Sept./Oct. | | | | | | | |
| 1999 | October | 13.33 | 6.3 | 27.30 | 3.87 | 302 | 37.5 |
| | November | 13.04 | 6.7 | 22.50 | 3.20 | 77 | 38.3 |

Table 2. Meat weight statistics for the Full Bay licence holders in SPA 7 (St. Mary's Bay) by month and year calculated from samples of the commercial catch.

| Year | Month | Meat weight (g) | | | | Sample size (no. of meats) | Meat count per 500 g |
|------|-----------|-----------------|------|------|-------|-------------------------------|-------------------------|
| | | Mean | Min. | Max. | SD | | |
| 1996 | June | 23.65 | 7.3 | 46.3 | 11.64 | 23 | 21.1 |
| 1997 | June | 20.40 | 5.0 | 88.7 | 10.25 | 390 | 24.5 |
| | July | 17.24 | 6.5 | 44.3 | 7.82 | 158 | 29.0 |
| | September | 27.47 | 16.1 | 40.6 | 7.60 | 42 | 18.2 |
| 1998 | June | 30.05 | 9.7 | 64.2 | 8.59 | 139 | 16.0 |
| 1999 | June | 19.99 | 15.5 | 36.6 | 3.65 | 121 | 25.0 |

Table 3. Meat weight statistics for the Full Bay licence holders in SPA 2 by month and year calculated from samples of the commercial catch.

| Year | Month | Meat weight (g) | | | | Sample size (no. of meats) | Meat count per 500 g |
|------|-----------|-----------------|------|------|------|-------------------------------|-------------------------|
| | | Mean | Min. | Max. | SD | | |
| 1998 | May | 6.77 | 3.1 | 10.7 | 1.36 | 364 | 73.9 |
| 1999 | September | 13.71 | 9.1 | 20.4 | 3.23 | 74 | 36.5 |

Table 4. Mean numbers per tow for the 1996–1999 scallop surveys in scallop production area 3. Percentage of clappers shown in brackets.

| Subarea | Year | Shell Height (mm) | | All sizes | No. of tows |
|--------------|------|-------------------|--------|--------------|-------------|
| | | < 80 | ≥ 80 | | |
| Brier Island | 1995 | 15.17 | 54.69 | 69.86(8.1) | 42 |
| | 1996 | 13.27 | 46.34 | 59.61(7.3) | 45 |
| | 1997 | 51.14 | 58.29 | 109.43(4.8) | 47 |
| | 1998 | 39.06 | 74.85 | 113.92(6.0) | 31 |
| | 1999 | 15.85 | 51.61 | 67.45(4.8) | 52 |
| Lurcher | 1995 | 43.68 | 137.44 | 181.13(16.8) | 60 |
| | 1996 | 35.07 | 89.61 | 124.67(11.1) | 69 |
| | 1997 | 47.76 | 113.91 | 161.68(5.4) | 73 |
| | 1998 | 32.92 | 108.95 | 141.87(3.8) | 69 |
| | 1999 | 122.79 | 92.38 | 215.16(2.3) | 63 |
| St. Mary's | 1999 | 42.22 | 36.57 | 78.80(1.4) | 38 |

Table 5. Average meat weights and meat counts for scallops with shell heights greater than 95 mm from 1999 survey from scallop production area 3.

| | Meat Weight g | | | Meat Count (per 500 g) | | |
|------|-------------------|--------------------------|-------------------|------------------------|--------------------------|-------------------|
| | East of 66°37' | From 66°37' to 66°40' | West of 66°40' | East of 66°37' | From 66°37' to 66°40' | West of 66°40' |
| 1997 | 15.57 | 9.97 | 7.78 | 32.1 | 50.20 | 64.23 |
| 1998 | 16.10 | 11.31 | 8.73 | 31.05 | 44.21 | 57.37 |
| 1999 | 20.58 | 15.85 | 12.52 | 24.3 | 31.54 | 39.93 |

Table 6. Estimated mean meat weights from meat weight samples by week for the 1997 fishing season in scallop production area 3 and 7. In cases where there were no meat weight samples in a week, mean weights were estimated using the mean weight from the nearest week or from the weighted average of adjacent weeks.

| Week | Date | Meat Weight (g) | Catch (kg) | No. of Samples | Numbers (1000's) |
|----------|--------|-----------------|------------|----------------|------------------|
| a) SPA 3 | | | | | |
| 22 | 03-Jun | 11.53 | 677 | 4 | 59 |
| 23 | 10-Jun | 12.92 | 10551 | 4 | 817 |
| 24 | 17-Jun | 12.90 | 11303 | 6 | 876 |
| 25 | 24-Jun | 12.77 | 15109 | 5 | 1183 |
| 26 | 01-Jul | 13.31 | 14449 | 7 | 1086 |
| 27 | 08-Jul | 15.68 | 13250 | 9 | 845 |
| 28 | 15-Jul | 13.74 | 14871 | 9 | 1082 |
| 29 | 22-Jul | 13.95 | 14331 | 8 | 1027 |
| 30 | 29-Jul | 12.76 | 14376 | 8 | 1127 |
| 31 | 05-Aug | 14.76 | 11594 | 5 | 786 |
| 32 | 12-Aug | 12.37 | 13380 | 7 | 1082 |
| 33 | 19-Aug | 12.37 | 737 | 0 | 60 |
| 34 | 26-Aug | 35.27 | 166 | 0 | 5 |
| 35 | 02-Sep | 35.27 | 748 | 1 | 21 |
| 36 | 09-Sep | 11.54 | 1998 | 1 | 173 |
| 37 | 16-Sep | 13.80 | 10674 | 2 | 773 |
| 38 | 23-Sep | 9.46 | 4824 | 2 | 510 |
| 39 | 30-Sep | 14.83 | 2868 | 3 | 193 |
| 40 | 07-Oct | 15.10 | 1592 | 2 | 105 |
| 43 | 14-Oct | 15.10 | 36 | 0 | 2 |
| 44 | 21-Oct | 15.10 | 164 | 0 | 11 |
| 45 | 28-Oct | 15.10 | 1563 | 0 | 104 |
| 47 | 04-Nov | 15.10 | 505 | 0 | 33 |
| 49 | 11-Nov | 15.10 | 223 | 0 | 15 |
| 50 | 18-Nov | 15.10 | 314 | 0 | 21 |
| b) SPA 7 | | | | | |
| 22 | 03-Jun | 22.17 | 1297 | 0 | 59 |
| 23 | 10-Jun | 22.17 | 11306 | 4 | 510 |
| 24 | 17-Jun | 20.17 | 11071 | 3 | 549 |
| 25 | 24-Jun | 26.89 | 3769 | 1 | 140 |
| 26 | 01-Jul | 18.75 | 1998 | 1 | 107 |
| 27 | 08-Jul | 21.52 | 2538 | 1 | 118 |
| 28 | 15-Jul | 21.52 | 2213 | 0 | 103 |

Table 7. Estimated mean meat weights from meat weight samples by week for the 1998 fishing season in scallop production area 3 and 7. In cases where there were no meat weight samples in a week, mean weights were estimated using the mean weight from the nearest week or from the weighted average of adjacent weeks.

| Week | Date | Meat Weight (g) | Catch (kg) | No. of Samples | Numbers (1000's) |
|------|--------|--------------------|---------------|-------------------|---------------------|
| 16 | 22-Apr | 15.78 | 179 | 0 | 11.34 |
| 17 | 29-Apr | 15.78 | 1683 | 0 | 106.65 |
| 18 | 06-May | 15.78 | 261 | 0 | 16.53 |
| 19 | 13-May | 15.78 | 1217 | 0 | 77.12 |
| 20 | 20-May | 15.78 | 1901 | 0 | 120.46 |
| 21 | 27-May | | | | |
| 22 | 03-Jun | 15.78 | 11100 | 5 | 703.42 |
| 23 | 10-Jun | 16.18 | 3399 | 1 | 210.07 |
| 24 | 17-Jun | 12.18 | 4206 | 1 | 345.32 |
| 25 | 24-Jun | 8.52 | 7232 | 1 | 848.82 |
| 26 | 01-Jul | 17.00 | 13648 | 8 | 802.82 |
| 27 | 08-Jul | 10.99 | 11881 | 2 | 1081.07 |
| 28 | 15-Jul | 13.14 | 16656 | 4 | 1267.57 |
| 29 | 22-Jul | 12.98 | 19686 | 3 | 1516.64 |
| 30 | 29-Jul | 15.29 | 15591 | 5 | 1019.68 |
| 31 | 05-Aug | 11.70 | 12325 | 1 | 1053.41 |
| 32 | 12-Aug | 11.38 | 8331 | 1 | 732.06 |
| 33 | 19-Aug | 10.76 | 6355 | 1 | 590.61 |
| 34 | 26-Aug | 10.76 | 45 | 0 | 4.18 |
| 35 | 02-Sep | 10.76 | 2097 | 0 | 194.88 |
| 36 | 09-Sep | 10.76 | 4923 | 0 | 457.52 |
| 37 | 16-Sep | 10.76 | 9778 | 0 | 908.73 |
| 38 | 23-Sep | 10.76 | 6620 | 0 | 615.24 |

Table 8. Estimated exploitation rates and catchability for Area 3 and 7 in 1997 and 1998 from the Leslie analysis.

| Model Quantities | 1997 | 1997 | 1998 |
|---------------------------|----------------|----------------------------|---------------|
| | SPA 7 | SPA 3 | SPA 7 |
| | 1 June–15 July | 1 June–15 July | 3 June–9 July |
| | | All Data | |
| Exploitation Rate (%) | 21 | 23 | 32 |
| Fishing Mortality (F) | 0.24 | 0.26 | 0.39 |
| Effort (hours) | 5223 | 13873 | 4507 |
| CPUE (numbers/hours) | 317 | 508 | 421 |
| q | 0.044 | 0.023 | 0.07 |
| Mean Meat Wt (g) | 21.57 | 13.49 | 30.44 |
| R^2 | 0.04 | 0.07 | 0.26 |
| p -level | 0.163 | 0.055 | 0.004 |
| | | Influential points removed | |
| Exploitation Rate (%) | 23 | | |
| Fishing Mortality (F) | 0.26 | | |
| Effort (hours) | 5226 | | |
| CPUE (numbers/hours) | 317 | | |
| q | 0.048 | | |
| Mean Meat Wt (g) | 21.57 | | |
| R^2 | 0.1 | | |
| p – level | 0.047 | | |

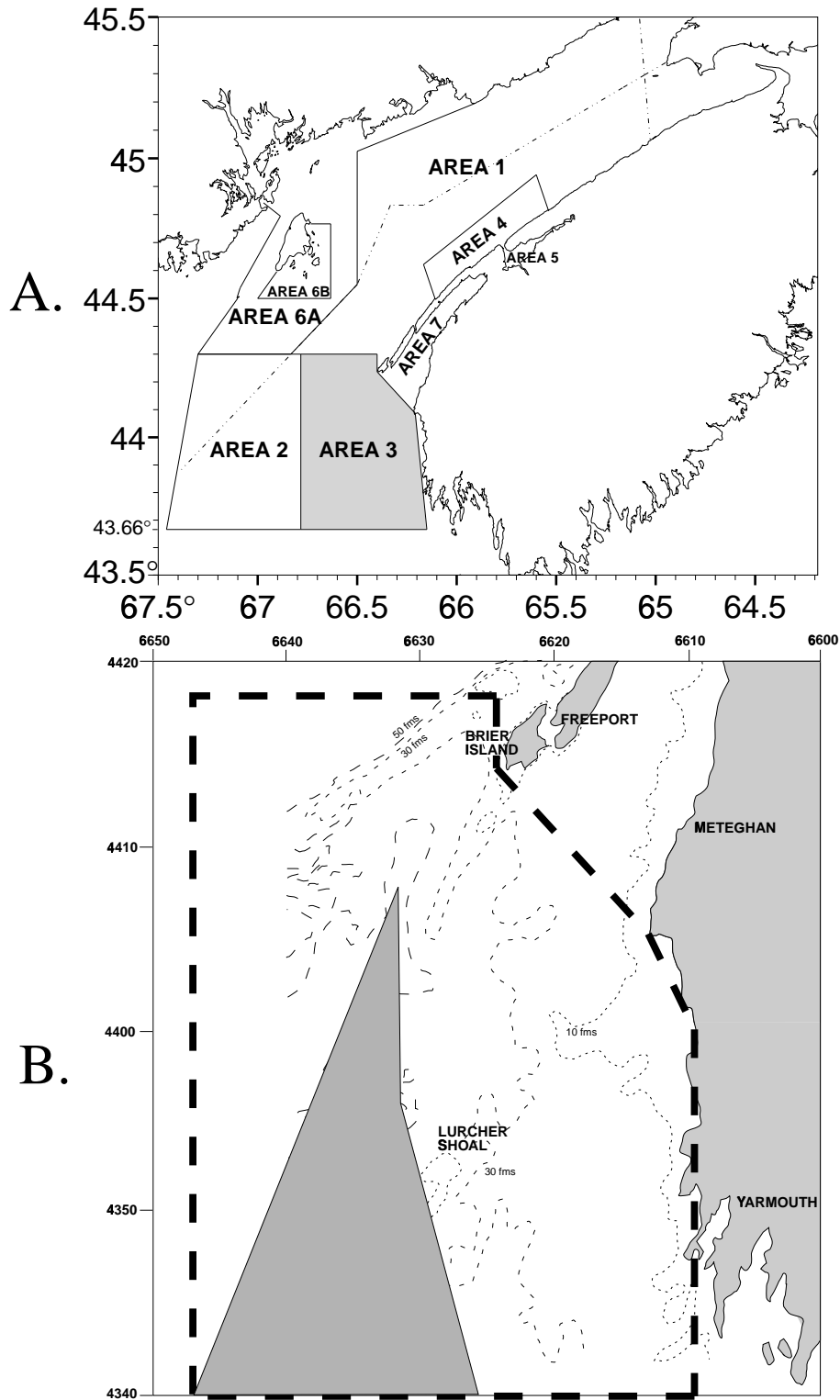


Fig. 1. A. Scallop production areas in the Bay of Fundy. B. Scallop production area 3. Shaded area was open from 1 March 1999 to 31 May 1999 and the dashed area was open from 1 June 1999 to 22 July 1999.

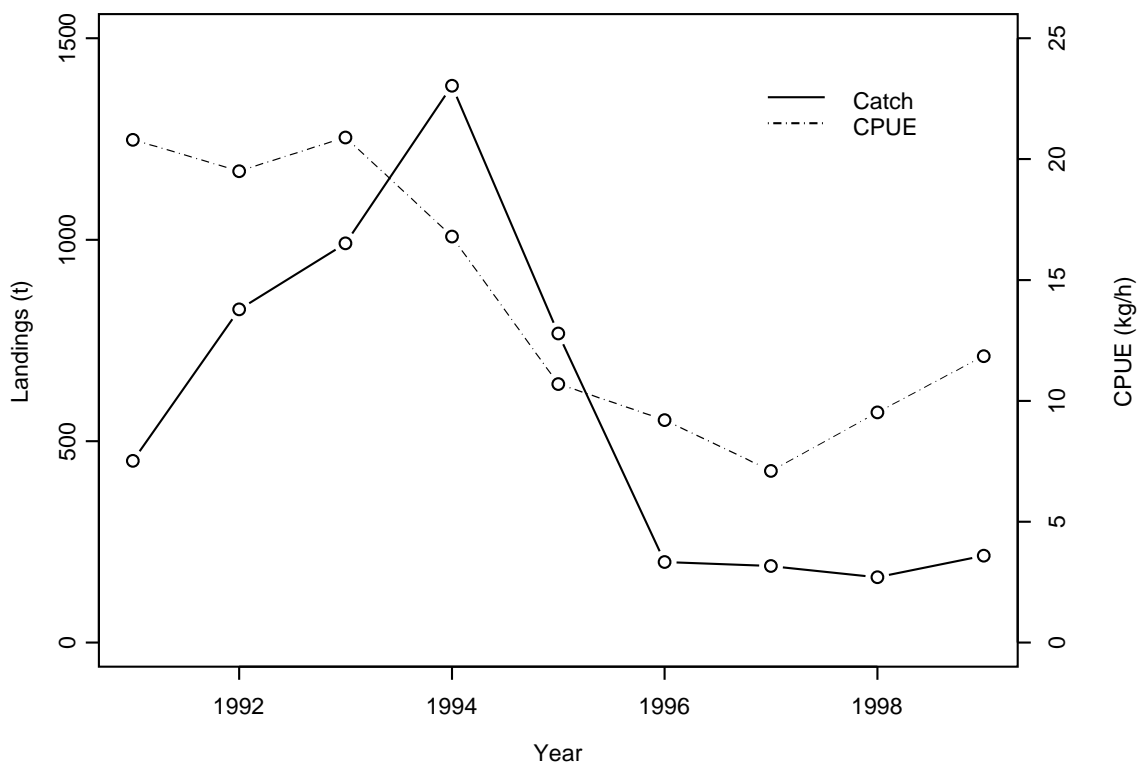


Fig. 2. Landings and commercial catch-per-unit effort for scallop production area 3.

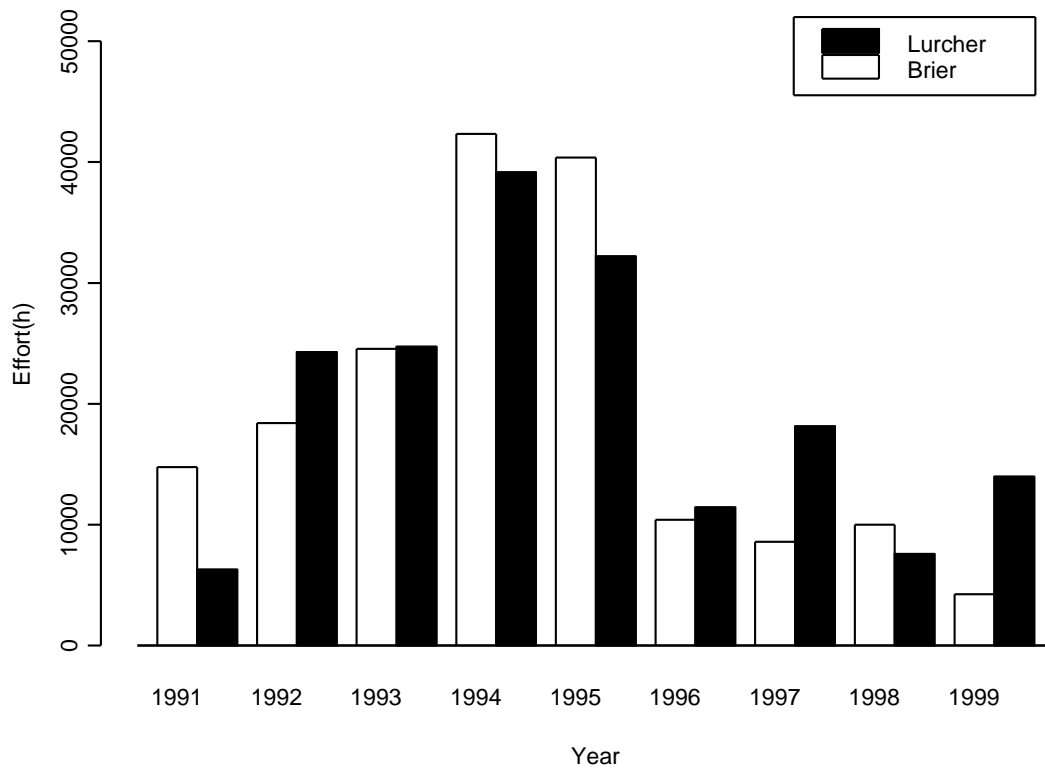


Fig. 3. Fishing effort (hours) in the Brier Island and Lurcher Shoal subareas of scallop production area 3.

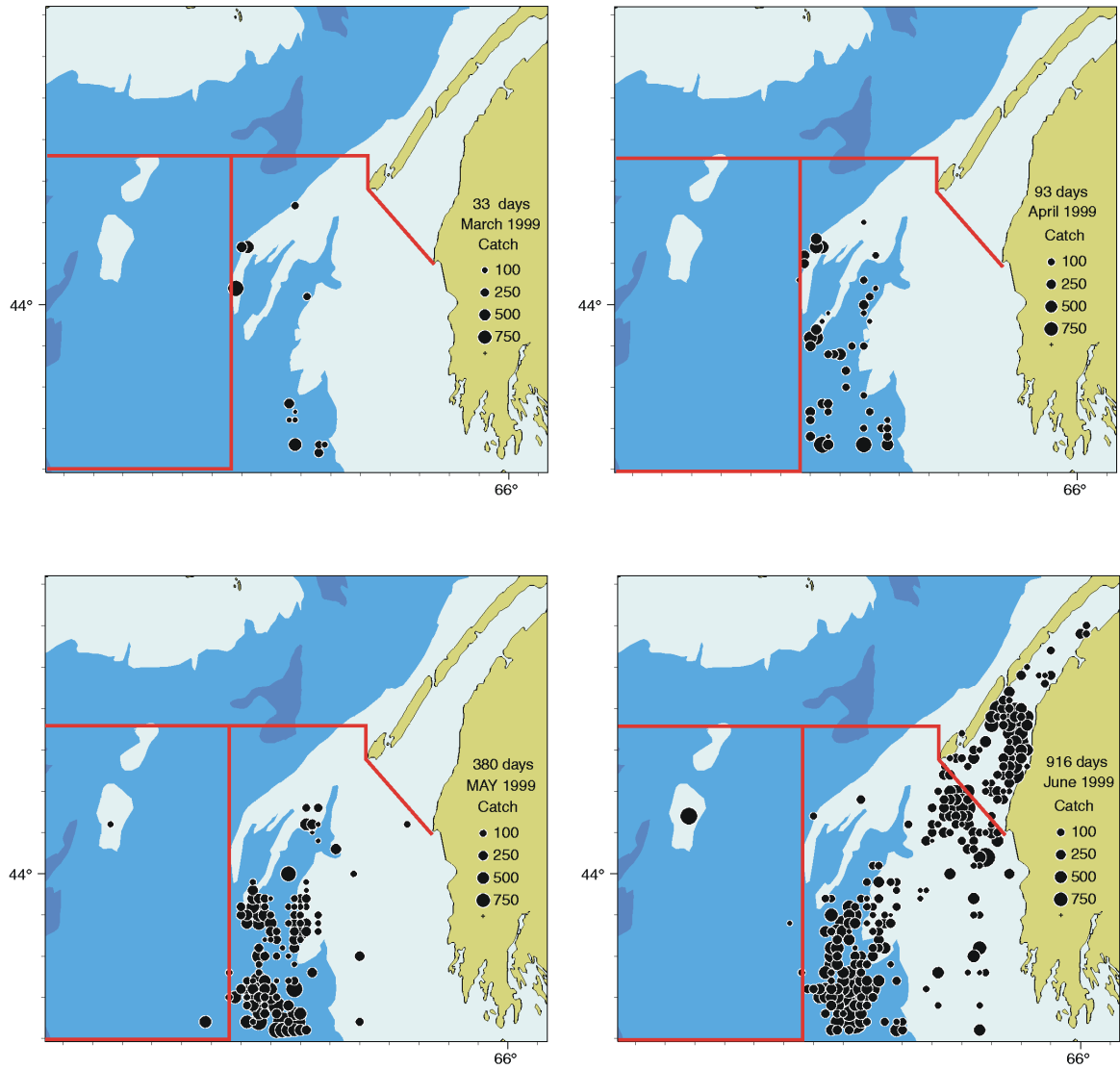


Fig. 4. Fishing locations and associated catch in 1999 from Full Bay fleet fishing logs for March to June inclusive.

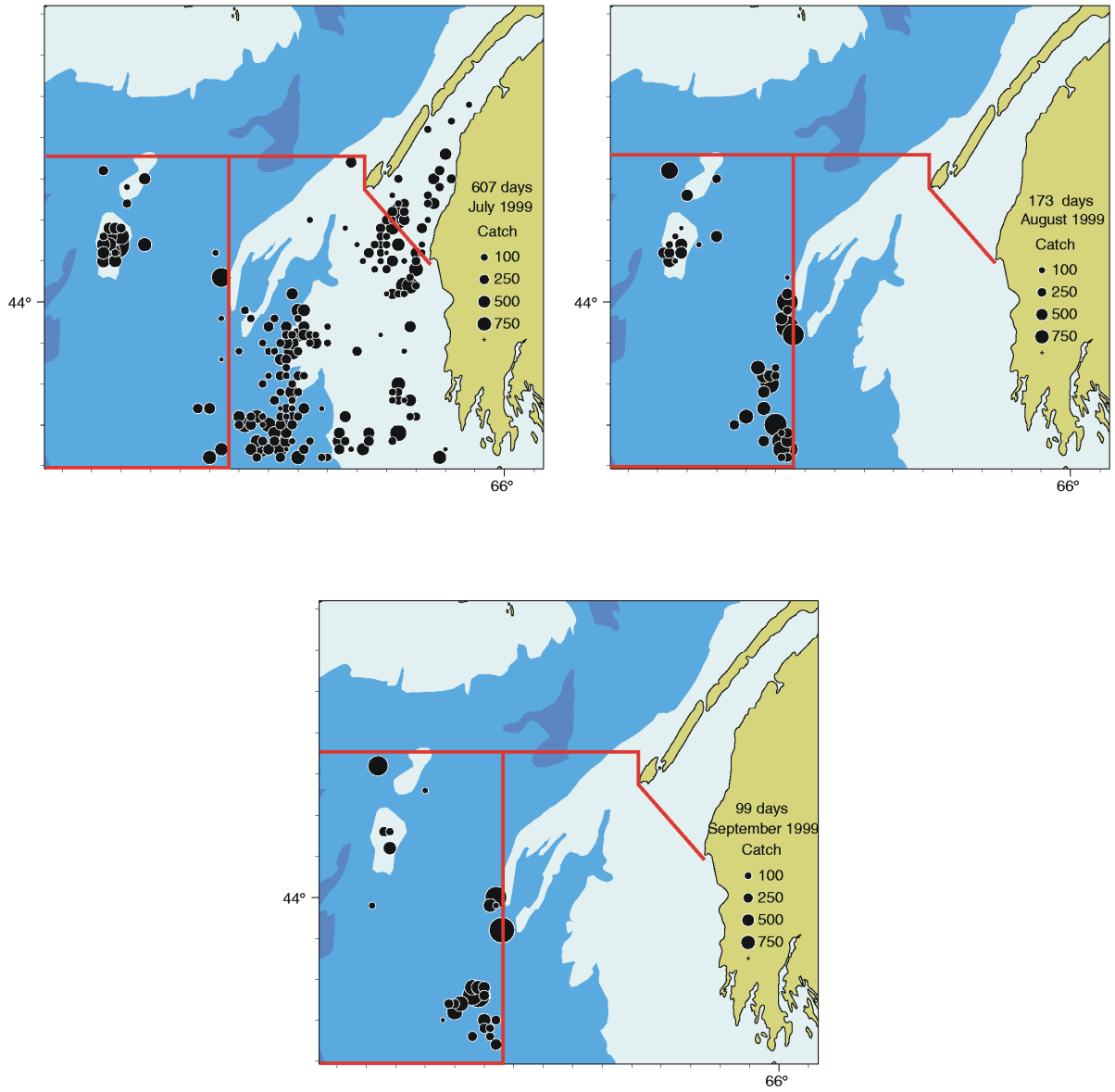


Fig. 5. Fishing locations and associated catch in 1999 from Full Bay fleet fishing logs for July to September inclusive.

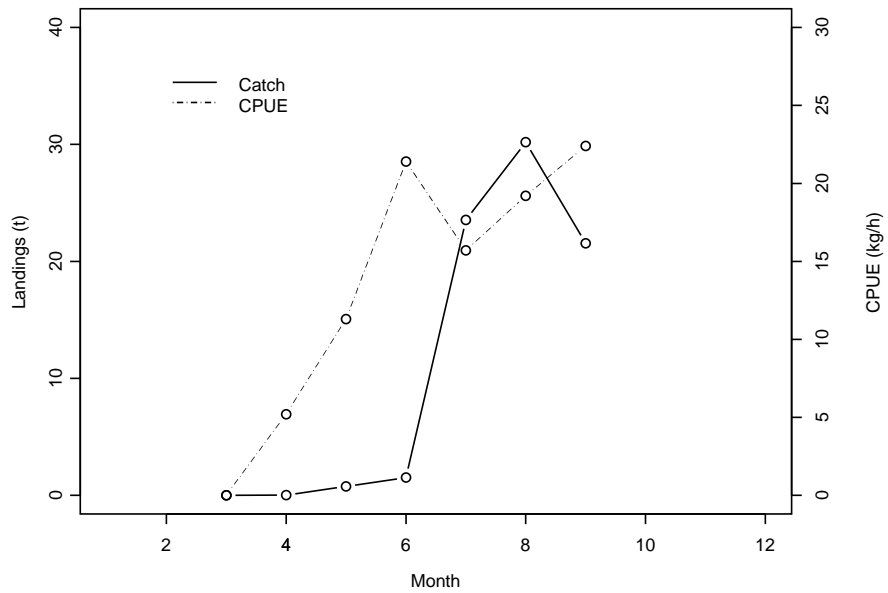


Fig. 6. Landings and commercial catch-per-unit effort for scallop production area 2 by month for 1999.

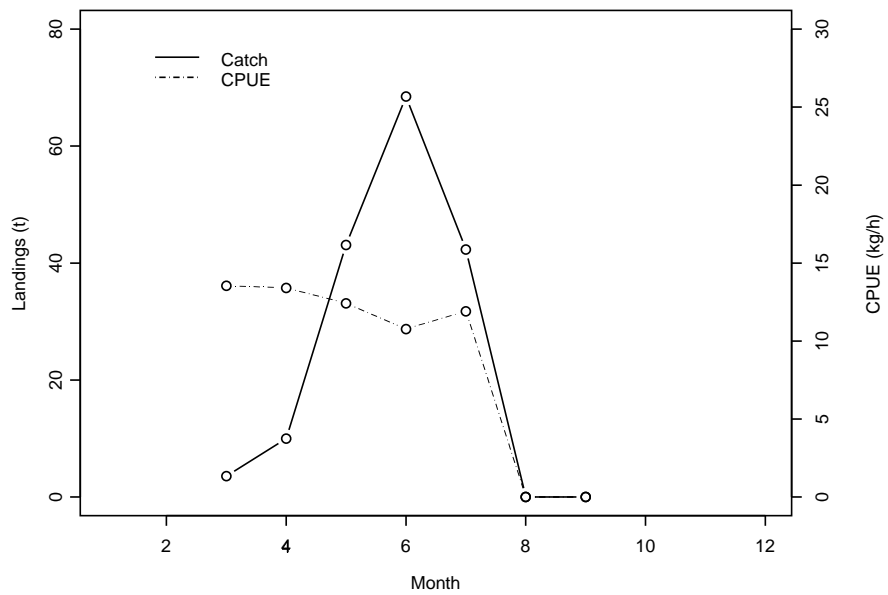


Fig. 7. Landings and commercial catch-per-unit effort for scallop production area 3 by month for 1999.

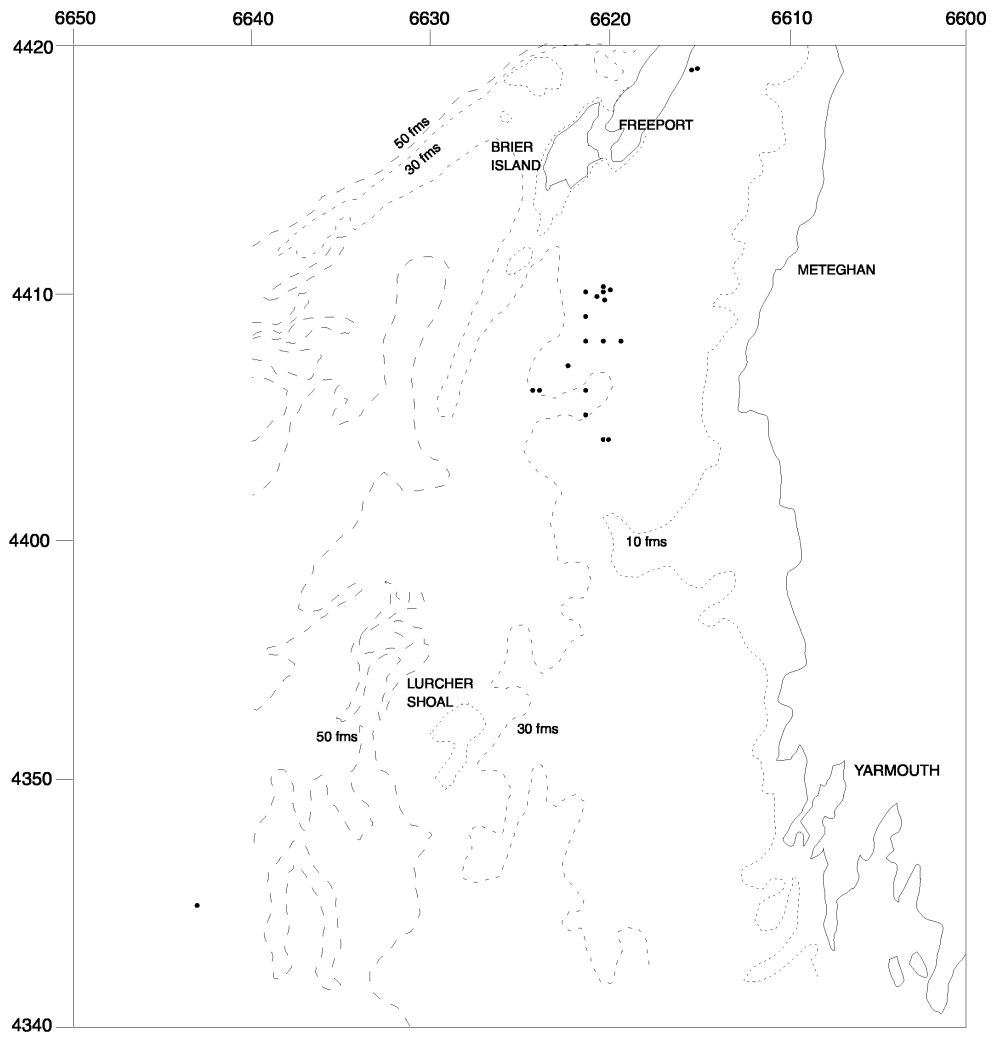


Fig. 8. Location of catches from which meat weight samples were taken in 1999.

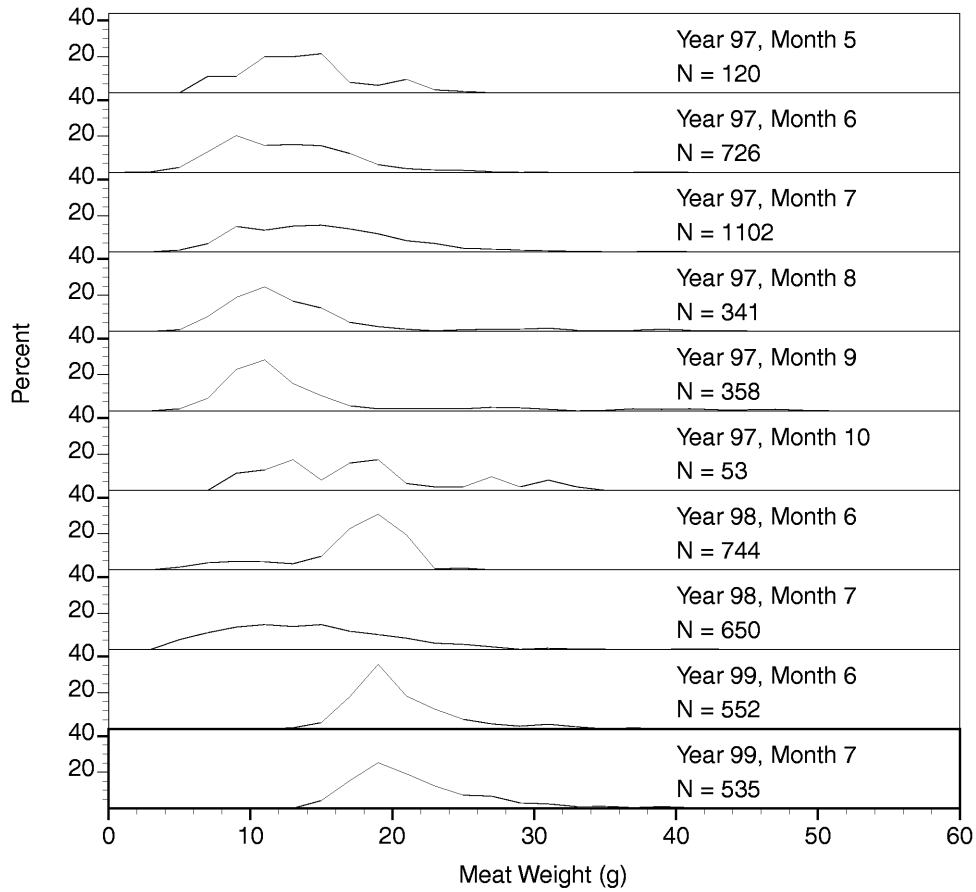


Fig. 9. Frequency distribution of meat weights from samples of the commercial catch in the Brier Island portion of SPA 3. Sample size of meats (N) given for each month.

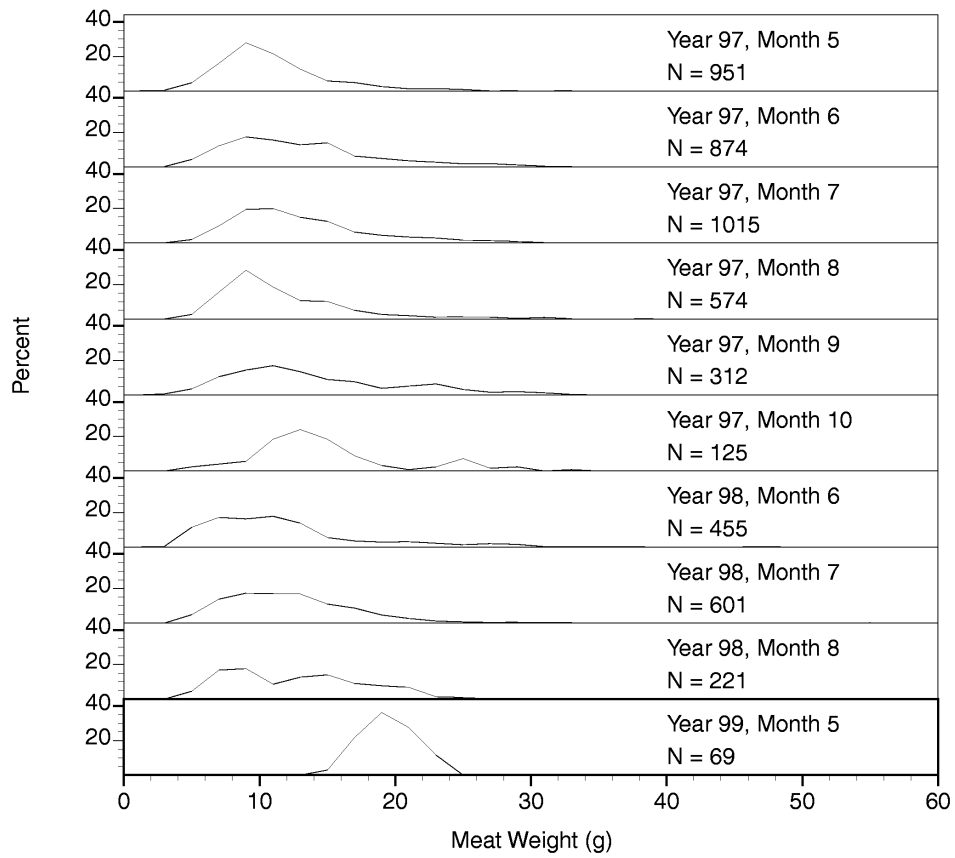


Fig. 10. Frequency distribution of meat weights from samples of the commercial catch in the Lurcher Shoal portion of SPA 3. Sample size of meats (N) given for each month.

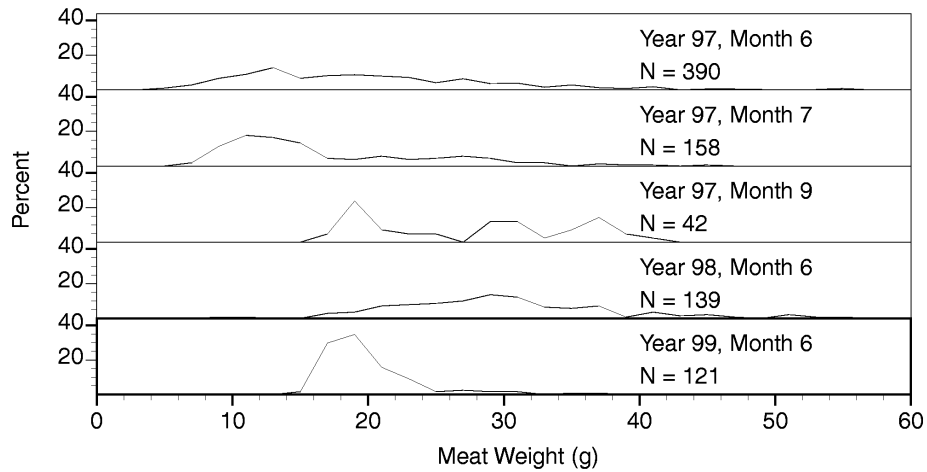


Fig. 11. Frequency distribution of meat weights from samples of the commercial catch in the St. Mary's Bay portion of SPA 3+7. Sample size of meats (N) given for each month.

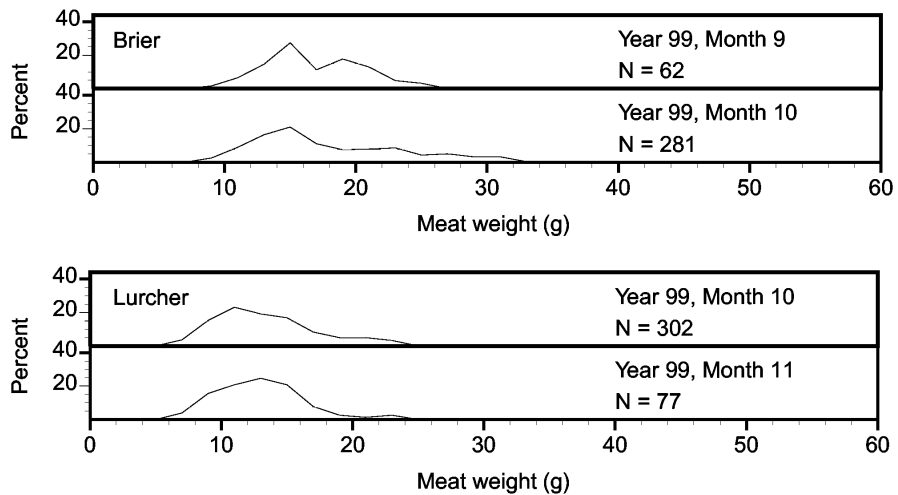


Fig. 12. Frequency distribution of meat weights from samples of the commercial catch in the September/October 1999 re-opening of SPA 3. Sample size of meats (N) given for each month.

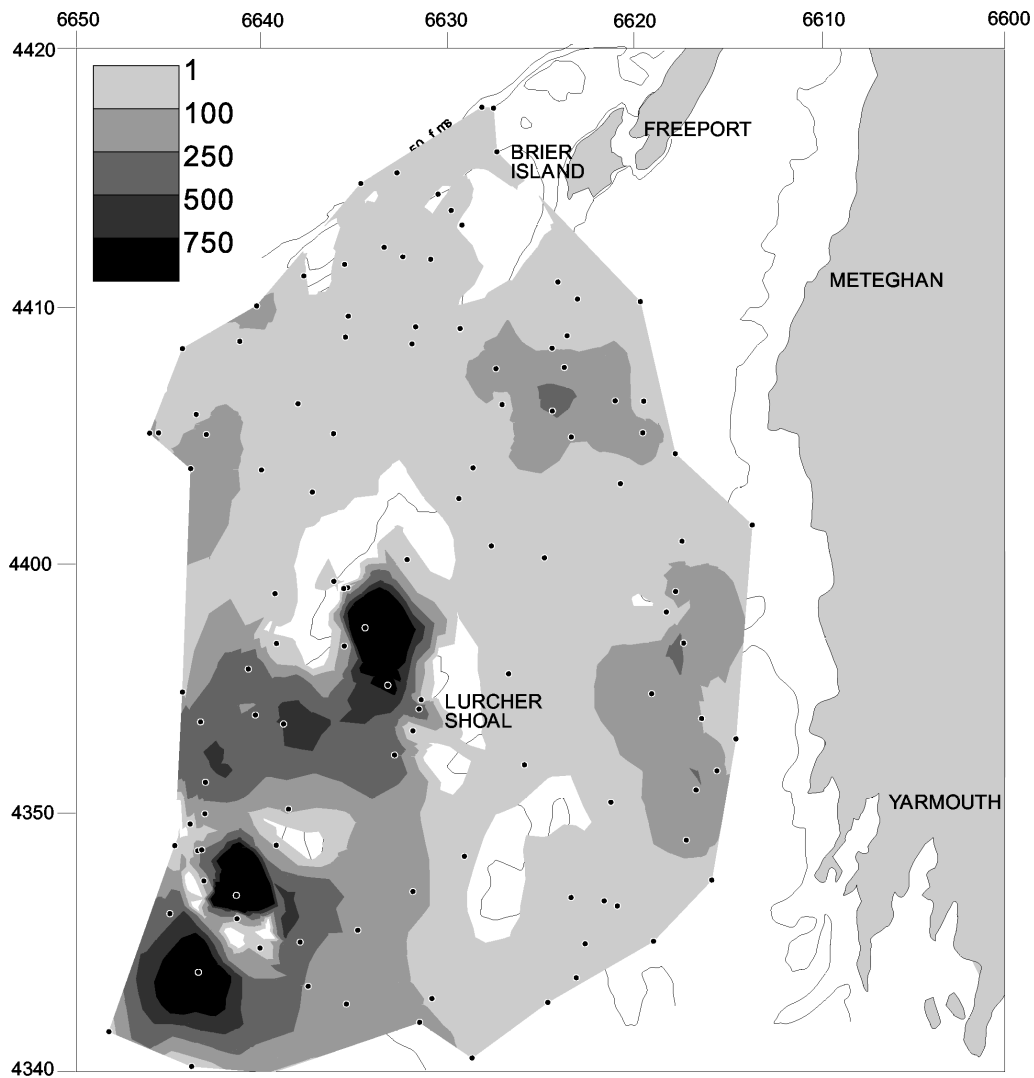


Fig. 13. Spatial distribution of scallops for all shell heights caught during the 1999 research survey in SPA 3. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

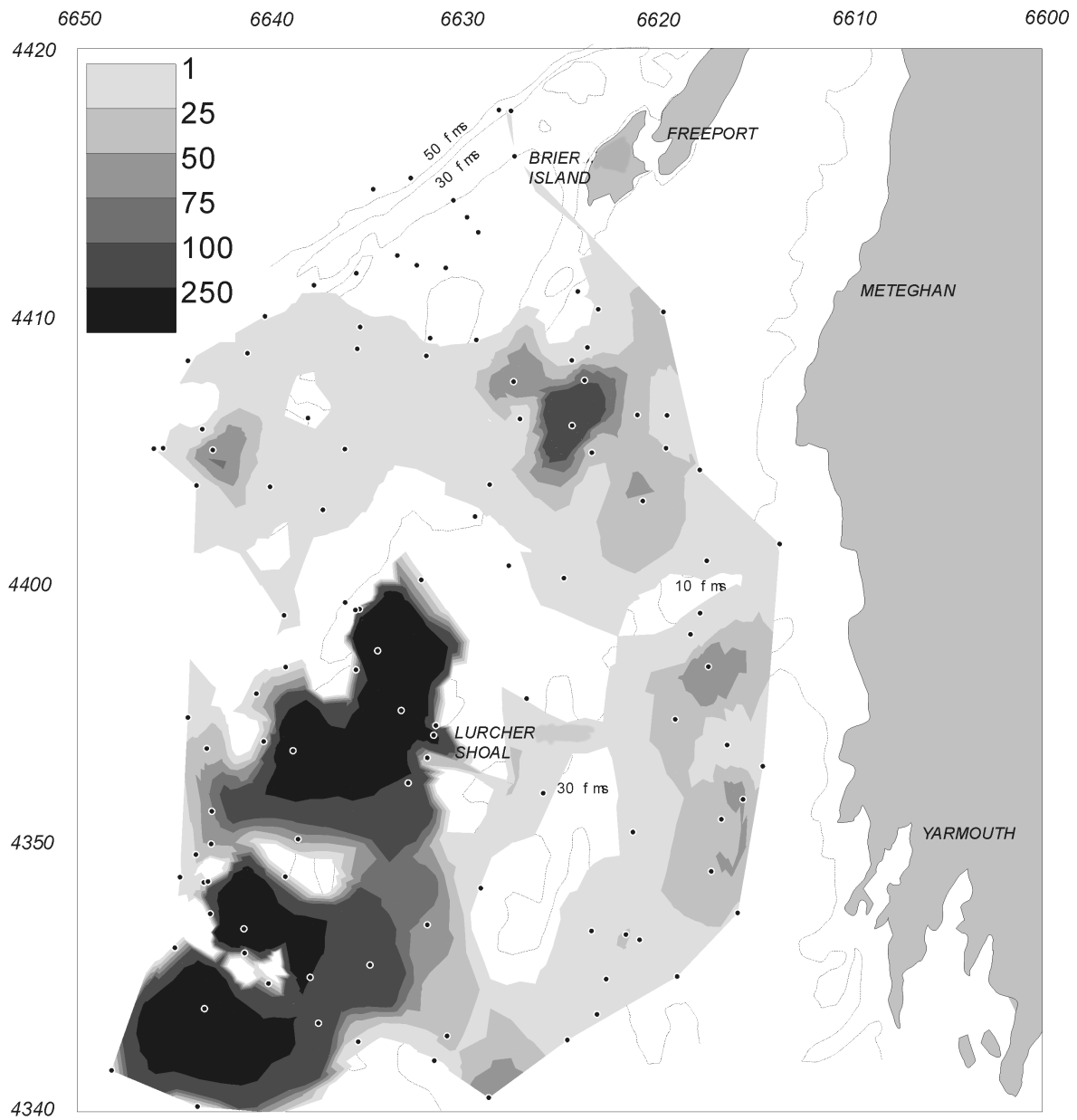


Fig. 14. Spatial distribution of scallops with shell height less than 80 mm shell height caught during the 1999 research survey in SPA 3. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

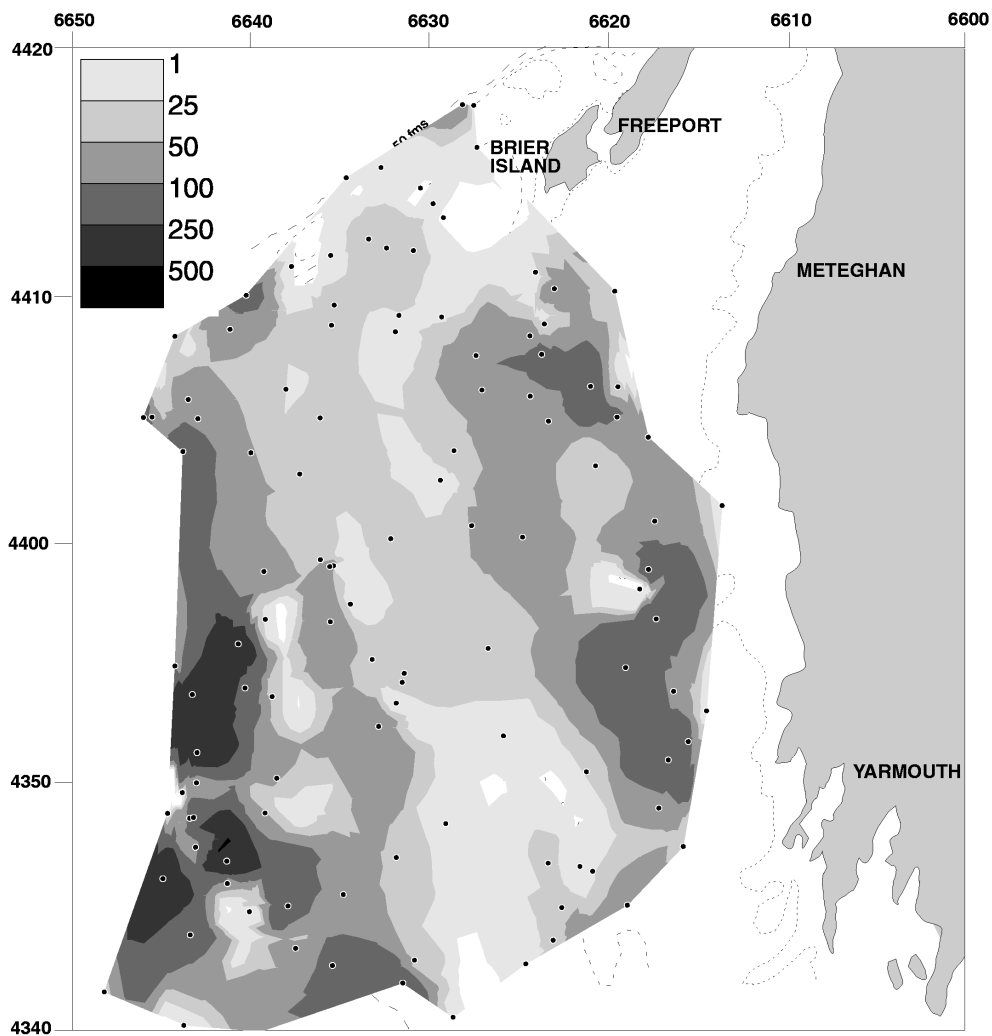


Fig. 15. Spatial distribution of scallops greater than 80 mm shell height caught during the 1999 research survey in SPA 3. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

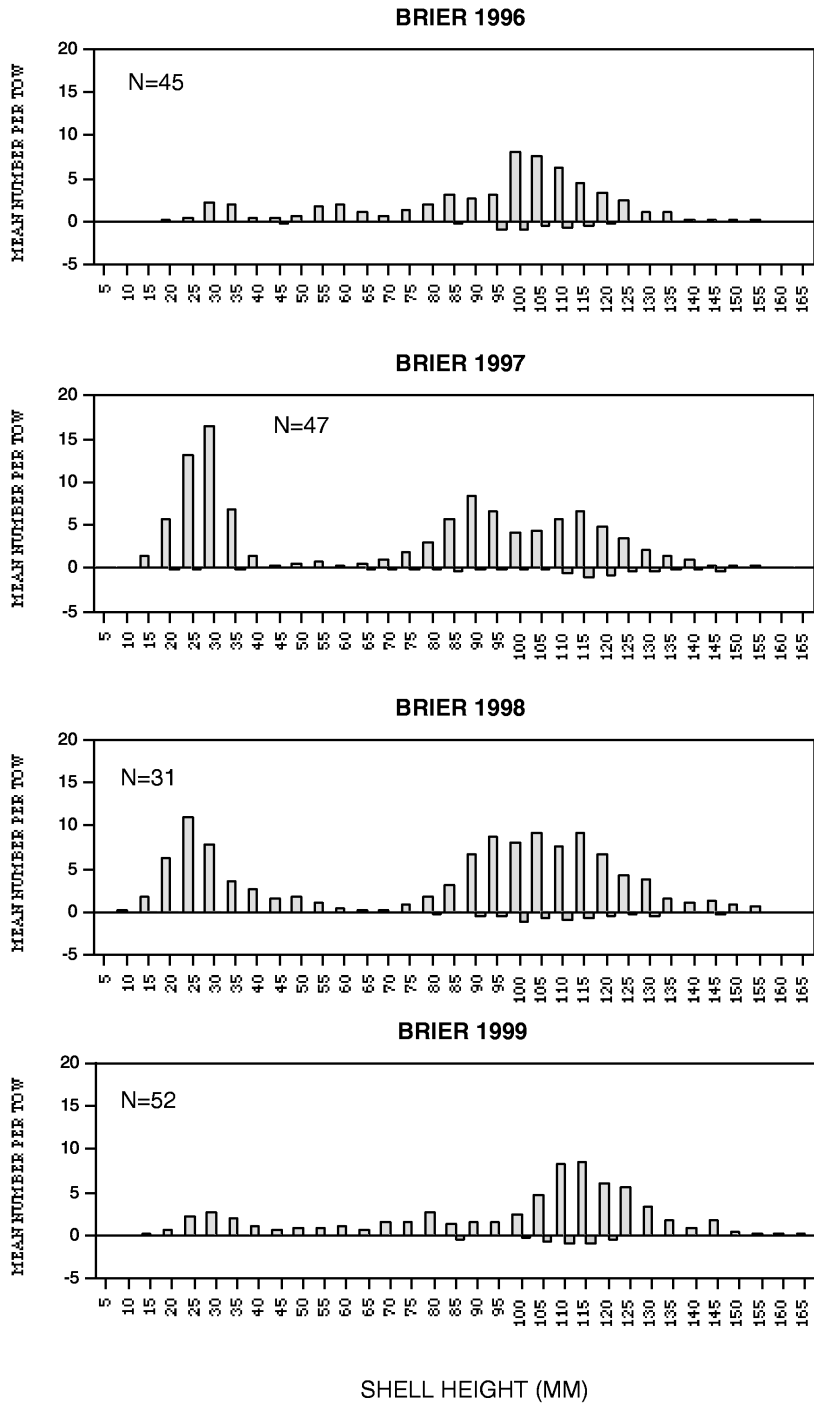


Fig. 16. Shell height frequency distribution of the mean number of scallops per tow caught in the Brier Island subarea of SPA 3 during the 1996–1999 stock surveys. The number of live and dead (clappers) animals is shown above and below the 0 frequency line, respectively. N = number of tows.

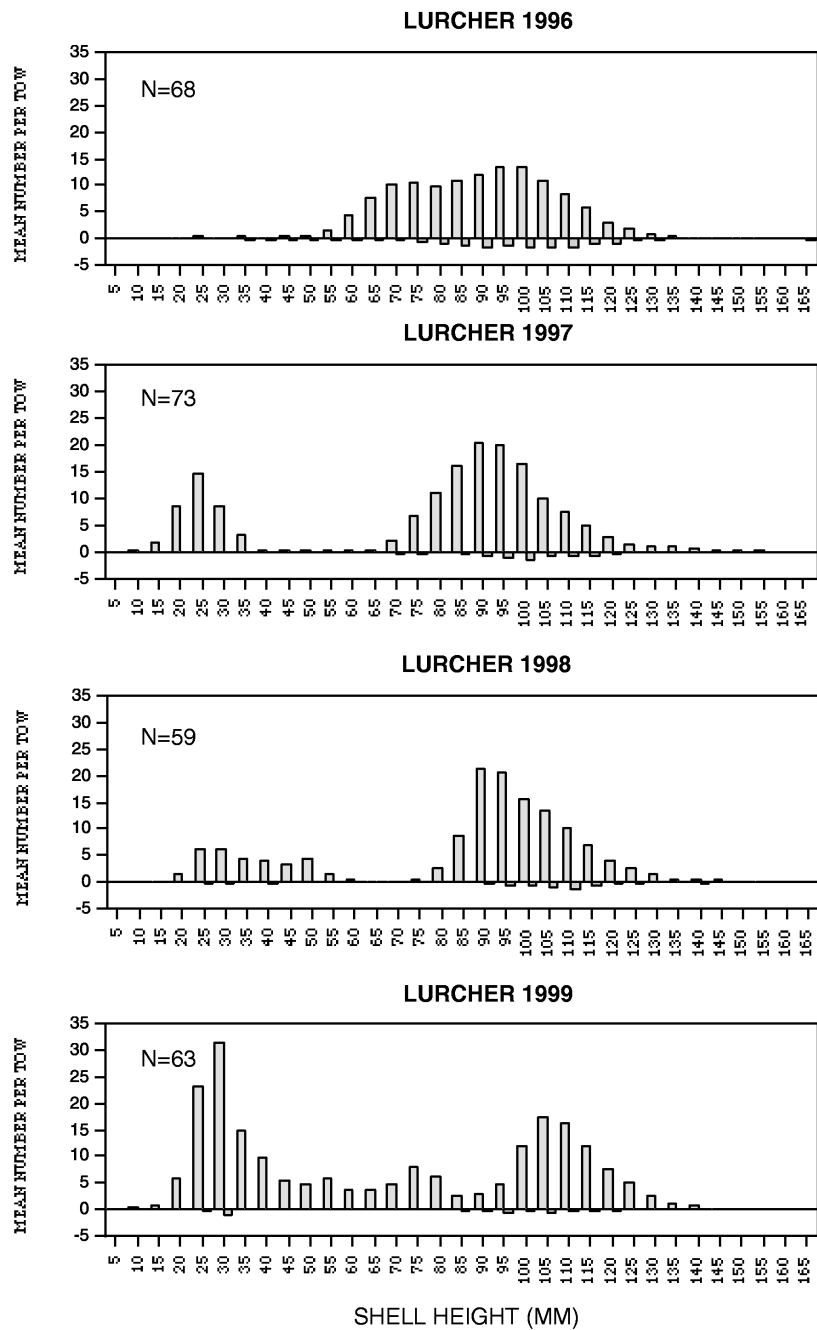


Fig. 17. Shell height frequency distribution of the mean number of scallops per tow caught in the Lurcher Shoal subarea of SPA 3 during the 1996–1999 stock surveys. The number of live and dead (clappers) animals is shown above and below the 0 frequency line, respectively. N = number of tows.

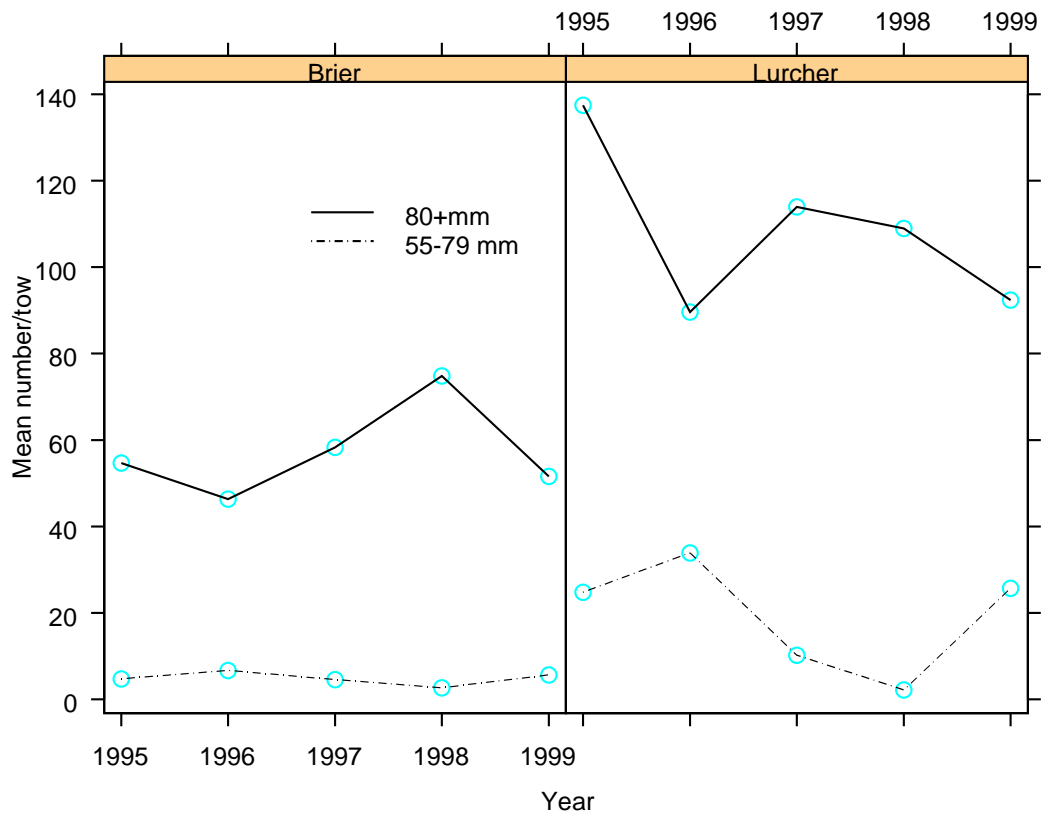


Fig. 18. Estimates of mean number of scallops by size range and subarea from August surveys of scallop production area 3.

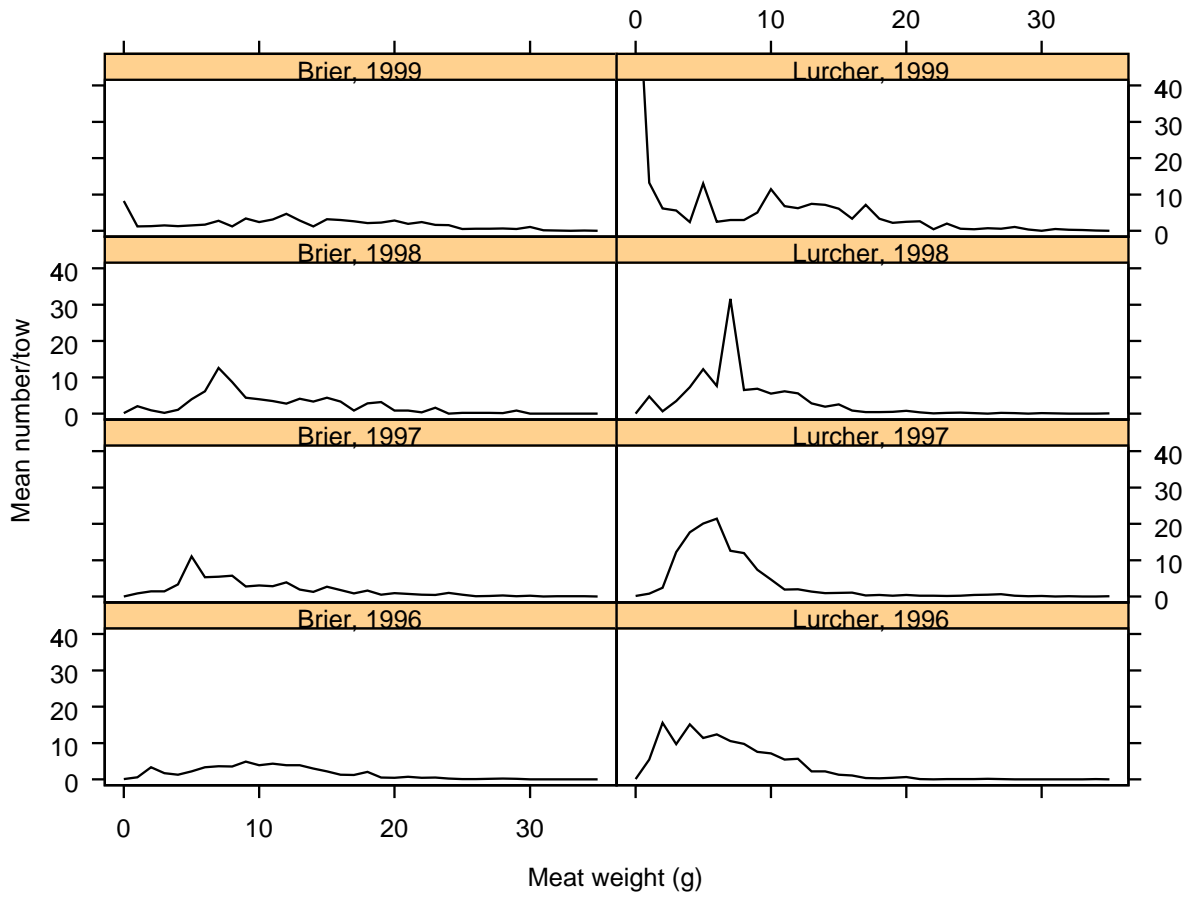


Fig. 19. Meat weight frequency distribution of the mean number of scallops per tow caught in the SPA 3 during the 1996–1999 stock surveys. Note that the mean number/tow axis was truncated to 40. The maximum mean number/tow for Lurcher in 1999 was 84 at a meat weight of 0.5 g.



Fig. 20. Trend in mean meat weight per tow from stock surveys in the a) Brier Island and b) Lurcher Shoal areas. Vertical lines indicate 95 percent bootstrap confidence intervals.

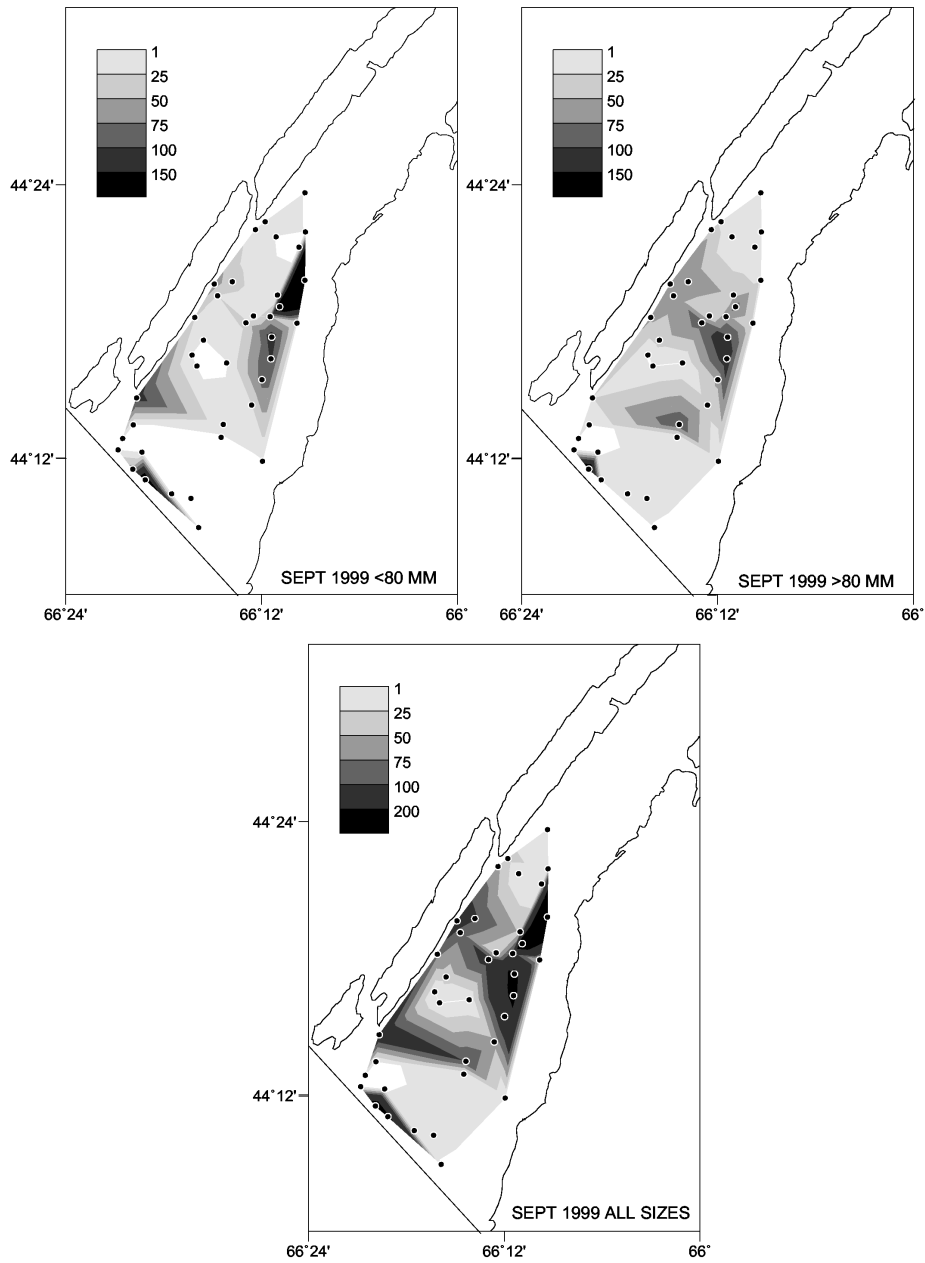


Fig. 21. Spatial distribution of scallops for shell heights less than or equal to 80 mm, greater than 80 mm and for all shell heights caught during the 1999 research survey in St. Mary's Bay. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

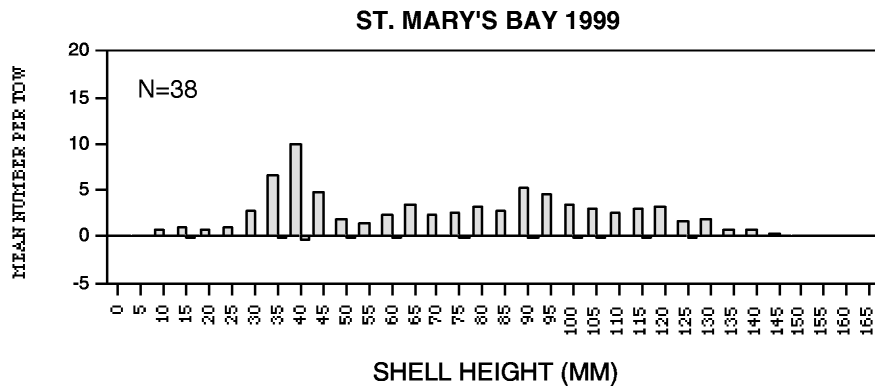


Fig. 22. Shell height frequency distribution of the mean number of scallops per tow caught in the St. Mary's Bay subarea of SPA 3 during the 1999 stock survey. The number of live and dead (clappers) animals is shown above and below the 0 frequency line, respectively. N = number of tows.

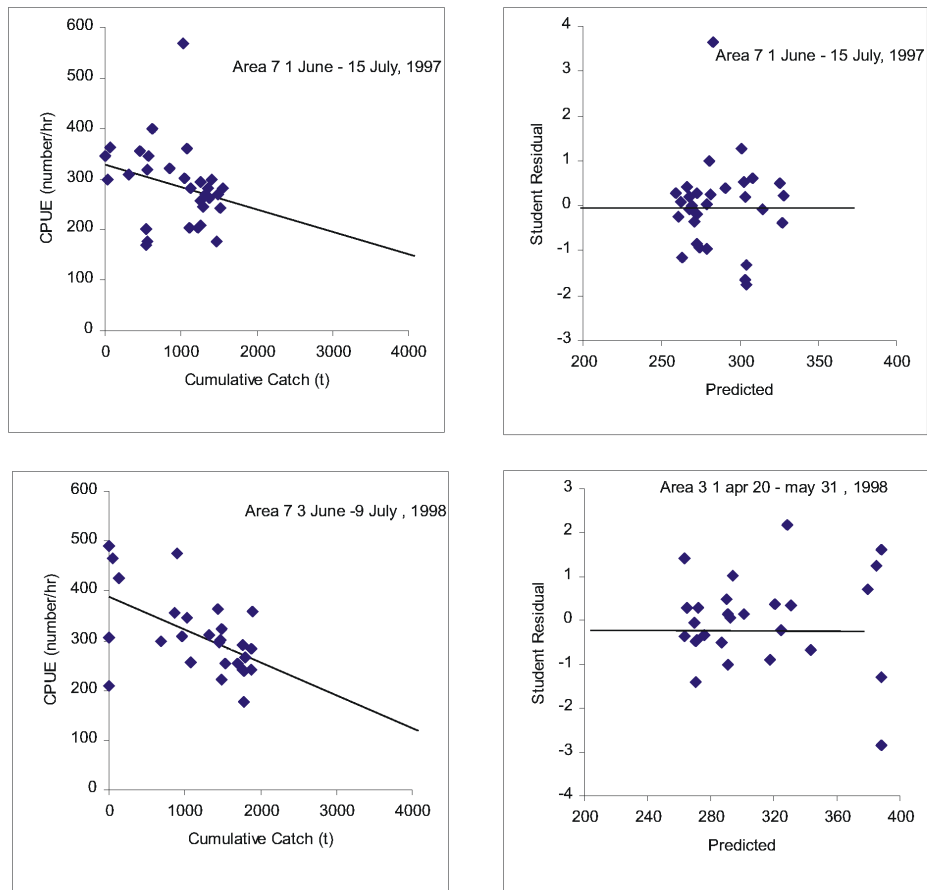


Fig. 23. Analysis of commercial catch rate data. Left panels: Plots of catch per unit effort (CPUE) against cumulative catch. Solid lines represent regression lines used in Leslie analysis. Right panels: Residual plots from regression analyses.