1991-1994 Bay of Fundy Scallop Stock Surveys and Fishery Statistics: Brier Island and Lurcher Shoal and an Evaluation of the Effectiveness of the Meat Count Regulation for these Stocks

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Abstract

The scallop beds below Brier Island and above 43°40' have been fished sporadically for decades. No landings were reported for the years 1988-90 when the fleet was targeting the strong year-classes off Digby. Following the decline of that fishery, activity increased on the beds below Brier Island. Landings have increased each year since 1990, with the highest landings being recorded in 1994, at 1240 mt. The landings from these stocks are the current mainstay of the Bay of Fundy fishery, supplying 75% of the 1994 catch. CPUE remains moderate-low relative to the Digby grounds, but has fallen by 15% during the last year.

The strong recruitment pulses (1988 and 1989 year-classes) which settled on Brier Island and Lurcher Shoal have been heavily fished at low yield. Surveys indicate that the 1994 stock on the Brier Island bed had been reduced by approximately 70% since 1992, and by 55% since 1993. The scallop bed in the vicinity of Lurcher Shoal saw a 66% decline in scallop numbers between the 1993 and 1994 surveys. The 1994 survey indicated moderate numbers of prerecruit scallops on both beds.

The meat count regulation of 72 meats per 500 g, May 1 to September 31, and 55 meats per 500 g October 1 to April 30, did nothing to protect the strong year-classes from growth overfishing. Large numbers of small scallops were harvested within the regulation count. While the age distribution remains broad, it is unlikely that a blended count could prevent the premature harvesting of small scallops.

With the decline of the Digby stock, the beds below Brier Island are expected to account for a greater portion of the total catch in 1995. Landings are expected to fall, however, as the remainder of the larger 1988 and 1989 year-classes approach a size which maximizes yield, the impact of the decline in abundance will not be readily seen, an effect which has already occurred to some extent in 1994. Hard fishing of these animals will lead to a greater decline in landings in 1996. A temporary closure east of 66°40'W and north of 43°40'N is recommended to allow the incoming year-class to reach an optimum yield, and the resident scallop stock to spawn in the absence of fishing pressure. The remainder of the 1988 and 1989 year-classes are largely concentrated in the deeper water west of this longitude.

Résumé

Les gisements de pétoncle situés au-delà de l'île Brier et au-dessus de la latitude 43°40' sont exploités sporadiquement depuis des décennies. Aucun débarquement en provenance de ces gisements n'a été déclaré dans les années 1988-1990, alors que les pétoncliers ciblaient les fortes classes d'âge au large de Digby. Après le déclin de cette pêche, l'activité s'est accrue dans les gisements situés au-delà de l'île Brier. Les débarquements ont augmenté tous les ans à compter de 1990, les plus forts, soit 1 240 tonnes métriques, ayant été enregistrés en 1994. Les débarquements en provenance de ce stock constituent actuellement l'essentiel de la pêche dans la baie de Fundy; ils représentaient 75 % des prises en 1994. Les PUE demeurent de modérées à faibles comparativement aux gisements de Digby, mais ont diminué de 15 % l'an dernier.

Les fortes poussées de recrutement (classes d'âge de 1988 et 1989) survenues dans les gisements de l'île Brier et de la basse de Lurcher ont été lourdement exploitées à faible rendement. Les relevés de recherche révèlent que le stock de 1994 de l'île Brier a été réduit d'environ 70 % depuis 1992 et de 55 % depuis 1993. Le gisement de pétoncles des alentours de la basse de Lurcher a connu un recul de 66 % du nombre de pétoncles entre le relevé de 1993 et celui de 1994. Ce dernier relevé dénote un nombre modéré de pré-recrues sur les deux gisements considérés.

Le règlement établissant le compte de chairs à 72 par 500 g du 1er mai au 30 septembre et à 55 par 500 g du 1er octobre au 30 avril n'a rien fait pour protéger les fortes classes d'âge de la surpêche des pétoncles en croissance. On a récolté un grand nombre de petits pétoncles dont la taille était cependant conforme au règlement. Bien que la distribution des âges reste vaste, il est peu probable qu'un compte pondéré puisse empêcher la récolte prématurée des petits pétoncles.

Avec le déclin du stock de Digby, on s'attend à ce que les gisements situés au-delà de l'île Brier fournissent une plus grande proportion des prises totales en 1995. Les débarquements devraient chuter; toutefois, comme le reste des fortes classes d'âge de 1988 et 1989 approche d'une taille qui maximise le rendement, les effets de la baisse de l'abondance ne seront pas immédiatement visibles, phénomène qui s'est déjà produit dans une certaine mesure en 1994. La pêche intensive de ces pétoncles occasionnera une plus forte baisse des débarquements en 1996. On recommande une fermeture temporaire à l'est de la longitude 66°40'O et au nord de la latitude 43°40'N pour permettre aux nouvelles classes d'âge d'atteindre un rendement optimal et au stock résident de se reproduire sans avoir à subir la pression de la pêche. Le reste des classes d'âge de 1988 et 1989 est largement concentré dans les eaux profondes situées à l'ouest de la longitude en question.

Introduction

The scallop beds in the lower Bay of Fundy have never supported an extensive, stable fishery, as have the beds off Digby, N.S. However, periodically, good recruitment has sustained short-term fishing on these grounds (Bourne 1964). The scallop beds below Brier Island and areas to the south above 43°40' N (Fig. 1), were heavily exploited in the 1950's and 1960's (Jamieson and Lundy 1979). In the 1970's, scallop fishing on these grounds was both minimal and sporadic, and the stocks were considered to have been depleted by the earlier over-fishing. However, at the end of the decade catches increased as both the offshore and Bay of Fundy fleets fished these beds. Most of this effort was incidental to concentrated effort expended on German Bank (4Xq) and beds south of Lurcher Shoal. Fishing continued in this fashion through to the end of 1986. As of January 1, 1987, following the Inshore/Offshore Agreement, the Bay of Fundy fleet restricted its activities to north of latitude 43° 40' N. Coincidentally, fishing effort ceased in the Brier Island area and more southerly beds (Robert et al. 1988). In 1987-88, exceptional catches in the traditional Bay of Fundy fishing grounds kept the fleet in the Digby area. The Digby stock continued to provide fishermen with high catches through to 1989. However, in 1989, after a three year hiatus, the fleet once again became mobile. At that time, the inshore Digby scallops suffered a mass mortality and the fleet moved across the Bay to exploit scallop beds off Cape Spencer, N.B. and surrounding areas (Kenchington and Lundy 1991). However, with the decline of the New Brunswick beds the fishermen once again began to consider the Brier Island stocks as a supplement to the Digby catches. In May of 1991 most of the fleet moved off the Digby grounds to the Brier Island beds and areas in the upper reaches of Lurcher Shoal. A large proportion of the fleet fished there until the opening of the inside fishing zone off Digby in October, 1991 (Lundy and Kenchington 1992). Landings from the Brier Island and Lurcher Shoal grounds have increased each year since 1990, with the highest landings being recorded in 1994. In 1993, landing from these stocks represented 55% of the total Bay of Fundy catch. In 1994, a minimum of 75% of Bay of Fundy catches were from the beds below Brier Island. During 1994, a Variation Order was effected which closed a large portion of these beds from November 19, 1994 to May 31, 1995, due to gear conflicts with the lobster industry.

This document presents data on scallop abundance and recruitment on the Brier Island and Lurcher Shoal grounds, and information on catches and fishing effort related to this stock. The utility of the meat count regulation with respect to these stocks is discussed.

Materials and Methods

Fishery Data

All vessels Full Bay of Fundy license holders are required to provide log book information which provide data on catch, location and effort. Currently, 99 vessels are required to report. The number of licenses have not changed since 1988 (Kenchington and Lundy 1992). Catch trends were estimated using the fishing logbook data available. Catches were broken down by area using the log data where location fished was known. Some logs provided full information (Class 1), others had only location and catch (Class 2) and still others had only general fishing area and catch with or without effort (Classes 3 and 5). The percent logged catch per area was calculated, and the estimated total catch per area was derived from the total sales slip catch reported by Statistics Branch (see below). Catch per unit effort (CPUE) was calculated from the Class 1 log data and recorded in kg per hour meter.

Fleet activity has also been monitored through sales slip records and port sampling information. All logbooks and sales slips recording catches from NAFO sub-area 4Xq were used to estimate landings. In addition, in 1991 some sales slips recorded location as NAFO sub-area 4Xr but identified the product as "Lurcher meats" due a sized-based market value. These were included in the landing estimates. Strict use of the NAFO sub-areas is inappropriate as the

NAFO boundary divides these fishing grounds. From 1992-1994, all landings in Meteghan and Yarmouth were attributed to these areas.

Fishermen report their landings, and sell their catch in terms of pounds of meat. Statistics Branch converts this to round weight (whole animal) using a conversion factor of 8.33. To convert Statistics Branch (DFO, Halifax) landings to metric tonnes of meat, the data are reconverted to pounds and then converted to metric weight in tonnes. Estimated landings were derived for each of the Brier Island and Lurcher areas.

Port Sampling of Commercial Catch

Port sampling of the commercial catch has been carried out in Digby, N.S. since 1981. When a vessel lands, two samples of approximately 500 grams each are removed from the catch, and date, vessel, location and depth fished are recorded. The catch muscle is then removed from the adductor muscle and each adductor muscle is weighed and recorded for each of the two samples. This separation of the muscles is done because the catch muscle is not always attached to the adductor, as a result of processing. The contribution of the catch muscle to the total weight is later prorated. The mean, standard deviation and range of meat weights are calculated on a monthly basis when data is available. A "meat count" of the sample is then calculated by dividing 500 (g) by the mean meat weight (g). The meat count regulation for this area is 72 meats per 500g from May 1 to September 31, and 55 meats per 500g from October 1 to April 30. There is a tolerance associated with this regulation.

Research Vessel Stock Surveys

The Department of Fisheries and Oceans has conducted six surveys of the Brier Island stocks. Surveys were conducted in 1982 and 1983, and from 1991-1994. The 1982 and 1983 stock assessment surveys were catch stratified and not considered further here (Robert et al. 1985). In 1994, 5 tows were made in St. Mary's Bay (Table 4) to determine if reports of good settlement in that area could be substantiated.

Stock surveys (1991-1994) were conducted during the last two weeks of August or the first week of September, using the research vessel "J.L. Hart" with 4 gang gear. The actual gear configuration has remained the same for all years. The 76 cm inside width drags are made of 7 rows of 4 mm steel wire rings 75 mm inside diameter knit with rubber washers, 9 across and 3 on the side fastened to an angle iron frame at the mouth and a piece of wood (2"x4") or plate steel at the tail end. This gear actively selects against small size scallops. Small scallops can avoid the drag path or if caught, escape through the steel rings (Robert and Lundy 1989). To estimate the relative abundance of small scallops (< 80 mm shell height) some drags were lined with 38 mm polypropylene mesh. However the abundance of scallops with shell height under 40 mm is not reliably estimated and can only be used as a qualitative index of recruitment. For analysis purposes the average number of scallops caught in unlined gear (> 80 mm) and the average number of scallops caught in lined gear (< 80 mm) were used and then prorated to conventional 7 gang gear to allow for annual comparisons.

From 1991-1994 a uniform 2 mile interval grid system was set over Brier Island Ledge and Lurcher Shoal (Fig. 3). This system was used because initially no log information was available with which to catch stratify the grounds. At each grid intersection a tow was made, provided the bottom was suitable. The total number of tows by area by year are listed in Table 4. All tows were 8 minutes in length. To eliminate the effects of tide and vessel speed on the area covered by the gear, the distance towed was determined either from latitude/longitude of the start and end of tow bearings, or from continuous recordings of location via a computer linked to navigation aids and standardized to a tow length of 800 meters (dragged area of 4256 sq. m). Data recorded for each tow were: 1) direction of tow (magnetic or true compass bearings), 2) depth (m), 3) weight of catch (kg) (individually for each drag), 4) types of substrate, and 5) shell

heights in 5 mm intervals for all live and dead (empty paired shells) scallops fished were recorded individually for each drag. Scallops from selected tows were collected for the calculation of meat weight-shell height regressions and for ageing (see below).

Ageing and Abundance Data

Scallops were collected for ageing during August research vessel surveys from 1991-1994. Thirty scallops were sampled from selected tows to include the full size range in the catch. Scallops were aged in the lab and the annual rings on the shell (Bourne 1964) were measured. Ageing by this method on Bay of Fundy scallops is thought to be accurate to ± 1 year (Roddick et al. 1994). A total of 613 animals have been aged to date. The scallops collected from the deep water (>100 m) on the Brier Island bed, were all from a single tow, and hence may not be representative of growth at this depth in this area. Overall, while coverage has improved, the ageing data set is still preliminary, and further data are required to produce robust models.

Four von Bertalanffy functions were used to describe the growth of the scallops below Digby Neck. The function is expressed as $L_t=L_{inf}(1-\exp(-k(t-t_0)))$, where, L_t is length at age, L_{inf} is the asymptotic length, k is the Brody growth coefficient, and t_0 is the age at which length is 0 (Ricker 1975). Functions were fit using the Levenberg-Marquardt method for computing parameter estimates using program NLR of the SPSS Release 4.0 software package (SPSS Inc. 1990). At each iteration, the estimates are evaluated against a set of control criteria. In these analyses, all iterations were stopped because the relative reduction between successive residual sums of squares was less than 1.000E-08. R^2 values were calculated as: 1 minus the residual sum of squares/corrected sum of squares. These growth curves were fit using data from all "rings" (multiple data points per individual). No attempt was made to weight the data, and there may be bias by a Rosa Lee effect (Roddick et al. 1994).

An analysis of the residual sums of squares was used to determine if fitting multiple growth curves to the same set of data was a significant improvement over using a single curve (Chen et al. 1992). Seven combinations of curves were evaluated. The use of four curves was a significant improvement ($F=5.43$, $P>0.01$) over the use of a single curve, or of a single curve by area or depth. The resultant parameters of the von Bertalanffy models are:

Depth	N	$L_{(inf)}$ (s.e.)	k (s.e.)	t (0) (s.e.)	R^2
Brier Island					
≤ 100 m	150	138.838 (2.301)	0.29412 (0.01894)	1.2395 (0.1270)	0.94
> 100 m	29	138.904 (4.752)	0.21082 (0.03494)	0.4052 (0.5451)	0.94
Lurcher Shoal					
≤ 100 m	269	128.130 (4.796)	0.31501 (0.47671)	1.3067 (0.3124)	0.49
> 100 m	168	125.187 (3.315)	0.24881 (0.03433)	0.5349 (0.4187)	0.75

These growth functions show the shallow water animals to be faster growing than those in deeper water, with scallops on Lurcher Shoal having better growth rates than the scallops at equivalent depth on the Brier Island beds.

The parameters of the growth functions differ from a previously published curve for this area (Robert et al. 1986), particularly with regard to L_{inf} which was significantly higher at 155.775. However, the 1986 curve was produced with data from scallops collected largely in shallow water, and included animals from German Bank (M. Lundy, pers. comm.). The function produced from the shallow water Lurcher Shoal scallops in our data set, was only able to describe 50% of the variance. These samples were collected from 5 tows and shell height ranged from 67 to 152 mm. The standard error around the Brody growth coefficient (k) is an order of magnitude greater than in the other models. Attempts to further depth stratify the regression did

not improve the R^2 value. It would appear that a factor other than depth or a depth-correlate is causing variability in growth rate in this area. One possibility is that the different cohorts in this area have different growth rates. More data will be required to test this hypothesis.

Scallops collected during the research vessel survey were measured to 5 mm shell height bins. The number of scallops were prorated to a 7 gang, 800 m tow, and the number in each height interval were calculated over the total number of tows. This height frequency distribution was converted to an age frequency distribution using the growth curves detailed above. Because growth rings are laid down in early spring, and the stock surveys were conducted in late August-early September, when the scallops have laid down most of their shell, prior to ring formation, the numbers at age + 0.5 years are recorded.

Spatial distribution of the scallops was contoured using ACON 5.01 (Black 1988) derived from Delaunay triangles and inverse distance weighted interpolation (Watson and Phillip 1985) as detailed in Robert et al. (1990). The prorated numbers were used as input. The resulting "volume" estimates (i.e. abundance integrated over area) are less accurate in areas of low station densities.

Shell Height-Meat Weight Regressions

Samples were collected (see Ageing Data above) for calculating the relationship between shell height and meat weight. The wet weight of the adductor muscle, gonad and soft parts (mantle and other organs) were recorded to 0.01 g. Data were used to calculate regressions by area of the ln (shell height) on ln (meat weight). These regressions are not used further here. Regressions produced by Kenchington and Lundy (1993) are used to determine the meat weights which correspond to the minimum shell height (76 mm) on each bed.

Results

Fishery Performance

Landings have increased each year since 1990, with the highest landings being recorded in 1994 (Table 1). The landings from these stocks are currently the mainstay of the Bay of Fundy fishery, supplying 75% of the 1994 catch. Log compliance in 1994 was 85%, an increase of over 20% from 1993. Of those filing logbooks, 81% fished below Brier Island at some time during the year (Table 2). In 1994, CPUE was similar on both grounds, however in 1993, CPUE was higher on the Lurcher beds. CPUE remains moderate-low, but has fallen on average by 15% during the last year (Table 2). Because the strong 1988 and 1989 year-classes were fished at low yield, CPUE did not increase markedly when they entered the fishery in 1992 and 1993. Fishing locations according to log information are illustrated by year in figure 1. Although the number of logs ranged from 29 to 84 through this series (Table 1), the dramatic increase in activity seen from 1991 to 1992 is consistent with fishermen's comments on their activities at the time. Each year has successively seen increased fishing effort, with 1994 showing the fleet expanding into previously unfished areas (e.g. northeast of Lurcher Shoal). The areas closed by Variation Order (1994-117, 1995-001) are shown on figure 1. The area east of the solid line was closed on November 19, 1994 until May 31, 1995. The shaded portion of the figure indicates the area which opened earlier, on February 28, 1995.

Port Sampling of Commercial Catch and Evaluation of the Meat Count Regulation

The mean meat weight (g) per month and associated statistics are given in Table 3. Most of the samples were obtained during the summer months. These data do not include the weight of the catch muscle, however, this has been calculated as 5-7% of the total weight, and would not have changed our conclusions (e.g. 4 g meat could have been landed as a 4.28 g meat with catch on). Also, fishermen do not remove the entire muscle when "shucking" the meat. A portion of

the muscle is commonly left on each valve. The percent of the meat discarded has not been calculated for Digby shuckers, and is expected to vary with shell shape in the different parts of the Bay, and with catch abundance. The range of scallop sizes allowed the meat count (72 meats per 500 g) to be met on both grounds throughout our sampling periods (with one exception, Table 3). The weight frequency of the catch is illustrated in figure 2A, B, C. In some cases, different year-classes can be detected. Generally, fishing in 1994 saw a removal of larger sized scallops than in preceding years.

Within the meat count regulation, meats as small as 3 g (or 3.2 g with catch muscle) were commonly harvested on the Brier Island and Lurcher Shoal beds (Table 3). The minimum meat weight associated with the minimum shell height (76 mm) is approximately 4.6 g (including catch muscle) for each bed (Kenchington and Lundy 1993). Thus scallops below the minimum shell height were harvested (Fig. 2A, B). For these scallops to have been legally harvested and the residual discarded, that residual would have had to amount to one third (30%) of the total weight, which is improbable. Unfortunately, enforcement of the shell height regulation is difficult, as it requires boarding at sea. This is because scallops are landed as meats and initial processing takes place on board the vessel. Minimum meat size harvested in St. Mary's Bay was generally twice that of the other beds (Table 3). The weight frequency histograms for St. Mary's Bay (Fig. 2C) contrast with those of Brier Island and Lurcher Shoal (Fig. 2A, B). They are generally more platykurtic in their shape, with more larger meats being harvested.

Figures 2A and B show that the large year-classes were generally fished at low yield, and that on both beds the bulk of the catch weighed under 10 g. It would appear that prerecruits are not adequately protected by the meat count regulation due to the ability to readily blend very large meats. Roddick et al. (1994) suggested reducing the meat counts for the inside zone off Digby, but as Table 3 and figure 2 show, counts as low as 30 would have to be effected to prevent growth overfishing in this area. Even with counts of 30 meats/500g, small scallops can be harvested in large numbers with the present population structure and some directed effort on the older animals (see Fig. 2C, June 1994).

In hindsight, it would have been more productive to have closed these fishing grounds until the large year-classes reached optimum yield levels. Closure and the consequences of growth over fishing on these beds were carefully considered by the industry, however, the lack of other viable fishing grounds forced the above scenario. Had the fishery been prosecuted conservatively, these grounds had the potential of providing good catches for at least 6 years, as has been the case on the Digby beds.

Stock Survey

The average number of scallops at age caught in the 1991-1994 stock surveys are given in Table 4. Both survey areas have recently had years with higher than average numbers of prerecruit scallops, an order of magnitude greater than other years (Table 4). The beds immediately below Brier Island (Fig. 3) had a large number of 2.5 year old scallops in the 1992 survey (1989 year-class), whereas further south, below Lurcher Shoal, greater numbers of 3.5 and 4.5 year old scallops were found in 1993 (1988 and 1989 year-classes). These animals may be from the same year-class (1989?), however, there was probably a second good year-class which settled only on the Lurcher beds, which was not detected in the surveys prior to 1993 due to the number of tows and their location (Fig. 3). The settlement of these strong year-classes does not appear to have extended into St. Mary's Bay, however, survey coverage of that area was restricted and some fishermen reported "seed" in that area (Table 4). Data from the commercial catch supports this conclusion (see above). In 1994, moderate numbers of prerecruits were detected in the survey in both areas (Fig. 4). However, their distribution was not even, and they appear to occur in high densities at a few stations. Unlike the strong recruitment pulse which settled largely in the inside fishing zone off Digby (Kenchington and Lundy 1992), the small scallops on these beds are largely mixed with the adults, rendering it difficult to avoid the

settlement areas when fishing. The incidence of "clappers" (paired empty shells) on both beds has been low and stable in the surveys, however, some of the 1994 logbooks report high incidence of clappers in deep water.

On the Brier Island beds the dominant age-class is still that which first appeared in the survey in 1992 as 2.5 year old scallops. Their numbers however have been greatly reduced after two years of fishing. This reduction coincides with increased effort in the areas where they settled (contrast Figs. 1 and 3). Surveys indicate that the stock has been reduced by approximately 70% since 1992, and by 55% since 1993. The targeting of the fleet on the high density areas (Fig. 1), and the subsequent depletion of the resource is readily seen in the survey distribution maps (Fig. 3). On Lurcher Shoal, strong recruitment pulses first observed as 3.5 and 4.5 year old scallops in 1993, resulted in a peak density in 1993. According to port sampling data, the 1994 fishery was largely dependent on these year-classes, which are now 5.5-6.5 years old.

Prognosis

The strong recruitment pulses which settled on Brier Island and Lurcher Shoal have been heavily fished at low yield. The meat count regulation did nothing to protect the young scallops, and it is doubtful that values could be set which would. There has been no large recruitment pulse since the settlement of these animals, however recruitment has continued at a moderate level. With the decline of the Digby stock, the beds below Brier Island are expected to account for a greater portion of the total catch in 1995. Landings are expected to fall, however, as the remainder of the larger 1988 and 1989 year-classes approach a size which maximizes yield, the effect of increased effort will not be felt immediately. Hard fishing of these animals will lead to a greater decline in landings in 1996.

Management Options

The 1994 survey suggests that the 1988 and 1989 year-classes are numerically the most abundant on these beds. These animals are concentrated in the deep water off Lurcher Shoal, where growth is poor. We suggest that the area east of 66°40'W and north of 43°40'N (Fig. 4) be temporarily closed to allow the incoming 1992 year-class (Fig. 4) to reach an optimum yield, and to allow the resident scallop stock to spawn in the absence of fishing pressure. The scallops west of this longitude encompass for the most part the remainder of the 1988 and 1989 year-classes, especially for the Lurcher area. When the grounds are re-opened for fishing, appropriate minimum meat sizes should be enforced. The meat count regulation for the Bay of Fundy should be removed. There is concern that the February 28, 1995 opening of the closure area, will result in increased effort on the prerecruit scallops which are concentrated in this area (Fig. 4).

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Table 1. Estimated Catches (mt) of Scallop Meat For the Full Bay License Holders Derived from Percentages of Log Information from Each Zone Applied to the Statistics Branch Sales Slip Landings.

Year	German /Lurcher	Brier Island	Total (mt)	% Log Compliance
1980	108.5	163.3	271.8	-
1981	246.5	240.4	486.9	95.6
1982	150.4	203.6	354.0	95.5
1983	42.0	45.8	87.8	96.1
1984	37.9	28.5	66.4	92.7
1985	1.9	12.7	14.6	95.7
1986	59.6	3.6	63.2	85.1
1987*	1.6	0.0	1.6	55.0
1988	0.0	0.0	0	17.6
1989	0.0	0.0	0	14.6
1990	0.0	0.0	0	13.8
1991	189.0	260.9	449.9	29.0
1992	459.3	367.5	826.8	48.5
1993	544.2	402.1	946.3	63.6
1994†	595.8	645.0	1240.8	84.0

* In September 1986 the Inshore/Offshore Agreement between fleet sectors formally restricted the inshore fleet from fishing below latitude 43°40' N. German/Lurcher landings from this date forward are from Lurcher Shoal only.

† Data for 1994 is preliminary.

Table 2. Fishery Characteristics for the Outer Reaches of the Bay of Fundy (NAFO 4Xr) and German/Lurcher (NAFO 4Xq) for the Bay of Fundy fleet. Catches are in Metric Tons of Meat and CPUE Pertains to Class 1 Catch Only. Data Prior to 1991 from Robert et al. (1988).

		4Xr			4Xq			
Year	Number of Vessels	Log catch	Class 1 catch	CPUE (kg/hm)	Log catch	Class 1 catch	CPUE (kg/hm)	Total log catch
1979	38	0.05	0.05	4.72	258.25	182.37	25.64	258.30
1980	37	135.31	119.05	12.05	89.91	65.96	10.17	225.22
1981	44	179.23	174.71	10.64	185.51	125.57	8.75	364.74
1982	45	161.25	155.06	7.52	119.11	78.11	6.33	280.36
1983	27	35.24	30.86	5.13	32.30	16.76	2.82	67.54
1984	29	24.90	23.96	3.12	32.90	25.29	3.30	57.8
1985	14	9.71	9.61	3.42	1.45	0.30	0.71	11.16
1986	32	2.11	2.11	1.19	34.62	22.41	20.66	36.73
1987	1	0.00	0.00	0.00	0.41	0.41	7.09	0.41
1988	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-
1991	17	56.42	32.87	3.23	40.87	25.57	5.52	97.28
1992	33	157.30	100.33	3.64	196.63	127.51	3.45	353.93
1993	47	209.63	106.98	3.14	283.69	139.61	4.19	493.32
1994*	68	379.65	210.08	3.10	350.73	216.85	3.08	730.38

*Preliminary

Table 3. Meat Weight Statistics for the Full Bay License Holders by Month and Fishing Ground Calculated from Port Samples of the Commercial Catch.

Year	Month	Meat weight (g)				Sample size	Meat count
		Mean	Min	Max	s.d.	(n meats)	per 500 g
Brier Island Fishing Grounds							
1983	May	10.62	3.66	17.95	3.20	85	47.1
	June	9.00	3.96	27.17	4.19	106	55.6
1991	May	13.55	6.59	38.84	5.70	74	36.9
	June	20.23	4.45	37.55	6.93	50	24.7
1992	June	12.91	5.60	26.20	4.03	77	38.7
	July	13.36	2.80	59.20	8.86	434	37.4
	Sept.	8.64	3.80	17.00	2.12	583	57.9
1993	April	12.50	3.30	25.60	4.74	318	40.0
	May	10.59	3.40	29.60	5.99	280	47.2
	June	9.98	3.90	26.70	3.58	200	50.1
	Sept.	11.31	3.60	42.90	6.51	379	44.2
	Nov.	14.00	7.30	23.70	3.37	71	35.7
1994	March	20.91	9.30	37.00	6.75	53	23.9
	April	19.00	4.90	42.00	7.64	419	26.3
	May	13.64	5.50	22.00	3.20	292	36.7
	June	16.18	4.60	51.50	7.26	1055	30.9
	July	22.00	11.00	37.50	6.30	111	22.7
Lurcher Shoal Fishing Grounds							
1991	June	6.67	2.19	27.58	1.95	1210	75.0
	July	9.17	3.08	33.67	5.15	437	54.5
	August	7.73	3.70	25.51	3.09	134	64.7
1992	June	9.84	3.30	29.00	3.86	312	50.8
	July	10.88	2.50	38.40	4.59	907	46.0
	August	15.20	9.40	27.00	2.75	66	32.9
	Sept.	9.17	4.60	15.70	2.14	446	54.5
1993	April	8.89	3.00	23.80	3.79	225	56.2
	May	7.00	3.00	25.30	2.44	711	71.4
	June	8.21	3.10	17.00	2.02	122	60.9
	Sept.	10.04	3.50	27.80	3.96	597	49.8
	Nov.	14.06	6.10	30.40	4.77	142	35.6
1994	April	15.72	5.60	43.50	7.10	380	31.8
	May	14.40	3.60	32.30	3.80	851	34.7
	July	12.31	4.80	34.30	4.05	971	40.6

Table 3. cont'd. Meat Weight Statistics for the Full Bay License Holders by Month and Fishing Ground Calculated from Port Samples of the Commercial Catch.

Year	Month	Meat weight (g)				Sample size	Meat count
		Mean	Min	Max	s.d.	(n meats)	per 500 g
St. Mary's Bay Fishing Grounds							
1990	June	17.65	8.05	34.78	4.97	57	28.3
1992	June	34.10	7.10	71.60	13.78	132	14.7
1993	January	29.47	7.90	60.40	15.92	39	17.0
	May	18.80	7.90	68.70	11.09	105	26.6
	June	42.84	7.80	70.70	13.13	109	11.7
1994	June	17.09	3.70	67.30	11.42	465	29.3
	July	28.89	7.60	64.60	12.31	33	17.3

Table 4. 1991-94 Stock Survey. Average Number of Scallops-at-Age Caught in a Seven-Gang Digby Drag Projected from the Average of an End and a Middle, Unlined Bucket for Recruits (age >4 years) and from the Average of an End and a Middle, Lined Bucket for Prerecruits (age ≤4 years).

	Age (years)										
	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5+	Total	No. of Stations
Brier Island Survey											
1991	30	8	6	13	8	8	4	3	18	98	35
1992	510	28	10	24	14	14	8	5	17	630	31
1993	35	168	87	97	27	12	8	5	16	455	37
1994	44	18	63	89	22	11	7	5	9	268	48
Lurcher Survey											
1991	16	55	14	54	36	7	1	1	6	190	24
1992	13	36	113	89	61	17	10	3	13	355	16
1993	48	515	244	153	66	35	18	8	18	1105	44
1994	44	19	128	125	59	25	10	5	15	430	48
St Mary's Bay Survey											
1994	1	3	8	9	2	3	1	1	6	34	5

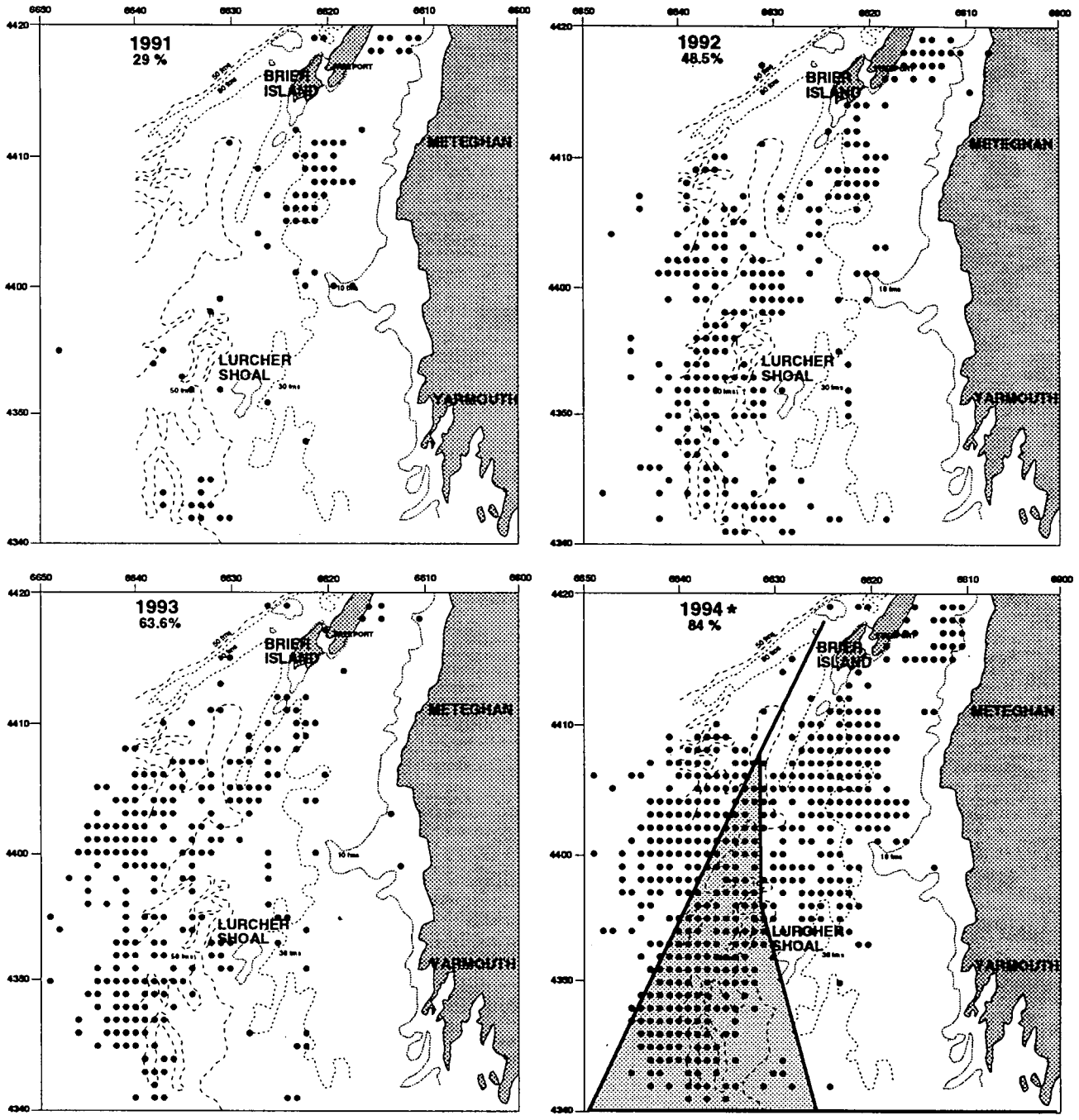


Fig. 1. Fishing locations (1991-1994*) on the fishing grounds below Brier Island, N.S. as reported from fishing logbooks (% log compliance shown). In 1994 the Scotia-Fundy Region Close Time Variation Orders, 1994-117 and 1995-001, closed the area east of the solid lines to scallop dragging from Nov. 19, 1994 until May 31, 1995 and the shaded area until Feb. 28, 1995.
*1994 preliminary data

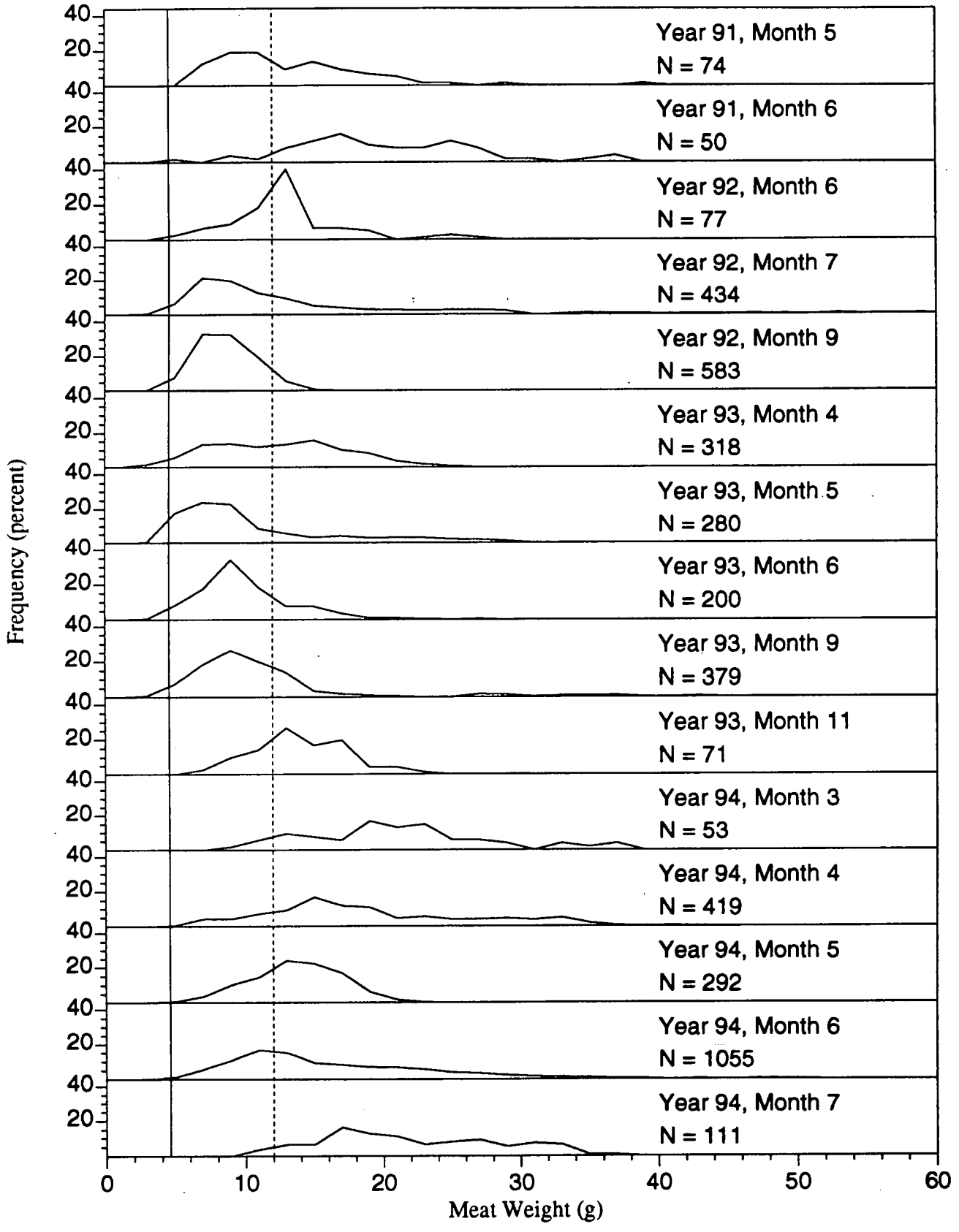


Fig. 2A. Frequency distribution (percent) of meat weights from the commercial catch from the Brier Island fishing grounds. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth over fishing meats larger than 12 g should be harvested.

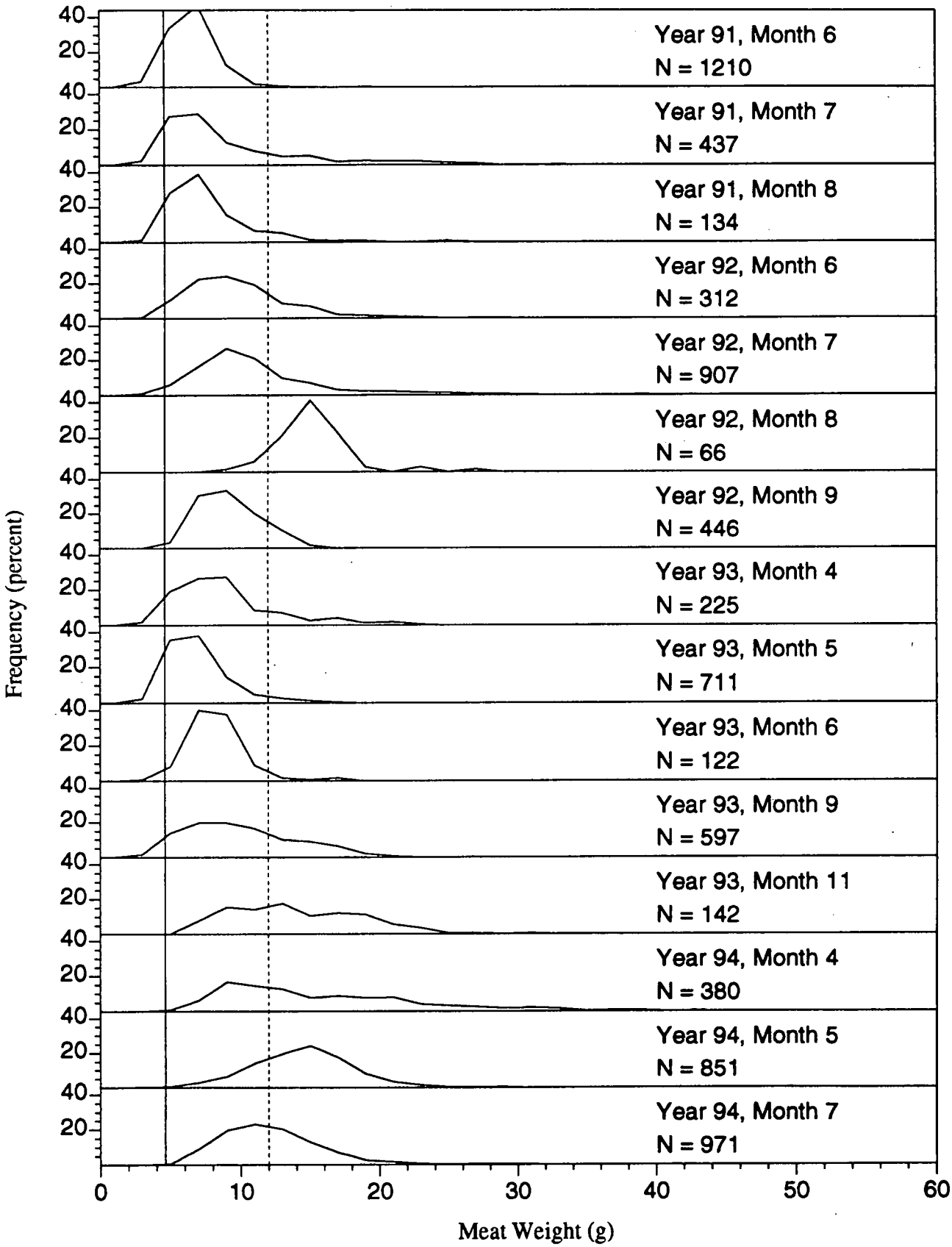


Fig. 2B. Frequency distribution (percent) of meat weights from the commercial catch on Lurcher Shoal. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth over fishing meats larger than 12 g should be harvested.

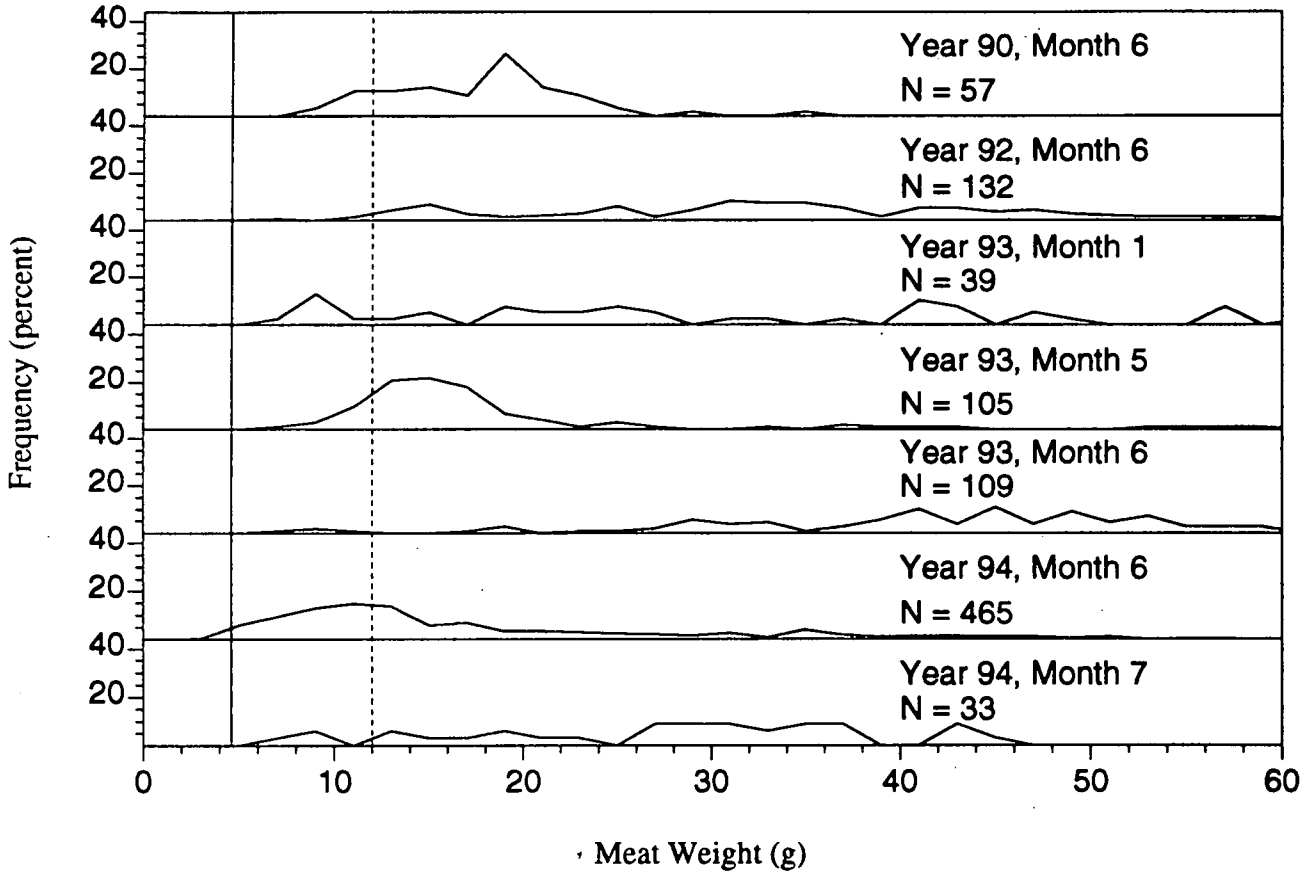


Fig. 2C. Frequency distribution (percent) of meat weights from the commercial catch in St. Mary's Bay. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g, To avoid growth over fishing meats larger than 12 g should be harvested.

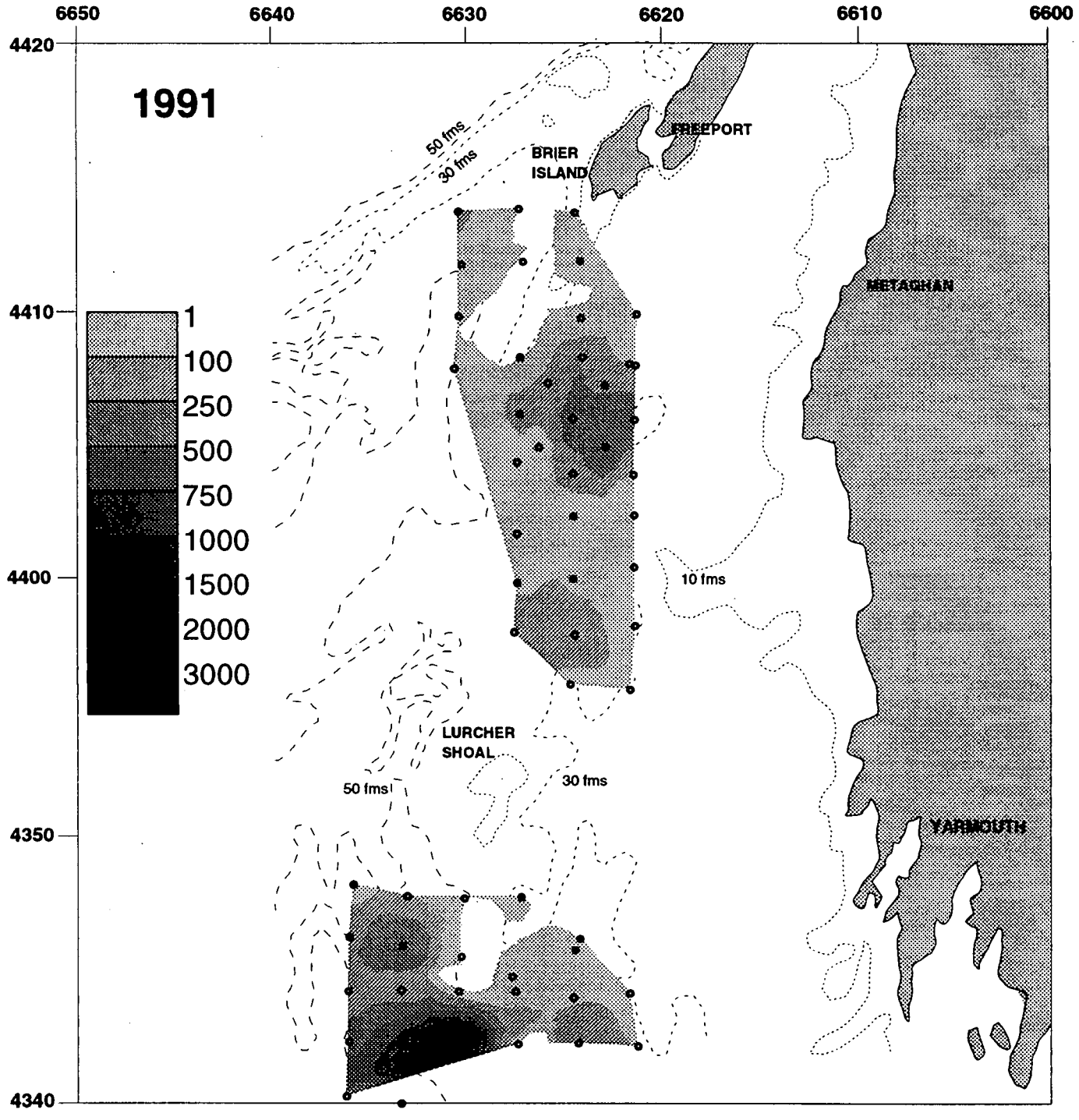


Fig. 3. 1991-1994 stock surveys. Spatial distribution of scallops contoured using ACON 5.01 derived from Delaunay triangulation and inverse distance weighted interpolation. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Closed circles depict tow locations.

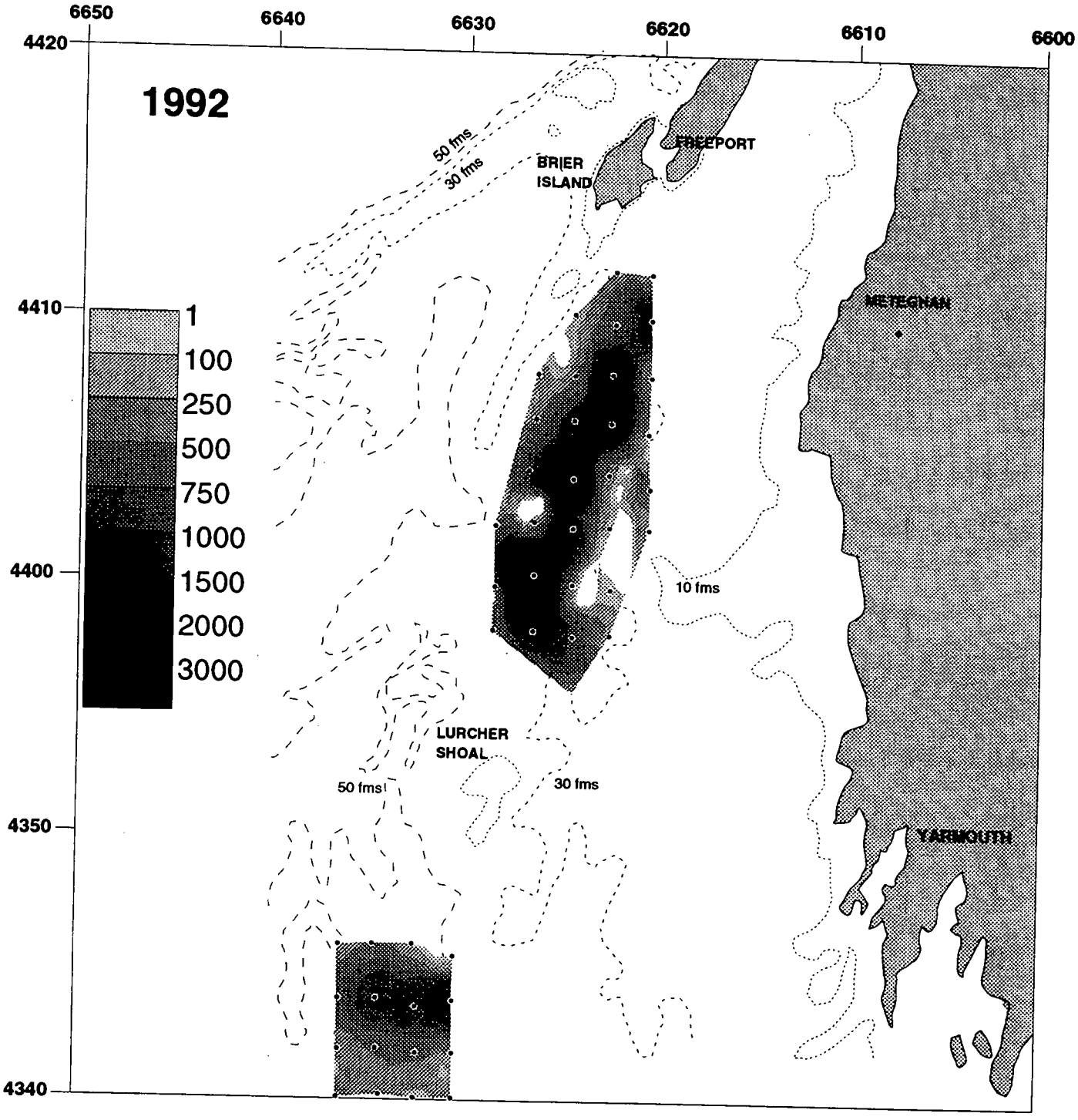
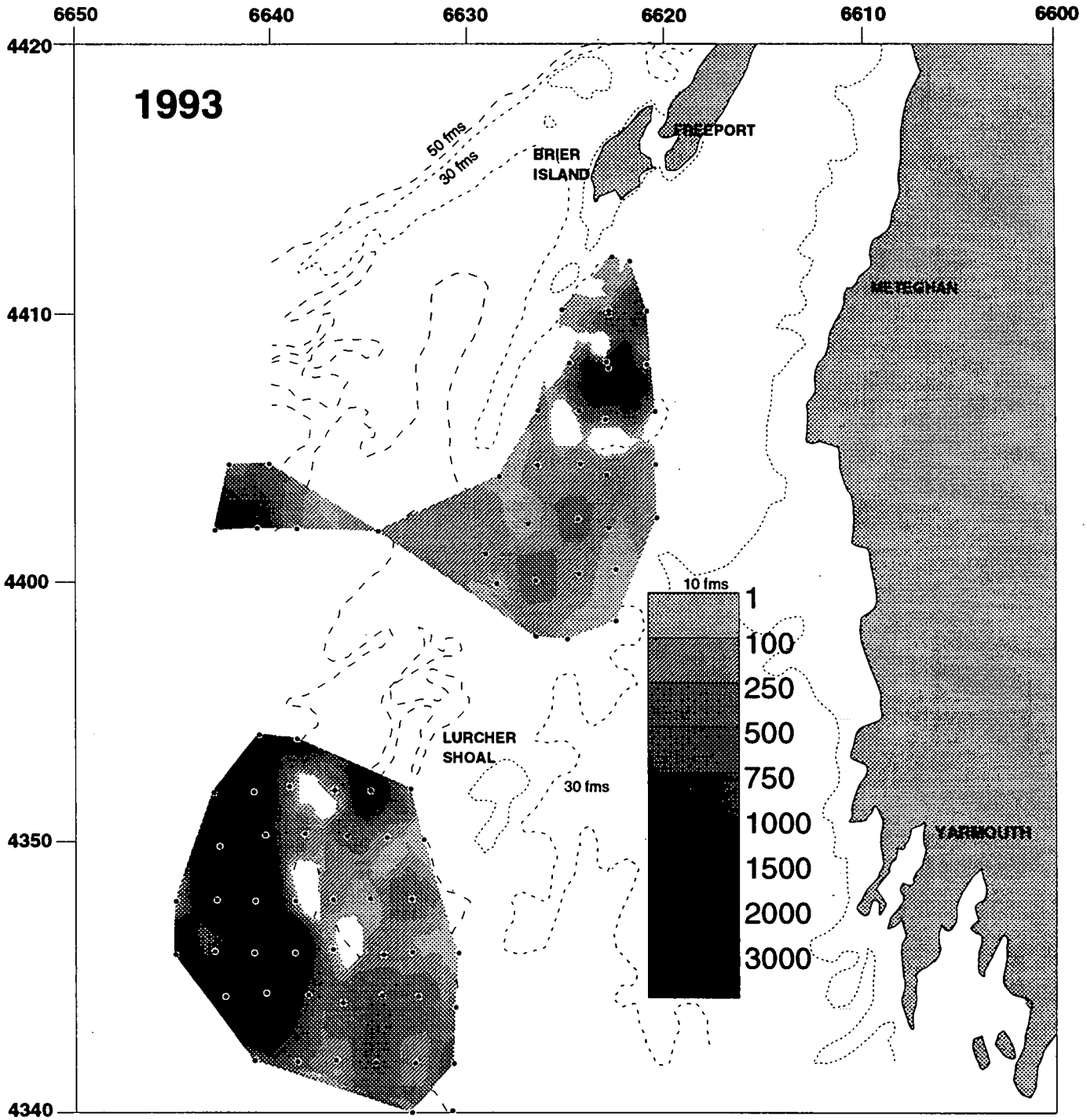


Fig. 3. cont'd. 1991-1994 stock surveys. Spatial distribution of scallops contoured using ACON 5.01 derived from Delaunay triangulation and inverse distance weighted interpolation. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Closed circles depict tow locations.



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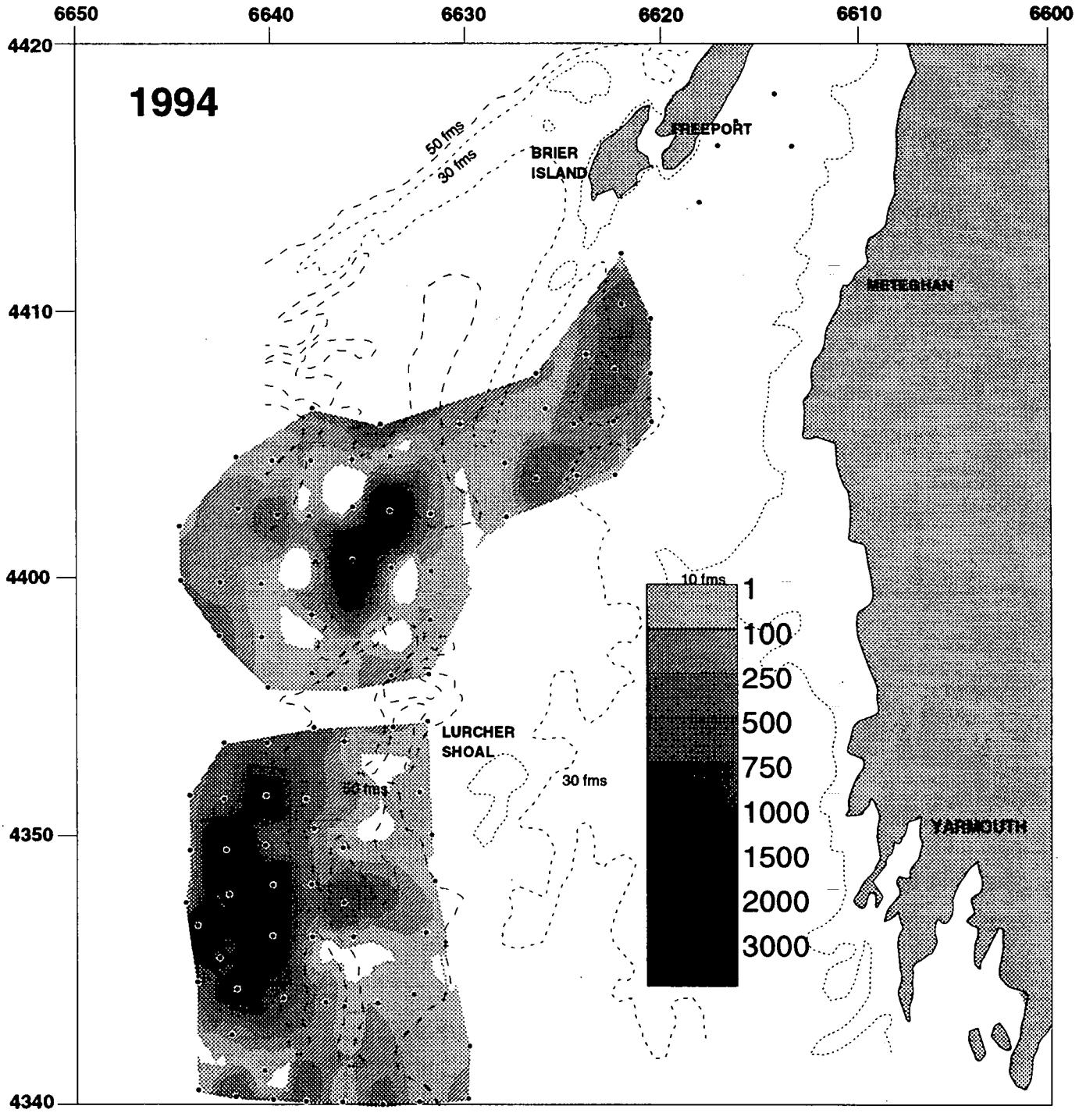

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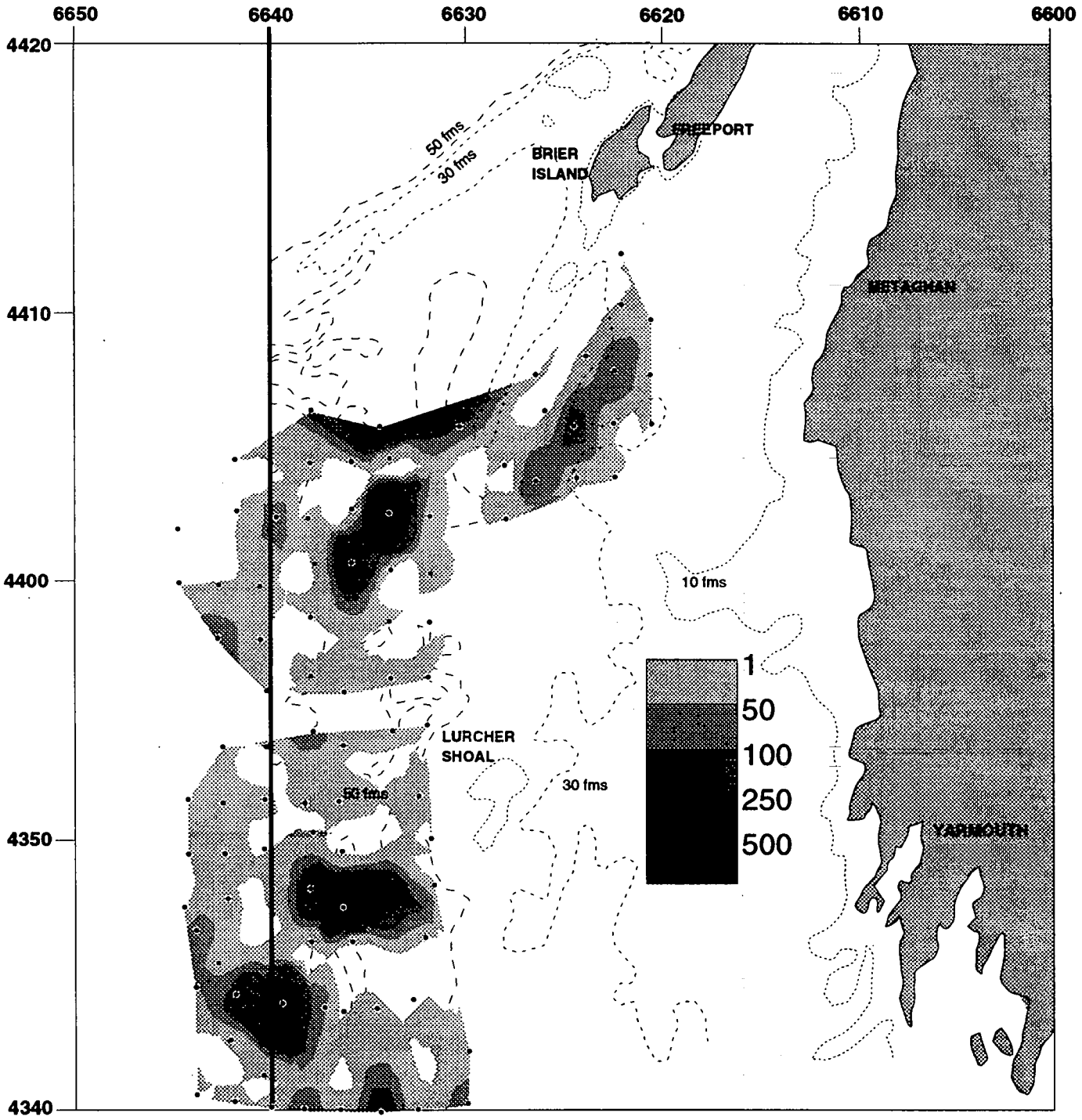

Fig. 4. Spatial distribution of 2 year old scallops (prerecruits) found during the 1994 stock survey. The solid line indicates a possible closure line for management consideration.