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An Overview of the Scallop Fishery in the Bay of Fundy 1986 to 1994 with a Report on Fishing Activity
Trends Amongst the Dual License Holders in the Full Bay Fleet

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Abstract

The total catch landed in the Bay of Fundy in 1994 by all license types was approximately 2270 mt, which is comparable to 1993 landings. Thirty-seven percent of this was landed in Digby (District 38) by the vessels over 25.5 G.T. Statistical District 36 (Meteghan) was the only District to show a strong increase in landings in 1994 compared to 1993. Meat weights for the Inside Zone winter fishery off Digby remain at a large size with average weights of over 30 g appearing regularly through 1991 to 1994. Large meats were also landed from the Outside Zone off Digby. However, when aggregations of small scallops were found they were fished heavily at low yield. The activities of the dual (groundfish/scallop) license holders were documented from 1981 to 1994. The recent effect of small groundfish quotas has been a movement of the dual licensed fleet into directed scallop fishing. Multiple groundfish quotas are transferred to a single boat allowing that boat to fish the quota economically, while the original owners of the quota free their boats up to fish scallop-only. Scallop-only fishing amongst the dual license holders was highest in 1994 with over 90% of this fleet targeting scallops.

In both the Inside and Outside Zones, older animals (7 years old and greater) comprise the greater part of the numbers, as determined from stock surveys. In 1994, there was some indication of pre-recruits (less than age 4) in both areas. This is the largest recruitment pulse seen in the surveys since the large year classes that entered the fishery in 1987 and 1988, however it is not very strong. The spatial distribution of scallops has been quite uniform over the beds, in contrast to earlier years. However, the frequency of empty tows has progressively increased, and stations with fewer than 100 animals per tow dominate the 1994 survey. Bottom temperature during the annual surveys has ranged from 4.6 to 8.6°C, with 1991 and 1994 being warm years in June.

Résumé

Les prises totales débarquées dans la baie de Fundy en 1994 par les titulaires de tous types de permis se chiffraient à environ 2 270 tonnes métriques, ce qui est comparable aux débarquements de 1993. Trente-sept pour cent de ces prises ont été débarquées à Digby (district 38) par des bateaux de plus de 25,5 tonnes de jauge. Le district statistique 36 (Meteghan) a été le seul à connaître en 1994 une forte augmentation par rapport à l'année précédente. Les chairs provenant de la zone intérieure de pêche hivernale, au large de Digby, demeurent grosses et atteignent couramment depuis 1991 un poids moyen de plus de 30 g. Des chairs de grosse taille provenant de la zone extérieure de Digby ont également été débarquées. Toutefois, en présence de concentrations de petits pétoncles, les pêcheurs ont fortement exploité ces dernières, à faible rendement. On rend compte des activités des titulaires de double permis (poisson de fond/pétoncle) de 1981 à 1994. Les petits quotas de poisson de fond fixés récemment ont entraîné un mouvement de la flottille de titulaires de double permis vers la pêche dirigée du pétoncle. Les quotas de poissons de fond multiples sont transférés à un seul bateau, apte à les exploiter de façon rationnelle, tandis que les détenteurs initiaux de ces quotas libèrent ainsi leurs bateaux pour pratiquer la pêche exclusive du pétoncle. Celle-ci a atteint son plus fort parmi les détenteurs de permis double en 1994, alors que cette flottille ciblait le pétoncle dans une proportion de 90 %.

Tant dans la zone intérieure que dans la zone extérieure, les plus vieux pétoncles (7 ans et plus) composent l'essentiel de l'effectif, comme l'indiquent les relevés de recherche sur le stock. En 1994, on trouvait des indices de prérecrues (moins de 4 ans) dans les deux zones. Il s'agit là de la plus grosse poussée de recrutement observée dans les relevés depuis l'apparition des fortes classes d'âge recrutées à la pêche en 1987 et en 1988, quoiqu'elle ne soit pas très forte. La distribution spatiale des pétoncles a été relativement uniforme entre tous les gisements, contrairement aux années précédentes. Toutefois, la fréquence des traits vides a progressivement augmenté et les stations où l'on compte moins de 100 animaux par trait dominant le relevé de 1994. Les températures du fond au cours des relevés annuels ont varié de 4,6 à 8,6 °C, le mois de juin ayant été chaud en 1991 et en 1994.

Introduction

The scallop beds off Digby, N.S. have been unstable over the last decade. Two strong recruitment pulses, first observed in 1986 and 1987 as 2 year old animals, contributed to unprecedented high landings in 1988 through to 1991. While scallop abundance increased in many parts of the Bay due to these year classes, the greatest concentration of scallops was centered on the inside fishing zone (< 6 miles from Parker's Cove to Centreville, open October 1 to April 30) and off Cape Spencer, N.B. In the spring of 1989, the incidence of "clappers" (empty paired shells) off Digby rose from an average of 3% over the previous four years to approximately 23%. By the fall, this value further increased to 51%, with over 90% dead in some areas. Approximately 6,000 metric tons of scallops were lost (excluding catches for that year of 2644 mt, and any potential yield of these animals).

Consequently, the Full Bay [of Fundy] fleet targeted the Cape Spencer bed, on the New Brunswick side, during the winter of 1989-90. This fleet returned to fish the Inside Zone in October 1990. In May 1991, poor catches in the Outside Zone (area of the bed outside the Inside Zone, with no seasonal closure) led to fishing off Brier Island and the Lurcher Shoals. The Full Bay fleet returned to the Inside Zone in October of 1991. Since 1992, much of the effort has been concentrated on the Brier Island and Lurcher Shoal stocks. These beds are detailed in another document (Kenchington et al. 1995a). A quantitative stock assessment of the Digby fishing grounds has been prepared (Kenchington et al. 1995b). However, information not required for the VPA input was not detailed.

This document presents data on fishery performance of the Bay of Fundy license holders, evaluated through a presentation of landings by Statistical District, and fleet sector revenue. Since DFO surveys of the beds around Grand Manan, off Saint John, N.B. (Cape Spencer), and in the Upper Bay were discontinued in 1992, this data provides the only assessment of activities in these areas.

Commercial meat weight data (1981 to 1994) is presented for the Full Bay license holders and the weight distribution of the catch is related to the meat count and size regulations.

In addition, we have done a preliminary assessment of the relationship between groundfish and scallop activity amongst the dual license holders. Through the last decade, there have been great changes in the both industries. However, the relationship between the two has only cursorily been examined (Kenchington and Lundy 1992).

The spatial distribution of scallops on the Digby beds, and corresponding temperature data are reported for 1991 to 1994.

Fishery Performance

Data Sources

Information on the fishery is gathered from two main data sources: logbooks and sales slips (Commercial Data Division, Program Coordination and Economics Branch, DFO).

All Full Bay of Fundy license holders are required to provide logbook information that provides data on catch, location and effort. Currently, 99 vessels are required to report (Table 1). The number of Full Bay licenses has remained the same since 1990, however the number of active licenses has varied from year to year (Table 1). There has been an improvement in the overall log compliance of this fleet (an increase from 28% coverage in 1991 to 87% coverage in 1994) and the quality and quantity of logs per vessel has improved. Catch per unit effort (CPUE) was calculated from the Class 1 (complete) logbook data and recorded in kg of catch per hour towed per meter of gear (kg/hm). Mid Bay [of Fundy] and Upper Bay [of Fundy] fleet sectors are not required to provide logbook information, unless their vessels are over 25.5 G.T. (a few Mid Bay vessels fall into this category). Although some license holders from these sectors have voluntarily submitted logbooks, the data from these have not been processed due to a lack of personnel. All logbook records are retained should resources become available in the future.

Sales slip data from 1986 to 1994 are reported by vessel size class and Statistical District (Fig. 1), with 1994 landings additionally broken down by month. Generally vessels weighing more than 25.5 gross tonnes are Full Bay license holders. There were no landings reported from Districts 41 or 43. For the Digby fleet, logbook records are used to determine further what portions of the total sales slip catch for the fleet was harvested from which of three scallop beds (Kenchington et al. 1995a, b). This breakdown is not reported again here. Annual landed value of the catch determined from sales slip data and broken down by fleet sector, was obtained from Commercial Data Division, Program Coordination and Economics Branch, DFO.

A listing of all Full Bay scallop licenses and any associated licenses by year (1981-1994) was obtained by special request from Licensing Unit, Resource Allocation and Licensing Branch, DFO. This list had to be collected because of the common practice of license transfers. Information on license transfers within a year, and the number of dual scallop/groundfish license holders was provided. Landings by vessel (CFV number) by month by year were obtained from Commercial Data Division of Program Coordination and Economics Branch (DFO) (Their Table 22). By cross referencing the two listings it was possible to track vessel landings by license. This data was organized into the number of licenses that were unused, fishing scallops only, fishing groundfish only, and fishing both groundfish and scallops, by month from 1981-1994. We do not have information on the number of days fished in each category from these sources. This data indicated that mixed fishing was greater than scallop-only fishing in recent years, and gave results that were inconsistent with the fishermen's statements of their activities. This was because bycatch landings are recorded as well as landings due to directed fishing. As our interest was in using this data to evaluate the impact of the directed fisheries on each other, we classified vessels which landed scallop *and* less than 10 mt of groundfish a year as scallop-only. Some vessels landed less than this amount of groundfish annually, particularly in the 1980s, but did not land scallop with the groundfish on a monthly basis. These were classified as groundfish-only for that month. The 10 mt cut off was not chosen arbitrarily from a continuous level of landings. Most vessels we attributed bycatch to, landed less than 10 mt annually. In contrast, directed groundfish landings amongst dual license holders were higher, with at least 24 mt being landed and generally an order of magnitude greater than this. These assumptions were verified by contacting the owners of several dual licensed vessels and elucidating their fishing practices.

Port sampling of the commercial catch has been carried out in Digby, N.S. since 1981 (Kenchington et al. 1995b). Two, 500 g meat samples were collected from co-operating vessels as they landed. Individual meat weights and fishing location were recorded from each sample.

1994 Landings By Statistical District , Vessel Size Class and Month

The total catch landed in the Bay of Fundy in 1994 by all license types was approximately 2270 mt. Thirty-seven percent of this was landed in Digby by the vessels over 25.5 G.T.

The 1994 landings in the Upper Bay are provided by month in Table 2. Total landings were approximately 49 mt, with 84% of this being landed by small vessels (under 25.5 G.T.). Fishing in the Upper Bay is generally conducted from April through to December, due to ice in the early winter months. Landings are generally harvested from resident stocks.

In 1994, landings for the southwest New Brunswick area, including Grand Manan (District 50) were approximately 254 mt (Table 3). The greatest activity in this District was seen in January, February, and in March consistent with the seasonal fishery noted by Robert and Lundy (1986). A large area south of Grand Manan is closed from April 1 to the second Tuesday in January by variation order. The effect of this closure is seen in the landings from the smaller vessels which largely fish these beds. Landings by the larger vessels in District 50 continue throughout the year.

The landings for Statistical Districts 48 and 49 (Saint John and surrounds, Table 4) were approximately 122 mt. Most of these landings were in District 49 (Fig. 1), and by vessels under 25.5 G.T. Combined landings of Districts 48 to 53 were approximately 376 mt.

Landings in Statistical Districts on the Nova Scotia side of the Bay of Fundy are shown in

Tables 5 and 6, and detailed in Kenchington et al. (1995a, b). In contrast to other Statistical Districts, landings in these areas are almost exclusively by vessels over 25.5 G.T.

Annual Trends in Landings By Statistical District and Vessel Size Class (1986-1994)

Statistical District 36 was the only District to show a strong increase in landings in 1994 compared to 1993. Annual landings in the Upper Bay Districts (Districts 40, 44, 79, 24) are illustrated in figure 2. Most of the landings in these Districts since 1986 are reported by small vessels under 25.5 G.T., however, in 1989, landings from the larger vessels begin to appear. Landings by the over 25.5 G.T. vessels in the Upper Bay declined again by 1994.

Annual landings in the Grand Manan area and surrounds are shown in figure 3. In contrast to the Upper Bay, landing pattern by vessel size has shifted during the period of 1986-1994. In Grand Manan itself (District 50), where the majority of the catch is landed in this area, small vessels contributed most to the catch from 1986 to 1988. Since 1988, most of the landings have been by over 25.5 G.T. vessels. This pattern is also seen in District 53, beginning in 1991. In District 51 large vessels dominated the catch from 1988 to 1991, however from 1992 small vessels have landed more in this area. In District 52, small vessels have consistently dominated the catch since 1986, however the total amount landed in this District is small relative to Districts 50, 51 and 53.

The annual landings by vessel size class from 1986 to 1994 for the Saint John area (Districts 48, 49) are shown in figure 4. Smaller vessels contribute most to the landings in these areas. Landings in District 48 peaked in 1989 and 1990 as the result of an exceptionally strong year class reaching the legal size limit in this area. These landings have since declined to just above 1986 and 1987 levels. In District 49 landings peaked in 1993 and remain high. Landings for the combined area peaked in 1989 and 1990 at 735 mt, but are currently at approximately 382 mt, a level consistent with landings reported by Robert and Lundy (1986) from 1981 to 1985.

Annual landings for the Digby area, including Digby Neck, (District 37, 38, 39) are shown in figure 5. Large vessels have consistently dominated the catch in this time series. Some landings by small vessels were reported in 1989 from the Parker's Cove area (District 39). Landings in District 38 (Digby) have declined steadily since the peak in 1989, while landings in Districts 34 and 36 (Meteghan, Yarmouth, Fig. 6) have increased sharply since 1991. These landings reflect the heavy exploitation by the Digby fleet, of the grounds in the Brier Island and Lurcher Shoal areas beginning in 1990 (Kenchington et al. 1995a).

Relationship Between Landings and Value By Fleet Sector (1986-1994)

Although the District landings show trends by geographical area and vessel size class, the performance of each fleet sector can only be estimated from these data. Figure 7 illustrates the landings and revenue by each fleet sector. Recently, market price for Bay of Fundy scallops has been determined by size, with larger meats demanding the highest price. Thus the relationship between landings and revenue is not strictly one of amount caught versus dollar paid, as size of the product is factored into the value.

Landings and revenue for the Full Bay fleet peaked in 1989 and then fell in 1990 and 1991. Prior to 1992 revenue followed the landing pattern, however in 1992 market prices began to increase and in 1994 revenue was at its second highest value. Landings and revenue were also linked in the Mid Bay fleet statistics until 1992, however revenue peaked in 1993. A similar pattern is seen in the Upper Bay fleet until 1994. Revenues and landings in 1994 have dropped dramatically. This was not seen in the landings by Statistical District, implying either that many of the landings in these Districts are by vessels with other than Upper Bay licenses, or that the data is incorrect. A full account of the economic performance of the fleet from 1986 to 1993 can be found in Digou (1994).

Spatial Distribution of Fishing Effort Amongst Full Bay Licensed Vessels

Figure 8 illustrates the distribution of fishing effort for the Full Bay license holders, as reported from log records. The number of log records has increased dramatically, since 1991, thus the distribution of effort cannot be compared directly from year to year, but only relatively, within a year. However, the extent of the area fished is more comparable between years, assuming a random submission of logs. The inside fishing zone off Digby is closed to fishing from May 1 to September 30, thereby reducing the potential number of fishing days for that area. Similarly, St. Mary's Bay is open to scallop fishing in January and June only. In 1991 we begin to see the localization of fishing effort below Brier Island. By 1992, effort has increased below Brier Island and on the Cape Spencer bed on the New Brunswick side. In 1993, the fleet has expanded right up into the upper reaches of the Bay, contracting somewhat in 1994. In 1994, some areas below Brier Island saw more than 200 days of fishing. The location of the catch has been identified for the Full Bay license holders using log records (Kenchington et al. 1995b), confirming the location of effort on the Brier Island and Lurcher Shoal beds.

Estimations of CPUE have improved with the increase in log data and Class 1 data. In 1991, CPUE on the Digby grounds was estimated at 4.4 kg/hm. CPUE has fallen each year and is currently estimated as 2.0 kg/hm, the lowest value reported to date (see Kenchington et al. 1995b).

Commercial Meat Weight Distribution: Full Bay Licensed Vessels

Meat weights for the Inside Zone winter fishery off Digby (Table 7) remain at a large size with average weights of over 20 g appearing regularly through 1991 to 1994. The regulation meat count for the fishery from October 1 to April 30 is 55 meats per 500 g. All of our port samples were within this count, with 1994 samples ranging from 21.8 - 36 meats per 500 g. The meat weight frequency distribution of the port samples (Fig. 9a) indicates that the minimum shell height regulation was respected. However, when aggregations of small scallops are found they have been fished heavily at low yield (Fig. 9a).

Port sampling statistics for the Outside Zone off Digby are given in Table 8. The meat count for the summer fishery is 72 meats per 500 g (see above for winter count). Meat counts were respected in both the winter and summer fisheries in this zone (Table 8). In 1994, the minimum shell height regulation was respected (Fig. 9b), however, violations appear throughout the time series in previous years. Significant amounts of small scallops are regularly harvested.

Trends In The Number of Multiple Licenses Amongst the Full Bay License Holders

The number of Full Bay license holders with only one license (scallop) has gradually increased from 12 in 1981 to 31 in 1993 and 1994. However, the number of Full Bay license holders with one additional license has remained roughly the same since 1981 (Table 9). The number with two, three and four additional licenses has declined. This means that the increase in scallop-only license holders has been drawn from those with more than one license. Additional licenses since 1981 have included those for groundfish, squid, herring, lobster, shrimp, swordfish, crab, mackerel and salmon (Table 10). Presently, there are no crab, mackerel, or salmon licenses, and only 2 shrimp licenses. The majority of the additional licenses are for groundfish and swordfish. Groundfish licenses have been reduced from 81 in 1981 to 58 in 1994. Swordfish licenses, on the other hand, were increased four-fold in 1986 from 7, rose to 50 in 1988, and have since declined to 24 in 1994 (Table 10). However, the majority of these licenses have been inactive. The number of licenses were compiled from the available statistics, however, from 1982 to 1984 the reporting and licensing system was being revised while many new vessels were being built to replace an ageing fleet. Consequently the total number of Full Bay licenses exceeds 99 in these years. To our knowledge, and in agreement with active fishers at the time, there has never been more than 99 Full Bay licenses. The increased numbers in these years may also include some New Brunswick based vessels, restricted to 7 miles from shore,

prior to the advent of the Mid Bay fleet in 1985.

Groundfish and Scallop Activity Amongst Dual License Holders

The percentages of scallop only, groundfish only and mixed fishing activity presented in Figures 10 and 11 do not total 100, as the percent inactive was not plotted. In any one month 1 to 80% of the vessels were inactive during this time series. High percentages of inactive vessels by month are seen in December and January throughout.

From 1981 to 1985, the majority of dual (groundfish and scallop) license holders fished scallops exclusively (Fig. 10) with no prominent monthly trend in activity (Fig. 11) excepting a slightly lower percentage of vessels fishing in the winter months (January especially) in some years. Those few vessels fishing groundfish exclusively showed the opposite monthly bias, that is a slightly higher percentage of vessels fishing the summer months (Fig. 11). Mixed fishing within a year (Fig. 10) was quite common, but was rare on a monthly basis (Fig. 11), suggesting that gear changes were timed somewhat to the month. During this period the groundfish TACs were high, although the catches of both cod (Campana and Hamel 1992) and haddock (Hurley et al. 1992) were declining.

In 1986 this pattern changed (Fig. 10) due to a number of factors. Scallop landings were at a low period and government surveys detected the presence of a large number of scallop prerecruits. As a result, the Inside Zone off Digby was extended to 8 miles from shore and closed to protect the incoming year classes. For the only time in this time series groundfish exclusive fishing was more active than scallop exclusive fishing on an extended monthly (Jan. 1986 to June 1987, excluding May 1986) basis. Coincident with the decline in the scallop fishery, the groundfish fishery was at a peak (1986; Digou 1994), further increasing the incentive for dual license holders to spend more time in this fishery (Fig. 10). In this year, and continuing through to 1987, a strong mixed fishery appears, with vessels spending a part of each year (Fig. 10) fishing both scallop and groundfish. Mixed fishing within a month is insignificant (Fig. 11).

Exploitation of the large year classes off Digby began with the opening of the Inside Zone off Digby in October 1987, resulting in strong directed scallop fishing with over 75% of vessels active (Fig. 11). In both 1987 and 1988, the even activity pattern of early years is gone, and increased activity is associated with the opening of the Inside Zone each year. In 1988 and 1989 all dual license holders were scallop fishing from October to December. Groundfish exclusive activity fell dramatically from August of 1988 through to the summer of 1990, and total landings by this gear sector show a decline from 1986 to 1990 (Digou 1994). In 1987 and 1988 the groundfish fishery was closed or restricted several times during the year.

From 1989 to 1994 scallop activity is high all year (generally over 60%), with no strong monthly trends. In 1994, there was more scallop-only fishing than in any year previous with over 90% of the dual license holders targeting scallops. In 1989, the groundfish stocks had largely disappeared and the mobile gear sector < 65 ft exceeded their cod/haddock/pollock (CHP) quotas (introduced in 1989 - c.f. Hurley et al. 1992) and were tied up in June (Figs. 10, 11). By the second half of 1990 groundfish exclusive fishing picked up and is regulated by CHP trip limit (Hurley et al. 1992). ITQs were introduced to this fleet in 1991. The decline in groundfish activity associated with the ITQ cuts of September 1993 can readily be seen (Fig. 11). Groundfish fishing ceased for the next three months and has not returned to any significant degree due to very low quotas. Not apparent in Figure 10 is the large increase in groundfish bycatch from 1990 to the present. In 1990, approximately 10% of the scallop fishing vessels landed groundfish (largely monkfish tails and liver) bycatch. This has increased steadily to approximately 50% in 1994. These landings can be distinguished from directed groundfish activities, as their annual groundfish landings by vessel are well below 10 mt.

Figure 12 shows the relationship between the percentages of vessels fishing scallop and groundfish and those fishing scallop-only by year. While the correlation is significant, it is largely driven by the post-1986 data points.

Thus the consequence of small groundfish quotas has been a movement of the fleet into directed scallop fishing. Multiple groundfish quotas are transferred to a single boat allowing that

boat to fish the quota economically, while the original owners of the quota free their boats up to fish scallop-only. In short the groundfish stocks are being conserved at the expense of the scallop stocks in this area.

Research Vessel Stock Surveys

The Department of Fisheries and Oceans has conducted annual June surveys of the traditional scallop beds off Digby, N.S. since 1978. Stock surveys of the Upper Bay, and New Brunswick stocks had been done periodically during this time, but have not been assessed since 1992 due to Departmental budget cuts restricting surveys of these areas. Specifically, Grand Manan stocks were surveyed from 1979 to 1983, 1985 to 1987 (cf. Robert and Lundy 1987), and from 1988 to 1991 (Robinson and Chandler 1990, Robinson et al. 1992), the last report including the Cape Spencer area.

Stock surveys of the Digby grounds (1991-1994) were conducted using the research vessel "J.L. Hart" with 4 gang gear (Kenchington et al. 1995a). There was no change to the gear configuration during this time. To estimate the relative abundance of small scallops (< 80 mm shell height) two drags were lined with 38 mm polypropylene mesh. However, abundance of scallops with shell height under 40 mm is not reliably estimated and can only be used as a qualitative index of recruitment (Kenchington et al. 1995a). For analytical 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. The lengths of the tows were also standardized to 800 m.

From 1991-1994, survey stations were randomly assigned according to one of three areas: Core Area, Below Core Area and Above Core Area (Robert et al. 1985), which were originally defined according to commercial catch levels. From 1991 to 1992, the Area Strata were arbitrarily assigned 75, 10 and 15 stations respectively with the intent of weighting the number of stations in favour of the Core Area, which has historically been the most productive. In 1993 and 1994, the number of stations per strata was changed to reflect the relative geographic area of each stratum. Accordingly 53, 16 and 31 stations were assigned to the Core Area, Below Core Area and Above Core Area strata respectively. Details of station assignment within Areas are provided in Kenchington et al. (1995a). Bottom temperature was recorded from 1991-1994 for each tow using a VEMCO digital sub-surface temperature recorder (Vemco Ltd., Shad Bay, N.S.).

Ageing and Abundance Data

Scallops from the commercial catch and research vessel surveys (Kenchington et al. 1995a) were aged in the lab and the annual rings on the shell (Bourne 1964) were measured. Three depth-dependent von Bertalanffy growth curves have been established using data from 1982-85 to convert shell height to numbers-at-age matrices (Robert et al. 1985, Robert et al. 1990).

Kenchington et al. (1995b) used two growth curves, one for the VPA inside zone and one for the VPA outside zone to determine the catch-at-age. In this paper the depth-related curves are used to better characterize the entire stock, as there are shallow banks in the Outside Zone.

The parameters of the curves are:

Depth (m)	Asymptotic Shell Height (mm)	t_0	k
00-85	143.210	1.3800	0.2221
86-105	133.763	1.4011	0.2414
>105	125.989	1.4469	0.2610

Scallops collected during the research vessel surveys were measured to 5 mm shell height increments. The numbers 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.

Spatial distribution of the scallops and bottom temperature were 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 or temperature was used as input. The resulting "volume" estimates (i.e. abundance integrated over area) are less accurate in areas of low station densities.

1991-1994 Digby Stock Surveys

The average number of scallops-at-age per standard tow caught in the 1991-1994 stock surveys are given in Table 11. In both the Inside and Outside Zones, older animals (7 years old and greater) comprise the greater part of the numbers. In 1994, there was some indication of pre-recruits (less than age 4) in both areas. This is the largest recruitment pulse seen in the surveys since the large year classes that entered the fishery in 1987 and 1988, however it is not very strong.

The spatial distribution of scallops determined from the survey data (1991 to 1994) is illustrated in figure 13. The distribution of scallops has been quite uniform over the beds, in contrast to earlier years (Kenchington and Lundy 1992). However, the frequency of empty tows has progressively increased, and stations with fewer than 100 animals per tow dominate the 1994 survey (Fig. 13). Bottom temperature during the surveys (Fig. 14) has ranged from 4.6 to 8.6°C, with 1991 and 1994 being warm years in June. This warm water recording is consistent with the summary of hydrographic conditions in the Gulf of Maine which suggest that the warm temperatures persisted for the second half of the year and were oceanic in origin. Over the survey area, there are larger changes between years, than between stations within a year. Bottom temperature will be used to interpret growth curves and year class strength, once a greater time series has been established.

Prognosis

Landings in the Bay of Fundy remained stable in 1994, and with the low value of the Canadian dollar, procured a good price on the Boston market (Fig. 15). However, abundance on the Digby grounds is very low and CPUE is the lowest on record in this area. The bulk of the 1994 landings was harvested below Brier Island (Kenchington et al. 1995a, b) where two strong recruitment pulses have sustained the fishery. These have now been largely fished down, and landings in 1995 are expected to decline. The scallop beds are not able to support the high level of fishing effort that they have sustained recently. Increased fishing effort is attributed in part to the small groundfish quotas available to the 58 dual license holders. The future of the fishery depends on the protection of incoming year classes and the prevention of growth and recruitment overfishing.

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Table 1. Number of (1) Full Bay of Fundy licensed vessels (Source: Licensing Unit, Resource Allocation and Licensing Branch, DFO, Halifax) , (2) active scallop fishing licenses for vessels over 25.5 G.T. supposed to follow log procedures, and (3) vessels complying with log procedures.

Year	(1)	(2)	(3)
1981	99	64	65
1982	107	67	63
1983	115	84	74
1984	106	81	76
1985	96	69	67
1986	96	66	57
1987	95	80	44
1988	98	88	16
1989	98	96	14
1990	99	95	13
1991	99	91	26
1992	99	90	44
1993	99	97	62
1994	99	91	79

Table 2. 1994 landings in metric tonnes of scallop meats by Statistical District for the Upper Bay. King's Co.: 40; Cumberland Co.: 24, 44; Albert Co.: 79. (1 indicates landings from vessels < 25.5 G.T., and 2 indicates landings from vessels \geq 25.5 G.T.). Source: Commercial Data Division, Program Coordination and Economics Branch, DFO, Halifax.

Month	40		24		44		79	
	1	2	1	2	1	2	1	2
February	-	-	-	-	0.12	-	-	-
March	-	-	-	-	0.12	-	-	-
April	1.68	0.60	0.24	-	3.24	0.84	2.40	0.36
May	0.36	0.24	1.20	-	3.72	0.96	1.80	0.24
June	2.40	0.36	0.84	-	2.04	0.24	1.92	0.24
July	0.84	0.48	1.32	-	3.00	0.72	2.16	0.60
August	1.44	0.72	0.24	-	0.36	-	2.40	0.36
September	1.44	0.96	0.36	-	0.24	-	1.20	-
October	0.48	-	0.24	-	0.12	-	1.08	-
November	0.48	-	0.12	-	0.12	-	0.48	-
December	-	-	0.12	-	0.12	-	0.24	-
Total	9.12	3.42	4.68	-	13.20	2.76	13.68	1.80

Table 3. 1994 landings in metric tonnes of scallop meats by Statistical District for Grand Manan and surrounds. Grand Manan: 50; Campobello: 51; Charlotte Co.: 52, 53. (1 indicates landings from vessels < 25.5 G.T., and 2 indicates landings from vessels ≥ 25.5 G.T.). Source: Commercial Data Division, Program Coordination and Economics Branch, DFO, Halifax.

Month	50		51		52		53	
	1	2	1	2	1	2	1	2
January	19.21	10.20	6.48	1.89	1.28	-	0.96	0.60
February	16.57	12.85	9.72	3.36	1.08	-	1.20	0.48
March	11.88	9.84	4.20	2.16	1.32	-	0.48	0.84
April	5.40	8.28	3.24	3.48	0.12	-	0.12	0.48
May	2.52	9.24	3.00	4.44	0.00	-	0.36	0.36
June	1.44	16.81	2.40	6.24	0.12	-	1.08	0.60
July	2.88	9.96	1.92	-	0.36	0.12	0.60	1.44
August	2.04	7.44	1.33	2.40	0.12	-	1.08	1.80
September	3.24	5.40	2.16	-	-	-	0.36	2.28
October	1.92	6.24	0.96	-	-	-	0.60	1.20
November	0.36	1.44	0.60	-	0.12	-	-	1.44
December	1.08	2.40	0.84	-	0.36	-	0.12	1.56
Total	68.14	100.10	36.85	23.97	4.88	0.12	6.99	13.09

Table 4. 1994 landings in metric tonnes of scallop meats by Statistical District for Saint John and surrounds. Saint John: 48, 49. (1 indicates landings from vessels < 25.5 G.T., and 2 indicates landings from vessels ≥ 25.5 G.T.). Source: Commercial Data Division, Program Coordination and Economics Branch, DFO, Halifax.

Month	48		49	
	1	2	1	2
January	0.12	0.72	4.08	1.08
February	0.12	-	5.28	2.40
March	2.04	2.52	8.16	1.32
April	4.20	3.60	6.84	1.08
May	4.32	2.16	4.08	3.24
June	1.56	2.04	2.76	3.00
July	1.20	0.60	7.32	6.24
August	2.76	0.96	6.84	3.12
September	2.40	0.96	4.768	5.16
October	1.68	0.24	3.00	4.32
November	0.24	0.24	0.36	0.48
December	0.24	0.96	0.36	0.84
Total	20.88	15.00	53.76	32.28

Table 5. 1994 landings in metric tonnes of scallop meats by Statistical District for Digby and surrounds. Digby: 37, 38, 39. (1 indicates landings from vessels < 25.5 G.T., and 2 indicates landings from vessels ≥ 25.5 G.T.). Source: Commercial Data Division, Program Coordination and Economics Branch, DFO, Halifax.

Month	37		38		39	
	1	2	1	2	1	2
January	-	1.80	-	14.89	-	1.68
February	-	4.68	-	51.86	-	2.88
March	-	4.32	-	77.79	-	3.36
April	-	2.40	0.12	58.94	-	4.08
May	-	8.04	0.12	66.99	-	2.88
June	-	17.29	0.72	83.79	-	6.72
July	-	7.68	-	93.16	-	2.52
August	-	5.76	-	85.59	-	4.20
September	-	6.36	-	96.04	-	5.28
October	-	0.36	-	114.05	-	1.80
November	-	0.12	-	40.70	-	1.80
December	-	-	0.12	47.18	-	2.16
Total	-	58.81	1.08	830.98	-	39.36

Table 6. 1994 landings in metric tonnes of scallop meats by Statistical District for Yarmouth (34) and Meteghan (36). (1 indicates landings from vessels < 25.5 G.T., and 2 indicates landings from vessels ≥ 25.5 G.T.). Source: Commercial Data Division, Program Coordination and Economics Branch, DFO, Halifax.

Month	34		36	
	1	2	1	2
January	-	-	-	8.04
February	-	6.60	-	27.01
March	-	38.42	-	67.95
April	-	46.94	-	43.58
May	-	58.82	-	46.22
June	-	64.95	-	22.09
July	-	57.38	-	75.63
August	-	42.86	-	47.18
September	-	41.54	-	62.91
October	-	21.97	-	22.21
November	-	14.17	-	8.40
December	-	6.00	-	0.72
Total	-	399.65	-	431.94

Table 7. Meat weight (g) statistics by month (1-12) and year (19xx) for the Inside Zone off Digby, calculated from port samples of the commercial catch.

Year	Month	n	Mean (g)	s.d.	Min.	Max.	Meat Count no. of meats/500g
91	10	573	28.09	9.69	7.58	57.03	28.1
92	7	310	9.49	2.58	3.40	21.80	9.5
92	8	143	13.31	3.93	4.90	25.00	13.3
92	9	79	29.74	9.97	9.10	55.90	29.7
92	10	1575	18.81	9.17	3.90	66.20	18.8
92	11	991	24.06	12.65	5.00	79.50	24.1
92	12	569	26.97	11.07	4.30	62.50	27.0
93	1	848	20.37	10.75	2.30	54.90	20.4
93	2	555	15.34	8.29	4.30	52.70	15.3
93	3	1217	14.77	5.98	4.80	41.20	14.8
93	4	49	22.28	7.88	5.80	37.20	22.3
93	5	251	14.95	4.04	5.40	26.60	15.0
93	7	251	15.00	5.36	5.90	31.80	15.0
93	8	42	21.58	5.08	10.70	36.20	21.6
93	10	882	21.94	8.84	6.80	57.40	21.9
93	11	444	25.55	8.42	8.30	50.60	25.6
93	12	363	21.06	7.59	8.00	40.90	21.1
94	1	94	22.96	8.26	8.70	40.40	23.0
94	2	353	16.93	8.44	2.86	44.30	16.9
94	5	137	15.30	4.67	5.30	27.50	15.3
94	10	523	14.83	6.83	4.50	46.30	14.8
94	11	59	17.34	3.39	11.20	28.40	17.3
94	12	505	13.88	6.42	4.60	36.80	13.9

Table 8. Meat weight (g) statistics by month (1-12) and year (19xx) for Outside Zone off Digby (6-16 miles), calculated from port samples of the commercial catch.

Year	Month	n	Mean (g)	s.d.	Min.	Max.	Meat Count no. of meats/500g
91	5	1992	13.14	4.14	3.80	31.98	38.1
91	6	483	10.36	5.77	2.11	35.54	48.3
91	7	746	14.78	4.68	3.82	35.86	33.8
91	8	791	14.07	4.45	4.04	29.37	35.5
91	9	678	14.84	6.22	4.36	37.65	33.7
91	10	171	17.59	5.51	5.98	36.93	28.4
92	6	268	11.32	4.18	3.50	25.40	44.2
92	7	224	8.68	2.44	3.00	15.20	57.6
92	8	352	17.18	5.47	5.80	40.80	29.1
92	9	983	14.86	7.05	3.30	49.90	33.6
92	10	946	14.89	7.62	3.50	45.60	33.6
92	11	858	16.04	8.20	4.80	41.90	31.2
92	12	636	15.50	8.09	4.10	48.10	32.3
93	1	1174	15.73	7.60	5.00	39.20	31.8
93	2	980	16.61	7.08	4.20	46.90	30.1
93	3	999	15.82	5.43	3.80	39.60	31.6
93	4	787	15.49	7.86	1.30	50.20	32.3
93	5	1271	11.87	5.84	2.60	31.20	42.1
93	6	1192	14.07	6.43	3.20	62.60	35.5
93	7	783	14.48	5.19	4.60	34.00	34.5
93	8	290	14.75	3.56	6.50	26.80	33.9
93	9	591	12.77	5.74	4.70	45.40	39.2
93	10	692	17.73	6.77	5.20	44.00	28.2
93	11	717	18.40	6.99	5.40	45.80	27.2
93	12	130	15.96	6.77	6.90	33.90	31.3
94	1	265	15.37	7.59	4.70	45.80	32.5
94	2	41	24.06	3.68	18.70	29.80	20.8
94	3	535	16.08	7.27	5.10	54.80	31.1
94	4	500	13.38	4.91	1.21	31.70	37.4
94	5	179	12.90	4.08	3.80	27.50	38.8
94	7	724	15.42	5.81	4.20	39.60	32.4
94	8	384	14.12	5.28	4.10	31.30	35.4
94	9	335	17.80	5.99	5.90	40.70	28.1
94	11	47	25.37	8.87	9.60	47.20	19.7
94	12	63	17.38	6.11	5.00	30.30	28.8

Table 9. Number of Bay of Fundy scallop licenses with 'n' additional licenses from 1981-94.
Source: Licensing Unit, Resource Allocation and Licensing Branch, DFO, Halifax.

Year	Number of Additional Licenses						# Scallop Lic.
	0	1	2	3	4	5	
1981	12	35	31	17	4	-	99
1982	16	38	40	10	3	-	107
1983	20	41	39	12	3	-	115
1984	21	41	28	12	4	-	106
1985	19	37	28	8	4	-	96
1986	10	38	31	13	3	1	96
1987	8	34	39	10	2	2	95
1988	12	33	38	11	3	1	98
1989	16	38	33	9	1	1	98
1990	19	42	27	9	1	1	99
1991	25	36	28	8	1	1	99
1992	29	38	22	8	1	1	99
1993	31	39	19	8	1	1	99
1994	31	40	18	8	1	1	99

Table 10. Number of Full Bay of Fundy scallop licenses and additional licenses carried from 1981-94. Source: Licensing Unit, Resource Allocation and Licensing Branch, DFO, Halifax.

Year	Scallop	Groundfish	Squid	Herring	Lobster	Shrimp	Swordfish	Crab	Mackerel	Salmon
1981	99	81	12	36	23	3	5	-	4	1
1982	107	86	12	32	20	2	6	1	1	1
1983	115	91	15	30	20	3	7	-	1	1
1984	106	79	13	30	16	1	7	-	3	-
1985	96	73	12	25	12	2	7	-	2	-
1986	96	74	12	26	10	3	30	-	1	-
1987	95	73	12	17	9	3	45	-	1	-
1988	98	68	12	17	8	3	50	-	1	-
1989	98	61	13	13	4	2	47	-	-	-
1990	99	61	12	9	7	2	42	-	-	-
1991	99	64	13	9	6	2	32	-	-	-
1992	99	61	12	9	4	2	27	-	-	-
1993	99	59	11	9	4	2	25	-	-	-
1994	99	58	11	9	4	2	24	-	-	-

Table 11. 1986-1994 stock surveys: 1986 to 1989. Number of scallops-at-age caught in a seven-gang Digby drag projected from an end, unlined bucket for recruits (age >4 years) and from a centre, lined bucket for prerecruits (age ≤4 years). 1990 to 1994. 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	3	4	5	6	7	8	9	10+	Total	No. of Stations
Zone stratum:											
Inside 6 mile											
1986	591	186	18	10	16	17	10	9	17	874	48
1987	457	373	727	253	18	10	8	7	22	1875	38
1988	52	298	662	788	527	55	12	7	19	2420	45
1989	7	98	86	292	288	159	49	16	13	1008	59
1990	1	4	22	53	53	70	49	21	18	291	57
1991	3	4	6	15	32	29	24	17	24	154	38
1992	2	4	8	7	13	18	21	17	24	114	42
1993	5	7	5	12	15	15	15	13	31	118	38
1994	10	9	9	6	8	12	13	11	19	99	42
Outside 6 mile											
1986	230	26	17	33	38	38	31	21	30	464	72
1987	51	355	296	31	31	26	18	11	22	841	81
1988	11	94	178	715	87	30	19	10	15	1159	59
1989	2	12	39	187	177	94	17	5	8	541	51
1990	1	8	20	71	68	53	32	13	13	279	79
1991	2	3	6	25	44	47	41	27	27	222	62
1992	2	6	14	18	38	46	33	20	25	202	48
1993	2	2	5	21	27	22	20	14	23	136	62
1994	5	15	7	11	15	21	19	13	16	122	54

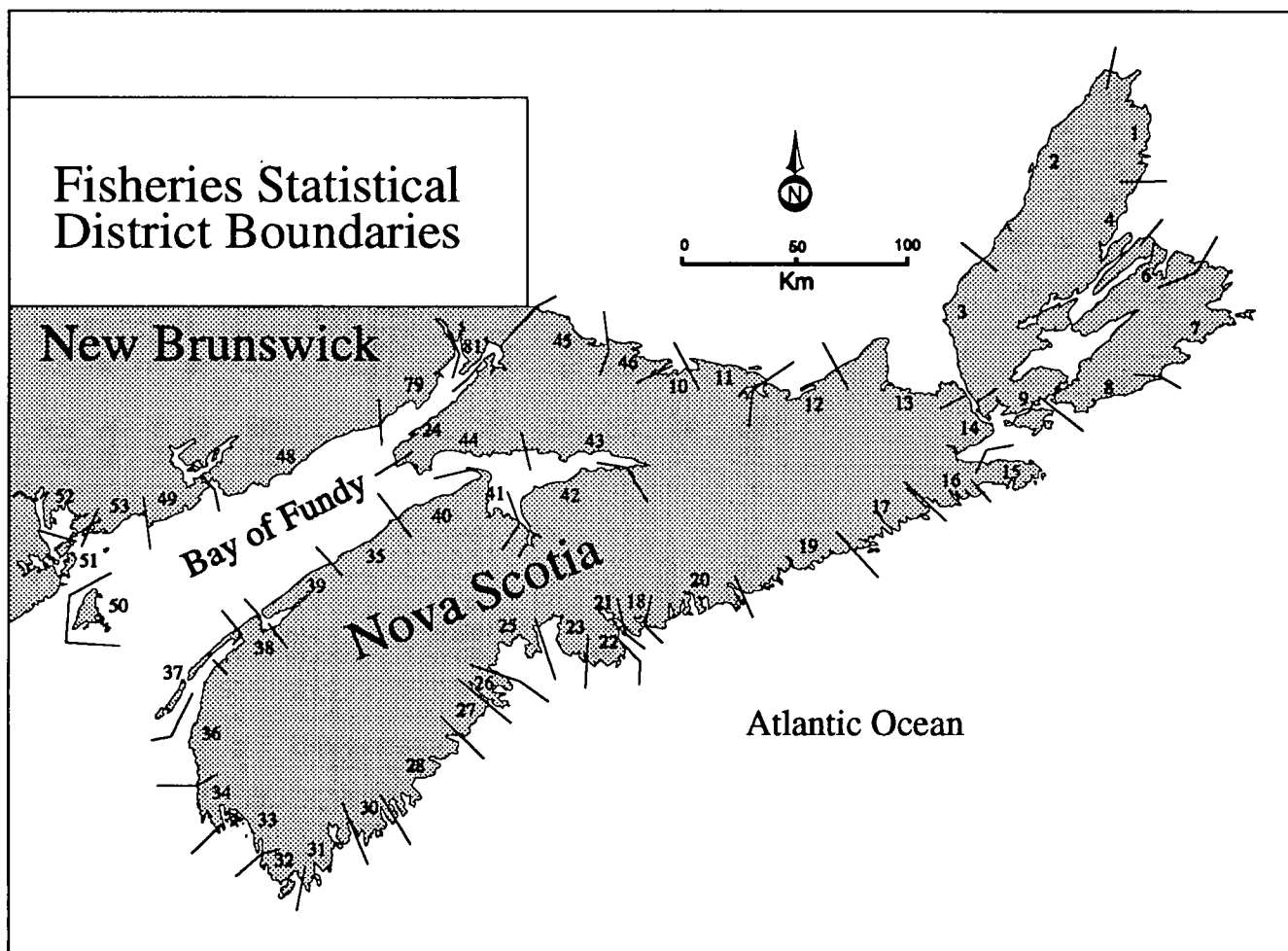


Figure 1. Statistical District boundaries for landing statistics as reported by Commercial Data Division, Program Coordination and Economics Branch, DFO.

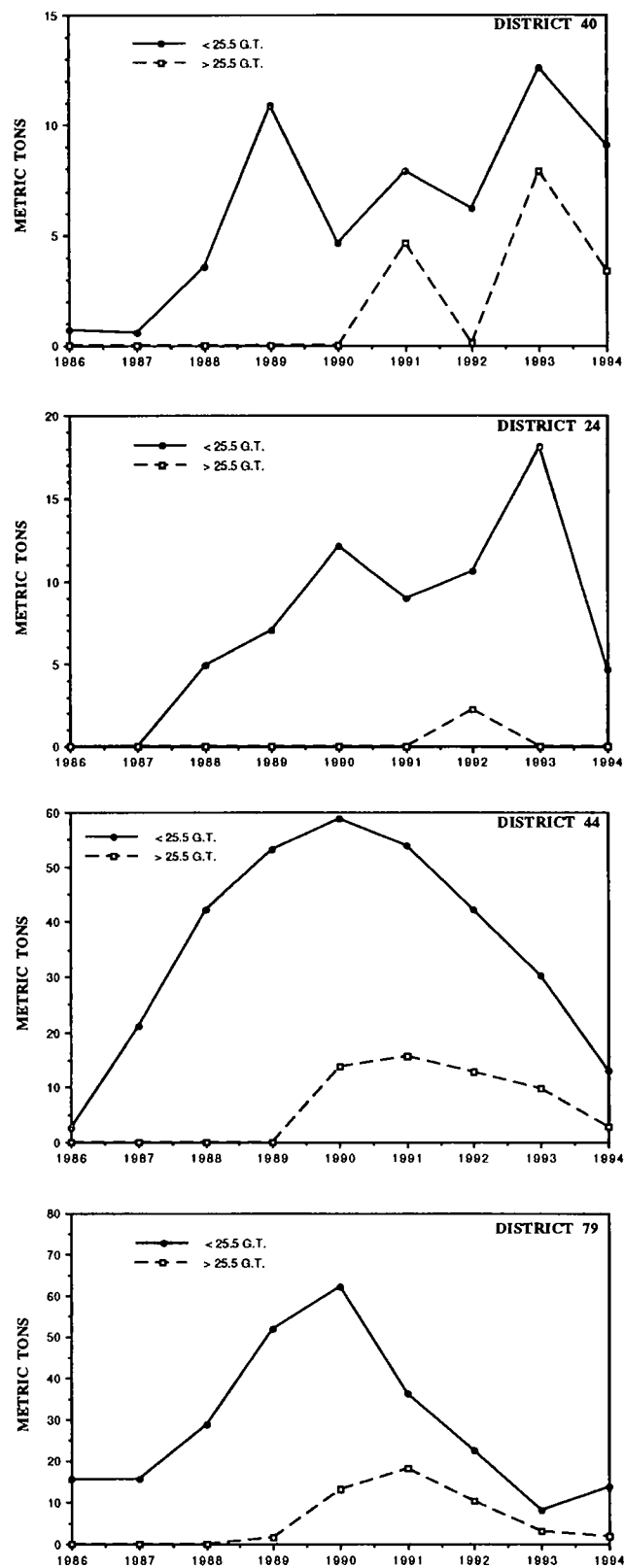


Figure 2. Annual landings (1986-1994) for the Upper Bay Districts by vessel size class.

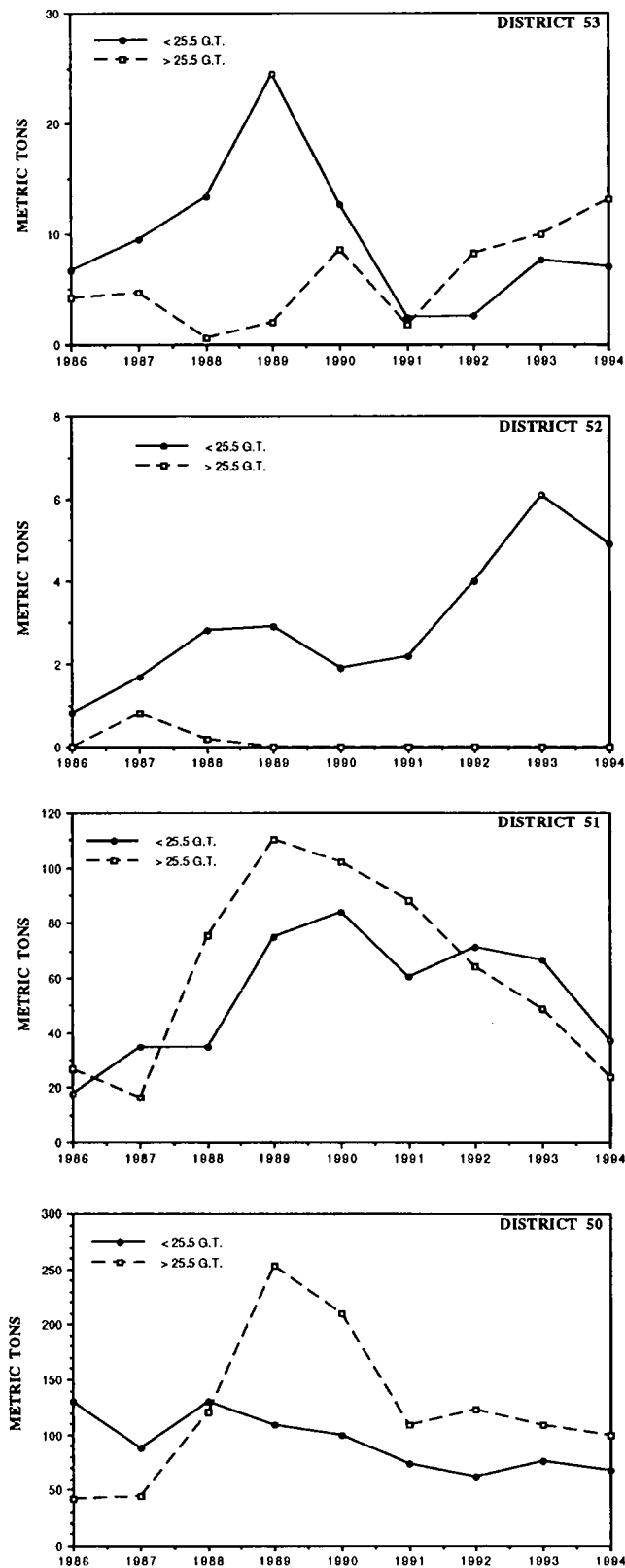


Figure 3. Annual landings (1986-1994) for the Districts in the Grand Manan area and surrounds by vessel size class.

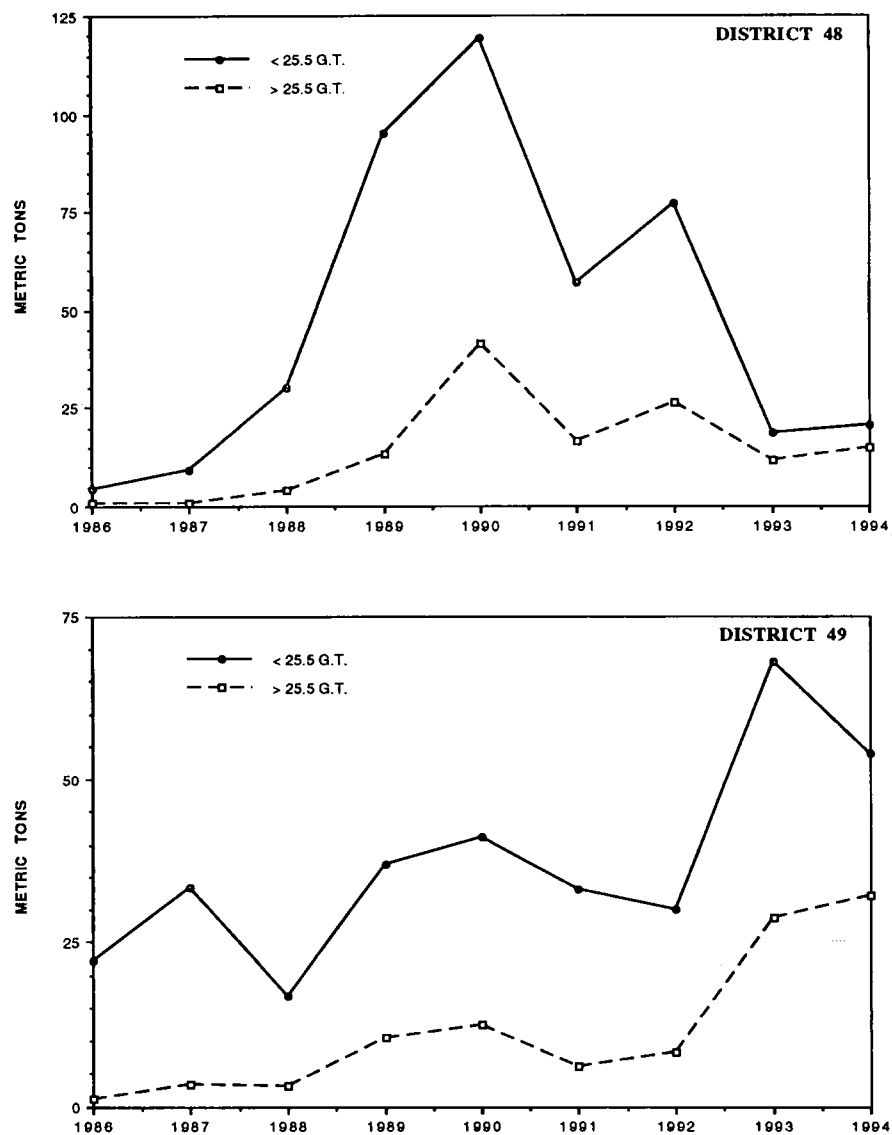


Figure 4. Annual landings (1986-1994) for the Districts in the Saint John, N.B. area by vessel size class.

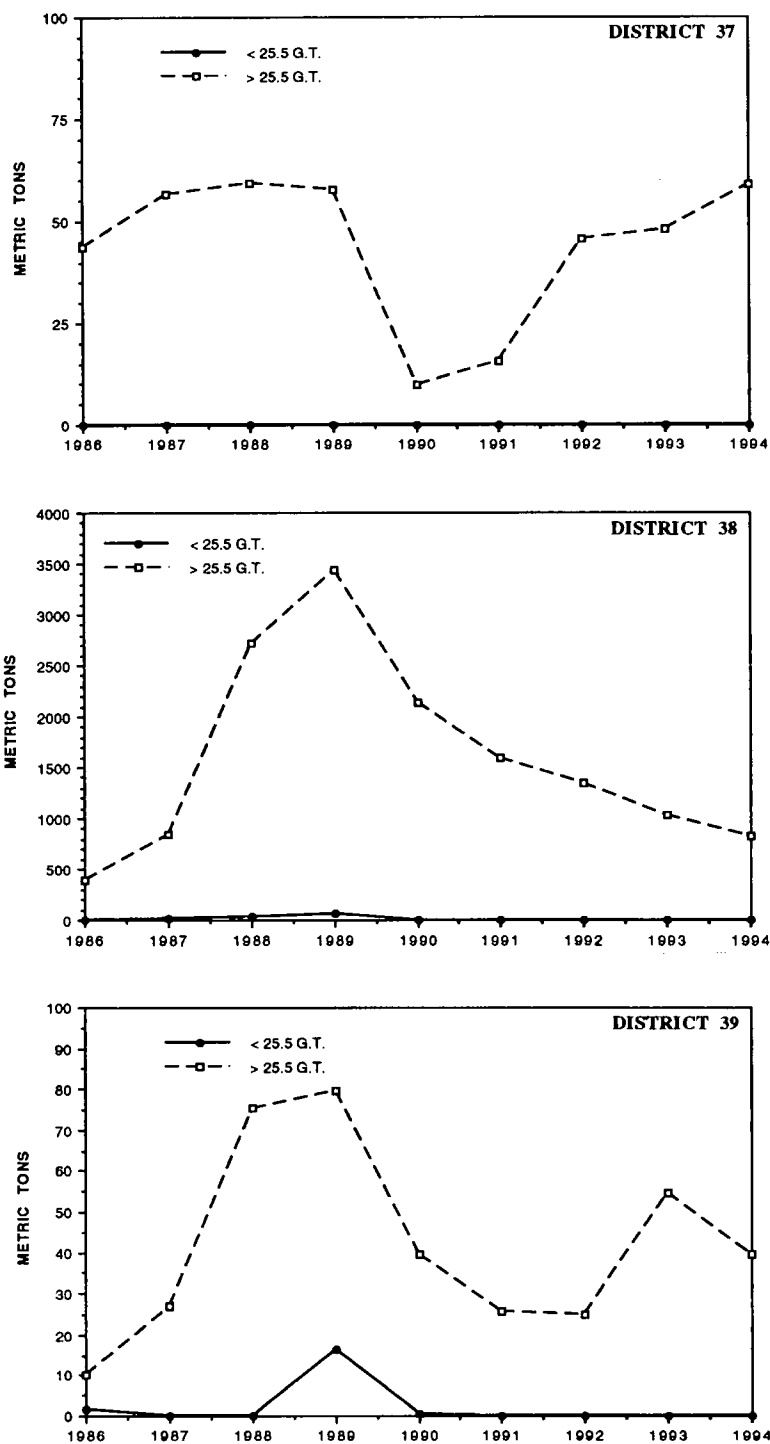


Figure 5. Annual landings (1986-1994) for the Districts in the Digby area by vessel size class.

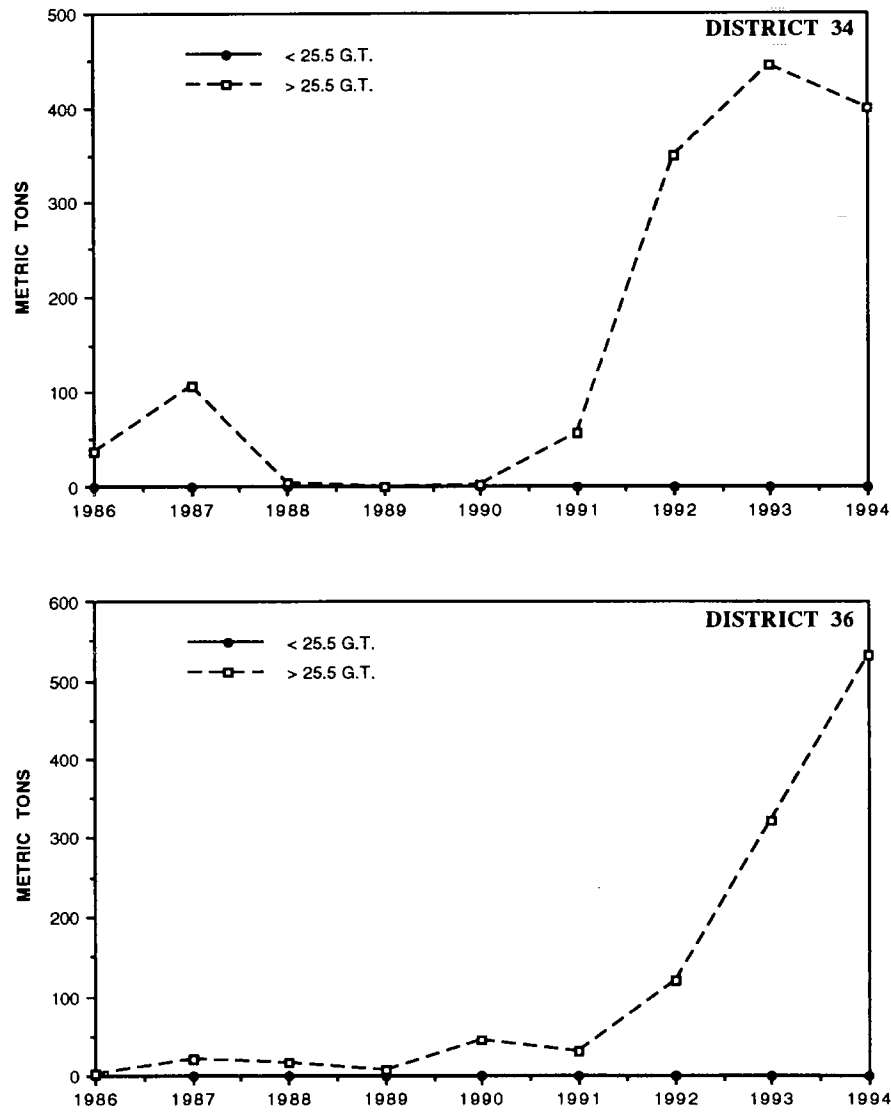


Figure 6. Annual landings (1986-1994) for the Yarmouth (34) and Meteghan (36) Districts by vessel size class.

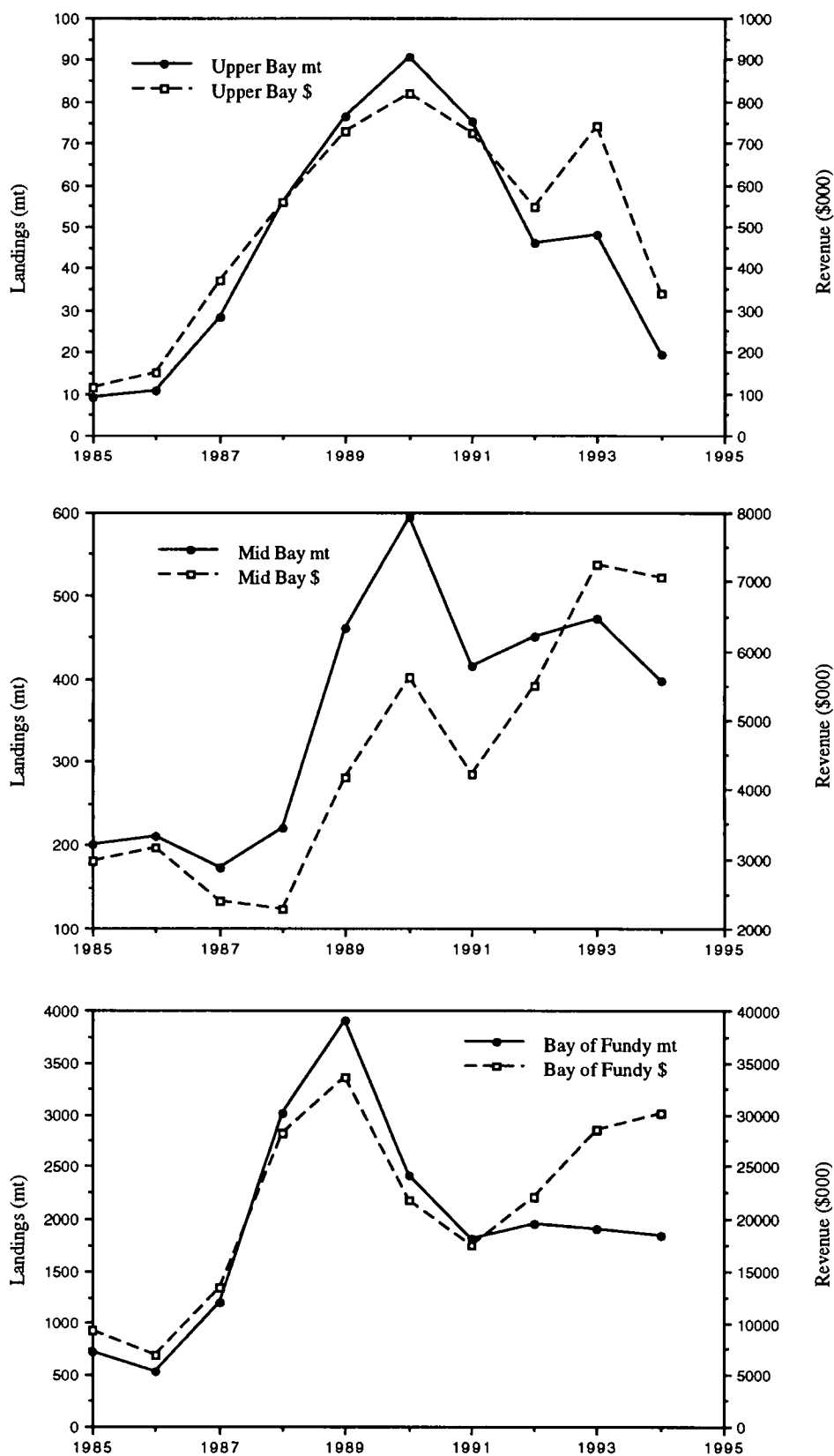


Figure 7. Annual landings and revenue (1985-1994) by fleet sector in the Bay of Fundy.

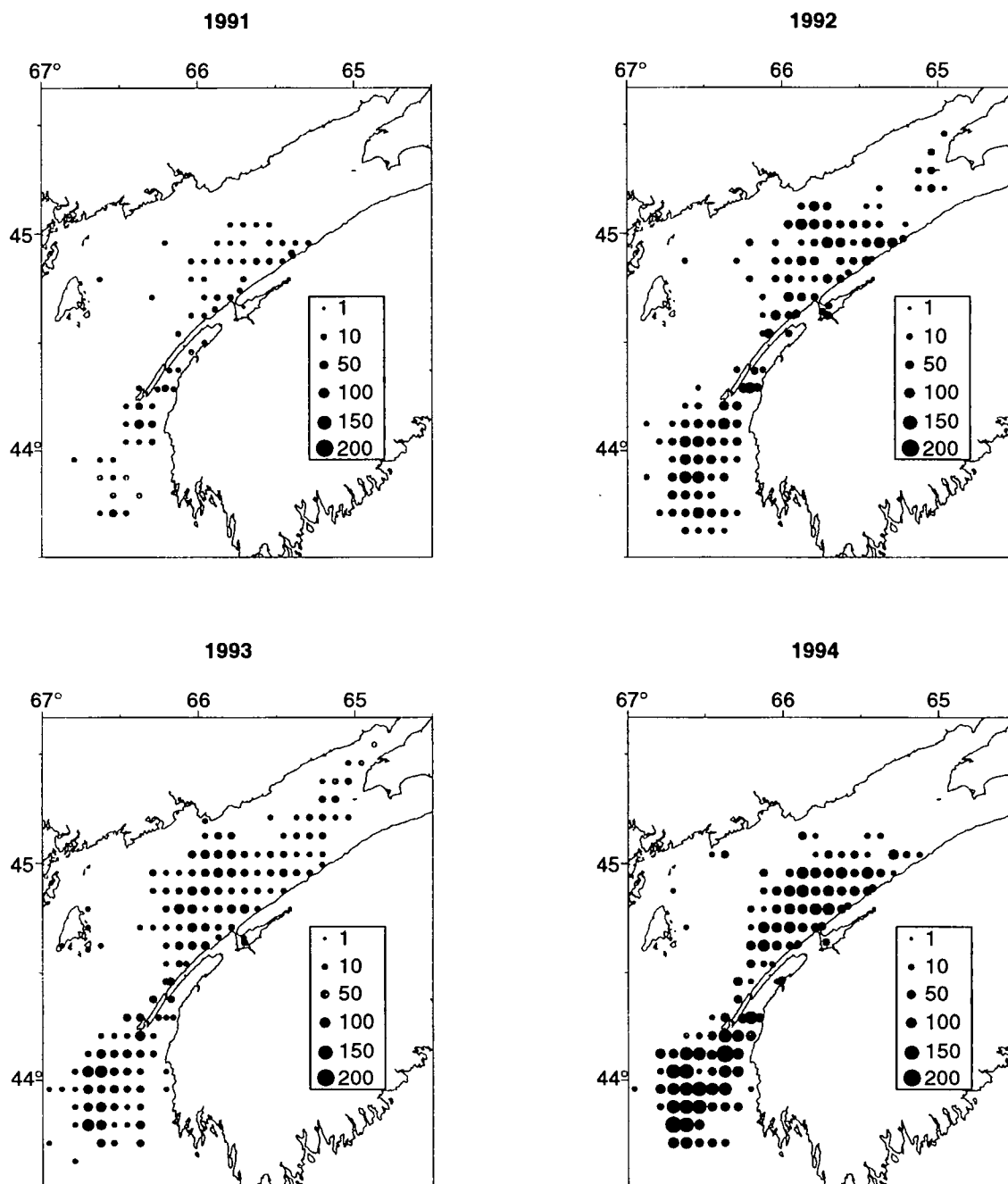


Fig. 8. Distribution of fishing locations (days fished) by 5 minute square for 1991-1994* for the Bay of Fundy fleet as reported from fishing logbooks. Increasing symbol size depicts increasing number of days fished.

*1994 preliminary data

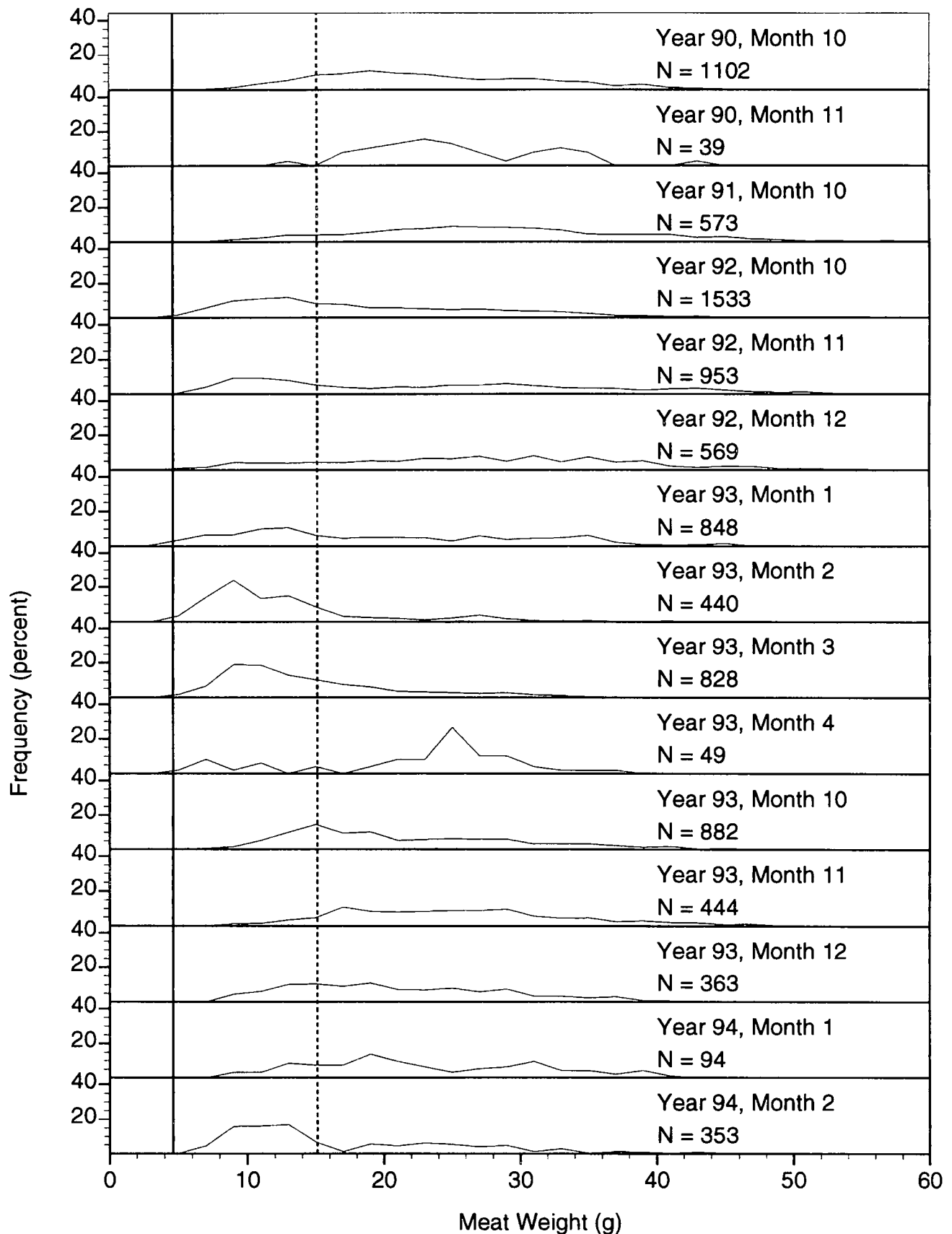


Figure 9a. Frequency distribution (percent) of meat weights from the commercial catch from the regulated inside zone off Digby. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth overfishing meats larger than 15 g should be harvested.

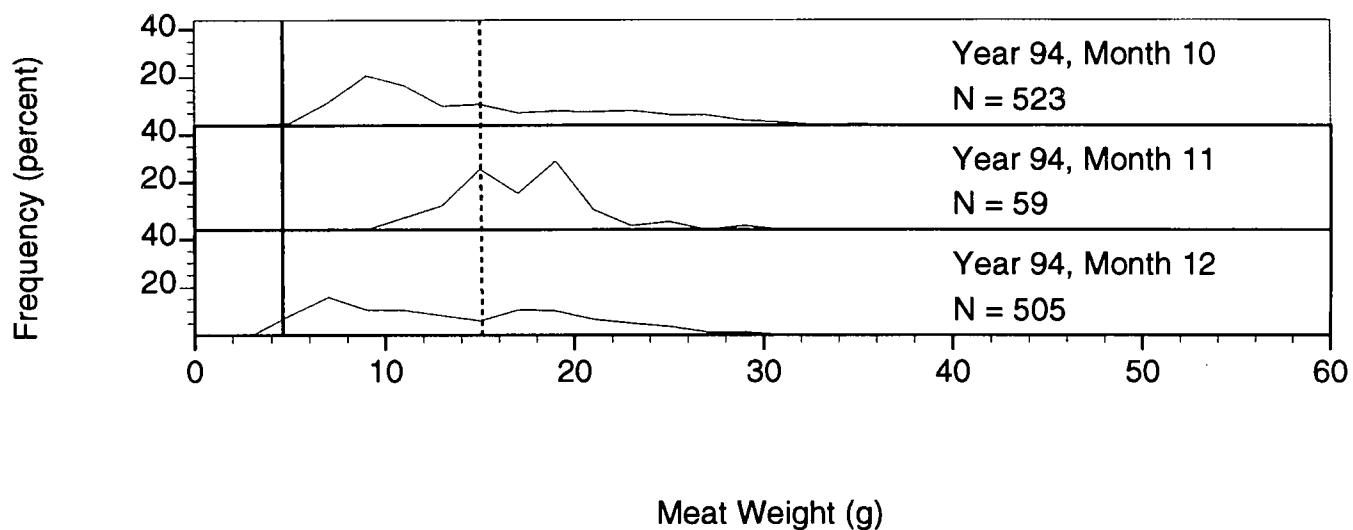


Figure 9a cont'd. Frequency distribution (percent) of meat weights from the commercial catch from the regulated inside zone off Digby. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth overfishing meats larger than 15 g should be harvested.

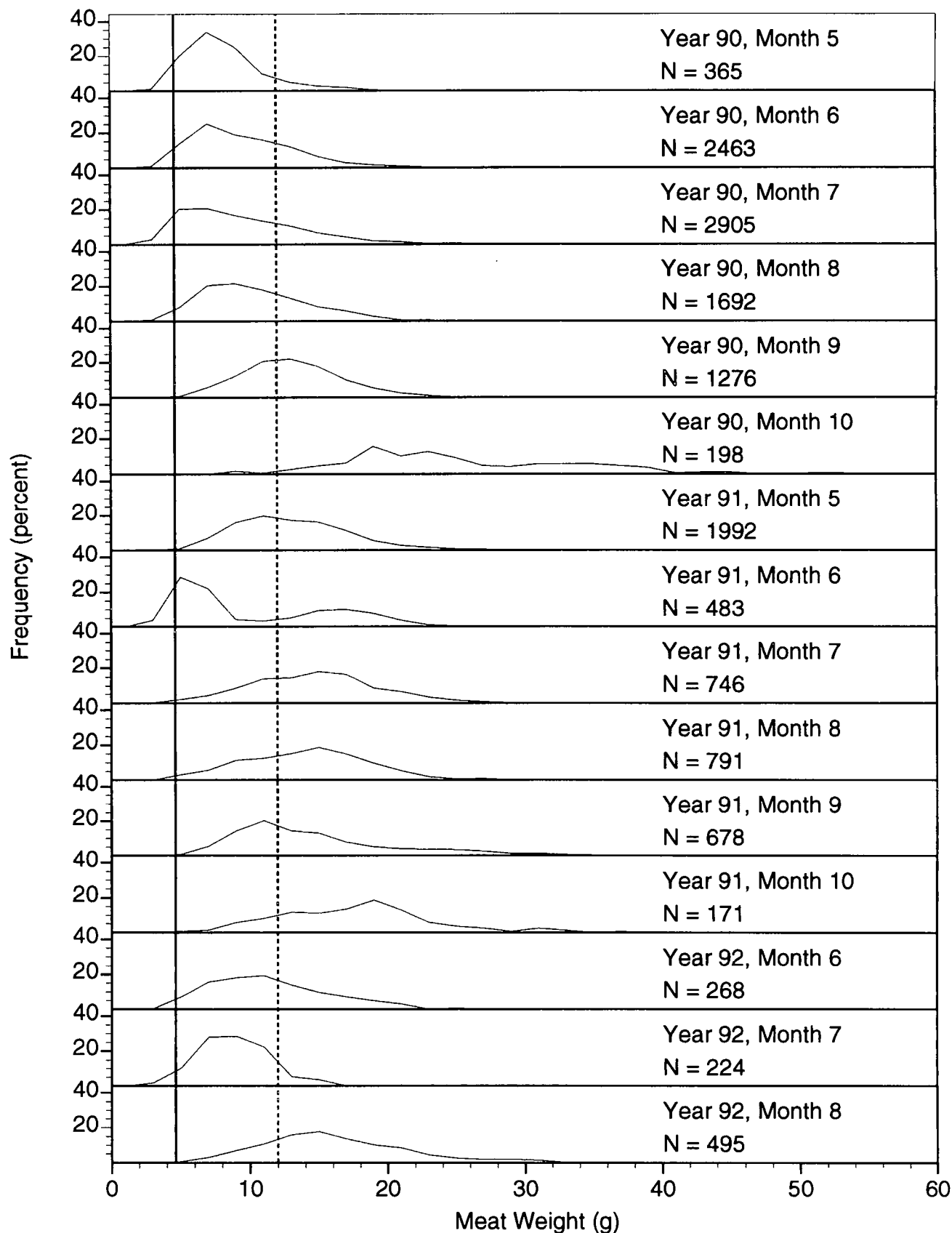


Figure 9b. Frequency distribution (percent) of meat weights from the commercial catch from the outside zone off Digby. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth overfishing meats larger than 15 g should be harvested.

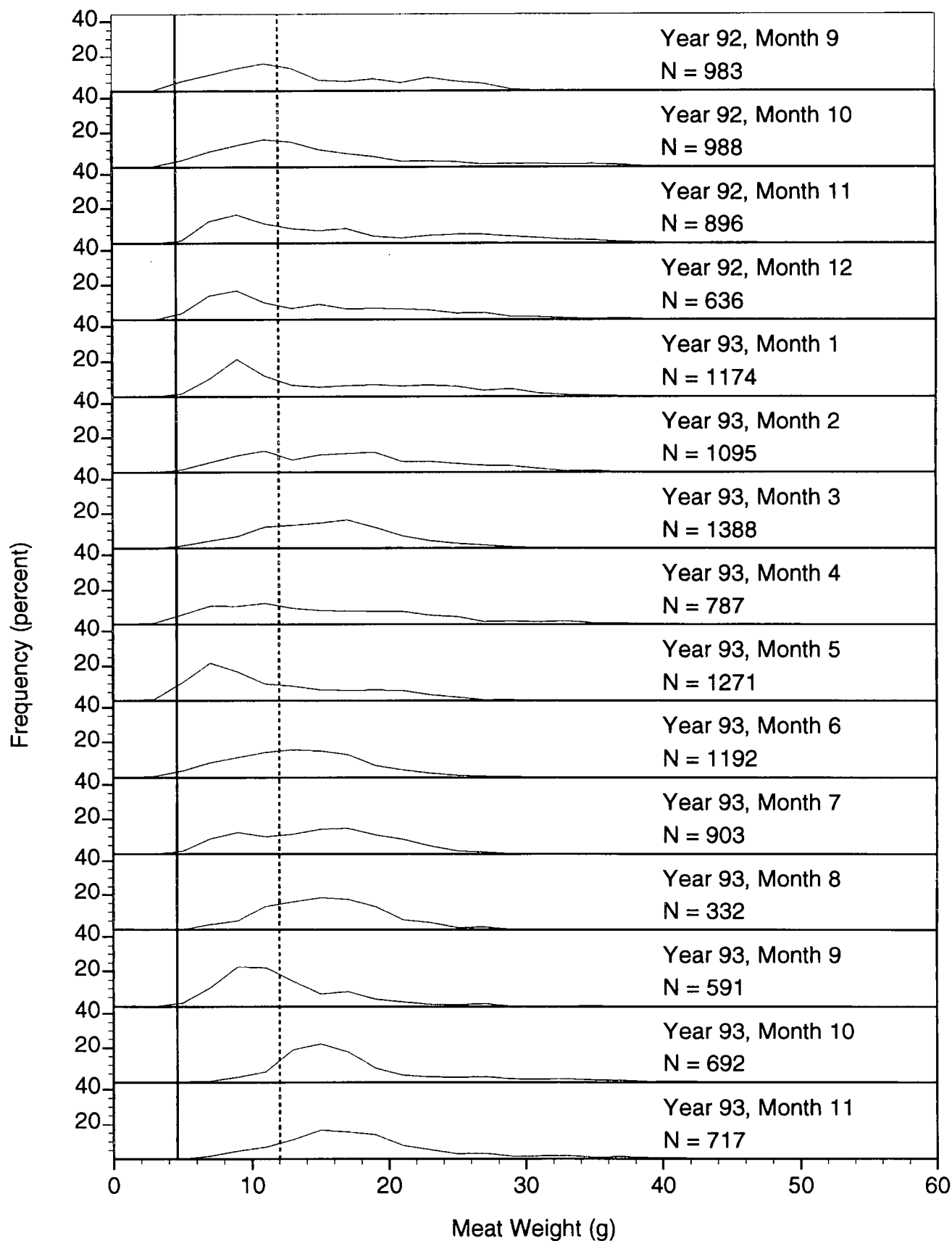


Figure 9b cont'd. Frequency distribution (percent) of meat weights from the commercial catch from the outside zone off Digby. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth overfishing meats larger than 15 g should be harvested.

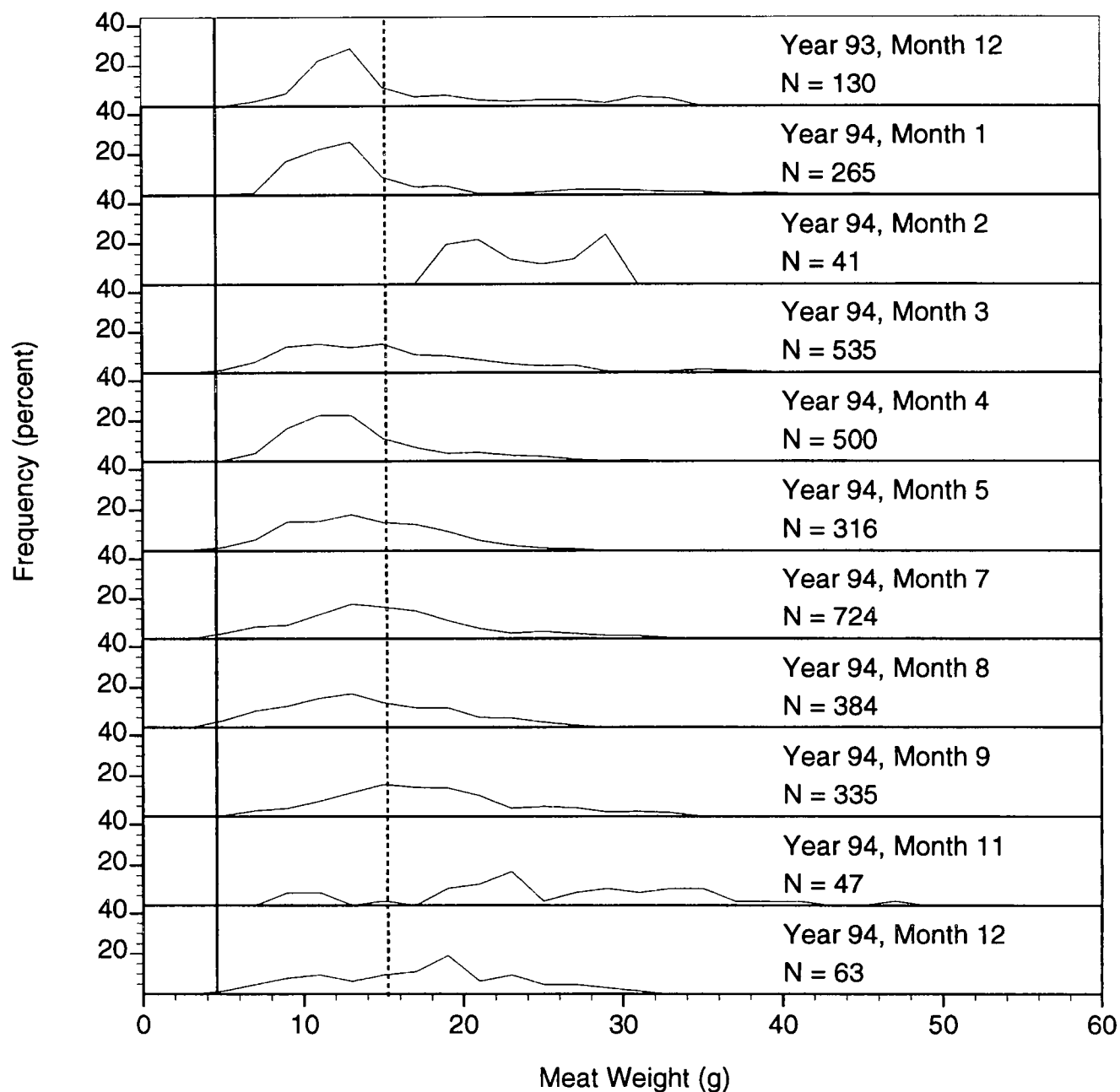


Figure 9b cont'd. Frequency distribution (percent) of meat weights from the commercial catch from the outside zone off Digby. The minimum meat size which corresponds with the 76 mm shell height is 4.6 g. To avoid growth overfishing meats larger than 15 g should be harvested.

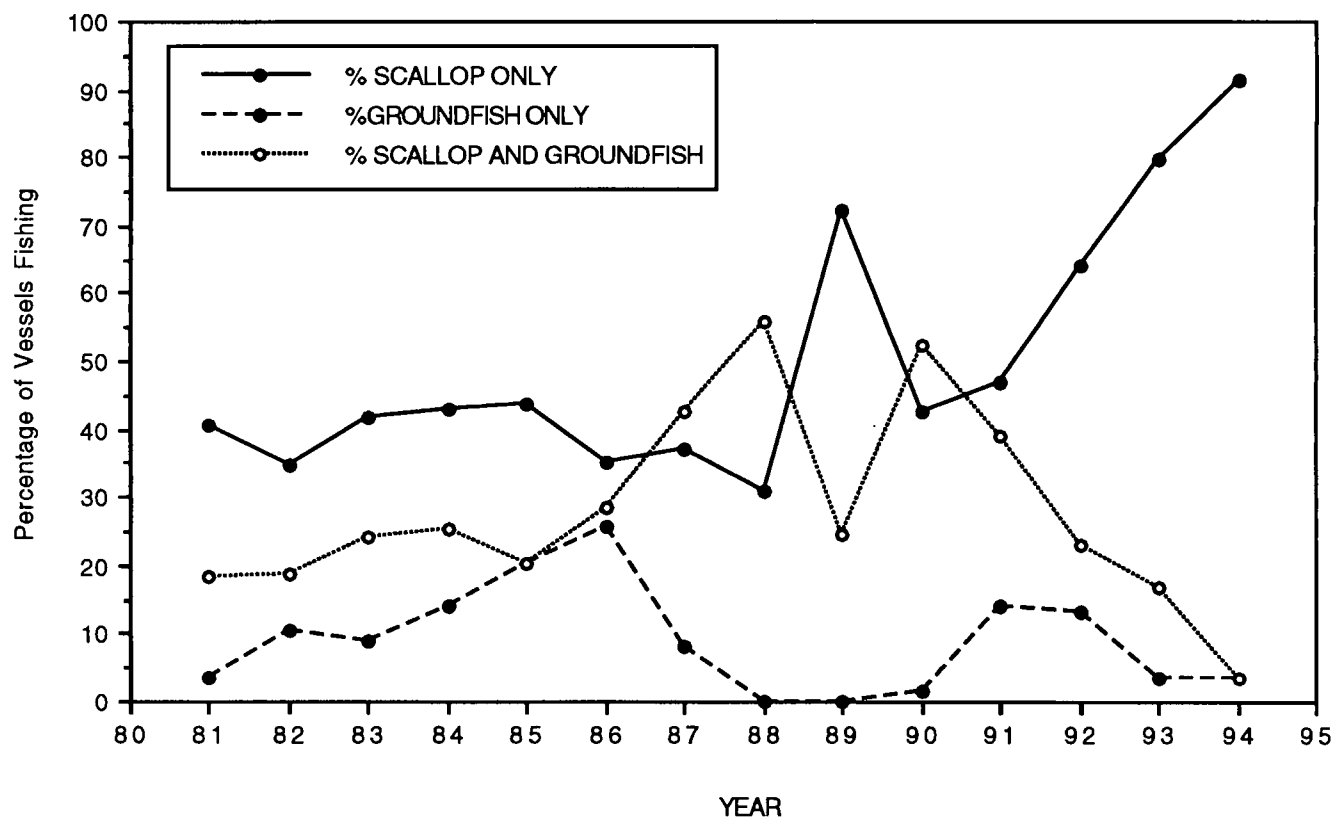


Figure 10. Annual trends in active licenses amongst the dual (groundfish, scallop) license holders in the Full Bay fleet.

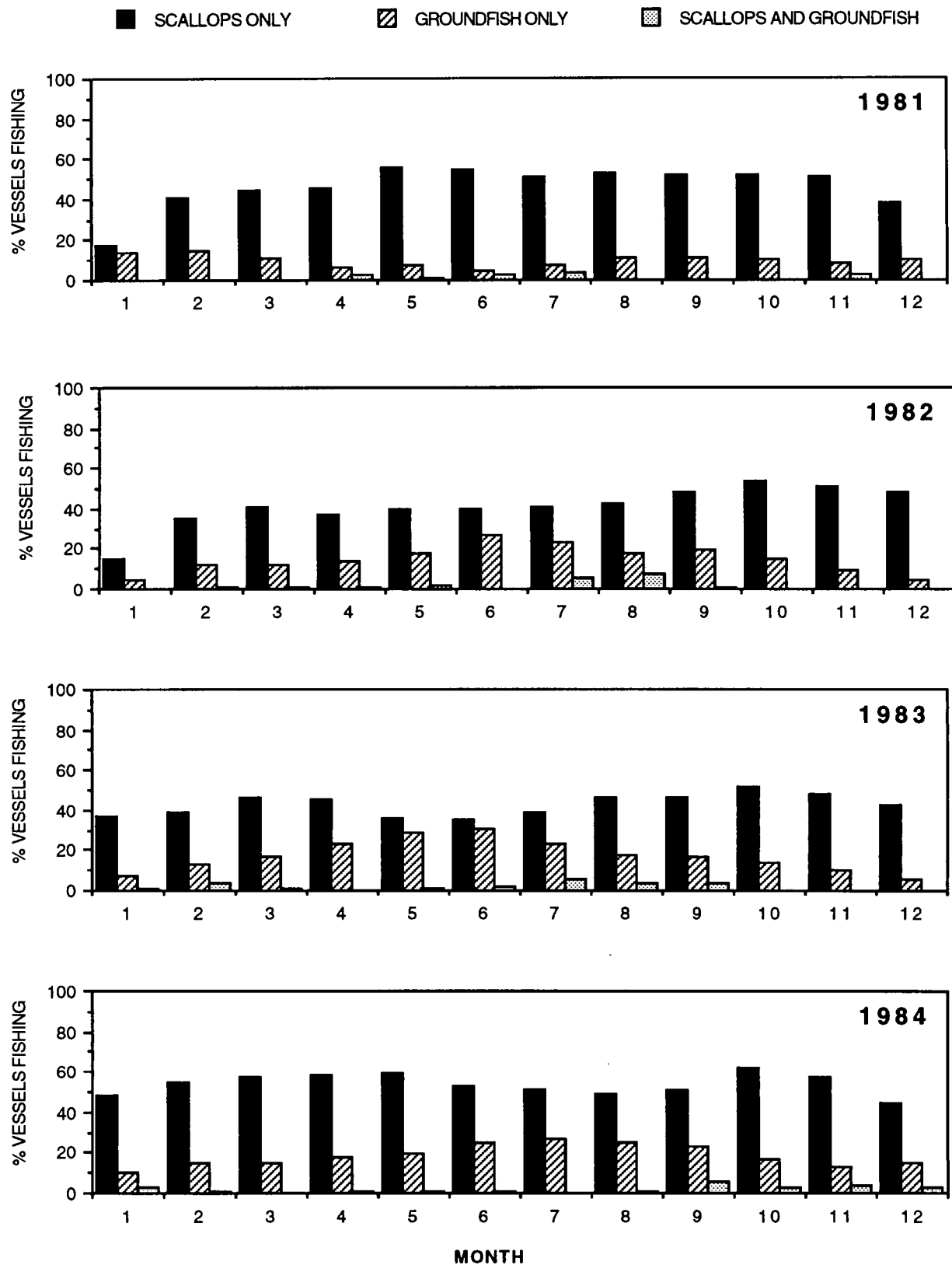


Figure 11. Monthly trends in active licenses by year amongst the dual (groundfish, scallop) license holders in the Full Bay fleet.

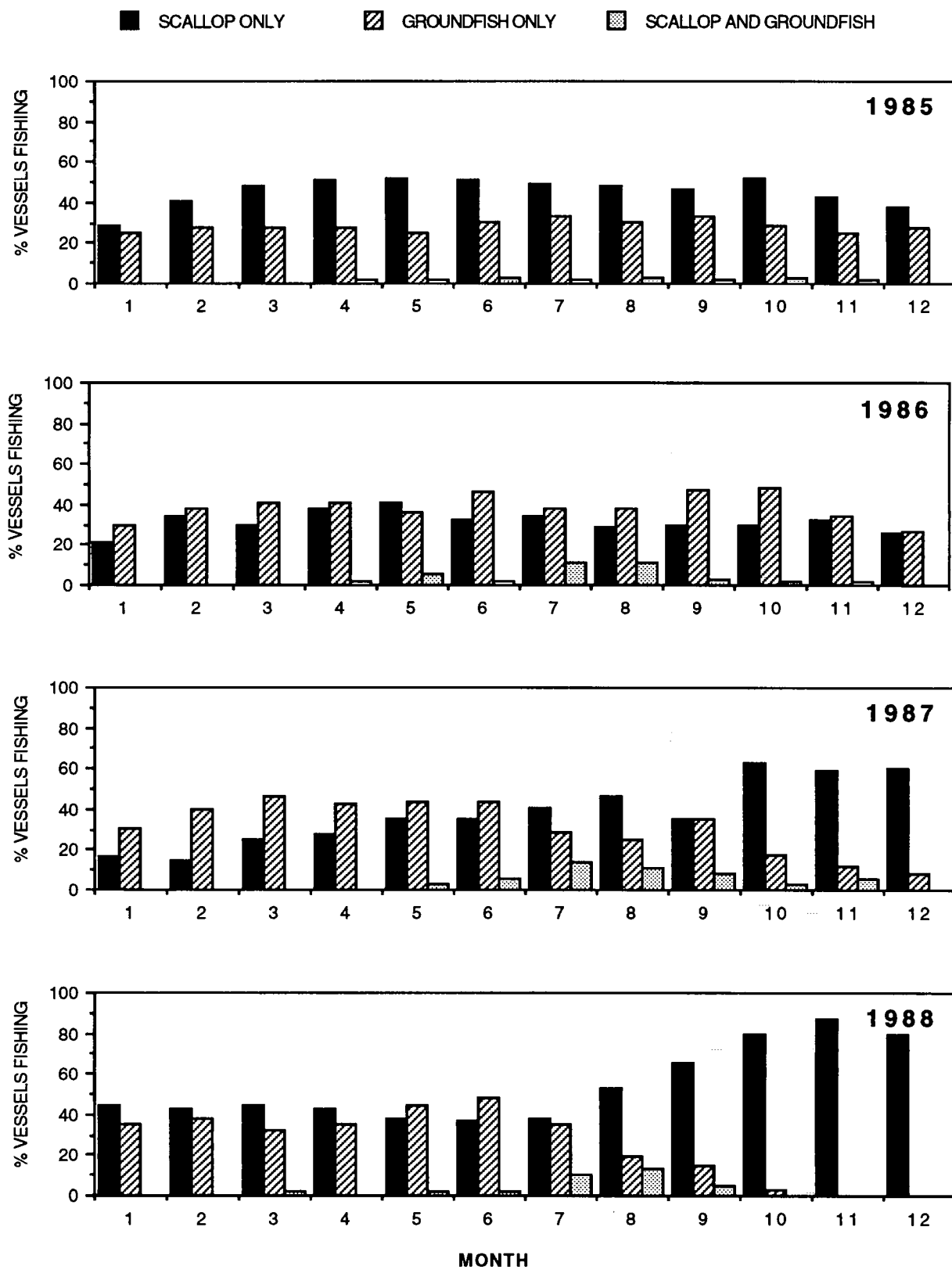


Figure 11 cont'd. Monthly trends in active licenses by year amongst the dual (groundfish, scallop) license holders in the Full Bay fleet.

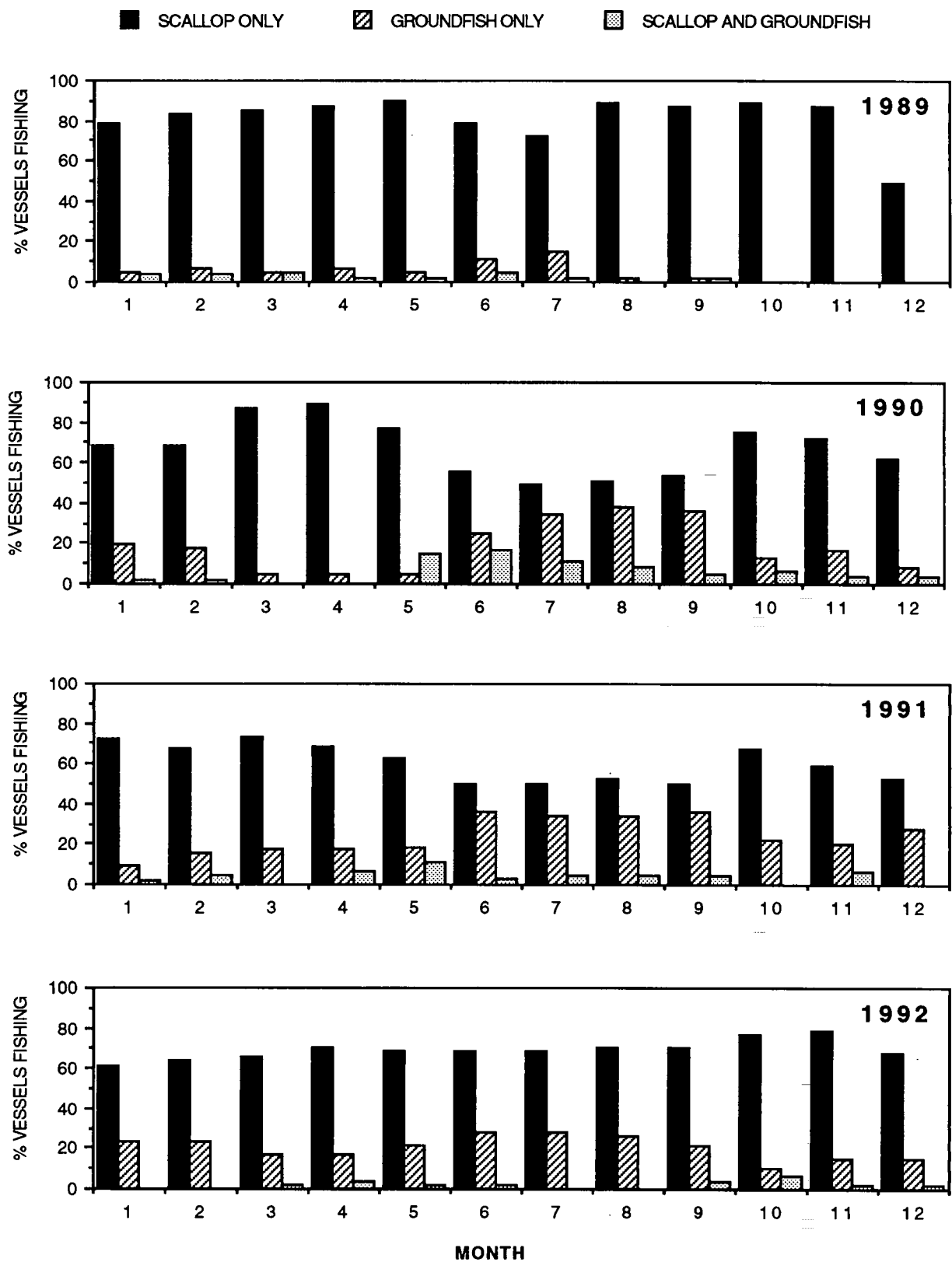


Figure 11 cont'd. Monthly trends in active licenses by year amongst the dual (groundfish, scallop) license holders in the Full Bay fleet.

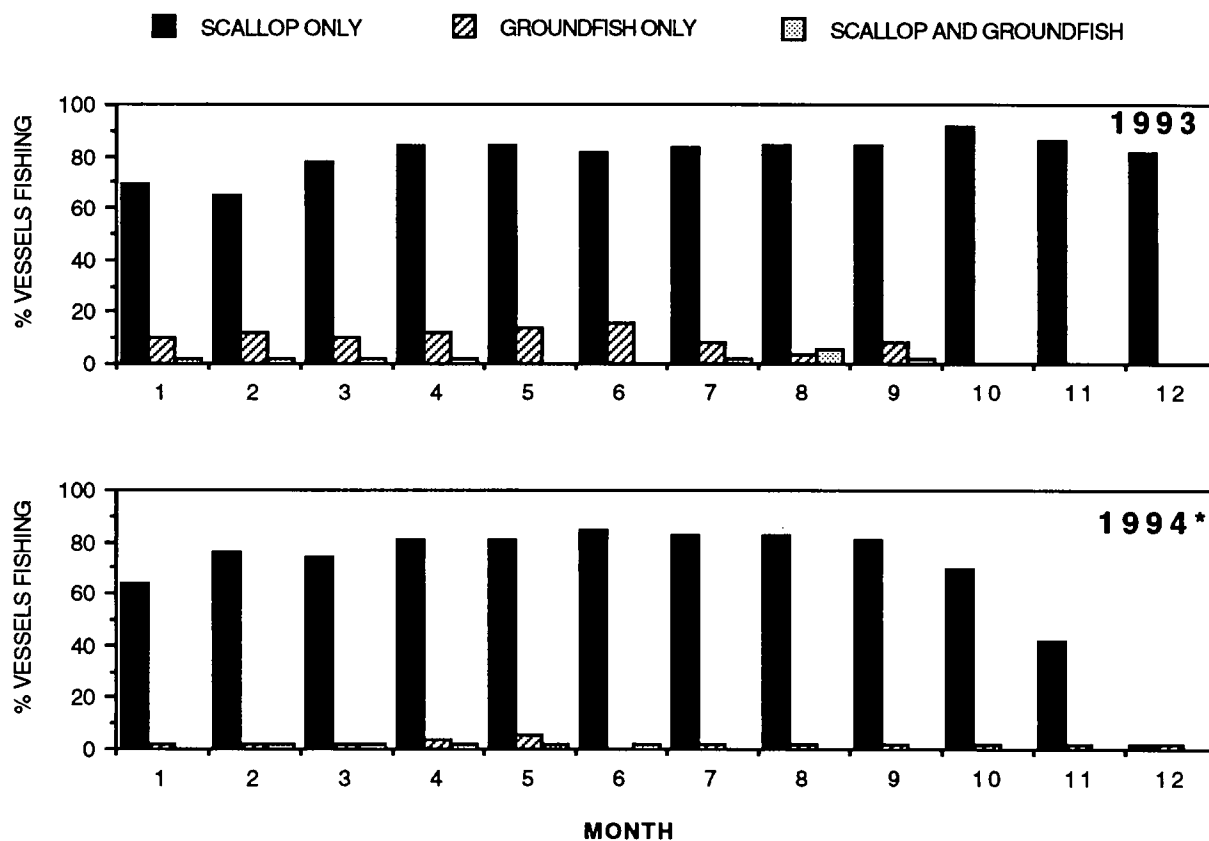


Figure 11 cont'd. Monthly trends in active licenses by year amongst the dual (groundfish, scallop) license holders in the Full Bay fleet.
 *1994 preliminary data

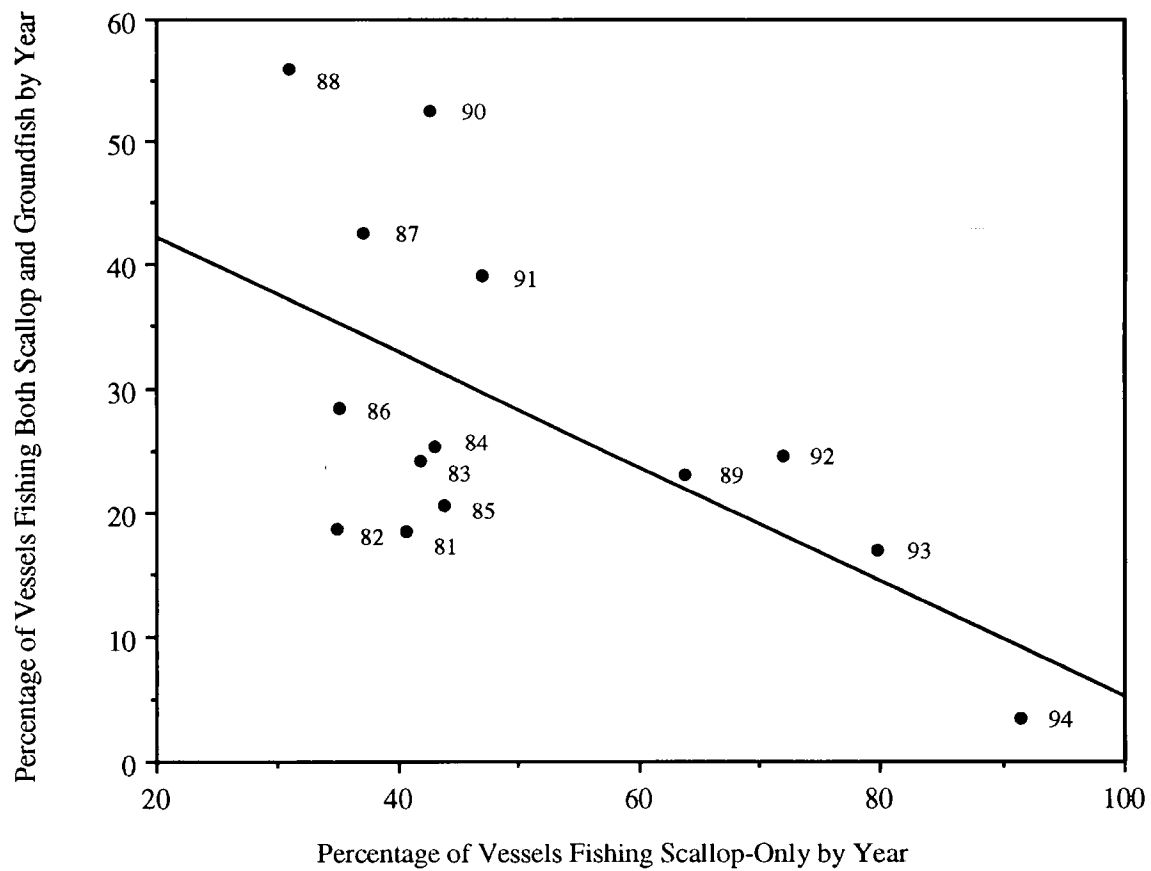


Figure 12. Relationship between the percentages of vessels fishing scallop and those fishing groundfish and scallop by year.

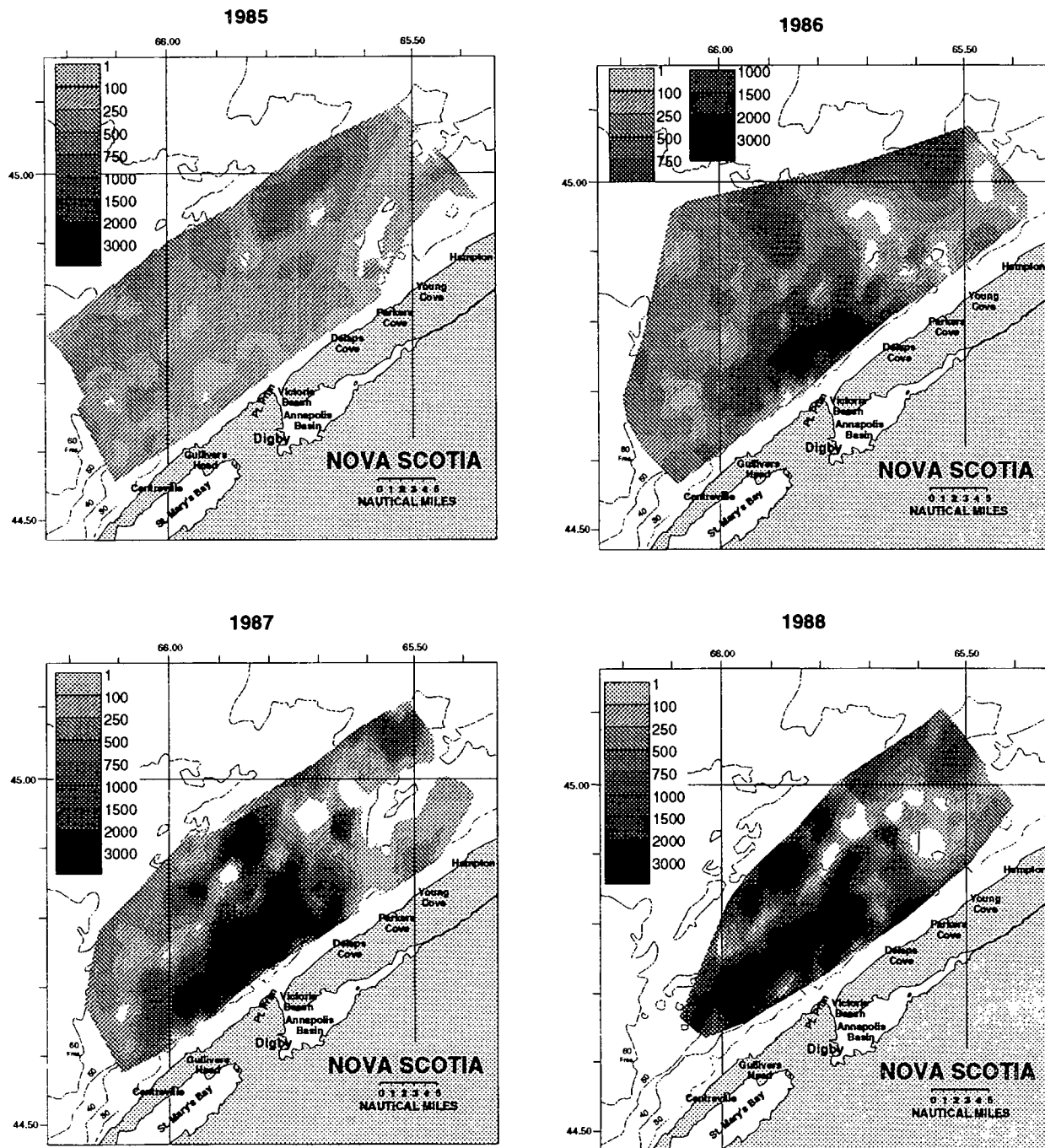


Figure 13. 1985-94 survey catch rates. Scallop distribution of all ages combined on a yearly basis from abundance isopleths of survey data. Darkening shades of grey within isopleths refer to increasing number of scallops per standard tow (grey scale in upper corner of plot).

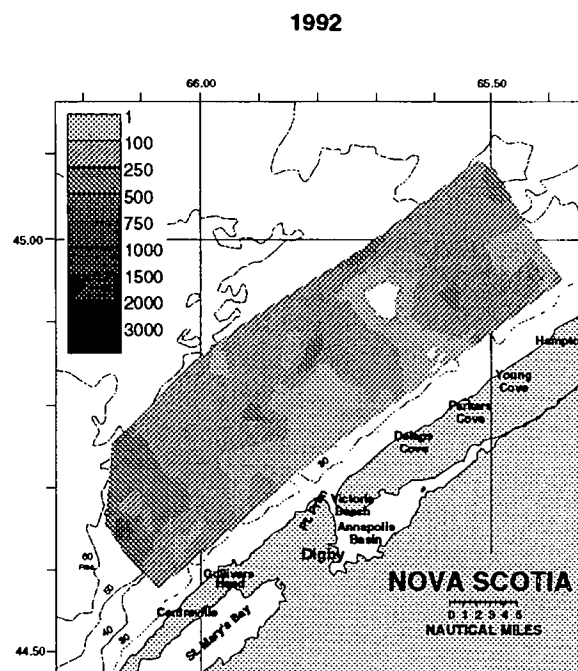
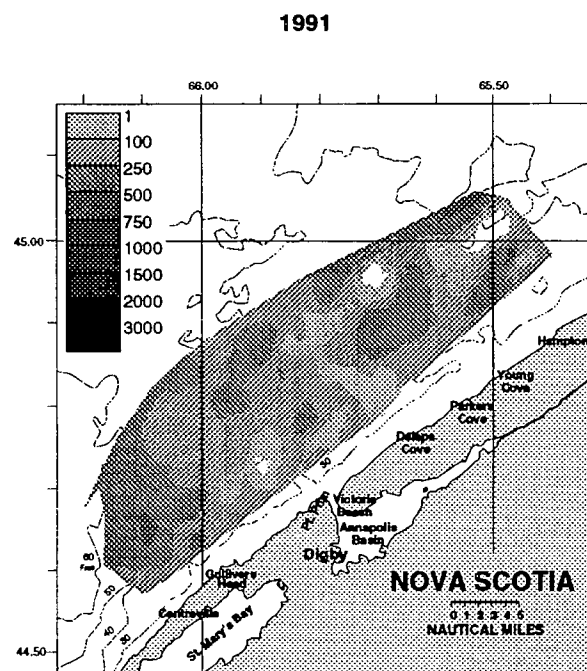
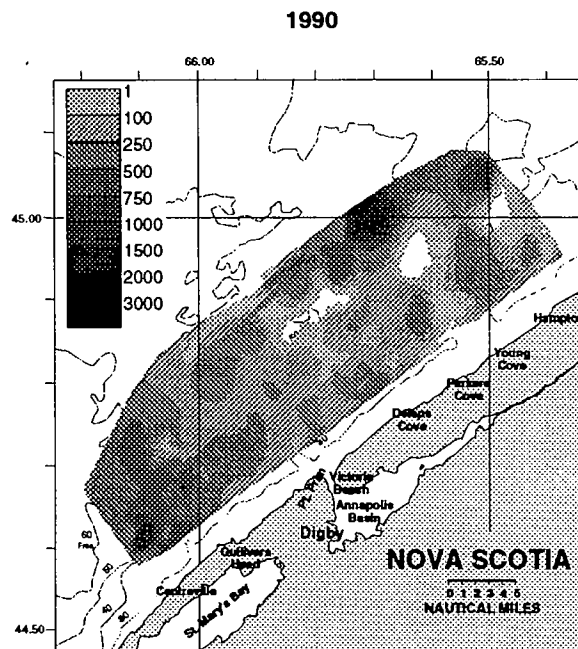
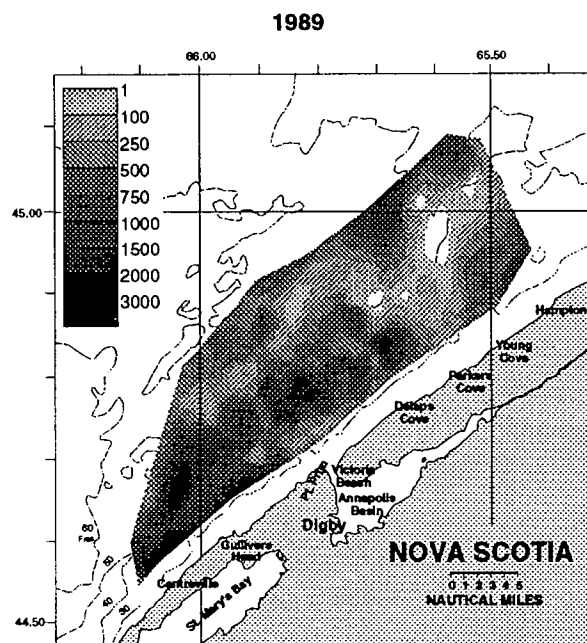


Figure 13 Cont'd. 1985-94 survey catch rates.

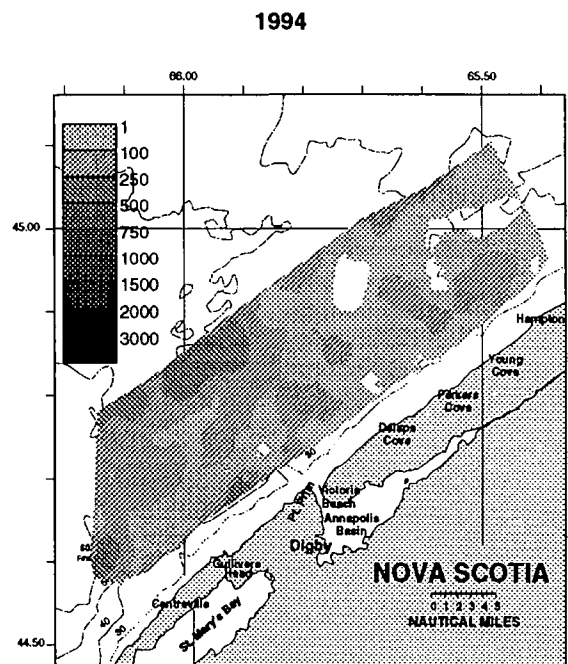
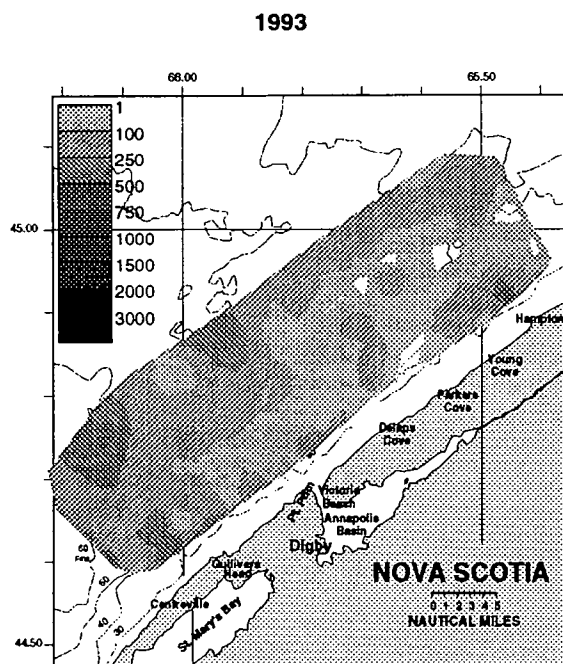


Figure 13 Cont'd. 1985-94 survey catch rates.

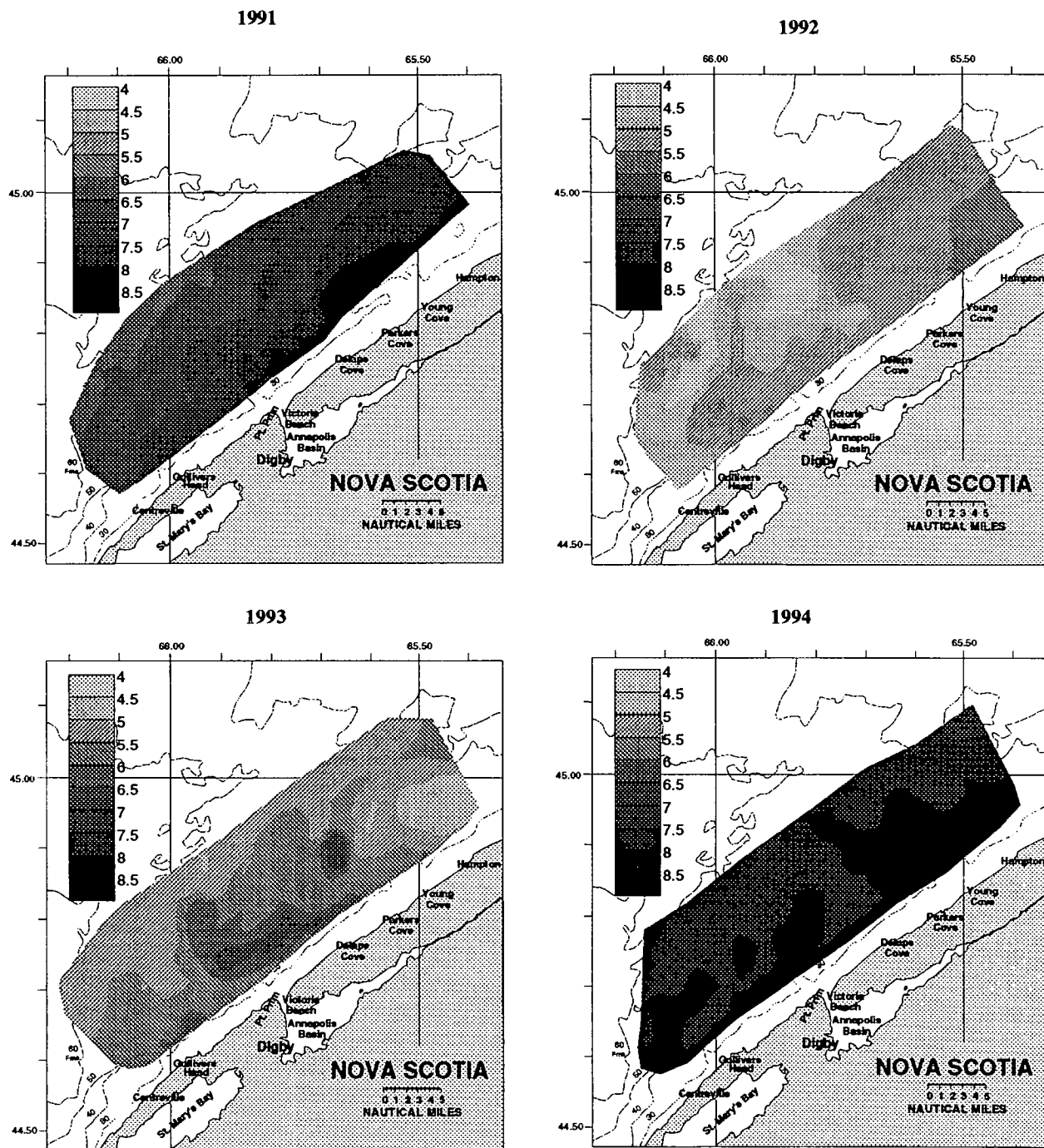


Figure 14. Bottom temperature (degrees Celsius) on the traditional fishing grounds off Digby, N.S. recorded from annual research vessel surveys (1991-1994). Darkening shades of grey refer to increasing temperature (grey scale in upper corner of plot).

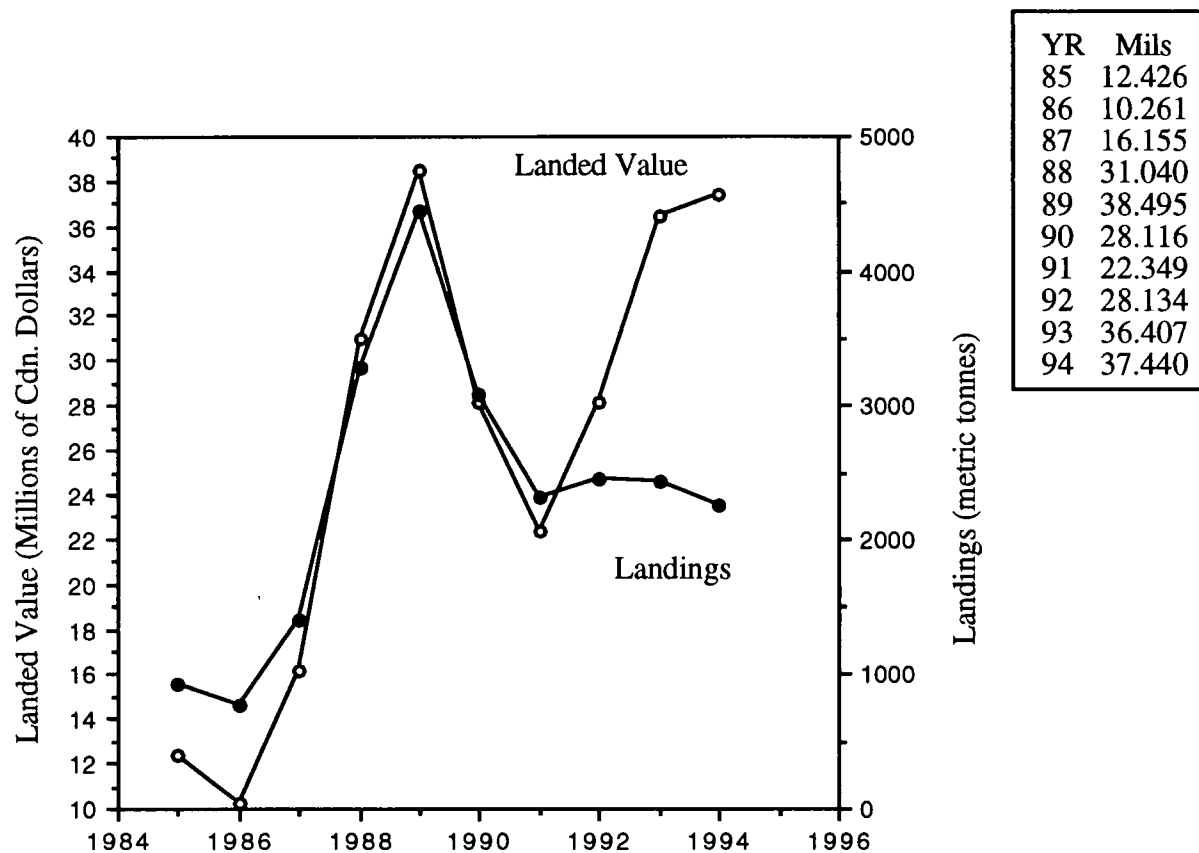


Figure 15. Relationship between scallop landings and the landed value of the catch for all fleet sectors combined.