Scallop Fishing Grounds on the Scotian Shelf - 1990

By

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ABSTRACT

For the last ten years the Sable Island / Western Bank area (NAFO SA 4W) has sustained continuous exploitation with catches of a few hundred tons per year but at a low (0.200 kg / crhm) catch-rate because of low but regular recruitment in the southwestern section of Western Bank. This fishery has operated on a competitive basis thus far. After a lapse of 5 years, an experimental fishery started on the northern side of Browns Bank (NAFO SA 4X) in the western area of the Scotian Shelf. The experimental fishery is conducted with a size limit different from the Georges Bank one and a quota divided into entreprise allocations. Such measures allowed a rationalised exploitation of scallop beds that would not have been realised otherwise. For two consecutive years this management strategy has worked well. Although recent CPUE's have dropped 20 %, they are still relatively high. With the good abundances at age estimated from survey results, it might be worthwhile to consider more experimental fishing activity.

RESUME

Au cours des dix dernières années la région de l'Ile -de- Sable et du banc Western (OPANO SA 4W) a soutenu une exploitation continue avec des prises de quelques centaines de tonnes par année malgré des taux de capture peu élevés (0.200 kg/crhm) grâce à un recrutement faible mais régulier dans la partie sud-ouest du banc Western. Cette pêche opère sur une base compétitive jusqu'à maintenant. Après un interval de cinq ans le banc Browns (OPANO SA 4X) dans la partie ouest du plateau néo-écossais a été retourné à l'exploitation avec une pêche expérimentale concentrée dans sa partie nord. La pêche expérimentale opère avec une taille minimale différente de celle du banc Georges et un contingent divisé en allocations par entreprise. Ces mesures ont permis une exploitation rationnelle de bancs de pétoncles qu'on n'aurait pu réalisée autrement. Cette stratégie de gestion a bien fonctionné pour deux années consécutives. Les PPUEs sont encore relativement élevées malgré une chute récente de 20 %. Etant donné les bons estimés d'abondances à l'âge des inventaires de stock, il serait bon de considérer une autre saison de pêche expérimentale.

INTRODUCTION

The traditional fishing patterns of the deep-sea fleet have always included Georges Bank as the main ground exploited with scallop beds on the Scotian Shelf as alternates (Fig. 1), sometimes in an opportunistic fashion. Scotian Shelf scallop beds have been visited more often since fishing activities on Georges Bank have been restricted to the zone east of the ICJ line (Oct. 1984) and are directed by an Enterprise Allocations system (E.As.) for catch removals. Since the beginning of the offshore fishery in the late 1950's, exploitation of the Scotian Shelf had been somewhat irregular. That pattern of exploitation changed with the 1980's. Some eastern Scotian Shelf grounds now sustain continuous exploitation.

Scallop beds on the northern side of Browns Bank were fished for the second consecutive year. More than the 200 t allocated were caught. On the eastern Scotian Shelf, there was a 20 % decline in the Sable Island / Western Bank catches from last year but these values are still in the high range for NAFO SA 4W.

METHODS

Fishery Information

There are two sources of information to estimate the respective fishery contributions of scallop fishing grounds on the Scotian Shelf. The Statistics Division, Department of Fisheries and Oceans, Halifax, compiles, on a yearly basis, landings by vessel size and by NAFO sub-subareas. Log information as to the origin of the catch provided by vessels is the other source. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas are not tailored to the physical location of particular scallop beds and may cut a major scallop bed in two. This inadequacy of the statistics system was previously described in Robert et al (1984).

All vessels (over 25.5 G.T. or 14 m L.O.A.) fishing the Scotian Shelf are required to keep logbooks to record daily fishing activities. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of gear, and number of crew (crhm). Catch-rate estimates may be computed when complete effort data (location, hours fished, gear, etc.) are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the Class 1 catch. The productivity in terms of removals of a specific scallop bed may also be established assuming that the catch with known location is representative of the total catch from that bed.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m, is excluded from a 12 nautical miles zone near-shore, and waters in the Bay of Fundy and approaches north of latitude 43° 40' N following the Inshore / Offshore Agreement (fall 1986). The Bay of Fundy fleet, mostly L.O.A. between 14 and 19.8 m (Bay of Fundy licensed vessels), has to restrict its activities on the Scotian Shelf to the upper parts of the Lurcher Shoals above latitude 43° 40' N following the Agreement.

The deep-sea fleet uses a New Bedford offshore scallop drag varying in width from 3.96 to 4.88 m. Two drags are fished simultaneously, one on each side of the vessel.

Catch Sampling

Catch sampling information is available for selected components of the deep-sea fleet only.

Port coverage varies greatly, from none for southwest Nova Scotia ports like Yarmouth and Saulnierville to somewhat fair in the Lunenburg - Riverport area. Sampling of the catch is rather sporadic and does not meet target levels to sample the catch adequately.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to stratify survey stations which are randomised within a low, medium, and high stratum. Catches from the deep-sea fleet over the year prior to the survey are considered. At times, an exploratory stratum may be added. Annual surveys are carried out during May on a Government research vessel. In 1990, neither Middle Grounds nor the western section of Banquereau Bank on the Eastern Shelf were surveyed. After the 'experimental' fishery on Browns Bank during August - September 1989, the survey focussed mainly on the exploited area to estimate a relative stock size toward the 1990 fishery. The German Bank / Lurcher Shoals segment of the Scotian Shelf annual stock survey was not carried out because of the low levels of fishing activity.

The survey gear was a 2.44 m wide New Bedford offshore dredge (75 mm ring size) lined with 38 mm stretch mesh polypropylene netting. Tows were of ten minutes duration; distance towed was determined either from Loran C bearings, at start-end of tow, or from continuous recording via a micro computer. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5 mm intervals for all live scallops and cluckers (shells with both valves still attached at the hinge); 2) tow location with Loran C bearings; 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow in minutes; 6) substrate type; 7) fullness of the drag (count of the number of vertical rings covered by the catch); and 8) total scallop catch as a round weight (kg).

Standardised survey catch-rates were contoured to represent the spatial distribution of the scallop aggregations. Abundance estimates are also derived. Data points describe a three dimensional surface with latitude, longitude, and number of scallops per tow to be plotted. A surface is formed by defining Delaunay triangles from an algorithm found in Watson (1982); the data points become the vertices of triangles connecting nearest neighbour points. The surface between adjacent contour levels, in this case the abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface by inverse weighing of gradients (slopes of triangles). The sides of the Delaunay triangles are divided into equal segments (chords) to establish the interpolation points. For example, dividing the sides into 4 segments gives 16 subtriangles. The interpolation points become new vertices. This method assumes that the data points near the point in question contribute more than distant points (see also Watson and Philip 1985). Each triangle is assumed to have a flat surface. The summation of the volumes of all triangles under the contoured surface is equal to the total volume, here the abundance estimate for the survey area. The degree of interpolation will affect the volume estimates. Experimental work indicates that volume estimates stabilise with a minimum of variation (5 %) (Robert et al 1989) after 16 or more subtriangles. A complete description of the procedure may be found in Black (MS 1988).

Relevant Biological Information

Biological information dealing only with growth rate and meat weight on shell height allometry are given here. Biological data has been gathered since 1982 as part of an on-going study of somatic and gonadal growth cycles.

Recently, areas such as Sable Island / Western Bank have better sampling coverage from the commercial fleet than the Browns Bank area where little fishing activity has taken place.

Samples from 1982 to 1989 surveys and samples collected from the fleet up to 1989 were used in the analyses. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells that have been ring read for each area. It also gives the regression parameters for estimating meat yield as a function of shell height and the number of animals examined. In an attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year

have been included in the analysis to approximate a 'year round' value. With a small sample from Banquereau Bank collected during the stock surveys some biological information was tentatively derived until more material is collected. The Sable Island area presents a wide range of depths (20 - over 100 m) where scallop concentrations occur, leading to a great deal of heterogeneity in growth patterns. However, all data were pooled together to generate one equation for the area.

RESULTS

Scallop Fleets

Following the 1986 Inshore / Offshore Agreement, the Bay of Fundy fleet was restricted to a very small section of the Shelf, i.e. the northern Lurcher Shoals. The deep-sea fleet however, continued to exploit scallop grounds on the Scotian Shelf (Table 2), especially in the eastern area. During the last two years, about half of the vessels of the deep-sea fleet have also fished the northern section of Browns Bank in the western area of the Shelf.

With Georges Bank catch removals now limited under an enterprise allocation system, the deep-sea fleet is shifting some of the traditional effort to scallop grounds on the Scotian Shelf in NAFO subareas 4V and 4W. Catch-rates in NAFO 4W have usually been below average (especially compared to Georges Bank rates). In 1990 the experimental fishery got underway for the second consecutive year in NAFO SA 4X on Browns Bank and its northern approaches (Tusket area). Total catches of over 210 t were recorded with above average catch-rates, over 0.500 kg/crhm. No fishing activity was recorded for German Bank / Lurcher Shoals.

To give methodical coverage to all fishing areas (Fig. 1) (from east to west), each area is looked at with respect to: a fishery profile, an estimate of its productivity in terms of distribution of scallop beds and abundance, catch sampling, and survey results. The Eastern Shelf includes Banquereau Bank, Middle Grounds, Western Bank, and the Sable Island area. The Western Shelf includes Browns Bank, the Tusket area, and German Bank / Lurcher Shoals.

Banquereau Bank

Historically speaking, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area. Catches average less than 10 t per year (Table 3). It is a natural, geographical extension of Sable Island Bank to the east. Highest landings (16 t) were reported in 1986. But this trend could not be maintained as less than 1 t was landed annually since. Official statistics do not report any catches for 1988 or 1989. These catches have also originated from TMS (Ten Minute Square) on Banquereau Bank adjacent to Sable Island Bank. Catch levels and the profile of catch-rates thus far do not indicate the presence of an important stock biomass.

The six exploratory tows carried out on Banquereau Bank in 1989 indicated as in previous surveys an extremely low abundance; furthermore, the most recent survey suggests the presence of only the oldest age class (Robert et al 1990). The area was not surveyed in 1990.

Middle Ground

Middle Ground is a shallow bank of which 500 square nautical miles carry commercial densities of scallops. Scallop production has been fairly sporadic with a 100 % increase in catches from 1985 to 1986 followed by a serious drop thereafter (Table 4). Catch-rates had been moderate at best, 0.500 kg/crhm in 1982, but declined gradually to an average of 0.150 between 1986-89. Then landings and CPUEs improved slightly. For the period 1989-90, around 20 t were landed annually with relatively good catch-rates at 0.300 kg/crhm.

Sampling of the catch (Table 5) indicates that a wide range of meats are shucked with an

average meat weight comparable to the ones obtained from Georges Bank. This profile varies little between years although only a small number of meats are weighed. Very low catches in 1988 prevented sampling of the catch. In 1989 there was an important weight drop (33 %) in the average meat, from 21.4 to 14.4 g which later stabilised around 15 g.

Stock surveys had shown low abundance of scallops at age except for the first survey in 1983. The prerecruit index rose significantly in 1988 but overall mean numbers at age are very low (see Robert et al (1990) for more information). The 1989 and 1990 Scotian Shelf stock surveys did not carry any sampling on Middle Grounds given the relatively small fishery performance recently.

Sable Island / Western Bank

When the deep-sea fleet began to fish scallop grounds in the Sable Island area in 1980, it confined itself to a small area of Western Bank at the edge of the continental shelf within the 100 m isobath (Fig. 1). Gradually, fishing activities extended their range not only along the edge of the shelf (in a northeasterly direction) but also over Western Bank, Sable Island Bank, and in the immediate vicinity of Sable Island up to Banquereau Bank (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). The distribution of commercial effort for 1990 is illustrated in figure 2. Annual catches have been low (Table 4) until 1986 (1983 excepted) when a sharp, 10 fold increase occurred from 1985 to 1986. Catches then declined sharply for a short time before rising substantially again (430 t in 1990). Since the beginning, this fishery has had a strong seasonal component; the vast majority of the effort is expanded during spring and summer (Fig. 3). Effort expanded to over 3 millions crew-hour-meters (crhm) in 1986 and produced catch-rates under 0.200 kg/crhm. Recent effort in the 1.6 - 1.8 million crhm range provides for 25 % better catch-rates, at 0.250 kg/crhm. Such CPUE values for Sable / Western Bank are low compared to the more productive Georges Bank.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighbouring Middle Grounds, (Table 5) 12 versus 20+ g. The 1987 catch sampling recorded both the smallest and largest shucked scallop meat since the fishery began in 1980 (2 - 98 g). About 50 % of the catch was scallops between 7 and 10 years of age. The size distribution of the catch was fairly typical (Table 5) of the historical profile for the area in 1989 and again in 1990.

The 1990 Sable / Western Bank stock survey had 90 catch-stratified stations (Table 6). Since the start of annual stock surveys five years ago, the 1988 survey had observed the second greatest abundance at age (Table 7) with sizable quantities of prerecruits and quite a few recruits as well (Table 8), especially young recruits (ages 5-6). The 1990 survey results continued to show the post-1988 decreasing abundance trends.

The distributions and relative densities (numbers at age per standard tow) of selected age groups by shaded contours are plotted in figures 4 to 6 for the last 3 survey years. The area surveyed is not exactly duplicated in its physical dimensions from year to year and varies between 4,000 to 6,000 sq. km (Table 9). The fishing fleet, in its first years, was exploring for new grounds and shifted effort from one scallop bed to another. Therefore, it was not necessarily covering all available grounds; 1986 is a case in point (see also Robert et al 1987). There is also a small scallop bed to the north of Sable Island that attracts fishing interest from time to time. Each contour plot shows that high abundances are to be found mainly near the edge of the continental shelf rather than on Western Bank per se or in the immediate vicinity of Sable Island. The area where important concentrations are found is very limited geographically speaking, less than 1,500 sq. km. The maps of density at age (Figs 4 to 6) tend to indicate aggregation of prerecruits in the southwest corner of the area surveyed while recruited age groups disperse themselves from this corner along the edge of the Shelf.

Abundance at age estimates ($n*10^6$) (Table 10) were derived by integrating the volumes under the contoured surfaces. Contours were smoothed by subtriangulation (16 subtriangles) of the surface. The volume estimates show the gradual rise in abundance of scallops in the Western Bank area with a fairly large component of recruits for 1988, then, the gradual decline. These

estimates follow the same general trends as the relative survey catch-rates (Table 7). Biomass estimates have been tentatively calculated for ages 5 - 7 to give an indication of possible trends in the stock biomass. It is not possible to obtain such biomass estimates for older ages; their density being too low over the fishing grounds. No correction is made for the efficiency of the gear. Gear behaviour has not been studied on these particular grounds.

Browns Bank / Tusket Area

Scallop aggregations, when commercially important, are found along the southern edge of Browns Bank (NAFO sub-subarea 4Xp) around the 100 m isobath and on the northern side of the Bank (Tusket, NAFO sub-subarea 4Xo) but in much deeper waters.

Before the 1986 Inshore / Offshore Agreement these scallop beds used to be exploited by both fleets, the deep-sea fleet landing more than the Bay of Fundy fleet except in 1986; nowadays, only the deep-sea fleet fishes these beds. Table 11 has data for the deep-sea fleet. Despite discrepancies between statistical landings and logged catches, the scallop production from the Browns Bank area has decreased erratically.There had been a small resurgence of landings in 1988 associated with very high catch-rates at 1.8 kg/crhm however.

At industry's request, steps were initiated in 1989 to undertake an experimental fishery in NAFO SA 4X covering Browns Bank, Tusket and German / Lurcher scallop grounds. Although there was no indication of important recruitment from prior research surveys, biomass had had an opportunity to accumulate because of the low fishing effort in previous years. The low activity resulted partially from the management plan grouping both the fast growing Georges Bank stock and the slowest Browns Bank's, under the same meat count regime. The 33 meats per 500 g regime contributes to yield optimisation on Georges Bank but does not reciprocate to the same extent for the stocks of Browns, Tusket or German / Lurcher because of different growth-rates and allometric relationships (shell height - meat weight) which are all lower than for Georges Bank. The experimental fishery stipulated a meat count of 55 per 500 g was to be adhered to, until a quota of 400 t was caught. The quota was arrived at by industry members of the Offshore Scallop Advisory Committee. This meat count is an improvement, as it allows fuller exploitation of these scallop beds although it is not necessarily an optimum figure.

The fishery took place in September for 6 weeks until meats were so small that catch-rates dropped and crews complained that shucking of the catch had become quite tedious. Some vessels had started fishing the area in June under the Georges Bank management plan (33 meats per 500 g, enterprise allocations, etc.). These pre-September catches amounted to about 30 % of the total.

Over 90 % of the 350 t caught came from a very small area of the northern side of Browns Bank overlapping SA 4Xp and 4Xo. The Tusket area had the highest mean CPUE (Table 11) but Browns Bank was still adequate at 0.660 kg/crhm. A few vessels explored other beds on the southern part of Browns but interest subsided as densities were low (1 - 2 t of logged catches) and meat size small. Mean CPUE derived from 1 - 2 t of logged catches of some Ten Minute Squares (TMS) above 2 kg/crhm were not necessarily comparable to the northern side figures because of the low catch representation.

In 1990 the deep-sea fleet requested a second year of experimental fishery under a quota of 200 t allocated among the different enterprises. The fishery took place in August except for one November trip and caught 210 t approximately (logged catches), exceeding the set TAC by 5 %. Catch-rates were still very good, over 0.500 kg/crhm but lower than in 1989 by about 20 %. Figure 7 maps locations fished, which like in 1989, are highly concentrated (Robert et al 1990) in the northern approaches of Browns Bank. Also, the fleet did not venture any exploratory tows on Browns Bank in 1990.

The meat weight distribution in the catch (Table 12) varies greatly on an annual basis but the percentage examined is too small to draw any conclusion. Browns Bank catches were not sampled after 1984 until the beginning of the experimental fishery in 1989. According to catch

sampling the average meat weight of the 1989 experimental fishery was quite small, under 9 g; in fact, it is one of the main reasons why the fishery shut down before reaching its quota. In 1990 meat weight improved to10.43g on average and did not restrict the fishery.

Previous surveys had found high concentrations of age 2 juveniles in a well delimited area of southeastern Browns Bank (Table 13). However, these year classes did not contribute to a fishery renewal. Very heavy mortality rates appear to have been experienced by possibly 3 successive year classes of scallops on the southern edge of Browns Bank (Robert et al 1986). Both the 1986 and 1987 surveys established the paucity of prerecruits and recruits. Survey work was not performed after that. It is interesting to relate the observed recruitment failure with the low catch levels of 1 t reached in the TMS area during the 1989 experimental fishery.

The 1990 stock survey was conducted in the area experimentally fished the year before but also in its immediate vicinity. Survey results from 23 stations indicate that, except for the area where the fleet was concentrating its efforts, scallop densities were very low. In the area of particular interest, recruited densities were good (Table 13) and, more importantly, it appears that prerecruits and juveniles are present in sizable quantities (Table 14).

German Bank / Lurcher Shoals and the Outer Reaches of the Bay of Fundy

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44° North); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches for the Bay of Fundy and the deep-sea fleets (Table 15) diverge for these respective areas illustrating the misrepresentation resulting from the statistical area boundaries as presently set. Biological differences exist between German Bank and Lurcher Shoals; growth rate being slower on German Bank relative to Lurcher Shoals and the outer reaches of the Bay of Fundy (Robert et al 1986).

During the recent exploitation of this area, the amount of fishable stocks steadily declined from its initial level until 1985 (Table 15). Catch-rates were also following the same trends. A slight reversal of the downward trend appears to take place in 1986. The deep-sea fleet landed under 2 t. ; the Bay of Fundy fleet took relatively small quantities but at catch-rates similar to the high values encountered in 1979. In 1987 this fleet conducted only one fishing trip landing less than 1 t of meats at moderate catch-rates (7 kg/hm). No fishing activity is reported for 1988. As part of the 1989 experimental fishery, over 5 t were caught on German Bank, at a moderate CPUE. Sampling of the catch (Table 16) has been scanty or did not take place. The large meat weight (mean, 48 g) sampled in 1989 suggests that the effort was expanded on remnants of the population that had sustained the German Bank fishery prior to 1985. No fishing activity was recorded for 1990.

The abundance of large, old scallops was declining according to the last survey results available. Very low levels of fishing activity took place between 1985-89. The annual stock survey did not extend to the German Bank / Lurcher Shoals area after 1985.

Exploitation of scallop grounds in the outer reaches of the Bay of Fundy has been decreasing after the landing pulse of the early 1980s (Robert et al 1986). Catch-rates have behaved similarly. Landings by both the Bay of Fundy and the deep-sea fleets had been minimal in 1986. However the deep-sea fleet managed a catch-rate (0.458 kg/crhm) comparable to values obtained during the initial stages of the recent fishery of these scallop beds. The Bay of Fundy fleet, the only fleet entitled to exploit the area beginning in 1987, has not fished these beds since.

CONCLUSION

The Eastern shelf is sustaining continuous exploitation with catches of a few hundreds tons per year but at a low (0.200 kg/crhm) catch-rate. Low but regular recruitment in the southwestern section of Western Bank appears to replenish scallop beds in the area. On the Western Shelf, an experimental fishery concentrated on the northern approaches of Browns Bank. It is a short term fishery lasting only a few months at best each time, but it fills the deep-sea fleet's expectations of continuous, maintained high returns for the offshore fishery. The experimental fishery, conducted with a size limit different from the Georges Bank one and a quota to be split into enterprise allocations, allowed a rationalised exploitation of scallop beds that would not have been realised otherwise. For two consecutive years this management strategy has worked well. Although recent CPUE's have dropped, they are still relatively high. With the high abundances-at-age estimated from survey results, it might be worthwhile to consider more experimental fishing activity.

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Table 1.- Updated biological data on growth-rate and meat yield (year round values) for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Banquereau Bank	N = 60	N = 90
	H_∞ = 128.105 mm	intercept = -11.003
	t_0 = 1.5233	slope = 2.913
	k = 0.2579	
Middle Grounds	N = 414	N = 289
	H_∞ = 156.210 mm	intercept = -10.305
	t_0 = 1.3650	slope = 2.801
	k = 0.1980	
Sable, Western Bank	N = 3,716	N = 3,734
	H_∞ = 136.628 mm	intercept = -11.381
	t_0 = 1.3375	slope = 2.999
	k = 0.2269	
Browns Bank	N = 459	N = 480
	H_∞ = 109.910 mm	intercept = -15.712
	t_0 = 1.4402	slope = 3.867
	k = 0.2873	

Table 2.- Number of vessels from the deep-sea fleet fishing scallop grounds on the Scotian Shelf as per log information. The Western Shelf includes German Bank / Lurcher Shoals, Browns Bank, and the Tusket area. The Eastern Shelf includes Middle Grounds, Western Bank, the Sable Island area, and Banquereau Bank. The last column indicates the number of vessels that used both areas of the Shelf.

Year	Western Shelf	Eastern Shelf	Scotian Shelf
1986	4	55	3
1987	0	33	0
1988	3	15	1
1989	29	35	16
1990	24	34	13

Table 3.- Fishery characteristics for the Banquereau Bank area (NAFO 4V) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1980	3.30	7.17	7.17	20,171	0.355
1981	0.00	0.00	–	--	–
1982	0.69	0.42	0.42	1,092	0.387
1983	5.37	3.26	3.26	7,343	0.444
1984	3.18	0.63	0.63	939	0.672
1985	0.24	N/A	N/A	N/A	N/A
1986	15.64	11.15	10.98	45,849	0.239
1987	0.65	0.51	0.51	4,617	0.110
1988	0.00	0.00	0.00	0,000	--
1989	0.00	0.00	0.00	0,000	--
1990	0.83	0.00	0.00	0,000	--

Table 4.- Fishery characteristics for the Middle Grounds area (NAFO 4We) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	-	-	-	-	-
1980	3.65	1.42	1.42	5,434	0.262
1981	-	-	-	-	-
1982	72.39	62.09	61.12	122,106	0.501
1983	105.16	104.92	100.59	309,055	0.325
1984	11.90	9.94	8.34	47,585	0.175
1985	26.89	21.59	21.59	99,345	0.217
1986	51.27	51.28	50.46	345,552	0.146
1987	6.70	7.03	6.64	44,274	0.150
1988	0.28	0.29	0.29	1,707	0.169
1989	20.84	21.70	21.70	66,551	0.326
1990	19.04	33.63	33.63	109,777	0.306

Fishery characteristics for Sable Island and Western Bank (NAFO 4Wf-j)

1979	-	-	-	-	-
1980	60.99	50.48	50.48	219,987	0.229
1981	0.56	0.00	0.00	0	-
1982	64.10	61.40	61.40	243,779	0.252
1983	185.15	166.47	164.45	886,072	0.186
1984	71.30	64.65	63.58	370,231	0.172
1985	64.93	76.00	76.00	294,217	0.258
1986	618.35	585.26	551.88	3,070,138	0.180
1987	415.80	412.01	394.23	2,339,915	0.168
1988	100.43	100.42	93.99	414,920	0.227
1989	516.39	515.36	489.54	1,830,668	0.267
1990	424.67	403.94	387.07	1,615,586	0.240

Table 5.- Nature of the catch from NAFO SA 4W determined by analyses of scallop meat weights.

	% catch examined	meat weight (g)				n meats
	catch landed	mean	min	max	s.d.	
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1259
1984	0.0392	14.84	4.23	46.97	0.14	314
1985	0.0175	22.88	6.31	66.40	0.22	217
1986	0.0134	22.73	4.33	61.51	0.23	302
1987	0.0436	21.48	2.34	68.23	0.30	137
1988	-	-	-	-	-	-
1989	0.0441	14.46	4.22	61.45	0.11	636
1990	0.0417	16.45	5.74	59.69	0.16	483
Sable Island/Western Bank						
1980	0.0133	9.46	3.87	22.11	0.04	860
1981	-	-	-	-	-	-
1982	0.0015	9.15	4.65	15.38	0.11	102
1983	0.0339	13.49	2.25	72.43	0.04	4658
1984	0.0161	11.10	2.65	42.48	0.07	1034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11397
1987	0.0319	14.35	2.22	98.14	0.04	9226
1988	0.0045	11.57	4.07	34.60	0.09	394
1989	0.0215	13.14	3.16	72.91	0.02	8440
1990	0.0099	13.97	2.52	71.89	0.05	2994

Table 6.- Number of survey stations in NAFO SA 4V and 4W by year and by stratum type.

Banquereau Bank	1987	1988	1989	1990
exploratory	5	5	6	0
total	5	5	6	0

Middle Grounds	1983	1984	1985	1986	1987	1988	1989&90
low catch	4	8	5	4	6	6	0
medium catch	4	-	-	-	-	-	-
high catch	12	12	5	6	6	-	-
total	20	20	10	10	12	6	0

Sable/Western Bank	1984	1985	1986	1987	1988	1989	1990
low catch	14	7	13	5	4	11	10
medium catch	13	25	42	27	14	33	30
high catch	13	8	10	58	72	62	50
exploratory	-	-	10	-	-	-	-
total	40	40	75	90	90	106	90

Table 7.- Average number of scallops at age caught in a lined 2.44 m New Bedford offshore dredge by catch stratum in the Sable Island - Western Bank area.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1985 stock survey											
low	71	55	27	15	12	7	6	2	9	205	222
medium	9	15	16	7	6	6	5	2	7	74	59
high	59	112	40	33	24	6	4	2	0	281	181
1986 stock survey											
low	1	3	2	2	1	0	1	1	5	15	15
medium	2	2	4	2	2	1	1	1	6	20	30
high	1	0	1	1	1	1	2	2	6	13	9
exploratory	0	0	0	0	0	0	0	0	1	3	2
1987 stock survey											
low	0	1	2	2	1	1	1	1	5	14	12
medium	2	4	6	9	6	2	1	1	6	37	51
high	12	23	35	34	16	5	3	2	5	134	149
1988 stock survey											
low	1	2	1	0	0	0	0	1	3	7	4
medium	3	6	8	11	10	4	1	1	4	48	70
high	25	41	48	50	29	10	3	2	3	210	222
1989 stock survey											
low	3	8	5	7	3	2	0	0	3	33	57
medium	0	2	4	7	6	3	1	1	4	28	38
high	8	34	50	42	24	10	4	1	2	181	229
1990 stock survey											
low	4	1	1	2	3	2	1	1	2	21	34
medium	2	2	6	8	8	4	2	1	3	38	47
high	22	9	26	31	23	9	3	1	2	130	107

Table 8.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum in the Sable Island - Western Bank area.

	Age (years)		
	2-4	5-10	11+
1984 stock survey			
low	10	14	4
medium	32	21	3
high	16	28	2
1985 stock survey			
low	153	43	8
medium	40	27	6
high	212	69	0
1986 stock survey			
low	6	5	5
medium	8	8	5
high	2	8	5
exploratory	0	0	1
1987 stock survey			
low	3	6	5
medium	12	20	5
high	70	61	4
1988 stock survey			
low	4	2	2
medium	17	28	3
high	114	95	2
1989 stock survey			
low	16	12	3
medium	6	19	3
high	92	82	1
1990 stock survey			
low	6	9	2
medium	11	24	2
high	56	67	1

Table 9.- Extent of the area where scallop beds were surveyed on Sable / Western during research stock surveys.

	Area surveyed in km ^{2}				
	1986	1987	1988	1989	1990
Western Bank	3,726.38	5,944.07	3,891.46	5,889.65	6,142.34
Above Sable Island	339.48	19.14	-----	60.84	-----
Below Sable Isand	175.57	-----	-----	-----	42.39
Total	4,241.43	5,963.21	3,891.46	5,950.49	6,184.73

Table 10.- Volume estimates in n (10 ^{6}) for the Western Bank area derived from research survey data. Biomass estimates (t) are given for recruited ages.

	Age (years)						Biomass
	2	3	4	5	6	7	
1986	3.529	2.962	4.181	4.256	3.205	0.946	50.10
1987	18.121	35.799	59.083	45.214	20.913	7.965	439.71
1988	24.450	49.712	55.302	57.716	33.128	11.450	679.15
1989	6.806	26.547	46.083	46.066	27.725	13.321	616.62
1990	11.590	8.906	25.715	33.282	27.480	12.949	543.29

Table 11.- Fishery characteristics for the Browns Bank - Tusket area (NAFO 4Xp and 4Xo) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
4Xo					
1979	0.00	13.70	13.70	21,964	0.624
1980	13.17	40.79	33.41	60,979	0.548
1981	0.36	1.40	1.40	2,219	0.632
1982	47.55	70.87	65.76	86,204	0.763
1983	42.70	53.11	44.96	78,613	0.572
1984	10.57	13.24	13.24	45,619	0.290
1985	0.00	0.84	0.84	2,155	0.389
1986	0.00	0.00	0.00	0	-
1987	0.00	0.00	0.00	0	-
1988	4.22	0.00	0.00	0	-
1989	16.14	42.31	35.04	44,918	0.780
1990	8.95	34.73	34.73	61,132	0.568
4Xp					
1979	73.05	77.90	76.62	145,118	0.528
1980	258.23	205.91	199.25	479,388	0.416
1981	24.98	12.86	12.65	19,578	0.646
1982	114.07	83.40	82.84	217,580	0.381
1983	63.32	34.83	33.46	135,526	0.247
1984	16.60	4.95	4.95	26,565	0.186
1985	6.93	15.54	15.54	36,413	0.427
1986	4.64	4.00	4.00	6,948	0.576
1987	0.00	0.00	0.00	0	-
1988	0.00	5.16	5.16	2,853	1.808
1989	321.20	277.76	189.98	287,667	0.660
1990	191.77	170.95	146.01	275,101	0.531

Table 12.- Nature of the catch from Browns Bank/Tusket area determined by analyses of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0022	16.29	4.01	58.66	0.18
1980	0.0195	10.54	1.37	87.46	0.04
1981	0.0080	35.75	13.71	55.37	0.35
1982	0.0020	16.39	2.90	47.13	0.18
1983	0.0000	---	---	---	---
1984	0.0062	21.98	6.46	68.63	0.51
1985	0.0000	---	---	---	---
1986	0.0000	---	---	---	---
1987	0.0000	---	---	---	---
1988	0.0000	---	---	---	---
1989	0.0388	8.93	3.70	49.90	0.01
1990	0.0022	10.43	4.13	42.79	0.07

Table 13.- Average number of scallops at age caught in a lined 2.44 m New Bedford offshore dredge in the Browns Bank / Tusket area.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1983 stock survey											
low	368	2	0	1	1	1	1	1	2	676	1068
high	248	1	0	0	0	1	2	3	10	416	969
1984 stock survey											
low	0	0	0	0	0	0	0	0	0	0	--
medium	94	53	6	3	0	0	2	3	14	209	280
high	58	0	0	0	6	12	9	4	4	118	184
1985 stock survey											
exploratory	244	0	0	0	0	0	1	2	14	286	328
low	0	0	0	0	0	0	0	0	0	1	0
high	1	0	0	0	0	0	0	0	2	6	6
1986 stock survey											
exploratory	1	0	0	0	1	3	2	1	5	15	14
low	0	0	0	0	0	0	0	0	1	5	0
high	0	0	1	0	0	0	0	0	1	2	0
1987 stock survey											
exploratory	9	1	0	0	0	0	0	1	3	24	37
1990 stock survey											
exploratory	174	122	65	60	35	26	20	15	29	547	713

Table 14.- Summary of average number of scallops at age per tow for prerecruits (shell height under 75 mm or age less than 5 years) and recruits (shell height over 75 mm) by catch stratum.

	Age (years)		
	1-4	5-10	11+
Browns Bank / Tusket 1983			
low	416	6	1
high	308	9	7
Browns Bank / Tusket 1984			
low	0	0	0
medium	156	11	11
high	61	34	1
Browns Bank / Tusket 1985			
exploratory	247	6	11
low	0	0	0
high	1	0	2
Browns Bank / Tusket 1986			
exploratory	1	8	4
low	0	0	1
high	1	0	1
Browns Bank / Tusket 1987			
exploratory	12	2	2
Browns Bank / Tusket 1990			
exploratory	362	165	20

Table 15.- Fishery characteristics for the German Bank / Lurcher Shoals area (NAFO 4Xq) for the two fleets. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertains to Class 1 catch only. (Catches supported by sales slips only are in parentheses.)

Bay of Fundy fleet Year	Landings	Logged catches	Class 1 catch	Effort (hm)	CPUE (kg/hm)
1979	293.82	258.25	182.37	7,112	25.64
1980	113.72	89.91	65.96	6,485	10.17
1981	194.73	185.51 (46)	125.57	14,352	8.75
1982	99.06	119.11 (16)	78.11	12,348	6.33
1983	43.68	32.30 (6)	16.76	5,949	2.82
1984	11.07	32.90	25.29	7,660	3.30
1985	2.80	1.45	0.30	416	0.71
1986	23.94	34.62	22.41	1,085	20.66
1987	0.66	0.41	0.41	57	7.09
1988	0.00	0.00	0.00	00	------
1989	0.00	0.00	0.00	00	------

Deep-sea fleet Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	102.32	147.10	145.20	157,729	0.921
1980	1269.71	1132.69	1021.86	1,614,441	0.633
1981	379.69	207.63	188.78	318,221	0.593
1982	659.74	535.84	403.51	954,628	0.423
1983	587.76	465.88	420.45	1,092,569	0.385
1984	207.13	175.83	156.45	581,969	0.269
1985	33.76	16.60	15.91	46,295	0.344
1986	1.59	0.00	0.00	0	---
1987	0.00	0.00	0.00	0	---
1988	0.00	0.00	0.00	0	---
1989	5.54	4.54	4.01	9,112	0.440
1990	0.00	0.00	0.00	0	---

Table 16.- Nature of the catch from German Bank / Lurcher Shoals areas determined by analyses of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0019	11.39	4.74	34.15	0.06
1980	0.0135	11.66	2.20	85.82	0.02
1981	0.0084	12.74	2.34	75.27	0.04
1982	0.0171	16.04	3.69	76.92	0.03
1983	0.0010	11.99	3.35	44.13	0.11
1984	0.0008	22.69	3.88	53.52	0.42
1985	0.0000	-	-	-	-
1986	0.0000	-	-	-	-
1987	0.0000	-	-	-	-
1988	0.0000	-	-	-	-
1989	0.1012	47.93	27.41	76.19	0.32
1990	0.0000	-	-	-	-

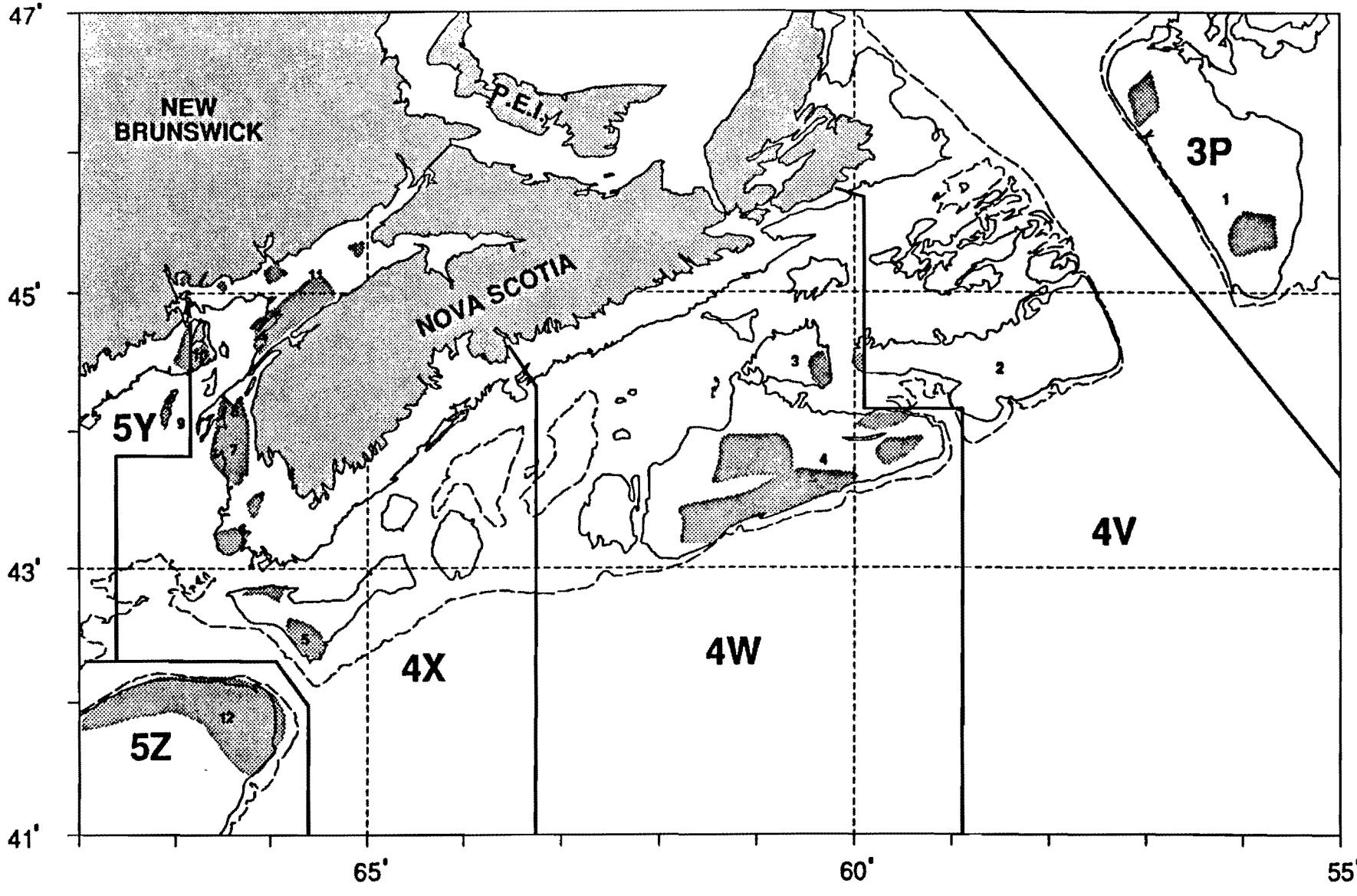

Figure 1.- Scallop fishing areas on the Scotian Shelf and St. Pierre Bank. The 100 and 200 m isobaths are represented. Areas in numerical order are: (1) St. Pierre Bank; (2) Banquereau Bank; (3) Middle Ground; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches of the Bay of Fundy; (9) Southwest Bank; (10) Grand Manan area and (11) the Bay of Fundy area. Georges Bank (12) is also shown.

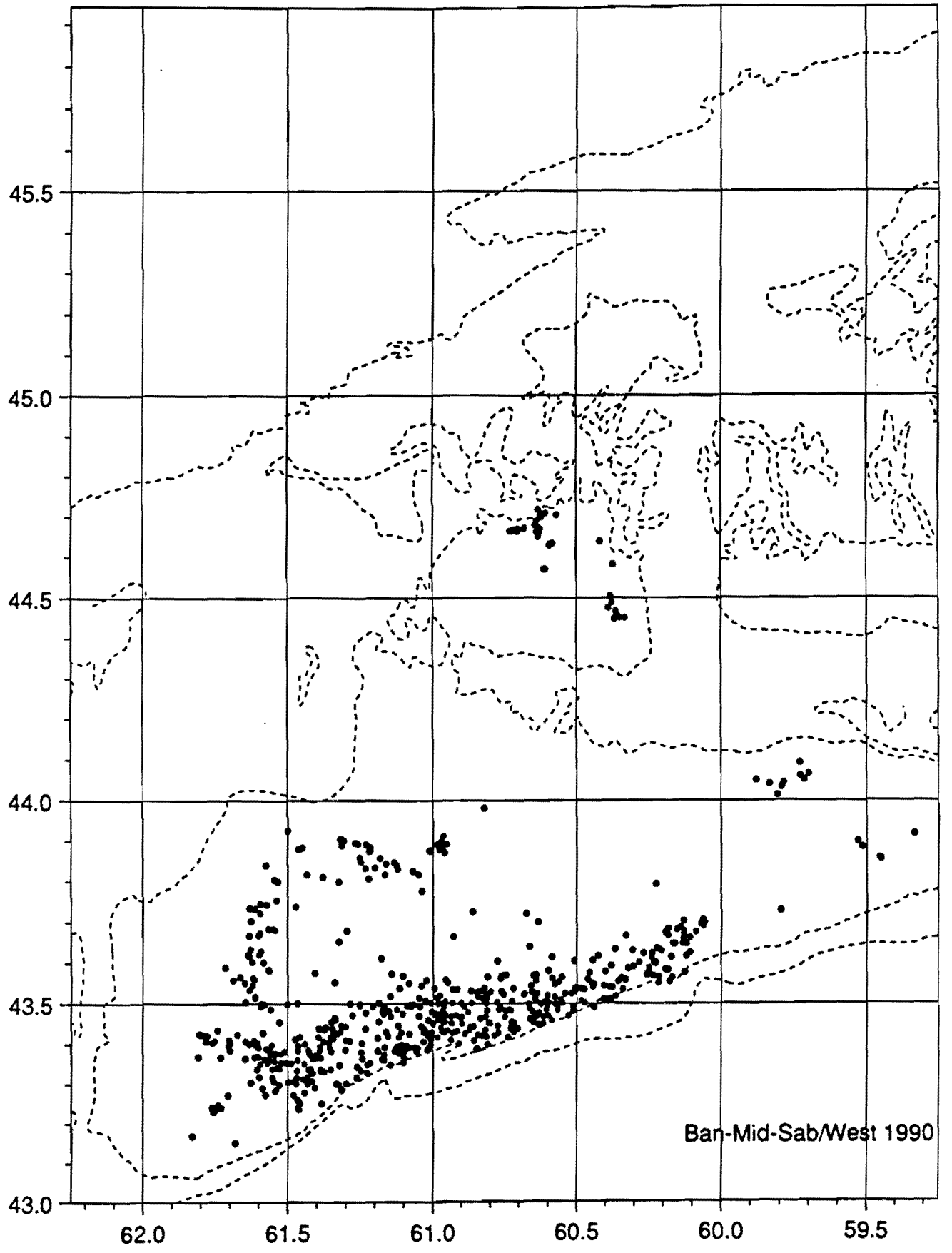

Figure 2.- Distribution of commercial effort by the deep-sea fleet on the eastern Scotian Shelf in 1990. Each dot corresponds to a fishing location visited at least once.

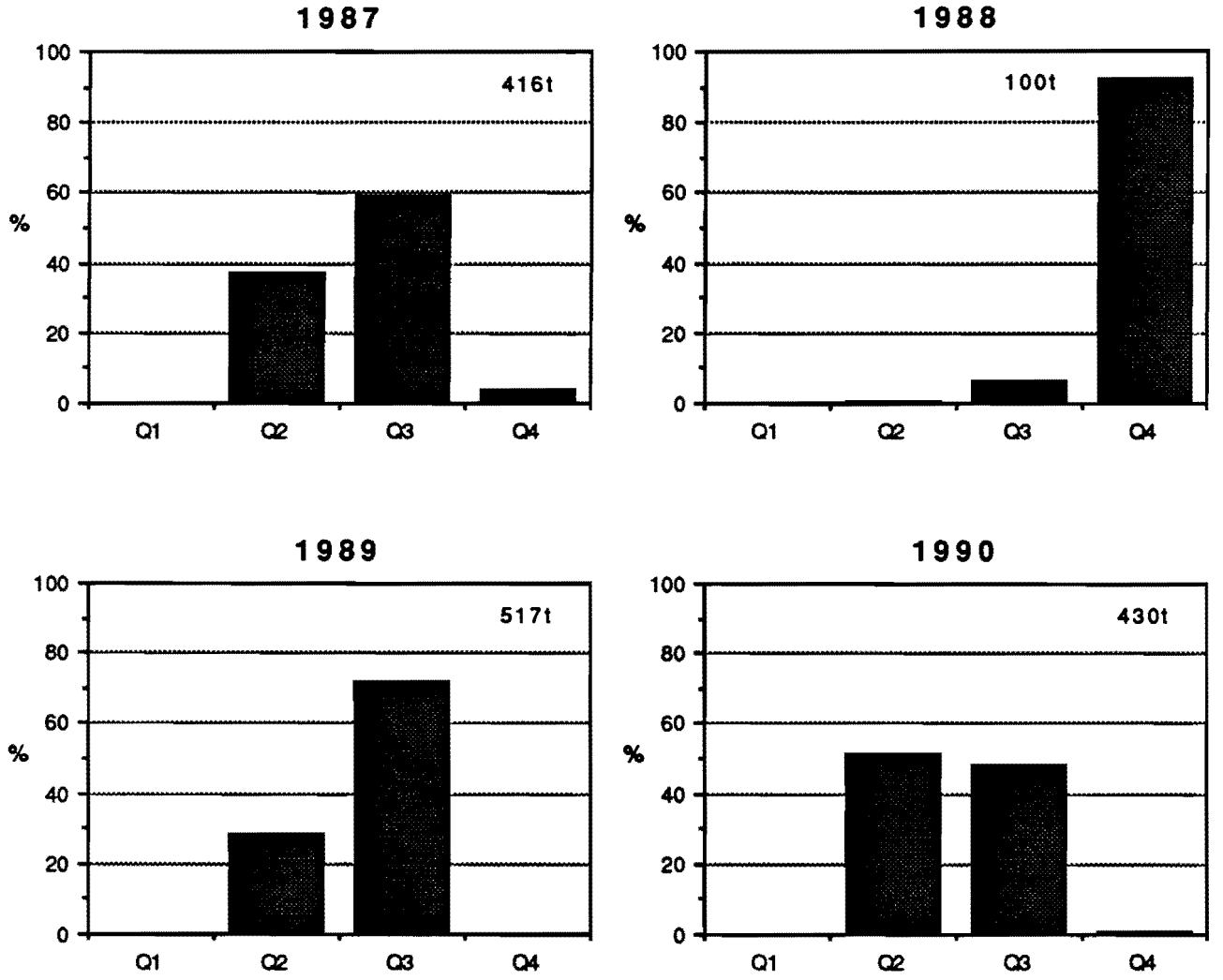

Figure 3.- Seasonality of catches from the Western Bank, Sable Island area in terms of percentage of annual statistical catches per quarter increment. Total for the year is given in the upper right corner of each graph.

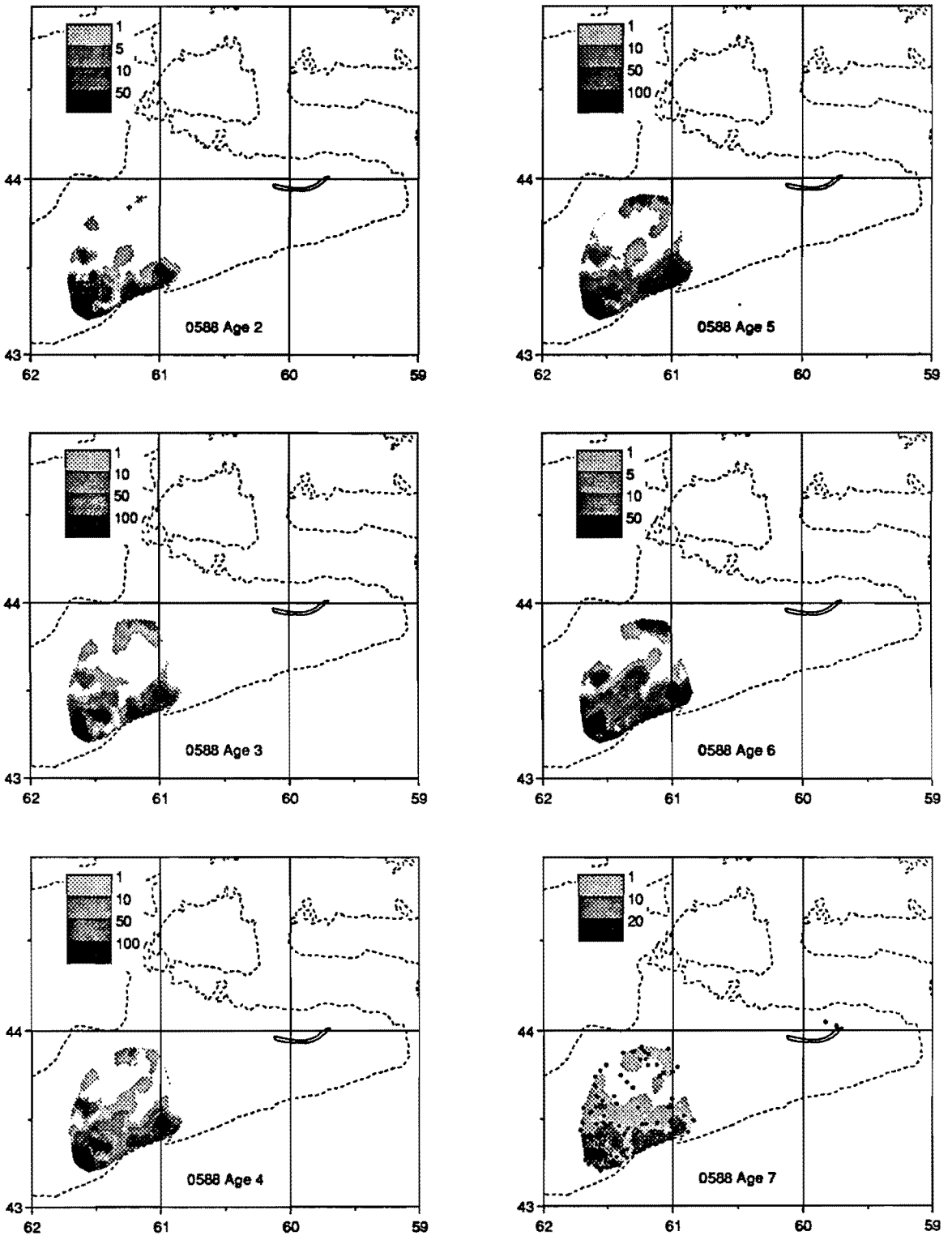

Figure 4.- 1988 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

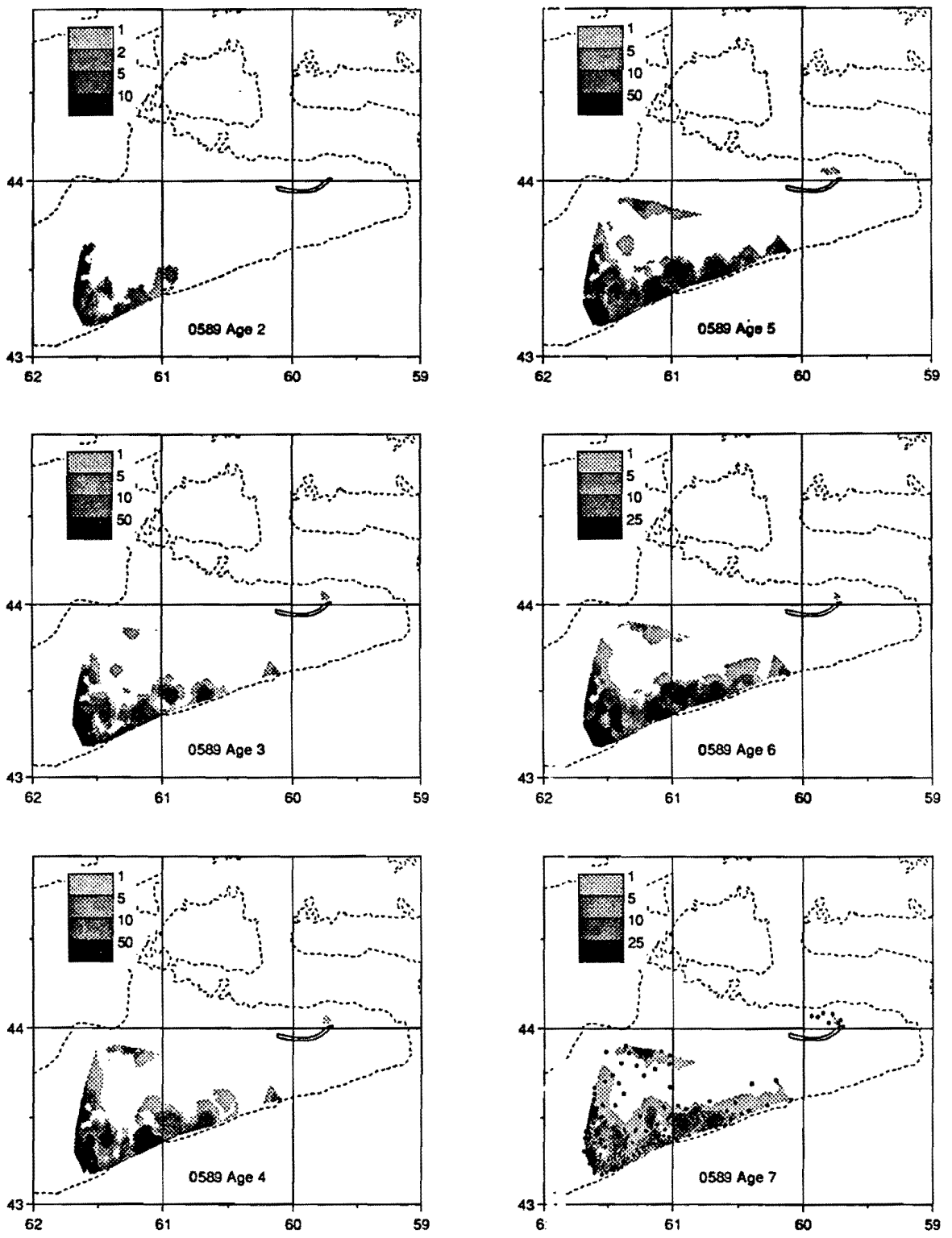

Figure 5.- 1989 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

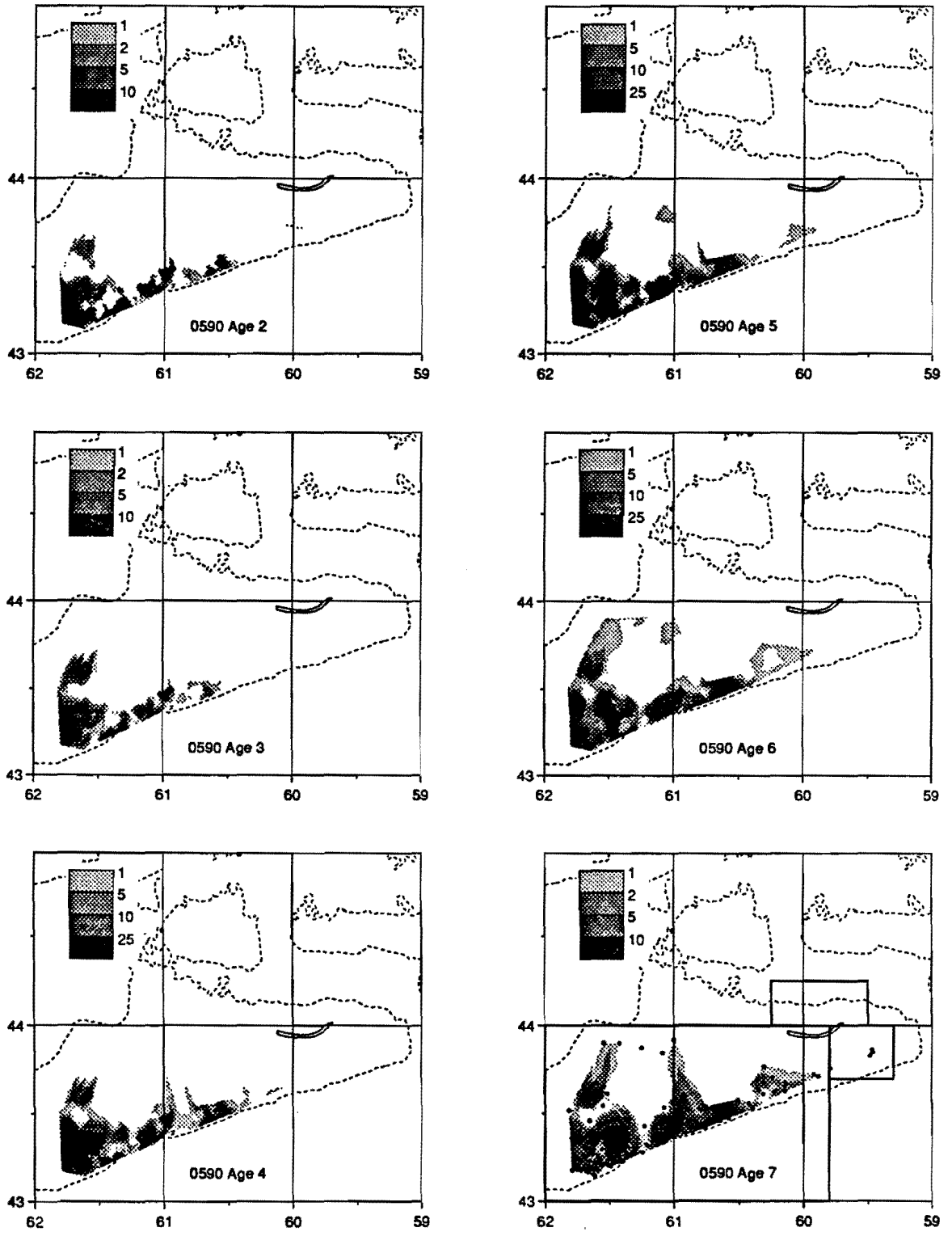

Figure 6.- 1990 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

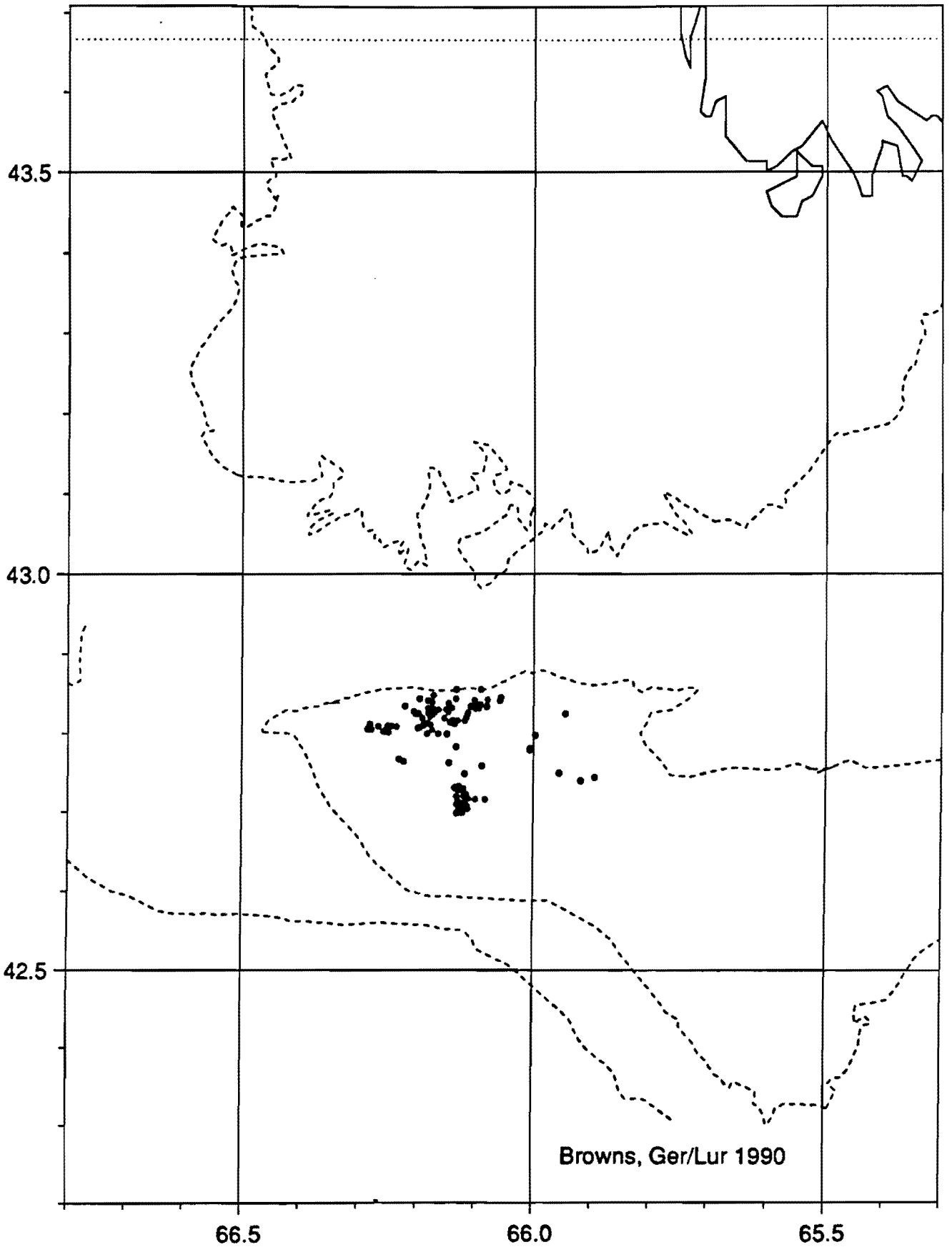

Figure 7.- Distribution of commercial effort by the deep-sea fleet on the western Scotian Shelf in 1990. Each dot corresponds to a fishing location visited at least once. There was no fishing activity on German / Lurcher in 1990.