Scallop Fishing Grounds on the Scotian Shelf - 1988

By

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ABSTRACT

On the Scotian Shelf, scallop beds occur, in a patchwork fashion, from Banquereau Bank to the east, to the Lurcher Shoals at the approaches to the Bay of Fundy to the west. Historically, these grounds had never sustained production (measured by catch) for more than a few years until recently when significant effort was diverted to these beds.

The traditional fishing patterns of the deep-sea fleet have always included Georges Bank as the main ground exploited with the Scotian Shelf as an alternate, sometimes in an opportunistic fashion. Nowadays, Scotian Shelf scallop beds have become of greater importance and are visited regularly. Prior to the era of restricted access to Georges Bank and prior to the introduction of effort reduction measures, Georges Bank was typically accounting for over 95 % of the 'offshore' fleet catches. Recently, Scotian Shelf scallop beds in NAFO subareas 4V-W and 4X contribute a much larger share of the 'offshore' fleet catches as well as some more distant grounds in NAFO subarea 3P i.e. Saint Pierre Bank. During the last five years Georges Bank catches represented on average 85 % of the total for the fleet. It would appear that the fishing interest generated by the Scotian Shelf scallop stocks, especially in the eastern areas, is here to stay. In 1988 the Scotian Shelf did not generate high levels of catches, about 100 t, but catch-rates improved 35 % over 1987. However, catches from Saint Pierre Bank were the highest ever reported at almost 1,000 t.

RESUME

On trouve des bancs de pétoncles parsemés sur le plateau néo-écossais à partir du banc Banquereau à l'est jusqu'aux haut-fonds de Lurcher aux approches de la Baie de Fundy à l'ouest. Du point de vue historique, ces bancs n'ont jamais produit d'une façon soutenue d'après les captures, pour plus de quelques années jusqu'à récemment.

La flotte hauturière a, par habitude, toujours exploité le banc Georges comme lieu de pêche principal et, bien souvent d'une façon opportuniste, le plateau néo-écossais en alternative. Dernièrement les bancs de pétoncles du plateau ont pris plus d'importance et sont visités régulièrement. Avant l'ère de l'accès limité sur le banc Georges et avant l'introduction de mesures pour réduire l'effort, le banc Georges fournissait habituellement plus de 95 % des prises de la flotte hauturière. Récemment les bancs de pétoncles sur le plateau néo-écossais dans les sous-régions de l'OPANO 4V- W et 4X contribuent une plus grande part des prises hauturières ainsi que des bancs beaucoup plus éloignés dans la sous-région de l'OPANO 3P, tel le banc Saint-Pierre. Au cours des cinq dernières années le banc Georges a représenté en moyenne 85 % du total pour la flotte. Il semblerait que l'intérêt engendré par les bancs de pétoncles du plateau néo-écossais, surtout dans l'Est, va demeurer. En 1988 le plateau néo-écossais n'a pas produit des prises élevées, 100 t environ, mais les taux de capture se sont améliorés de 35 % sur 1987. Cependant, les captures du banc Saint Pierre ont été les plus hautes jamais enregistrées à près de 1,000 t.

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 regularly since fishing activities on Georges Bank have been restricted to the zone east of the ICJ line (Oct. 1984) and are now (June 1986) directed by an Enterprise Allocations system (E.As.) for catch removals (Fig. 2). Ever since the beginning of the offshore fishery in the late 1950's, exploitation of the Scotian Shelf was somewhat irregular. That pattern of exploitation has changed with the 1980's. It now appears that some Scotian Shelf grounds may sustain continuous exploitation.

The Scotian Shelf west of longitude 65 ^{0} W (Fig. 1) has not attracted much fishing interest since the implementation of the Inshore / Offshore Agreement in 1987 (see Robert et al 1988 for details) due to the present lack of commercial scallop stocks on German/Lurcher. During the last year some fishing trips directed 'exploratory' effort, for under 10 t worth of catches, on Browns Bank which had not been exploited for the last 5 years. Further east, 1988 has been a year of relatively minimum activity on Sable/Western Bank while emphasis was placed on Saint. Pierre Bank which yielded the highest landings on record.

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). The separation of the fleets (1987 onward) at latitude 43^0 40' N is adding another dimension to the inadequacy of the statitical reporting system. Lurcher Shoals have scallop beds spreading both north and south of latitude 43^0 40' N so that scallop catches statistically compiled in NAFO sub-subarea 4Xq may still originate from the inshore and / or offshore fleets. One must assume the catches from vessels under 19.8 m come from the upper reaches of the Lurcher Shoals (north of the separation line) while vessels over 19.8 m fish German Bank and the lower Lurcher Shoals (south of the line). Fortunately, little fishing activity is presently taking place in this area.

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 ground may also be established assuming that the catch with known location is representative of the total catch from that ground.

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 43^0 40' N following the Inshore / Offshore Agreement. 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 between latitudes 43^0 40' and 44^0 00' N following the Agreement.

Despite the different size of vessels, both fleets use an offshore-type scallop drag which width may vary from 2.4 to 4.9 m (8-16 feet). The Bay of Fundy fleet fishes only one drag at a time while the deep-sea fleet fishes two drags simultaneously, one on each side. These are slightly wider than the ones used by the Bay of Fundy fleet. On occasion, a Bay of Fundy vessel may use a gang of Digby-type drags.

Catch Sampling

Catch sampling information is available for 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. However, since the exploitation of scallop grounds on the Scotian Shelf was somewhat irregular until very recently, 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 randomly stratify survey stations. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out during May on a Government research vessel. As in 1987 some exploratory tows were performed at the western end of Banquereau Bank around latitude 44^0 30' N., longitude 60^0 00' W. The Browns Bank segment of the Scotain Shelf annual stock survey was dropped from the 1988 schedule due to the low levels of fishing activity as well as the German / Lurcher area.

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 desk-top 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.

In addition to establishing a stratified mean number per tow, the data was 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 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 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. Work is still in progress to refine the procedure. A complete description 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 1987 surveys and samples collected from the fleet up to 1987 were used in the analysis. 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 and DISCUSSION

Scallop Fleets

Previous to 1984, over 100 vessels from the deep-sea fleet and the Bay of Fundy fleet were exploiting scallop grounds on the Scotian Shelf (Table 2). This activity declined during 1984, 1985 to increase again in 1986. Following the Inshore / Offshore Agreement, the Bay of Fundy fleet was restricted to a very small section of the Shelf and only one vessel fished the area according to the information available. The deep-sea fleet activities have steadily declined. In 1988, only 17 vessels exploited the Scotian Shelf; they turned their interest toward Saint Pierre Bank where 52 vessels conducted at least one trip.

For both fleets, the Scotian Shelf fishery is not a feature as permanent as the Georges Bank fishery for the deep-sea fleet and the traditional scallop grounds within the Bay of Fundy for the Bay of Fundy fleet. 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 are below average (especially compared to Georges Bank rates). Following a sizable recruitment pulse on the traditional scallop beds exploited by the Bay of Fundy fleet, catches in the Bay rose to heights never reached before. It is doubtful that this fleet will venture out of the Bay over the short term.

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.

Banquereau Bank

Historically speaking, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area, catches averaging 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; this coincided with the highest landing for the Sable Island area. But this trend could not be maintained according to the 1987 figure of under 1 t with a 50 % drop in CPUE. Official statistics do not report any catches for 1988. 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 5 exploratory tows carried out on Banquereau Bank (Table 4) in 1988 gave results almost similar to the 1987 ones (Table 5). Few scallops were caught, confined to age 5 + with a low abundance per tow. Prerecruits were absent in the lined gear (Table 9).

Middle Ground

Middle Ground is a shallow bank of which 500 square nautical miles carries 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 6). Catch-rates had been moderate at best, 0.5 kg/crhm in 1982, to decline gradually to an average of 0.15 for the last three years.

Sampling of the catch (Table 7) indicates that a wide range of meats are shucked (2 - 68 g) with a relatively large mean weight. This profile varies little between years although only a small number of meats are weighted. Very low catches in 1988 prevented catch sampling.

Stock surveys (tables 4, 8-9) 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.

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). Annual catches have been low (Table 6) until 1986 (1983 excepted) when a sharp, 10 fold increase occurred from 1985 to 1986. High 1986 catches correspond to the highest effort values observed. The 1987 catch figure is relatively high with about 2.5 million crhm for total effort. Catch-rate values have always been low. Although 1988 catches have dropped to only 25 % of the previous year's, there has been a noticeable improvement in catch-rates, going up 35 % from 1987.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighboring Middle Grounds, (Table 7) 12 versus 20+ g. The 1987 catch sampling recorded the smallest and largest shucked scallop since the fishery began in 1980 (2 - 98 g). About 50 % of the catch was scallops between 7 and 10 years of age, a fair mix of year-classes but the growth pattern of this area is complex. The very little sampling of the catch carried out in 1988 shows a decrease in the average weight of meats shucked from 14.4 to 11.6 g.

Since the start of annual stock surveys five years ago, the 1988 survey observed the second greatest abundance at age (Table 10) with sizable quantities of prerecruits and quite a few recruits as well (Table 11), especially young recruits (ages 5-6). Age group frequencies (Fig. 3) show the depletion of old scallops.

The distributions and relative densities (numbers at age per standard tow) of selected age groups by shaded contours are plotted in Figs 4 - 6. The area surveyed is not exactly duplicated in its physical dimensions from year to year. 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). Despite that, each plot shows that high abundances are to be found more regularly near the edge of the continental shelf rather than on Western Bank per se or in the immediate vicinity of Sable Island. In addition, the area where important concentrations are found is very limited geographically speaking, less than 1,500 sq. km.

Abundance at age estimates ($n*10^6$) for the last three years were derived by integrating the volumes under the contoured surfaces. Contours were smoothed by subtriangulation (4 segments) of the surface. This would lead to rough biomass approximations (recruiting age 5 only, expressed in tons of meats) as follows:

Age	1986	1987	1988
2	2.39	19.13	24.22
3	2.06	35.96	37.97
4	4.13	58.69	41.78
5	3.36	44.99	45.09
	(16.40)	(219.55)	(220.04)

Also, no correction is made for the efficiency of the gear. Gear behaviour has not been studied on these particular grounds. But if one was to assume the figure for other grounds valid here, the factor involved could be in the order of 5-10 X.

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.

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; Table 12 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; the same may be said for catch-rates until 1985. From then on, the deep-sea fleet CPUE shows a modest recovery while the Bay of Fundy fleet CPUE rises sharply. However, these last values may be non-representative (Robert et al 1988). There has been a small resurgence of landings in 1988 with very high catch-rates at 1.8 kg/crhm.

The meat weight distribution in the catch (Table 13) varies greatly on an annual basis but the percentage examined is too small to draw any conclusion. Browns Bank catches have not been sampled after 1984.

Previous surveys had found high concentrations of juveniles in a well delimited area of southeastern Browns Bank (Table 14). However, these year-classes did not contribute to a fishery revival. 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 pre-recruits and recruits. The stock will remain in a somewhat collapsed state due to the massive disappearance of year-classes at the juvenile stage, the lack of older animals in any quantity and the absence of prerecruits during the most recent surveys.

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 degrees North); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches for both fleets (Tables 15 and 17) diverge for these respective areas illustrating the misrepresentation resulting from the statistical areas 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 levels 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. Sampling of the catch (Table 16) has been scanty or did not take place.

The abundance of large, old scallops was declining (Table 18) until the most recent survey. Very low levels of fishing activity took place from 1985 onward. The annual stock survey did not extend to the German/Lurcher 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 (Table 17). 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 the area in 1987, did not exploit these beds nor in 1988.

CONCLUSION

Outlook

Although Browns Bank produced superior CPUEs in 1988, they resulted in a catch of less than 10 t. This exploration was conducted early in the year. If great stock improvement would have been perceived at the time, the interest sparked in the fleet would have generated more landings. Such was not the case. The area explored was located on the northwest side of Browns Bank; historically, it has not supported highly productive scallop beds.

Even though the Sable Island / Western Bank area had a rather poor fishery performance in 1988, the available data on recruitment indicate that these scallop beds could sustain some effort levels. However, it would not offer the same possibilities as the long standing Georges Bank. As an alternate to Georges Bank, the Scotian Shelf is relied upon more and more nowadays compared to the historical past (Fig. 2). Prior to the era of restricted access to Georges Bank and prior to the introduction of effort reduction measures, Georges Bank was typically accounting for over 95 % of the 'offshore' fleet catches. The emphasis on the historical contribution of the Georges Bank catches is represented by the percentage distribution of logged catches from different areas for the year 1981 in Fig. 2. During the seventies for example, brief stop-overs on scallop beds in NAFO subarea 4X were taking place but fishing trips were not usually directed to those grounds. Fishing ventures in NAFO subarea 4W scallop areas were more exploratory in nature. Recently, Scotian Shelf scallop beds in NAFO subareas 4V-W and 4X contribute a much larger share of the 'offshore' fleet catches as well as some more distant grounds in NAFO subarea 3P i.e. Saint Pierre Bank. As figure 2 illustrates, during the last five years Georges Bank catches represent on average 85 % of the total for the fleet compared to 95 % + previously. It would appear that the fishing interest generated by the Scotian Shelf scallop stocks, especially in the eastern areas, is here to stay.

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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_∞ = 128.105mm	intercept = -11.003
	t_0 = 1.5233	slope = 2.913
	k = 0.2579	
Middle Grounds	N = 417	N = 289
	H_∞ = 161.504mm	intercept = -10.305
	t_0 = 1.3360	slope = 2.801
	k = 0.1851	
Sable, Western Bank	N = 2,726	N = 2,052
	H_∞ = 138.399mm	intercept = -11.451
	t_0 = 1.3253	slope = 2.997
	k = 0.2232	
Browns Bank	N = 398	N = 420
	H_∞ = 114.046mm	intercept = -16.265
	t_0 = 1.3456	slope = 3.997
	k = 0.2636	

Table 2.- Number of vessels by fleet fishing scallop grounds on the Scotian Shelf as per log information.

Year	Bay of Fundy under 19.8m L.O.A.	Deep-sea over 19.8m L.O.A.	Total
1979	38	75	113
1980	37	75	112
1981	44	76	120
1982	45	75	120
1983	27	73	100
1984	29	50	79
1985	14	34	48
1986	32	55	87
1987	1	33	34
1988	0	17	17

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 pertaining 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	--

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

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

Sable/Western Bank	1983	1984	1985	1986	1987	1988
low catch	N/A	14	7	13	5	4
medium	N/A	13	25	42	27	14
high	N/A	13	8	10	58	72
exploratory	N/A	-	-	10	-	-
total		40	40	75	90	90

Banquereau Bank	1987	1988
exploratory	5	5
total	5	5

Table 5.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, in the western section of Banquereau Bank.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1987 stock survey											
exploratory	0	0	0	1	9	4	1	1	1	18	25
1988 stock survey											
exploratory	0	0	0	0	7	8	1	1	0	17	30

Table 6.- 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 pertaining 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
		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

Table 7.- Nature of the catch from NAFO SA 4W determined by the analysis 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	-	-	-	-	-	-
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

Table 8.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Middle Grounds.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1983 stock survey											
low	0	0	0	1	0	0	0	0	0	2	2
medium	0	0	2	13	8	1	0	0	2	26	15
high	0	0	3	31	9	0	0	0	1	55	67
1984 stock survey											
low	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	2	6	4	2	1	2	17	16
1985 stock survey											
low	0	0	3	6	2	4	1	0	0	20	23
high	0	0	0	0	0	3	3	0	1	10	13
1986 stock survey											
low	0	0	0	0	0	0	1	1	3	7	7
high	0	0	1	0	3	6	4	2	2	17	10
1987 stock survey											
low	0	2	0	1	1	0	0	1	2	6	8
high	0	0	0	0	0	1	1	0	3	6	4
1988 stock survey											
exploratory	5	10	16	4	2	1	1	1	2	51	56

Table 9.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, Middle Grounds area.

	Age (years)		
	2-4	5-10	11+
1983 stock survey			
low	0	1	0
medium	2	23	1
high	3	40	1
1984 stock survey			
low	0	6	0
high	0	16	1
1985 stock survey			
low	3	13	0
high	0	6	1
1986 stock survey			
low	0	4	1
high	1	16	1
1987 stock survey			
low	2	4	1
high	0	3	2
1988 stock survey			
exploratory	31	10	1
Banquereau Bank			
1987 stock survey			
exploratory	0	16	1
1988 stock survey			
exploratory	0	17	0

Table 10.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Sable Island - Western Bank area.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1984 stock survey											
low	4	2	4	5	3	3	1	1	5	28	39
medium	22	6	3	8	6	4	1	1	4	60	63
high	5	5	6	10	9	3	3	2	3	46	39
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

Table 11.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, 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

Table 12.- 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 pertaining 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	-
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

Table 13.- Nature of the catch from Browns Bank/Tusket area determined by the analysis 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	-	-	-	-

Table 14.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm 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

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

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	------

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	-

Table 16.- Nature of the catch from German Bank/Lurcher Shoals area determined by the analysis 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	-	-	-	-

Table 17.- Fishery characteristics for the outer reaches of the Bay of Fundy (NAFO 4Xr) for both fleets. It is not possible to estimate landings from the Bay of Fundy fleet from this area; 4Xr statistical landings also include the traditional fishing grounds off Digby. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Bay of Fundy fleet Year	Logged catches	Class 1 catch	Effort (hm)	CPUE (kg/hm)
1979	0.05	0.05	11	4.72
1980	135.31	119.05	9,881	12.05
1981	179.23	174.71	16,416	10.64
1982	161.25	155.06	20,626	7.52
1983	35.24	30.86	6,011	5.13
1984	2490	23.96	7,674	3.12
1985	9.71	9.61	2,814	3.42
1986	2.11	2.11	1,771	1.19
1987	0.00	0.00	0	-
1988	0.00	0.00	0	-

Deep-sea fleet Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	-	-	-	-	-
1980	16.86	65.63	60.91	126,700	0.481
1981	2.53	47.59	44.37	111,596	0.398
1982	0.03	87.44	58.66	154,694	0.379
1983	13.02	83.76	70.26	205,023	0.343
1984	4.55	24.35	20.11	98,465	0.204
1985	1.48	5.73	4.08	16,702	0.244
1986	0.00	2.79	2.79	6,092	0.458
1987	0.00	0.00	0.00	0	-
1988	0.00	0.00	0.00	0	-

Table 18.- Summary of average number of scallops at age caught for pre-recruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age (years)		
	1-4	5-10	11+
German Bank / Lurcher Shoals 1983			
low	0	15	8
medium	0	36	9
high	0	35	8
German Bank / Lurcher Shoals 1984			
low	0	15	3
medium	0	29	5
high	0	38	6
German Bank / Lurcher Shoals 1985			
low	0	6	7
medium	0	17	5
high	0	24	3

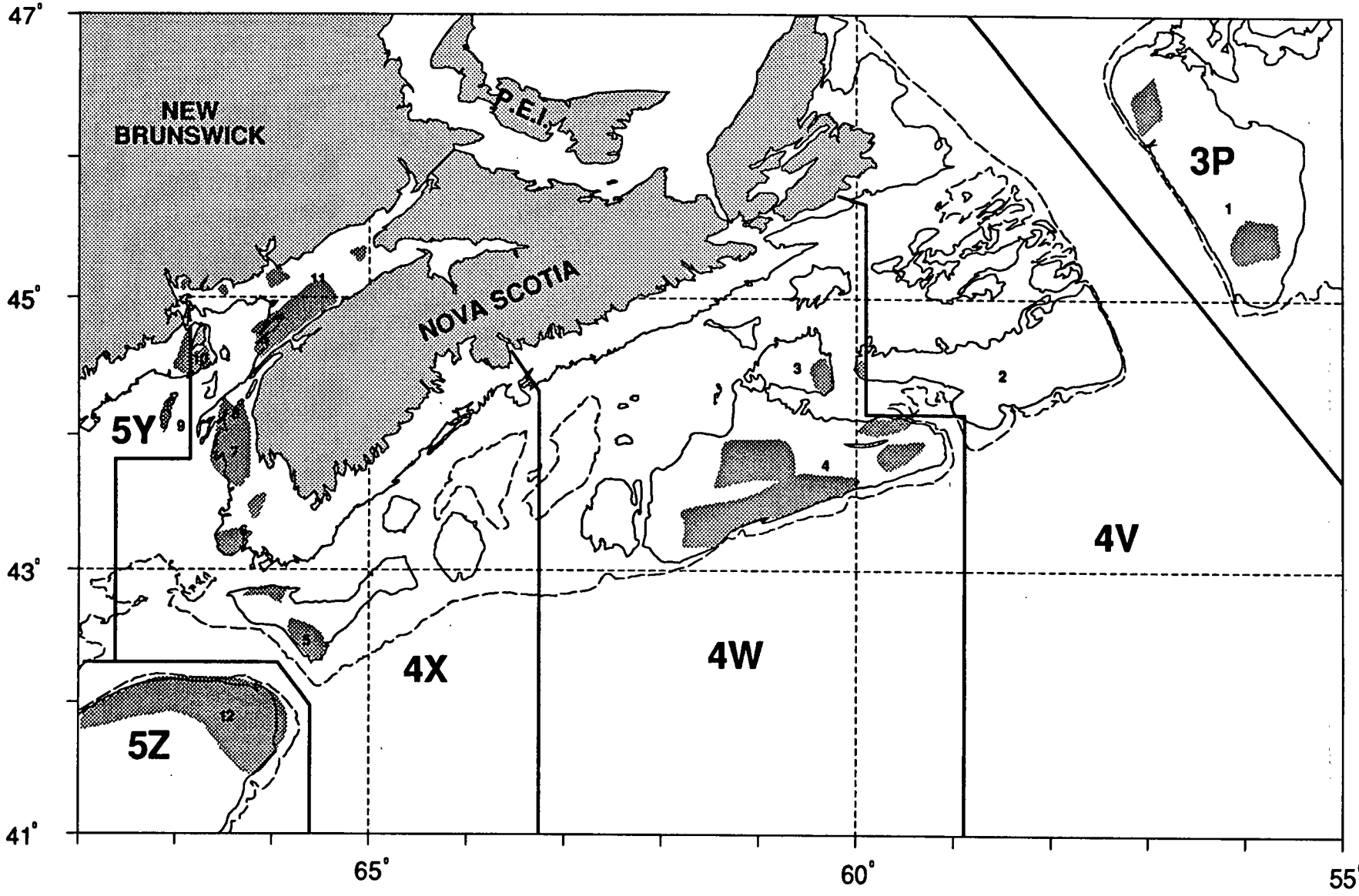

Figure 1.- Scallop fishing areas on the Scotian Shelf and St.Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St.Pierre Bank; (2) Banquereau Bank; (3) Middle Ground; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches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

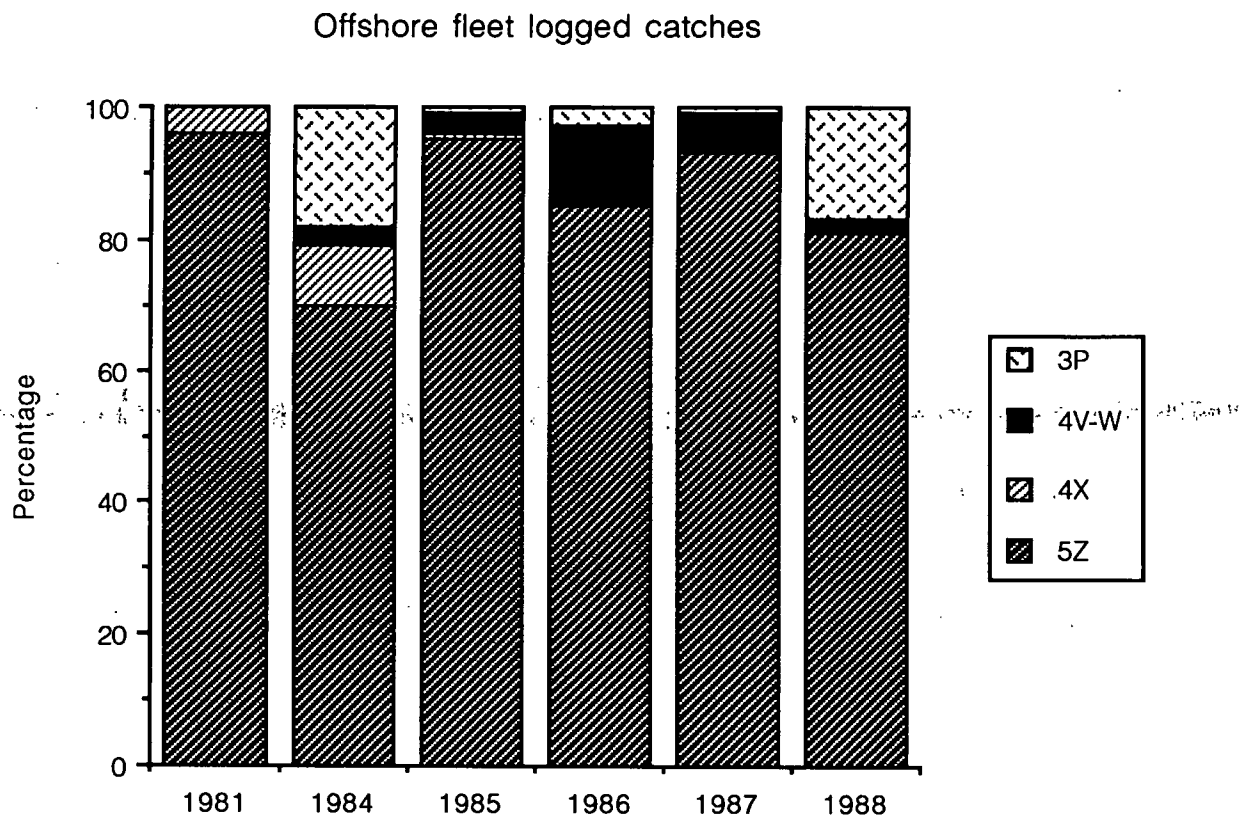

Figure 2.- Contributions expressed in percentages, of scallop beds in NAFO area 3P (Saint Pierre Bank), 4V-W (Banquereau Bank, Middle Grounds, Sable Island - Western Bank), 4X (Browns Bank and the German / Lurcher area), and 5Z (Georges Bank) to the total logged catches of the offshore fleet for the last 5 years. Figures for 1981 are used as an historical benchmark.

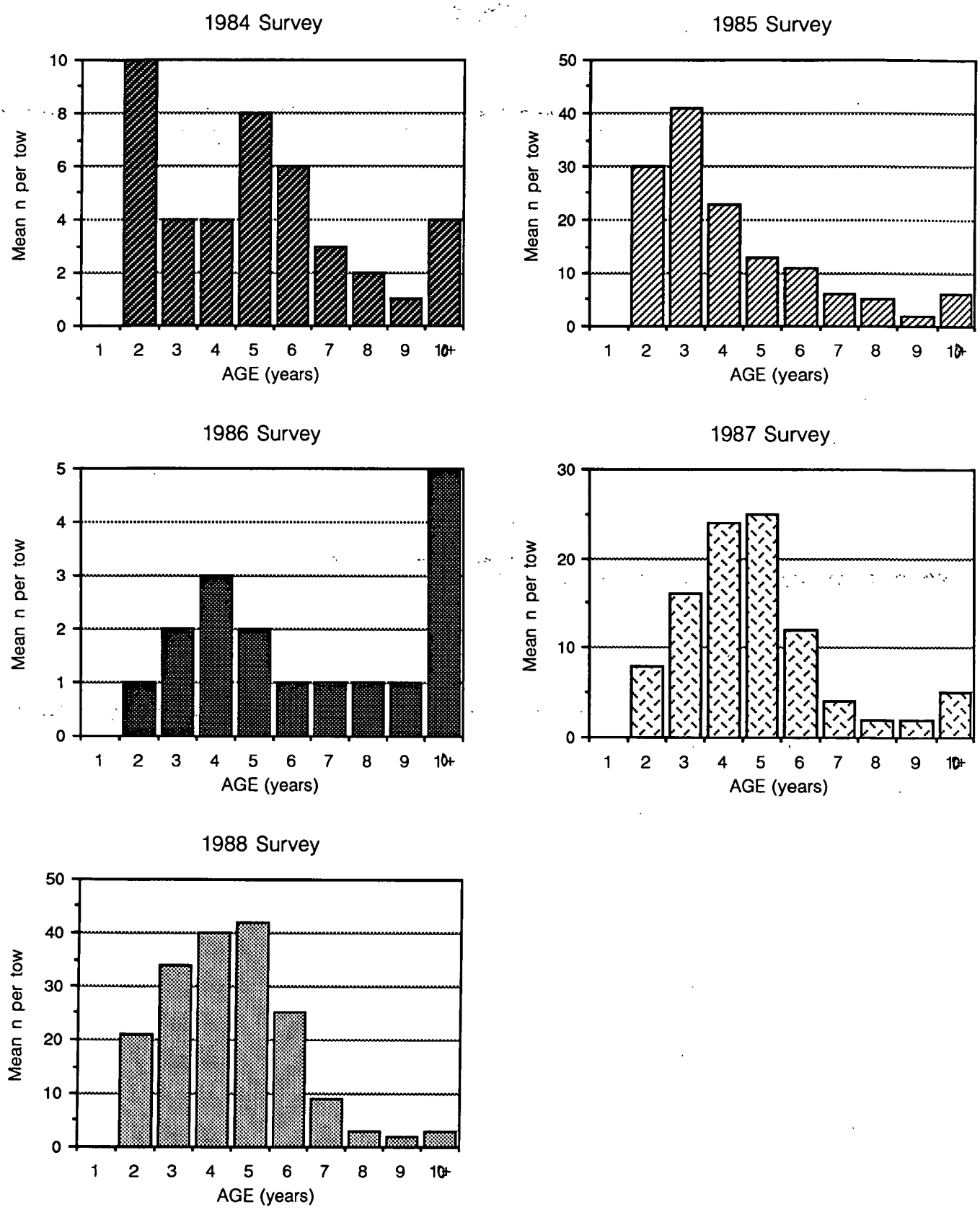

Figure 3.- Age frequency distribution. Total weighted average per tow for the 1984 to 1988 stock surveys of the Sable Island - Western Bank area.

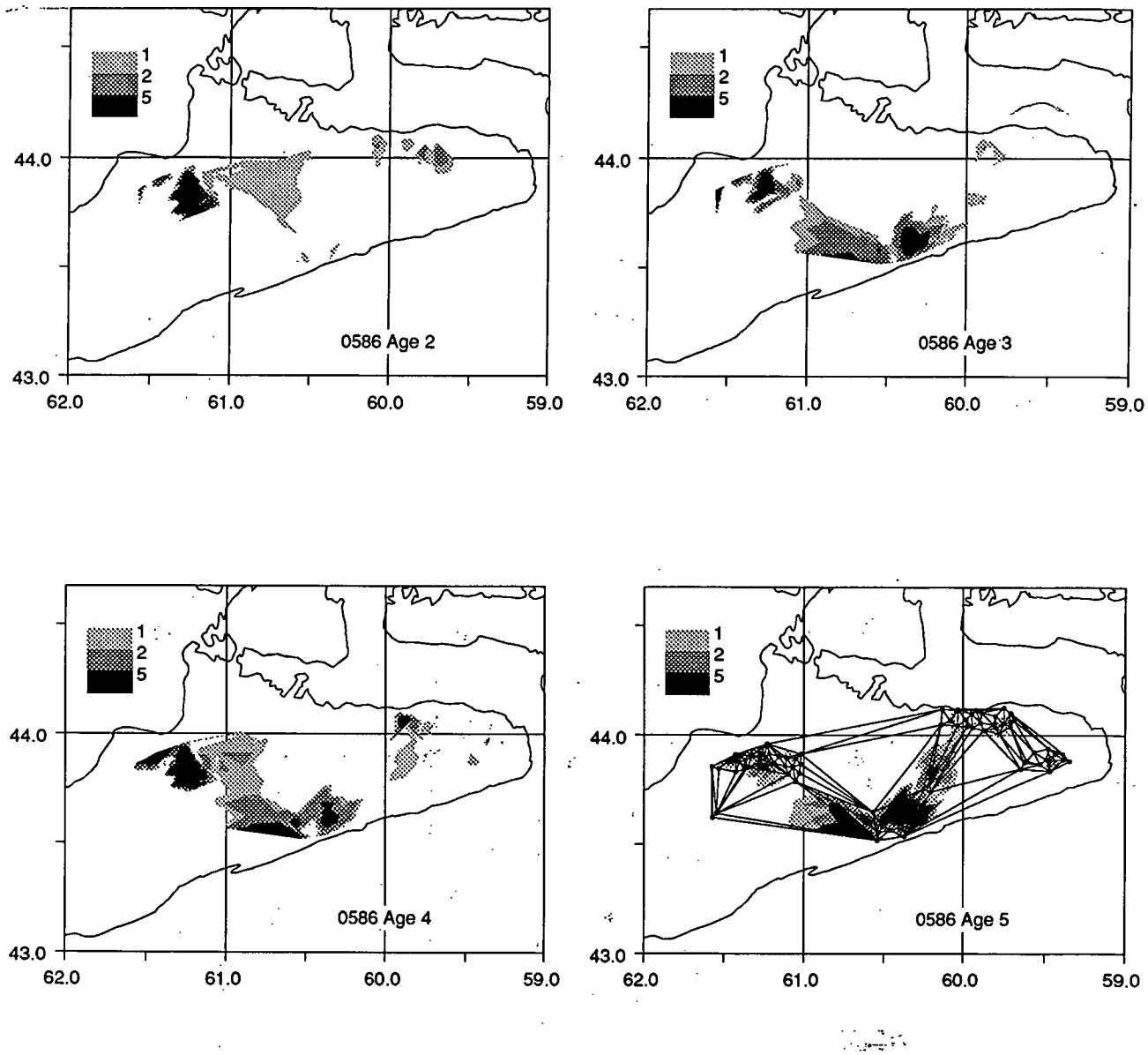

Figure 4.- 1986 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 5 shows the data points and Delaunay triangles.

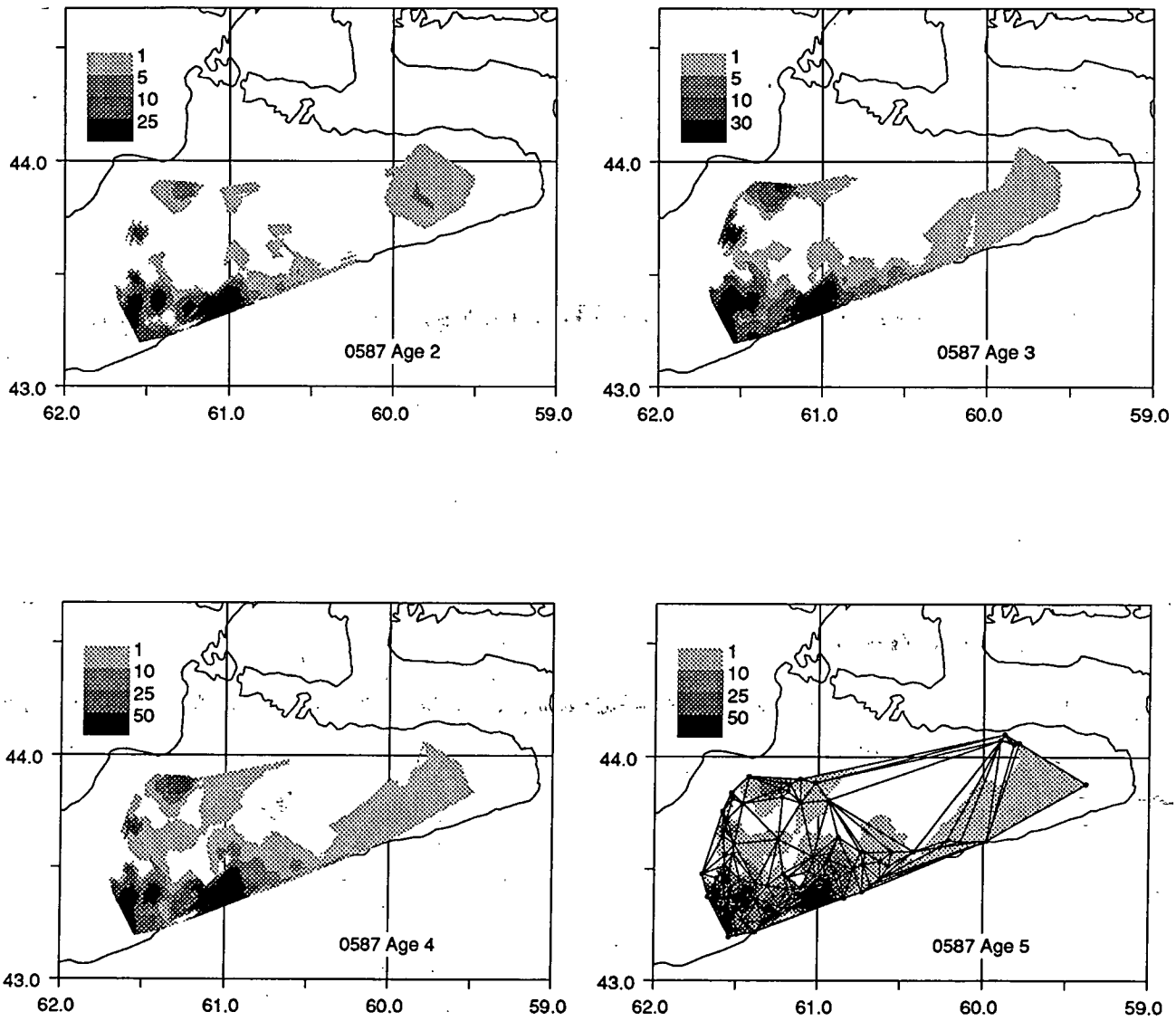

Figure 5.- 1987 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 5 shows the data points and Delaunay triangles.

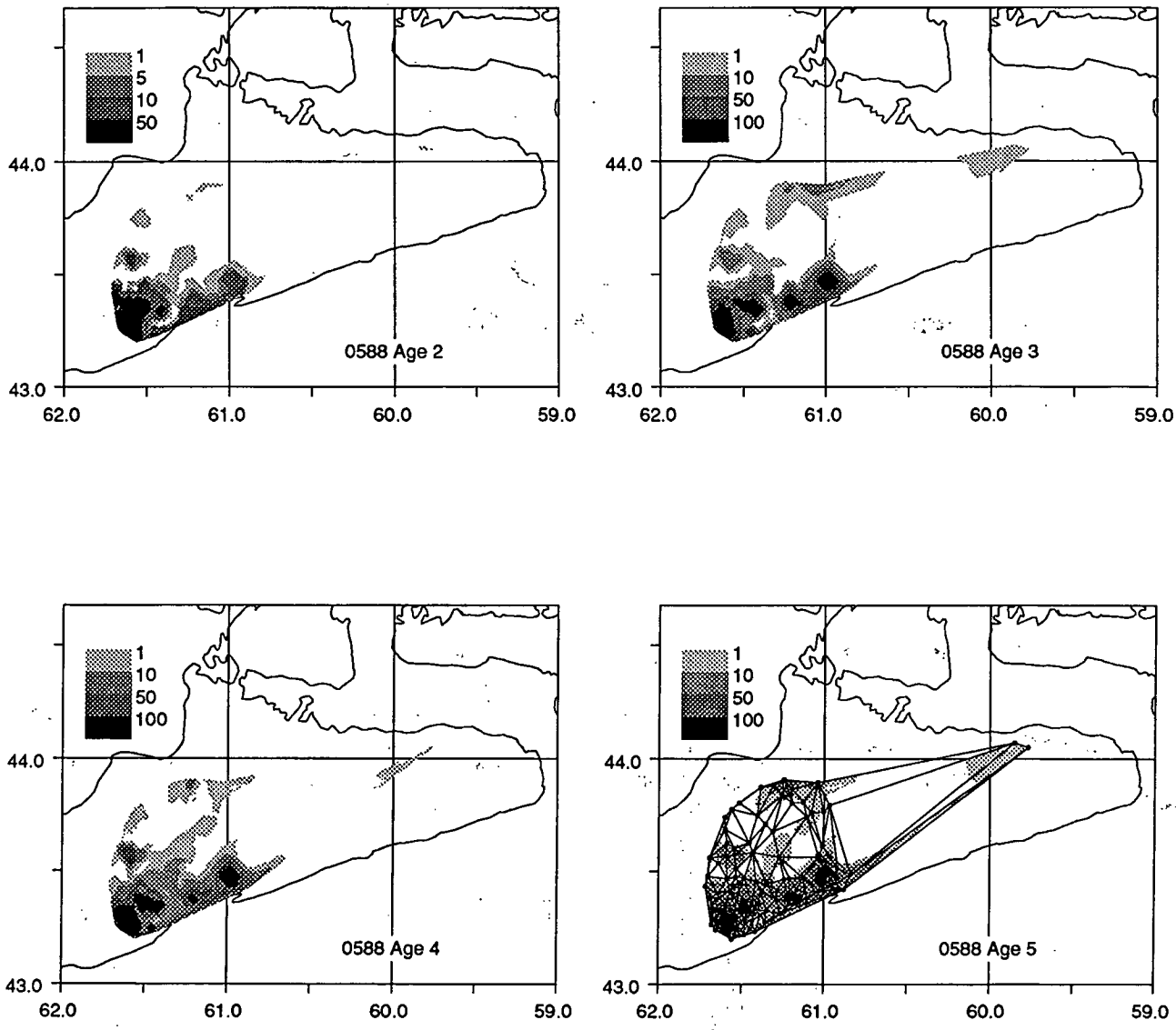

Figure 6.- 1988 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 5 shows the data points and Delaunay triangles.