DFO Atlantic Fisheries
Research Document 95/141

MPO Pêches de l'Atlantique
Document de recherche 95/141

Activity report for 1994 - Scotian Shelf scallop fishing grounds

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ABSTRACT

In 1994 the entreprise allocation management regime was extended to all offshore scallop fishing grounds on the Scotian Shelf. At industry's request the meat count was lowered for the western Scotian Shelf including Browns Bank and German Bank.

Industry proposed a TAC of 150 t for the eastern Scotian Shelf in 1994 given the depressed stock biomass. Only 13 t were caught on Middle Grounds and survey results indicated low abundance of recruited ages. The Sable Island Bank/Western Bank area had catches around 100 t with CPUE's 40% better than in 1993. Research survey results gave the lowest abundance index since surveys began in 1984.

On the western Scotian Shelf, the German Bank scallop fishery is seasonal. 600 t were caught with good CPUE's. Survey work resumed after a 9-year interruption. Large scallops (age 10+) were quite abundant.

RESUME

En 1994, le système de gestion d'allocations par entreprise a été appliqué à tous les bancs de pétoncles hauturiers sur le plateau néo-écossais. Le compte de chairs a été réduit pour la partie ouest du plateau incluant les bancs Browns et German à la demande de l'Industrie.

L'industrie proposa un TPA de 150 t pour la partie est du plateau néo-écossais en 1994 vu le bas niveau de la biomasse du stock. Seulement 13 t ont été pêchées sur Middle Grounds et l'inventaire de recherche indique une faible abondance des ages recrutés. Les captures de la région Western / l'Ile-de-Sable sont d'à peu près 100 t avec des taux de capture 40 % supérieurs à 1993. L'inventaire de recherche produisit l'index d'abondance le plus faible depuis le premier inventaire en 1984.

Dans la partie ouest du plateau néo-écossais, la pêche aux pétoncles sur le banc German est saisonnière. On pêcha 600 t avec des bons taux de capture. L'inventaire de recherche a repris après un lapse de 9 ans. Les gros pétoncles (age 10+) étaient relativement abondants.

INTRODUCTION

In 1994 the entreprise allocation management regime was extended to all offshore scallop fishing grounds on the Scotian Shelf. At industry's request the meat count was lowered for the western Scotian Shelf including Browns Bank and German Bank to 40 meats per 500 g.

Scallop fishing grounds on the eastern Scotian Shelf (Banquereau Bank, Middle Grounds, Western and Sable Island Banks Fig.1) have been grouped under one allocation management plan. A catch limit would contribute to rehabilitate these depressed stocks. The limit of 150 t was based on the low-end of annual historical catches. Total catches for 1994 were less than the TAC, 116 t, with catch-rates 40 % better than in 1993.

On the western Scotian Shelf, the German Bank fishery resumed in 1993 after a 7-year interruption. It is seasonal to avoid gear conflict (lobster traps). No biological information existed to derive a TAC. In 1993 a 200 t TAC was harvested over 7 weeks. For 1994 a 'roll-over' TAC was agreed upon by industry and fishery managers. Increments of 200 t quota over a 6-week period were repeated provided that catch-rates were not dropping significantly and the meat count was met without difficulties. From June to mid-October, 600 t were caught with good CPUE's.

METHODS

Fishery Information

There are two sources of information to estimate the respective fishery contributions of scallop fishing grounds on the Scotian Shelf. Offshore scallop landings are now monitored at dockside by an independent agency; sales slips used to be issued by fish buyers. Amounts landed and (NAFO / Scallop Fishing Area) areas fished are then compiled by the Statistics Division, Department of Fisheries and Oceans, Halifax. The other source of information about the origin of the catch is from logbooks. Logged catches are used to estimate catch removals on a scallop bed basis. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas do not correspond 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. (MS 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. 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 status of scallop beds

above latitude 43° 40' N is not addressed in this document.

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

Sampling of the catch is sporadic and does not meet target levels to sample the catch adequately. Port coverage varies greatly, from none for southwest Nova Scotia ports like Yarmouth, Liverpool, and Saulnierville to somewhat fair in the Lunenburg - Riverport area. Not all ports are necessarily involved in any particular Scotian Shelf fishery. Efforts are being made to collect data from the Browns Bank fishery given its recent importance.

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 arbitrarily set strata. At times, an exploratory stratum may be added. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out in May. During the 1994 survey, comparison fishing was carried out between the retiring Government vessel and a commercial scallop dragger. These results are reported elsewhere. To maintain the homogeneity of the survey data series, the data from the Government vessel are presented here. With the implementation of catch limit on the eastern Scotian Shelf, it was felt necessary to have a good baseline data. Survey stratification by the 1993 catch would not have provided that coverage since the grounds exploited were very limited. More tows were added to the survey (exploratory stratum) to cover grounds fished in the past on Sable Island/Western Bank area and Middle Grounds. The survey design for German Bank was based on the limited 1993 fishing activities with exploratory tows added to enhance coverage.

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 (unlined for German Bank). Tows were of ten minutes duration; distance towed was determined from the continuous recording of Loran C bearings via a microcomputer or, exceptionally, from bearings taken at the start and the end of the tow. 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 (Loran C bearings); 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow (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).

Standardized survey catch-rates were contoured to represent the spatial distribution of the scallop aggregations. 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 relative abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface using the inverse weighting 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, a potential 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. MS 1989) after 16 or more subtriangles. A complete description of the procedure may be found in Black (MS 1988).

Fishery Performance on a Scallop Bed Basis

Catch data were plotted from locations provided in logbooks to investigate the concentrations of fishing activity presumably related to abundance, hence location of scallop beds exploited commercially. Log returns for the Scotian Shelf fishery are excellent with over 90 % class 1 data. Isolines of fishery data were drawn and surfaces contoured similar to the plotting of survey catch-rates, thus mapping the distribution and fishery characteristics of scallop beds.

Relevant Biological Information

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

Areas such as Sable Island / Western Bank have good sampling coverage from the commercial fleet as exploitation spreads over the last 15 years.

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 which rings have been 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. Some biological information was tentatively derived with a small sample from Banquereau Bank collected during earlier stock surveys until more material is assembled. The Sable Island area presents a wide range of depths (20 - 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 the Lurcher Shoals on the Scotian Shelf. The deep-sea fleet continued to exploit scallop grounds in other areas of the Shelf (Table 2). Good catches have sustained exploitation on the western Shelf, especially over the last 3 years when a fair portion of the fleet is fishing Browns Bank. The status of Browns Bank stocks is presented in another document. Vessels also fished German Bank for the first time in 1993, after a lapse of 7 years. With a declining fishing performance and the small TAC applied to the eastern Shelf, fewer vessels used the area. The proportion of vessels fishing on the Scotian Shelf as a whole has steadily increased.

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 refers here to German Bank / Lurcher Shoals.

Banquereau Bank

Historically, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area. Catches average less than 10 t per year (Table 3). Highest landings (16 t) were reported in 1986. This trend could not be maintained as less than 1 t was landed annually for the next 5 years. Catches have originated from the westernmost section of Banquereau Bank,

adjacent to Sable Island Bank. Around 3 t were caught in 1992 with slightly higher CPUE's. Catch levels and the profile of catch-rates do not indicate the presence of an important stock biomass. The fleet expands the area under exploitation in years of poor catch-rates on the eastern Shelf; catches are reported for Banquereau Bank under that scenario. In 1993, nearly 7 t (Table 3) were caught from the west tip of Banquereau; catch-rates were low. No fishing activity was reported for 1994.

The 1989 survey carried out six exploratory tows on Banquereau Bank. Abundance was extremely low based on only the oldest age class (Robert et al. MS 1990). The area has not been given survey coverage since.

Middle Grounds

Middle Grounds (Fig. 2) is a shallow bank of which 900 km^2 may carry commercial densities of scallops. Scallop production has been irregular over the last ten years (Table 4). From practically no landings reported in 1988, catches have been relatively low but rising gradually from 20 to 50 t to drop to 13 t in 1994. Catch-rates have varied little during that period.

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. Since 1989 there has been an important weight drop (33 %) in the average meat, from 21.4 to 14.4 g which later stabilised around 15 g. Low catch volumes prevented sampling in 1991, 1992; and 1994. The average meat weight had dropped around 20 % in 1993 from when it was last sampled.

Stock surveys had shown low abundance of scallops except for the first survey in 1983. The prerecruit index rose significantly in 1988 but overall mean numbers at age are very low. Given the relatively low fishery performance no survey work was carried out between 1989-91 and 1993. Survey tows were carried out on Middle Grounds (Table 6) in 1994 to establish a baseline data. Tables 7 and 8 indicate a lower abundance than in the last survey. No prerecruits were found. Recruited numbers (age 5+) from the 1994 survey correspond to 34 % of the recruits estimated in the 1983 survey.

Sable Island / Western Bank

The eastern Scotian Shelf has been exploited on a continuous basis for 15 years. Annual landings have never exceeded 700 t. Western Bank and the Sable Island area have the main scallop beds exploited by that fishery. In years of poor performance, exploitation extends to the immediate vicinity of Sable Island, and Banquereau Bank and Middle Grounds (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). Prior to 1985 the fishery had low landings, usually under 100 t and low catch-rates (compared to Georges Bank) (Table 4). After this exploration period, landings increased substantially but CPUE's remained in the low range. The expansion of fishing activities around Sable Island and to the western part of Banquereau Bank continued in 1993 but with a 50 % drop in catches, under 200 t. CPUE's concurrently declined by 15 % from already low rates in 1992. Hence the proposal for a catch limit of 150 t in 1994 to allow for a possible rehabilitation of the stock. Actual catches of less than 100 t over a very limited area (Fig. 2) provided for better CPUE's than in 1993 (0.266 kg/crhm on average). As the CPUE contour plot (Fig. 2) shows, there were very few areas with catch-rates greater than 0.4 kg/crhm.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighbouring Middle Grounds, (Table 5). Scallops between 7 and 10 years of age made up about 50 % of the catch. Beginning in 1988 the average meat weight in the catch has risen gradually from 11.6 to 16.6 g in 1993, suggesting a minimum input of young age classes recruiting to the fishery. The average meat weight landed did not change from 1993 to 1994.

Half of the sampling stations of the 1994 survey (Table 6) were selected to explore areas not presently fished (Fig. 3) to get baseline data. The stratified average number of scallops at age for 1994 (Table 9) is the lowest recorded since surveys began in 1984 with very low estimates for prerecruits (Table 10). Recruited numbers (age 5+) in the 1994 survey are only 20 % of recruits found in the 1988 survey. The 1988 survey had the highest number of recruits of the survey series from 1984 to 1994.

German Bank / Lurcher Shoals

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44° N); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches 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. MS 1986). Prior to the Inshore / Offshore Agreement of 1986, the offshore fleet could fish throughout the area (NAFO sub-subarea 4Xq); after 1986 their fishing activities are restricted to below latitude 43° 40' N. Table 11 provides the recent history of the German Bank fishery. Post 1975 catches for German Bank south of the Line have been estimated from logged catches for the fleet sector(s) that fished that year.

During the early 1980's, catches were important but steadily declined until 1985 (Table 11). Catch-rates were also following the same trends. After 7 years of very little activity the fishery resumed in 1993. The 1993 TAC of 200 t was caught in its entirety over a brief 6-week period starting in June; CPUE's were high at 0.756 kg / crhm. Incursions of vessels from the Bay of Fundy fleet also took place during 1993. Reports from the fishermen involved would have them fishing well into the fall. From estimates of mean landing per trip, number of vessels involved and frequency of such trips, an additional 700 t could easily have been harvested from German Bank. In 1994, the fishery proceeded on June 1st for 20 weeks until October 15 with a 200 t 'roll-over' TAC. A 'roll-over' TAC means that a 200 t quota was put in place for the period June 1st to mid-July and in-season catch-rates and counts (40 meats per 500 g) were monitored. As long as CPUE's did not drop appreciably (>25 %) and meat counts were met without difficulties, an additional 200 t quota could be caught over the next 6-week period. Industry decided on the termination of the fishery after 600 t had been caught in mid-October, well in advance of the opening of the lobster fishing season in late November. Overall, the 1994 CPUE improved 10 % over 1993 (Table 11). During the first period, from June 1st to July 15, grounds were explored and dense patches exploited (Fig. 4). As the same aggregations were more or less fished during the next 2 periods (July 15 - August 31; August 31 - October 15) (Fig.4) CPUE's stabilised at slightly lower values than the ones encountered in the first period. Meat counts ranging between 28 and 33 were well below the limit of 40. The following table summarises the weekly catch-rates plotted in figure 4.

	Cumulative catch	Weekly mean CPUE	CPUE s.d.
Period 1	204 t	0.98 kg/crhm	0.20
Peiord 2	390 t	0.77 kg/crhm	0.12
Period 3	600 t	0.78 kg/crhm	0.10

Sampling of the catch has been scanty or did not take place (Table 12). 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. Since the fishery resumed in 1993, the average meat weight in the catch corresponds to a count under 30 per 500 g. The lowering from 55 count to 40 count did not have any effect on the fishery. Very little mixing of small under 10 g (50+ count) scallops is taking place, but a distinct targetting of beds of large 15-20 g (33 - 25 count) scallops.

Survey work resumed in 1994. Results from the last survey in 1985 are given in table 13 for

comparison. The 1985 research survey covered the German / Lurcher area while the 1994 survey took place south of the 43° 40' line only. At present, commercial size scallops (age 5+) but more so large scallops (age 10+) are very abundant relative to survey results prior to 1986 (Table 14). Given the age distribution of the scallops surveyed, they may represent a biomass accumulated over the recent past. Since the gear is unlined, the lack of young prerecruits (age 3) in the survey does not indicate their absence in the stock. However, the abundance index of age 4 prerecruits, better retained by the gear, is rather low. In 1992, during the course of a survey to evaluate scallop beds within the 12-(nautical) mile limit, south of the Line, some tows with lined Digby gear were carried out in the offshore zone, beyond the 12-mile limit (Kenchington and Lundy MS 1992). They reported locally abundant concentrations of over 2000 scallops per standard tow (Digby gear).

DISCUSSION AND CONCLUSION

Starting in 1994, all scallop fishing grounds on the Scotian Shelf were managed by quota divided into entreprise allocations. The meat count was lowered from 55 to 40 meats per 500g for German Bank.

The 1994 TAC for the eastern Scotian Shelf was set at a low level, 150 t in an attempt to rehabilitate the stock. Catches were low, 116 t, but catch-rates were 40 % better than the previous year. The abundance index from research survey estimates did not indicate that incoming year classes would be strong enough to add sizable quantities of biomass to the stock, hence the TAC could possibly be raised. Year classes already present at low levels are the ones that will contribute to the fishery for both Middle Grounds and the Sable Island / Western Bank area. The TAC advice is based on patterns of historical landings and research survey results given the limited information on stock biomass and exploitation rate. The first estimate ranks logged catches during 1980 - 1994 ascendingly. The 25 % quartile value is selected somewhat arbitrarily as a TAC level given the relatively low biomass estimates as shown in the surveys and commercial CPUE's trends. 15 t corresponds to the first quartile limit of Middle Grounds historical catches (Figure 5). For the Sable Island / Western Bank area, the first quartile (25 %) of ranked logged catches would put a TAC at 100 t. The second estimate looks at recruited abundance. The number of recruits found in the 1994 Middle Grounds survey corresponds to 34 % of recruits found in the first survey in 1983 (Table 7). The 1983 catch, 105 t, was the highest on record (34 % of 105 t = 35 t). Recruits of the 1994 survey in the Sable Island / Western Bank area represent 20 % of recruits in the 1988 survey, the survey with the maximum number of recruits in the survey series (1984 - 1994) (Table 9). 20 % of the maximum catches recorded in 1986 (585 t) would be 120 t. Following this evaluation, a TAC in the range of 15 - 35 t is proposed for Middle Grounds and a TAC between 100 and 120 t for the Sable Island / Western Bank area.

Historically, the German Bank fishery could be characterised as sporadic with moderate to high catch-rates. So far there is no indication that recruitment would be important and take place over a large area. The present size composition indicates accumulation of older scallops (ages 10+) according to survey results. The 200 t TAC set in 1993 corresponded to an average annual catch level for German Bank over the period 1975 - 1993. The harvest figure for 1994, 600 t, is not a level that has been sustained in the past. A TAC of 200 t or less would be more appropriate to spread the German Bank scallop production over more harvest years. Irregular recruitment events may render sustainable exploitation difficult.

The updated meat count regulation (40 meats per 500 g) should insure that growth overfishing is prevented for the recruiting year classes while allowing the accumulated biomass of older scallops to be harvested even more effectively.

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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	
German Bank	N = 600	N = 598
	H_∞ = 130.945 mm	intercept = -13.750
	t_0 = 1.3870	slope = 3.463
	k = 0.2300	

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
1991	22	30	12
1992	31	30	20
1993	34	27	23
1994	34	16	15

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. Catches are from logbook information. Effort is calculated from Class I data. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	3.30	7.17	0.16	20	45.90	0.355
1981	0.00	0.00	-	-	-	-
1982	0.69	0.42	0.01	1	45.45	0.387
1983	5.37	3.26	0.06	7	56.18	0.444
1984	3.18	0.63	0.01	1	68.18	0.672
1985	0.24	0.00	-	-	-	-
1986	15.64	11.15	0.35	47	31.81	0.239
1987	0.65	0.51	0.01	4	15.15	0.110
1988	0.00	0.00	-	-	-	-
1989	0.00	0.00	-	-	-	-
1990	0.83	0.00	-	-	-	-
1991	0.63	0.81	0.01	3	28.64	0.240
1992	2.82	2.50	0.01	8	34.21	0.303
1993	5.79	6.84	0.19	26	36.96	0.264
1994	0.00	0.00	-	-	-	-

Table 4.- Fishery characteristics for the Middle Grounds area (NAFO 4We) and the Sable Island, Western Bank area (NAFO 4Wf-j) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches are from logbook information. Effort is calculated from Class I data. h: hours; crhm: crew-hour-meter.

Middle Grounds Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	3.65	1.42	0.04	5	33.20	0.262
1981	0.00	0.00	-	-	-	-
1982	72.39	62.09	0.89	124	69.50	0.501
1983	105.16	104.92	2.54	323	41.24	0.325
1984	11.90	9.94	0.44	59	22.83	0.175
1985	26.89	21.59	0.77	99	27.86	0.217
1986	51.27	51.28	2.86	351	17.91	0.146
1987	6.70	7.03	0.37	47	19.18	0.150
1988	0.28	0.29	0.01	2	21.54	0.169
1989	20.84	21.70	0.55	67	39.70	0.326
1990	19.04	33.63	0.94	110	35.92	0.306
1991	31.54	35.18	0.83	96	42.62	0.365
1992	38.68	43.12	1.26	152	34.25	0.284
1993	39.11	53.72	1.67	201	32.09	0.267
1994	12.61	12.97	0.32	35	40.77	0.372
Sable Island/Western Banks Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1980	60.99	50.48	1.66	220	30.50	0.229
1981	0.56	0.00	-	-	-	-
1982	64.10	61.40	1.80	244	34.13	0.252
1983	185.15	166.47	7.14	895	23.31	0.186
1984	71.30	64.65	3.04	376	21.30	0.172
1985	64.93	76.00	2.54	295	29.92	0.258
1986	618.35	585.26	26.72	3251	21.90	0.180
1987	415.80	412.01	20.20	2452	20.40	0.168
1988	100.43	100.42	3.58	442	28.02	0.227
1989	516.39	515.36	15.67	1930	32.88	0.267
1990	414.25	403.94	14.64	1683	27.59	0.240
1991	356.40	352.57	10.85	1241	32.49	0.284
1992	482.57	477.88	17.68	1975	27.03	0.242
1993	204.46	186.11	8.39	969	22.17	0.192
1994	103.53	97.02	3.18	365	30.49	0.266

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.e.	
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1,259
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
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	0.0125	13.45	5.38	68.45	0.13	499
1994	-	-	-	-	-	-
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	4,658
1984	0.0161	11.10	2.65	42.48	0.07	1,034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11,397
1987	0.0319	14.35	2.22	98.14	0.04	9,226
1988	0.0045	11.57	4.07	34.60	0.09	394
1989	0.0215	13.14	3.16	72.91	0.02	8,440
1990	0.0099	13.97	2.52	71.89	0.05	2,994
1991	0.0050	13.08	4.25	31.31	0.04	1,365
1992	0.0114	15.37	3.46	59.51	0.04	3,526
1993	0.0178	16.58	2.55	68.88	0.07	2,022
1994	0.0168	16.46	3.99	52.97	0.08	1,055

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

Banquereau Bank	1987	1988	1989	1990	1991	1992
exploratory	5	5	6	0	0	0
total	5	5	6	0	0	0

Middle Grounds	1988	1989	1990	1991	1992	1993	1994
explo/low catch	6	0	0	0	8	0	12
medium catch	-	-	-	-	-	-	-
high catch	-	-	-	-	-	-	-
total	6	0	0	0	8	0	12

Sable/Western Bank	1988	1989	1990	1991*	1992	1993	1994
low catch	4	11	10	4	20	21	15
medium catch	14	33	30	22	24	29	13
high catch	72	62	50	50	26	18	1
exploratory	-	-	-	-	12	12	29
total	90	106	90	76	82	80	58

* The original allocation by stratum was not followed in 1991. Shipcrew overtime restrictions did not allow for the scheduled coverage of the sampling area.

Table 7.- 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+		
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
Stratified average for each survey:											
1983	0	0	2	21	7	0	0	0	1		
1984	0	0	0	2	4	3	1	1	1		
1985	0	0	2	3	1	4	2	0	1		
1986	0	0	1	0	2	4	3	2	2		
1987	0	1	0	1	1	1	1	1	3		
1988 stock survey											
exploratory	5	10	16	4	2	1	1	1	2	51	56
1992 stock survey											
exploratory	1	6	3	7	3	1	1	0	0	22	27
1994 stock survey											
exploratory	0	0	0	4	4	1	0	0	1	12	21

Table 8.- 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, for the Middle Grounds area.

	Age (years)		
	2-4	5-10	11+
Middle Grounds			
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
1992 stock survey			
exploratory	10	12	0
1994 stock survey			
exploratory	0	9	1

Table 9.- 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+		
1991 stock survey											
low	1	9	7	11	8	10	6	4	5	60	60
medium	1	9	5	8	9	6	2	1	3	45	47
high	2	16	7	9	11	7	3	1	2	57	83
1992 stock survey											
low	13	3	8	8	6	4	2	1	3	49	77
medium	4	8	22	12	12	7	3	2	3	74	69
high	14	8	20	17	15	8	3	1	1	88	95
1993 stock survey											
low	1	7	6	7	6	4	3	2	4	39	37
medium	2	14	15	24	10	6	3	2	4	79	77
high	4	22	25	35	20	11	4	1	1	123	62
1994 stock survey											
exploratory	1	2	6	6	6	3	2	1	3	29	31
low	2	6	9	6	3	2	1	1	1	31	70
medium	0	1	2	3	3	2	1	1	2	16	14
high	1	1	2	10	14	8	2	0	2	42	-
Stratified average for each survey:											
1984	10	4	4	8	6	3	2	1	4		
1985	30	41	23	14	10	6	5	2	6		
1986	1	2	3	2	1	1	1	1	5		
1987	8	16	24	25	12	4	2	2	5		
1988	21	34	40	42	25	9	3	2	3		
1989	5	21	31	27	16	7	3	1	3		
1990	13	6	17	20	16	7	2	1	2		
1991	2	14	6	9	10	7	3	1	2		
1992	10	7	17	13	11	7	3	1	2		
1993	2	12	13	19	10	6	3	2	3		
1994	1	3	6	6	5	2	1	1	2		

Table 10.- 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+
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
1991 stock survey			
low	17	41	3
medium	15	27	2
high	25	32	1
1992 stock survey			
explo/very low	4	10	4
low	24	22	2
medium	34	37	2
high	42	43	1
1993 stock survey			
explo/very low	8	16	3
low	14	23	3
medium	31	46	3
high	51	72	0
1994 stock survey			
explo/very low	9	18	2
low	17	13	1
medium	3	10	2
high	4	34	2

Table 11.- Landings for the German Bank/Lurcher Shoals area (NAFO 4Xq) for all fleet sectors until 1986 inclusive. After 1986 landings are for the deep-sea fleet only. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Catches for German Bank only, south of lat. 43 ° 40' N have been estimated from logbook information for all fleet sectors. Effort is calculated from Class I data from the deep-sea fleet. h: hours; crhm: crew-hour-meter.

Year	Landings	Catches	Effort		CPUE	
			h 10^3	crhm 10^3	kg/h	kg/crhm
1968	15.77					
1969	33.26					
1970	10.01					
1971	16.91					
1972	4.68					
1973	1.63					
1974	0.00					
1975	0.00					
1976	18.84					
1977	0.32					
1978	0.00					
1979	102.32	350.49	2.89	375	121.22	0.934
1980	1269.71	638.12	7.26	909	84.03	0.671
1981	379.69	185.74	1.45	198	109.46	0.880
1982	659.74	243.71	4.52	544	52.48	0.436
1983	587.76	225.52	4.61	537	48.90	0.420
1984	207.13	63.09	1.86	200	33.92	0.316
1985	33.76	11.25	0.39	45	28.89	0.250
1986	1.59	1.00	0.00	0	-	-
1987	0.00	0.00	-	-	-	-
1988	0.00	0.00	-	-	-	-
1989	5.54	5.00	0.07	10	63.68	0.440
1990	0.00	0.00	-	-	-	-
1991	0.00	0.00	-	-	-	-
1992	0.25	0.25	0.01	<1	126.50	0.998
1993	200.00*	200.00*	1.63	255	118.46	0.756
1994	599.67	599.67	4.64	720	129.16	0.833

*additional removals, see text.

Table 12.- Nature of the catch from German Bank determined by analyses of scallop meat weights from the offshore fleet for selected years when a fishery took place.

	% catch examined	meat weight (g)				n meats
	catch landed	mean	min	max	s.e.	
1983	0.0010	11.99	3.35	44.13	0.11	533
1984	0.0008	22.69	3.88	53.52	0.42	81
1989	0.1012	47.93	27.41	76.19	0.32	117
1993	0.0142	17.41	5.20	67.10	0.06	1635
1994	0.0129	16.59	6.03	67.04	0.03	4678

Table 13.- Average number of scallops at age caught in an unlined 2.44 m New Bedford offshore dredge by catch stratum on German Bank. Pre-1994 data for comparison only.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1985 stock survey											
low	0	0	0	0	0	1	2	2	8	13	7
medium	0	0	0	0	2	6	4	3	7	28	30
high	0	0	0	3	5	6	5	3	5	27	37
1994 stock survey											
exploratory	0	0	0	2	12	31	30	18	13	107	107
low	0	0	1	3	2	4	4	5	7	25	41
medium	0	0	0	4	3	1	1	2	10	21	41
high	2	1	8	20	64	17	3	5	51	172	315
very high	0	0	0	0	0	1	4	10	89	103	82
Stratified average for each survey:											
1985	0	0	0	1	3	6	4	3	6		
1994	0	0	1	4	14	15	13	11	33		

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. Pre-1994 data for comparison only.

	Age (years)		
	1-4	5-10	11+
German Bank / Lurcher 1985			
low	0	6	7
medium	0	17	5
high	0	24	3
German Bank 1994			
exploratory	0	101	5
low	1	22	3
medium	0	13	8
high	11	117	43
very high	0	29	75

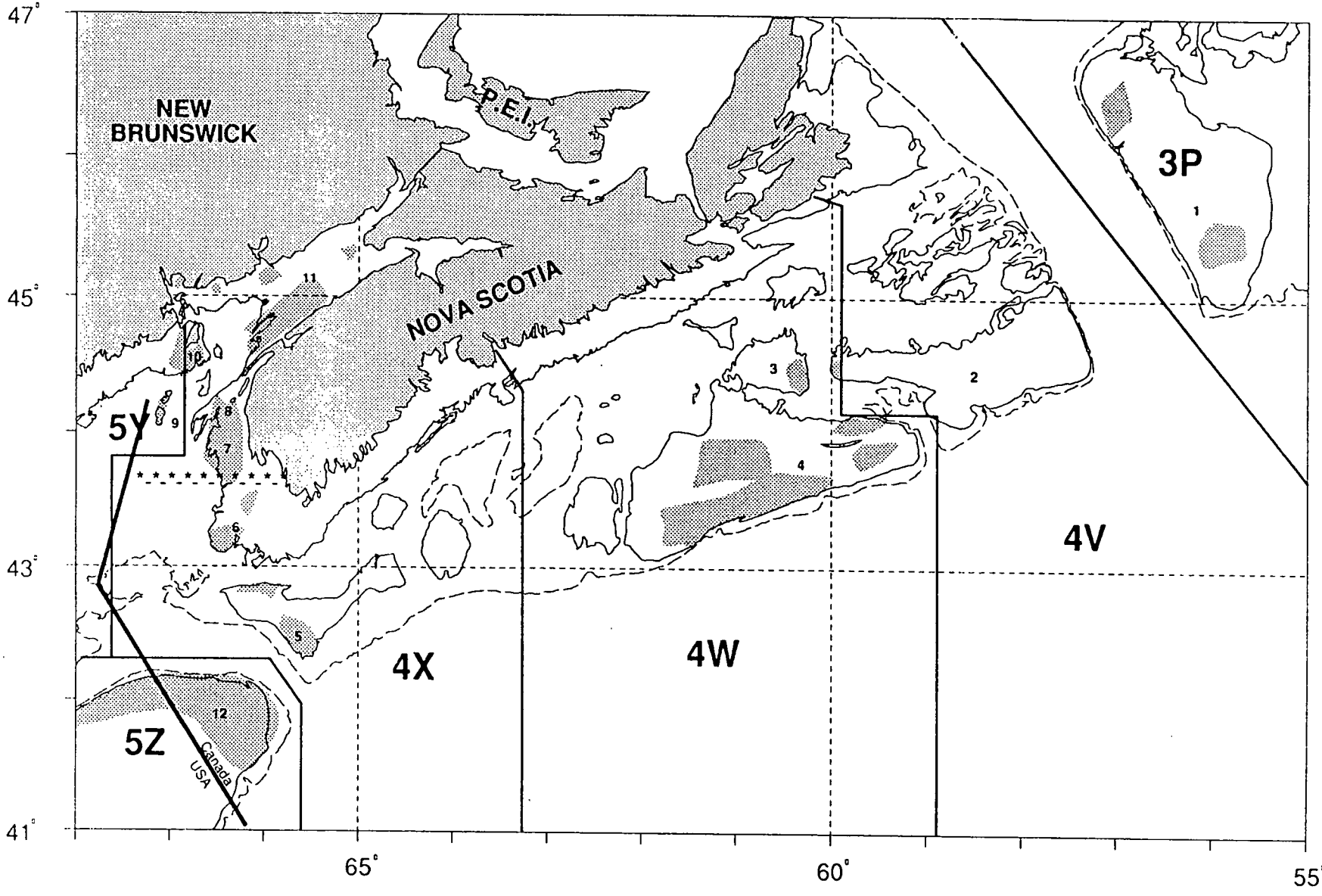

Figure 1.- Scallop fishing areas on the Scotian Shelf and St. Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St. Pierre Bank; (2) Banquereau Bank; (3) Middle Grounds; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches 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. A line of asterisks shows the 43° 40' line below (7) Lurcher Shoals.

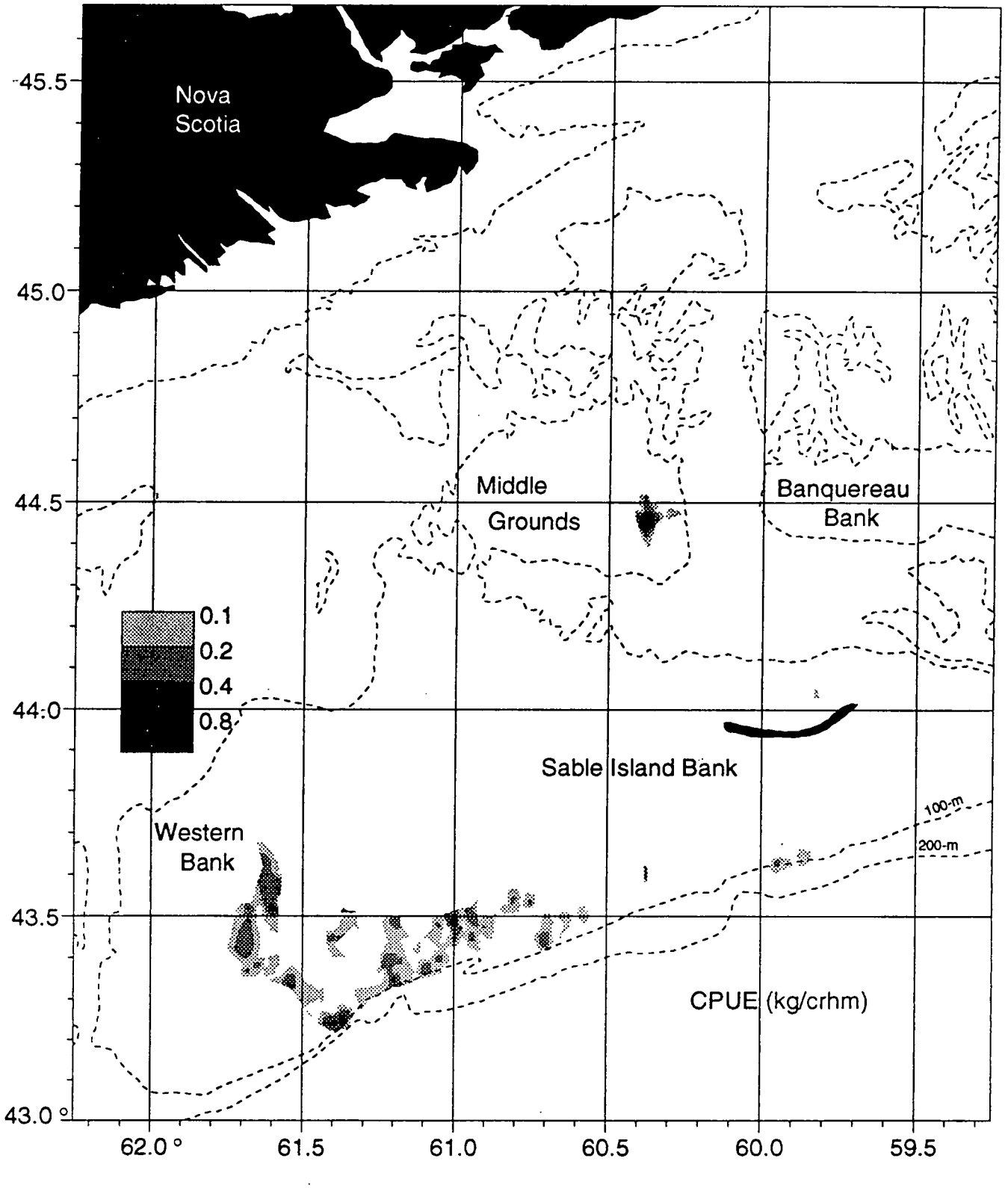

Figure 2.- Distribution of commercial CPUE by the deep-sea fleet on the eastern Scotian Shelf in 1994. The darkest shade represents over 0.8 kg/crhm.

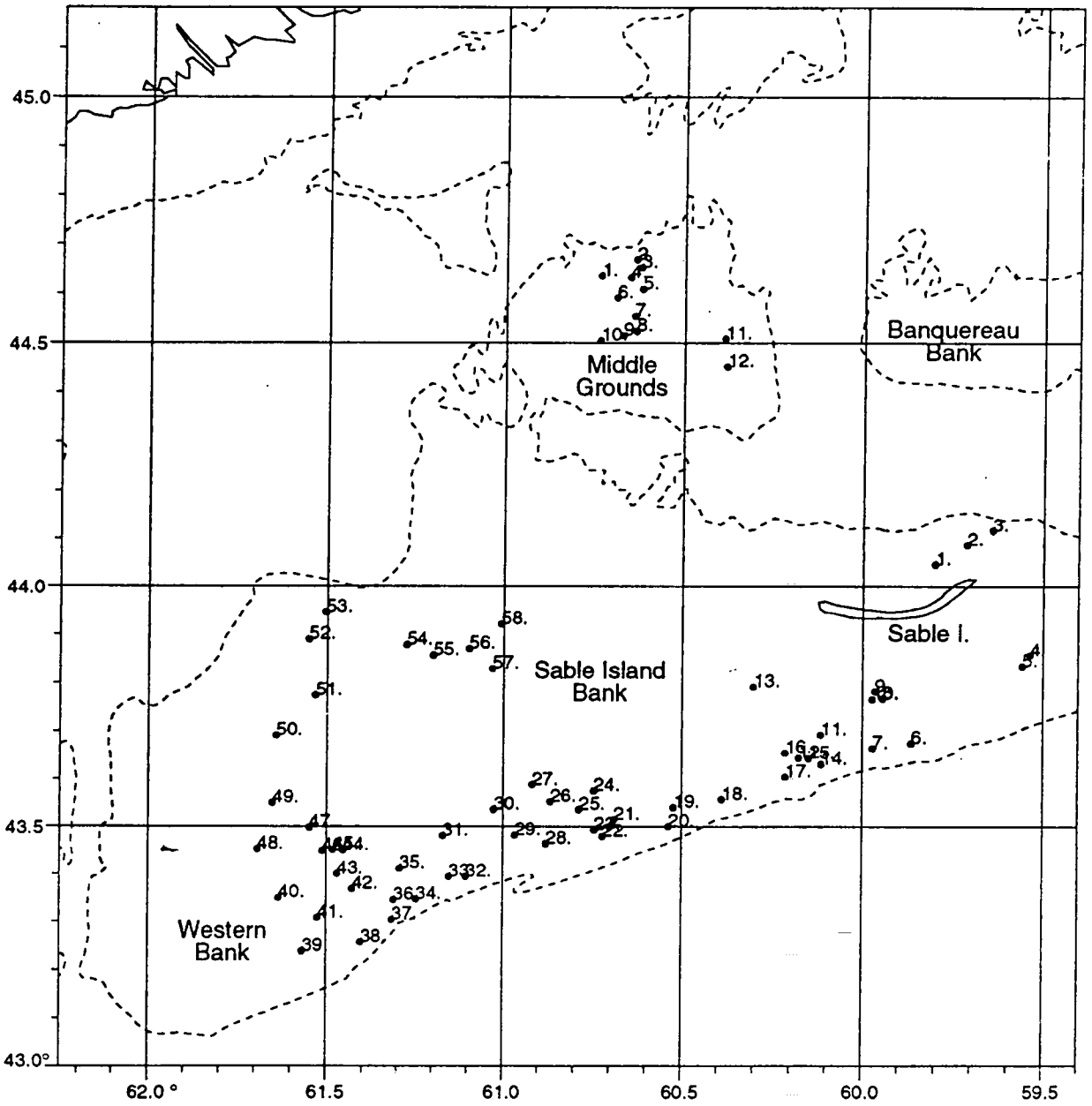

Figure 3.- Location of survey stations of the 1994 eastern Scotian Shelf stock survey. The dashed line is the 100-m isobath.

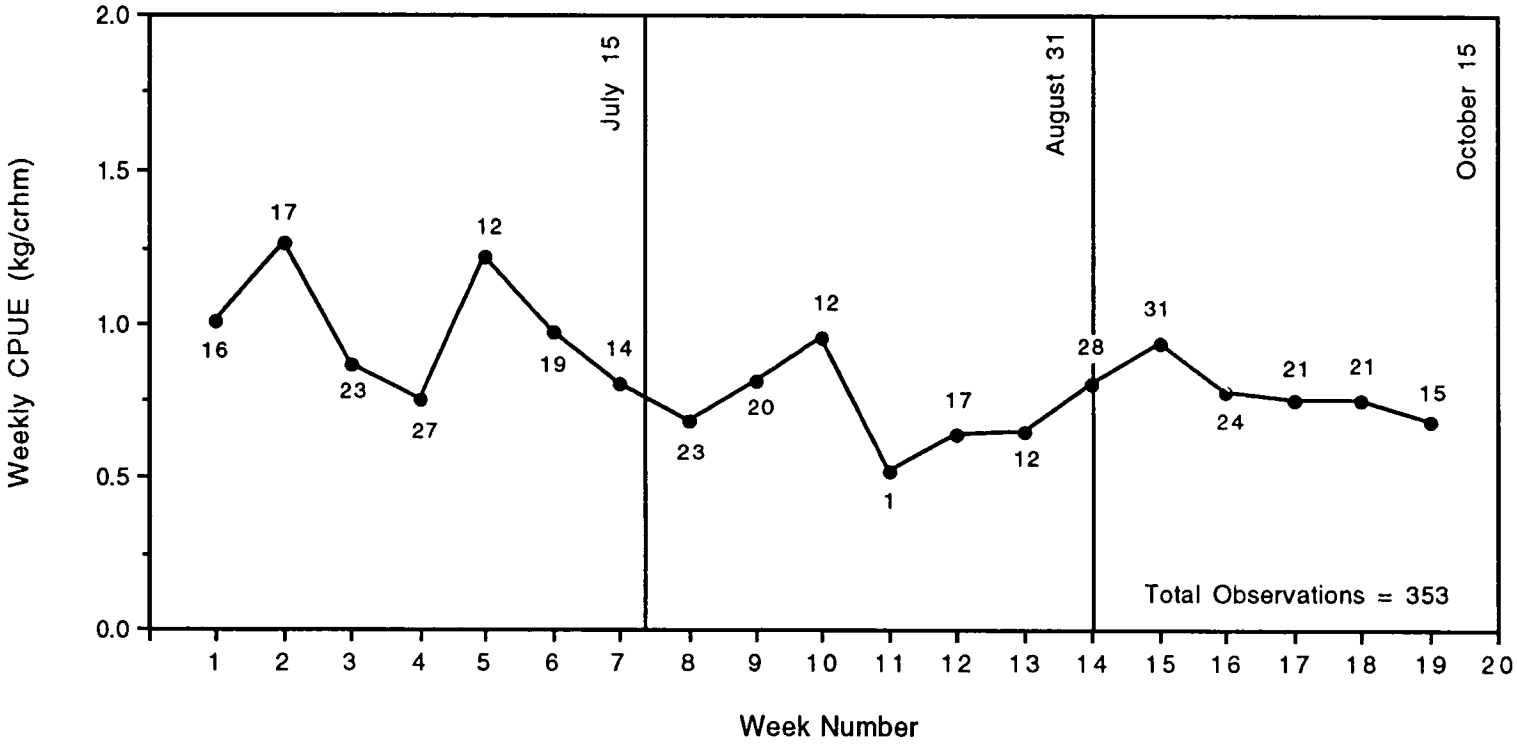

Figure 4.- Fluctuations in weekly catch-rates during the 3 periods of the 1994 German Bank fishery. The total number of days fished during the week is indicated on the graph.

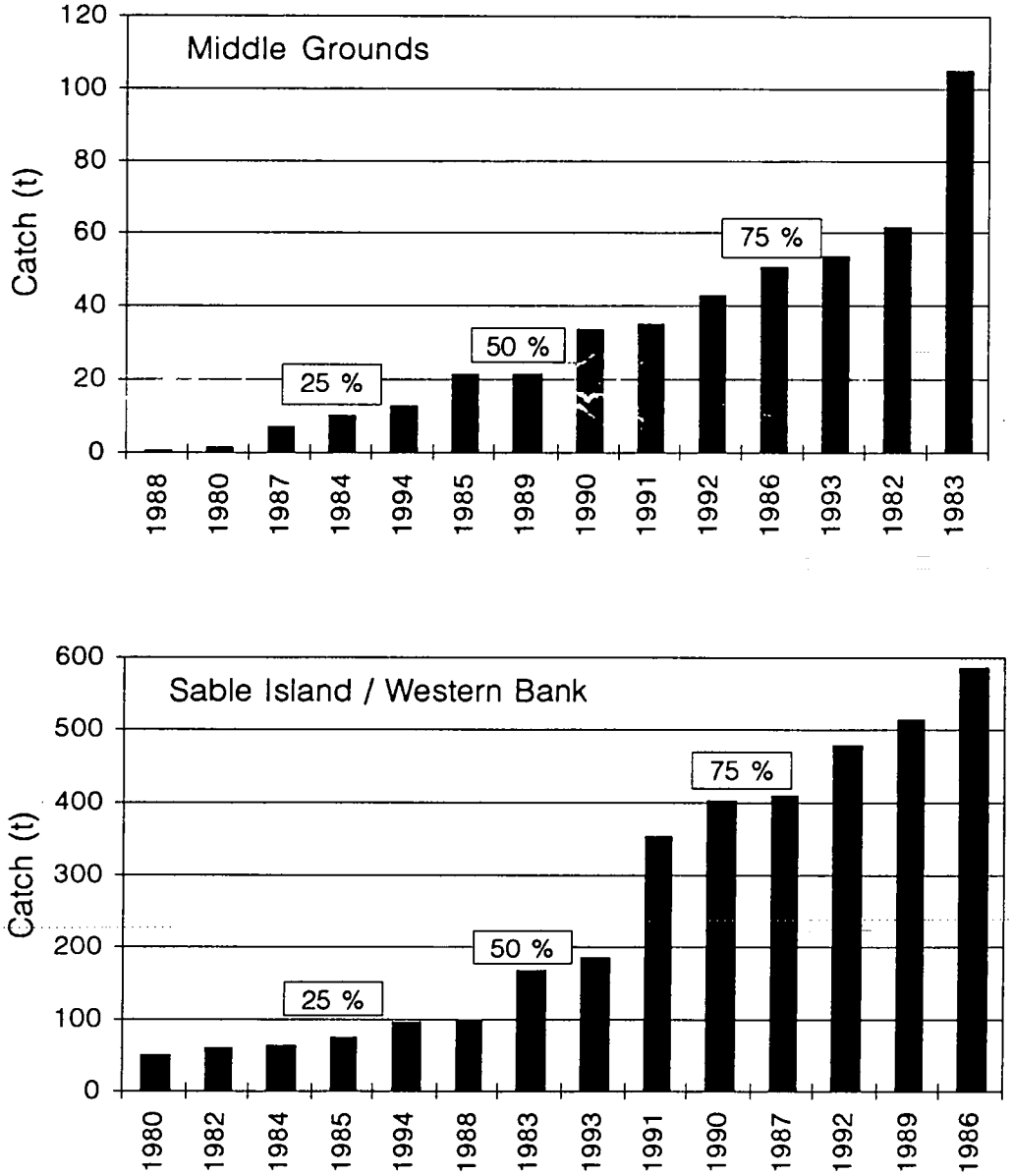

Figure 5.- Catches from 1980 to 1994 (year found on x-axis) have been ranked ascendingly. A quartile percentage has been assigned on an ordinal scale as shown for Middle Grounds in the upper graph and Sable / Western in the bottom graph. There was no catch in 1981.