Exploratory Survey for the Iceland Scallop *Chlamys islandica* (O.F. Müller) on the Eastern Grand Banks of Newfoundland, NAFO Div. 3N

by

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Abstract

A random stratified survey for Iceland scallops was conducted in NAFO Subarea 3N. A total of 196 sets was completed with an unlined 12 ft (3.6 m) New Bedford scallop drag.

Iceland scallops were commonly found over most of the area north of 44°30′; they were unevenly distributed however. Two aggregations were located between the 37 and 40 fm isobaths. A smaller bed was found in slightly deeper water off the Lilly Canyon. The three aggregations discovered to date were restricted to relatively small areas. More importantly, overall average densities within the aggregations were low (0.33 to 2.0 scallops/m²) and probably unattractive to the offshore fleet. Distance to shore facilities and the need to manually shuck scallops onboard would pose undue problems for their immediate exploitation by the middle-distance fleet.

Résumé

Dans le cadre de l'étude d'un échantillon de pétoncles d'Islande stratifié au hasard dans la sous-zone 3N de l'OPANO, on a procédé à 196 relevages d'une drague à pétoncle New Bedford non doublée de 12 pi (3,6 m).

Les pétoncles d'Islande étaient présents dans la majeure partie du secteur situé au nord de la latitude 44°30′, quoique irrégulièrement répartis. On en a trouvé deux concentrations entre les isobathes de 37 et de 40 brasses ainsi qu'un petit gisement dans les eaux plus profondes situées au large du canyon Lilly. Les trois regroupements découverts jusqu'ici étaient relativement peu étendus. De plus, les densités y étaient faibles (de 0,33 à 2,0 pétonceles par mètre carré), donc de peu d'attrait vraisemblablement pour la flottille de pêche hauturière. La distance qui sépare ces gisements des installations à terre et la nécessité d'écailler manuellement les pétoncles à bord poseraient trop de problèmes pour qu'on puisse envisager une exploitation immédiate de cette ressource par la flottille de pêche semi-hauturière.

Introduction

The Grand Banks of Newfoundland (Fig. 1) are among the most biologically productive continental shelves in the world and support some of the world's largest fisheries. Collectively they constitute one of the few areas in the Northwest Atlantic where potentially valuable invertebrate resources remain virtually unexploited. The benthic communities here are composed of primarily Arctic-boreal and boreal species. While polychaetes are the most numerous, molluscs and echinoderms account for the greater percentage of weight (Hutcheson et al. 1981). Commercial exploitation of one of the molluscan species, the Stimpson's surf clam, Mactromeris polynyma, a discontinuous circumboreal species, has just begun (July 1989). Others, like the sea cucumber (Cucumaria frondosa) remains unfished, or like the Iceland scallop, Chlamys islandica, only sporadically or lightly fished. A 9-day fishing excursion in 1987, for example, removed about 8 t meats (18,000 lb). All catches came from NAFO Div. 3L (approx. 46°25'N, 49°43'W). While anecdotal information on the magnitude of these resources abound, little quantitative work has been undertaken. Few systematic surveys have been directed at the Iceland scallop on the Grand Bank - the largest of three offshore banks off the south and southeast coast of Newfoundland (Dickie and Chiasson 1955; Rowell et al. 1966; Rodger and Davis 1982). These exploratory surveys, including the major contracted study in 1982, were problematical from the viewpoint of estimating standing stock (Naidu and Cahill 1989). Much of the area examined during these surveys was beyond the range of reliability for Decca. Also, the Loran C transmitting station at Fox Harbour had not come on stream causing undue problems for navigation and ability to accurately repeat stations.

Convinced of the commercial viability of the Iceland scallop resource, a major fishing company brought in a factory trawler from Norway in 1989. The ATLANTIC ENTERPRISE completed some 2084 5 m-rake tows over a 20-day period. Catches were dismal with only 2.7 t meats landed (Naidu and Cahill 1989). Industry was stymied on a course of action. Consequently, the Department of Fisheries and Oceans (Newfoundland Region) commenced its own resource survey for Iceland scallops on the Grand Bank. Because of the very large area (59,070 m^2 in waters $\leq$199 fm) and limited ship time, it was decided to carry out the work over a three-year period beginning in the summer of 1989. NAFO Div. 3N (Fig. 2) was selected for the first phase because of the acute paucity of information from this area. Besides, the Southeast Shoal encompasses a relatively large shelf (3092 m^2), shallower than 30 fm, where the likelihood of locating beds of the sea scallop, Placopecten magellanicus, was greater than in the north and northeast portions of the Bank. The sea scallop is the preferred scallop species in the Northwest Atlantic and discovery of new beds would have been providential.

The survey also allowed us to record the incidental presence in the dredge catch of Stimpson's surf clams (Spisula polynyma) and Greenland cockles (Serripes groenlandicus) - two large bivalves hitherto unexploited in this area. Observations on the sedimentary environment, and the incidental capture of live animals and/or shells would assist us in generating a more effective survey design for the species when a suitably equipped vessel became available.

Materials and Methods

A random stratified survey design was employed using Pitt's (1976) groundfish stratification scheme for NAFO Subarea 3N (Fig. 2). Fishing stations within strata were randomly allotted in proportion to their relative area. A total of 152 preassigned stations distributed over 11 strata covering 15,750 m^2 was fished. Randomly assigned additional sets (N = 44) were completed in and around areas where moderate to

good catches had been encountered in order to provide more precise estimates of relative abundance.

The survey was conducted between August 16 and 28, 1989 onboard the 82 m stern trawler, GADUS ATLANTICA. All tows were made with an unlined 12 ft. (3.66 m) New Bedford offshore dredge equipped with 3" rings. Rings were interconnected with three and four links on the top and belly, respectively. Towing speed was approximately 3 knots with a warp to depth ratio of 3:1. All tows covered one nautical mile.

Upon completion of each set live scallops were sorted, bushelled into baskets and weighed whole. Depending on the volume of the catch and anticipated steaming time to the next fishing station, either the whole catch or a randomly selected weighed subsample was set aside for individual shell-height measurements to the nearest mm. Cluckers (persistent paired valves still attached at the hinge line) were separately sorted, counted and measured. A total of 7023 live scallops and 320 cluckers were measured.

Individual scallop meats (N = 411) were dissected out from scallops of known weight and size for yield determinations. These were brought back to the laboratory in individually labelled 6 oz whirl pack plastic bags. A broad range of scallop sizes was selected to ensure adequate descriptions of the regressions between shell height (mm) and adductor muscle weight (g). Regressions were computed only for areas where aggregations were encountered.

Bottom temperatures using XBTs were recorded at fishing stations where moderate to good catches were recorded.

Natural mortality of Iceland scallops was computed directly from percent occurrence of cluckers (Dickie 1955) according to the equation:

$$M = 1 - e^{-\left(\frac{C}{t}\right)\left(\frac{1}{L}\right)} .365$$

where M = annual natural mortality rate C = number of cluckers in a sample L = number of live scallops in the same sample t = average time in days required for natural clucker disarticulation (see Mercer 1974).

Results

Areal distribution of fishing stations (Fig. 3) and intensity of coverage within NAFO Div. 3N were such that the 11 strata were each fished at the rate of about one set for every 33 to 107 mi^2 with an overall average intensity of one set per 80 mi^2 (Table 1). The distribution and prevalence of various sediment types and faunal assemblages were recorded, but are not further discussed in this document. Suffice to say that shells of Stimpson's surf clam, Spisula polynyma, were found in 36% (70 out of 196) of sets completed during the survey. Approximately 11% (21 out of 196) contained evidence of the Greenalnd cockle, Serripes groenlandicus. Nine (9) sets produced both species. There was no evidence of bar clams, Spisula solidissima, that had been previously reported from this area (Rowell et al. 1966). One tow at 44°14'N, 49°44'W was significant in that it took about 13 bushels of the small bivalve, Mesodesma deauratum ($\bar{x}$ = 34.0 mm, anterior-posterior axis). This species has been reported to form some of the most dense single species communities (3010 to 5890 individuals/m^2) on the continental shelves of North America (Hutcheson 1981).

With the exception of five disarticulated shells (valves) of sea scallops, only Iceland scallops were captured from the area surveyed. Four of the five sea scallops consisted of left shells each measuring 100 mm, 105 mm, 115 mm, and 120 mm. They were taken at 44°08.5′N, 50°30.7′W from a depth of 33 fms. The remaining partly broken right shell measuring just over 140 mm came from 54 fms (42°56.1′N, 58°04.1′W). No live sea scallops were taken.

Bottom temperature (Table 2) varied narrowly from 0.48°C in 35 fm (65 m) to a low of -1.21°C in 38 fm (70 m).

Abundance

Of the 152 preassigned stations, only 66 (or 43%) produced scallops. Most of the catches came from north of 44°30′N (Fig. 4). Only 16% of sets (11 out of 69) south of this contained scallops. The best catch to the south was 3.9 kg, all other catches being less than 1.0 kg. Elsewhere catches were highly variable pointing to a very patchy distribution. Overall, better catches ($\geq$500 scallops/tow, Table 3) came from two restricted areas, one just southwest of Carson Canyon between 31 and 50 fm and the other in the slope area straddling the 31-50 and 51-100 fm isobaths off the Lilly Canyon (Fig. 4). For convenience these are separately referred to as aggregations IV and V, respectively. But even here catches were highly variable (Table 4). Catch rates (catch numbers/tow, catch weights/tow, mean and modal shell heights) are summarized in Table 5.

Estimates of minimum trawlable biomass and standing stock are summarized in Table 6. The extremely large estimate of standing stock projected for Div. 3N is the result of the multiplicative effect of the areal expansion technique used in the random stratified technique and must be considered unrealistic for a contagiously distributed species. Separate patch estimates for the two aggregations, each approximately 75 mi^2 and 15 mi^2 to the north (Area IV) and south (Area V) respectively are also included. One of the aggregations (Area III, Fig. 5) discovered during a previous survey (Rodger and Davis 1982) was missed during our survey in 1989, but their data were used to approximate abundance in that aggregation. These are included in Table 6.

Shell-height Composition

The majority of Iceland scallops in NAFO Div. 3N was in the 65-95 mm range (Fig. 6). While fewer in numbers, the larger scallops came from the shallowest depth strata ($\leq$30 fms) with an overall mean size of 85.7 mm (Table 7). Mean size of scallops sampled from the 31 to 50 fm and 51-100 fm depth ranges was 80.7 $\pm$ 10.7 mm and 82.5 $\pm$ 9.9 mm respectively and were found to be significantly different ($p < 0.05$) (Table 7). Scallops in the two aggregations (Table 4) were also large and near-identical in average size (SH): 82.7 $\pm$ 7.5 mm (Area IV) versus 82.8 $\pm$ 8.6 mm (Area V). The difference in mean shell heights was not significant ($p > 0.05$).

Shell Height/Meat Weight Relationships

The following shell height/meat weight regressions were computed for Iceland scallops from the two aggregations located during the survey (Fig. 7).

Area IV (southwest of Carson Canyon):

$$\log_{10}W = 2.6466\log_{10} H-3.984 \quad (r^2 = 0.8587, N = 104)$$

where W = adductor muscle (meat) weight (g); H = run in one line.

H = shell height (mm), tangential dorso-ventral axis.

Area V (Lilly Canyon):

$$\log_{10}W = 2.6325\log_{10} H-3.956 \quad (r^2 = 0.7809, N = 307)$$

Also, for the aggregation (Area III) missed during our survey we have from Naidu and Cahill (1989):

Area III:

$$\log_{10}W = 3.075\log_{10} H-4.946 \quad (r^2 = 0.761, N = 285).$$

For St. Pierre Bank we have:

$$\log_{10}W = 2.720\log_{10} H-4.327$$

Overall, for a given shell size, individual meat yield was highest for scallops from aggregations IV and V, followed by aggregation III (Table 8). For comparable shell sizes, meat yield in Iceland scallops is lowest on the northwest slope of St. Pierre Bank (Table 8) which is the westernmost extension of the Grand Banks of Newfoundland.

Natural Mortality

Allowing for forced disarticulation of cluckers during tows (see Naidu 1988) overall, annual natural mortality rate was computed to be 0.078, a value higher than 0.044 and 0.056 reported for pre-exploited aggregations on the Grand Banks (Naidu 1988).

Meat Yield

Biological meat yields varied from 13.3% of in-shell weight in Stratum 373 (31-50 fm) to a high of 16.6% in Stratum 382 (51-100 fm) with an overall mean of 14.7% (Table 9). Mean adductor muscle (meat) weights from the two scallop aggregations were 12.15 g in Area IV to 13.5 g in Area V corresponding to a meat count/500 g of 41.2 and 37.1 respectively (Table 10), i.e. average counts were about 11% higher southwest of Carson Canyon (Area IV) than in the Lilly Canyon area (Area V).

Discussion

Only Iceland scallops, Chlamys islandica, have been reported from previous exploratory and fishing excursions to the Grand Bank (Dickie and Chiasson 1955; Rowell et al. 1966; Rodger and Davis 1982). Our survey encountered five disarticulated shells of the sea scallop, Placopecten magellanicus. Two additional shells had also been

taken during recent fishing trials onboard the factor trawler ATLANTIC ENTERPRISE (P. Matthews, pers. comm.[1]). The occasional presence of this species this far east, even if the evidence here offered is only circumstantial, supports the hypothesis sometimes challenged (Sinclair et al. 1985) of larval drift in this species (Squires 1962; Naidu and Anderson 1984). The closest commercial aggregation of sea scallops is on St. Pierre Bank, some 250 mi northwest of the Grand Bank recovery location. Eastern Grand Banks are influenced by several water masses. The cold Labrador Current flows from the north while warm north American waters affect the tail and nose of the Bank. The presence of sea scallops this far east, therefore, is not altogether surprising.

Commercial gear with 3-top, 4-bottom link configuration was used throughout the survey as it would be the preferred gear-type for harvesting the species in these waters (Capt. Allan Skinner, pers. comm.[2]). The unlined gear with this link configuration is known to underestimate scallop numbers by some 68% and is more efficient than lined gear at retaining larger scallops (50% selection point is 73.6 mm, Naidu and Cahill 1989).

The survey located two scallop aggregations. One of these encompassing some 15 mi^2 was in the area of the Lilly Canyon (Area V). A larger aggregation (Area IV) estimated at about 75 mi^2 was found 27 miles to the northeast of the Lilly Canyon bed. Both these potentially attractive areas had been missed during the contracted survey in 1982 partly because of the desertion midway during the survey of a rigid survey design (see Naidu and Cahill 1989). The aggregation near the Lilly Canyon area had been located and fished by the factory trawler ATLANTIC ENTERPRISE in February 1989. Nearly 50% of the experimental fishing effort had been directed here. Coincidentally, our research survey missed a patch estimated at about 145 mi^2 (Area III, Fig. 5) that had been located during the contracted exploratory survey (Rodger and Davis 1982). These 'hit and misses' bear out some of the drawbacks of the random stratified survey design particularly for exploratory work for a contagiously distributed species over a very large area. In summary, it is evident that there are at least three aggregations within NAFO Div. 3N (Fig. 5). Beds of Iceland scallops within these aggregations appear to be small. Estimates of biomass are given separately for each of these areas including the one discovered in 1982, but missed during our survey. For aggregation III, we use the results from the 1982 survey (Naidu and Cahill 1989). Efficiency of capture (no. entering dredge/no. in dredge path) and gear selectivity (no. of scallops caught/no. entering dredge) is assumed to be 30% and 68%, respectively. Biomass estimates are for catches where catch numbers/tow exceeded 500 scallops. Based on the overall meat count of 40.4/500 g this translates into 6.2 kg/tow - a catch level that might be attractive to the middle distance fleet. Commercial yield would be somewhat lower because of losses in yield related to rapid manual shucking. Naidu (1988) reported that this loss in yield was negatively correlated to shell size and decreased from about 30% at 60 mm to 11% at 90 mm, with an average loss of 23%. When overall gear efficiency (efficiency of capture and gear selectivity) is taken into account, minimum average density in areas where catch rates $\geq$500 scallops/rake mile is approximately 0.33 scallops/m^2. Maximum average density (Table 4) is estimated to be only about 2 scallops/m^2 and not particularly high for this species. Underwater photographs from independent studies associated with offshore hydrocarbon exploration on the Grand Banks point to higher densities, sometimes approaching 13 scallops/m^2 (Naidu and Cahill 1989). Elsewhere, as in populations at Jan Mayen (west of

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Straumflaket) mean density over a 60 km² area has been estimated to be as high as 9.9 shells/m² (Rubach and Sundet 1988). Anomalously high densities of approximately 60 live scallops/m² have also been reported in Balsfjord in northern Norway (Brun 1968).

Naidu and Cahill (1989) reported that for a given size, Iceland scallops from St. Pierre Bank had a higher meat yield than those from the Grand Banks. Their comparisons were based on incidental catches of Iceland scallops from shallow water ($\leq$30 fm, Strata 314 and 320) where surveys for sea scallops are customarily conducted. The comparisons used in this paper (Table 8) are probably the more valid, as commercial aggregations from the northwest slope in Stratum 312 ($\geq$30 fm) are employed (Naidu and Cahill, unpub. data). It must be noted, however, the Iceland scallops on St. Pierre Bank were sampled in April, whereas those from the Grand Bank were sampled later in the year (August). Seasonal changes in average meat weights within and between the two areas are presently unknown.

The slightly higher mortality of 0.078 for Iceland scallops, compared to a mean value of 0.05 earlier reported for the species in this area (Naidu 1988) may be in part due to pooling of observations over a very large area (Caddy 1975) and/or a reflection of incidental (added) mortality inflicted upon individuals during experimental fishing operations in the area conducted some six to seven months prior to the survey. Although the mean time for natural clucker disarticulation used in this study was experimentally determined by Mercer (1974) to be 210.8 days, recent work has shown cluckers to persist much longer with 50% disarticulation time approximately 335 days (Naidu, unpubl. data).

In summary, Iceland scallops were found unevenly distributed over the area investigated (NAFO Div. 3N). They were commonly found over most of the area north of 44°30′. Two aggregations were located between the 37-40 fm isobaths. A smaller bed was found in slightly deeper water off the Lilly Canyon. The three aggregations discovered to date were restricted to relatively small areas. More importantly, overall average densities within the aggregations were low (0.33 to 2.0 scallops/m²) and probably unattractive to the current offshore scallop fleet. Distance to shore facilities (160 mi southeast of Cape Race, Fig. 3), constraints imposed by weather and the need to manually shuck scallops onboard would pose undue problems for their immediate exploitation by the middle-distance fleet.

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Table 1. Distribution of fishing sets by depth (fm) within NAFO Div. 3N.

Stratum	Depth range (fm)	Area (n mi²)	No. sets	Mean area per set (mi²)
375	≤30	1,593	15	106
376	≤30	1,499	14	107
360	31-50	2,992	31	96
361	31-50	1,853	18	103
362	31-50	2,520	24	105
373	31-50	2,520	37	68
374	31-50	931	16	58
383	31-50	674	17	40
359	51-100	421	4	105
377	51-100	100	3	33
382	51-100	647	17	38
TOTALS		15,750	196	80

Table 2. Distribution of bottom temperature (°C) in areas of scallop abundance in NAFO Div. 3N on the Grand Bank of Newfoundland, August 1989.

Set	Position	Depth (m)	Temperature (°C)
160	45°02.6′N, 50°50.9′W	65	0.48
52	44°57.6′N, 49°18.0′W	69	-1.06
182	45°19.1′N, 49°03.7′W	69	-1.15
39	45°16.6′N, 49°02.0′W	70	-1.21
1	45°45.4′N, 50°53.4′W	75	0.21
172	44°54.9′N, 49°20.9′W	101	-1.06
178	44°57.3′N, 49°07.8′W	160	-1.16

Table 3. Fishing sets in NAFO Div. 3N with Iceland scallop catch numbers per one mile tow ≥500.

Obs.	Latitude	Longitude	Catch no./tow	Weight	No. scallops/kg
1	45°16.0'N	48°57.5'W	2,773	215.8	13
2	44 53.0	49 21.3	1,784	134.2	13
3	44 59.3	49 21.8	1,717	116.0	15
4	44 53.8	49 16.0	1,613	125.1	13
5	45 14.8	49 00.6	1,200	119.4	10
6	45 14.8	49 02.9	1,064	82.1	13
7	45 17.1	49 02.9	885	70.0	13
8	45 17.8	49 04.4	826	67.2	12
9	45 16.0	49 04.9	808	64.9	12
10	45 21.6	48 55.8	807	62.2	13
11	45 10.1	49 06.4	782	63.5	12
12	45 18.7	49 03.1	762	70.5	11
13	45 21.5	48 53.5	761	58.3	13
14	45 13.4	49 03.0	755	58.3	13
15	45 19.0	48 57.5	704	70.9	10
16	45 22.9	48 52.5	653	45.6	14
17	44 54.9	49 10.4	609	39.2	16
18	45 07.5	49 09.0	575	44.8	13
19	45 06.7	50 42.5	562	31.0	18
20	44 50.9	49 17.2	542	43.4	13
21	45 17.7	49 00.1	539	50.6	11

Table 4. Summary of catch rates (catch numbers and weights (kg)/tow), mean sizes (shell height, mm) and modal shell heights of Iceland scallops in each of two aggregations in NAFO Div. 3N in 1989.

	Area IV (SW of Carson Canyon)	Area V (Lilly Canyon)
Number of sets	20	5
Mean no./tow (±S.D.)	773.7 (±540.0)	930.8 (±729.4)
Mean weight (kg)/tow (±S.D.)	63.61 (±43.2)	70.31 (±55.7)
Mean shell height (mm) (±S.D.) (N)	82.7 (±7.5) (3,108)	82.8 (±8.6) (958)
Modal shell height (mm)	85	82
Percent ≥60 mm	98.7	98.6

Table 5. Summary of catch rates (catch numbers and weight (kg)/tow), mean sizes (shell height, mm), and modal shell heights of Iceland scallops from NAFO Div. 3N.

	Div. 3N (total)	Stratum 375	Stratum 376	Stratum 360	Stratum 361	Stratum 362	Stratum 373
Mean no./tow (±S.D.)	130.8 (±353.8)	6.5 (±22.0)	0	0.6 (±1.6)	17.3 (±57.7)	75.8 (±146.0)	273.4 (±368.1)
Mean weight (kg)/tow (±S.D.)	10.2 (±27.7)	0.6 (±1.91)	0	0.02 (±0.05)	0.6 (±2.2)	4.3 (±8.1)	23.2 (±31.4)
Mean shell height (mm) (±S.D.)	81.1 (±10.6)	85.7 (±8.6)	-	72.8 (±15.6)	63.2 (±16.0)	73.9 (±12.9)	84.6 (±7.4)
(N)	(7,023)	(86)		(18)	(202)	(1,138)	(2,657)
Modal shell height (mm)	85	83	-	48	70	76	85
Percent ≥60 mm	96.2	96.5	-	77.8	69.3	90.4	99.0

	Stratum 374	Stratum 383	Stratum 359	Stratum 377	Stratum 382
Mean no./Tow (±S.D.)	262.9 (±596.3)	353.6 (±697.2)	4.0 (±8.0)	18.3 (±30.0)	175.2 (±399.0)
Mean weight (kg)/tow (±S.D.)	19.3 (±42.8)	28.4 (±54.6)	0.3 (±0.5)	1.3 (±2.3)	13.1 (±30.4)
Mean shell height (mm) (±S.D.)	84.1 (±7.4)	79.9 (±7.9)	79.8 (±7.8)	83.4 (±12.1)	82.5 (±9.8)
(N)	(596)	(1,013)	(16)	(54)	(1,243)
Modal shell height (mm)	87	80	86	87	83
Percent ≥60 mm	98.5	97.7	93.8	92.6	98.1

Table 6. Estimates of minimum trawlable biomass and standing stock [numbers and weights (t, round)] of Iceland scallops on the Grand Banks of Newfoundland (NAFO Div. 3N) in 1989, in each of the three commercial aggregations (Areas III, IV, and V) where catch numbers/tow $\geq$500 scallops. Separate and pooled estimates are given for the three aggregations. Abundance estimates for Area III are based on a 1982 survey (see Naidu and Cahill 1989).

Area	No. of sets (Area - mi²)	Minimum trawlable biomass		Standing stock	
		95% Confidence limits (mean)		95% Confidence limits (mean)	
		Weight (t, whole)	Numbers ($x10^{-6}$)	Weight (t, whole)	Numbers ($x10^{-6}$)
NAFO Div. 3N (total area)	196 (15,750)	193,761-389,108 (291,435)	514-1,031 (772)	193,761-389,108 (291,435)	2,518-5,053 (3,786)
Area III	27 (140)	3,574-7,070 (5,322)	57.6-109.6 (83.6)	317,504-34,673 (26,089)	283-537 (410)
Area IV	20 (75)	1,651-3,186 (2,419)	19.8-39.0 (29.4)	8,092-15,620 (11,856)	97-191 (144)
Area V	5 (15)	0.9-1,060 (535)	0.2-14.0 (7.1)	43-5,198 (2,621)	1-68 (35)
Areas III, IV and V combined	52 (230)	6,360-10,191 (8,275)	92.3-147.9 (120.1)	31,177-49,955 (40,566)	453-725 (589)

Table 7. Summary of catch rates (catch numbers and weights (kg)/tow), mean sizes (shell height, mm) and modal shell heights of Iceland scallops by depth strata in NAFO Div. 3N.

	≤30 fm	31-50 fm	51-100 fm
Number of strata	2	6	3
Number of sets	29	143	24
Mean no./tow (±S.D.)	3.4 (±15.9)	157.2 (385.9)	127.1 (±341.6)
Mean weight (kg)/tow (±S.D.)	0.3 (±1.4)	12.3 (±30.3)	9.5 (±26.0)
Mean shell height (mm)	85.7 (±8.6)	80.7 (±10.7)	82.5 (±9.9)
(N)	(86)	(5,624)	(1,313)
Modal shell height (mm)	83	85	87

Table 8. Distribution of size-specific meat weights and meat counts/500 g in Iceland scallops in NAFO Div. 3N (Areas III, IV, and V) in comparison to NAFO Div. 3Ps. Figures computed from shell-height (mm)/meat weight (g) regressions (see P. 5 and 6).

Shell height (mm)	Meat weight (g)				Meat count/500 g			
	3N				3N			
	Area III	Area IV	Area V	3Ps	Area III	Area IV	Area V	3Ps
50	1.9	3.3	3.3	2.0	263.2	151.5	151.5	250.0
55	2.5	4.2	4.2	2.6	200.0	119.0	119.0	192.3
60	3.3	5.3	5.3	3.2	151.5	94.3	94.3	156.3
65	4.3	6.6	6.5	4.0	116.3	75.8	76.9	125.0
70	5.3	8.0	7.9	4.9	94.3	62.5	63.3	102.0
75	6.6	9.6	9.5	5.9	75.8	52.1	52.6	84.7
80	8.1	11.4	11.3	7.1	61.7	43.9	44.2	70.4
85	9.7	13.3	13.3	8.3	51.5	37.6	37.6	60.2
90	11.6	15.5	15.5	9.7	43.1	32.3	32.3	51.5
95	13.7	17.8	17.8	11.3	36.5	28.1	28.1	44.2
100	16.0	20.4	20.4	13.0	31.3	24.5	24.5	38.5

Table 9. Percent meat yield, mean meat weight (g), and meat count/500 g for Iceland scallops from the Grand Banks of Newfoundland in 1989.

Set no.	Stratum	N	Whole wt. (kg)	Meat wt. (g)	Mean meat wt. (g)	Percent yield (biological)	Meat count (no./500 g)
48	373	207	18.10	2696.0	13.0	14.9	38.4
183	373	174	18.05	2406.5	13.8	13.3	36.2
56	382	135	11.00	1821.0	13.5	16.6	37.1
43	383	282	19.90	2955.8	10.5	14.5	47.7
TOTALS		798	67.05	9879.3	12.4	14.7	40.4

Table 10. Percent meat yield, mean meat weight (g), and meat count/500 g for Iceland scallops from two aggregations (Area IV and V) on the Grand Banks of Newfoundland, 1989.

Area	N	Whole wt. (g)	Meat wt. (g)	Mean meat wt. (g)	Percent yield	Meat count/ 500 g
IV	663	56.05	8,058.3	12.15	14.4	41.15
V	135	11.00	1,821.0	13.50	16.6	37.06

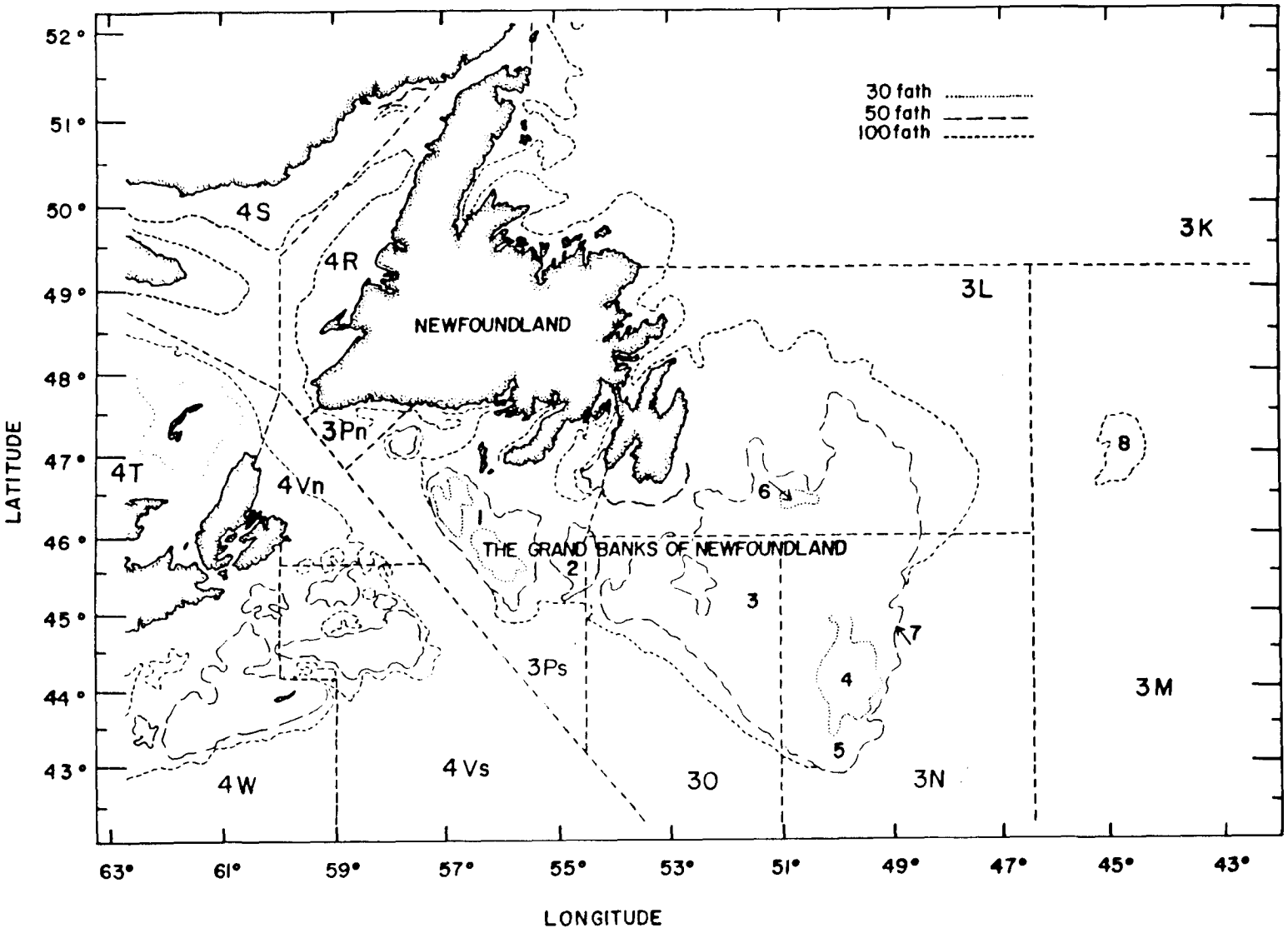

Fig. 1. The Grand Banks of Newfoundland showing the three major offshore plateaus: 1. St. Pierre Bank, 2. Green Bank, and 3. Grand Bank. Other place names mentioned in the text: 4. Southeast Shoal, 5. Tail of the Bank, 6. Virgin Rocks, 7. Lilly Canyon, 8. Flemish Cap.

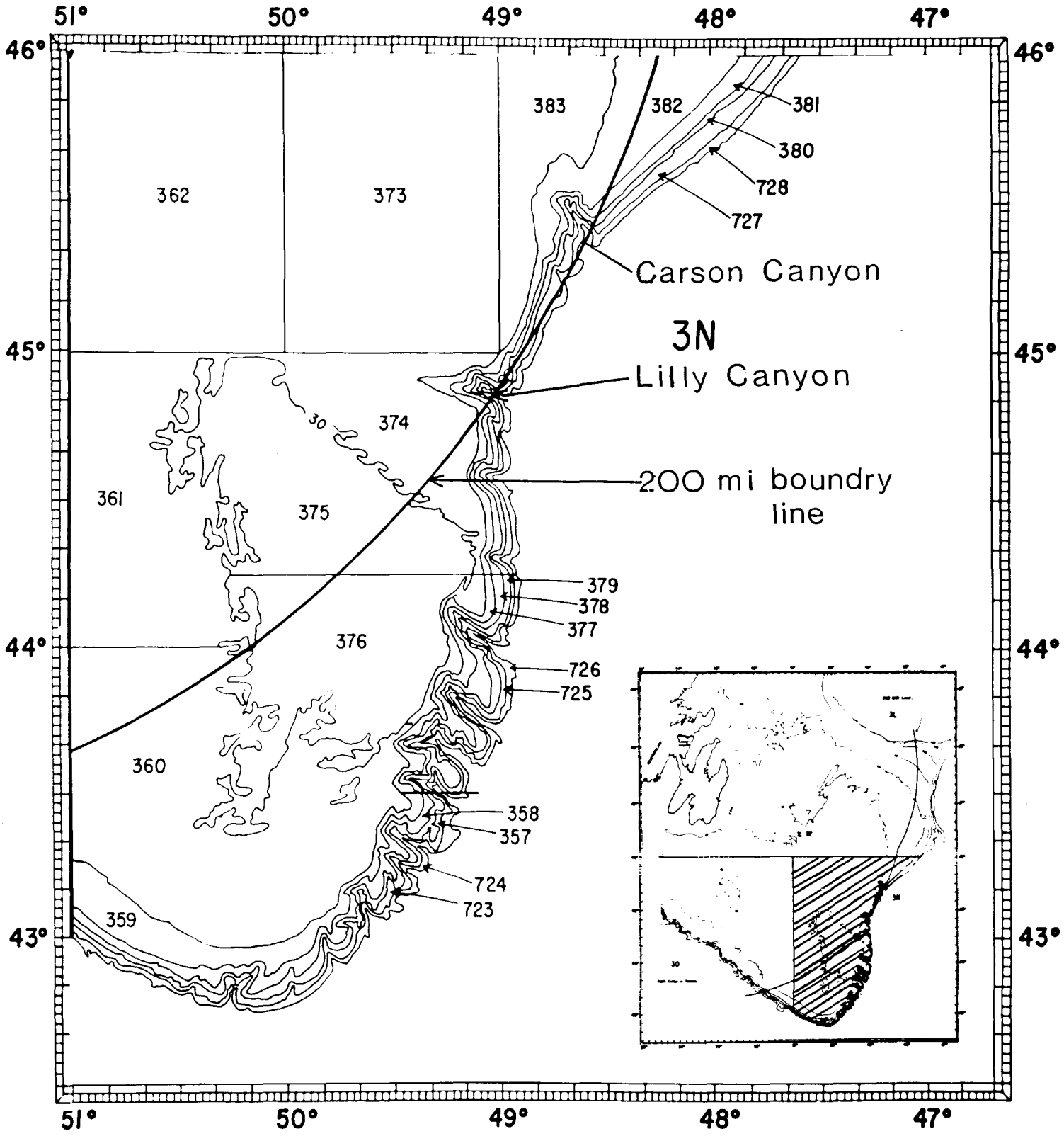

Fig. 2. Stratification scheme for NAFO Div. 3N (Pitt 1976). Inset shows location of 3N on the Grand Banks of Newfoundland in relation to NAFO Div. 3L and 30.

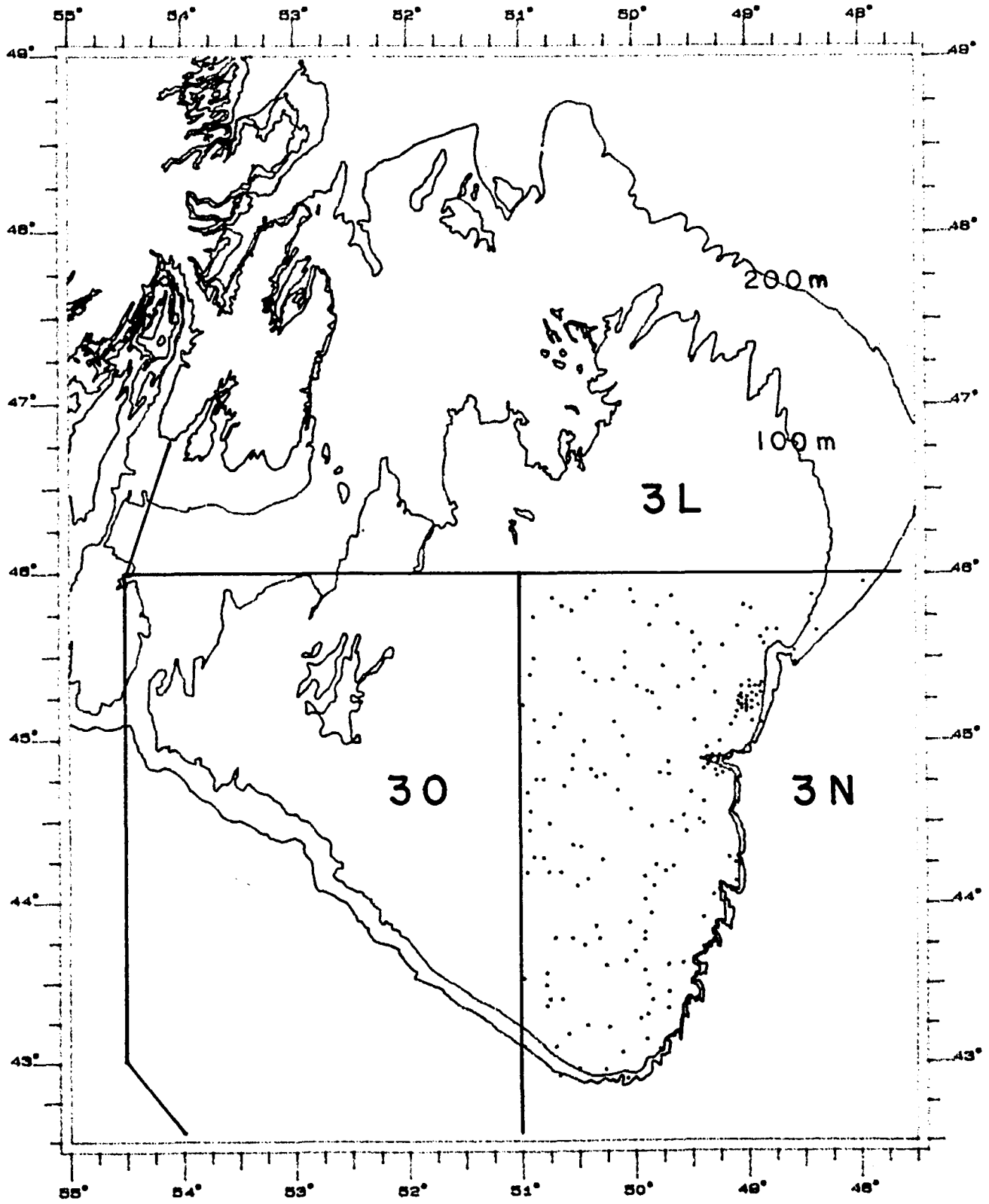

Fig. 3. Distribution of fishing stations in NAFO Div. 3N for the exploratory survey for Iceland scallops, Chlamys islandica.

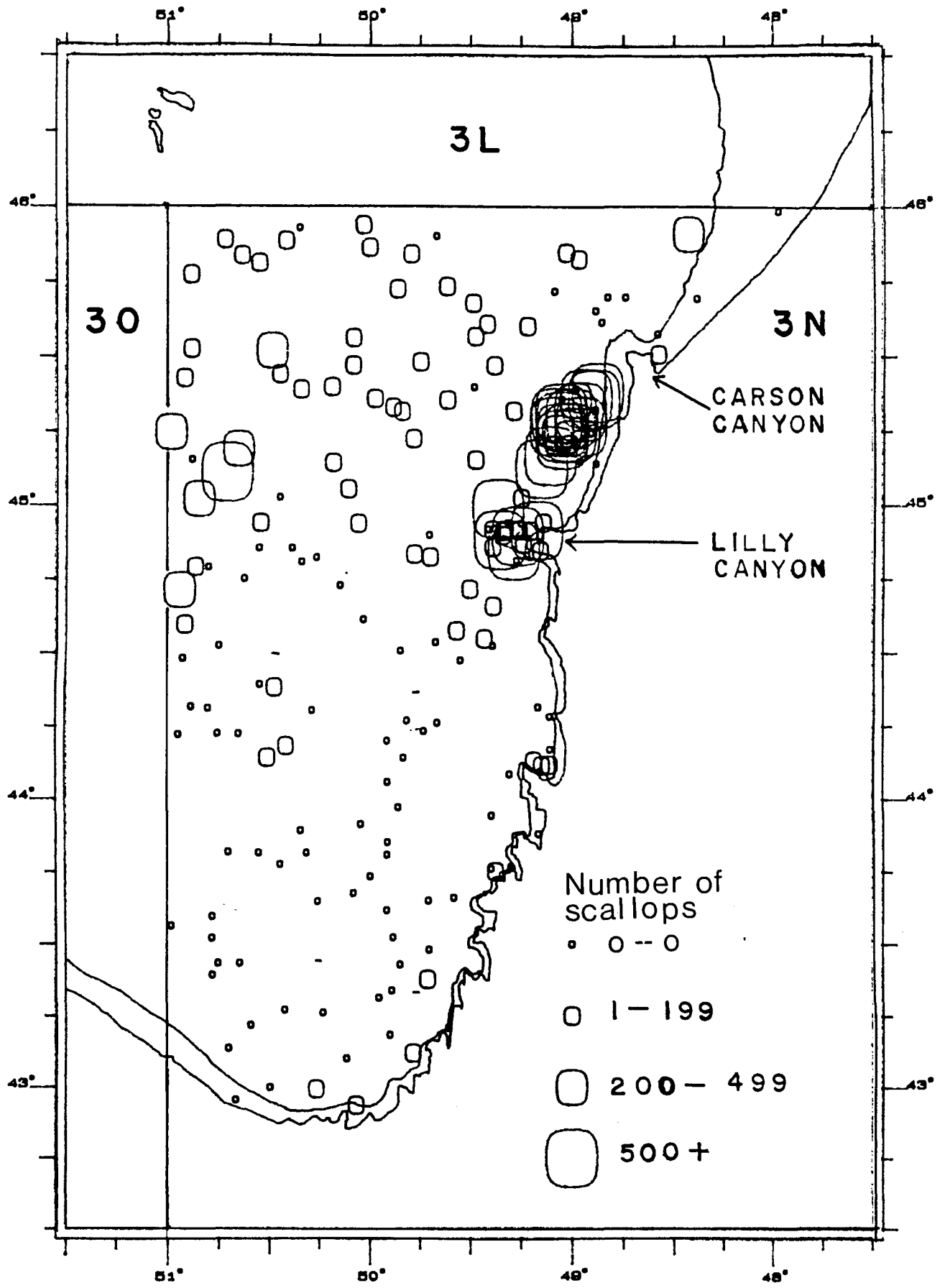

Fig. 4. Catches of Iceland scallops (no./tow) in NAFO Div. 3N (Grand Banks of Newfoundland) during a research vessel survey of the area in 1989.

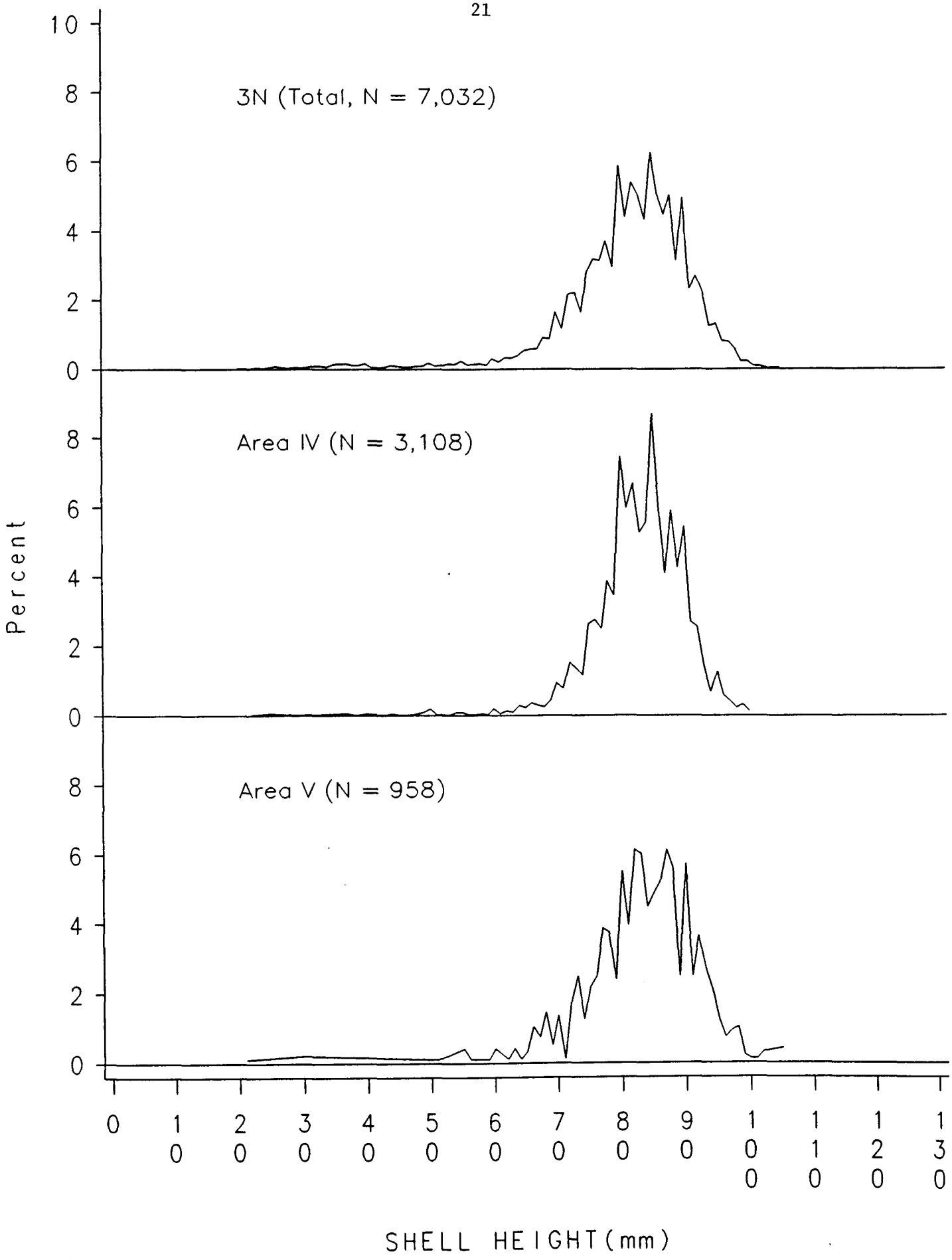

Fig. 5. Shell-height distributions of Iceland scallops in NAFO Div. 3N (Grand Banks of Newfoundland) in August 1989.

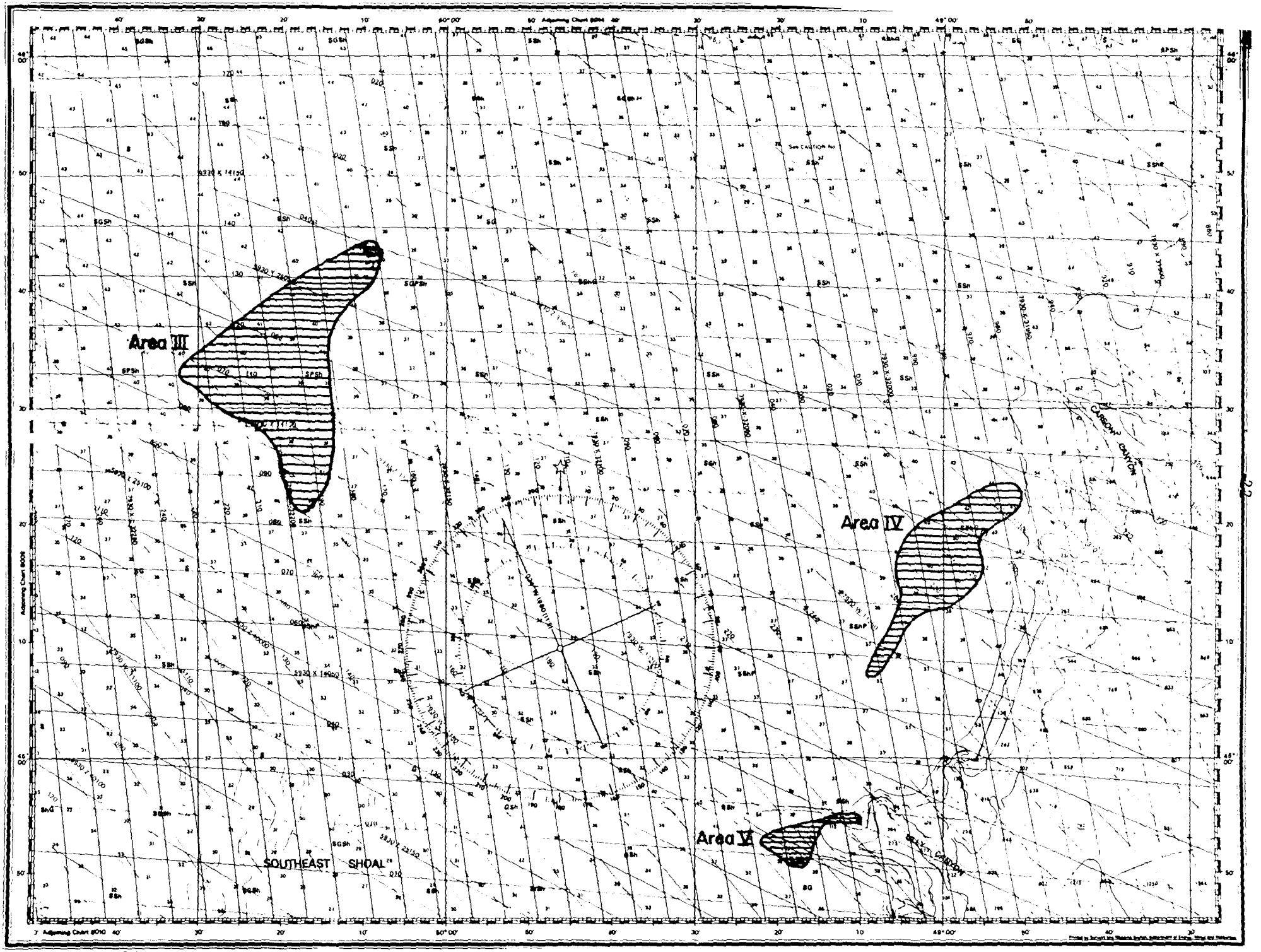

Fig. 6. Distribution of aggregations of the Iceland scallop, Chlamys islandica, in NAFO Div. 3N on the Grand Banks of Newfoundland where catch numbers/tow mile

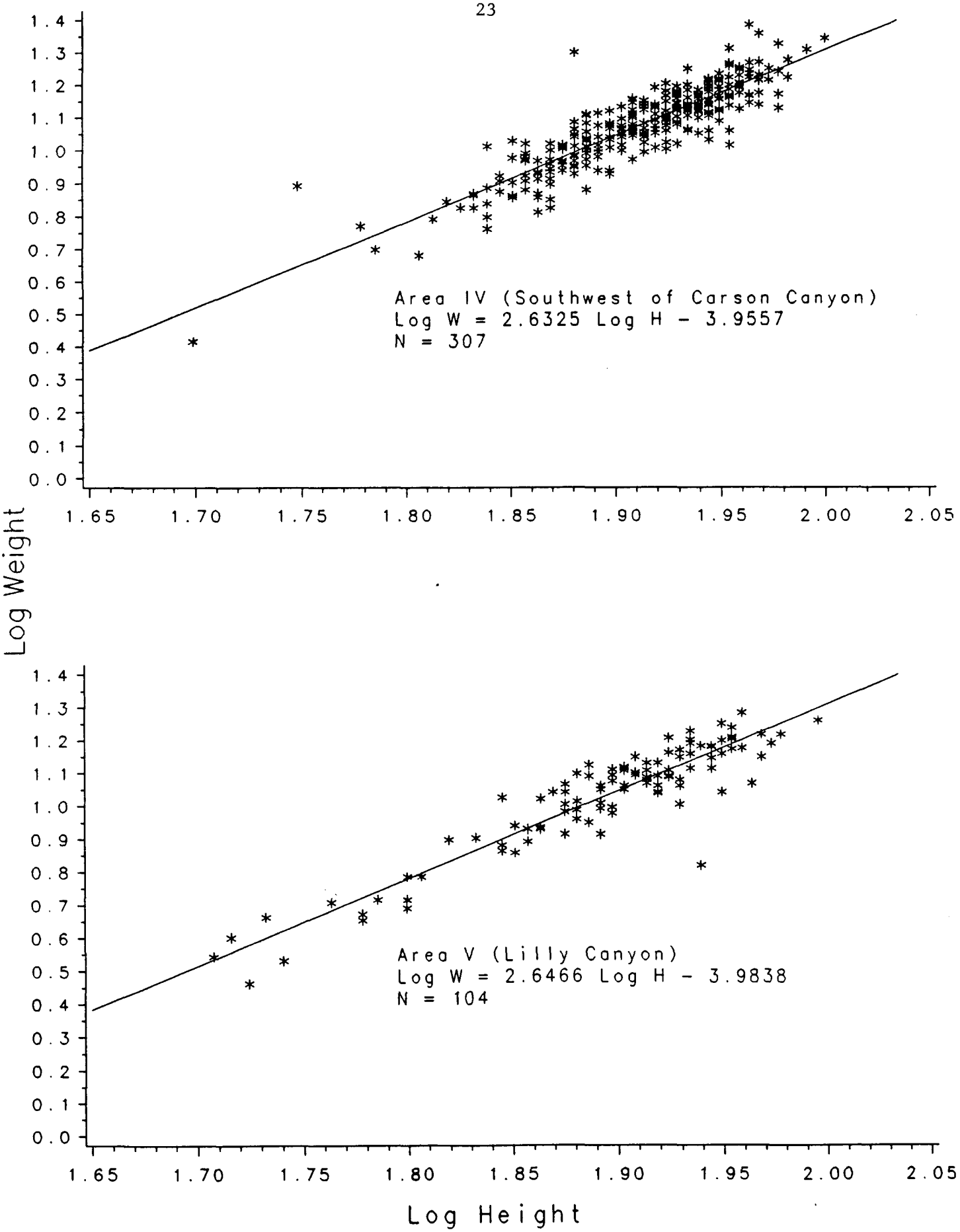

Fig. 7. Relationship between adductor muscle (meat) weight (g) and shell size (SH, mm) in Iceland scallops from two scallop aggregations in NAFO Div. 3N on the Grand Banks of Newfoundland in August 1989.