Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 92/31

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 92/31

A Re-examination of the Abundance of Iceland Scallops, *Chlamys islandica*, along the Northern Edge of St. Pierre Bank (NAFO Div. 3Ps)

by

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Abstract

Abundance of the Iceland scallop, Chlamys islandica, along the northern edge of St. Pierre Bank (NAFO Div. 3Ps) is reassessed. Using a stratified random survey using optimally allocated fishing sets, it was determined that minimum dredgeable biomass in the target area to be between 5,887 and 9,527 t ($\bar{x}$ = 7,707 t) of shell stock. At assumed gear efficiencies of between 33% and 75%, this would correspond to an overall biomass of between 1,522 and 3,468 t. Overall, the results are concordant with those similarly obtained in 1990.

Résumé

On réévalue l'abondance des pétoncles d'Islande (*Chlamys islandica*) le long de la limite nord du banc de St. Pierre (division 3Ps de l'OPANO). En recourant à l'échantillonnage aléatoire stratifié avec un déploiement optimal des engins, on a établi que la biomasse minimale capturable à la drague dans la zone cible se situait entre 5 887 et 9 527 t - (x = 7 707 t) de pétoncles en coquille. Dans l'hypothèse d'une efficacité des engins de l'ordre de 33 à 75 p. 100, cela correspondrait à une biomasse globale se situant entre 1 522 et 3 468 t. Dans l'ensemble, les résultats concordent avec ceux obtenus de manière semblable en 1990.

Introduction

Beginning in 1989, components of the middle-distance fleet (45-64.9 ft, LOA) began prosecuting aggregations of the Iceland scallop, Chlamys islandica, hitherto underutilized, along the northern edge of St. Pierre Bank (Fig. 1). A severe economic downturn in the east coast (Atlantic) fishing industry has renewed corporate interest in a number of underutilized species including the Stimpson's surf clam, Mactromeris polynyma, and the Iceland scallop. With the availability now of processing equipment to mechanically-extract meats from the Iceland scallop (Naidu 1989), there was a perception, sometimes inflated, of a new opportunity for the offshore fleet consisting of some 56 active vessels in the 89-141 ft range. All offshore vessels operate out of Nova Scotia. One of the companies conducted some trials on the feasibility of shell-stocking the mollusc for onshore mechanical shucking. While several other proponents also developed proposals to harvest the mollusc from St. Pierre Bank, only Grand Bank Seafoods Inc. (a subsidiary of Clearwater Fine Foods) was successful in procuring an initial but exclusive offshore allocation for 1991 of 4200 t shellstock (to be harvested mostly along the northwest edge of St. Pierre Bank). An additional 1000 t was to be allocated later during the fishing season. Future quotas were to be allocated depending on both scientific information to be gathered on the resource during the 1991 fishery as well as on the satisfactory resolution of the Canada-France boundary dispute. Industry has always insisted that long-term viability of its initiative on St. Pierre Bank is dependent on finding additional commercial concentrations outside the northern edge. In this spirit and in consultation with the Department of Fisheries and Oceans, industry had indicated that they wished to conduct further exploratory surveys. Start-up problems delayed the onset of the fishery and none of the initial allocation was utilized. Given the particular circumstances of the initiative, DFO agreed to "roll-up" the 1991 and 1992 allocation into a 10,000 t quota to be harvested over 14 months beginning in November 1991. After a number of delays, the fishery finally commenced February 1992. To date, little information has become available to be of any use in this assessment.

In the absence of precise estimates of gear efficiency for the offshore rake for Iceland scallops, CAFSAC in 1991 had used a bracketed array of efficiencies ranging from 33% to 75% and estimated fishable biomass north of 46°30' to be between 12,000 and 26,000 t shellstock (equivalent to between 1,600 and 3,700 t meats (Naidu 1991)). Based on preliminary Y/R calculations, CAFSAC recommended that catches of between 300 and 700 t meats would be consistent with an $F_{0.1}$ exploitation of the resource. As incidental non-yield mortality of this relatively sedentary species is high (Naidu 1988) and as rather optimistic parameters were used in the preliminary computations of Y/R, estimates of equilibrium yield were considered high biased (Naidu 1991). Also, it was postulated that large-scale removal of shells from the fishing grounds may have yet-to-be-determined long-term effects on recruitment. For these reasons a cautious approach was recommended for the exploitation of this slow-growing species.

Materials and Methods

As further exploratory work was being contemplated pending financial assistance from the government, we decided to restrict our work to re-assess the large and significant Iceland scallop aggregation along the northern edge only. Prospects here for their commercialization have previously been identified to be higher than elsewhere on the bank (Naidu 1991, Naidu et al. 1992). A stratified random design was employed (Smith and Somerton 1981). Empirical information from the 1990 survey (Naidu 1991) was used to advantage to generate a more optimal survey design than hitherto employed (Table 1). New information made available to us by the IFREMER laboratory in St. Pierre was also factored into the design. Using catch-rate information from 1990, the seven strata encompassing some 612 mi^2 were subdivided into ten strata (Table 2, Fig. 2). Sets were optimally allocated (Cochran 1977) in proportion to stratum-specific areas and catch-rates within the strata according to the equation.

$$N_h = \frac{n\, A_h\, S_h}{\Sigma\,(A_i S_i)}$$

where N_h = number of sets in strata 'h';
n = total number of sets available;
A_h = area of stratum 'h';
S_h = CPUE in stratum 'h';
$\Sigma^h(A_i S_i)$ = sum of product of individual stratum areas and stratum-specific CPUE.

Two strata (912 and 918, Fig. 2) covering 184 mi^2 resulting from the restratification were dropped from the survey because of the low catches encountered in 1990. Consequently, only eight of the ten new strata (428 mi^2) were fished. Also, a malfunction in Loran C onboard the research vessel and attendant problems with positioning rendered questionable six of the 125 predetermined fishing sets within two strata (914 and 917) - a total of 64 mi^2 or approximately 15% of the 428 mi^2 to be surveyed. All analyses and biomass estimates were therefore confined to only six strata covering 364 mi^2 (about 60% of the area used in 1990 north of 46°30').

The survey was conducted between August 22 and September 3, 1991 with an 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.

As in 1990, we were again privileged to have yet another experienced fishing master, Capt. W. Slauenwhite of Clearwater Fine Foods Inc., accompany us. His knowledge of the area was used to advantage to make additional sets along tracts of sea bottom never-before-fished. A French scientist, M. J.-C. Mahé, working out of the IFREMER laboratory in St. Pierre also participated in the mission.

Upon completion of each set live scallops were sorted by species, 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. Clucker weights were substracted from sampled and total catch weights as was the combined weight of residual debris (sand, broken shell fragments, pebbles, etc.).

Individual scallop meats were dissected out from samples of known weight and size for overall yield and to determine the relationship between theoretical (biological) meat weight and shell size. Overall yields from shellstock are for commercial-sized scallops only ($\geq$60 mm). Individual meats were brought back to the laboratory in labelled 6 oz. whirl pak plastic bags for accurate weight determinations. A broad range of scallop sizes was selected to ensure adequate descriptions of the regressions between shell height (mm) and adductor muscle weight (g) (n = 884). Shells from which meats were extracted were brought back to the laboratory for ageing. Regressions were computed only for areas where commercial aggregations were encountered.

Bottom temperatures were taken with CTD's.

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 mortality rate;
c = number of cluckers in a sample adjusted to account for tow-induced disarticulation (Naidu 1988);
L = number of live scallops in the sample;
t = average time in days (210.8) required for natural clucker disarticulation (Mercer 1974).

Results and Discussion

We have re-examined Canadian exploratory work on St. Pierre Bank (Dickie and Chiasson 1953, 1955, Somerville and Dickie 1957, MacPhail and Muggah 1965, Rowell et al. 1966a, 1966b, Naidu 1991, Naidu et al. 1983a, 1983b, 1992, Naidu and Cahill 1984, 1985). We have also incorporated published and unpublished information from IFREMER in Saint-Pierre et Miquelon (e.g. Migayrou and Moguedet 1990). From these composite data it is apparent that while there are a lot of sea scallops (Fig. 3) and Iceland scallops (Fig. 4) disposed over St. Pierre Bank, there are only limited areas where the density of each species is such that commercial operations are feasible. The bulk of Iceland scallop aggregations is located within the 40-75 m isobaths along the edge north of 46°30'. Two smaller aggregations in shallower ($\leq$55 m) water further south are problematical in that both sea and Iceland scallops are frequently intermixed. Relative contributions are highly variable. A directed fishery for Iceland scallops in these areas would have a negative impact on the settlement and survival of sea scallops, a species of common and widespread interest to all enterprises prosecuting the species. Elsewhere, Iceland scallop densities would appear to be commercially unattractive.

Approximately 364 mi² of sea bottom in waters ranging from 43 to 88 m were fished during the 13 fishing days (Fig. 5). Distribution of fishing sets by strata and intensity of coverage within each strata are summarized in Table 3. Coverage varied from one set/50 mi² in the lowest density strata to a high of one set/0.95 mi² in the highest density strata, with an overall coverage of about one set/3 mi². As expected, catches were highly variable over the areas surveyed (Fig. 6, Table 4). Number of scallops/kg (shellstock) varied from a low of 7.6 ($\bar{x}$ depth = 49 m) to a high of 30 ($\bar{x}$ depth = 88 m). Overall, number/kg from the most attractive strata (916 and 911) was 18.6 (Table 5).

Twenty-four additional exploratory sets completed at the discretion of Capt. Slauenwhite and the IFREMER scientist, M. J.-C. Mahé, south of 46°30′ but outside of the two mixed aggregations failed to locate significant new deposits. The best catch from these exploratory sets consisted of 20.5 kg at 45°31.8′N and 55°25.7′W in 86 m. Meats from this station were off-white and stringy in consistency with a relatively low yield of only 12.3% (compared to 14.85% along the northern edge).

The bulk (92%) of scallops taken measured ≥60 mm (Fig. 7), a size well below the knife-edge (h_{50}) selection retention size (69.4 mm) recently estimated for this species (Millar and Naidu 1991). Mean shell height varied from 65.4 mm (from 88 m) to 86.5 mm (from 49 m). In the densest strata (916 and 911), mean shell size varied narrowly between 73 and 74 mm. Overall mean and modal size were 74 mm and 75 mm, respectively (Table 6). Mean adductor muscle weight varied from 6.3 g to 13.0 g. Meat yield varied from 12.4% to 16.4% (Fig. 8). Mean adductor muscle weight from the two most promising aggregations was 10.2 g (Table 7), corresponding to an overall biological yield of 14.85% (of shellstock) and a meat count of 48.8/500 g (44.5/lb).

The relationship between shell size (SH) and individual meat weight was examined for the two most productive strata only (916 and 911). Size-specific meat weight at size (Table 8) was computed from the following regressions:

Stratum 911: $\log W = 2.9383 \log SH - 4.58$ ($r^2 = 0.9604$; $n = 251$)
(size range 25-90 mm)

Stratum 916: $\log W = 2.9449 \log SH - 4.58$ ($r^2 = 0.9120$, $n = 633$)
(size range 37-95 mm)

Stratum-specific biomass estimates (minimum trawlable) are summarized for all strata (Table 9). Overall, it is estimated that the areas surveyed carry a minimum trawlable biomass of between 5,887 and 9,527 t ($\bar{x}$ = 7,707 t) of shellstock. Assuming (as in 1991) gear efficiencies of 33%, 50%, and 75% we estimate this to translate into 1,522-3,468 t meats (Table 10). Because of the revised stratification it is not possible to make exact comparisons over identical areas between 1991 and 1992. The best approximation would be a comparison of abundance over the northern area only. This was attempted using only four of the six strata (911, 913, 915, and 916) along the northern edge. Minimum trawlable biomass within the 184 mi² area during 1991 was estimated at 5,188-8,414 t shellstock ($\bar{x}$ = 6,801) (Table 11) vs 5,693-11,803 ($\bar{x}$ = 8,748) in 1990 (Naidu 1991). Using the same bracketed array of gear efficiency and an overall meat-yield of 14.85%, this translates into 1,343-3,060 t meats compared to the 1990 estimate of between 1,640 and 3,700 t (Table 12). Allowing for the smaller area (184 mi² vs 234 mi² in 1990) and fishery removals estimated at approximately 100 t meats, it is apparent that the two estimates are not widely divergent. Even with a gear efficiency of 33%, the lowest in the bracketed array used both in 1990 and 1991, fishable biomass is estimated to be only between 15,719 and 25,494 t ($\bar{x}$ = 20,607) shellstock. Consequently, a TAC of 10,000 t of shellstock for the northern area would appear to be excessive and untenable if sustainability is desired. Moreover, the high exploitation rate may not be compatible with this slow-growing species.

Stratum-specific natural mortality rates computed from percent occurrence of cluckers are summarized in Table 13. Anomalously high mortalities were observed in Stratum 915. Elsewhere mortality varied from a low of 0.06 to 0.16 with an overall mean of 0.12.

Sea scallop contribution to the total catch amounted to only 3.3% (5.3% by weight) (Table 14). A broad size-range (50-140 mm) was evident (Fig. 7). A full 96% of the sea scallop contribution came from Stratum 916. Assuming a 20% gear efficiency for this species, total biomass in the areas surveyed is estimated to be between 1,690 and 5,873 ($\bar{x}$ = 3781) t shellstock (Table 15) equivalent to about 169 and 587 t ($\bar{x}$ = 378 t) meats. Within the stratum (916) where sea scallop bycatch is likely to make the most significant contribution to the fishery now targetting for Iceland scallops, minimum trawlable sea scallop biomass is estimated to be between 189-405 ($\bar{x}$ = 297 t) shellstock. Iceland scallop biomass in this area is estimated to be between 3,078-5,610 ($\bar{x}$ = 4344) t shellstock.

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Table 1. Stratification of northern portion of St. Pierre Bank used during resource surveys for Iceland scallops in 1990 and 1991.

1990			1991		
Stratum	# of units	Area (mi^2)	Stratum	# of units	Area (mi^2)
312	30	102.0	910	41	139.4
314	34	115.6	911	18	61.2
315	18	61.2	912[1]	13	44.2
316	44	149.6	913	7	23.8
321	5	17.0	914[2]	5	17.0
401	13	44.2	915	10	34.0
402	36	122.4	916	19	64.6
			917[2]	14	47.6
			918[1]	41	139.4
			919	12	40.8
Σ = 7	180	612.0	Σ = 10	180	612.0

[1] no survey sets generated in stratification due to low scallop densities.

[2] excluded from analysis. Navigational problems made data collected in these strata questionable.

Table 2. Allocation of fishing sets by strata for a resource survey for Iceland scallops in August 1991.

Stratum	A_h (mi^2)	S_h ($\bar{x}$ wt (kg)/tow	A_iS_i	N_h
910	139.4	3.5	487.9	3
911	61.2	90.1	5,514.1	38
912	44.2	1.6	70.7	0
913	23.8	19.9	473.6	3
914	17.0	13.6	231.6	2
915	34.0	17.7	601.8	4
916	64.6	153.2	9,896.7	68
917	47.6	10.7	509.3	4
918	139.4	0.2	27.9	0
919	40.8	9.2	375.4	3
		Σ =	18,188.6	n = 125

Table 3. Distribution of fishing sets by strata, areas and intensity of coverage during a resource survey for Iceland scallops on St. Pierre Bank, August 1991.

Stratum	Mean depth (m)	Area (mi^2)	No. of sets	No. sets/mi^2
910	59.3	139.4	3	0.02
911	71.1	61.2	38	0.62
913	88.0	23.8	3	0.13
915	49.0	34.0	4	0.12
916	49.5	64.6	68	1.05
919	43.0	40.8	3	0.07
TOTALS	57.4	363.8	119	0.33

Table 4. Stratum-specific mean numbers and weights (kg) of Iceland and sea scallops per tow mile on St. Pierre Bank, August 1991.

			Iceland		Sea	
Stratum	Mean depth fished (m)	No. of sets	Mean #'s (±S.D.)	Mean wt. (kg) (±S.D.)	Mean #'s (±S.D.)	Mean wt. (kg) (±S.D.)
910	59.3	3	34.0 (±55.5)	2.4 (±3.9)	0	0
911	71.1	38	1421.5 (±1894.2)	77.9 (±99.7)	0.2 (±0.7)	0.02 (±0.06)
913	88.0	3	28.0 (±48.5)	0.9 (±1.6)	0.7 (±1.2)	0.05 (±0.09)
915	49.0	4	12.8 (±24.2)	1.7 (±3.2)	0.8 (±1.5)	0.1 (±0.3)
916	49.5	68	2526.3 (±3388.7)	132.7 (±161.2)	109.9 (±197.7)	9.1 (±13.7)
919	43.0	3	519.7 (±465.7)	35.7 (±33.5)	112.7 (±83.0)	22.0 (±17.1)
TOTALS	57.4	119	1912.6 (±2880.2)	101.8 (±140.0)	65.7 (±158.8)	5.8 (±11.8)

Table 5. Number of Iceland scallops per kg (round) caught on St. Pierre Bank, August 1991.

Stratum	Total number	Total weight (kg)	No./kg (all scallops)	No./kg (scallops ≥60 mm)	% ≥60 mm
910	102	7.1	14.4		100.0
911	54,015	2961.9	18.2	17.3	94.3
913	84	2.8	30.0		79.8
915	51	6.7	7.6		100.0
916	171,785	9,024.7	19.0	17.8	91.0
919	1,559	107.1	14.6	13.6	94.6
Σ	227,596	12,110.3	18.8	17.6	92.2

Table 6. Stratum-specific means and modal shell heights (mm) of Iceland scallops on St. Pierre Bank, August 1991.

Stratum	N	Mean shell height (mm) (±S.D.)	Modal shell height (mm) (±S.D.)	Range	
				Max.	Min.
910	71	82.6 (±4.5)	82	91	70
911	6,317	73.8 (±9.0)	77	103	20
913	79	65.4 (±8.8)	60	89	33
915	35	86.5 (±7.3)	91	101	70
916	12,231	73.7 (±10.4)	75	104	6
919	651	76.4 (±9.7)	81	99	24
Overall	19,384	73.9 (±10.0)	75	104	6

Table 7. Stratum-specific biological meat yields, average meat weights and meat counts/500 g of Iceland scallops from St. Pierre Bank, August 1991.

Stratum	N	Whole wt. (kg)	Meat wt. (g)	$\bar{x}$ meat wt. (g)	No./500 g	% Yield
911	770	55.8	8,274.6	10.8	46.5	14.83
916	1,216	81.1	12,057.4	9.9	50.4	14.87
Σ	1,986	136.9	20,332.0	10.2	48.8	14.85

Table 8. Size-specific meat weights (g) for Strata 911 and 916 computed from shell-height/meat-weight regressions, 1991.

Shell height (mm)	Stratum 911	Stratum 916
40	1.3	1.4
45	1.9	2.0
50	2.6	2.7
55	3.4	3.5
60	4.4	4.5
65	5.6	5.8
70	6.9	7.2
75	8.5	8.8
80	10.3	10.6
85	12.3	12.7
90	14.5	15.0
95	17.0	17.6
100	19.8	20.4

Table 9. Estimates of minimum trawlable stratum-specific and overall biomass (kg, whole weight) of Iceland scallops on St. Pierre Bank, 1991.

Stratum	No. of sets	Total	Av./set	Units	Total wgt.	Variance
910	3	7.13	2.377	70631.7	167868	14.90
911	38	2961.94	77.946	31009.0	2417023	9945.58
913	3	2.76	0.920	12059.1	11094	2.54
915	4	6.66	1.665	17227.2	28683	10.43
916	68	9024.70	132.716	32731.7	4344032	25985.95
919	3	107.13	35.710	20672.7	738221	1120.27

Total	Upper	Lower	Mean	Upper	Lower	Effective degrees of freedom
7,706,921	9,527,183	5,886,660	41.8101	51.6851	31.9352	41

Table 10. Estimates (mean + 95% confidence bands) of Iceland scallop biomass (t, meats) on St. Pierre Bank, 1991.

Gear efficiency	Biomass (t, meats)
33%	2649-4287 ($\bar{x}$ = 3468)
50%	1748-2830 ($\bar{x}$ = 2289)
75%	1163-1882 ($\bar{x}$ = 1522)

Table 11. Estimate of minimum trawlable biomass (kg, whole weight) of Iceland scallops along the northern aspect of St. Pierre Bank, 1991.

Stratum	No. of sets	Total	Av./set	Units	Total wgt.	Variance
911	38	2961.94	77.946	31009.0	2417023	9945.6
913	3	2.76	0.920	12059.1	11094	2.5
915	4	6.66	1.665	17227.2	28683	10.4
916	68	9024.70	132.716	32731.7	4344032	25986.0

Total	Upper	Lower	Mean	Upper	Lower	Effective degrees of freedom
6,800,832	8,413,645	5,188,019	73.106	90.4430	55.7689	103

Table 12. Comparison of estimates (means and 95% confidence bands) of Iceland scallop biomass (t, meats) along the northern edge of St. Pierre Bank in 1990 and 1991.

Gear efficiency	1990 (234 mi²)	1991 (184 mi²)
33%	2408-4992 ($\bar{x}$ = 3700)	2334-3786 ($\bar{x}$ = 3060)
50%	1605-3328 ($\bar{x}$ = 2467)	1541-2499 ($\bar{x}$ = 2020)
75%	1068-2213 ($\bar{x}$ = 1640)	1025-1662 ($\bar{x}$ = 1343)

Table 13. Stratum-specific natural mortalities for Iceland scallops on St. Pierre Bank computed from ratio of cluckers to live scallops, August 1991. Clucker numbers are adjusted by a factor of 1.22 to allow for tow-induced disarticulation.

Stratum	Live	Cluckers	M
910	98	3.7	0.062669
911	7,359	594.6	0.130563
913	84	8.5	0.161533
915	49	50.1	0.829495
916	13,521	963.4	0.116063
919	707	74.5	0.166740
Totals	21,818	1,694.8	0.125844

Table 14. Stratum-specific contributions (numbers and weights (kg, round)) of sea and Iceland scallops during a resource survey on St. Pierre Bank, August 1991 (percent contributions in brackets).

	Numbers		Weight (kg, round)	
Stratum	Iceland	Sea	Iceland	Sea
910	102 (100.0)	9 (0)	7.13 (100.0)	0 (0)
911	54,015 (99.9)	8 (0.1)	2961.94 (99.9)	0.75 (0.1)
913	84 (97.7)	2 (2.3)	2.76 (94.9)	0.15 (5.1)
915	51 (94.4)	3 (5.6)	6.66 (92.4)	0.55 (7.6)
916	171,785 (95.8)	7470 (4.2)	9024.70 (93.6)	617.33 (6.4)
919	1,559 (82.2)	338 (17.8)	107.13 (61.8)	66.10 (38.2)
Σ	227,596 (96.7)	7821 (3.3)	12110.32 (94.7)	684.88 (5.3)

Table 15. Estimates of minimum trawlable stratum-specific and overall biomass (kg, whole weight) of sea scallops in areas where survey work for Iceland scallops had been directed.

Stratum	No. of sets	Total	Av./set	Units	Total wgt.	Variance
910	3	0.00	0.000	70631.7	0	0.000
911	38	0.75	0.020	31009.0	612	0.004
913	3	0.15	0.050	12059.1	603	0.008
915	4	0.55	0.138	17227.2	2369	0.076
916	68	617.33	9.078	32731.7	297151	188.190
919	3	66.10	22.033	20672.7	455488	292.634

Total	Upper	Lower	Mean	Upper	Lower	Effective degrees of freedom
756,223	1,174,587	337,859	4.1025	6.3722	1.8329	2

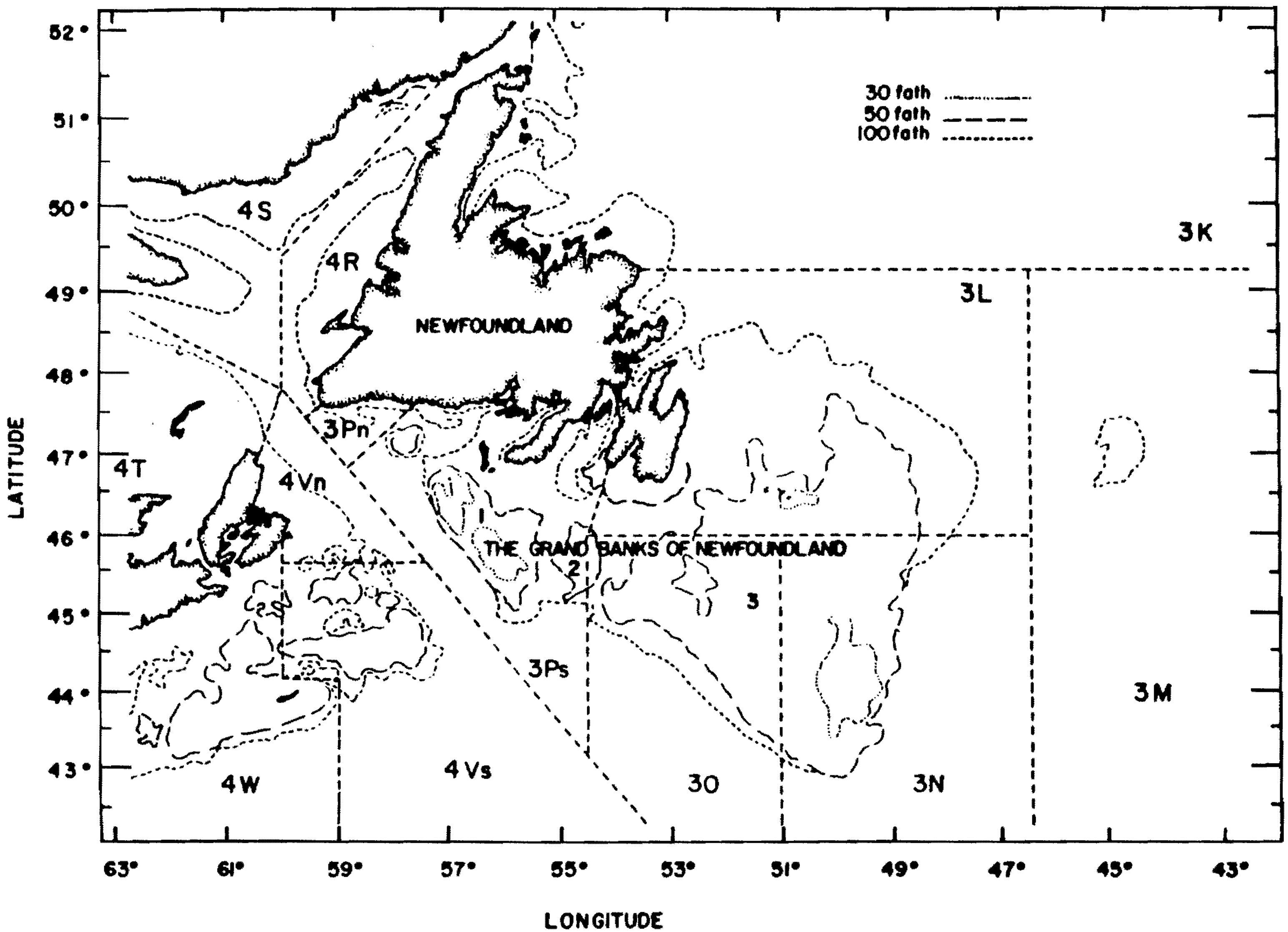

Fig. 1. The Grand Banks of Newfoundland showing the three major plateaus: 1. St. Pierre Bank, 2. Green Bank, and 3. Grand Bank.

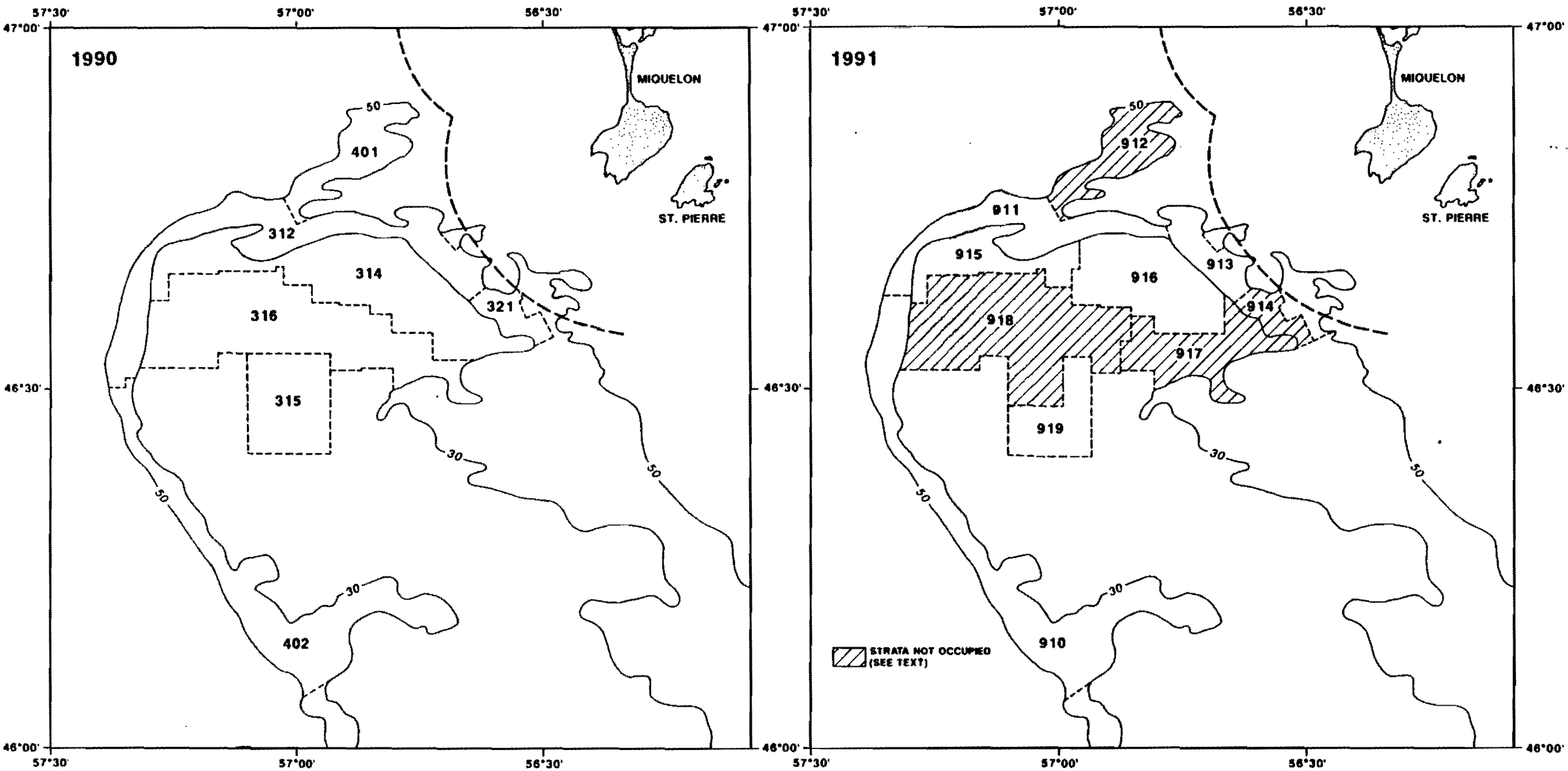

Fig. 2. Stratification scheme used in two surveys for Iceland scallops on the northern portion of St. Pierre Bank, 1990 and 1991. French territorial waters demarcated by broken line.

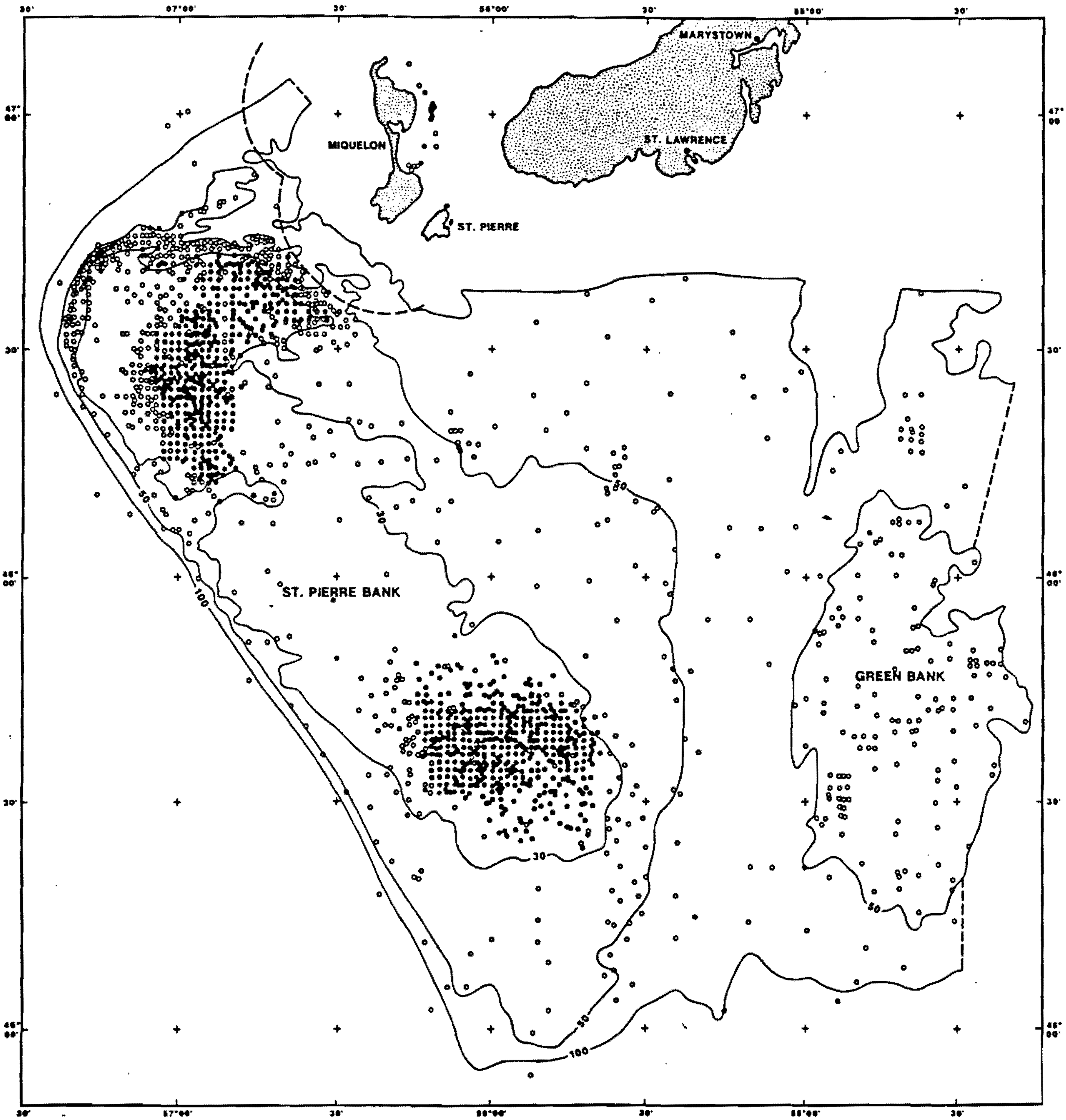

Fig. 3. Distribution (composite) of sea scallops in NAFO Div. 3Ps. Each circle represents a research survey station. Closed and open circles represent presence or absence respectively (1979-91).

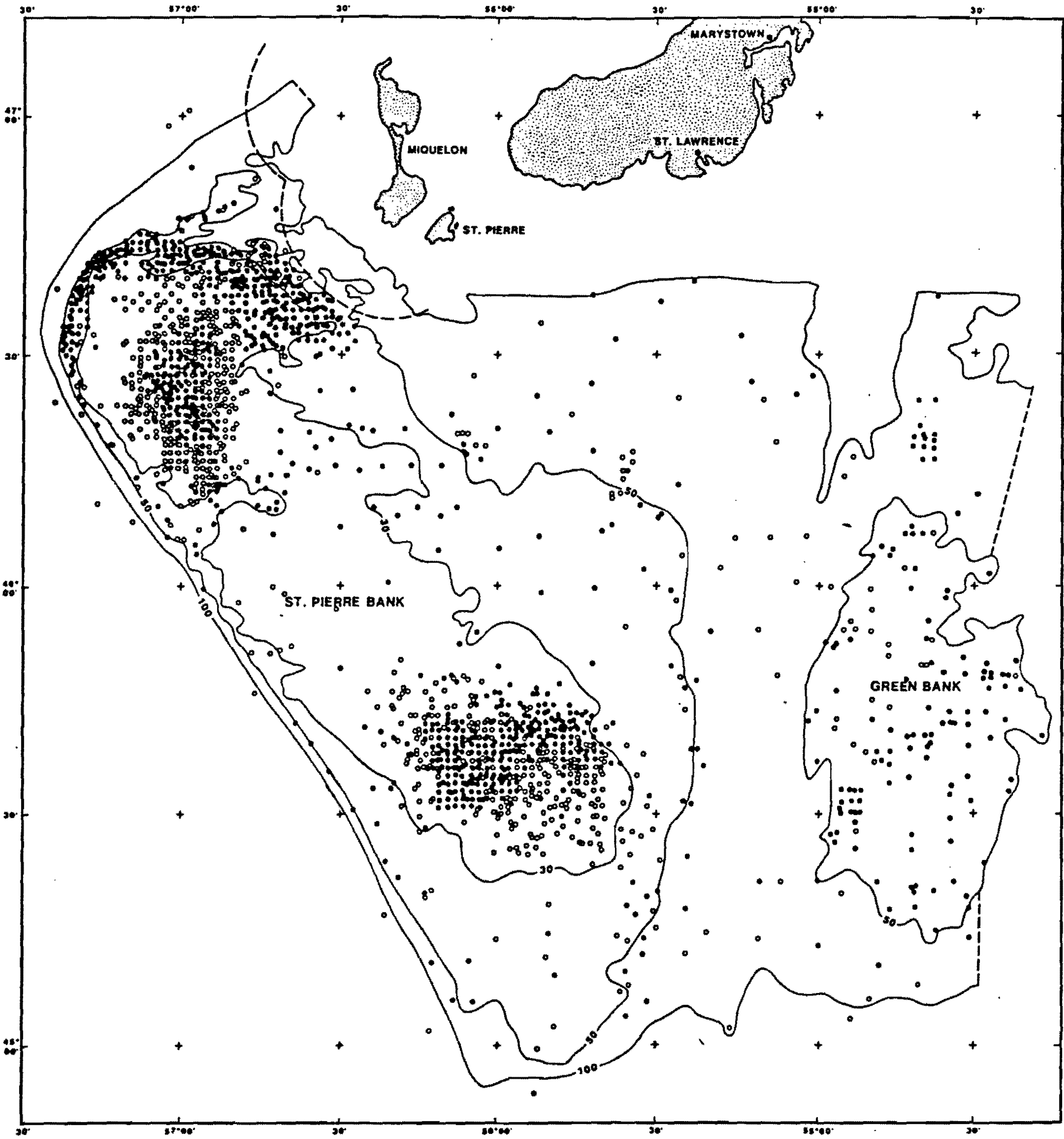

Fig. 4. Distribution (composite) of Iceland scallops in NAFO Div. 3Ps. Each circle represents a research survey station. Closed and open circles represent presence or absence respectively (1979-91).

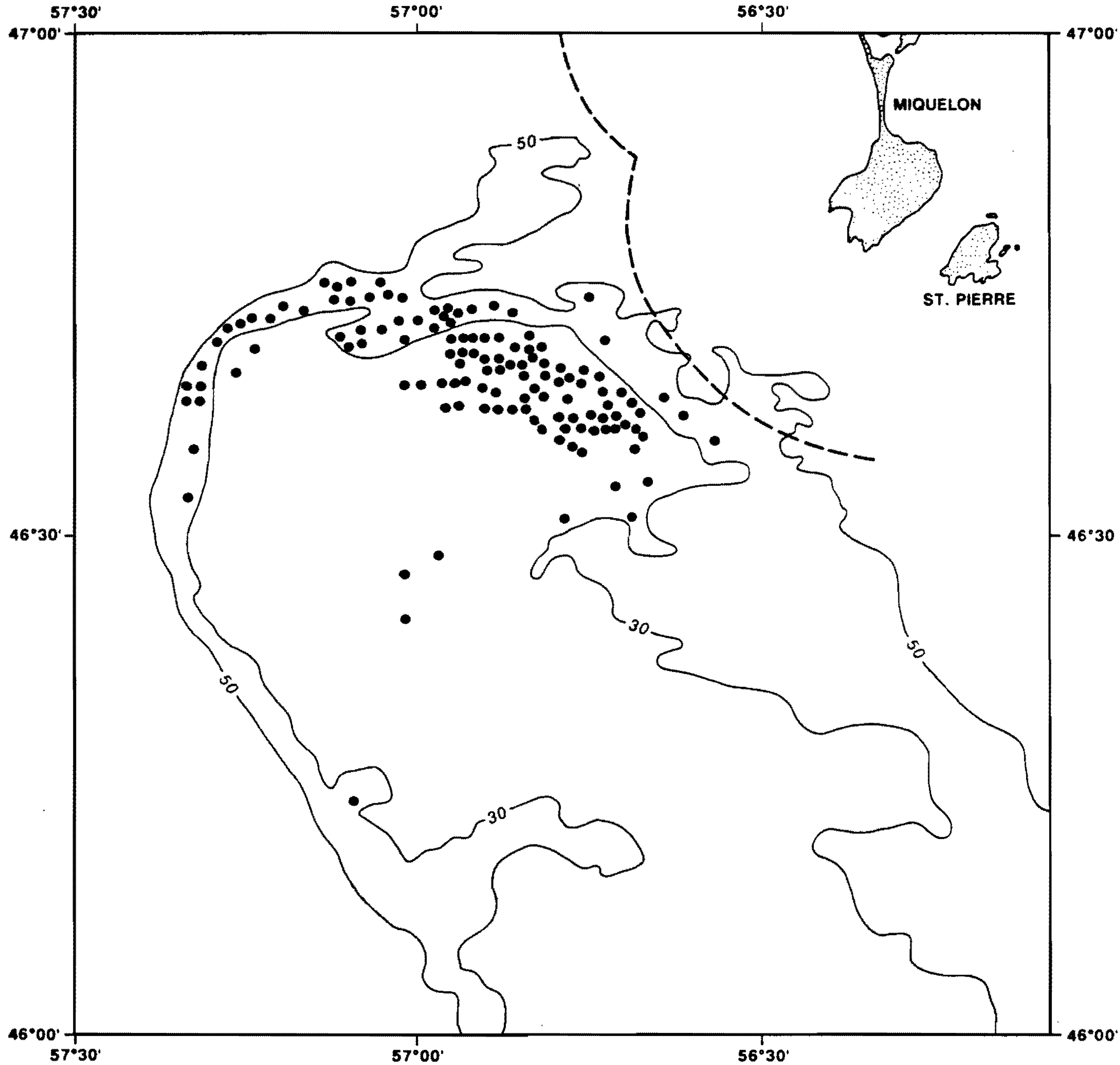

Fig. 5. Distribution of survey stations for the Iceland scallop, Chlamys islandica, on St. Pierre Bank, 1991. French territorial waters demarcated by broken line.

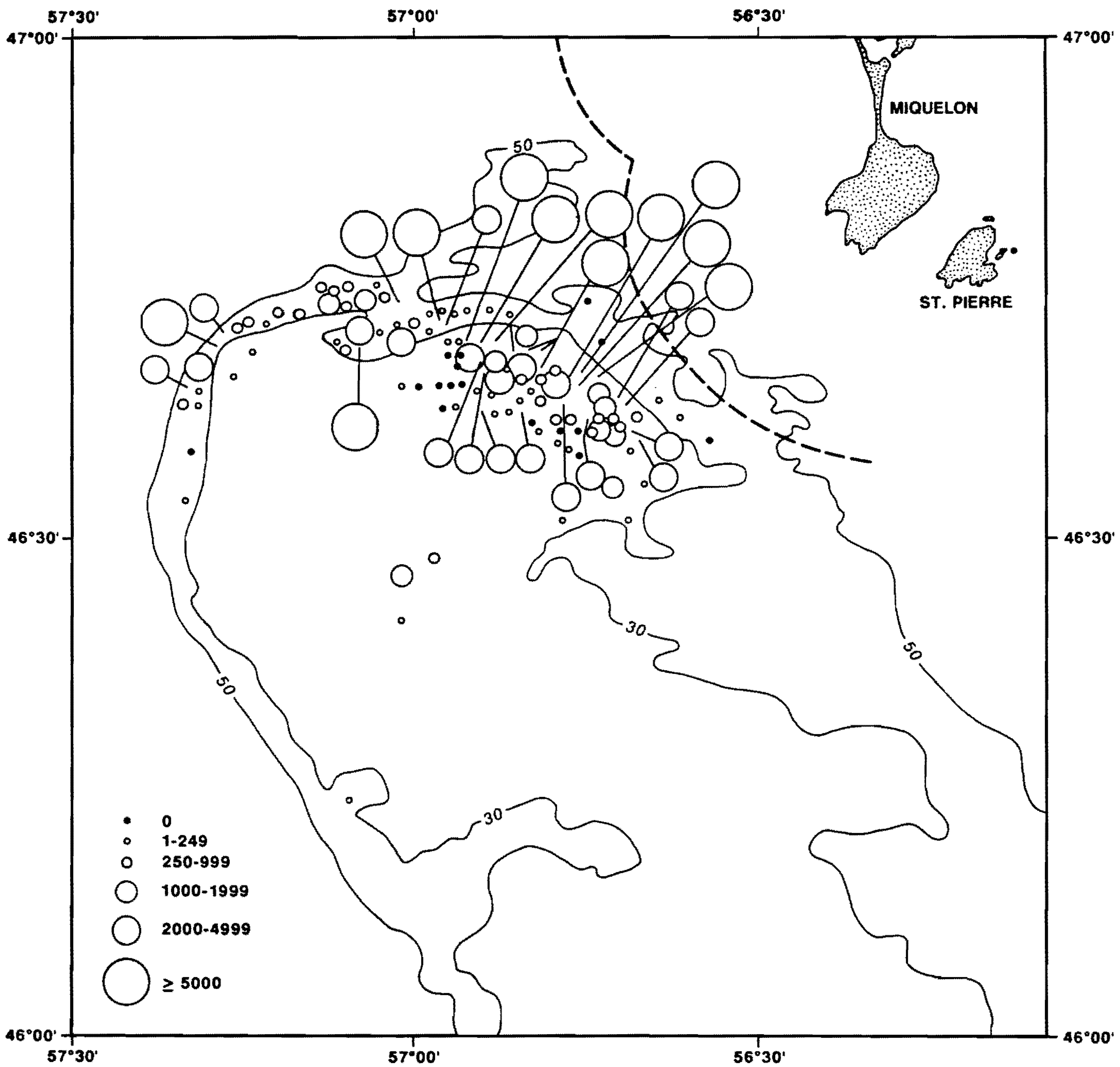

Fig. 6. Distribution of Iceland scallops (nos./tow) on St. Pierre Bank, 1991. French territorial waters demarcated by broken line.

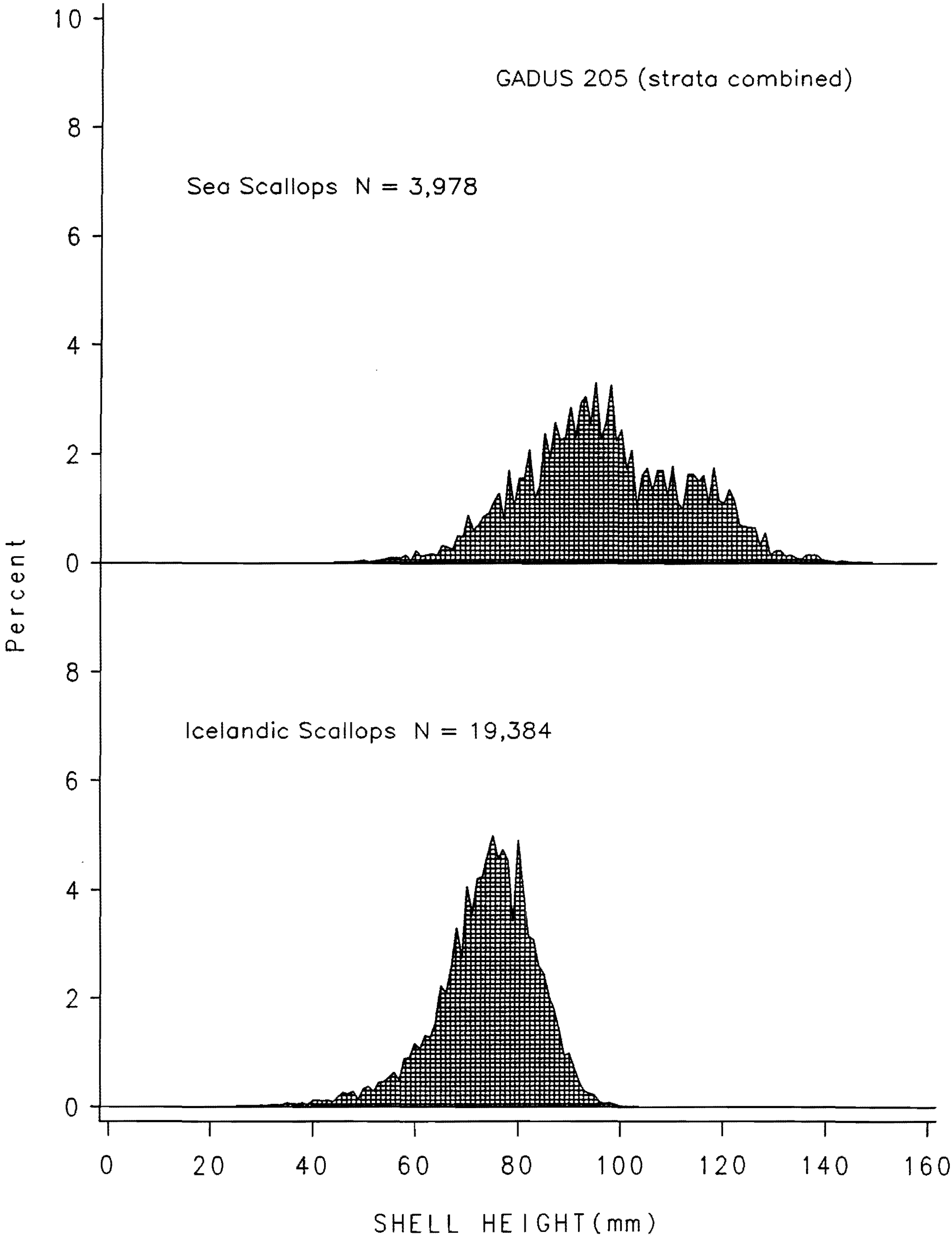

Fig. 7. Shell-height (mm) distribution of sea scallops and Iceland scallops on

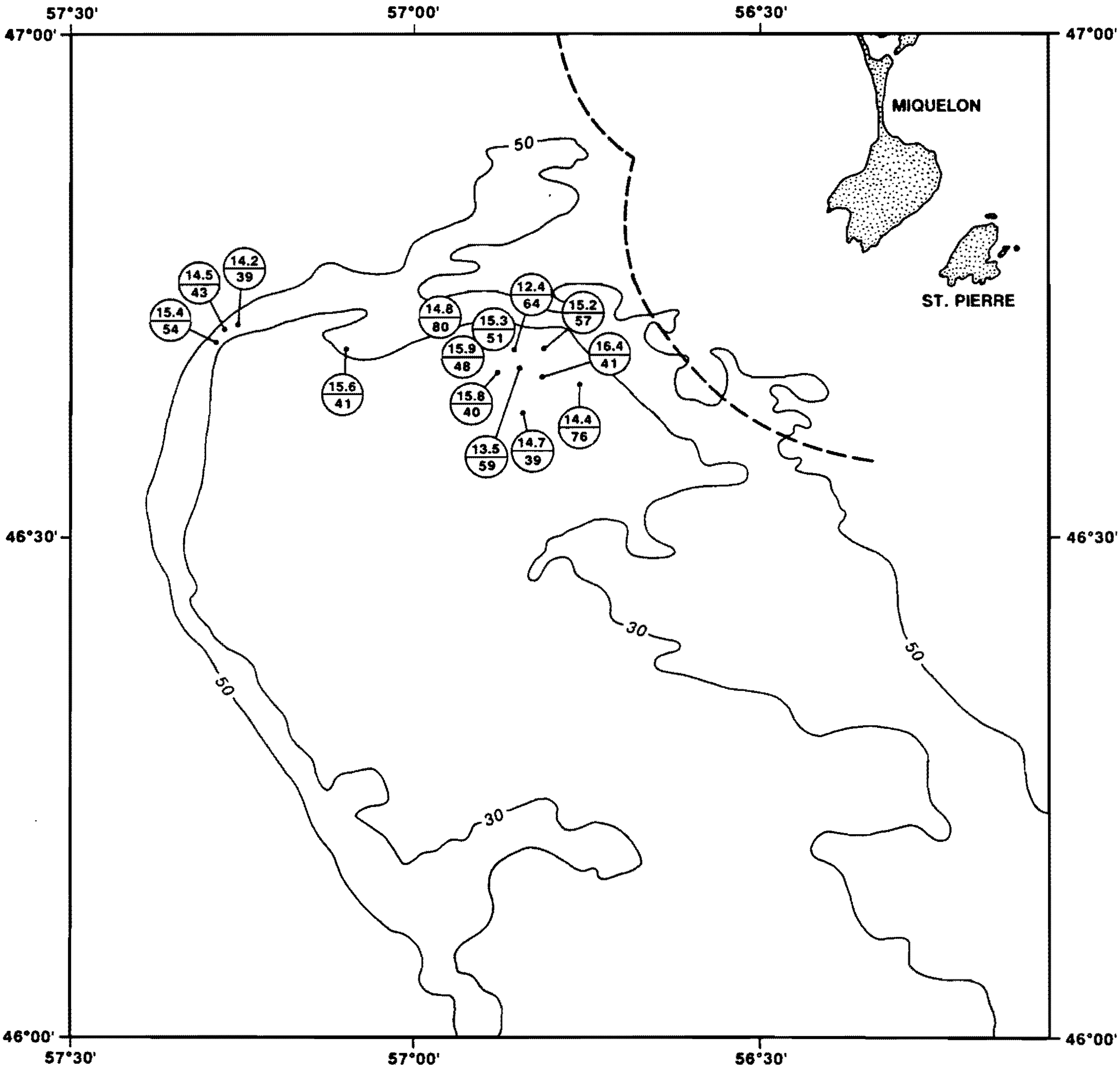

Fig. 8. Spatial distribution of meat yield (%, top) and meat count (nos./500 g) of Iceland scallops (≥60 mm, SH) on St. Pierre Bank, 1991. French territorial waters demarcated by broken line.