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Status and Assessment of St. Pierre Bank Scallop Stocks 1982-83

by

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Abstract

Stock assessments in each of two areas of St. Pierre Bank where active fisheries were underway in 1982 and 1983 are presented. The assessments are based on estimates of biomass (removals and residuals), relative age frequencies, and changes in catch per unit of effort. Landings from the second year of renewed activity have receded somewhat to 594 MT from 717 MT in 1982, a drop of some 17% while concomitant effort (days fished) dropped marginally by 4%. Within-season CPUEs have registered declines in each of two years, as have overall CPUEs which have dropped from 0.666 to 0.413 kg/CHRM (kilogram per crew hour meter). Preliminary estimates suggest that annual mortality for the two most-abundant age groups of sea scallops to be of the order of 1.755 (4-6-yr-olds) and about 0.182 for the older accumulated cohorts in the south. Some scattered contagions from the 1977 and 1978 year-classes are still available for exploitation and will be the basis of short-term production on St. Pierre Bank. There is some evidence of fresh recruitment, particularly in the northern area, but its potential remains to be evalulated.

Meanwhile, a conservative exploitation policy is recommended for this fringe area of sea scallop distribution until basic biological questions relating to recruitment are resolved. Optimizing yield per recruit by limiting small meat content would better address the problem of growth overfishing in the area than has been possible through the present meat-count Regulation.

Résumé

On trouvera dans le présent document une évaluation de stock dans chacune de deux régions du banc de Saint-Pierre où était pratiquée une pêche active en 1982 et 1983. Les évaluations sont fondées sur des estimations de biomasse (récoltée et résiduelle), des fréquences d'âges relatives et des changements de prises par unité d'effort. Les débarquements de la deuxième année du renouveau d'activité ont été quelque peu inférieurs à ceux de la première année, passant de 717 t en 1982 à 594 t en 1983, une baisse d'environ 17 %, alors que l'effort de pêche (jours de pêche) n'avait diminué que de 4 %. Les PUE, durant la saison, ont accusé des diminutions chacune des deux années. Il en a été de même de l'ensemble des PUE, qui ont passé de 0,666 à 0,413 kg/CHRM (acronyme anglais pour "crew hour meter": équipage, heure, mètre dragué). Des estimations préliminaires donnent à penser que la mortalité annuelle des deux groupes d'âge de pétoncles géants les plus abondants est de l'ordre de 1,755 (4-6 ans) et environ 0,182 chez les cohortes plus âgées accumulées au sud. Il existe encore quelques groupements éparpillés des classes d'âge de 1977 et 1978 pouvant être exploitées et qui seront à la base d'une production à court terme sur le banc de Saint-Pierre. Il existe certains indices d'un recrutement nouveau, en particulier au nord, mais son potentiel n'a pas encore été évalué.

Nous recommandons entre-temps une politique d'exploitation conservatrice pour ces groupes marginaux de pétoncles géants, jusqu'à ce que soient résolues certaines questions de recrutement. Une optimisation du rendement par recrue par limitation de la teneur en chairs de petite taille serait plus appropriée à la solution du problème d'une surexploitation de la croissance dans la région que le règlement actuel concernant le nombre de chairs.

Introduction

St. Pierre Bank is a westward extension of the vast apron of shelf extending off the Avalon and Burin Peninsulas commonly called the Grand Banks of Newfoundland. Depth zonation in this area by and large delineate sea scallop distribution; thus the 30 fm contour marks the limit of sea scallop (*Placopecten magellanicus*) distribution restricting its occurrence to less than 13% of the total area of the Bank (or 2,294 out of 17,575 sq. n. mi). The Iceland scallop (*Chlamys islandica*), on the other hand, has a broader depth range (Naidu et al. 1983a), and in the target area found to depths down to 100 fms or over 60% of the Bank. St. Pierre Bank is unique in that two scallop species occur frequently in the same areas (Ibid 1983). Fishing effort, however, is directed principally at sea scallops confined to fairly restricted areas within the 30 fm isobath and Iceland scallops contribute to the by-catch (Naidu et al. 1983b). Relative contributions are highly variable and pose undue problems to species-specific management.

The fishery is prosecuted exclusively by Maritime-based vessels which traditionally fish the rich Georges Bank but make opportunistic excursions into other areas, including St. Pierre Bank. Declining catches in Georges Bank, coupled with a new management strategy for the common fishery in this area, has encouraged diversion of effort into other areas, especially east of 4X. An unprecedented effort into St. Pierre Bank in 1982 resulted in a record removal of 717 MT of scallop meats. Landings have receded somewhat in 1983 to 594 MT. Effort in 1983 dropped to 795 boat days from 828 the previous year, down 4%. In spite of its distance from home ports, reduced catch rates elsewhere, particularly Georges Bank, coupled with substantial price increases in 1983 continued to make excursions to St. Pierre Bank relatively attractive.

Estimates of exploitable biomass in 1982 pointed to continued short-term production on St. Pierre Bank (Naidu et al. 1983b). With the passing of another fishing season and the completion of a second research cruise to the Bank in September 1983, it was decided to update the initial assessment.

History of production

This has been reviewed in some detail by Naidu et al. (1983b). Production is more or less negatively correlated to fishery performance elsewhere on the Atlantic seaboard, particularly Georges Bank. Although annual contributions to total offshore catches from this area have been relatively small (Table 1), the inordinate effort directed into this area over the last couple of years and the concomitant dramatic increases in landings to record levels have given this fishery a fresh, rejuvenated profile.

Regulations

When the most recent pulse began in 1982, offshore scallop regulations, including a meat count of 45/500 g specific to sea scallops, continued to apply. However, enforcement became problematical because of the presence in the catch of Iceland scallops, then technically excluded from the definition of scallop. An amendment to the Fisheries Act dated 28 October 1982 made the Regulations applicable to Iceland scallops as well as sea scallops.

Management options for this mixed-species fishery are extremely limited and fraught with difficulties (Naidu et al. 1983b). Realizing this, it was decided that reducing growth overfishing, particularly of sea scallops, until they reach a size range approaching maximum Y/R was to be an immediate objective. To this end, the Invertebrates and Marine Plants Subcommittee recommended that the sea scallop meat count for Georges Bank (30/lb.) be extended to St. Pierre Bank. In an attempt to encourage the exploitation of the smaller Iceland scallop, presently underutilized, particularly outside of the two shallow-water strata, a meat count of 50/lb (55/500 g) was recommended. These regulations would have required vessels to bag and land meats separately. The lower of the two counts was to apply to mixed catches.

In 1983, however, at the request of Scotia-Fundy Region, the Resource Management Branch (Newfoundland Region) agreed to retain the 45/500 g meat count for St. Pierre Bank, at least for the 1983 fishing season. Undue hardship on industry, as well as mixed composition of catches, were cited as reasons (Naidu 1984). The 45 count was applicable to both sea and Iceland scallops. This arrangement has held in abeyance implementation of CAFSAC advice generated in 1983. The modification was extended to all offshore scallop zones east of 4X (i.e. 4V, 4W, 3P, 3L).

Materials and Methods

In addition to sources of data already identified in the preliminary assessment (Naidu et al. 1983b), more recent data from a 9-day cruise (20-28 September 1983) to St. Pierre Bank are incorporated into this assessment. Biological port sampling data from 1983 are also included. As in previous years, fishing logs were collected by DFO, Scotia-Fundy, compiled and summarize by the Fisheries Research Branch, and turned over to us courtesy of the scallop scientist, Dr. G. Robert.

Research Cruise

A systematic line survey was conducted in each of two target areas in 3Ps to determine the spatial distribution and abundance of the two scallop species (Fig. 1). The survey was restricted to the two general areas where sea scallops had been taken during the Beothic Venture exploratory survey in 1979 (Naidu et al. 1983a) but covered smaller areas than those used in the Needler cruise in January 1983 (Naidu et al. 1983b). Two survey grids had been established during the latter survey, largely on the basis of the distribution of fishing effort in 1982; these were revised in September 1983 using 67 additional sightings by tracker aircraft and patrol vessels (Fig. 2 and 3). Navigational aids on offshore vessels provide precise locational data with only about 4% of reported positions falling outside of the areas surveyed in September 1983 (Fig. 4). Total areal coverage over the two strata was reduced by some 22% (28% in 314 and 15% in 320) and overlap during the two consecutive periods reduced to 59 and 47% respectively. Only 53% of the January grounds were resurveyed during the September cruise (Table 2).

Weather conditions were ideal throughout the cruise duration. A total of 156 one-mile survey sets was completed with a 12 ft (3.6 m) New Bedford dredge equipped with 3 in. rings. A 1.5 in. nylon net liner was to have been used during the survey, but the frequency of damage resulted in its being removed after only seven sets. As the survey was primarily for sea scallops whose modal sizes in the two areas were greater than the size at which full retention is achieved (80 mm, Caddy 1971) dredge selection was probably not critical for the species. Live scallops and cluckers (dead scallops still attached at the hinge line) were sorted by species, weighed separately and individual shell-height frequencies recorded to the nearest mm. Where random subsamples were used, the relationship between their numbers and weights was used in extrapolations.

Individual scallop meats (555 sea scallops and 390 Icelandics) were removed from scallops of known size for meat weight determinations. These were brought back to the laboratory in individually labelled 6 oz whirl pak plastic bags. A broad range of scallop sizes was selected to ensure adequate descriptions of the regressions between shell height and adductor muscle weight for each of the two species.

Observer data

A trained observer was placed on an offshore scalloper operating on St. Pierre Bank (5-13 August 1983). Commercial shell-height frequencies, catch rates, and composition of catches were recorded. Culling practice for the incidental scallop species were also documented.

Gear selectivity

The selection curve for the offshore dredge developed by Caddy (1971b) is used in this study. Zero escapement is assumed for $\geq 4^+$ sea scallops (approximately 80 mm).

Biomass Estimates

Stratum-specific biomass was derived for each species using two types of data: (a) preselected stations (all sets) extrapolated to the total survey area, and (b) postselected sets yielding $\geq$5 kg and extrapolated to the estimated area of scallop abundance. A compensating polar planimeter was used in determining areas. Areal expansion was limited to contagions most likely to attract commercial effort. Overall gear efficiency of 15.4% is assumed in this study (Caddy 1971b).

Natural mortality

Natural mortality was computed directly from the percent occurrence of cluckers that died from natural causes according to the equation (Dickie 1955):

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

where a is natural mortality, C is the number of cluckers in a sample, L is the number of live scallops in the same sample, and t is the average time in days required for natural clucker disarticulation. Times required for natural clucker disarticulation for sea (70 days) and Iceland scallops (211 days) were those determined experimentally by Dickie (1955) and Mercer (1974) respectively.

Results

Distribution of sets, catches and sample sizes of the two species taken during the two cruises to the Banks are compared (Table 3). Nearly 86% of all sea scallops and 48% of Iceland scallops (by numbers) caught during the September cruise were sampled for shell-height distributions.

Growth

Rings on the upper valves were used to determine ages and in back calculations for growth in both sea and Iceland scallops. Von Bertalanffy growth parameters were calculated from back measurements and the results reported last year (Naidu et al. 1983b, Table 4). Age-shell height keys developed for the two species were used in estimating scallop numbers at age for both research and commercial catches.

Shell Height Composition

Sea Scallops

Research

Typically sampled frequency distributions of sea scallops are unimodal in the north (Table 5) and bimodal in the south (Table 6, Fig. 5), the two distributions sharing a common mode at 95 mm. A significant gap between the 100-120 mm range is evident in the south. Sea scallops in the 80-90 mm size range that made up 44% of the sampled distribution in the north in January 1983 continued to dominate survey catches but with modal heights having progressed to the 90-99 mm range. Whereas a full 95% of sea scallops in the north were ≤99 mm in January (Table 7), their relative contribution by numbers was reduced to 76% in September. Scallops ≥100 mm now make up 24% of the sampled distribution (up from 5% in January). Similarly, in the south, the smaller of the two size groups was reduced to 24% from 41% in January and scallops ≥100 mm increased correspondingly from 59% to 76%. Shell-height distribution in the south continued to be negatively skewed.

No sea scallop spat (prerecruits) were observed. Indeed, there were no scallops below 40 mm in the north and none below 30 mm in the south.

Commercial

Commercial height frequencies (Fig. 6) were not dissimilar to those observed during resource surveys. To the north the smaller size group (≤99 mm) contributed 93% of the total fished (n = 1,123); to the south only one in two sampled (n = 3,119) belonged to this group, the majority (65%) being ≥100 mm (Table 7).

Iceland scallops

Research

About all that can be said of this species is that they tend to be smaller in the northern area with a narrower range of shell sizes than in the south. A full 99% of Iceland scallops sampled in the north during January were under 80 mm (Fig. 7) with no significant reductions in this size group in September. To the south, scallop numbers <79 mm decreased to 36 from 60% in January (Tables 8 and 9). Relative contribution of the larger size group had increased substantially during the 8-month period from 40 to 60%. Some *Chlamys* spat were taken in both strata as is frequently the case on most scallop cruises to the area.

Approximately 80% of Iceland scallops retained for shucking were ≥80 mm, but there was further culling during shucking.

Age composition

Research

Age composition of sea scallops (Fig. 8, Table 10a) point to the continued persistence and dominance of the 1977 and 1978 year-classes (6- and 5-yr olds) which collectively made up 72% of the total catch sampled. Some recruitment is evident in the north. The January survey appears to have underestimated 3^+ scallops, as nearly 23% of scallops taken in September were determined to be 4-yr-olds. Gear selectivity may have underestimated their abundance during the initial survey, as scallops are known not to be fully recruited until age four when they are approximately 80 mm in shell height (Caddy 1971b, Naidu et al. 1983b). Whereas there were very few scallops beyond 6^+ in the north (<5% of catch), the southern area, in addition to the 5- and 6-yr-olds (29%) which appear to be prevalent over most of the Bank, also contained substantial quantities (56% by numbers) of scallops older than 9 yrs. Relative age frequencies and modal ages were typically greater in the southern area.

Other than having progressed one year, age frequencies of Iceland scallops from research surveys do not show marked changes (Table 10b). Some reduction in numbers of scallops older than 8+ is evident, particularly in the south.

Commercial

Commercial frequencies (Fig. 9, Table 11a) during the study period were obtained by measuring shell heights at sea and subsequently assigning ages. This is the easiest way of obtaining requisite data on scallop age frequencies in the commercial catch. Again, the numerical superiority of 4-yr-olds is clearly evident in the north but not as conspicuous in the south. The 1977 and 1978 year-classes (combined) were reduced to 39 from 79% in the north and from 44 to 33% in the south, indicative, no doubt, of significant removals by the fishery. Unlike the northern area, the fishery here was still removing significant numbers of 9- and 10-yr-old scallops as well as accumulated age cohorts which collectively made up about 49% of the sampled catch.

Significant reductions were evident during the year for southern Icelandics for age groups beyond 7^+ (Table 11b). Comparable data were not available for the northern area. Of a sample of 172 Iceland scallops retained for shucking in the southern area, 79% were $\geq$80 mm (observer information).

Shell height-meat weight relationships

The following meat weight-shell height regressions were computed for the two species.

Sea scallops $\ln(w) = 3.15 \log H - 5.07$ ($r^2 = 0.938$, $n = 554$)
Iceland scallops $\ln(w) = 3.04 \log H - 4.72$ ($r^2 = 0.923$, $n = 388$)

where W = adductor muscle weight (g)
H = tangential dorso-ventral shell height (mm)

Natural mortality

Stratum-specific natural mortalities are summarized in Table 12. Yield-per-recruit calculations are based on $M = 0.10$ and 0.20 for sea scallops and $M = 0.15$ and 0.20 for Iceland scallops.

Scallop distribution

The spatial distribution and abundance of the two scallop species in the two target areas are shown in Fig. 10-13. The values of three variables (latitude, longitude and catch numbers) are plotted on the same figure to produce 3-D plots. Approximate survey areas are indicated. Lines of longitude are referred to by standard survey transects defined in 1982 (Naidu et al. 1982). Areal differences in the two surveys should be taken into account. Care should also be exercised in interpreting the 3-D plots as vertical scales

(Z-axis, representing abundance) vary from plot to plot, depending on the range in numbers of scallops caught. The numerical superiority of any single peak, relative to others in the same plot, has the effect of supressing some of the smaller mounds (e.g. January distribution of giants in the north at 46°31', Fig. 10). Tilt (rotation about the y-axis) and rotation about the Z-axis also have the effect of concealing smaller peaks. The prominent contagion earlier referred to has obviously been fished down considerably as have other contagions, but the smaller scale for the September plot allows greater resolution. Similarly, the plots for southern sea scallops are impaired by the rather small number of observations in January (49 sets vs. 85 in September), producing "holes" and reducing the impact of the January plot. The overlap in the spatial distribution of the two species in both areas is particularly striking in the plots.

Biomass estimates

Stratum-specific biomass (minimum available) was estimated (Tables 13-16). Estimates in Table 13 are derived from total area surveyed and, therefore, represent an upper estimate. Those in Table 14 are based on areas most likely to attract commercial effort and are probably more realistic from a fisheries viewpoint. The latter were converted to actual biomass by using an overall gear efficiency of 15.4% (Caddy 1971).

Total sea scallop biomass estimated in January 1983 (Table 15) was in the range of 9925-16171 MT (round) with a mean at 13046 MT, corresponding to 1572 MT shucked meats (conversion factor of 8.3). The September 1983 survey gave a biomass in the range of 6227-8227 MT with a mean at 7227 MT (round) (Table 16). Fishery removals to September 1983[1] (between the two surveys) were in the order of 554 MT meats (or 4598 round), pointing to a residual biomass of 8448 MT (round) corresponding to 1014 MT meats. This is higher than the mean projected for commercially attractive contagions (7227 MT) but still short of the range predicted for the total areas surveyed (6883 to 9676 MT round).

Catch rates (research)

With the exception of sea scallops from the south and Iceland scallops from both south and north, catch rates (scallop numbers/tow mile) in the two areas surveyed were not significantly different ($p > 0.05$) for the two species (Table 17). To make comparisons more meaningful in the context of an ongoing fishery, abundance indices were compared using survey sets from scallop contagions responsible for 91 and 80% of production in 1982 and 1983 respectively. This was achieved by selectively employing only those survey sets that fell into the appropriate 10' squares (Table 18). These were pooled for by-stratum comparisons. Reductions in catch rates of sea scallops were

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[1]From Scallop Weekly Report, Statistics Division, DFO, Scotia-Fundy Region.

evident in the northern area only, and were highly significant ($p < 0.01$). Estimates of numerical abundance of sea scallops in the south and Iceland scallops in both areas, as measured by numbers of scallops caught/tow mile, did not change significantly ($p > 0.05$) during the period January to September. Finally, sea scallop abundance was compared using duplicate tows along common transects during the two surveys, regardless of the distribution of commercial effort in the areas (Table 19). This is perhaps the most appropriate relative to actual changes in abundance between January and September 1983. Again, no significant changes were demonstrable ($p > 0.05$) for sea scallops to the south; but as in comparisons using commercial contagions, catch numbers/nautical mile had been significantly ($p < 0.01$) reduced in the north.

It is apparent that scallop accumulations built up over periods of feeble fishing activity have encouraged high exploitation rates on some scallop patches. Some scattered contagions are still available for exploitation and will be the basis of short-term production on St. Pierre Bank.

Catch numbers of Iceland scallops in the north were most probably underestimated in September because of the presence of an inordinately large number of small scallops (Table 20) and the use of uncovered gear. In spite of this, however, no significant differences in abundance between January and September were demonstrable ($p > 0.05$). The problem of escapement in Iceland scallops may not have been as serious in the south as the majority of scallops here had reached sizes at which full retention would have been achieved. Again there was no significant difference in the mean number of Iceland scallops per tow ($p > 0.05$). The large variance associated with each of the computed means makes comparisons difficult and inferences suspect.

Catch rates (commercial)

Overall catch has dropped from 717 MT in 1982 to 594 MT (shucked meats) in 1983, a drop of some 17% while total effort (days fished) dropped by only 4% (Table 21). Average CPUEs have receded to 0.413 kg/CHRM from 0.666 kg/CHRM (Table 22). Within-season CPUEs also registered declines in each of the two years (Fig. 14).

In 1982, approximately 64% of total fishing days were spent in the northern area resulting in 66% of removals (Table 23). Number of days spent here in 1983 dropped by 5% compared to the previous year but removals remained at about the same level (65%). Catches in the south have decreased by some 30 MT (14%) in spite of a 25% increase in effort.

Estimation of total mortality

In the absence of emigration out of or immigration into the area (including recruitment) between the two resource surveys we can assume that the decline in numbers per standard tow is a result of mortality and can approximate total mortality (Z) to be $\log_e \frac{N_0}{N_1}$. For the three measures of abundance we have in this study, mortality approximations for all sizes of scallops would be as follows:

Stratum	All tows	Tows in commercial units	Duplicate tows along transects
314	1.278 (72%)	1.432 (76%)	1.755 (83%)
320	-	0.131 (12%)	0.182 (16%)

Validity of the above estimates may be questioned. We, therefore, examined changes in numbers at age in the duplicate tows over the same area (Table 24) and found supporting evidence to suggest the occurrence of high mortalities of the 4-6 yr old cohorts in the northern strata ($Z = 1.826$) and moderate mortalities of these cohorts to the south ($Z = 0.545$). Total mortality for the older cohorts (8-11 yrs) in the south was approximately 0.221 (Table 25). While these mortalities were computed for a 12-month period, in fact they were sustained within a 5-month duration between January-September 1983. It is apparent that most of this mortality is attributable directly or indirectly to heavy fishing in the area during the period of study.

Growth and yield/recruit (Y/R)

Estimates of size at age were obtained through back measurements of shell heights at age. Growth in sea scallops accelerates beginning in the second year when a doubling of size occurs, increasing about half as much again in the third (Table 26). Height increments taper off beyond age 7 when shell size is about 110 mm. Average adductor muscle weight doubles during the third year of life to about 8.4 g (54 meats/lb) and triples between ages 4 and 7 (24.1 g; 19 meats/lb) while corresponding shell size increases by only 40%. Over the following 3 yrs, shell size increases by only 15% while meat weight increases by 50% to 37.5 g (12 meats/lb).

For comparable shell heights beyond 65 mm Iceland scallops provide greater biological yield than do sea scallops (Table 25).

Sea and Iceland scallops were considered fully recruited at 4^+ and 8^+ respectively and yield-per-recruit calculated for values of fishing mortalities up to 2.0. Fishing mortality was assumed to be "knife edge" with respect to age. For fishing mortalities between 0.5 and 2.0, greatest Y/R is obtained by delaying age at first capture to between 9^+ and 10+ for sea scallops when shell heights are about 124 mm and 129 mm respectively (Fig. 15). For lower levels of fishing mortality (F = 0.3-0.5) optimal ages are lower. Since natural mortality on St. Pierre Bank is about 0.10, minimum age of 9+ would result in the greatest yield/recruit over a wide range of fishing mortalities (F = 0.5-2.0). For higher values of M, minimum age for maximum Y/R occurs at about 7 (Fig. 15b).

Maximum yield per recruit in Iceland scallops occurs at a mean age of first capture between 8 and 9 for high rates of fishing mortality ($F \geq 1.6$, $M = 0.15$). Only slight gains are possible by delaying capture beyond age 8

(Fig. 16). Maximum yield/recruit calculated for a value of F corresponding to the estimated fishing mortality of a heavily fished Chlamys population (F = 0.59) in the northeastern Gulf of St. Lawrence (Naidu et al. 1982) occurs at 8^+ with an average biological yield of about 8.8 g or a meat count of 52. Realized yield would be somewhat lower with correspondingly higher meat counts.

Discussion

Sea scallops

Changes in population age and size compositions on St. Pierre Bank are more or less consistent with removals by the fishery, with variable, sometimes heavy culling of Iceland scallops. There is some evidence pointing to fresh sea scallop recruitment particularly in the north. However, it must be recognized that at least some of the scallops assigned to the 3^+ category may, in fact, be 4-yr-olds whose growth has been checked through repeated gear encounters during the intensive fishery of the last two years. The use of an age-height key would overestimate their numbers. The retention characteristics of the gear, on the other hand, would tend to underestimate their numbers. For these reasons it is somewhat premature to determine its relative strength and potential contribution to the fishery. It is worthy of note that at least in inshore areas of Newfoundland the 1979 year-class has been determined to be at least as strong as the one of 1976 (Naidu and Cahill, unpublished). If it proves to be significant, industry would be well advised to refrain fishing areas of recent recruits/prerecruits. Because of low natural mortality in the area, delaying exploitation for one or two years would only result in substantial increases in yield. It should also decrease extensive mortality among prerecruits (Jamieson et al. 1981; Caddy 1975; Naidu et al. 1982).

The yield equation is an explicit long-term representation of a fishery between yield and fishing and assumes equilibrium conditions. The fishery on St. Pierre Bank is anything but stabilized, occurring on sporadic rather than continuous basis. Yield-per-recruit considerations must therefore be viewed with caution. It is apparent that in the northern area, sea scallops are being exploited well before yield is optimal. Paradoxically, in the south, yield-per-recruit is lost at both ends through exploiting a combination of recently recruited and very old accumulated age cohorts. Whilst this opportunistic strategy allows easy compliance with the existing meat count (45/500 g), it can hardly be considered desirable as yield is being lost at both ends of the spectrum. The meat-count Regulation that has been in force since 1973 is highly manipulative and compliance readily achieved through blending large meats with smaller ones, the latter frequently being predominant in the landed catch. This strategy unfortunately legitimizes the harvesting of considerable numbers of small (sublegal) scallops relative to those that would meet the stipulated meat count (Naidu 1984). Young scallops are fished up too quickly (almost as soon as they become recruited) to realize potential benefits from subsequent accelerated growth rates. A similar situation has been described for Browns and German Banks (Jamieson et al. 1980). Once large numbers of small meats are taken, vessels must locate and fish older scallops that may be less numerous, and from a population view point, past providing maximum Y/R.

On St. Pierre Bank this strategy results in a pattern of fishing that is not necessarily economical. In 1982, for example, boats operating in the northern area where mean meat weight was about 8.5 g (meat count 53/lb) were frequently obliged to sail 60 nautical miles south to procure larger meats in order to bring down the average count to accepted levels (45/500 g). Initially, this was not problematical because of the availability in the south of contagions of accumulated biomass. The absence of directed effort into St. Pierre Bank between 1974-77 (inclusive) and the minimal effort over the subsequent four years with average removals of about 8.5 MT (meats/year) had built up the necessary accumulations. The feeble effort here coincided with periods of record production on Georges Bank. In 1980, however, catches on Georges Bank dropped to less than 50% of 1978 levels and the offshore fleet began to move eastward, including St. Pierre Bank, beginning in 1982. The massive effort diversion into the Bank (equivalent to an average of 2.0 and 1.5 offshore vessels fishing every day in 1982 and 1983 respectively) and concomitant high removals have reduced scallop densities in many areas. This is likely to result in increased "search" fishing.

Sea scallop catch rates and CPUEs in the north, which produced 97 and 82% of catches from that area in each of the two years, have declined significantly. In the south although mean catch rates of sea scallops in the four 10' squares most heavily fished (contributing to 83 and 77% of removals from the southern stratum in each of 1982 and 1983 respectively) have declined by some 40%, we were unable to demonstrate decreases in catch rates in these areas to be statistically significant. The high variance associated with mean catch rates (number of scallops/nautical mile) is problematical and probably undermines the biological validity and precision of inferences here. Be that as it may, it is evident that the lower abundance within scallop contagions in the south kept effort here to about 52 and 68% of those in the north in each of 1982 and 1983. CPUEs in some of the units have in fact increased, pointing perhaps to the discovery and systematic harvesting of new patches in the south. Ensuring non-violative meat counts, while not a major preoccupation, must have been a motivation to fishing this area. By and large, the beds here were, and continue to be, peripheral to the recently recruited 5- and 6-yr-olds to the north.

There is some evidence of new sea scallop recruitment on the Bank, particularly to the north. The minor peak at 75 mm is thought to be 3-yr-olds in 64-80 mm size range that is just now recruiting into the fishery. This is supported by one sample of sea scallops (N = 2173) obtained in December 1983, which had a mean meat weight of 7.4 ± 2.7 g or a meat count of 68/500 g. This is in close agreement with the meat weight at height data (Table 26). Caution should be exercised in attempting to reconcile commercial meat weight data with biological yield. The latter is a standard anatomical weight determination with meat recovery approaching 100%. This allows precise weight determinations at any given size. Commercial yield, on the other hand, is variously affected during the shucking process. Shucking experience (including angle of knife entry), speed, and size of scallops affect yield (Naidu and Cahill, unpublished). Communal shucking frequently illicits a competitive response which may sacrifice yield to volume. It is not uncommon to see portions of severed adductor muscle bases several mm thick remain attached to recently-shucked discarded valves. An attempt should be made to address this problem and feature the loss into future assessments.

Iceland scallops

The distributions of sea and Iceland scallops overlap in the two target strata where directed fisheries occur for sea scallops. Although preliminary values of L_∞ computed for Iceland scallops (Naidu et al. 1982, Table 4) tend to be higher here than elsewhere on the Bank, where Chlamys biomass is frequently higher (Naidu et al. 1982a), modal shell heights in each of the two areas during the September survey were 70 and 85 mm in strata 314 and 320 respectively, up from 65 and 85 mm in January 1983. Assuming modal heights during the period of peak production (May-August) to be somewhere in between, it is difficult to understand why the commerical fleet is loathe to shucking this species, especially in the south. While large numbers of scallops would have to be shucked only to produce violative counts in the north, the meat-count stipulation would have been readily met in the south. At comparable shell heights, there is potentially greater biological yield from Iceland scallops than from sea scallops (Tables 26 and 27). Because of an apparent attitudinal problem to harvesting this species, as well as the alleged greater difficulty attendant with shucking them because of prolonged tight shell closure, considerable culling occurs in this species and only the very large ones (≥80 mm) appear to be retained for shucking. There is also a problem of "dirty" meats because of the frequency with which portions of the excretory organ and gonad (collectively called "guts") remain attached to the meats.

Some of the anomalous positions reported in vessel logs coincide with areas of Iceland scallop abundance (Naidu et al. 1983a) pointing to the beginning of directed effort for this species, hitherto incidental to the larger variety. As there is no species separation in bagged meats it is impossible to ascertain its contribution to the total catch.

Iceland scallops are almost fully grown by the time they are exploited by the gear currently used. Increasing fishing effort for this species will catch more scallops, which being almost fully grown have little potential growth left, and in time, would only die of natural causes. As long as no gear changes occur and fishing is with offshore dredges equipped with 3" rings, Iceland scallops are implicity protected by being inherently small compared with the directed species. No additional regulation would appear necessary, particularly in an area where they are only taken incidentally.

Conclusions

- The scallop fishery on St. Pierre Bank expanded very rapidly beginning in 1982. Total effort expended in the area was equivalent to an average of 2.0 and 1.5 vessels operating daily in each of 1982 and 1983 respectively.

- The analysis of commercial catch and effort statistics showed that total catch and CPUEs over the period have fallen. The continued intensive fishery was largely responsible for the declines. High fishing mortality within high density contagions in the north resulted in annual mortalities approaching 70-80% for all sizes of scallops.

- Declining total catches and CPUEs in the two target areas of exploitation must be recognized, particularly in the context of the production history for this area. There is very little area for further expansion.

- High catch rates have depleted sea scallop numbers in many areas. Some scattered contagions are still available for exploitation and will be the basis of short-term production on St. Pierre Bank.

- We must conclude that removals from the area have peaked and should continue to decline even with the 1979 year-class becoming recruited into the fishery. If this newly-recruited year-class proves to be significant, fishing the Banks may continue to be profitable. Mean size at capture may also be expected to drop, pushing the meat count upwards. This makes revision to the meat-count Regulation, to limit small-meat content, more pressing. Age at first exploitation should be increased for sea scallops to bring it closer to that providing maximum yield-per-recruit for this area.

- The likelihood of extensive sea scallop recruitment in the next few years is minimal as no prerecruits were observed in the area. Fishery will have to rely solely on residual biomass estimated here to be less than 7000 MT (round). This may result in quick reductions of standing stock to levels that may discourage extensive deployment of effort into the Bank until another strong recruitment pulse comes along.

- Fishery performance here is likely to continue to depend on the relative abundance and availability of sea scallops elsewhere on the Atlantic seaboard, particularly Georges Bank. St. Pierre Bank will continue to be productive in the short term if prices do not significantly recede from 1983 levels.

- Shifting effort into exploiting Iceland scallops elsewhere on the Bank will naturally affect short to medium-term fishery performance. Iceland scallops are almost fully grown by the time they are exploited by the gear currently used. As long as no gear changes occur, Iceland scallops are implicitly protected by being small, compared to the directed species and no additional Regulations appear necessary.

- A conservative exploitation policy is recommended in this fringe area of sea scallop distribution until basic biological questions relative to patterns of recruitment are resolved. One of these must include optimizing Y/R through the stipulation of a maximum small meat "content" that better addresses the problem of growth overfishing in the area than has been possible through the meat count Regulation.

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Table 1. Canadian scallop landings (MT meat) from Georges and St. Pierre Banks.

Year	Georges Bank	St. Pierre Bank
1951	91	-
1952	91	-
1953	136	106
1954	91	143
1955	136	153
1956	317	107
1957	771	70
1958	1179	2
1959	1950	-
1960	3401	9
1961	4580	-
1962	5669	-
1963	5941	40
1964	5986	343
1965	4434	14
1966	4878	-
1967	5019	164
1968	4822	9
1969	4318	83
1970	4097	127
1971	3908	27
1972	4161	29
1973	4223	36
1974	6137	-
1975	7414	-
1976	9726	-
1977	13089	-
1978	12189	23
1979	9207	1
1980	5221	35
1981	8013	-
1982	4306	717
1983 (provisional)	2839	594 (to Dec. 14, 1983)

Table 2. Areal coverage (nautical sq. miles) during two scallop surveys.

Vessel	Dates	Stratum 314	Stratum 320
Needler	5-19 Jan. 1983	159	144
Gadus	20-28 Sept. 1983	113	122
Overlap		94 (59%)	67 (47%)

Table 3. Catch summaries of research vessel cruises to St. Pierre Bank.

Gadus Atlantica (20-28 September 1983)

		Total catch				Total sampled			
		Giants		Icelandics		Giants		Icelandics	
Stratum	No. sets	Weight (kg)	Nos.	Weight (kg)	Nos.	Weight (kg)	Nos.	Weight (kg)	Nos.
314	71	736.9	6943	289.7	6049	597.0	5437	117.8	2406
320	85	901.3	3371	546.6	6513	871.0	3180	320.0	3663
Totals	156	1638.2	10,314	836.3	12,562	1468.0	8617	437.8	6069

Alfred Needler (5-19 January 1983)

		Total catch				Total sampled			
		Giants		Icelandics		Giants		Icelandics	
Stratum	No. sets	Weight (kg)	Nos.	Weight (kg)	Nos.	Weight (kg)	Nos.	Weight (kg)	Nos.
314	108	696.1	9189	187.1	4281	486.3	6310	144.4	3189
320	49	147.4	610	119.5	1756	147.4	582	96.9	1394
Totals	157	843.5	9799	306.6	6037	633.7	6892	241.3	4583

Table 4. Summary of von Bertalanffy parameters for sea and Iceland scallops from various depth strata on St. Pierre Bank (from Naidu et al. 1983b).

A. Sea Scallops (Placopecten magellanicus)

Depth (fms)	Stratum	L_∞	K	t_0
0-30	314	N.A.	N.A.	N.A.
	320	146.9	0.216	0.349

B. Iceland Scallops (Chlamys islandica)

Depth (fms)	Stratum	L_∞	K	t_0
0-30	314	110.0	0.181	0.380
	320	106.5	0.203	0.367
31-50	312	93.5	0.176	0.242
	315	92.4	0.173	0.174
	321	89.6	0.174	0.345
	325	102.1	0.126	0.148
51-100	317	96.6	0.173	0.478
	319	89.9	0.166	0.239
	322	85.9	0.153	0.160
	323	97.2	0.131	0.100
	324	114.0	0.120	0.051

Table 5. Sea scallop shell-height frequency (research 1983) in 10 mm intervals from St. Pierre Bank - Stratum 314 (north).

mm Group	Needler #	Needler %	Gadus #	Gadus %
0-9	0	0	0	0
10-19	0	0	0	0
20-29	0	0	0	0
30-39	0	0	0	0
40-49	2	0.0	0	0
50-59	13	0.2	1	0.0
60-69	198	3.1	2	0.0
70-79	1532	24.3	131	2.4
80-89	2788	44.2	1222	22.5
90-99	1362	21.6	2516	46.3
100-109	389	6.2	1294	23.8
110-119	13	0.2	247	4.5
120-129	3	0.1	9	0.2
130-139	3	0.1	8	0.2
140-149	6	0.1	6	0.1
150-159	1	0.0	1	0.0
Totals	6310		5437	

Table 6. Sea scallop shell-height frequency (research 1983) in 10 mm intervals from St. Pierre Bank - Stratum 320 (south).

mm Group	Needler #	Needler %	Gadus #	Gadus %
0-9	0	0	0	0
10-19	0	0	0	0
20-29	0	0	0	0
30-39	2	0.3	0	0
40-49	0	0	0	0
50-59	2	0.3	1	0.0
60-69	12	2.1	5	0.2
70-79	54	9.3	25	0.8
80-89	84	14.4	210	6.6
90-99	79	13.6	458	14.4
100-109	26	4.5	387	12.2
110-119	57	9.8	258	8.1
120-129	131	22.5	776	24.4
130-139	108	18.6	792	24.9
140-149	24	4.1	255	8.0
150-159	2	0.3	13	0.4
160-169	1	0.2		
Totals	582		3180	

Table 7. Stratum-specific distribution of shell heights. a. Research b. Commercial.

Vessel (Month)	STRATUM 314		STRATUM 320	
	50-99 mm	≥ 100 mm	50-99 mm	≥ 100 mm
a. NEEDLER (JAN 1983)	5984 (95%)	324 (5%)	235 (41%)	580 (59%)
b. Commercial (AUG 1983)	1049 (93%)	74 (7%)	1092 (35%)	2027 (65%)
a. GADUS (SEPT 1983)	4138 (76%)	1299 (24%)	769 (24%)	2411 (76%)

Table 8. Iceland scallop shell-height frequency in 5 mm intervals from St. Pierre Bank - Stratum 314 (north).

mm Group	Needler #	Needler %	Gadus #	Gadus %
0-4	0	0	0	0
5-9	0	0	0	0
10-14	0	0	0	0
15-19	0	0	0	0
20-24	0	0	0	0
25-29	1	0.0	0	0
30-34	0	0	0	0
35-39	1	0.0	2	0.1
40-44	7	0.2	0	0
45-49	44	1.4	1	0.0
50-54	100	3.1	17	0.7
55-59	351	11.0	40	1.7
60-64	1059	33.2	195	8.1
65-69	1016	31.9	613	25.5
70-74	435	13.6	888	36.9
75-79	155	4.9	484	20.1
80-84	19	0.6	126	5.2
85-89	0	0	30	1.3
90-94	1	0.0	7	0.3
95-99	0	0	3	0.1
100-104	0	0	0	0
105-109	0	0	0	0
110-114	0	0	0	0
115-119	0	0	0	0
Totals	3189		2406	
0-79 mm	3169	99.4	2240	93.1
≥80	20	0.6	166	6.9

Table 9. Iceland scallop shell-height frequency (research 1983) in 5 mm intervals from St. Pierre Bank - Stratum 320 (south).

mm Group	Needler		Gadus	
	#	%	#	%
0-4	2	0.1	0	0
5-9	0	0	0	0
10-14	1	0.1	0	0
15-19	0	0	0	0
20-24	2	0.1	0	0
25-29	0	0	0	0
30-34	5	0.4	0	0
35-39	6	0.4	2	0.1
40-44	11	0.8	2	0.1
45-49	39	2.8	7	0.2
50-54	44	3.2	21	0.6
55-59	87	6.2	37	1.0
60-64	145	10.4	109	3.0
65-69	125	9.0	205	5.6
70-74	147	10.5	389	10.6
75-79	219	15.7	551	15.0
80-84	280	20.1	932	25.4
85-89	210	15.1	892	24.4
90-94	65	4.7	410	11.2
95-99	6	0.4	90	2.5
100-104	0	0	14	0.4
105-109	0	0	0	0
110-114	0	0	1	0.0
115-119	0	0	1	0.0
Totals	1394		3663	
0-79 mm	833	59.8	1323	36.1
≥80	561	40.2	2340	63.9

Table 10a. Age frequency of sea scallops (research), 1983.

	Year	Stratum	N	Scallop Age (%)											
				2	3	4	5	6	7	8	9	10	11	12	13+
Needler	1983	314	6313	0.1	8.4	56.5	29.6	4.8	0.4	0.1	0	0	0	0	0.1
	1983	320	582	0.3	4.6	19.4	16.0	5.2	5.2	6.4	10.7	17.2	5.0	0.9	9.3
Gadus	1983	314	5446	0	0.4	22.7	51.5	20.5	3.1	1.4	0.1	0	0	0	0.2
	1983	320	3190	0	0.3	6.6	16.9	11.8	4.4	6.8	13.7	17.5	7.6	1.1	13.3

Table 10b. Age frequency of Iceland scallops (research).

	Year	Stratum	N	Scallop Age (%)									
				1	2	3	4	5	6	7	8	9	10+
Needler	1983	314	3189	0	0	0.6	14.9	56.5	22.3	4.7	0.9	0.1	0
	1983	320	1394	0.2	0.5	3.5	13.8	19.3	25.3	19.4	12.3	3.8	2.0
Gadus	1983	314	2408	0	0	0.1	2.6	33.3	42.5	15.6	4.5	1.3	0.2
	1983	320	3668	0	0	0.3	3.5	12.7	26.1	23.9	21.5	5.5	6.5

Table 11a. Age frequency of sea scallops (commercial), 1982-83.

	Year	Strata	N	Scallop Age (%)										
				3	4	5	6	7	8	9	10	11	12	13+
Kathyrn M	1982	314	1527	19.8	58.6	20.6	0.8	0.1	0.1	0	0	0	0	0.1
Clouston	1983	314	1125	3.2	56.9	32.4	6.8	0.4	0.3	0	0	0	0	0
	1983	320	3130	0.4	10.0	23.2	10.2	2.4	5.2	11.5	16.9	6.7	1.2	12.3

Table 11b. Age frequency of Iceland scallops (commercial, but not necessarily landed).

	Year	Strata	N	Scallop Age (%)								
				2	3	4	5	6	7	8	9	10+
Kathyrn M	1982	320	539	-	-	-	5.6	21.7	29.5	26.3	9.5	9.4
Clouston	1983	314	846	-	-	5.6	52.4	33.8	6.3	1.9	0.1	-
	1983	320	1178	0.1	0.3	6.5	19.7	27.1	20.4	16.6	5.3	4.2

Table 12. Stratum-specific natural mortality for sea and Iceland scallops on St. Pierre Bank.

Source	Stratum	Sea Scallops	Iceland Scallops
Needler 83	314	0.080	0.085
	320	0.159	0.206
	Totals	0.084	0.128
Gadus 83	314	0.049	0.071
	320	0.174	0.174
	Totals	0.094	0.131

Table 13. Stratum-specific estimates of minimum available biomass (MT round) on St. Pierre Bank (September 1983). All predetermined survey stations used and extrapolated to total survey area.

Stratum	No. Sets	Area (nautical sq. mi.)	Biomass (MT, round) 95% Confidence limits (mean) Giants	Biomass (MT, round) 95% Confidence limits (mean) Icelandic
314	71	118	439-802 (621)	(-37)-525 (244)
320	85	122	537-774 (655)	198-597 (397)
Totals	156	240	1060-1491 (1276)	299-984 (641)

Table 14. Stratum-specific estimates of minimum available biomass (MT round) on St. Pierre Bank (Sept. 1983). Only stations yielding catches ≥5.0 kg used and extrapolated to commercially attractive areas.

	No. sets ≥5.0 kg		Estimated area (nautical sq. mi)		Biomass (MT, round) 95% confidence limits (mean)	
Stratum	G	I	G	I	Giants	Iceland
314	40	7	87	17	561-946 (753)	(-144)-766 (311)
320	57	16	53	20	337-453 (395)	168-425 (296)
Totals	97	23	140	37	959-1267 (1113)	296-878 (587)

Table 15. Stratum-specific biomass on St. Pierre Bank (Naidu et al. 1983b). Minimum available biomass (x 6.5) using overall gear efficiency of 15.4% (Caddy 1971).

Stratum	No. sets ≥5.0 kg	Estimated area (nautical sq. mi) G	I	Biomass (MT, round) 95% confidence limits (mean) Giants		Iceland	
314	35	55	17	7184-13045	(10115)	537-1220	(879)
320	14	40	28	1719-4144	(2931)	570-3159	(1864)
Totals	49	95	45	9925-16171	(13046)	1416-4070	(2743)

Table 16. Estimated biomass of giant scallops in commercially-attractive contagions using overall gear efficiency of 15.4% (Caddy 1971).

Stratum	Biomass (MT) Round		Meats	
314	3643-6143	(4890)	439-740	(589)
320	2188-2942	(2565)	263-354	(309)
Total	6227-8227	(7227)	750-991	(871)

Table 17. Mean scallop catch per tow on St. Pierre Bank using all sets from two survey cruises in January (*Needler*) and September (*Gadus*) 1983.

	314		320		Combined	
	Needler	*Gadus*	*Needler*	*Gadus*	*Needler*	*Gadus*
Sea scallops						
Numbers (S.D.)	255.3 (497.9)	97.9 (123.5)	37.4 (54.8)	39.7 (33.0)	187.2 (425.7)	66.2 (91.2)
Weight (kg S.D.)	19.3 (36.9)	10.4 (12.8)	9.0 (12.1)	10.6 (8.9)	16.1 (31.6)	10.5 (10.8)
Iceland Scallops						
Numbers (S.D.)	116.4 (276.1)	85.2 (423.0)	107.5 (209.9)	76.6 (181.5)	113.6 (256.6)	80.5 (314.1)
Weight (kg S.D.)	5.2 (12.4)	4.1 (19.9)	7.3 (15.4)	6.4 (15.0)	5.9 (13.4)	5.4 (17.4)

Table 18. Mean scallop catch (numbers)/tow using most productive commercial 10' squares.

Stratum	Area	10' square		% Removals (of total) 1982	1983	% Removals (by strata) 1982	1983	# of Sets Needler	Gadus	Scallop numbers (SD)/standard tow Needler (Jan 83)	Gadus (Sept 83)	Commerical CPUE 1982	1983
Sea scallops													
	A	461	565	7.9	5.9	11.9	9.2	8	8	189.0 (257.7)	64.1 (53.9)	0.678	0.402
314	B	462	565	19.2	25.2	29.1	38.9	22	22	463.1 (545.5)	131.8 (171.6)	0.632	0.455
	C	462	570	37.1	22.1	56.2	34.1	36	21	320.3 (470.0)	129.6 (111.3)	0.859	0.437
Subtotal				64.2	53.2	97.2	82.2	66	51	352.0 (479.8)	120.3 (135.4)	x̄ = 0.720	x̄ = 0.431
	D	454	555	7.9	9.1	24.8	26.3	12	16	36.5 (59.0)	36.4 (24.2)	0.580	0.444
	E	454	554	4.2	2.0	13.3	5.7	3	7	14.0 (12.5)	22.1 (14.1)	0.602	0.382
320	F	453	560	9.3	3.4	16.2	35.1	8	16	58.9 (73.8)	35.0 (29.8)	0.529	0.299
	G	453	555	5.1	12.2	29.1	9.9	4	6	29.3 (42.9)	53.0 (44.5)	0.473	0.253
Subtotal				26.5	26.7	83.4	77.0	27	45	39.6 (58.1)	35.9 (28.7)	x̄ = 0.546	x̄ = 0.345
Totals				90.7	79.9	-	-	93	96	261.3	80.7	x̄ = 0.621	x̄ = 0.382
Iceland scallops													
314	A									36.4 (85.6)	- -		
	B									105.3 (198.7)	177.1 (740.8)		
	C									260.4 (410.3)	78.5 (174.4)		
Subtotal										181.5 (335.0)	108.7 (497.0)		
320	D									254.0 (264.6)	232.6 (273.9)		
	E									111.0 (7.9)	48.9 (88.3)		
	F									188.3 (327.8)	26.3 (42.6)		
	G									3.0 (2.4)	27.8 (48.0)		
Subtotal										181.4 (257.8)	103.4 (192.4)		
Totals										181.5	106.2		

Table 19. Stratum-specific scallop abundance (total nos/tow mile) along common transects during two research surveys in January (Needler) and September (Gadus), 1983.

Stratum	Transect	No. sets		Scallop Nos.		Nos./tow	
		January	September	January	September	January	September
Sea Scallops							
314	14	8	10	2103	1085	262.9	108.5
	15	8	10	5610	878	701.3	87.8
	16	8	10	3315	1362	414.4	136.2
	17	8	10	3822	642	477.8	64.2
	18	8	8	4206	973	525.8	121.6
	19	11	8	4512	1072	410.2	134.0
	20	10	8	2064	830	206.4	103.8
	21	11	5	1437	112	130.6	22.4
Totals		72	69	27069	6954		
Mean numbers/tow						376.0±573.4	100.8±124.1
320	60	7	5	336	119	48.0	23.8
	62	7	3	78	58	11.0	19.3
	64	7	3	165	89	23.6	29.7
	68	7	5	381	293	54.4	58.6
	70	7	5	630	149	90.0	29.8
	72	7	5	57	181	8.1	36.2
Totals		42	26	1647	889		
Mean numbers/tow						39.2±58.1	34.2±32.0
Iceland Scallops							
314	14	8	10	240	241	30.0	24.1
	15	8	10	513	44	64.1	4.4
	16	8	10	993	3516	124.1	351.6
	17	8	10	1131	339	141.4	33.9
	18	8	8	2415	733	301.9	91.6
	19	11	8	4032	855	366.5	106.9
	20	10	8	2259	295	225.9	36.9
	21	11	5	972	26	88.4	5.2
Totals		72	69	12555	6049		
Mean numbers/tow						174.4±323.5	87.7±428.9
320	60	7	5	393	59	56.1	11.8
	62	7	3	351	668	50.1	222.7
	64	7	3	1386	1206	198.0	402.0
	68	7	5	858	98	122.6	19.6
	70	7	5	561	67	80.1	13.4
	72	7	5	981	41	140.1	8.2
Totals		42	26	4530	2139		
Mean numbers/tow						107.9±217.9	82.3±169.7

Table 20. Mean and modal shell heights for sea and Iceland scallops from St. Pierre Bank. (Needler, Jan. 1983; Gadus Atlantica, Sept. 1983.)

Species	Stratum	Mean Jan. 1983	Mean Sept. 1983	Mode Jan. 1983	Mode Sept. 1983
Giants	314	85.0 (N = 6310)	95.0 (N = 5437)	84	95
	320	109.3 (N = 582)	117.7 (N = 3180)	127	130
Iceland	314	64.6 (N = 3189)	71.1 (N = 2406)	65	70
	320	73.4 (N = 1394)	80.8 (N = 3663)	85	85

Table 21. Catch and effort data for St. Pierre Bank scallop fishery. (From ICNAF and NAFO Statistical Bulletins, 1982 and 1983 data from Fisheries Research Branch, Scotia-Fundy.)

Year	MT meats	Effort days	CPUE (MT meats/day)
1963	20	19	1.1
1964	262	277	0.9
1965	13	16	0.8
1966	-	-	-
1967	138	172	0.8
1968	9	13	0.7
1969	82	147	0.6
1970	125	172	0.7
1971	27	55	0.5
1972	29	45	0.6
1973	20	35	0.6
1974	-	-	-
1975	-	-	-
1976	-	-	-
1977	-	-	-
1978	9	7	1.3
1979	1	2	0.5
1980	23	26	0.9
1981	-	-	-
1982	717	828	0.9
1983	594	795	0.7
Totals	2069	2609	0.8

Table 22. Stratum-specific effort (days), removals (kg) and CPUEs (kg/CHRM) 1982-83.

Stratum	10' Square		Area	Effort (days) 1982	Effort (days) 1983	Total Removals (kg) 1982	Total Removals (kg) 1983	CPUE (kg/CHRM) 1982	CPUE (kg/CHRM) 1983
	462	563		1		906		0.745	
314	462	564		1		792		0.321	
	461	565	A	53	51	54,032	32,309	0.678	0.402
	462	565	B	154	187	131,969	137,350	0.623	0.455
	463	565		1	51	854	45,974	0.393	0.579
	461	570		12	13	9,597	9,397	0.942	0.415
	462	570	C	270	154	255,013	120,441	0.859	0.437
	463	570		1	5	983	4,524	1.031	0.439
	464	565			3		2,067		0.332
	464	570			3		927		0.381
Subtotals and means				493	467	454,146	352,989	$\bar{x}$ = 0.699	$\bar{x}$ = 0.430
Percent contribution (of total)				(64.2)	(59.0)	(66.1)	(64.9)		
	453	554		11	31	10,870	20,778	0.629	0.496
320	454	555	D	60	69	54,076	49,664	0.580	0.444
	454	554	E	33	14	28,937	10,737	0.602	0.382
	453	560	F	46	121	35,349	66,170	0.529	0.299
	453	555	G	75	49	63,573	18,646	0.473	0.253
	454	560		8	12	7,382	7,826	0.773	0.409
	453	561		4	10	4,055	5,384	0.441	0.304
	454	561		5	11	3,033	8,909	0.263	0.437
	454	562		2		2,007		2.573	
	455	563		1		1,600		0.599	
	460	565		5		4,151		0.454	
	453	553		2	2	1,133	376	0.613	0.197
	453	562		1		223		0.391	
	455	565		2		1,711		0.641	
Subtotals and means				255	319	218,100	188,490	$\bar{x}$ = 0.683	$\bar{x}$ = 0.358
Percent contribution (of total)				(33.2)	40.3)	(31.7)	(34.6)		
	460	570}				1,515		0.365	
OTHER	461	555}		6		2,180		2.630	
	463	555}				1,782		2.284	
	464	555				2,421		0.568	
	453	551			2		677		0.355
	462	552			2		1,483		
	461	552		1		819		0.395	
	455	553		1		687		0.276	
	461	553		1		997		0.481	
	463	562		1		1,407			
	454	564		1		39		0.645	
	453	565		7		1,003		0.423	
	465	565		2	1	2,115	419	0.453	0.253
Subtotals and means				20	5	14,965	2,579	$\bar{x}$ = 0.852	$\bar{x}$ = 0.304
Percent contribution (of totals)				(2.6)	(0.6)	(2.2)	(0.5)		
Total								$\bar{x}$ = 0.666	$\bar{x}$ = 0.413

Table 23. Catch and effort distribution on St. Pierre Bank.

Year	Days (%)		Removals MT (%)	
	314	320	314	320
1982	493 (64)	255 (33)	454 (66)	218 (32)
1983	467 (59)	319 (40)	353 (65)	188 (35)

Table 24. Sea scallop numbers at age in duplicated transects in two areas of St. Pierre Bank.

		Age (yr)												
		2	3	4	5	6	7	8	9	10	11	12	13	Totals
314	Needler	1.0	21.9	148.3	72.1	13.7	1.0	1.0	-	-	1.0	1.0	1.0	257.7
	Gadus	-	1.0	18.1	40.8	16.2	2.5	1.1	1.0	1.0	1.0	1.0	1.0	79.3
320	Needler	1.0	1.7	6.8	5.9	2.5	1.9	2.8	5.6	6.1	2.1	1.0	3.6	39.6
	Gadus	-	-	1.6	4.8	3.7	1.7	2.1	4.7	6.1	2.8	1.0 (0.46)	5.3	33.2

Table 25. Age-specific estimates of Z for sea scallops, 1982-83.

Age	Stratum 314	Stratum 320
3-4	0.254	-
4-5	1.721	0.464
5-6	1.991	0.622
6-7	2.268	0.595
7-8	-	-
8-9	-	-
9-10	-	-
10-11	-	1.038
11-12	-	2.025
Z_{3-6}	1.591 (80%)	0.490 (39%)
Z_{8-11}	(not computed)	0.211 (20%)
All ages	1.571	0.238

Table 26. Meat weight at age in sea scallops from St. Pierre Bank (Stratum 320).

Age (yr)	Shell Height (mm)	Meat Weight (gm)	No. Meats/lb
1	19.3	0.1	5,044.4
2	44.1	1.3	354.7
3	64.1	4.1	109.4
4	80.2	8.4	53.9
5	93.1	13.5	33.7
6	103.6	18.9	24.1
7	112.0	24.1	18.8
8	118.8	29.0	15.6
9	124.3	33.5	13.6
10	128.7	37.4	12.2
11	132.2	40.6	11.2
12	135.1	43.5	10.4
13	137.4	45.9	9.9

Table 27. Meat weight at age in Iceland scallops from St. Pierre Bank (Stratum 320).

Age (yr)	Shell Height (mm)	Meat Weight (gm)	No. Meats/lb
1	11.7	-	15,133.3
2	28.0	0.5	908.0
3	41.6	1.7	273.5
4	52.9	3.5	131.6
5	62.4	5.7	79.5
6	70.3	8.2	55.3
7	76.9	10.8	42.1
8	82.4	13.3	34.1
9	86.9	15.7	29.0
10	90.8	17.9	25.3
11	93.9	19.8	22.9
12	96.6	21.6	21.0
13	98.8	23.2	19.6

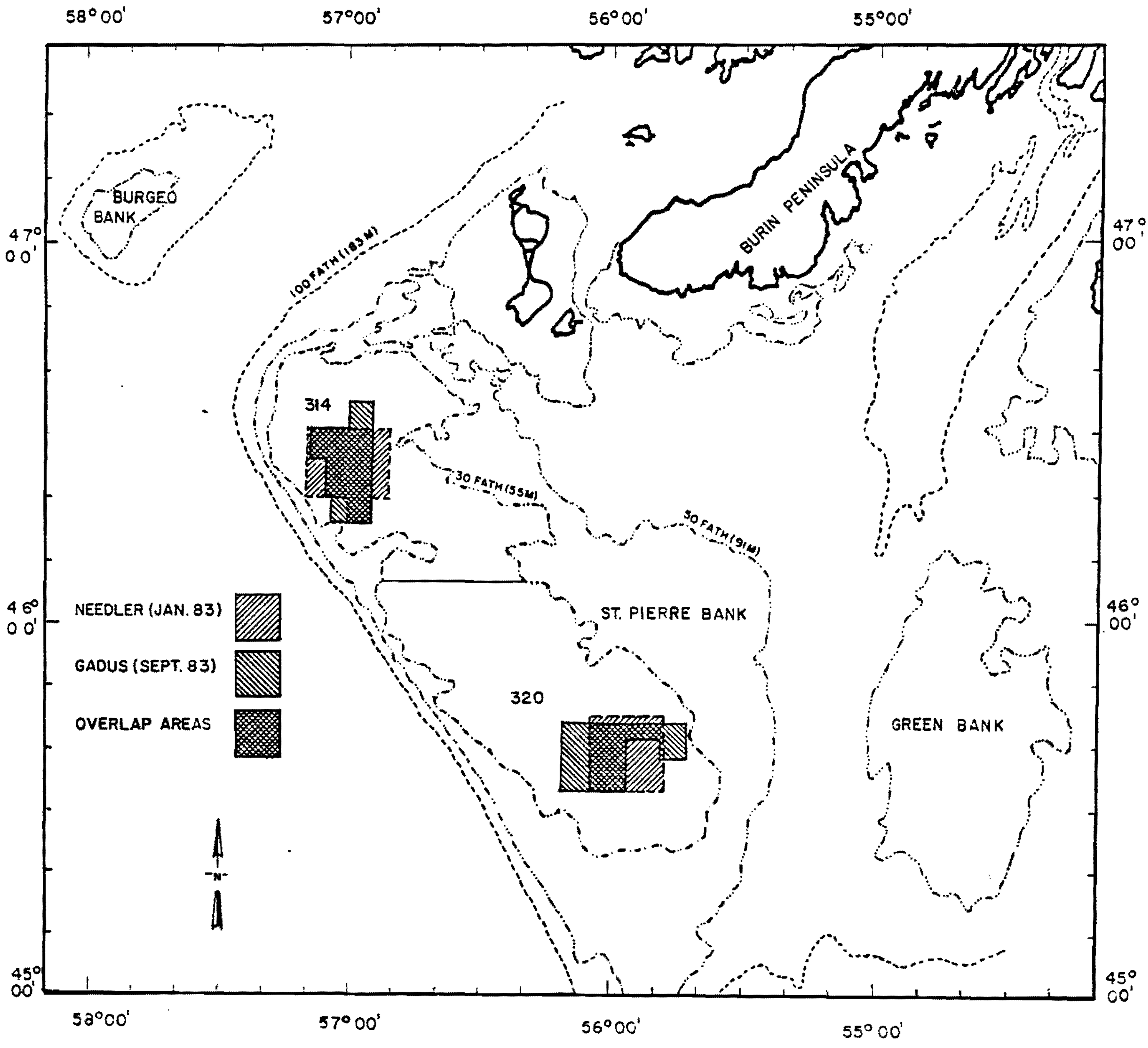


Fig. 1. Scallop survey areas on St. Pierre Bank (NAFO Div. 3Ps).

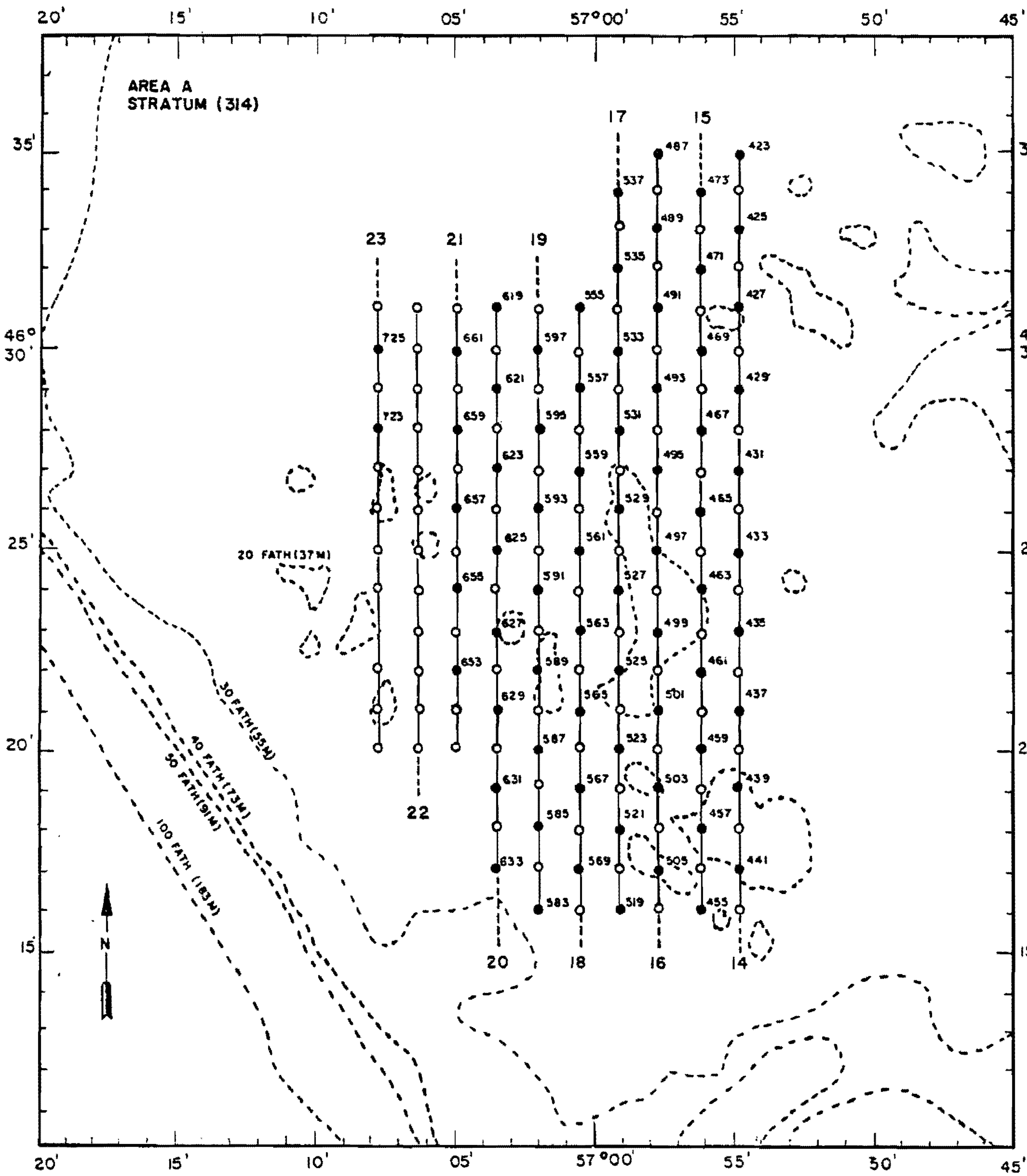


Fig. 2. Distribution of research stations occupied in Stratum 314 (northern area) of St. Pierre Bank during Gadus Atlantica cruise (September 1983).

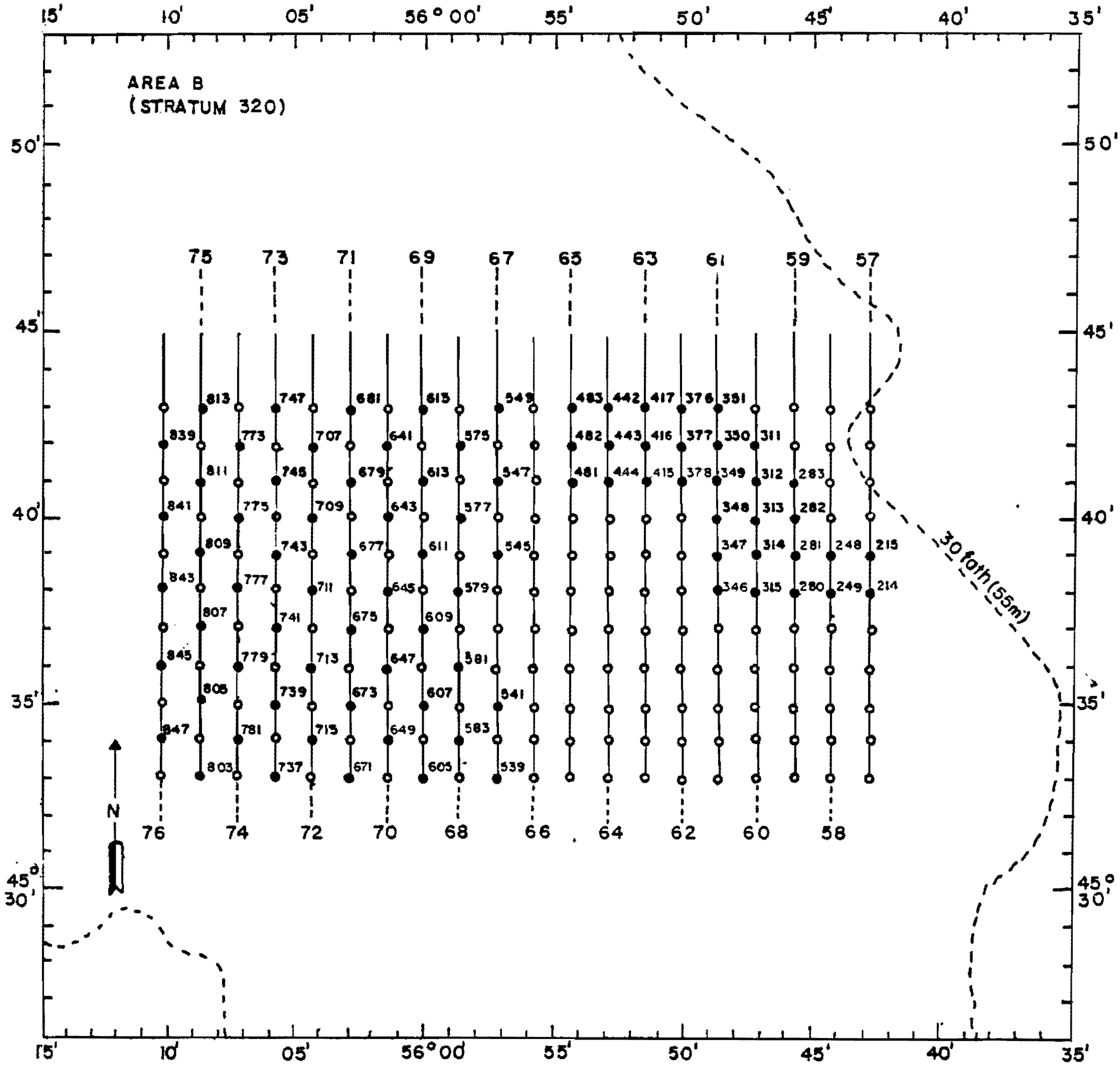


Fig. 3. Distribution of research stations in Stratum 320 (southern area), St. Pierre Bank during Gadus Atlantica cruise (September 1983).

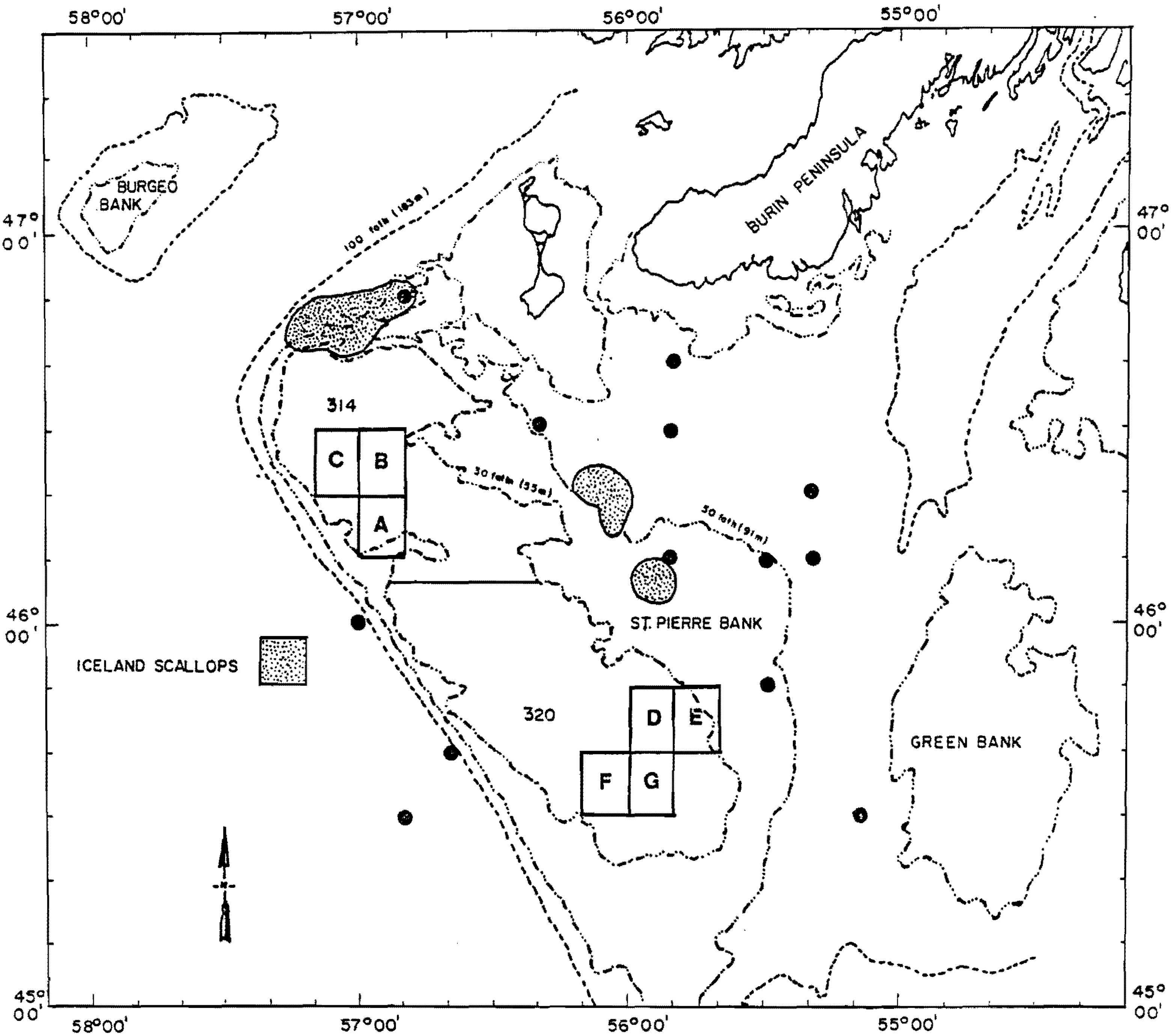


Fig. 4. Seven most productive commercial 10' squares in 1982-83 and anomalous positions (solid circles) reported during 1983.

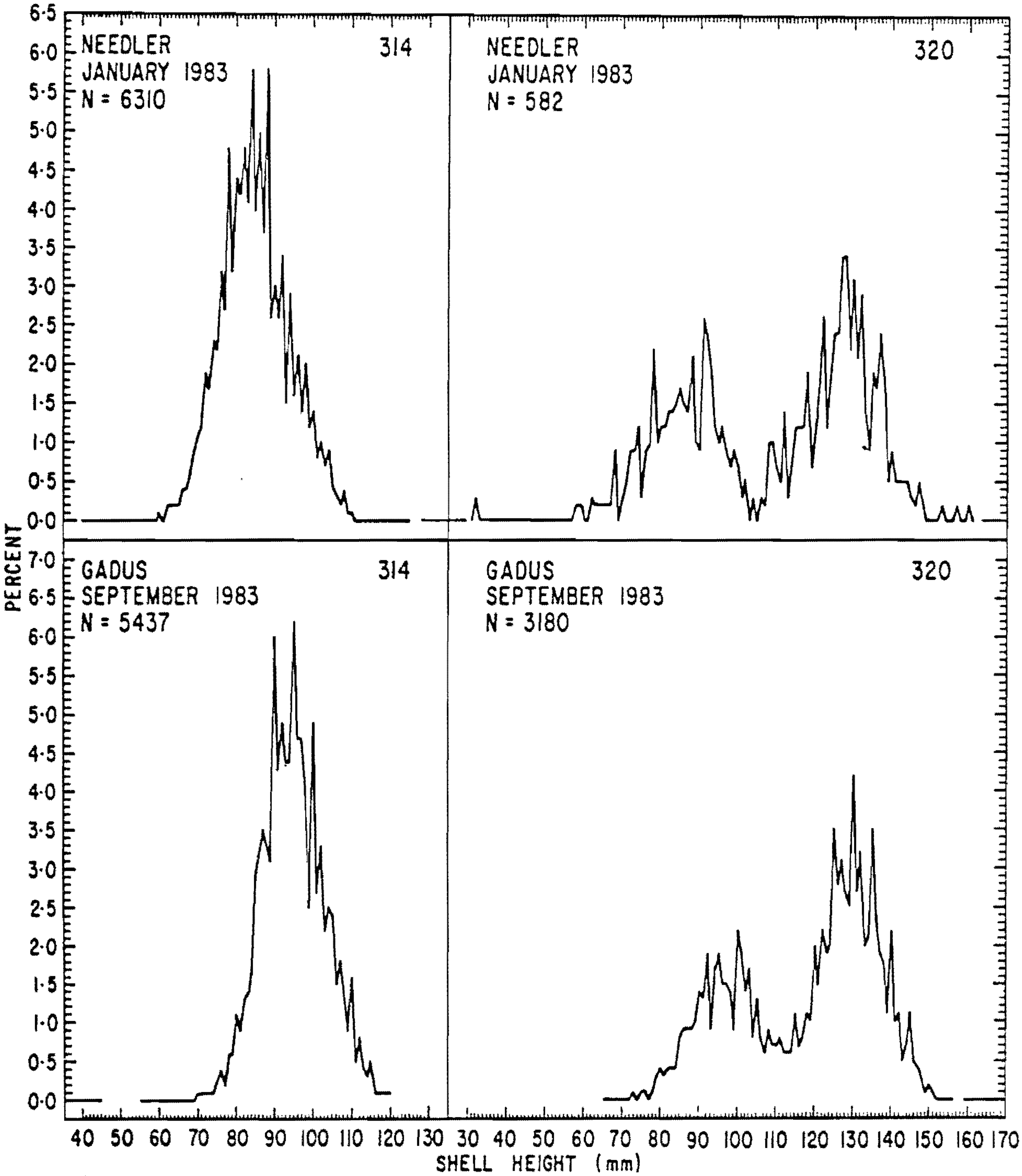


Fig. 5. Research shell-height frequencies of sea scallops from two target areas on St. Pierre Bank (1983).

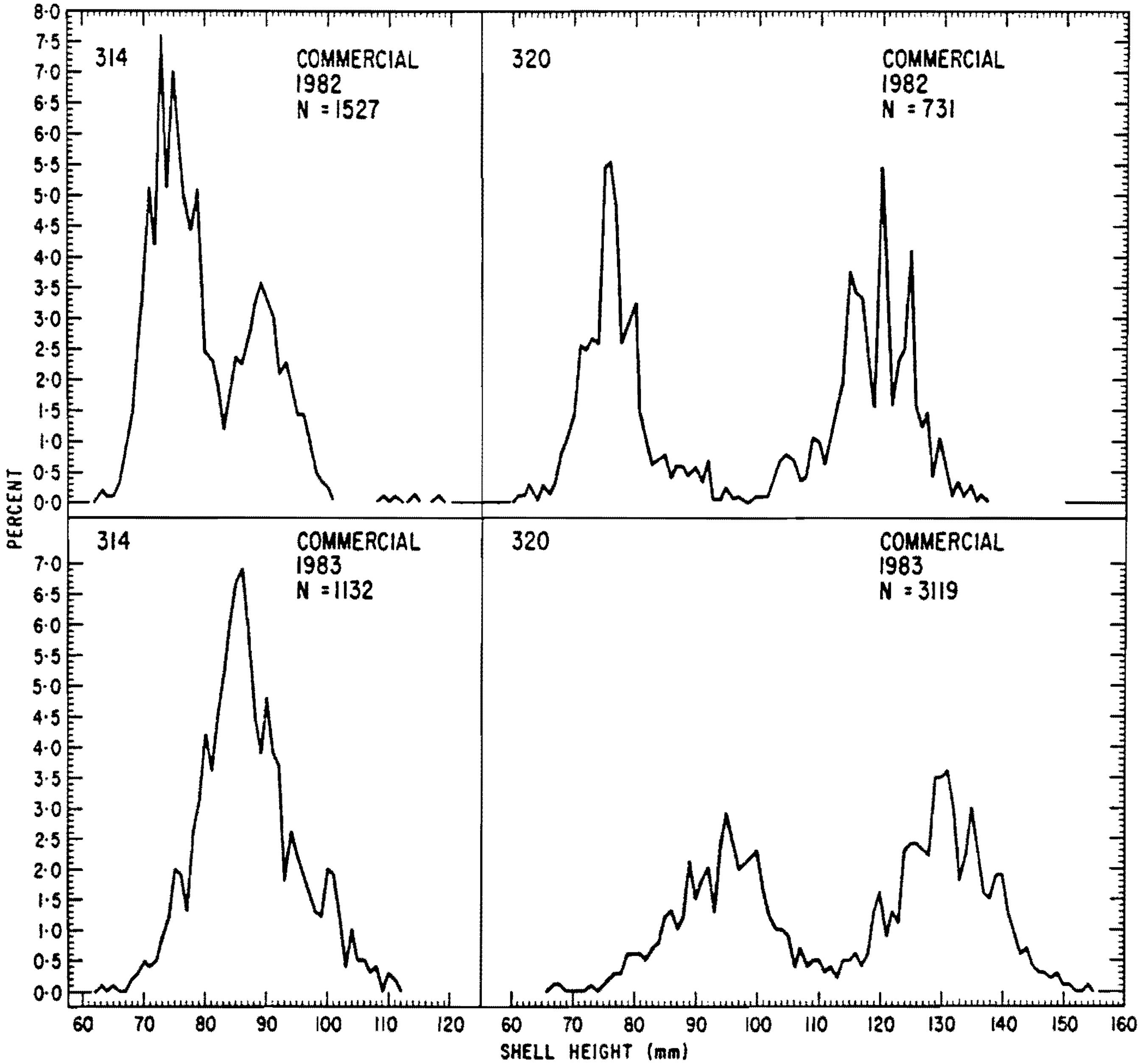


Fig. 6. Commercial shell-height frequencies of sea scallops from two target areas on St. Pierre Bank (1982-83).

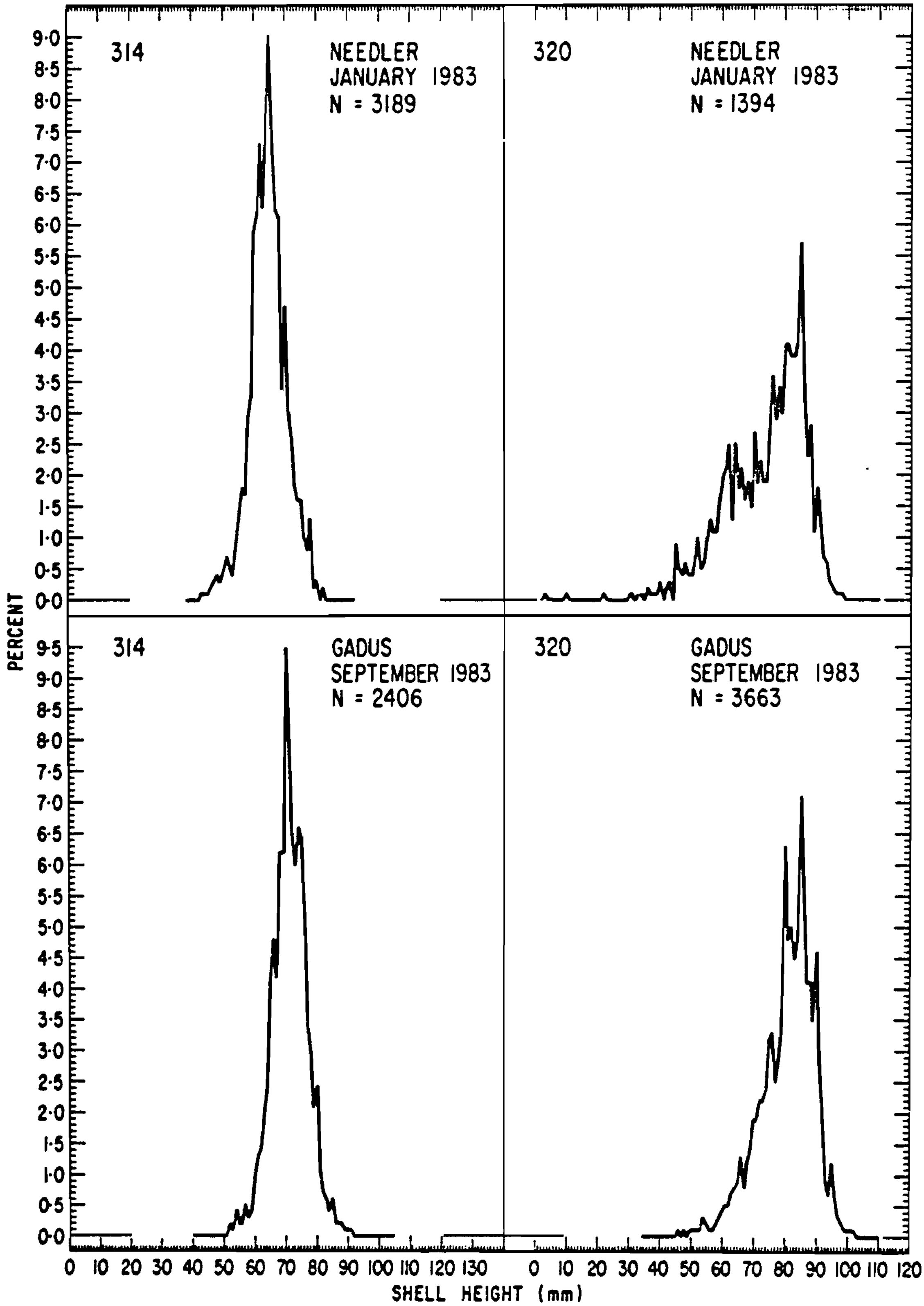


Fig. 7. Research shell-height frequencies of Iceland scallops on St. Pierre Bank (1983).

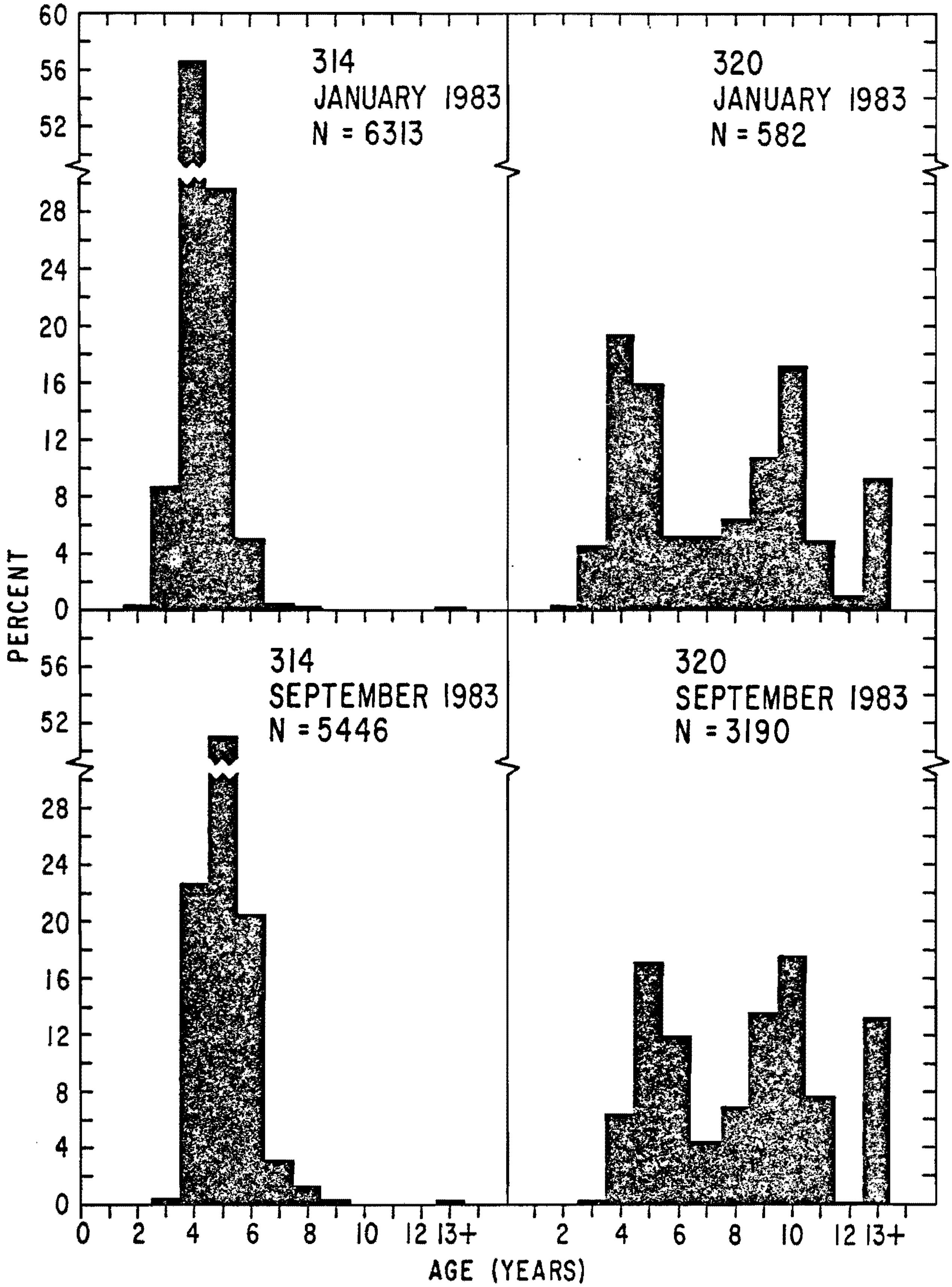


Fig. 8. Age frequencies (research) of sea scallops from St. Pierre Bank (1983).

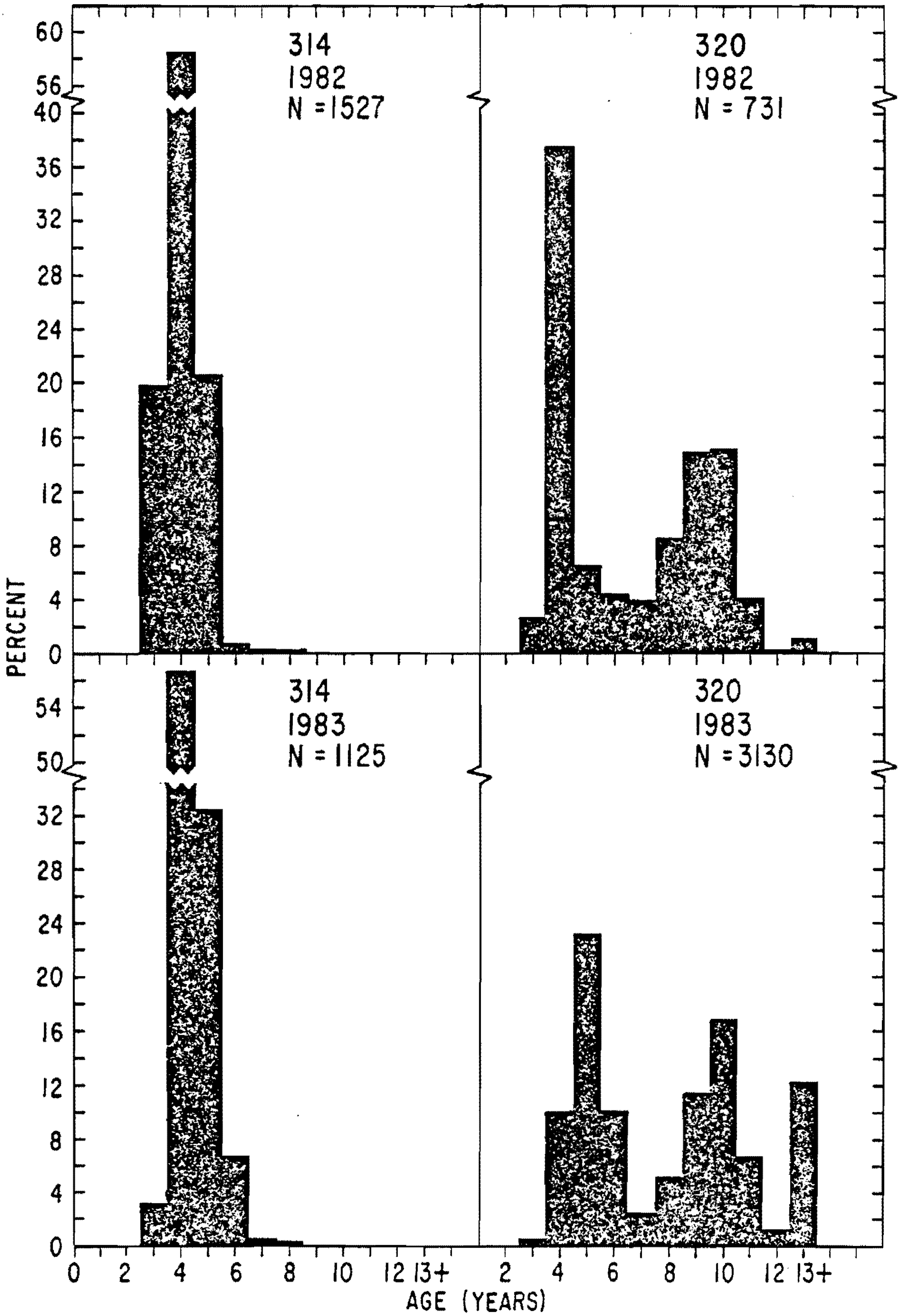


Fig. 9. Age frequencies (commercial) of sea scallops from St. Pierre Bank (1982-83).

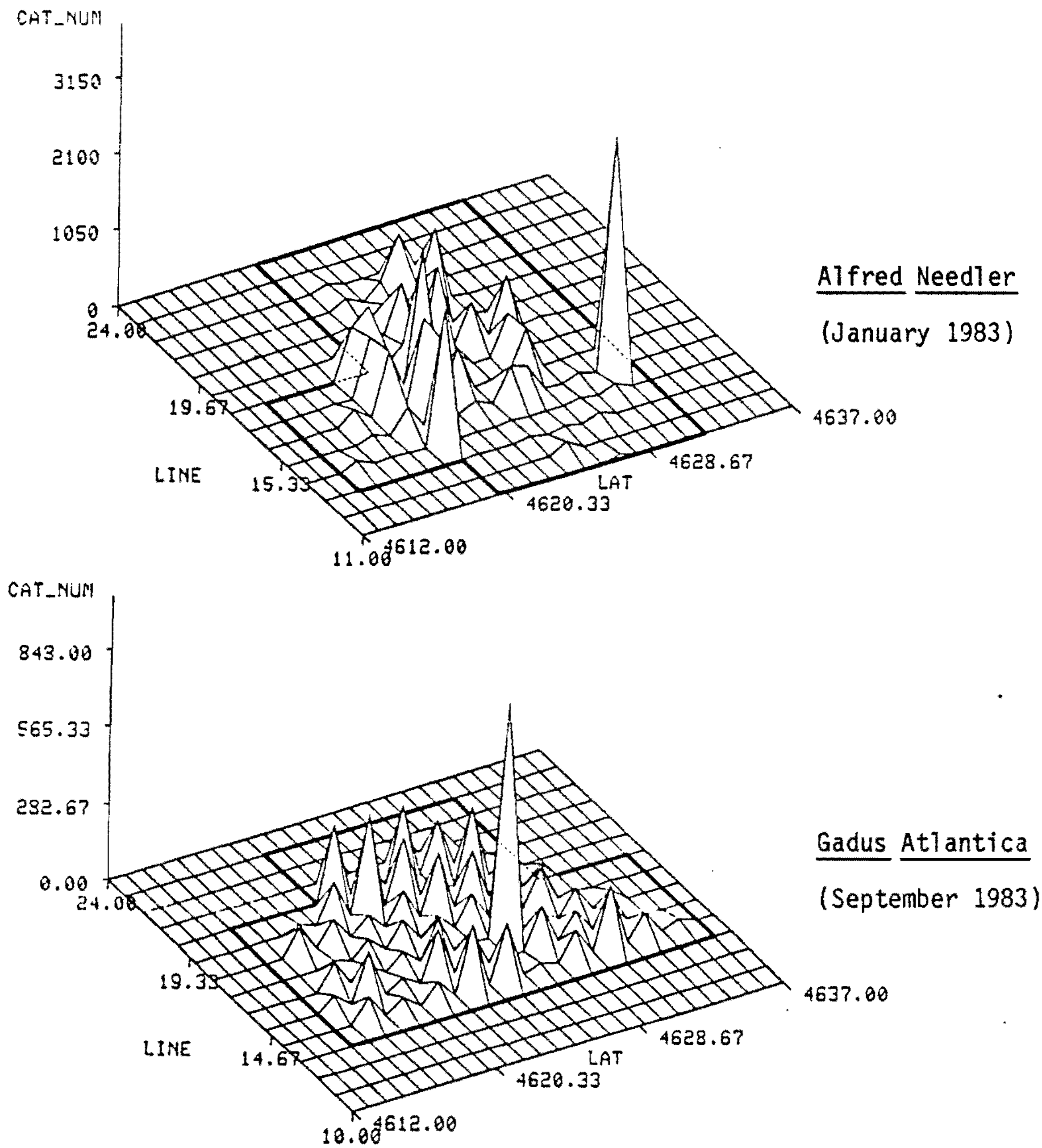


Fig. 10. Spatial distribution and abundance (catch numbers) of sea scallops in Stratum 314 (north), St. Pierre Bank.

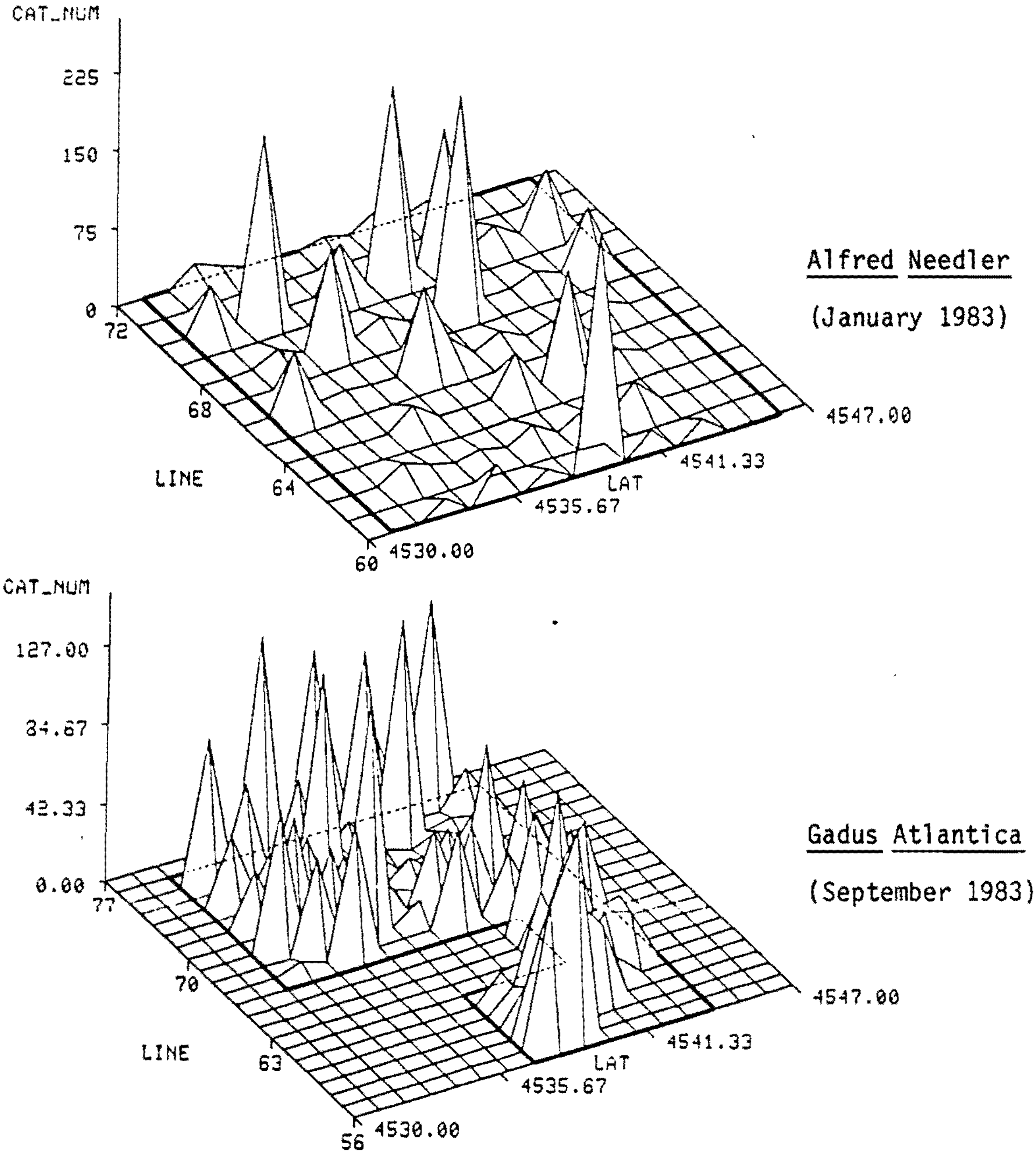


Fig. 11. Spatial distribution and abundance (catch numbers) of sea scallops in Stratum 320 (south), St. Pierre Bank.

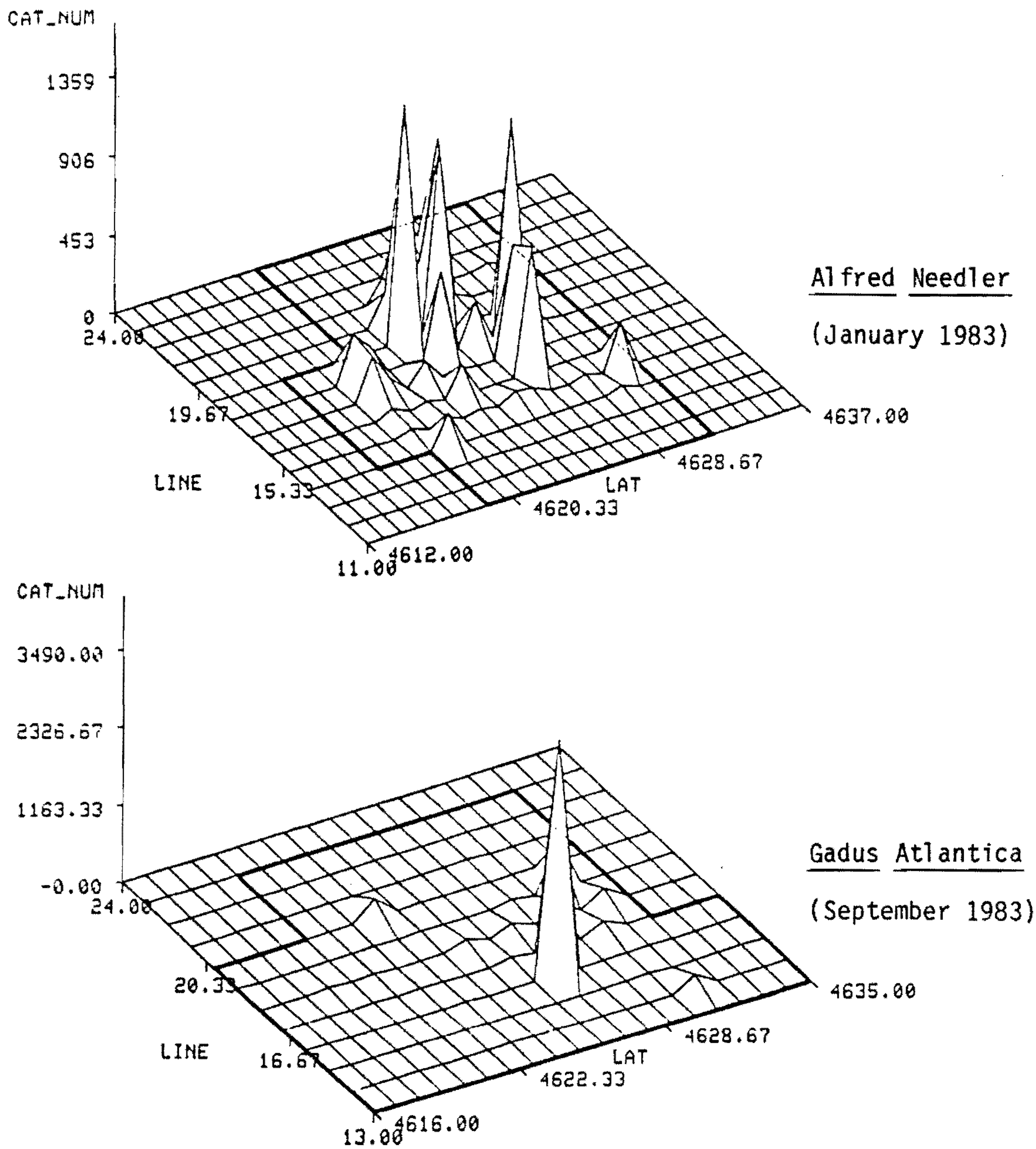
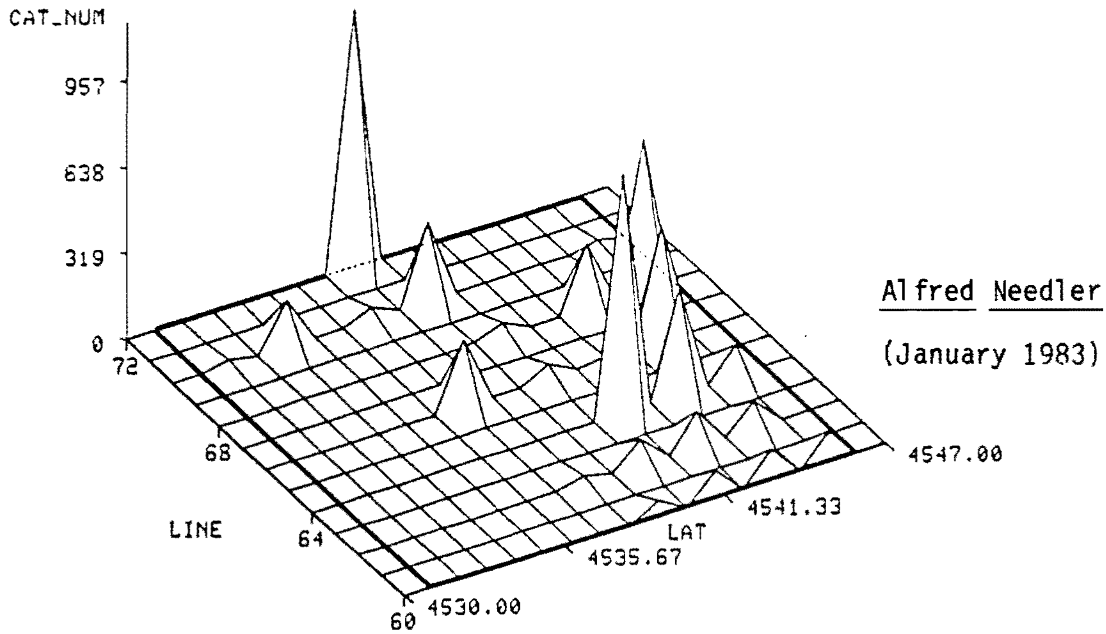


Fig. 12. Spatial distribution and abundance (catch numbers) of Iceland scallops in Stratum 314 (north), St. Pierre Bank.



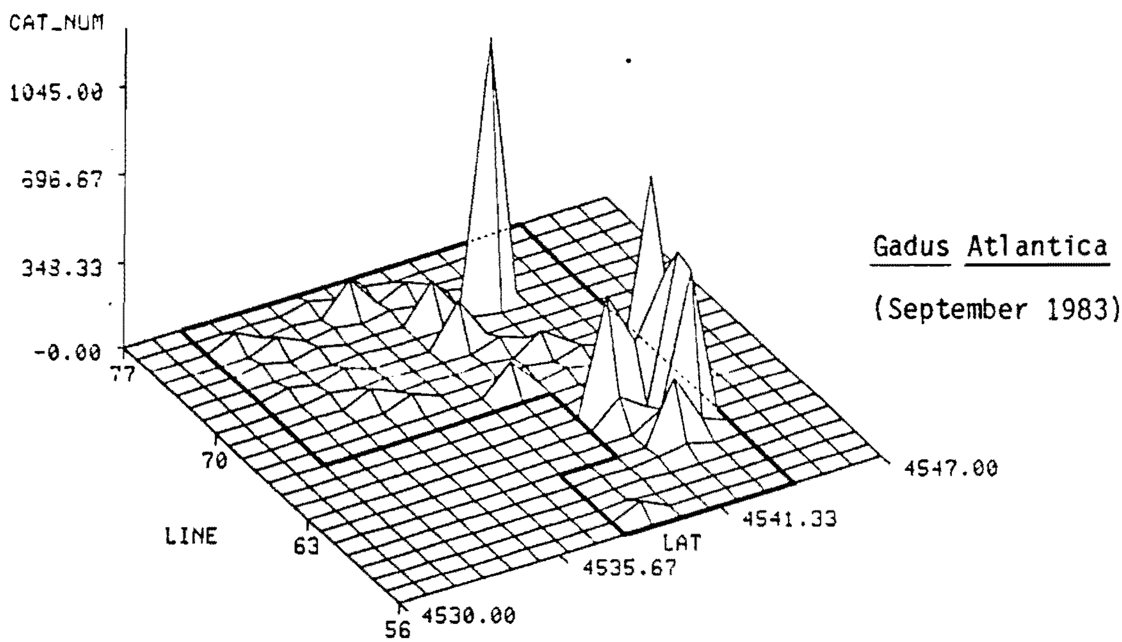


Fig. 13. Spatial distribution and abundance (catch numbers) of Iceland scallops in Stratum 320 (south), St. Pierre Bank.

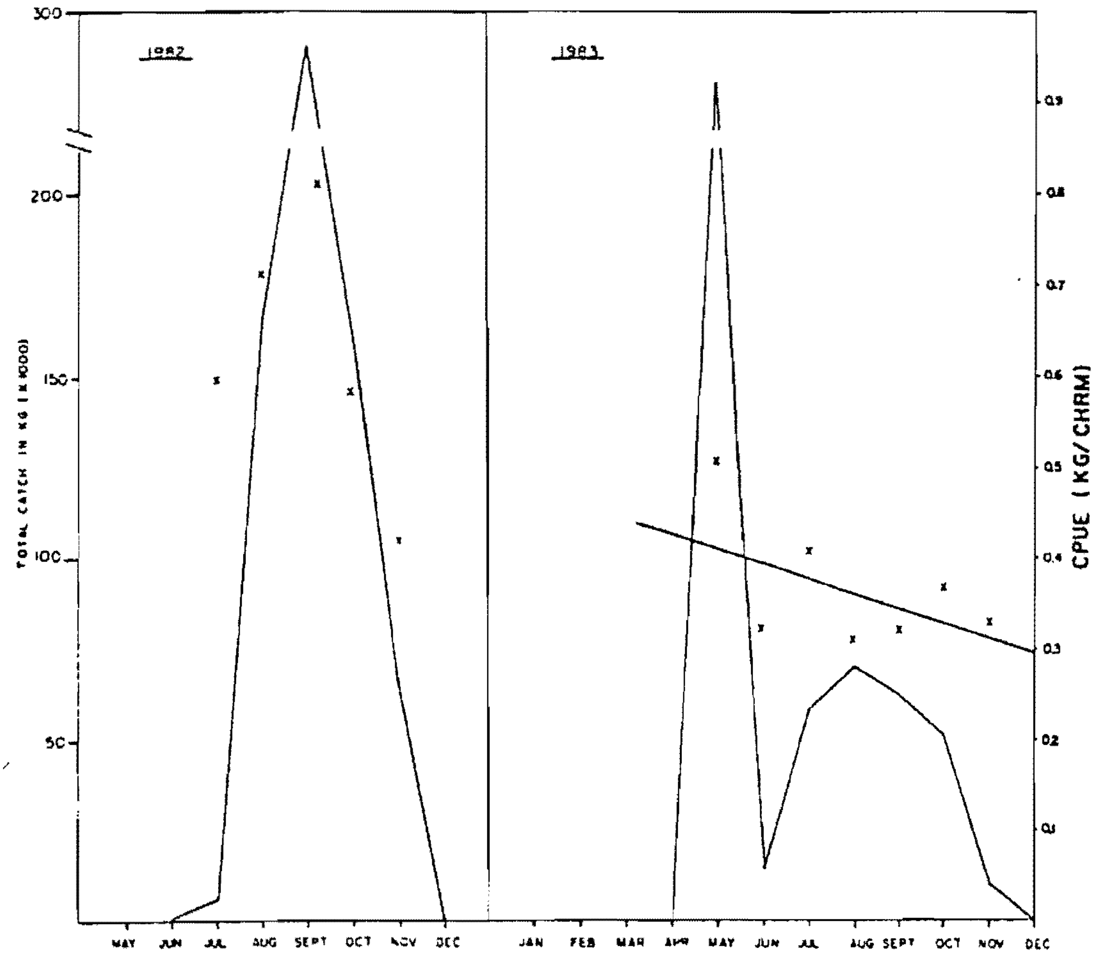


Fig. 14. Total catch and catch per unit of effort (kg/CHRM) on St. Pierre Bank, 1982-83.

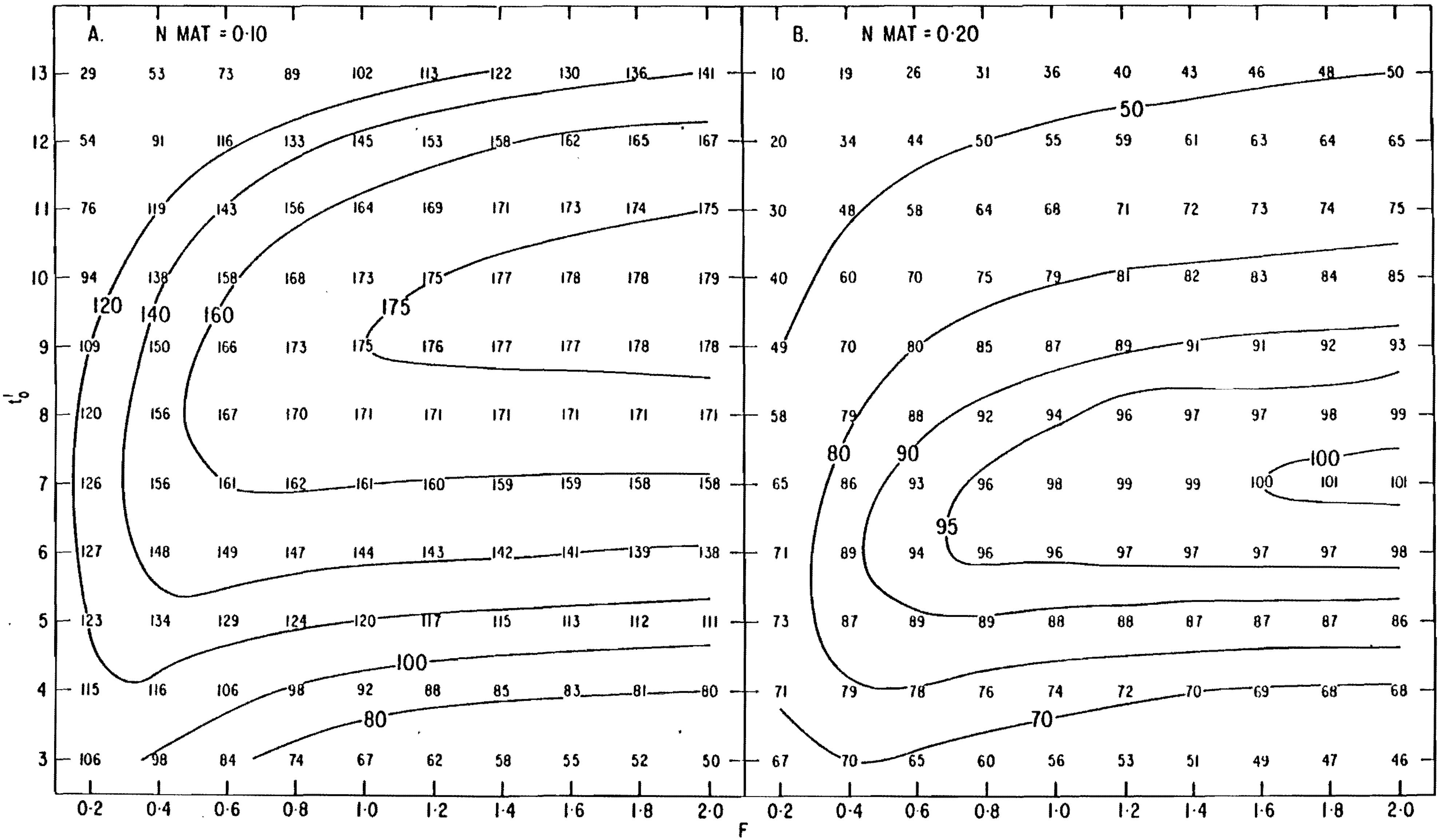


Fig. 15. Yields and yield isopleths (kg/10,0000 recruits) for sea scallops from St. Pierre Bank (t'_0 = age (yr) of first capture, F = fishing mortality).

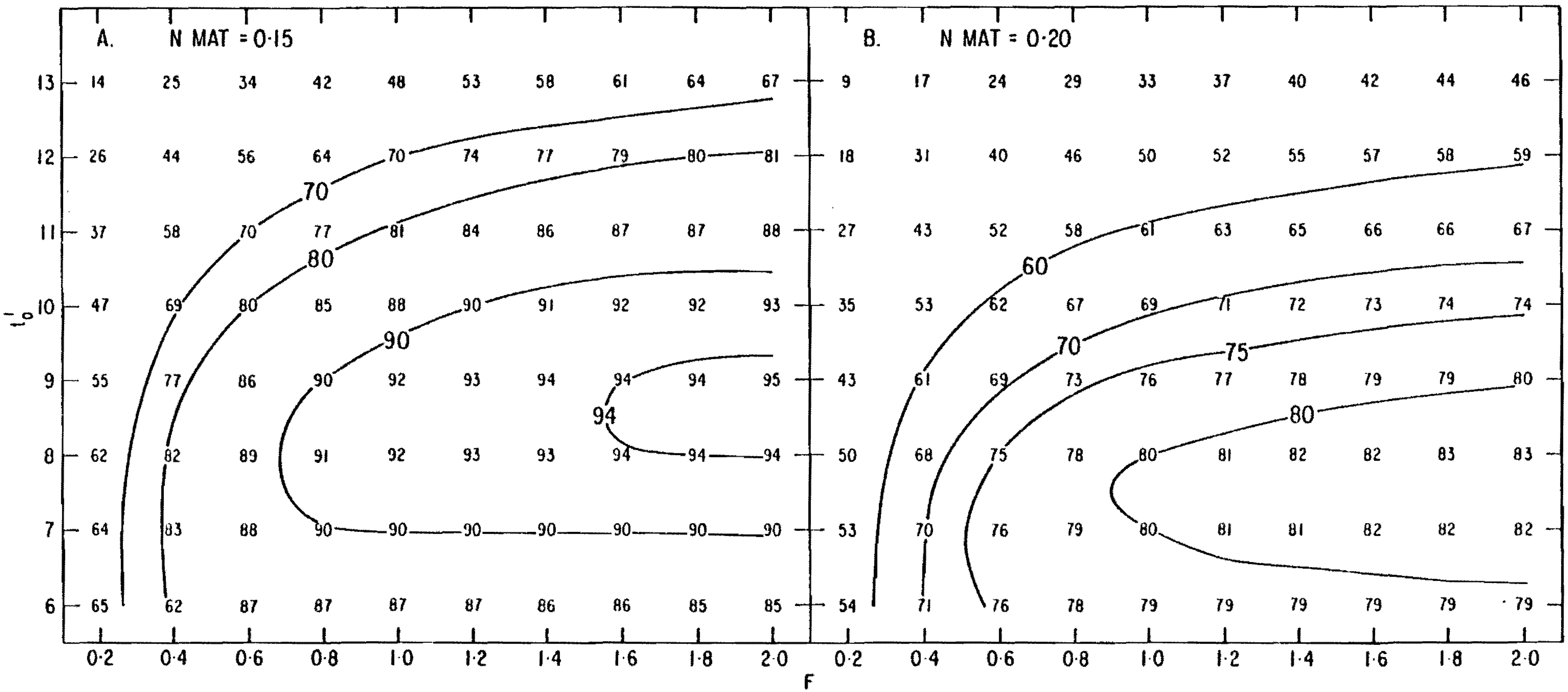


Fig. 16. Yields and yield isopleths (kg/10,0000 recruits) for Iceland scallops from St. Pierre Bank (t_0' = age (yr) of first capture, F = fishing mortality).