Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 98/71

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/71

Not to be cited without
permission of the authors[1]

Ne pas citer sans
autorisation des auteurs[1]

Survey of sea scallop abundance and distribution in western Northumberland Strait (SFA 22), June 1997

John Mark Hanson

Invertebrate Fisheries Division,
Science Branch, Maritimes Region,
Gulf Fisheries Center,
P. O. Box 5030, Moncton NB
E1C 9B6

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1998
Canada

Abstract

Sea scallop abundance and distribution in the western half of Northumberland Strait (Scallop Fishing Area [SFA] 22, southern Gulf of St. Lawrence) were evaluated by means of a research survey in June 1997. This was the first research survey conducted since 1986 and the first, since research on sea scallops began in SFAs 21 to 24, to cover an entire fishing area. There was a discrete concentration of sea scallops in the eastern part of the SFA (Cape Tormentine area) that was comprised of individuals 40 to 109 mm shell height (SH) - animals > 109 mm were very rare. There were several smaller concentrations in the western part of the SFA. Unlike the eastern concentration, sea scallops > 109 mm SH were found throughout the western end of the survey area. The total (40 to 155 mm SH) estimated population (not corrected for dredge efficiency) was 9.97 million animals. This was equivalent to 131 tonnes as meat, of which 115 t were from animals > 79 mm SH. Assuming a dredge efficiency of 10%, the post-fishing season abundance of sea scallops > 79 mm SH was 1149 t of meats in a survey area of 2,812 km^2. Population abundance has declined over estimates from surveys conducted 1979 to 1986. Moreover, there was no indication of strong recruitment; therefore, an increase in fishable biomass is unlikely in the next few years.

Résumé

L'abondance et la répartition du pétoncle géant dans la moitié ouest du détroit de Northumberland (zone de pêche du pétoncle, ZPP, 22, sud du golfe du Saint-Laurent) ont été évaluées par relevé de recherche en juin 1997. Il s'agissait du premier relevé de recherche à être effectué depuis 1986 et le premier à couvrir toute la zone de pêche, car les relevés du pétoncle géant ont débuté dans les ZPP 21 à 24. Une concentration distincte de pétoncle géant a été décelée dans la partie est de la ZPP (cap Tormentine). Elle était formée d'individus de hauteur de coquille (HC) variant entre 40 et 109 mm, les individus de plus de 109 mm étant très rares. Plusieurs autres concentrations moins importantes ont aussi été décelées dans la partie ouest de la ZPP. Contrairement à la concentration de l'est, des pétoncles de HC supérieure à 109 mm ont été décelés dans toute la partie ouest de la zone du relevé. La population totale estimée (individus de HC de 40 à 155 mm), non corrigée en fonction de l'efficacité de la drague, s'élevait à 9,97 millions d'animaux. Cela correspond à 131 tonnes de chairs, dont 115 t pour les animaux de HC de plus de 79 mm. Si l'on suppose une efficacité de la drague de 10 %, l'abondance de pétoncles de plus de 79 mm de HC après la saison de pêche était de 1 149 t de chairs, pour une aire de relevé de 2 812 km^2. L'abondance a diminué, comparativement aux estimations faites suite aux relevés de 1979 à 1986. Rien n'indiquait un important recrutement et il est donc improbable qu'il y ait augmentation de la biomasse exploitable au cours des prochaines années.

Introduction

There currently is little information available on the abundance and distribution of sea scallops (*Placopecten magellanicus*) in the southern Gulf of St. Lawrence. There are four scallop-fishing areas (SFAs 21 to 24) under the jurisdiction of the Maritimes Region (Figure 1). Waters adjacent to the Province of Quebec are managed by the Laurentides Region. The last research surveys in SFAs 21 to 24 were conducted in 1986 (Lanteigne et al. MS1987) and commercial sampling ceased in 1988 (Lanteigne & Davidson MS1989). Past surveys were of limited geographic coverage; they focused on areas currently being fished rather than sampling all possible habitat (e.g., Jamieson et al. MS1980a; Worms & Chouinard MS1983; Lanteigne et al. MS1987). Thus, these earlier surveys were of limited use to document changes in scallop distribution. This study used a different approach; the survey covered all of SFA 22 and used geostatistics to obtain overall population abundance estimates. This document reports the abundance estimates, distribution contours, and biological information relevant to the sea scallop population that inhabits SFA 22 -- the western half of Northumberland Strait.

Methods

This was a fisheries-independent survey. A 3.7 X 3.7 km grid was overlain over all of SFA 22 for water 5 m and deeper. Four strata were arbitrarily designated based on natural features or bathymetry (each stratum contained about 90 stations) and 30 sampling stations were randomly drawn within each stratum. Extra stations were added when relatively high catches occurred in a stratum (if time permitted). These strata were not used in the data analyses because population estimates were based on kriging rather than stratified random means. We successfully fished 121 stations (Fig. 2). Two planned stations were dropped due to time constraints but three additional stations were added near sea scallop concentrations

The survey was conducted on the CCGV*Opilio*, 3 to 16 June 1997. The timing corresponded to the end of the fishing season to avoid interference with fishing vessels. Most scallop fishing vessels had finished fishing for the year and were preparing to fish other species. Sea scallops were collected with a shallow water scallop drag (= toothed Northumberland or Gulf dredge; Jamieson et al. MS1980a) comprised of eight 48-cm (external measure) steel buckets with 76 mm diameter rings and all steel washers. Four buckets were lined with 38-mm (stretch mesh) shrimp netting. The dredge was towed for 8 minutes at a speed of about 5.6 km/h (about 800 m). Beginning and end locations were determined using differential GPS and tow length (from locking of drum brake to beginning of haul back) was provided by the GPS log. Every live sea scallop captured was measured (shell height SH in mm) and the shell retained for age-determination. Meat weights were measured for a subsample of 509 individuals.

Abundance and Distribution

The abundance of sea scallops > 80 mm SH was based on the four unlined buckets; that of sea scallops 40 to 79 mm SH was based on the four lined buckets. Each tow was standardized to an area of 2,000 m^2. For purposes of analysis, the entire scallop fishing area was considered as a unit and abundance and distribution estimates were determined by ordinary kriging, which is becoming increasingly popular as a means of estimating abundance and quantifying distributions of marine organisms (e.g., Swain & Morin 1996; Hebert et al MS1997; Wade et al. 1997), including sea scallops (Hanson MS1997). Density contours (point kriging with fitted variograms) were plotted for four size-groupings: 40-79 mm, 80-109 mm, 110-155 mm, and 40-155 mm SH. Abundance estimates (block kriging) were calculated for the same four size-groups but the area was divided into two due to the large gap between areas of relatively high concentrations of sea scallops and fundamental differences in biological characteristics of the sub-populations. The first area was located near Cape Tormentine (650 km^2); the second represented the rest of the surveyed area (2,162 km^2). The sea scallop sub-populations inhabiting these two areas received substantially different fishing effort, which was reflected in the age-distributions, size-distributions, and size-at-age of sea scallops of commercial size. The distribution polygons used to generate the abundance estimates encompassed only the area within the survey stations, i.e., there was some suitable scallop habitat within SFA 22 that was not surveyed and it was ignored.

Shell height- and age-distributions

Shell height distributions were determined (in 5-mm increments) for the northwestern Strait and southeastern Strait (Cape Tormentine area) separately. Ages were determined for all sea scallops captured during the survey. The survey was done just as sea scallops were beginning their seasonal growth, thus, the outer edge represented shell height-at-annulus. In the rare cases where new growth was apparent, the shell height-at-annulus was recorded. Separate age-distributions were prepared for the western-most and eastern-most sectors of the survey area. Very few sea scallops were collected in central part of the survey area; therefore, these animals were ignored.

Meat weight determination

Meat weights were measured on 509 individuals. For about 150 animals > 20 g meat weight, the fresh weight was measured (± 1 g, wet weight) at sea. After three days, the sea conditions became too rough to continue this practice and, for the remainder of the survey, the entire animal was frozen intact and subsequently dissected and weighed (to 0.001 g, wet weight) in the laboratory. A sample consisted of all sea scallops captured for about 50% of the sets (sets were chosen at random). A single meat weight-shell height regression was calculated for the entire survey region. A meat weight - shell height key was used to convert shell-height frequency distributions into meat-weight distributions.

The shell-height frequency distributions were bumped up to the population estimated by ordinary kriging for the two sub-populations in the survey zone. The estimates were then multiplied by 10 to correct for dredge efficiency. Caddy (1989) and Worms (MS1984) have used a value of 5 to 8 % efficiency for this type of dredge but the 1997 survey was conducted in early June rather than the late July-August period of the published studies so that bottom temperatures in the 1997 survey were almost 10 °C colder, which means the sea scallops were less active. Furthermore, I used a much wider dredge than the first studies, which reduced escape around the ends in the swept area. Finally, fishermen felt 10% efficiency was the appropriate for this dredge when asked during industry consultations.

Results and Discussion

Distribution (Fig. 3)

There were clear differences in the locations of concentrations of the various size-groups of sea scallops. For the 40-79 mm and 80-109 mm SH size-classes, there was a clear concentration in the southeastern area (Cape Tormentine) but almost no sea scallops > 110 mm SH. There was a large area of almost no sea scallops of any size in the central part of the survey area. Two strong concentrations of 40-79 mm and 80-109 mm SH animals were found in the northwestern part of the survey area. Sea scallops > 110 mm SH were widely dispersed in the northern-western part of the survey area.

The location of sea scallop concentrations changes from year-to-year. A couple of examples illustrate this point. In 1979 (Jamieson et al. MS1980a), sea scallops were abundant in the Bedeque Bay area (currently almost devoid of them), Cape Tormentine, and off the northwest shore of PEI but scarce near West Point and Escuminac -- two areas of relatively high abundance in 1997. In 1983 (Worms MS1984), there were concentrations near West Point (similar to 1997) and offshore from Richibucto (currently almost none). In 1985 (Worms et al. 1986), there were sea scallop concentrations near Richibucto, the northwest shore of PEI, Egmont Bay, and Bedeque Bay -- all areas where sea scallops currently are scarce. The ability of the scallop fleet to locally eliminate sea scallop populations has long been a concern for this SFA (Jamieson et al. MS1980a,b; Worms MS1984) and the status of the fishery does not appear to have improved. In contrast, fishable concentrations seem to persist in the southeastern (Cape Tormentine) area despite the heavy concentration of fishing effort in this area.

Survey coverage is always a concern when studying se scallop populations because management areas usually dictate surveys zones rather than mapping the actual population areas and the current survey does not differ in this respect. The northern-most concentrations suggest that there may be substantial quantities of sea scallops outside of the survey area. This is, of course, true because SFA 22 is contiguous with SFA 21 -- the line of demarcation is one of management convenience. Sea scallop habitat is continuous in water of about 5 to 35 m depths from the end Chaleur Bay along the coast of New Brunswick, throughout Northumberland Strait, all around PEI, and along the west coast of Cape Breton (Worms & Chouinard MS1983, MS1984; Worms MS1984; Worms et al. MS1986). The population around the Magdalen Islands is physically separated from that of the mainland and there are patches of sea scallops along the Gaspé shoreline. Whether there are genetically distinct populations of sea scallops in this area is unknown.

Abundance

The total (scallops 40 to 155 mm SH) population abundance in SFA 22 (not corrected for dredge efficiency) was 10 million animals, of which 7.2 million were of commercial size (>79 mm SH).

Table I. Estimated numbers (based on ordinary kriging) of sea scallops in SFA 22 (CVs in parentheses), June 1997

size	North-western area	South-eastern area	Sum
area (km^2)	2,162	650	2,812
40 - 79 mm	1.64 million (44.7%)	1.40 million (22.6%)	3.04 million
80 - 109 mm	3.30 million (28.2%)	1.34 million (29.6%)	4.64 million
> 109 mm	2.24 million (1.67%)	0.35 million (90.5%)	2.59 million
40 - 155 mm	7.17 million (30.4%)	2.80 million (15.5%)	9.97 million

The average density of sea scallops in SFA 22 at the end of the 1997-fishing season was low compared to previous surveys. Research surveys have been conducted periodically in SFA 22. Similar methods and dredges were used in all years. SFA 22 was divided into 2 zones: Cape Tormentine and the northwestern area.

Table II. Average density of sea scallops in SFA 22. Catches were expressed as number/m^2 for sea scallops > 70 mm SH. Catch rates were not corrected for dredge efficiency.

Year	Cape Tormentine	Northwestern Area
1967	No data	0.0165
1979	0.0032	0.0062
1980	0.0171	0.0078
1981	0.0069	0.0091
1983	0.0032	0.0036
1986	0.0051	No data
1997	0.0027	0.0030

The 1997 catch rates were the lowest in the time series while the catchability in 1997 was better than in previous surveys because the 1997 survey was conducted in early June at water of about 8 to 10 °C while the previous years' surveys were done in July or August when water temperature are much warmer and sea scallops more active. Moreover, there was no sign of strong recruitment in 1997. Taken together, these results indicate the abundance of this population will not increase in the short term.

The overall density from the 1997 survey (based on kriging and assuming 10% dredge efficiency) would be 0.035/m^2 for sea scallops > 39 mm SH. In the past, the densities in this part of the Strait were as high as 4-6 animals/m^2 (Dickie & MacInnes 1957; Caddy 1968) and averaged 0.5/m^2 over much of the area in 1983 (Worms MS1984). Caddy (1968) evaluated sea scallop densities on the Richibucto beds by means of divers and a dredge and obtained densities of 1.4 animals/m^2 on mud and 4.2/m^2 on sand (overall average 1.9/m^2). Currently, there are almost no sea scallops present on this formerly productive bed. Jamieson et al (MS1980b) expressed abundance in the western part of the Strait (1997 strata 1 and 2) as number/58 cm bucket/800 m standard tow (same type of bucket as used in this survey). They observed averages of 3.2 to 5.3 animals per standard tow, which corresponds to 13.8 to 28.8 commercial scallops/ 2000 m^2. For the same area, the current study estimated an average of 5.5 commercial-sized animals/ 2000 m^2. The two surveys are not strictly comparable because Jamieson et al. (MS1980b) only focused on the areas fished; however, the values seen in the 1997 survey do not suggest the population has increased either. Thus if the population estimates reported for 1980 were cause for serious concern, then those estimated for the 1997 survey must be viewed with greater concern because scallop abundance seems to have decreased further.

Biological characteristics

Size-distributions (Fig. 4): The size-distributions clearly differed between the eastern and western parts of the survey area. Animals > 109-mm SH were almost absent from the eastern (Cape Tormentine) area. This is consistent with the very high level of fishing activity in this area.

Age-distributions (Fig. 5): The age-distributions clearly differed between the two areas with animals older than age-10 almost absent from the eastern area. This again is consistent with the concentrated heavy fishing pressure removing the larger and older animals from the Cape Tormentine area.

Size-at-age curves (Fig. 6): The size-at-age curves were essentially identical until age-6 then the mean size of Cape Tormentine sea scallops becomes up to 10 mm smaller-at-age. Chouinard & Mladenov (1991) noted that Cape Tormentine sea scallops were consistently smaller than those in Chaleur Bay and off Pictou Island (eastern Strait). They speculated that some aspect of the thermal regime, or some other physical factors, at Cape Tormentine were responsible for the smaller size-at-age. Although a difference in environmental conditions between regions is a valid cause of differences in bivalve growth, sea scallop populations are also subjected to the effects of intense size-selective fishing (Caddy 1989). Where size-selective fishing intensity (per unit area effort) is higher at one area than another, the size-selectivity of the fishery will result in the area with highest fishing pressure showing the lowest average size-at-age, all other variables being equal (Hanson et al. 1989; Hanson & Chouinard 1992; Krohn & Kerr 1997). However, this size-selectivity operates in addition to, rather than independent from, the effects of any other relevant factors.

Meat weight relationship (Fig. 7): The meat-weight on shell height relationship shows the typical pattern of increased variation with size. One possible use in the SFA 22 context is that the scatter diagram suggests that a 3.5-inch ring would be needed to largely avoid meat weights of < 15 g – a desire that has been expressed by industry during public consultations.

Biomass estimate: By expanding the size-distribution for the two sea scallop groups in SFA 22 by the corresponding population estimate and applying the meat weight key, one obtains a biomass distribution not corrected for dredge efficiency. The overall survey biomass for commercial sized animals was 115 t.

Table III. Meat Weight (tonnes) in survey area (not corrected for dredge efficiency)

Shell height (mm)	Strata 1 to 3	Stratum 4	Total
40 - 155	102.3	28.7	131.0
79 – 155	93.4	21.5	114.9
110 – 155	45.8	2.9	48.6

Assuming 10% dredge efficiency, there were 1,150 mt of meats in commercial-sized sea scallops left in the 2,812 km^2 portion of SFA 22 surveyed at the end of the 1997 fishing season. As was shown by the size-distributions, animals > 109 mm SH were all but absent from the eastern-most (Cape Tormentine) area. The fishermen felt that 10% efficiency was more correct than the 5-8% estimate published by (Caddy 1968; Worms MS1984) because the previous work was done after the scallop fishery ended and at much warmer water temperatures. During May to the first week of June, the water temperatures on scallop grounds rise from near freezing to 8 to 10 °C, which means the animals are less active and more vulnerable to the dredge in spring than during summer months. Using the lower correction factor is also a less hazardous (to the stock) approach than assuming only 5% efficiency, which doubles the apparent population biomass.

Acknowledgments

E. Wade performed the kriging analyses. Technical support was provided by A. Bédard and L.-A. Davidson. Thanks to M. Biron and L.-A. Davidson for their valuable comments on an earlier version of this document.

References

Caddy, J. F. 1968. Underwater observation on scallop (*Placopecten magellanicus*) behaviour and drag efficiency. Journal of the Fisheries Research Board of Canada 25: 2123-2141.

Caddy, J. F. 1989. A perspective on the population dynamics and assessment of scallop fisheries, with special reference to sea scallop, *Placopecten magellanicus* Gmelin. p. 559-589. *In* J. F. Caddy [ed.]. Marine invertebrate fisheries: their assessment and management. John Wiley and Sons, Inc. New York, NY.

Chouinard, G.A. & Mladenov, P. V. 1991. Comparative growth of the sea scallop (*Placopecten magellanicus*) in the southern Gulf of St. Lawrence. In J.-C. Theriault [ed.] The Gulf of St. Lawrence: small ocean or big estuary? Canadian Special Publication of Fisheries and Aquatic Sciences 113: 261-267.

Dickie, L. M. & MacInnes, C. D. 1958. Gulf of St. Lawrence scallop explorations -- 1957. Fisheries Research Board of Canada Manuscript Report Series No. 650.

Hanson, J. M. MS1997. Results of 1996 research surveys of sea scallop abundance in areas near Grand Manan Island and Cape Spencer, Bay of Fundy. Department of Fisheries and Oceans Canadian Stock Assessment Secretariat Research Document 97/46. 20 p.

Hanson, J. M. & Chouinard, G. A. 1992. Evidence that size-selective mortality affects growth of Atlantic cod (*Gadus morhua* L.) in the southern Gulf of St. Lawrence. Journal of Fish Biology 41: 31-41.

Hanson, J. M., Mackay, W. C. & Prepas, E. E. 1989. Effect of size-selective predation by muskrats (*Ondatra zebithicus*) on a population of unionid clams (*Anodonta grandis simpsoniana*). Journal of Animal Ecology 58: 15-28.

Hebert, M., Wade, E., DeGrace, P., Biron, M. & Moriyasu, M. MS1997. 1996 assessment of snow crab (*Chionectes opilio*) stock in the southern Gulf of St. Lawrence (Areas 12, 18, 19, 25/26, and Zones E and F). Department of Fisheries and Oceans Canadian Stock Assessment Secretariat Research Document 97/86. 60 p.

Jamieson, G. S., Witherspoon, N. B. & Lundy, M. J. MS1980a. Assessment of Northumberland Strait scallop stocks - 1979. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 80/73. 38 p.

Jamieson, G. S., Witherspoon, N. B. & Lundy, M. J. MS1980b. Assessment of Northumberland Strait scallop stocks - 1980. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 80/78. 45 p.

Krohn, M. & Kerr, S. R. 1997. Declining weight-at-age in northern cod and potential importance of the early years and size-selective fishing mortality. NAFO Science Council Studies 29: 43-50.

Lanteigne, M. & Davidson, L.-A. MS1989. Évaluation de la pêcherie du pétoncle géant (*Placopecten magellanicus*) dans le sud du golfe de Saint Laurent, 1988. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 89/20. 23 p.

Lanteigne, M., Davidson, L.-A. & Worms, J. MS1987. Status of southern Gulf of St. Lawrence scallop stocks - 1986. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 87/84. 40 p.

Swain, D. P. & Morin , R. 1996. Relationship between geographic distribution and abundance of American plaice (*Hippoglossoides platessoides*) in the southern Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Sciences 53: 106-119.

Wade, E., LeBlanc, M. & Moriyasu, M. 1997. Geostatistical analysis of sediment distribution in the southern Gulf of St. Lawrence snow crab fisheries. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2177. 16 p.

Worms, J. MS1984. Scallop biomass and density estimates in the southern Gulf of St. Lawrence. . Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 84/90. 26 p .

Worms, J. M. & Chouinard, G. MS1983. Status of southern Gulf of St. Lawrence scallop stocks - 1982. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 83/68. 52 p.

Worms, J. M. & Chouinard, G. MS1984. Status of southern Gulf of St. Lawrence scallop stocks - 1983. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 84/57. 48 p.

Worms, J., Lanteigne, M. & Davidson, L.-A. MS1986. Status of the southern Gulf of St. Lawrence scallop stocks - 1985. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 86/55. 46 p.

Figure 1. Boundaries of the principal scallop fishing areas in the southern Gulf of St. Lawrence.

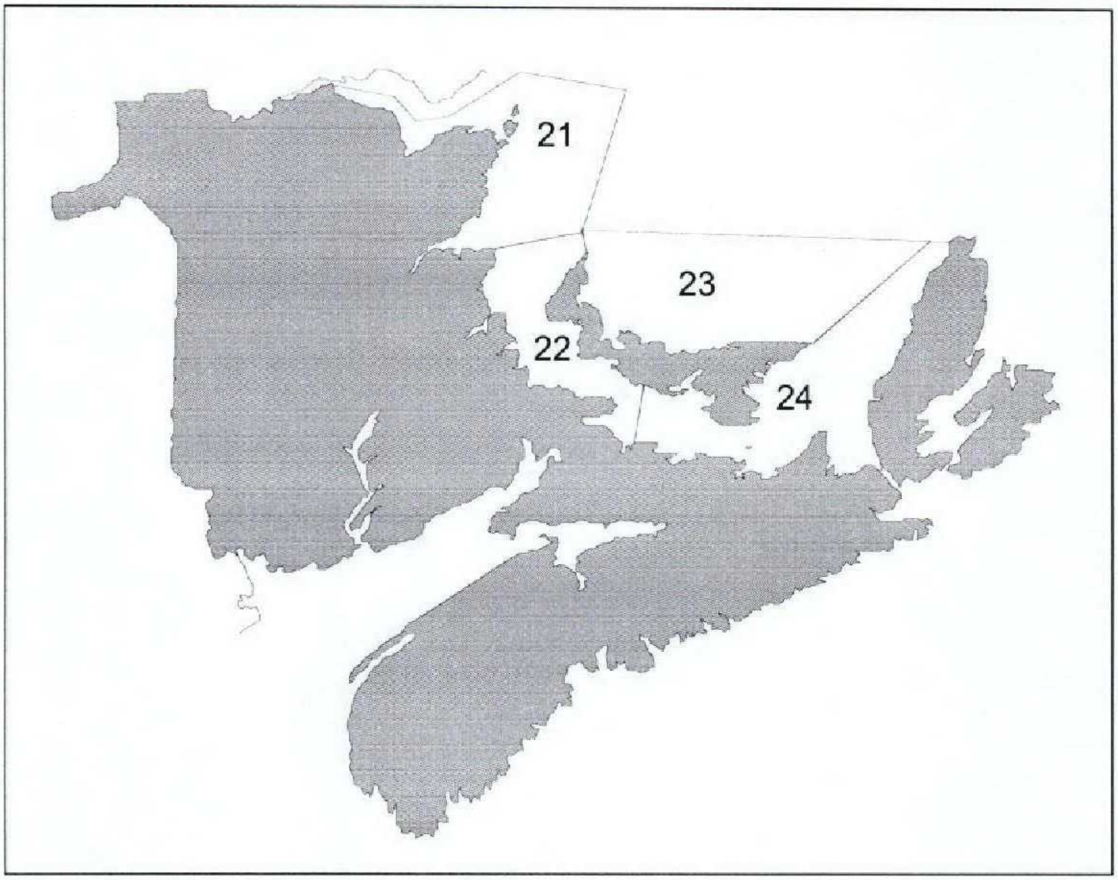


Figure 2. Locations of survey sets in Scallop Fishing Area 22 during the 1997 research survey.

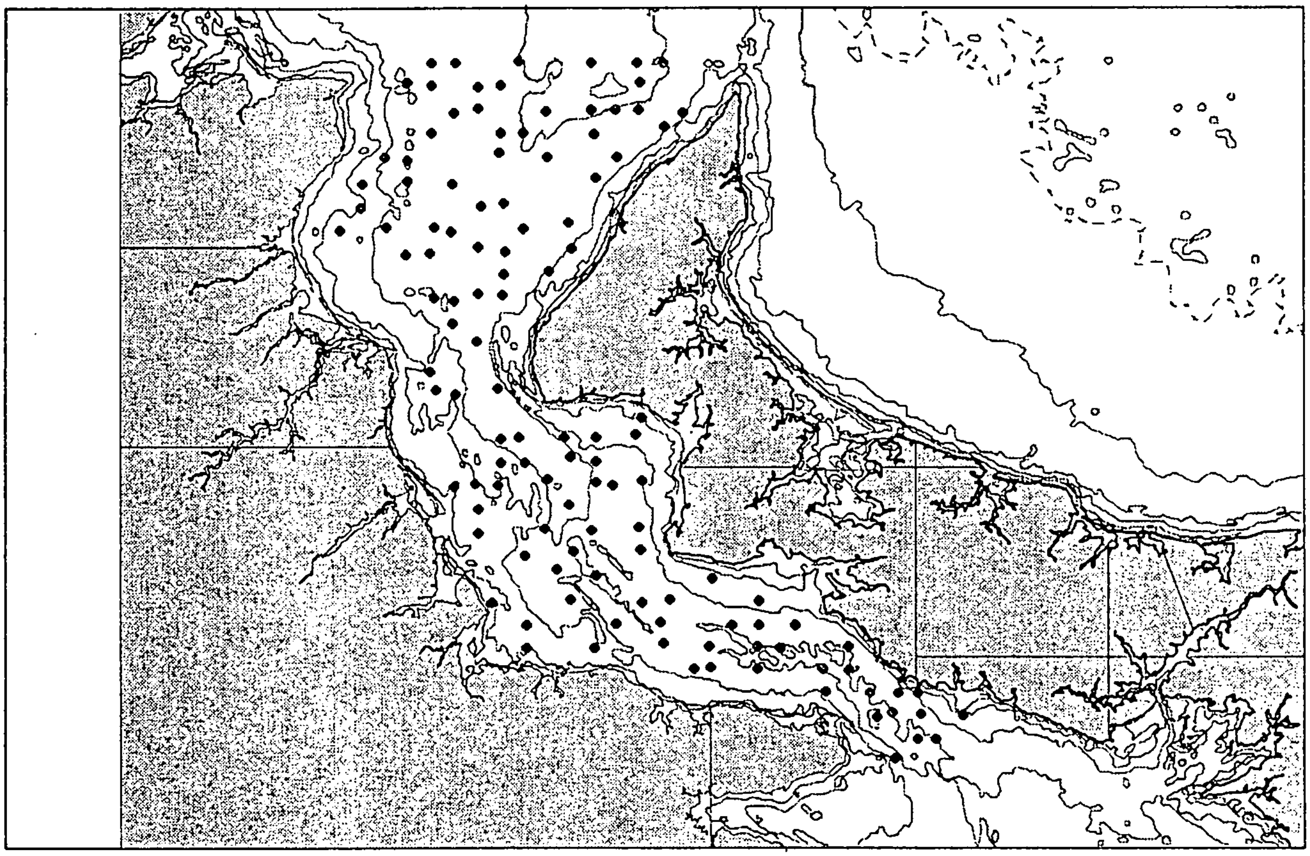


Figure 3A. Location of concentrations of sea scallops 40-79 mm SH in SFA 22 during June 1997.

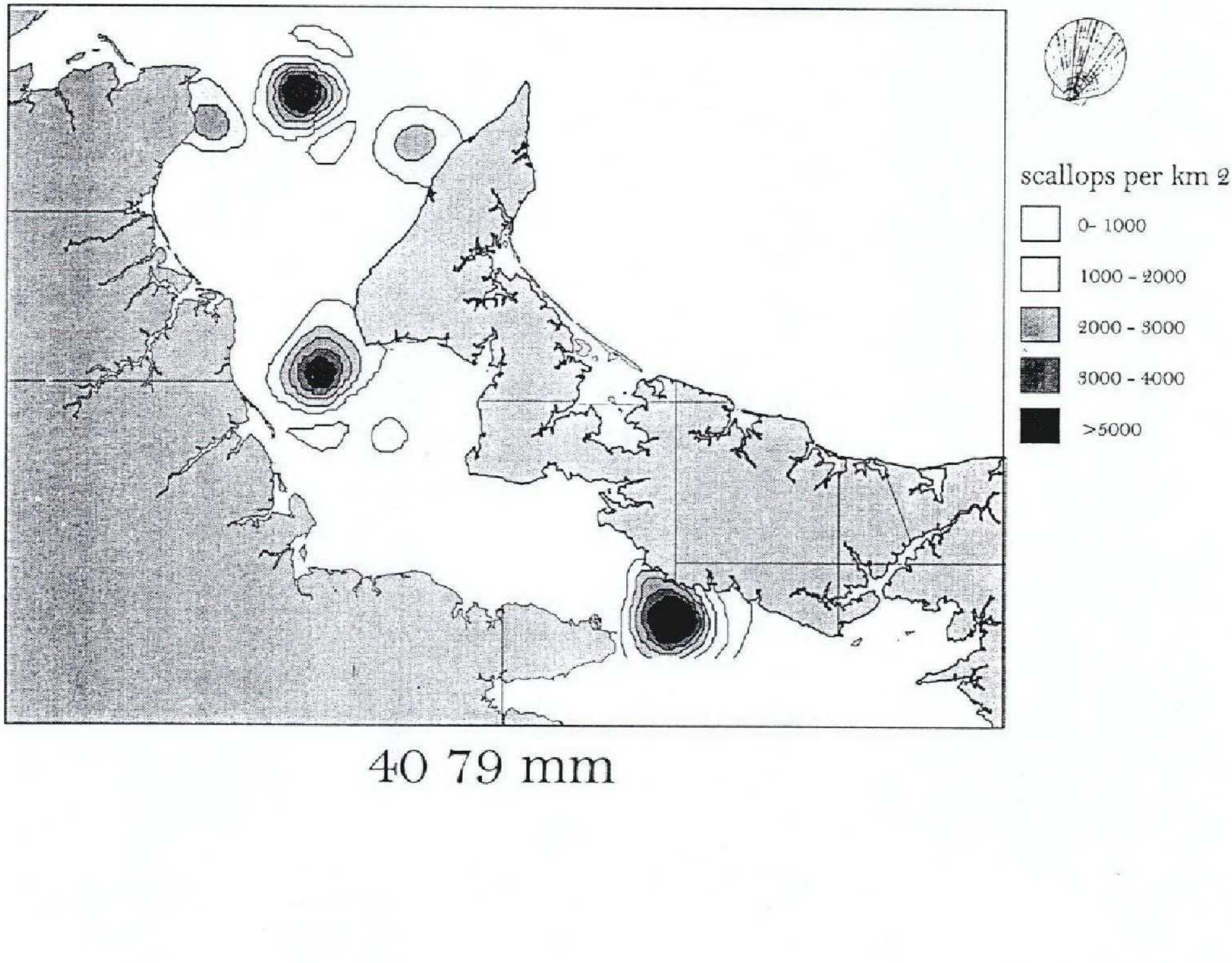


Figure 3B. Location of concentrations of sea scallops 80-109 mm SH in SFA 22 during June 1997.

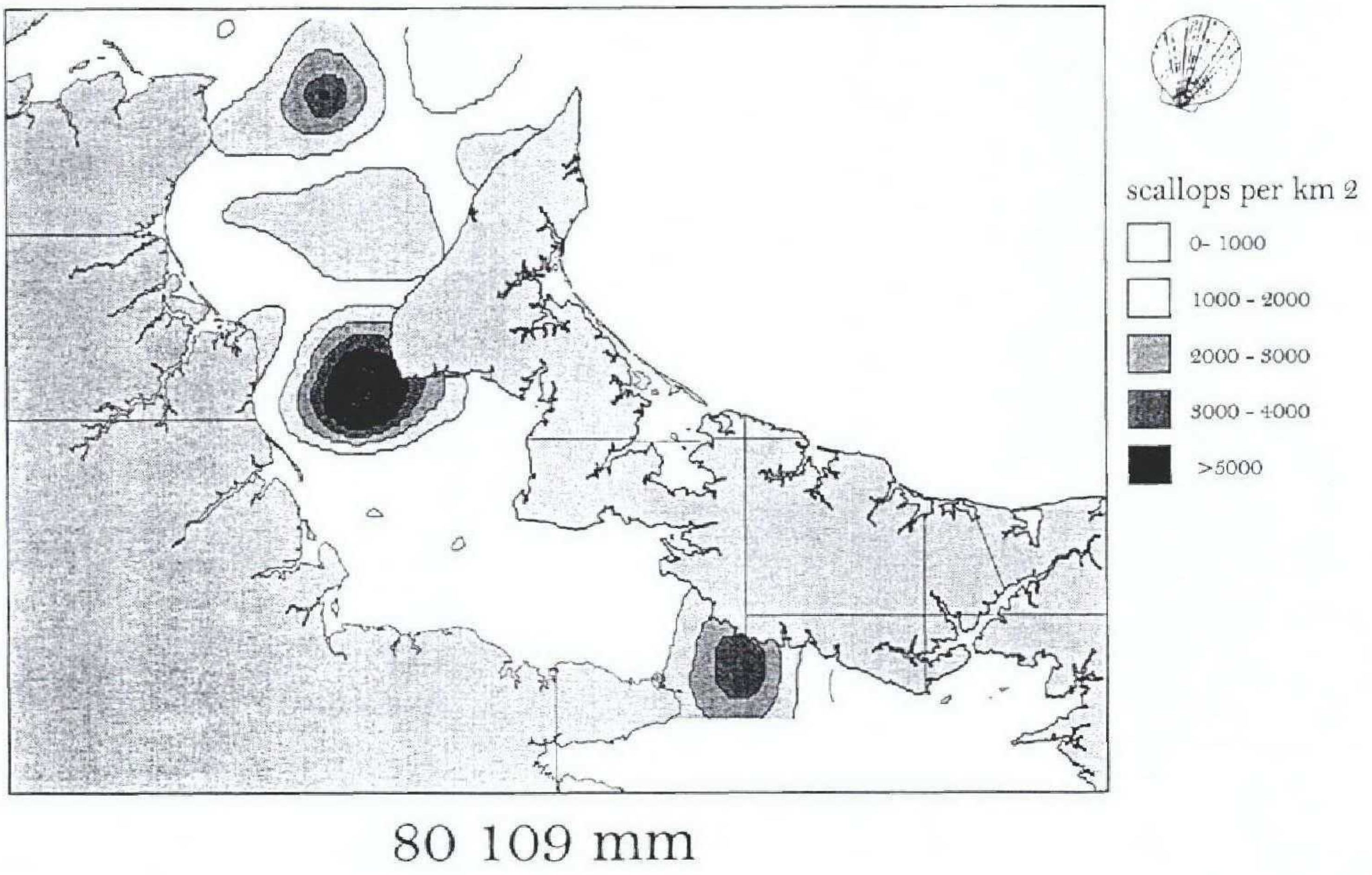
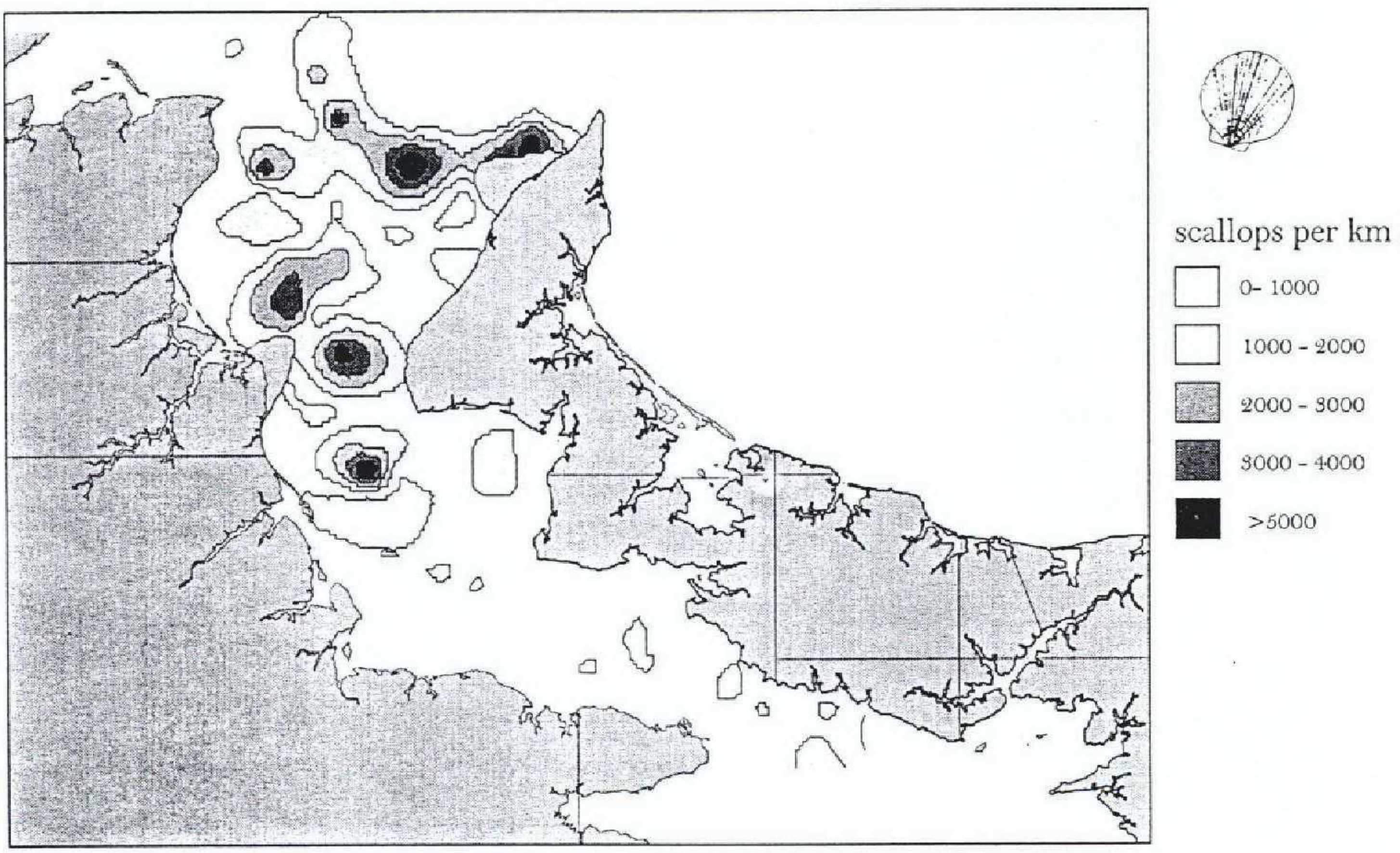


Figure 3C. Location of concentrations of sea scallops 110-155 mm SH in SFA 22 during June 1997.



110 155 mm

Figure 3D. Location of concentrations of sea scallops 40-155 mm SH in SFA 22 during June 1997.

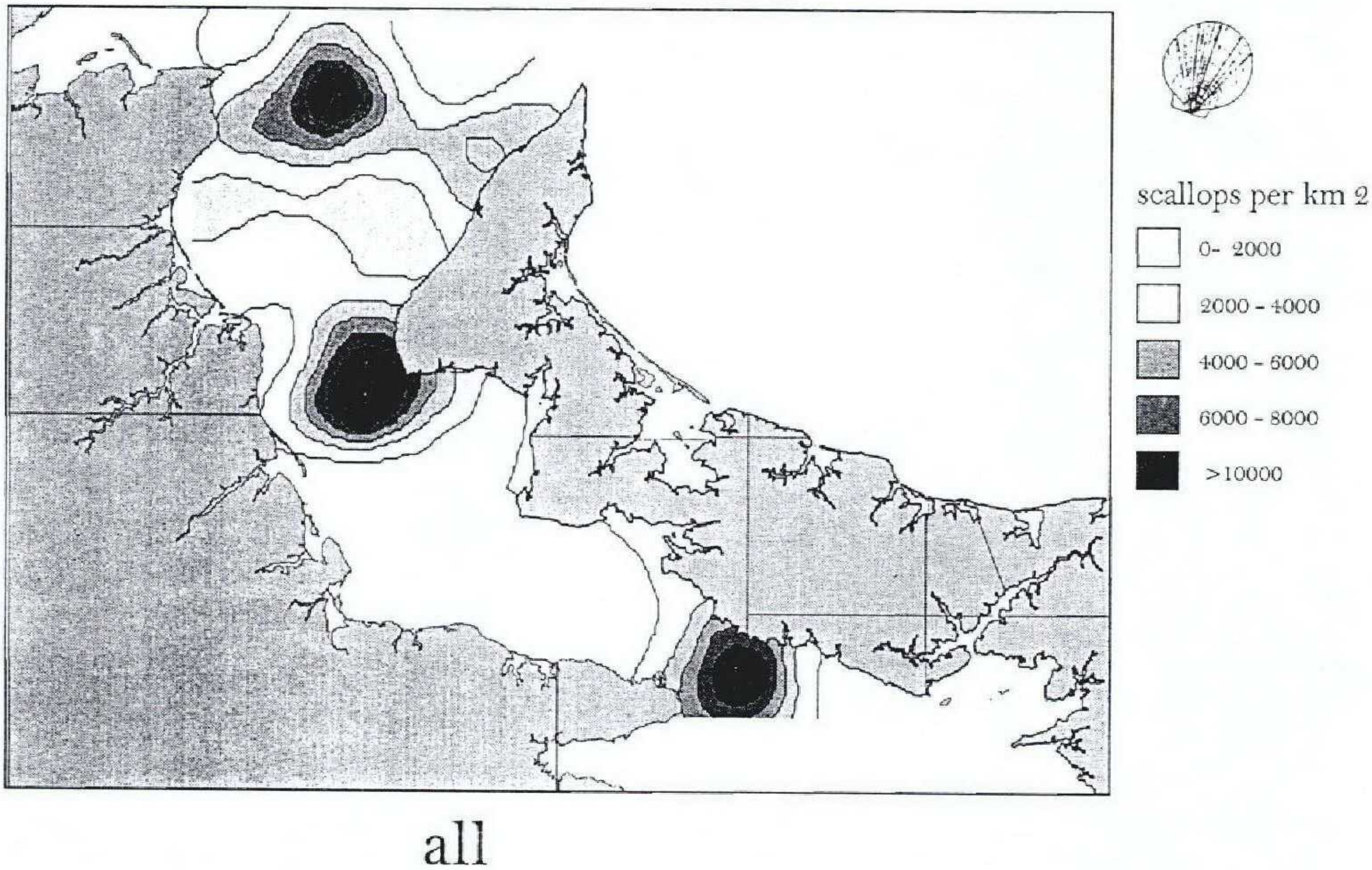


Figure 4. Shell height distributions of sea scallops in the south-eastern part of the survey area (open bars) and the north-western part of the survey area (solid bars).

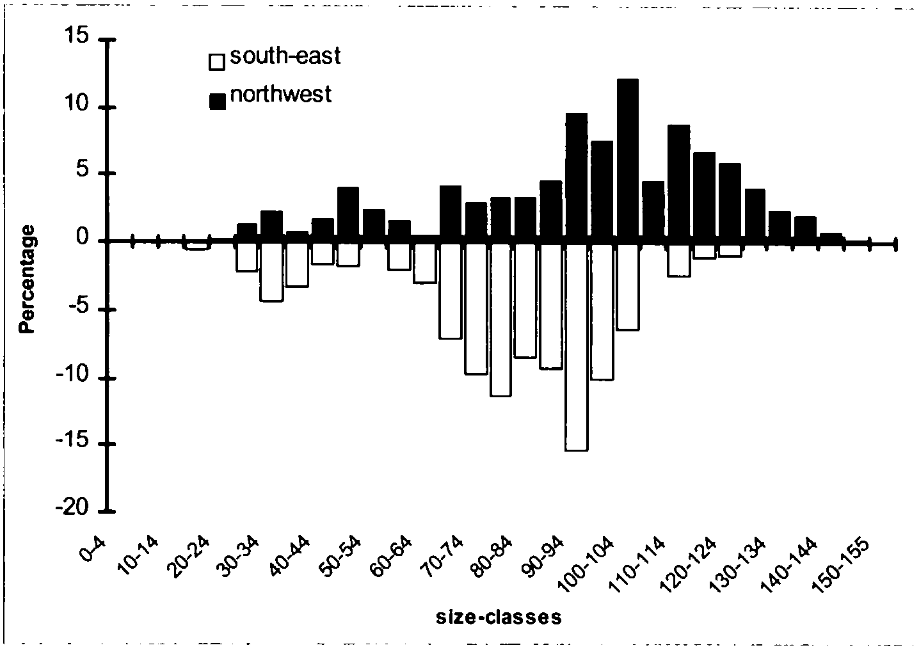


Figure 5. Age distributions of sea scallops in the south-eastern part of the survey area (open bars) and the north-western part of the survey area (solid bars).

Figure 6. Shell height–at-annulus of sea scallops in the south-eastern part of the survey area (solid line) and the north-western part of the survey area (dashed line).

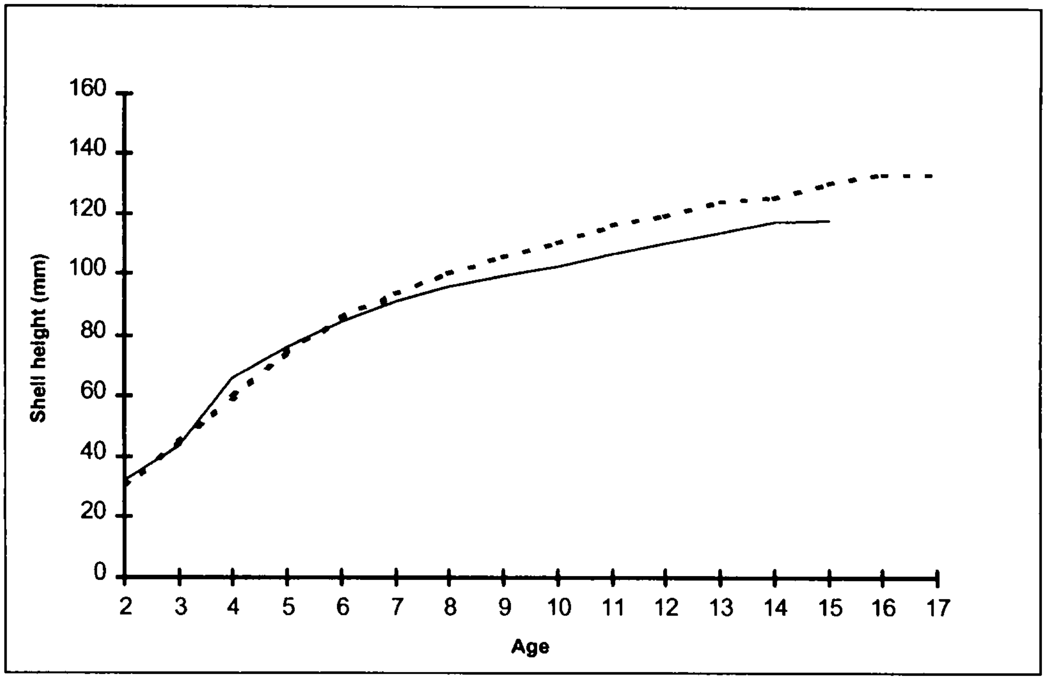


Figure 7. Scatter plot of meat weight (wet weight) and shell height for sea scallops in SFA 22, June 1997. Ln Y = 2.92 Ln X −10.75; $r^2 = 0.96$; $P \ll 0.001$.