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Distribution, Abundance, and Preliminary Estimates of Production Potential for the Ocean Quahaug (*Arctica islandica*) and Stimpson's Surf Clam (*Spisula polynyma*) on the Scotian Shelf

by

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ABSTRACT

Both the ocean quahaug (Arctica islandica) and Stimpson's surf clam (Spisula polynyma) resources of the Scotian Shelf appear to have potential for future exploitation. Six areas, totalling 2,452 km², on Western and Sable Island Banks had a mean quahaug density of 0.256 kg/m² and a biomass on the order of 628 kilotons. Additionally, two areas, totalling 2,298 km², on Banquereau Bank had a mean surf clam density of 0.244 kg/m² and a biomass on the order of 561 kilotons. Mean densities of ocean quahaugs and Stimpson's surf clams on the remaining areas of these banks were 0.042 and 0.034 kg/m² respectively and unlikely to support commercial activity.

Using instantaneous natural mortality (M) rates of 0.020 and 0.043 for ocean quahaugs, a MSY of between 6,277-13,495 t was derived. For Stimpson's surf clam a MSY of 16,821 t was derived using M=0.060.

RESUME

Les ressources de la plate-forme Scotian en quahaug nordique (Arctica islandica) et en mactre de Stimpson (Spisula polynyma semble offrir dans les deux cas un potentiel intéressant pour une future exploitation. Six zones, d'une superficie totale de 2 452 km^2, sur les banc Western et de l'Ile de Sable possédaient une densité moyenne de quahaug nordique de 0,256 kg/m^2 et une biomasse de l'ordre de 628 kilotonnes. En outre, deux zones, totalisant 2 298 km^2, sur le Banquereau possédaient une densité moyenne en mactres de 0,244 kg/m^2 ainsi qu'une biomasse de l'ordre de 561 kilotonnes. Les densités moyennes de quahaug nordique et de mactre de Stimpson dans les zones restantes de ces banc étaient respectivement de 0,042 et de 0,034 kg/m^2 et peu propices au soutien d'une activité commerciale rentable.

En se servant de taux instantanée de mortalité naturelle (M) de 0,020 et de 0,043 pour les quahaugs nordique, les auteurs ont dérivé un RMC situé entre 6 277 et 13 495 t. Pour ce qui est de la mactre de Stimpson, un RMC de 16 821 t a été extrapolé à partir d'un M de 0,060.

INTRODUCTION

In 1980, a fisheries development program was initiated by the Invertebrates and Marine Plants Division, Halifax, to determine resource potentials of the ocean quahaug (Arctica islandica) and other underutilized clam species on the Scotian Shelf. Between 1980 and 1983, exploratory hydraulic dredge surveys were conducted in nearshore areas along the southshore of Nova Scotia between St. Mary's Bay and St. Margaret's Bay, and on the offshore banks of the Scotian Shelf. These were the first surveys to suggest that both A. islandica and the Stimpson's surf clam, Spisula polynyma might have commercial potential in some areas of the Scotian Shelf (Rowell and Chaisson, MS 1983). The offshore areas of Sable Island and Western Banks were found to have the highest concentrations of A. islandica and Banquereau Bank the greatest concentrations of S. polynyma.

While to date in eastern Canada, A. islandica supports only small inshore fisheries in southwest Nova Scotia and Prince Edward Island, in the eastern United States this species supports major fisheries on offshore banks. The recent findings of concentrations on the Scotian Shelf may therefore, result in the development of a fishery.

Although there are no known concentrations of S. polynyma off the eastern United States; a similar species, Spisula solidissima, supports major fisheries. Consequently, S. polynyma concentrations on the Scotian Shelf are thought to have commercial potential as a substitute for S. solidissima.

This paper is directed primarily at describing the A. islandica and S. polynyma resources of those areas appearing to have greatest commercial potential. Accordingly, information on the resource level in inshore (S.W. Nova Scotia) and nearshore areas (St. Anns Bank) is provided only in summary form. For the offshore areas, general distribution and densities are provided for both species. Catch rates, minimum biomass estimates, and ranges of probable MSY levels are presented only for those banks having definable areas of contiguous stations with moderate to high densities (i.e. ≥ 0.100 kg/m^2).

MATERIALS AND METHODS

Inshore Surveys

Inshore surveys (generally within 3 nm of shore) were conducted in 1980 from a 11.6 m chartered vessel, the Garry and Renee II, and in 1981 and 1982 from the 14.6 m Department of Fisheries and Oceans vessel Sigma T. The operations are described by Rowell and Chaisson (MS 1983).

Nearshore and Offshore Surveys

The nearshore and offshore surveys (depths >25 m) on the Scotian Shelf from 1980 to 1983 were conducted using the U.S. National Marine Fisheries Service research vessel Delaware II.

The vessel was equipped with a stern mounted hydraulic dredge fitted with a submersible pump (Crossen and Smolowitz, 1980). The dredge measured

5.2 m in length with a 152.4 cm wide cutting blade and used approximately 7,570 liters of water per minute. Cutting depth of the blade was set at 20.3 cm, and the dredge cage was fitted with a 5.1 cm square mesh steel liner. The length of the cutting blade and the distance towed were used to determine area dredged per station.

Areas to be surveyed, with suitable bottom sediment types and approximate maximum working depths of 85 m, were first determined from surficial geology and hydrographic charts. Where areas were large enough for a systematic grid survey, sampling stations were established along Loran C lines (approx. 5 nm or 9.3 km apart) at intervals of 5 nm to 10 nm (9.3 km to 18.5 km). During the survey operations, suitability of the topography and bottom sediment type at the designated station were determined prior to dredging. If suitable bottom was not found after a search of the immediate station area, the station was omitted.

Tow depths ranged from 29 m to 92 m with 99% of the stations in less than 85 m. Tows were usually 5 minutes in duration, and the actual tow length was determined using the vessel's doppler navigational gear.

On completion of each tow, the dredge contents were dumped on deck and the catch was sorted. Major clam species were separated and the volume of each was measured in bushels. For each clam species, up to one bushel was measured for length-frequency and the remaining clams counted. Length was taken as the maximum shell measurement in the anterior-posterior plane. Total weight per bushel was also obtained at selected stations on each bank, and samples were frozen for later determination of length-weight relationships.

Length frequency distributions of the two species were determined for each station. Using the overall length-weight relationships for each species, the mean weight of sample at each station was obtained by compounding the mean weight of clams at each size class. The resulting mean weight was then multiplied by the total number of clams in the catch to obtain an estimate of the total catch weight. The total catch weight was then divided by the number of square meters covered in each tow to give density in kg/m^2.

Stations with densities ≥ 0.1 kg/m^2 for either *A. islandica* or *S. polynyma* were considered to suggest significant concentrations. Where these stations were contiguous, boundary lines were drawn to best describe the areas of higher density. The areas encompassed were calculated using a Hewlett Packard 9825 digitizer with a planimeter program package.

Biomass estimates were made by areal expansion, using mean station density, for each of these higher density areas.

Estimates for Maximum Sustainable Yield (MSY) or C_{max} were calculated using the formula $C_{max} = X\ M\ B_o$ (Gulland, 1971) where M = instantaneous rate of natural mortality; B_o is the virgin stock size; and X, the proportion of B_o which may be harvested annually, is 0.5.

RESULTS AND DISCUSSION

General Distribution and Densities

Inshore and offshore areas surveyed through 1980-1983 are shown in Figure 1.

Distribution and abundance of the target species observed in the inshore surveys (Area A in Figure 1) are reported elsewhere (Rowell and Chaisson, MS 1983). In summary, the inshore survey, totalling 161 km^2, indicated small areas of high ocean quahaug density (mean =0.505 kg/m^2) dispersed widely among a number of bays in southwestern Nova Scotia. No concentrations of Stimpson's surf clam were found inshore.

A total of 259 stations were sampled in the nearshore and offshore areas using Delaware II (Rowell and Chaisson MS, 1983; Chaisson, and Rowell, MS 1985).

In the nearshore area of St. Ann's Bank (Area B in Figure 1) and from the smaller banks immediately north of Banquereau (Artimon, Canso, Misaine) catches were very limited. Fifty-two preselected stations were visited on St. Anns Bank, of which only 9 could be fished. Very small numbers of A. islandica and S. polynyma were taken at only 3 and 4 stations respectively. Again, on the 11 stations that proved fishable on the smaller banks north of Banqureau very small catches were taken.

On the major offshore banks, aside from Western and Sable Island Banks, where the greatest concentrations of A. islandica were found, and Banquereau Bank, where the greatest concentrations of S. polynyma were found, no contiguous stations having high densities were encountered (Fig. 2-5). At most dredgeable offshore stations A. islandica densities were usually less than 0.099 kg/m^2, with occasional densities up to 0.2 kg/m^2. S. polynyma also occurred often in these offshore areas and, again, densities were generally less than 0.099 kg/m^2. However, with S. polynyma there were more occurrences of stations with densities greater than 0.2 kg/m^2, particularly in the areas shown in Figure 2.

Areas of high densities of A. islandica and S. polynyma are shown in Figure 4 and 5 respectively. A. islandica was present in 111 of the 130 stations (85%) sampled on Sable Island Bank and Western Banks. Although 46% of the stations also carried S. polynyma, densities of this species did not exceed 0.099 kg/m^2.

S. polynyma was present in 65 of the 70 stations (93%) sampled on Banquereau Bank. Although 26% of the stations carried A. islandica, their densities were generally less than 0.099 kg/m^2 with one station having a density in the range of 0.1-0.2 kg/m^2.

Table 1 presents information on the range and mean densities of the two species on the offshore banks and for the combined inshore area. Mean densities were generally very low for all areas with the exception of A. islandica on Areas 1-6 of Western and Sable Island Banks at 0.256 kg/m^2 and S. polynyma on Areas 1-2 of Banquereau Bank at 0.244 kg/m^2. The remaining area of Western and Sable Island Banks, although large

(11,830 km^2), had a mean density of only 0.042 kg/m^2. Similarly, on Banquereau, the 6,884 km^2 area remaining outside of Area 1 and 2 had a mean density of only 0.034 kg/m^2. Inshore densities for A. islandica were generally higher than those found in the offshore and both the highest station density (9.4 kg/m^2) and mean density (0.505 kg/m^2) were found inshore. Despite high densities, the areal extent of the inshore A. islandica resource is more limited and hence unlikely to support a major fishery. No S. polynyma were found inshore.

Fogarty (MS 1979, 1981) reported mean ocean quahaug densities of 0.329 kg/m^2 and 0.377 kg/m^2 and a peak density of 4.45 kg/m^2 from hydraulic dredge surveys in Rhode Island Sound and off Martha's Vineyard. Fogarty (1981) also presents an estimated mean density of 0.401 kg/m^2 for Rhode Island based on grab and SCUBA sampling by Bearse (1976). These estimates, from an inshore environment, are of the same order of magnitude as those reported here for inshore areas of the Scotian Shelf. Fogarty (1981) also provides data on inshore versus offshore meat weight (kg/m^2) which suggest that A. islandica densities in the offshore waters are considerably lower than those seen inshore. This corresponds to the density patterns observed between inshore and offshore areas of the Scotian Shelf.

Catch Rates

Catch rate information, in numbers and in U.S. bushels per standard 5 minute tow, for A. islandica in Areas 1-6 of Western and Sable Island Banks are presented in Table 2 and for S. polynyma in Areas 1-2 of Banquereau Bank in Table 3.

Mean catches of A. islandica for Areas 1-6 ranged in numbers from 585 to 1,076 and from 1.9 to 3.1 bushels per standard tow (Table 2). Murawski and Serchuk (MS 1983) report ocean quahaug abundance in mean numbers per standard 5 minute tow for the six Fisheries Conservation Zone (FCZ) assessment areas off the northwestern U.S. for the period between 1965 to 1982. The vessel and gear on which these catch rates are based is the same as used in this survey of the Scotian Shelf. In the two most productive assessment areas, Long Island and Southern New England, mean numbers per tow, ranging from 216 to 329 and 146 to 305 respectively, were well below those seen in Areas 1-6 of Western and Sable Island Bank. This may be, in part, a reflection of the long period of exploitation off the U.S. while the Scotian Shelf resource is in a virgin state.

Mean catches of S. polynyma for Areas 1-2 ranged in numbers from 232 to 506 and from 1.6 to 2.6 bushels per standard tow (Table 3). Hughes and Bourne (1981) report on overall catch rate of 22.2 bu. per hour, with a range of 11.3 to 35.5 bu. per hour for individual survey blocks during a survey of S. polynyma in Alaskan waters. The gear used in the Alaskan survey had a cutting blade of 184 cm, 20.7% wider than that used in our survey. If their catch rates are adjusted to correspond to a 152.4 cm cutting blade and standard 5 minute tow, the overall mean catch rate is 1.5 bu. and the range among the means of individual survey blocks is 0.8 to 2.4 bu. Murawski and Serchuk (MS 1984) report abundance for the surf clam S. solidissima in mean numbers per standard 5 minute survey tow for four assessment zones off the northeastern U.S. for the period between 1965-1984. Mean numbers for all

areas and years are generally well less than 100 per tow and, with one exception (621.33 during the December 1978 survey), ranged between 2.06 and 162.89 per tow. These catch rates are well below those seen for S. polynyma in Areas 1-2 of Banquereau Bank. Again, this maybe in part a reflection of the major fisheries operating off the U.S. and the virgin state of the Scotian Shelf resource.

Biomass

Mean densities, biomass, and 90% C.I. on the biomass estimates for A. islandica in Areas 1-6 of Western and Sable Island Banks and S. polynyma in Areas 1-2 of Banquereau Bank are presented in Table 4. Estimates have been restricted to these areas since the density and catch rates over the remaining areas of the banks are, on the basis of the data available from this survey, too low to suggest any commercial fishery potential. Further surveys with tighter sampling patterns could, however, locate fishable concentrations in these remaining areas.

It is common practice to estimate abundance of clam stocks by areal expansion (Murawski and Serchuk, MS 1979; Serchuk and Murawski, MS 1980; Fogarty, 1981). Here, the mean catch per tow (kg/m^2) in the area is multiplied by the total bottom area. Because of factors such as the gear not fishing 100% of the clams in its path, or the dredge not retaining 100% of catch, these provide only minimum estimates of biomass. It is recognized that the boundary lines of the high density areas, as presented in Figure 4 and 5, are subjective and that the areal estimates and resultant biomass estimates could be influenced by any error in their placement. Errors are also inherent in the limited number of sampling stations per unit of area used in exploratory surveys such as these. The choice of a 90% C.I. on the biomass estimates was based on recognition of the exploratory nature of the surveys.

Biomass for A. islandica in the combined Areas 1-6 (2,452 km^2) of Western and Sable Island Banks is estimated at 627,712 t with a 90% C.I. of 534,536-720,888 t. For S. polynyma in combined Areas 1-2 (2,298 km^2) of Banquereau Bank the biomass is estimated at 560,712 t with a 90% C.I. of 395,256-726,168 t.

The remaining areas, while unlikely to support commercial fishing due to low densities, do contain large biomasses. On Western and Sable Island Banks the biomass of A. islandica in the remaining area (11,830 km^2) is estimated at 496,860 t; while the remaining area of Banquereau (6,884 km^2) on Banquereau Bank the biomass of S. polynyma is estimated at 234,056 t. These commercially unfishable stock components should provide a substantial buffer against recruitment overfishing.

Potential for Sustained Yield

Preliminary estimates of maximum sustainable yield (Table 5) have been derived for A. islandica in combined Areas 1-6 and for S. polynyma in combined Areas 1-2 using Gulland's (1971) model $C_{max} = 0.5\ M\ B_o$ at rates of natural mortality considered likely to apply for each species respectively. Gulland's model is particularly useful for cases, such as these exploratory surveys, where insufficient data are available for the application of dynamic pool or surplus production models. The model has been, and continues to be, used in the assessment of U.S. clam fisheries and was considered appropriate for preliminary assessment of the Alaskan S. polynyma stock by Hughes and Bourne (1981).

Rather than presenting a wide range of possible instantaneous rates of natural mortality for A. islandica we selected two rates. The lower of these, 0.020, is the intermediate of three natural mortality values currently used in assessments of U.S. ocean quahaug stocks (0.01, 0.02, 0.03). Serchuk and Murwaski (MS 1980) provide survivorship data suggesting mortality rates of between 0.02-0.027. M = 0.043, used as our higher mortality rate, is that calculated from age and length-frequency analysis of ocean quahaugs in inshore N.S. waters (Rowell and Chaisson, MS 1983).

For S. polynyma in Alaskan waters, Hughes and Bourne (1981) found a maximum age of 25 years, and using Ricker's (1975) model derived two very different values of M (0.1272 and 0.2504) in different years of their survey (1977 and 1978). In calculating values of MSY, they used the mean of these two rates (M=0.19). Rowell and Chaisson (MS 1983), using the growth curve of Feder et al. (1976) for Alaskan Clams and the length frequency data for clams from Banquereau Bank, calculated a M=0.245. Limited age data (Fig. 6) for Banquereau Bank S. polynyma suggest that the maximum age for these clams is as high as 50-60 years. The apparently much slower growth rate and older maximum age of Banquereau Bank clams suggest a much lower rate on instantaneous mortality is likely to apply. In view of this, a further calculation of M was made using the 95% rule ($M=3/T_{max}$), where T_{max} represents the age at which 95% of a cohort in the population would have died off. Available age data indicate that T_{max} would be roughly 50 years, and M=0.06. When this approach to the estimation of M is applied to Alaskan clams with a T_{max} of roughly 25 years, a value of M=0.12 is derived, agreeing well with the lower of the two estimates developed by Hughes and Bourne (1981).

Using the mortality rates of 0.020 and 0.043 for A. islandica, a MSY of between 6,277-13,495 t may be projected for Areas 1-6 on Western and Sable Island Banks (Table 5). Application of a 90% C.I. increases this range to between 5,345-15,499 t.

Application of the more conservative of our estimates of natural mortality (M=0.06) in the Gulland model indicates an MSY on the order of 16,821 t is possible for Areas 1-2 of Banquereau Bank. Use of a 90% C.I. gives a range on the MSY estimate of between 11,858-21,785 t.

It has been shown for the surf clam S. solidissima that dredge induced mortalities of clams left unfished may vary between 30-92% depending on dredge performance (Meyer et al., 1981). Murawski and Serchuk (MS 1979) applied a correction to the MSY's derived by Gulland's model to reflect dredge induced mortality. U.S. Fishery Management Plans for ocean quahaugs have also taken account of the influence of dredge related mortalities on MSY levels, using a range of values (0.4, 0.5, 0.6) and reducing the MSY level accordingly. This correction was based on the belief that dredge mortality to non-harvested quahaugs was between 40 to 60% of the amount harvested (Anonymous, MS 1981). When the generally high harvesting efficiency of hydraulic dredges is taken into account, it seems unlikely that dredge induced mortality would reach these levels. However, the potential for such non-catch mortality warrants a conservative approach to the initial exploitation of the resource.

CONCLUSIONS

Densities of A. islandica and S. polynyma are relatively low over most areas of the Scotian Shelf and few areas are likely to support commercial activity. Three offshore banks (Western, Sable Island, and Banquereau) do show concentrations likely to be capable of supporting commercial fishing actiities, Western and Sable Island Banks for A. islandica and Banquereau Bank for S. polynyma.

While concentrations of A. islandica and S. polynyma appear restricted to specific areas of Western and Sable Island Banks and Banquereau Bank respectively, a large biomass of each species exists on the remaining areas of these banks. The existence of these large biomasses in apparently commercially unfishable concentrations provides a substantial buffer against recruitment overfishing.

Inshore areas of S.W. Nova Scotia also have concentrations with sufficiently high densities of A. islandica to support smaller fisheries.

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Table 1. Range and mean densities (kg/m^2) of *A.islandica* and *S.polynyma* by bank and area.

Bank	Area (km^2)	*A. islandica* Density (kg/m^2)		*S.polynyma* Density (kg/m^2)	
		Range	Mean	Range	Mean
Emerald	457	0.0 - 0.044	0.009	0.0 - 0.0	0.0
Middle	2,304	0.0 - 0.191	0.032	0.002 - 0.149	0.023
Western and Sable					
Areas 1-6	2,452	0.034 - 0.585	0.256	* *	*
Remainder	11,830	0.0 - 0.182	0.042		
Total	14,282	0.0 - 0.585	0.094	0.0 - 0.060	0.005
Banquereau					
Areas 1-2	2,298	* *	*	0.066 - 0.678	0.244
Remainder	6,884			0.001 - 0.335	0.034
Total	9,182	0.0 - 0.172	0.005	0.001 - 0.678	0.092
Browns	680	0.001 - 0.016	0.002	0.001 - 0.264	0.023
Roseway	100	0.0 - 0.036	0.005	0.001 - 0.320	0.051
Inshore	161	0.0 - 9.400	0.505	0.0 - 0.0	0.0

* Low densities and the area boundaries are not appropriate for this species.

Table 2. Catch rates for *A. islandica* on Sable Island Bank and Western Bank Areas 1-6 for standard 5 minute tows.

Area	Number of Quahaugs	Bushels (U.S.)	Area	Number of Quahaugs	Bushels (U.S.)
1	681	1.7	5	378	1.0
	1,470	3.5		343	1.3
	$\bar{X}$ 1,075.5	2.6		597	1.5
	S.D. 557.9	1.27		884	3.0
				404	1.5
				1,021	4.5
2	610	2.0		80	0.5
	481	2.0		898	4.5
	1,046	4.0		437	1.6
	546	2.0		1,056	2.6
	512	2.0		934	2.8
	$\bar{X}$ 639.0	2.4		597	2.0
	S.D. 232.5	0.89		278	1.2
				281	1.3
3	423	2.0		$\bar{X}$ 584.9	2.1
				S.D. 318.6	1.24
	702	3.3			
	956	4.0			
	$\bar{X}$ 693.7	3.1	6	362	1.6
	S.D. 266.6	1.01		1,422	3.3
				230	-0.8
4	383	1.0		$\bar{X}$ 671.3	1.9
				S.D. 653.4	1.28
	1,198	3.0			
	663	2.5			
	1,536	4.7			
	$\bar{X}$ 945.0	2.8			
	S.D. 519.2	1.53			

Table 3. Catch rates for *S. polynyma* on Banquereau Bank Areas 1 and 2 for standard 5 minute tows.

Area	Number of Clams	Bushels (U.S.)
1	115	0.8
	256	1.5
	175	1.1
	668*	3.25*
	243*	2.25*
	768*	4.5*
	373*	2.0*
	785*	2.5*
	518*	2.5*
	765*	2.5*
	833*	3.25*
	330*	2.5*
	890*	5.0*
	360*	2.5*
	$\bar{X}$ 505.6*	2.6*
	S.D. 271.5	1.16
2	99	1.0
	516	3.5
	191	1.3
	123	0.5
	$\bar{X}$ 232.3	1.6
	S.D. 193.1	1.33

*Stations with 2 minute tows. Number of clams and volume (bushels) are corrected to the standard 5 minute tow length.

Table 4. Mean densities, biomass and 90% C.I. on the biomass estimates for *A. islandica* on Areas 1-6 of Western and Sable Island Banks and *S. polynyma* on Areas 1-2 of Banquereau Bank.

Species and Bank	Area (km^2)	Density (kg/m^2)	Biomass (t)	90% C.I.	
A. islandica					
Western and Sable					
Area 1	109	0.296	32,264	-12,644	77,172
2	654	0.236	154,344	69,978	238,710
3	381	0.232	88,392	43,815	132,969
4	191	0.366	69,906	34,953	104,859
5	968	0.222	214,896	172,304	257,488
6	149	0.287	42,763	-9,089	94,615
Total 1-6	2,452	0.256	627,712	534,536	720,888
S.polynyma					
Banquereau					
Area 1	1,589	0.248	394,072	262,185	525,959
2	709	0.230	163,070	-7,090	333,230
Total 1-2	2,298	0.244	560,712	395,256	726,168

Table 5. Estimates of MSY and 90% C.I. on the MSY estimates for *A. islandica* on Areas 1-6 combined of Western and Sable Island Banks and *S. polynyma* for Areas 1-2 combined of Banquereau Bank at selected rates of natural mortality (M).

Species and Bank	Biomass t	M	MSY t	90% C.I. on MSY	
A. islandica					
Western and Sable					
Areas 1-6	627,712	0.020	6,277	5,345	7,209
		0.043	13,495	11,493	15,499
S. polynyma					
Banquereau					
Areas 1-2	560,712	0.060	16,821	11,858	21,785

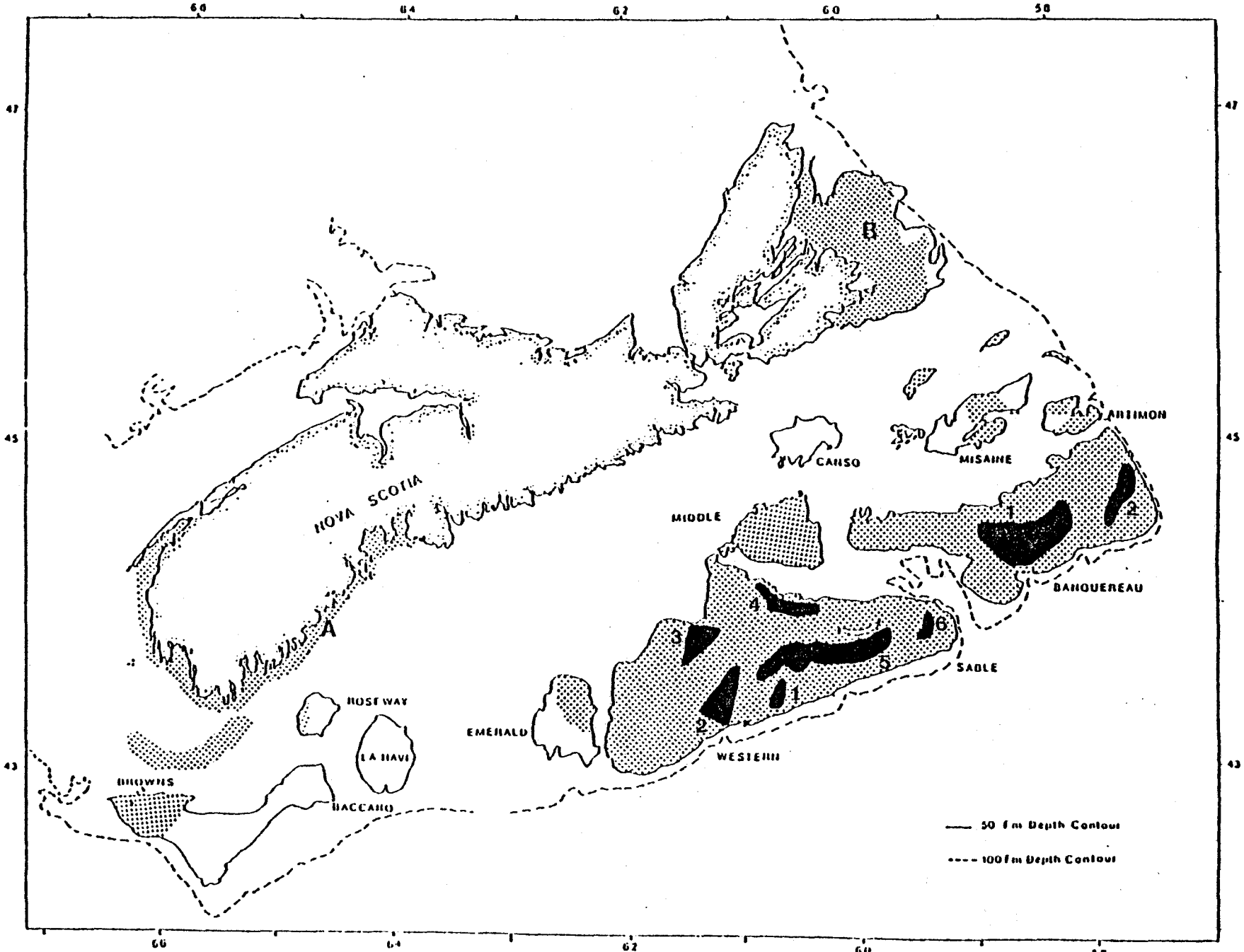

Figure 1. Areas of the Scotian Shelf surveyed between 1980 and 1983.

*A - inshore area surveyed using 2 small (11.6 m and 14.6 m) vessels.
*B - St. Ann's Bank area surveyed in 1983 using Delaware II.

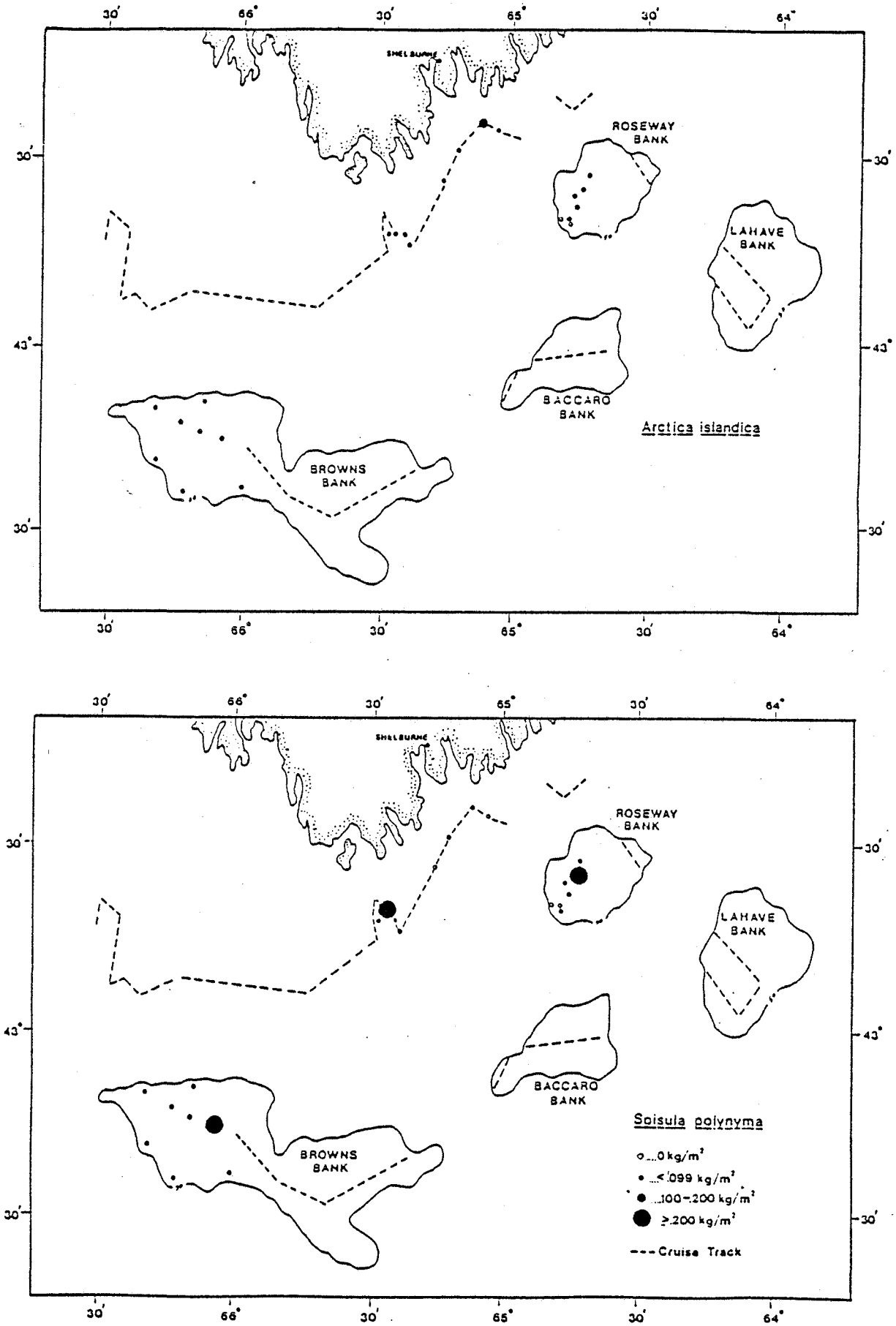

Figure 2. Location of stations surveyed on Browns Bank, Roseway Bank, and the nearshore area showing densities (kg/m^2) of A. islandica and S. polynyma.

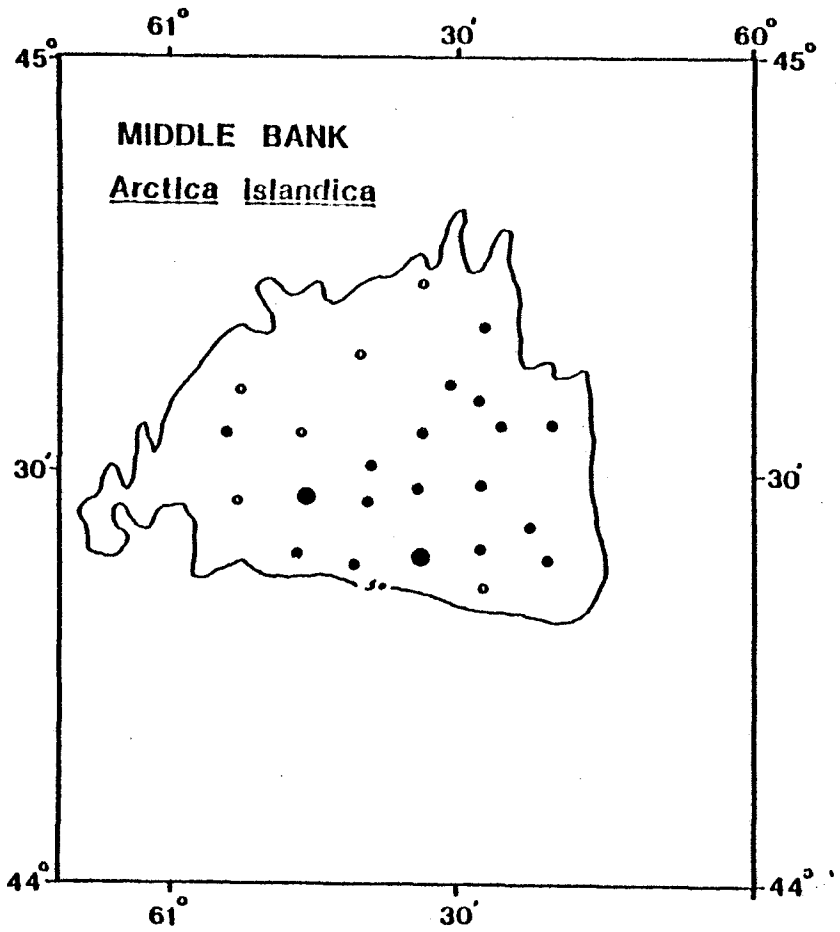

Fig. 3A. Location of stations surveyed on Middle Bank showing densities (kg/m^2) of A. islandica.

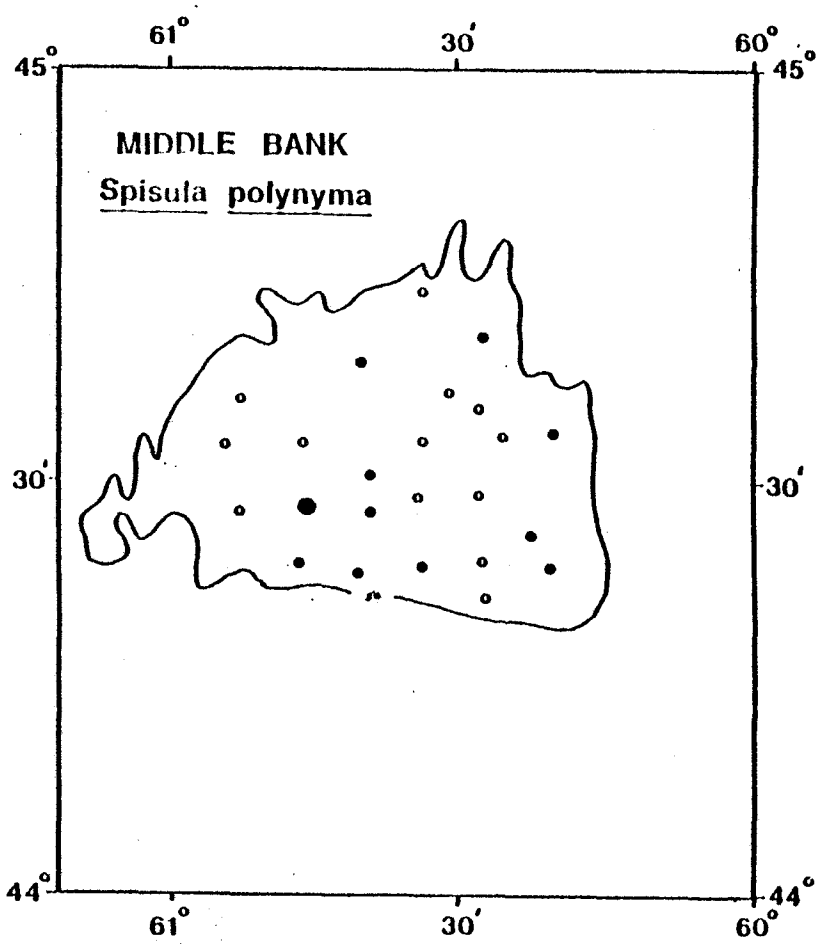

Fig. 3B. Location of stations surveyed on Middle Bank showing densities (kg/m^2) of S. polynyma.

KEY

- o.....0 kg/m^2
- •.....<.099 kg/m^2
- ●..... 100-200 kg/m^2

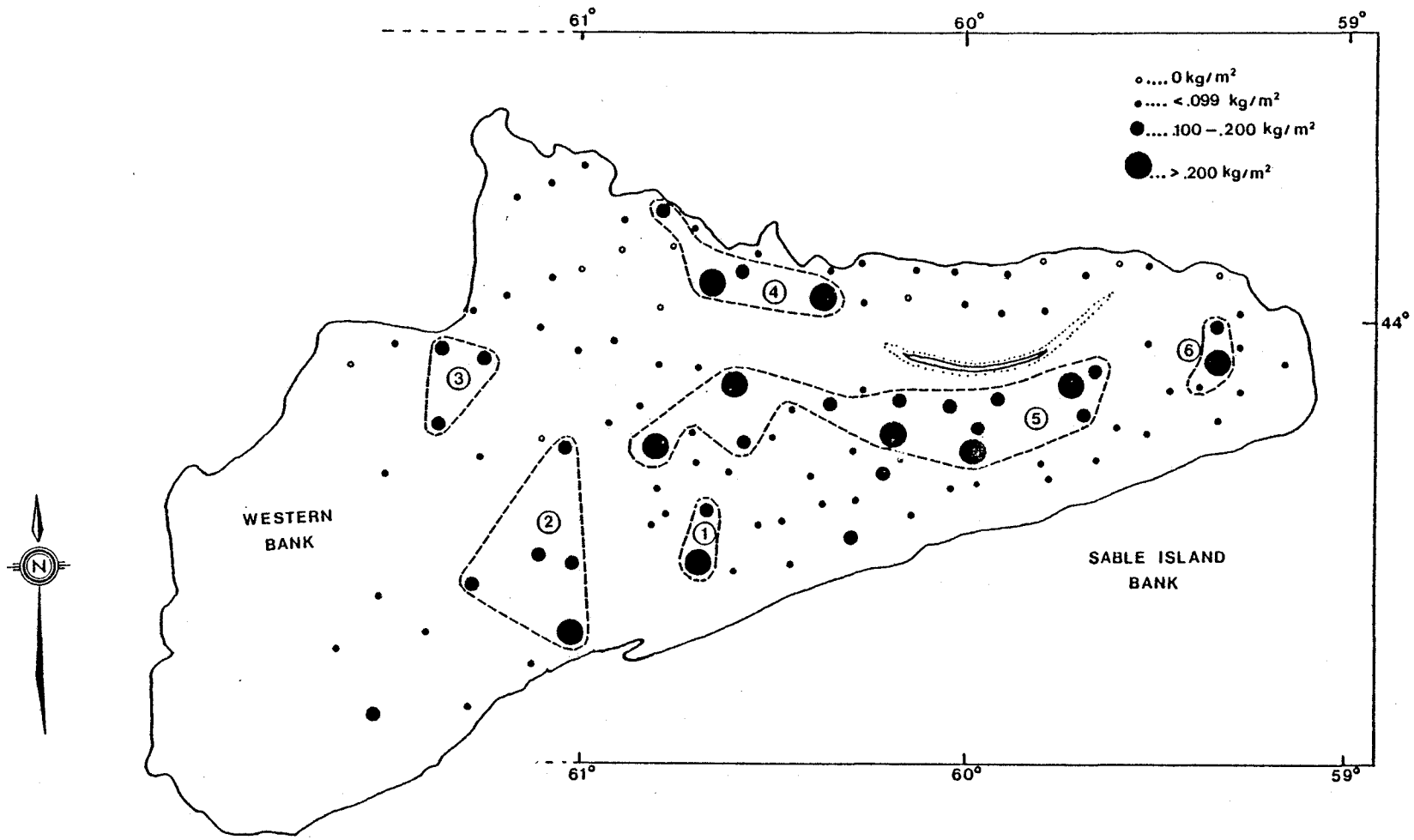

Figure 4. Locations of stations on Sable Island Bank and Western Bank in 1981-1982 showing densities (kg/m^2) of A. islandica and boundaries of areas 1-6 having the most significant concentrations.

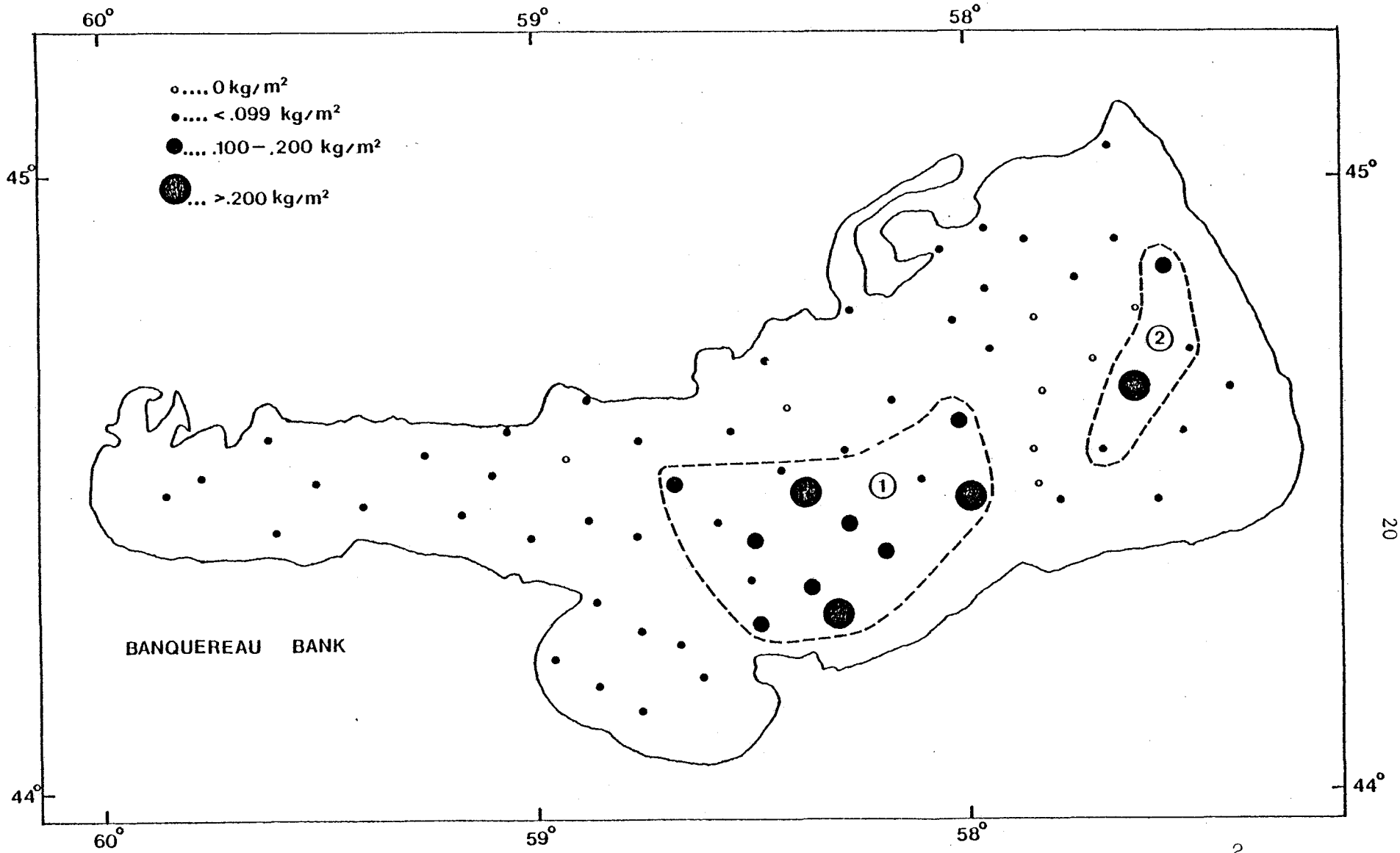

Figure 5. Locations of stations on Banquereau Bank surveyed in 1981 to 1982 showing densities (kg/m^2) of S. polynyma and boundaries of areas 1 and 2 having the most significant concentrations.

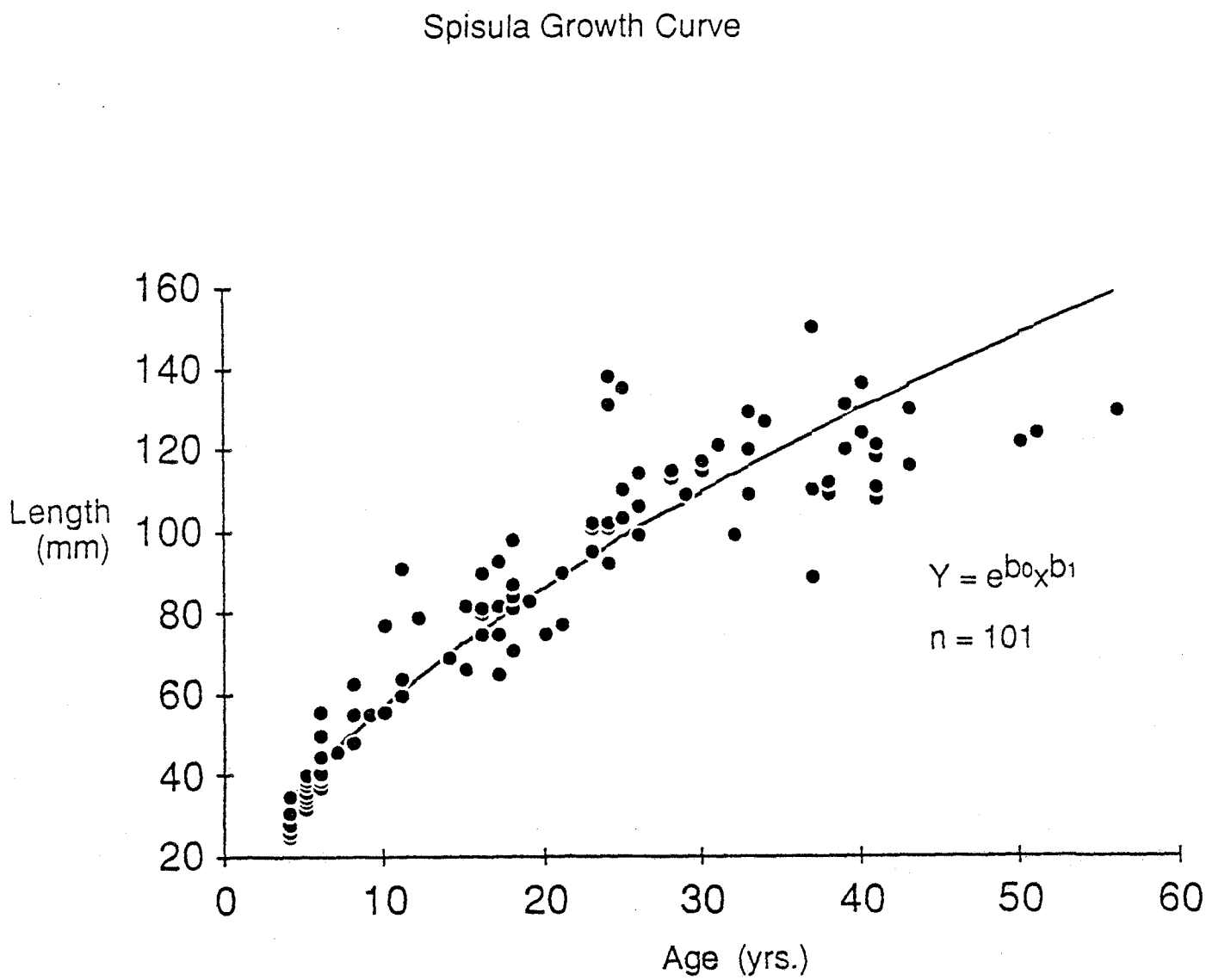

Figure 6. Growth curve for Banquereau Bank Spisula polynyma.