Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 84/29

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 84/29

Aspects of Scallop Recruitment on St. Pierre Bank in Relation to Oceanography and Implications for Resource Management

by

K. S. Naidu and J. T. Anderson
Fisheries Research Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland   A1C 5X1

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

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur des études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

Sea scallops on St. Pierre Bank are in the northern fringe of their distribution range. Their numbers may be substantially influenced by a number of critical factors, sometimes limiting for the species. Fringe populations may be expected to be more susceptible to population fluctuations, including those resulting from their exploitation. The question of whether the scallop fishery on St. Pierre Bank can or should be managed on a sustained basis will depend largely on recruitment mechanisms for the species. Specifically, we would want to know if the population is sustained through recruitment from within or if the beds depend on larval drift from the outside. There are few empirical data. This document explores some possibilities and proposes a cautious and conservative management strategy for sea scallops on St. Pierre Bank.

Résumé

Le pétoncle géant du banc de Saint-Pierre est en bordure nordique de l'aire de l'espèce. Plusieurs facteurs critiques, parfois même limitatifs, sont susceptibles d'influencer ses nombres. On peut s'attendre que de telles populations périphériques soient plus susceptibles aux fluctuations d'abondance, y compris celles qui résultent de leur exploitation. La question de savoir si la pêche des pétoncles sur le banc de Saint-Pierre peut ou doit être gérée sur une base soutenue dépendra en grande partie des mécanismes de recrutement de l'espèce. En particulier, il nous faudra savoir si la population se maintient par recrutement interne, ou si les lits dépendent de la dérive de larves venant de l'extérieur. Les données empiriques sont rares. Nous examinons dans le présent document diverses possibilités et proposons une stratégie de gestion prudente et conservatrice du pétoncle géant du banc de Saint-Pierre.

Introduction

St. Pierre Bank is a westward extension of the continental shelf off eastern Canada commonly called the Grand Banks of Newfoundland (Fig. 1). Approximately 10,450 sq. nautical miles is in waters less than 200 fms.

Two species of pectinids are found on the shelf. The giant or sea scallop, Placopecten magellanicus, is a west Atlantic species and has a bathymetric range (Fig. 1) from the north shore of the Gulf of St. Lawrence to Cape Hatteras, North Carolina (Posgay, 1957). The most northerly record of capture of giant scallops was made at the northeast entrance to Pistolet Bay, Newfoundland (Squires, 1962). They are usually found in depths ranging from about 10 to 60 fms (18-110 meters) but they occur in shallower water in the northern portion of their range. Verrill and Smith (1873) recorded them from Passamaquoddy Bay and Bay of Fundy in depths as shallow as one fathom (2 m) as has been the case near Ship Cove, Newfoundland (51°36'N, 55°38'W; Naidu, unpubl. data). Merrill (1959) extends the bathymetric range down to 210 fms (384 m). Where conditions are favourable, scallops frequently occur in high densities called "beds". Such concentrations usually support commercial fisheries. Sea scallop beds of sufficient extent and density to support commercial fisheries occur from Virginia Capes (latitude 36°50'N) to Port au Port Bay (latitude 48°40'N). They have been exploited commercially on Georges Bank, off Cape Cod, along the coast of Maine, Bay of Fundy, southern Gulf of St. Lawrence, Scotian Shelf (Browns Bank, Emerald Bank, Sable Island Bank, Banquereau), Port au Port Bay and St. Pierre Bank. In the centre of its range directed fisheries for the mollusc have been quite successful and have withstood moderate to heavy exploitation over varying periods. Georges Bank, where most of the fishing is concentrated, is the world's largest producer of scallops. Most of these areas continue to be prosecuted by the fishery. Towards the extremes of their range scallops have generally been less successful and have not withstood continued heavy exploitation (Dickie and Medcof, 1963).

The Iceland scallop (Chlamys islandica), on the other hand, is a subarctic species and has its main distribution within the subarctic transitional zone - subarctic or northerly boreal (Ekman, 1953). In Newfoundland, fishable populations are normally found in waters deeper than 30 fms (55 m), usually on hard bottom with variable substrate composition consisting of sand, gravel, shell fragments, and stones. Being a filter feeder, the species is most abundant in areas characterized by strong currents such as the Straits of Belle Isle in the northeastern Gulf of St. Lawrence (Naidu et al., 1982). Other areas where Iceland scallops are found in quantity include St. Pierre Bank (3Ps) and along the Labrador shelf. Iceland scallops are also found, sometimes in substantial quantities, over most of the Grand Banks (3L, N, O).

Recently "substantial beds" of Iceland scallops have been confirmed off Nantucket, Massachusetts, the southernmost extent of their range (Stevens, unpublished data) in waters averaging 33 fms (60 m). While their presence this far south (41°32'N) is not altogether surprising their abundance in commercial densities providing ground for at least half a dozen boats is! Removals for the fleet are of the order of 10,000-15,000 bushels/month (50,000-750,000 lb in shell).

The resurgence of the scallop fishery on St. Pierre Bank to unprecedented levels beginning in 1982 has raised fresh concerns on how to best manage this fishery. The concerns are valid because of its peripheral location. Situated as it is along the northern fringe of its distribution range we may reasonably expect their numbers to be substantially influenced by a number of critical factors, sometimes limiting for the species. Fringe populations may be expected to be more susceptible to population fluctuations, including those resulting from exploitation.

The question of whether the scallop fishery on St. Pierre Bank can or should be managed on a sustainable basis will by and large depend on recruitment mechanisms for the two species in question. Specifically we would want to know if scallop populations are sustained through recruitment from within or if the beds depend on larval drift from the outside. These are broad and difficult questions that will require such time and resources that managers are unlikely to commit. There are few empirical data. All we can do is to identify the possibilities and guess at what is most likely in the context of species biology and hydrography of the environment.

The following possibilities may be entertained for each of the two species:

a. The beds are completely self-sustaining, all recruitment coming from within. This would point to the existence of oceanographically stable larval retention mechanisms on the Bank.

b. The area is wholly dependent on recruitment from the outside pointing to "parent beds" giving rise to spatially-removed secondary beds.

c. A combination of (a) and (b) with temporal variations in relative contributions.

St. Pierre Bank is unique in that two species of scallops are found frequently occurring on the same beds. The fishery, however, is directed principally at the larger sea scallop which is the mainstay of the offshore scallop fishery. Iceland scallops taken incidentally and retained are heavily culled and only the larger ones (≥80 mm) appear to be retained for shucking.

Sea Scallops

Production of sea scallops on St. Pierre Bank has been variously described as sporadic (Dickie and Chiasson 1955), regular (Somerville and Dickie 1957) and irregular (Naidu et al. 1983a). Irrespective of source it is apparent that recruitment and hence production of sea scallops in this area is highly variable (Table 1). This is borne out by age and shell-height frequency distributions of the species from this area (Naidu et al, 1983a and 1983b). An accumulation of sea scallop year classes was reported in the northern area (Stratum 314) in 1979 with the majority (83%) of animals greater than 135 mm representing scallops >12+ years. A marked paucity of younger age groups was also noted in 1979. By 1983 significant recruitment had taken place and up to 57% (numbers) was made up of the 1978 year class.

Iceland Scallops

For one reason or another the presence of the smaller Iceland scallops has been ignored during earlier scallop explorations (Dickie and Chiasson 1955; Somerville and Dickie 1957). Naidu et al. (1983a) reported the species to be widely distributed over the Banks in depths ranging from 25-100 fm, the better catches coming from 40 to 50 fm. Shell heights of Iceland scallops over the Bank were more or less normally distributed. The presence of several consecutive year classes of Iceland scallops led the authors to suggest that recruitment patterns in this species were relatively more stable than for sea scallops.

Oceanography of St. Pierre Bank

The oceanography of St. Pierre Bank has not been directly studied. However, characteristics of its water circulation and influences from other water masses can be inferred from other studies, all of which are based on Lagrangian measurements of water movement (i.e. drifter studies). Most indications are that waters over St. Pierre Bank are highly variable, influenced by one of three different water masses largely under control of surface wind stress.

The dominent influence appears to be the Labrador Current. The inshore branch of the Labrador Current flowing south through the Avalon Channel turns west around Cape Race. While some of this water continues west the flow is weak (.05 m s^{-2}), with most of the water flowing south through Haddock Channel to join the offshore branch of the Labrador current which is moving westward along the outer margins of the Grand Banks (Petrie and Anderson 1983). The weak westward flow over St. Pierre Bank appears to be subject to wind events, especially from the south and west. Drifter studies have indicated transport of surface water from the northern Scotian Shelf across the Laurentian Channel onto St. Pierre Bank. This water then moves either inshore along the south coast of Newfoundland or eastwards against the flow of the Labrador Current (Huntsman et al. 1954; Trites et al. 1981; R. Trites, unpubl. data). There is also an indication that surface outflow from the Gulf of St. Lawrence reaches St. Pierre Bank as well (Petrie and Anderson 1983). Finally, bottom drifters released on top of St. Pierre Bank either moved onto the Scotian Shelf or inshore towards Fortune Bay (Ibid.).

From these data there is little indication of a strong or persistent mean current flow in the vicinity of St. Pierre Bank. As such, there is no direct indication of topographically induced circulation around the Bank and consequently no retainment mechanism based on mean water circulation. In particular, St. Pierre Bank appears to be highly variable oceanographically with no defineable structure.

Specifics

In a major study of stock discreteness and abundance in herring stocks (Iles and Sinclair 1982) the authors advance a rather persuasive hypothesis suggesting that the number of herring stocks and their size may be determined by distinct, geographically stable larval retention areas. The hypothesis has far reaching implications for other species inhabiting tidally energetic areas contiguous to the shore, including scallops.

Features associated with an estuarine entrainment-type circulation (Tully and Barber 1960) may provide larval retention mechanisms for some coastal populations in Newfoundland. Surface water circulation near the Strait of Belle Isle also point to a correlation, even if only circumstantial, between water currents and occurrence of scallop concentrations (beds). Drift water bottles released in the Straits of Belle Isle (Huntsman et al 1954) frequently ended up almost precisely where Iceland scallop aggregations are found. These include the Straits of Belle Isle (Fig. 2), Bay of Islands (Fig. 3), the western region of Port au Port Peninsula (Fig. 4) and locations near the northwest slope of St. Pierre Bank (Fig. 5) where significant concentrations of Iceland scallops occur, some supporting commercial fisheries for the mollusc. There are empirical data showing presence of Iceland scallop larvae (spat) even in areas where few or no adults are found (Naidu and Cahill, unpublished). These observations might support the larval drift hypothesis. Eventual destination, survival and subsequent establishment of adult populations appear to be influenced by other factors, possibly including temperature (Dickie 1955; Naidu and Cahill 1983). In at least one of the areas (Bay of Islands) an entrainment process is likely. The basic requirement for the establishment of an estuarine system is the presence of a supply of freshwater which exceeds losses by evaporation or freezing. Tully (1958) described structure, entrainment[1] and transport in coastal embayments. Freshwater moves outward from the embayment at the surface, entraining sea water from below to form a transition zone in which a halocline forms. This is defined by a discontinuity in the logarithimic plot of salinity structure, where the salinity is nearly constant (Tully and Barber 1960). The upper part of the halocline is nearly isohaline, because of mixing. Below the halocline is a lower zone in which the vertical and horizontal salinity gradients are small. Here, the motion is inward toward the source region. Such a system no doubt operates in many coastal areas around Newfoundland and is probably critical to retaining scallop larvae over some parent beds to effect recruitment into these beds, however this analogy may not be extended to offshore areas such as St. Pierre Bank.

A major exploratory survey for scallops in 3Ps in 1979 delineated sea scallop distribution to two shallow areas of the Bank ($\leq$30 fms). Shell height and age distributions of sea scallops was strongly skewed to the left with an accumulation of old individuals to the south and a recent history of low recruitment over most of the Bank. By 1983, however, significant recruitment

[1]entrainment refers to the movement of a definable water mass into an area for a period of time.

had occurred particularly in the north from two consecutive year-classes (1977 and 1978). This recruitment pulse formed the basis of an opportunistic fishery in the area beginning in 1982. As in previous years an overcapacity in harvesting is rapidly fishing down the recently recruited animals as well as the accumulated age cohorts. Shell heights and ages of Iceland scallops, on the other hand, were approximately normally distributed over wide areas of the Bank suggesting that recruitment in this species to be somewhat more stable than for sea scallops (Naidu et al. 1983a). The coextensive distribution of both Iceland and sea scallops in well-defined areas of St. Pierre Bank is particularly interesting because of the temporal segregation of spawning and settlement times in the two species. While yet to be documented, this may be indicative of the existence of a fairly stable concentration/retention mechanism in the area. The absence of sea scallops over wider areas of St. Pierre Bank where adult scallop survival is almost assured may suggest that such retention mechanisms may well exist and are probably very localized. If retention mechanisms were solely operative it would be of interest to reconcile the apparent stable recruitment for Chlamys with variable recruitment in Placopecten.

If scallop populations on the Bank are sustained by recruitment pulses from without, it is tempting (on the basis of current patterns) to suggest that sea scallop larvae probably originate from scallop populations in the Gulf of St. Lawrence and/or the Scotian Shelf. By the same token we may postulate that fugitive Chlamys larvae are carried down by the Labrador Current. The presence of stable self-recruiting (self-sustaining) Chlamys populations as far south as Nantackett, however, contradicts the larval drift theory, at least for that relict population.

Caddy and Gulland (1983) have attempted to classify fisheries according to to their natural patterns of variation as: steady, cyclical, irregular and spasmodic. They have suggested that assessment and management of fish stocks must take these patterns into account whether from an economic, legislative or managerial viewpoint, as well as their impact on resource assessment. Only those considered "steady" may be reconciled with classical text-book "steady-state" assumptions. For cyclical, irregular or spasmodic stocks, the authors underline the importance of factoring patterns of variation for purposes of assesssment. Depending on location, sea scallop populations have been described as both cyclical (Caddy 1979) and irregular (Caddy 1983). Our data base on St. Pierre Bank sea scallop stocks is too rudimentary to even attempt to categorize the fishery other than in very general terms.

Historically, St. Pierre Bank has never sustained a continuous scallop fishery for more than a few years at a time, nor is it every likely to. Age composition of sea scallops here points to short periods of high recruitment preceeded and followed by variable periods of poor recruitment. Regardless of source of recruitment it is clear that it is sporadic. Given the unpredictability of the frequency and strength of recruitment pulses we must adopt a cautious and conservative management strategy for St. Pierre Bank. Situated as it is in the northern fringe of its distribution range we may reasonably expect sea scallop dynamics to be more sensitive to exploitation than populations in the center of their range. Knowledge of the recruitment patterns and origin of recruits has great bearing on optimization of the fishery and should be examined further.

References

Caddy, J. F. 1979. Long-term trends and evidence for production cycles in the Bay of Fundy scallop fishery. Rapp. P.-v. Réun. Cons. Int. Explor. Mer 175: 97-108.

Caddy, J. F., and J. A. Gulland. 1983. Historical patterns of fish stocks. Marine Policy, Vol. 7(4): 267-278.

Caddy, J. F. 1983. An alternative to equilibrium theory for management of fisheries. FAO Consultation on the regulation of fishery effort (fishing mortality) 17-26 January, 1983. Rome, Italy.

Dickie, L. M. 1955. Fluctuations in abundance of the giant scallop, Placopecten magellanicus (Gmelin) in the Digby area of the Bay of Fundy. J. Fish. Res. Bd. Canada 12(6): 797-857.

Dickie, L. M., and L. D. Chiasson. 1955. Offshore and Newfoundland scallop explorations. Fish. Res. Bd. Canada. Atl. Biol. St., St. Andrews, N. B. Gen. Series Circular, No. 25, 4 p.

Dickie, L. M., and J. C. Medcof. 1963. Causes of mass mortalities of scallops (Placopecten magellanicus) in the southwestern Gulf of St. Lawrence. J. Fish. Res. Bd. Canada, 20(2): 451-482.

Ekman, S. 1953. Zoogeography of the sea. Sidgwick and Jackson, London, 417 p.

Huntsman, A. G., W. B. Bailey, and H. B. Hachey. 1954. The general oceanography of the Strait of Belle Isle. J. Fish. Res. Board Can., 11: 198-260.

Iles, T. D., and M. Sinclair. 1982. Stocks of herring: Their discreteness and abundance. Science 215(4533), pp 627-633.

Merrill, A. S. 1959. A comparison of Cyclopecten nannus Verrill and Bush and Placopecten magellanicus (Gmelin). Occ. Papers on Mollusks, Harvard Univ., 2(25): 209-228.

Naidu, K. S., F. M. Cahill, and D. B. Lewis. 1982. Status and assessment of the Iceland scallop, Chlamys islandica in the northeastern Gulf of St. Lawrence. CAFSAC Res. Doc. 82/02, 66 p.

Naidu, K. S., and F. M. Cahill. 1983. Scallop culture report 1981-82. Report submitted to Department of Fisheries, Government of Newfoundland and Labrador. 51 p.

Naidu, K. S., F. M. Cahill, and D. B. Lewis. 1983a. Scallop survey in NAFO Division 3Ps (including Green, St. Pierre and Burgeo Banks). CAFSAC Res. Doc. 83/4, 27 p.

Naidu, K. S., D. B. Lewis, and F. M. Cahill. 1983b. St. Pierre Bank: An offshore scallop buffer zone. CAFSAC Res. Doc. 83/16, 48 p.

Petrie, B., and C. Anderson. 1983. Circulation on the Newfoundland continental shelf. Atmos.-Oc. 21: 207-226.

Posgay, J. A. 1957. The range of the sea scallop. The Nautilus. 71(2): 55-57.

Somerville, G. M., and L. M. Dickie. 1957. Offshore scallop explorations - 1957. Fish. Res. Bd. Canada, Atl. Biol. Stn., St. Andrews. N. B., Gen. Series Circular No. 30, 4 p.

Squires, H. J. 1962. Giant scallops in Newfoundland coastal waters. Bull. Fish. Res. Bd. Canada, No. 135, 29 p.

Trites, R. W., D. J. Lawrence, and C. K. Ross. 1981. An application of satellites and remote sensing to studies of surface circulation in NAFO Subareas 3 and 4. NAFO SCR Doc. 81/IX/98.

Tully, J. P. 1958. On structure, entrainment and transport in estuarine embayments. J. Mar. Res. 17: 523-535.

Tully, J. P., and F. G. Barber. 1960. An estuarine analogy in the Sub-Arctic Pacific Ocean. J. Fish. Res. Bd. Canada. 17(1): 91-112.

Verrill, A. E., and S. I. Smith. 1873. Report upon the invertebrate animals off Vineyard Sound and adjacent waters, with an account of the physical features of the Region. Report of the U.S. Fish. Comm. for 1871-72.

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	5569	-
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)

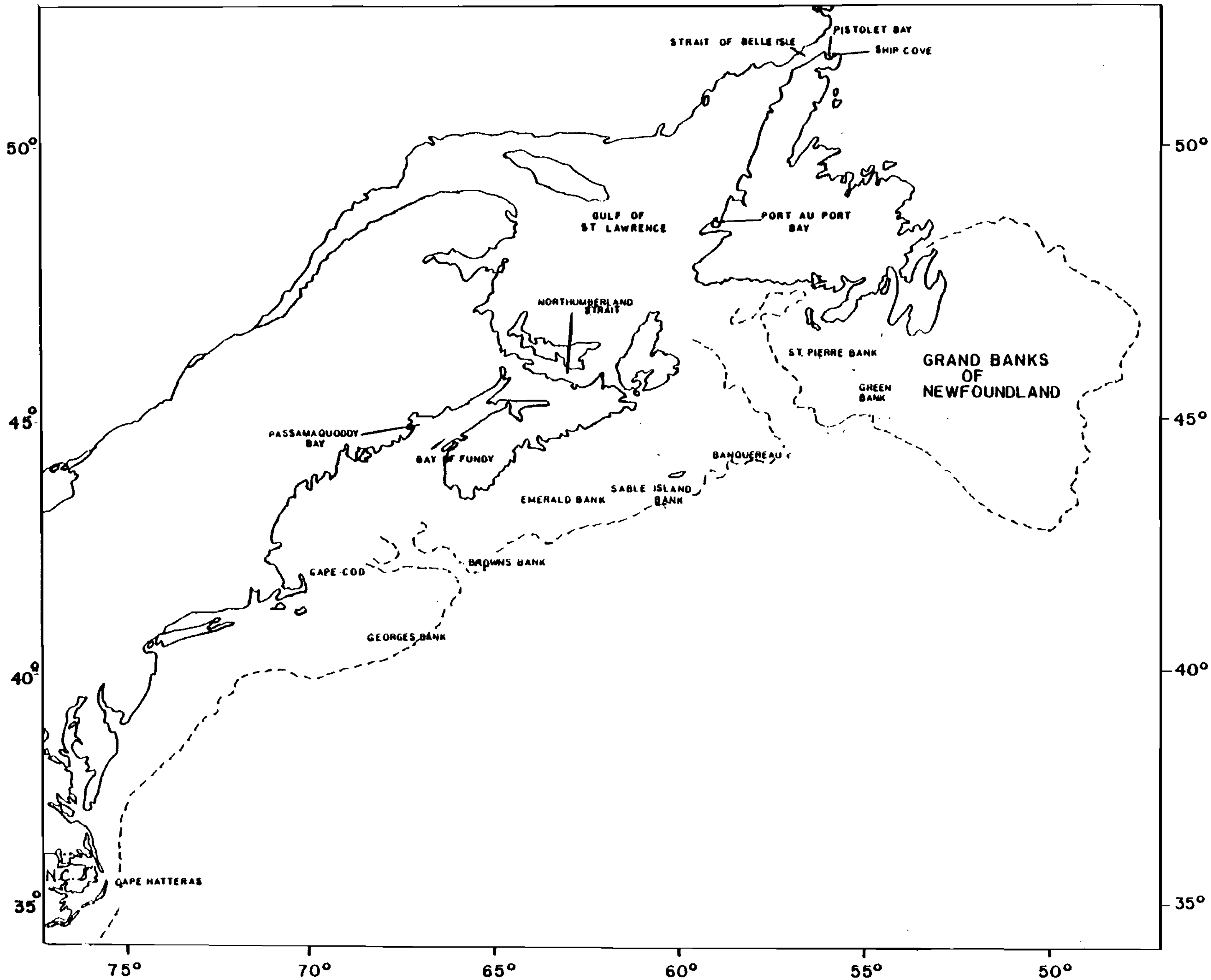

Fig. 1. Distribution range of sea scallops (place names mentioned in text).

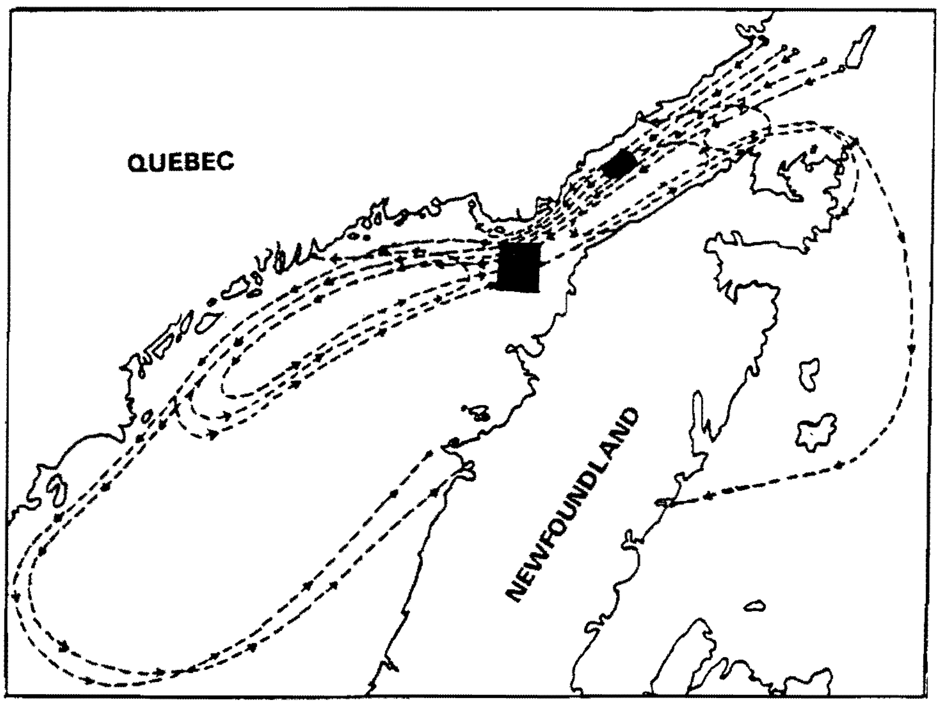

Fig. 2. Interpretation of courses taken by drift bottles set out between Chateau Bay, Labrador and Belle Isle on August 19, 1923 (from Huntsman, A.G., W. B. Bailey and H. B. Hachey, 1954). Shaded areas indicate areas where Iceland scallops are found in abunoance.

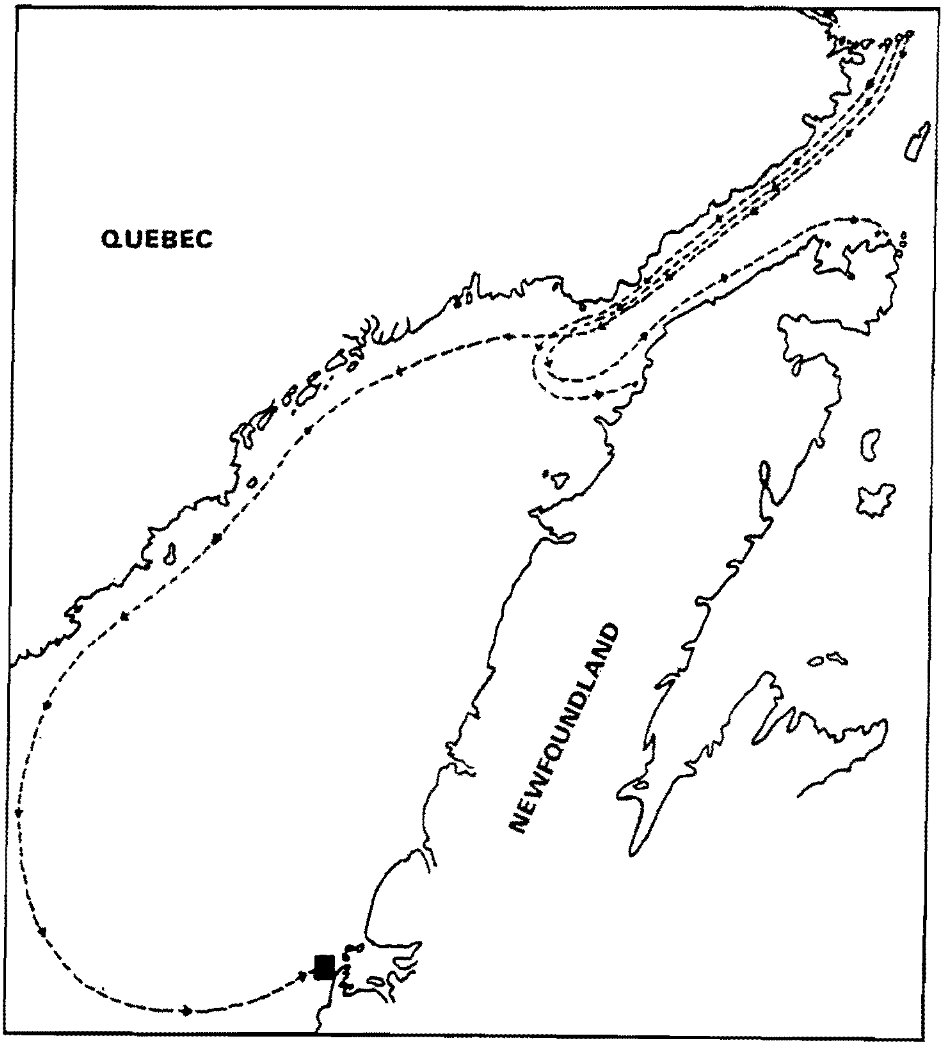

Fig. 3. Interpretation of courses taken from drift bottles set out from Battle Harbour, Labrador, eastward on August 18, 1923 (from Huntsman, A.G., W. B. Bailey and H. B. Hachey, 1954). Shaded areas coincides with Iceland scallop beds.

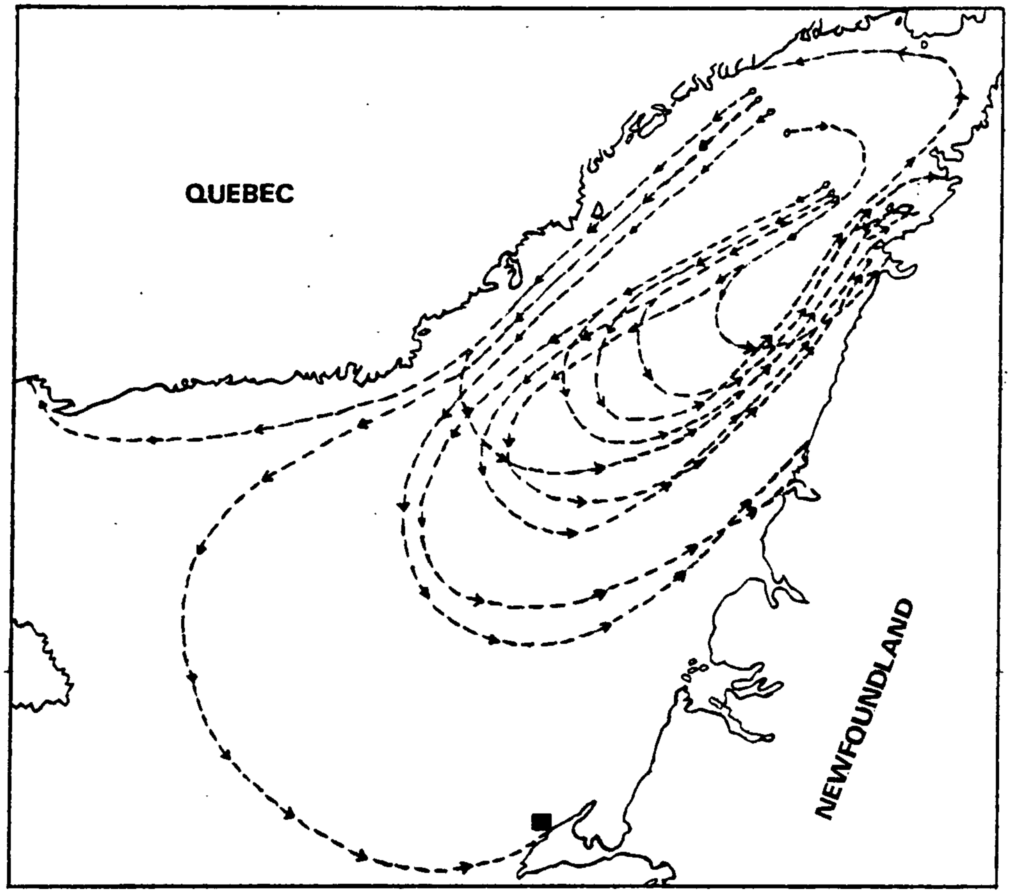

Fig. 4. Interpretation of courses taken by drift bottles set out between Point Rich, Newfoundland and Lobster Bay, Quebec, on July 31, 1923 (from Huntsman, A.G., W. B. Bailey and H. B. Hachey, 1954). Shaded areas coincides with Iceland scallop beds.

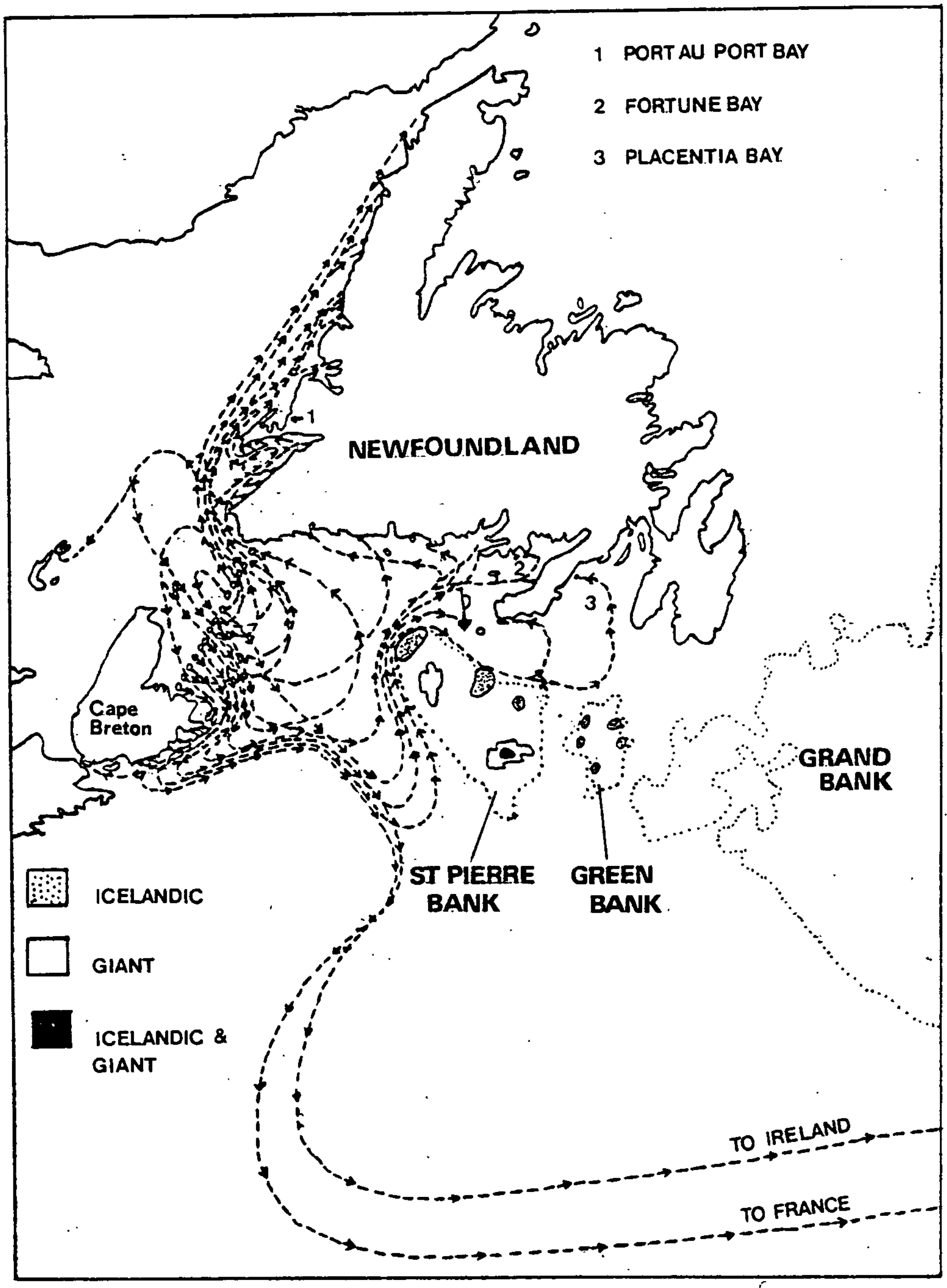

Fig. 5. Interpretation of courses taken by drift bottles set out between Sydney, Cape Breton and Port-aux-Basques, Newfoundland, on July 6 and 7, 1922 (from Huntsman, A.G., W. B. Bailey and H. B. Hachey, 1954).