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Stock Identification Studies of Greenland halibut (*Reinhardtius hippoglossoides*) in the Northwest Atlantic from Tagging Experiments

by

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INTRODUCTION

The Greenland halibut (Reinhardtius hippoglossoides) is widely distributed in the northwest Atlantic from Arctic regions to as far south as the Scotian Shelf, (Atkinson et al. 1981). It constitutes a major component of the commercial groundfish resource in the northwest Atlantic particularly in the areas of West Greenland, eastern Newfoundland, and the Gulf of St. Lawrence. It is presently managed as three separate stocks throughout the region as follows:

1) The Baffin Island-West Greenland,
2) Labrador-eastern Newfoundland, and
3) Gulf of St. Lawrence stocks. Recent TAC's in place in these areas are 25,000 t, 55,000 t, and 7,500 t respectively.

In the northwest Atlantic, spawning occurs in the deep warm waters of Davis Strait (Jensen 1935; Smidt 1969) at about 67°N. The eggs and small larvae then drift northward along the Greenland coast and Baffin coast. Those caught by the polar currents are taken down along the Baffin, Labrador, and Newfoundland east coasts and colonize the continental banks and slopes along the way (Templeman 1973). Upon approaching maturation these fish are believed to migrate into deep water and move northward to the spawning area. This pattern of movement would indicate that Greenland halibut throughout the range form one continuous stock although there is evidence of some spawning occurring in the Gulf of St. Lawrence area (Bowering 1977).

The implications of management strategy by three separate compartments with regard to the accuracy of international fish stock assessment of this species have recently become an important consideration by fisheries management. This is a result of these recent hypotheses that the stock complex from Davis

Strait to the northern Grand Bank (Chumakov 1975; Bowering 1977) is a single discrete spawning unit, as well as the evidence of considerable mixing of two stocks in the Gulf of St. Lawrence (Bowering 1979, 1980, 1981). The management bodies of NAFO and CAFSAC have therefore recommended considerable research be placed into the accurate delineation of Greenland halibut stocks in the northwest Atlantic, in order to elucidate the problem and enhance management effectiveness of this very valuable resource. This paper will highlight results of Greenland halibut stock identification studies by tagging experiments carried out mainly due to the foregoing recommendation as well as review other independent stock identification studies of Greenland halibut.

MATERIALS AND METHODS

The migratory patterns of Greenland halibut were investigated by means of tagging studies. Five different tagging studies were conducted in the eastern Newfoundland areas: a) White Bay - Oct.-Nov., 1969 using longlines, b) Trinity Bay - Oct.-Nov., 1971 using longlines, c) offshore Funk Island Bank - April 1979 using bottom otter trawls, d) offshore mid-Labrador - Sept.-Oct., 1980, and e) Fortune Bay - Sept.-Oct., 1979.

The longlining tagging was carried out on board the Canadian research vessel Marinus, a small wooden side trawler using 3-5 tubs of longline gear. Each tub contained eight 100-m lines with hooks 2 m apart. The hooks were baited with frozen capelin obtained from a cold storage plant and were placed near the sea bottom at 300-350 m for a maximum of 2-4 hours.

The bottom otter trawl tagging was conducted by the Canadian research vessels Gadus Atlantica and Shamook using commercial size gear to allow for the escapement of smaller fish and invertebrates which could damage the catch. Sets ranged from 10-30 min duration at depths of 350-450 m depending upon the abundance of Greenland halibut in the area. For both types of experiments, a canvas recovery tank with running sea water was placed near where the specimens would come on board ship and the fish were immediately placed in the tank. Only fish in good condition were tagged and those damaged or with excessive scale loss were discarded.

The fish were tagged with 1 cm diameter Peterson discs. These were attached 2-4 cm below the dorsal fin near the head by means of 0.32 mm diameter stainless steel wire. After tagging the fish were placed in a recovery tank until they appeared in active condition after which they were returned to the

sea. Totals of 266, 410, 2976, 9477, and 1008 Greenland halibut were tagged in the White Bay, Trinity Bay, Funk Island Bank, mid Labrador, and Fortune Bay tagging studies respectively.

RESULTS AND DISCUSSION

a) White Bay Tagging

From 266 Greenland halibut tagged in 1969, 41 tags have been returned for a total of 15% return. Of the 41 tag returns, 1 was returned during the same fishing season, 19 in 1970, 13 in 1971, 6 in 1972, 1 in 1974, and 1 in 1976. Almost half of the returns came from the White Bay area, near the site of the tagging operations (Fig. 1). Many others were taken eastward in the deep waters of the Notre Dame Channel and Funk Island Deep during the winter with the most southerly recapture taken in Trinity Bay 2 years after being released, a distance of about 240 nautical miles. On April 2, 1972 a capture was made near the continental slope at 52° north latitude, 230 nautical miles north east of White Bay. Another was captured on March 7, 1971 southeast of Hamilton Bank also near the continental slope about 250 nautical miles from White Bay. In the spring of 1974 a tagged Greenland halibut was taken southeast of Nain Bank at the edge of the continental slope at a distance of 370 nautical miles north of the tagging site. The two longest distance migrations occurred in 1971 and 1976. In July of 1971, a tagged Greenland halibut was captured on the continental slope of west Greenland more than 850 nautical miles north of White Bay while on October 2, 1976 another was taken at the continental slope of the Baffin Bank region, more than 780 nautical miles north of White Bay (Fig. 1, see inset).

b) Trinity Bay tagging

Of 410 Greenland halibut tagged in Trinity Bay in 1971, 145 recaptures were reported for a total of 35% returned (Fig. 2). Of the 145 recaptures, 62 were taken in 1972, 68 in 1973, 14 in 1974, and 1 in 1975. None have been reported since that time. Most of the recaptures from this study were taken within 50 miles of the tagging site with only 3 tag returns reported outside Trinity Bay. These were less than 100 nautical miles from the tagging site (Fig. 2). The most distant recapture from the tagging site was reported on October 10, 1972 at the mouth of Bonavista Bay at 49° north latitude.

c) Funk Island Bank tagging

There were 2976 Greenland halibut tagged during this study and only 42 have yet been returned for a total of just over 1% (Fig. 3). Of these, 23 tags were returned in 1979, 14 returned in 1980, and 5 in 1981. Most of these returns were taken in the near shore gillnet fishery of White Bay, Notre Dame Bay, Funk Islands east with two recaptured in the Bonavista Bay area in July, 1979 and October 16, 1980. The most northerly recapture was just east of Smokey, Labrador, July 2, 1981.

d) Mid-Labrador tagging

There were 9447 Greenland halibut tagged during this study with only 14 yet returned (Fig. 4). Of the 14 recaptures, 1 was returned in 1980, 12 were returned in 1981, and 1 was returned in 1982. Of the 14 recaptures 6 had moved from the channel area where tagging was carried out, to the continental slope area. The most northerly recapture was taken at 60°15'N 60°54'W on October 28, 1981 at a depth of 643 m, a distance of 240 miles from the tagging site. The most southerly return from the Channel tagging area was taken at 53°07'N, 52°W in a depth of 840 m, a distance of 340 miles from the tagging site. There was a distance of approximately 600 miles between these two most distant returns.

e) Fortune Bay tagging

There were 1008 Greenland halibut tagged in this study (Fig. 5) with 13 tags returned to date. Of these, 9 were returned in 1980 and 4 were returned in 1981. None were caught outside Fortune Bay and for practical purposes all were taken in very close proximity of the tagging site.

The results of the White Bay tagging study suggest that Greenland halibut migrate from the near shore deep bays of the northeast Newfoundland coast to the deep waters outward towards the continental slope as well as northward as far as Baffin Island and West Greenland. Although information on sex and maturity of these tagged fish was not available it is possible that these fish were part of a spawning migration and, if so, would support previous hypotheses of Templeman (1973), Chumakov (1975), Zilanov et al. (1976) and Bowering (1977) of a northward spawning migration. The tag returned from Baffin Bank in fact was taken from a 10 kg Greenland halibut in excess of 1 m in length which would assuredly have been a mature female.

Long distance migrations of Greenland halibut have been reported on various occasions from other areas. One Greenland halibut tagged at north Iceland in July 1973 was captured 4 months later in the Barents Sea (Sigurdsson 1979). Another tagged from a Soviet Union research trawler off the Icelandic east coast on January 1970 was recaptured in the Barents Sea in August 1972 (Nizovtsev 1974). At least two captures were made in the Faroe Islands area from tagging studies off northeast Iceland and one capture in the Shetland Island area range from tagging studies at northeast Iceland (Sigurdsson 1979). One Greenland halibut tagged in Lichtenau Fjord at southwest Greenland in June 1955 was recaptured off Vestfirdir in northwest Iceland in June 1959, the only known data implying a connection between the stocks at Iceland and West Greenland (Smidt 1969).

Investigations by Kosier (1970), Chumakov (1969) and Sigurdsson (1979) in the Icelandic region have shown through tagging studies that Greenland halibut in that area perform long distance spawning migrations as well as feeding migrations. During the summer feeding period the Greenland halibut remained near the point of release and that a prespawning migration to the west and northwest into the Denmark Strait (the assumed spawning grounds) began at the end of September. Having spawned in April-May, the fish migrated eastward, returned to their summer feeding grounds north of Iceland. Chumakov (1969) reported dense concentrations of Greenland halibut moving eastward from the deepwater trench between Greenland and Iceland. Catches were found to fluctuate widely because the fish were migrating to the summer feeding grounds and consisted entirely of post-spawning fish.

Jensen (1935) and Smidt (1969) found a similar situation in West Greenland. Maturing Greenland halibut migrate from the fjords of west Greenland to the south of the Davis Strait ridge which extends across from Greenland to Canada. Here they spawn in waters of 600-1000 m in depth. After spawning, there is a migration towards the coast and into the fjords where the summer fishery consists mainly of post-spawning Greenland halibut.

Indications from Bowering (1980a, 1981) and Tremblay and Axelsen (1980, 1981) suggest a similar occurrence in the Gulf of St. Lawrence. Bowering (1980a, 1981) found from the commercial Newfoundland trawler fishery and research vessel surveys that a pre-spawning concentration of Greenland halibut occurs in the southeast Laurentian Channel in winter where the Newfoundland trawler fishery is located. Tremblay and Axelsen (1980, 1981) found that in

summertime Greenland halibut are more concentrated in the western part of the Gulf of St. Lawrence and are found associated with the shrimp fishery in this area. It is probable that this indicates a feeding migration since Greenland halibut feed heavily on shrimp (Smidt 1969; Bowering and Parsons 1981).

Results from the Trinity Bay tagging study did not yield much in the way of distant migrations with most tags recovered near the tagging site. However, for the three recaptures outside Trinity Bay there was an indication that these fish moved in a northerly direction.

The results of the Funk Island Bank tagging study clearly indicate an inward migration from the offshore area to the nearshore deep bays along the northeast Newfoundland coast. Most tag returns were from the summer gillnet fishery for Greenland halibut which occurs in the deep nearshore bays and channels from southern Labrador to Trinity Bay. The inward movement may be a feeding migration similar to that reported for cod in the same area (Templeman 1979) and for Greenland halibut at west Greenland (Jensen 1935; Smidt 1969). Here both species have been reported to feed heavily on capelin (Lear MS 1970; Templeman 1979) and to follow them towards coastal areas in summer. Most of the Greenland halibut in this study were relatively small and were not likely to be maturing. Consequently, it is unlikely that they would move further north in a spawning migration at this time. However, the large deep sea offshore fishery in the Labrador area for Greenland halibut has decreased substantially over the past few years (Bowering 1980b; Bowering and Brodie 1981) and any Greenland halibut that may have migrated northward there may well have gone undetected. The same may be said for the mid-Labrador study, however, from this study there is clear evidence of Greenland halibut moving over considerable distance in both north and south directions with almost half the returns taken from the deep waters of the continental slope area. Bowering et al. (1982) indicated that the biomass of Greenland halibut in the Labrador channels is now less than half that of 1980 despite the fact that very little fishing occurs here. The tags returned from this study (although few) may therefore be an indicator of a mass migration to the deep waters of the northern continental slope from the Labrador channels. Had fishing been more intense in this area, it is likely that many more tagged fish would have been recaptured.

The Fortune Bay tagging experiment speaks for itself. Few Greenland halibut are found between Fortune Bay and the Gulf area. It is also unlikely that Greenland halibut would move between Fortune Bay and eastern areas due to

the unfavorable conditions of the Avalon Channel separating the two. Therefore, the stock of Greenland halibut in the Fortune Bay area is most likely to be self-contained. It is interesting to note that for all tagging studies there were no tags recovered from within the Gulf of St. Lawrence. This would suggest no migration to the Gulf area from eastern areas, at least as adults.

Other Studies

Meristics

The first investigation into stock identification of Greenland halibut in the Northwest Atlantic was published by Templeman (1970). He analysed meristic characters of Greenland halibut from samples collected from West Greenland to the southern Grand Bank and the northern Gulf of St. Lawrence. A univariate statistical analysis of vertebral numbers averages revealed no significant differences throughout the range under investigation with the exception of the Gulf of St. Lawrence. This area was significantly different from all other areas. He concluded that vertebral averages were not particularly useful in separating Greenland halibut stocks of the Northwest Atlantic apart from the possible separation of the Gulf of St. Lawrence population. More recently, Misra and Bowering (In prep.) analyzed meristic characters of Greenland halibut throughout the range using a newly developed multivariate analysis technique published in Bowering and Misra (1982). The results indicated that the Gulf of St. Lawrence and Fortune Bay stocks were separate from all eastern areas but the analysis did not distinguish between the Fortune Bay stock and the Gulf of St. Lawrence stock. In eastern areas it was suggested that Greenland halibut from Davis Strait to the northern Grand Bank probably form one continuous stock, however, there was strong evidence to indicate that some localized spawning occurs as well, particularly in the Hamilton Bank-Northeast Newfoundland Shelf area.

Biochemical Genetics

Fairbairn (1981) investigated allele and genotype frequencies at 16 electrophoretically detectable protein loci, from tissue samples of Greenland halibut throughout the range from Davis Strait to the northern Grand Bank (Fig. 6). Her analysis suggested that Greenland halibut from the northwest Atlantic area form a single genetically homogeneous stock. She concluded that Greenland halibut in the Gulf of St. Lawrence form a separate stock from the eastern Newfoundland area although this stock was not completely isolated

since it showed similarities to the Labrador areas. Her conclusions are probably most accurate with particular reference to the Gulf of St. Lawrence since most fish from this area were found to be genetically different. However, while the population of Greenland halibut from Davis Strait to the northern Grand Bank appears to be genetically homogeneous it cannot be concluded on the strength of this evidence alone that it is a single spawning unit.

Parasites as Biological Tags

Khan et al. (1982) studied stock delineation of Greenland halibut in the northwest Atlantic by analysing the prevalence of trypanosome and piroplasm infections as biological tags (Fig. 7). Results from the study suggested that Greenland halibut from the Davis Strait, northern Labrador, and the northern Grand Bank form a single stock. The southern Labrador data were different from the other areas and might represent an isolated population, but the authors concluded it was part of a cline in the prevalence data. The Gulf of St. Lawrence data were distinct from that of all other areas north and east of Newfoundland and was considered as evidence of a separate stock there. Results of this study was also able to distinguish significantly between the Greenland halibut of the Gulf of St. Lawrence from those of the Fortune Bay area. This was not possible from other studies except as inferred from the tagging results of Fig. 5.

Biochemical properties

Dey (1982) investigated the Phosphoglucomutase enzyme of Greenland halibut muscle with regard to molecular weight, PH, amino acid contents, and reaction to inhibitory agents. He tested samples from southern Labrador, northern Grand Bank, and the Gulf of St. Lawrence. Statistically, the southern Labrador and northern Grand Bank samples could not be separated, however, the Gulf of St. Lawrence sample differed significantly from samples of both other areas. While the results were in tune with other investigations on stock identification it was not entirely clear whether these differences in the biochemical properties of isozymes were genetically or environmentally induced.

In conclusion, it would appear that the Gulf of St. Lawrence and Fortune Bay both support separate stocks, although there is clear evidence that some mixing occurs between the Labrador area and the Gulf area. All studies suggest that there is a single continuous stock from the Davis Strait area to the

northern Grand Bank. However, this is some indication that localized spawning may occur particularly in the southern Labrador area.

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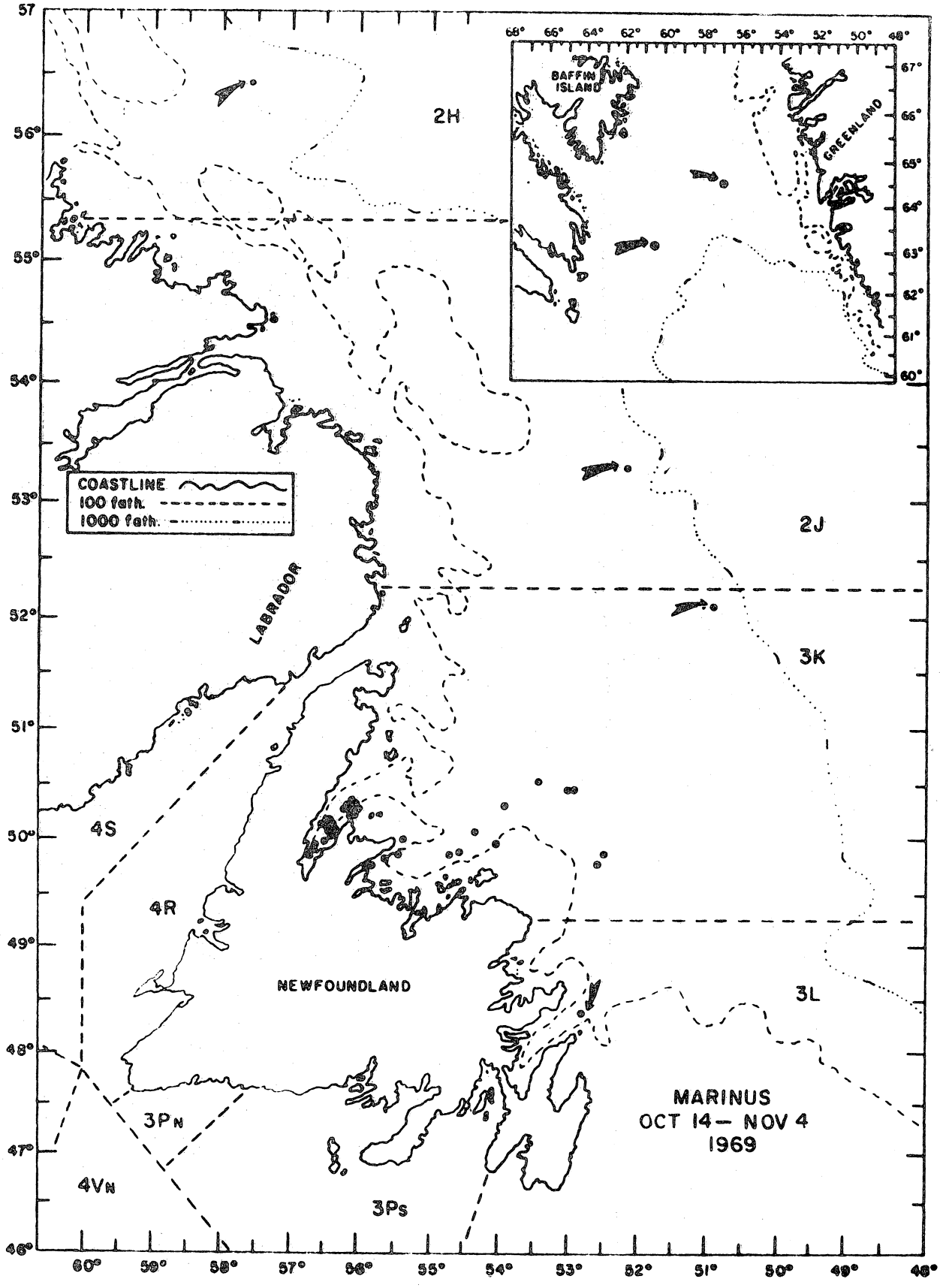

Fig. 1. Positions of the Greenland halibut tag returns for the White Bay tagging experiment October-November, 1969.

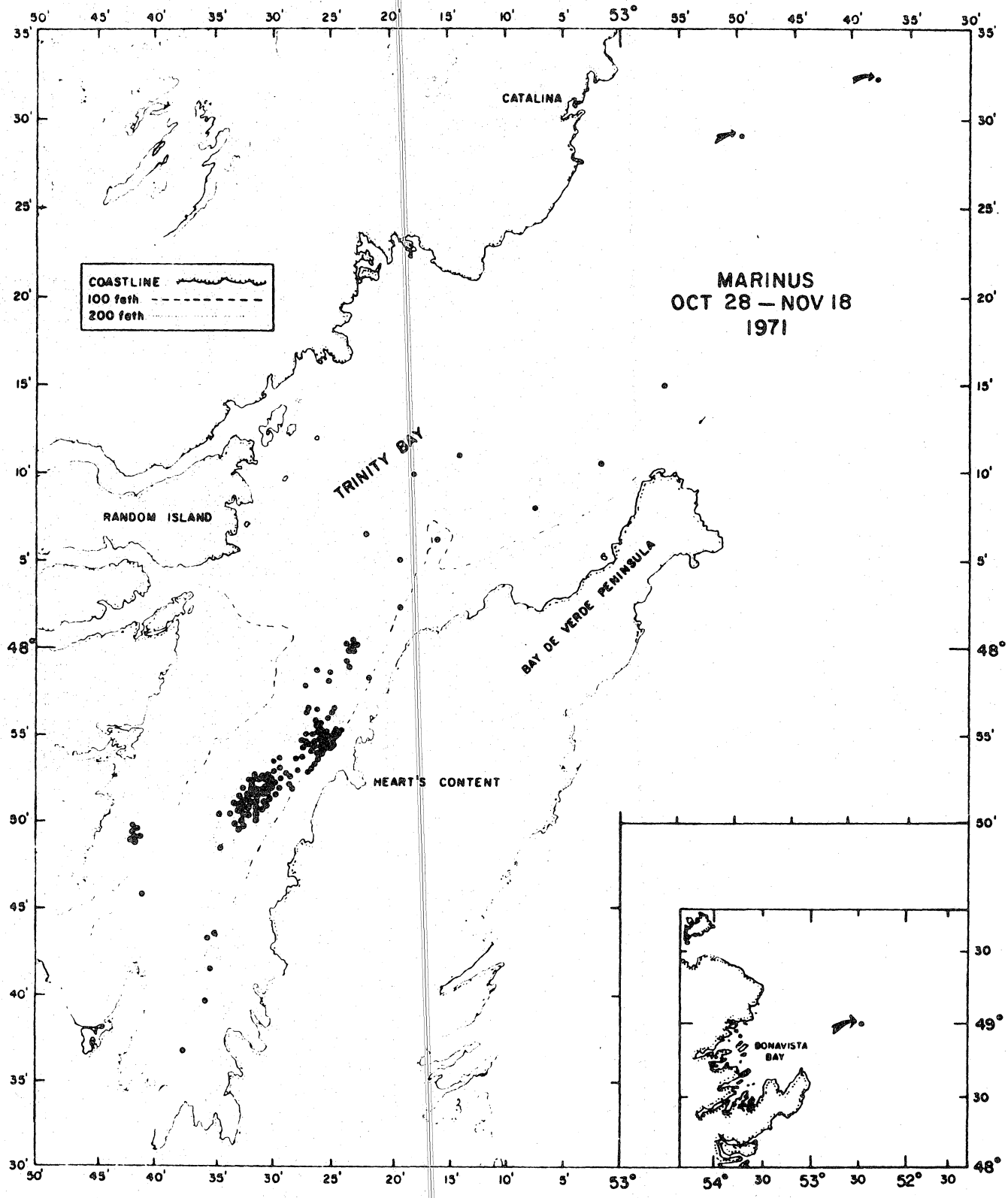

Fig. 2. Positions of the Greenland halibut tag returns for the Trinity Bay tagging experiment October-November, 1971

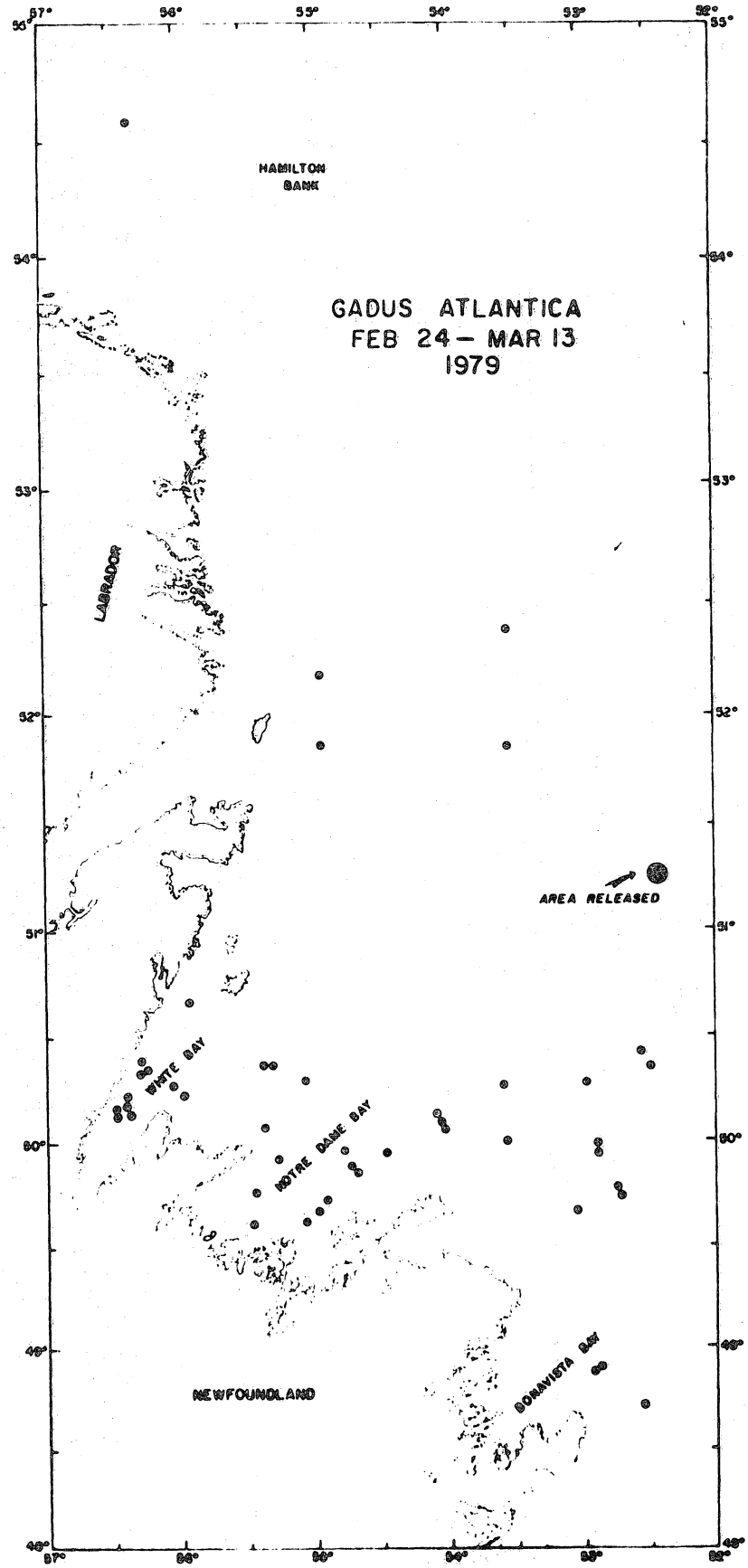

Fig. 3. Positions of the Greenland halibut tag returns for the Funk Island Bank tagging experiment February-March, 1979.

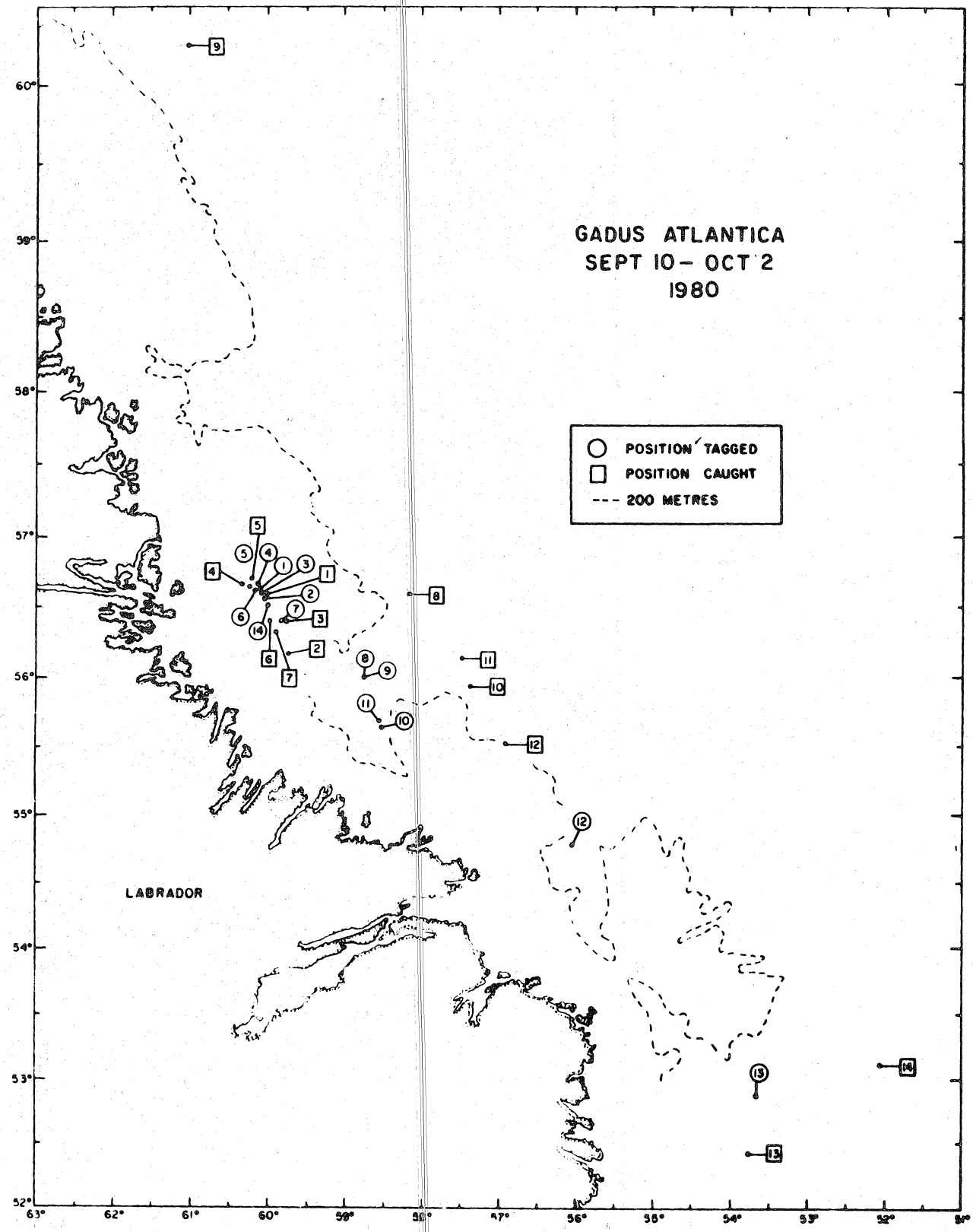

Fig. 4. Positions of the Greenland halibut tag return for the mid-Labrador tag experiment September-October, 1980.

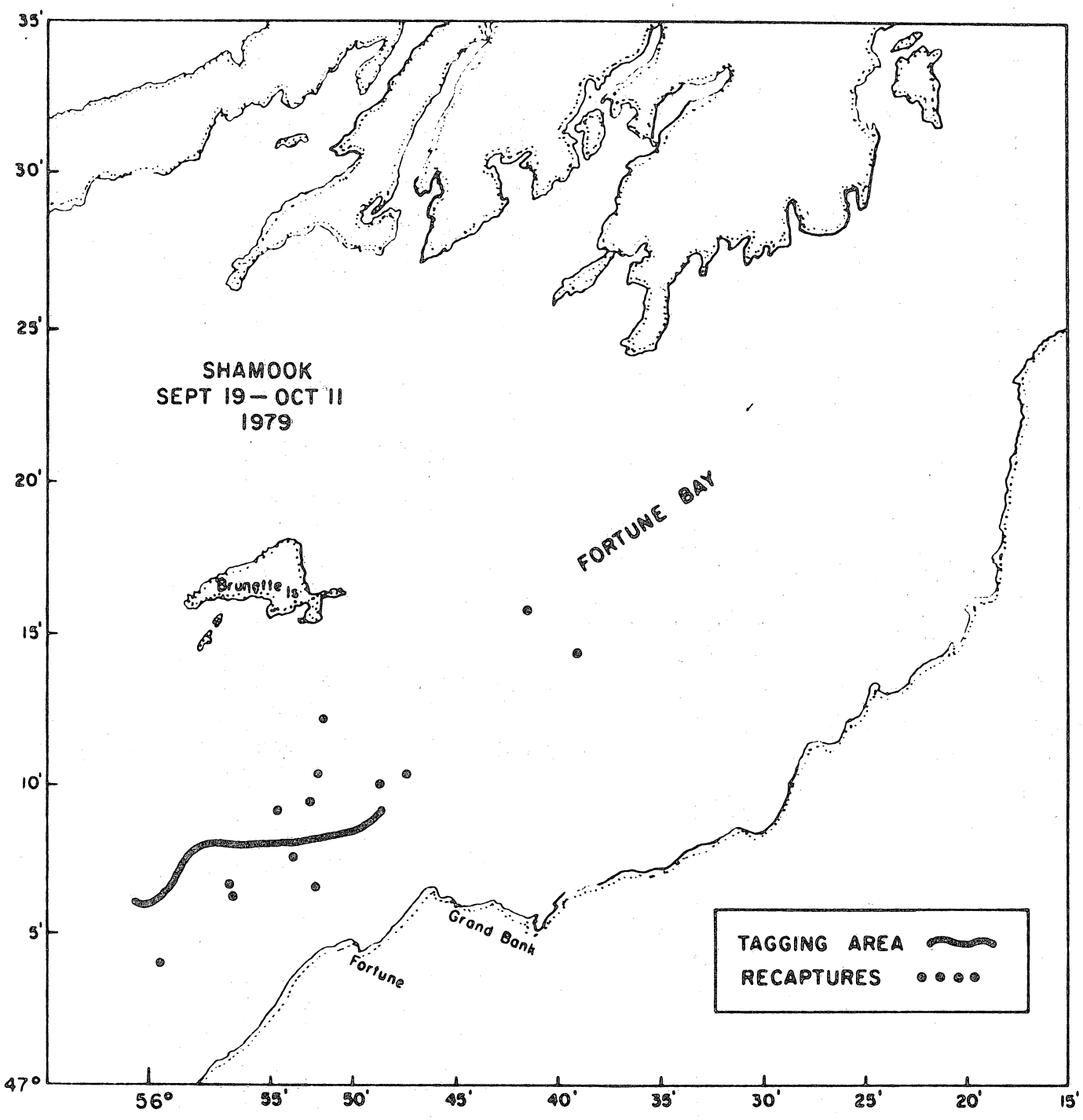

Fig. 5. Positions of the Greenland halibut tag return for the Fortune Bay tag experiment September-October, 1979.

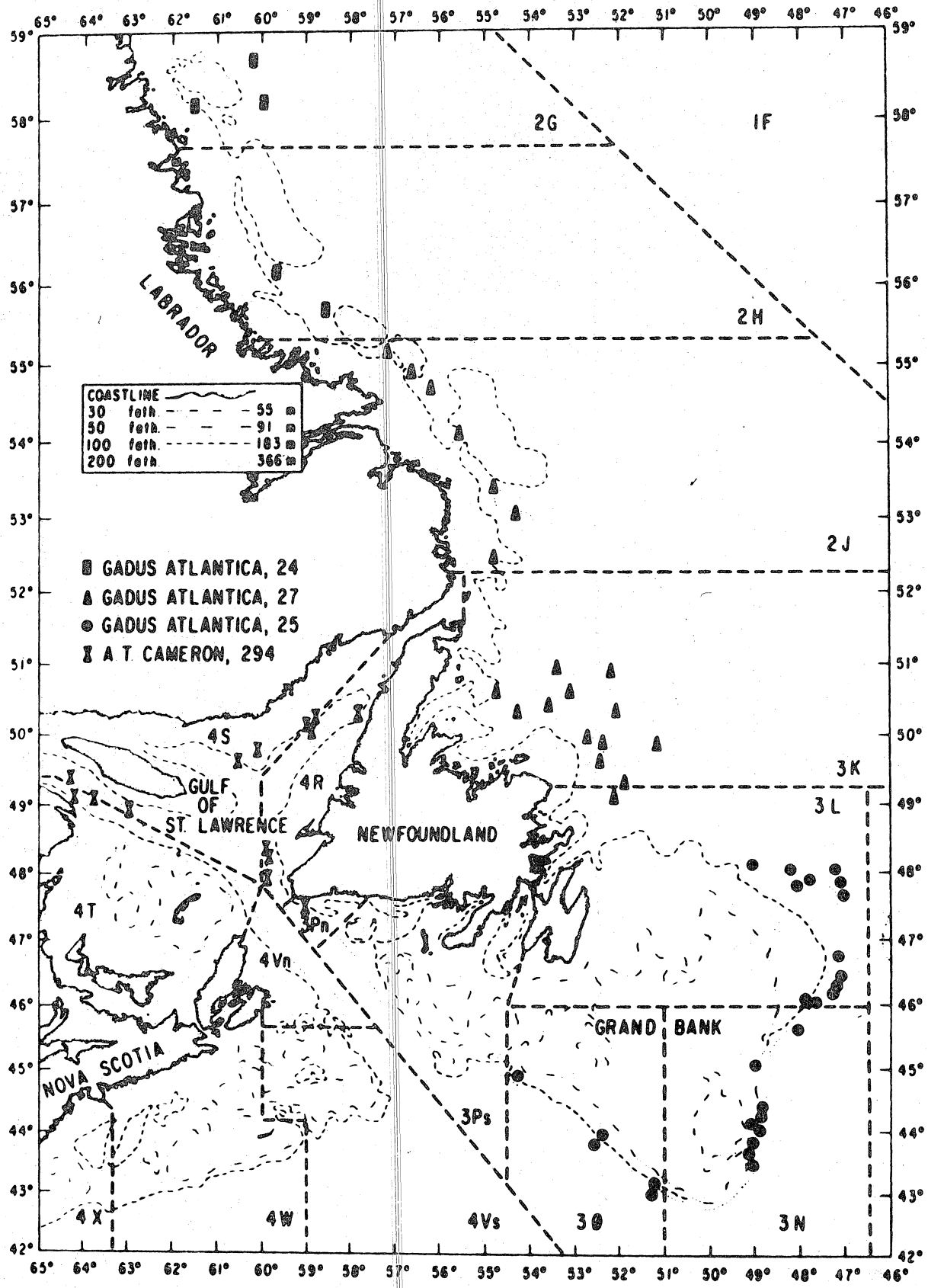

Fig. 6. Distribution of Greenland halibut samples by trip in the Gulf of St. Lawrence and the Northwest Atlantic used in the biochemical genetics analysis (from Fairbairn, 1981).

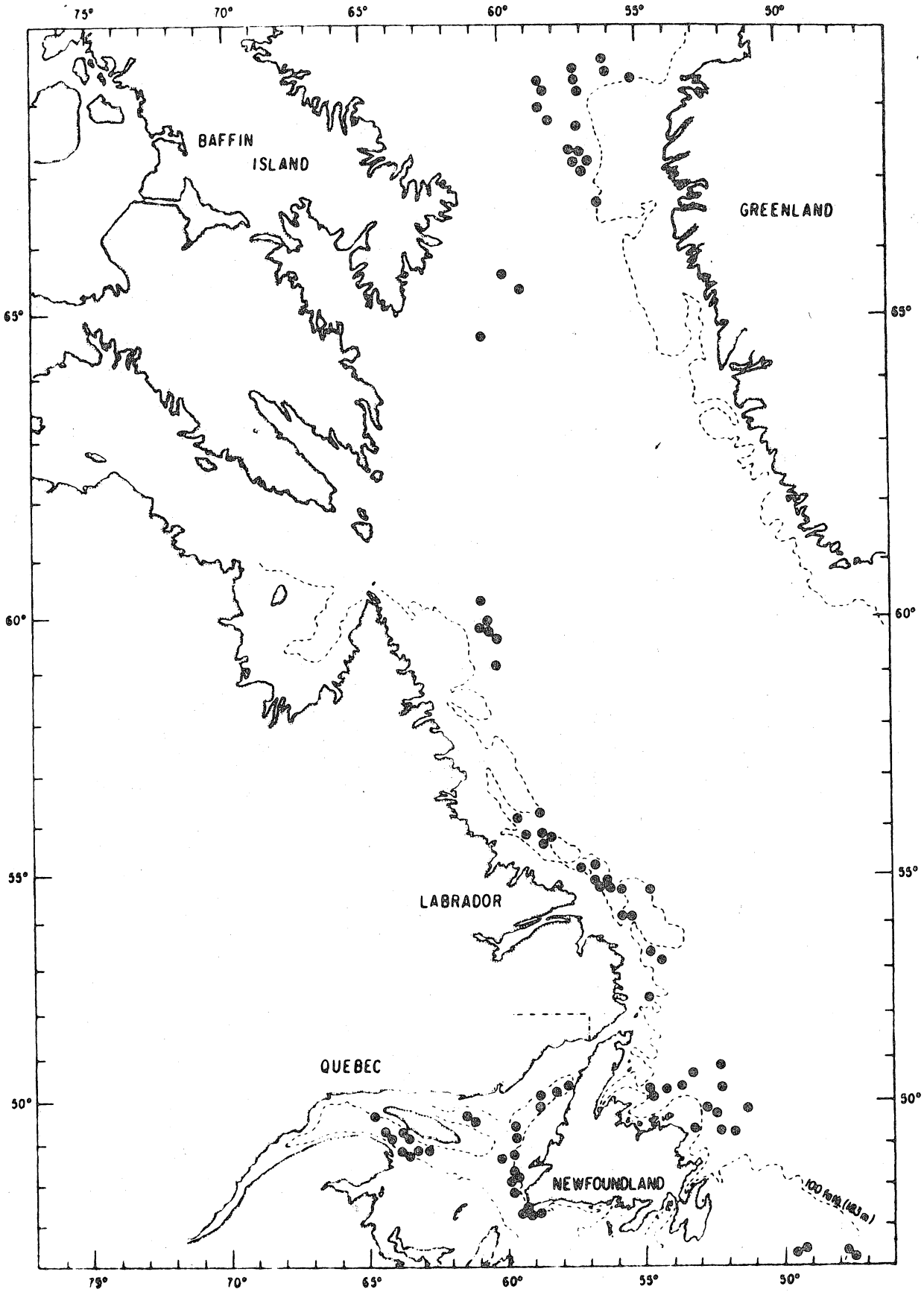

Fig. 7. Distribution of Greenland halibut samples used in the parasitology study (from Khan et al. 1982).