RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 3002
(B.g. 14)

ICNAF Res.Doc. 73/57
(Also ICES/ICNAF Salmon Doc. 73/14)

ANNUAL MEETING - JUNE 1973

Distribution and migrations of salmon in the Northwest Atlantic

by

A. W. May
International Fisheries Branch
Fisheries and Marine Service
Environment Canada, Ottawa

Introduction

Until the advent of the commercial salmon fishery at West Greenland in the early 1960's, data on movements of salmon in the sea were limited to the results of coastal tagging experiments and very occasional records of individual salmon taken on offshore fishing banks during fishing operations for other species. The fact that salmon were seasonally present at West Greenland had been known for some time (Jensen, 1939, 1948; Neilsen, 1961). Recaptures of a Scottish tagged salmon in 1956 and a Canadian tagged salmon in 1960, plus scale reading to evaluate the river age composition, indicated that most of the fish present were of non-Greenlandic origin (Hansen, 1961).

The first recorded exploitation of these salmon was a catch of 60 metric tons by native Greenlanders in 1960, using set gillnets attached to the shore. This fishery reached a peak of 1539 tons in 1964. Since that time it has fluctuated around an average level of about 1100 tons, including since 1969 catches by drift nets as well as shore nets (Fig. 1). Fishing takes place all along the west coast from Nanortalik in the south to Umanak in the north (approximately 60° N to 70° N) during the months of August to November. A very small shore net fishery also operates at Angmagssalik (about 66° N) on the east coast. Drift net fishing by vessels based in Europe began in 1965, and catches reached a peak of 1240 tons in 1971 (Fig. 1). Fishing takes place close to the shore as well as some 30 to 40 miles offshore, and has gradually developed to cover the same north-south distribution as the inshore fishery.

Distribution of river ages in the Greenland catch includes fish of river ages 1 to 7; about half being of age 2 and 90% of the catch being of ages 2 to 4 (Munro, MS, 1969). Well over 90% of the salmon taken are 1+ sea years in age. (May, MS, 1970a; Munro, MS, 1970).

Origin of West Greenland Salmon

Although eggs have been stocked in several West Greenland streams, only the Kapisiglit River in Godthaab Fjord is known to carry a regular natural spawning run (Hansen, 1961). On the other hand, as smolt tagging programs have increased, an increasing number of returns has been reported from Greenland, totalling in the 1964 to 1971 period over 1600 from North America and over 450 from Europe (ICES/ICNAF, 1972). During the same period Greenland returns of 52 tagged North American kelts and 23 tagged European kelts have been recorded. The pattern of tag recoveries shows that fish of North American and European origin are rather evenly mixed throughout the season and along the West Greenland coast (ICES/ICNAF, 1972).

Most of the Greenland returns are of fish tagged in Canada, the United Kingdom and the United States, though tags have also been recorded from fish tagged in Iceland, Ireland, France, Norway, Sweden and Denmark. Because of great variability in design of these tagging experiments it is not possible to use the data to estimate sources of origin in quantitative terms, but it is clear that most of the fish present at Greenland originate in Canada and the United Kingdom.

It is worth noting at this point that during the 1963 to 1971 period over 1 1/2 million smolts have been tagged in North America and over 600 thousand in Europe. Over 2000 returns have been recorded at Greenland and almost 5000 returns of 2 sea year salmon have been recorded in home waters. It is known that the North American and European fish are completely mixed at Greenland and it is also known that fish return from Greenland to Europe and North America, yet no salmon tagged in North America has ever been recaptured in Europe or vice versa. Results of the tagging experiments therefore point quite strongly to a directed migration of salmon to and from Greenland.

The numbers of fish undertaking this migration are unknown, as is the oceanic mortality during the migration to and from Greenland. It may be assumed that mortality is much greater during the outward migration since the fish are much smaller and the time period two to three times as long. It is also evident that virtually all the fish present at Greenland would, if surviving, return to spawn as 2 sea year individuals, the remainder being previous spawners and fish spending more than two years at sea.

Recapture rates at Greenland and in home waters from tagging of wild smolts in Canada, Scotland and England during the period 1963 - 1970 are plotted in Figures 2 - 4. For all three areas there is an upward trend in recapture rates from Greenland. This could be due simply to increasing catches at Greenland, or to better reporting of tags, better survival of tagged smolts or to an increased portion of the smolt run being present at Greenland. Trends in recapture rates for Canadian and English tagged smolts are similar in Greenland and home waters to 1967; Scottish tagging shows divergent trends in recapture rates from 1963 to 1968. Declines in recapture rate of the 2 sea year component in home waters are evident from 1963 in Scottish experiments, from 1965 in Canadian experiments and from 1967 in English experiments. Trends in recapture rates of grilse are similar to those for 2 sea year fish in Canada (except 1968) England, and Scotland (except 1966).

Although this gross presentation produces highly variable results, the trends in recapture rates do point to a general decline in home waters recaptures of the 2 sea year component of the runs from fairly high rates in the early to mid - 1960's. If, in fact, there is a cause and effect relationship between trends in recapture rates at West Greenland and home waters, as the graphs imply (Figs. 2 - 4), the inferential conclusion is that the salmon caught at Greenland would have migrated to the respective home waters countries had they not been captured at Greenland.

Marine Tagging Experiments

Prior to tagging experiments at Greenland as a consequence of increased salmon fishing in the mid - 1960's, salmon had been tagged at sea only close to the shore, and at the most a few months before the fish entered fresh water to spawn. Many such experiments on both sides of the North Atlantic have elucidated migration routes as the salmon approached their home streams.

Salmon were first tagged along the shore at Greenland in 1965, and in offshore areas including the Labrador Sea in 1969. During the period from 1965 to 1970 about 2000 salmon were tagged during the autumn at West Greenland, and in the Davis Strait and Labrador Sea, but mainly relatively close to the shore along the Greenland coast by scientists from Denmark, Canada, the United Kingdom and United States. During this period

a great deal of effort was expended in attempts to capture salmon by some means other than set gillnets and driftnets in order to improve the viability of fish for tagging purposes. Although fish in better condition have been captured by other means, the numbers caught per unit of fishing effort are so low that tagging experiments using other catching techniques are impractical. Thus most tagging near the shore has been carried out using nets set overnight, and most offshore tagging using drift nets which were frequently patrolled by a small open boat whenever they were set (May, MS, 1970b; Minet, 1972).

Under these circumstances, and taking into account the more "delicate" condition of salmon during this period (e.g. scales easily lost) it is not surprising that returns from such tagging have been low. It is likely that a high tagging mortality is a consequence of the technique, and of 2042 fish tagged between 1965 and 1970, only 88 recaptures have been made; 61 at Greenland and 27 in home waters to the end of 1971. Of the Greenland recaptures, three were made in the year following tagging. Size at recapture indicated that all three had not spawned, and therefore may have returned to home waters as 3 sea year fish if not recaptured at Greenland. Of the home waters recaptures all but one were made in the year following tagging, the exception being a fish which made its way from Disko Bay to northeast Newfoundland in 75 days. Home waters recaptures have been recorded in Canada (12), Scotland (6), England and Wales (3), Ireland (5) and Spain (1) for a total of 27 (45% to North America and 55% to Europe). Recaptures within Europe have almost invariably been within rivers, whereas those in Canada have been mainly from coastal fisheries in which fish destined for more distant areas may have been intercepted. All the recaptures, except as noted above, were of fish tagged at 1+ sea years in age and recaptured at 2 sea years. All returns have been from tagging at West Greenland, i.e. none from small numbers of salmon tagged in the mid-Labrador Sea. [1]

In addition to the autumn tagging in the Labrador Sea and at West Greenland, a Canadian research vessel has tagged salmon in the Labrador Sea in spring each year since 1970. Numbers tagged have been relatively small,

[1] As this paper was going to press, a report was received of a recapture in Ireland (1972) of a salmon tagged in autumn, 1971 in the Labrador Sea, at 58° 09' N, 52° 27' W.

27 in 1970 and 59 in 1971. Fish have been tagged from both drift nets and surface longlines, resulting in four recaptures of 46 fish tagged from drift nets and seven recaptures of 40 fish tagged from longlines. All eleven returns have been from Canadian coastal fisheries or rivers, six along the east coast of Newfoundland and five in the Gulf of St. Lawrence (Fig. 5). All fish tagged were 2 sea years in age, as were virtually all the fish caught. All returns occurred in the year of tagging.

Tagging of salmon taken in drift nets by research vessels has been carried out also in several Canadian coastal areas in recent years; at Port aux Basques in 1969, in the Miramichi estuary in 1970 and in Southern Labrador in 1971. Large commercial fisheries have existed in all three areas, though the Port aux Basques and Miramichi drift net fisheries were closed in 1972. In Labrador the commercial fishery is by set gillnets along the shore.

The Port aux Basques experiment, intended as a "dry run" for the first attempt to tag salmon from drift nets at Greenland, produced returns essentially similar in pattern to those from a 1937 experiment in the same area (Belding and Prefontaine, 1938). Of 247 salmon tagged, virtually all of 2 sea years, 106 or 43% were recaptured and reported (Fig. 6). 70% of the returns were from commercial and angling fisheries in Quebec and New Brunswick; most of the remainder from the Newfoundland West Coast. Single recaptures were reported from southern Labrador and west Greenland. Almost all the recaptures occurred during the year of tagging.

The 1971 southern Labrador tagging was carried out late in the season because of a delay caused by a mechanical breakdown on the research vessel. As a result, the run of 2 sea year fish had tapered off and most of the 145 fish tagged were grilse.

Most of the 37 recaptures in 1971 were taken near the tagging area and in areas to the south, including one return from the northeastern tip of Newfoundland and three from the Strait of Belle Isle (Fig. 7).

Oceanic Distribution in the Northwest Atlantic

The Canadian research vessel "A. T. CAMERON" has occupied several hundred fishing stations for Atlantic salmon since 1965. Much of the fishing has consisted of repetitive sets at single fishing stations in connection with tagging experiments. Most has been carried out with drift nets (including

all fishing in the Davis Strait and West Greenland areas), with longlines being used also east of the Canadian continental shelf in spring. Stations have been fished in each month from March to October, and over the area between 43° N and 70° N. Catches are expressed as numbers of fish caught per nautical mile of drift nets per hour fished or, for longline fishing, as number of fish per thousand hooks per hour fished, and are shown in Figure 8 as catches in spring (March-June) and summer-autumn (July-October).

Salmon may be found in spring in surface waters east of the Canadian shelf from northern Labrador to the southern Grand Bank. The most westerly positions shown (Fig. 8) parallel to the shelf off Labrador and northeast Newfoundland, follow fairly closely the edge of the arctic ice pack in spring, so that the salmon are found in relatively cool surface waters (3 to 6° C), with very few individuals being taken at temperatures of 2° C or less. The greatest concentrations in spring are taken about 300 miles east of the Strait of Belle Isle. Virtually all the fish taken have been of 2 sea years in age. It is of interest to note that a small commercial longline fishery operated at approximately 58-60° N, 53-58° W in the spring of 1970 (Kanneworff, MS, 1970), but was subsequently prevented from doing so under the terms of a 1970 ICNAF agreement on salmon fishing on the high seas.

In late summer and autumn fish are concentrated along the west Greenland coast, and as far as 30-40 miles offshore. However, relatively good catches have also consistently occurred in the mid-Labrador Sea, about halfway between southern Labrador and southern Greenland, in an area where salmon are also found in spring. Smaller catches have been obtained in other parts of the Labrador Sea, and a very few salmon have been taken in summer at the edge of the loose ice field in the western Davis Strait. Virtually all the salmon taken in this summer and autumn fishing have been 1+ sea years in age. Surface temperatures in areas where abundance is greatest range from about 3° C to 8° C.

Discussion and Conclusions

It is clear that substantial proportions of that part of the smolt run from many north Atlantic countries, destined to return as 2 sea year salmon, migrate to Greenland and adjacent waters in the Labrador Sea. They are known to spend at least 4-5 months off the Greenland coast during their second year at sea, at which time they feed heavily on small fish. This fact,

coupled with results from tagging experiments at Greenland and the absence of transatlantic movements indicate very strongly that these are directed movements. Salmon are rarely caught in bottom-fishing gear, and although very little off-bottom (midwater) fishing has been done in these areas, the weight of evidence to date suggests that at least during the second year at sea salmon are distributed within a few metres of the surface.

The presence of abundant food organisms during August to December along the Greenland coast, combined with favourable surface temperatures, are obviously factors in maintaining concentrations in this area over the late summer and autumn period. Templeman (1967) has pointed out that the large anti-clockwise eddy in the south Labrador Sea offers conditions favourable for the concentration of several species, including salmon and potential salmon prey. Lear (MS, 1971) and Lear and May (1971) have subsequently shown that salmon in this area feed heavily on arctic squid (Gonatus sp.) and Paralepis sp.

One is tempted to speculate that movements of salmon to and from Greenland are related to the pattern of oceanic circulation in the north Atlantic as a whole. It may be noted that fish from both Europe and North America could reach Greenland by swimming against the current, provided the European fish take a circuitous detour to the south and west. In contrast, they could return to the home areas by taking a similar route with the current (Fig. 9).

There is as yet no knowledge of oceanic distribution during the first sea year, nor the whereabouts during this period of fish destined to return either as grilse or as 2 sea year salmon. On the Canadian side of the Labrador Sea, many Labrador and Newfoundland rivers have salmon runs composed almost entirely (80 to 90%) of grilse, and large numbers of 1 sea year fish are taken in commercial fisheries. It is possible that some portion of the 1 sea year fish taken commercially are not, in fact, destined to spawn as grilse, but rather as 2 sea year or older fish. There is as yet no evidence to support such an assumption, but the possibility does exist.

Salmon of 2+ sea years in age (potential 3 sea year spawners) are apparently present in relatively small numbers at Greenland, though they have formed a relatively large proportion of small experimental longline catches (Munro, MS, 1970). Salmon of 3 sea years in age have long formed

the basis of a small winter fishery in northeast Newfoundland. Recaptures from a small tagging experiment indicate a return migration from this area mainly to rivers in the western Gulf of St. Lawrence.

Templeman (1965) has reviewed a number of Canadian coastal tagging experiments. Many smolt tagging experiments in Canadian mainland rivers, plus similar experiments in the State of Maine, have resulted in a varying proportion of returns from Labrador and Newfoundland, mainly from the Newfoundland east coast (e.g. Kerswill, 1955). Salmon tagged in northern Newfoundland produced recaptures mainly from Labrador and the northeastern Gulf of St. Lawrence (Belding and Préfontaine, 1961). However tagging on the Newfoundland east coast (Blair, 1956) produced significant returns of 2 sea year fish, and a few returns of grilse from Gulf of St. Lawrence rivers. Many Newfoundland recaptures may have been of fish on their way to this area. Migration past southwest Newfoundland to the western and northern Gulf have been described by Belding and Préfontaine (1938) and May (MS, 1970).

For some of the larger Canadian rivers, notably the Miramichi, the combination of local tagging plus local recaptures from more distant tagging, allows a fairly accurate presentation of the migration pattern between the 1+ sea year stage and Greenland and the return to the river as 2 sea year spawners. To take the Miramichi as an example, it is known that fish of Miramichi origin are widely distributed at Greenland. In the March-April period they are present in the mid-Labrador Sea east of the Canadian Shelf. In late May and early June fish of Miramichi origin are present along the Newfoundland east coast as part of a large mixed population, and at the same time are abundant on the southwest coast as they pass through the northeast part of Cabot Strait. They reach the Miramichi estuary in greatest abundance in mid June, two to three weeks after the peak of the southwest Newfoundland fishery.

Acknowledgements

I am indebted to Messrs. W. H. Lear and R. H. Payne for much of the data on oceanic distribution and Labrador Sea tagging. Tagging experiments at Port aux Basques and southern Labrador were under the field supervision of Messrs. R. F. Burfitt and W. N. Batten.

References

Belding, D. L. and G. Prefontaine 1938. Studies on the Atlantic salmon. II Report on the salmon of the 1937 Port aux Basques (Newfoundland) drift-net fishery. Contr. Inst. Zool. Univ. of Montreal, No. 3, 58pp.

1961. A report on the salmon of the north shore of the Gulf of St. Lawrence and of the northeastern coast of Newfoundland. Contr. Dept. Fisheries Quebec, No. 82, 104pp.

Blair, A. A. 1956. Atlantic salmon tagged in east coast Newfoundland waters at Bonavista. J. Fish. Res. Bd. Canada 13(2): 219-232.

Hansen, P. M. 1961. Nyttefisk i de grønlandske farvande (Commercial fish in Greenland waters). Grønlandske Erhverv (Greenland occupations) I: 1-84. FRB Translation No. 1948.

ICES/ICNAF 1972. Report of the ICES/ICNAF Joint Working Party on North Atlantic Salmon. ICNAF Res. Doc. 72/32, 49pp.

Jensen, Ad. S. 1939. Concerning a change of climate during recent decades in the Arctic and Subarctic regions, from Greenland in the West to Eurasia in the East, and contemporary biological and geophysical changes. Biol. Medd. Kbh., 14(8): 1-75.

1948. Contributions to the ichthyofauna of Greenland, 8-24. Spolia Zool. Mus. Hauniensis, 9: 1-182.

Kanneworff, P. MS, 1970. Catch statistics and age/length distribution of Atlantic salmon from the southern part of the Davis Strait. ICNAF Res. Doc. 70/65, 3pp. + corrigenda.

Kerswill, C. J. 1955. Recent developments in Atlantic salmon research. Atl. Salmon Journal, 1955, No. 1, pp. 26-30.

Lear, W. H. MS, 1971. Food and feeding of Atlantic salmon at sea. ICNAF Res. Doc. 71/2, 13pp.

Lear, W. H. and A. W. May, 1971. Paralepis coregonoides borealis (Osteichthyes: Paralepididae) from Davis Strait and Labrador Sea. J. Fish. Res. Bd. Canada 28(8): 1199-1203.

May, A. W. MS, 1970a. Size and age of salmon from west Greenland, 1968 and 1969. ICNAF Res. Doc. 70/3, 6pp.

1970b. Drift net tagging of Atlantic salmon. ICNAF Res. Doc. 70/2, 12pp.

Minet, J. P. 1972. Techniques Canadiennes de capture et de marquage du saumon Atlantique dans les eaux du Labrador et du Groenland occidental. Science et Pêche, No. 212, 15pp.

Munro, W. R. MS, 1969. Salmon work in Greenland, 1968. ICNAF Res. Doc. 69/70, 5pp.

MS, 1970. Greenland salmon research programme, 1969. Pelagic long lining cruises by the RV Adolf Jensen. ICNAF Res. Doc. 70/44, 5pp.

Neilsen, J. 1961. Contributions to the biology of the Salmonidae in Greenland, I-IV. Medd. Grønland, 159(8): 1-75.

Templeman, W. 1965. Atlantic salmon from the Labrador Sea and off west Greenland, taken during A.T. CAMERON cruise, July-August, 1965. ICNAF Res. Bull. 4: 5-40.

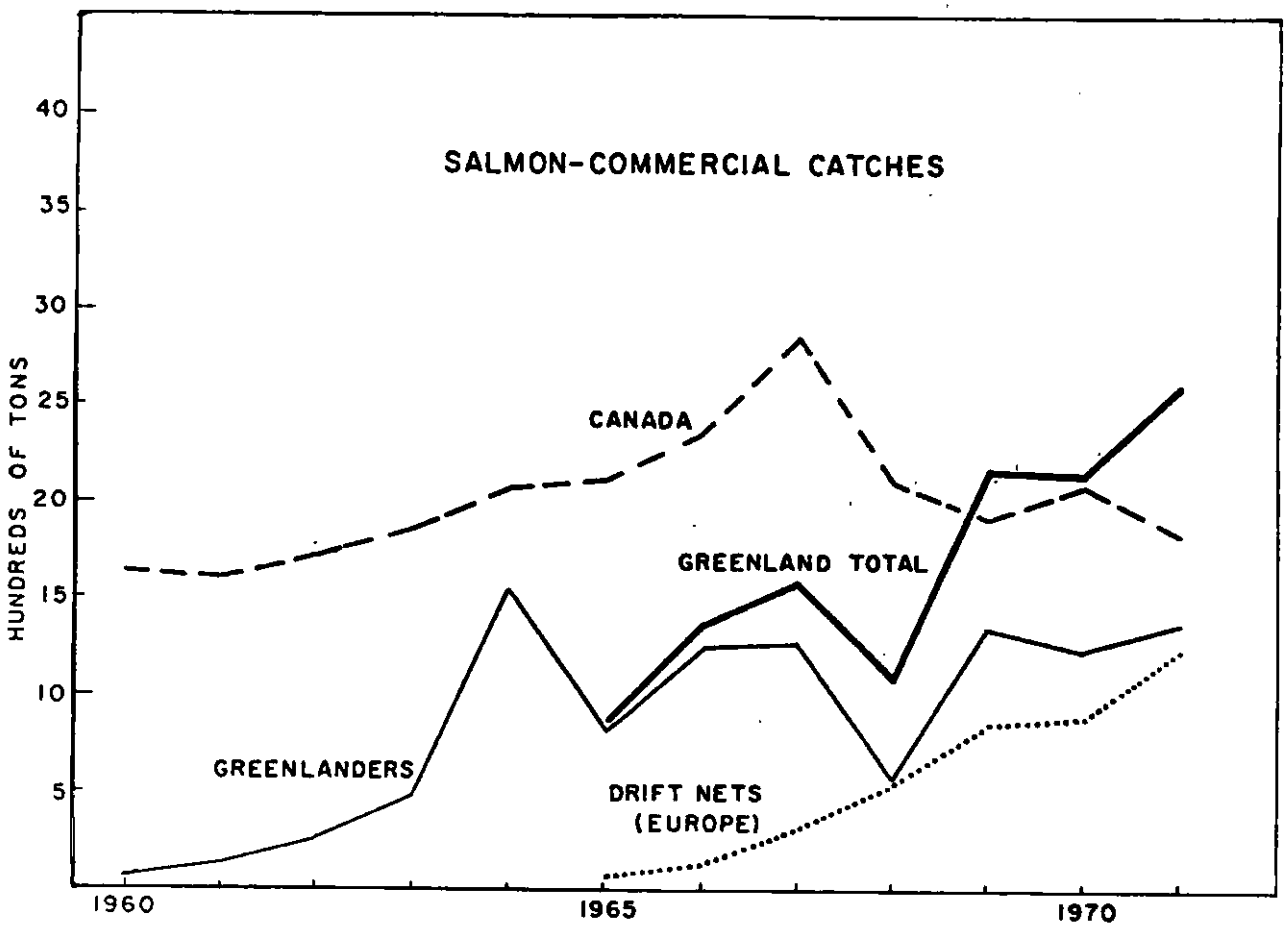

Figure 1. Commercial catches of Atlantic salmon in Canada and Greenland, 1960 - 1971.

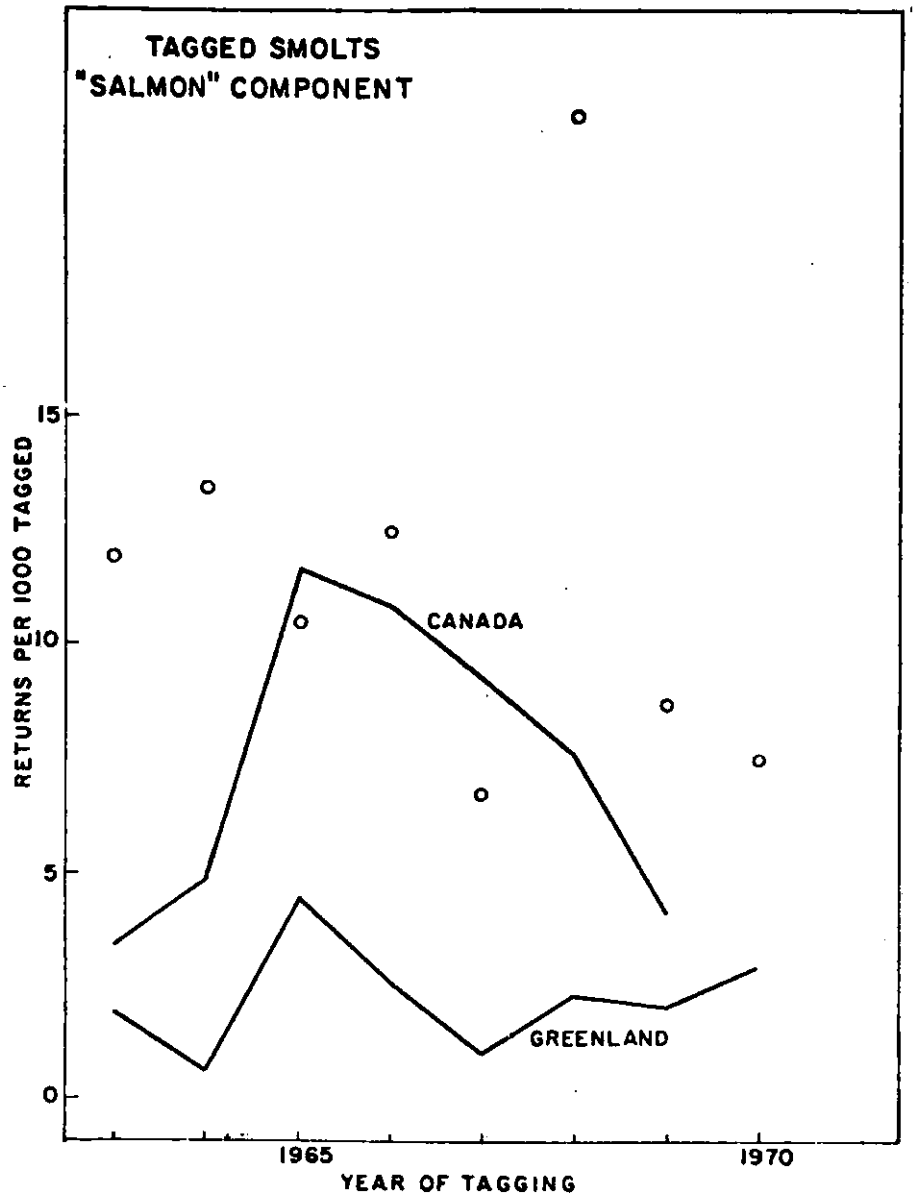

Figure 2. Return rates from Canadian wild smolt tagging experiments, 1963 - 1970. Open circles are recaptures as "grilse".

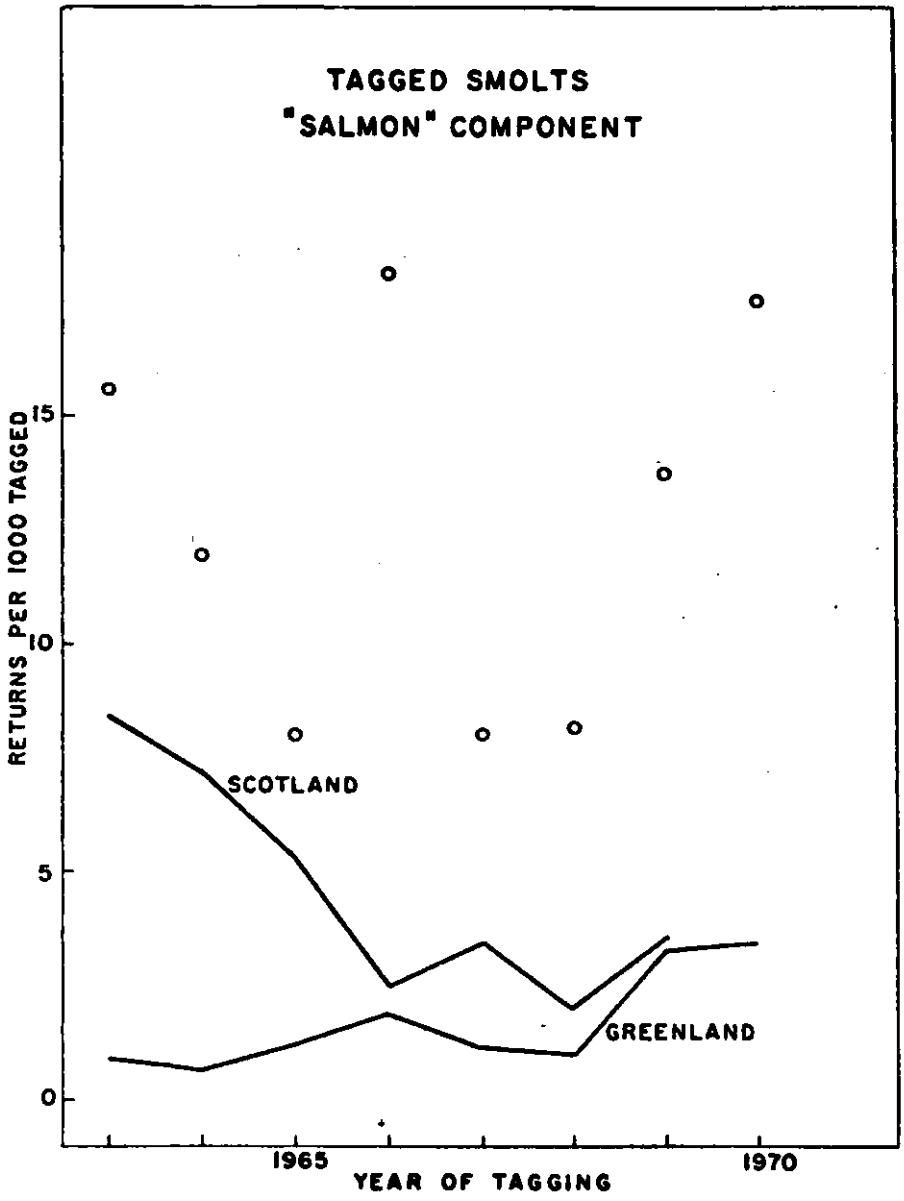

Figure 3. Return rates from Scottish wild smolt tagging experiments, 1963 - 1970. Open circles are recaptures as "grilse".

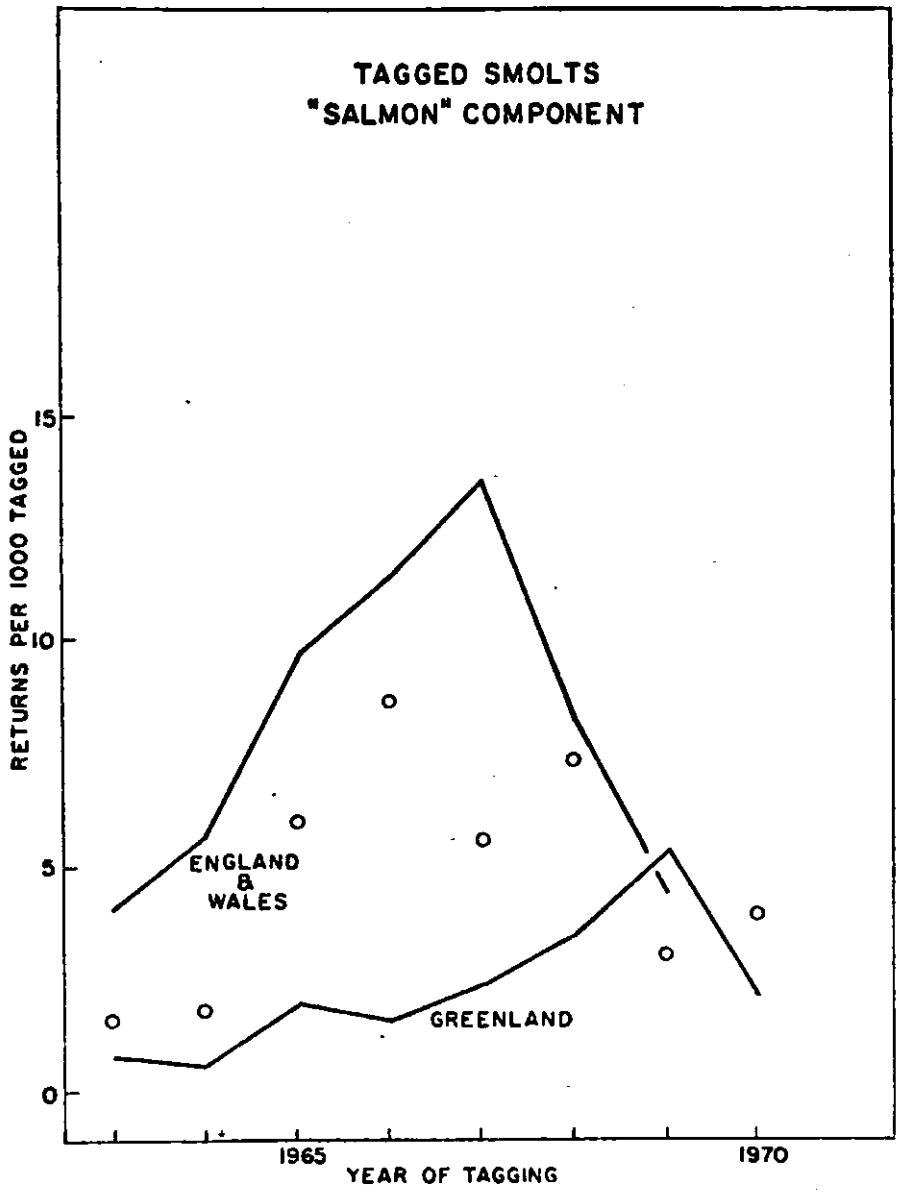

Figure 4. Return rates from wild smolt tagging in England and Wales, 1963 - 1970. Open circles are recaptures as "grilse".

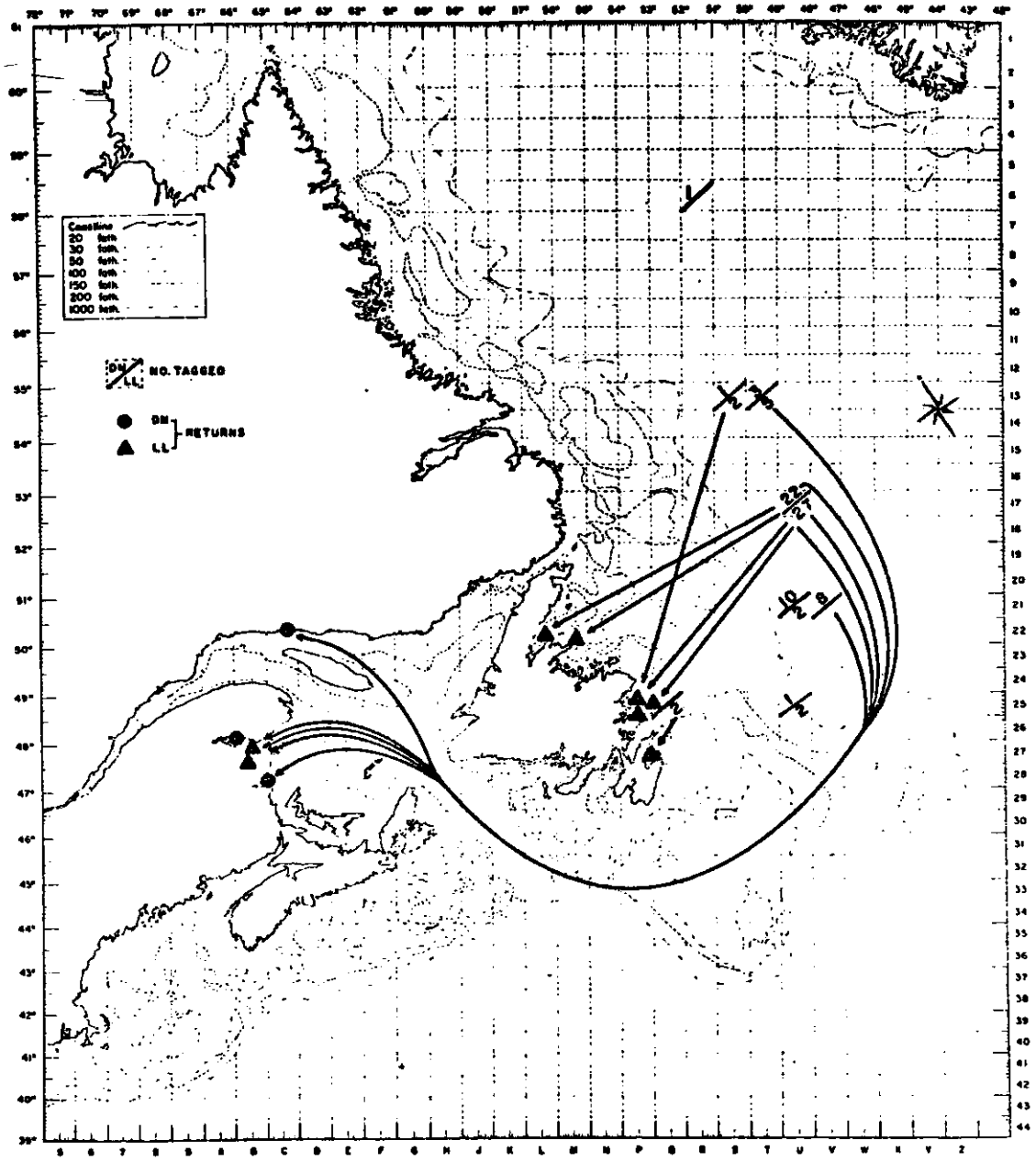

Figure 5. Recaptures of salmon tagged as 2 sea year individuals in the Labrador Sea, 1970 and 1971. DN = driftnet, LL = longline. Numbers refer to number tagged.

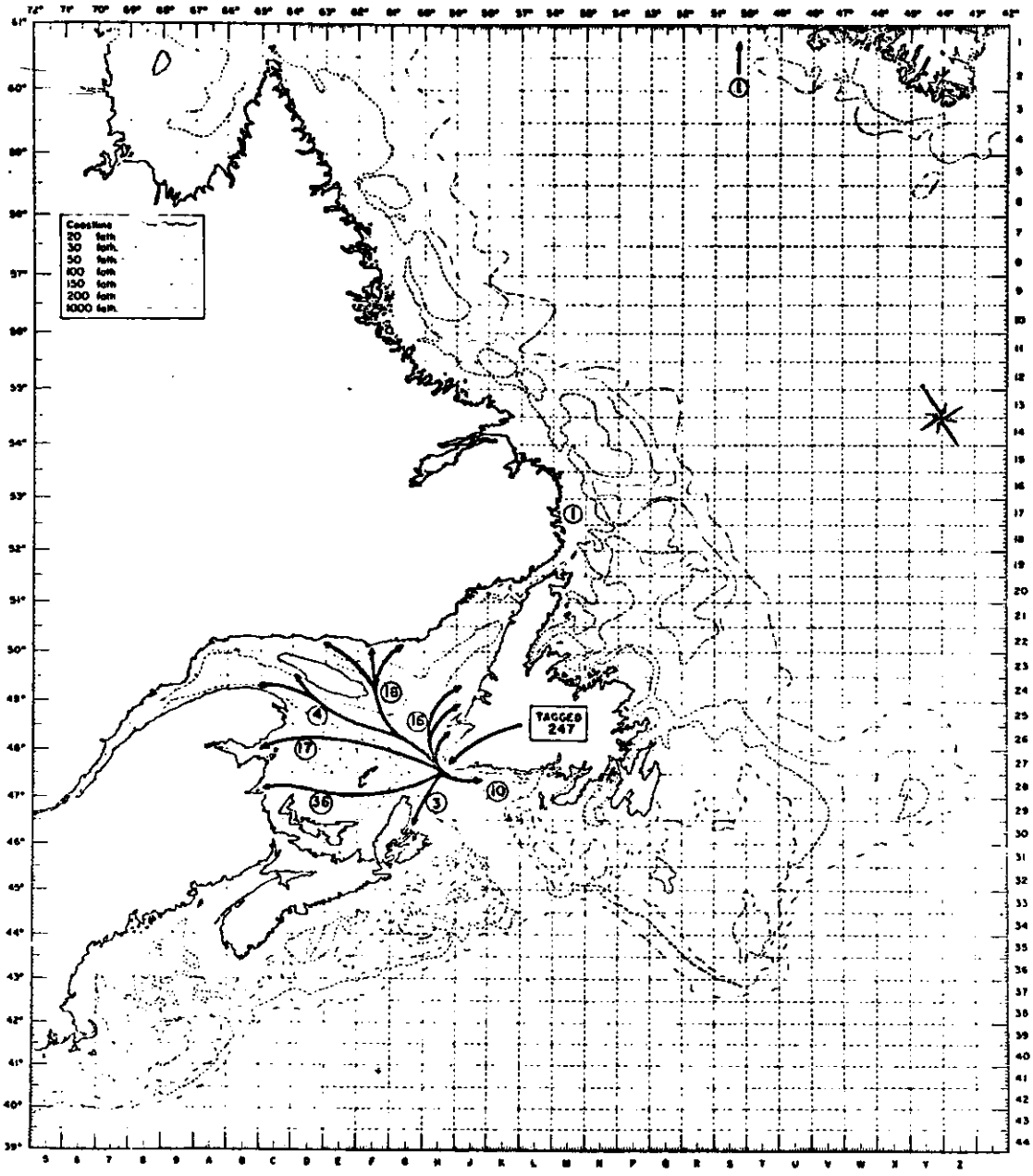

Figure 6. Recaptures of salmon (mainly 2 sea year individuals) tagged off southwest Newfoundland in 1969. Numbers refer to number of recaptures in each general area indicated.

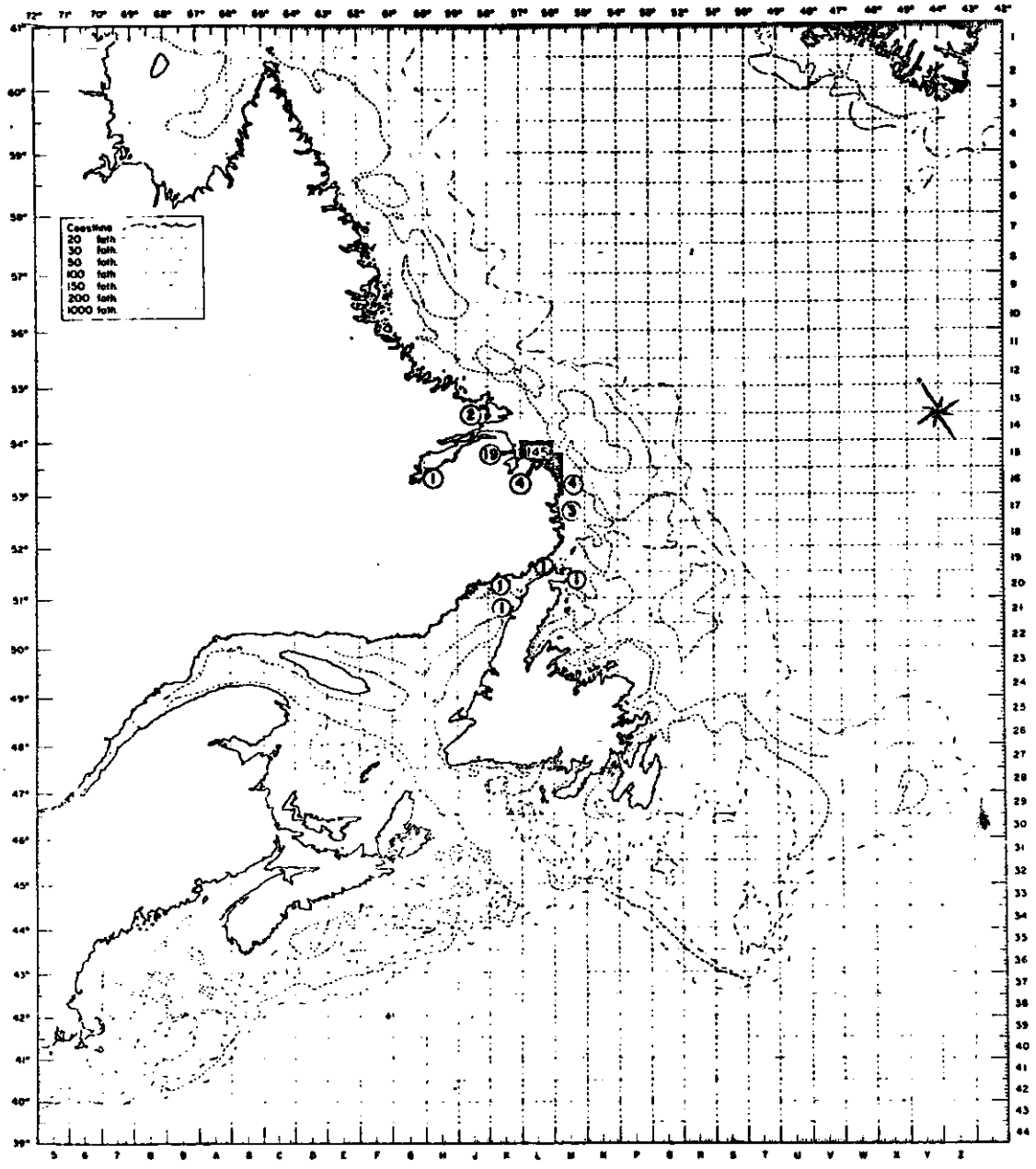

Figure 7. Recaptures of salmon (mainly 1 sea year individuals) tagged in southern Labrador in 1971. Circled numbers refer to number of recaptures in each general area.

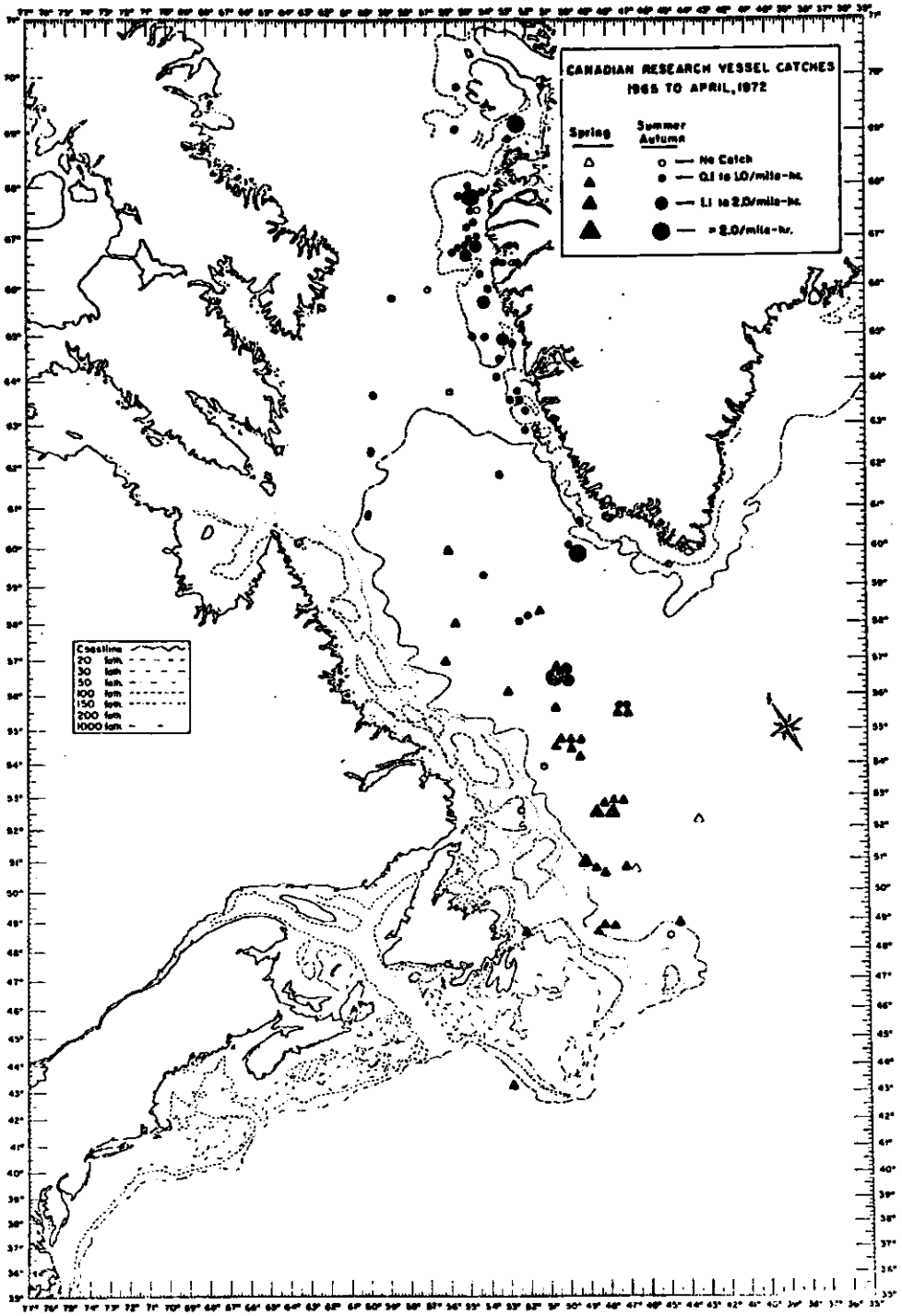

Figure 8. Research vessel catches of salmon in the northwest Atlantic, 1965 to April 1972. Catches are expressed as numbers of fish per mile of net per hour fished (or for some longline catches in spring as number per thousand hooks per hour fished).

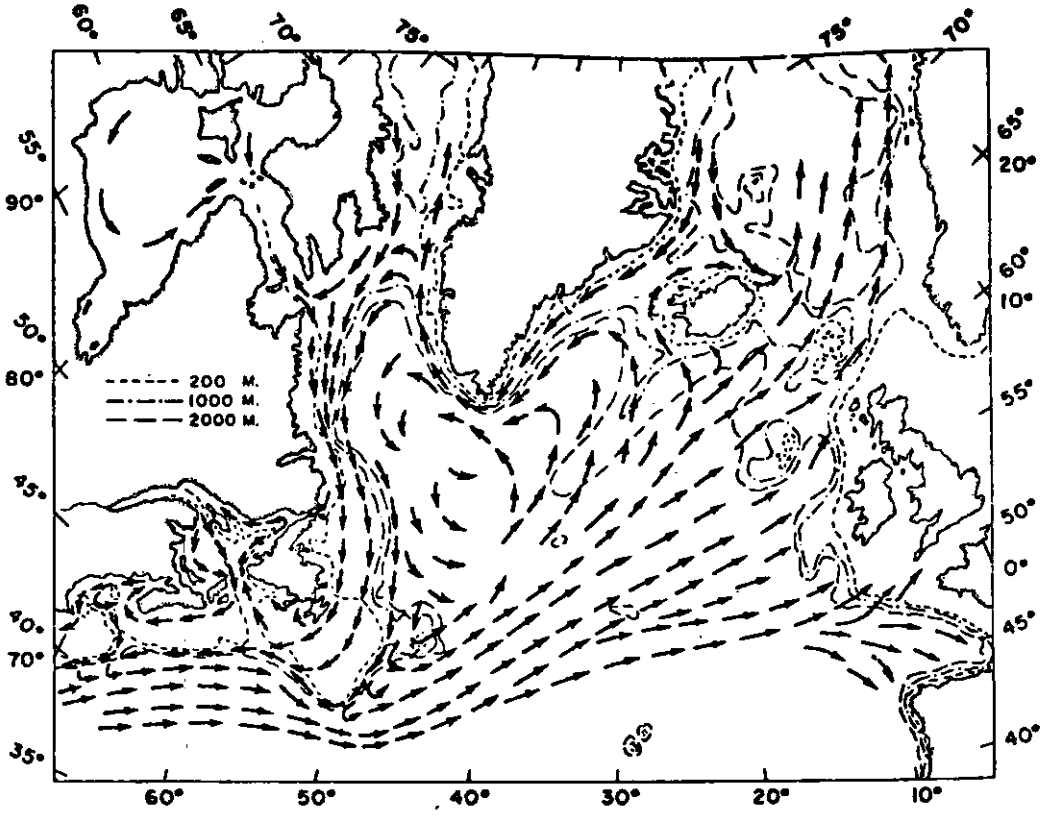

Figure 9. Surface circulation in the northwest Atlantic (from Templeman, 1965).