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Movements of Herring Tagged
in the Bay of Fundy

by

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INTRODUCTION

In 1972, ICNAF enacted regulatory measures to control the exploitation of herring in Div. 4XWb, 5Y, and 5Z and Statistical Area 6 and in 1973 enacted similar controls for the Div. 4VWa fishery. The information available on stock identity was limited at that time and stock inter-relationships and boundaries were largely related to known or suspected spawning grounds and the geographical location of fishing effort (see Fig. 1). One of the major problems facing management of the herring fisheries in the Bay of Fundy, the Gulf of Maine, and Georges Bank has been 'the origin of the New Brunswick sardines'. It has been variously hypothesized that this relatively large Canadian juvenile fishery exploits pre-recruits from the Southwest Nova Scotia stock, the Jeffrey's Ledge stock, the Georges Bank complex, or combinations of all three.

In 1973-74, Canada initiated extensive tagging operations in the Bay of Fundy in an attempt to clarify some aspects of the stock identity problem. The purpose of this document is to report on the recaptures made to April, 1975.

MATERIALS AND METHODS

The dates, areas, numbers, and length ranges of the fish tagged during 1973-74 are given in Table 1. The length frequencies of the fish for the various tagging experiments are presented in Appendix 1.

Table 1

<u>Area</u>	<u>Date</u>	<u>No. fish tagged</u>	<u>Length range (cm)</u>
Grand Manan	Nov. 21-30/73	3370	13-21
	Dec. 3-5/73	8777	14-29
	June 24-27/74	3860	20-30
Campobello	July 24-31/74	8133	14-30
S. W. Nova Scotia	Aug. 20-31/74	23938	19-35

The fish were all marked with external tags which were applied with a tagging gun (tags and guns manufactured by Floy Tag and Manufacturing Inc. of Seattle). Generally, the FD-68 Anchor tag with a 2 inch length of #20 vinyl tubing as the external portion was applied, although a small number of dart tags were also applied in 1973. External tags were used because the majority of herring caught in Subareas 4 and 5 and Statistical Area 6 by the International fleet is processed for food, thus external tags have a greater probability of being detected than internal ones.

The tag was inserted into the dorsal musculature at the base of the dorsal fin. Ideally, the anchor portion of the tag should be inserted deep enough so that it passes between, and anchors against, the interneural rays of the dorsal fin. During the actual tagging operations, however, this aim was not always achieved.

Fish recaptured several months after tagging exhibited a wound at the point of insertion which appeared to be caused by movement of the exposed portion of the tag. No infection was apparent; larger wounds invariably occurred in cases where the anchor portion of the tag was not securely embedded in the musculature.

Fish tagged off Grand Manan Island, 1973 and off southwest Nova Scotia in August, 1974, were taken from purse seines while those tagged during June and July, 1974, at Grand Manan and Campobello Islands were taken from weirs. Only lively fish were tagged; those that had suffered severe scale loss or appeared lethargic were discarded.

An incentive reward of \$1.00 was paid for each tag returned.

Description of the Fisheries

In order to qualify the results of the tagging experiments relative to overall distribution, a brief description of the Canadian Bay of Fundy herring fisheries, as well as other fisheries from which recoveries were made is warranted.

1. Bay of Fundy

During the period January to mid-April, small Canadian purse seiners traditionally exploit juvenile herring on the New Brunswick side of the Bay of Fundy between Saint John and Grand Manan. This fishery generally exploits 12-18 cm herring, but larger herring are occasionally taken. From mid-April to the end of September, most of this New Brunswick area is closed to purse seining operations by Canadian domestic regulations (Fig. 2). The institution of this closed area has essentially eliminated purse seining in the Bay of Fundy from mid-April to latter May due to a general absence of fish elsewhere in the Bay of Fundy during this period. In June, the Canadian adult purse seine fishery in Div. 4XWb commences off southwest Nova Scotia and in past years has continued until October. With quota restrictions in force, however, the 1974 fishery closed in mid-August. Subsequently, the purse seiners again exploited juvenile herring which had returned to the Saint John area, and with the removal of the closure line at the end of September operated between Saint John and Grand Manan.

The weir fishery on the New Brunswick side of the Bay consists of about 250 weirs, largely concentrated southwest of Saint John. On the Nova Scotia side of the Bay there are only about 30 weirs, largely concentrated in St. Mary's Bay, along Long Island shore, and in Annapolis Basin. The weirs on both sides of the Bay are operational and fishing by mid-April; most weirs are shut down in October, but some continue fishing into December.

Gill net fishing is largely restricted to southwest Nova Scotia and catches by this gear are concentrated around the fall spawning period.

The Canadian fishery in Div. 4XWb, from which all of the Bay of Fundy returns have occurred, took about 124,000 m.t. in 1974. The USSR caught about 20,000 m.t. offshore in Div. 4XWb in 1974. No recaptures have been reported, but since the USSR fishery is prosecuted largely between April and July, only recaptures from the 1973 tagging experiments would have been possible during 1974.

2. Cape Breton

The Canadian fishery in Div. 4VWa is conducted entirely by purse seine during the November-February period. The fishery commences in mid-November in the Sydney Bight area of Subdiv. 4Vn, generally moving southwest almost exclusively into Subdiv. 4Wa in January.

This fishery took over 16,000 m.t. from Subdiv. 4Vn and 27,000 m.t. from Subdiv. 4Wa during the 1974-75 fishery.

3. ICNAF Divisions 5Y and 5Z and Statistical Area 6

The 1974 catches of herring in Subarea 5 and Statistical Area 6 were approximately 164,000 m.t. The majority of the catch is normally taken during the August-September period in the Georges Banks and Jeffreys Ledge areas, although there is a relatively small January-March US pair trawler fishery which operates along the New England coast. This US fishery generally takes 10-15,000 m.t. yearly. Along the middle and eastern part of the Maine coast, only a

sporadic purse seine fishery occurs along with a relatively small fixed gear fishery.

RESULTS

The recapture data is summarized in Table 2, and the geographical distribution of recaptures is presented in Figures 3-8. All recaptures were included in Table 2, but those lacking a catch location were necessarily excluded from the figures, thus the number of recaptures given in the table may exceed that derived from the figures. Over 48,000 fish were tagged during 1973-74, and to mid-April, 1975, a total of 1143(2.4%) recaptures were reported. Canadian recaptures were made by both purse seine and weir fisheries; those recaptured from January-April and November-December were primarily by purse seine, those taken from April-October were primarily by weirs.

There was a substantial difference, however, in the percentage recovery from the different tagging experiments (Table 2), ranging from 0.3% for the Duck Island experiment in 1973 to 13.7% for the Mill Cove experiment conducted on July 24, 1974. Neither the difference in percentage return nor the geographical distribution of the returns appeared to be related to the size of the fish tagged. The fish tagged on November 22, 1973, and July 24, 1974, were largely juvenile fish (see Appendix 1), yet the rate of return for both areas was as high as for the other experiments (Table 2). Further, the long distance recaptures from these smaller fish were comparable to that of the other tagging experiments on the New Brunswick side; 5 fish tagged on November 22 were recaptured off Nova Scotia in 1974 (see Fig. 3a-c), and of those tagged on July 24, one was recaptured off Mt. Desert Rock, another near Round Pound and another south of Portland (see Fig. 5a-c).

It was arbitrarily decided that fish captured within 3 miles (4.8 km) of the tagging site and within two weeks after release should be considered as local recaptures and would be of little value in determining movement. Only 329 (29%) of the recaptures were in this category although the majority of recaptures were taken in, or at the entrance to, the Bay of Fundy. Seventy-four recaptures (6.4%) were made outside the environs of the Bay of Fundy, and 7 of these recaptures were made at distances greater than 300 km from the tagging sites. The farthest movement was over 600 km, made by a fish tagged at Mill Cove on July 31, 1974, and recaptured off Gabarus Bay (Subdiv. 4Vn) on Jan. 14, 1975.

The long distance movement is of little value in establishing potential rate of movement mainly because the fisheries at the more distant points are seasonal and the fish may have been in the area of recapture prior to commencement of the fishery. Recaptures made within the Bay of Fundy, however, do give some information on the potential for daily movement. One fish tagged on June 27 at Whale Cove was recaptured on June 28 in St. Marys Bay, indicating a movement of over 45 km in less than 2 days; another tagged on July 24 at Mill Cove was recaptured at Mt. Desert Rock on July 29, indicating a minimum movement of 25 km/day.

Tagging Experiments

1. Grand Manan — 1973

The recaptures have been presented in three figures (3a-c) which suggest a general pattern of movement. Following the tagging experiment in November-December, the fish dispersed along the New Brunswick coast (Fig. 3a) with some movement westward along the Coast of Maine. Except for 7 recaptures made at the mouth of Passamaquoddy Bay, no other tagged fish were taken between the end of April and early June (Fig. 3b). The distribution of recaptures between May and December (Fig. 3b, c) suggest a summer distribution around the entrance to the Bay of Fundy on both the New Brunswick and Nova Scotia sides with a movement to the New Brunswick side during fall and winter.

This suggested movement away from the Nova Scotia side during the fall and winter is based on the lack of recaptures by the Nova Scotia weir fishery during September and October. The purse seine fishery did not operate during the fall and winter off southwest Nova Scotia.

2. Grand Manan — 1974

The distribution of recaptures from this June tagging experiment (Figs. 4a, b) follow a similar pattern to the 1973 experiment. During the summer period, the fish appear concentrated around the entrance to the Bay of Fundy on both sides of the Bay, although some movement also occurred westward along the Maine coast. Part of this aggregation apparently moves to the New Brunswick side of the Bay in the fall, where they appear to remain during winter. Two recaptures from Div. 4VWa in January, 1975, indicate that another part of the aggregation moves eastward to contribute to the winter fishery northeast Nova Scotia, and 1 recapture off Narraganset Bay indicates some movement into the western part of Div. 5Z (Fig. 4b).

3. Campobello — 1974

Recaptures from this experiment (Figs. 5a-c) were concentrated on the New Brunswick side of the Bay of Fundy. The tagging experiment, however, was conducted in late July and the results are thus in accordance with the interpretation of the results of the previous tagging at Grand Manan Island, indicating movement away from Nova Scotia to the New Brunswick side in the fall. In addition, 1 recapture was made in Div. 4VWa in January, 1975, and 4 in the western part of Div. 5Y in November, 1974, and March, 1975, again indicating overwintering movements similar to that observed from the Grand Manan tagging.

4. Nova Scotia (Long Island - Boar's Head) — 1974

Recaptures from this tagging experiment in August (Figs. 6a, b) augment the results of the New Brunswick tagging experiments. Shortly after tagging, the fish dispersed along the Nova Scotia side of the Bay of Fundy and across to the New Brunswick side. As observed in the New Brunswick experiments, a part of this aggregation appears to remain on the New Brunswick side during the winter.

The recapture of 12 fish from this tagging experiment in the January, 1975, Div. 4VWa fishery, however, suggests that a much larger proportion of this group of fish than of New Brunswick tagged fish moved eastward during winter. Three recaptures were also made in the western part of Subarea 5 in February-April, 1975, again indicating some movement westward in the winter.

5. Southwest Nova Scotia — 1974

The distribution of recaptures from this tagging experiment (Fig. 7) indicates a great degree of dispersion during winter. Almost 51% of the recaptures (28 fish) were made by the Canadian Div. 4VWa fishery in January, 1975, and 7 recaptures were made in the western part of Div. 5Y between December, 1974, and March, 1975. Recaptures in the Bay of Fundy again suggested a general overwintering movement by the fish remaining in the Bay to the New Brunswick side.

DISCUSSION

Figure 8 summarizes the recaptures for the 1973 and 1974 tagging experiments. Tagged herring moved eastward to Div. 4VWa and westward to Div. 5Y from both the New Brunswick and Nova Scotia 1974 tagging locations. All of the experiments suggested the same general movement within the Bay of Fundy. This movement involved an overwintering period on the New Brunswick side during October-April with subsequent movement to the entrance of the Bay on both sides from June to September.

The importance of these returns, however, must be put in proper context by the nature of the fisheries involved. The presence of fishing effort in any geographical location is based on the historical performance in that area during the time which the gear would be operational. This is especially valid for fixed gears and explains why the majority of the weirs in both New Brunswick and Nova Scotia are located near the entrance of the Bay. The virtual absence of weirs and purse seine activity in the upper reaches of the bay of Fundy indicate an absence of fish; further, the relatively small number of weirs in the Saint John area indicate a lack of fish there during summer, although a substantial juvenile purse seine fishery operates there in January-April.

In 1974, on the New Brunswick side of the Bay of Fundy, there was an almost continuous effort directed on herring by the purse seine fishery from January to April and September to December and by the weirs from April to October. Although they are described as juvenile fisheries (fish <23 cm in length) larger fish are taken in substantial numbers (see Miller and Halliday, MS 1974). On the Nova Scotia side in 1974, the weirs were fishing from April to October and the purse seine fishery operated from June to late August. These fisheries also exploiting both juvenile and adult herring.

The paucity of recaptures during the period May to mid-June suggests that few tagged fish were in the Bay of Fundy. If there had been substantial quantities in the Bay, and outside of the closed area (Fig. 2), the purse seine fleet would have exploited it. The absence of a purse seine fishery during this period, therefore, indicates a general absence of fish in the Bay which would be available to the fleet. The New Brunswick weirs did catch fish during this period, but few recaptures were made, suggesting that few fish of the size which were tagged (Appendix I) were in the area. It is possible that the fish were along the eastern coast of Maine at that time, but there was insufficient effort in that area to prove or disprove that possibility (the Canadian fleet is prevented from exploiting them by the U.S. 12 mile limit and the U.S. effort there is small and sporadic).

The majority of recaptures from the New Brunswick experiments were taken off New Brunswick over a prolonged period, suggesting that a substantial proportion of the tagged fish remain there. It is possible, however, that a greater proportion of fish move across to the Nova Scotia side than the recaptures would suggest. Most of the fish caught on the New Brunswick side were processed as food while approximately 90% of the purse seine catch on the Nova Scotia side was processed as fish meal. Consequently, the chances of recovery of external tags from the southwest Nova Scotia purse seine fishery was greatly reduced. Very few recaptures from Nova Scotia, in fact, were made by purse seine; most recaptures were made by Nova Scotia weirs, the majority of these catches being also processed for food.

The tagging experiments on the Nova Scotia side indicated a substantial movement of fish to the New Brunswick side and considering the different processing methods and the general similarities in long distance movement from all the experiments, even though of different magnitudes, it is quite possible that there is considerably more movement of fish between New Brunswick and Nova Scotia than suggested by the recapture data.

All the recaptures (43) from the 1974-75 Div. 4VWa fishery occurred during January, 1975. During the November-December, 1974 portion of that fishery, over 15,700 m.t. were taken, of which 79% was from Subdiv. 4Vn. In January, 27,800 m.t. were taken, 85% being from Subdiv. 4Wa. The majority of the fishing effort, and recaptures (40), in January occurred at the entrance to, and south of Chedabucto Bay in Subdiv. 4Wa; the fishing effort and recaptures (3) in Subdiv. 4Vn in January were concentrated around Gabarus Bay, just east of the Subdiv. 4Vn-Wa dividing line. The absence of recaptures during November and December when the fishery primarily occurred in Subdiv. 4Vn and the location and proportion of recaptures made in Subdiv. 4Vn in January suggest that the large majority of tagged fish migrated only as far as Subdiv. 4Wa. The rate of tag recaptures in this fishery was close to 1.5 per day, and had the fishery not been closed by quota restrictions at the end of January, additional tags would have probably been recovered.

It is difficult to assess the importance of the recaptures made in the western part of Subarea 5. No recoveries were made during the peak fisheries during August and September on Georges Bank or Jeffreys Ledge; one was recaptured on Cashes Ledge on December 17, 1974. Only 2 recaptures were made in Div. 5Z, the remainder in Div. 5Y, all during the relatively small U.S. fishery between January-March.

Samples examined during the tagging experiments off southwest Nova Scotia in late August indicated that the gonads of almost all the fish being tagged were full or recently spent. If the full fish were to subsequently spawn on Georges Bank or Jeffreys Ledge, they were geographically far removed from their spawning grounds at a time when spawning should be commencing.

The most plausible conclusions to be drawn from the present tagging results are that a large proportion of the fish found in, and around, the Bay of Fundy remain there for a substantial portion of the year. It is a complex, however, of more than one group. A substantial portion of those found off southwest Nova Scotia during summer, and to a lesser extent those off New Brunswick, overwinter in Subdiv. 4Wa. Another, smaller portion overwinters in the western part of Subarea 5; the relationship between this group and the southwest Nova Scotia stock or the Georges Bank or Jeffreys Ledge stock cannot be surmised from these data.

REFERENCES

- Miller, D. S. and R. G. Halliday. MS 1974. An assessment of the 4X-4Wb herring stock. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 74/13. 38 p.

Table 2. Recaptures from herring tagging 1973-74. Recaptures are shown as percentages of those tagged and are given in two categories: I) total recaptures, II) excluding those recaptured within two weeks of the tagging date and three miles of the tagging site.

<u>Location</u>	<u>Date</u>	<u>Number</u>	<u>Total Number</u>	<u>%I</u>	<u>%II</u>
Duck Island, N. B.	Nov. 21/73	790	2	0.3	0.3
North Head, N. B.	Nov. 22/73	938	75	8.0	7.8
Whale Cove, N. B.	Nov. 30/73	1642	33	2.0	1.8
	Dec. 3/73	4726	77	1.6	1.4
	Dec. 5/73	4051	90	2.2	1.7
	June 24/74	1041	26	2.5	2.2
	June 27/74	2819	117	4.2	3.2
Mill Cove, N. B.	July 24/74	1375	189	13.7	8.4
	July 25/74	1600	176	11.0	4.5
Head Hbr., N. B.	July 26/74	1000	14	1.4	0.6
Mill Cove, N. B.	July 29/74	2173	66	3.0	2.2
	July 31/74	1985	130	6.5	3.6
Long Island, N. S.	Aug. 20/74	5985	59	1.0	1.0
Cape Fourchu, N. S.	Aug. 21/74	5978	28	0.5	0.5
Cape St. Mary, N. S.	Aug. 22/74	5978	35	0.6	0.6
Boar's Hd., N. S.	Aug. 31/74	5997	26	0.4	0.4

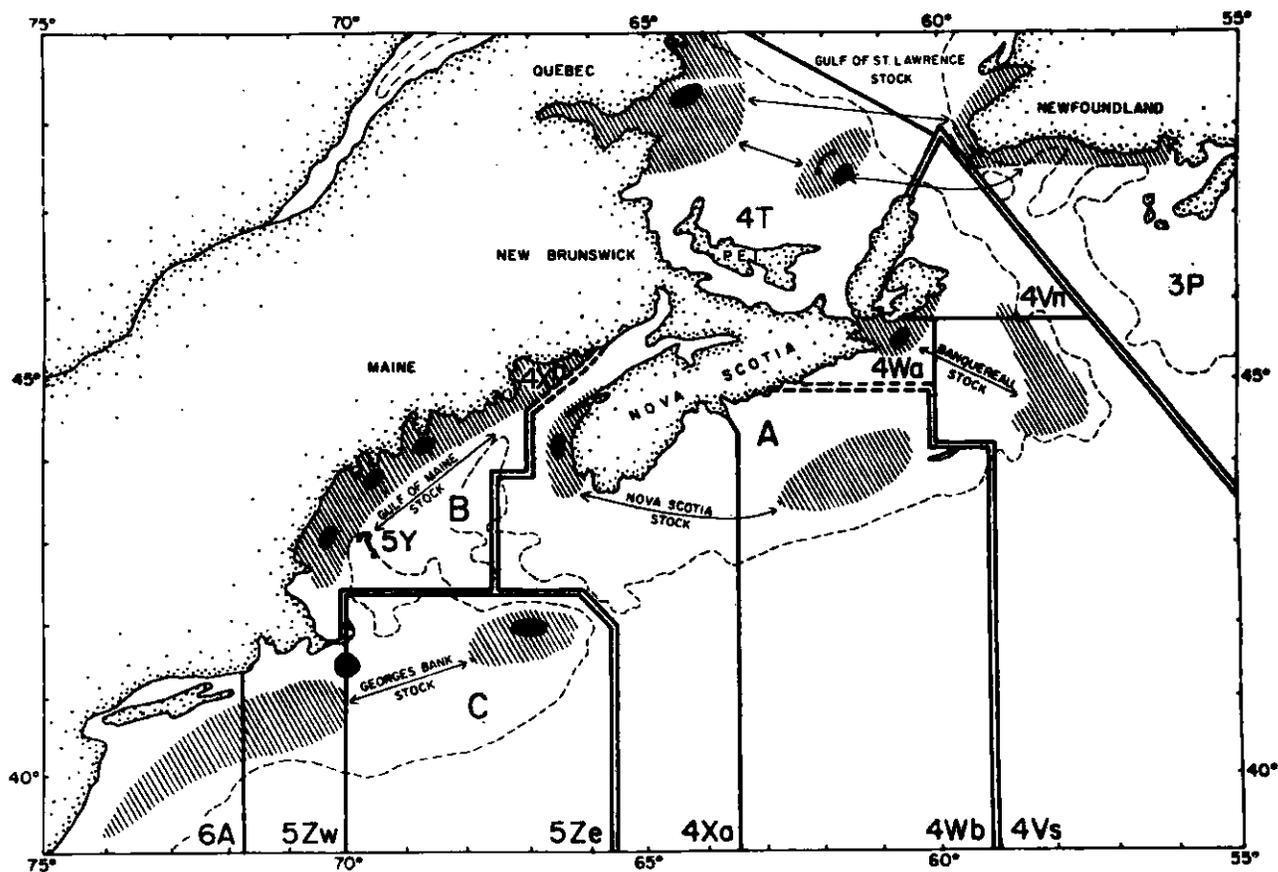


Fig. 1. Herring stock structure in the ICNAF area as assumed by the Herring Working Group at the 1972 Annual Meeting (double lines indicate stock boundaries and the solid black areas indicate the general spawning grounds). (Taken from Redbook, 1972, Part 1, pg. 62).

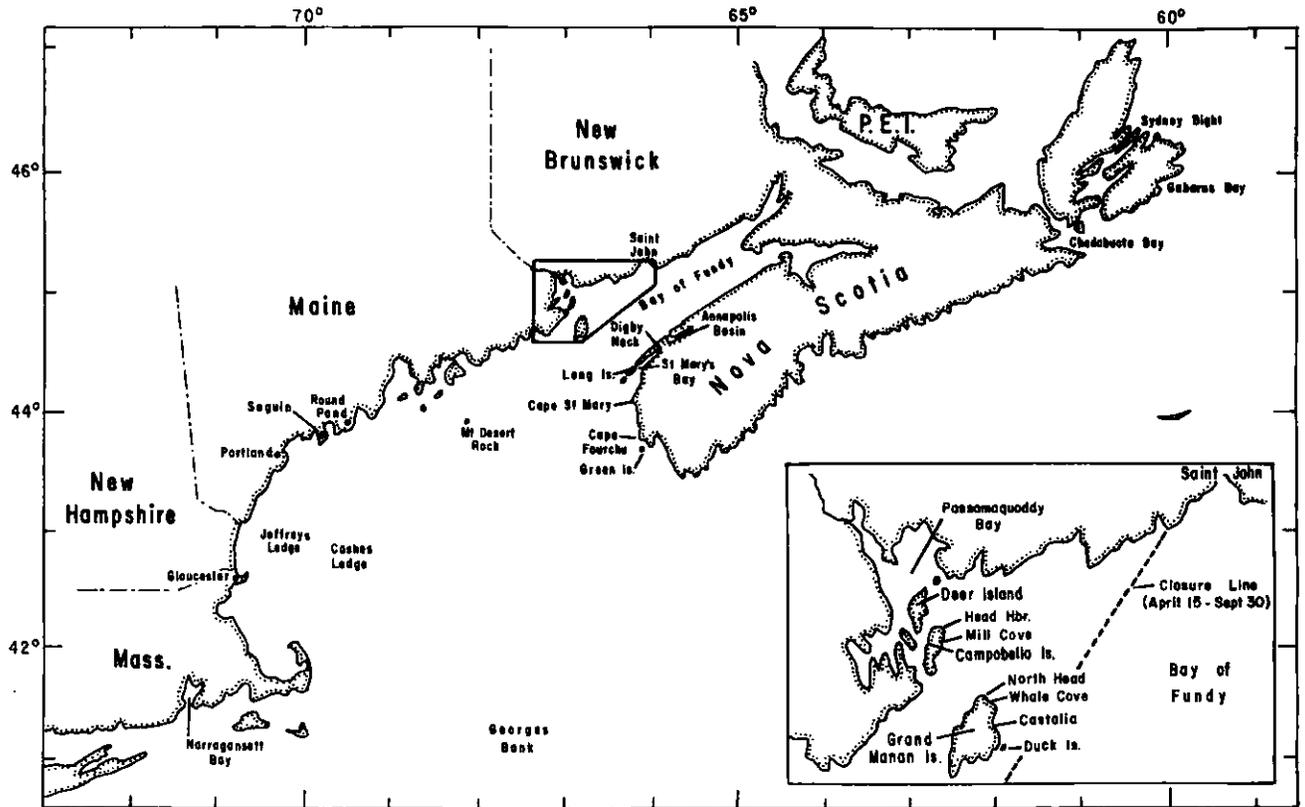
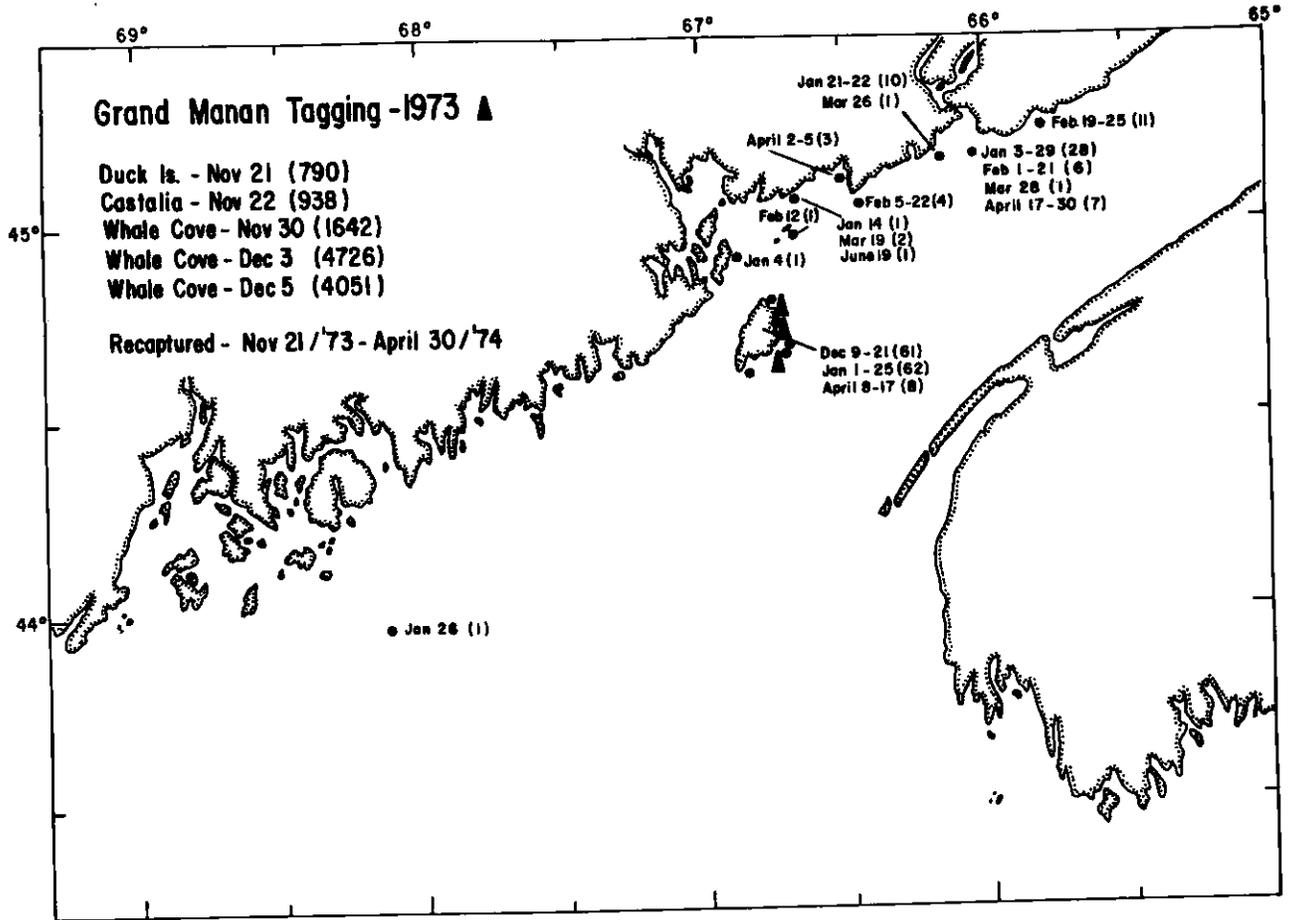


Fig. 2. Map of those parts of ICNAF Subareas 4 and 5 where tagging experiments were conducted in 1973-74 and recoveries made in 1974-75.



Figs. 3a-c Distribution of recaptures (●) from herring tagging experiments off Grand Manan (▲) in 1973. The number of recaptures from each recapture area is given in parentheses after the time interval indicated.
 a) Recaptures during the period Nov. 21, 1973 to April 30, 1974.

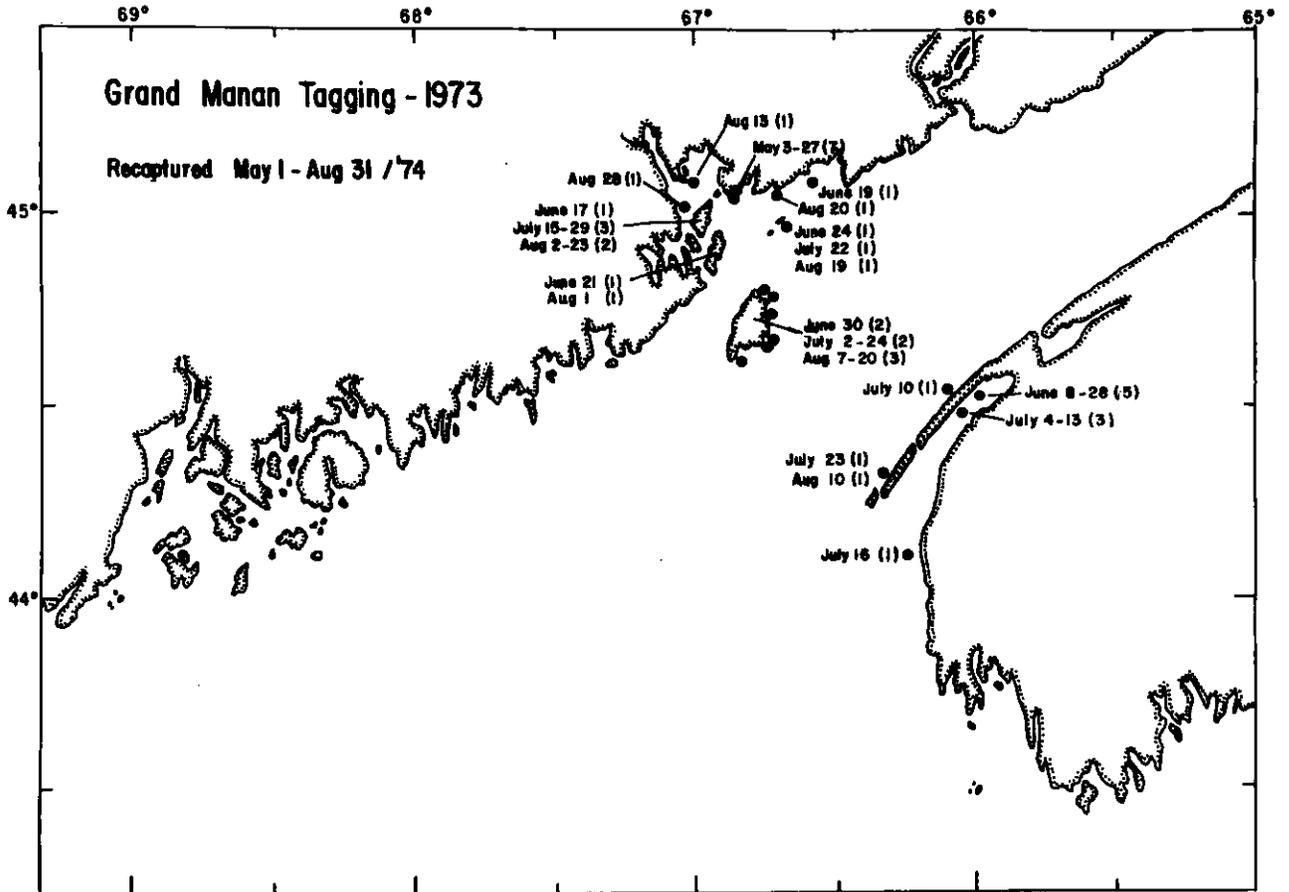


Fig. 3b. Distribution of recaptures (●) during the period May 1 - August 31, 1974, from herring tagging experiments off Grand Manan in 1973.

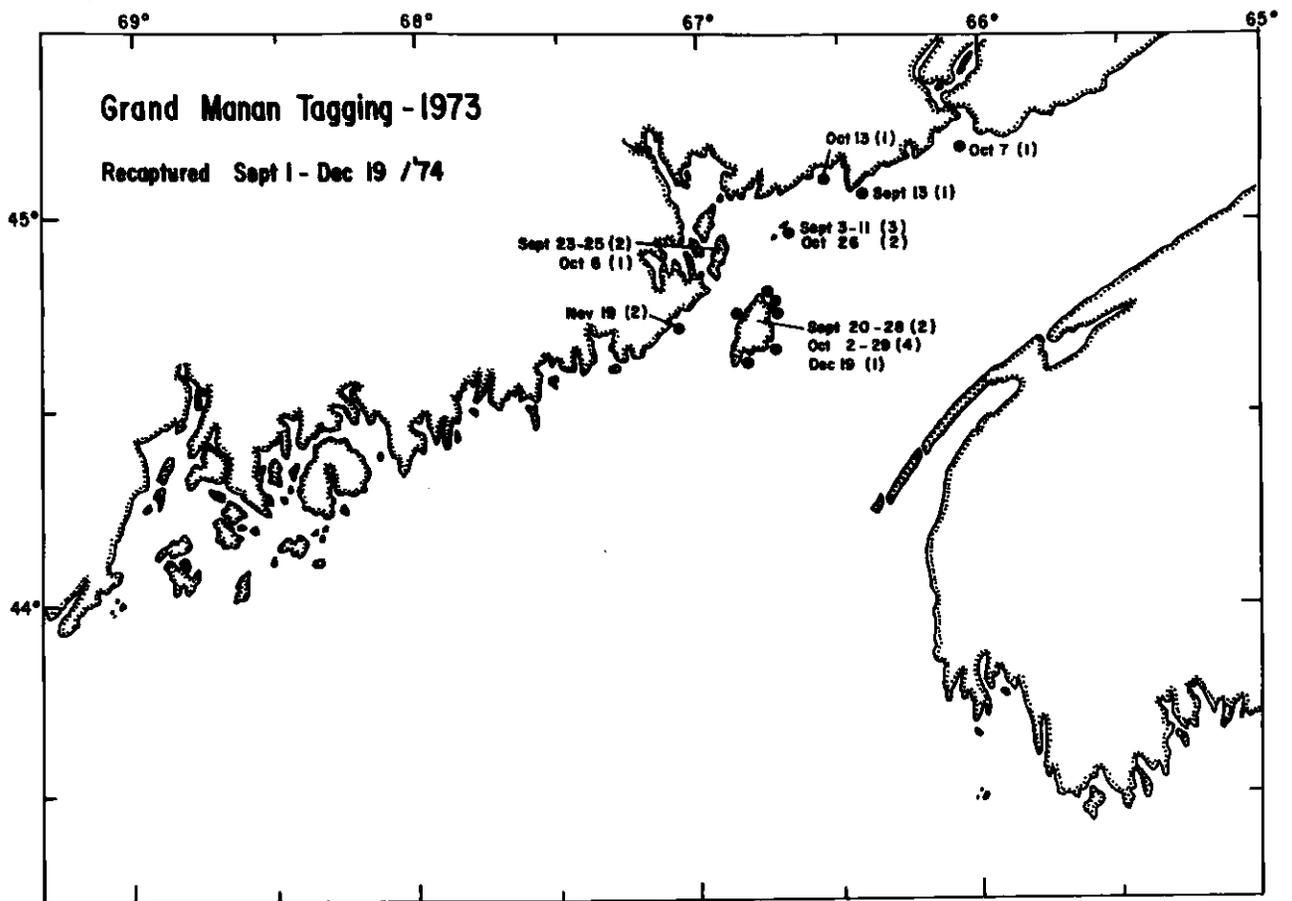


Fig. 3c. Distribution of recaptures (●) during the period September 1 - December 19, 1974 from herring tagging experiments off Grand Manan in 1973.

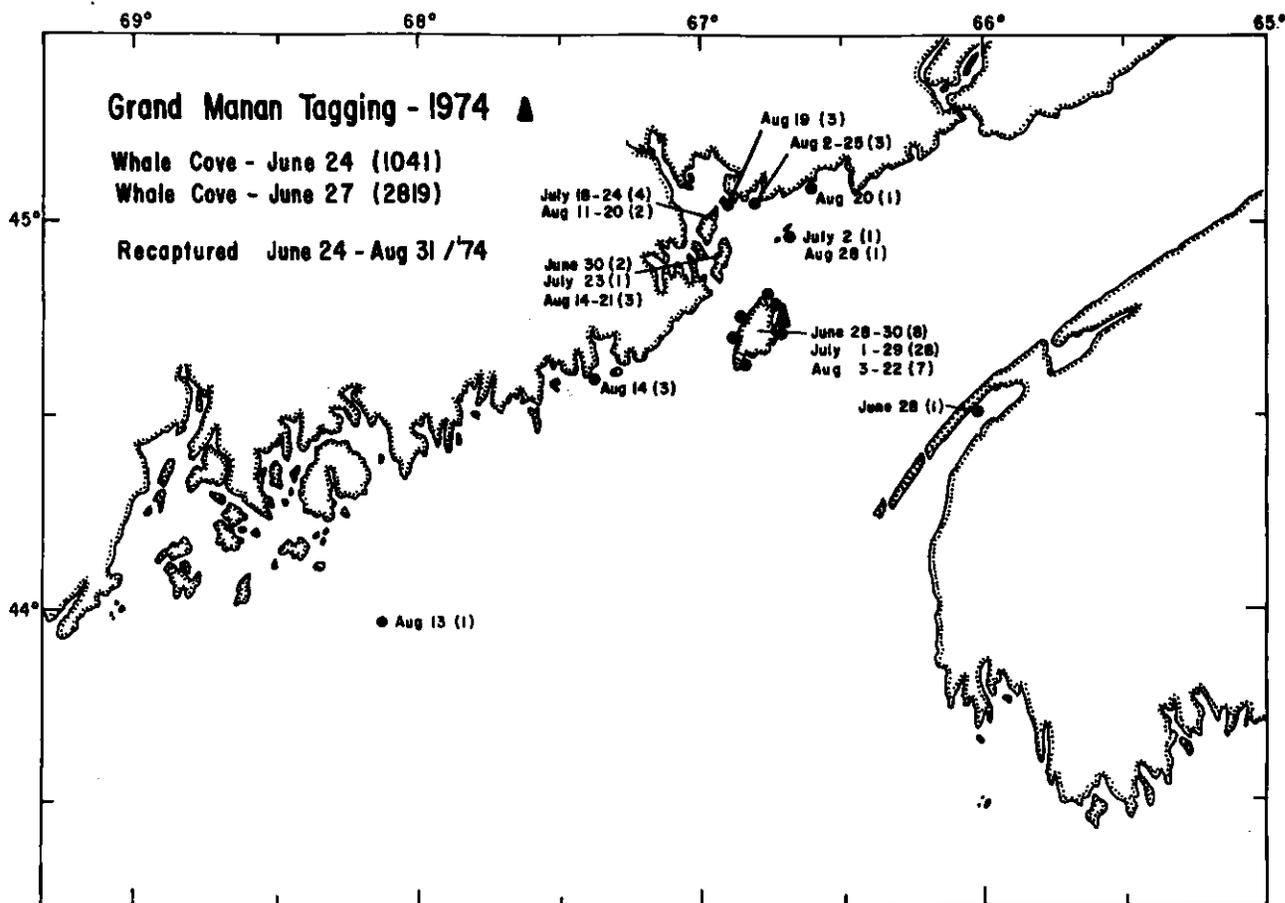


Fig. 4a, b. Distribution of recaptures (●) from herring tagging experiments off Grand Manan (▲) in 1974. The number of recaptures for each recapture area is given in parentheses after the time interval indicated. a) Recaptures during the period June 24 - August 31, 1974.

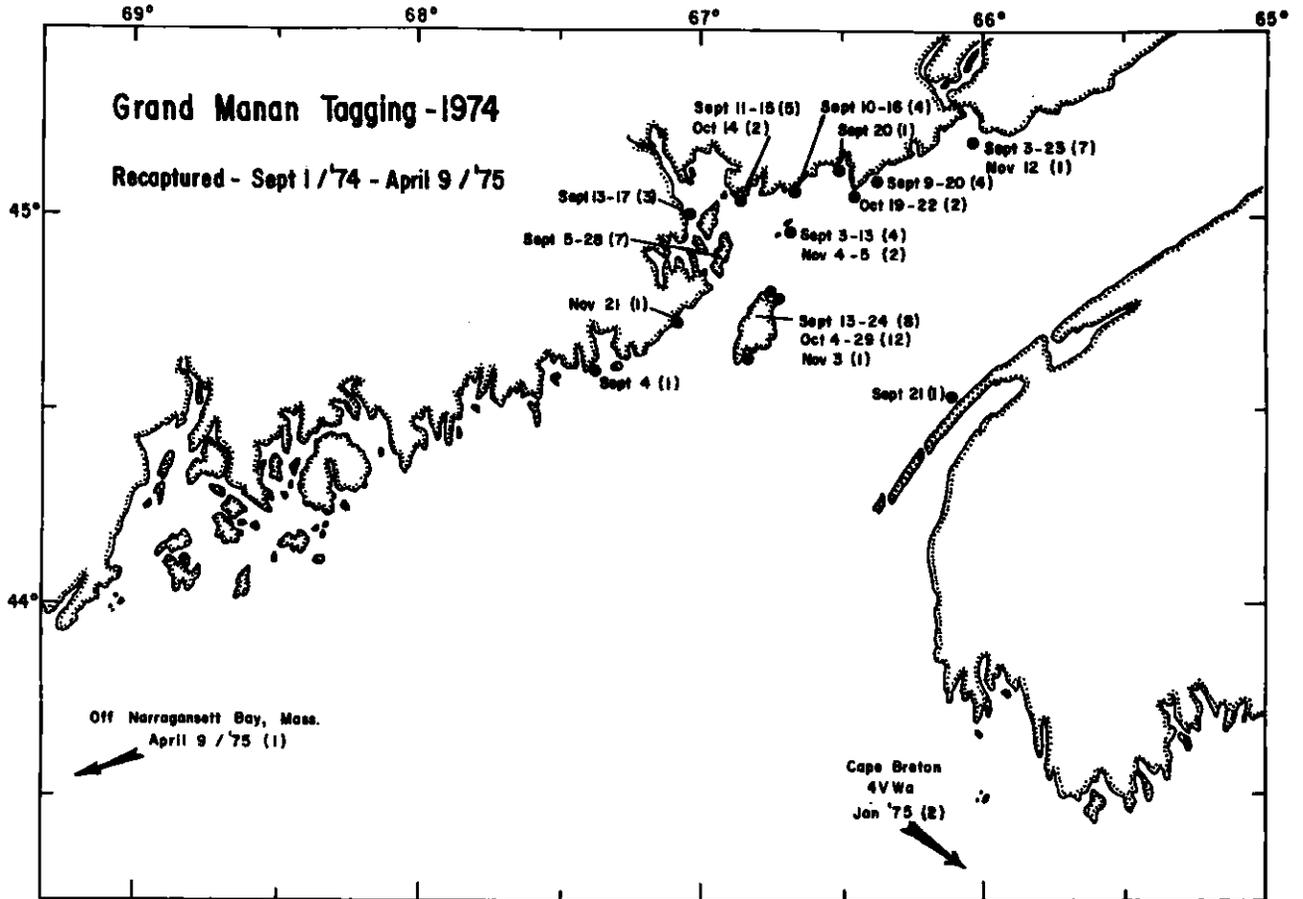


Fig. 4b. Distribution of recaptures (●) during the period September 1, 1974 to January 31, 1975 from herring tagging experiments off Grand Manan in 1974.

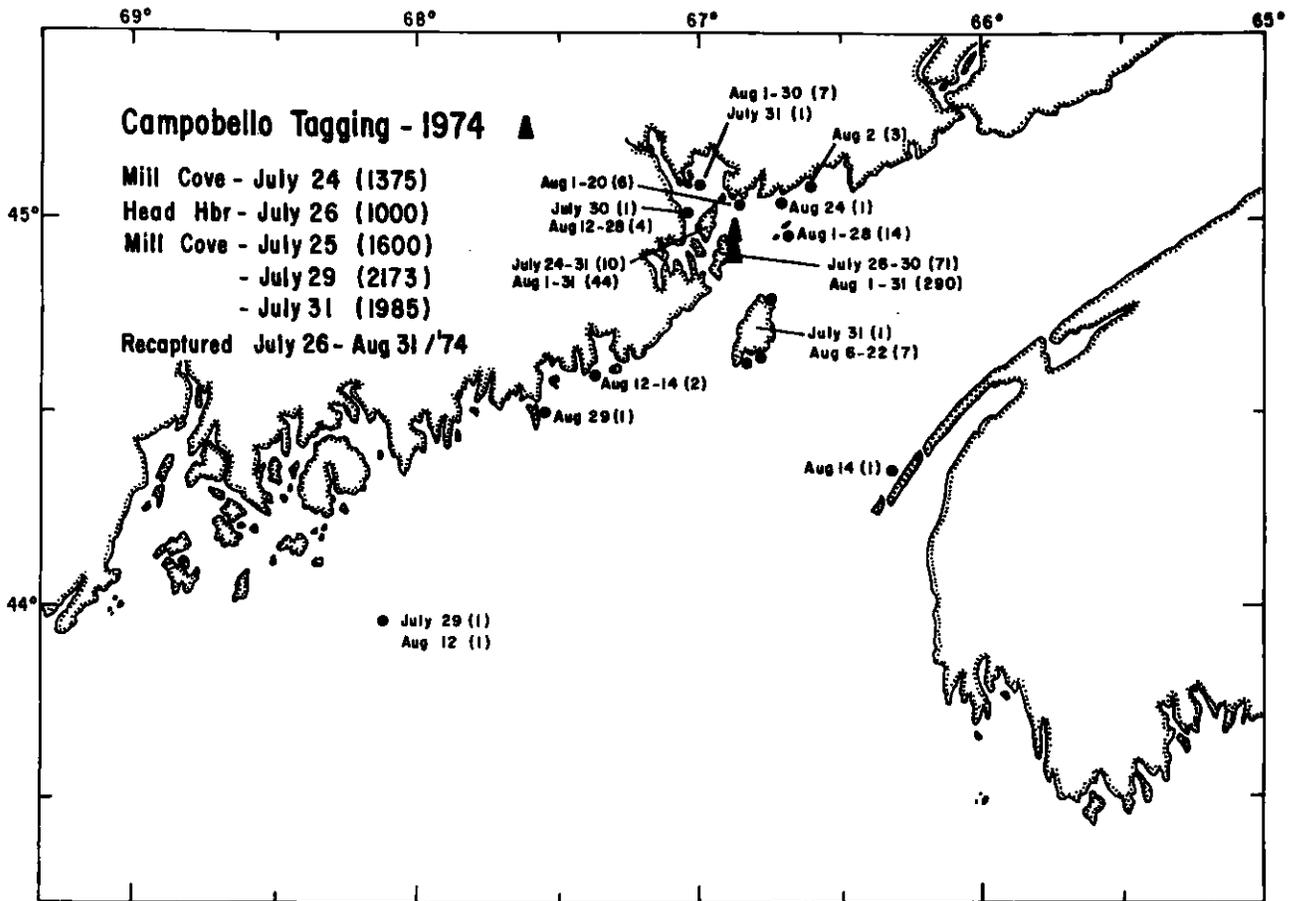


Fig. 5a-c. Distribution of recaptures (●) from herring tagging experiments off Campobello (▲) in 1974. The number of recaptures for each recapture area is given in parentheses after the time interval indicated.

a) Recaptures during the period July 26 - August 31, 1974.

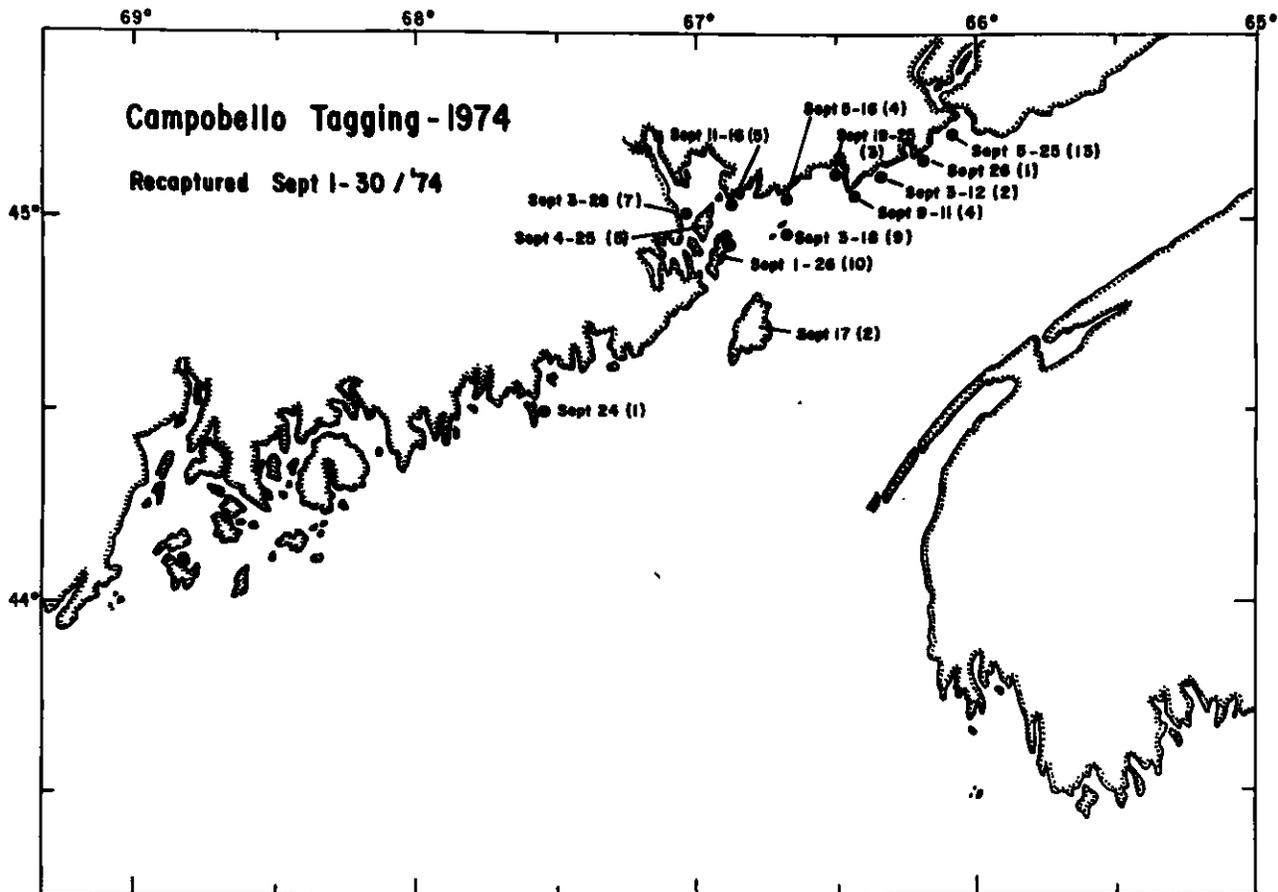


Fig. 5b. Distribution of recaptures (●) during the period September 1 - 30, 1974, from herring tagging experiments off Campobello in 1974.

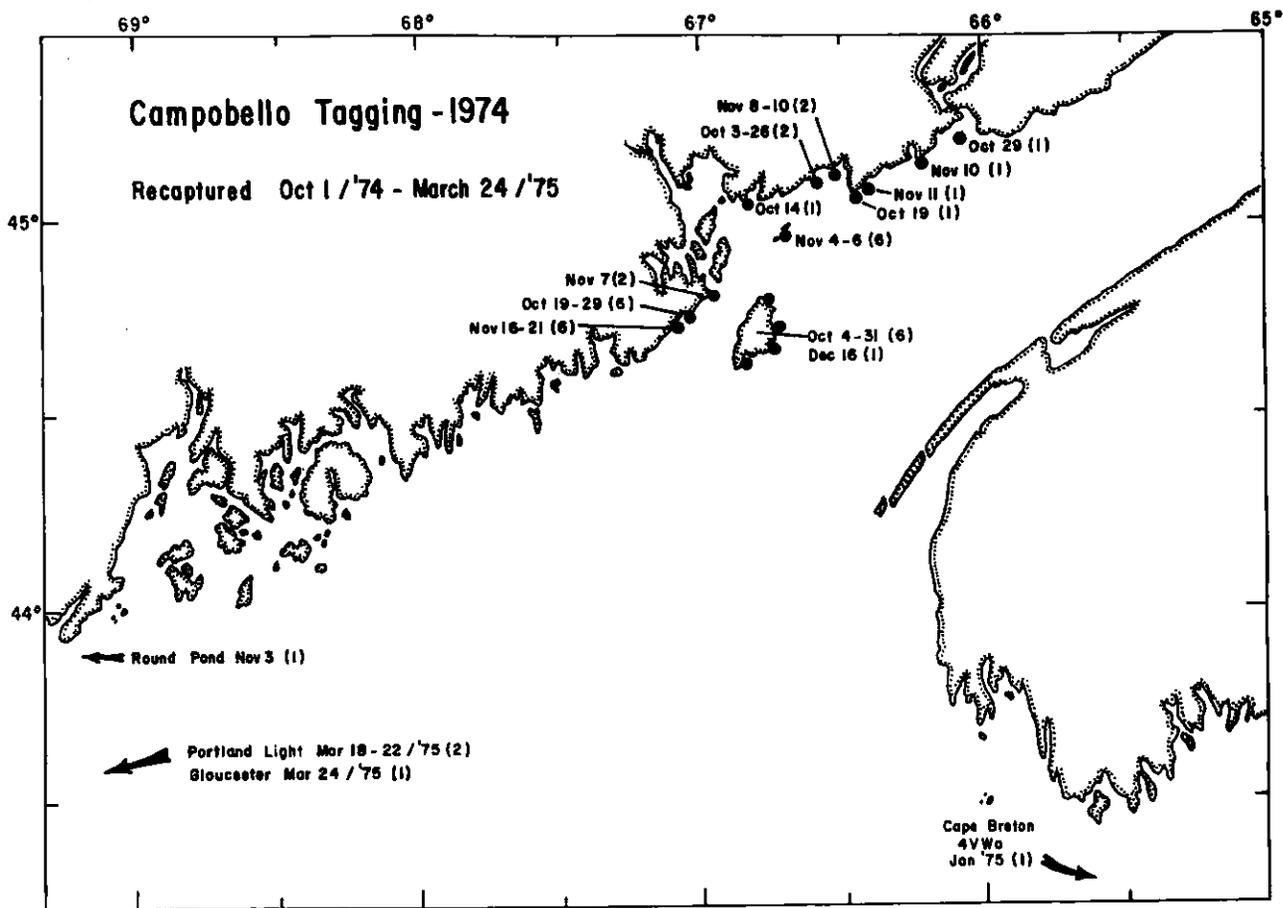


Fig. 5c. Distribution of recaptures (●) during the period October 1, 1974, to March 24, 1975, from herring tagging experiments off Campobello in 1974.

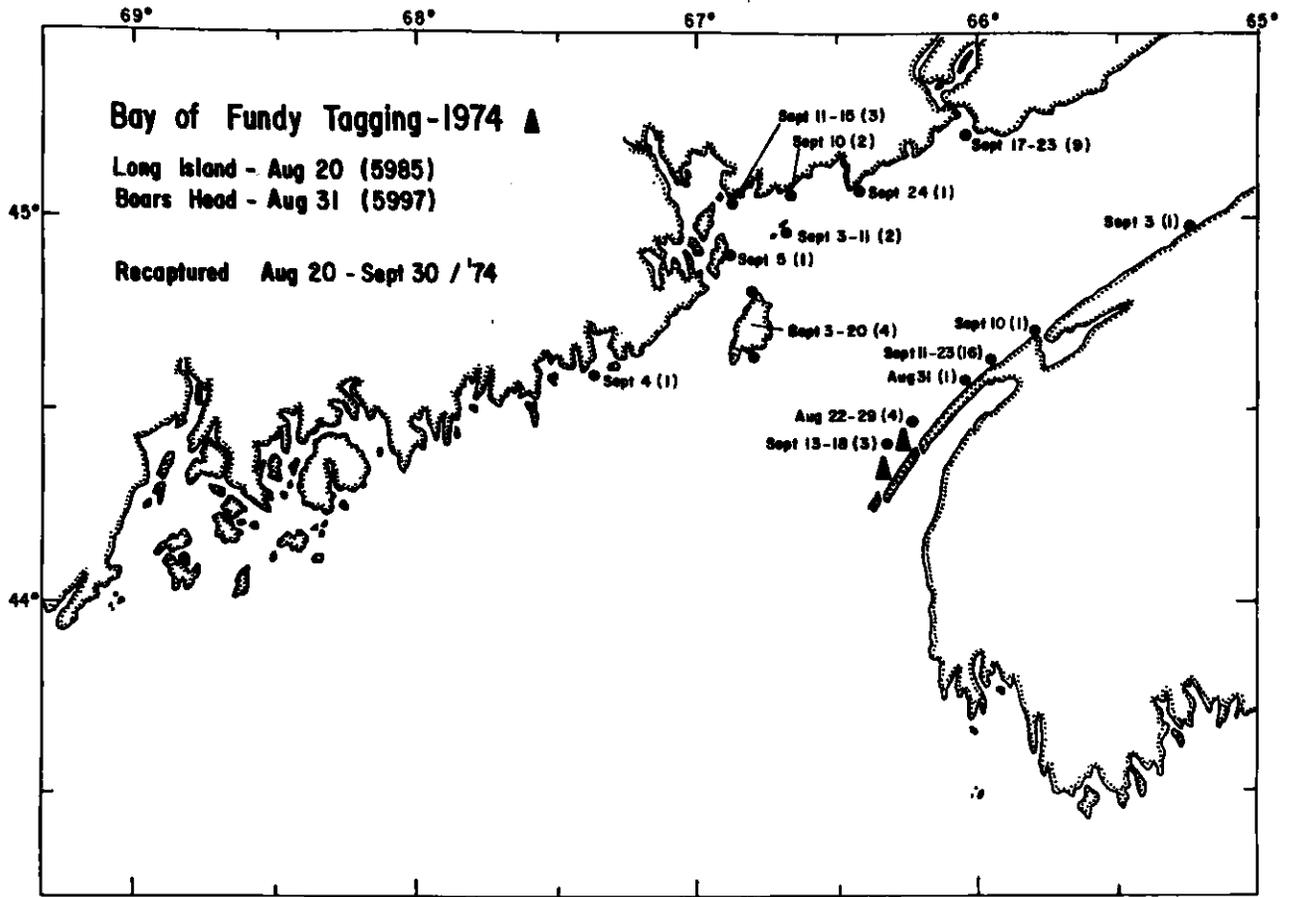


Fig. 6a, b. Distribution of recaptures (●) from herring tagging experiments off Long Island shore, Nova Scotia, (▲) in 1974. The number of recaptures for each recapture area is given in parentheses after the time interval indicated.

a) Recaptures during the period August 20 - September 30, 1974.

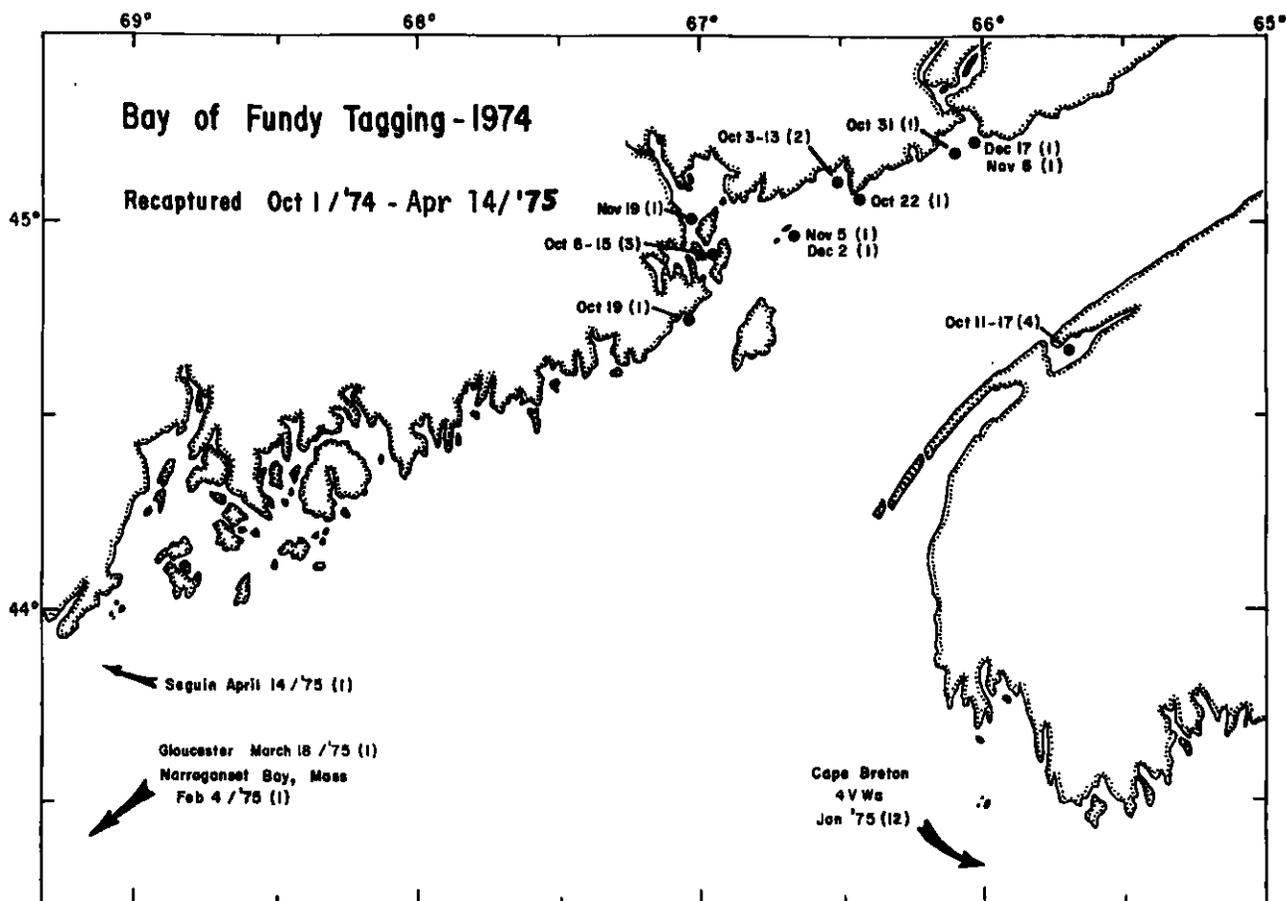


Fig. 6b. Distribution of recaptures (●) during the period October 1, 1974, to April 14, 1975, from herring tagging experiments off Long Island shore, Nova Scotia in 1974.

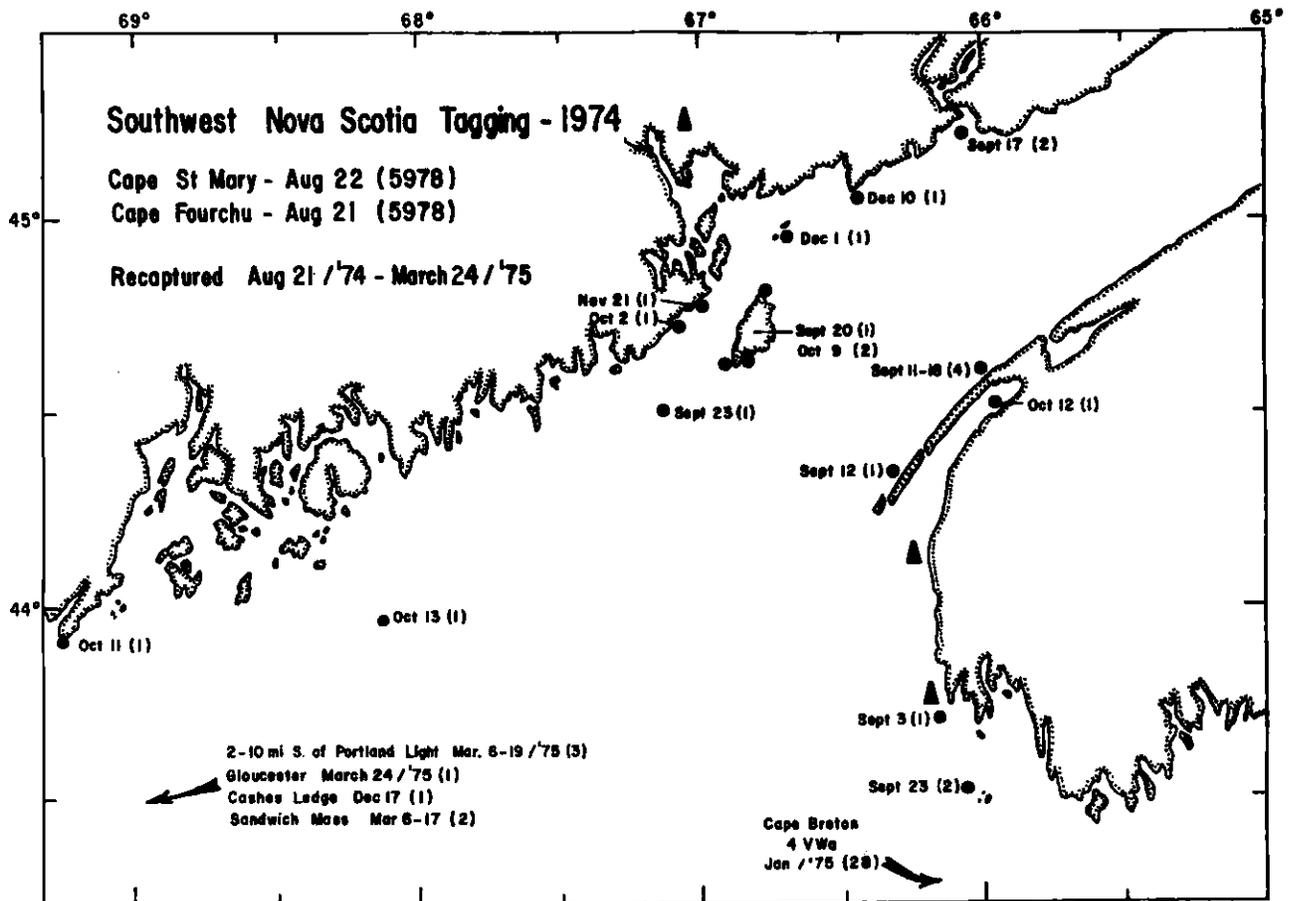


Fig. 7. Distribution of recaptures (●) from herring tagging experiments off Cape Fourchu and Cape St. Mary, Nova Scotia (▲) in 1974. The number of recaptures for each recapture area is given in parentheses after the time interval indicated.

Appendix 1. Length frequency samples of herring taggings in the Bay of Fundy.

	1973										1974											
	Nov. 22	Dec. 3	June 27	July 24	July 25	July 26	Aug. 20	Aug. 21	Aug. 22	Aug. 31	Nov. 22	Dec. 3	June 27	July 24	July 25	July 26	Aug. 20	Aug. 21	Aug. 22	Aug. 31		
13	1																					
14	1	1																				
15				14																		
16	1			15																		
17	9	1		28	1																	
18	41	2		35	4																	
19	34	4		20	3																	
20	9	3	1	11	13																	
21	1	5	3	17	2																	
22		3	2	4	8																	
23		12	4	6	16																	
24		13	19	8	31																	
25		24	12	4	15																	
26		34	9	4	15																	
27		8	9	2	1																	
28		1	8	3	2																	
29		2	10																			
30			1																			
31																						
32																						
33																						
34																						
35																						
T.	97	113	78	168	97	158	121	109	115	95												