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Atlantic Cod Tagging off the Southern Canadian Mainland

BY

R. A. McKENZIE

Fisheries Research Board of Canada
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W. E. RICKER
N. M. CARTER
Editors

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ABSTRACT

From 1924 to 1940 about 21,750 cod were tagged in the Bay of Fundy, off the outer coast of Nova Scotia and in the southern and western Gulf of St. Lawrence, 3,000 by the St. Lawrence Biological Station of Laval University, and the remainder by the Fisheries Research Board of Canada's Biological Station at St. Andrews, N.B. Of those tagged in the inshore waters of the Nova Scotia mainland from 1934 onwards, 27% were recaptured, of those on the banks off Nova Scotia, 5.4%, in the southern Gulf, 6.7%, and about Gaspé, 20%. The high percentages in the first and last areas apparently were related to intensive fisheries on relatively stationary stocks.

Cod populations present in summer inshore from the Bay of Fundy to Canso were largely stationary, mixing only slightly with their neighbours along shore or offshore. On the banks off eastern Nova Scotia mixing was not sufficient to make one homogeneous population, cod summering in the Banquereau area being more or less separate from those about Sable Island. There was an annual migration, best developed close to the Laurentian Channel, of cod wintering on the eastern banks and the inshore grounds off the outer coast of Nova Scotia and summering about northern Cape Breton or in the Gulf of St. Lawrence; there were apparently divisions within this migratory stock. Most of the cod of the Gaspé–Anticosti and Prince Edward Island–northern New Brunswick areas apparently remained in the Gulf, with some mixing between populations resident in the Gulf but not enough to make a single homogeneous population. A distinct group of cod spawned in the autumn in inlets of the outer coast of Nova Scotia. Only 2% of all the cod recaptured had crossed the Laurentian or Fundian channels, the cod population of the area under review being distinct from those of grounds off Newfoundland or New England. All these findings from tagging accord with those from an analysis of vertebral counts.

Movements of cod were related to submarine physiography, deep channels acting as barriers. Within the area as a whole, movement increased from west to east, as does the seasonal range of water temperatures. Larger cod moved, on the average, more than smaller. Average size of cod increased with depth. Cod of the same size from deeper water moved more than those from shallower water. Movements have been related to spawning in some instances. No large-scale, well-defined movements related to feeding were shown, although concentrations of food are believed to influence movements. Seasonal changes in local fisheries for cod were related to movements indicated by tagging.

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INTRODUCTION

Cod fishing is one of man's oldest occupations in the northwestern Atlantic, the Grand Banks off Newfoundland being famous from early days for the cod caught by the fishermen of many nations who then, as now, made special trips across the Atlantic for this purpose. To this day, the cod is more important to the northwestern Atlantic fisheries than any other species. The cod fishery and cod stocks are under study by the member nations of the International Commission for the Northwest Atlantic Fisheries to determine whether regulation of the fishery is needed to maintain the yield at its optimum level. In such a study, knowledge of the divisions of the cod stock or "populations" and of the movements of cod is of first importance. This paper summarizes, from this point of view, the results of tagging of cod by Canada to and including 1940 in the Bay of Fundy, on the Scotian Shelf and in the southwestern Gulf of St. Lawrence, all in the Commission's Sub-area 4.

The first of these taggings, carried out as part of the cod investigations by the Board's Biological Station, St. Andrews, N.B., was in 1924 and some results of tagging to 1930 have already been published by Huntsman (1932) and McKenzie (1934a). The cod of certain inshore areas showed little movement; other stocks exhibited restricted or extended orderly movements and some apparently random wandering.

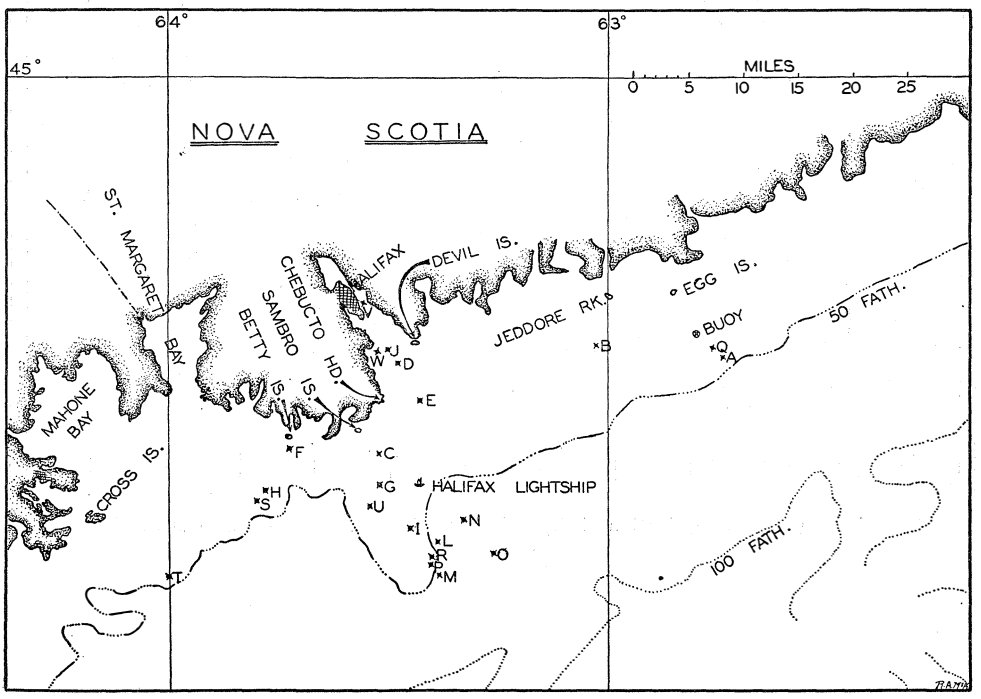

FIG. 1.—Cod tagging locations near Halifax, N.S., 1934, 1935 and 1936.

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This paper deals mainly with the results of taggings from 1930 to 1940 in many of the principal cod fishing areas in the Bay of Fundy, off the outer coast of Nova Scotia and in the southwestern Gulf of St. Lawrence. These taggings are listed in Tables I and II, and their positions shown in Figures 1 to 3. In all, 96 cod were tagged in the Bay of Fundy, 2,923 in inshore waters of the outer coast of Nova Scotia, 5,291 on the banks of eastern Nova Scotia and 2,360 in the Gulf of St. Lawrence, making a total of 10,670. The results of the earlier taggings, which totalled about 8,400, are presented again for comparison. Results are also included from taggings, by Dr. J.-L. Tremblay, of the St. Lawrence Biological Station, Grand River, Quebec. He tagged 1,032 in 1938 and 1,947 in 1939, about the end of the Gaspé Peninsula, off Miscou Point and off the northwest end of Anticosti Island, all in the northwestern Gulf of St. Lawrence. This paper thus summarizes the results of tagging a grand total of about 21,750 cod.

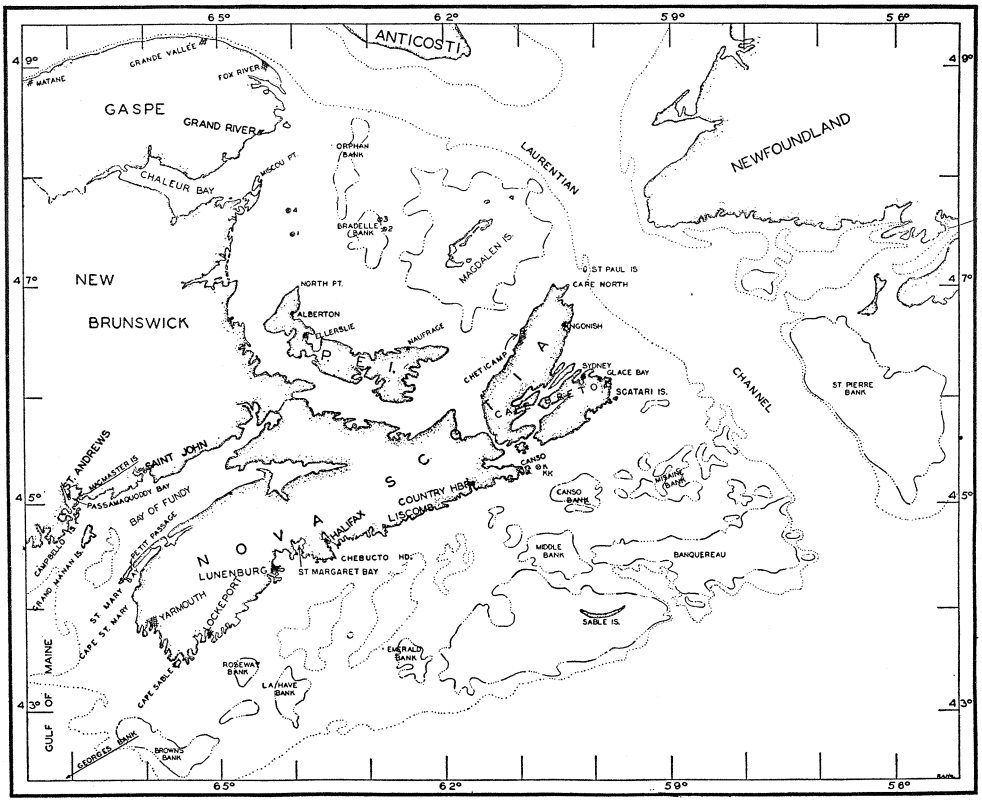

FIG. 2.—The Bay of Fundy, Scotian Shelf, and the Gulf of St. Lawrence west of the Laurentian Channel.

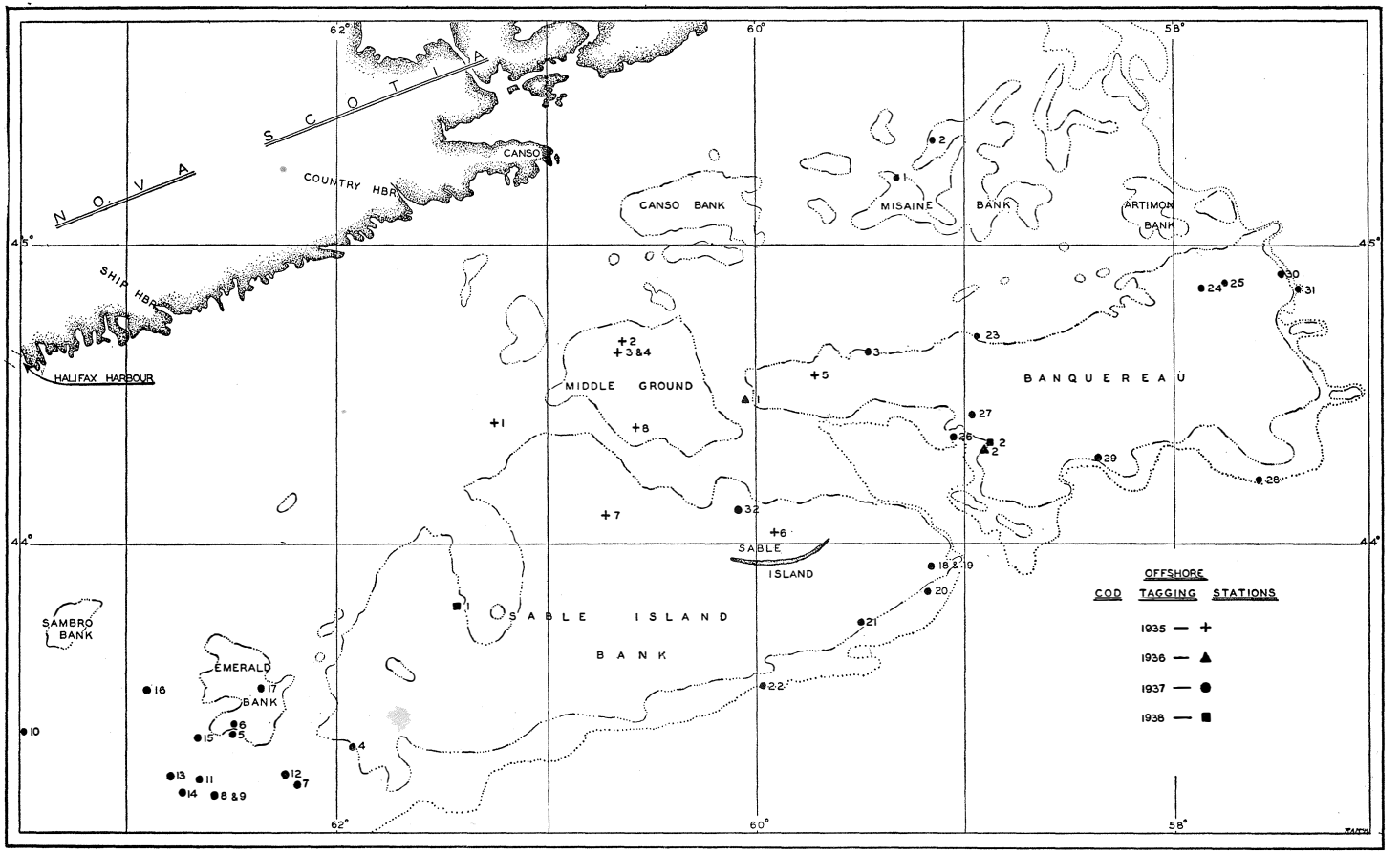

FIG. 3.—Cod tagging locations on banks off eastern Nova Scotia, 1935 to 1938 inclusive.

TABLE I.—Cod tagged in inshore waters of the Bay of Fundy and the outer coast of Nova Scotia, 1934 to 1938

Place	Date	Depth		Bottom temperature	Number tagged
		fath.	*m.*	°C.	
OUTER COAST NOVA SCOTIA	1934				
Egg Island, N.S. (*A*, Fig. 1)	May 22, 24	44	80	1·0–1·5	488
Jeddore Rock, N.S. (*B*, Fig. 1)	May 25, 26	25	45	2·75	807
Halifax, N.S. (*C* to *J*, Fig. 1)	June 4-29	10–44	18–80	1·9–6·0	688
Canso, N.S. (*K*, Fig. 2)	July 31	15	28	5·4	344
Canso, N.S. (*KK*, Fig. 2)	Aug. 1	15	28	6·8	134
Halifax, N.S. (*V* and *W*, Fig. 1)	Oct. 6-Dec. 6	8–16	15–30	6·0–14·0	15
Total					2,476
	1935				
Halifax, N.S. (*L* to *O*, Fig. 1)	May 3-10	48–86	87–158	0·7–5·0	152
Ingonish, N.S. (Fig. 2)	June 10	14	25	0·4	49
Halifax, N.S. (*V* and *W*, Fig. 1)	Oct. 2-Nov. 22	8–16	15–30	6·0–14·0	51
Total					252
	1936				
Halifax, N.S. (*P* to *U*, Fig. 1)	May 6-9	38–52	70–95	1·4–1·7	102
Halifax, N.S. (*V* and *W*, Fig. 1)	Oct. 13-Nov. 12	8–16	15–30	6·0–14·0	93
Total					195
1934-1936 Total					2,923
BAY OF FUNDY	1938				
MacMaster and Campobello Island, N.B., Bay of Fundy (Fig. 2)	July 21, 22; Nov. 17				13
	1939				
Petite Passage and St. Mary Bay (Fig. 2)	Apr. 21-28				83
1938-1939 Total					96

TABLE II.—Cod tagged on eastern Nova Scotian Banks and in the Gulf of St. Lawrence

Place	Date	Depth		Bottom temperature	Number tagged
		fath.	*m.*	°C.	
EASTERN NOVA SCOTIAN BANKS	1935				
Middle Bank (Sta. 1-8, Fig. 3).....	May 13; June 15-29	20–79	37–144	1·2–6·8	294
	1936				
W. Banquereau (Sta. 1-2, Fig. 3)...	Apr. 23, 26	55–65	101–119	.....	499
	1937				
Misaine Bank (Sta. 1-2, Fig. 3).....	Mar. 1	49–50	90–92	.....	115
Banquereau (Sta. 3, Fig. 3).....	Mar. 2	46	84	1·5	41
Emerald Bank (Sta. 4-17, Fig. 3)...	Mar. 5-26	48–85	88–156	?	386
SE. Sable Island (Sta. 18-22, Fig. 3).	Mar. 28-29; Apr. 2-6	40–60	73–110	?	975
Banquereau (Sta. 23, Fig. 3).....	Apr. 18	70	128	?	286
E. Banquereau (Sta. 24-25, Fig. 3)..	Apr. 19-20	28–40	51–73	0·5–?	828
SW. Banquereau (Sta. 26-27, Fig. 3)	Apr. 30-May 3	38–62	70–113	1·5–?	82
S. Banquereau (Sta. 28-29, Fig. 3)..	May 4, 5	40–75	73–137	.....	425
NE. Banquereau (Sta. 30-31, Fig. 3)	May 28, 29	27–48	49–88	4·0–?	855
Sable Island (Sta. 32, Fig. 3).....	May 30	20	37	3·2	253
Total.....	.....	.....	.....	.....	4,246
	1938				
W. Sable Island Bank (Sta. 1-2, Fig. 3)	Apr. 20, 24	30–70	55–128	1·5–?	252
1935-1938 Total.....	.....	.....	.....	.....	5,291
GULF OF ST. LAWRENCE	1930 to 1936				
Off Ellerslie, P.E.I. (Fig. 2).....	July-Nov.	7–16	13–29	.....	312
	1936				
North Point, P.E.I. (Sta. 1, 4, Fig. 2)	Aug. 5, 8	20–21	36–38	−0·8–0·0	155
Bradelle Bank (Sta. 2, 3, Fig. 2)....	Aug. 6, 7	26–30	48–54	−0·5–0·0	261
Total.....	.....	.....	.....	.....	416
	1937				
1-4 miles off Cheticamp Island (Fig. 2)	July 21-26	17–37	31–67	0·2–4·0	795
	1939				
5-17 miles off Alberton, P.E.I. (Fig. 2)	July 8-17	10–23	18–42	1·8–2·2	696
	1940				
7 miles off Naufrage, P.E.I. (Fig. 2).	Aug. 24	25	45	.....	141
1930-1937 and 1939-1940 Total.....	.....	.....	.....	.....	2,360

METHODS

The tag used in all the work reported here was the monel metal strap tag so well illustrated by Schroeder (1930). This is a flat strip of metal about 5 cm. long and 0.5 cm. wide, bent into a U shape with one end pointed and bent at right angles to pass through a slit in the tip of the other arm. Using special pliers, enough pressure is applied to force the pointed arm through the flesh and through the slit in the other arm, and to clinch it. The great majority of the tags were placed ventrally on the caudal peduncle as far up on the scales as the opening between the tips of the arms of the tag would permit.

In the offshore tagging in 1937, alternate groups of tags were placed on the caudal peduncle and on the operculum to see if any better returns would be obtained from tags in the latter position. On the operculum the tag was pushed on from the posterior free edge as far as possible and as high up the side as possible, and clinched through the operculum from the inside out, thus leaving no rough edges next to the gills. Of the returned tags 53% were from the operculum and 47% from the caudal peduncle—an insignificant difference. In other taggings scarlet celluloid discs were threaded onto alternate monel metal strap tags to see if, by being more conspicuous, more would be returned, but no great difference resulted, 48% of the returned tags being without and 52% with discs.

It was also noted that tagging apparently had some temporary effect on the susceptibility of the fish to capture by hook and line fishing. An inspection of all the recaptures from 2,200 cod tagged on eleven different days during 1934, 1935 and 1936 shows that none were recaptured on the day following tagging and that the recaptures increased irregularly to a maximum during the fourth week following tagging.

As a general rule cod of all sizes were tagged just as they were caught, if in good condition. In 1938, however, only "steak" cod (a commerical size category including only cod of over 10 lb. gutted weight) were tagged to determine the movements of a certain school of large cod which appeared just west of Sable Island almost every year about mid-winter.

Where tagging was done from the research vessel *Zoarces* (Captain A. E. Calder), lengths were usually recorded but, to avoid delay and damage to the condition of the fish, no scales taken.

In the inshore tagging of 1935 and 1936 off Halifax, the offshore in 1935 and that off Naufrage, P.E.I., in 1940, the fish were caught on longlines set for short periods only. In the 1934 inshore tagging off Halifax, the tagging off Ellerslie, P.E.I., from 1930 to 1936, the tagging off Cheticamp, N.S., in 1937 and that off Alberton, P.E.I., in 1939, the fish were taken with handlines. At Ingonish the cod tagged in 1935 were caught in traps. The autumn spawning cod, tagged from 1934 to 1936 in Halifax Harbour, were caught in gill nets as these fish were not

feeding and would not take a hook as a rule. The offshore tagging in 1936 to 1938, and that off North Point, P.E.I., and on Bradelle Bank in the Gulf of St. Lawrence in 1936, was done in dories operated from Lunenburg fishing schooners. The smaller uninjured fish, caught on regular sets of commerical longlines, were taken from the hook, passed to the tagger (the third man in the dory), tagged and released over the side; large fish were tagged without being taken from the water, one man tagging while a second held the snood line with the hook still in the fish, releasing it later when the tag was in place.

Beginning in 1934, fifty cents was paid as a reward for all cod and haddock tags received at the Board's Biological Station, St. Andrews, N.B., accompanied by information as to where and when the fish were caught, and from 1932-1940 as much publicity as possible was given to the tagging program. Progress reports, new tagging projects and unusual recaptures were all given newspaper publicity. Posters were displayed in post offices, on wharves and in other prominent places. Personal canvassing of the fishing centres where marked fish were most likely to be landed was also carried out at short intervals in order to bring about the maximum return of tags.

THE TAGGINGS AND THE RECAPTURES

The taggings and the resulting recaptures are summarized below and most of them plotted in Fig. 4 to 46. For convenience in comparison they are arranged according to the areas where the taggings were done, starting with the Bay of Fundy and ending with the Gaspé area.

The term "tagging region" is used to indicate the area within 12 miles (20 km.) of the tagging position. No attempt has been made in figures or in text to indicate conjectured routes and all distances mentioned are shortest distances between tagging and recapture points. The terms "summer" and "winter" denote the periods May to October and November to April respectively, dividing the year approximately into the warmer and colder halves in the water. In most figures the number of cod tagged is shown in a circle at the tagging position and symbols are used to indicate the places and times of the recaptures.

Bay of Fundy

St. Andrews, N.B. Seven cod were tagged on July 21 and 22, 1938, off MacMaster Island, and 6 on Nov. 17, 1938, off Campobello Island (Fig. 2; Table I), all in Passamaquoddy Bay off St. Andrews, N.B. One (tagged July 22) was recaptured on the northeast part of Georges Bank on Feb. 28, 1939, about 200 miles from the point of tagging (Fig. 4).

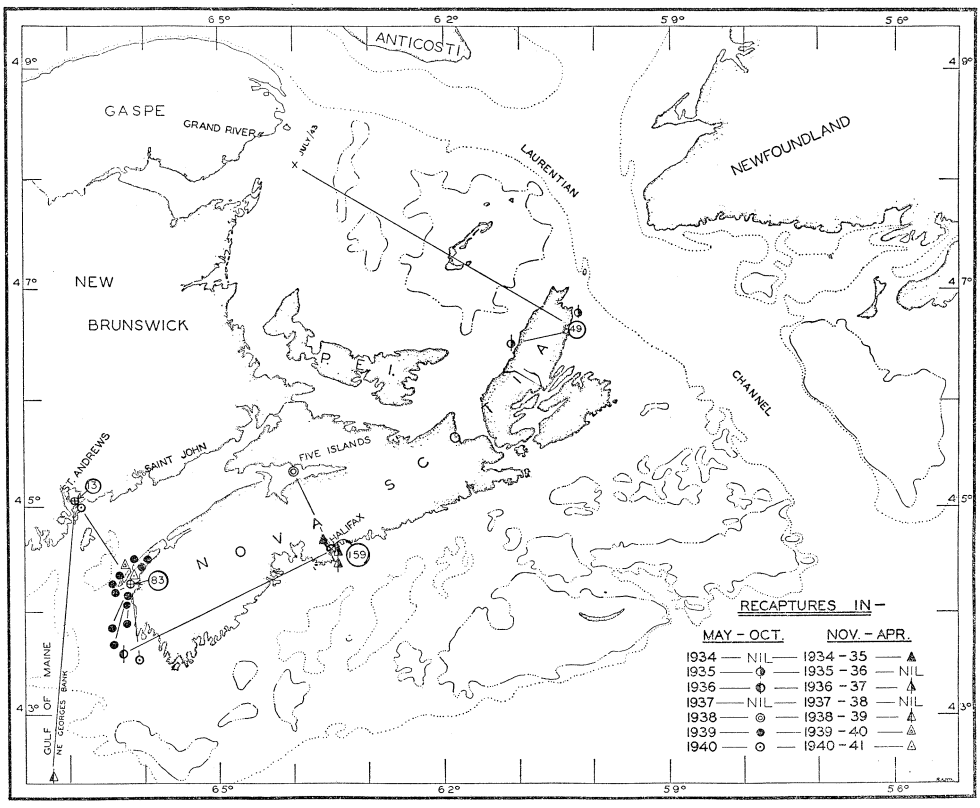

FIG. 4.—Recaptures of autumn-spawning cod tagged at Halifax in 1934, 1935 and 1936, and of cod tagged at Ingonish in 1936, near St. Andrews in 1938, and in St. Mary Bay in 1939.

ST. MARY BAY, N.S. From Apr. 21 to 28, 1939, 83 cod were tagged in St. Mary Bay, N.S. Altogether 15 were recaptured, all before May, 1941, and 13 during the "summer". All told, seven were recaptured outside the tagging region, yet not far away, all but one (which crossed the Bay of Fundy to the vicinity of St. Andrews) being retaken in inshore waters off southwestern Nova Scotia (Fig. 4). Of 61 cod tagged on the Nova Scotian side of the Bay of Fundy in 1926 to 1930, only 3 were recaptured.

INSHORE WATERS OF WESTERN NOVA SCOTIA

SEAL ISLAND. Figures 5 to 8 give the recaptures from June, 1927, Seal Island tagging (McKenzie, 1934a) and show that, "winter" or "summer", about 80% of the 190 recaptures of the 1,840 cod tagged were made either in the tagging region or within 50 miles eastward along the outer Nova Scotian coast east of Cape Sable. The movement within this region was shown to be eastward during the late summer and westward again during the winter in somewhat deeper water. The remaining 20% were scattered in all directions.

SHELBURNE, N.S. The recaptures of the 4,011 cod tagged off Shelburne, N.S., during the months of June to October, 1926 (McKenzie, 1934a) are shown in Fig. 9 to 16. The recaptures from the June and August taggings (Fig. 9, 13) show no movement away from the tagging region at all. Eighty-five to 90% of the recaptures from the July, September and October taggings (Fig. 10-12, 14-16) were made in or very near the tagging region, the only movement being a slight shift on shore for the summer and off shore for the winter. The size of the symbols makes those clustered about the tagging position cover more area on the charts than did the actual recaptures. The remaining 10% to 15% of the recaptures were made almost entirely to the eastward, being found farther and farther away year by year.

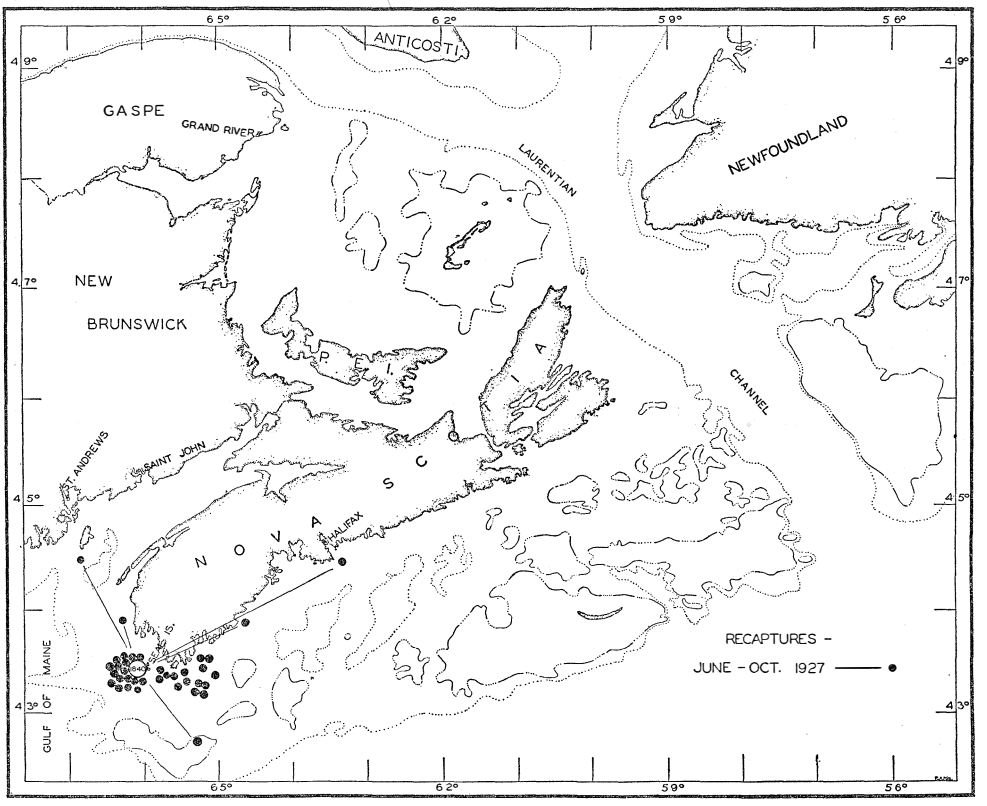

FIG. 5.—Recaptures, June to October, 1927, of cod tagged off Seal Island, N.S., in June, 1927.

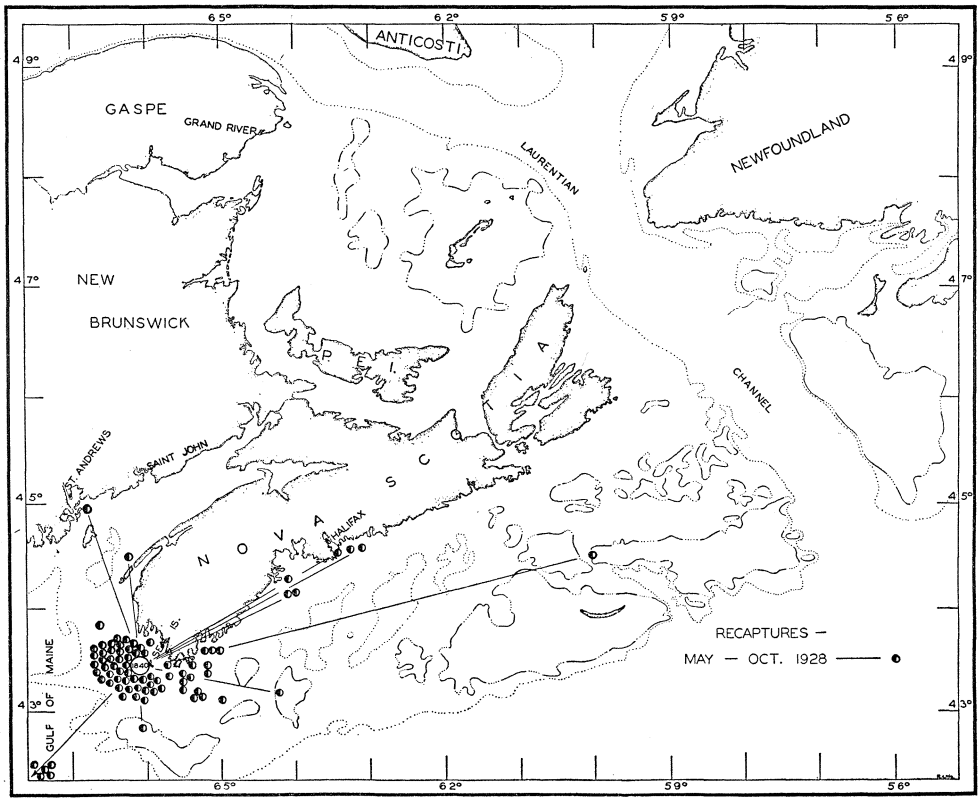

FIG. 6.—Recaptures during "summer", 1928, of cod tagged off Seal Island, N.S., in June, 1927.

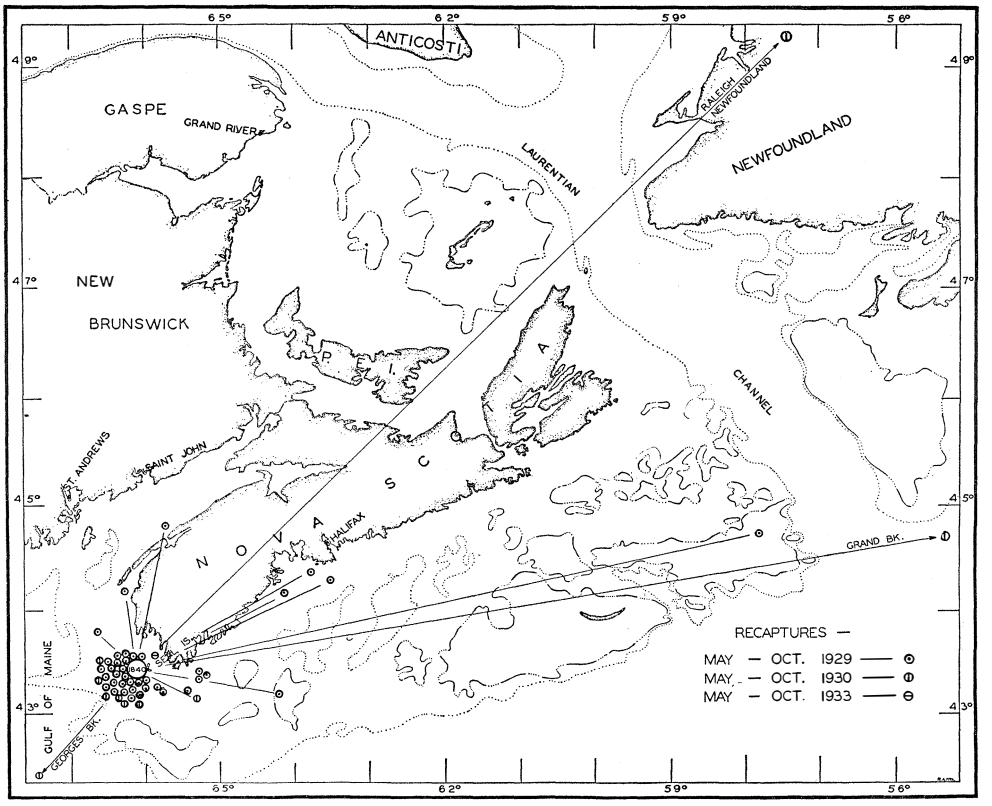

FIG. 7.—Recaptures during "summers" of 1929, 1930 and 1933 of cod tagged off Seal Island, N.S., in June, 1927.

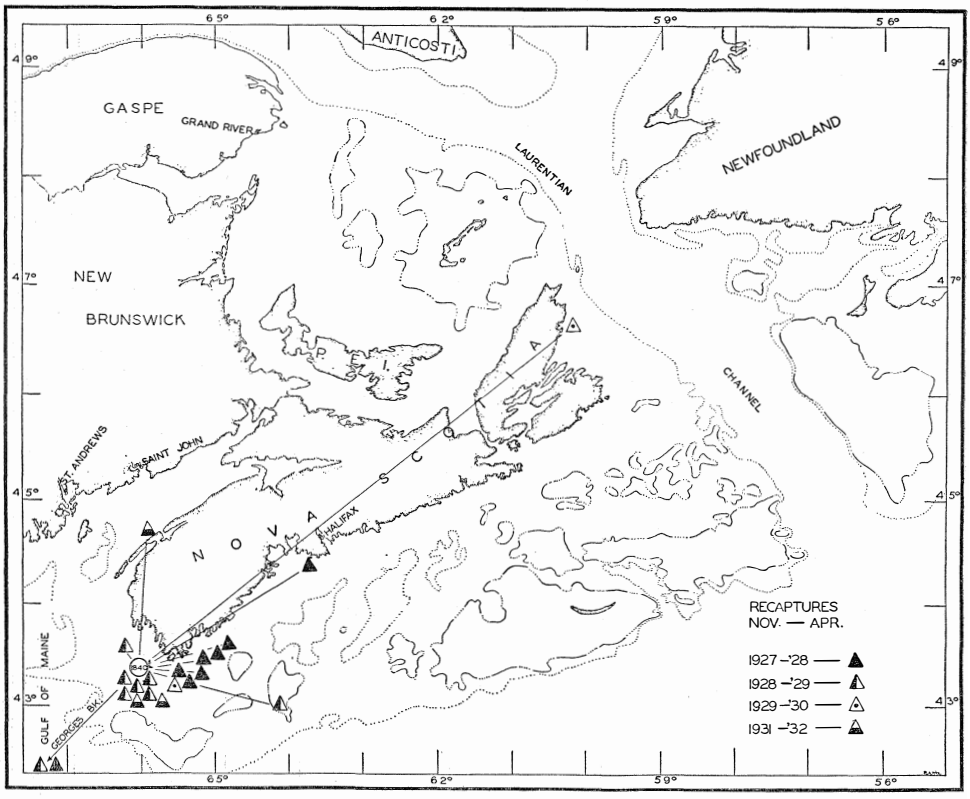

FIG. 8.—Recaptures during "winters" of 1927-1928, 1928-1929, 1929-1930 and 1931-1932 of cod tagged off Seal Island, N.S., in June, 1927.

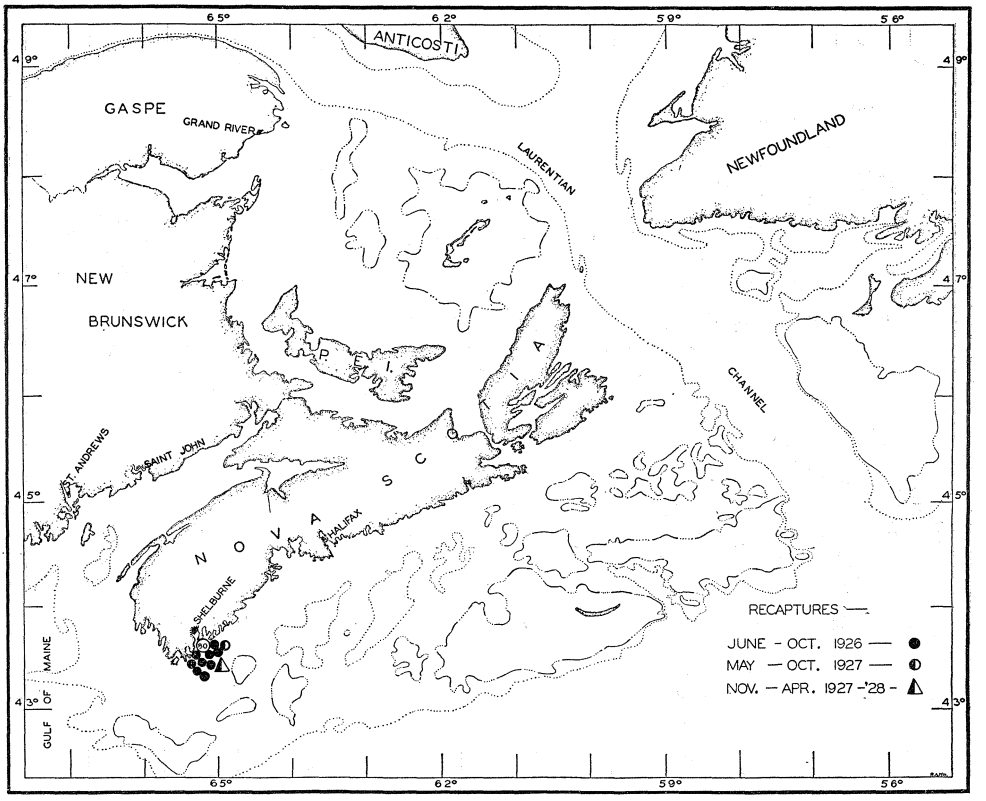

FIG. 9.—Recaptures of cod tagged off Shelburne, N.S., in June, 1926.

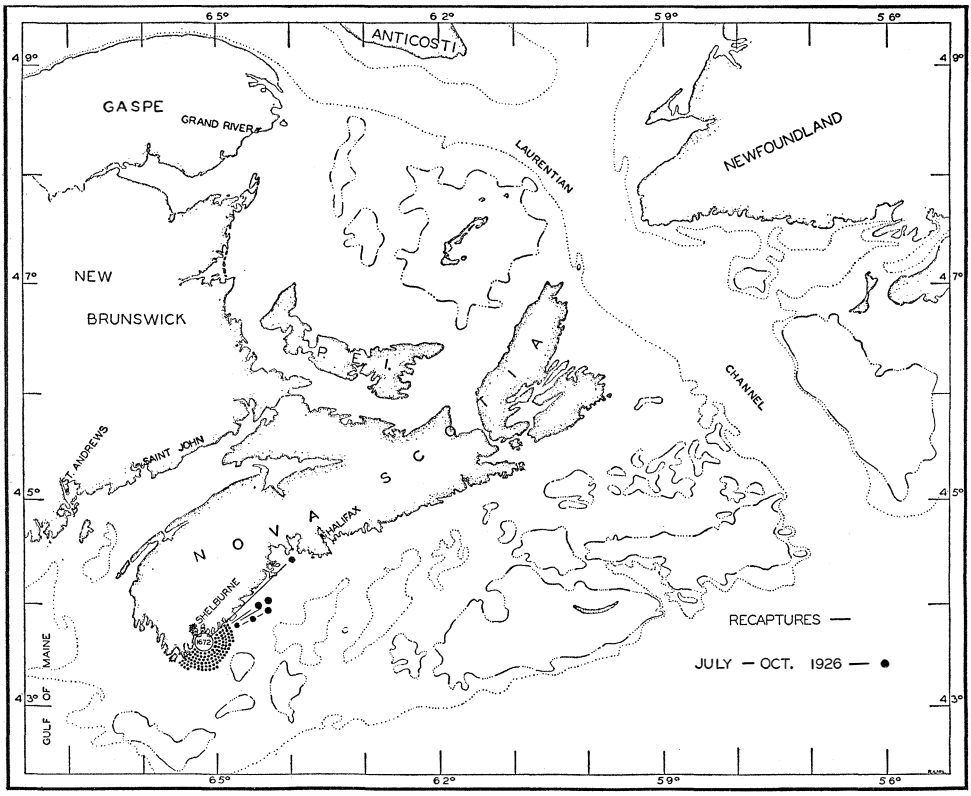

FIG. 10.—Recaptures to October, 1926, of cod tagged off Shelburne, N.S., in July, 1926.

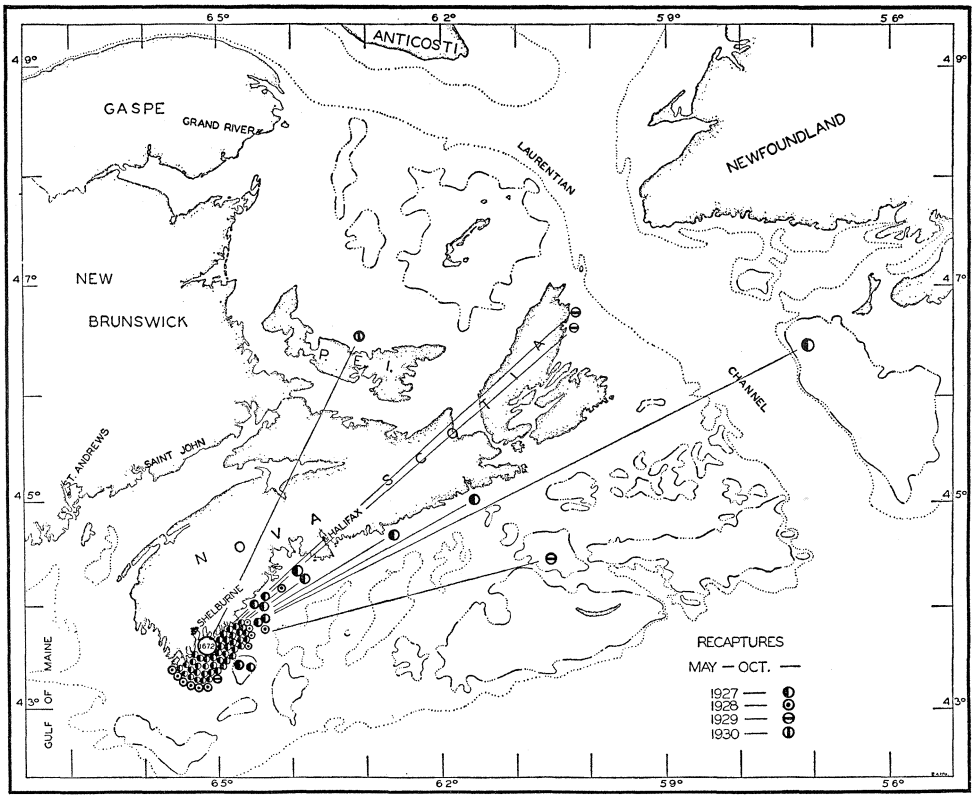

FIG. 11.—Recaptures during "summers" of 1927, 1928, 1929 and 1930 of cod tagged off Shelburne, N.S., in July, 1926.

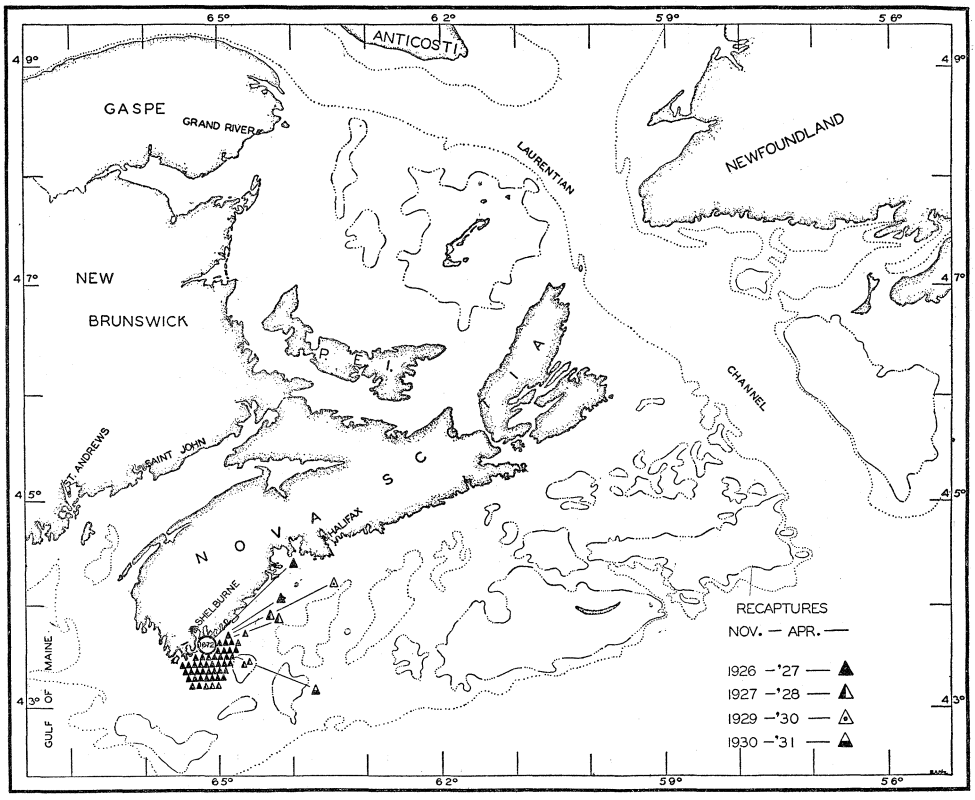

FIG. 12.—Recaptures during "winters" of 1926-1927, 1927-1928, 1928-1929, and 1930-1931 of cod tagged off Shelburne, N.S., in July, 1926.

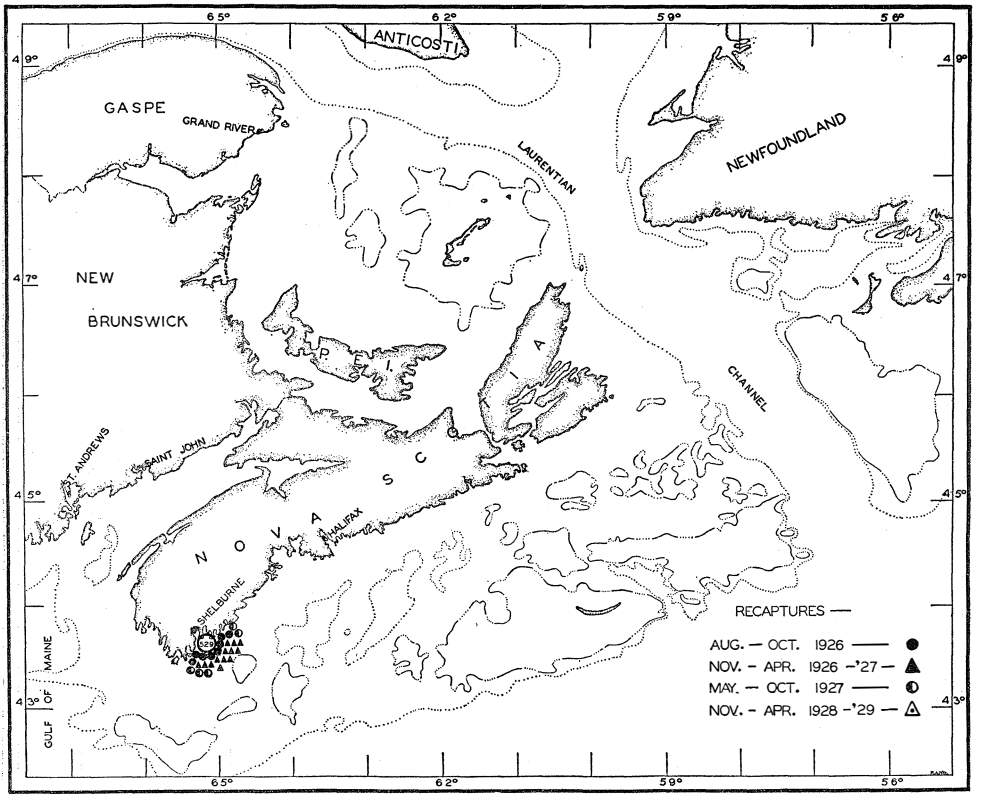

FIG. 13.—Recaptures of cod tagged off Shelburne, N.S., in August, 1926.

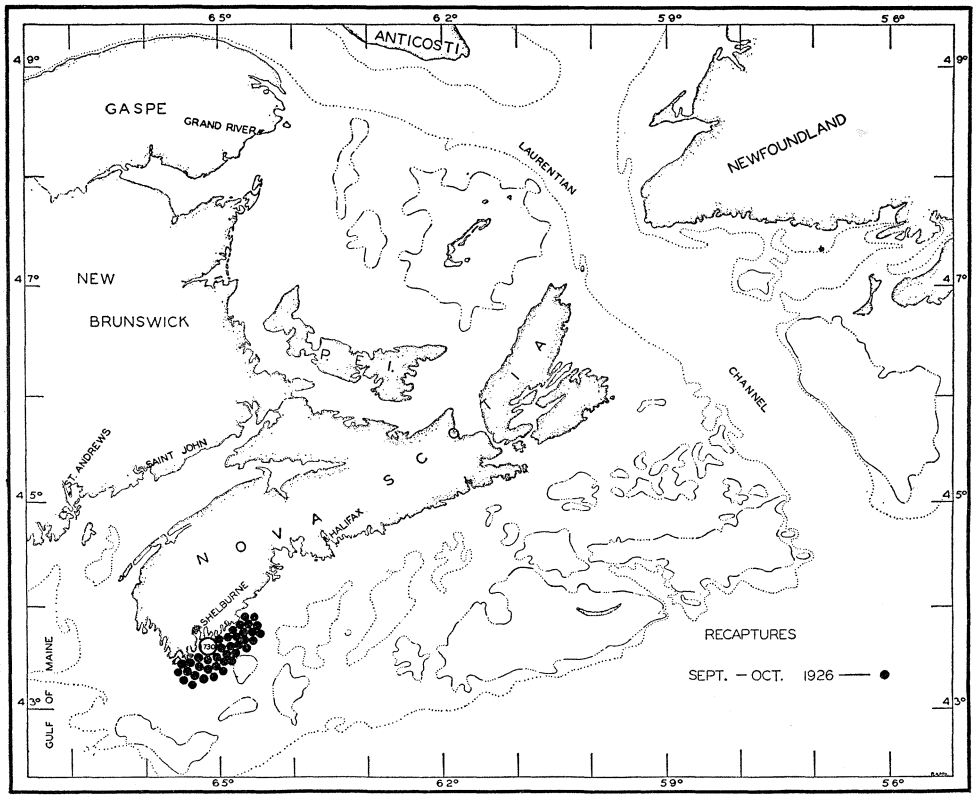

FIG. 14.—Recaptures to October, 1926, of cod tagged off Shelburne, N.S., during September and the first day of October, 1926.

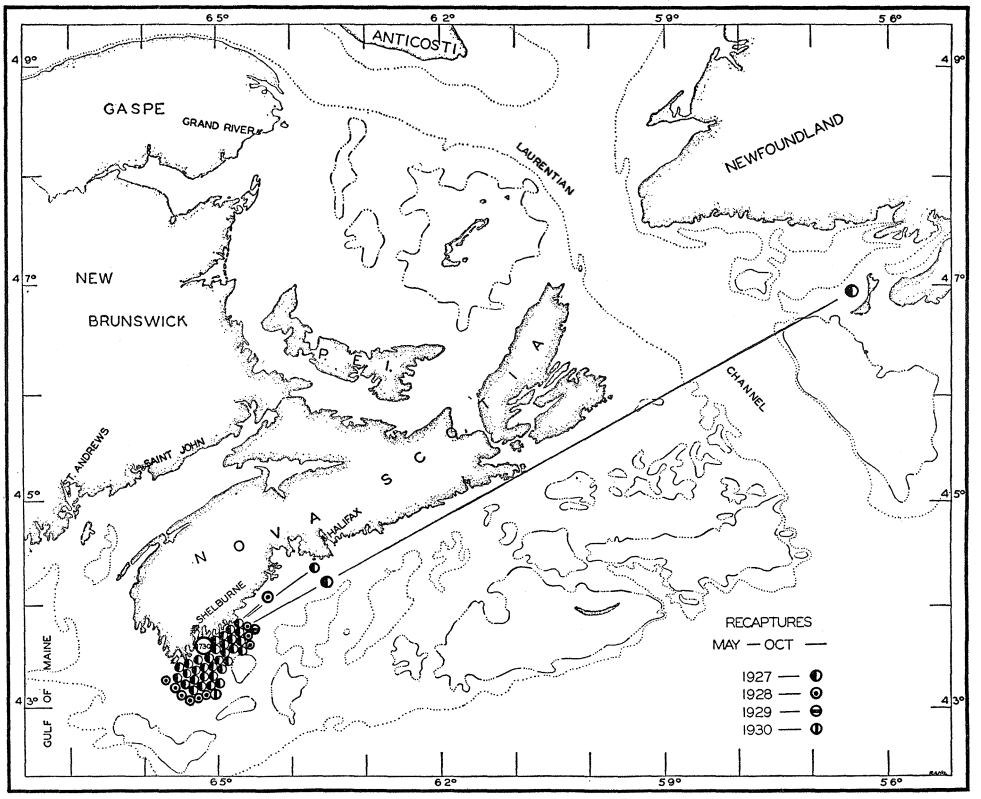

FIG. 15.—Recaptures during "summers" of 1927, 1928, 1929 and 1930 of cod tagged off Shelburne, N.S., during September and the first day of October, 1926.

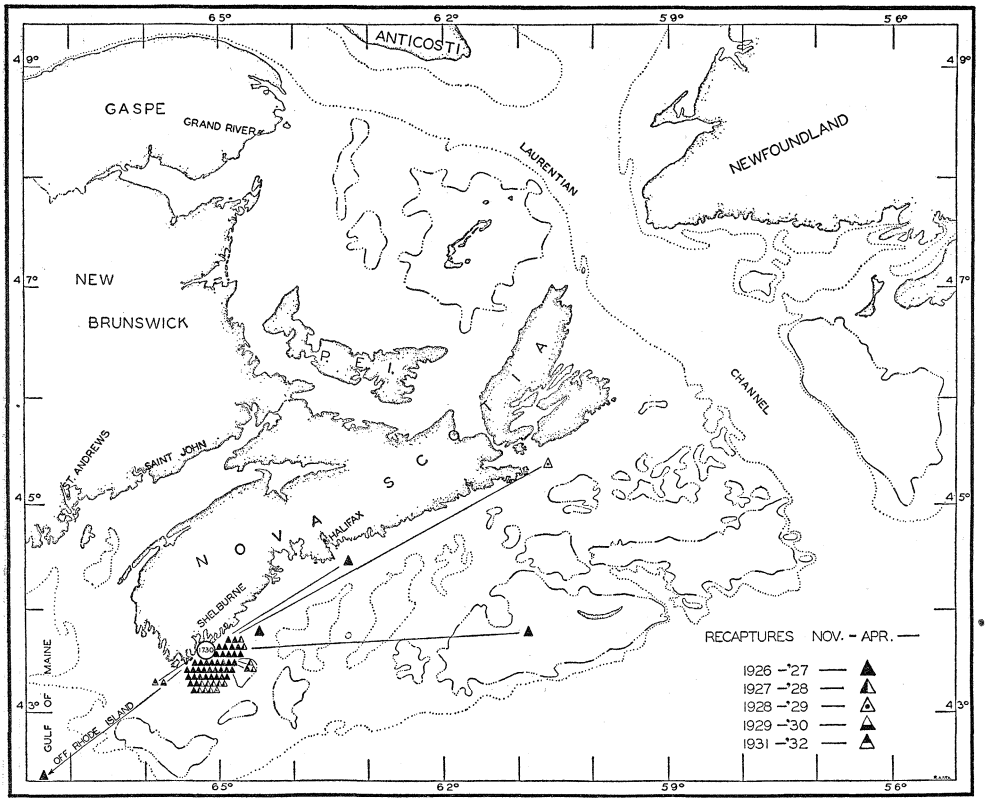

FIG. 16.—Recaptures during "winters" of 1926-1927, 1927-1928, 1928-1929, 1929-1930 and 1931-1932 of cod tagged off Shelburne, N.S., during September and the first day of October, 1926.

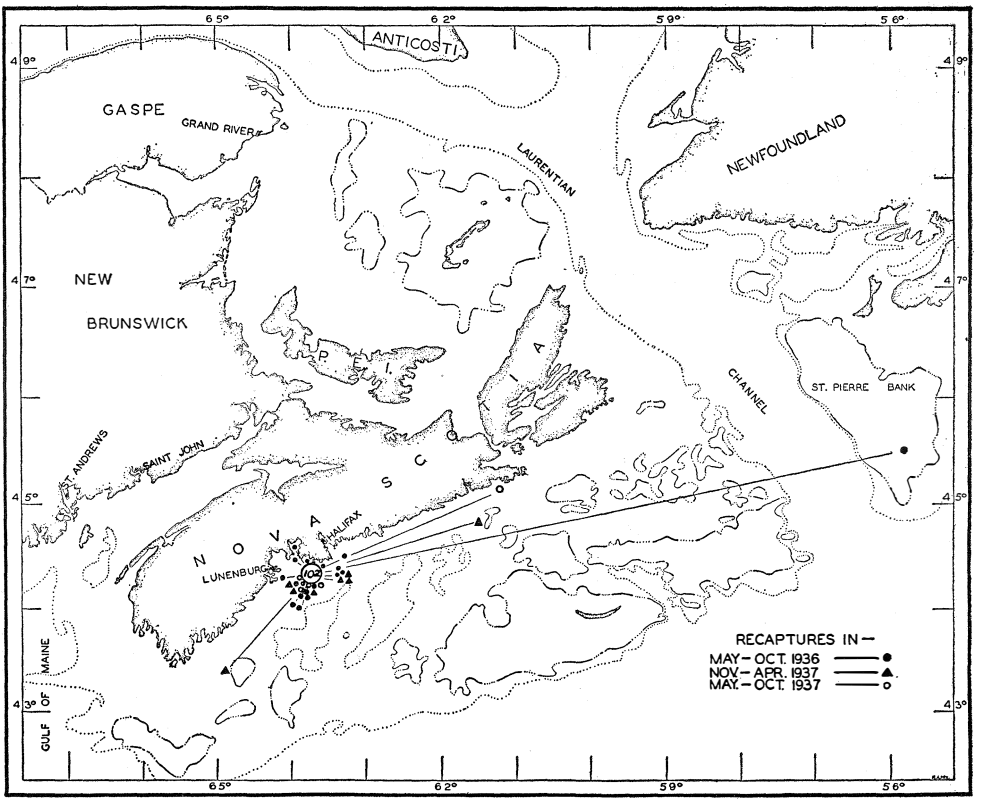

FIG. 17.—Recaptures from cod tagged in the Lunenburg–Halifax area, May, 1936.

LUNENBURG–HALIFAX, N.S., 1936. In early May, 102 cod were tagged at six inshore positions from Halifax to Lunenburg (P to U, Fig. 1, Table I) in water 70 to 95 m. (38 to 52 fath.) in depth and in temperatures of 1.4 to 1.7°C. Three fish each were tagged at positions *Q* and *R* and none recaptured. From the other four taggings 32 recaptures were made, 24 during "summers" and 8 during "winters", one-quarter from outside the tagging region in each season. Figure 17 indicates that most were retaken inshore from Halifax to Lunenburg where they were tagged, one going westward and two eastward along the coast and one to St. Pierre Bank. None were recaught in the Bay of Fundy, on the Nova Scotian offshore Banks, nor in the Gulf of St. Lawrence.

HALIFAX, N.S., 1934. During June, 688 cod were tagged off Halifax at sixteen different times and/or positions (Fig. 1, Table I). The 1 to 155 cod for the various taggings came from water 18 to 80 m. (10 to 44 fath.) deep and of temperature 1.9 to 6.0°C. Of the 179 recaptures during the "summers", 27 were outside the tagging region; in the "winters" 31 were recaptured, 15 outside the tagging region. Of the 210 recaptured 42 were outside the tagging region and 15 of them over 100 miles away.

In Fig. 18 are shown all the recaptures made during the "summers" following tagging. The greatest number were recaught close to the Halifax area. Little spreading along the coast occurred in the first summer, but this increased in the next three summers. All the "winter" recaptures are plotted in Fig. 19 and, while most of them (24) were along shore, 7 were offshore.

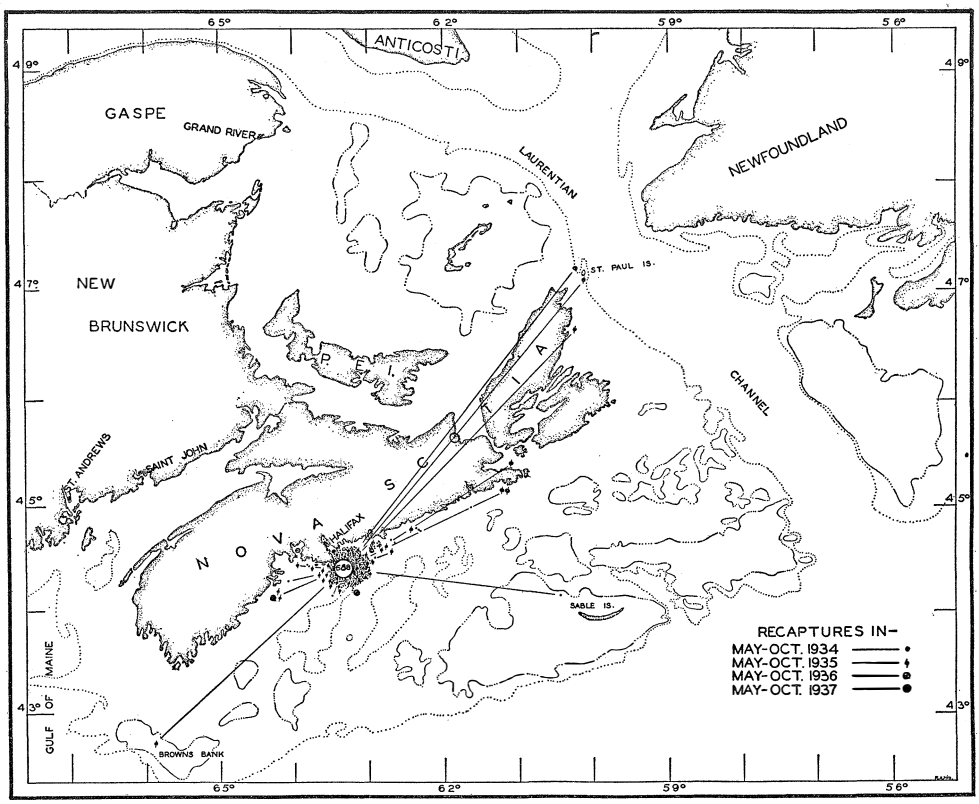

FIG. 18.—Recaptures in May to October, 1934, 1935, 1936 and 1937, of cod tagged near Halifax in June, 1934.

HALIFAX, N.S., 1935. In the first ten days of May, 152 cod were tagged near Halifax at *L* to *O* (Fig. 1, Table I). At *L*, *M*, and *N*, 150 were tagged in temperatures of 0.7 to 0.9°C. and at depths of 87 to 132 m. (48 to 72 fath.); at *O*, 2 were tagged at 5.0°C. in 158 m. (86 fath.) and neither recovered. Of the 36 recaptures from *L*, *M*, and *N*, 19 were outside the tagging region, 8 only very short distances away. During the "summers" 25 were recaptured, 14 outside the tagging regions; during the "winters" 11 were recaptured, 5 outside the tagging regions. Figure 20 shows that most of the recaptures were in the Halifax inshore area, some spread along the shore both in "summer" and in "winter", and 3 in offshore waters.

EGG ISLAND TO JEDDORE ROCK, N.S., 1934. Late in May two taggings (*A* and *B*, Fig. 1 and Table I) totalling 1,295 cod were carried out in inshore waters about 25 miles east of Halifax Harbour. At *A*, 488 cod were tagged and 118 recaptured; at *B*, 807 tagged and 255 recaptured. Of the 373 recaptures most (349) were made in the "summers" and of these only 60 were outside the tagging region. During the "winters" only 24 more were retaken but 22 came fron outside the tagging region. Of the 82 recaptures from outside the tagging region, 18 were from more than 100 miles away.

Figures 21, 22 and 23 show the positions of all the "summer" recaptures. By far the greatest number were close to where the fish were tagged but there was some spreading along the coast in both directions and a few wandered away considerable distances—three being taken in the Gulf of St. Lawrence and two off southern Newfoundland. In Fig. 24 all the "winter" recaptures are plotted and are shown to have occurred on both the inshore and offshore fishing grounds off Nova Scotia.

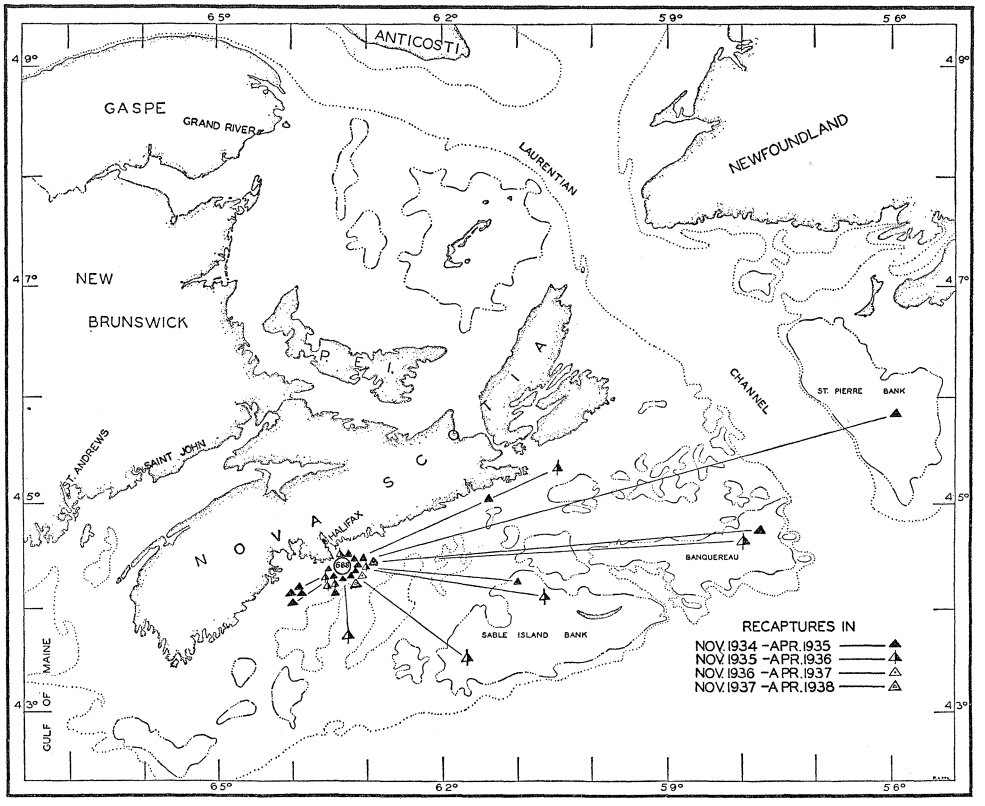

FIG. 19.—Recaptures in November to April, 1934, 1935, 1936 and 1937, of cod tagged near Halifax in June, 1934.

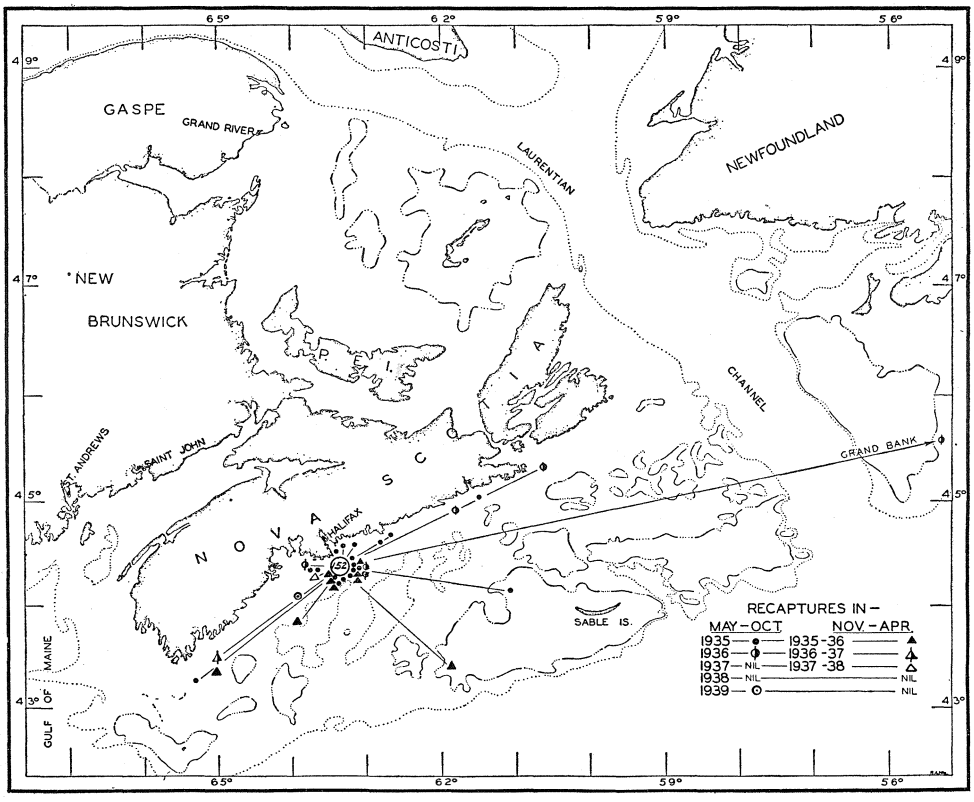

FIG. 20.—Recaptures of cod tagged near Halifax, May, 1935.

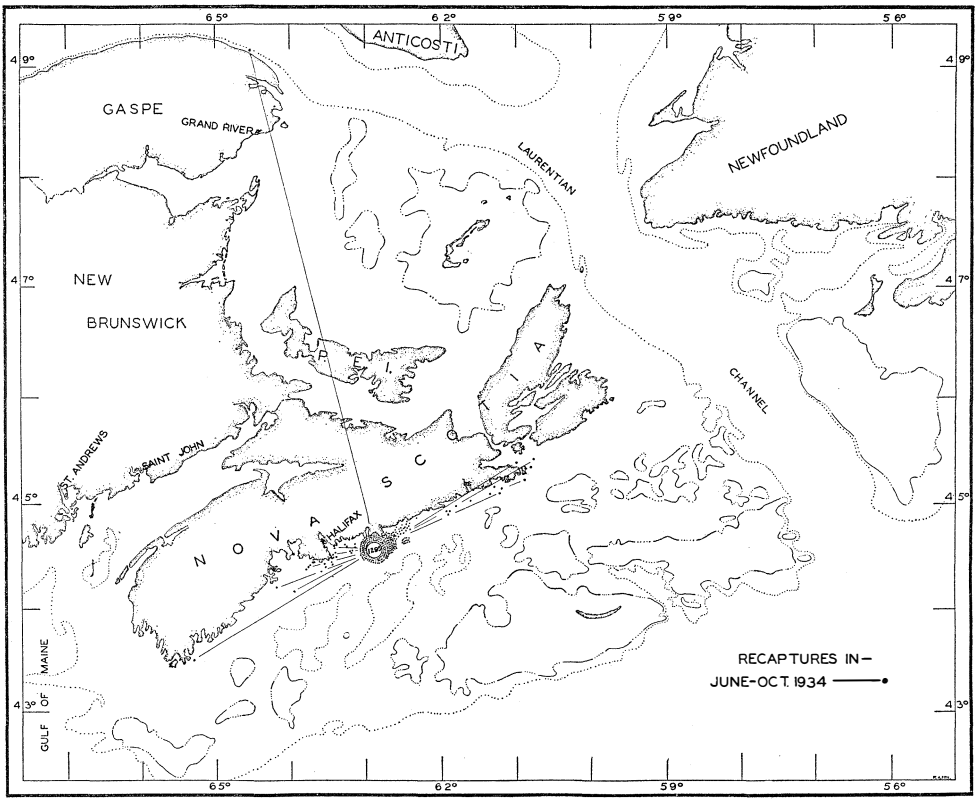

FIG. 21.—Recaptures to October, 1934, of cod tagged in the Jeddore Rock to Egg Island area, N.S., in May, 1934.

66183—3

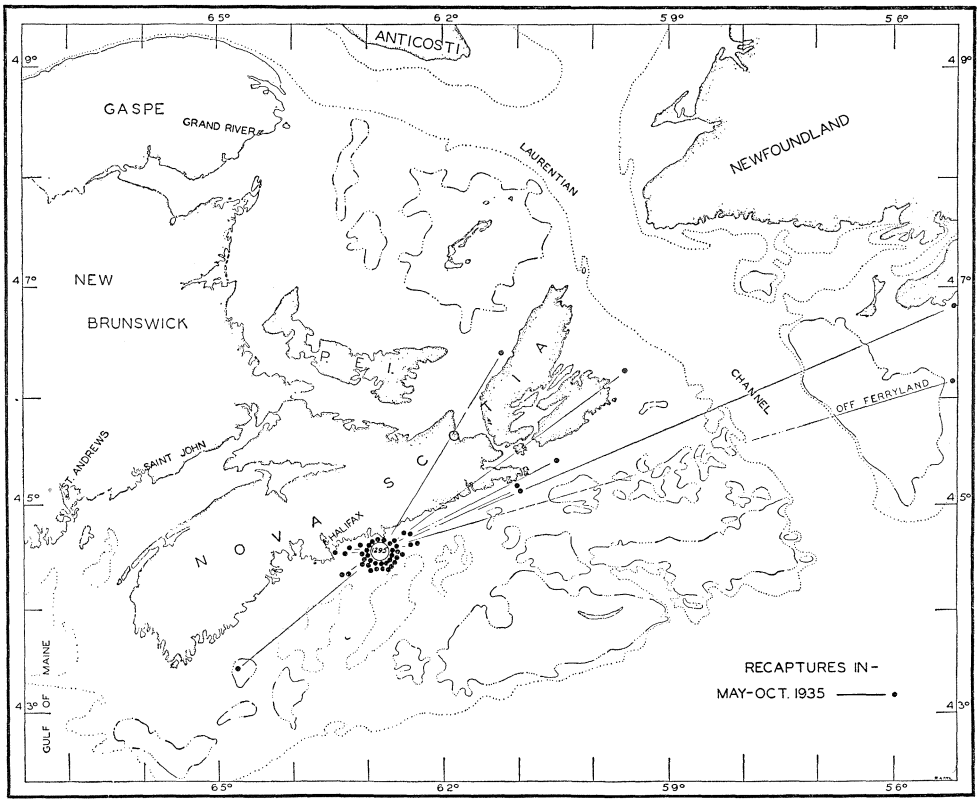

FIG. 22.—Recaptures in May to October, 1935, of cod tagged in the Jeddore Rock to Egg Island area, N.S., in May, 1934.

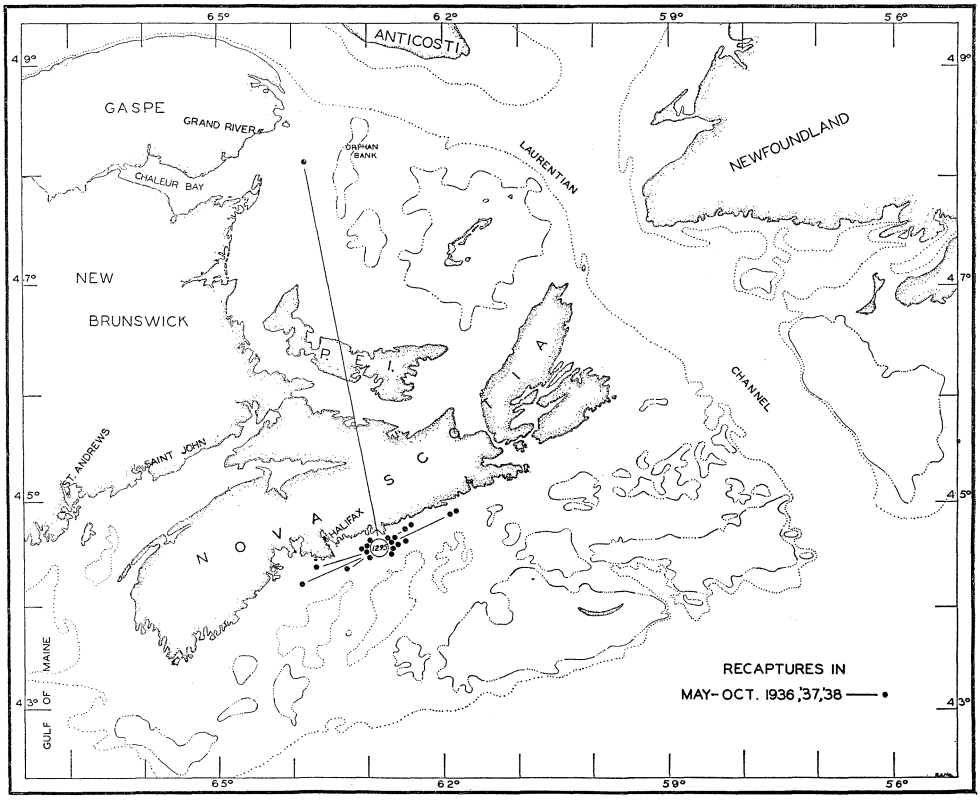

FIG. 23.—Recaptures in May to October, 1936, 1937 and 1938 of cod tagged in the Jeddore Rock to Egg Island area, N.S., in May, 1934.

66183—3½

CANSO, N.S., 1934. On July 31, in 28 m. (15 fath.) of water with a bottom temperature of 5.4°C., 344 cod with an average length of 64.6 cm. were tagged (Fig. 2; Table I). At the same place but in water of 6.8°C., 134 more cod with an average length of 60.5 cm. were tagged on August 1. Forty were recaptured from the July 31 tagging and 15 from the August 1 tagging. The returns from these two taggings were so different that they are presented separately.

Twelve of the 33 "summer" and 4 of the 7 "winter" recaptures fron the first day's tagging were made outside the tagging region—a total of 16, six of them over 100 miles away. None of the 11 "summer" and only one of the 4 "winter" recaptures from the second day's tagging was made outside the tagging region.

Figure 25 shows that the majority of the recaptures from the July 31 tagging were close to Canso, with 4 from the east coast of Cape Breton and 5 from the eastern offshore grounds. No recaptures were made east of Cape Breton until after the first summer and winter, and none were taken in the Gulf of St. Lawrence, east of the Laurentian Channel or west of a line directly off Halifax. Figure 26 shows all the recaptures from the August 1 tagging clustered about the point of tagging, with one exception. The larger, colder-water fish tagged on July 31 seem to have been a more migratory group than those tagged on August 1.

AUTUMN-SPAWNING COD, HALIFAX, N.S. From Oct. 6 to Dec. 6, 1934, 15 of the cod which spawn in the autumn were tagged at *V* and *W* (Fig. 1 and Table I) in Halifax Harbour; only one was recaptured—close to where it was tagged and less than a month later. From Oct. 2 to Nov. 22, 1935, 51 cod were tagged in the same areas and one was recaptured off Yarmouth, N.S., in the

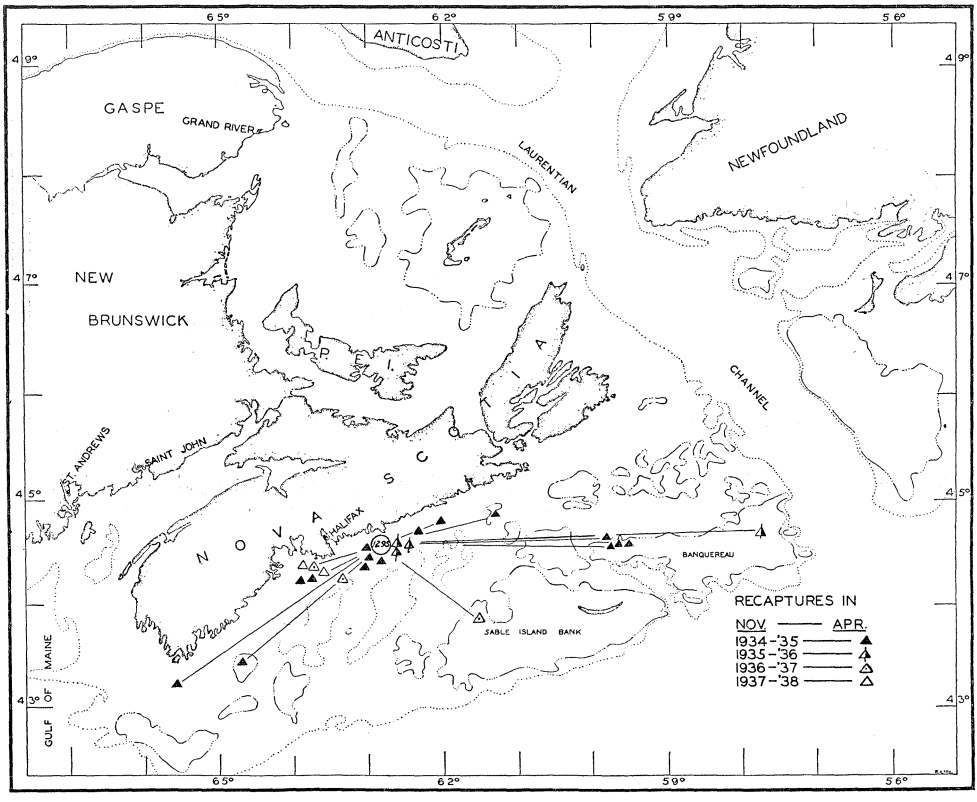

FIG. 24.—Recaptures in November to April, 1934-1938, of cod tagged in the Jeddore Rock to Egg Island area, N.S., in May, 1934.

"winter" of 1936-37. From Oct. 12 to Nov. 13, 1936, 93 more were tagged; of these, three were recaptured near Halifax in the winter of 1936-37 and one at the head of the Bay of Fundy in May, 1938. These returns are shown in Fig. 4.

Offshore Grounds off Eastern Nova Scotia

Emerald Bank, 1937. During Mar. 5 to 26, 386 were tagged at fourteen different stations off the southern part of Emerald Bank. All stations except number 10 were close to Emerald Bank (Fig. 3) in depths of 88 to 117 m. (48 to 64 fath.) None of the 19 tagged cod at station 10 (about 25 miles west of Emerald Bank and south of Sambro Bank in 156 m. (85 fath.)) was recaptured. Of the remaining 367 cod tagged at Emerald Bank, 14 were recovered, 2 within and 12 away from the tagging regions. Only 5 of the recaptures were made during the "summers" and these all outside the tagging regions at distances of 75 to 325 miles, 3 of them being over 200 miles. During the "winters" 9 recaptures were made, 7 being outside the tagging regions, one about 125 miles away, the others all within 35 miles. Figure 27 (A) shows the "summer" recaptures widely spread—eastern offshore banks, eastern inshore waters in the Canso region and southern Newfoundland and Orphan Bank well into the western side of the Gulf of St. Lawrence—and the "winter" recaptures all on the eastern offshore banks, one on Banquereau and the other 8 on western Sable Island Bank, most of them within 35 miles of the tagging regions.

Western Sable Island Bank, 1938. On Apr. 20, 1938, 248 large cod were tagged at station 1 on Sable Island Bank (Fig. 3). Of the 21 recaptures, 10 were during the "summers", all outside the tagging region at an average distance of 48 miles, while 11 were during the "winters", all except one outside the tagging region at an average distance of 71 miles. Figure 28 shows that 9

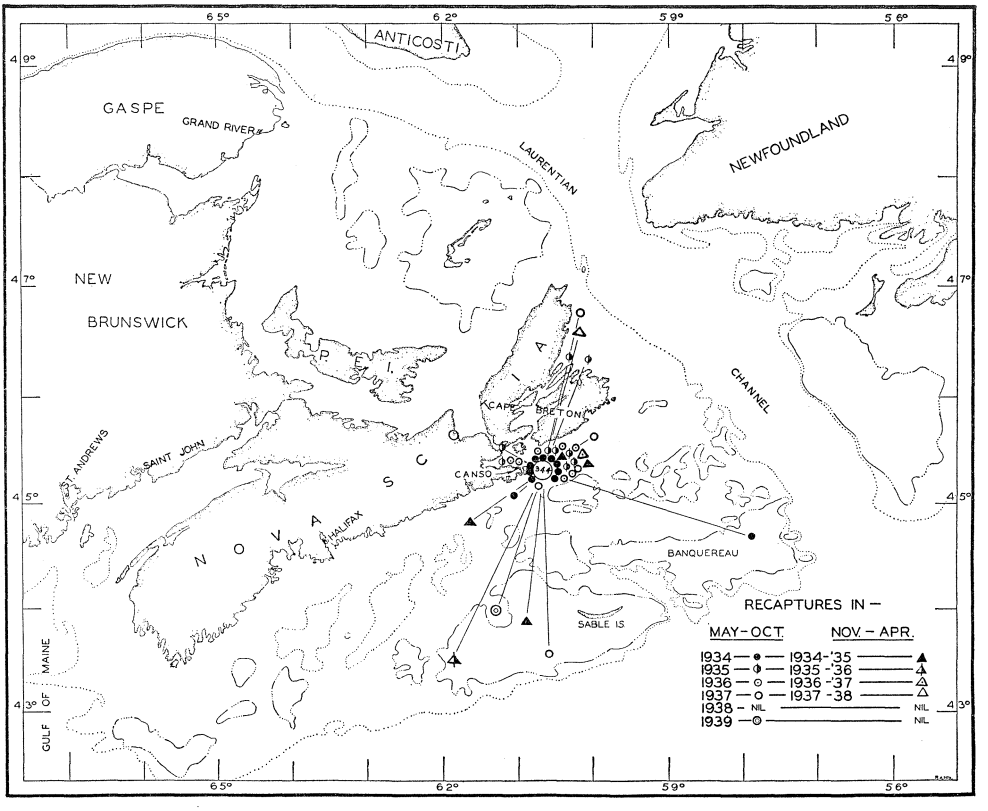

Fig. 25.—Recaptures of cod tagged off Canso, July 31, 1934.

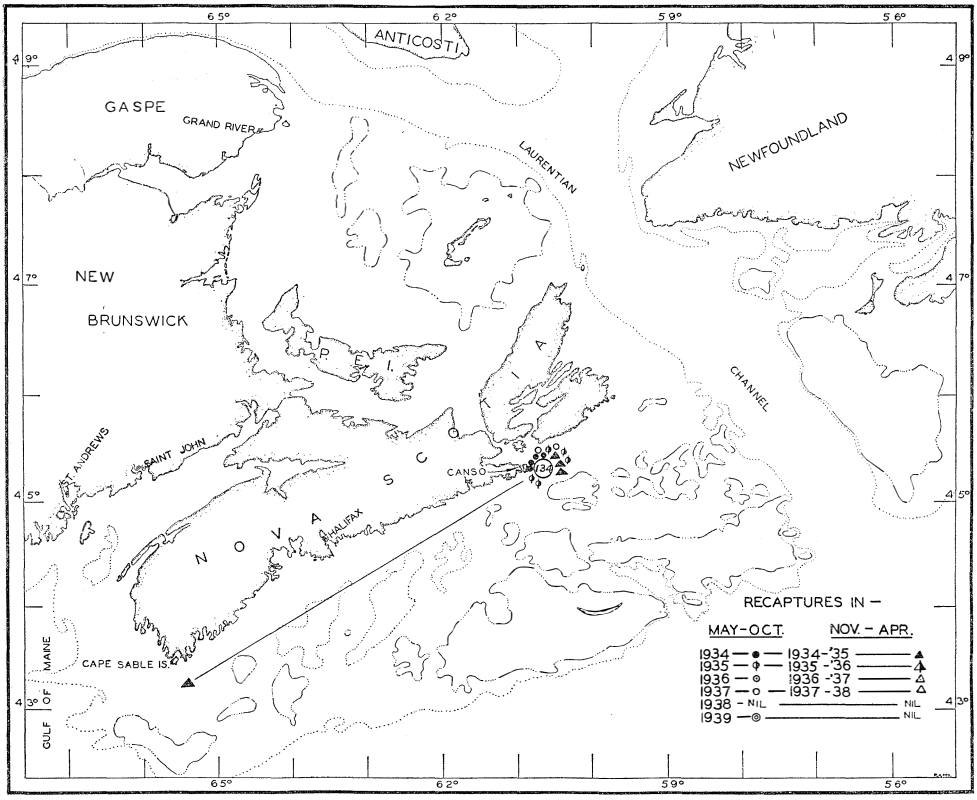

FIG. 26.—Recaptures of cod tagged off Canso, August 1, 1934.

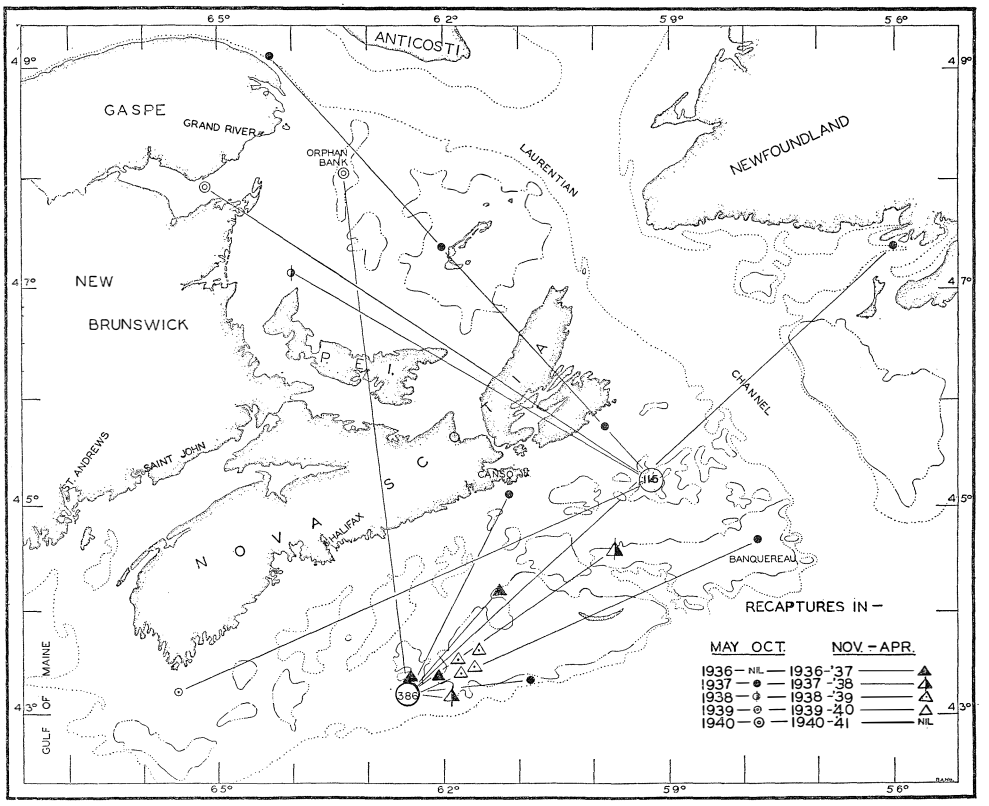

FIG. 27.—Recaptures of cod tagged March 5-26, 1937, in the Emerald Bank region and March 1-2, 1937, on Misaine Bank.

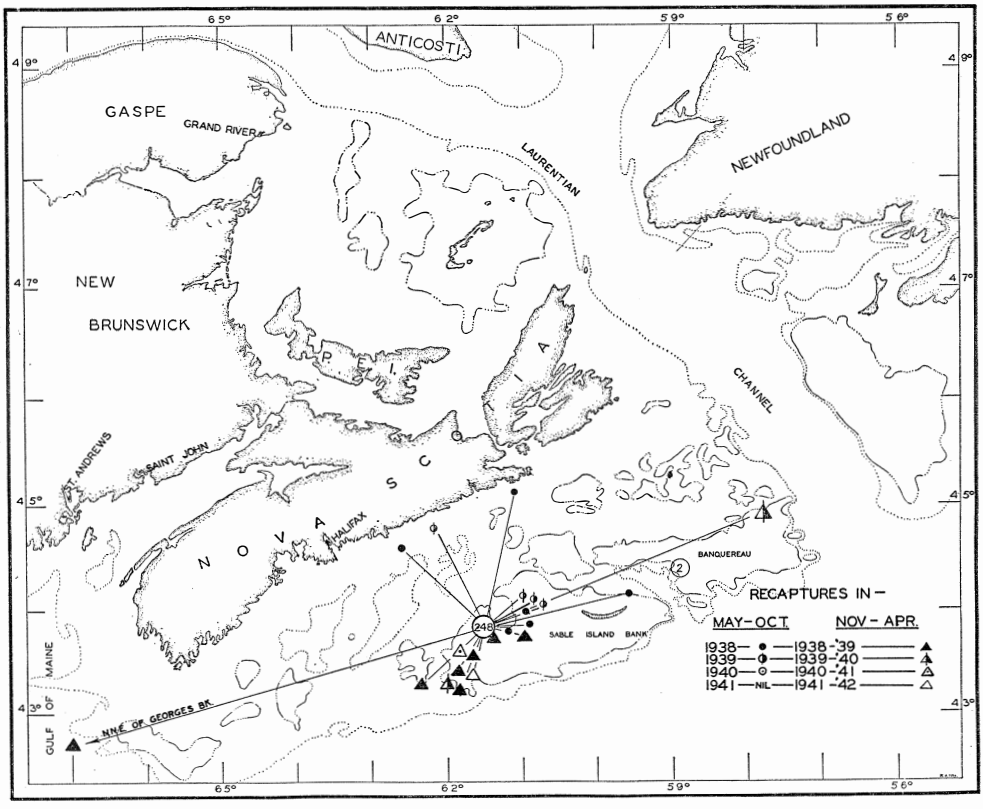

FIG. 28.—Recaptures of cod tagged on western Sable Island Bank, April 20, 1938.

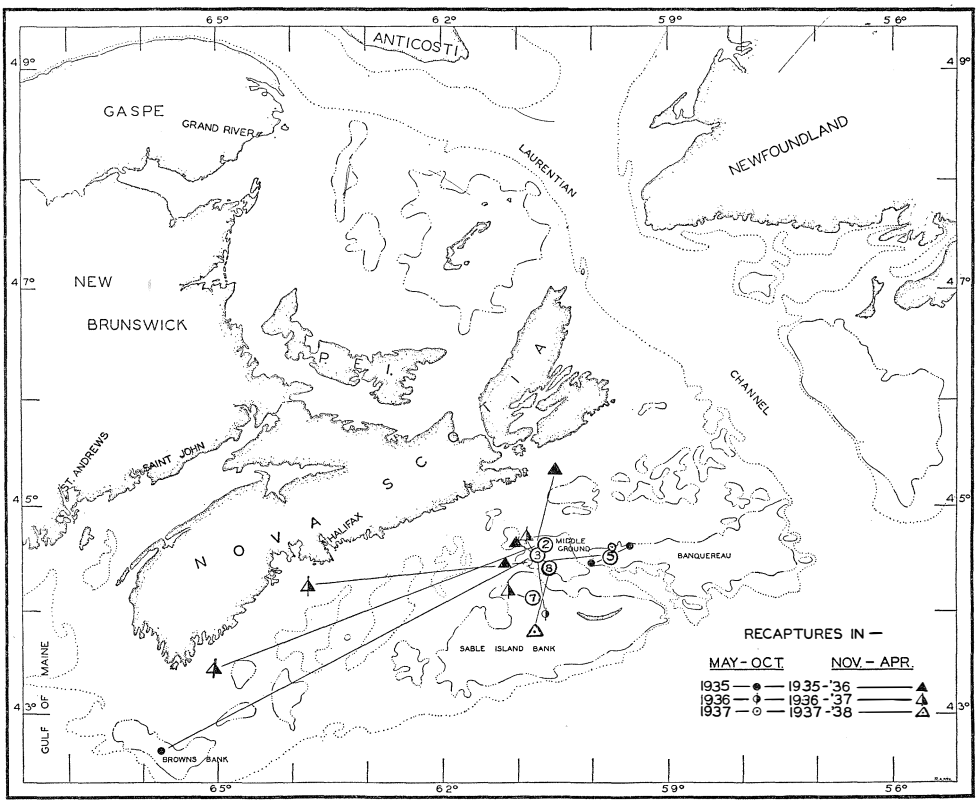

FIG. 29.—Recaptures of cod tagged north and northwest of Sable Island May 13 and June 15-29, 1935.

66183—4

of the "winter" recaptures were on the western end of Sable Island Bank, one on eastern Banquereau and one on northeast Georges Bank. Seven of the 10 "summer" recaptures were on the eastern half of Sable Island Bank and 3 inshore along eastern Nova Scotia. Fifteen of the 21 recaptures were made during the months of March, April and May.

North and Northwest of Sable Island, 1935. Table II and Fig. 3 show the offshore taggings in 1935 just north and northwest of Sable Island on Sable Island Bank, Middle Ground and the western end of Banquereau. At 8 stations 6 cod were tagged May 13 and 288 June 15-29, all but 22 at stations 3, 4, 5 and 8. Figure 29 shows that most of the 13 recaptures were made in the general tagging district north or west of Sable Island while three were taken inshore and one on Browns Bank. None was recaught in the Bay of Fundy, the Gulf of St. Lawrence or off Newfoundland.

North of Sable Island, 1937. On May 30, 253 cod were tagged at station 32 just north of Sable Island (Fig. 3) and 18 were recaptured, all but one outside the tagging region. During the "summers" 11 were recaptured, all outside the tagging region at an average distance of about 58 miles; during the "winters" 7 were recaptured, 6 outside the tagging region at an average distance of 78 miles and one inside. Figure 30 shows that most of the recaptures were made between the tagging position and the eastern Nova Scotian shore at Liscomb and Country Harbour —14 of the 18 being taken in this district. One of the others was taken south of Sable Island and the other 3 inshore at the east and west extremities of Nova Scotia. "Summer" and "winter" recaptures were made both inshore and offshore.

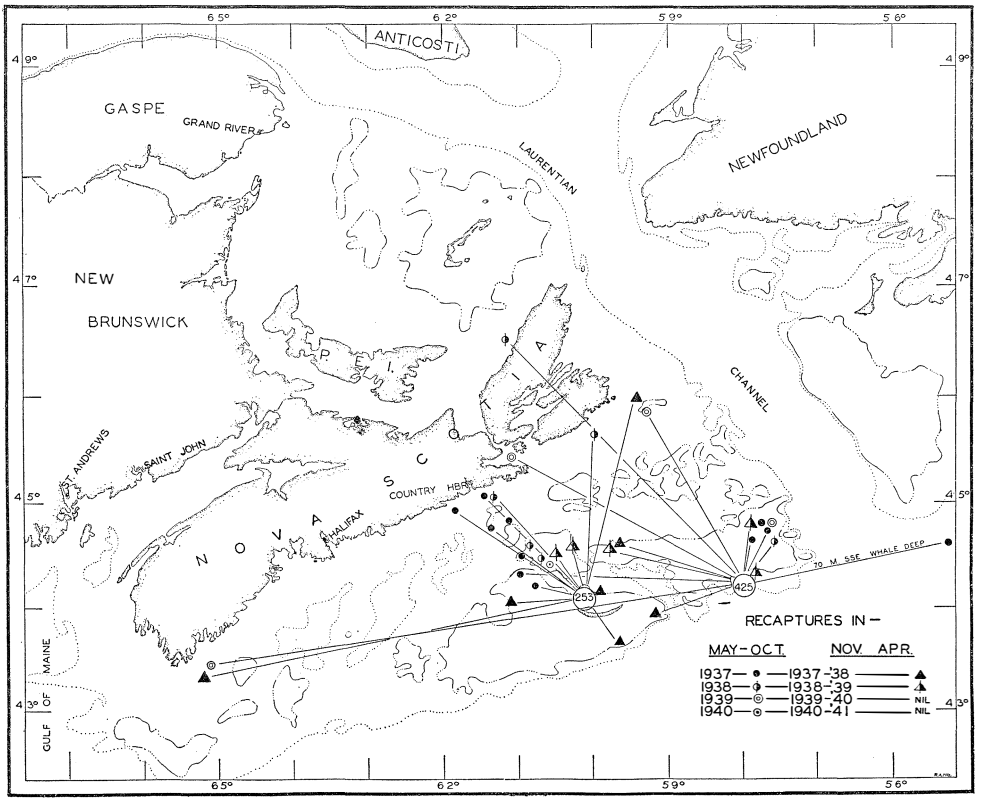

Fig. 30.—Recaptures of cod tagged at station 32 north of Sable Island, May 30, 1937, and on southern Banquereau, May 4 and 5, 1937.

South and East of Sable Island, 1937. From March 28 to April 6 inclusive, 975 cod were tagged at stations 18 to 22 (Fig. 3) along the edge of the bank south and east of Sable Island. Of the 46 recaptures 16 were within the tagging regions and 30 outside at various distances up to 425 miles, half of them being 100 miles or farther away. During the "summers" only one recapture was inside the tagging regions while the other 13 were outside at an average distance of 205 miles; during "winters", 15 recaptures were inside and 17 outside at an average distance of about 95 miles. In Fig. 31 it is shown that, with exception of one inshore just west of Halifax and one off eastern Cape Breton, all 32 "winter" recaptures were made on the eastern offshore banks—Misaine, Banquereau, Sable Island and Emerald. During the "summers" 6 were taken on banks off Nova Scotia, 2 on the Newfoundland Banks, 2 inshore off Newfoundland and Cape Breton and 4 in the northwestern part of the Gulf of St. Lawrence off Gaspé. None was retaken in the Bay of Fundy, on the western offshore banks, in the southwestern part of the Gulf of St. Lawrence or on the Newfoundland side of the Gulf.

Western Banquereau, 1936. On Apr. 23 and 26, 499 cod were tagged on the western part of Banquereau, 422 at station 1 and 77 at station 2 shown in Fig. 3. Of the 19 recaptures only one was from the latter. Seventeen were away from the tagging region, only one winter recapture being close to where the fish was tagged. Figure 32 shows that only 2 of the "summer" recaptures were offshore; the other 6 were along shore from Halifax eastward around Cape Breton to the eastern end of Prince Edward Island. During the "winter" seasons all 11 recaptures were offshore except one off Canso in November and one off Ingonish in April—the earliest and latest months of the "winter" season. No recaptures were made west of Halifax, in the central or northern part of the Gulf of St. Lawrence or off Newfoundland.

On Apr. 24, 1938, 4 were tagged at station 2 (Fig. 3) but there were no recoveries.

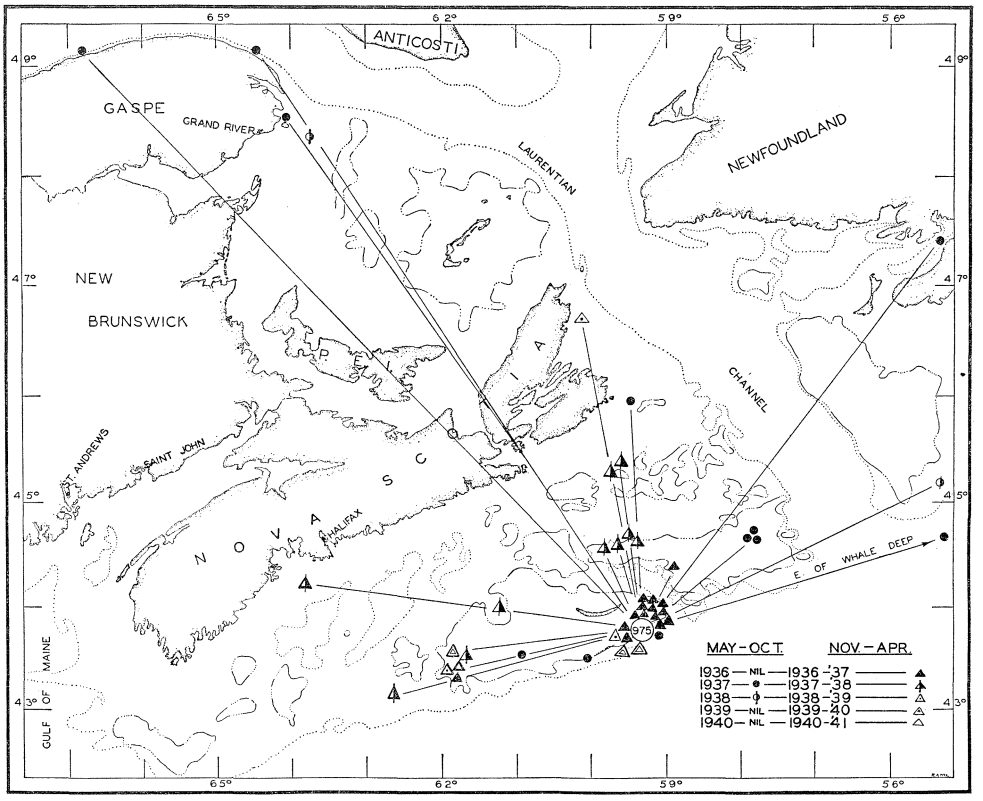

Fig. 31.—Recaptures of cod tagged south and east of Sable Island Bank, March 28-April 6, 1937.

66183—4½

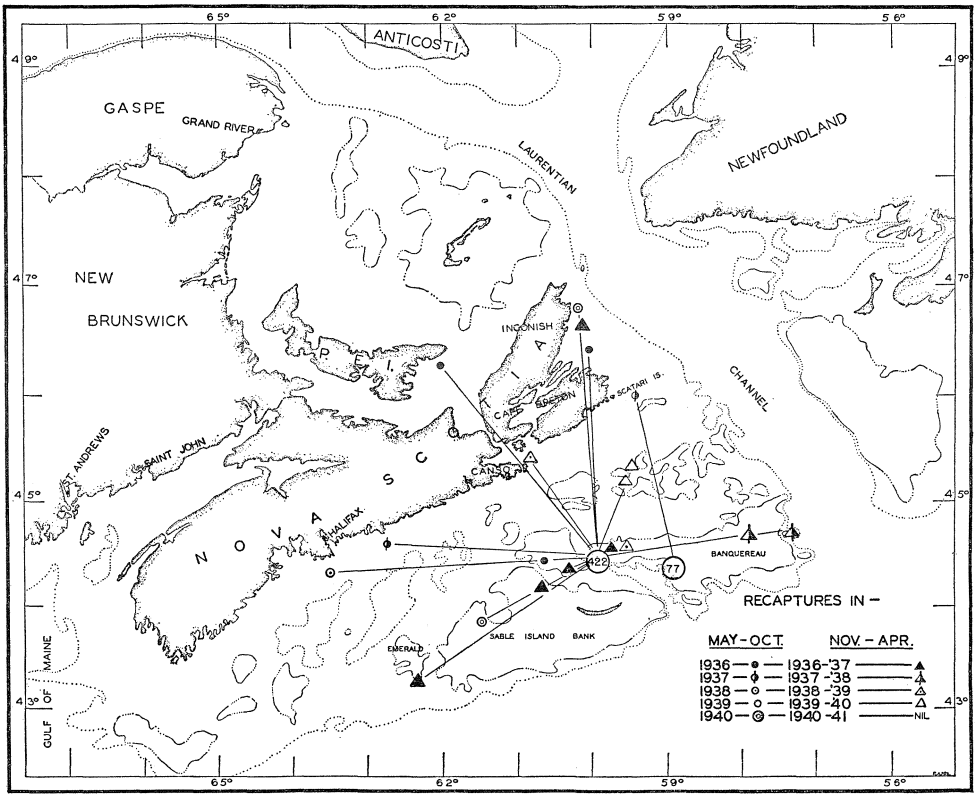

FIG. 32.—Recaptures of cod tagged on western Banquereau, April 23 and 26, 1936.

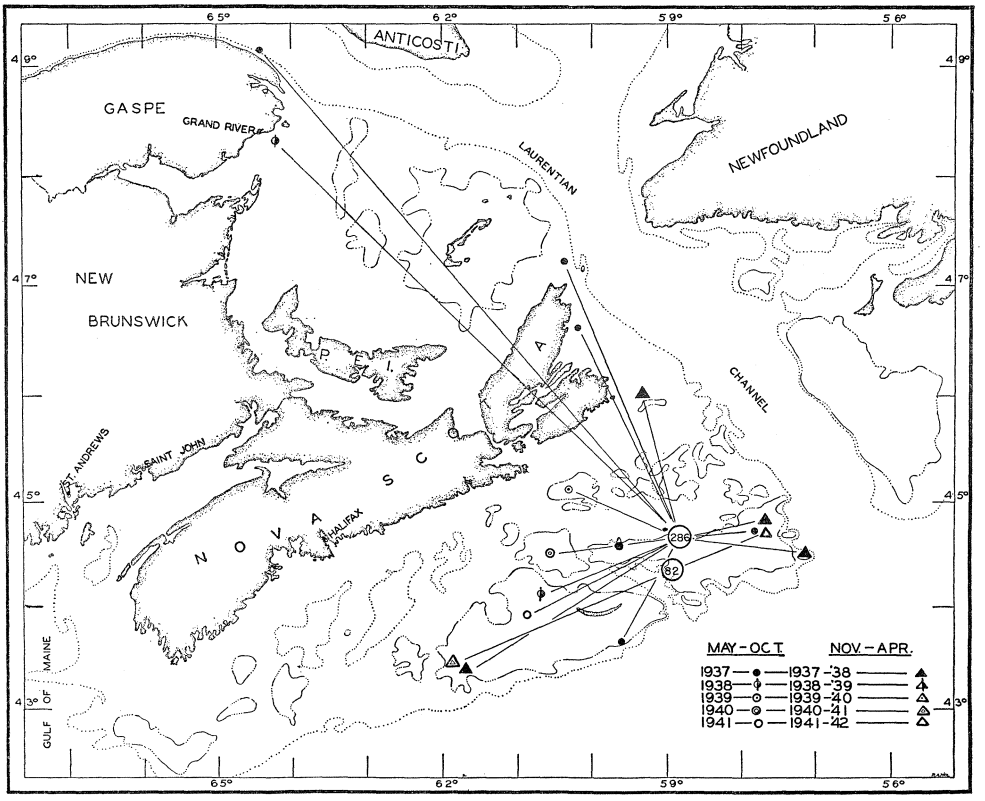

FIG. 33.—Recaptures of cod tagged on Banquereau, April 18, 1937 (286), and April 30 and May 3, 1937 (82).

MISAINE BANK, 1937. On Mar. 1, 115 cod were tagged on Misaine Bank about 50 miles off the south coast of Cape Breton, 53 at statinn 1 and 62 at station 2 (Fig. 3). The 6 recaptures (1 from station 1 and 5 from station 2) were all made during the "summers" and outside the tagging region—one 40 miles and the others from 175 to 325 miles away. Figure 27 (B) shows the positions of the recaptures, 2 inshore (1 at each end of Nova Scotia) and 4 well into the western Gulf of St. Lawrence; none was offshore, near the tagging regions, in the Bay of Fundy or off Newfoundland. At station 3 (Fig. 3), south of Misaine Bank on the northern edge of Banquereau, 41 cod were tagged on March 2, 1937, but none recaptured.

CENTRAL BANQUEREAU, 1937. On Apr. 18, 286 cod were tagged at station 23 (Fig. 3) about mid-way along the northern edge of Banquereau. Fifteen recoveries were made during the next 5 years, all outside the tagging region, 5 over 100 miles and one 350 miles away. Most (11) were taken during the "summers", at an average distance of 130 miles, only 4 being taken during the "winters", at an average distance of 78 miles. Figure 33A shows that 3 of the "winter" recaptures were on the eastern offshore banks and one off southeastern Cape Breton, and that the "summer" recaptures were over a wider area—7 on the eastern offshore banks, 2 off Cape Breton and 2 off Gaspe. No recaptures were made in the Bay of Fundy or the western offshore banks, inshore off the Nova Scotian mainland or anywhere off Newfoundland.

On Apr. 30 and May 3, 9 and 73 cod were tagged at stations 26 and 27 respectively (Fig. 3). None of the former was recaptured and only 2 of the latter. One of these recaptures was made in early February, 1938, and the other in early April, 1941 (Fig. 33), both on the eastern offshore banks and during the "winters".

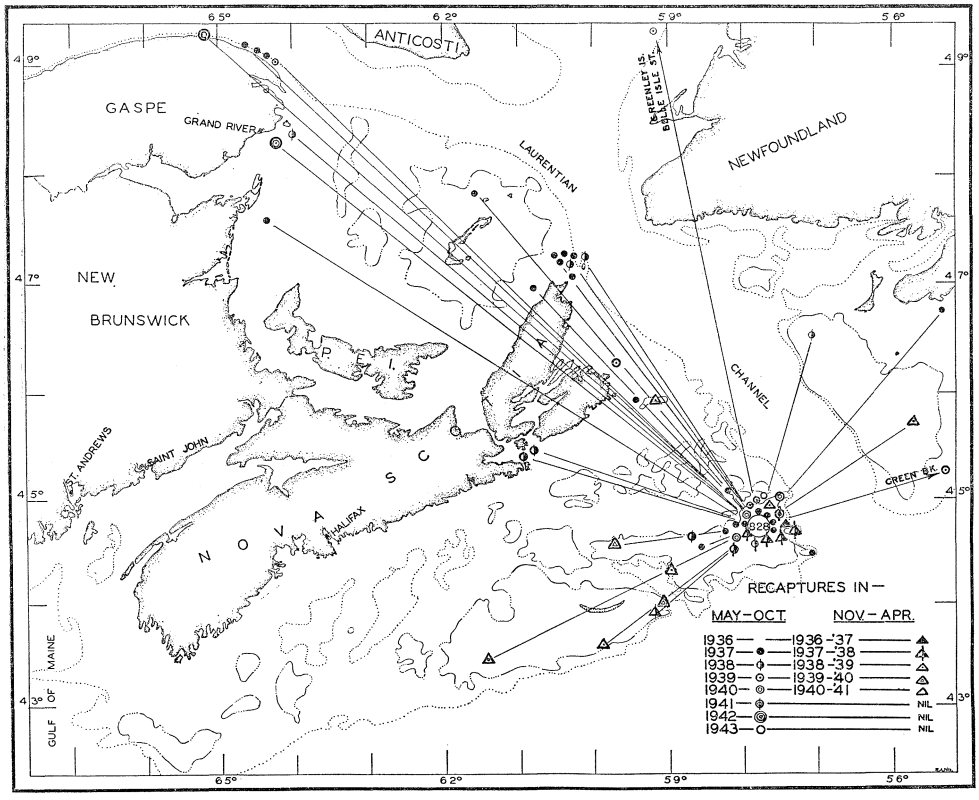

FIG. 34.—Recaptures of cod tagged on eastern Banquereau, April 19 and 20, 1937.

SOUTHERN BANQUEREAU, 1937. At stations 28 and 29 (Fig. 3) on the southern edge of Banquereau, 150 and 275 respectively were tagged on May 4 and 5. Nine of the former and 7 of the latter were recaught during the 3 years following tagging, 15 being taken outside the tagging region. During the "summers" 11 were recaptured, all outside the tagging region and at an average distance of 117 miles from the point of tagging; during the "winters" one was recaptured within the tagging region and 4 "outside" at an average distance of 55 miles. Figure 30 shows that the 5 "winter" recaptures were all offshore on eastern Sable Island Bank and Banquereau. Six of the "summer" recaptures were on these banks but one was on the Grand Banks and 4 in Nova Scotia inshore waters from Cape Sable eastward to the northwest shore of Cape Breton. None was in the Bay of Fundy, on the western offshore banks or far into the Gulf of St. Lawrence.

EASTERN BANQUEREAU, 1937. At stations 24 and 25 (Fig. 3), on what is known as the "Eastern Shoal Water" of Banquereau, 434 and 394 cod were tagged on April 19 and 20, 1937, respectively. Of the 58 recaptures (26 from the former and 32 from the latter) 41 were outside the tagging regions and only 17 within. Of the 45 recaptures in the "summers", 32 were outside the tagging regions at an average distance of 216 miles from station 24 and 155 miles fron station 25; of the 13 in the "winters" 9 were outside the tagging regions but at average distances of only 89 miles from station 24 and 86 miles from station 25. The positions of the recaptures are shown in Fig. 34, no distinction being made between the two groups because there is little difference in the recapture patterns. No recaptures were in the Bay of Fundy, the outer Nova Scotian mainland inshore waters or the western offshore banks. In fact only 4 were as far westward as Sable Island Bank, the remainder of the offshore recaptures being on Banquereau or

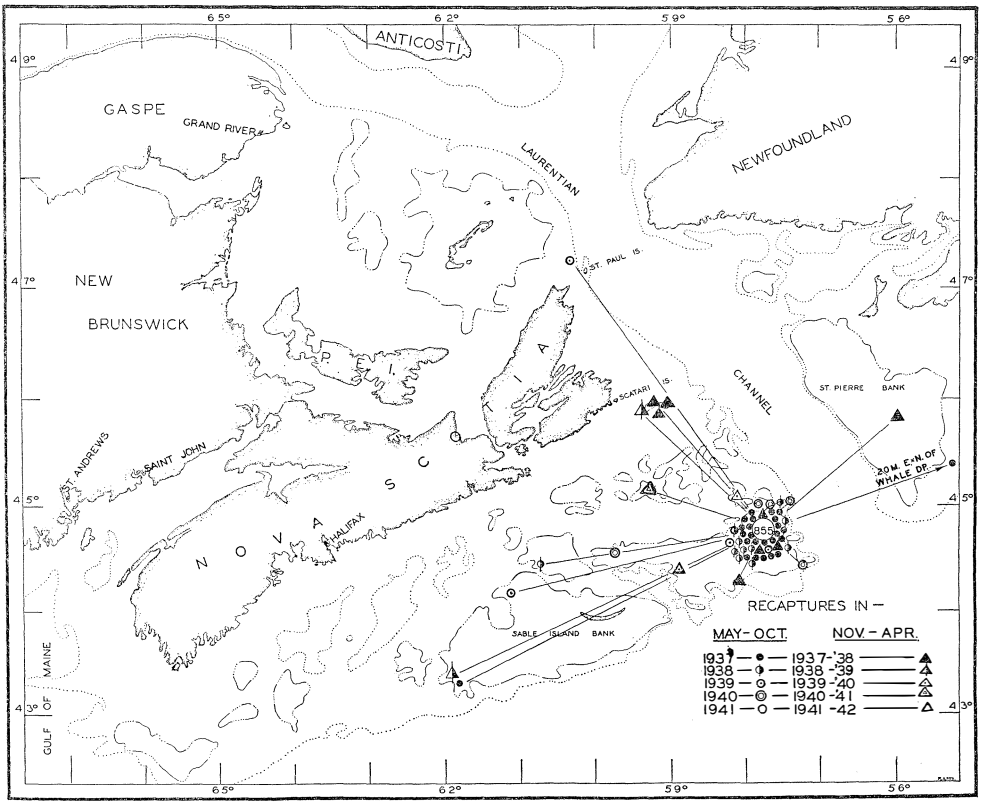

FIG. 35.—Recaptures of cod tagged on the northeastern edge of Banquereau, May 28 and 29, 1937.

still farther east on St. Pierre and Green Banks. All the recaptures on western Banquereau and Sable Island Bank were in the "winters" while those on eastern Banquereau and the Newfoundland Banks were divided between "summer" and "winter", about 75% being in late April, May and early June. More recaptures during the "summers" were made off Cape Breton, especially the northern part, and in the Gaspé region of the northwestern Gulf of St. Lawrence; one was in Belle Isle Strait. No recaptures were made in the Gulf during the winter.

At stations 30 and 31 (Fig. 3), on the extreme northeastern edge of Banquereau, 686 and 169 were tagged on May 28 and 29 respectively. Forty-seven of the former and 11 of the latter were recovered. Thirty-five of the station 30 and all (11) of the station 31 recaptures were in the "summers". Figure 35 shows all the recaptures. All those outside the tagging regions, except one in the "summer" of 1940 on the extreme southeast corner of Banquereau, originated from tagging at station 30. Ten recaptures were made at a distance during the "winters" compared to 7 in the "summers", but their distribution was quite similar, showing a spread to the Newfoundland offshore banks, the Nova Scotian eastern offshore banks and inshore waters off eastern Cape Breton. No recaptures were inshore to the west or in the Bay of Fundy, nor were any in the Gulf of St. Lawrence.

Cape Breton and the Gulf of St. Lawrence

Glace Bay, 1927. The 62 recaptures of 2,198 cod tagged off Blace Gay, Cape Breton Island, in July and August 1927, are shown in Fig. 36 and 37. In the "summer" most of the recaptures were along the Cape Breton coast while during the "winters" most were on the eastern

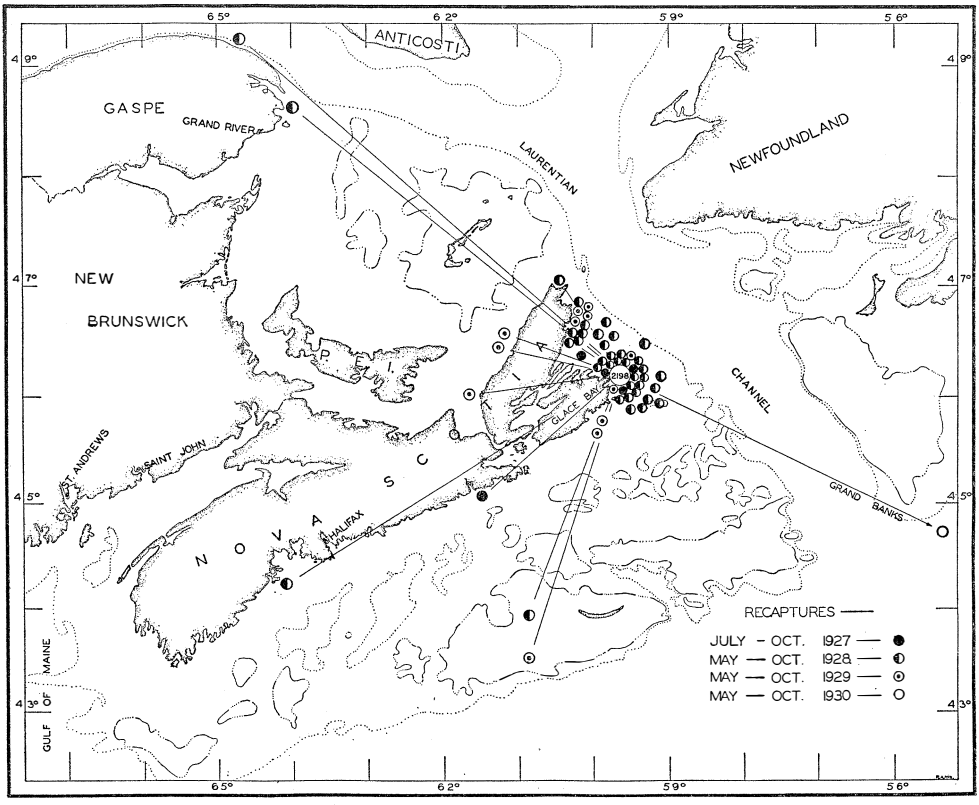

Fig. 36.—Recaptures during "summers" of 1927-1930 of cod tagged off Glace Bay, N.S., July and August, 1927.

offshore banks. A more detailed analysis in an earlier paper (McKenzie, 1934a) indicates that most of these fish left the inshore waters of eastern Cape Breton in November before fishing ceased, sojourned on the offshore banks during the winter and returned inshore by May.

INGONISH, 1935. On June 10, 49 cod were tagged from a mackerel trap off Ingonish in northern Cape Breton, where they had been caught in 25 m. (14 fath.) of water at 0.4°C. (Fig. 2, Table I). Three were recaptured, all northward along shore towards or in the Gulf of St. Lawrence. One of them was taken at the mouth of Chaleur Bay on July 12, 1943, a little over 8 years after tagging and 200 miles away (Fig. 4).

CHETICAMP, N.S., 1937. From July 21 to 26, 795 cod were tagged in 31 to 67 m. (17 to 37 fath.) of water and temperatures of 0.2°C. to 4.0°C., one to 4 miles off Cheticamp Island, Cape Breton (Table II, Fig. 2). A total of 68 were recaptured, half within the tagging regions and half outside. During the "summers" 43 were recaptured, the majority (31) inside the tagging region; during the "winters" 25 were recaptured, 22 outside the tagging region. Those taken outside the tagging locations, both "summer" and "winter", were at an average distance of 104 miles.

Figure 38 shows the 43 "summer" recaptures. By far the greatest number were taken in the Cheticamp region. Those outside the Gulf were caught early or late in the "summer" (on Banquereau in October, in Chedabucto Bay in May and off Scatari in May and October); those in the Gulf were caught in July, August or September (south of the Magdalen Islands in July and off Gaspé in July, August and September).

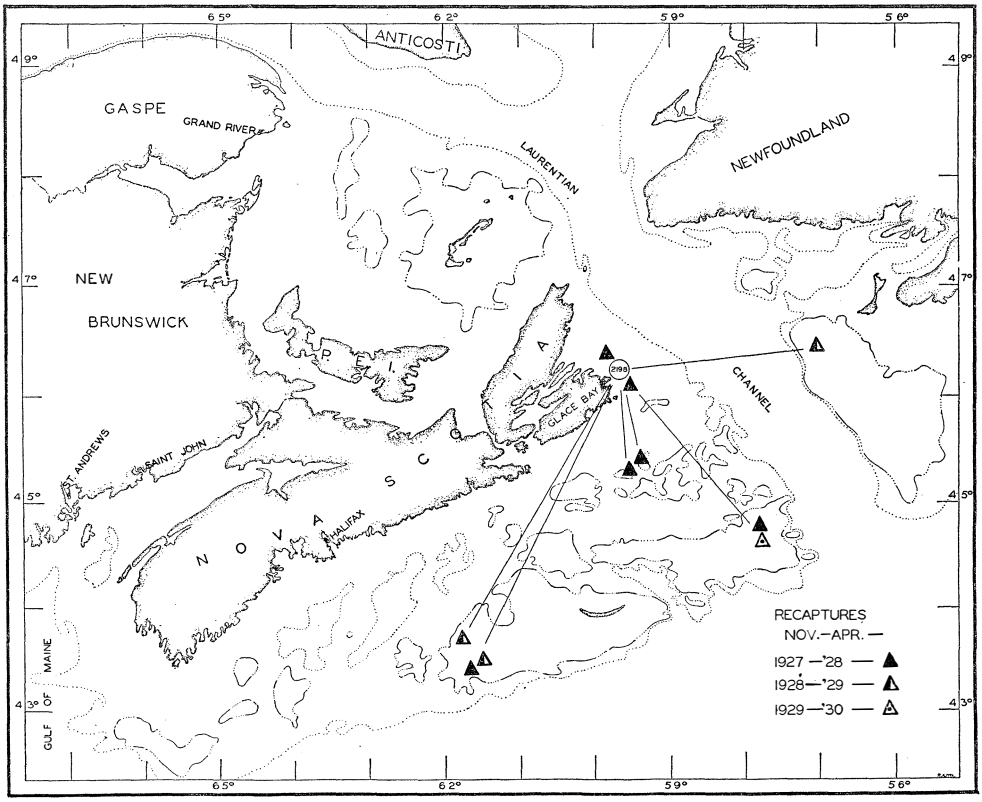

FIG. 37.—Recaptures during "winters" of 1927-1928 to 1929-1930 of cod tagged off Glace Bay, N.S., July and August, 1927.

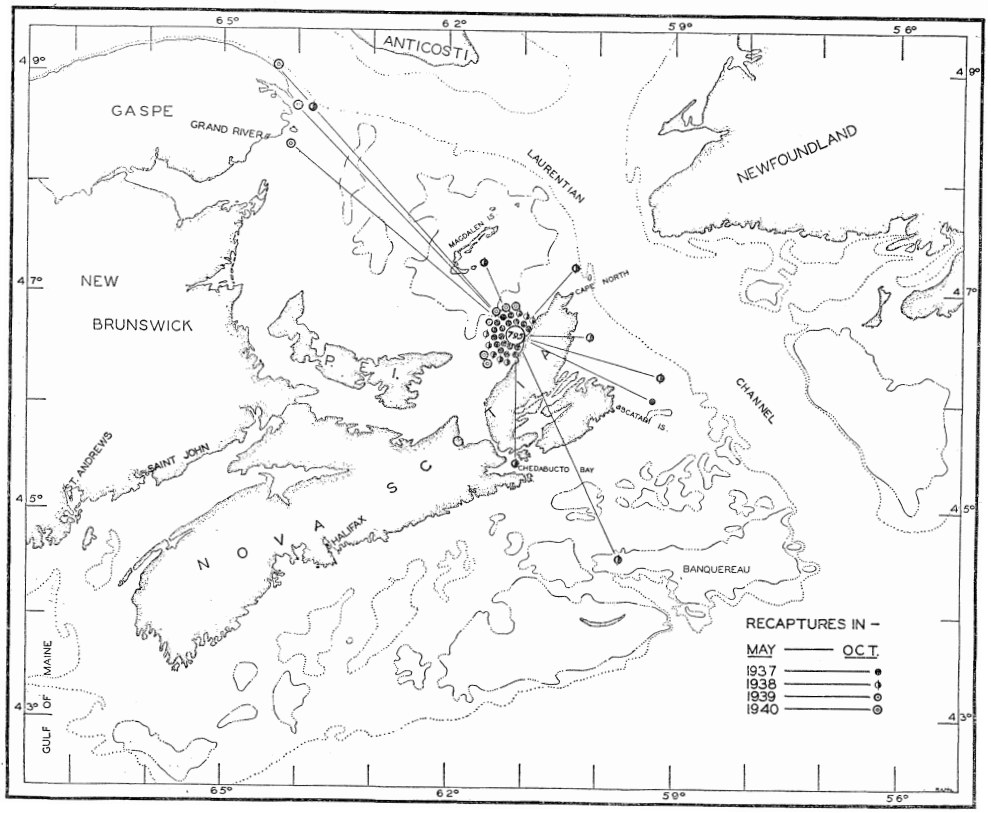

FIG. 38.—Recaptures during the "summers" of 1937 to 1940 of cod tagged off Cheticamp, N.S., July, 1937.

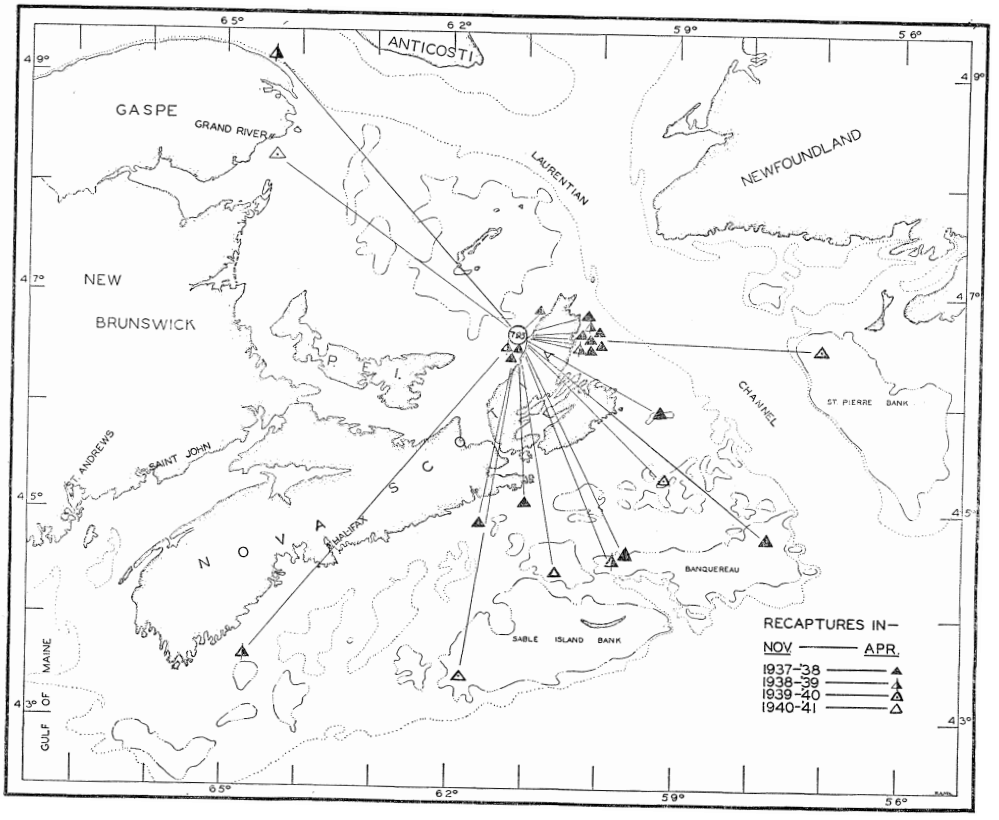

FIG. 39.—Recaptures during the "winters" of 1937 to 1941 of cod tagged off Cheticamp, N.S., July, 1937.

The "winter" recaptures are plotted in Fig. 39 and, with the exception of one taken on St. Pierre Bank in December, 1939, and one off southwestern Nova Scotia in April, 1939, they were made in much the same areas as those during the "summer" periods. The two off Gaspé were taken in November, 1938 and 1939. Comparatively few were recaught during the "winter" off the northwest coast of Cape Breton, a much higher proportion being taken outside the Gulf than in the "summer".

NAUFRAGE, P.E.I., 1940. On Aug. 24, 141 cod caught on line trawl were tagged in 45 m. 7 miles off Naufrage, P.E.I. (Table II, Fig. 2). Six were recaptured outside the tagging region—5 during the "summers" at an average distance of 93 miles and one in November, 1940, at a distance of 30 miles. The single recapture inside the tagging region was in September, 1940. Figure 40 shows that four of the recaptures were off eastern Prince Edward Island, two off Gaspé and one off eastern Cape Breton.

ELLERSLIE, P.E.I., 1930 TO 1936. From 1930 to 1936, 312 cod were tagged off Ellerslie, P.E.I. (McKenzie, 1934a) in the southwestern Gulf of St. Lawrence during the months of July to November. A total of 12 were retaken—7 within the tagging region and 5 outside. Figure 41 shows that only one was recaptured at a great distance (across the Laurentian Channel in the Fortune Bay region of the Newfoundland south coast) and that this was the only recapture made outside the Gulf.

ALBERTON, P.E.I., 1939. From July 8 to 17, 696 cod caught by handlining were tagged off Alberton, P.E.I., from depths of 18 to 42 m. (10 to 23 fath.) of water and bottom temperatures of

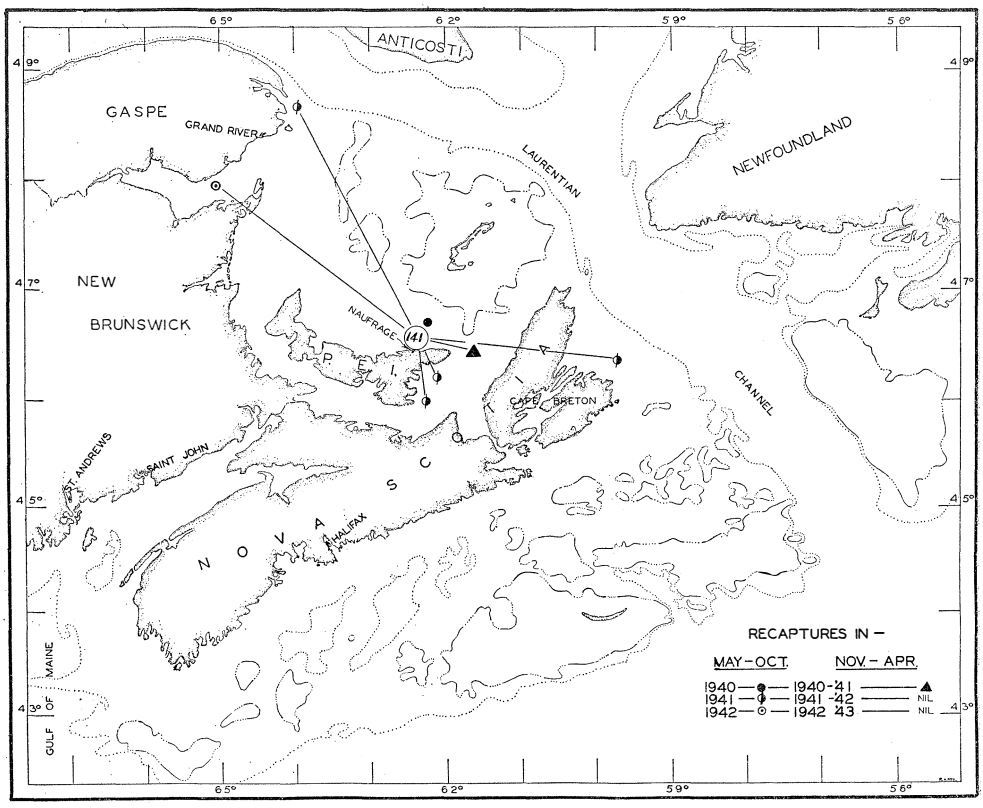

FIG. 40.—Recaptures of cod tagged off Naufrage, P.E.I., in August, 1940.

1.8°C. to 2.2°C. (Table II, Fig. 2). Of the 44 recaptures the 4 made in "winter" were all outside the tagging region at an average distance of 121 miles, and 27 of the 40 "summer" recaptures were also outside the tagging regions at an average distance of 101 miles. Figure 42 indicates that 13 recaptures were off Alberton, one in western Northumberland Strait, 19 northwards to the north side of Gaspe, 2 off the Magdalen Islands, 2 off eastern Prince Edward Island, 6 off northern Cape Breton and one on Banquereau, in June 1941. The "winter" recaptures were all in November and December.

BRADELLE BANK AREA, 1936. On Aug. 6 and 7, 261 were tagged at stations 2 and 3 (Fig. 2) on Bradelle Bank. Ten were recaptured, all outside the tagging regions at an average distance of 72 miles. Figure 43 shows the 9 "summer" recaptures in the southwestern Gulf and the single "winter" recapture outside the Gulf on St. Pierre Bank.

On Aug. 5 and 8, 155 cod were tagged at stations 1 and 4 (Fig. 2) west of Bradelle Bank. Figure 44 shows the positions and times of the 17 recaptures. Sixteen were taken during the "summers", outside and one inside the tagging region, but all within the southwestern Gulf of St. Lawrence. The lone "winter" recapture was on western Banquereau, 250 miles away, in January.

GASPÉ REGION, 1938 AND 1939. Dr. J.-L. Tremblay, Director at that time of the St.-Lawrence Biological Station at Grand River, tagged 2,979 cod in the Gaspé–Anticosti region in 1938 and 1939. From mid-July to mid-September, 1938, 1,032 were tagged off Cape Gaspé, Grand River and Miscou Island; from June to September, 1939, 1,947 were tagged around Gaspé and the west end of ANTICOSTI ISLAND.

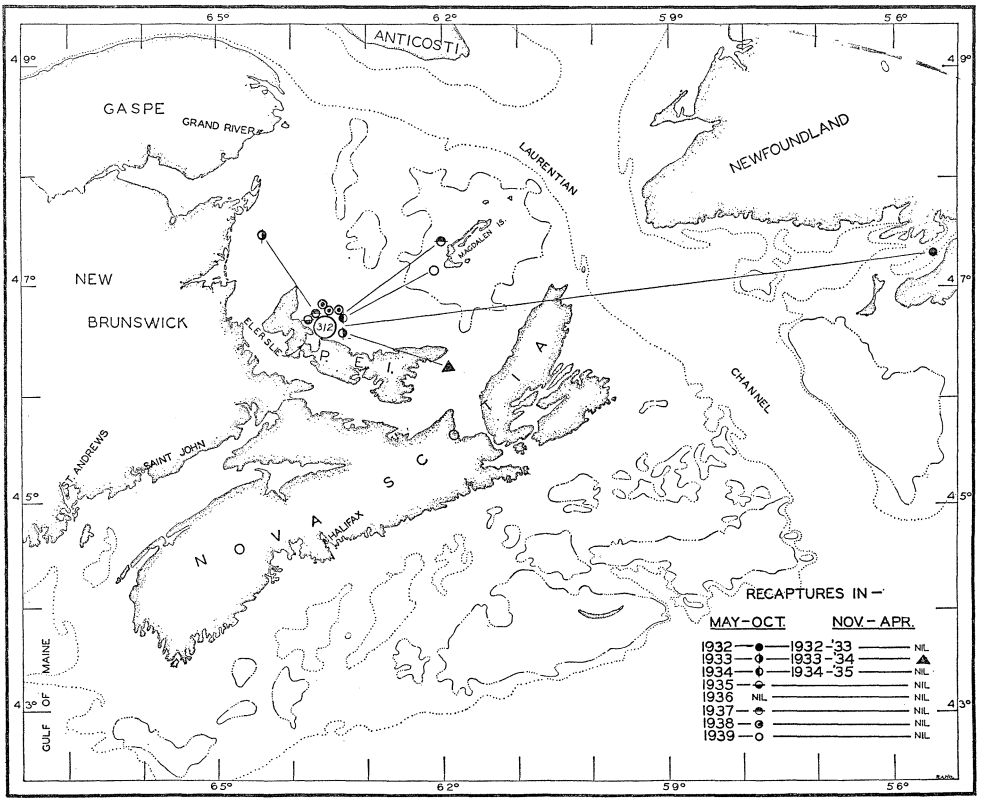

FIG. 41.—Recaptures of cod tagged off Ellerslie, P.E.I., 1930 to 1936.

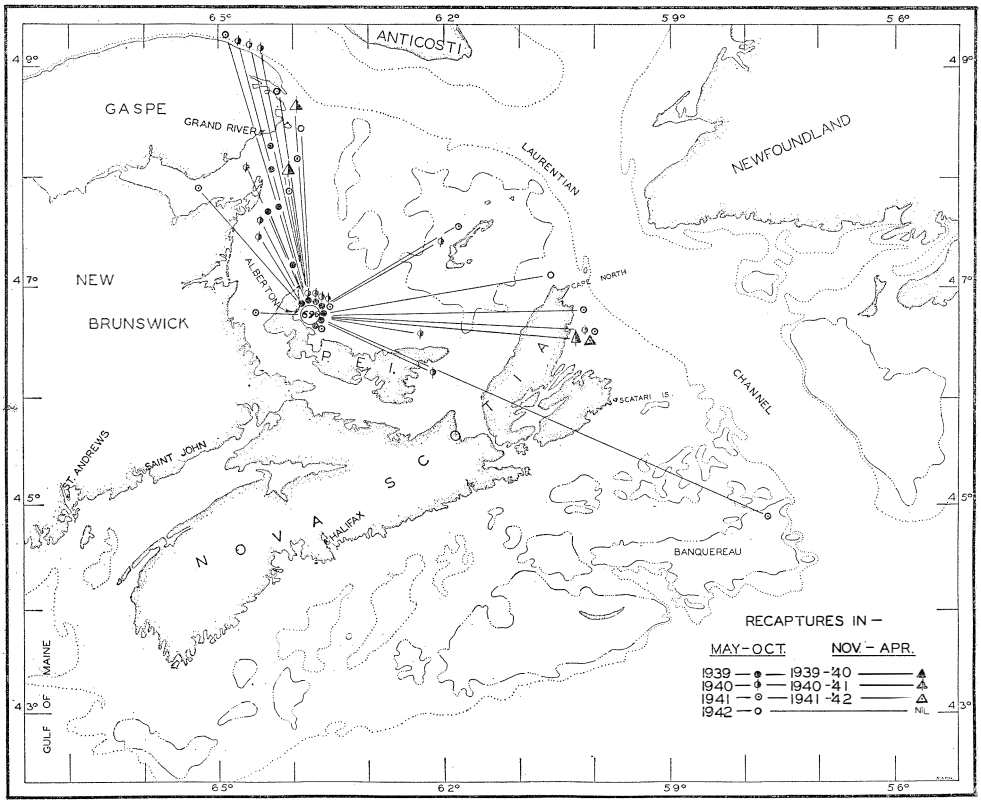

FIG. 42.—Recaptures of cod tagged off Alberton, P.E.I., in July, 1939.

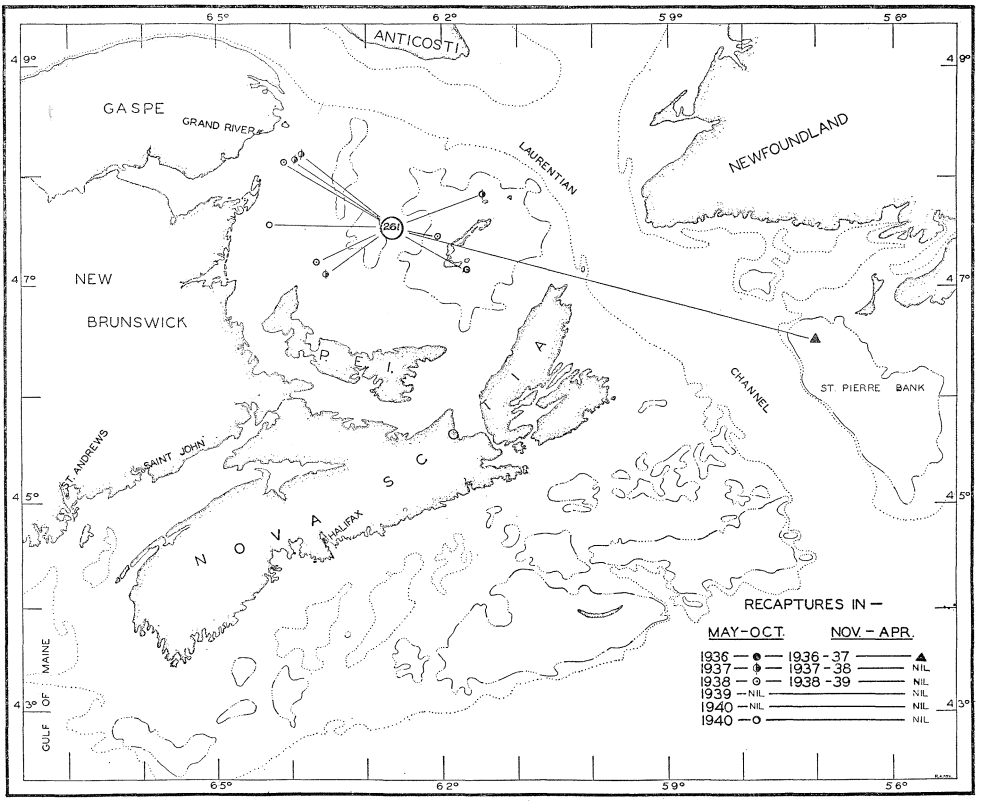

FIG. 43.—Recaptures of cod tagged, August 6 and 7, 1936, on the eastern edge of Bradelle Bank.

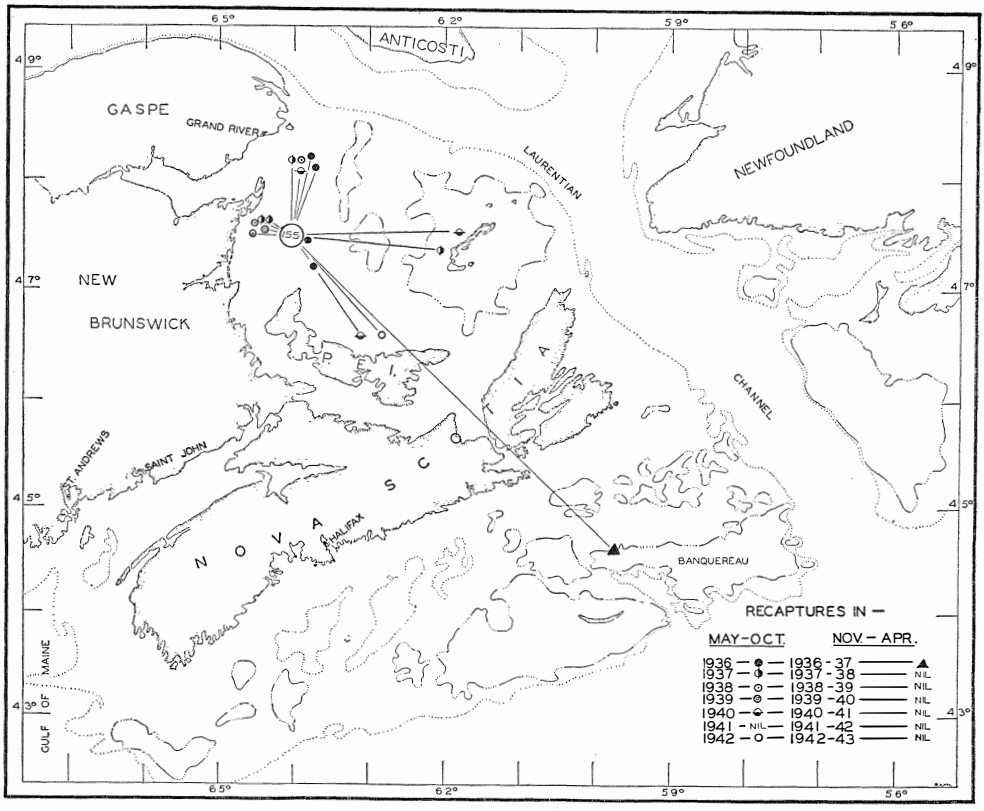

FIG. 44.—Recaptures of cod tagged August 5 and 8, 1936, off North Point, P.E.I., and west of Bradelle Bank.

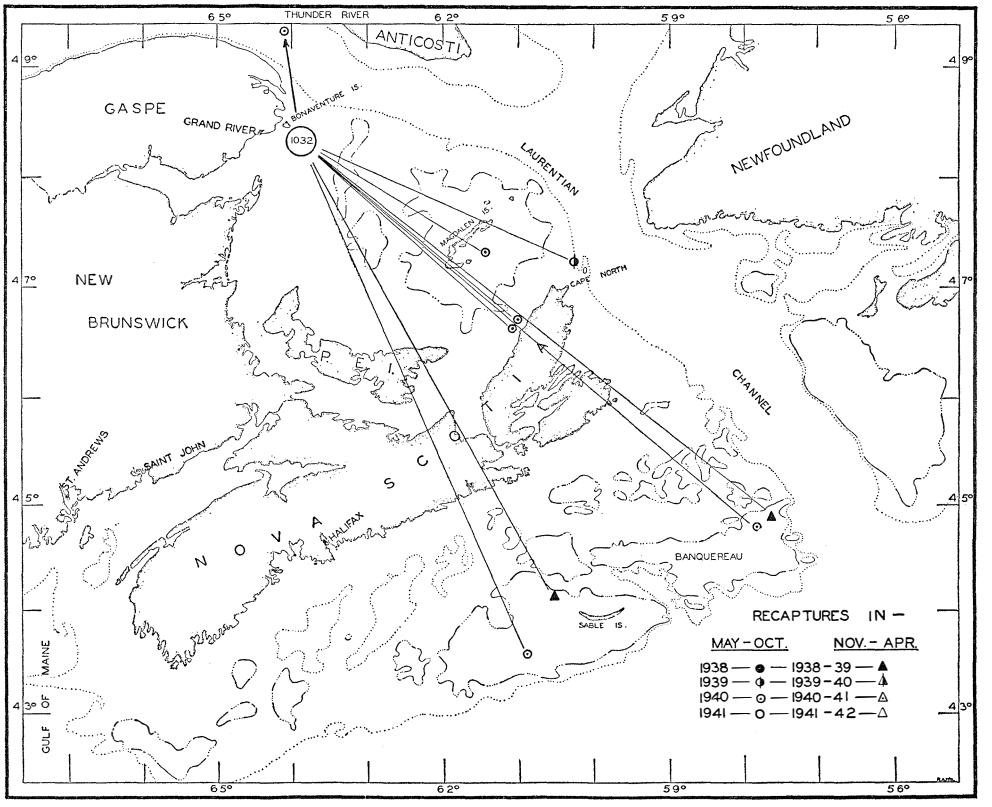

FIG. 45.—Distant recaptures of cod tagged off eastern Gaspé and the Bay of Chaleur in the summer of 1938 by Dr. J.-L. Tremblay.

Of the 231 recaptures from the 1938 taggings only 9 were over 100 miles away, 7 during the "summers" and 2 in the "winters" (in April and December). Figure 45 shows the 9 distant recaptures—one north of the west end of Anticosti, 4 between the Magdalen Islands and Cape Breton and 4 on the banks off eastern Nova Scotia outside the Gulf of St. Lawrence.

Of the 354 recaptures from the 1939 taggings only 18 were over 100 miles away, 6 during the "summers" (only 2 outside the Gulf) and 12 during the "winters" (all outside the Gulf). Figure 46 shows that 14 of these distant recaptures were outside the Gulf of St. Lawrence—8 on the east coast of Cape Breton, 4 on banks off eastern Nova Scotia and 2 near Port-aux-Basques, Newfoundland.

Over 95% of the returns came from close to the tagging areas.

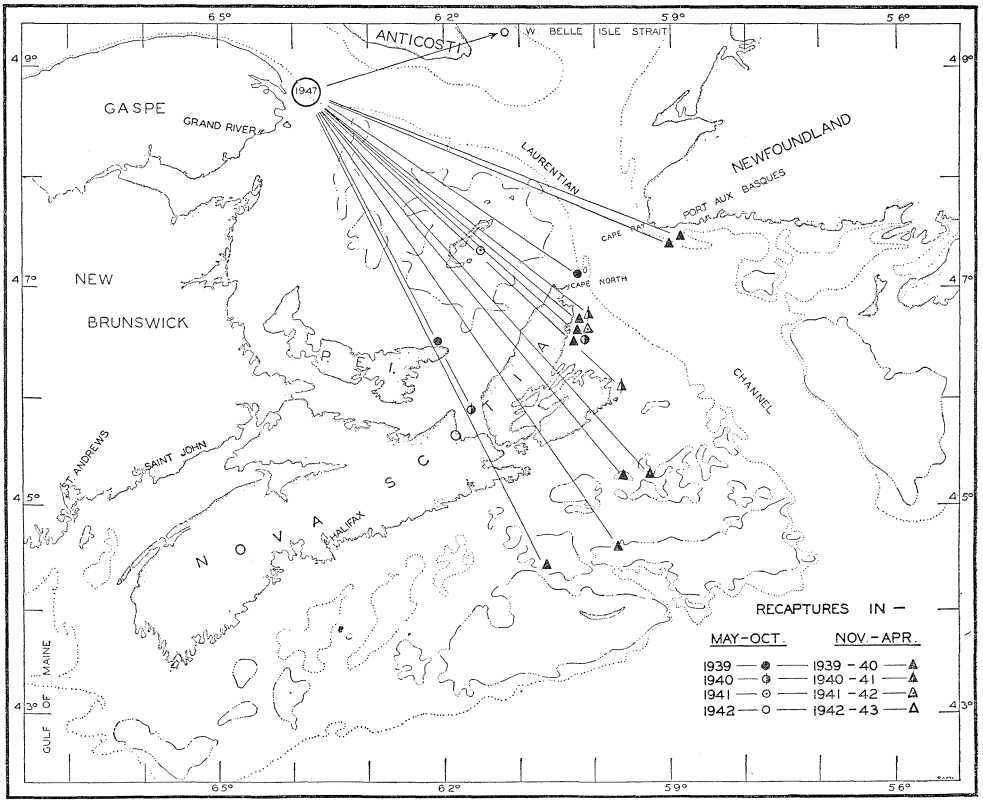

FIG. 46.—Distant recaptures of cod tagged in the Bay of Chaleur, around Gaspé and off the western part of Anticosti Island in the summer of 1939 by Dr. J.-L. Tremblay.

SUMMARY OF RECAPTURES

The results of the taggings in the years 1934 to 1939 are summarized in Table III, which gives for each tagging the number of cod tagged, the numbers recaptured in each 12-month period following the tagging, the total number and proportion recaptured and the number of recaptures outside the tagging region, and the proportion which these constituted of the total recaptures.

PROPORTIONS RECAPTURED. Table III shows a total of 1,174 returns from 10,625 tagged cod or about 11% recaptured. The proportions recaptured differ widely between regions. Of the cod tagged in the Bay of Fundy and the inshore waters of the Nova Scotia mainland, 27% were recaptured, the proportion apparently being greatest in the central part of the outer coast of Nova Scotia. The autumn-spawning stock of Halifax Harbour is an exception with the low proportion of 3% from the rather small sample tagged. A much smaller proportion (5.4%) of the cod tagged on the banks off Nova Scotia were recaptured than of the cod tagged inshore in Nova Scotia. The proportion was similarly low (6.7%) in the Gulf of St. Lawrence.

A number of explanations are possible for these variations in the proportions caught, among which may be mentioned variations in the conditions for tagging and consequently in the mortality it causes, and variations in the effectiveness of measures to encourage the return of tags. The data do, however, suggest that the almost year-round fishery in the relatively stationary stocks along the outer coast of Nova Scotia caught, in the years studied, a higher proportion of the cod present than did either the offshore fishery or that of the southwestern Gulf of St. Lawrence. This has some support from the somewhat faster decline in the number of recaptures from year to year after tagging in the former area than in the two latter. In this connection it is interesting to note that 585 or 20% of the 2,979 cod tagged by Dr. J.-L. Tremblay in the Gaspé region were recaptured, perhaps again a result of an intensive fishery in a stock which is mainly resident.

PROPORTIONS TAKEN OUTSIDE TAGGING REGIONS. The "distant" returns listed in the last two columns of Table III are those outside the "tagging region", as defined earlier in this paper, i.e., more than 12 miles from the place of tagging. Even with this rather narrow definition it will be seen that most of the returns from taggings about the mainland of Nova Scotia were "within the tagging region", although this was not usually true of the returns from offshore taggings or those in the Gulf of St. Lawrence. Reference to Fig. 4 to 46 for details of the recaptures shows, however, that many of the recaptures which were "outside the tagging region" and thus "distant" in Table III came from the same topographical area and do not indicate long movements. In some instances (e.g., the earlier taggings at Shelburne, N.S.) very small proportions of the recaptures indicate movement to a great distance. Similarly, over 95% of the recaptures of the cod tagged in the Gaspé region were within 100 miles of the places where the

TABLE III.—Proportions of cod tagged 1934 to 1939 recaptured in successive 12-month periods after tagging

Tagging	Number tagged	Numbers recaptured in year								Total recaptures		Distant recaptures	
		1st	2nd	3rd	4th	5th	6th	7th	9th	No.	%	No.	%
St. Andrews, N.B., 1938	13	1	.....	.....	.....	.....	.....	.....	.....	1	8	1	100
St. Mary Bay, N.S., 1939	83	12	3	.....	.....	.....	.....	.....	.....	15	18	7	47
Halifax–Lunenburg, N.S., 1936	102	27	5	.....	.....	.....	.....	.....	.....	32	31	8	25
Halifax, N.S., 1934	688	143	54	9	4	.....	.....	.....	.....	210	31	42	20
Halifax, N.S., 1935	152	27	7	1	.....	1	.....	.....	.....	36	24	19	53
Egg Island, N.S., 1934	488	99	10	7	2	.....	.....	.....	.....	118	24	42	36
Jeddore Rock, N.S., 1934	807	194	44	9	5	3	.....	.....	.....	255	32	40	16
Canso, N.S., July 31, 1934	344	20	11	6	2	1	.....	.....	.....	40	12	16	40
Canso, N.S., August 1, 1934	134	11	2	2	.....	.....	.....	.....	.....	15	11	1	7
Sub-total	2,811	534	136	34	13	5	.....	.....	.....	722	27	176	24
Autumn spawners, Halifax, 1934-36	159	4	1	.....	.....	.....	.....	.....	.....	5	3	2	40
Emerald Bank, 1937	386	7	3	3	1	.....	.....	.....	.....	14	4	12	86
Western Sable Island Bank, 1938	248	13	6	1	1	.....	.....	.....	.....	21	8	20	95
N. and NW. of Sable Island, 1935	294	6	5	2	.....	.....	.....	.....	.....	13	4	7	54
N. of Sable Island, 1937	253	11	6	.....	1	.....	.....	.....	.....	18	7	17	95
S. and E. of Sable Island, 1937	975	36	5	2	3	.....	.....	.....	.....	46	5	30	65
Western Banquereau, 1936	499	8	4	3	2	2	.....	.....	.....	19	4	18	95
Misaine Bank, 1937	115	3	1	1	1	.....	.....	.....	.....	6	5	6	100
North Central Banquereau, 1937	286	9	3	1	1	1	.....	.....	.....	15	5	15	100
South Central Banquereau, 1937	82	1	.....	.....	1	.....	.....	.....	.....	2	2	2	100
Southern Banquereau, 1937	425	7	5	4	.....	.....	.....	.....	.....	16	4	15	94
Eastern Banquereau, 1937	828	28	15	7	5	1	1	1	.....	58	7	41	71
Northeastern Banquereau, 1937	855	33	13	5	7	.....	.....	.....	.....	58	7	19	33
Sub-total	5,246	162	66	29	23	4	1	1	.....	286	5·4	202	71

Ingonish, N.S., 1935	49	2	.....	.....	.....	.....	.....	.....	1	3	6	2	67
Cheticamp, N.S., 1937	795	36	18	7	7	.....	.....	.....	.....	68	9	34	50
Naufrage, P.E.I., 1940	141	5	1	1	.....	.....	.....	.....	.....	7	5	6	86
Ellerslie, P.E.I., 1930-36	312	5	5	2	.....	.....	.....	.....	.....	12	4	5	42
Alberton, P.E.I., 1939	696	17	16	9	2	.....	.....	.....	.....	44	6	31	71
Eastern Bradelle Bank, 1936	261	2	7	.....	.....	1	.....	.....	.....	10	4	10	100
W. of Bradelle Bank, 1936	155	9	2	1	4	.....	1	.....	.....	17	11	16	94
Sub-total	2,409	76	49	20	13	1	1	.....	1	161	6·7	104	65
Total	10,625	776	252	83	49	10	2	1	1	1,174	11	484	41

tagging was done. The taggings thus indicate a tendency of most cod to stay in the same area, in spite of the long distances travelled by some. There is a tendency to notice in the figures those which have moved great distances more than those recaptured close to where they were tagged.

That there is some tendency for the cod tagged at one place to spread over a greater area as the years go by is shown by the increasing percentages of recaptures outside the tagging regions (Table IV) and by reference to the details of the more distant recaptures in Fig. 4 to 46. These details do, however, show the strong tendency for the pattern of distribution of returns from each tagging to recur year after year. There is, in other words, some stability in the patterns of movement rather than a high degree of random movement over great distances.

TABLE IV.—Percentages of recaptures outside the tagging regions in successive 12-month periods after tagging

——	1st	2nd	3rd	4th
Bay of Fundy and inshore waters of Nova Scotia.....	20	30	41	38
Banks off eastern Nova Scotia.....	65	77	86	65
Cape Breton and Gulf of St. Lawrence.....	57	68	75	77

THE COMMERCIAL FISHERY

Recaptures of tagged fish depend on fishing operations. The numbers of recaptures vary according to the number of tagged fish present and the amount of fishing effort expended.

Information is not available on the fishing effort in all parts of the area under consideration here. The catches, however, do indicate variations in fishing effort as well as in abundance of fish. As background for the interpretation of the recaptures of tagged cod the 1939 cod landings are therefore presented in Table V according to 10 sub-divisions and 4-month periods.

TABLE V.—Cod landings on the Canadian Atlantic coast, 1939 (thousands of pounds)

Districts	Jan.-Apr.	May-Aug.	Sep.-Dec.	Totals	Percentage
Bay of Fundy (to Cape Sable)	939	4,916	1,292	7,147	
Southwestern Nova Scotia (to St. Margaret Bay)	2,785	7,328	3,802	13,915	14
Eastern Nova Scotia (to Canso)	621	5,110	2,480	8,211	11
Cape Breton (S. and E. coasts)	505	3,307	4,914	8,726	
Southwest Gulf of St. Lawrence (to North Point, P.E.I.)	0	11,401	3,660	15,061	36
Northwest Gulf of St. Lawrence	0	25,258	11,581	36,839	
Offshore grounds of western Gulf of St. Lawrence	0	1,052	2,711	3,663	
Banks off eastern Nova Scotia	13,429	6,678	6,841	26,948	
St. Pierre Bank	76	3,919	5,098	9,093	17
Grand Bank	0	16,559	7,965	24,524	22
Total	18,355	85,529	50,242	154,127	100
Percentage of total	12	55	33		

The Bay of Fundy and inshore waters of the outer Nova Scotian coast, including the south and east coasts of Cape Breton, yielded 25% of the total landings. These were not produced uniformly throughout the year, for 13% were made during January to April, 54% during May to August and 33% during September to December. Weather during the winter limits the operations of the small boat fleet that produces these landings and is probably mainly responsible for the smallness of the catches.

The western Gulf of St. Lawrence contributed 36% to the total landings but none at all during January to April. Ice dominates the picture at this time of year, covering the harbours in the Gulf for long periods. Even Sydney and Louisburg are blocked in the late winter. Fishing is very intense during May to August and two-thirds of the Gulf catch is made at that time. Only half as much is landed from September to December and here again bad weather is largely responsible as most of the Gulf fishing fleet consists of small boats.

Seventeen percent of the catch was contributed by the banks off eastern Nova Scotia. Unlike any other district, half was caught during January to April, the remainder being equally divided between the other two periods. St. Pierre and Grand Banks yielded 22% of the total landings, practically none during January to April and almost two-thirds from May to August. Vessels other than Canadian also made substantial catches on these offshore grounds.

Thus the May to August period was the most important for the cod fishery as a whole, 55% of the landings being made at this time. Fishing by the inshore boats from the Bay of Fundy to Gaspé reached its peak at this time of year with one exception. This is the east coast of Cape Breton where September to December yielded the greatest landings. May to August was also best for the Grand Banks, but the landings from St. Pierre Bank and the "offshore" waters of the western Gulf reached their yearly maxima in September to December. From January to April the landings were at a low level in all regions except the banks off eastern Nova Scotia. At this period of the year most of the Lunenburg vessels operated in this area instead of on the Grand Banks where they fish in summer. About half the annual landings from this area were made at this time, and they constituted 73% of the January to April landings of the whole coast.

The landings vary enough from district to district and season to season to have great influence in the numbers of recaptures. It is especially important to remember that lack of recaptures in any area at a time when catches are low or absent must not be interpreted to mean that there were no cod or no tagged cod there.

POPULATIONS INDICATED BY RECAPTURES OF TAGGED COD

Inshore Populations from Bay of Fundy to Canso

The single recapture from 13 cod tagged near St. Andrews, N.B. (Fig. 4) was on Georges Bank, suggesting a possible relationship of the cod of the north side of the Bay of Fundy with those of the New England region, but this tagging was so small as to be hardly significant. All the other taggings from the Bay of Fundy to Canso indicate relatively stationary stocks with slight mixing with neighbouring stocks, with the exception of the autumn-spawning cod of the Halifax area as noted below.

The tagging at St. Mary Bay (Fig. 4) indicates that the cod of that area were primarily resident within the outer Bay of Fundy. Recaptures from the substantial tagging at Seal Island (Fig. 5-8) were predominantly local, exhibiting little scattering and limited shorewise movement. Recaptures of the 4,011 cod tagged near Shelburne (Fig. 9-16)— were still more predominantly local at all times of year.

The tagging of 2,988 cod in inshore waters from Halifax to Canso yielded 730 recaptures, 76% of which were within the various tagging regions (Fig. 17-26). The recaptures more than 25 miles away were 83% in the inshore waters of Nova Scotia from Cape Sable to Scatari Island (31% to the westward and 52% to the eastward of the tagging regions), 10% offshore (principally on the banks off eastern Nova Scotia), 4% from the northern Cape Breton coast, 1% from the Gulf of St. Lawrence and 2% from the waters south of Newfoundland. There was a tendency for some cod to move to the banks off eastern Nova Scotia in the winter. In all, 14 cod were retaken in these offshore waters during the three "winter" periods following tagging and only 4 during the "summer" period. The difference seen in Table V between the January—April and May—August landings from the banks off eastern Nova Scotia does not seem to be sufficient in itself to account for this difference between the "summer" and "winter" recaptures in these waters. It is believed, therefore, that there is some movement offshore for the winter and return for the summer.

To summarize, the inshore cod populations from the Bay of Fundy to Canso are largely stationary with slight mixing between neighbouring populations and slight mixing (and apparently seasonal movement) between the Halifax–Canso area and neighbouring offshore banks. It should, however, be pointed out that all of these inshore taggings were in the "summer" months and the rarity of distant returns does not preclude the possibility that cod belonging to more migratory stocks are present during the colder half of the year.

These conclusions accord with the results of an analysis of vertebral counts (McKenzie and Smith, 1955) which showed a cline from low counts off Digby in the west to high off Canso in the east, the cod of any one inshore area in this region being distinguishable on this basis from those of adjacent areas.

Autumn Spawning Population of Central Nova Scotia

Evidence is set forth by McKenzie (1940) indicating that there is a recognizable population of cod which spawns in comparatively warm water during the autumn in certain inlets such as Halifax Harbour and St. Margaret Bay along the outer coast of Nova Scotia. The tagging of 159 cod (caught with gill nets which did not yield a high proportion of fish in condition for tagging) during the autumns of 1934 to 1936 on spawning grounds in Halifax Harbour yielded 5 recoveries, 3 being within the harbour and 2 outside of it (Fig. 4), both considerable distances to the southwest, one off Yarmouth and one in the head of the Bay of Fundy.

The fact that only 3% of these cod were recaptured compared to over 20% from the other inshore taggings in the general Halifax region suggests that these cod were more migratory in nature than the other inshore cod and did not remain at all times of year in regions where the fishing intensity was as great as in the inshore waters off Halifax.

Populations on the Banks off Eastern Nova Scotia

Figures 27 to 35, in which are plotted the results of taggings on the banks off eastern Nova Scotia, show that the recaptures were more scattered than those of cod tagged in inshore waters from Canso west. The higher proportion of the recaptures made outside the tagging regions has already been noted (Table III). In most cases, however, there were more recaptures in the general vicinity of the tagging than anywhere else and this is pronounced in some cases. This accords with the results of an analysis of vertebral counts (McKenzie and Smith, 1955) from which it was concluded that the cod about Sable Island were distinguishable from those of Banquereau. It is evident, then, that the movement is not great or random enough to create a single homogeneous offshore population.

All taggings up to Apr. 26 on offshore banks, even as far west as Emerald Bank (Fig. 27), yielded recaptures in the Gulf of St. Lawrence; those from April 30 on yielded none. Figure 47 summarizes the recaptures from May to October from all taggings in the former category and shows that the movement was mainly towards and into the Gulf of St. Lawrence. Table VI summarizes the recaptures in the Gulf and about Cape Breton from offshore taggings arranged according to time of year. Figures 34 and 35 show the returns from two taggings on eastern Banquereau. The first on Apr. 19 to 20, 1937, had 9 returns from the Gulf of St. Lawrence and 12 from Cape Breton; the second on May 28 to 29, 1937, had no returns from the Gulf and 5 from Cape Breton. These results indicate that as late as April, cod which will summer in the Gulf of St. Lawrence are present on these offshore grounds but that in May they have moved away, leaving a more resident population behind. The movement of cod tagged in the Gulf of St. Lawrence to these offshore grounds is the return phase of the above seasonal migration and is described in a later section.

Recaptures of cod tagged on offshore grounds up to April 26 were 64% on offshore banks, 11% inshore from Canso west, 8% about Cape Breton, 12% in the

TABLE VI.—Recaptures of cod tagged on the banks off eastern Nova Scotia

Place and date of tagging		Reference	Number tagged	Total number of recaptures	Number of recaptures	
					Cape Breton (including NW. coast)	Elsewhere in Gulf of St. Lawrence
Misaine Bank	Mar. 1, 1937	Fig. 27	115	6	1	4
Emerald Bank	Mar. 3-26, 1937	Fig. 27	386	14	0	1
SE. of Sable Island	Mar. 28 to Apr. 6, 1937	Fig. 31	975	46	2	4
Central Banquereau	Apr. 18, 1937	Fig. 33	286	15	3	2
Eastern Banquereau	Apr. 19-20, 1937	Fig. 34	828	59	12	9
Western Banquereau	Apr. 23-26, 1936	Fig. 32	499	19	5	1
Western Sable Island Bank	Apr. 30, 1938	Fig. 28	252	21	0	0
Central Banquereau	Apr. 30 to May 3, 1937	Fig. 33	82	2	0	0
Southern Banquereau	May 4-5, 1937	Fig. 30	425	16	3	0
Eastern Banquereau	May 28-29, 1937	Fig. 35	855	58	5	0
N. of Sable Island	May 30, 1937	Fig. 30	253	18	2	0
N. of Sable Island	June 15-29, 1935	Fig. 29	288	13	1	0

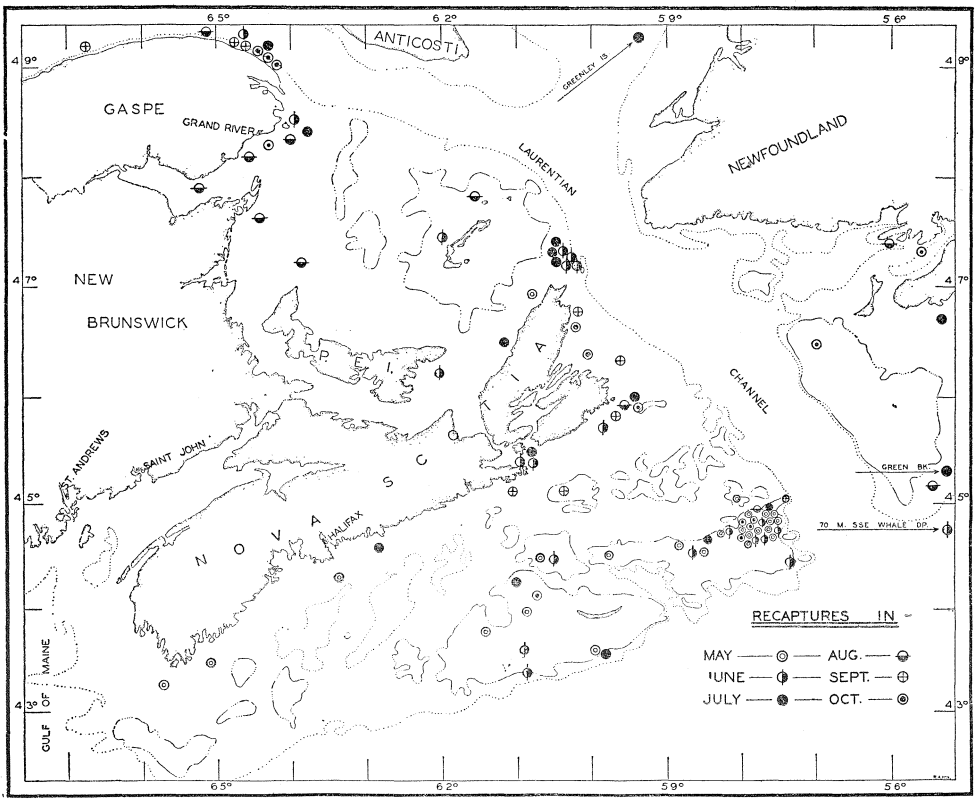

FIG. 47.—The recaptures during "summers" (May to October) from all offshore taggings with any returns from within the Gulf of St. Lawrence, i.e., all taggings earlier than April 30.

western Gulf of St. Lawrence and 5% off Newfoundland. When the recaptures during the "summer" months (May to October) are considered separately (Fig. 47) we find that 57% are outside the banks area, mainly about Cape Breton and in the Gulf, indicating that the movement towards and into the Gulf is quite substantial. Table VII shows the shift in the recaptures from offshore in May to Cape Breton and the Gulf in July, August and September, with a suggestion of a shift back in October. The proportion of the recaptures from these early spring taggings made in the Gulf seems to decrease as the distance from Cape North (at the entrance to the Gulf) increases: from Misaine Bank (115 miles) 4 out of 6; from central Banquereau (150 miles) 2 out of 15; from eastern Banquereau (170 miles) 9 out of 59; from south and east of Sable Island (195 miles) 4 out of 46; from Emerald Bank (240 miles) 1 out of 14. Thus the seasonal movement into the Gulf appears to involve more of the cod on the eastern parts of the offshore grounds than on the western.

The distribution of recaptures within the Gulf (Fig. 47) suggests that the movement from Cape North to Gaspé is along the western edge of the Laurentian Channel. Scarcity of recaptures near Prince Edward Island and

TABLE VII.—Recaptures from offshore tagging prior to April 30 according to district and month of recapture

Month of recapture	Recaptures from	
	Eastern offshore banks	Cape Breton and Gulf of St. Lawrence
May	20	3
June	10	11
July	4	9
August	1	8
September	2	7
October	4	5
	41	43

northern New Brunswick, in spite of much fishing at this season, is combined with the large numbers of returns about Gaspé especially along the Laurentian Channel.

The tagging in eastern Banquereau in late May (Fig. 35) indicates the resident nature of the population left behind by the movement into the Gulf. The recaptures are concentrated on eastern Banquereau and of the 45 "summer" recaptures all but 2 are on the banks off eastern Nova Scotia.

Tagging on offshore grounds west of central Banquereau up to late April yielded few recaptures from Nova Scotian inshore waters, but 27% of the recaptures from taggings in late April, May and June on western Banquereau, Middle Ground and Sable Island Banks were in inshore waters, the other 73% being offshore. The "summer" recaptures from these taggings are plotted in Figure 48. With the exception of one on Browns Bank, all were in the tagging regions or immediately northward in inshore waters off eastern Nova Scotia. Examination of the recaptures month by month indicates that in May all 8 recaptures were offshore but that from June to October the recaptures were about equally divided between offshore and inshore. A summer movement inshore from the grounds about Sable Island is indicated, the counterpart of the movement offshore in the winter noted above in connection with taggings from Halifax to Canso. A summer movement northward mainly across Middle Ground and the shallow areas between it and the shore would account for the reported shift of fishermen in the Egg Island district eastward in early summer to meet fish coming from the east.

To summarize, cod on the banks off eastern Nova Scotia do not constitute one homogeneous population. Mixing between Banquereau and the more western banks is not complete. Cod, which summer in the Gulf of St. Lawrence and about Cape Breton, winter on the banks, moving northward in April to

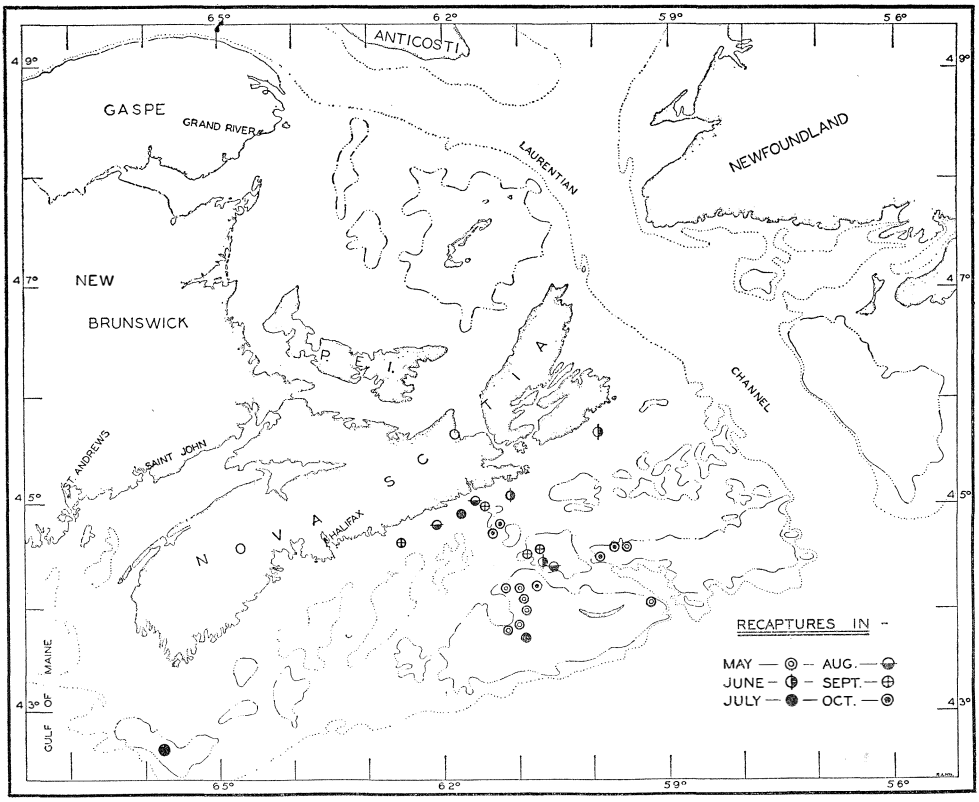

FIG. 48.—Recaptures during "summers" (May to October) from cod tagged north of Sable Island, June 15-29, 1935, and May 30, 1937, and on western Sable Island Bank, April 30, 1938.

leave a more stationary population on the banks. This movement is more important on the eastern than on the western banks but there is a somewhat later movement northward and inshore from the banks about Sable Island.

POPULATIONS ABOUT CAPE BRETON AND IN THE GULF OF ST. LAWRENCE

EASTERN CAPE BRETON. The tagging of 2,198 cod off Glace Bay in July and August, 1927, has indicated (McKenzie, 1934a and Fig. 36 and 37) that the stock summering there left in November before fishing ceased, spent the winter on offshore banks and returned in May to the east coast of Cape Breton. A few were caught in the Gulf of St. Lawrence in the following summers, or south and west along the Nova Scotian coast or on the banks, but most of the summer recaptures were back on the east coast of Cape Breton. This seems, therefore, to have been a relatively discrete migratory stock wintering mainly on the offshore banks and summering mainly on the east coast of Cape Breton.

NORTHWESTERN CAPE BRETON. After 795 cod were tagged off Cheticamp in July, 1937, no recaptures were made outside the Cheticamp area until October, 1937. From then until January, 1938, recaptures were made progressively

farther south of Cape Breton as far as Banquereau. One was retaken off Liscomb, N.S., in February but, in spite of fishing in eastern offshore waters, no more were recaptured until 2 in May inshore off south and east Cape Breton. From then until October, 1938, only one was recaught outside the Gulf of St. Lawrence and this off Ingonish in August. During the succeeding years the same pattern of recaptures was maintained with the addition of a few from Gapsé. A definite movement out of the Gulf appeared to occur each winter with a return each summer, mainly to the Cheticamp area.

Whether or not all these northwest Cape Breton cod left the Gulf in the winter cannot be determined as no fishing takes place there for almost six months. Fishermen believe they follow them northeastward along the coast in the autumn, meet them there in the spring and move back with them, indicating a large-scale movement out and in. Winter recaptures show that many did leave the Gulf. That most of those which did go out returned each summer is shown by the paucity of recaptures outside the Gulf in summer in spite of very intensive summer fisheries, especially along the Nova Scotia coast. There thus appears to be a more or less distinct migratory population summering in the Gulf, mainly in the Cheticamp area, and wintering outside the Gulf.

SOUTHWESTERN GULF OF ST. LAWRENCE. The taggings at Naufrage, Ellerslie, Alberton, Bradelle Bank and North Point (Fig. 40-44) were in a part of the Gulf where few recaptures from offshore tagging were made (Fig. 47). While only 26% of the recaptures from these taggings came from the tagging regions themselves, 89% were in the Gulf all during the summer and only 11% (10 fish) outside the Gulf. Unlike the cod tagged at Cheticamp and recaptured outside the Gulf only from late autumn to early spring, these were recaptured outside the Gulf during various months of the year (January—1, May—1, June—3, July—2, November—1 and December—2), half during the summer, and at quite widely separated places from Fortune Bay, Newfoundland, to western Banquereau in June. They represent scattering rather than a concerted seasonal migration. The cod of this Prince Edward Island–Miscou region of the Gulf of St. Lawrence may thus be considered mainly resident in this region although not as restricted in movement as, for example, the inshore fish at Halifax. Many of them moved northward during the summer, some as far as the north side of Gaspé.

GASPÉ REGION. Dr. Tremblay tagged 2,979 cod in the Gaspé area in 1938 and 1939 and almost 20% (585) were recaptured. Only about 27 were more than 125 miles away. Over 95% of the recaptures were in the Gulf, chiefly in the intense fishery around Gaspé in June to November. This fishery yielded almost 30% of the Canadian summer catch in 1939 (Table V) and the cod stock supporting such a catch must be quite large. If there were a mass movement out of the Gulf for the winter, many more recaptures might be expected outside the Gulf.

Figures 45 and 46 show that, of the 17 recaptures outside the Gulf, all but 3 were during the period of November to April. The small number of recaptures

during May to October, when the fishery is intense around Cape Breton, off southern Newfoundland and on the Grand Banks and the banks off eastern Nova Scotia, indicates that most of the Gaspé cod returned to the Gulf in the summer.

We may thus conclude that a large part of the Gaspé cod remained within the Gulf but that some did go outside the Gulf through Cabot Strait in the winter and returned again in the summer.

GULF OF ST. LAWRENCE AS A WHOLE. Table VIII shows that the farther from Cape North the tagging was done, the smaller the proportion of recaptures outside the Gulf of St. Lawrence. These recaptures are summarized in Fig. 49 and 50. About twice as many recaptures were made outside the Gulf in "winter" as in "summer". The "winter" recaptures from tagging at Cheticamp and Gaspé were almost three times as numerous as the "summer", whereas the "winter" recaptures from tagging in the Prince Edward Island area were only two-thirds as numerous as the "summer". This suggests that there is a more definitely seasonal migration of cod from Gaspé and Cheticamp (both near the Laurentian Channel) than from the Prince Edward Island area although con-

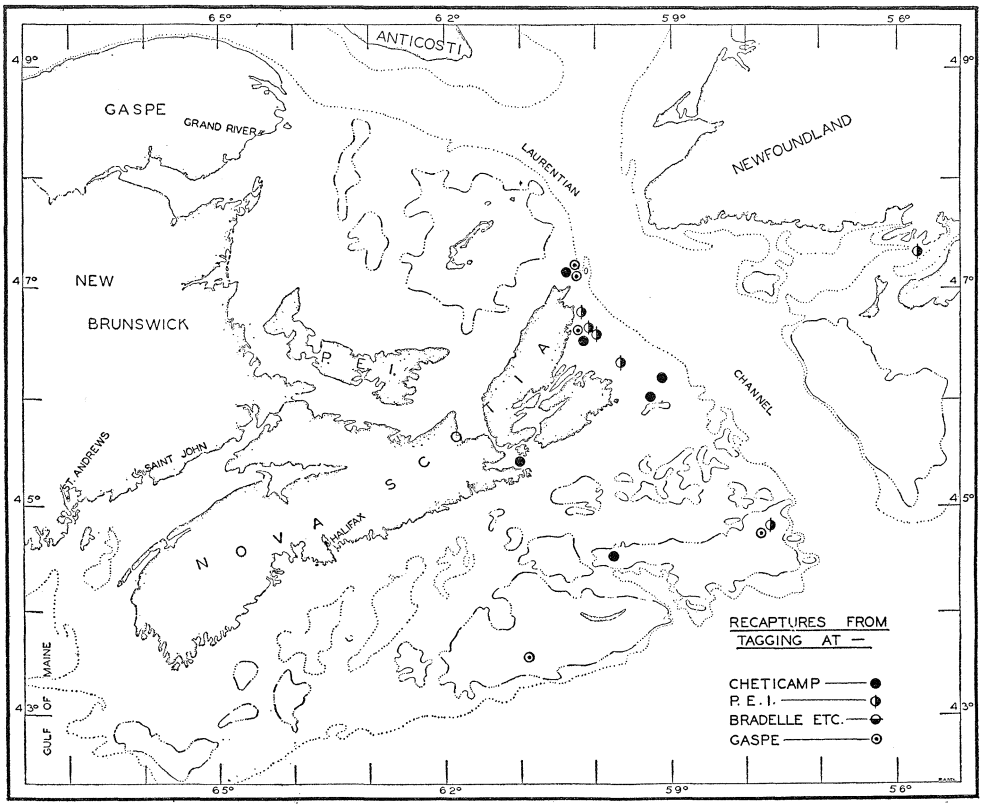

FIG. 49.—Recaptures during "summers" (May to October) made outside the Gulf of St. Lawrence from all the taggings inside the western Gulf of St. Lawrence.

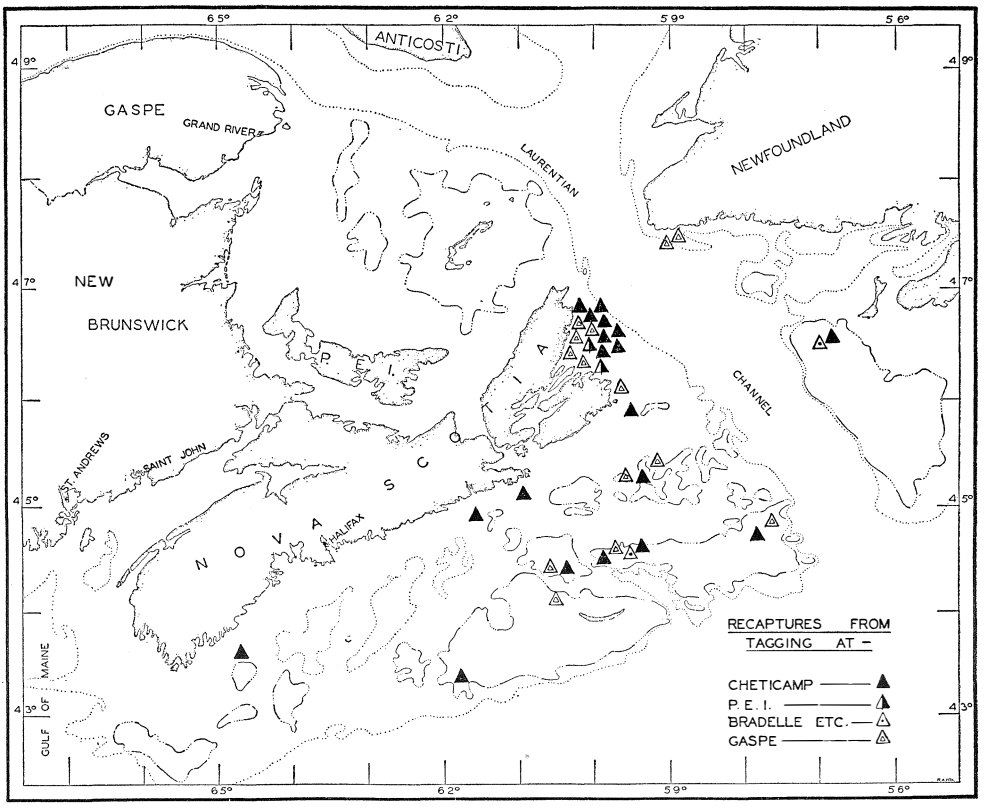

FIG. 50.—Recaptures during "winters" (November to April) made outside the Gulf of St. Lawrence from all the taggings inside the western Gulf of St. Lawrence.

siderable numbers of cod do move out of the Gulf from the latter. This accords with the apparent tendency for recaptures in the Gulf from offshore taggings to be distributed along the Laurentian Channel.

TABLE VIII.—Percentage of recaptures outside the Gulf from tagging inside arranged according to distance of tagging from Cape North, N.S.

Tagging at	Straight line distance to Cape North (*miles*)	Percentage of recaptures made outside the Gulf
Cheticamp	35	35
Naufrage	90	14
Bradelle	110	10
Ellerslie	140	8
Alberton	150	11
North Point	150	6
Gaspé 1938	ca. 175	2
Gaspé 1939	ca. 175	4

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"Winter" offshore recaptures of cod tagged at Canso were all west of a line from Canso to the eastern end of Sable Island; "winter" offshore recaptures of cod tagged at Glace Bay, Cheticamp and Gaspé were mainly east of this line, the proportion increasing from Glace Bay to Gaspé. This again suggests an association of the seasonal migration in and out of the Gulf of St. Lawrence with the Laurentian Channel.

The "summer" cod stock of northwest Cape Breton Island thus appears to be a discrete population a large part of which (possibly all) winters outside the Gulf of St. Lawrence. The cod of the Prince Edward Island to Bradelle Bank to Miscou Point area appear to be predominantly resident in the Gulf, with a few wanderers going outside the Gulf. The cod of the Gaspé area appear to be mainly resident in the Gulf but with a small percentage leaving the Gulf in the autumn and returning in the spring.

Summary of Populations

We may summarize the cod population in the area and period under review as follows:

(1) From the Bay of Fundy to Canso, cod tagged in summer belonged to local inshore populations which were largely stationary and mixed slightly with their neighbours either along shore or offshore.

(2) The cod on the banks off eastern Nova Scotia did not mix enough to make one homogeneous population, those summering in the eastern area (Banquereau) being more or less separate from those of the western offshore grounds about Sable Island. Some of the latter moved to inshore areas from Halifax to Canso in the summer, leaving the banks apparently in May or June.

(3) There was an annual migration of cod which spent the winters on the eastern banks and inshore grounds off the outer coast of Nova Scotia and the summers about northeastern Cape Breton or in the Gulf of St. Lawrence. The migration seems to have been best developed close to the Laurentian Channel, involving more cod on the eastern than on the western banks and more at Cheticamp and Gaspé than in the area about Prince Edward Island and northern New Brunswick. There may have been divisions within this migratory stock as, for example, those summering about Glace Bay and Cheticamp.

(4) The evidence indicates that most of the cod of the Gaspé–Anticosti and the Prince Edward Island–northern New Brunswick areas remained in the Gulf, although winter distribution in the Gulf could not be studied because there was no fishery. The recaptures showed some mixing of the cod stocks in these areas but the patterns were not the same and the cod resident in the Gulf did not constitute a single homogeneous group.

(5) The cod which spawn in the autumn along the outer coast of Nova Scotia seemed to differ from neighbouring inshore stocks in their movements as well as in their spawning habits.

These conclusions from tagging agree with the results of an analysis of vertebral counts (McKenzie and Smith, 1955) in every particular—the local

differences along the coast from the Bay of Fundy to Canso, the distinction between Sable Island and Banquereau stocks, the evidence of seasonal migrations (especially of a population moving in and out of the Gulf), and the differentiation of more than one stock within the Gulf. The evidence from taggings is inadequate for a definition of the latter although confirming the heterogeneity.

Of the more than 2,200 recaptures of about 21,750 cod tagged between the Laurentian and Fundian channels only 33 were across the former in Newfoundland waters and only 11 across the latter on grounds off New England. It is clear that the cod stocks southwest of the Laurentian Channel are substantially distinct from those northeast of it. This, too, is confirmed by the vertebral counts.

Some hesitancy is proper in applying these results to present conditions as the most recent taggings reported here were more than fifteen years ago. Since the taggings were made, changes in oceanographic conditions, or the effects of fishing on the stocks themselves, may have influenced their movements. It seems, however, reasonable to expect that the principal features will remain—the existence of local divisions of the stock and the rather limited movements of most of the cod of this region in spite of some well-defined seasonal migrations and of some long-range scattering which, in the present state of our knowledge, appears to be random wandering.

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MOVEMENTS OF COD IN RELATION TO VARIOUS FACTORS

The taggings described here were carried out under a great variety of conditions and by different persons, the main aim being to tag large numbers of cod to determine where and when they would go. It was not always possible to obtain full information on size of fish, degree of sexual maturity, vertebral numbers, age and growth, or hydrographic conditions. However, some such information is at hand and it seems worthwhile to summarize the evidence of the influence of a number of factors on the movements of the cod.

Movements in Relation to Submarine Physiography

Figure 51 shows the submarine physiography of the Gulf of St. Lawrence and neighbouring areas. The continental shelf with its fishing banks extends from 75 to 125 miles off the Nova Scotian coast before it drops down into the depths of the ocean.

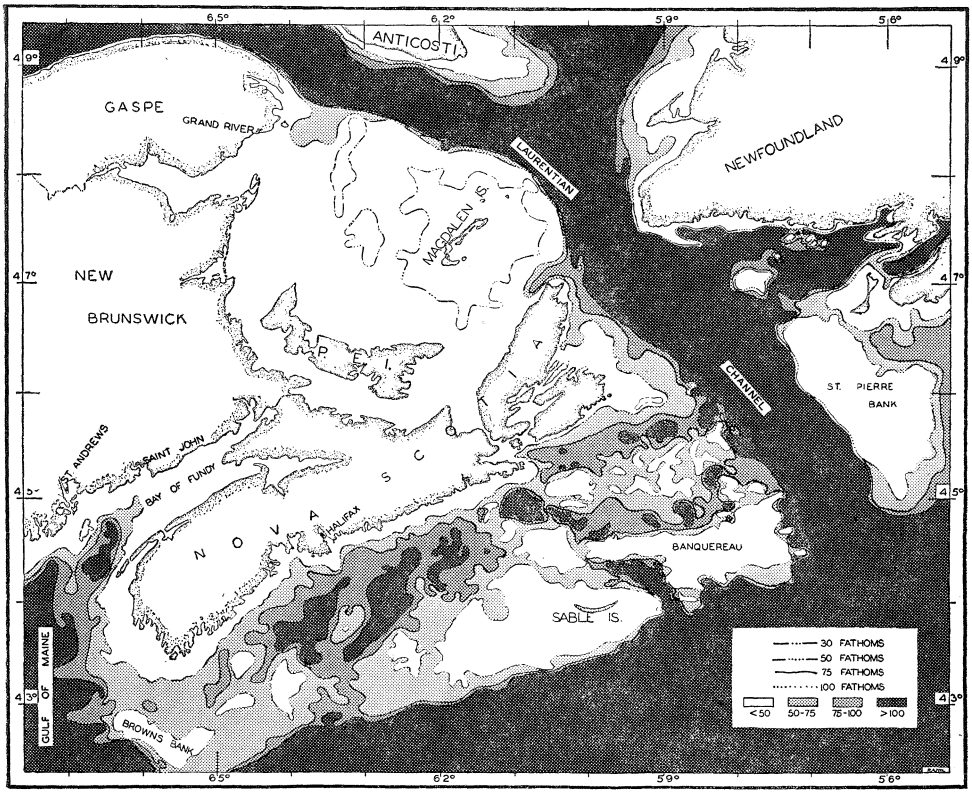

Fig. 51.—Submarine physiography of the Gulf of St. Lawrence and Scotian Shelf.

The Laurentian Channel extending into the Gulf of St. Lawrence is 25 to 50 miles wide, has water deeper than 275 fath. (500 m.) between Cape Breton and Newfoundland and deeper than 175 fath. (320 m.) between Gaspé and Anti-

costi Island. It apparently acts to some degree as a barrier to cod moving eastward towards Newfoundland, as only 33 of the more than 2,200 recaptures were made on the Newfoundland side.

Separating the Nova Scotian Banks from Georges Bank is the Fundian Channel (not shown on Fig. 51, but just southwest of Browns Bank) which connects the Gulf of Maine with the deep waters outside the continental shelf. At its narrowest point, between Browns and Georges banks, it is about 15 miles wide and over 125 fath. (230 m.) deep. Only 11 of the more than 2,200 recaptures reported here were made west of this channel. They came mainly from the 6,000 cod tagged in the Bay of Fundy and at Seal Island and Shelburne, and constitute only about 3 % of the recaptures from these taggings. It thus appears that this Channel forms a barrier in some degree to cod.

Off Halifax there is a deep area in the continental shelf which has been called the Scotian Gulf and it is connected with deep ocean waters by a channel just over 75 fath. (135 m.) in depth. The offshore taggings dealt with in this account were all east of this channel, some immediately east of it on Emerald Bank. The lack of recaptures on the banks west of the channel suggest that the channel acts as a barrier.

These channels seem to be responsible in a great degree for the fact that the cod tagged in the waters around Nova Scotia and the western Gulf of St. Lawrence seldom moved out of the area between the Laurentian and Fundian channels. Within this area other factors, such as water temperature, size of fish, etc., are believed to have influenced the movements of the cod.

Relation of Water Temperatures to Movements of Cod

McKenzie and Hachey (1939) have shown that the success of the spring and summer cod fishery off Halifax is correlated with bottom temperatures there. Thompson (1932, 1933, 1934, 1935, 1943), Le Danois (1932) and, more recently, Templeman, have cited many instances of the relationship of the occurrence of cod to water temperatures. McKenzie (1934b) has shown that feeding of cod in captivity decreases as the temperature approaches 0°C., and that large cod may go without food for weeks at a time. For various sizes of cod there are optimum temperatures above which feeding decreases. Dr. A. H. Leim (personal communication) found that a 52-cm. cod exhibited no apparent discomfort until the temperature fell to −1.2°C., that respiration ceased at −1.5°C., and the heart beat at −1.9°C. Dannevig (1930) has shown that natural mortality of younger cod sometimes occurs along the Norwegian coast when temperatures are as low as −1.0°C. Thus there is ample evidence that temperature influences the distribution, feeding and survival of cod.

Tidal mixing in the Bay of Fundy prevents much stratification and temperatures there vary little from surface to bottom, summer surface temperatures being the coldest in the area under review. Off the outer Nova Scotian coast, on the other hand, the waters are stratified in summer, more highly towards the northeast. They are divided into an upper warm layer, an intermediate cold

layer and a bottom warm layer (Hachey, 1934, 1935, 1937). The waters of the the Gulf of St. Lawrence are also highly stratified in summer. Sandström (1919) showed that an intermediate ice-cold layer extended in summer across the Gulf, covering much of the bottom in the southwest section of the Gulf, and this has been confirmed by more recent investigations (Lauzier, 1952 and recent MSS). Thus in summer there is increasing stratification from the Bay of Fundy, where the waters are well mixed, around Nova Scotia into the Gulf of St. Lawrence, where there is strong stratification.

In the winter the Gulf of St. Lawrence is ice covered to a considerable degree and the water ice cold to a considerable depth. As winter progresses, similar conditions extend out of the Gulf and in a southerly and westerly direction from Cape Breton. In the period under review icy water, much of it below 0°C. and some even below −1.0°C., generally extended by late winter from surface to bottom (except in the deeper gullies) for some distance along the coast of Nova Scotia and offshore at least to, if not always over, the more eatern banks. Warming occurred in surface waters in spring but the cold water persisted through the summer as the intermediate cold layer noted above.

About western Nova Scotia and the entrance to the Bay of Fundy, where temperature variations are not extreme either from season to season or depth to depth, cod fishing is carried on 12 months a year and, as noted above, tagging shows that the cod of this region move relatively little. About eastern Nova Scotia and in the Gulf of St. Lawrence, where there are marked seasonal changes and strong stratification, the fishery is seasonal and movements of cod greater. Around eastern Nova Scotia the fishery is prosecuted for only about eight months a year and there is much movement, some of it involving substantial populations as off northeast and northwest Cape Breton. The seasonal movements of cod within the western Gulf remain largely unknown. Although it appears that most of these cod remain in the Gulf over winter, they may well move into deeper, warmer Laurentian Channel. Table IX, in which inshore taggings have been

TABLE IX.—Recaptures from taggings in outer Nova Scotian inshore waters

District	Year tagged	Number tagged	Number recaptured	Percentage recaught	
				Within tagging region	Outside tagging region
Seal Island	1927	1,840	190	80	20
Shelburne	1926	4,011	431	89	11
Halifax	1934	688	210	80	20
Egg Island–Jeddore Rk	1934	1,295	372	80	20
Canso	1934	478	55	69	31
Glace Bay	1927	2,198	67	32	68
Cheticamp	1937	795	68	50	50

grouped by districts irrespective of depth or bottom water temperature, shows the greater movement of the cod from the more eastern areas about Nova Scotia. Thus, hydrographic conditions have an important influence on the movements of the cod in these regions.

The exact position of the intermediate cold layer off the outer coasts of Nova Scotia and Cape Breton is influenced by weather and temperatures in the fishing grounds and can change rapidly from day to day. The tagging at Canso exemplifies the effects of such a change. This tagging was done at the same location on two consecutive days in bottom water of 5.4°C. the first day and 6.8°C. the second day. On the first day 344 cod of average length, 64.6 cm., were tagged and 40 percent of the 40 recaptures were outside the tagging region. On the second day only 134 were tagged. These were smaller (average length 60.5 cm.) and only one of the 15 recaptures was outside the tagging region. The influx of warmer water on the second day was associated with a drop in catch and a smaller average size of the fish. The size range was about the same on the two days but the proportion of larger cod was smaller during the second day. Table X shows that more cod were caught outside the tagging region from the first than from the second day's tagging and that, while the cod recaptured locally were of the same average size as those tagged, the cod caught at a distance were larger. The influx of warmer water was thus associated with a decrease in the numbers of larger cod, which appeared to move more freely than the smaller.

TABLE X.—Lengths of cod tagged off Canso, N.S. and recaptured to the end of 1935

Lengths	July 31, 1934			August 1, 1934		
	Number tagged	Recaptures to end 1935		Number tagged	Recaptures to end 1935	
		In tagging region	Outside tagging region		In tagging region	Outside tagging region
cm.						
35– 39	1	0	0	1	0	0
40– 44	3	0	0	2	0	0
45– 49	18	0	0	16	1	0
50– 54	54	1	0	23	3	0
55– 59	79	4	0	31	2	1
60– 64	56	5	3	22	2	0
65– 69	69	1	4	11	1	0
70– 74	29	1	1	11	2	0
75– 79	17	2	0	11	1	0
80– 84	7	2	1	5	0	0
85– 89	5	0	0	0	0	0
90– 94	2	0	0	0	0	0
95– 99	0	0	0	0	0	0
100–104	3	0	0	1	0	0
105–109	0	0	0	0	0	0
110–114	1	0	1	0	0	0
Totals.....	344	16	10	134	12	1
Av. lengths.....	64·6	64·8	71·3	60·5	60·8	55·0

The tagging off Cheticamp on the northwest coast of Cape Breton was carried out on five almost consecutive days at different depths and temperatures. It is seen in Table XI that the percentage recaptures from each day's tagging decreased with increasing depth and decreasing bottom temperatures but that the proportion recaptured away from the tagging region was greater in the colder, deeper water. Again colder water is associated with longer movements.

TABLE XI.—Summary of the Cheticamp taggings of July, 1937. On July 24 fishing was with handlines while the boat was drifting; on all other days the boat was anchored. In this and similar tables, the numbers retaken outside (or inside) the tagging region are given as a percentage of the total recaptures.

——	Number tagged	Depth	Temperature	Recaptures	Outside tagging region
		metres	°C.	%	%
July 24	51	31–37	2·5–4·0	18	33
July 21	99	31	4·0	14	43
July 22	179	37	2·5	11	53
July 23	238	72	0·4	5	55
July 26	228	67	0·2	7	60

THE RELATION OF SIZE OF COD TO THEIR MOVEMENTS

Strubberg (1916) showed that the older fish of the Faroe Islands region were more migratory than the younger and smaller, and Hansen, Jensen and Tåning (1935) drew attention to the fact that off western Greenland the northward shift to the northwest Greenland Banks was made chiefly by large fish. At Shelburne, N.S., the inshore cod, as they grew older and larger, were found by McKenzie (1934a) to remain progressively a little farther off shore each year. The habits of the cod thus vary somewhat according to size of fish involved.

Table XII shows the lengths (according to 10-cm. size groups) of typical catches made at various depths off Halifax during the summer of 1934. The

TABLE XII.—Length frequencies of cod caught off Halifax at various depths during the summer of 1934, arranged at 10-cm. intervals. Measurements are in centimetres to the end of longest caudal ray, with the tail spread naturally.

Depth	40+	50+	60+	70+	80+	90+	100+	110+	Av. length
metres									*cm.*
45	69	341	276	94	14	7	3	.....	60·5
50	35	188	113	54	10	6	2	.....	60·5
75	.....	29	40	23	7	5	7	.....	69·7
80	12	107	170	122	34	19	7	2	68·1

average length increased with the depth. In Table XIII the average length of all the cod measured and tagged from Halifax to Canso, 1934 to 1936 inclusive, is shown according to depth, and here too, the larger were taken in the deeper water. Thus, on the average, smaller cod prefer shallower waters than larger.

TABLE XIII.—The average length of the cod tagged in inshore waters from Halifax to Canso, N.S., 1934 to 1936 inclusive

Depth	Av. length	Number
metres	*cm.*	
20– 49	61·2	1,470
50– 79	64·5	852
80–109	68·1	314
110–139	65·8	43
140–169	94·5	2

Of the recaptures of all cod tagged inshore from Halifax into the Gulf as far as Prince Edward Island in the first year and a half after tagging, 37.5% of those within the tagging regions and only 23.3% of those outside the tagging regions were "scrod". The measurements were taken at the time of tagging and "scrod" are fish up to 59 cm. in length. Table XIV shows that the average length at tagging of all cod from these taggings recaptured outside the tagging regions was 3.6 cm. greater than the average length of those caught inside. A comparison of the recaptures inside and outside of the various regions according to depth at the tagging positions shows that (Table XV) more and more cod were recaptured outside of the tagging region as the tagging positions increased in depth.

TABLE XIV.—A comparison of the average lengths, at tagging, of the cod recaptured inside and outside of the tagging region (TR); with the number of fish concerned shown in brackets

Tagging area	Inside	Outside
	cm.	*cm.*
Halifax, 1934	62·6 (171)	62·7 (35)
Halifax, 1935	65·4 (14)	66·7 (7)
Halifax, 1936	66·5 (27)	72·3 (4)
Jeddore Rock, 1934	62·6 (222)	63·4 (30)
Egg Is., 1934	72·5 (72)	74·0 (41)
Canso, 1934	64·3 (42)	69·5 (12)
Cheticamp, 1937	63·7 (36)	68·4 (32)
Naufrage, 1940	46·0 (1)	69·3 (6)
Average	64·2 (585)	67·8 (167)

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It has been shown above that in these inshore waters the fish on the average were larger in the deeper water, that those recaptured outside the tagging regions were larger on the average when tagged than those recaptured inside the tagging regions, and that the fish tagged in deeper water showed a greater tendency to move away from the tagging regions than those tagged in shallower water. It remains to be determined, however, whether or not fish of a certain length in deep water had a greater tendency to move than those of the same length in shoal water.

TABLE XV.—Recaptures made outside the tagging regions according to depths at tagging positions

Year of tagging	Depth	Percentage of total recaptures taken outside tagging regions
	metres	
1934	20	0
1934	25	0
1934	45	13
1934	45	16
1934	50	19
1936	70–95	25
1934	75	37
1934	80	36
1935	87–132	53

To this end Tables XVI to XXXII have been prepared for all the taggings where approximately a hundred or more cod were measured and tagged. These tables show the numbers measured and tagged in each 10-cm. group and the recaptures according to these same length groups during various periods of time following the taggings, as well as the proportions of these various size groups recaptured outside the tagging regions. To more easily separate the effect of size from the effect of depth in the migration pattern, Table XXXIII has been prepared as a summary of the foregoing tables. In it the inshore taggings are arranged according to three ranges of depths and the respective recaptures according to 10-cm. length groups (as tagged) whether or not they were recaptured inside or outside of the tagging region. To avoid possible complication due to growth between tagging and recapture only the recaptures made to the end of the next calendar year following each tagging—a total of approximately 18 months in each case—have been used in this table. The smaller and larger sizes were not numerous in the taggings or recaptures and only the 50-60, 60-70, 70-80 and possibly the 80-90 cm. length groups should be compared. In the 50-60 cm. group 15% of the recaptures from the shoal-water taggings were made outside the tagging regions, 21% from the intermediate-depth taggings and 32% from the deep water taggings. In the 60-70 cm. group the percentages were

TABLE XVI.—Recaptures of cod tagged at Egg Island, N.S., 1934, at station A (Fig. 1). Depth 80 m.; temperature 1·0–1·5°C.; mean length of cod tagged 68·1 cm. The last column in this and succeeding tables shows the percentage of all recaptures which were taken outside the tagging region

Length (*cm.*)	Number tagged	1934							Yearly totals					Grand total	Total percentage	Outside tagging region
		May	June	July	Aug.	Sept.	Oct.	Nov.	1934	1935	1936	1937	1938			
40+	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0	.....
50+	107	1	2	1	1	2	.....	.....	7	.....	.....	.....	.....	7	7	14%
60+	170	.....	11	12	4	5	1	.....	33	5	2	1	.....	41	24	34%
70+	122	1	13	4	7	5	.....	3	33	4	2	.....	1	40	33	32%
80+	34	.....	7	4	1	.....	.....	1	13	1	.....	.....	.....	14		
90+	19	.....	1	1	2	.....	.....	.....	4	.....	1	1	.....	6	40	32%
100+	7	.....	2	1	.....	.....	.....	.....	3	.....	1	.....	.....	4		
110+	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1		
Totals.....	473	2	36	23	15	12	1	4	93	10	6	2	2	113	24	30%

TABLE XVII.—Recaptures of cod tagged off Jeddore Rock, N.S., 1934, at station B (Fig. 1). (Depth 45 m.; temperature 2·8°C.; mean length of cod tagged 60·5 cm.)

Length (*cm.*)	Number tagged	1934								Yearly totals					Grand total	Total percentage	Outside tagging region
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1934	1935	1936	1937	1938			
40+	69	.....	3	4	.....	1	.....	.....	.....	8	4	1	.....	.....	13	19	15%
50+	341	3	26	10	11	13	3	3	1	70	15	2	3	1	91	27	15%
60+	276	1	32	20	13	8	4	2	.....	80	13	5	1	.....	99	35	15%
70+	94	1	11	9	2	1	.....	.....	.....	24	11	1	1	2	39	39	13%
80+	14	.....	3	2	1	.....	.....	.....	.....	6	1	1	.....	.....	8		
90+	7	.....	.....	1	.....	.....	.....	1	.....	2	.....	1	.....	.....	3	50	12%
100+	3	.....	.....	1	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1		
Totals.....	804	5	75	47	27	23	7	6	1	191	44	11	5	3	254	32	15%

TABLE XVIII.—Recaptures of cod tagged off Halifax, N.S., 1934, at station E (Fig. 1). (Depth 50 m.; temperature 1·9–2·7°C.; mean length of cod tagged 60·5 cm.)

Length (*cm.*)	Number tagged	1934							Yearly totals				Grand total	Total percentage	Outside tagging region
		June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1934	1935	1936	1937			
40+	35	.....	2	1	.....	.....	.....	.....	3	2	.....	.....	5	14	0%
50+	188	2	9	9	3	1	1	1	26	19	3	1	49	26	18%
60+	113	5	9	7	.....	.....	.....	1	22	13	2	3	40	35	22%
70+	54	3	5	2	1	.....	2	.....	13	8	.....	.....	21	39	19%
80+	10	.....	1	1	.....	.....	.....	.....	2	1	.....	.....	3		
90+	6	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	1	33	17%
100+	2	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	2		
Totals.....	408	10	26	21	4	1	3	2	67	44	6	4	121	30	19%

TABLE XIX.—Recaptures of cod tagged off Halifax, N.S., 1934, at station I (Fig. 1). (Depth 75 m.; temperature 2·5–3·0°C.; mean length of cod tagged 69·7 cm.)

Length (*cm.*)	Number tagged	1934				Yearly totals			Grand total	Total percentage	Outside tagging region
		July	Aug.	Sept.	Nov	1934	1935	1936			
50+	29	3	.....	.....	3	6	3	.....	9	31	56%
60+	40	2	3	3	1	9	5	3	17	42	41%
70+	23	1	1	.....	.....	2	2	.....	4	17	50%
80+	7	2	.....	.....	.....	2	1	.....	3		
90+	5	1	.....	.....	.....	1	.....	.....	1	32	33%
100+	7	1	1	.....	.....	2	.....	.....	2		
Totals.....	111	10	5	3	4	22	11	3	36	32	44%

TABLE XX.—Recaptures of cod tagged off Canso, July 31, 1934. (Depth 28 m.; temperature 5·4°C.; mean length of cod tagged 64·6 cm.)

Length (*cm.*)	Number tagged	1934			Yearly totals					Grand total	Total percentage	Outside tagging region
		Aug.	Sept.	Nov.	1934	1935	1936	1937	1939			
30+	1	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
40+	21	.....	.....	.....	.....	.....	1	.....	.....	1	5	100%
50+	134	2	.....	.....	2	3	.....	2	.....	7	5	0%
60+	124	5	1	1	7	6	6	1	.....	20	16	45%
70+	46	.....	1	1	2	2	1	1	1	7	15	43%
80+	12	1	1	.....	2	1	.....	1	.....	4		
90+	2	.....	.....	.....	.....	.....	.....	.....	.....	0	28	60%
100+	3	.....	.....	.....	.....	.....	.....	.....	.....	0		
110+	1	.....	.....	.....	.....	1	.....	.....	.....	1		
Totals...	344	8	3	2	13	13	8	5	1	40	12	40%

TABLE XXI.—Recaptures of cod tagged off Canso, August 1, 1934. (Depth 28 m.; temperature 6·8°C.; mean length of cod tagged 60·5 cm.)

Length (*cm.*)	Number tagged	1934	Yearly totals				Grand total	Total percentage	Outside tagging region
		Aug.	1934	1935	1936	1937			
30+	1	.....	.....	.....	.....	.....	0	.....	.....
40+	18	1	1	.....	.....	.....	1	6	0%
50+	53	1	1	5	.....	.....	6	11	17%
60+	33	1	1	2	.....	1	4	12	0%
70+	22	1	1	2	1	.....	4	18	0%
80+	5	.....	.....	.....	.....	.....	0	.....	.....
90+	0	.....	.....	.....	.....	.....	0	.....	.....
100+	1	.....	.....	.....	.....	.....	0	.....	.....
Totals.....	133	4	4	9	1	1	15	11	7%

TABLE XXII.—Recaptures of cod tagged off Halifax, N.S., 1935, at station L (Fig. 1). (Depth 87 m.; temperature 0·65°C.; mean length of cod tagged 65·1 cm.)

Length (*cm.*)	Number tagged	1935					Yearly totals		Grand total	Total percentage	Outside tagging region
		May	July	Aug.	Sept.	Dec.	1935	1936			
40+	7	.....	.....	.....	.....	1	1	.....	1	14	0%
50+	13	.....	1	.....	.....	1	2	2	4	31	75%
60+	25	2	.....	2	.....	.....	4	2	6	24	17%
70+	14	1	1	.....	1	.....	3	1	4	29	50%
80+	3	.....	.....	.....	.....	.....	.....	2	2		
90+	0	.....	.....	.....	.....	.....	.....	.....	0	40	50%
100+	1	.....	.....	.....	.....	.....	.....	.....	0		
110+	1	.....	.....	.....	.....	.....	.....	.....	0		
Totals.....	64	3	2	2	1	2	10	7	17	27	24%

TABLE XXIII.—Recaptures of cod tagged off Halifax, N.S., 1934, at station G (Fig. 1). (Depth 45 m.; temperature 2·65°C.; mean length of cod tagged 60·1 cm.)

Length (*cm.*)	Number tagged	1934					Yearly totals				Grand total	Total percentage	Outside tagging region
		July	Aug.	Sept.	Oct.	Nov.	1934	1935	1936	1937			
30+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
40+	9	.....	.....	.....	1	.....	1	3	.....	1	5	55	20%
50+	33	2	1	2	1	1	7	1	1	.....	9	27	22%
60+	25	5	1	3	1	.....	10	1	1	1	13	52	15%
70+	6	.....	.....	1	.....	.....	1	.....	.....	.....	1	17	0%
80+	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
90+	2	.....	.....	1	.....	.....	1	.....	.....	.....	1	20	0%
100+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
Totals....	79	7	2	7	3	1	20	5	2	2	29	37	17

23, 28, and 30; in the 70-80 group, 20, 26, and 33; while in the 80-90 cm. group they were 8, 0, and 29. These data thus indicate that length for length the cod in deeper inshore water had a greater tendency to move than those in shoaler water. Our findings in respect to the habits and characteristics of cod in relation to their size thus fall in line with those of other investigators. It has also been found that fish of a given size in deep water move more than comparable fish in shoal water.

RELATION OF SEXUAL MATURITY TO MOVEMENTS OF COD

Hjort (1926) pointed out that extensive migrations were undertaken by cod off northern Norway for the purpose of spawning in more southern waters off the Lofoten Islands. Schmidt (1931) showed that the cod about Iceland shifted to the southwest coast to spawn and also that in some years mature cod made the 700- to 1,200-mile journey from various parts of Greenland before spawning on the same grounds off southwestern Iceland. Thus, in the eastern

TABLE XXIV.—Recaptures of cod tagged off Halifax, N.S., 1936, at stations P, S, T and U (Fig. 1). (Depth 70-95 m.; temperature 1·40-1·70°C.; mean length of cod tagged 67·9 cm.)

Length (*cm.*)	Number tagged	1936								Yearly totals		Grand total	Total percentage	Outside tagging region
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1936	1937			
40+	9	.....	.....	.....	.....	.....	.....	1	.....	1	1	2	22	0%
50+	21	2	1	.....	2	1	.....	1	.....	7	4	11	52	9%
60+	22	.....	0	1	1	1	1	.....	.....	4	1	5	23	40%
70+	27	.....	1	.....	1	1	1	2	.....	6	1	7	26	43%
80+	10	.....	1	1	.....	1	.....	.....	1	4	1	5		
90+	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	35	33%
100+	4	.....	1	.....	.....	.....	.....	.....	.....	1	.....	1		
110+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
Totals.....	96	2	4	2	4	4	2	4	1	23	8	31	32	26%

TABLE XXV.—Recaptures of cod tagged off Cheticamp, N.S., July 21 and 22, 1937. (Depth 34-37 m.; temperature 2·5-4·0°C.; mean length of cod tagged 66·0 cm.)

Length (*cm.*)	Number tagged	1937						Yearly totals					Grand total	Total percentage	Outside tagging region
		July	Aug.	Sept.	Oct.	Nov.	Dec.	1937	1938	1939	1940	1941			
30+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
40+	28	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	4	0%
50+	84	1	.....	4	.....	1	.....	6	1	1	.....	.....	8	10	15%
60+	88	.....	1	1	.....	1	2	5	3	1	2	.....	11	12	45%
70+	52	.....	1	2	1	1	.....	5	2	1	.....	1	9	17	67%
80+	24	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1		
90+	15	.....	.....	.....	.....	.....	.....	.....	2	.....	1	.....	3		
100+	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	9	75%
110+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
120+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
Totals.....	298	1	2	7	1	3	2	16	10	3	3	1	33	11	49%

TABLE XXVI.—Recaptures of cod tagged off Cheticamp, N.S., July 23, 1937. (Depth 72 m.; temperature 04·°C.; mean length of cod tagged 65·0 cm.)

Length (*cm.*)	Number tagged	1937					Yearly totals			Grand total	Total percentage	Outside tagging region
		July	Aug.	Sept.	Oct.	Nov.	1937	1938	1939			
40+	8	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
50+	57	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
60+	99	1	.....	1	.....	1	3	2	1	6	6	50%
70+	41	1	.....	.....	1	.....	2	2	.....	4	10	50%
80+	6	.....	1	.....	.....	.....	1	.....	.....	1		
90+	5	.....	.....	.....	.....	.....	.....	.....	.....	0	8	0%
100+	0	.....	.....	.....	.....	.....	.....	.....	.....	0		
110+	1	.....	.....	.....	.....	.....	.....	.....	.....	0		
Totals	217	2	1	1	1	1	6	4	1	11	5	45%

TABLE XXVII.—Recaptures of cod tagged off Cheticamp, N.S., July 24, 1937. (Depth 30-40 m.; mean length of cod tagged 62·4 cm.)

Length (*cm.*)	Number tagged	1937				Yearly totals			Grand total	Total percentage	Outside tagging region
		July	Aug.	Nov.	Dec.	1937	1938	1940			
30+	1	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
40+	4	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
50+	19	1	.....	.....	1	2	1	.....	3	16	33%
60+	15	.....	1	1	.....	2	1	1	4	27	50%
70+	7	.....	.....	.....	1	1	1	.....	2	29	0%
80+	2	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
90+	2	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
Totals.....	50	1	1	1	2	5	3	1	9	18	33%

TABLE XXVIII.—Recaptures of cod tagged off Cheticamp, N.S., July 26, 1937. (Depth 67 m.; temperature 0·2°C.; mean length of cod tagged 62·8 cm.)

Length (*cm.*)	Number tagged	1937				Yearly totals				Grand total	Total percentage	Outside tagging region
		Sept.	Oct.	Nov.	Dec.	1937	1938	1939	1940			
40+	6	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
50+	90	.....	.....	1	.....	1	2	3	.....	6	7	67%
60+	94	1	.....	.....	.....	1	2	1	3	7	7	57%
70+	24	.....	1	.....	1	2	.....	.....	.....	2	8	50%
80+	7	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
90+	3	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
100+	3	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
Totals	228	1	1	1	1	4	4	4	3	15	7	60%

TABLE XXIX.—Recaptures of cod tagged in St. Mary Bay, Apr. 21-29, 1939.
(Depth 27-42 m.; mean length of cod tagged 82·7 cm.)

Length (*cm.*)	Number tagged	1939						Yearly totals			Grand total	Total percentage	Outside tagging region
		May	June	Aug.	Sept.	Oct.	Dec.	1939	1940	1941			
40+	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
50+	6	.....	.....	.....	.....	.....	1	1	.....	.....	1	17	0%
60+	12	.....	.....	2	1	1	.....	4	.....	.....	4	33	50%
70+	19	.....	1	.....	1	.....	.....	2	1	1	4	21	75%
80+	12	1	.....	.....	.....	.....	.....	1	.....	.....	1		
90+	17	1	.....	.....	.....	.....	.....	1	.....	.....	1		
100+	8	.....	2	.....	.....	.....	.....	2	1	.....	3	14	33%
110+	3	1	.....	.....	.....	.....	.....	1	.....	.....	1		
120+	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	0		
Totals....	80	3	3	2	2	1	1	12	2	1	15	19	47%

TABLE XXX.—Recaptures of cod tagged off Naufrage, P.E.I., Aug. 24, 1940.
(Depth 45 m.; mean length of cod tagged 71·3 cm.)

Length (*cm.*)	Number tagged	1940		Yearly totals			Grand total	Total percentage	Outside tagging region
		Sept.	Nov.	1940	1941	1942			
40+	4	1	.....	1	.....	.....	1	25	0%
50+	22	.....	.....	.....	1	.....	1	5	100%
60+	51	.....	1	1	3	.....	4	8	100%
70+	34	.....	.....	.....	.....	.....	0	.....	.....
80+	7	.....	.....	.....	.....	.....	0		
90+	13	.....	.....	.....	.....	.....	0		
100+	5	.....	.....	.....	.....	1	1	7	100%
110+	2	.....	.....	.....	.....	.....	0		
120+	2	.....	.....	.....	.....	.....	0		
Totals.....	140	1	1	2	4	1	7	5	86%

TABLE XXXI.—Recaptures of cod tagged on Middle Ground, June, 1935. (Depth 43-48 m.; temperatures 1·2–3·6°C.; mean length of cod tagged 68·4 cm.)

Length (*cm.*)	Number tagged	1935			Yearly totals				Grand total	Total percentage	Outside tagging region
		July	Nov.	Dec.	1935	1936	1937	1938			
30+	2	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
40+	4	.....	.....	.....	.....	.....	.....	.....	0	.....	.....
50+	27	.....	1	.....	1	.....	.....	.....	1	4	100%
60+	71	1	.....	.....	1	1	1	.....	3	4	33%
70+	48	.....	.....	1	1	1	1	.....	3	6	67%
80+	14	.....	.....	.....	.....	.....	.....	1	1		
90+	7	.....	.....	.....	.....	.....	.....	.....	0	4	0%
100+	2	.....	.....	.....	.....	.....	.....	.....	0		
Totals.....	175	1	1	1	3	2	2	1	8	5	50%

TABLE XXXII.—Recaptures of cod tagged on western Banquereau, June, 1935. (Depth 65 m.; temperature 0·9°C.; mean length of cod tagged 65·8 cm.)

Length (*cm.*)	Number tagged	1935		Yearly totals		Grand total	Total percentage	Outside tagging region
		Oct.	Dec.	1935	1937			
30+	1	.....	.....	.....	.....	0	0	.....
40+	5	.....	.....	.....	.....	0	0	.....
50+	21	.....	.....	.....	.....	0	0	.....
60+	44	1	1	2	2	4	9	75%
70+	14	.....	.....	.....	.....	0	0	.....
80+	5	1	.....	1	.....	1		
90+	2	.....	.....	.....	.....	0		
100+	0	.....	.....	.....	.....	0	12	0%
110+	0	.....	.....	.....	.....	0		
120+	1	.....	.....	.....	.....	0		
Totals.....	93	2	1	3	2	5	5	60%

North Atlantic, spawning sometimes takes place after migrations of considerable magnitude, usually in the period from winter into early summer and in comparatively cool water (Fulton, 1904).

Cod spawning in the area under consideration here is at its height from late winter in the more southerly to late summer in the more northerly regions. Spawning reaches a peak again in late autumn in certain localities, as it does in the Bornholm Deep and the Danzig Basin in the Baltic Sea (Kandler, 1938; Poulsen, 1931).

On the New Brunswick side of the Bay of Fundy spawning began during the winter and reached a peak in May (McKenzie, 1934c); on the Nova Scotian side the peak was in April, all of both sexes being mature ("running") during tagging in St. Mary Bay, Apr. 21-28, 1929. Spawning on the inshore grounds west of Halifax appeared to be at its height in April. Off Halifax there was heavy spawning during April and May, practically finished by June. At Canso many of the males were still running in June but spawning appeared to be over in July. Spawning along the east coast of Cape Breton appeared to coincide with that at Canso, being completed by late July.

Offshore west of Halifax Collins (1885) reported spawning on Browns Bank the last half of May. However on the western end of Sable Island Bank and south of Emerald Bank the males began to "run" in early March and spawning occurred from late March to mid-April, the majority being spent by late April. For some weeks prior to early April the cod catches on that part of southwestern Sable Island Bank known to fishermen as the "cow pen" increased and in early April the landings of "steak" cod (a commercial category of large cod) from this region reached a peak (McKenzie, 1942). The fish which gave rise to these

large landings appeared to congregate in this area for spawning. In the Sable Island–Middle Ground region spawning appeared to be a little later, for the majority were spent by mid-May and the gonads were again in early stages of recovery from spawning by early July. While there is no evidence of cod moving into this region for spawning there was a post-spawning movement inshore by some to the waters off eastern Nova Scotia.

On western Banquereau the gonads were in late pre-spawning stages of development during April and all the males were "running" in June. On eastern Banquereau on Apr. 20, 1937, most males were "running". Great numbers of ripe ovaries with transparent eggs were seen. Fishing reached a peak in late April and May in this region (McKenzie, 1942) and cod appear to have congregated in this "Eastern Shoals" region then for spawning. According to Dr. W. Templeman (personal communication), examination of several hundred cod from this region in mid-May, 1950, indicated that about 12% of the females were spent and 83% were in the stage with large numbers of clear eggs which immediately precedes spawning. Our tagging in late May, 1937, showed that the cod present on eastern Banquereau at this time were resident whereas those tagged in the same location in late April were migratory, leaving Banquereau shortly after spawning. The cod on Misaine Bank in early March were all in early pre-spawning stages and presumably spawned considerably later, perhaps about Cape Breton or in the Gulf of St. Lawrence.

In the Gulf of St. Lawrence spawning appeared to be at its height around the Magdalen Islands and off northwestern Cape Breton in July, many spent fish being found in early August. The tagging in late July, 1937, off northwest Cape Breton indicated that more of these spawning cod were in temperatures below 1°C. than above. Dannevig (1919) found numbers of cod eggs in two series of tows along a line northeastward from East Point, P.E.I., between the Magdalen Islands and Cape North in the second week of June, and in early August, 1915, and in irregular tows in this same area from June 1 to Aug. 18. The cod which move out of the Gulf for the winter from northwest Cape Breton thus appear to return in the early summer in time to spawn in late June and July.

Off Prince Edward Island spawning cod were taken in water temperatures of 1.8°C. to 2.2°C., and July seemed to be the peak month of spawning. From Bradelle Bank towards Orphan Bank and Miscou Point, spawning was a little later; only about one-third of the males extruded milt during the handling involved in tagging in early August, 1936. Bottom temperatures during the 1936 tagging in this region ranged from 0.0°C. down to −0.8°C. Bigelow and Welsh (1925) also report spawning fish in this area late in August. Cruises in early June and in August, 1915, from the Miramichi estuary to the eastern tip of Anticosti Island revealed numbers of cod eggs in this region, especially in the Miscou Bank to Orphan Bank vicinity (Dannevig, 1919).

On the southern side of the inner half of Bay Chaleur about one-quarter of the males were found "running" in July and it was reported by the fishermen that the peak of spawning occurred in this district from mid-August into September. Off the mouth of Bay Chaleur and the eastern part of Gaspé about

TABLE XXXIII.—Summary of the recaptures according to tagging depths and lengths of cod when tagged. Only recaptures to end of the next calendar year following tagging are included. "In": inside the tagging region; "Out": outside the tagging region.

Lengths (*cm.*) / Tagging stations	40+		50+		60+		70+		80+		90+		100+		110+	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
TAGGING DEPTH 27-49 METRES																
Jeddore Rock, N.S. (Station B, Fig. 1)	10	2	73	12	81	12	30	5	7	0	2	0	0	1	.....	.....
Canso, N.S., 1934	1	0	10	1	9	7	6	1	2	1	.....	.....	.....	.....	0	1
Halifax, N.S. (Station G, Fig. 1)	3	1	6	2	9	2	1	0	.....	.....	1	0	.....	.....	.....	.....
Cheticamp July 21 and 22, 1937	1	0	6	1	4	4	3	4	1	0	0	2	.....	.....	.....	.....
Cheticamp July 24, 1937	.....	.....	2	1	2	1	2	0	.....	.....	.....	.....	.....	.....	.....	.....
St. Mary Bay	.....	.....	1	0	2	2	1	2	1	0	1	0	1	2	1	0
Naufrage, P.E.I.	1	0	0	1	0	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Totals	16	3	98	18	107	32	43	11	11	1	4	2	1	3	1	1
Percentage	.....	16	.....	15	.....	23	.....	20	.....	8	.....	33	.....	75	.....	50

TAGGING DEPTH 50-72 METRES

Halifax, N.S. (Station E, Fig. 1)	5	0	37	8	28	7	17	4	3	0	1	0	1	0	.....	.....
Cheticamp July 23, 1937	.....	.....	.....	.....	2	3	2	2	1	0	.....	.....	.....	.....	.....	.....
Cheticamp July 26, 1937	.....	.....	1	2	1	2	1	1	.....	.....	.....	.....	.....	.....	.....	.....
Totals	5	0	38	10	31	12	20	7	4	0	1	0	1	0	.....	.....
Percentage	.....	0	.....	21	.....	28	.....	26	.....	0	.....	0	.....	0	.....	.....

TAGGING DEPTH 73-95 METRES

Egg Island (Station A, Fig. 1)	.....	.....	6	1	27	11	27	10	10	4	3	1	3	0	.....	.....
Halifax, N.S. (Station I, Fig. 1)	.....	.....	4	5	9	5	2	2	2	1	1	0	1	1	.....	.....
Halifax, N.S. (Station L, Fig. 1)	1	0	1	3	5	1	2	2	1	1	.....	.....	.....	.....	.....	.....
Halifax, N.S. (Stations P, S, T, V, Fig. 1)	2	0	10	1	3	2	4	3	4	1	.....	.....	0	1	.....	.....
Totals	3	0	21	10	44	19	35	17	17	7	4	1	4	2	.....	.....
Percentage	.....	0	.....	32	.....	30	.....	33	.....	29	.....	20	.....	33	.....	.....

a third of the cod were found to be spawning in mid-August, 1937, with the others about equally divided between almost ripe and spent. Dannevig (1919) found numbers of cod eggs off the eastern end of the Gaspé peninsula from early June to mid-August, 1915.

During October and November spawning occurred along the outer Nova Scotian coast in St. Margaret Bay, Halifax Harbour, and to a small degree in Chedabucto Bay (McKenzie, 1940). Ambrose (1867) also found cod spawning in St. Margaret Bay, N.S., in October and mentioned that they were short chunky fish. Neilsen (1893) found autumn cod spawning in Trinity Bay, Newfoundland, and Graham (1923) indicated the possibility of these being a different race. This agrees with our observations and is perhaps related to the small average number of vertebrae. The autumn-spawning cod of Halifax Harbour move onto the spawning grounds in late September and early October, and spawn mainly in falling temperatures of 12°C. to 8°C. They spend the winter off the mouth of the harbour and in the early spring disappear until the following autumn. This movement, well up the harbours and into warm water, seems definitely associated with spawning for at this season there are usually no other cod within miles.

Cod movements thus are associated with spawning in the case of the autumn spawners on the outer Nova Scotian coast and the summer spawners off northwestern Cape Breton. In offshore waters the congregation of "steak" cod on southwestern Sable Island Bank in early April, and the concentrations on eastern Banquereau in late April and early May, also appear to be related to spawning.

Relation of Feeding to Movement of Cod

Fish usually eat little or nothing during spawning and feed actively when spawning is over. Schmidt (1931) indicates that after spawning the Icelandic cod move back to the northeastern coast of Iceland and some to Greenland, this spreading out during the summer providing better opportunities for feeding and growth. Friele (1879) points out that, after spawning at Lofoten when cod lose much weight, the presence of capelin is important to cod abundance off northern Norway, and Hansen (1949) that extensive migrations are associated with feeding on capelin and sand lance in Greenland. In 1948 Templeman showed that along the Newfoundland coast large schools of cod follow the spawning capelin each year close in to shore.

The area under consideration exhibits no large-scale, well-defined cod movements in relation to feeding. The movement into the Gulf of St. Lawrence from offshore might be considered a dispersal after spawning for feeding. The same is true of the movement of cod tagged on Sable Island Bank, Middle Ground and western Banquereau in late April, May and June, to inshore waters of eastern Nova Scotia after spawning. Herring spawning along the Nova Scotian coast during the spring and early summer increases the food available there. We do not have enough information to assess the importance of the relationship between cod movement and feeding.

THE EFFECTS OF MOVEMENT OF COD ON THE FISHERY

The seasonal patterns in the cod landings of various districts have been noted. Each district in Table V had periods of high and of low landings or even of none at all. Some of the low points were attributable to bad weather or ice conditions. Some of these changes are, however, associated with the pattern of population movements developed above.

The inshore cod landings of south western Nova Scotia usually show a peak in late spring or early summer. The cod of this region, after spending the winter in the deeper inshore waters, move back towards shore, being found in quantity in the shoalest water for the year about July (McKenzie, 1934a). The same shift to deeper water was shown to take place off Halifax (McKenzie, 1934a) and the recaptures from the 1934 Halifax tagging were found to originate in water 50% deeper during the winter than the summer. The return movement to shallower depths in the spring and early summer accounts in no small degree for the mid-summer peak in the landings of this region. In the Halifax area, unlike other parts of the outer coast of Nova Scotia, there is usually a perceptible increase in landings in January as compared to November and December. At this time of year the autumn spawning cod from Halifax Harbour and St. Margaret Bay have usually moved out of the inlets. The mixing there with the other inshore cod may help to improve the fishing to some extent until severe winter weather interferes.

Along the eastern coast of Cape Breton and at the Magdalen Islands there are two annual peaks in the cod fishery—one in June and one in the autumn (Table XXXIV). We have seen that cod move inshore in early summer towards

TABLE XXXIV.—Monthly cod landings on the east coast of Cape Breton and the Magdalen Islands, 1939, in thousands of pounds.

	East coast Cape Breton	Magdalen Islands
January	498	0
February	0	0
March	0	0
April	0	0
May	243	30
June	1,181	1,961
July	880	975
August	611	981
September	490	362
October	1,103	1,135
November	753	727
December	1,948	0

the Gulf of St. Lawrence along eastern Cape Breton to the Magdalen shallows and even as far as Gaspé. This movement is believed to be at least partially responsible for the success of the fishery in these regions in June. The peak in the autumn may be due in part to cod movement out of the Gulf at this time of year.

On the northwest coast of Cape Breton it is reported that numbers of the fishermen shift operations early each summer some distance to the northeastward along the coast in order to meet the cod moving onto their grounds from the northeast. In the autumn it is reported that they again shift operations towards the northeast along shore but this time they move gradually eastward, following the fish as the schools seem to move towards Cape North and away for the "winter". The arrival in early summer of these fish from the northeast precedes the peak of the summer fishery in this region.

The cod landings from the Nova Scotian eastern offshore banks usually showed two peaks each year—one in March and April on the western part of Sable Island Bank and Emerald Bank, and one on eastern Banquereau in October and November (McKenzie, 1942). We have already noted that the former was associated with a concentration of large spawning cod. The latter coincided with the increase in the numbers of recaptures from the offshore and Gulf taggings after the summer low period. It seems that the movement of cod to the "Eastern Shoals" of Banquereau from the Cape Breton and western Gulf area was large enough to bring about the yearly peak in the fishery on this bank.

ACKNOWLEDGMENTS

The cordial co-operation of the Captains and crews of the following vessels from which tagging operations were conducted is gratefully acknowledged: Captain Wm. Deal of the *E. F. Zwicker*, Captain George Himmelman of the *Haligonian*, Captian Frank Meisner of the *Harriet and Vivian*, Captain Oran Mossman of the *Marjorie and Dorothy*, as well as the assistance of R. Kaiser, R. Fralich and W. Brown in tagging.

Thanks are extended to: C. K. Darrach, then of the Board's Technological Station, Halifax, N.S., for his assistance in the collection of information and records, and his tagging of over four thousand cod on offshore grounds; Captain A. E. Calder of the M.V. *Zoarces* of the Board's Biological Station, St. Andrews, N.B., for his supervision of the tagging of about five thousand cod and for sharing, during the past twenty years, his large fund of knowledge of Canadian Atlantic fish and fisheries acquired over a lifetime spent on the Atlantic coast, much of it in biological fisheries work; Drs. Wm. C. Herrington and Alfred Perlmutter, of the U.S. Fish and Wildlife Service, for information and records, and all those who supplied information and records of tag recaptures; Drs. A. G. Huntsman, J. R. Dymond, A. H. Leim, and W. J. K. Harkness for much helpful advice.

Special thanks are due to Dr. J.-L. Tremblay, then Director of the Station Biologique du St. Laurent, and to his co-workers, for use of the results of their extensive tagging program around Gaspé that served as a counterpart to the eastern offshore tagging. The tagging off Ellerslie, P.E.I., was carried out by Dr. A. W. H. Needler, when in charge of oyster investigations there.

Finally, grateful appreciation is extended to Dr. W. R. Martin, now in charge of groundfish investigations, and to Dr. A. W. H. Needler, Director formerly of the Board's Biological Station, St. Andrews, and now of its Biological Station, Nanaimo, B.C., for their untiring and kindly criticisms and helpful suggestions in the preparation of this paper.

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Manuscript reports containing the details concerning the taggings and recaptures discussed in this account are on file at the Fisheries Research Board of Canada's Biological Station, St. Andrews, N.B., Canada.