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Migration and Intermingling of Cod in Relation to the Canadian  
200-mile Limit Around the Nose (NAFO Division 3L) and the  
Tail (NAFO Division 3N) of the Grand Bank

by

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Introduction

With the inception of the 200-mile limit in 1977, the distribution and range of most of the major cod stocks in the Newfoundland-Labrador area were enclosed within the zone. The distribution of Atlantic cod extends beyond the 200-mile limit in two specific and biologically significant areas. These are the nose of the bank, mainly in the eastern part of NAFO Div. 3L and the northeastern part of 3N and the tail of the bank which is a large area encompassing about two-thirds of the total area of the Southeast Shoal of the Grand Bank in NAFO Div. 3N as well as a part of 3Q (Fig. 1).

The aim of this paper is to present published data and some recent results of cod tagging to demonstrate the relationship among the cod stocks which occur in NAFO Div. 2J, 3K, 3L, and 3NQ and of the cod whose distribution lies outside the 200-mile limit mainly along the nose and tail of the Grand Bank.

Results of Tagging Experiments

For the purpose of analyzing the results of past tagging experiments (Templeman and Fleming 1962; Templeman 1974 and 1979), the nose of the Bank has been defined as those unit areas between 45°N and 48°N which lie outside or partially outside (>one-third of the area of the unit outside) the 200-mile limit. The tail of the Bank has been defined in a similar way for the areas south of 45°N to 42°30'N (Fig. 1).

During 25-27 April 1964, 768 cod were tagged at a depth of 294-391 m on the nose of the Bank at a position which corresponds to the 200-mile limit boundary (Templeman 1979). During May-September of the tagging year (1964), 24 tags were reported of which 21 were on the central part of the Grand Bank in the vicinity of the Virgin Rocks and the Eastern Shoals (Fig. 2). There was one recapture from inshore in the St. Mary's Bay area. During October-December 1964 there were two recaptures, one from the coastal area east of Cape Race and one from the southeast Grand Bank on the 200-mile limit boundary.

During January-May of succeeding years after the tagging year most of the reported recaptures were from the Grand Bank although there was one from Western Newfoundland in the Gulf of St. Lawrence (Fig. 3). There were two returns from outside the 200-mile limit on the nose and the tail of the Bank. Most of the recaptures were from the central part of the Grand Bank.

During June-September 1955-74, most of the recaptured tags were reported from the central part of the Grand Bank in the vicinity of the Virgin Rocks (Fig. 4) confirming the pattern demonstrated during the year of tagging. Six tags were reported from the southern Grand Bank and two from the northern edge of the Grand Bank. There were 4 returns from coastal Newfoundland, all in NAFO Div. 3L. There was one return from Nain Bank, Labrador (NAFO Div. 2H).

The results of this tagging suggest that the cod which are concentrated on the nose of the Bank during spring migrate during summer, westwards over the central part of the Grand Bank and to the coastal area mainly around the Avalon Peninsula. There is also some migration to the southern Grand Bank. There is negligible migration northwards beyond the northern boundary of NAFO Div. 3L.

During 19-22 March 1983, 1984 mainly adult cod (45 cm and larger) were tagged on the northeastern slope of the Grand Bank (Fig. 5) about 50 miles inside the 200-mile boundary. The single tag return during each of March and April suggested that some of the cod were beginning to migrate from the deeper water up to the northern slope of the Grand Bank. During June-September 1983 there were seven returns, four from inshore in NAFO Div. 3L and three from the vicinity of the Virgin Rocks and the Eastern Shoals of the Grand Bank. During October-December there was one return near the coast of the southwest Avalon Peninsula and one from the northern part of NAFO Div. 3Ø. During January-May 1984, there were two returns from the vicinity of the tagging area on the northeastern slope of the Grand Bank and one from the nose of the Bank outside the 200-mile limit (Fig. 6).

During June-September 1984, there were five returns, three from the Virgin Rocks, one off Cape Bonavista and one near Fogo (Fig. 7). The returns during the June-September periods of 1983 and 1984 indicate a summer migration to the central part of the Grand Bank mainly the shallow area around the Virgin Rocks and Eastern Shoals and some inshore migration to coastal Newfoundland, mainly in NAFO Div. 3L.

During 1947 and 1948 about 4,200 cod were tagged in the Newfoundland and Labrador inshore areas and on the Grand Bank and St. Pierre Bank (Templeman and Fleming 1962). From these taggings, there was only one recapture from the nose of the Bank, outside the 200 mile limit. This was the only recapture from 58 cod tagged at a depth of 70-73 m on the central part of the Grand Bank (Table 1).

During 1954-55 there were 18,822 adult Atlantic cod (50 cm or more in length) tagged in the feeding season (April-November) at 13 localities in the Newfoundland area (Templeman 1974). About 26% of these cod were subsequently recaptured and reported. There were 21 recaptures reported from the nose of the Bank and 19 from the tail of the Bank (Table 1). Of the 22 recaptures on the nose of the Bank, there were 8 from inshore tagging at Fermeuse, 3 from Bonavista and 1 each from Cape Pine and Cape St. Mary's. There were 7 recaptures from tagging at the Virgin Rocks, indicating a relationship among the cod which migrate inshore to eastern Newfoundland to feed during the summer, those of the Virgin Rocks and those of the nose of the Grand Bank. Of the 19 recaptures from the tail of the Bank, 6 were from taggings on the Southeast Shoal, indicating a relationship between the cod found on the Shoal in summer and the cod found on the tail of the Bank during all times of the year but mainly October-May (Table 1). Other recaptures were from taggings at Fermeuse, Cape Pine, Cape St. Mary's, St. Pierre Bank, and the Virgin Rocks.

During 1962-66, there were 47,560 cod tagged at many inshore localities from northern Labrador, southwards along the Labrador coast around the Newfoundland coast and the Quebec North Shore, from offshore localities from Hamilton Bank to the Eastern Grand Bank, Flemish Cap, St. Pierre Bank and Gulf of St. Lawrence (Templeman 1979). From these taggings there were about 15,500 recaptures (32.6%). In addition to those recaptures reported in Fig. 5-7, there were 34 recaptures from the nose of the Bank and 11 from the tail of the Bank (Table 2). Of the 34 recaptures on the nose of the Bank, there were 24 from taggings at inshore localities in NAFO Div. 3L, 5 from offshore areas in 3L and the remainder from 3Ps and 3K, again indicative of migration from inshore feeding areas to the nose of the Bank outside the 200-mile limit.

Of the 11 returns from the tail of the Bank, there was 1 return from tagging on Hamilton Bank while the most returns were from taggings in 3L, 3N, 3O, and 3Ps. There were 5 returns on the tail of the Bank from taggings in inshore localities in NAFO Div. 3L.

About 25,000 Atlantic cod (>45 cm and larger) were tagged from prespawning concentrations on Hamilton Bank, Belle Isle Bank, Funk Island Bank, and northern Grand Bank during February-March 1978-81 (Lear 1984). From the Hamilton Bank tagging, there were only two recaptures from the nose of the Grand Bank while from the Belle Isle Bank there were none. From the three tagging experiments on northern Funk Island Bank during 1978, 1979, and 1981 there was only one return from the nose of the Bank and one from the tail of the Bank. From the taggings on the eastern and southeastern slopes of Funk Island Bank, there were only two recaptures from the nose of the Bank and two from the southern Grand Bank. From the western and southwestern Funk Island Bank taggings, there was only one return from the nose of the Bank. The tagging on the north cape of the Grand Bank resulted in 12 recaptures along the eastern slopes of the Grand Bank in the area of the nose. These recaptures were obtained during May-December and indicated a summer migration of some of the north cape component southwards along the eastern slopes of the Grand Bank, outside the 200-mile limit.

Of 35,293 cod tagged in Subareas 2 and 3 from 1960-66 by scientists of the Polar Research Institute (PINRO), none were reported being recaptured on the nose or tail of the Bank (Konstantinov 1967).

Of 1,884 cod tagged in NAFO Div. 2H, 2J, and 3K during 1960-62, there were no recaptures reported from the nose or tail of the Bank (Sidorenko and Postolaky 1963).

During 1960-64, a total of 22,534 cod were tagged off Labrador and northern Newfoundland (Subarea 2 and NAFO Div. 3K) (Postolaky 1966). From this tagging, no recaptures were reported on the nose or the tail of the Grand Bank.

### Vertebral Averages

On the basis of vertebral averages Templeman (1962) stated that in the deep water over or close to 185 m on the northern and northeastern parts of the Grand Bank, there are large schools of cod with vertebral numbers very similar (54.8-55.3 including urostylar half-vertebra) to those of the coastal and offshore populations of the east coast of Newfoundland and Labrador. The southern part of the Grand Bank shallower than 90 m, the southwestern slope and the southern two-thirds of the eastern slope are occupied by cod with vertebral averages between 53.2 and 54.3 with almost all the averages below 54 (including the urostylar half-vertebra). There is a small area of mixtures of the northern and southern types lying near the 185 m contour on the eastern slope of the Grand Bank between 45°30'N and 46°N, i.e. the nose of the Bank.

Templeman (1981) analyzed 416 cod vertebral samples (about 42,000 specimens) collected from the Newfoundland and adjacent areas during 1947-71. The vertebral averages from the northern, eastern, and southern Grand Bank areas for the 1947-60 and 1961-71 periods have been extracted from Templeman's (1981) figures. These averages (Fig. 8) illustrate Templeman's (1962) conclusions regarding the low vertebral averages on the southern and eastern Grand Bank (specifically the tail of the Bank). On the northeastern slopes of the Grand Bank, the cod are characteristic of the high-vertebral average Labrador-East Newfoundland (2J3KL) cod stock complex. However, relatively unmixed schools of high-vertebral count fish appear to have migrated along the eastern slope of the Grand Bank (i.e. nose of the Bank) as far south as 45°30'N (Div. 3N), as evidenced by a sample with a vertebral mean of 55.28 (Fig. 8). There were some samples with vertebral averages of intermediate value (54.13 to 54.82) which indicated intermingling of northern cod with more southern groups on the nose of the Bank. One particular sample from about 46°N with an average of 53.82 indicated an unmixed school of southern cod from the southern Grand Bank.

### Evidence from Infection of Cod with the Adult Copepod Lernaeocera branchialis

Infection rates of cod with the adult copepod Lernaeocera branchialis were found useful as evidence of inshore and offshore migrations of cod (Templeman et al. 1976). In Div. 3L, cod from offshore west of 50°W (mainly northwest Grand Bank and slopes and Avalon Channel) had high rates of infection, similar to those of inshore cod, at the 21-40 cm range. The larger cod had lower rates of infection than inshore cod, but higher at all length ranges, especially at 11-40 cm than cod from east of 50°W. Templeman et al. (1976) concluded that the smaller of the offshore cod of Div. 3L west of 50°W visited the shore as much as cod of these sizes taken inshore in 3L. However, about half the offshore cod of the larger sizes from west of 50°W apparently migrated from areas where little or no direct infection occurred such as NAFO Div. 3L (east of 50°W, i.e. nose of the Bank) and southern Grand Bank (NAFO Div. 3N and 3O). They found that the smaller and the larger northern Grand Bank cod, from Div. 3L east of 50°W, had comparatively little infection by the copepod and consequently much less relationship with the coast than fish of intermediate length (41-60 cm) which had about half the infection of offshore fish west of 50°W and between one-third and one-quarter that of the coastal fish of 3L. They concluded that the smaller fish are likely to be native to the area and that many of the larger fish were immigrants from the centres of low infection, Div. 3N and 3O.

### Summary

1. Results of tagging on the nose of the Bank at the boundary of the Canadian 200-mile limit indicate that Atlantic cod, which overwinter in this area, migrate during summer, westwards over the central part of the Grand Bank and to the coastal area mainly around the Avalon Peninsula. There is also some migration to the southern Grand Bank (NAFO Divisions 3N and 3O) during the summer.
2. Results of tagging at inshore locations in eastern and southern Newfoundland (mainly in NAFO Division 3L) indicate that some of the cod which migrate inshore during the summer, also migrate to the nose of the Grand Bank either during the winter or may remain outside the Canadian 200-mile limit in summers of subsequent years.
3. Results of inshore tagging also confirm that some of the cod which inhabit the coastal area of southeastern Newfoundland during summer may migrate to the area of the tail of the Bank outside the Canadian 200-mile limit during subsequent years.
4. Results of tagging on the Southeast Shoal indicate a subsequent migration of some cod to the tail of the Bank outside the Canadian 200-mile limit.
5. Cod of the western Grand Bank were also observed, from results of tagging to display a migration to the area of the tail of the Bank outside the Canadian 200-mile limit.
6. On the basis of vertebral averages of cod sampled on the eastern and southern Grand Bank it is concluded that the cod in the area of the northeastern Grand Bank are characteristic of the high-vertebral average Labrador-east Newfoundland (2J3KL) cod stock

complex. In the area around the nose of the Bank the averages are generally of intermediate value indicating a mixture of cod from the northern and southern Grand Bank. However, relatively unmixed schools of high-vertebral count cod were observed to migrate along the nose of the Bank as far south as 45°30'N (NAFO Division 3N).

7. The southern part of the Grand Bank shallower than 90 m, the southwestern slope and the southern two-thirds of the eastern slope (i.e. tail of the Bank) are occupied by cod with vertebral averages between 53.2 and 54.3 (i.e. southern Grand Bank type).
8. On the basis of infection rates of cod with the adult copepod (Lernaeocera branchialis) it can be concluded that about half the offshore cod of the larger sizes of NAFO Division 3L from west of 50°W (mainly northwest Grand Bank and Avalon Channel) apparently migrated from areas where little or no direct infection occurred such as NAFO Division 3L (east of 50°W, i.e. nose of the Bank) and southern Grand Bank (NAFO Divisions 3N and 3O).

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Table 1. Tagging locations, dates, and numbers tagged for cod tagging experiments from which some cod were subsequently recaptured on the nose and the tail of the Grand Bank. (Data extracted from Templeman and Fleming 1962 and Templeman 1974).

Tagging Location	Date Tagged	Number tagged	Recapture period	Number of recaptures		
				Total	Nose of the Bank	Tail of the Bank
Central Grand Bank (45° 50'N; 50° 25'W)	June 6 1948	58	Nov.-Dec. 1948-1952	1	1	0
Bonavista (48°47'30"N, 53°02'38"W)	September 24-Oct. 2 1954	2690	June-Sept. 1955-1966	386	3	0
Fermeuse (46°52'30"N; 52°50'W)	Nov. 10-27 1954	2693	Jan.-May 1955-1965	103	0	1
"	"	"	June-Sept. 1955-1965	583	8	2
"	"	"	Oct.-Dec. 1955-1965	101	0	1
Cape Pine (46°34'N, 55°33'15"W)	Oct. 15-17 1954	1351	Jan.-May 1955-1964	50	0	1
"	"	"	June-Sept. 1955-1964	267	1	1
Cape St. Mary's (46°41'30"N, 54°02'W)	Oct. 19-21 1954	1335	Jan.-May 1955-1968	74	0	1
"	"	"	June-Sept. 1955-1968	317	1	1
"	"	"	Oct.-Dec. 1955-1968	28	0	1
St. Pierre Bank (46°34'30"N, 56°57'W)	May 20-June 2 1954	1343	Jan.-May 1955-64	57	0	2
"	"	"	June-Sept. 1955-1964	166	0	1
Virgin Rocks (46°32'N, 50°48'N)	Sept. 27-Oct. 1 1955	1522	Jan.-June 1956-1967	73	2	0
"	"	"	July-Sept. 1956-1967	160	5	0
"	"	"	Oct.-Dec. 1956-1967	37	0	1
Southeast Shoal (44°54'N, 50°03'W)	Sept. 11-14 1955	490	Jan.-May 1956-1963	22	0	2
"	"	"	June-Sept. 1956-1963	21	1	2
"	"	"	Oct.-Dec. 1956-1963	9	0	2

Table 2. Tagging locations, dates, and numbers tagged for cod tagging experiments from which some cod were subsequently recaptured on the nose and the tail of the Grand Bank. (Data extracted from Templeman 1979).

Tagging Location	Date Tagged	Number tagged	Recapture period	Number of recaptures		
				Total	Nose of the Bank	Tail of the Bank
NE Hamilton Bank	Apr. 20-22, 1966	1120	June-Aug. 1965-1974	91	0	1
SE Hamilton Bank	May 10-14, 1964	1152	June-Sept. 1965-1974	26	1	0
S. Side Hawke Channel	May 15-16, 1964	768	June-Sept. 1965-1974	262	1	0
Grey Islands	Nov. 8-19, 1963	1152	June-Sept. 1964-1974	380	6	1
Cape Bonavista	Oct. 1-13, 1962	1536	June-Sept. 1963-1974	419	8	0
Baccalieu Island	Oct. 14-Nov. 2, 1964	1920	June-Sept. 1963-1974	84	2	0
Cape Spear	Nov. 3-25, 1962, 1964	1152	Jan.-May 1966-1974	294	3	1
" "	Nov. 22-Dec. 18, 1965	"	June-Sept. 1966-1974	122	1	1
Fermeuse	Oct. 5-25, 1963	2304	Jan.-May 1964-1974	816	4	0
" "	" "	"	June-Sept. 1964-1974	83	1	0
Fortune	Oct. 23-Nov. 11, 1965	384	June-Sept. 1966-1974	50	0	1
North Cape Grand Bank	Apr. 18-20, 1964	1536	June-Dec. 1964	26	1	0
" " " "	May 20-21, 1964	"	June-Sept. 1965-1974	47	1	0
Virgin Rocks	July 6-8, 1963	1152	Feb.-May 1964-74	109	2	0
" "	" "	"	June-Sept. 1964-1974	175	1	3
Western Grand Bank	Apr. 28-30, 1964	1920	June-Sept. 1964-1974	31	1	1
Halibut Channel	May 4-13, 1965	863	June-Sept. 1964-1974	224	0	2
Cape Pine to Point Lance	Jan. 16-20, 1963	2304	Jan.-May 1964-1974	25	1	0
N. St. Pierre Bank	Jan. 22-25, 1965	1152	Oct.-Dec. 1964-1974			
	Nov. 6-Dec. 12, 1963					
	Sept. 14-20, 1965					
	May 3-24, 1963					

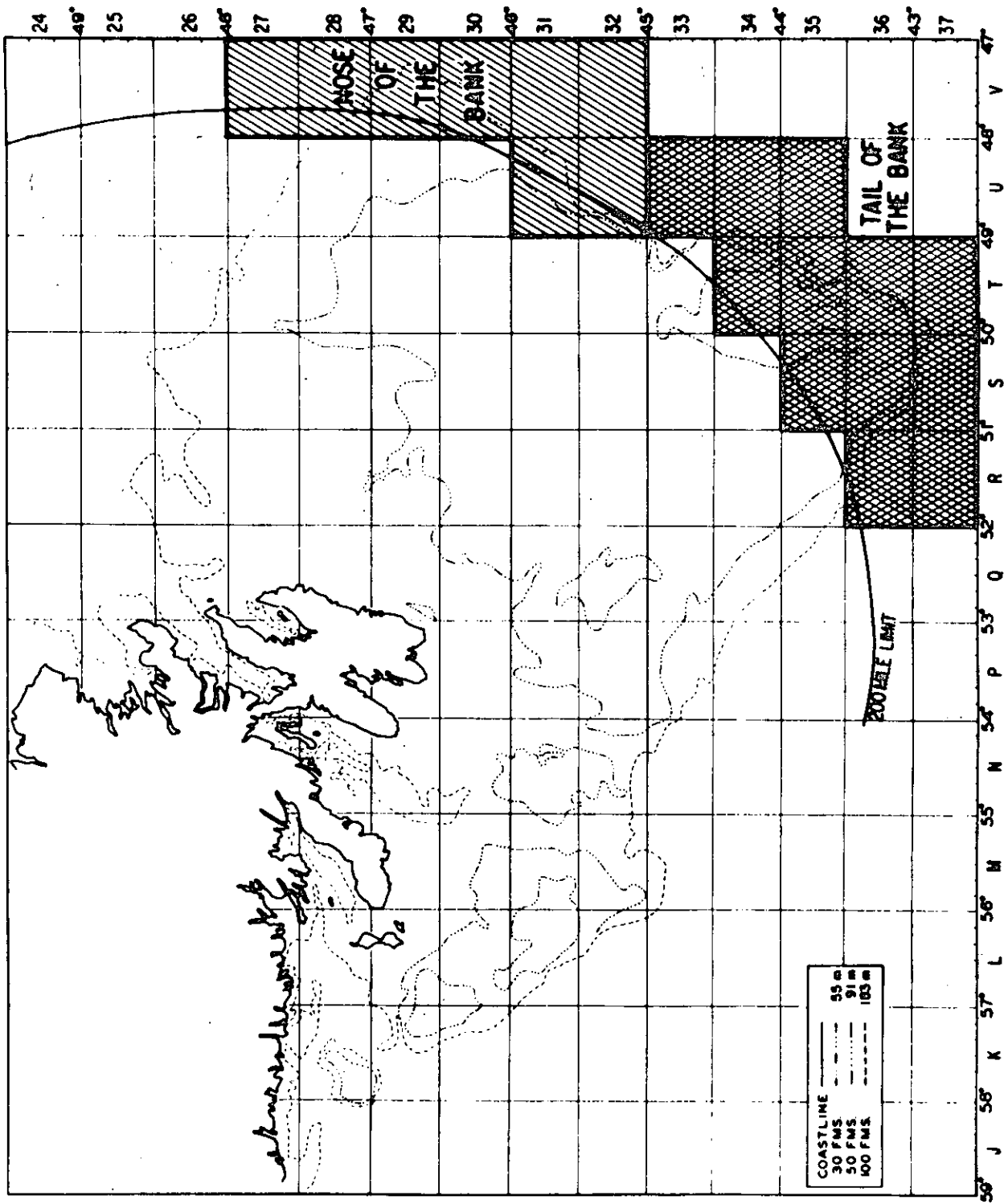


Fig. 1. Area map of the Grand Banks showing the Nose of the Bank and Tail of the Bank as defined for presentation of tagging results.

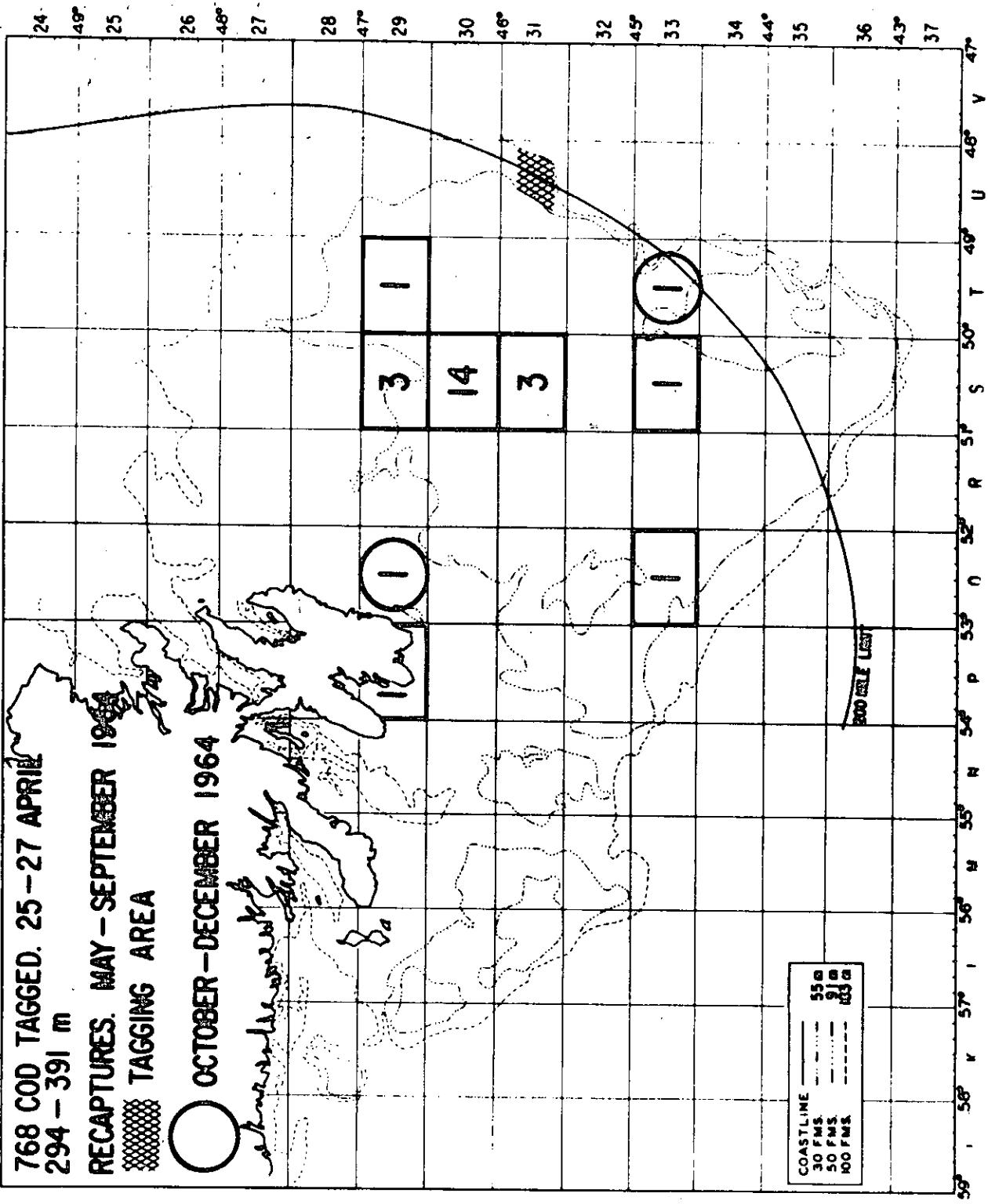


Fig. 2. Location of returns during May-September and October-December 1964 from 768 cod tagged on the eastern Grand Bank during 25-27 April, 1964.



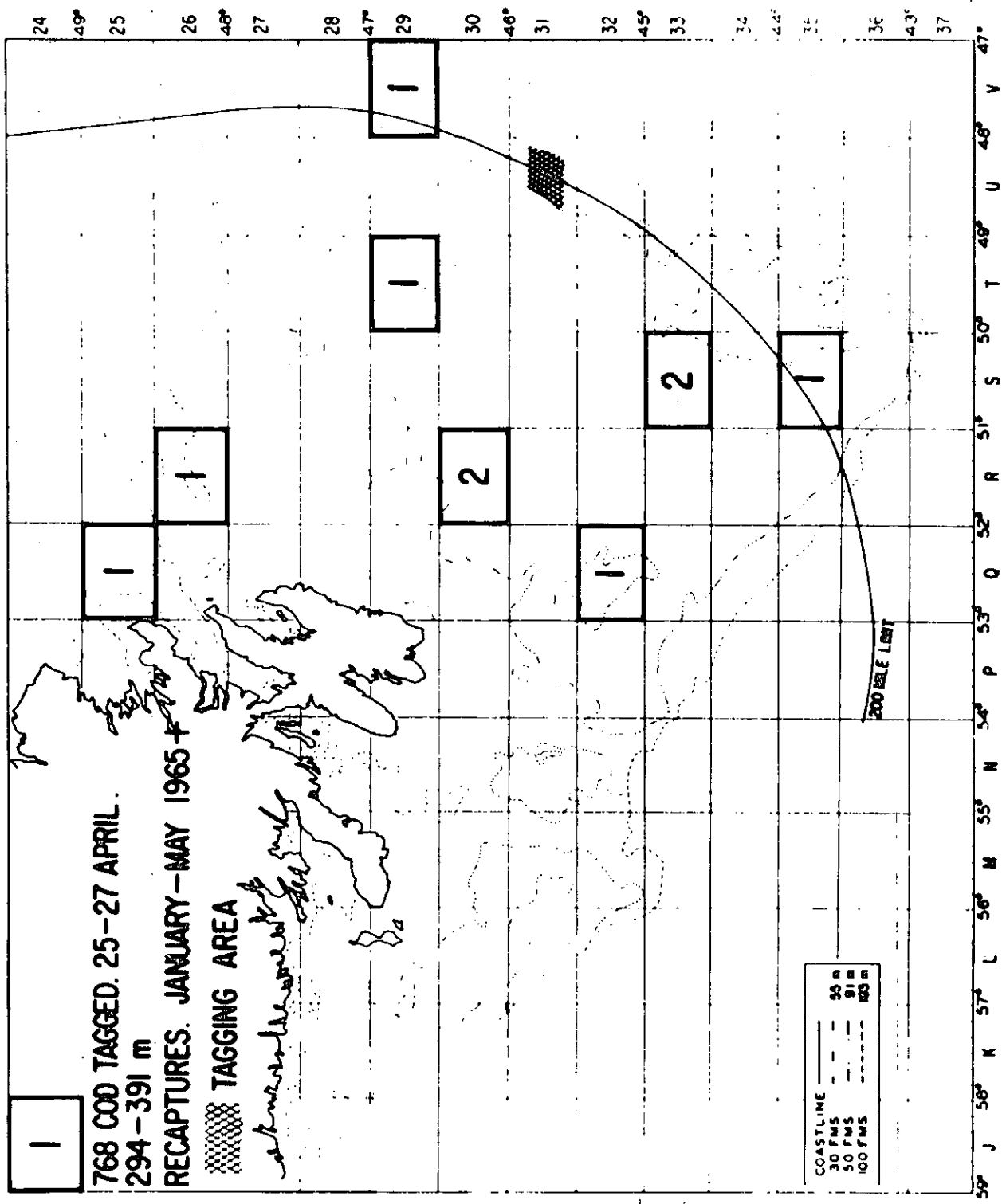


Fig. 3. Location of returns during January-May 1965-76 from 768 cod tagged on the eastern Grand Bank during 25-27 April, 1964.

1 - MAIN BANK - LABRADOR

768 COD TAGGED. 25-27 APRIL

294 - 391 m

RECAPTURES. JUNE-SEPTEMBER 1965

1 TAGGING AREA

1 OCTOBER-DECEMBER 1965+

*Labrador Current*

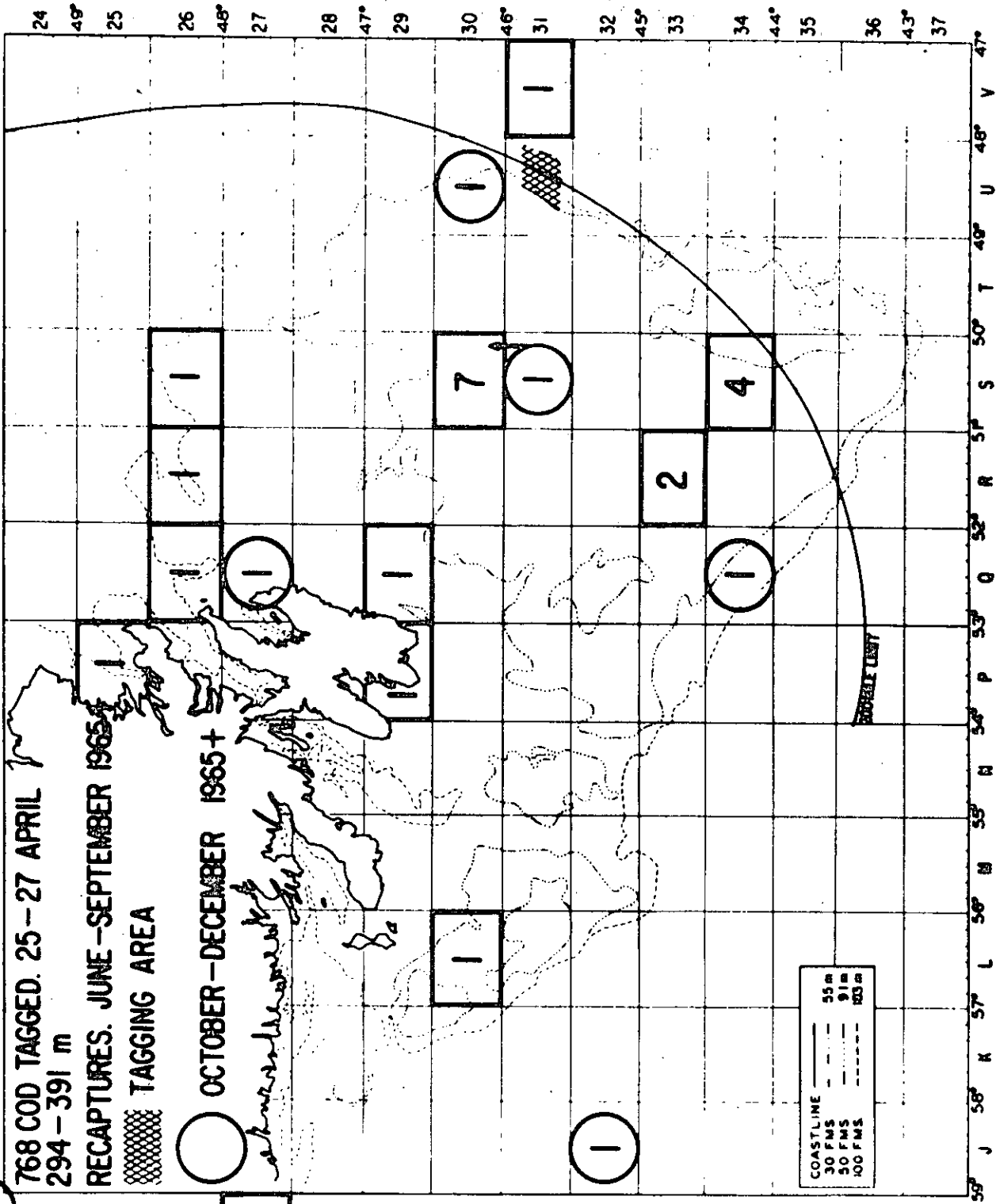


Fig. 4. Location of returns during June-September and October-December 1965-74 from 768 cod tagged on the eastern Grand Bank during 25-27 April, 1964.

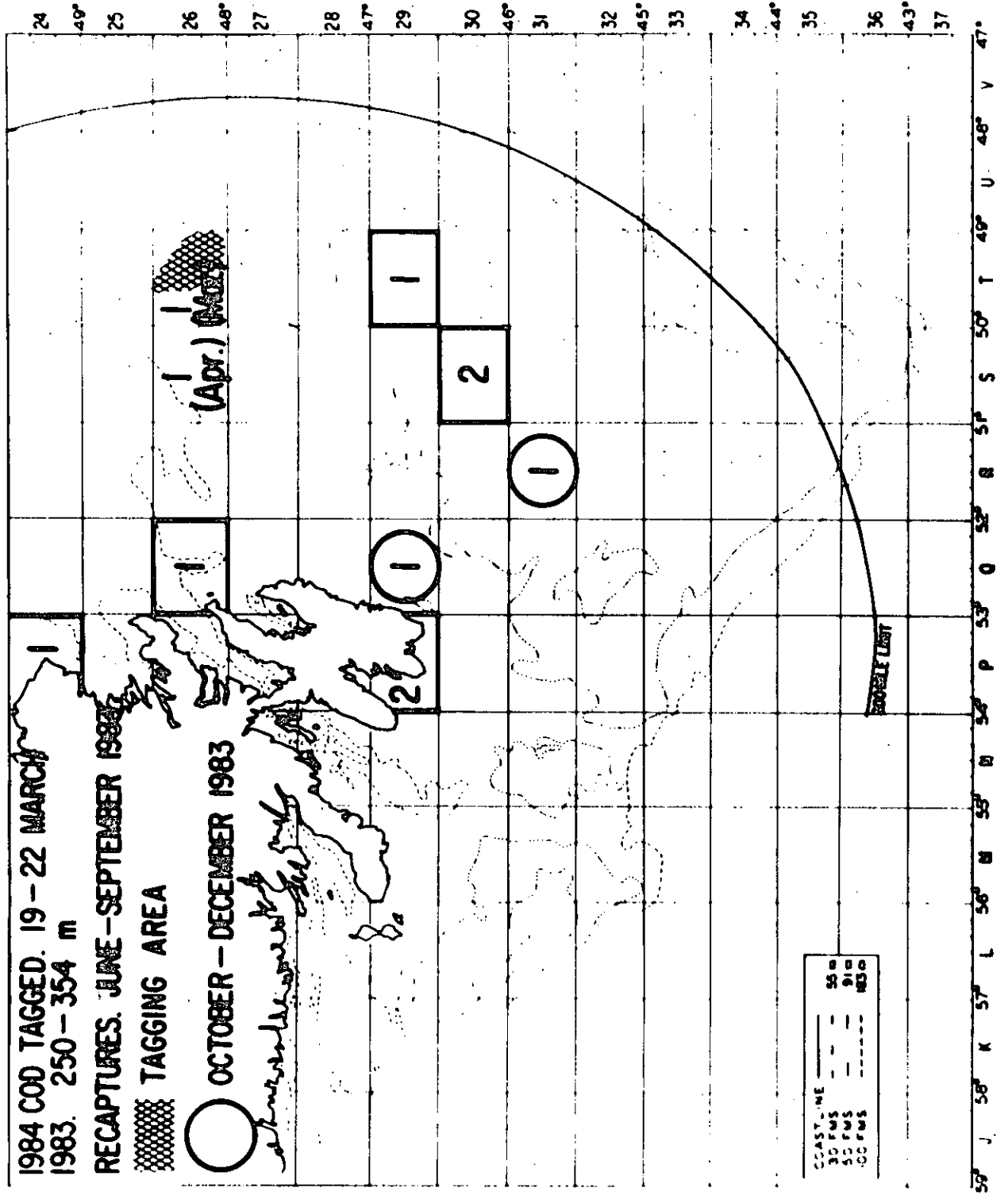


Fig. 5. Location of returns during April, March, June-September and October-December 1983 from 1984 cod tagged on the northeastern Grand Bank during 19-22 March, 1983.

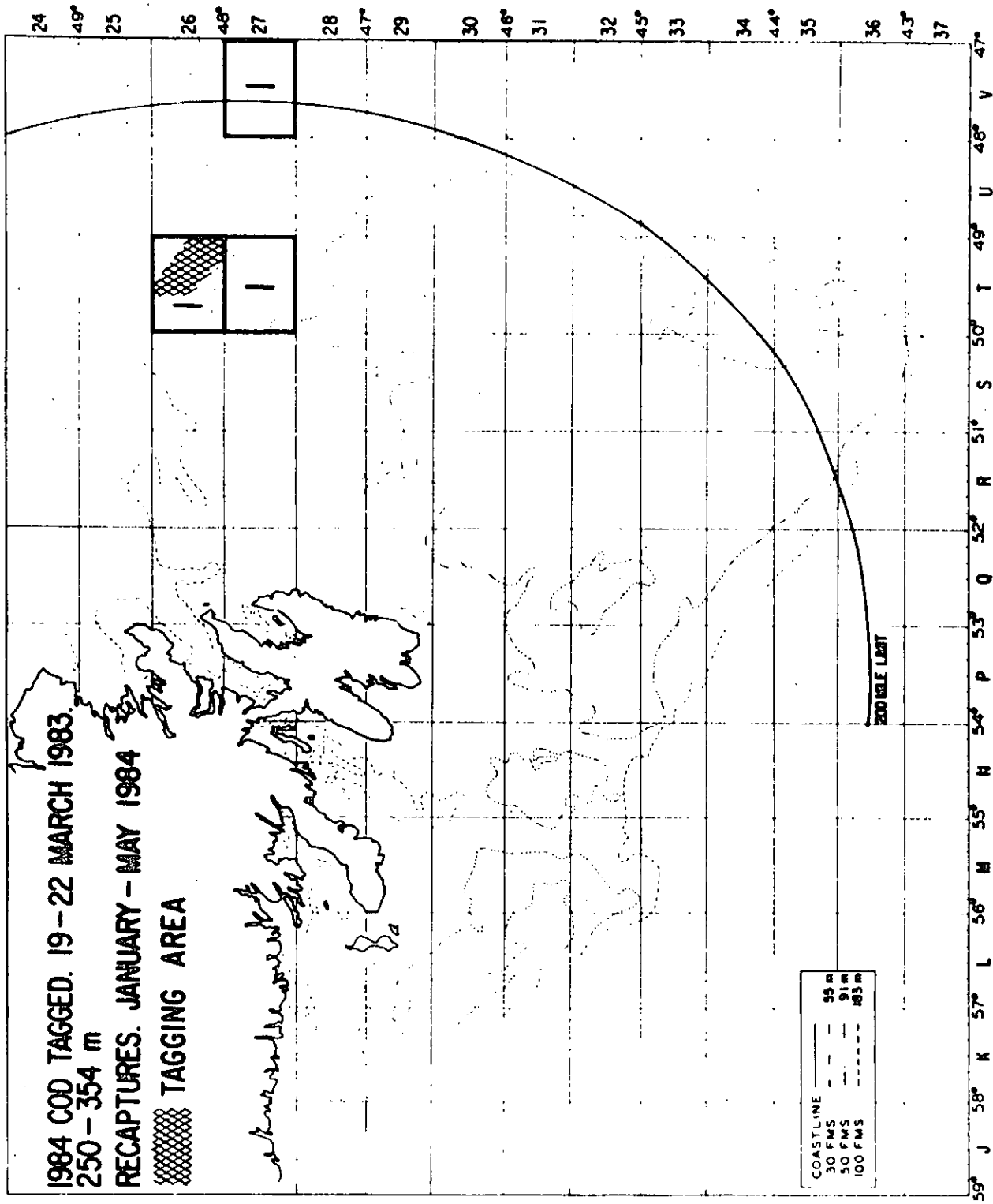


Fig. 6. Location of returns during January-May 1984 from 1984 cod tagged on the northeastern Grand Bank during 19-22 March, 1983.

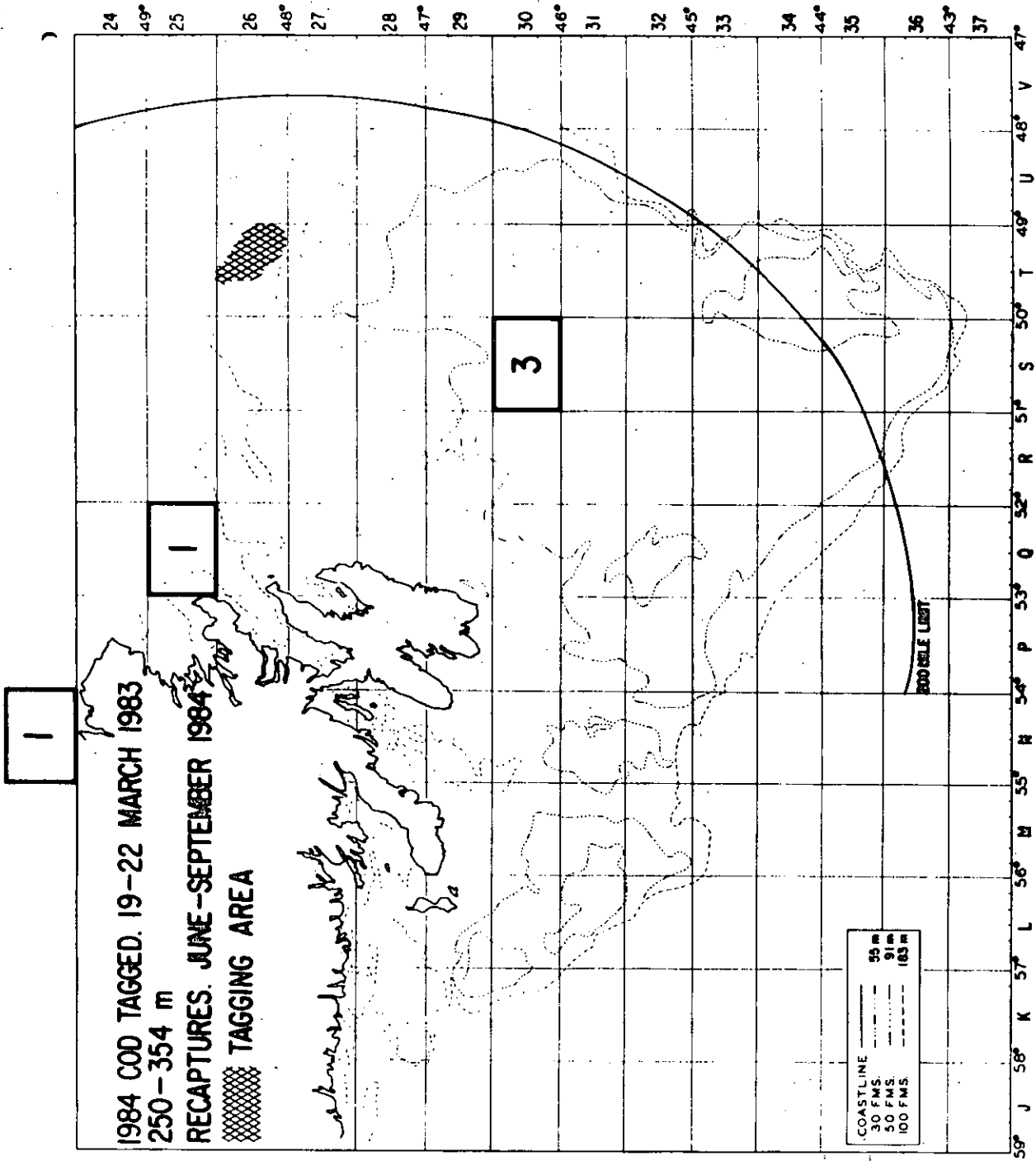


Fig. 7. Location of returns during June-September 1984 from 1984 cod tagged on the northeastern Grand Bank during 19-22 March, 1983.

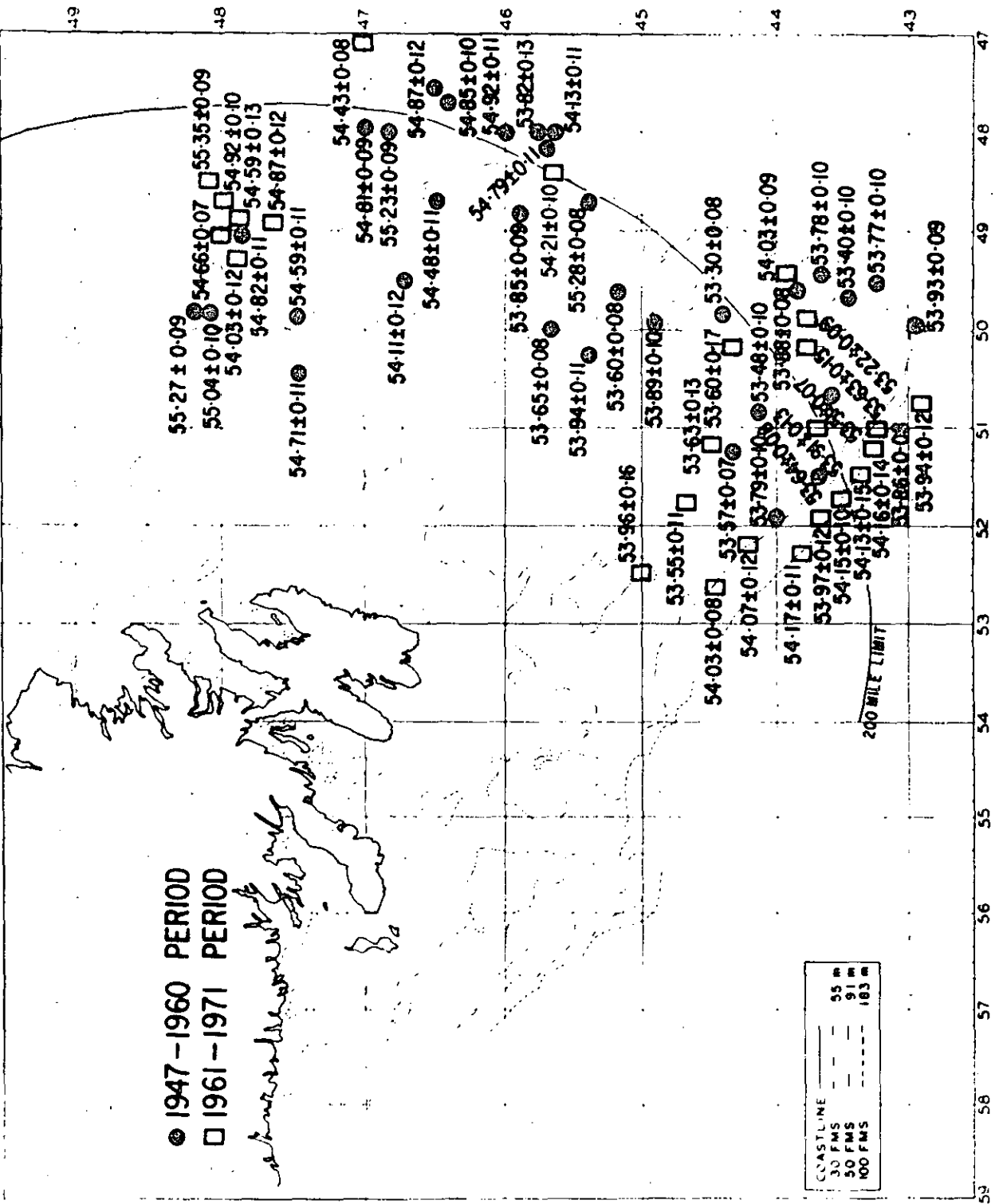


Fig. 8. Vertebral averages (including urostylar half-vertebrae) and standard errors for the samples from the eastern and southern Grand Bank for the 1947-60 and 1961-71 periods. (Data extracted from Templeman 1981.)