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The Timing of the Winter Migration of 4T Cod into 4Vn

by

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¹La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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ABSTRACT

Three independent sources of information, analysis of catch in NAFO Subdivision 4Vn, tagging studies, and movements of the mobile gear fishing fleet indicate that two groups of cod leave the Gulf of St. Lawrence (4T) to overwinter in the Sydney Bight region (4Vn). An analysis of length-at-age carried out on cod caught within 4Vn shows that Gulf of St. Lawrence cod (which are considerably smaller-at-age than Scotian Shelf cod) were present in large numbers in the autumn as well as the winter. Commercial fishing fleet movements corroborate cod tagging results which show migration of Gulf cod out of 4T which begins in October and is largely complete by December.

It is suggested that 4Vn resident cod would be better represented by the catch taken from this Subdivision during the months of May to November, inclusive; that is, not including December which is at present included in the 4Vn management season.

RÉSUMÉ

D'après les renseignements issus de trois sources indépendantes l'une de l'autre, soit l'analyse des prises dans la sous-division 4Vn de l'OPANO, des expériences de marquage et les mouvements de la flottille de pêche aux engins mobiles, deux groupes de morue quittent le golfe du Saint-Laurent (4T) pour venir passer l'hiver dans les environs Sydney Bight (4Vn). Une analyse de la longueur selon l'âge de la morue capturée dans 4Vn révèle une abondance de morue du golfe du Saint-Laurent (dont la longueur selon l'âge est considérablement inférieure à celle de la morue de la plate-forme néo-écossaise) tant à l'automne qu'au printemps. Les mouvements de la flotte de pêche commerciale confirment les résultats des expériences de marquage, lesquelles révèlent l'existence d'une migration de morue du golfe hors de 4T, qui commence en octobre et est généralement terminée en décembre.

On estime que les prises de mai à novembre dans 4Vn seraient plus représentatives du stock résidant dans cette sous-division; autrement dit, il faudrait exclure les prises de décembre, qui sont à l'heure actuelle comprises dans les données de gestion de 4Vn.

Introduction

The present system of statistical division of the collection of fisheries statistics is based on the grid established by the North American Council on Fisheries Investigations (NACFI) in 1932 and that was subsequently modified by the International Commission for the Northwest Atlantic Fisheries (ICNAF). The evolution of these fishing areas and the bases upon which they were established are detailed by Halliday and Pinhorn (1990). Evidence derived from movement of tagged fish (Martin 1953, McKenzie 1956) played a major role in the location of boundaries between fishing areas on the Eastern Scotian Shelf and Gulf of St. Lawrence.

Although the existence of separate cod stocks was recognised, the catch from the 4Vn area was not apportioned until 1974. At that time the present 4TVn (January to April) and 4Vn (May to December) management seasons were established. The goal of this paper is to show that cod catch in the 4Vn subdivision during the month of December would be better allocated to the 4TVn management unit.

Evidence

1. Tagging

The tagging data base for cod, originally begun by the Fisheries Research Board of Canada and most recently added to by the Department of Fisheries and Oceans, was recently examined. Information on cod tagged in the Gulf of St. Lawrence between 1955 and 1981 was used to address the issue of the timing of the overwintering migration of 4T cod into the 4Vn subdivision. A total of 30308 cod were tagged throughout the Gulf of St. Lawrence of which 27515 that were applied in two different areas are considered here (Table 1).

The southern Gulf of St. Lawrence was divided into five regions into which cod tag returns were aggregated (Figure 1). The returns were then combined by month over the entire time period. It must be stressed that percentage returns presented here should not be considered reliable since numbers have not been weighted in any way to account for the greater likelihood of tags being returned from areas experiencing greater fishing effort.

Tags returns showed evidence of at least two stocks of cod in the southern Gulf of St. Lawrence; one occurred mostly in the western Gulf in the Bay de Chaleur - Gaspé region (G1) and the origin of the other appeared to be the southeastern Gulf (G4 & G5). These two groups of cod correspond to stocks identified by McKenzie and Smith (1955) and supported by Templeman (1962). Confirmation for these groups being stocks appears to be provided by the identification of two major cod spawning areas by ichthyoplankton studies carried out by the Fisheries Research Board during the 1960's (Figure 4 in Lett 1980). Accumulations of cod eggs occurred between New Brunswick and the western end of Prince Edward Island (The Shediac Valley), and off the west coast of Cape Breton Island, Nova Scotia. In addition, concentrations of juvenile cod occur in much the same areas (Chouinard *et al* 1991).

Table 1: Number of tags applied to cod by year and month in

a) Western Gulf of St. Lawrence (G1)

	1955	1956	1958	1959	1960	1961	1964	1979	Total
MAY							997		997
JUN	810	1014	1043						2867
JUL	1875	267							2142
AUG	713	720		1991	58				3482
SEP	448				1589	1814		1965	5816
OCT			734		52				786
Total	3846	2001	1777	1991	1699	1814	997	1965	16090

b) South-eastern Gulf of St. Lawrence (G4 & G5).

	1956	1979	1980	1981	Total
APR	734			3530	4264
MAY			310		310
SEP		1974			1974
NOV			4877		4877
Total	734	1974	5187	3530	11425

From July through the summer and well into November, the western Gulf stock is found almost solely in the western part of the southern Gulf (G1); thereafter, these cod undertake a rapid migration out of the Gulf (Figs. 2a & b). The eastern Gulf stock undertakes a similar migration but it is less well-defined. The movement out of the Gulf also begins in November and probably at least half the stock is in 4Vn by the middle of December (Figures 3a & b). For both stocks, the movement back to the Gulf in the spring appears to be less abrupt, beginning in April and continuing through into June. Whereas the western stock seems to move back and forth more or less en masse, the movement of cod from the eastern stock appears to be less directed, for tags were returned from 4Vn during all months of the year. Most of the tags returns of western Gulf cod were from its home range (Figure 4a); whereas tags from the south-eastern Gulf cod were returned in about equal numbers from inside and outside the Gulf (Figure 4b). Over the entire period since 1955, more than 70% of all western Gulf tagged cod were recovered within their home range (G1), whereas only about 25% of eastern Gulf tagged cod (G4 & G5) were retaken in their home range. Nearly 40% of all recoveries of eastern Gulf tagged were from 4Vn.

The rates of return within the 4Vn subdivision of tags applied to cod in the western Gulf, eastern Gulf and in inshore 4Vn are compared in Figure 5. The effect of the migration is most noticeable by examining the returns of 4Vn inshore cod. The rates of return are much higher in the summer than in the winter due to the dilution effect of the influx of 4Tcod in the latter season. This dilution begins in November when the rate of return falls from about 23 tags per 1000 in October to about 14 tags per 1000 in November. The average rate of return during January to May is 8.2; therefore, the December rate of return of 7 is more or less equivalent to the average January to May value which would imply that by December the majority of 4T cod have left the Gulf.

2. Length at age.

A comparison was made of length frequency at age; cod caught in each of the summer and autumn periods were compared to cod caught during the winter period. Three age length keys were derived from samples of otter trawl landings taken in 4Vn in 1990 during the periods, January to April, May to August and September to December. The first of these keys presumably represent for the most part slower growing Gulf cod (4T) overwintering in Sydney Bight and the last two ought to represent mainly resident 4Vn cod. There is little correspondence between length modes at age when comparing 4TVn (Jan-Apr) and the May to August periods (Figure 6). However, when comparing 4TVn (Jan-Apr) and September to December periods, except for notably ages 4 and 8 (and 12 and older of which there are very few), there is a close correspondence of length modes at age (Figure 7). These data imply substantial numbers of Gulf cod present in 4Vn during the September to December period. The same comparisons made for longliners showed little or no correspondence between any of the age-length keys. An increasing proportion of the annual otter trawl catch has been caught during November and December in recent years (>60% in 1991), whereas the proportion of annual longliner catch taken during these same months has remained stable at about 20%. The longliner fleet tends to work in shallower inshore waters where they would exploit the resident 4Vn cod stock (MacKenzie 1934, Lambert unpublished data) and be more or less out of the main path of migrating 4T cod.

3. Fleet movements.

Much of the mobile fishing fleet is required by law to carry and record information on fishing activities in log books. About two years ago a new logbook format was developed; one of the new entries to be made now is the position of each fishing set or tow. This information is now accessible on the DFO statistical data base and is proving invaluable. It is now possible to follow the movements of fishing boats on a day to day basis in great detail. Since the fleet quickly locates and follows aggregations of fish it is possible to use its movements as a proxy for the movement of the main body of migrating fish.

The information on fleet location confirms the impressions given by analysis of cod tag returns. (Place names used in the following description of fleet movements can

be found in Figure 8). the location of fishing sets made by mobile gear during 1991 are detailed in Figure 9 (a to d) and for 1992 in Figure 10 (a to d).

During the last two weeks of October (Figures. 9a & 10a) fishing activity is confined to 4V & W along the western edge of the Laurentian Channel (the "Edge"), particularly in the Smokey Bank area. A concentration of boats can be seen in 1991 in the "Gutter" area off the north east tip of Cape Breton, but not 1992.

During the first two weeks of November (Figures. 9b & 10b) the boats become less scattered along the "Edge" as they concentrate in the Smokey Bank and "Gutter" area. A contingent of boats also moves into the Gulf to work the head and middle areas of the Cape Breton Trough off north-west Cape Breton; these are presumably exploiting the eastern Gulf stock which is beginning its migration out of the Gulf. Fishing activity intensifies in the "Gutter" along the edge of White Point Bank during the last two weeks of November (Figures. 9c and 10c). To the west fishing has moved north-east along the Cape Breton Trough. There are also indications of cod movement along the "Edge" north-west of St. Paul Island.

The migration of the western Gulf cod stock can be seen clearly during the first two weeks of December. Fishing activity is concentrated along the "Edge" from St. Paul Island to the north-west (Figure 9d). Sparse fishing activity occurs in the same area in 1992 (Figure 10d); however, a ban on fishing in 4Vn during December in 1992 is the cause of no sets being located in that subdivision and probably also accounts for the low activity off Cape North just outside 4Vn (the bulk of migrating 4T cod may well have moved into 4Vn by this time). As Figure 9d shows, Gulf cod had no doubt progressed well down into 4Vs, since the fishing fleet appears well strung out along the "Edge".

These plots give the impression that the eastern Gulf stock leads the migration out of the Gulf through the Cape Breton Trough and into 4Vn. Three to four weeks later they are followed by the western Gulf stock which follow a route along the Laurentian Channel edge north of the Magdalen Islands and south-east into 4Vn.

Discussion

The fishing industry has long known that cod leave the Gulf of St. Lawrence in the late autumn; anecdotal information contends as early as October in some years. It has also been observed by the industry that two streams of cod leave the Gulf and intermingle in the St. Paul Island - Cape North area as they proceed down along the edge of the Laurentian Channel into 4Vn and northern parts of 4Vs. Fishermen have reported that often they would begin fishing for migrating cod in the late fall off the north-west coast of Cape Breton; should catch rates fall off, they would steam north to the edge of the Laurentian Channel north-east of the Magdalen Islands to look for the other stream of migrating cod. The pattern in the rate of returns of eastern and western Gulf tagged cod confirms these observations both as to time and the number of groups of cod leaving the Gulf.

Although cod from the Gulf of St. Lawrence and cod resident in 4Vn were tagged in widely separated areas they are exploited by the same fishery during the winter period. Therefore, it ought to be possible to say something about the relative exploitation rates of the three groups. In theory, tag returns from the different stocks would be expected to be returned from the winter fishery, where they are mixed, in the same proportion as the relative numbers of tags originally applied to these stocks. However, returns of eastern and western Gulf tagged cod cannot be compared with any degree of reliability since these groups of fish were tagged approximately 25 years apart (see Table 1) and the fisheries that returned the tags were considerably different. The biomass of 4TVn cod was about 30,000 t greater in the later period (early 80's) than the earlier period (late 50's); however, the catch in the early 80's was about 20,000t less than during the earlier period, being constrained by quota management whereas it was not in the 50's (Hanson *et al* 1992). Furthermore, the efficiency and fishing power of the fleet in the early 80's was superior to that of the 50's fleet.

Between 1979 and 1981, 11,425 cod were tagged off the west coast of Cape Breton (G4 & G5) and 2923 cod in inshore areas of 4Vn. Therefore, eastern 4T cod tags ought to have been returned at a rate about four times higher than that of 4Vn cod tags. However, the rate of return of 4Vn tags from the winter fishery (9 per thousand) was on average almost twice as high as returns from eastern 4T tags (Figure 5). It is difficult to see why 4Vn cod would be more vulnerable than Gulf cod other than that the two groups are distributed differently. If this is so, and these distributions can be defined reliably, there is perhaps some hope that the exploitation rate of the individual cod stocks in the Sydney Bight winter fishery might be better controlled by a more judicious deployment of the fishing effort in the area.

At the time the fishery in the present 4Vn subdivision was originally split into two seasons for management purposes, the primary goal of the Fisheries Commission was to get a TAC in place; the associated major argument was whether or not there should be a seasonal split of this quota. In 1974 ICNAF advised that a quota of 70,000 for all of 4TVn should be partitioned to 60,000 (Jan to Apr) and 10,000 (May to Dec), since without this control ... "Over-exploitation of the southern Gulf of St. Lawrence stock in Subdiv. 4Vn in the spring could result, with subsequent under-exploitation of those stocks fished in Subdiv. 4Vn in summer." The matter of apportioning this quota among the Canadian and the foreign fishing fleets received considerable attention and was reported (ICNAF Proceedings 1974). Other than the fact that 4T cod overwintered in the Sydney Bight area, there appear to be no other biological considerations used in deciding on a split management area. It was known that 4T cod moved into 4Vn during December (Halliday 1974, ICNAF Redbook 1974) but there is no record of any debate over the appropriate time to place the division between management seasons thus we must conclude it was considered a minor matter. According to anecdotal evidence, the December/January division was adopted for convenience sake, to avoid the complication of non-calendar year TAC's.

In 1982, after more tagging studies, CAFSAC considered the most recent evidence on stock inter-relationships and migrations of cod in the Sydney Bight area to

evaluate whether the definition of management units by area and season were the most appropriate. It was concluded (CAFSAC Advisory Document 82/14) that "...4T cod overwinter along the edge of the shelf in Subdiv. 4Vn in the December-April period." and that "...cod which support the Subdiv. 4Vn summer fishery are heavily intermixed with 4T cod in the December-April overwintering concentrations along the edge of the Laurentian Channel in Subdiv. 4Vn. This complicates development of a management strategy which will optimize exploitation of both the 4T and 4Vn stocks." However, even though the beginning of the overwintering period for 4T cod in 4Vn was considered to be December, it was decided that the problem could not "... be resolved through adjustment of management units." and that "The presently defined management units continue to appear the most suitable from a biological point of view."

It seems clear that a large proportion of cod caught in 4Vn during the month of December, perhaps nearly all in recent years, are 4T migrant cod (Lambert 1992). From a bookkeeping point of view this catch would be better attributed to the Gulf stock. However, although the catch of cod during the May to November period may be a more accurate estimate of removals from the resident stock, there still remains the problem of catch of resident cod during the winter 4TVn fishery. Tag returns indicate that this catch is not trivial and resident cod may in fact be exploited at higher rate than Gulf cod. Until this issue is resolved the assessment of the 4Vn cod stock will remain intractable.

Acknowledgements

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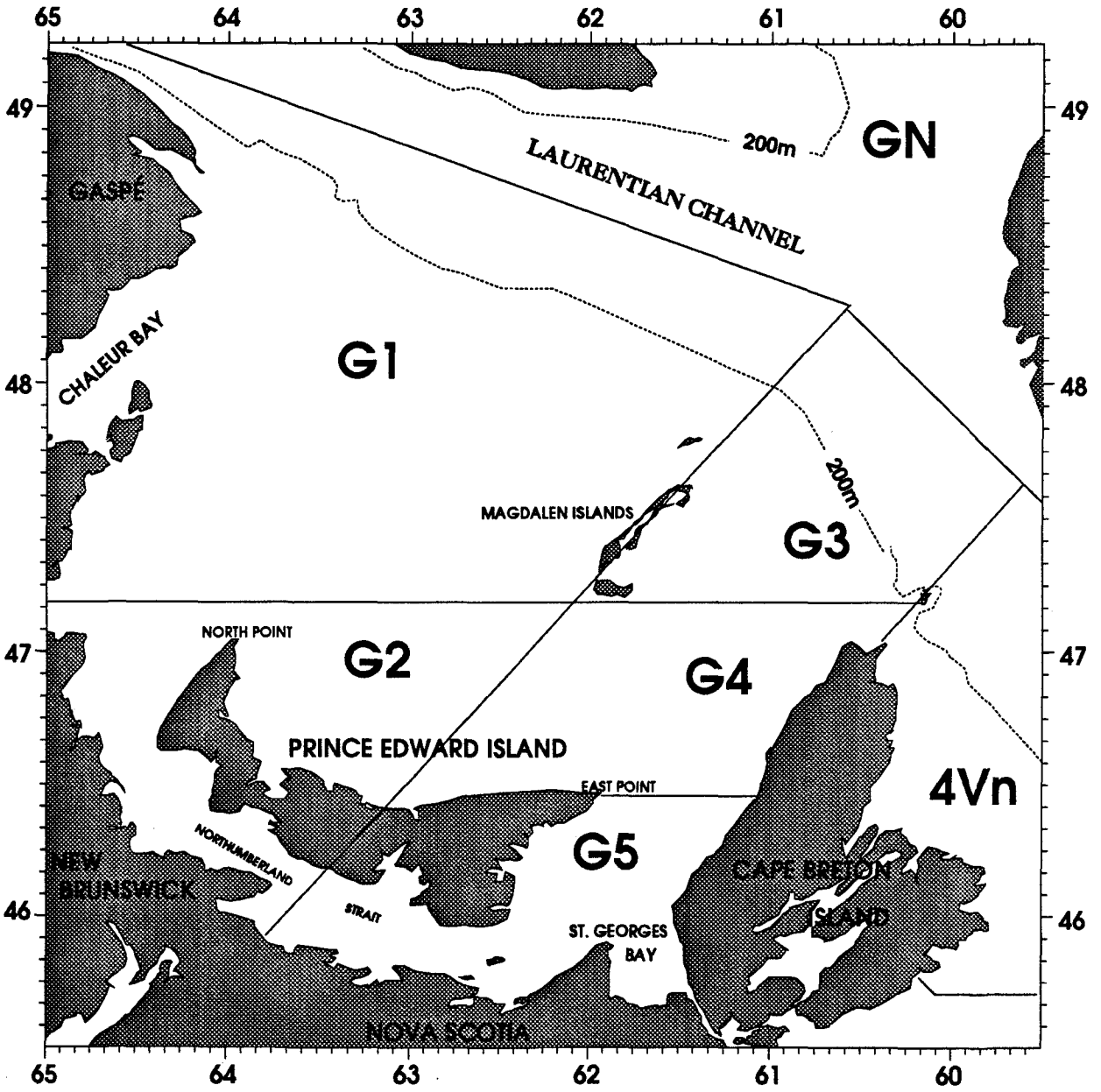


Figure 1

Areas of aggregation for cod tagging studies.

TAGGED CHALEUR/GASPE REGION IN SUMMER

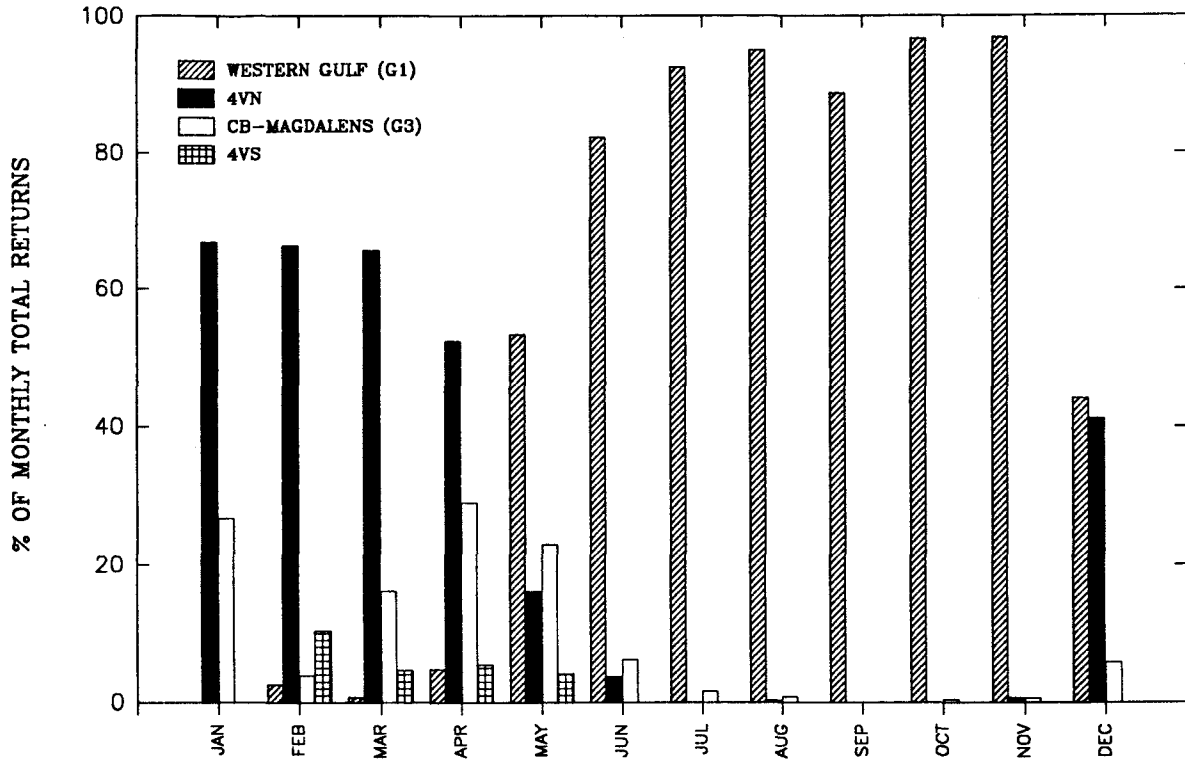


Figure 2(a)

TAGGED CHALEUR/GASPE REGION MAY TO OCTOBER

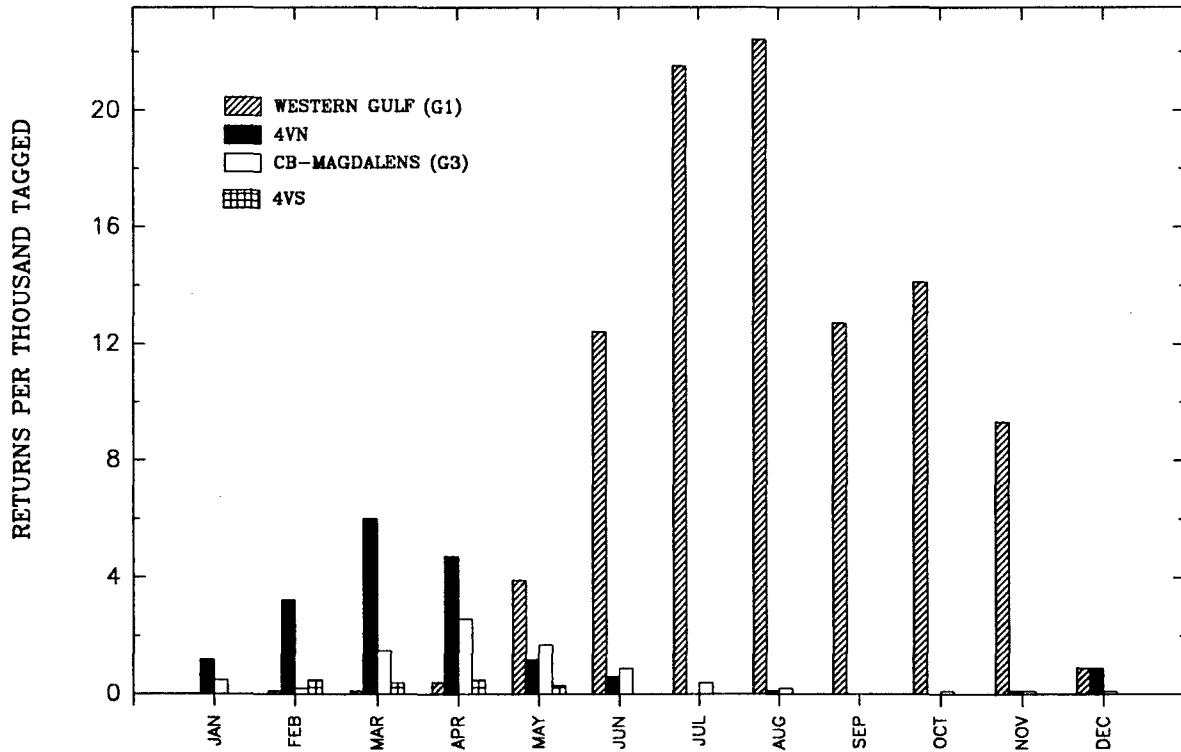


Figure 2(b)

2. Tag returns aggregated by month over years for cod tagged in the western Gulf of St. Lawrence; (a) percentage of total returned each month by area and (b) rate of return each month by area.

TAGGED OFF WESTERN CAPE BRETON MAY-NOVEMBER

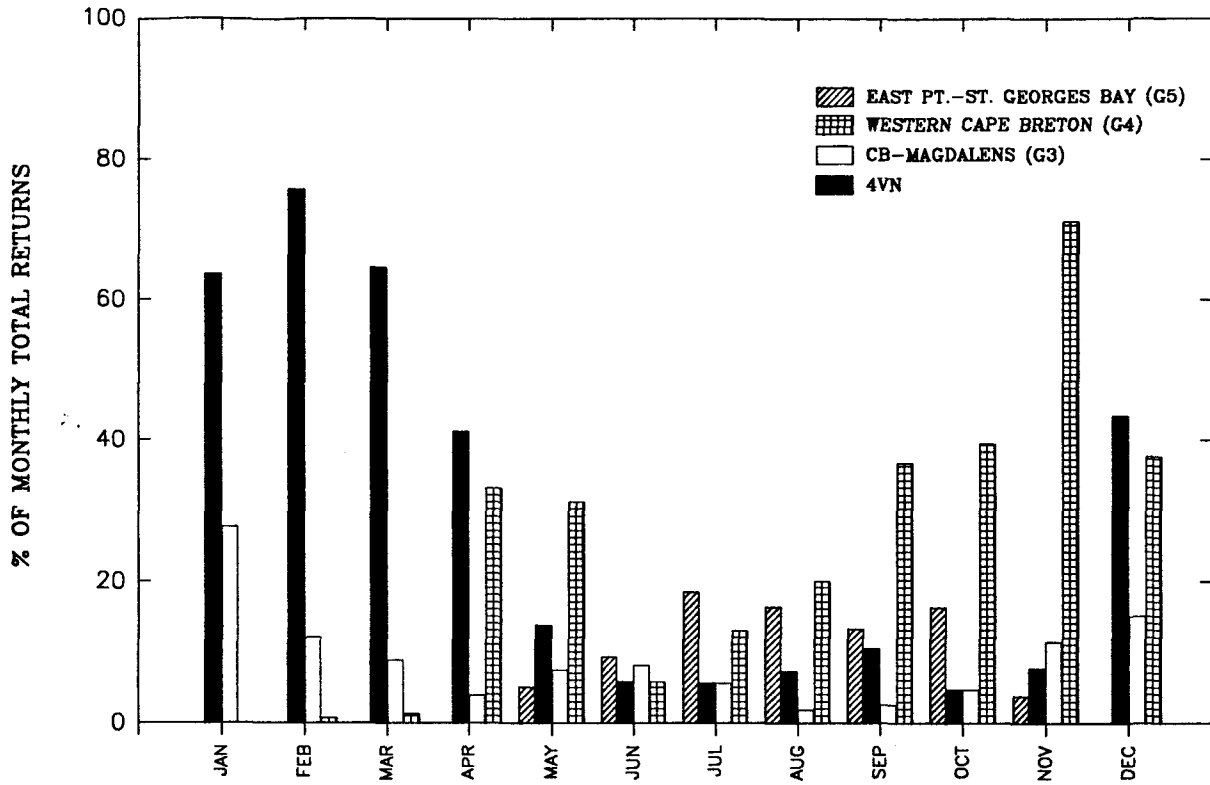


Figure 3(a)

TAGGED OFF WESTERN CAPE BRETON MAY-NOVEMBER

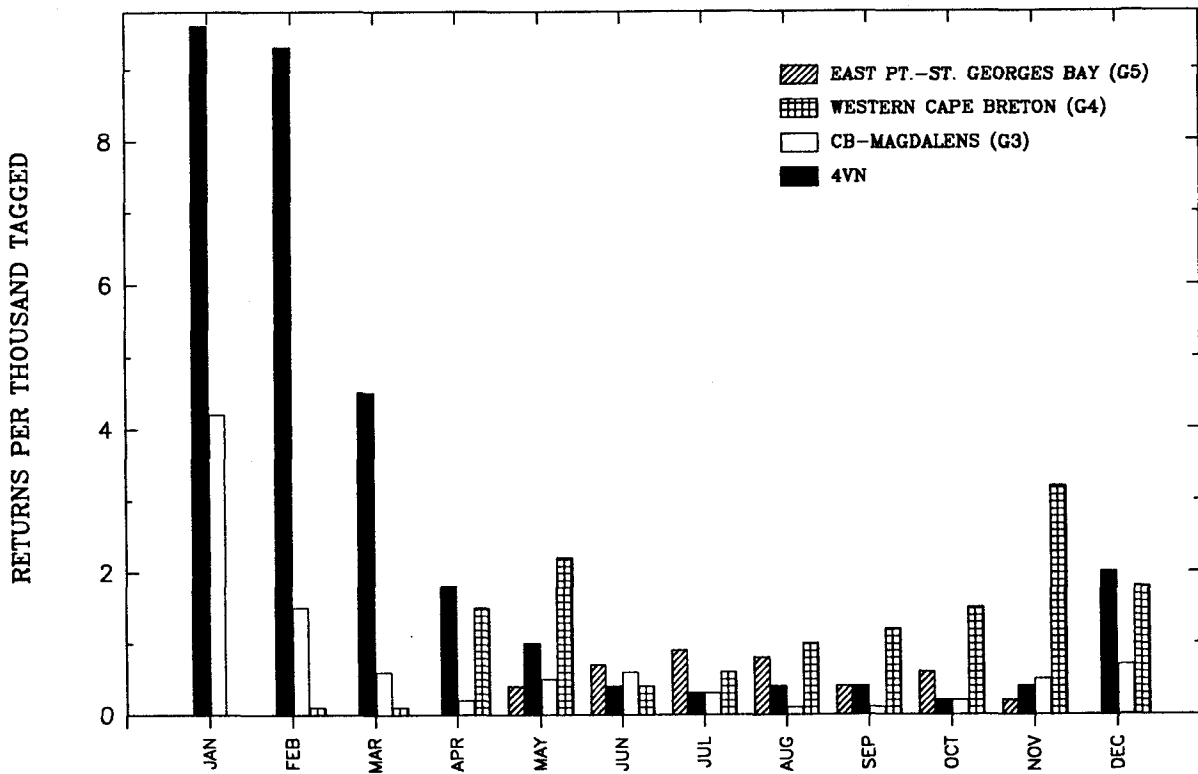
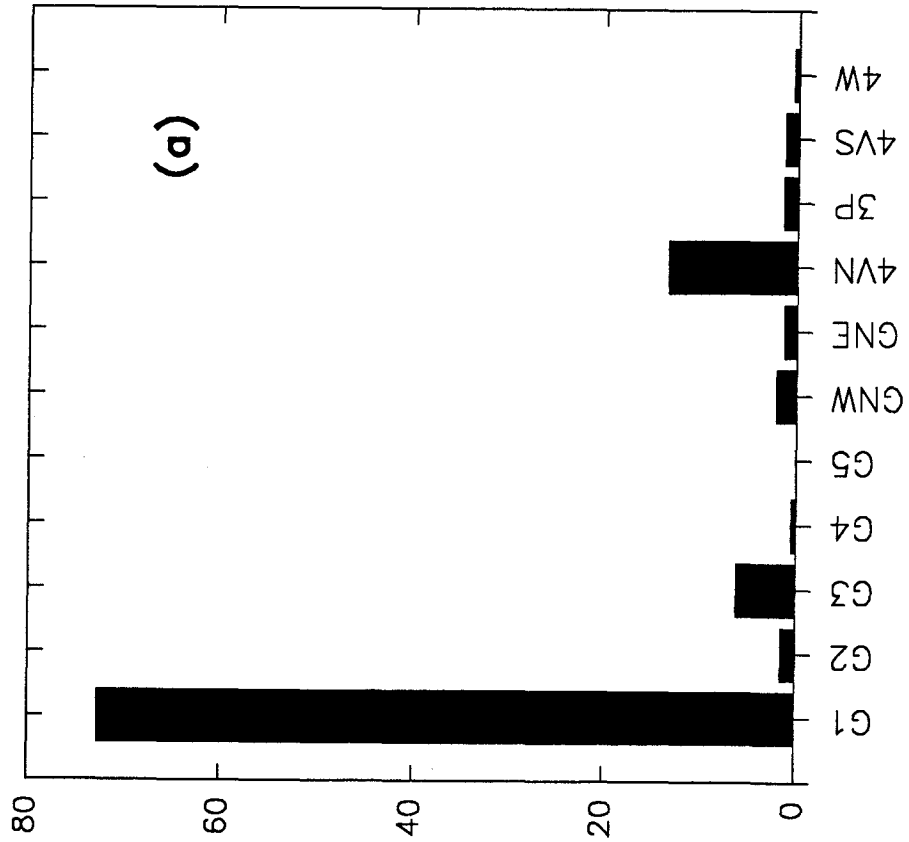


Figure 3(b)

3. Tag returns aggregated by month over years for cod tagged in the eastern Gulf of St. Lawrence; (a) percentage of total returned each month by area and (b) rate of return each month by area.

COD TAG RETURNS

TAGGED CHALEUR-GASPE REGION MAY TO OCT



TAGGED OFF W. C. BRETON MAY TO NOVEMBER

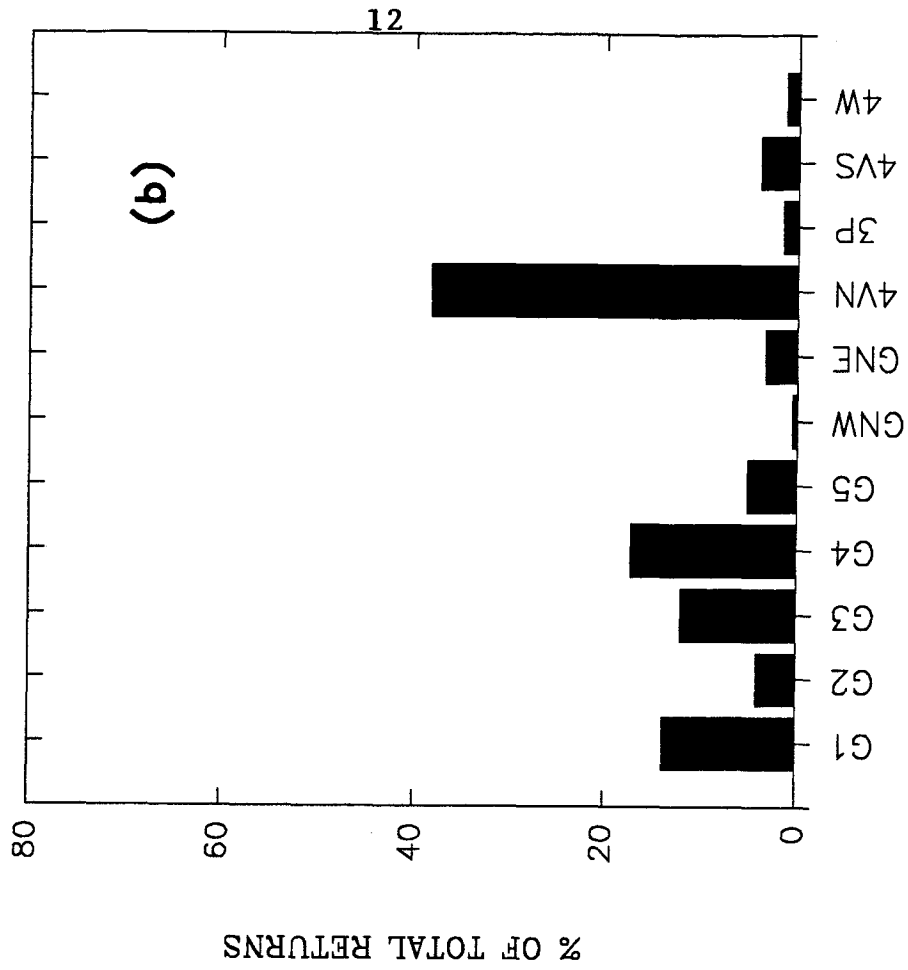


Figure 4

Proportional return of tags by area aggregated over years for cod tagged in (a) the western Gulf of St. Lawrence and (b) the eastern Gulf of St. Lawrence.

COD TAG RETURNS FROM 4VN

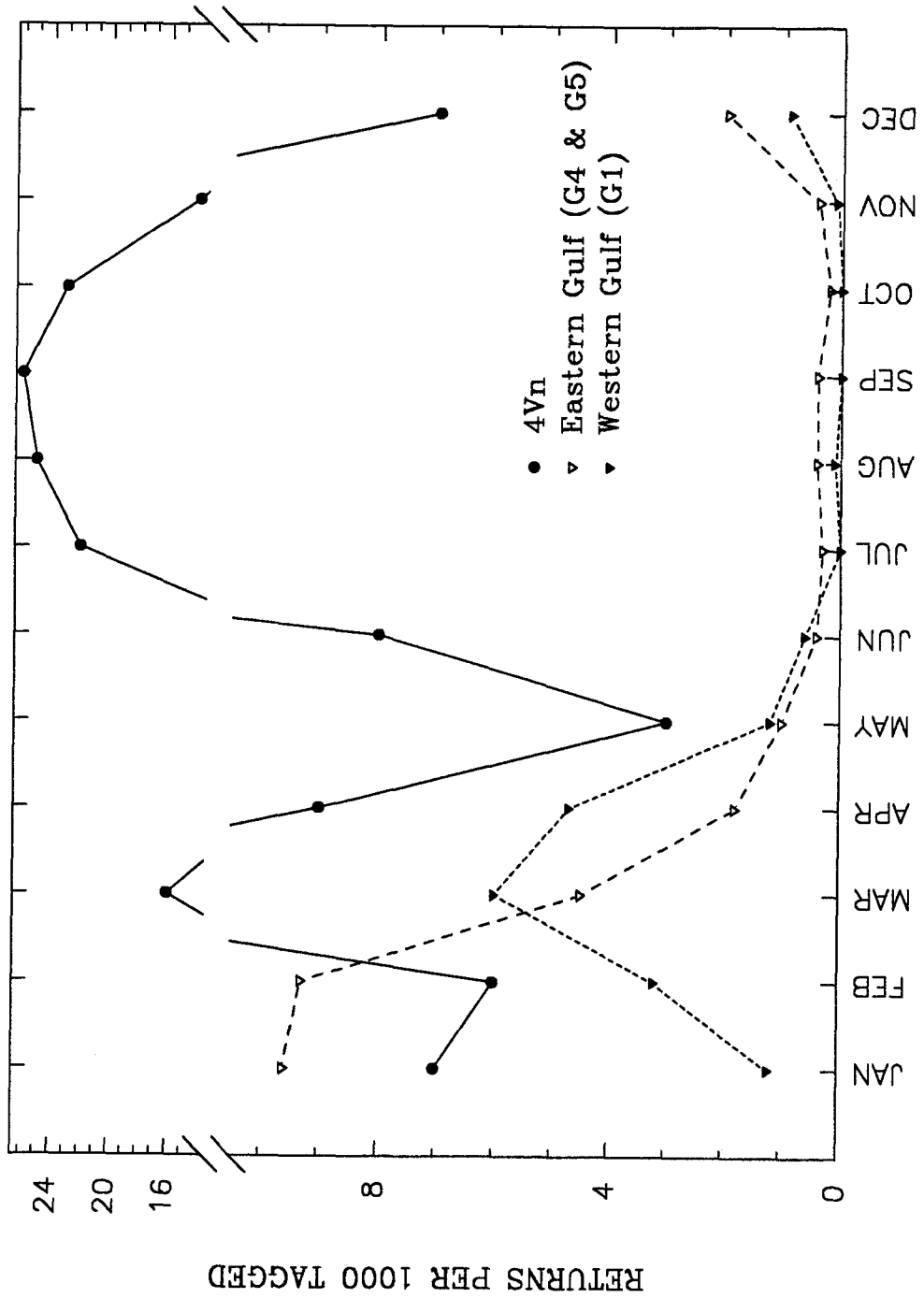


Figure 5

Rate of return in 4Vn of tags accumulated by month over years from cod tagged in the inshore area of 4Vn, the eastern Gulf of St. Lawrence and the western Gulf of St. Lawrence.

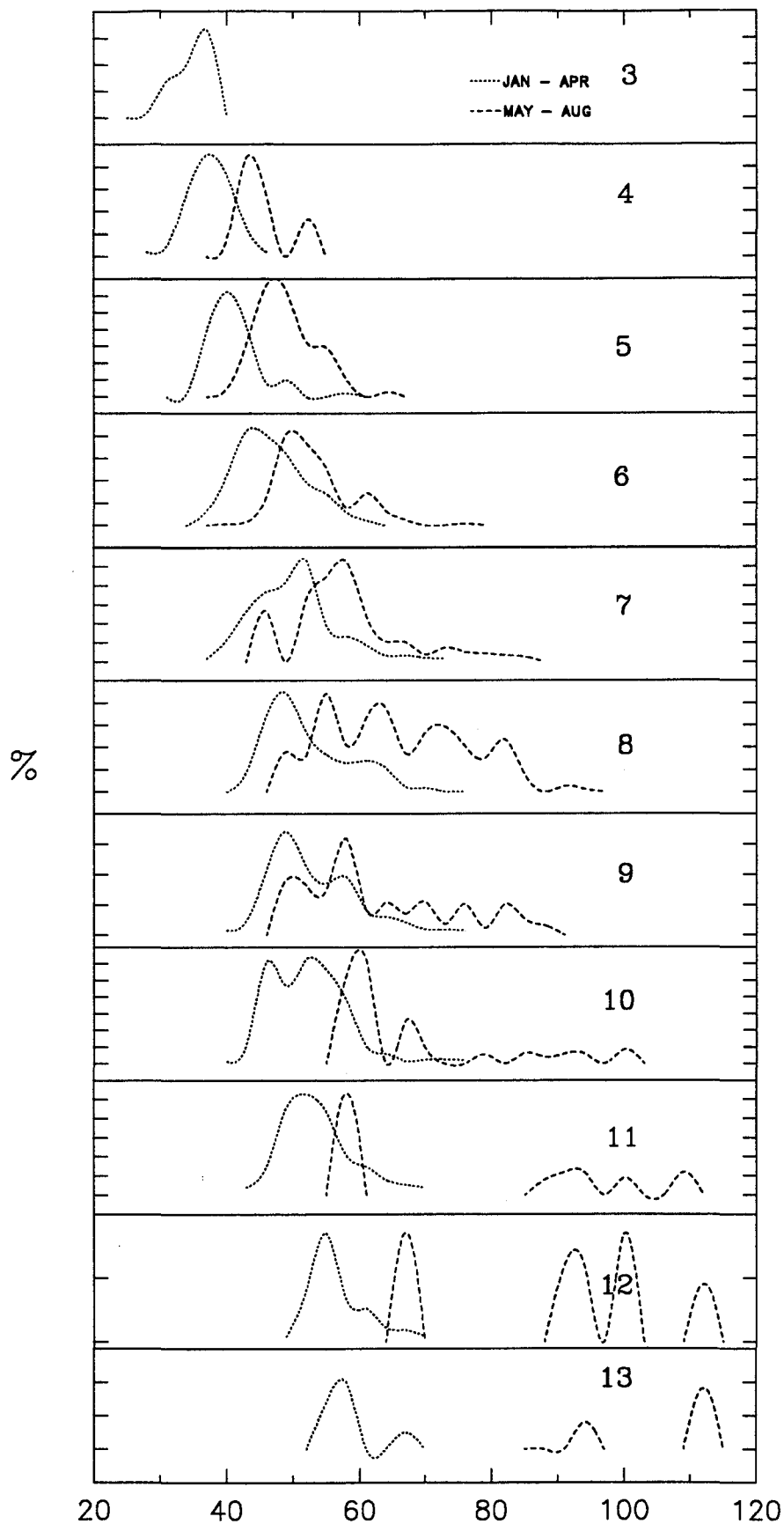


Figure 6

Comparison between two periods of length frequency at age of cod landed by otter trawlers in 4Vn . January to April and May to August, 1990.

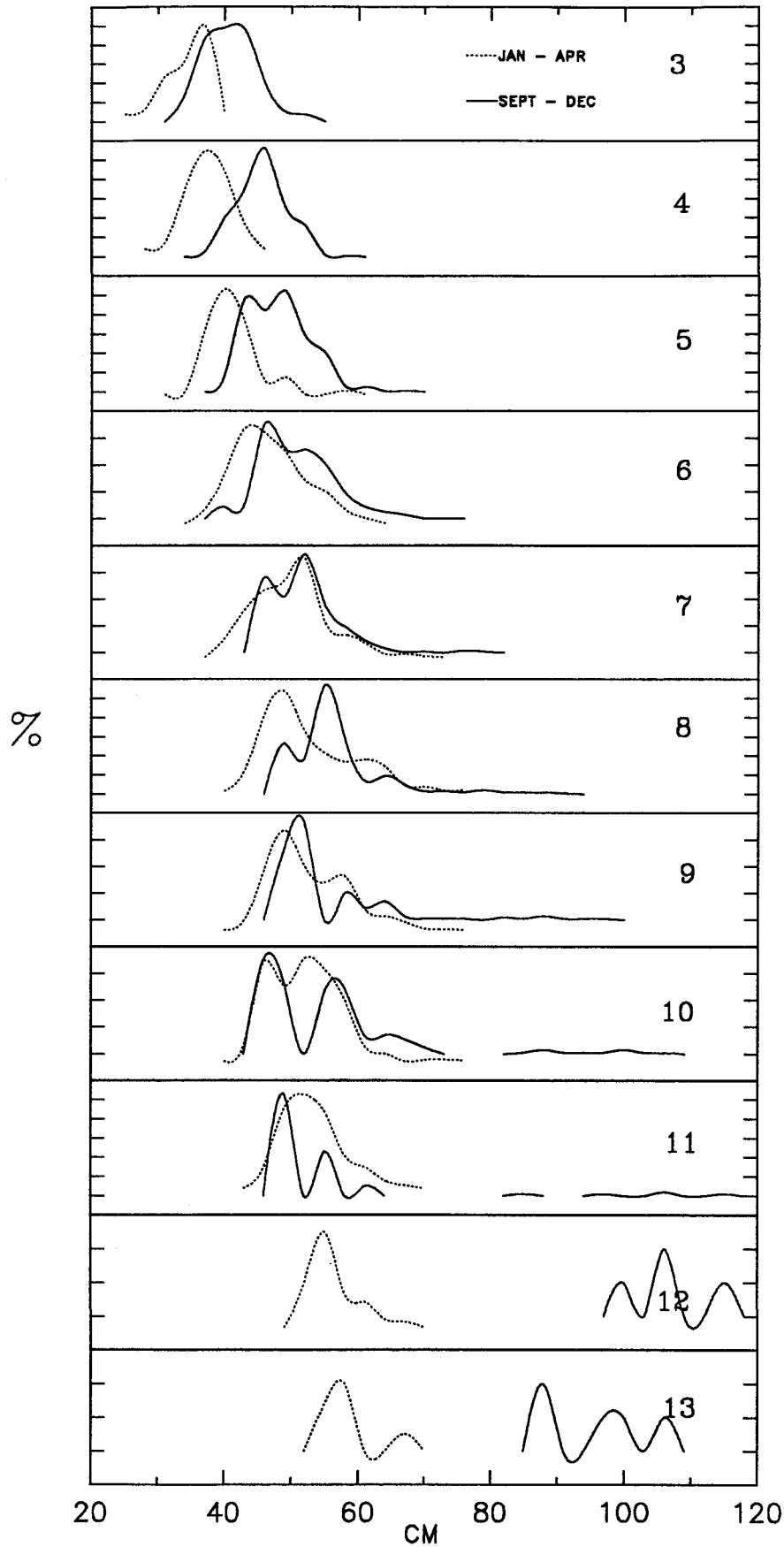


Figure 7

Comparison between two periods of length frequency at age of cod landed by otter trawlers in 4Vn, January to April and September to December, 1990.

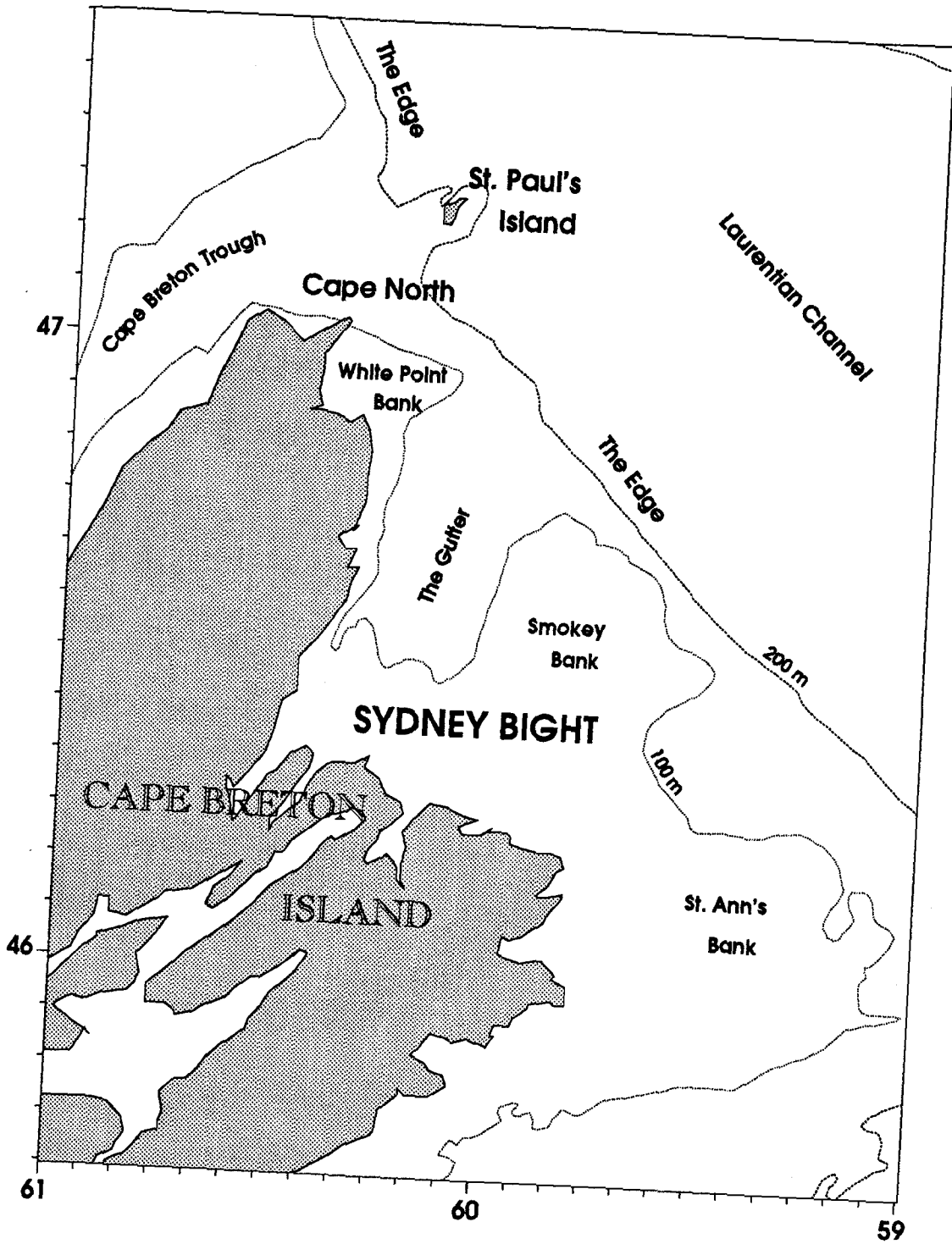


Figure 8

Map of Sydney Bight showing place names used in description of cod movements.

16-31 October 1991

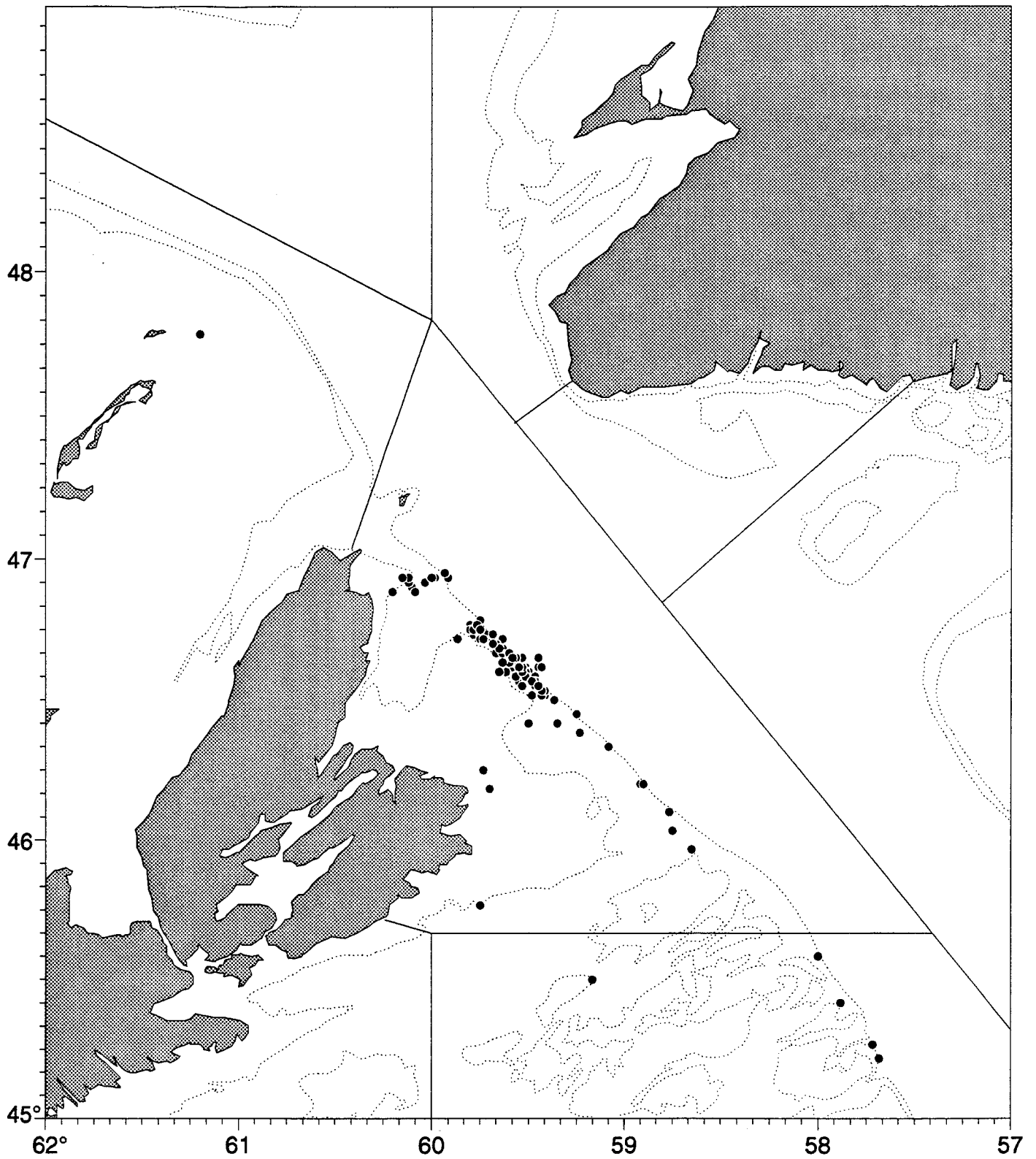
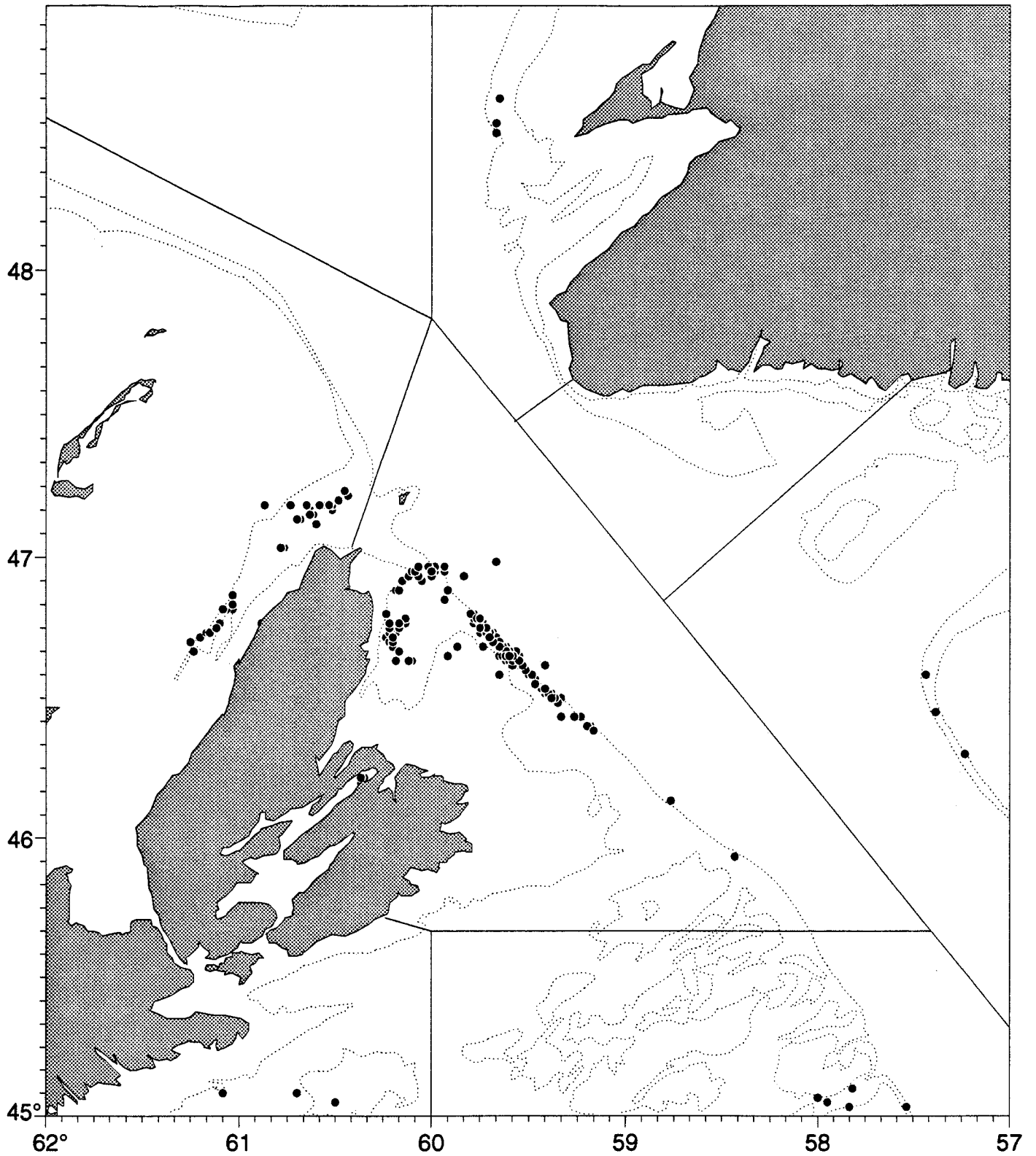


Figure 9(a)

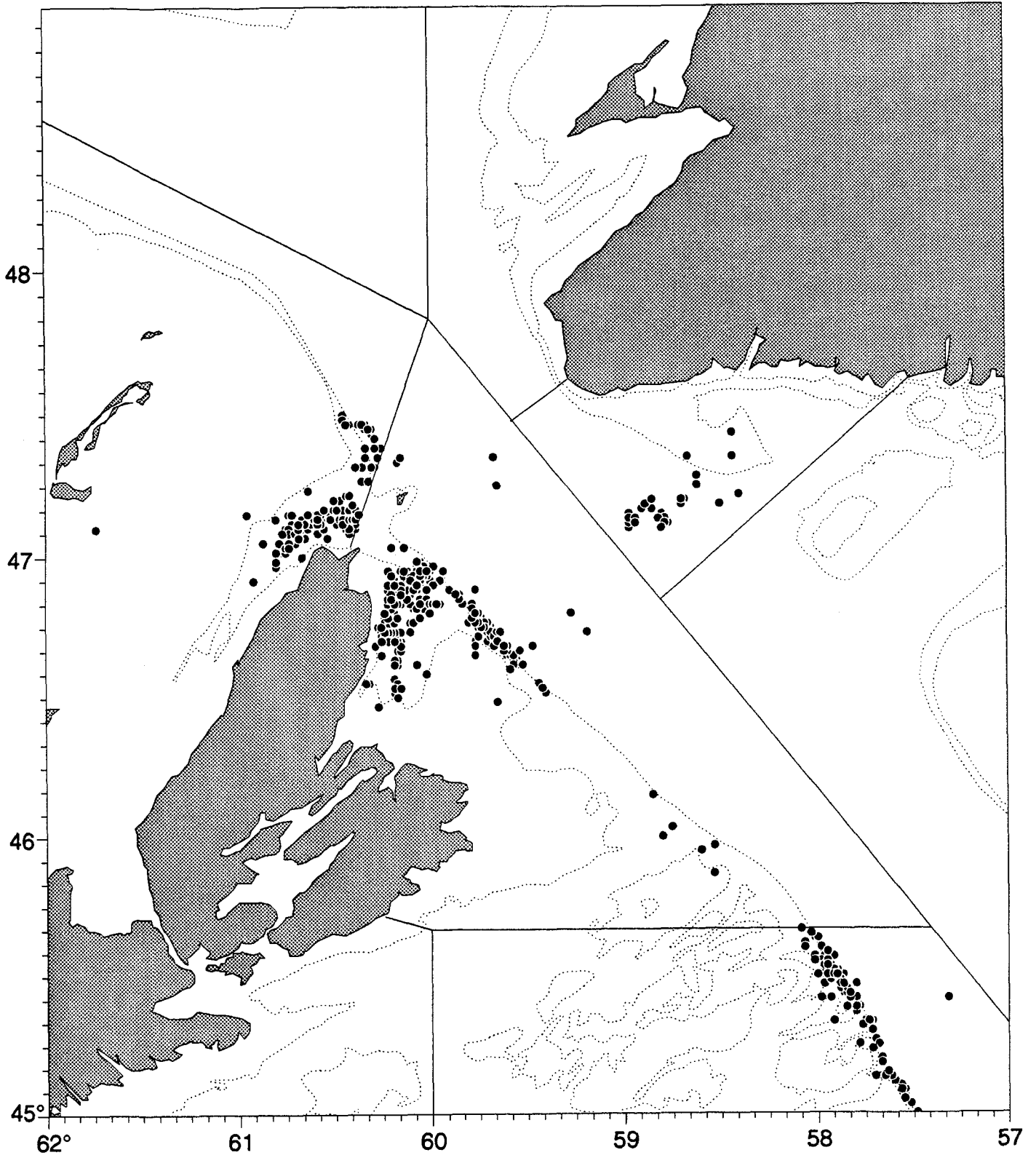
Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1991

1-15 November 1991

**Figure 9(b)**

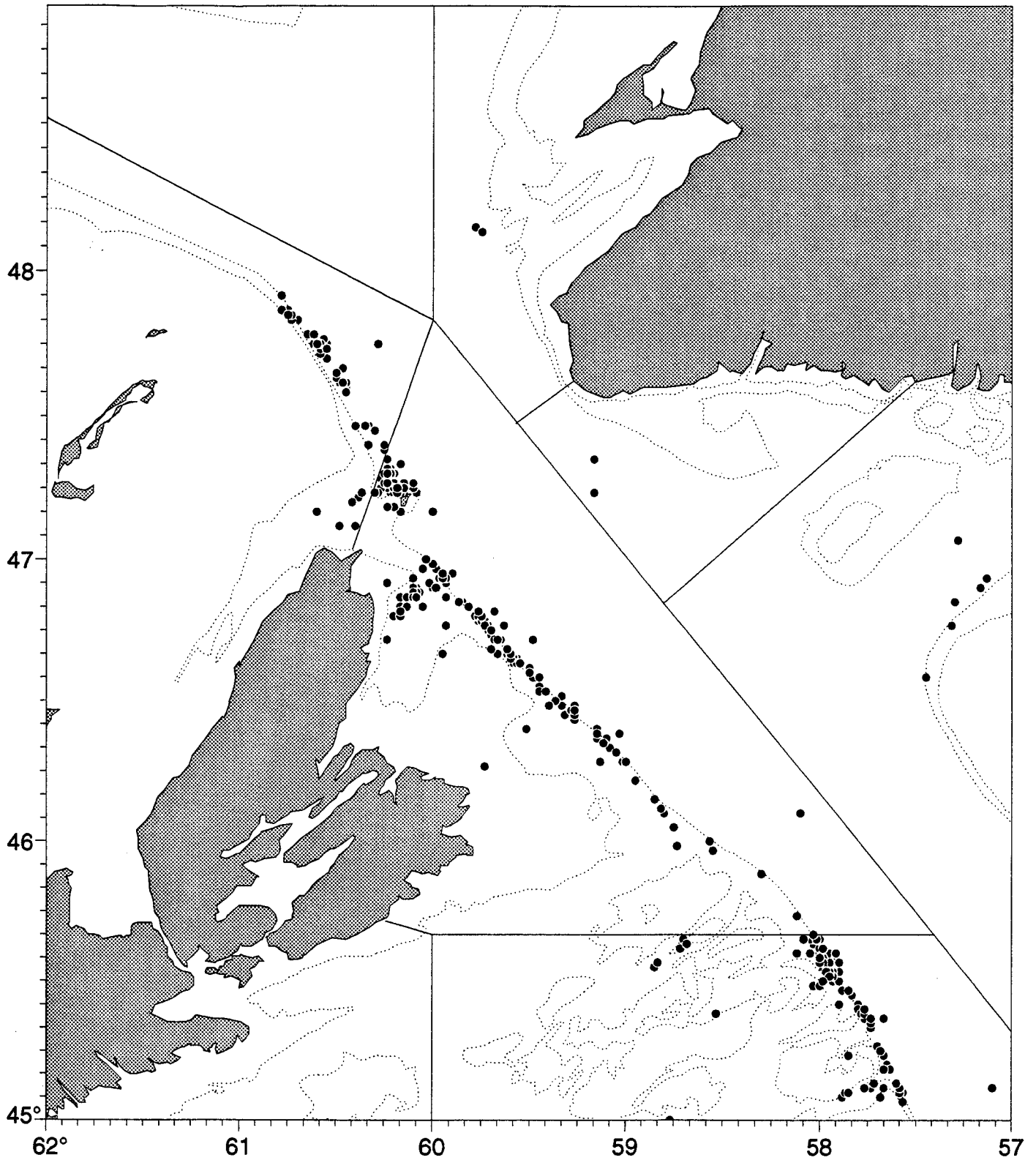
Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1991.

16-30 November 1991

**Figure 9(c)**

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1991.

1-15 December 1991

**Figure 9(d)**

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1991.

16-31 October 1992

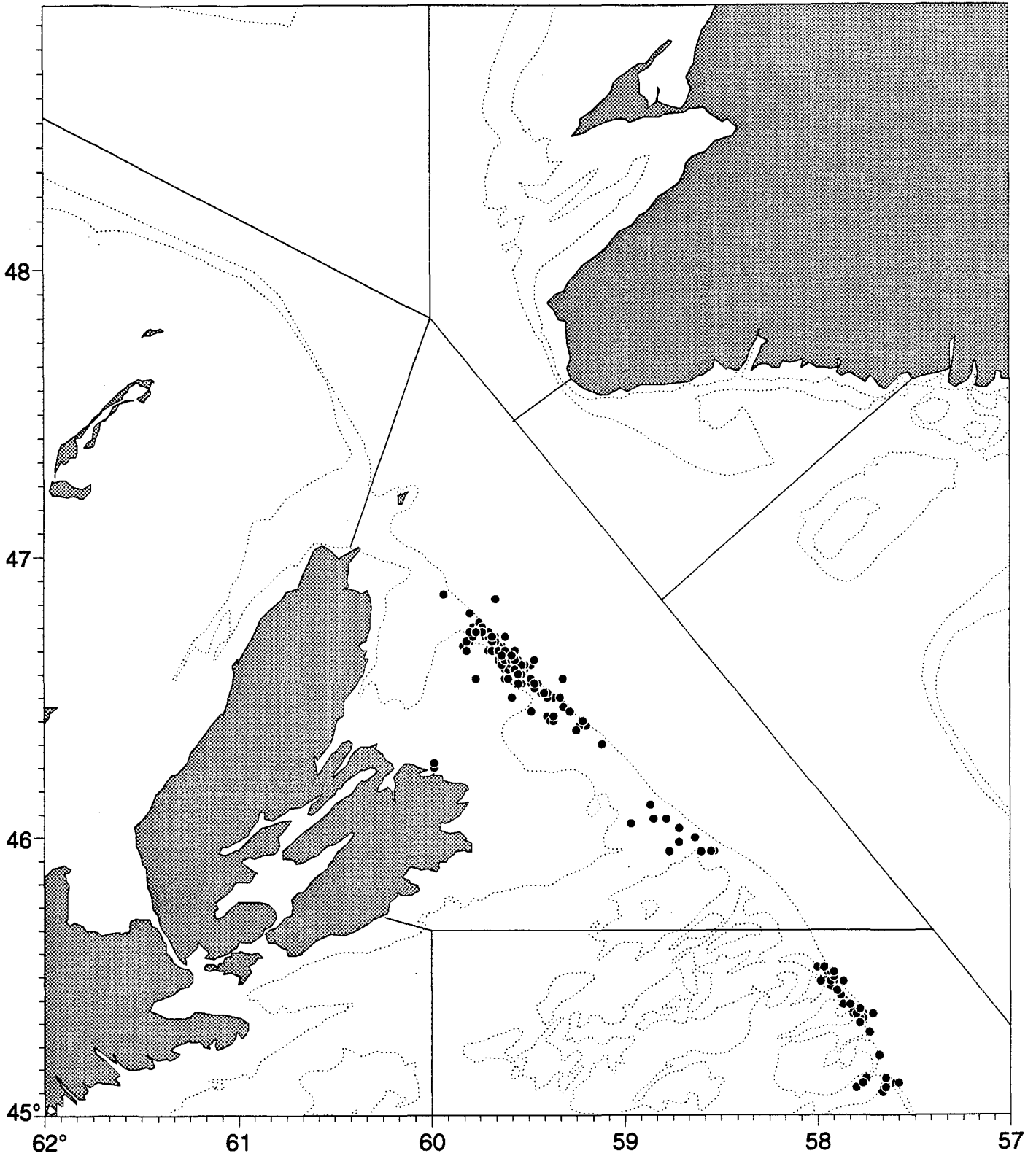


Figure 10(a)

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1992.

1-15 November 1992

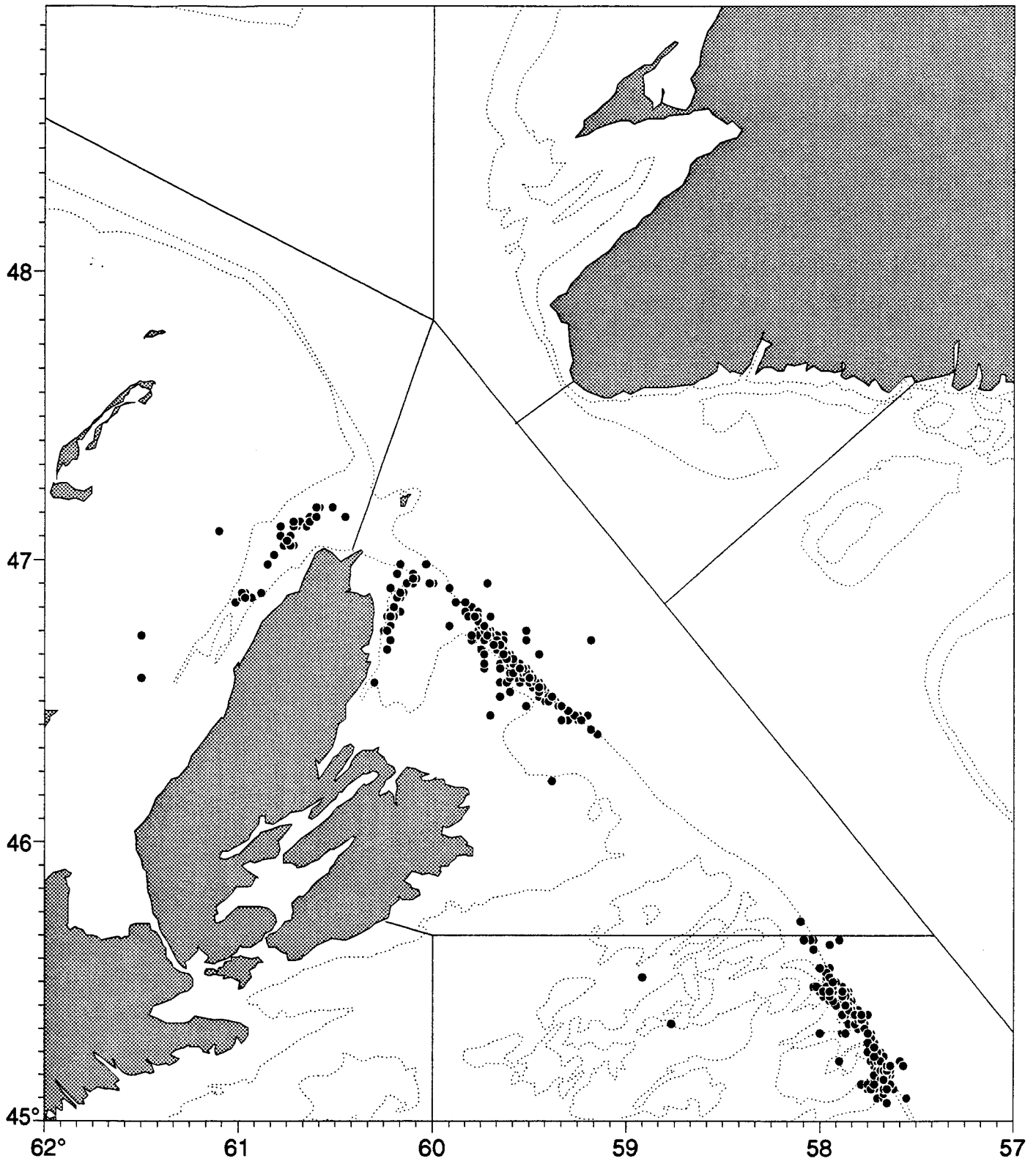
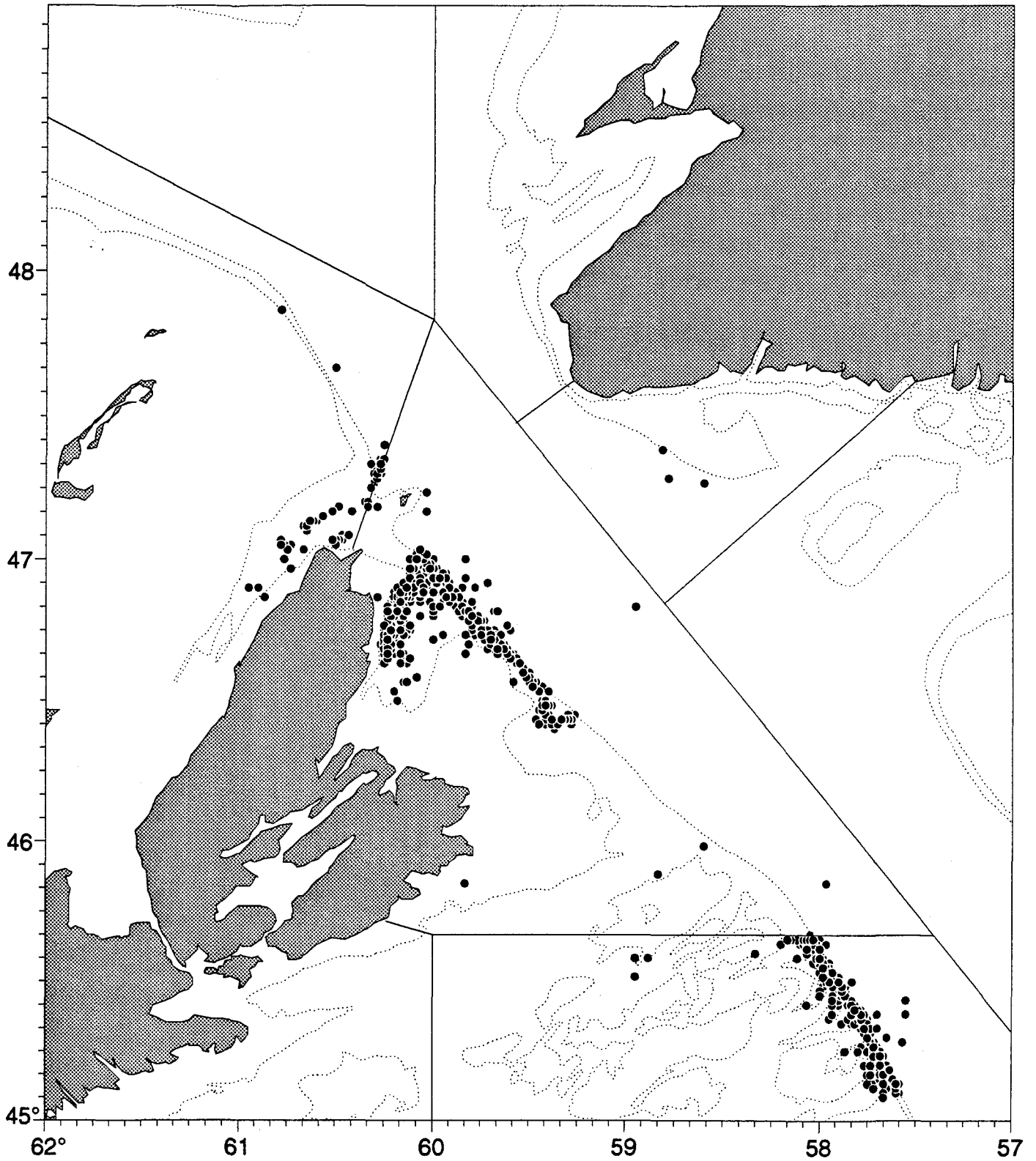


Figure 10(b)

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1992.

16-30 November 1992

**Figure 10(c)**

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1992.

1-15 December 1992

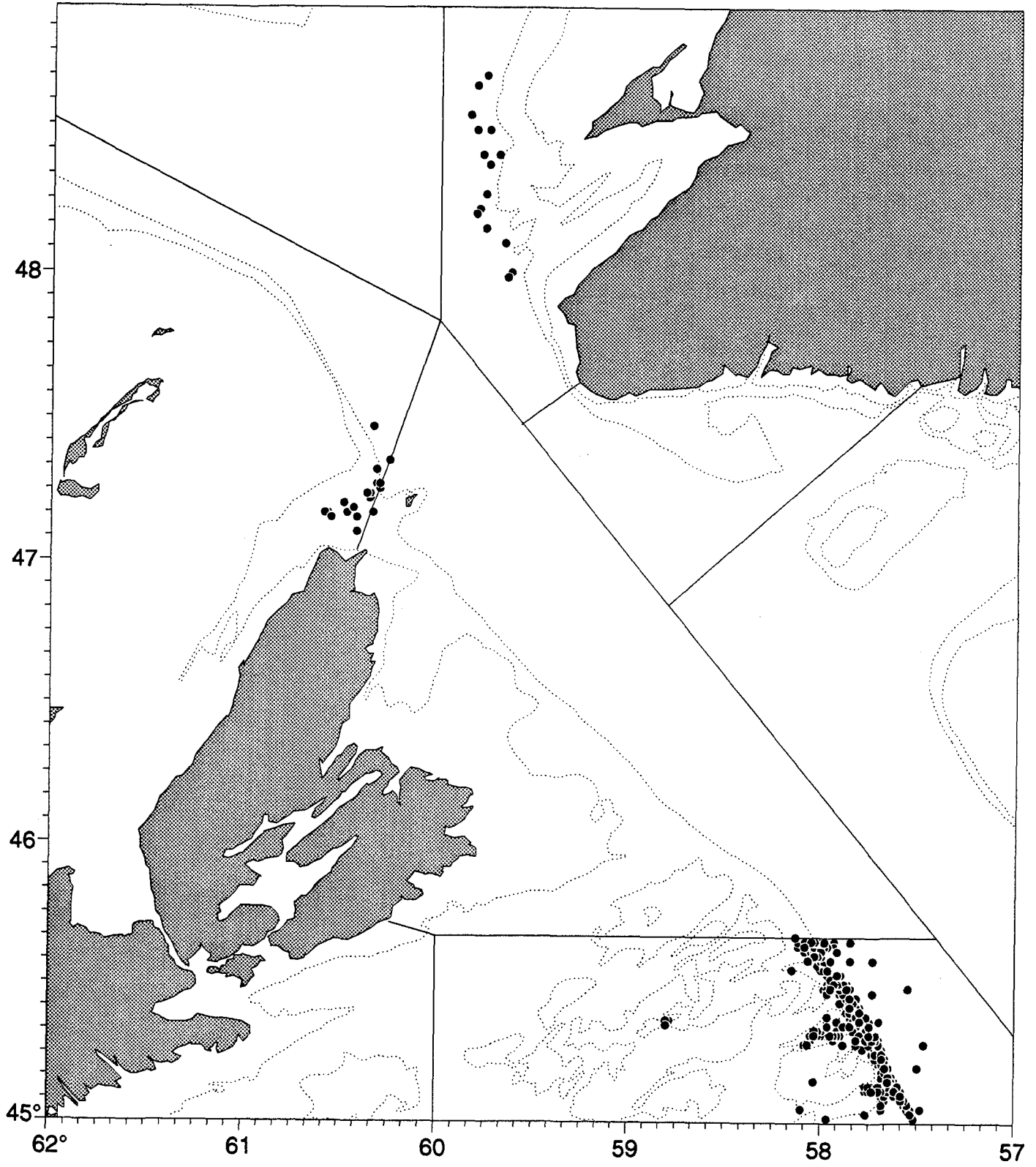


Figure 10(d)

Individual set locations of fishing boats using mobile gear in the Cape Breton area during 1992.