APPENDICES

Appendix 13.1 Fish and Fisheries: Mackerel

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13.1.1 Background

The Marine Fish Division (MFD) group which met related to the Gully Science Review requested that I comment on the distribution of mackerel on the Scotian Shelf from the survey work that I participated in some years ago. The work referred to is Kulka and Stobo (1981).

That work (November-December, 1976) was conducted before MFD has initiated the spring surveys. Our hypothesis was that juvenile mackerel may stay on the Scotian Shelf over winter rather than migrating south to Subarea 5 with the adults; the results support that hypothesis. The objective was to determine if mackerel remained on the Scotian Shelf over the winter in large numbers, and if so, was the distribution contiguous from the Scotian Shelf to the western portion of Georges Bank where the main winter fishery occurred. We used both a mid-water and bottom trawl; the vessel cruised a pre-determined tract and made a set, with the appropriate gear, whenever the sonar indicated trawlable numbers of fish. The cruise tract covered out to the edge of the Scotian Shelf and most of the deeper basins, the northeastern part of Georges, restricted the vessel to the near edge area of western Georges, and then expanded again bank-wide off Cape Cod (Fig. 13.1.1). The western extension inshore was due to the location of the winter mackerel fishery off Cape Cod and our desire to ensure that the vessel could catch mackerel with both gear types.

The survey therefore was not systematic, but rather exploratory. It did cover the area of the Gully, but that was essentially the most eastward point and it did not extend onto Banquereau Bank to any extent. We actually had only one set in the Gully, but no mackerel were found there. In fact, we found relatively few species in the study area east of Sable Island; the most abundant species was yellowtail, with American plaice and witch flounder the next two most abundant species.

Mackerel were found around Sable Island and across the Scotian Shelf, but mainly age groups 0 and 1. The data suggest that the overwintering mackerel are distributed in the offshore areas of the shelf; we also examined previous specialized winter cruises (between 1958-76) and observed similar results. The mean bottom depth for the Scotian Shelf mackerel catches was 118 m, considerably shallower than that in the Gully. Most of the mackerel were either caught in the bottom trawl or when the mid-water trawl was towed close to the bottom, suggesting a near bottom existence during winter. Examination of the summer RV survey results for the 1958-76 period suggested a more mid-shelf distribution, but again no obvious concentrations were observed near the Gully.

From that work I would conclude that the Gully is not an important aspect of mackerel population dynamics; nor would one expect another result. Mackerel spawn off Cape Cod in early spring and in the Gulf of St. Lawrence in mid-summer; there has been no documentation of mackerel spawning in the offshore areas of the Scotian Shelf. The migration of adults north appears to be along the mid- and inner areas of the Scotian Shelf from observations of trap catches and recreational fishery activity. Although there appears to be an annual run of mackerel going past Sable during mid-summer (W. Stobo, pers. comm.), there is no documented fishery in the area. The return migration in fall is even less well understood. The limited winter work suggests that there are relatively few adult mackerel on the Scotian Shelf during winter and that juveniles are probably scattered across the outer shelf.

13.1.2 References

Kulka, D.W. and W.T. Stobo. 1981. Winter distribution and feeding of mackerel on the Scotian Shelf and outer Georges Bank with reference to the winter distribution of other finfish species. *Can. Tech. Rep. Fish. Aquat. Sci.* No. 1038.

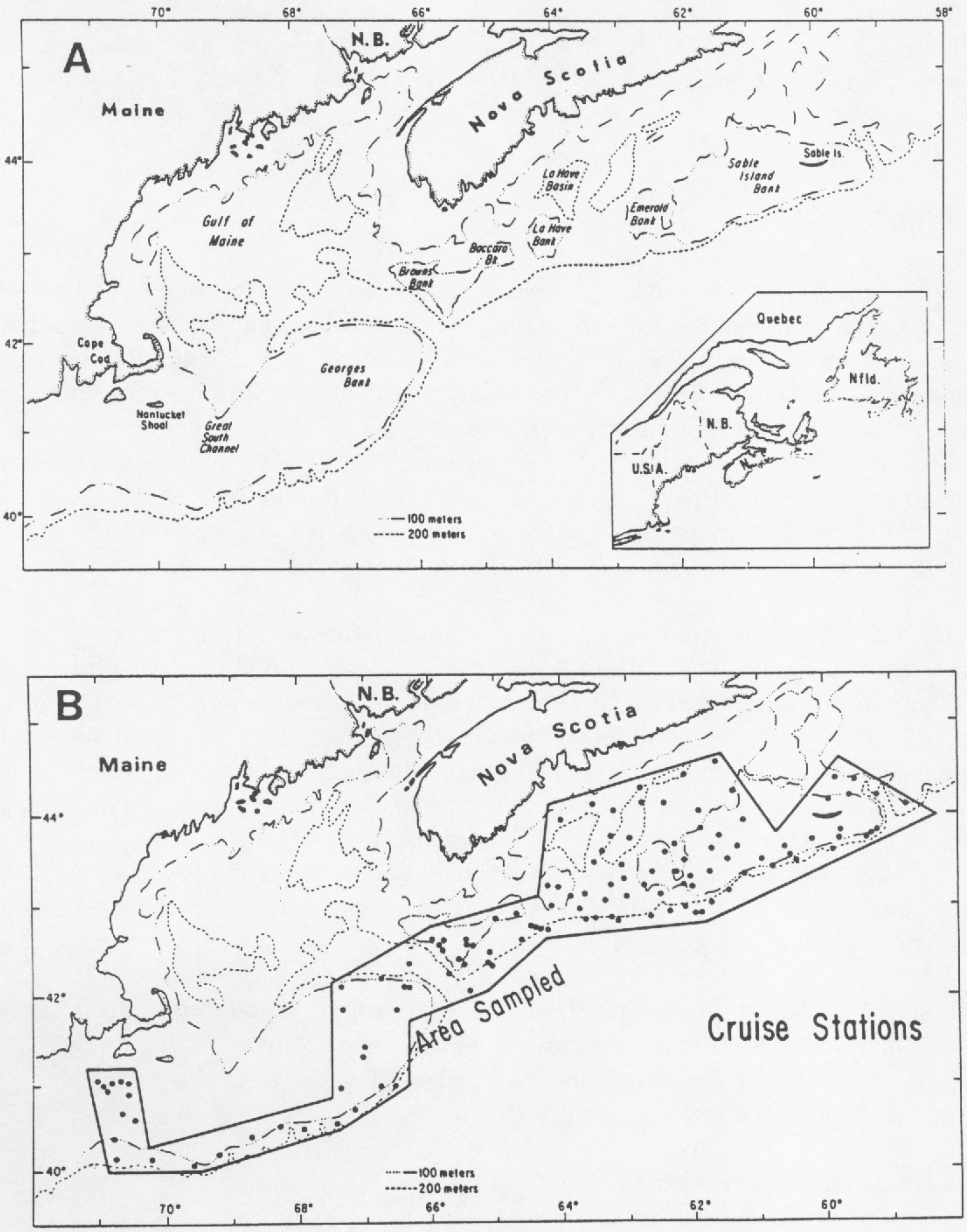

Fig. 13.1.1. Chart of the Scotian Shelf and Georges Bank showing: (A) depth contours; and (B) stations sampled, Nov. - Dec. 1976.

Appendix 13.2 Fish and Fisheries: Large Pelagic Fisheries

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13.2.1 Introduction and Methods

This document reviews the current geographic and seasonal distribution of large pelagics fisheries (swordfish, bluefin tuna, other tunas) within the Canadian Fishing Zone. These analyses are intended to provide background information for a Science Review of the Gully area on the Scotian Shelf, which is being considered for "Marine Protected Area" status. Most of the data used for this analyses originates from commercial log records provided by swordfish longline (1994-1996) and bluefin tuna (1988-96) fishermen. Although the harpoon fishery for swordfish accounts for up to 12% of the annual landings, information on catch location is insufficient for an analysis of swordfish distribution.

Detailed set information (*i.e.* latitude and longitude) for swordfish longline from log monitoring data is only available back to 1994, however, the number of observations since that time are considered adequate for determining the extent of this fishery. Plots of longline fishing effort are based on individual set locations while plots of nominal catch per unit effort (CPUE) are based on aggregated data (number or weight of fish per trip divided by total number of hooks per trip). The proportion of swordfishing trips, sets and catch in a rectangle approximating the Gully area (latitude: 43^{o} 30'-44 ^{o} 10'; longitude: 58 ^{o} 40'-59 ^{o} 20') was calculated and compared with annual totals for 1994 through 1996. Plots of catch location for bluefin tuna were based on positions reported by commercial fishermen in the bluefin log records.

Additional information on swordfish distribution was available from the Canadian International Observer Program database (1980-96) and from research surveys (1980, 1990-93) conducted by Science Branch. Distribution plots from this series show set locations and number of swordfish sampled.

13.2.2 Results and Discussion

Swordfish Longline - The Canadian swordfish longline fishery operates from Georges Bank to the western edge of the Grand Banks when swordfish migrate into Canadian waters during summer and fall. Pelagic longline gear is used to capture swordfish at night when they feed in surface waters. The gear is set early in the evening and hauled back the following morning. Typically, a trip consists of 8-14 sets of the gear with up to 1500 hooks/set, covering a distance of up to 60 km. Fishing effort generally progresses from west to east and back again along the edge of the continental shelf, following swordfish movements associated with seasonal warming trends of surface water temperature.

During the 1994, 1995 and 1996 fishing seasons, effort commenced in June with sets occurring in deeper waters along the edge of the Gulf Stream off the western and eastern Scotian Shelf (Figs. 13.2.1-3). Effort then spread along the shelf slope and off the western Grand Banks in July, becoming more concentrated in a narrow band along the edge of the continental shelf in August. During September and October, the fishery occured mainly along the edge and central portion of the Scotian Shelf. In 1996, fishing effort was greatly reduced due to poor environmental conditions (cold water temperatures and high winds) along the Shelf Slope.

Nominal CPUE (average number of fish per 1000 hooks) for 1994, 1995 and 1996 generally shows a pattern of increasing swordfish abundance from June to September, declining in October and November (Figs. 13.2.4, 5, and 6, respectively). In 1995, catch rates in the central Scotian Shelf region during September and October tended to be much higher than in 1994 and 1996, due to a shift in effort directed at larger fish (> 180 kg), which were concentrated in the deep basins.

The Canadian swordfish longline fleet has operated at the entrance of the Gully from 1994 through 1996 (Figs. 13.2.1-3), with moderate to high catch rates for swordfish (Figs. 13.2.4-6). During this period, the proportion of trips and sets in the Gully area averaged about 3% of the total for each fishing season, while catches represented 2-5% of total landings (Table 13.2.1).

Table 13.2.1. Number of trips, sets and total catch for the entire Canadian swordfish fishery vs the Gully area (latitude: 43^o 30'-44 ^{o} 10'; longitude: 58 ^{o} 40'-59 ^{o} 20') for 1994-96.

Year	Area	No. of Trips	No. of Sets	Landed wt (kgs rnd)
1994	All	427	3855	1583
	Gully	8	52	26
1995	All	418	3338	1376
	Gully	12	91	37
1996	All	343	2719	637
	Gully	9	90	29

Additional information on swordfish distribution in the Canadian Fishing Zone is available from sampling by Canadian research and observer programs. Research surveys for swordfish were conducted in 1980 and 1990 through 1993 during summer and fall. Observer data is available for the summar/fall (June-October) Canadian domestic fishery (1993-95) and for swordfish bycatch from the fall/winter (September-February) directed Japanese tuna longline fishery (1980-1996). Set locations and relative number of swordfish sampled per set from Canadian research and observer program collections (Fig. 13.2.7) and Canadian observer sampling on Japanese longline vessels (Fig. 13.2.8) indicate that catches in the Gully area did occur, but were of the same order of magnitude as in other areas along the Shelf slope.

The distribution and relative abundance of swordfish in the Canadian Fishing Zone is greatly influenced by oceanographic conditions and can vary considerably both seasonally and geograhically from one year to the next (Fig. 13.2.9). Therefore, it is difficult to distinguish between areas of localized high swordfish abundance attributed to oceanographic features or a preference for a specific physical habitat (*i.e.* like the Gully). Individual swordfish probably have a relatively short residence period in any particular area during their search for food on the Shelf and Shelf Slope. Tagging results have shown movements from west to east along the Shelf slope during the fishing season. Swordfish can feed on a wide variety of prey found throughout the water column (*i.e.* groundfish, pelagics, deepwater fish and invertebrates). While the Gully may offer a greater variety of prey items than other areas on the Scotian Shelf and Slope (due to higher levels of productivity), it is unlikely that the relative abundance of swordfish is higher in this area compared with other regions in Canadian waters (see Fig. 13.2.9).

<u>Albacore, Bigeye and Yellowfin Tuna Bycatch from Swordfish Longline</u> - Since 1993, there has been increase in the number of swordfish longline trips directed for other tunas (albacore, bigeye and yellowfin), which is attributed in part to declining quotas for swordfish. These trips occur mainly during June and July when water temperatures are quite variable and the relative abundance of swordfish tends to be low. Fishermen use circle hooks (which have better retention for tunas) in combination with conventional J-hooks on their longline gear, and a squid/mackerel bait mixture to attract these fish.

From 1994 through 1996, nominal catch rates (kgs round per 1000 hooks) were highest during June and July for albacore (Figs. 13.2.10-12) and yellowfin (Figs. 13.2.13-15), and from June through September for bigeye (Figs. 13.2.16-18). During these months, all three species were captured primarily along the western edge of the Scotian Shelf slope, and in deeper waters along the edge of the Gulf Stream. Overall, the relative abundance of all three species tends to be quite low in the vicinity of the Gully (and eastern Scotian Shelf) where their occurrence appears to be incidental.

<u>Bluefin Tuna Fishery</u> - The Canadian bluefin tuna fishery currently operates in several geographic areas off the Atlantic coast from July to November when bluefin migrate into Canadian waters. Since the late 1980's, the main commercial fisheries have included: Hell Hole tended line, Bay of Fundy harpoon, St. Margarets Bay trap, Gulf of St. Lawrence tended line/rod and reel, Chedabucto Bay rod and reel, and Grand Banks tended line/rod and reel. Recently, a tended line/rod and reel fishery has developed off Halifax, Nova Scotia.

Bluefin tuna capture locations within these geographic areas (fisheries) have been highly variable during the time series for which data on fishing location is available (1988-96, Figs. 13.2.17-19). Most notable in recent years is: a) the expansion of catches from the Hell Hole to adjacent areas on Georges Bank, Browns Bank and the Scotian Shelf, b) the development of an electric harpoon fishery in the Bay of Fundy in 1991 and a tended line/rod and reel fishery off Halifax in 1995, c) an expanding rod and reel fishery in Chedabucto Bay (beginning in 1990), d) a general decline followed by a recent increase in catches from the Grand Banks region off Newfoundland and e), a concentration of catches from the Gulf of St. Lawrence to the southern part of this region with higher catches in recent years.

Based on these spatial distributions, it is apparent that bluefin tuna form distinct aggregations in Canadian waters which can vary from one year to the next. However, no major concentrations are found offshore in the vicinity of the Gully or on the eastern Scotian Shelf. Although bluefin may be captured in this region on swordfish longline gear, the Canadian fleet is not allowed to land them so there is no information available from their log records.

13.2.3 Conclusions

It is apparent from this analysis of commercial log record data that the swordfish longline fishery currently operates within and adjacent to the Gully area on the Scotian Shelf. In terms of large pelagics species composition and relative abundance, there is no indication that this area is of greater or lesser importance as foraging habitat for swordfish than the rest of the Scotian Shelf, and it does not appear to be an area commonly occupied by any of the other tuna species (albacore, bigeye, yellowfin). Since there is no directed fishery for bluefin in this area or anywhere offshore on the eastern Scotian Shelf, it is not clear if they commonly occur in the Gully or not.

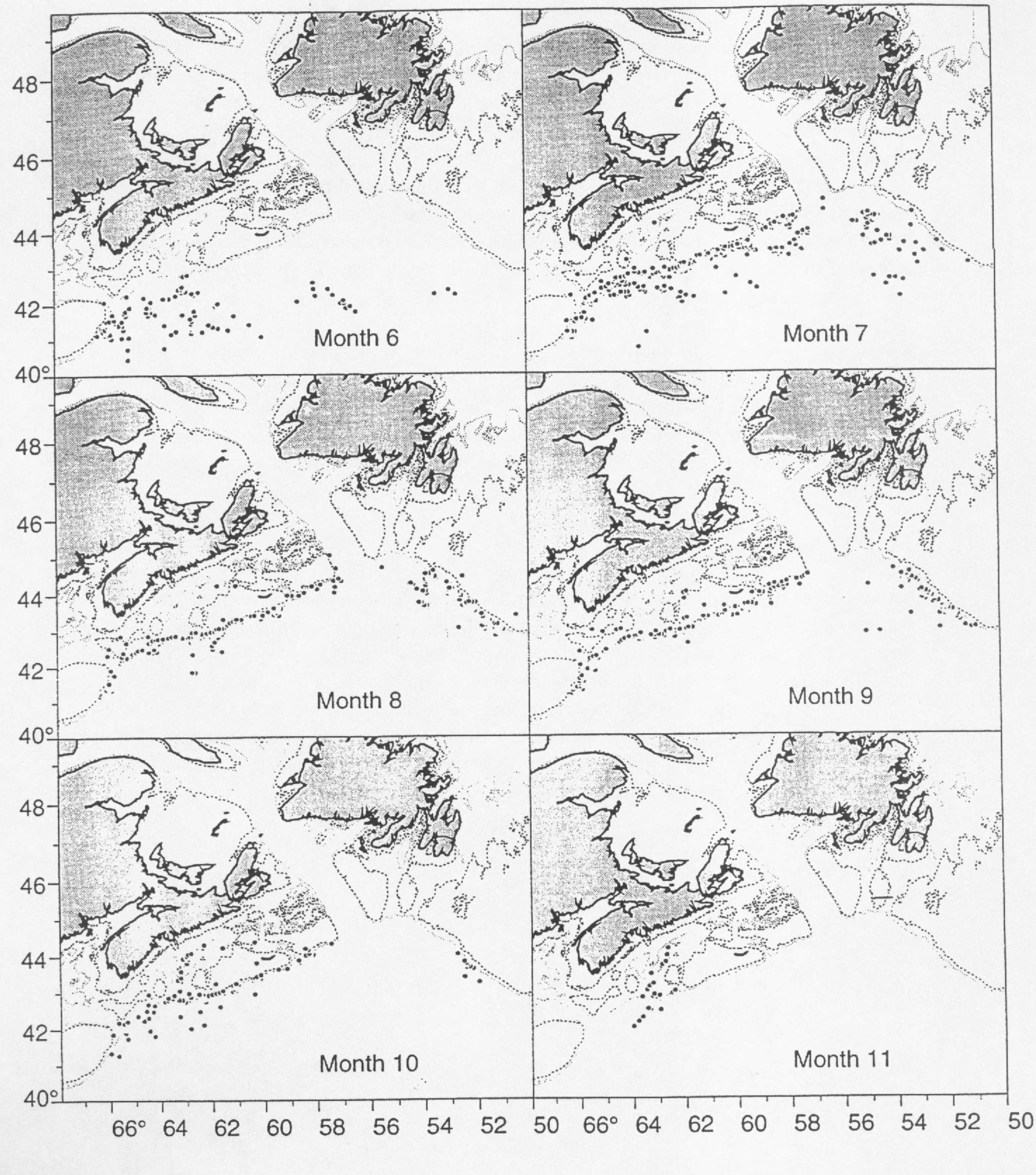

Fig. 13.2.1. Set locations by month for Canadian swordfish longline, June-November, 1994.

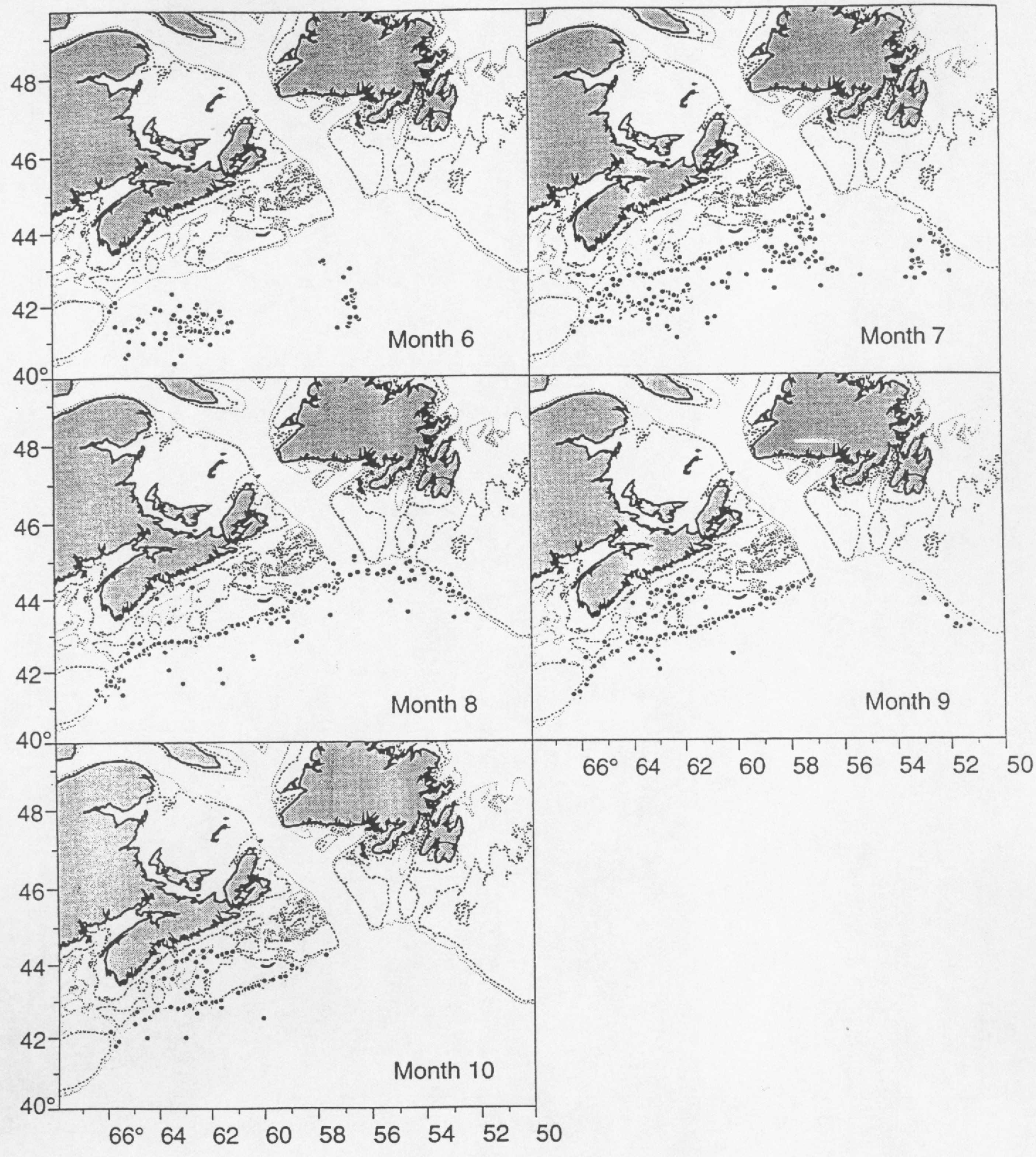

Fig. 13.2.2. Set locations by month for Canadian swordfish longline, June-October, 1995.

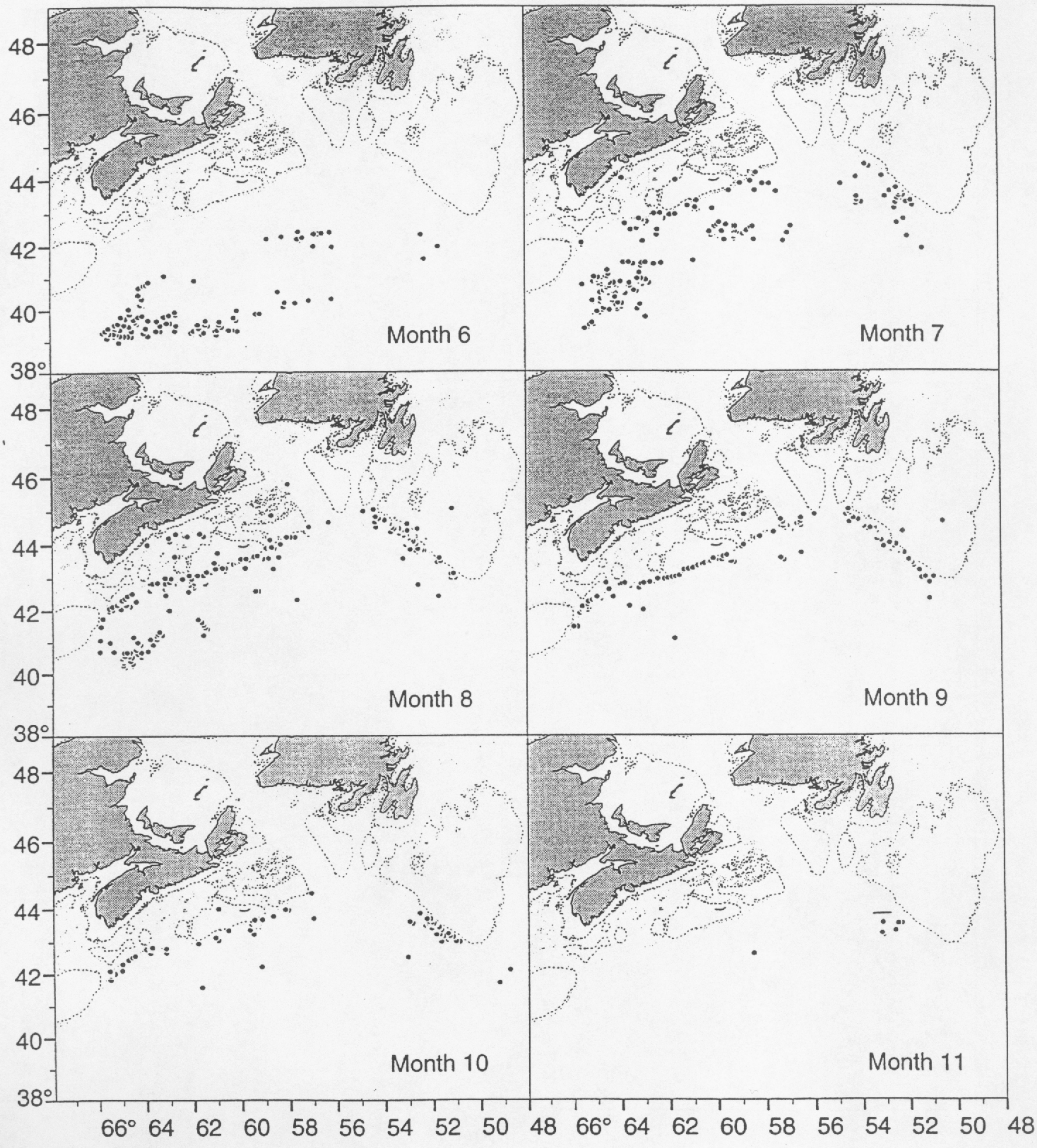

Fig. 13.2.3. Set locations by month for Canadian swordfish longline, June-November, 1996.

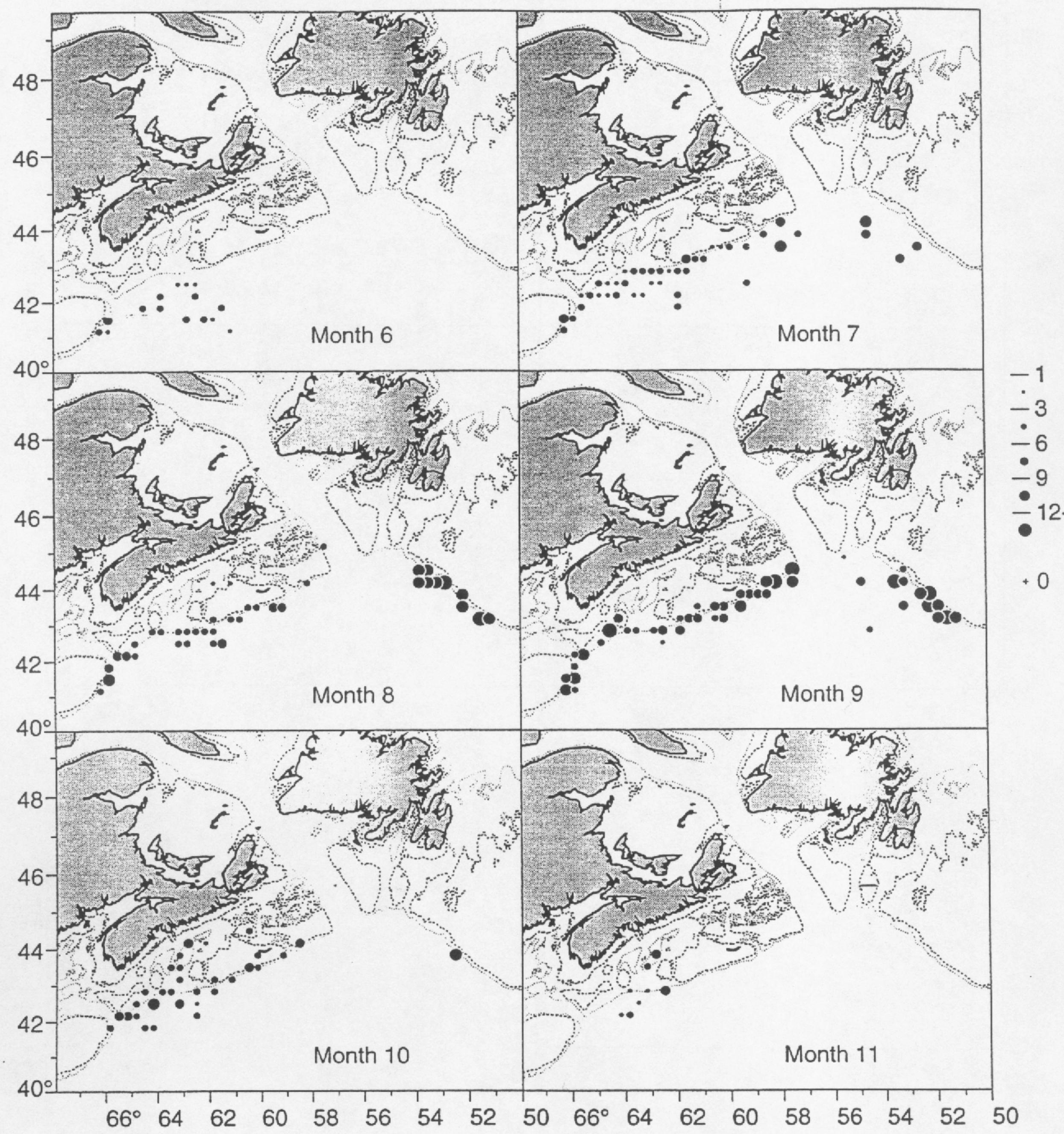

Fig. 13.2.4. Nominal CPUE (number of fish per 1000 hooks) aggregated by 20 minute squares for Canadian swordfish longline, June-November, 1994.

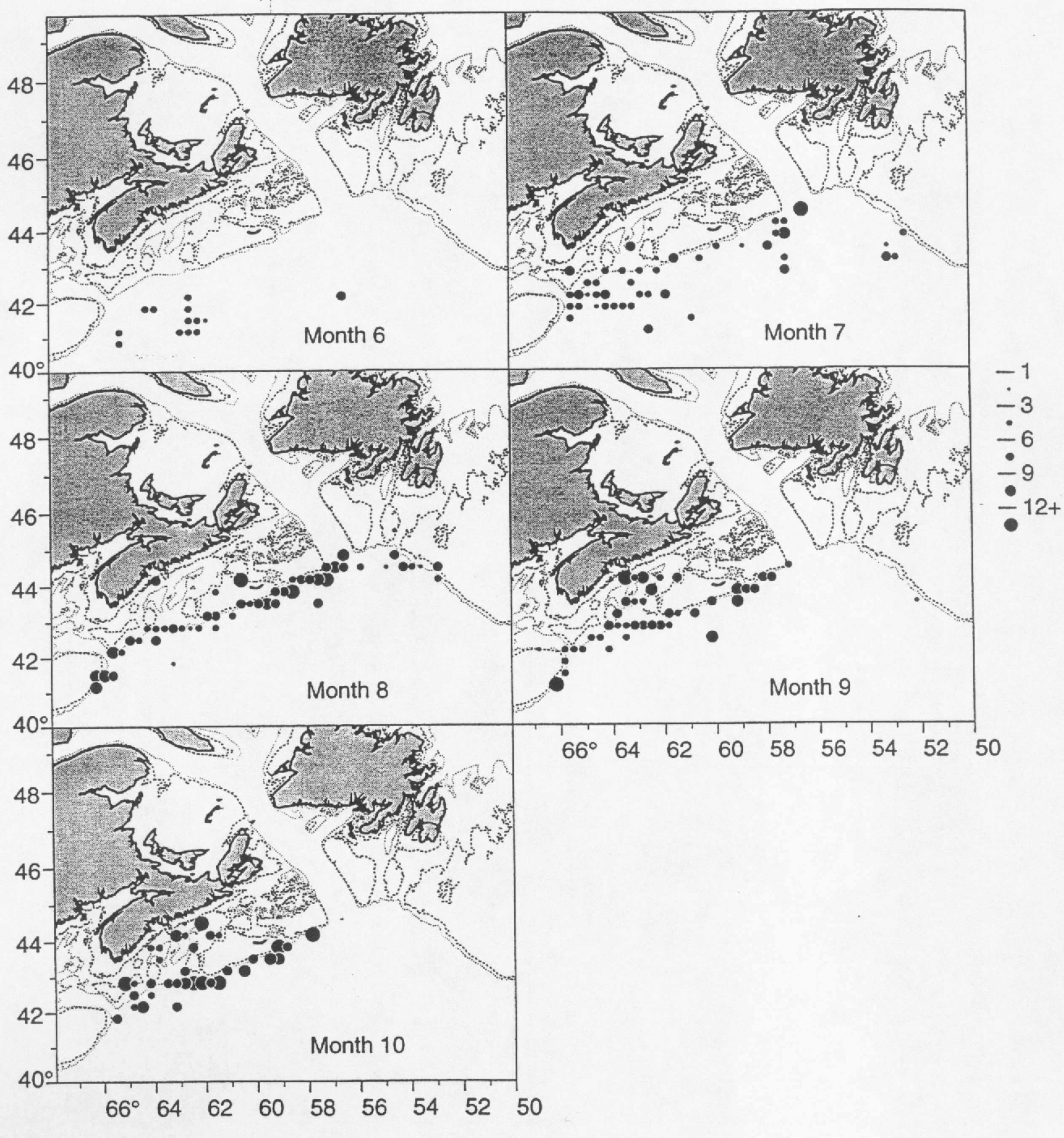

Fig. 13.2.5. Nominal CPUE (number of fish per 1000 hooks) aggregated by 20 minute squares for Canadian swordfish longline, June-October, 1995.

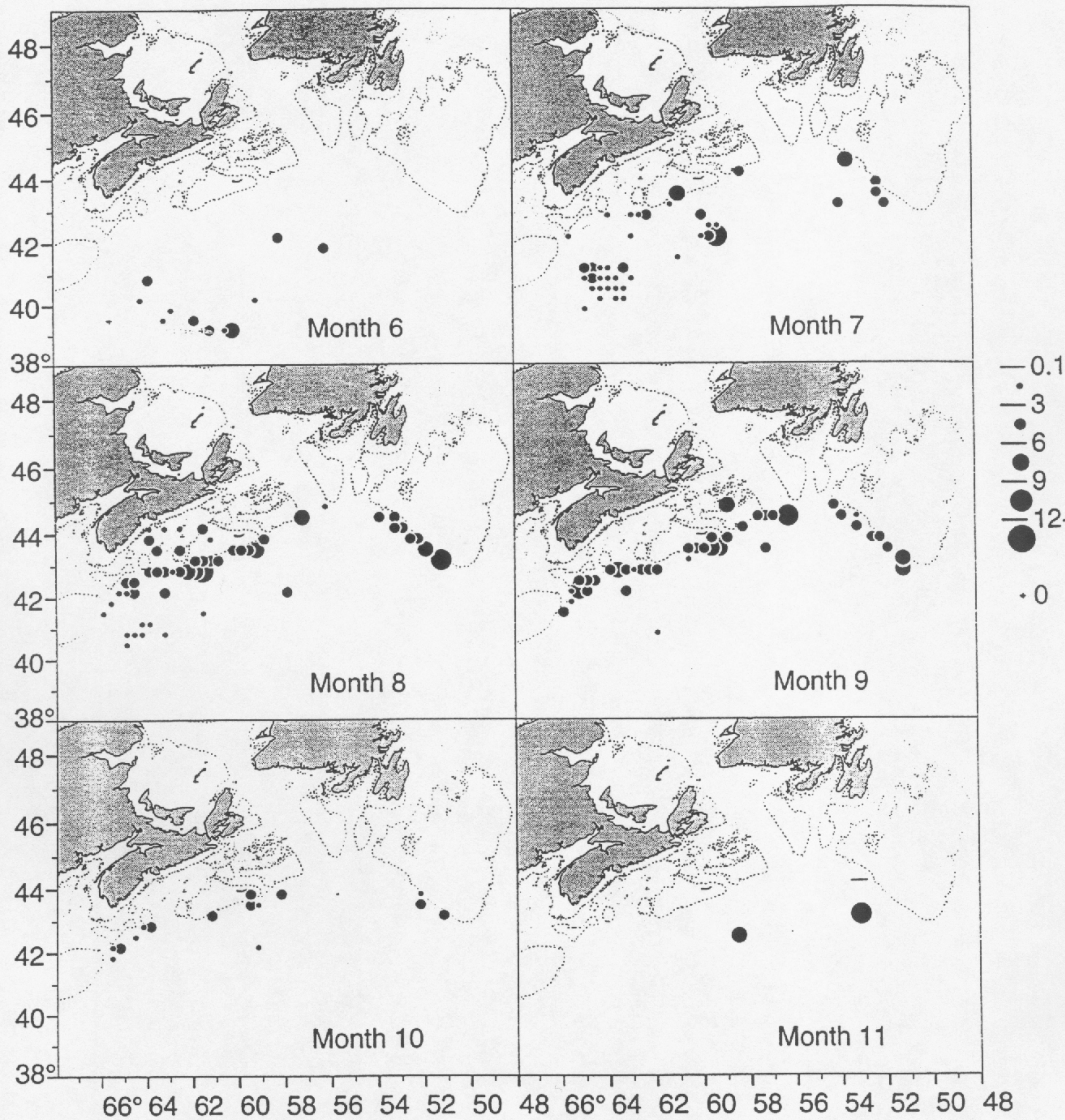

Fig. 13.2.6. Nominal CPUE (number of fish per 1000 hooks) aggregated by 20 minute squares for Canadian swordfish longline, June-November, 1996.

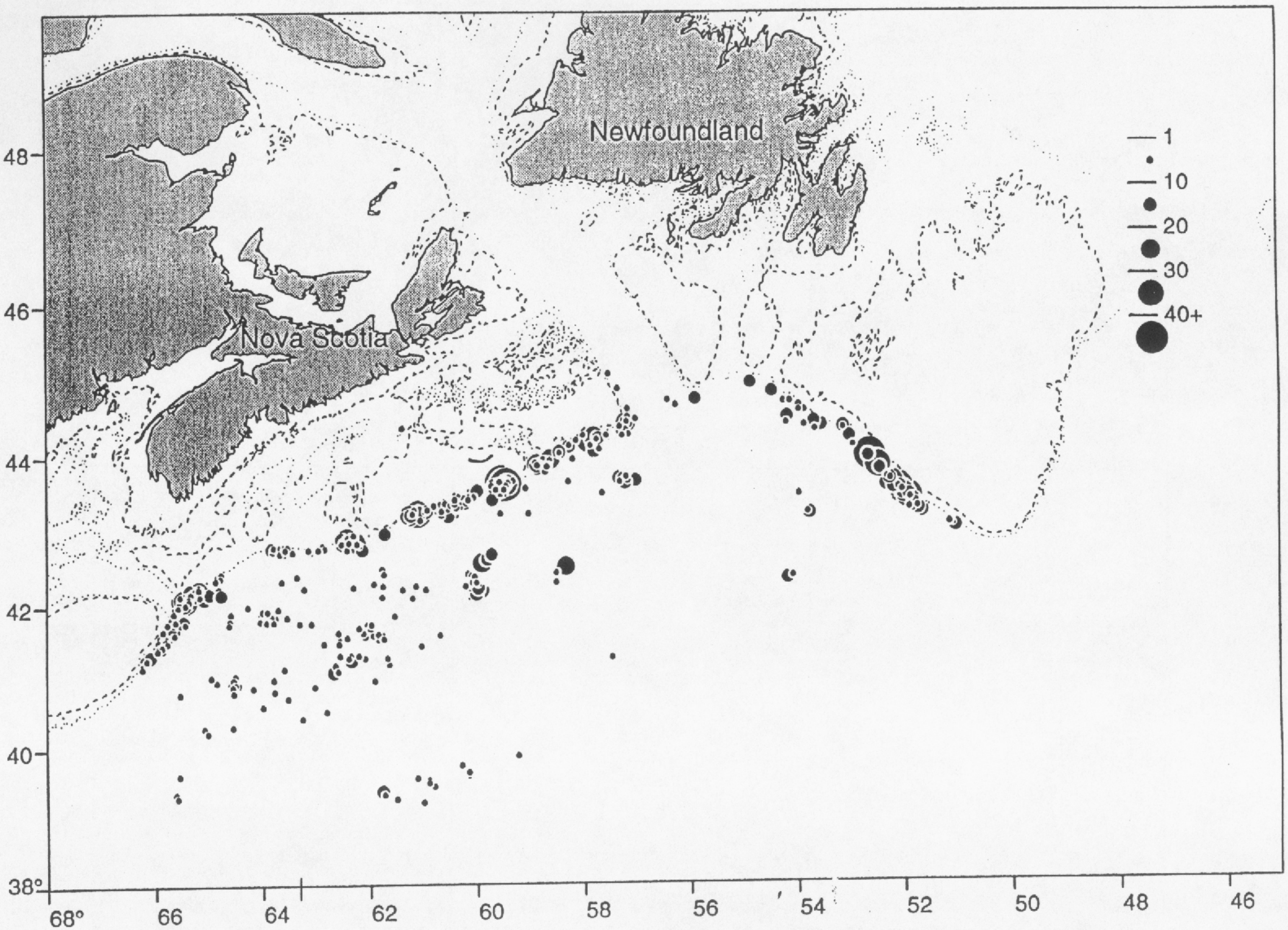

Fig. 13.2.7. Set locations and relative number of swordfish sampled per set from Canadian research and observer program sample collections, 1980-1996.

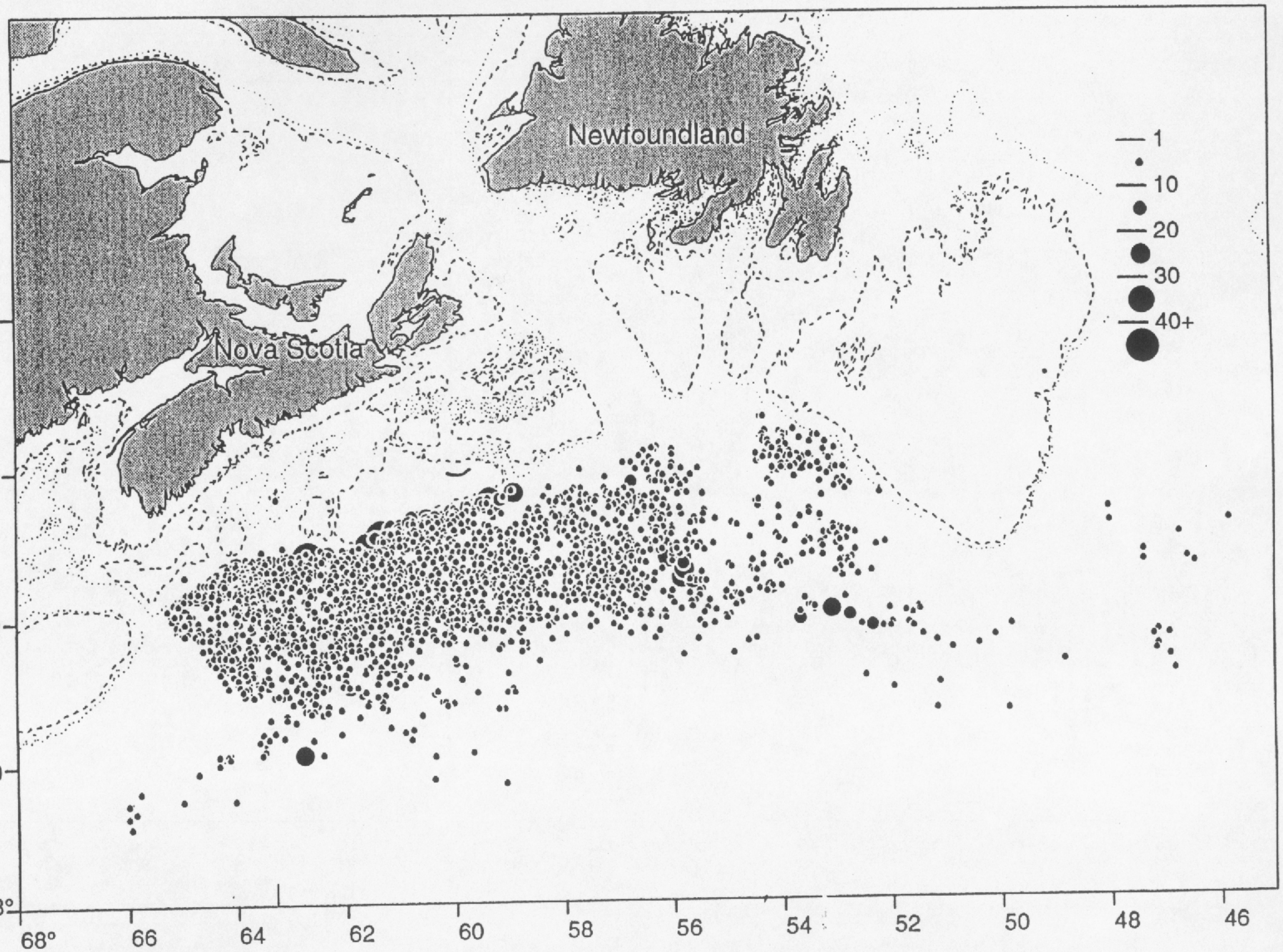

Fig. 13.2.8. Set locations and relative number of swordfish sampled per set on Japanese longline vessels from Canadian observer program sampling, 1980-1996.

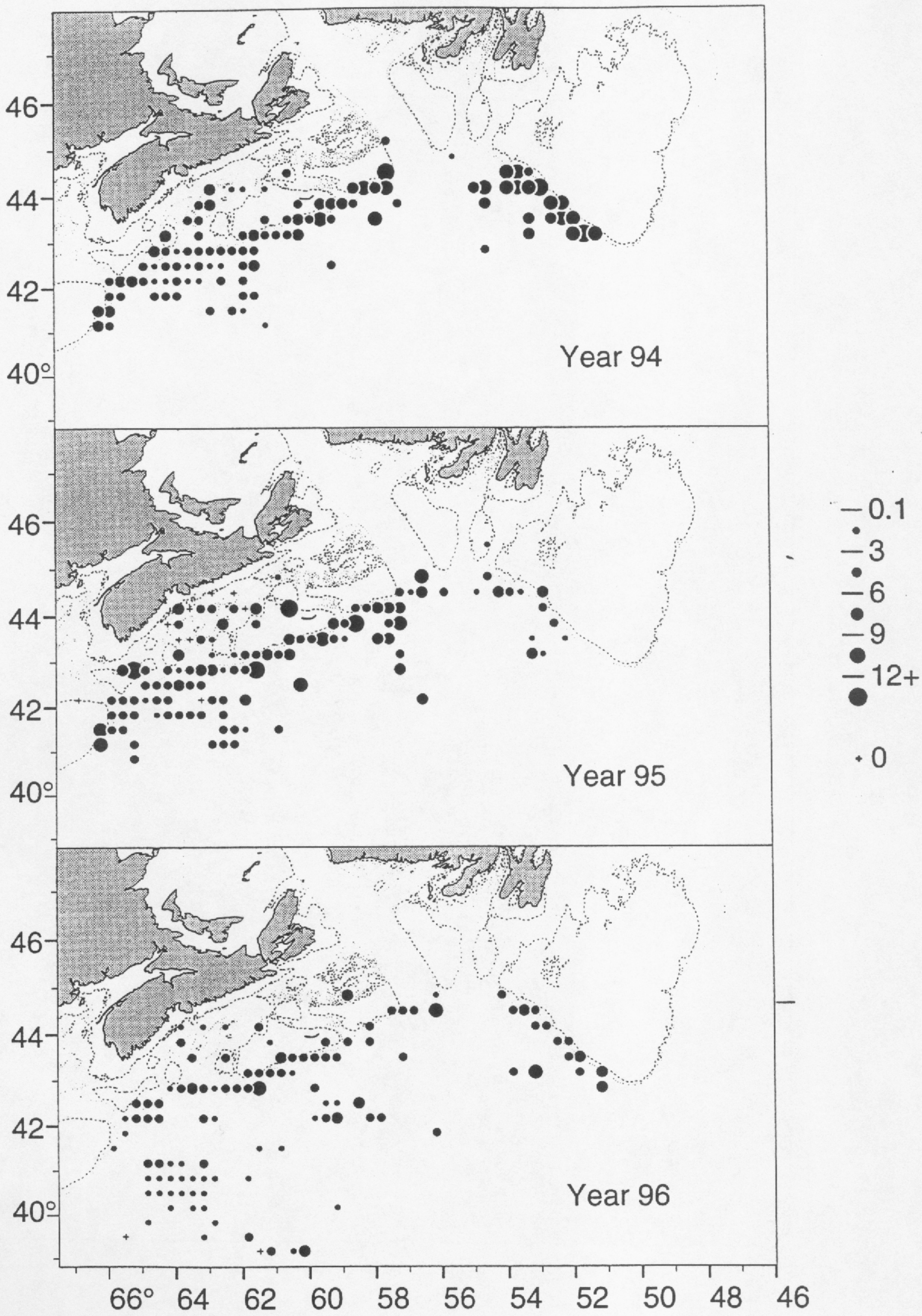

Fig. 13.2.9. Nominal CPUE (average number of fish per 1000 hooks) aggregated by 20 minute rectangles for the Canadian swordfish longline, 1994-1996.

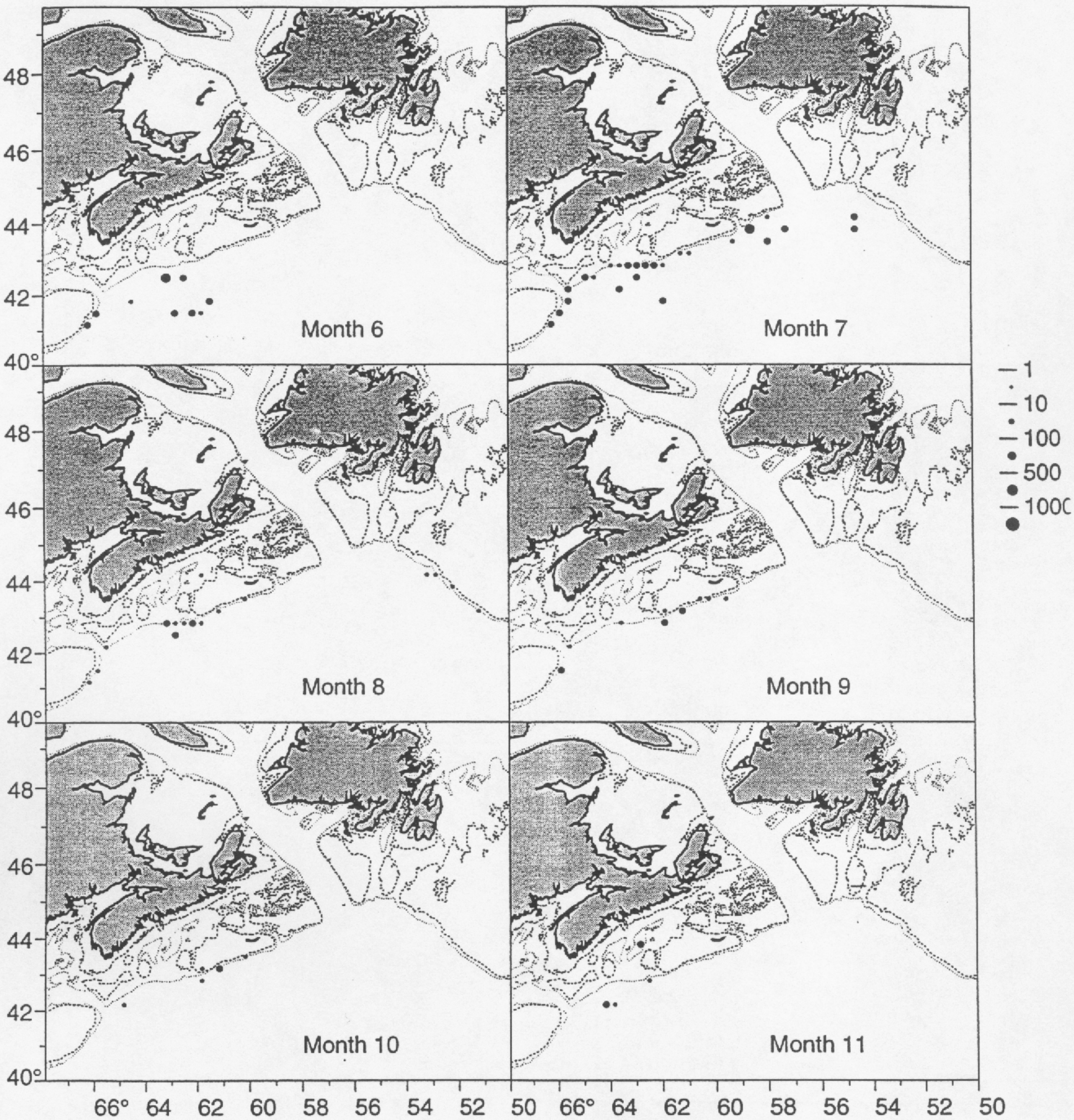

Fig. 13.2.10. Nominal CPUE (kgs of fish per 1000 hooks) for albacore aggregated by 20 minute rectangles from Canadian swordfish longline, 1994.

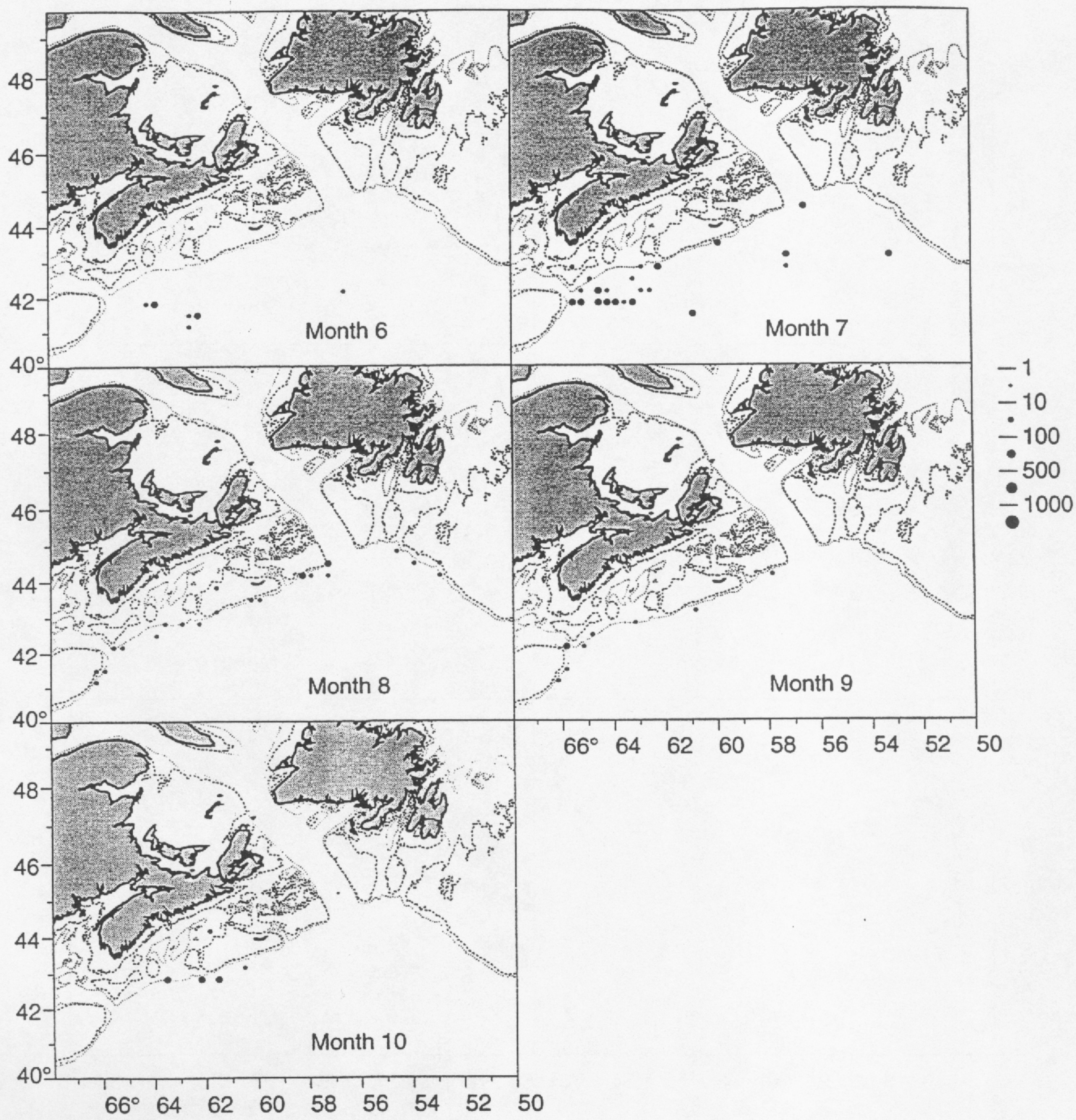

Fig. 13.2.11. Nominal CPUE (kgs of fish per 1000 hooks) for albacore aggregated by 20 minute rectangles from Canadian swordfish longline, 1995.

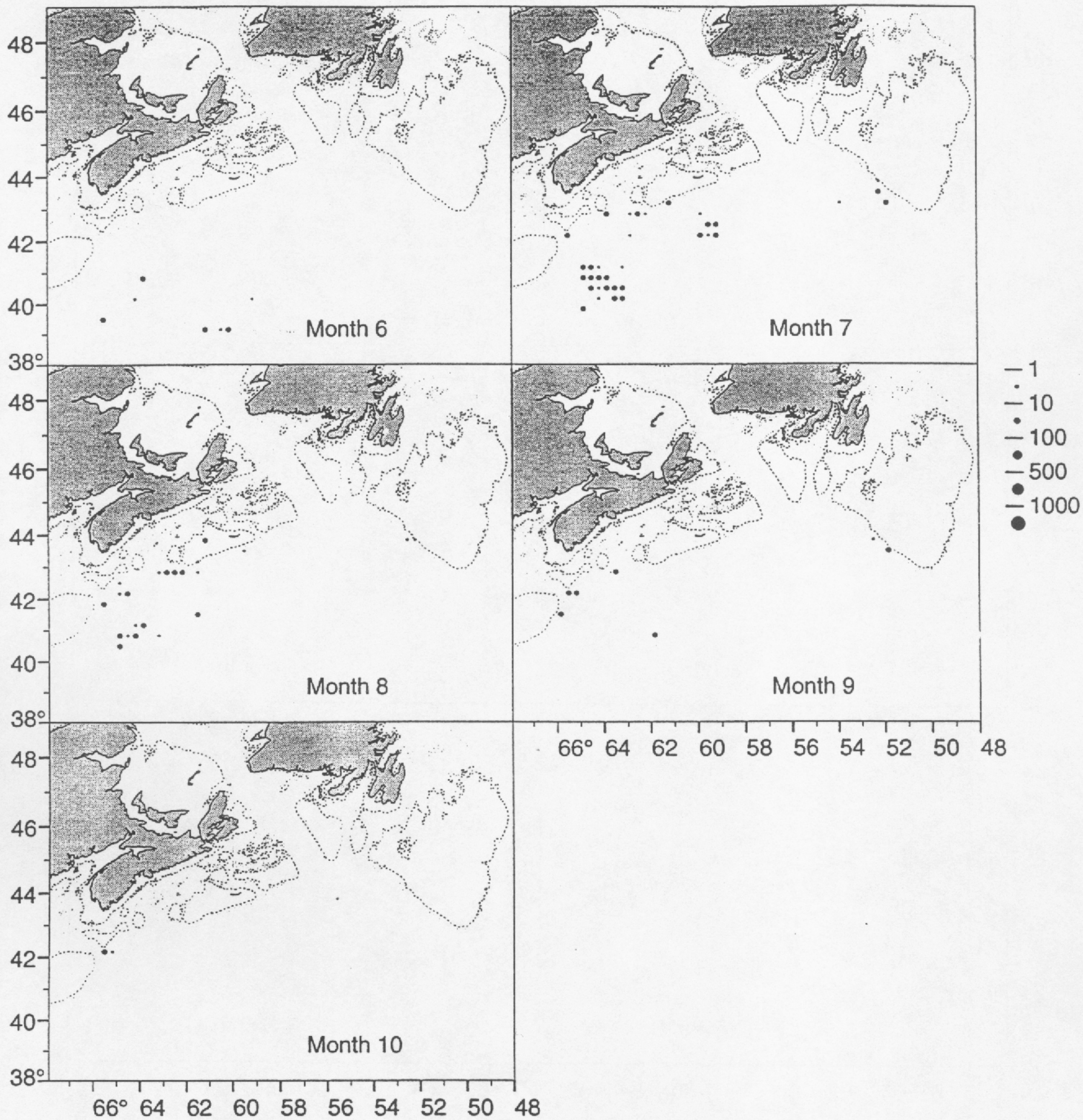

Fig. 13.2.12. Nominal CPUE (kgs of fish per 1000 hooks) for albacore aggregated by 20 minute rectangles from Canadian swordfish longline, 1996.

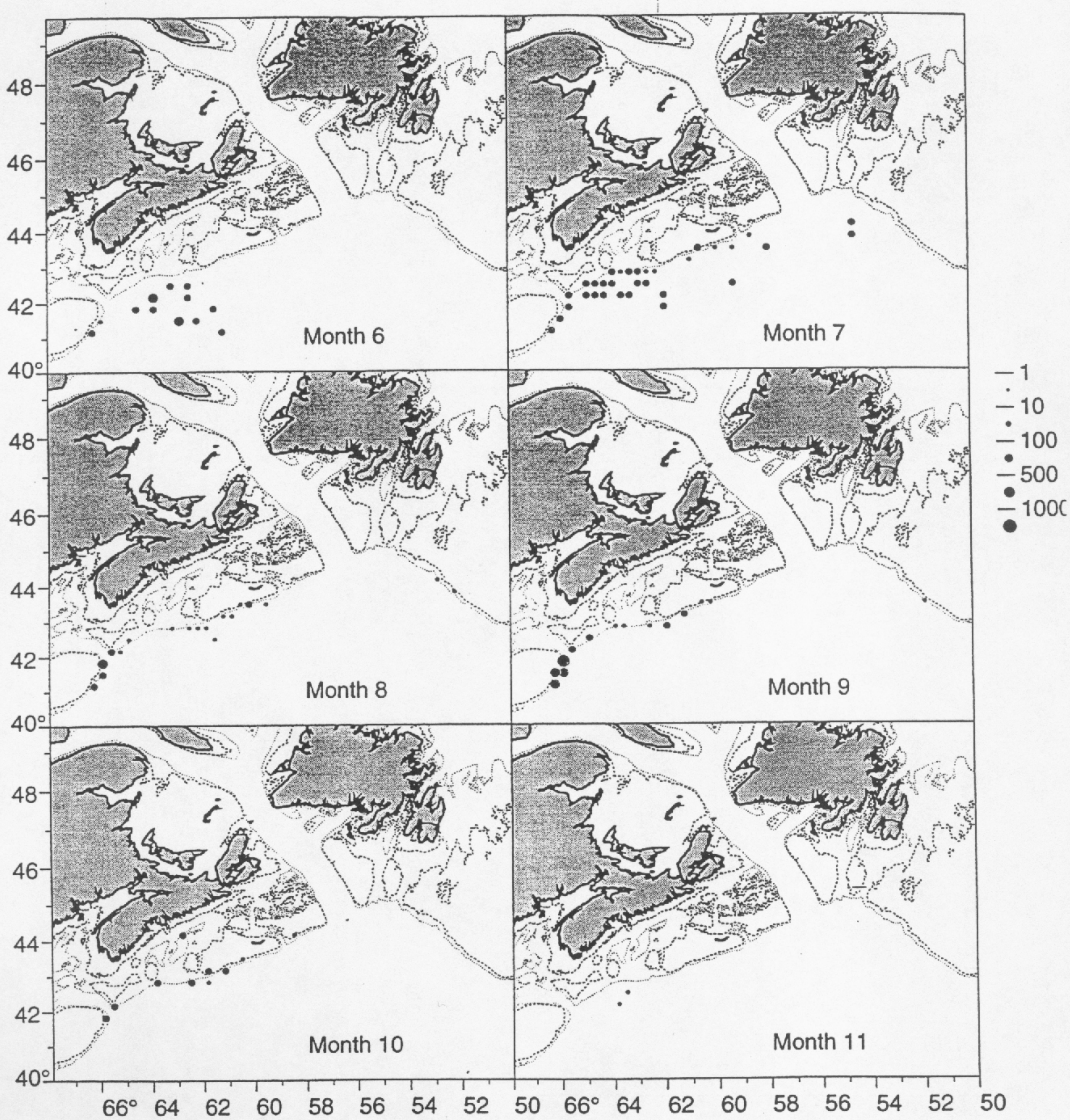

Fig. 13.2.13. Nominal CPUE (kgs of fish per 1000 hooks) for yellowfin aggregated by 20 minute rectangles from Canadian swordfish longline, 1994.

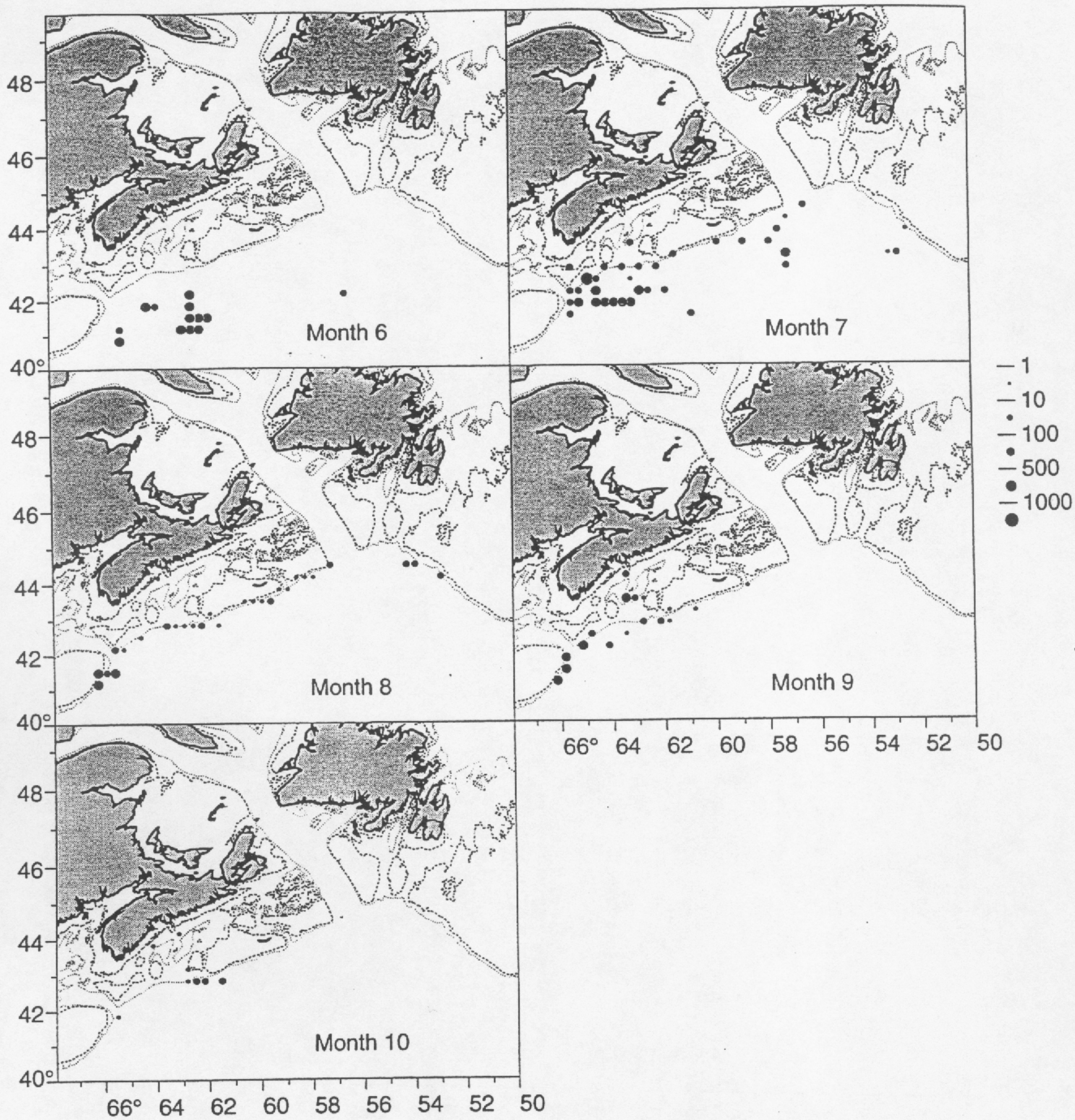

Fig. 13.2.14. Nominal CPUE (kgs of fish per 1000 hooks) for yellowfin aggregated by 20 minute rectangles from Canadian swordfish longline, 1995.

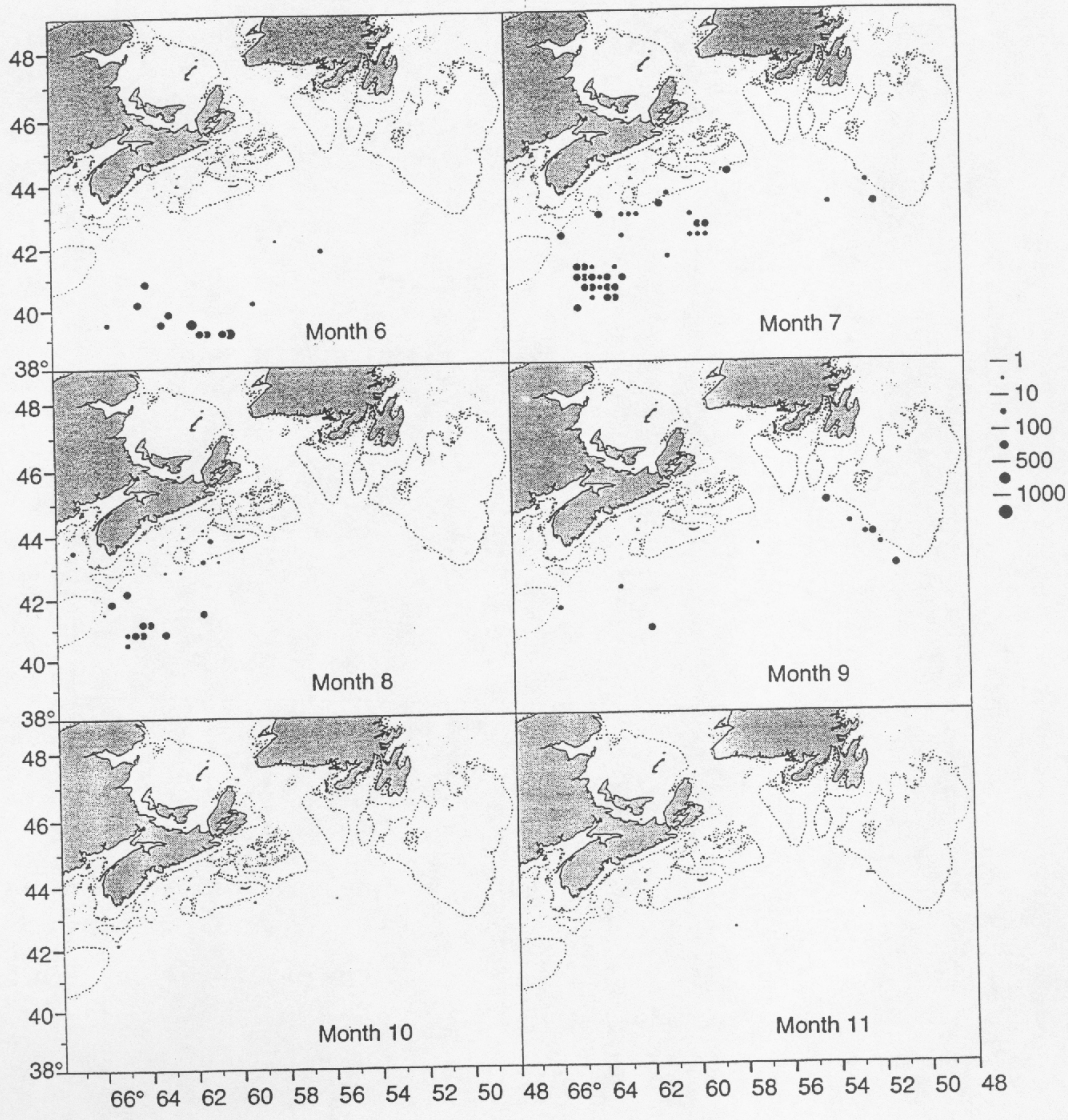

Fig. 13.2.15. Nominal CPUE (kgs of fish per 1000 hooks) for yellowfin aggregated by 20 minute rectangles from Canadian swordfish longline, 1996.

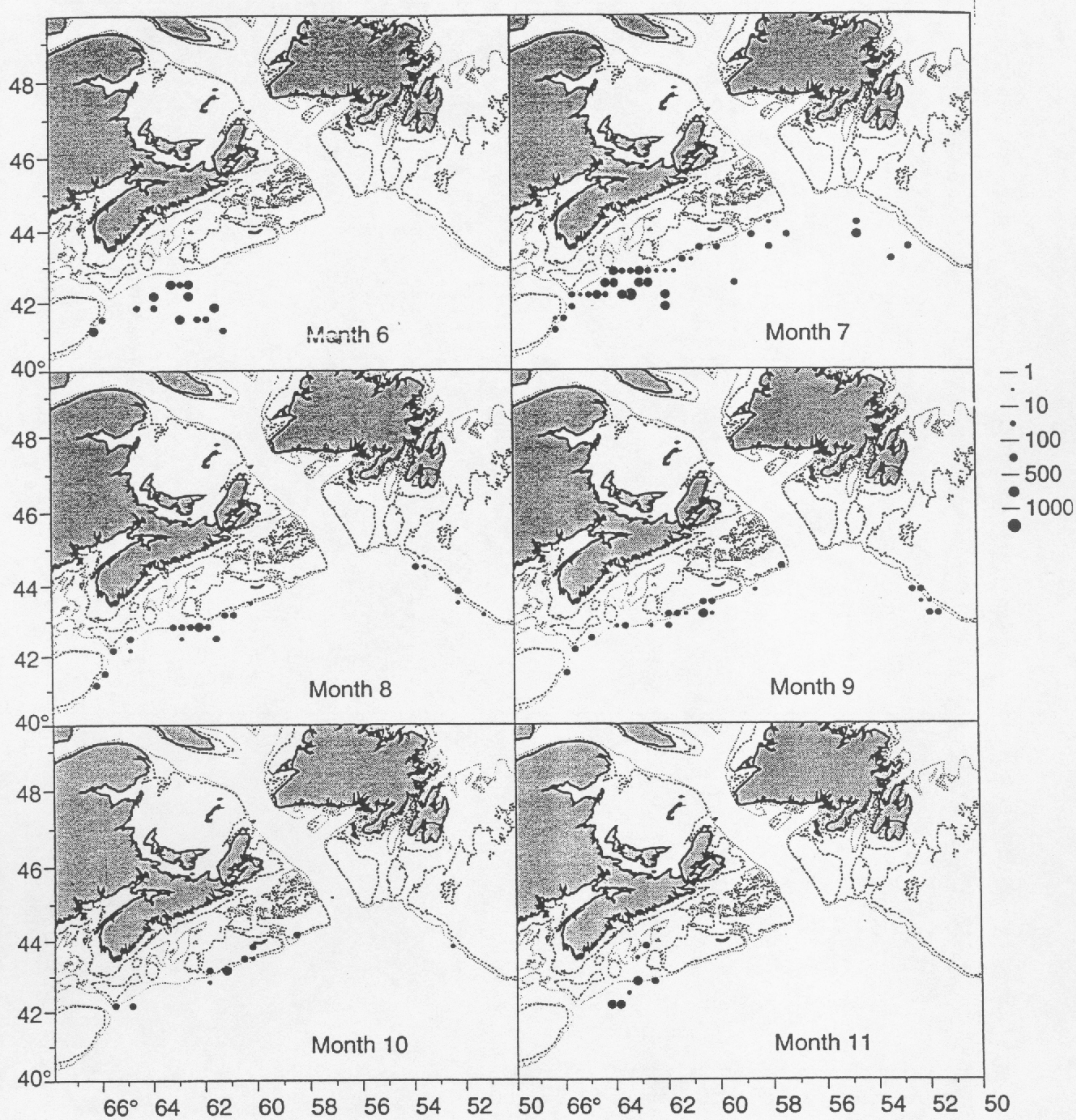

Fig. 13.2.16. Nominal CPUE (kgs of fish per 1000 hooks) for bigeye aggregated by 20 minute rectangles from Canadian swordfish longline, 1994.

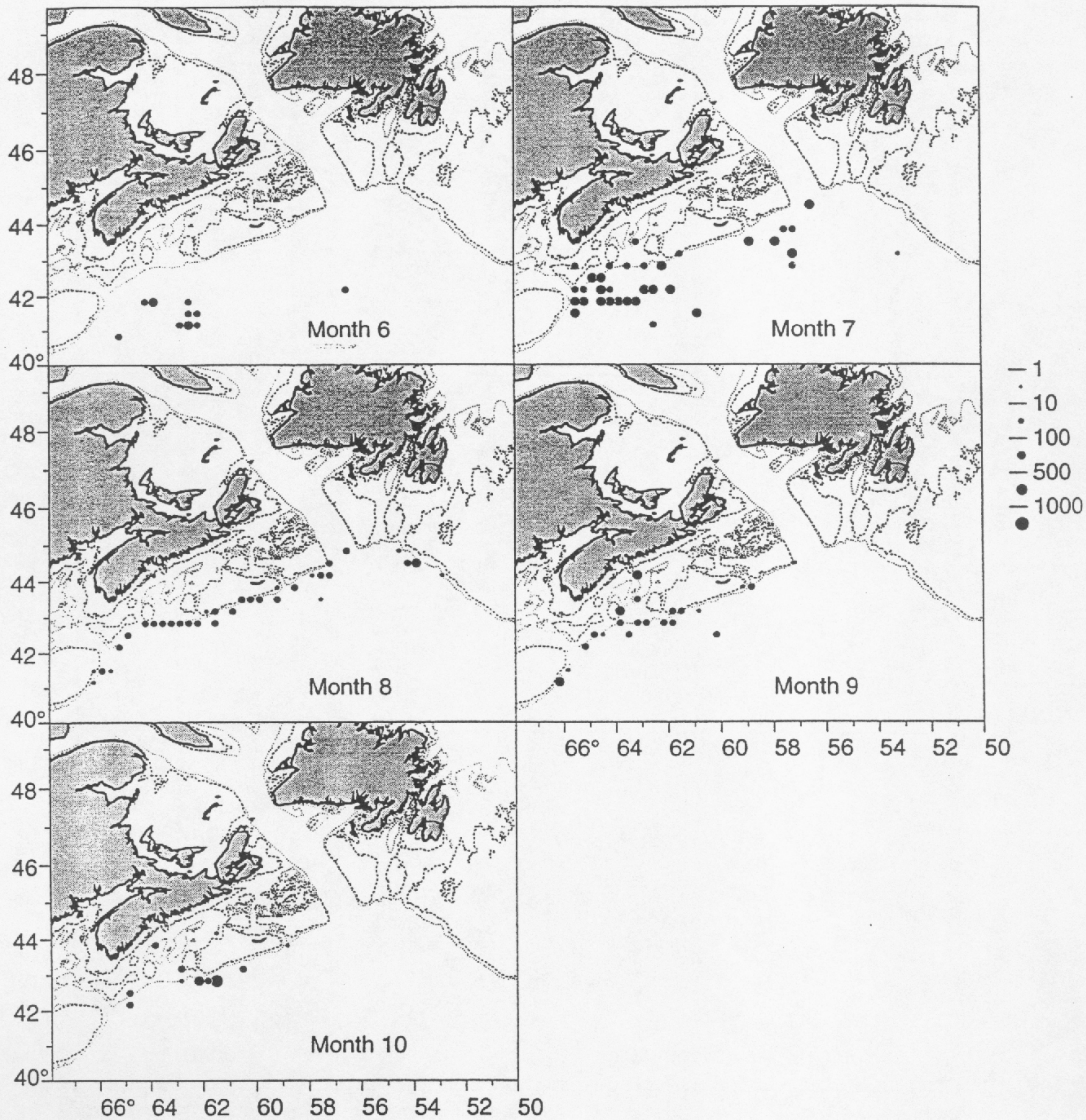

Fig. 13.2.17. Nominal CPUE (kgs of fish per 1000 hooks) for bigeye aggregated by 20 minute rectangles from Canadian swordfish longline, 1995.

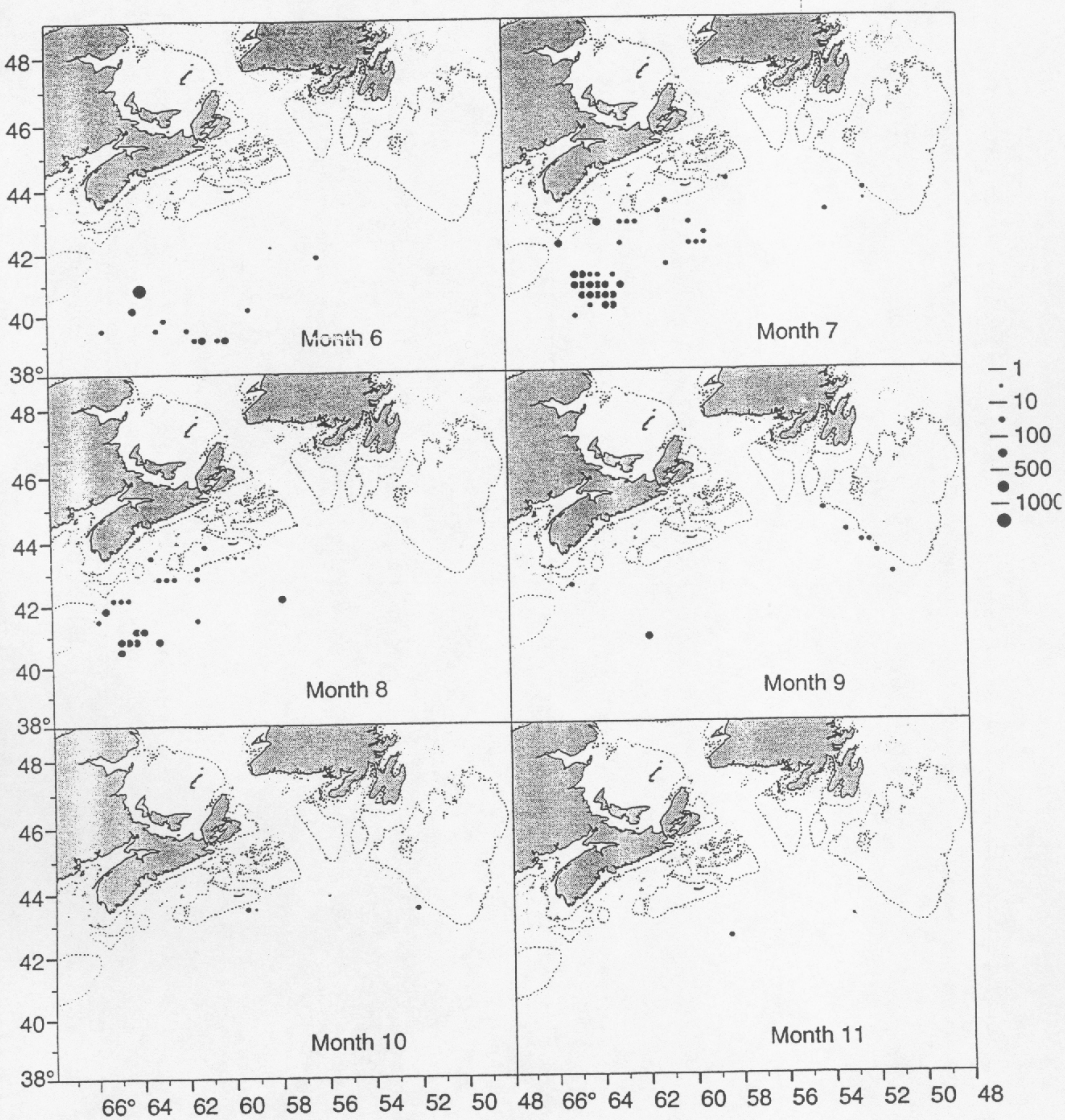

Fig. 13.2.18. Nominal CPUE (kgs of fish per 1000 hooks) for bigeye aggregated by 20 minute rectangles from Canadian swordfish longline, 1996.

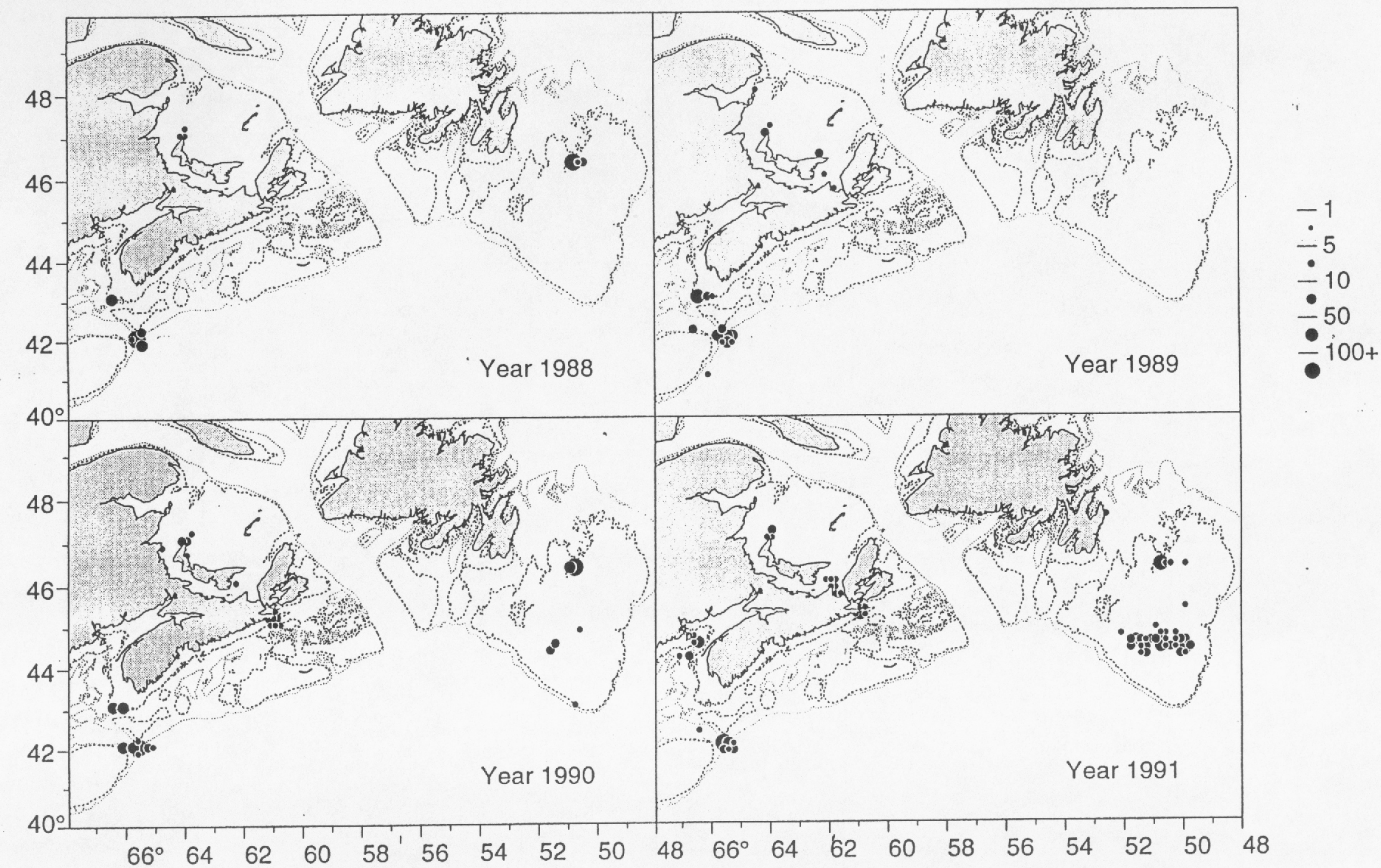

Fig. 13.2.19. Canadian bluefin tuna catch from log record data aggregated by 10 minute rectangles for 1988 through 1991 (Not all catch locations were available for plotting).

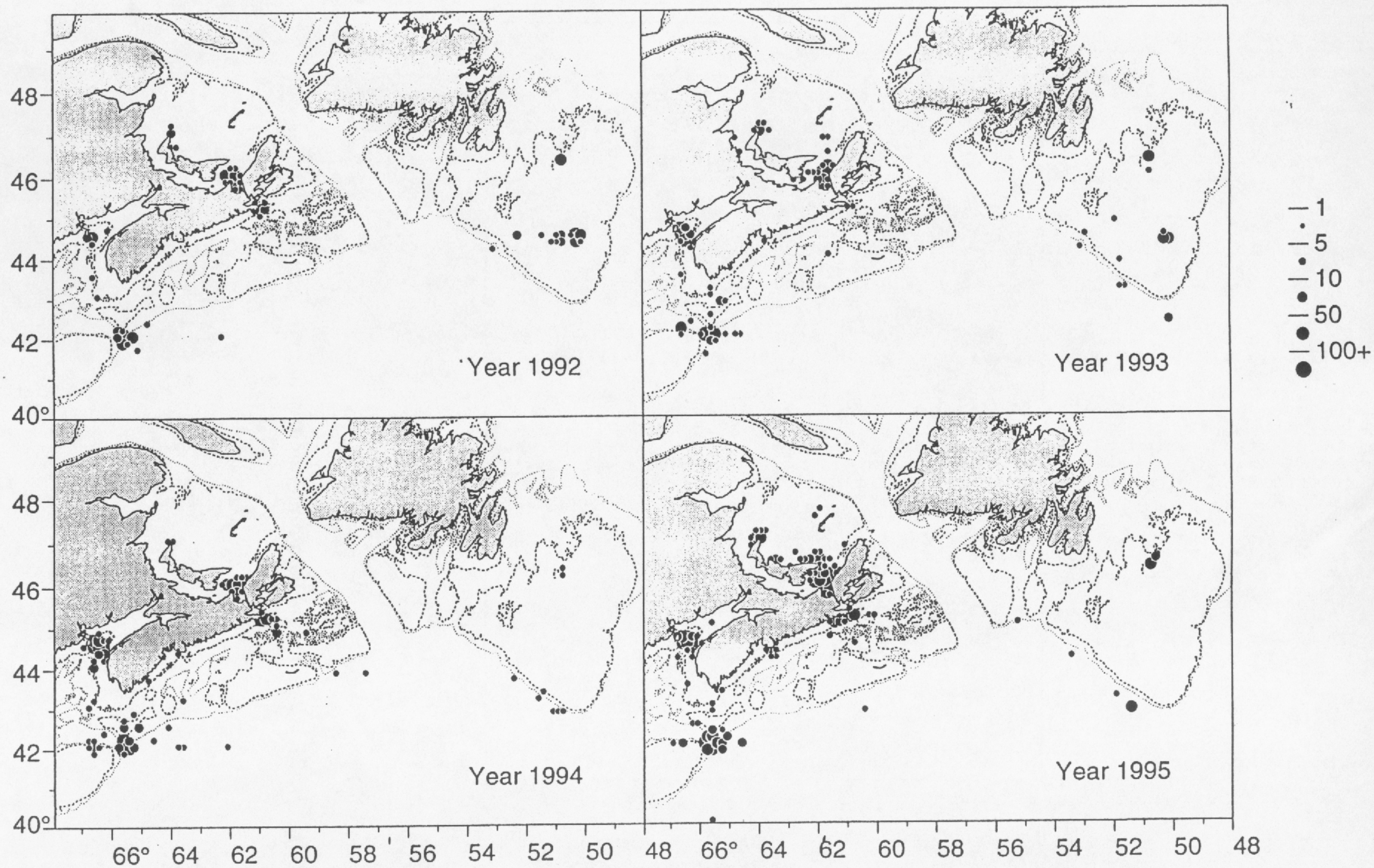

Fig. 13.2.20. Canadian bluefin tuna catch from log record data aggregated by 10 minute rectangles for 1992 through 1996 (Not all catch locations were available for plotting).

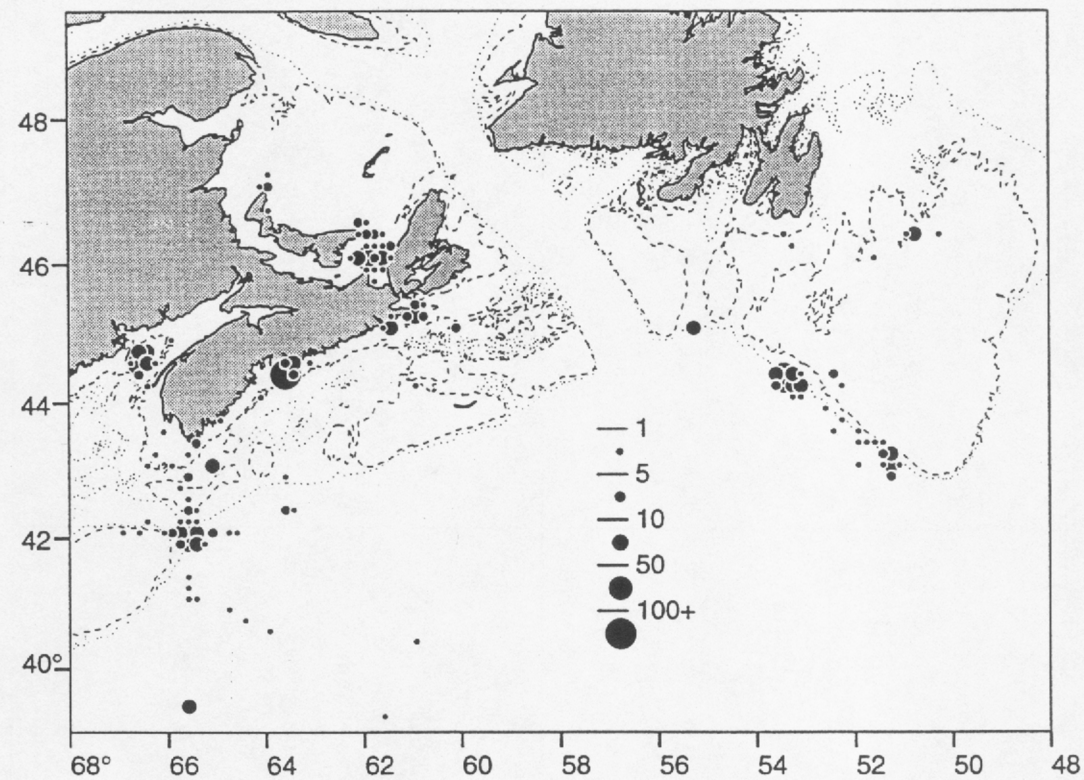

Fig. 13.2.21. Canadian bluefin tuna catch/10 minute square - 1996.