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Non-traditional groundfish species on Labrador Shelf and Grand Banks - Skate

by

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Abstract

With the decline in the "traditional" groundfish resources in the waters around Newfoundland, interest in the exploitation of alternate species has increased in recent years. In 1993, the Provincial Department of Fisheries carried out experimental fishing for skates and the work was continued in 1994 by the Federal Department of Fisheries and Oceans. Markets for skate wings were developed and directed fisheries began during 1994, continuing into 1995 and 1996. The first quotas were imposed in 1995 based on limited biological information. This study builds on the previous work by examining changes in the distribution of skates on the Grand Banks and Labrador Shelf, and updating the available information on biomass, abundance, and size in NAFO Divisions 3L, 3N, and 3O. Skates were found to form a continuous but highly-aggregated distribution on the Shelf and this distribution has become more truncated to the south since 1991. As well, survey indices of thorny skate declined in Divisions 3L and 3N while fluctuating in Division 3O. Research survey data from 1984 to 1995 were examined to provide some preliminary information to assist in management of the resource. Given the highly-aggregated nature of the distribution and the biological differences observed between areas, separating the management units to 3LN, 3O, and 3Ps would ensure that fishing effort is distributed over a wide area.

Résumé

Depuis le déclin des ressources « traditionnelles » de poisson de fond dans les eaux qui entourent Terre-Neuve, on voit croître ces dernières années l'intérêt pour l'exploitation d'autres espèces. En 1993, le ministère provincial des Pêches a mené une pêche expérimentale visant les raies, et le ministère fédéral des Pêches et des Océans a poursuivi ce travail en 1994. On a développé des marchés pour les ailes de raies, et des pêches dirigées ont commencé en 1994 et se sont poursuivies en 1995 et 1996. Les premiers quotas ont été imposés en 1995 à partir de données biologiques limitées. Notre étude tire parti des travaux antérieurs pour examiner les changements de la distribution des raies sur les Bancs de Terre-Neuve et sur le plateau du Labrador, et pour mettre à jour l'information sur la biomasse, l'abondance et la taille dans les divisions 3L, 3N et 3O de l'OPANO. Nous avons trouvé que les raies présentaient une répartition continue mais fortement agrégée sur le plateau, mais cette répartition est tronquée vers le sud depuis 1991. De plus, les indices scientifiques concernant la raie épineuse ont baissé dans les divisions 3L et 3N mais fluctuaient dans la division 3O. Nous avons examiné les données scientifiques recueillies entre 1984 et 1995 en vue de réunir une information préliminaire pouvant aider à gérer la ressource. Étant donné la nature fortement agrégée de la répartition et les différences biologiques observées d'une zone à l'autre, il serait bon de dissocier les unités de gestion en 3LN et 3O et 3Ps pour faire en sorte que l'effort de pêche soit réparti sur une vaste zone.

INTRODUCTION

Skates (*Raja sp.*), comprising about nine species, are distributed widely over the Grand Banks and the Labrador Shelf (Scott and Scott 1988). The dominant species, thorny skate *(R. radiata)* is a boreal to arctic species, distributed in both the eastern and western Atlantic, from Greenland to South Carolina on the western side. It is found over a wide range of depths (taken as deep as 1700m from commercial fisheries) in -1.4 to 14^0C on both hard and soft bottoms (McEacheran and Musick, 1975).

The exact life span of thorny skate in Newfoundland waters is not known. However, based on the time between tagging and recapture of some individuals, it is known that they can live at least 20 years (Templeman 1984a). They deposit egg cases containing single embryos. Skates only lay between 6 and 40 of these a year and egg size is related to the size of the parent. It is not known however, if survival rate is related to egg size. Males mature at smaller sizes than females and size at maturity increases from north to south. Limited data suggest that reproduction occurs year round on the Grand Banks. Also, Atkinson (1995) noted that female thorny skate in divisions 3LN mature at a smaller size than those further west in Division 3O and Subdivision 3Ps.

Thorny skate feed on a variety of items including both invertebrates and fish (Rodriguez Marin et al 1994, Templeman 1982b). Invertebrate food includes marine worms, crabs and whelks. Fish prey, which are increasingly important with increasing size, include sculpins, redfish, sand launce and haddock. Significant amounts of offal have been found in the stomachs of skate captured in the vicinity of commercial fishing. Limited information on predators of thorny skate around Newfoundland show that they have been found in the stomachs of seals, sharks and Atlantic halibut.

Historically, there has been only limited interest in directed fishing for skate in the waters around Newfoundland. Most of the reported catches have been by non-Canadian fleets. Canadian catches have traditionally been incidental to catches of other groundfish. Given their extensive distribution, skates have been a common bycatch in many fisheries, particularly offshore. Kulka (1982, 1984, 1985 and 1986a) reported that in the Newfoundland offshore trawl fisheries, skates consistently comprised the greatest "non-commercial" bycatch, particularly from the Grand Bank fisheries. During the early- to mid- 1980's, amounts caught annually were estimated at about 3,000 - 4,000 t for the Newfoundland offshore trawl fisheries. These discards were not recorded in the landing statistics even though there was skate mortality due to fishing. Similar amounts are thought to have been bycaught and discarded throughout the 1980's and early 1990's.

With the decline in the "traditional" groundfish resources in the waters around Newfoundland, interest in the exploitation of alternate species has increased. Given that skate was a common and sometimes abundant bycatch in other fisheries, it was targeted for development as a directed fishery. In 1993, the Provincial Department of Fisheries carried out experimental fishing for skates and the work was continued into 1994 by the Federal Department of Fisheries and Oceans (Atkinson, 1995). A marketing plan was formulated by Day (1991) and markets for skate wings were subsequently developed, particularly in Europe. A directed fishery that began in 1994 was primarily exploratory in nature. Commercial concentrations were located on the southern extent of the Whale Bank, Halibut Channel and just south of St. Mary's Bay (Fig. 1).

Atkinson (1995) reports on earlier suggestions for an unrestricted skate fishery around Newfoundland, similar to the current regime outside the Canadian 200 mile limit. However, because of concerns about the sustainability of the resource, a more conservative approach was adopted. Although only limited scientific information was available at the time, it was used as the basis for setting catch limits for 1995. Catch quotas were separated between two bank areas; the Grand Banks (divisions 3LNO) and St. Pierre Bank (Subdivision 3Ps). Catch limits were set based on 20% of the average trawlable biomass for research surveys for 1991-1993. This resulted in catch limits of 5,000 t and 1,000 t for 3LNO and 3Ps respectfully for 1995 and this allowed the quota to be split between the two fishing grounds.

In 1995 and 1996, skate has been regulated by a TAC of 6,000t and 2,000t respectively. Minimum allowable mesh size for otter trawls was 300 mm in the codend and 250 mm in the remainder of the trawl for mobile gear > 65 ft. For fixed gear (gillnet), minimum mesh size was set at 12 in. outside 12 nmi. and 10 ½ in. inside for vessels > 65 ft. Fishing seasons are Aug. 1 to Dec. 31 outside 12 nmi. and Apr. 1 to Dec. 31 inside. Maximum allowable bycatch in other fisheries was set at 5%.

In spite of increased fishing effort, little information exists on the biology and distribution of skate. Data have routinely been collected during research surveys in the northwest Atlantic but there has been only limited examination of skate data. A number of studies were published, mostly in the mid eighties, on the biology of thorny skate. Topics covered migration and abundance (Atkinson 1995, Templeman 1984b), feeding (Rodriguez Marin et al 1994, Templeman 1982a), length/weight and morphometrics (Templeman 1987, 1984c) and egg development (Templeman 1982b). Simon and Frank (1995) and (Atkinson, 1995) published the first assessments for thorny skate in NAFO Div. 4VsW and 3LNO respectively. Except for this preliminary work, none of the skate species have been formally assessed for their potential as a commercial resource off Newfoundland and Labrador. Elsewhere, Shreman and Parin (1994) have published on skate distribution in the Norwegian Sea. Skate studies on feeding in the Barents and Norwegian Sea are relatively common (Antipova and Nikiforova 1990, 1983, Berestovskiy 1989a, 1989b).

Although skate in commercial catches constitute a mix of species, thorny skate dominates in most areas. This paper reviews available information on biomass and abundance of thorny skate from research vessel surveys (1976-1994) in Newfoundland waters (Fig. 1), catch per unit effort in the directed commercial fishery and historical catches and commercial wing width data for 1995 and 1996. Based on commercial bycatch data, this paper also looks at the distribution of the most abundant species of skate in the commercial catches, namely thorny, spinytail, barndoor and smooth. Species mix and proportions of skate in the commercial catches are presented.

Distributional patterns observed may reflect population changes and can provide some basis for defining management units. These types of analyses can serve industry by providing information on potential fishing locations for the developing fisheries. More importantly, this study provides baseline biology of new target species and updates our knowledge of the species for assessment purposes.

METHODS

Data on skates have routinely been collected during research surveys for the various areas around Newfoundland. For this study, trawl data from 1951 to1995 were used to describe the distribution of thorny skate. Prior to 1971, the data were limited and surveys consisted of series of transects. A random stratified survey design was used on the Grand Bank (Div. 3LNO) after 1970 and in the St. Pierre Bank (Div. 3P) area after 1971. Doubleday (1981) provides a summary of the stratified-random survey design adopted after 1970 by the Newfoundland region. The survey data were examined for outliers based on survey conditions. Catch data were rejected when sampling speed > 0.5n. mi.

Commercial fishery data collected by observers (Kulka and Firth 1987) for the period 1981 to 1994 were also used to examine skate distribution. The data comprised bycatches from the various offshore trawl fisheries. The extent of the shelf was sampled differently for commercial and research data causing differences in species mix. The upper panel in Fig. 1 illustrates the total area of the shelf over the study area by intervals of bathymetry. While research surveys covered all areas inside 600 m equally, commercial vessels fished a greater proportion of the banks at depths greater than about 600 m. On the other hand, although sampling intensity (number of fishing sets) was an order of magnitude higher, commercial fishing is more aggregated. Thus spatial coverage inside 600 m was less extensive and a smaller proportion of the shallower depths were covered. As well, commercial trawl gear was more variable, larger in size and employed larger meshes.

For both research and commercial sources, skate catch rate (kg. per standard tow and kg. per hour towed) were grouped into five year intervals. Catch rate from individual sets (point data) were converted to density surfaces using potential mapping (Kulka *et al.* 1995). Potential mapping averages observations over a user defined diameter allowing a clear representation of overlapping data points, with minimal extrapolation. Black areas represent the highest density of skate (highest catch per tow or hour) and light grey, the lowest. A thick line outlines the sampled area. For commercial data, the graphs accompanying the plots of distribution show catch rate by percent of sampled area containing low, medium and high concentrations of fish, by depth (right).

Average distribution and density trends among 5 year groupings were compared from 1951 to 1994 for research data and from 1981 to 1994 for commercial bycatch data . Sampling coverage prior the 1976-80 year groups was sparse and not comparable to coverage in later year groups but provide some idea of their distribution in those years. Based in density distribution plots, data from spring research vessel surveys were split into northern (≥48°N) and southern (<48°N) components. Further analyses (ANOVA) report on temporal variability in catch, latitude, depth, temperature and size, north and south. Temporal variability in latitude, depth and temperature were calculated based on means per trip weighed by catch for each variable. In effect, this provides the centre of mass for skate examined relative to each factor (latitude, depth, temperature) across year groupings.

Using STRAP, annual biomass and abundance indices and average weight were derived for thorny skate from spring stratified random surveys to divisions 3LNO and Subdivision 3Ps from 1986 to 1995. Wing width of skate from the commercial catch were collected by fishery observers from the directed fishery.

RESULTS AND DISCUSSION

Biology and Distribution

Grouped Data (5 year)

Thorny skate (*R. radiata*) was the most common species, comprising greater than 90% of skates caught in research surveys. The second most common species from the surveys, smooth skate (*R. senta*) comprised about 5% of the catch while other species were taken only occasionally. The mix of skate species from the commercial trawl fisheries is somewhat different from the research vessel surveys. From commercial gears (Table 1), comprising many fisheries, thorny skate constituted only 81% of the skate catch. This is probably due to a difference in area fished (more deep sets) and gear (ie larger mesh size used for otter trawls). Other species: spinytail skate (*R. spinicauda*), barndoor skate (*R. laevis*), smooth skate (*R. senta*) and winter skate *(R. ocellata*) respectively made up 10%, 4%, 2% and 1% of the skate catch. Combined, all skate made up about 1% of total observed otter trawl, gillnet and longline catches.

From research records and prior to 1991, thorny skate was found to be distributed widely and continuously with moderate to high densities covering much of the seaward portion of the Grand Banks and onto the Labrador Shelf as far north as Lat. 50^0 (Figure 2a-c). There was a significant contraction in the distribution particularly after 1991. The distribution was truncated and higher concentrations occurred over a smaller area mainly south of Lat. 47^0 along the outer shelf of the Grand Banks. Of note is the disproportionate reduction in density on the tail of the Grand Bank outside the 200 mile limit, likely a result of more intense fishing activity in that area.

The pattern is similar for distributions derived from commercial fishing data (Fig. 3), although the commercial data are more difficult to interpret given the change in extent of fishing effort with time. The chart in the lower right of Fig. 3 also shows that the areas of high concentrations of skate in the mid-depths diminished over time. Of note is the reduction of density of skate outside the Canadian 200 mi. limit on the tail of the Grand Bank over time and particularly after 1985, a time of heavy fishing effort in this area. Thus, both research and commercial data show that considerable shifts have taken place in the distribution of thorny skate suggesting significant changes in the population. These changes occurred mainly after 1990 corresponding with the period of decline of many groundfish species (Atkinson 1993). As with other species, what affected these changes remains in question.

Three other species, spinytail (Fig. 4), barndoor (Fig. 5) and smooth (Fig. 6) comprised nearly all of the remaining skates in the commercial catches. These species are far less extensively distributed and the first two are primarily deeper water species. They are found in fairly high concentrations along the shelf edge in the deep channels between the banks. Shallower research surveys would have poorly sampled the spinytail and barndoor skate thus explaining the difference in species mix between research and commercial data. A southerly shift in the distribution can be seen for barndoor skate after 1985. Previously found in substantial amounts along the shelf edge north of Lat. 52^0, most of the concentrations were found along the shelf break between Lat. 48^0 and 50^0 after 1985, similar to the distributional shift for northern cod (Kulka *et al.* 1995 and Wroblewski *et al.* 1995). As well, smooth skate appears to be more common on the southern Grand Bank during 1991-94.

Noted contraction in density and distribution for thorny skate (Fig. 2) are corroborated by more stringent (traditional) statistical analysis (Fig. 7). Average catch weight in research surveys have declined and there was a significant southward shift for fish south of Lat. 48^0N in the years 1991 - 1994. A parallel shift could have occurred for the fish north of Lat. 48^0N although the data are more indicative of a northern shift in 1986 - 1990 and a return to previous conditions in 1991-1994.. Skate have moved to deeper, perhaps warmer waters over the entire distribution. We also note that male and female size have declined, particularly after 1986 - 1990.

Annual Data

Survey biomass indices (Fig. 8 and Table 2) shows a declining biomass in NAFO divisions 3L and 3N since 1986. The biomass indices fluctuated in Division 3O and Subdivision 3Ps until the early 1990's. The estimates for 3O and 3Ps have also declined in the early 1990's to the lowest level in the time series. A slight increase is notable in 3Ps (1994 and 1995) and 3O (1995).

Coupled with the decline in biomass indices in divisions 3LN, there has been a steady decline in the average size of skate found in the area (Fig. 8 and Table 2). No declines in skate size were observed in Division 3O but there has been a recent decline in Subdivision 3Ps. In 1994 and 1995, the mean weight of skate in divisions 3LN was only about 0.36 kg., compared to an average of about 1.15 kg. in 3O and 3Ps. These correspond to average wing widths of about 23 and 46 cm (9 and 18 inches) respectively. This compares with much larger mean weight of skate of 1.75 kg in divisions 3LN and 1.54 kg. in 3O and 3Ps in 1986-87.

Based on market conditions, the minimum acceptable size (wing width) is about 46 cm (18 inches). Atkinson (1995) noted that in the 3LN area, about 50% maturity is reached at about 46 cm (18 inches) wing width, but in 3OPs the width at 50% maturity is about 56 cm (22 inches). A limited number of measurements of wing width done by fishery observers shows that the mesh size used selected skate of a large enough size for the market. The size in directed catches from 3O and 3Ps ranged from 50 and 95 cm (average 77.2) in 1995 and 35 to 95 cm (average 69.4) in 1996 (Fig. 9).

The fishery

Tagging information indicates that they are sedentary species and generally do not undergo long migrations. Templeman (1984) observed that thorny skate generally move less than 100 km annually. However, fisheries log data collected from several foreign vessels fishing outside of the Canadian 200 mile limit during the summer show large catches being taken on the tail of the Grand Bank (Fig. 10) suggesting dense concentrations of skate in his area whereas spring research vessel surveys show little evidence of concentrations in this area after 1985 (refer to discussion above). If the fishing log data are reliable, then this would suggest that the skate do indeed have a variable seasonal distribution. However, a comparison of commercial distributions which contain data from all months (although not from outside the Canadian 200 mi. limit) and the spring survey data indicates a similar pattern and thus little or no migration.

Domestic landings of skate have increased from 3,424 t in 1994 to 4,940 t in 1995, mostly in 3O and 3Ps. These skate catches were taken from two small areas about 50 km long on the southern edge of Whale Bank just east of Haddock Channel in NAFO Div. 3O and in the southern portion of Halibut Channel in 3Ps (Fig. 11). These grounds, if representative of the entire fishery were only a small fraction of the distribution of the skate concentrated essentially in two spots along the southwest edge of the Grand Banks. Fig. 12, for 1991-94, a differently scaled distributional plot (than Fig. 2) from survey data, designed to accentuate areas of high (presumably commercial) skate concentrations and excluding areas of low concentrations shows that skate form several other aggregations of similar density and size compared to the two currently fished areas. The fishing effort was found to be concentrated on only a fraction of the distribution.

Local depletions may have occurred during 1994 and 1995 in the offshore area of Division 3O (Statistical Area 3Oa near the 3Ps boundary). The otter trawl allocation of 1,000 t was taken in approximately 3 weeks. during that period, catch rates steadily declined. When a portion of the 3,000 t reserve was allocated to this fleet, it went back to the 3Oa area but could not locate suitable concentrations of skate.

Catches reported to NAFO from the time of extension of jurisdiction averaged less than 5,000 t until 1985 when the reported catches from Division 3N increased significantly (Fig. 13). This increase was due to a great increase in foreign fishing effort outside the Canadian 200 mile limit (lower panel) which has continued into the 1990's. The reported catches peaked at almost 30,000 t in 1991. In 1990 and 1991, the high reported catches from Division 3L were associated with the effort directed toward Greenland halibut. With a reduction of reported foreign catches from division 3N and an increase in domestic catches in 3O and 3Ps, total catch was nearly identical for 1994 and 1995.

There is some concern about the accuracy of these reported catches. Canadian surveillance has suggested that in some years during the 1980's up to about 60% of the reported skate catches may have actually been misreported catches of other species. Surveillance estimates for 1992 to 1995 are 7,200, 7,350, 7,900 t and 3,050 respectively, lower than the reported catches for those years. Also, the inconsistency between research vessel data and reported landings on the tail of the Grand Bank suggests the possibility of misreporting in recent years.

CONCLUSION AND PROGNOSIS

In assessing the status of skate, attention should be paid to the recent distributional contraction and the declining biomass trend. This reduction in biomass and in the extent of the distribution may be signs of a declining stock. A similar pattern of distributional change was observed for northern cod (Kulka et al.1995) prior to its collapse and for other species Atkinson (1993). While fishing contributed to the mortality of skate, the observed contraction in the distribution of the stock, particularly in 1991-1994 occurred over an area much greater than the area fished. This suggests that significant non-fishery (environmental) influences may be effecting the distributional changes.

Based on the information available in the literature and the results of the preliminary analyses presented above, it appears possible to refine the existing management plan for the future. The current management plan is based on an exploitation rate of 20% of the research survey biomass index. Given that the productivity of skate is so low compared to other fish species (e.g. only 6 to 40 egg cases per year compared to 3 million plus eggs from cod), the 20% level may be too high and a more cautious approach may be to adopt 10 or 15%. This however, requires further examination and study since the catchability of the survey gear is unknown and distributional shifts suggest negative population changes.

As noted by Atkinson (1995), at wing width of 46 cm (18 inches), about 50% of thorny skate females in 3LN are mature, but only about 20% in 3OPs. Fifty percent maturity is not reached until at a wing width of about 56 cm (22 inches) in these areas. Therefore, similar harvesting strategies, if applied to the different areas, could have very different results over the longer term. As well, tagging studies (Templeman 1984a) and distributional comparisons suggest that thorny skate does not move to any great extent. If this is the case then localized fishing effort could deplete those limited areas that are now being fished. In addition, there are differences in trends of the annual biomass indices between areas (although biomass is low in all areas in recent years). The current management plan separates NAFO Div. 3LNO from 3Ps. Based on the highly aggregated nature of the distribution of thorny skate, patterns in the maturity ogives for females and differing indices among areas, it may be more appropriate to separate divisions 3LN from 3O and 3Ps to ensure that the fishing effort is distributed over a wide area.

Our distributional analyses show that density patterns are complex and dynamic even within divisions. How small scale distributional shifts can be incorporated into the region wide average required for stock assessment models is as yet unclear. It is evident that a firm knowledge of distribution and patterns over time provides insight to judge the appropriateness of these models and may be a good long term predictor of imminent collapse.

Results of more detailed analyses of the research survey data including the length frequency information would be useful in helping to devise a sustainable management strategy. As well, a clarification of actual skate catches outside the Canadian 200 mile limit in divisions 3LN would be enlightening. Finally, amounts of skate bycaught in other fisheries is of importance to future management of the fisheries since it was found to be the most common "non-commercial" bycatch during the 1980's and the domestic offshore catch was similar magnitude to the present directed fishery. Should traditional groundfisheries reopen, bycatch will have to be considered as an important component of the overall skate catch when assigning quotas.

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Table 1 - Percentage of skate species in the commercial offshore catches.

	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	Total
Otter Trawl												
Thorny	16.36	80.23	76.03	82.29	66.51	62.20	74.21	91.21	86.84	79.71	96.67	77.33
Spinytail	80.62	7.58	10.61	12.23	16.81	13.95	17.98	3.15	2.71	13.11	2.96	11.63
Winter	0.18	6.07	0.02	0.00	0.69	2.10	1.43	0.00	0.01	0.13	0.00	1.29
Smooth	0.18	3.30	8.03	0.44	1.68	1.38	1.60	0.12	0.17	0.54	0.11	2.54
Barndoor	0.06	2.73	4.11	4.69	11.62	19.20	4.79	3.54	10.26	6.49	0.23	6.41
Other	2.59	0.09	1.20	0.34	2.69	1.17	0.00	1.99	0.01	0.02	0.03	0.80
Total												100.00
Shrimp Trawl												
Thorny	57.98	89.03	87.48	89.80	94.33	87.06	92.91	75.82	95.85	97.39	97.47	87.59
Spinytail	25.75	3.71	6.80	9.73	4.81	1.40	1.06	4.89	2.82	2.04	1.77	5.88
Winter	14.57	5.90	3.60	0.04	0.01	0.52	0.07	0.03	0.39	0.18	0.00	2.04
Smooth	0.60	0.15	1.29	0.23	0.69	2.16	1.40	1.47	0.18	0.34	0.63	1.02
Barndoor	0.07	0.01	0.27	0.01	0.08	0.01	0.20	1.49	0.00	0.00	0.13	0.20
Other	1.04	1.22	0.55	0.20	0.08	8.86	4.36	16.30	0.76	0.05	0.00	3.28
Total												100.00
Gillnet												
Thorny	99.90	0.98	81.05	0.00						100.00		94.66
Spinytail	0.05	26.06	6.20	100.00						0.00		2.74
Winter	0.00	1.72	0.00	0.00						0.00		0.04
Smooth	0.05	0.00	0.99	0.00						0.00		0.12
Barndoor	0.00	0.00	11.33	0.00						0.00		0.84
Other	0.00	71.24	0.44	0.00						0.00		1.60
Total												100.00
Other Gear												
Thorny	73.39	18.42	98.67	90.21	3.72	6.11	0.00	0.48	2.53			71.68
Spinytail	6.91	81.28	0.05	1.33	7.94	28.95	0.00	0.00	72.22			8.49
Winter	2.02	0.00	0.00	0.00	2.78	0.00	0.00	12.08	0.00			0.98
Smooth	4.10	0.00	1.28	7.61	0.00	0.23	1.56	0.00	0.00			3.81
Barndoor	8.74	0.00	0.00	0.84	28.45	14.93	98.44	0.00	23.23			7.06
Other	4.85	0.30	0.00	0.01	57.10	49.77	0.00	87.44	2.02			7.97
Total												100.00
All Gears												
Thorny	79.47	65.99	81.20	84.72	79.03	71.69	86.57	83.29	86.11	82.30	96.70	80.78
Spinytail	14.03	14.99	8.66	11.22	10.86	8.68	6.10	3.96	4.09	11.49	2.91	9.54
Winter	2.54	9.32	1.22	0.01	0.39	1.30	0.48	0.09	0.05	0.14	0.00	1.28
Smooth	0.92	4.90	5.22	0.92	1.18	1.70	1.46	0.76	0.16	0.51	0.13	2.04
Barndoor	1.68	0.17	2.80	2.87	6.29	10.17	2.37	2.54	9.46	5.54	0.22	4.10
Other	1.36	4.63	0.90	0.27	2.26	6.47	3.02	9.36	0.12	0.03	0.03	2.27
Total												100.00

Table 2 - Biomass and abundance indices and mean weights from spring research surveys to divisions 3LNO and subdivision 3Ps, 1986-1995.

Biomass Index (t)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P
1986	27,506	43,435	18,360	18,871
1987	32,298	23,833	20,081	16,243
1988	27,616	19,561	34,399	12,396
1989	28,855	19,347	15,816	10,142
1990	17,839	18,693	24,388	25,114
1991	8,739	11,388	38,978	25,114
1992	4,623	9,074	22,807	15,843
1993	3,365	7,303	13,824	5,731
1994	1,543	4,013	11,368	6,511
1995	1,102	1,112	12,726	9,810

Abundance Index (thousands)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P
1986	21,170	22,064	8,733	14,991
1987	16,178	13,859	14,066	11,745
1988	14,475	10,940	17,765	8,193
1989	16,673	12,409	7,305	10,924
1990	18,156	29,610	16,578	9,208
1991	14,372	18,408	14,543	21,370
1992	15,242	8,531	14,697	9,319
1993	11,473	7,053	6,208	6,723
1994	6,611	7,258	7,895	7,943
1995	3,851	2,900	11,067	8,053

Mean Weights (kg)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P
1986	1.30	1.97	2.10	1.26
1987	2.00	1.72	1.43	1.38
1988	1.91	1.79	1.94	1.51
1989	1.73	1.56	2.17	0.93
1990	0.98	0.63	1.47	2.73
1991	0.61	0.62	2.68	1.18
1992	0.30	1.06	1.55	1.70
1993	0.29	1.04	2.23	0.85
1994	0.23	0.55	1.44	0.82
1995	0.29	0.38	1.15	1.22

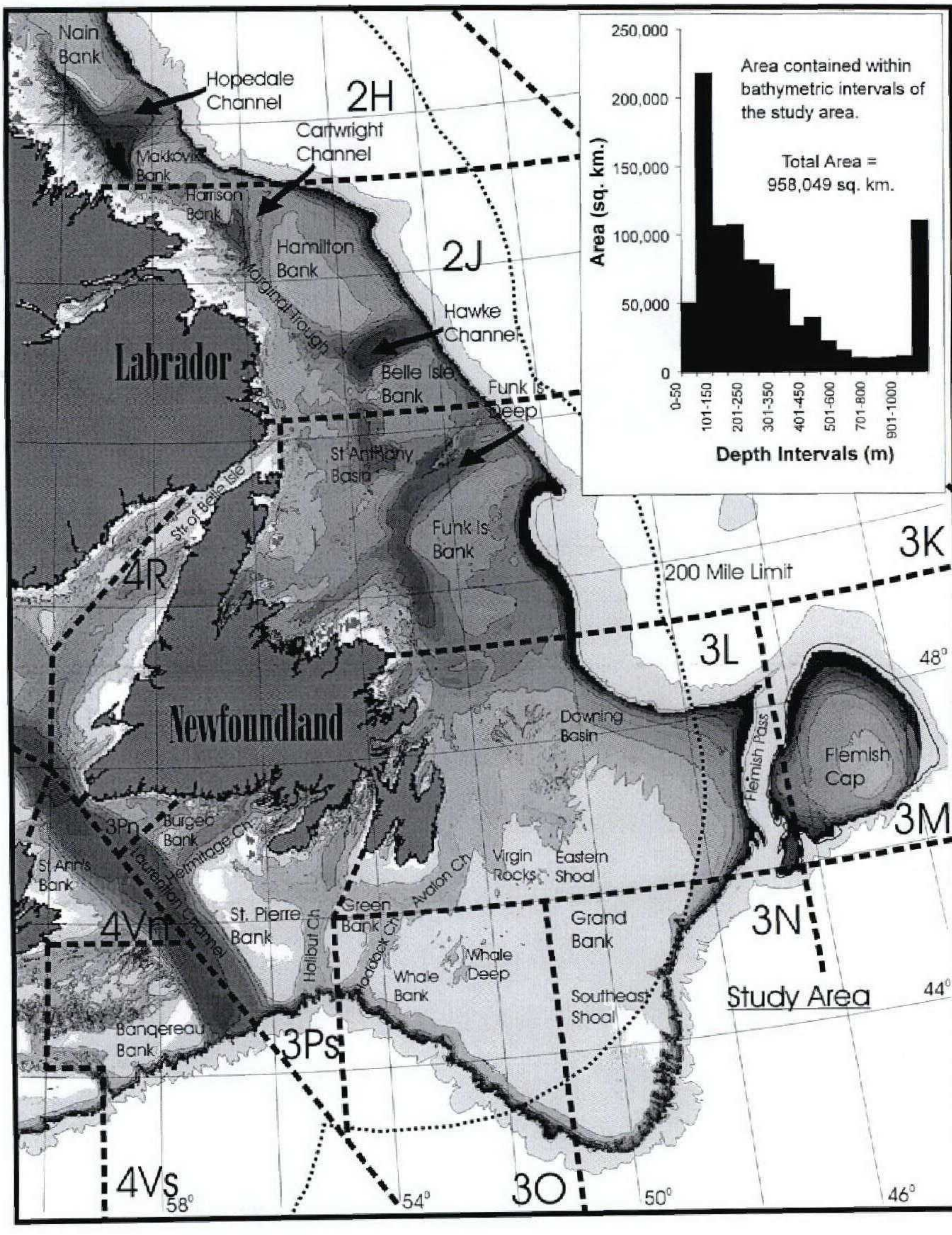

Figure 1 - Study area for non-traditional species showing bathymetry, NAFO Divisions and various bank features. Upper right panel shows area contained within each bathymetric interval.

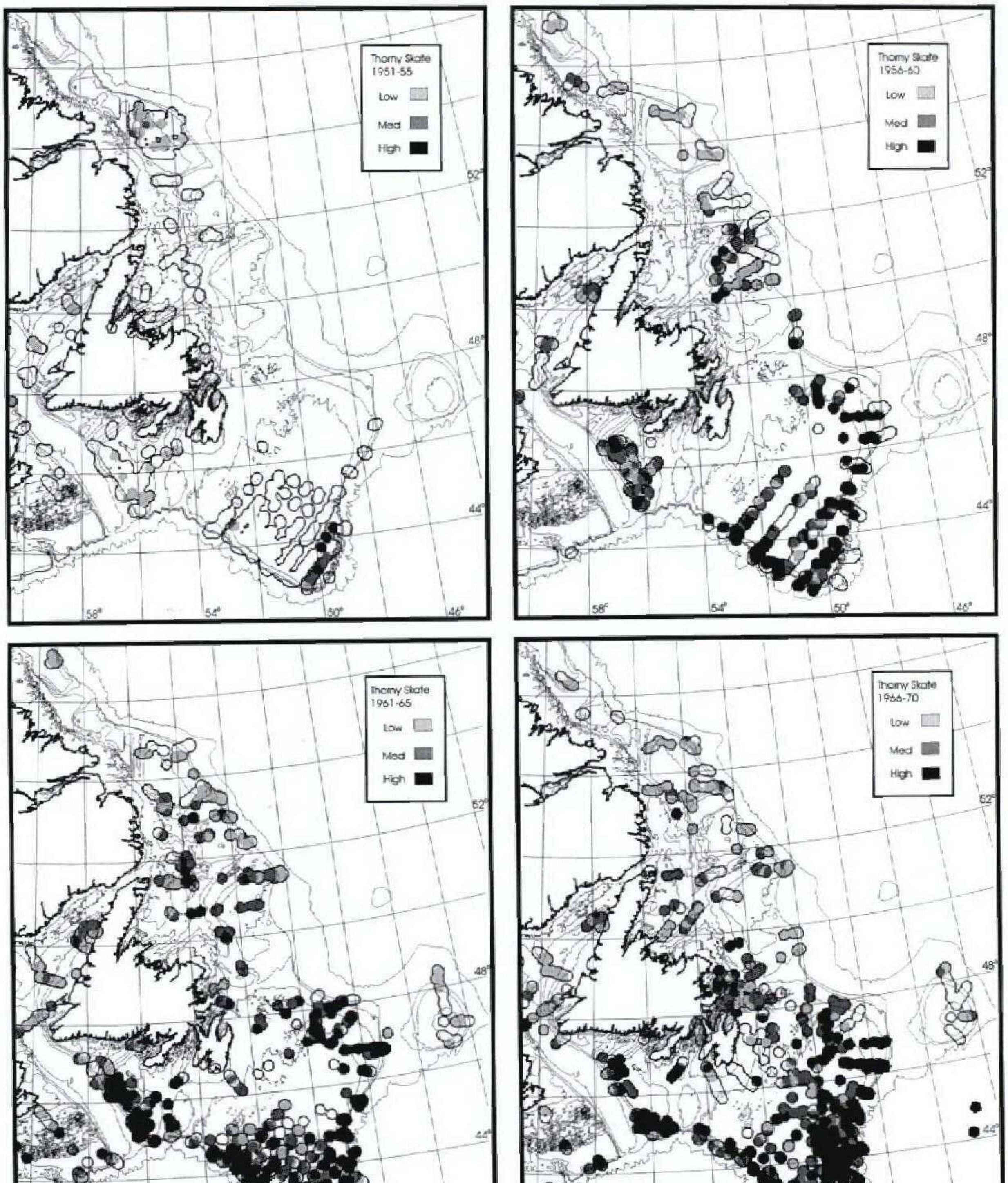

Figure 2a - Thorny skate distribution from research vessel surveys, 1951 to 1970 where high = > 11.6, med = 3.0 - 11.6 and low = < 3.0 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

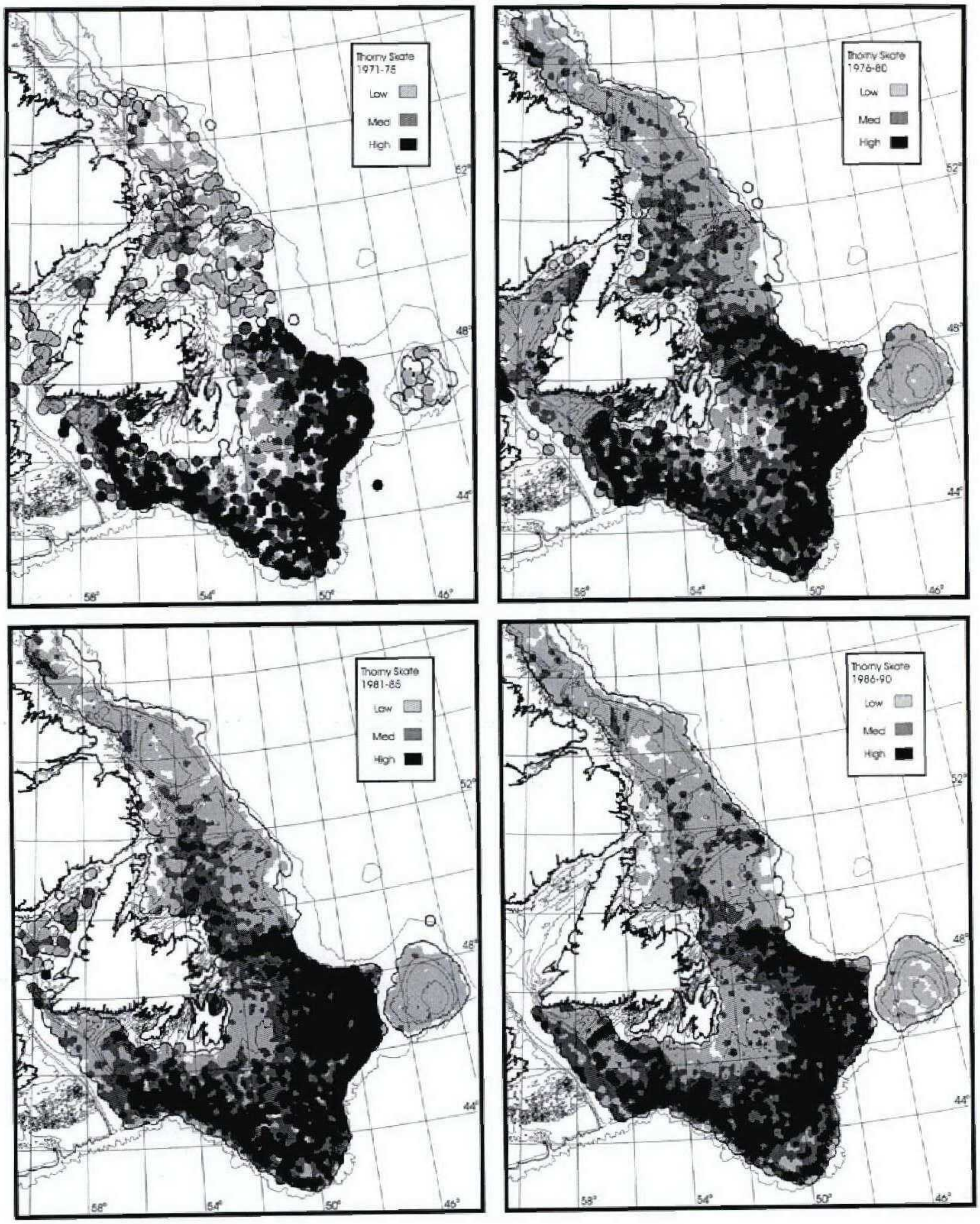

Figure 2b - Thorny skate distribution from research vessel surveys, 1970 to 1990 where high = > 11.6, med = 3.0 - 11.6 and low = < 3.0 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

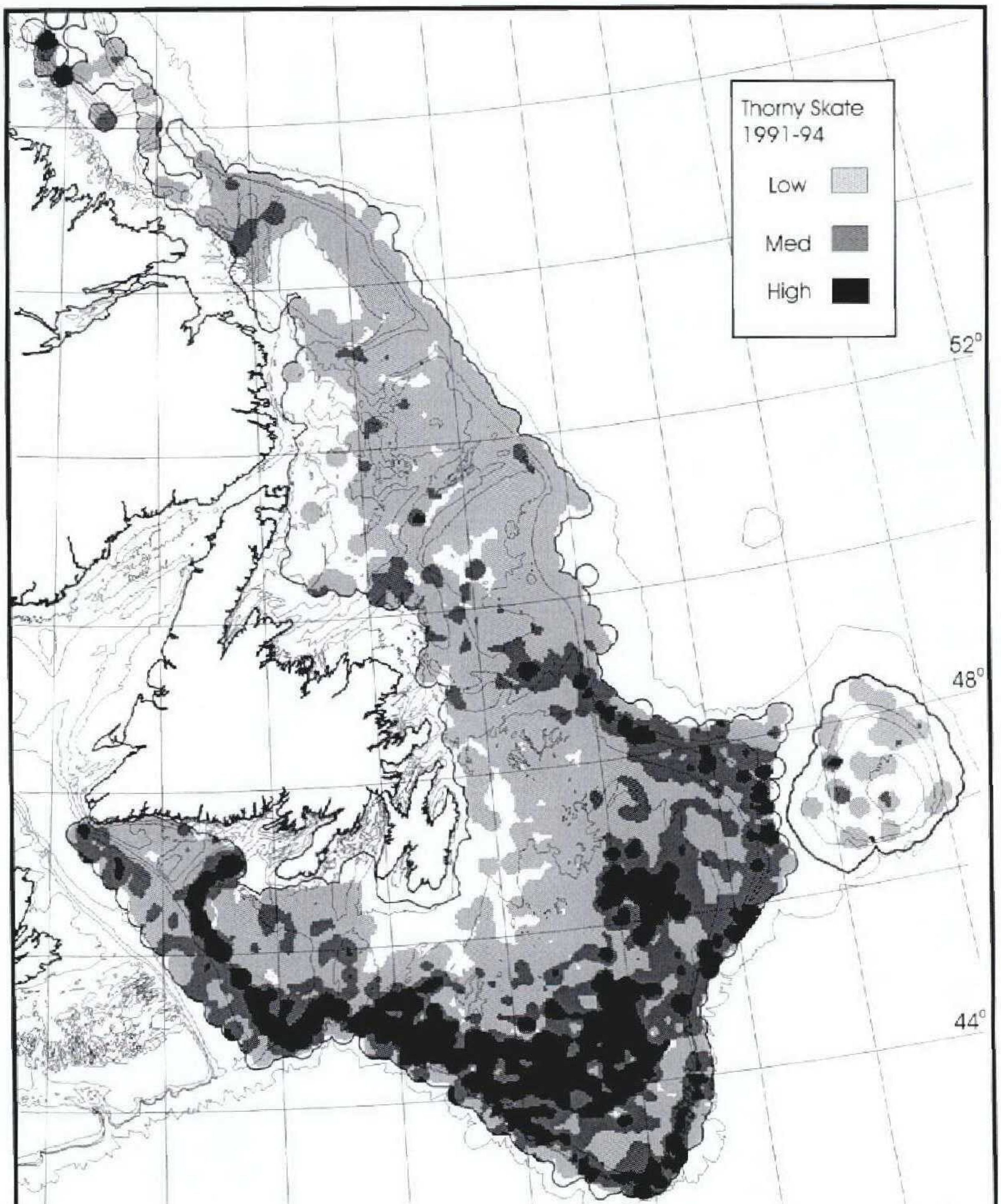

Figure 2c - Thorny skate distribution from research vessel surveys, 1991 to 1994 where high = > 11.6, med = 3.0 - 11.6 and low = < 3.0 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

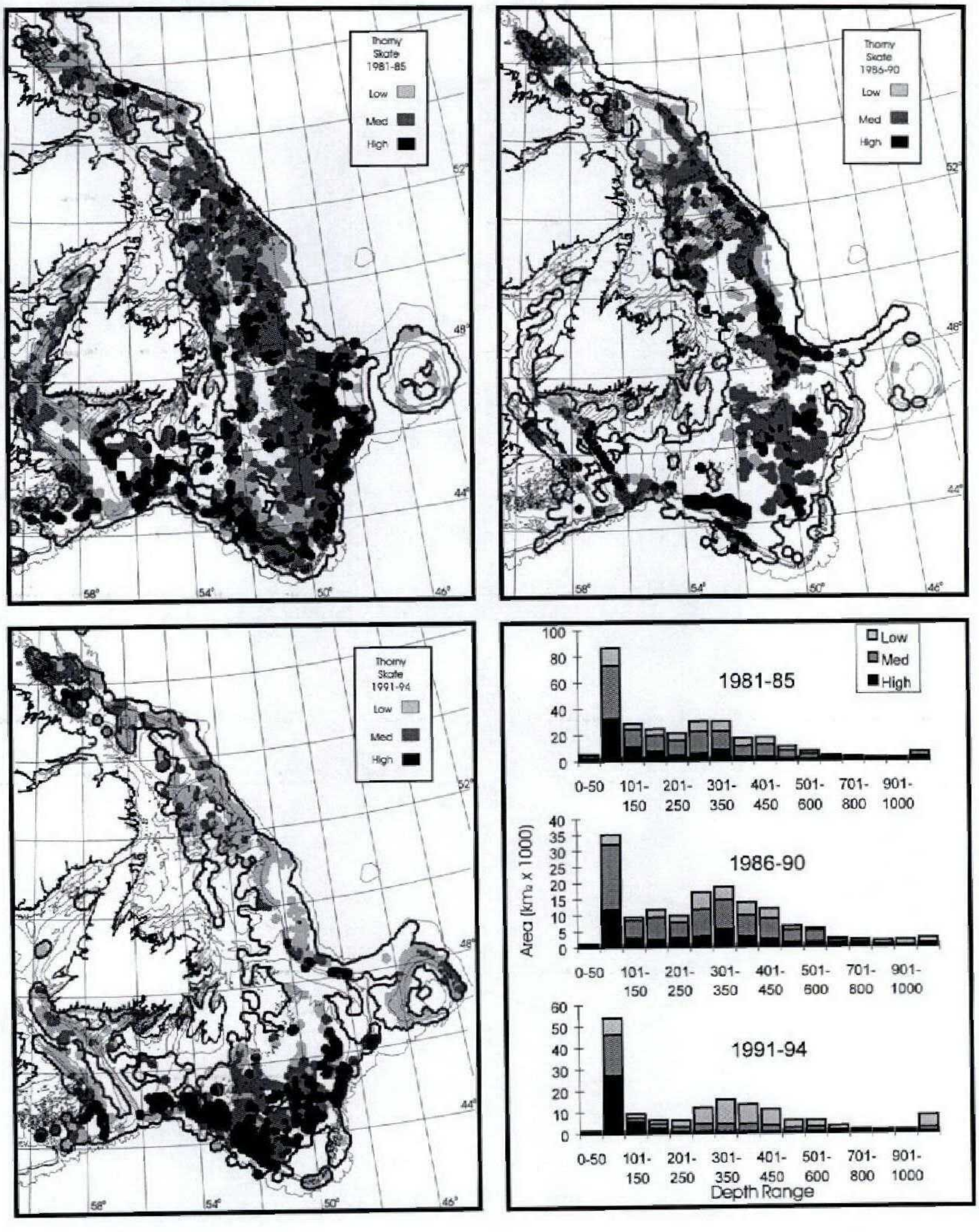

Figure 3 - Distribution of thorny skate during three time periods, 1981 to 1994. High = 25+ kg/hour, med = 5 - 25 and low = 0 - 5. The thick outline represents the area fished.

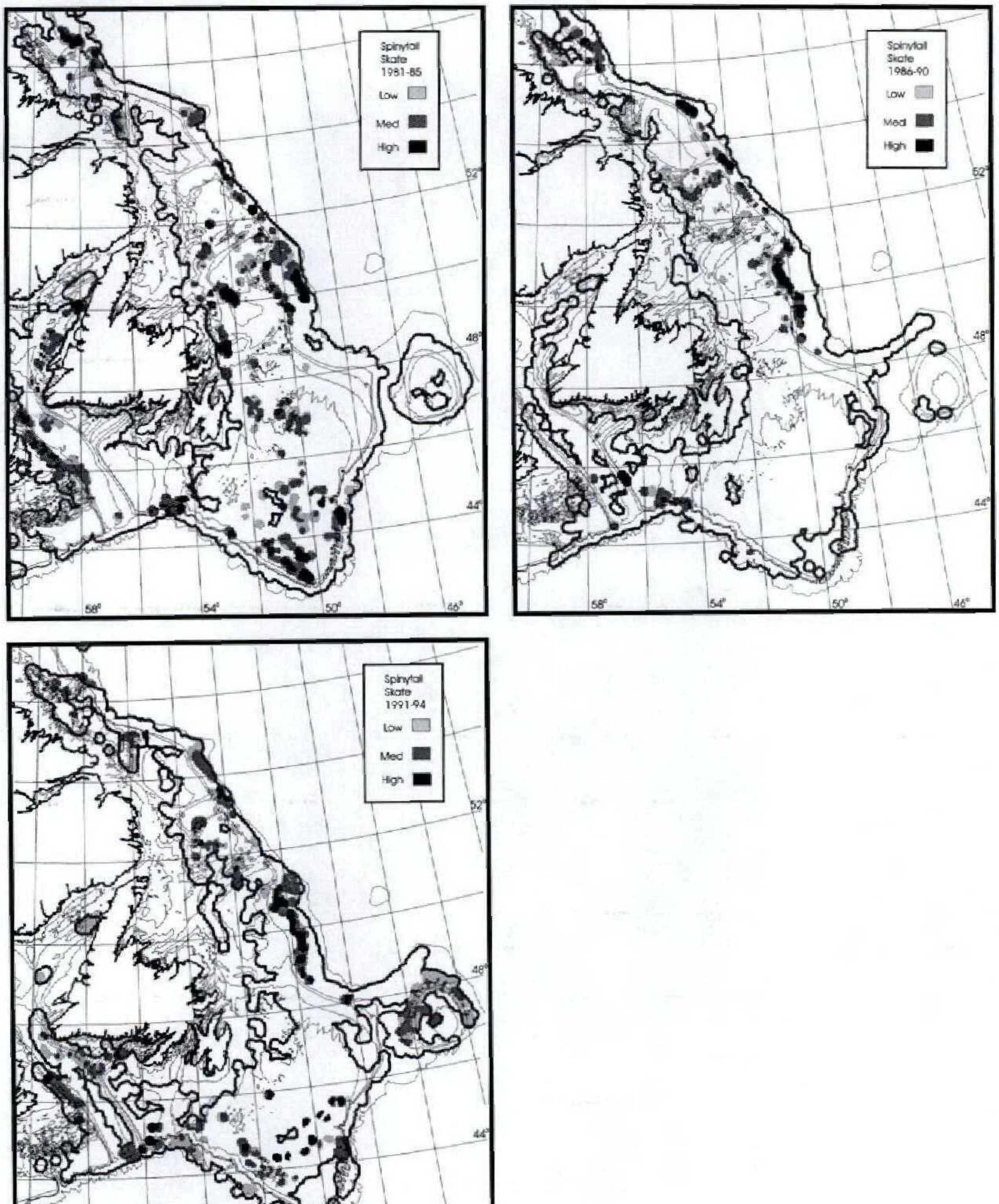

Figure 4 - Distribution of spinytail skate during three time periods, 1981 to 1994. High = 25+ kg/hour, med = 5 - 25 and low = 0 - 5. The thick outline represents the area fished.

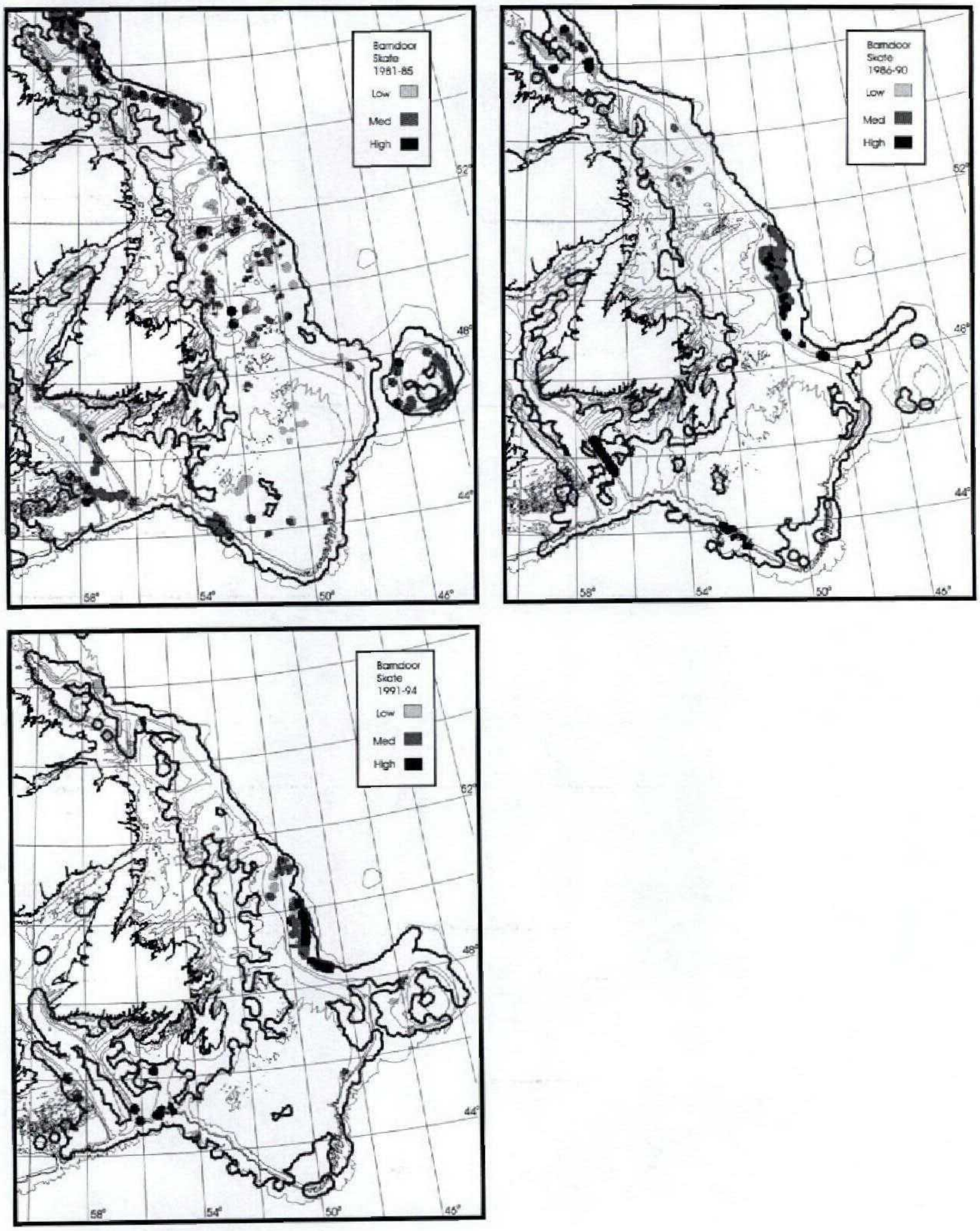

Figure 5 - Distribution of barndoor skate during three time periods, 1981 to 1994. High = 10+ kg/hour, med = 1 - 10 and low = 0 - 1. The thick outline represents the area fished.

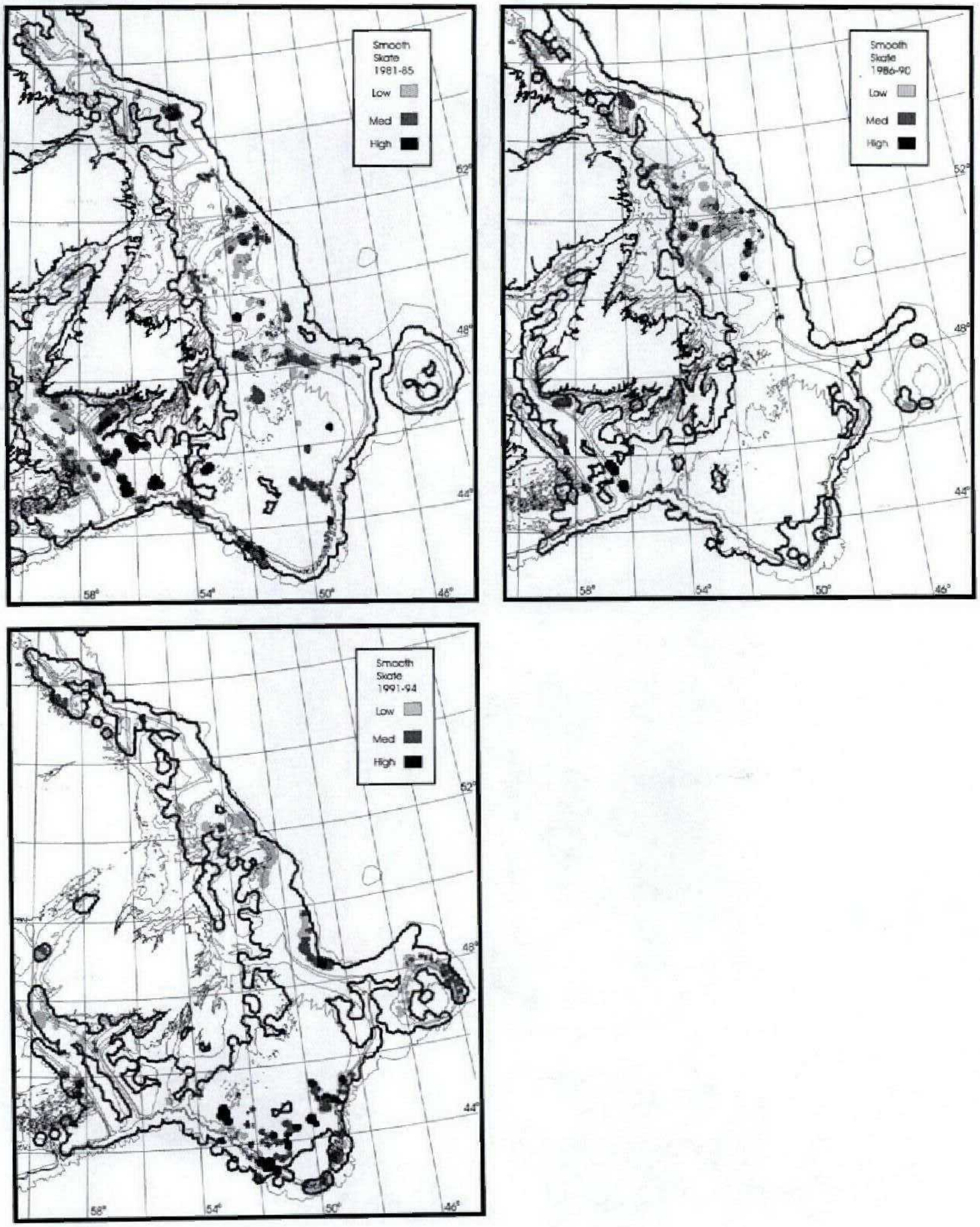

Figure 6 - Distribution of smooth skate during three time periods, 1981 to 1994. High = 10+ kg/hour, med = 1 - 10 and low = 0 - 1. The thick outline represents the area fished.

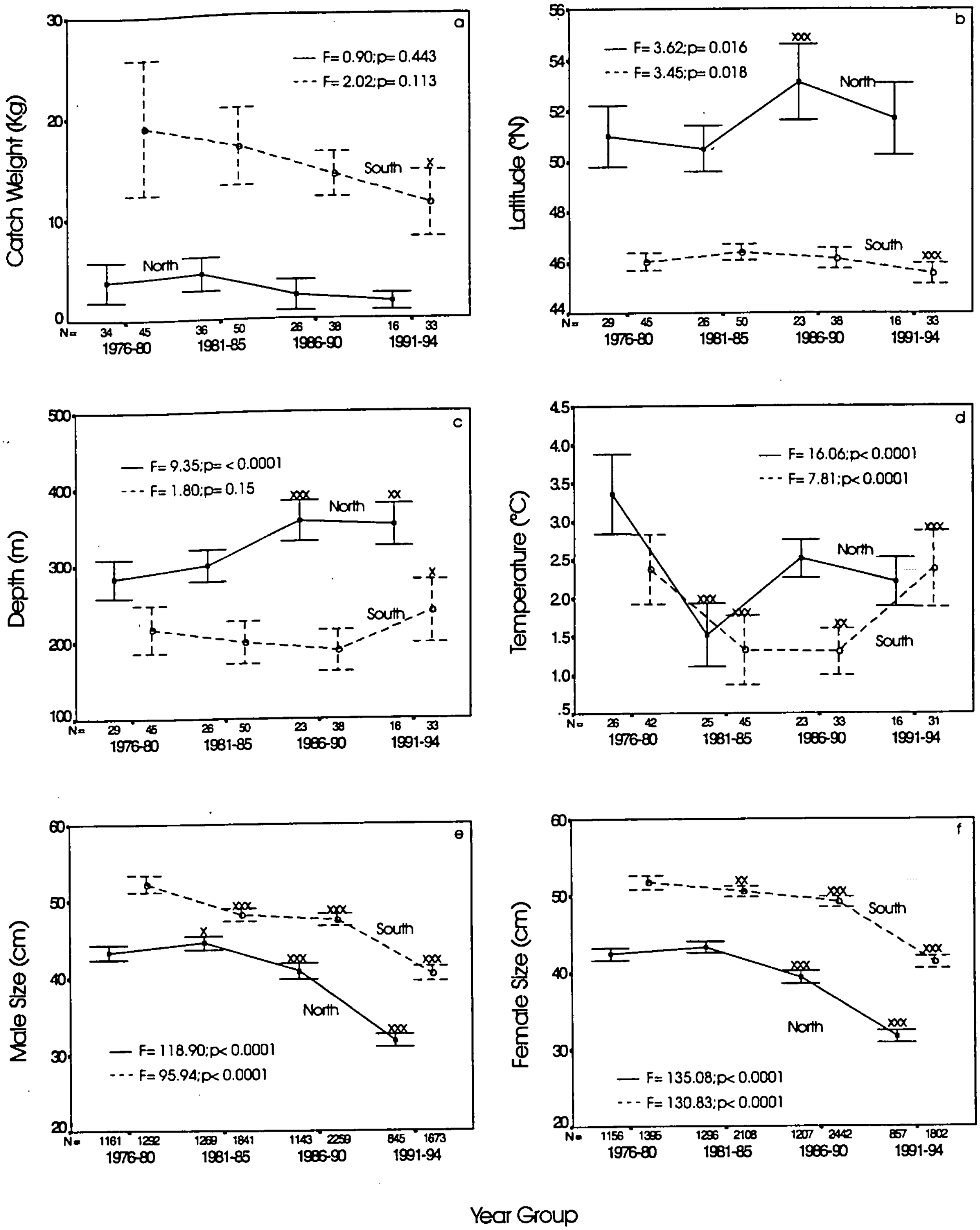

Fig. 7 . Thorny Skate 1976-1994. Data are averaged (± 95% CI) over trips (a,b,c, d) or fish (e,f) in each of 4 year groupings for latitudes > = 48°N (North) and latitudes < 48°N (South). Overall ANOVA statistics are given for North and South. N = sample size. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: p < 0.1; xx: p < 0.05; xxx: p < 0.01).

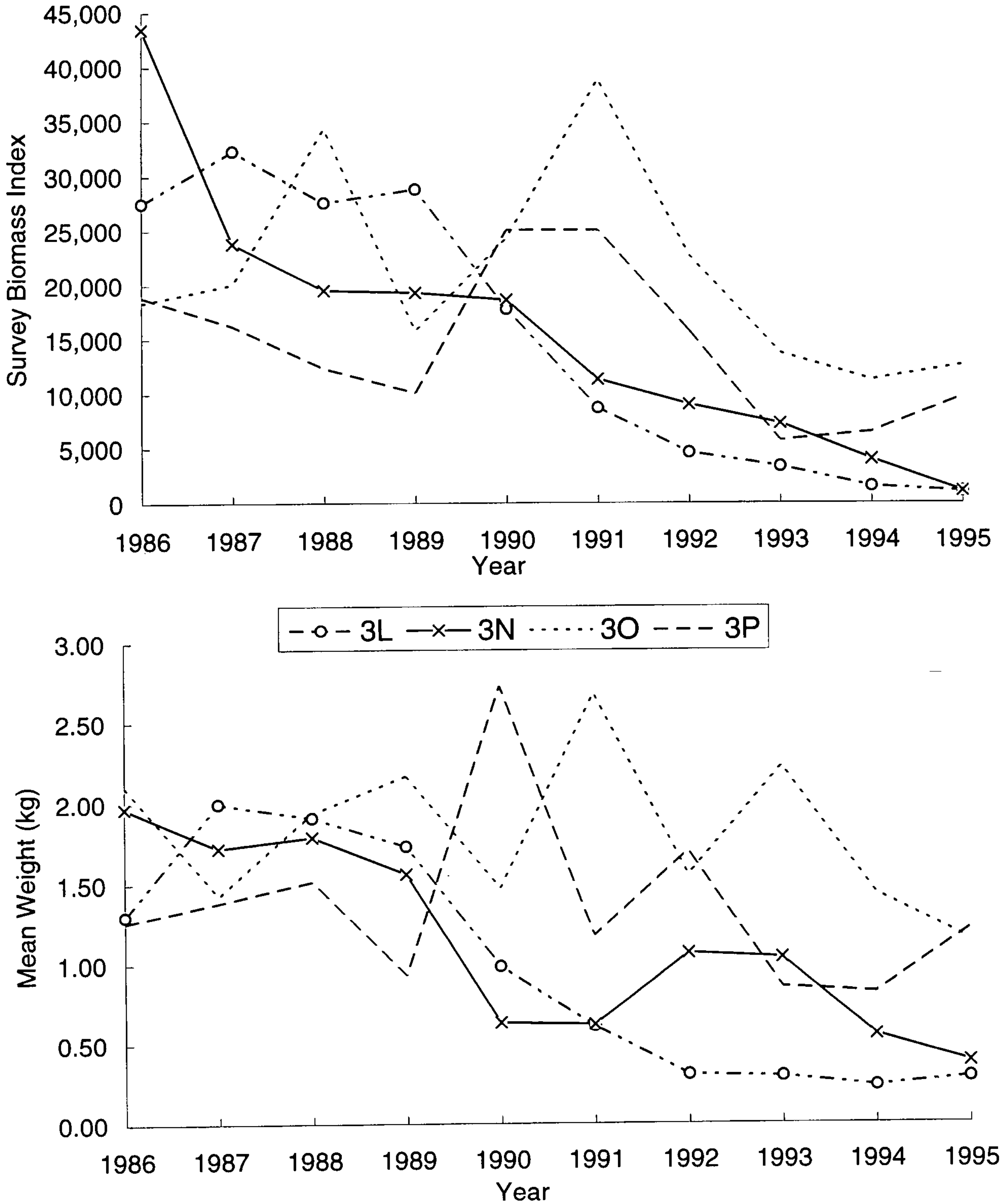

Figure 8 - Biomass and mean weight of thorny skate from research vessel cruises, 1986 to 1995.

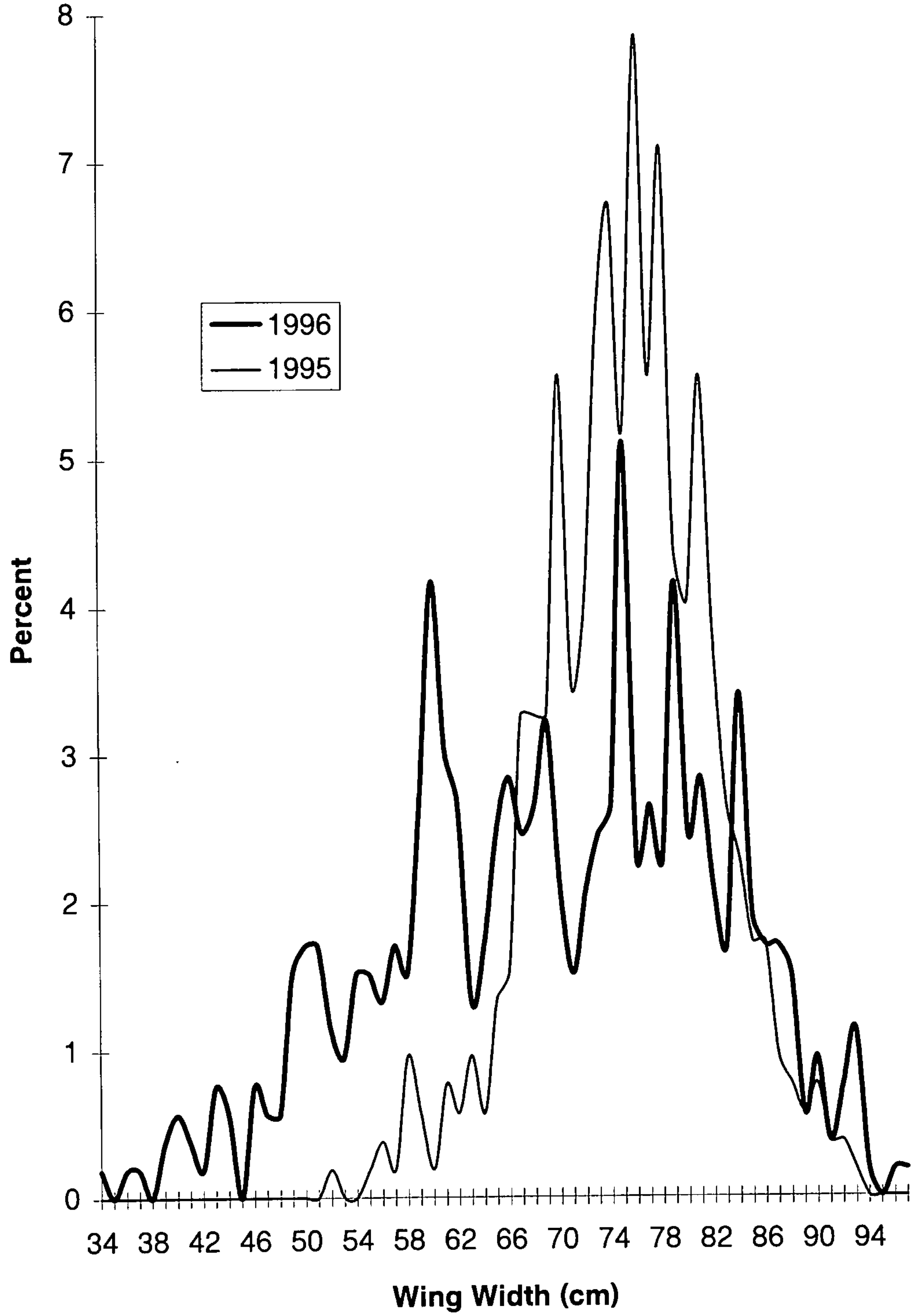

Figure 9 - Wing width frequency for commercial skate catches in NAFO Divs. 3O and 3Ps.

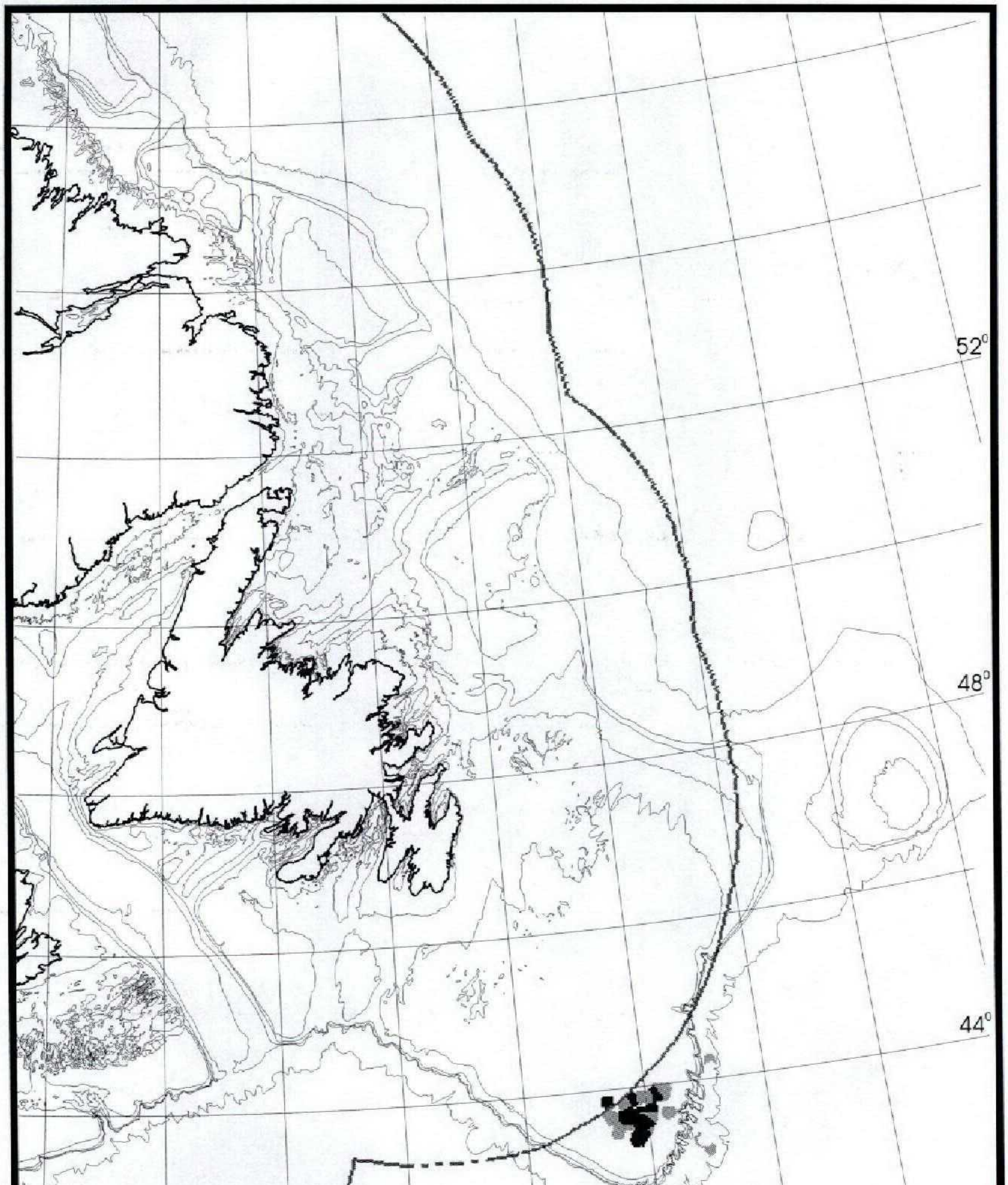

Figure 10 - Location of the skate fishery outside 200 miles as recorded from selected foreign log records in 1996. Light grey denotes daily catches less than 5 t, dark grey, 5 to 10 t and black where daily catch rates exceeded 12 t.

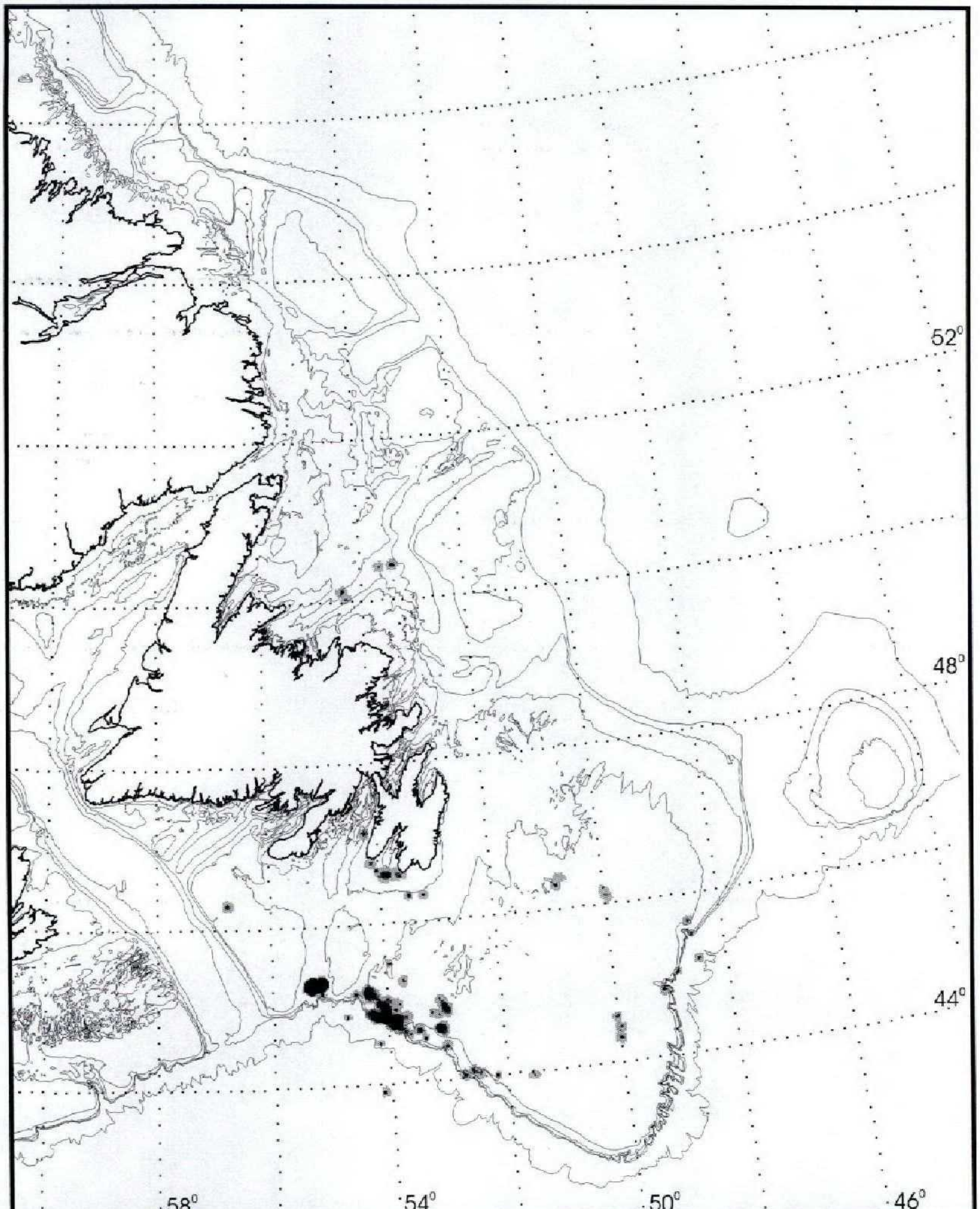

Figure 11 - Observed domestic directed skate grounds for 1994-1995. Black shows the most intensely fished areas.

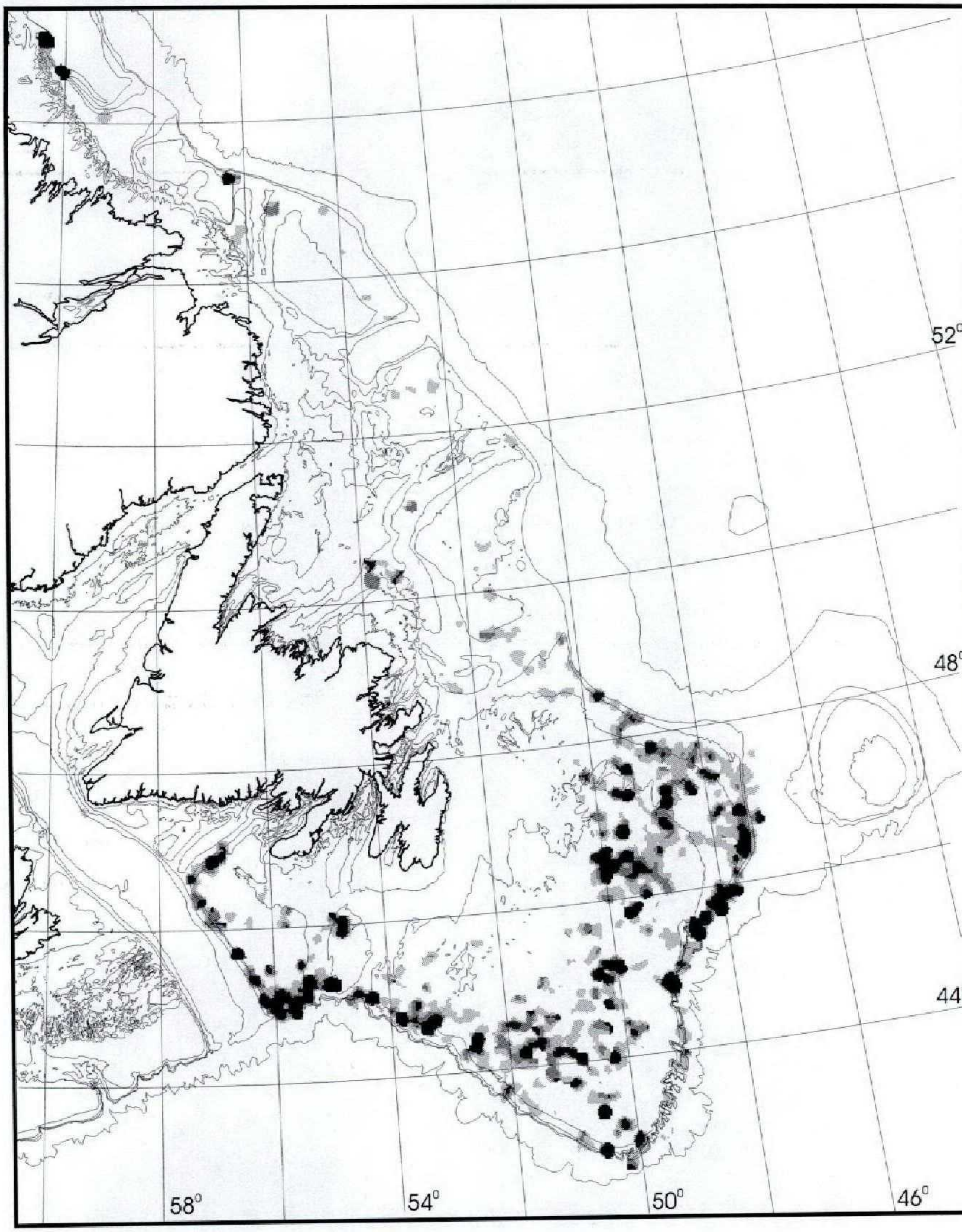

Figure 12 - Distribution of aggregations of thorny skate in 1991-94. Black areas indicate the densest aggregations. Areas of low density are excluded.