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Non traditional groundfish species on Labrador Shelf and Grand Banks Wolffish, Monkfish, White hake, and Winter (Blackback) Flounder

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 addition to skates for which there has been a directed fishery since 1994, monkfish, white hake, two species of wolffish, and winter (blackback) flounder have been considered as potential candidates for new or expanded fisheries. As well, all of these species are common as bycatch in other directed groundfisheries. Winter (blackback) flounder has been a minor commercial species since the early 1970s and white hake is directed for in other areas, specifically in the Gulf of St. Lawrence and the Scotian Shelf. To date, only limited experimental fishing has been done for these species off Newfoundland's south coast, on the Grand Banks and north. This paper provides a preliminary examination of available information on distributions, an analysis of abundance and biomass from research vessel survey data, a recent history of the landings, and available commercial length frequency data. In general , all species addressed in this paper showed a reduced distribution, primarily north of Latitude 48° N and a decline in biomass in certain areas. Limited data on size of fish in the commercial catches is presented for the first time for white hake, monkfish, and winter (blackback) flounder.

Résumé

Suite au déclin des ressources «traditionnelles» en poisson de fond dans les eaux de Terre-Neuve, l'intérêt pour la pêche d'autres espèces a augmenté. En plus de la raie qui est l'objet d'une pêche dirigée depuis 1994, la baudroie, la merluche blanche, deux espèces de loup et la plie rouge ont été considérées comme des candidates potentielles pour des pêches nouvelles ou accrues. En outre, toutes ces espèces sont communément capturées comme prises accessoires lors de la pêche dirigée d'autres espèces de poisson de fond. La plie rouge est l'objet d'une pêche commerciale de faible importance depuis le début des années 70, tandis que la merluche pêche est l'objet d'une pêche dirigée dans d'autres régions, notamment le golfe du Saint-Laurent et le plateau néo-écossais. Jusqu'à maintenant, seule une pêche expérimentale limitée de ces espèces a été faite sur la côte sud de Terre-Neuve, sur les Grands Bancs et au nord de ceux-ci. Sont présentés un examen préliminaire de l'information disponible sur la répartition, une analyse de l'abondance et de la biomasse basée sur les données de relevés de recherche, un compte rendu des débarquements récents et les données disponibles sur la fréquence des longueurs des prises commerciales. En général, toutes les espèces couvertes dans le présent article montrent une répartition diminuée, principalement au nord du 48° de latitude nord, et un déclin de la biomasse dans certaines régions. Sont aussi présentées pour la première fois des données limitées sur la longueur des prises commerciales de merluche blanche, de baudroie et de plie rouge.

INTRODUCTION

With the decline in the "traditional" groundfish resources in the waters around Newfoundland, interest in the exploitation of alternate species has increased. In addition to skates for which there has been a directed fishery since 1994, two species of wolffish, striped (*Anarhichas lupus*) and spotted (*A. minor*), monkfish (*Lophius americanus*), white hake (*Urophysis tenuis*) and winter or blackback flounder (*Pseudopleuronectes americanus*) have been considered as potential candidates for new or expanded fisheries. All are common bycatch with other directed ground fisheries. Blackback has been fished in the Gulf of St. Lawrence, inshore in many bays around Newfoundland for bait and since the early 1970's, for human consumption. White hake is a directed fishery in the Gulf of St. Lawrence and on the Scotian Shelf. To date, only limited experimental fishing has been done for these species off Newfoundland's south coast and on the Grand Banks for the purpose of expanding existing fisheries or to create new ones.

This paper reviews available information on biology, historical catches, biomass and abundance from research vessel surveys and distribution northeast of the Laurentian Channel, from the Grand Banks and the Labrador Shelf (Fig. 1). Information from both the research vessel surveys and the commercial fisheries (bycatch) are used to examine distributional changes. Distributional patterns observed may reflect any population changes and may also provide some basis for defining management units. Fish size from the commercial catches where available, are also presented. These types of analyses can serve industry by providing information on good fishing locations for the developing fisheries. More important, they provide baseline information for stock status analyses of the new target species.

Following is a brief description of the species based on Scott and Scott (1988) unless otherwise indicated and a summary of the general works published on the non-traditional species that are the subject of this paper.

Wolffishes, striped (*Anarhichas lupus*) and spotted (*Anarhichas minor*): Given their overlapping distribution, striped and spotted wolffish have often been studied together. In the northwest Atlantic, these two species are distributed from Davis Strait to Maine (Al'bikovskaya 1982). The spotted wolffish inhabits deep waters to beyond 475 m and temperatures of 3.1-4.0°C. The striped wolffish is also found further south in shallower depths (100-350 m.) and water temperatures as cold as 0.4°C. Tagging studies conducted on both species indicate little migration although there appears to be movement between deeper and shallower water by striped wolffish (Templeman 1984a). Striped wolffish in Newfoundland waters spawn in September, and the entire larval stage is spent close to the location of hatching (Templeman 1986, Templeman 1985). Information on spotted wolffish is more limited, but they appear to spawn in late autumn or early winter. Some information suggests that the larvae are pelagic. The food of wolffish includes a variety of bottom invertebrates as well as small amounts of fish (Rodriguez Marin *et al.* 1994, Al'bikovskaya 1983). They will also feed on offal from fishing operations.

For other areas, natural/fishing mortality in the Barents sea (Shevelev 1992), migration (Riget 1986)

and distribution/abundance off West Greenland (Riget and Messtorff 1987, Messtorff, 1986) have been examined. Age-length relationships are established for the Northeast Atlantic (Shevelev 1995). The aquaculture potential of these two species has been examined through egg rearing (Falk-Petersen and Hansen 1994), growth rate (Moksness 1994, Moksness and Stefanussen 1990) and feeding (Orlava *et al.* 1989a,b) experiments.

White hake (*Urophysis tenuis*): White hake are found in the Northwest Atlantic from Cape Hatteras in the south to the Gulf of St. Lawrence, Grand Banks, and off southern Labrador (Musick 1974). The areas of greatest abundance are the southern Gulf of St. Lawrence, Scotian Shelf and southwestern Grand Banks. They occur over a wide range of depths from 200-1000 m, and tolerate water temperatures from just above 0°C to 21°C although preferring 5-11°C. The diet of white hake is dominated by other fish species (i.e., cod, herring, flatfish, etc.).

Until recently, white hake was mainly taken as a by-catch in other fisheries in the 3LNOPs area. However, it is an important commercial species in the Gulf of St. Lawrence. Studies from this area are common and stock trends in NAFO Div. 4T have been assessed. More recent reports include Anon (1995), Anon (1994), Beacham and Nepszy (1980), Hurlburt *et al.* (1995), Morin and Hurlburt (1994), Hurlburt *et al.* (1994), Hurlburt *et al.* (1996) Chadwick and Robichaud (1993), Hurlburt and Chouinard (1992), Clay and Hurlburt (1990, 1989, 1988), Clay (1987, 1986), Clay *et al.* (1986). Stock discrimination studies exist (Clay *et al.* 1992, Hurlburt and Clay 1990). Age validation, size and maturity studies include Clay and Clay (1991), Beacham (1983) and Hunt (1982). Hake diet in the Gulf of St. Lawrence has been assessed (Coates *et al.* 1982). One study by Muir (1978) reports on hake distribution and abundance in NAFO divisions 3LNO.

Monkfish (*Lophius americanus*): The monkfish or goosefish (Lophius americanus) is a bottom dwelling fish that lives in relatively warm waters. In the western Atlantic it is found around the Grand Banks, throughout the Gulf of St. Lawrence, on the Scotian Shelf and in the Bay of Fundy, and further south to northern Florida. It has been found in depths from the tideline down to about 650 m, and in temperatures from 0-21°C. Limited studies have indicated a seasonal migration to shallower water in summer and deeper water in winter. Studies exist on age, growth and reproduction for fish sampled from Cape Hatteras to Georges Bank (Armstrong *et al.* 1992). Length/Weight relationships have been developed for Northeastern US fish (Almeida *et al.* 1995). Little work has been done on monkfish in this area.

Winter or blackback flounder (*Pseudopleuronectes americanus*): (McCraken 1954) found that winter flounder on the Atlantic coast of Canada is a shallow water species inhabiting muddy to moderately hard bottoms, generally not distributed deeper than 40 m. It tends to inhabit shallower depths during the summer months making it accessible fishing right next to the shore. They are distributed from southern Labrador, around Newfoundland where it is abundant and as far south as Georgia. This flounder is probable prey for monkfish, dogfish and sea raven (Dickie and MacCraken 1955) as well as several seal species (Mansfield 1967). Because of their shallow occurrence, they are also prey for some birds. (Tyler 1971). More recent reports pertaining to the fishery in the Gulf of St. Lawrence include Hanson and Courtney (1996) and Morin and Forest-Gallant (1996).

METHODS

Catch and length data on wolffish, monkfish and white hake have routinely been collected during bottom trawl research surveys for the various areas around Newfoundland. For this study, spring and fall research trawl data from 1951 to 1994, grouped into 5 year intervals, were used to describe their distributions. Prior to 1971, the data were limited and surveys consisted of series of transects. Stratified-random 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. Blackback, an inshore species was rarely captured during research surveys and is not included in this analysis.

Commercial fishery bycatch data collected by observers (Kulka and Firth 1987) for the period 1981 to 1994 were used to examine wolffish, monkfish and white hake distributions. Similar to research surveys, commercial offshore grounds did not overlap with the blackback distributions. 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 fished over the study area by intervals of depth. Commercial vessels fished a greater proportion of the banks at depths deeper than about 600 m than was sampled for research vessel cruises. On the other hand, although sampling intensity (number of fishing sets) was an order of magnitude higher, commercial fishing is more aggregated and spatial coverage inside 600 m was less extensive. As well, commercial trawl gear was more variable, larger in size and employed larger meshes causing differences in fish size and species mix.

For both research and commercial sources, by species, catch rate data (kg. per standard half hour tow and kg. per hour towed respectively) 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 (catch rate from sets) over a user defined diameter allowing a clear representation of overlapping data points, with minimal extrapolation. Fish density are depicted by three levels of grey shade, areas of highest density of fish (highest catch per tow or hour) represented by black and lowest density by a light grey. A thick line outlines the sampled area. For commercial data, the lower right panel accompanying the plots of distribution show catch rate by percent of sampled area containing low, medium and high concentrations of fish, by depth.

Average distribution and density trends among five year groupings were compared from 1951 to 1994 for research data and from 1981 to 1994 for commercial bycatch data. Research sampling coverage prior the 1976 was sparse and not comparable to coverage in later year groups but provide some idea of fish distribution for certain areas in those years.

Based on patterns observed in the density distribution plots, data from spring and fall research vessel surveys were split into Northern (≥48°N) and Southern (<48°N) components. In each of these areas, average catch, fish centre of mass relative to latitude, depth, temperature and finally fish size (males and females) were compared across year groupings for each species. Temporal variability in latitude,

depth and temperature were calculated based on means per trip weighed by catch for each variable. This provided the centre of mass for each species examined relative to each factor (latitude, depth, temperature) across year groupings. Temporal variability in these factors independent of fish catch (background variability) was also assessed. Statistical variability among year groups was described using ANOVA with Contrast to first test the overall variability of observed means and secondly to test the difference among sets of successive means. Sampling units were trips within year groups in all cases except for ANOVA on fish size where sampling units were individual fish within year groups. In an overall comparison (ANOVA) of sampling coverage, latitudinal and depth coverage was similar among year groups (Fig. 2) but contrasts showed that samples were collected at higher latitudes (54°N vs 52°N) in 1986-90 in the northern part of the sampling range and slightly further south in 1991-94 in the southern part. Temperature varied markedly among year groups, particularly between 1976-80 and 1981-85 where a 2°C downward shift (from ca. 3°C to 1°C) occurred.

Using STRAP (Smith and Somerton, 1981), annual biomass and abundance indices, and average weights were derived by NAFO Div. for the wolffishes from spring and fall stratified random surveys in NAFO divisions 2J3KLNO and for monkfish and white hake from spring surveys in NAFO divisions 3LNO and subdivision 3Ps from 1986 to 1995. Limited data on length of white hake, monkfish and blackback in the catch collected by fishery observers and port samplers from the commercial fisheries were used to examine size in the commercial catches.

RESULTS

Wolffishes

Year Group Comparison - Distribution Plots: Given their overlapping distribution, spotted and striped wolffish generally are taken together in commercial and research catches along with a third species, northern or broadhead wolffish *(A. denticulatus)*. Information on the distribution of this third species is not presented because it is of no commercial value. Of the species examined in this paper, spotted (Fig. 3) and striped wolffish (Fig. 4) are the most northerly distributed and have undergone the most drastic changes. From 1976 onward, the two wolffish species showed declining distribution in both intensity (lower catch rates) and extent, with much of the reduction occurring to the north.

Prior to 1986, spotted wolffish was extensively distributed north of the Grand Bank covering much of the shelf, with a few occurrences along the eastern Grand Bank shelf edge and on the Flemish Cap. High density areas were more prevalent in some of the deep channels between the banks. By 1991-94, most higher density areas had disappeared, the distribution was reduced to low density concentrations along the shelf edge and in the deep channels.

Striped wolffish was more widely distributed north of 48°N than spotted wolffish. For that northern component, a similar although less extensive reduction in density was observed. A separate aggregation of striped wolffish centred at Lat. 44^{0}N west of the Southeast Shoal on the tail of the Grand Bank remained largely unchanged since the 1970's. This southern component was well

separated from the concentrations on the Labrador Shelf.

Year Group Comparison - ANOVA: Total catch in survey trawls declined for spotted and striped wolffish in both the North and South (Fig. 5 and 6). Species centre of mass with respect to latitude varied among year groups but changes mirrored the more northerly sampling coverage in 1986-90 in the northern area and the more southerly coverage in the southern area in 1991-94. Within the each of the Northern and Southern areas, there is little evidence for a latitudinal shift in the centre of mass for these two species at either end of their distributions although the distributional plots, discussed above, demonstrated a greater reduction in density north of Lat. 48^{0}N. Fish depth distribution varied among year groups and increased systematically and significantly in the North for both species and in the South for spotted wolfish. Size declined except for striped wolffish (males and females) in the South.

Annual Survey Biomass Abundance Estimates: The biomass and abundance indices for spotted wolffish (Fig. 7 and Table 1) since 1986 show a dramatic decline in NAFO Div. 2J, 3K and 3L starting in 1989 when biomass was highest. In NAFO Div. 3N, 3O and 3Ps, biomass remained at low levels throughout the entire period. In the northern areas, NAFO Div. 2J, 3K and 3L, mean size showed a reduction over time except in 3L in 1995 when there was a substantial increase. Size of fish in NAFO Div. 3N tended to be smaller than the northern areas. Mean weight of individuals for NAFO Div. 3O, 3Ps are not plotted in Fig. 7 because of small sample size.

The biomass and abundance indices for striped wolffish since 1986 (Figure 8 and Table 2) show quite different patterns than for spotted wolffish. Biomass was highest in NAFO Div. 3N and lowest in 3L and north and showed a decline in all areas since 1986. Average size of fish was considerably greater for the southern Grand Banks concentration, particularly in NAFO Div. 3P, perhaps suggesting that this is a spawning area.

Commercial Fisheries: Currently, the catches of spotted and striped wolffish are unregulated. Although these two species have not been targeted for a directed fishery, their extensive distributions made them a common bycatch in many of the Labrador Shelf and Grand Bank fisheries. Wolffish are recorded together in the landing statistics as catfish. Fig. 9 shows that catfish landings declined after 1991 when many fisheries were closed.

Striped and particularly spotted wolffish have been marketable for years. Before the cod moratoria, otter trawlers landed most of the wolffish. Over the entire period, including post-moratoria, wolffish were also commonly landed from gillnets and to a lesser extent, longlines. During the early 1980's, about 92% of spotted and 74% of striped wolffish caught in the domestic offshore fisheries were landed, these numbers increasing in later years. The two species together comprised the second most abundant commercial bycatch in the offshore fisheries after skate.

Distributional maps of bycatch from commercial otter trawl fisheries for spotted (Fig. 10) and striped wolffish (Fig. 11) showed patterns and trends similar to the research vessel data. Some of the observed differences such as slightly greater extent may have related to differences in gears

(larger trawls and larger mesh that would affect size specific catchability), season (research surveys occurred in the spring only while commercial activity covered most months) and area fished (commercial data missed some of the shallower areas but provided more extensive coverage deeper than 600 m).

In the early 1980's, higher densities of spotted wolffish were taken as bycatch in the groundfish fisheries over a substantial portion of the study area between 50 and 1000m particularly directly north of the Grand Bank. The distribution became restricted to a small area equal to about 30% of the original area along the shelf edge northeast of the Grand Bank, in greater than 150 m. Similar to the research vessel results, the striped wolffish concentration on the tail of the bank remained stable while density and extent declined north of Lat. 48^0N, particularly after 1991.

White hake and monkfish

Year Group Comparison - Distribution Plots: White hake (Fig. 12) and monkfish (Fig. 13), showing similar distributions, are at the northern limits of their distribution on the Grand Banks and in the Gulf of St. Lawrence. They inhabited primarily the south western edge of the Grand Bank along the shelf break and in the Laurentian Channel. Distributional changes over time were far less extensive for these two species. Across year groups, the extent of the distributions remained largely unchanged perhaps with a slight reduction in density for white hake.

Year Group Comparison - ANOVA: Total catch in survey trawls declined dramatically for white hake (Fig. 14). There was no evidence of a decline in catch for monkfish (Fig. 15) and there is little evidence for a latitudinal shift in the centre of mass for either species. Fish depth distribution varied among year groups and increased systematically and significantly. Size declined for white hake although data were available from only two time periods. No data were available on monkfish sizes.

Annual Survey Biomass Abundance Estimates: The biomass and abundance indices for white hake (Figure 16 and Table 3) since 1986 show that most of the biomass is located in NAFO Div. 3O and 3P, particularly the latter. Biomass in both areas dropped in 1989 but has been relatively stable since. Average size in NAFO Div. 3O and 3P was lower but stable in recent years (since about 1991). Similarly, monkfish biomass is concentrated in NAFO Div. 3O and 3P (Figure 17 and Table 4). Biomass and average fish size for both of these areas fluctuated but dropped to low levels in recent years.

Commercial Fisheries: Until 1994 or 1995, white hake and monkfish landings were a product of bycatch from other fisheries. White hake was landed primarily from NAFO Div. 3P and 3O (Fig. 18) matching its southerly distribution. Until 1993, it was taken as a bycatch from gillnets and longlines. Experimental trawl fisheries contributed to an increase in landings for this gear but the fishery was often closed soon after opening because of high cod and haddock bycatch. Currently there are no catch limits for white hake although by-catches of other species during directed hake fisheries are tightly controlled. Length frequencies of commercial catch (Fig. 19) shows that there was a component of larger fish caught by longline gear in Div. 3O not taken by gillnets in Subdiv. 3Ps.

Average size of catch was 69 cm. in NAFO Div. 3O and 65 cm in 3Ps. There are no comparative data from earlier years of the fishery.

Monkfish was landed primarily from Div. 3O and 3P (Fig. 20) matching its southerly distribution. Until 1993, it was taken only as bycatch from the gillnet and longline fisheries. Experimental trawl fisheries contributed to an increase in landings for this gear beginning in 1991. Landings in 1995 declined from the previous four years. Currently, there is a 200 t TAC for this species in NAFO Div. 3LNOP. Based on limited sampling, length of monkfish taken in the commercial fishery covered a wide range, from 51 to 114 cm. with an average of 81 cm (Fig. 21). There are no comparative data from earlier years of the fishery.

Distributional maps of bycatch from commercial otter trawl fisheries for white hake (Fig. 22) and monkfish (Fig. 23) showed that these two species were taken at similar locations, primarily from the south western edge of the Grand Bank along the shelf break and in the Laurentian Channel. Both remained fairly stable during the 1980's and 90's. The distributions were similar to the research survey patterns although slightly more dispersed onto the bank, perhaps due to differences in gears (larger trawls and larger mesh that would affect size specific catchability), season (research surveys occurred in the spring only while commercial activity covered most months) and area fished (commercial data missed some of the shallower areas but provided more extensive coverage deeper than 600 m).

Blackback Flounder

Blackback flounder was rarely observed in either research or commercial catches because it is restricted to depths less than 60 m within the study area. Reported landings suggest that it is widely distributed near shore in many of the bays along the coast of Newfoundland and Labrador. Otherwise, there is little data available to describe the distribution of this species.

Commercial Fisheries: This species has been taken as bait for lobster for many years. In the early 1970's, several plants started to process winter flounder and it has since been taken for both food and bait. It is fished all around Newfoundland with gillnets set in shallow water. Landings, primarily from Div. 3K, 3L and 3P have been fluctuating since 1987 (Fig. 24). Measurements of landings done for the first time in Div. 3L in 1996 (Fig. 25), indicated that landed fish ranged from 29 to about 45 cm with an average landed size of 36 cm. There are no comparative data from earlier years of the fishery.

DISCUSSION

A restricted sample area from research surveys (transects mainly to the south before 1970 and poor coverage up to 1976) limited interpretation of trends in density distribution until the mid seventies. However, a visual comparison of pre-1976 to 1976-80 patterns indicates that distributions were similar. From 1976 to the present, all species in this study except monkfish, to varying degrees

suffered a constriction in distribution. Annual survey estimates and commercial bycatch distribution maps also point to a decline in total abundance and the declines were most evident in recent years. For monkfish, although both distribution and density remained stable across all year groups, annual biomass estimates have been in decline since 1986. All species showed declines in size over some part of their distribution from the early eighties to the nineties. The declining catches and sizes noted here for wolffishes and hake agree, generally, with other published accounts for these species: Hake catches have declined in NAFO 4T (Hurlbut *et al.* 1995, Clay and Hurlbut 1990), although perhaps less so than off Newfoundland (3Ps). Wolffish catches and average size off West Greenland have declined from 1982 to 1993 (Riget and Messtorff, Ratz 1994).

There is little consensus in the literature about the proximal cause for declines in fish catches throughout the Northwest Atlantic. Attempts to relate biomass indices to environmental signal have met with little success and overfishing hypotheses are not fully satisfactory in many instances. The latter is especially lacking for non-traditional species since directed fishing on these species has, for the most part, been nonexistent although bycatch mortality could have contributed. This pattern, including an extension of distributional extent to deeper waters has also been observed in some other species (Atkinson, 1993 and Kulka *et al.* 1995) during the same period. Also, some of the most intense fishing effort during this latter period was located on the shelf edge north of the Grand Bank where much of the northern species in this study and the vestiges of some commercial species ended up. This suggests significant non-fishery influences effecting the distributional and abundance changes.

CONCLUSION AND PROGNOSIS

In assessing the status of these species, attention should be paid to the declining biomass trends, particularly to the north, reduction in extent of the distribution in the north and increasing density to the south. These may be signs of a declining resource. While fishing contributed to the mortality of all species, the species continued to decline when fishing effort was greatly reduced.

The wolffishes, given the low densities over their entire distributions, even in earlier years, will likely never support a directed fishery. For white hake and monkfish, 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. Biomass estimates suggest that neither of these species are likely able to sustain a fishery greater than what is currently taken and current levels of fishing mortality may be excessive. Although a blackback fishery has been ongoing for years, little information is available to support any management decisions..

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Table 1 - Biomass, abundance and mean weight of spotted wolfish from research vessel surveys, 1986 to 1995.

Biomass (t)

Year	2J	3K	3L	3N	3O	3Ps	All Div.
1986	2,437	2,907	2,117	26	27	0	2,170
1987	1,908	3,439	2,646	4	0	0	
1988	2,030	3,014	3,402	24	64	216	3,706
1989	2,348	2,858	2,821	44	285	157	3,306
1990	1,136	1,736	207	25	48	0	280
1991	334	1,736	207	51	160	0	418
1992	627	779	431	69	5	0	505
1993	383	307	192	135	9	1	337
1994	263	168	145	6	6	0	
1995	13	441	422	149	10	17	597

Abundance (thousands)

Year	2J	3K	3L	3N	3O	3Ps	All Div.
1986	608	702	411	18	0	0	
1987	447	596	709	4	0	0	
1988	580	717	802	8	5	15	830
1989	582	685	650	0	24	0	674
1990	264	363	103	17	7	11	139
1991	143	363	103	35	14	0	152
1992	199	255	136	41	3	0	180
1993	165	94	117	47	0	4	169
1994	65	37	91	8	6	0	105
1995	134	496	68	57	4	5	134

Mean Weight (kg)

Year	2J	3K	3L	3N	3O	3Ps	Average
1986	4.01	4.14	5.16	1.46			3.31
1987	4.27	5.77	3.73	1.10			2.42
1988	3.50	4.20	4.24	3.00	14.00	13.96	8.80
1989	4.03	4.17	4.34				4.34
1990	4.31	4.78	2.01	1.46	6.46		
1991	2.33	4.78	2.01	1.47	11.25		4.91
1992	3.15	3.06	3.16	1.68	1.80		2.21
1993	2.33	3.27	1.63	2.86		0.22	1.57
1994	4.03	4.60	1.60	0.78	1.00		1.12
1995	0.10	0.89	6.22	2.62	2.33	3.50	3.67

Table 2 - Biomass, abundance and mean weight of striped wolfish from research vessel surveys, 1986 to 1995.

Biomass (t)

Year	2J	3K	3L	3N	3O	3Ps	All Div.
1986	495	1,716	2,557	15,158	1,750	1,927	21,393
1987	1,794	1,415	3,302	9,443	4,540	540	17,824
1988	2,157	1,731	2,378	7,851	4,234	312	14,774
1989	1,663	1,472	1,942	7,508	3,160	515	13,124
1990	950	687	1,792	11,102	2,353	306	15,552
1991	334	1,262	396	6,200	2,258	306	9,160
1992	381	387	431	6,560	1,749	43	8,783
1993	444	499	517	5,125	2,507	253	8,402
1994	137	302	553	12,111	2,600	208	15,472
1995	268	883	747	3,213	598	346	4,904

Abundance (thousands)

Year	2J	3K	3L	3N	3O	3Ps	All Div.
1986	462	2,014	1,567	1,378	311	619	3,875
1987	3,202	1,947	3,302	887	812	370	5,372
1988	2,323	2,247	2,023	786	1,231	256	4,296
1989	2,014	1,687	2,294	672	919	0	3,885
1990	1,276	840	2,139	1,347	662	154	4,303
1991	143	1,469	281	822	1,001	182	2,286
1992	628	570	136	716	360	101	1,313
1993	849	723	628	871	446	126	2,071
1994	215	419	840	1,483	472	127	2,921
1995	1,840	6,304	2,402	388	200	183	3,172

Mean Weight (kg)

Year	2J	3K	3L	3N	3O	3Ps	Average
1986	1.07	0.85	1.63	11.00	5.62	3.11	5.34
1987	0.56	0.73	1.00	10.65	5.59	1.46	4.67
1988	0.93	0.77	1.18	9.99	3.44	1.22	3.95
1989	0.83	0.87	0.85	11.17	3.44		5.15
1990	0.74	0.82	0.84	8.24	3.55	1.98	3.65
1991	2.33	0.86	1.41	7.54	2.26	1.68	3.22
1992	0.61	0.68	3.16	9.16	4.86	0.42	4.40
1993	0.52	0.69	0.82	5.88	5.62	2.01	3.59
1994	0.63	0.72	0.66	8.17	5.51	1.64	4.00
1995	0.15	0.14	0.31	8.29	2.99	1.89	3.37

Table 3 - Biomass, abundance and mean weight of white hake from research vessel surveys, 1986 to 1995.

Biomass (t)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	All Divs
1986	0	356	2,408	9,788	12,552
1987	0	43	2,750	8,769	11,563
1988	0	32	5,434	12,211	17,677
1989	0	0	923	3,366	4,289
1990	0	0	761	3,799	4,560
1991	0	0	1,229	3,799	5,028
1992	0	0	699	2,491	3,190
1993	0	0	592	2,623	3,214
1994	0	0	1,079	2,154	3,234
1995	0	0	334	2,323	2,657

Abundance (thousands)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	All Div.
1986	0	70	571	3,715	4,356
1987	0	95	1,114	3,979	5,187
1988	0	63	690	5,274	6,027
1989	0	0	252	3,774	4,026
1990	0	0	237	2,522	2,759
1991	0	0	1,229	3,158	4,387
1992	0	0	619	2,331	2,950
1993	0	0	336	2,383	2,719
1994	0	0	885	2,029	2,915
1995	0	0	189	2,094	2,284

Mean Weight (kg)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	Average
1986		5.12	4.21	2.63	3.99
1987		0.46	2.47	2.20	1.71
1988		0.51	7.88	2.32	3.57
1989			3.67	0.89	2.28
1990			3.21	1.51	2.36
1991			1.00	1.20	1.10
1992			1.13	1.07	1.10
1993			1.76	1.10	1.43
1994			1.22	1.06	1.14
1995			1.77	1.11	1.44

Table 4 - Biomass, abundance and mean weight of monkfish from research vessel surveys, 1986 to 1995.

Biomass (t)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	All Div.
1986	0	0	535	2,580	3,115
1987	0	0	916	2,843	3,759
1988	0	179	2,191	1,430	3,800
1989	0	0	359	2,220	2,579
1990	0	0	452	2,187	2,639
1991	0	0	909	2,187	3,096
1992	0	0	93	710	803
1993	0	0	185	569	754
1994	0	1	1,224	1,218	2,442
1995	0	0	38	166	204

Abundance (thousands)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	All Div.
1986	0	0	64	419	483
1987	0	0	157	412	569
1988	0	20	186	360	566
1989	0	0	44	235	279
1990	0	0	34	341	375
1991	0	0	196	425	621
1992	0	0	34	187	222
1993	0	0	29	110	140
1994	0	4	425	143	572
1995	0	0	232	1,090	1,323

Mean Weight (kg)

Year	Div. 3L	Div. 3N	Div. 3O	Div. 3P	Average
1986			8.37	6.16	7.26
1987			5.85	6.90	6.37
1988		9.00	11.79	3.97	8.25
1989			8.19	9.45	8.82
1990			13.34	6.41	9.87
1991			4.63	5.15	4.89
1992			2.70	3.79	3.24
1993			6.32	5.16	5.74
1994		0.13	2.88	8.53	3.85
1995			0.16	0.15	0.15

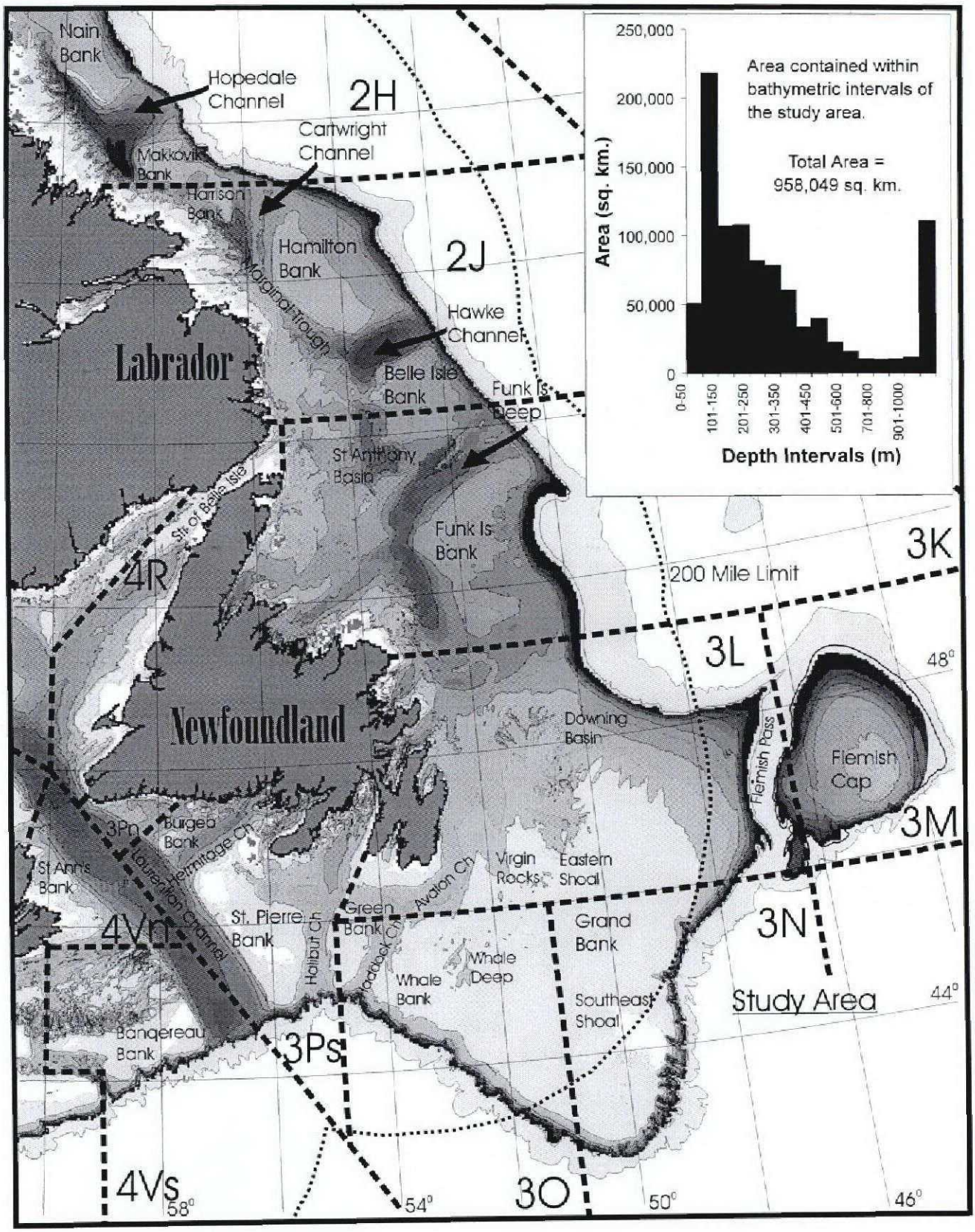

Figure 1 - Study area for non-traditional species showing bathymetry, NAFO Divisions and various bank features. Upper right panel shows area contained within each bathymetric interval.

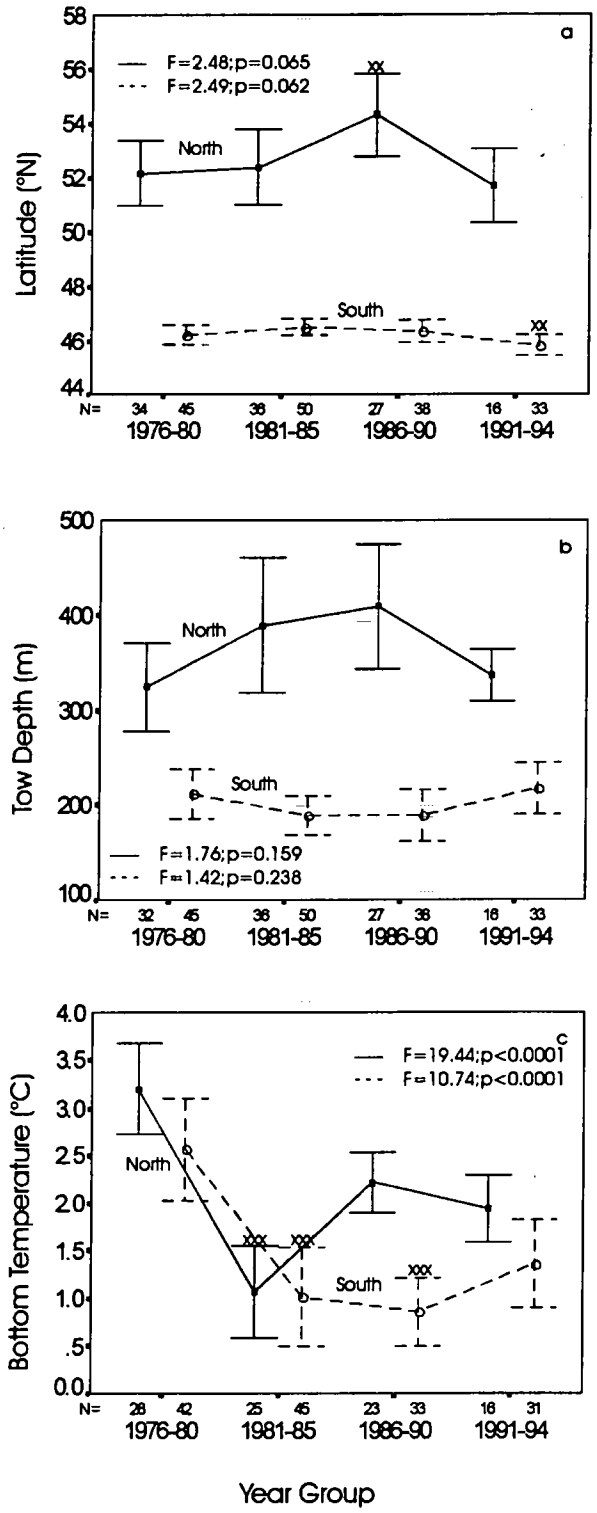

Fig. 2. Sampling conditions 1976-1994. Data are averaged (± 95% CI) over trips (N=No. of trips) in each of 4 year groupings for latitudes >=48°N (North) and latitudes < 48°N (South). Overall ANOVA statistics are given for North and South. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: $p < 0.1$; xx: $p < 0.05$; xxx: $p < 0.01$). Samples were collected at higher latitudes in 1986-90 in the Northern part of the sampling range and further South in 1991-94 in the Southern part. These results impact the interpretation of noted shifts in species distribution (Figs. 11 - 14) (See text).

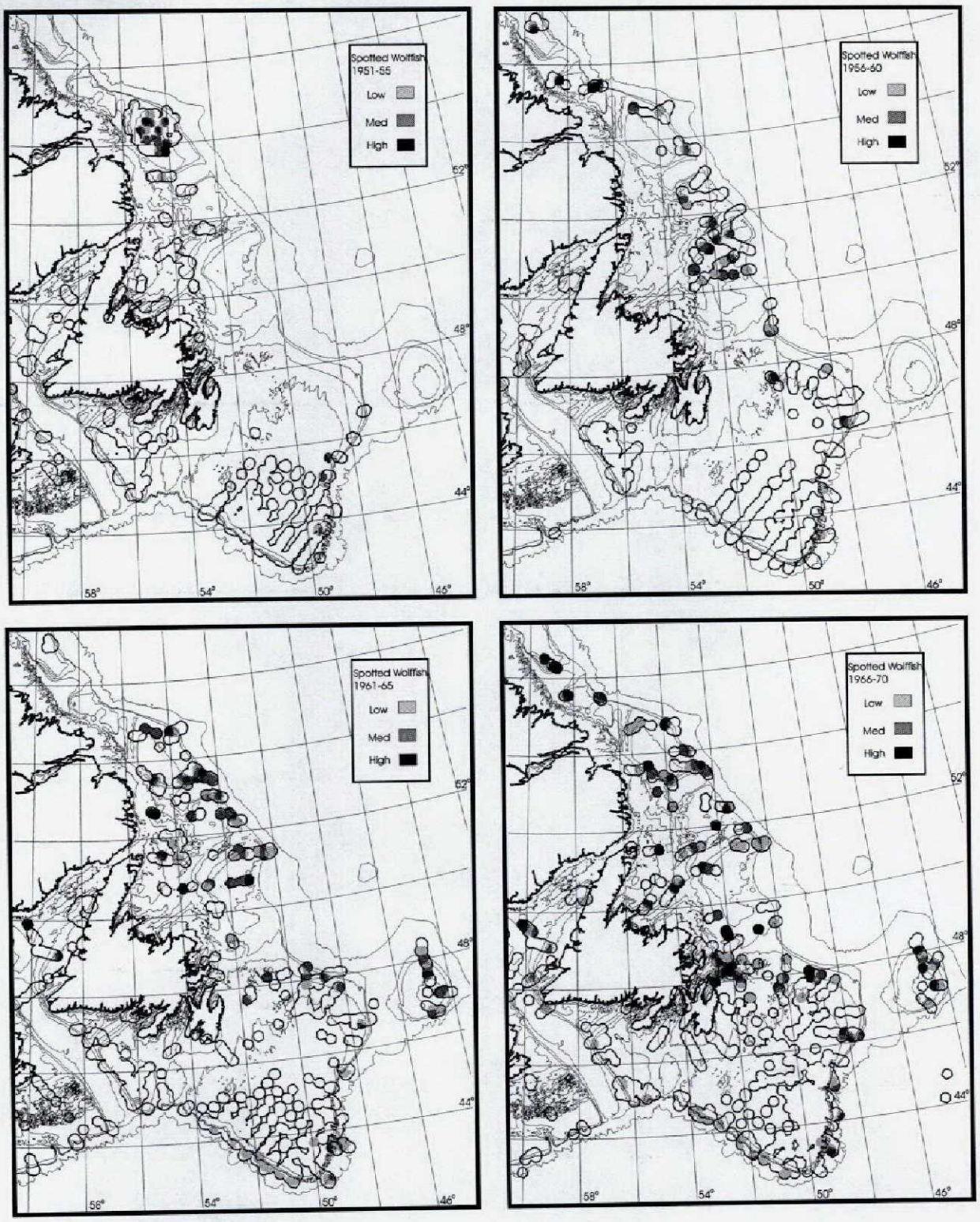

Figure 3a - Spotted wolffish distribution from research vessel surveys, 1951 to 1970 where high = > 6.35, med = 2.0 - 6.34 and low = < 1.99 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

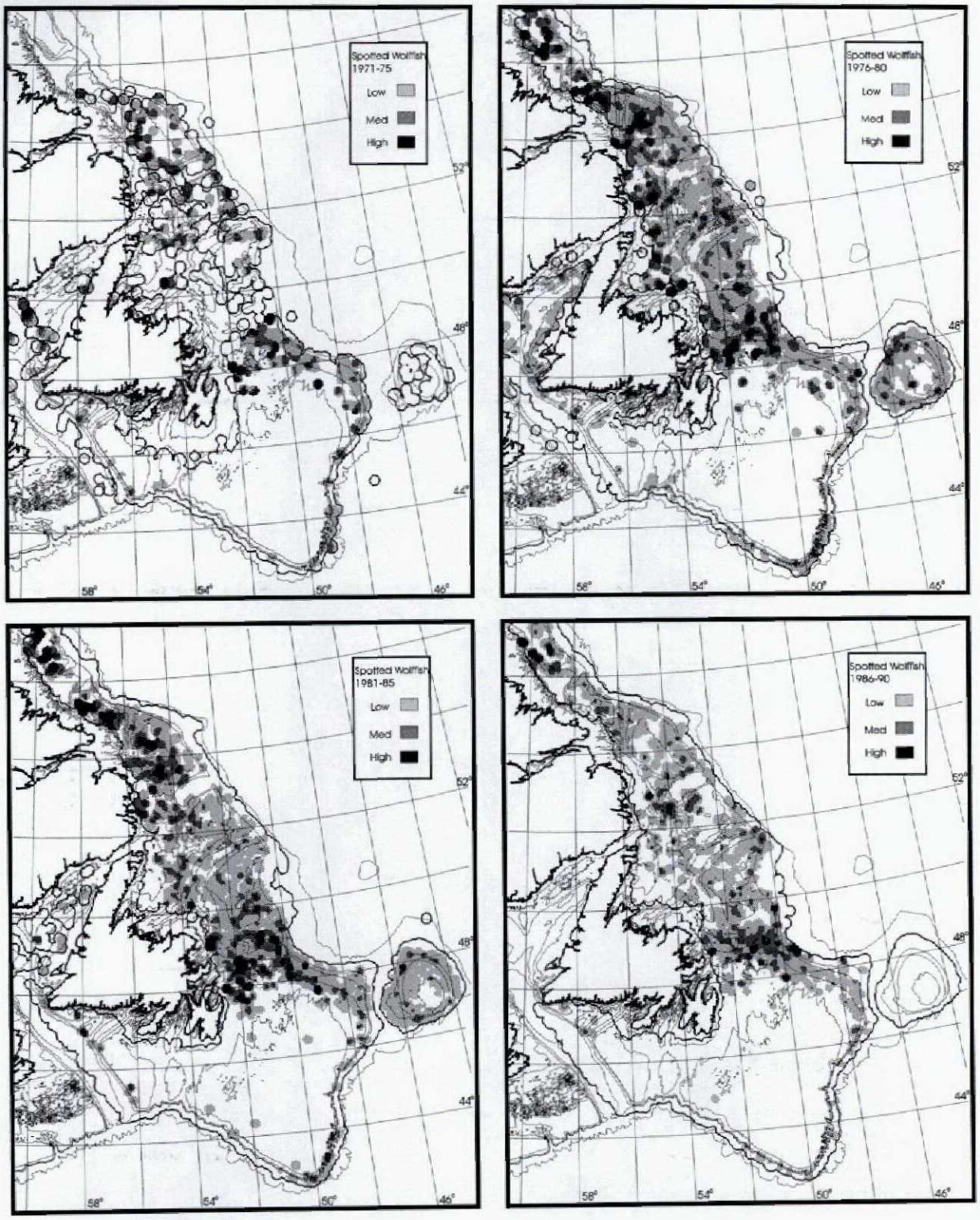

Figure 3b - Spotted wolffish distribution from research vessel surveys, 1971 to 1990 where high = > 6.35, med = 2.0 - 6.34 and low = < 1.99 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

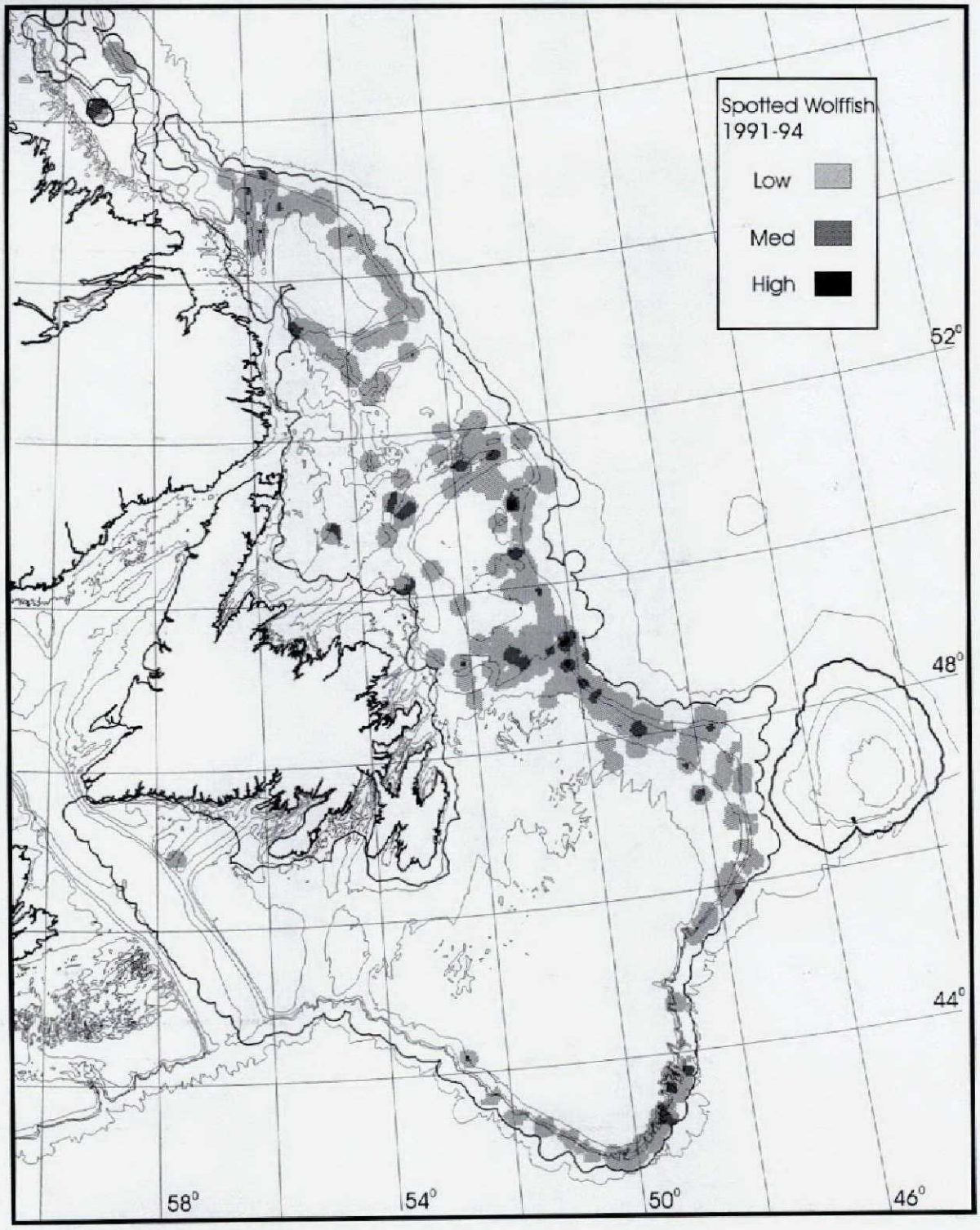

Figure 3c - Spotted wolffish distribution from research vessel surveys, 1991 to 1994 where high = > 6.35, med = 2.0 - 6.34 and low = < 1.99 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

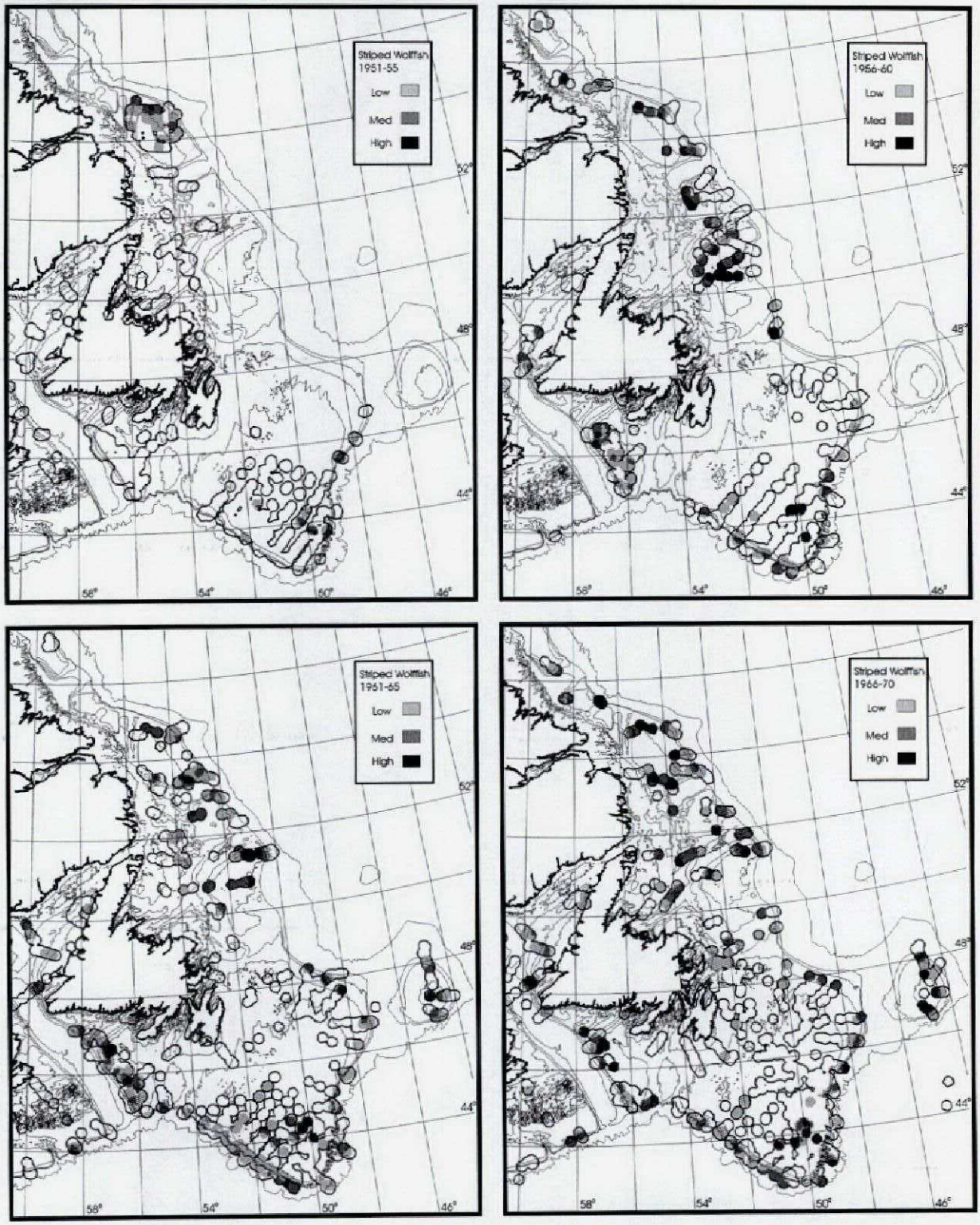

Figure 4a - Striped wolffish distribution from research vessel surveys, 1951 to 1970 where high = > 9.45, med = 3.1 - 9.44 and low = < 3.09 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

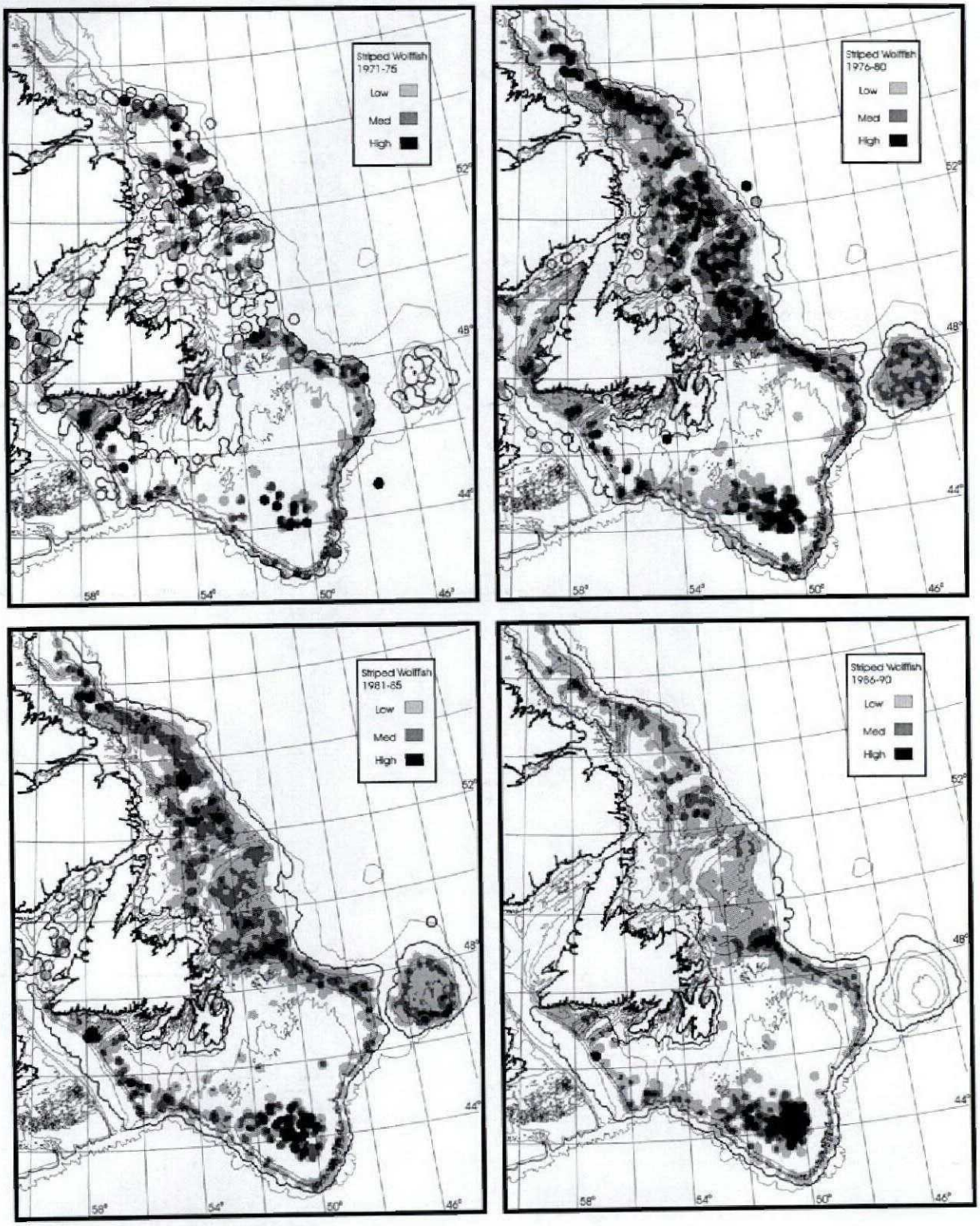

Figure 4b - Striped wolffish distribution from research vessel surveys, 1971 to 1990 where high = > 9.45, med = 3.1 - 9.44 and low = < 3.09 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

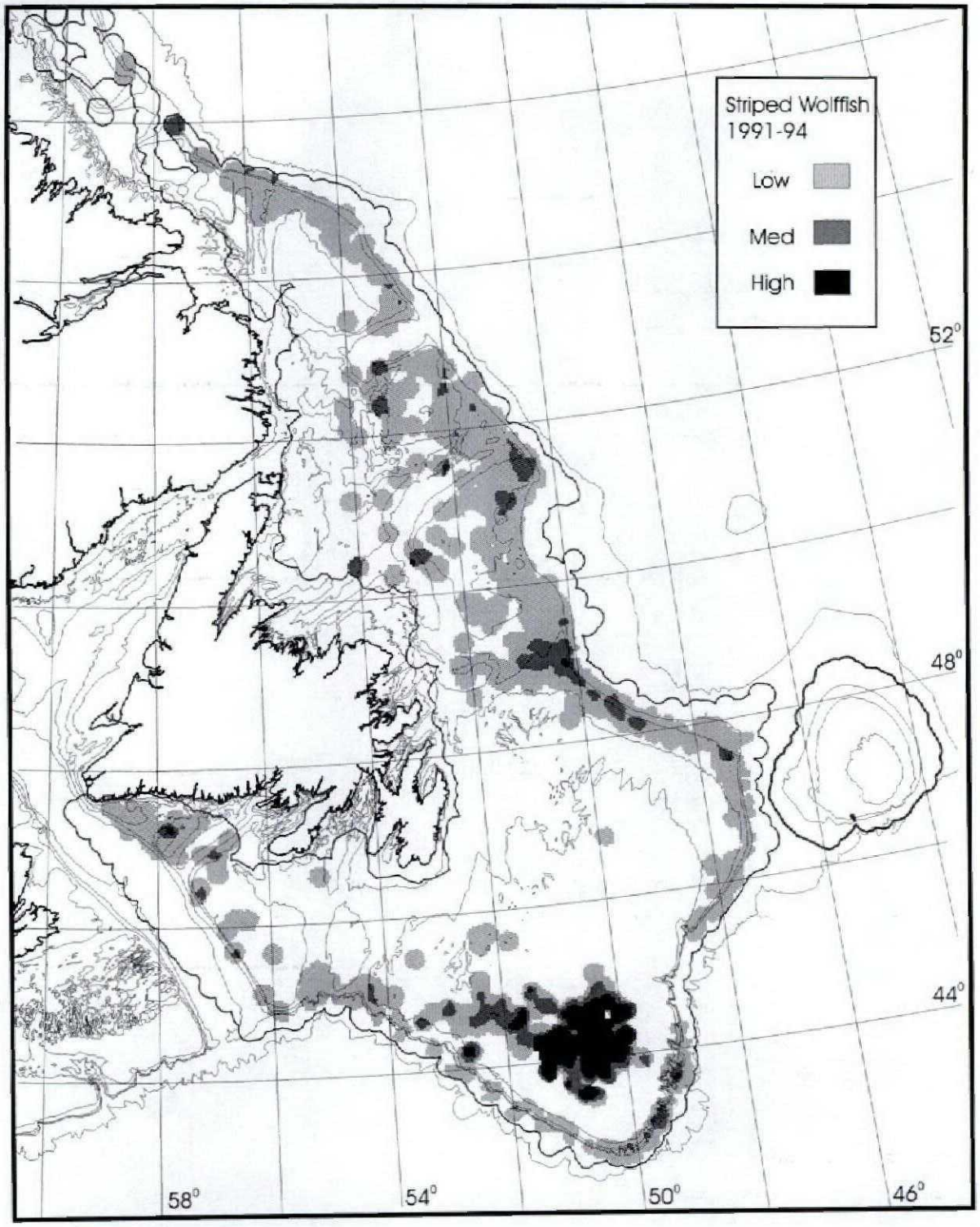

Figure 4c - Striped wolffish distribution from research vessel surveys, 1991 to 1994 where high = > 9.45, med = 3.1 - 9.44 and low = < 3.09 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

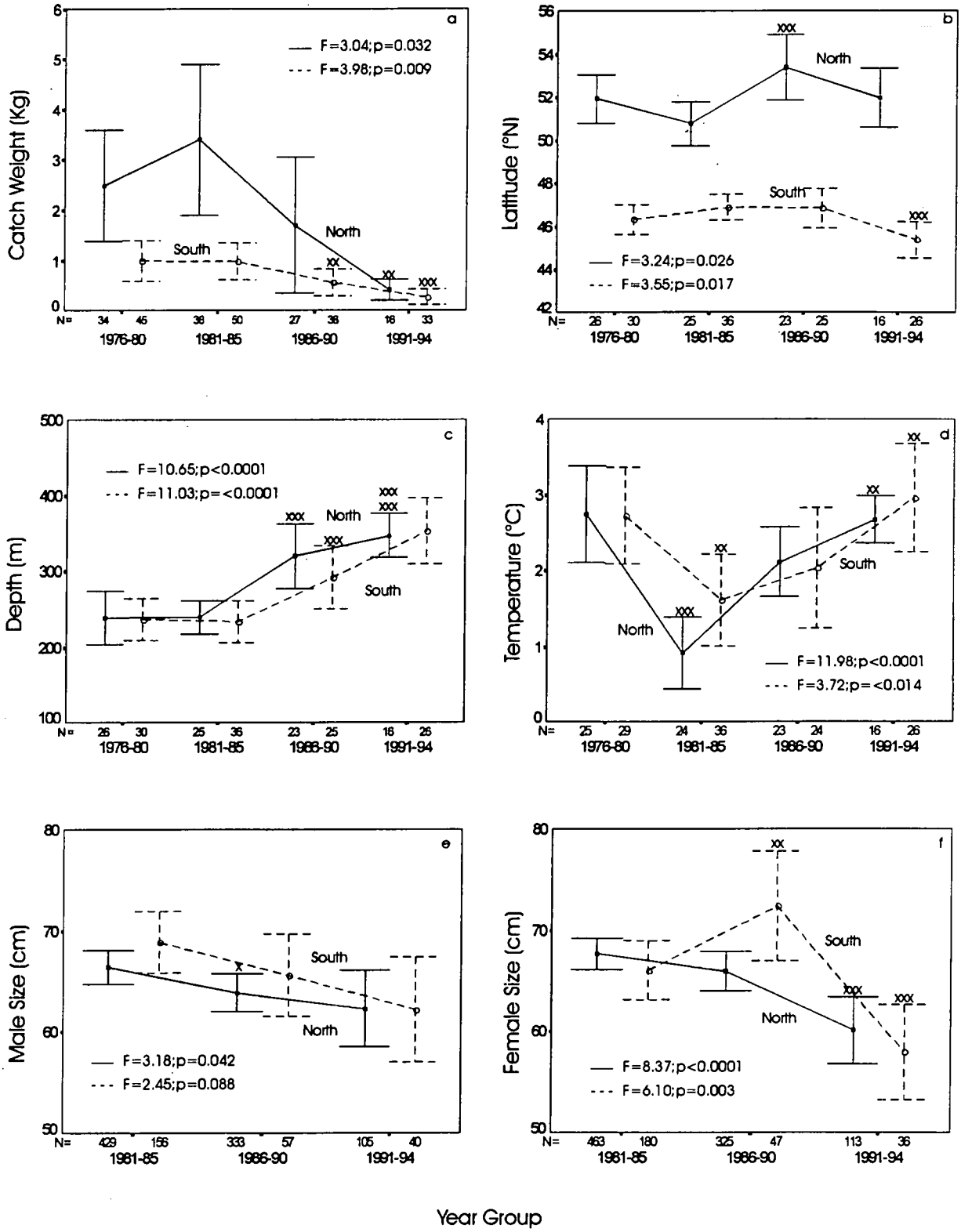

Fig.5 Spotted Wolffish 1976-1994. Data are averaged (±95% CI) over trips (a,b,c, d) or fish (e,f) in each of 4 year groupings for latitudes >=48°N (North) and latitudes < 48°N (South). Overall ANOVA statistics are given for North and South. N = sample size. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: p <0.1; xx: p < 0.05; xxx: p < 0.01). (Note: Size data prior 1981 are unavailable).

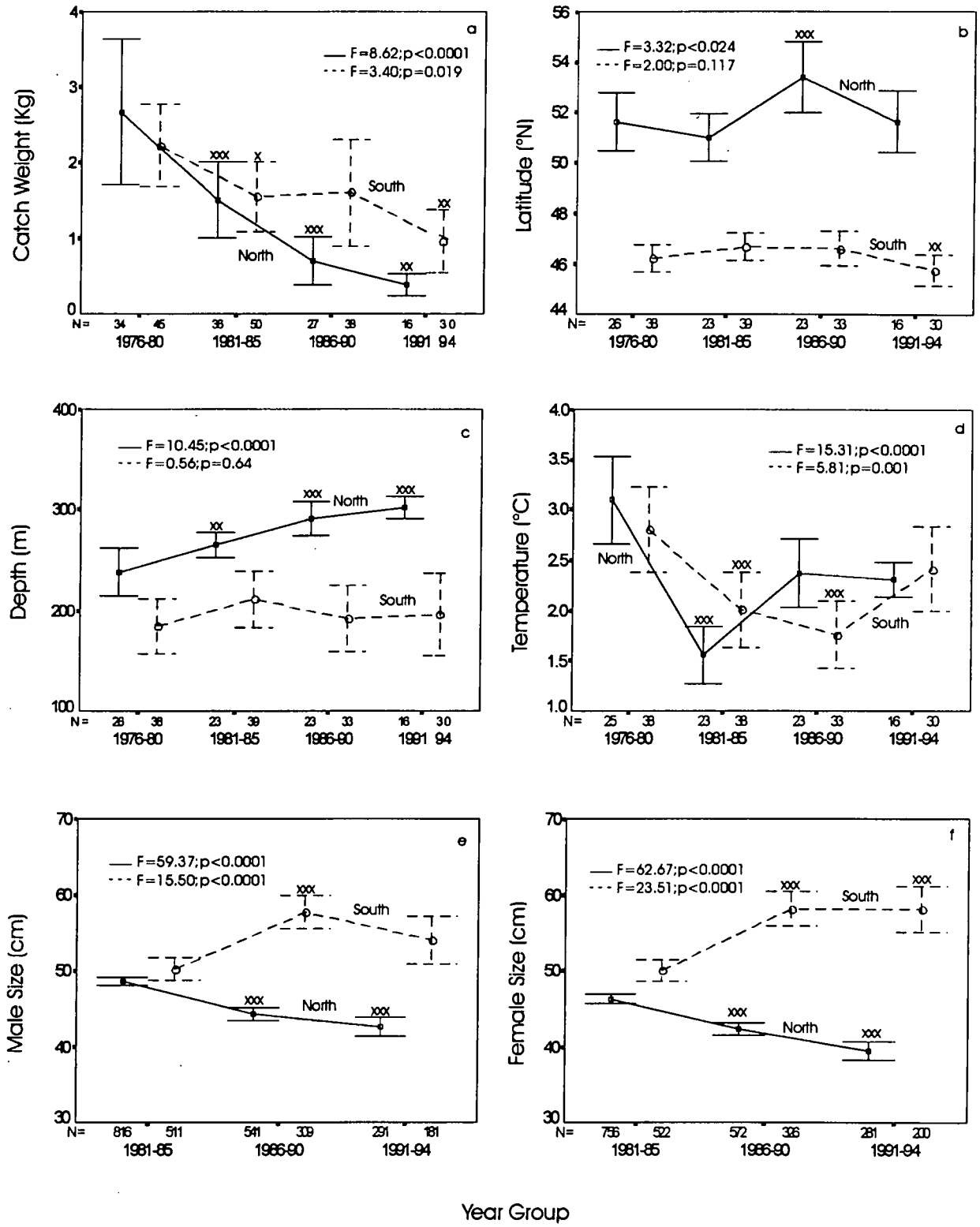

Fig. 6. Striped Wolffish 1976-1994. Data are averaged (±95% CI) over trips (a,b,c, d) or fish (e,f) in each of 4 year groupings for latitudes >=48°N (North) and latitudes < 48°N (South). Overall ANOVA statistics are given for North and South. N = sample size. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: p <0.1; xx: p < 0.05; xxx: p < 0.01). (Note: Size data prior 1981 are unavailable).

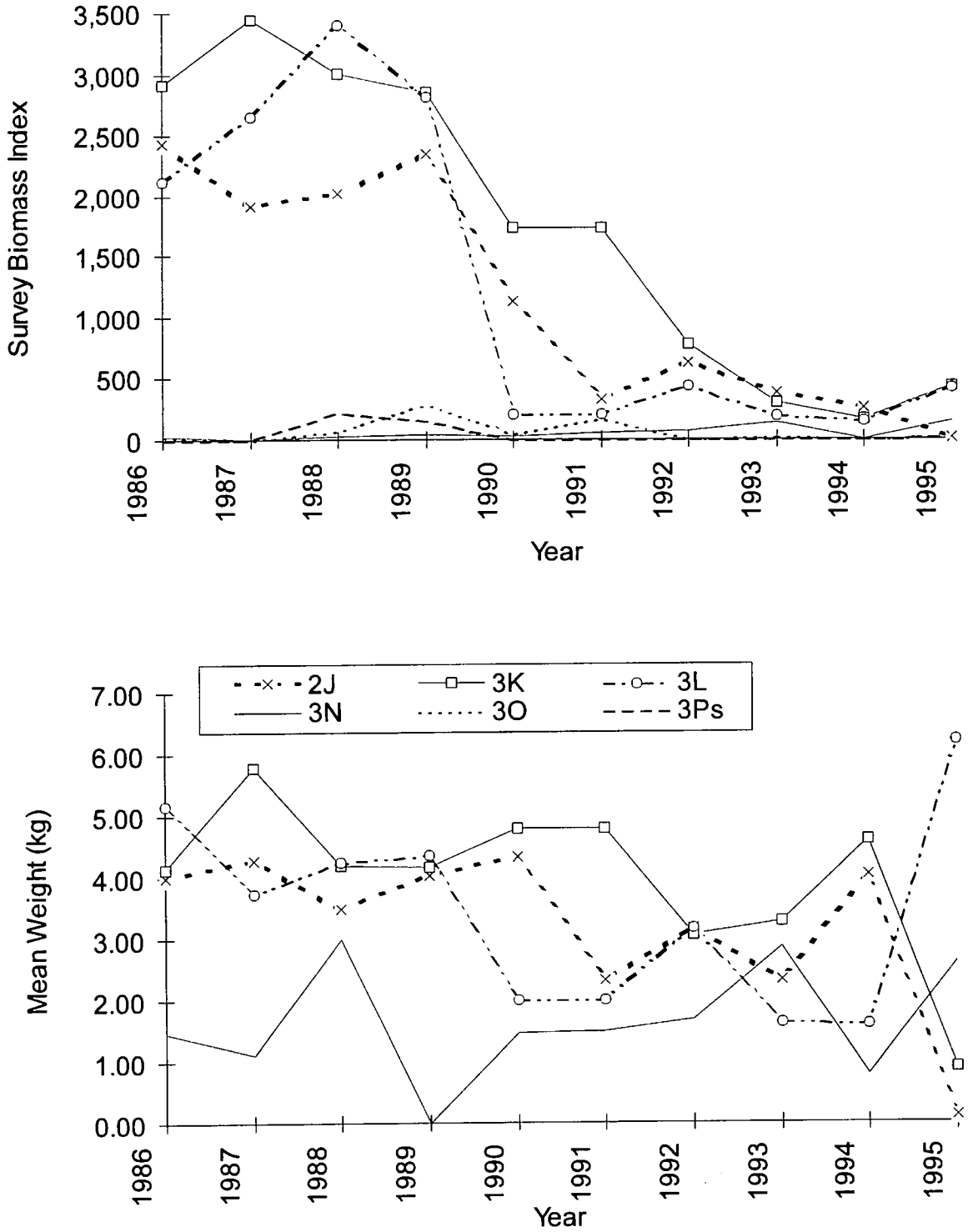

Figure 7 - Survey biomass index and mean weight per tow for spotted wolffish in NAFO Divisions 2J, 3K, 3L, 3N, 3O and Subdivision 3Ps, 1986 to 1995.

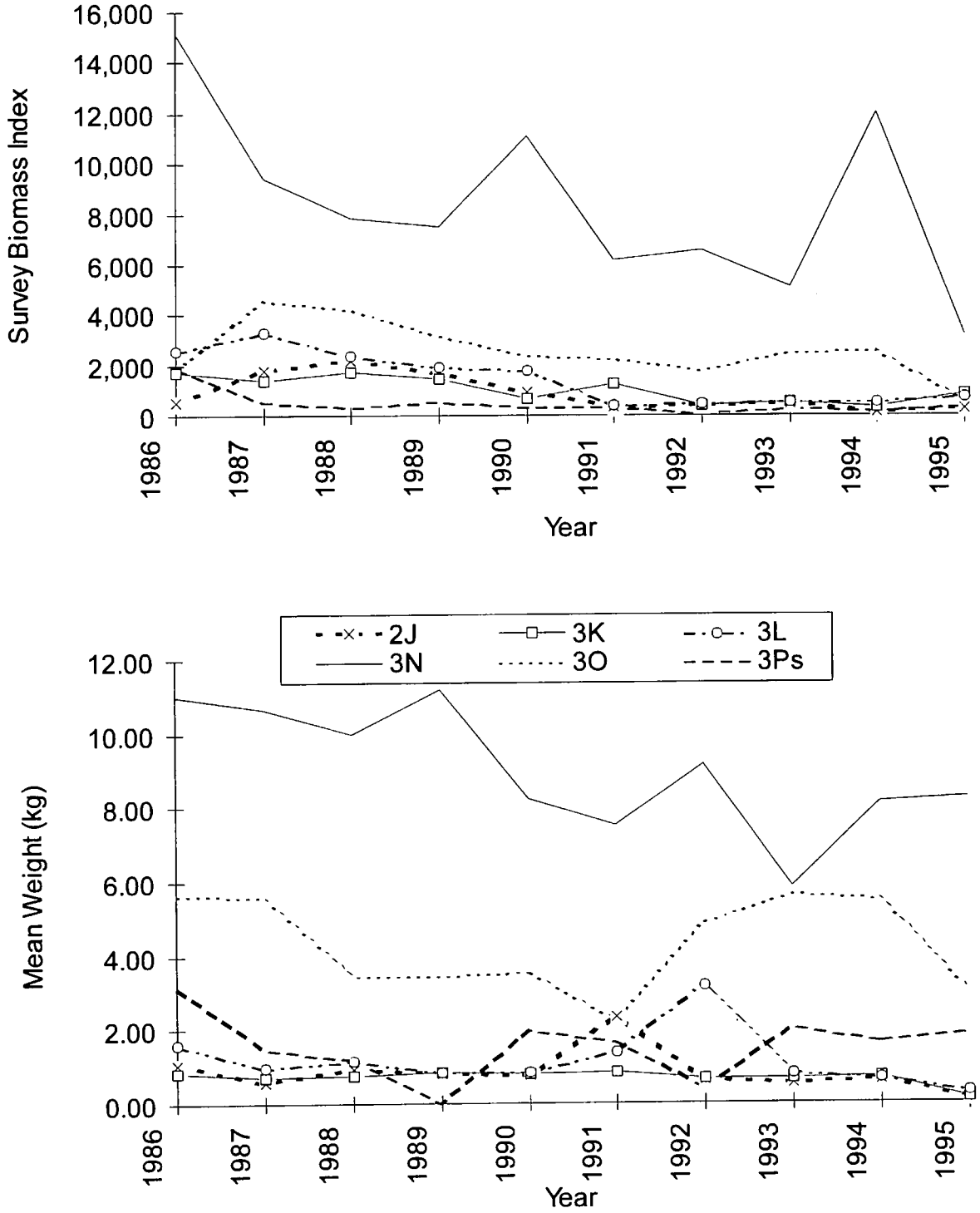

Figure 8 - Survey biomass index and mean weight per tow for striped wolffish in NAFO Divisions 2J, 3K, 3L, 3N, 3O and Subdivision 3Ps, 1986 to 1995.

Catfish

Year	2H	2J	3K	3L	3N	3O	3Pn	3Ps	Cdn. TAC
87	0	447	413	7131	2774	1108	521	1089	
88	19	100	943	4958	1716	545	235	728	
89	2	775	1181	5933	1007	531	286	683	
90	1	542	380	3274	187	284	203	653	
91	0	10	513	3588	500	396	436	867	
92	0	16	32	323	83	611	499	1043	
93	0	5	147	25	344	1128	662	582	
94	2	3	126	13	0	2	20	110	
95	0	1	48	6	0	4	86	124	

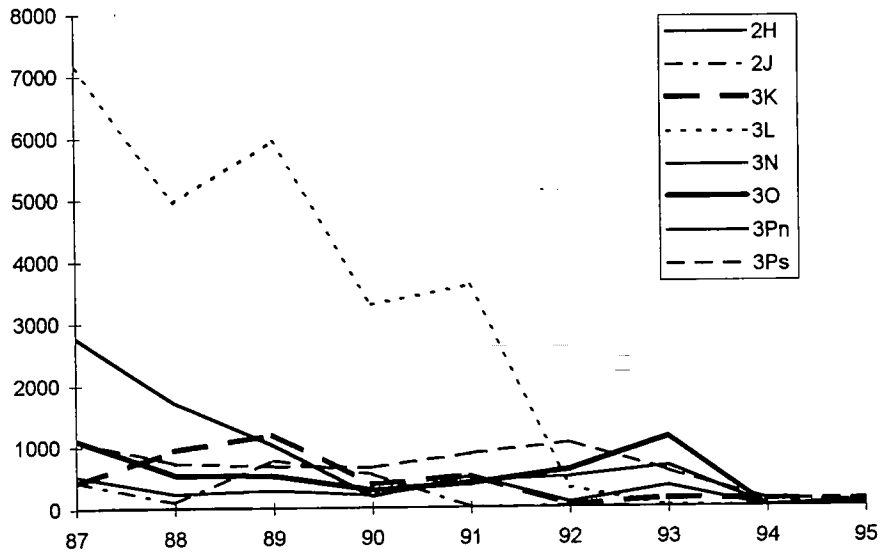

Figure 9 - Landings of catfish by NAFO Div., 1987-1995.

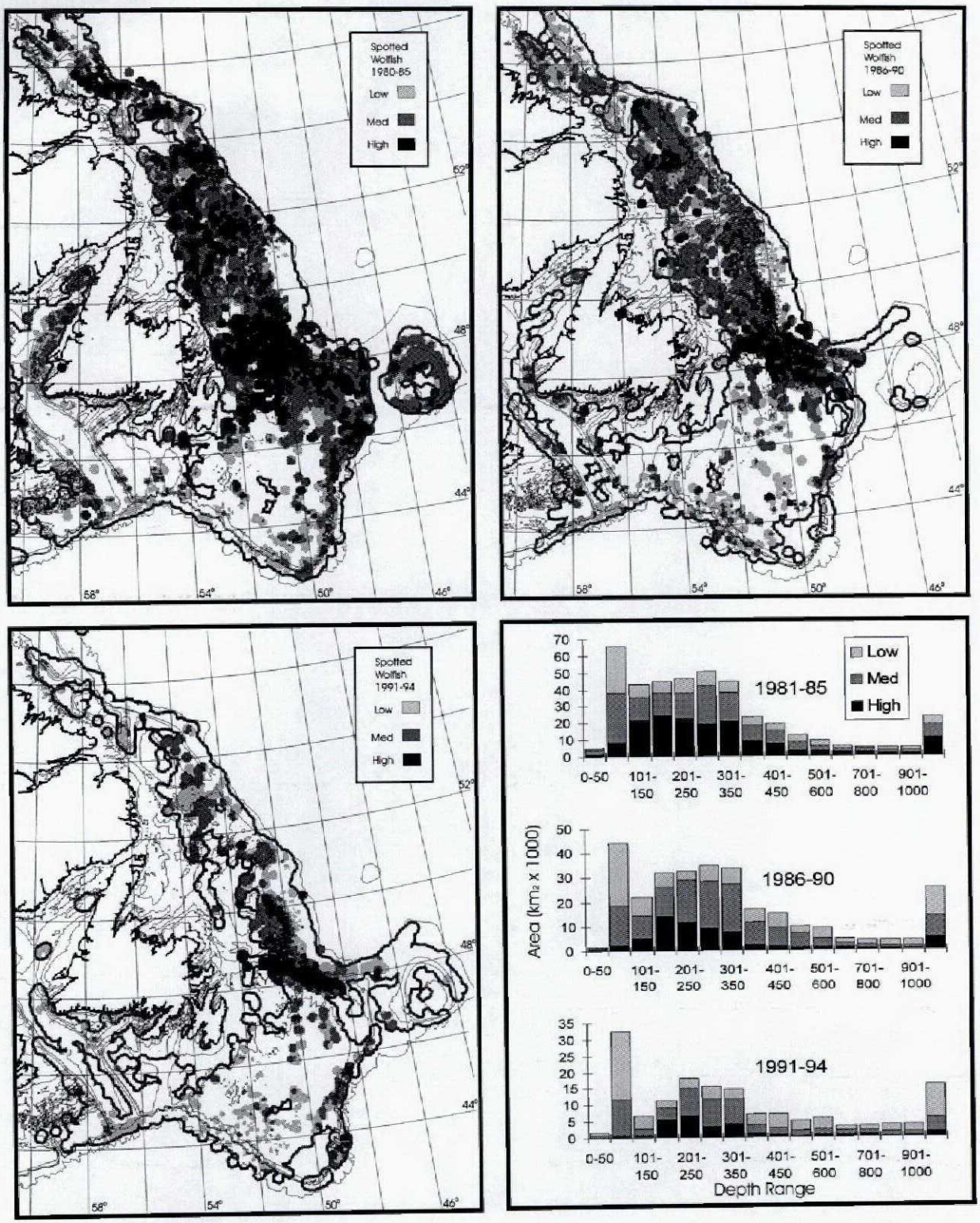

Figure 10 - Spotted wolffish distribution from commercial fisheries, 1981 to 1994 where high = > 10.0, med = 2.0 - 9.9 and low = < 1.9 kg. per hour. The thick outline represents surveyed area.

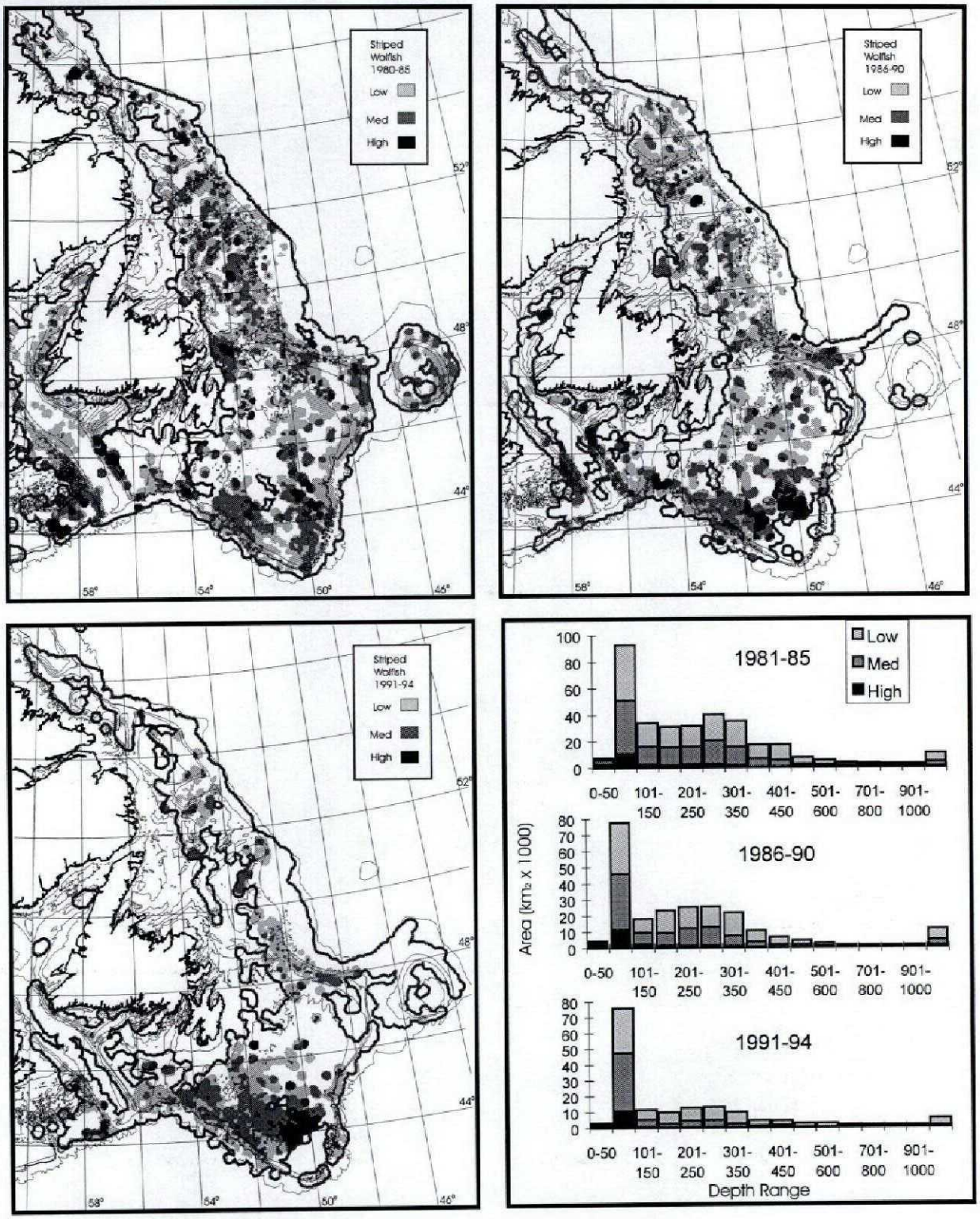

Figure 11 - Striped wolffish distribution from commercial fisheries, 1981 to 1994 where high = > 10.0, med = 2.0 - 9.9 and low = < 1.9 kg. per hour. The thick outline represents surveyed area.

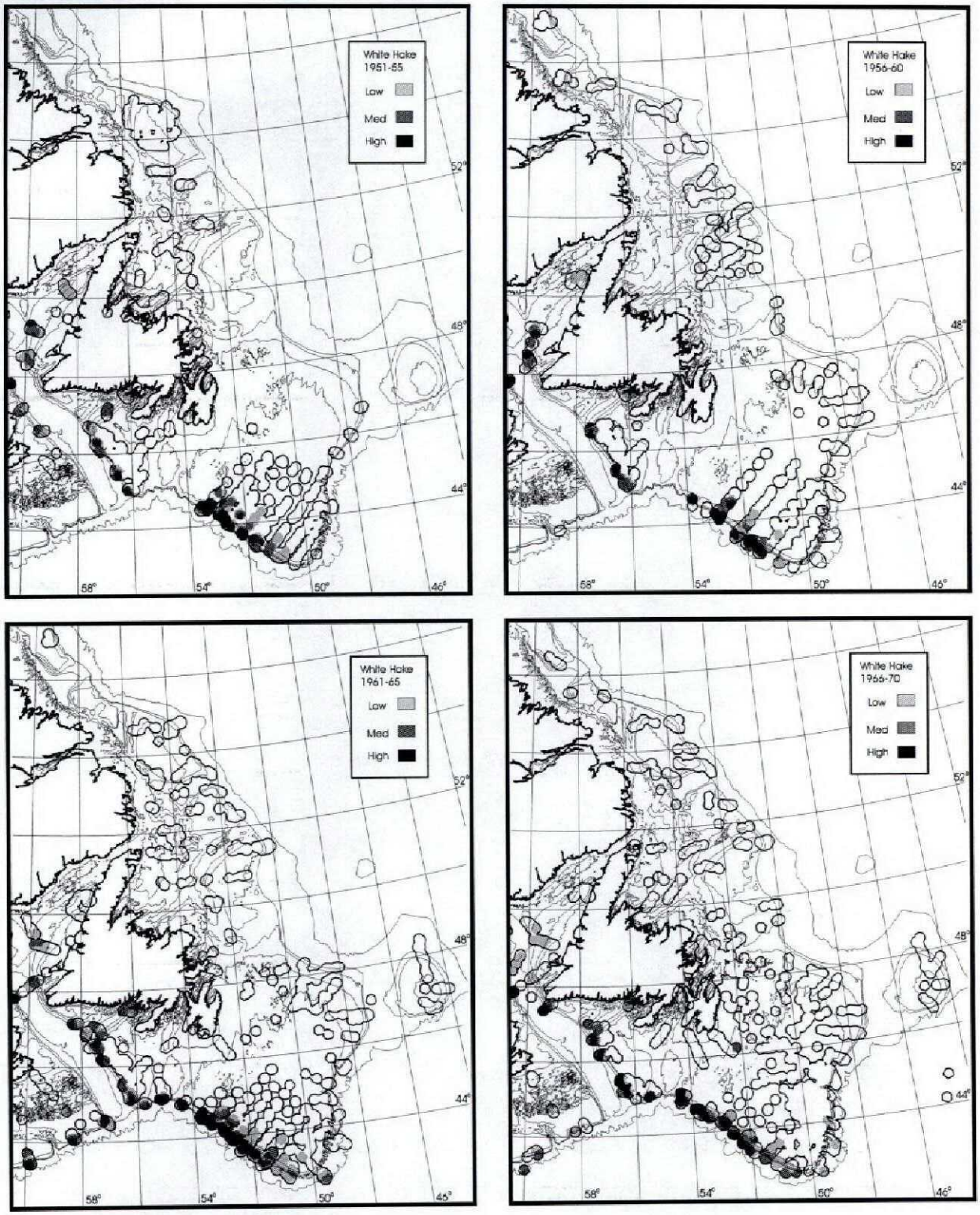

Figure 12a - White Hake distribution from research vessel surveys, 1951 to 1970 where high = > 17.86, med = 3.97 - 17.85 and low = < 3.96 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

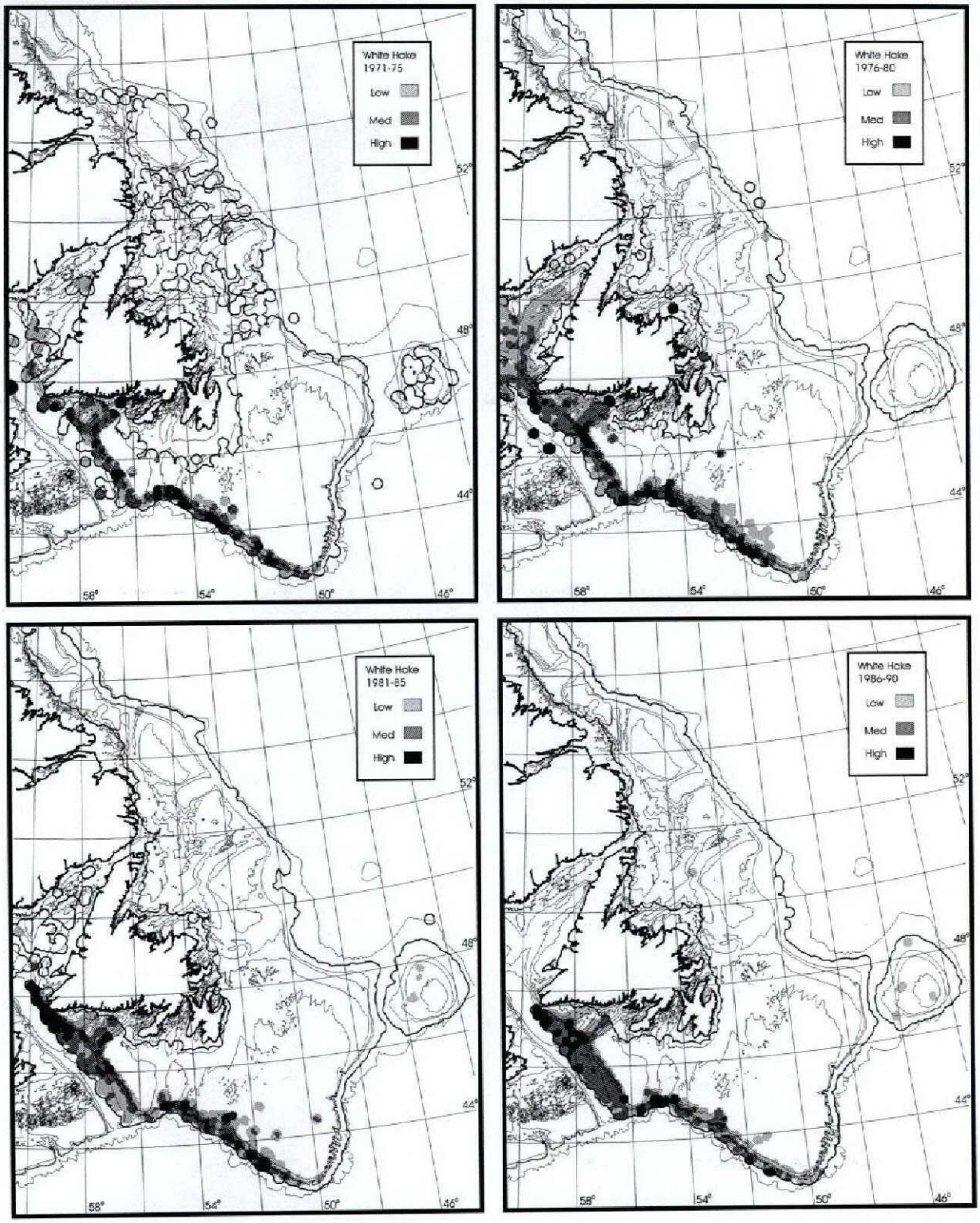

Figure 12b - White Hake distribution from research vessel surveys, 1971 to 1990 where high = > 17.86, med = 3.97 - 17.85 and low = < 3.96 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

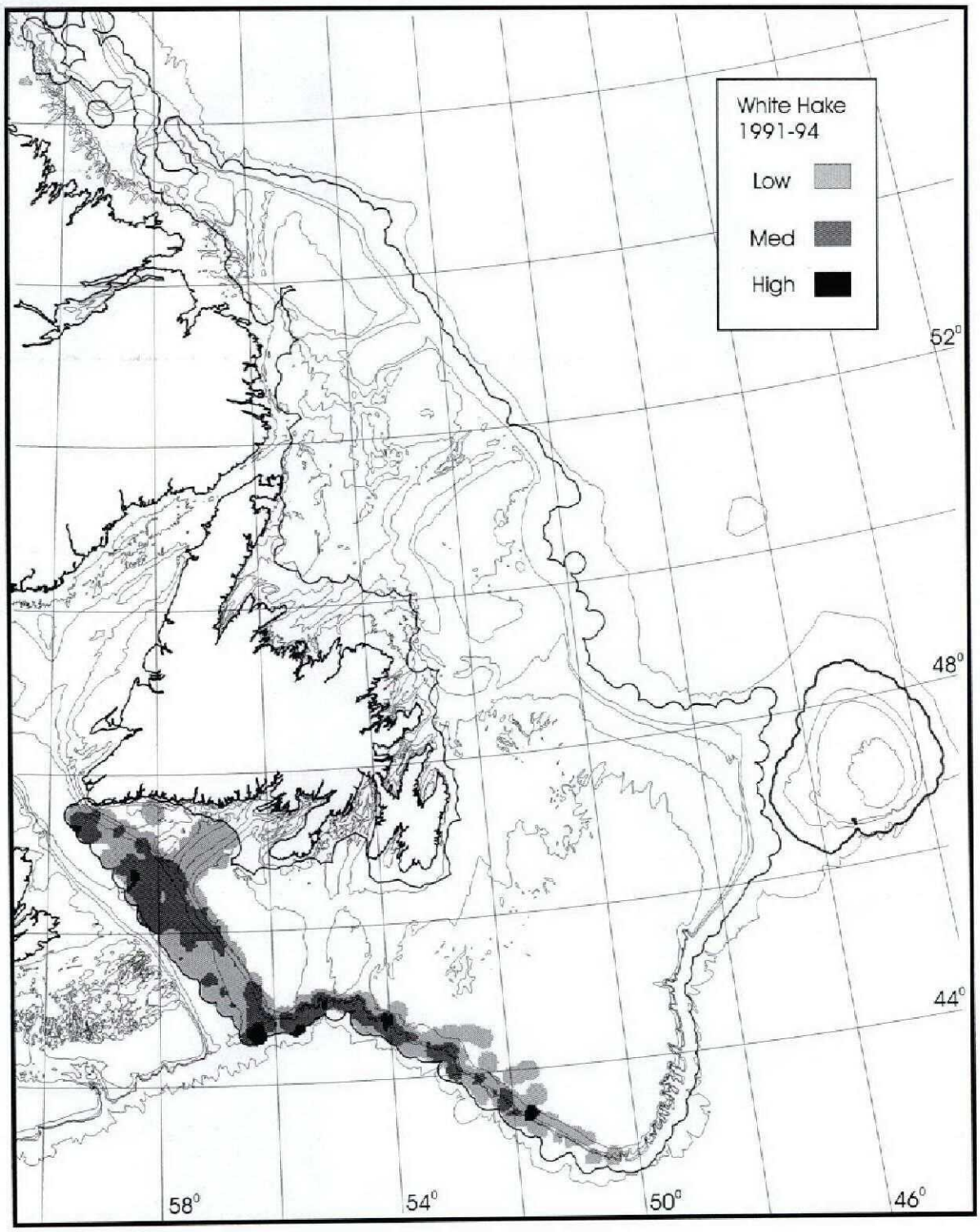

Figure 12c - White Hake distribution from research vessel surveys, 1991 to 1994 where high = > 17.86, med = 3.97 - 17.85 and low = < 3.96 kg. per tow. Catch rate categories are based on 35th and 75th percentile distribution. The thick outline represents surveyed area.

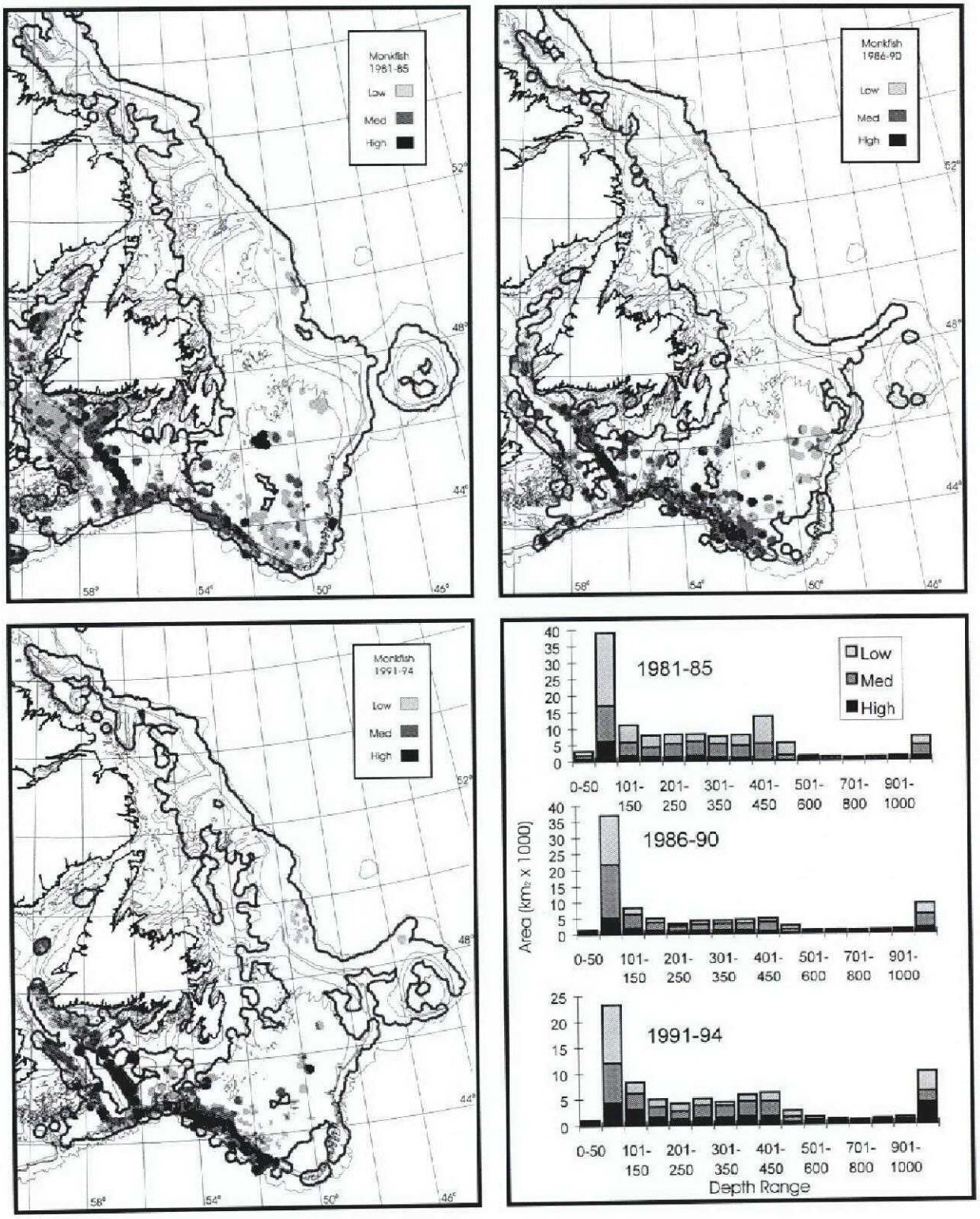

Figure 13 - Monkfish distribution from commercial fisheries, 1981 to 1994 where high = > 5.0, med = 1.0 - 4.9 and low = <0.9 kg. per hour. The thick outline represents surveyed area.

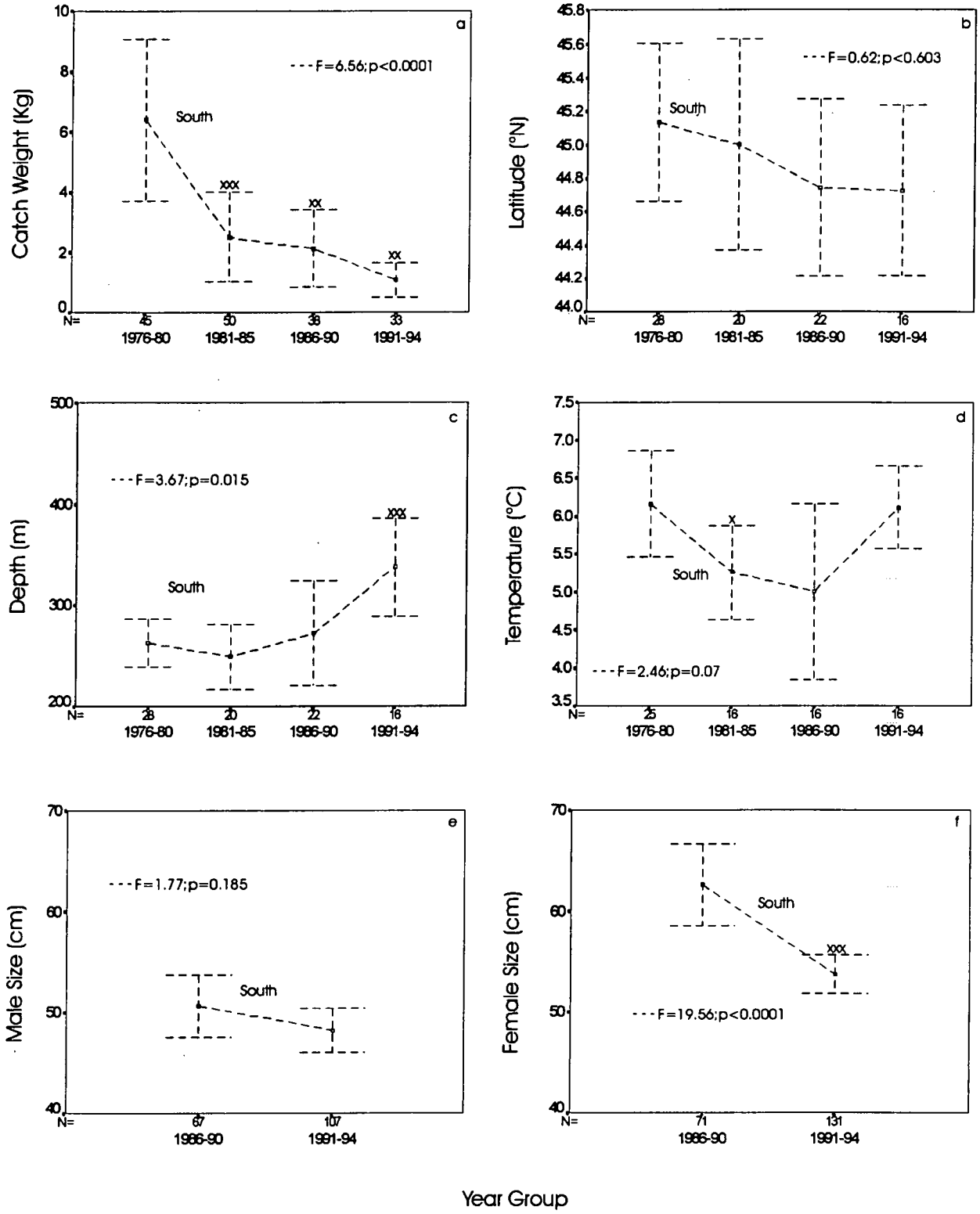

Fig. 14 White Hake 1976-1994. Data are averaged (±95% CI) over trips (a,b,c, d) or fish (e,f) in each of 4 year groupings for latitudes < 48°N (South). (Few fish occured at lat. > 48°N). Overall ANOVA statistics are given. N = Sample size. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: p <0.1; xx: p < 0.05; xxx: p < 0.01). (Note: Size data prior to 1986 are unavailable)

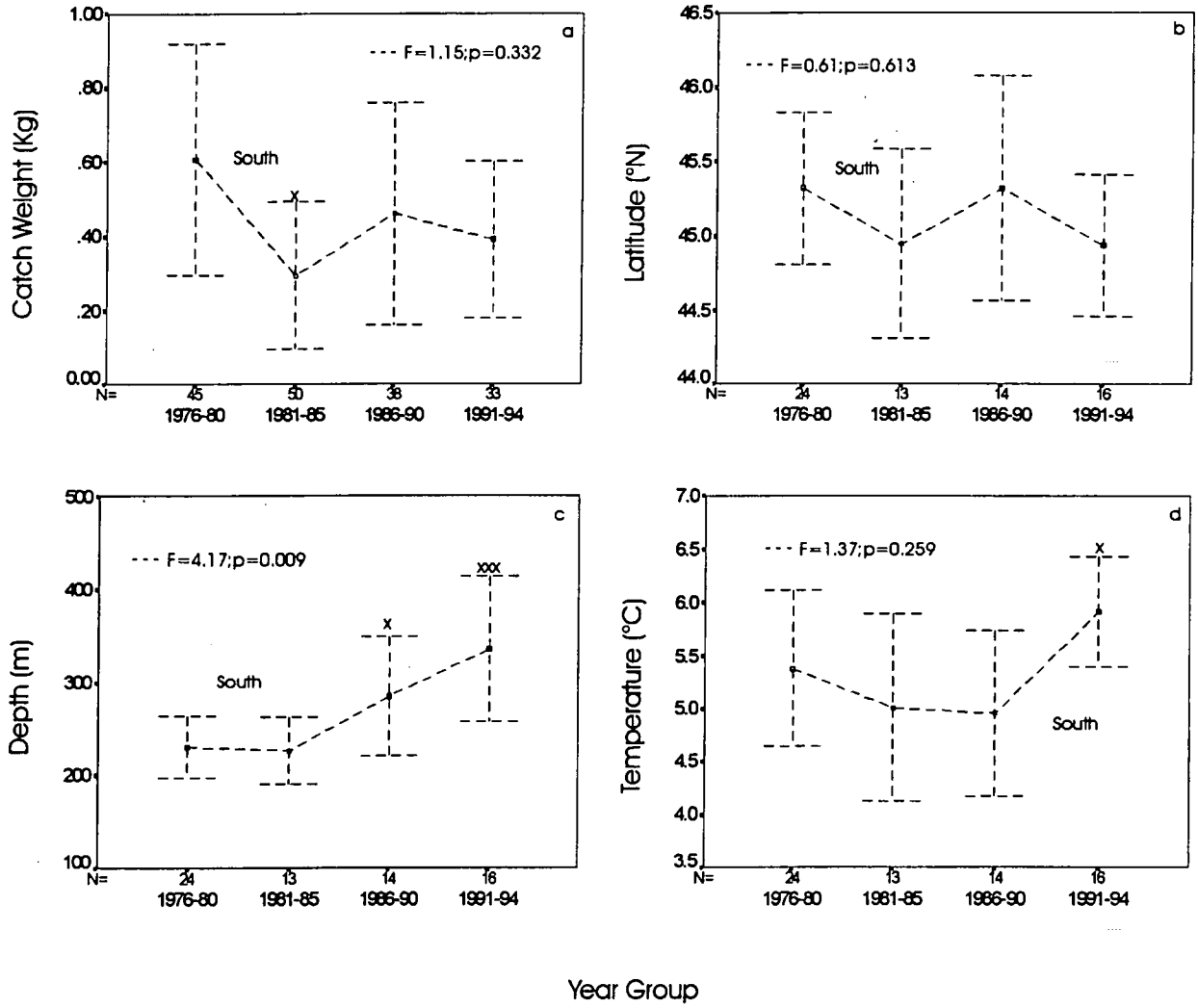

Fig. 15 Common Monkfish 1976-1994. Data are averaged (±95% CI) over trips in each of 4 year groupings for latitudes < 48°N (South). (Few fish occured at lat. >48°N). Overall ANOVA statistics are given. N = Sample size. Contrast analysis results (Ho: Mean = Previous mean) are reported (x: p <0.1; xx: p < 0.05; xxx: p < 0.01). (No size data are available).

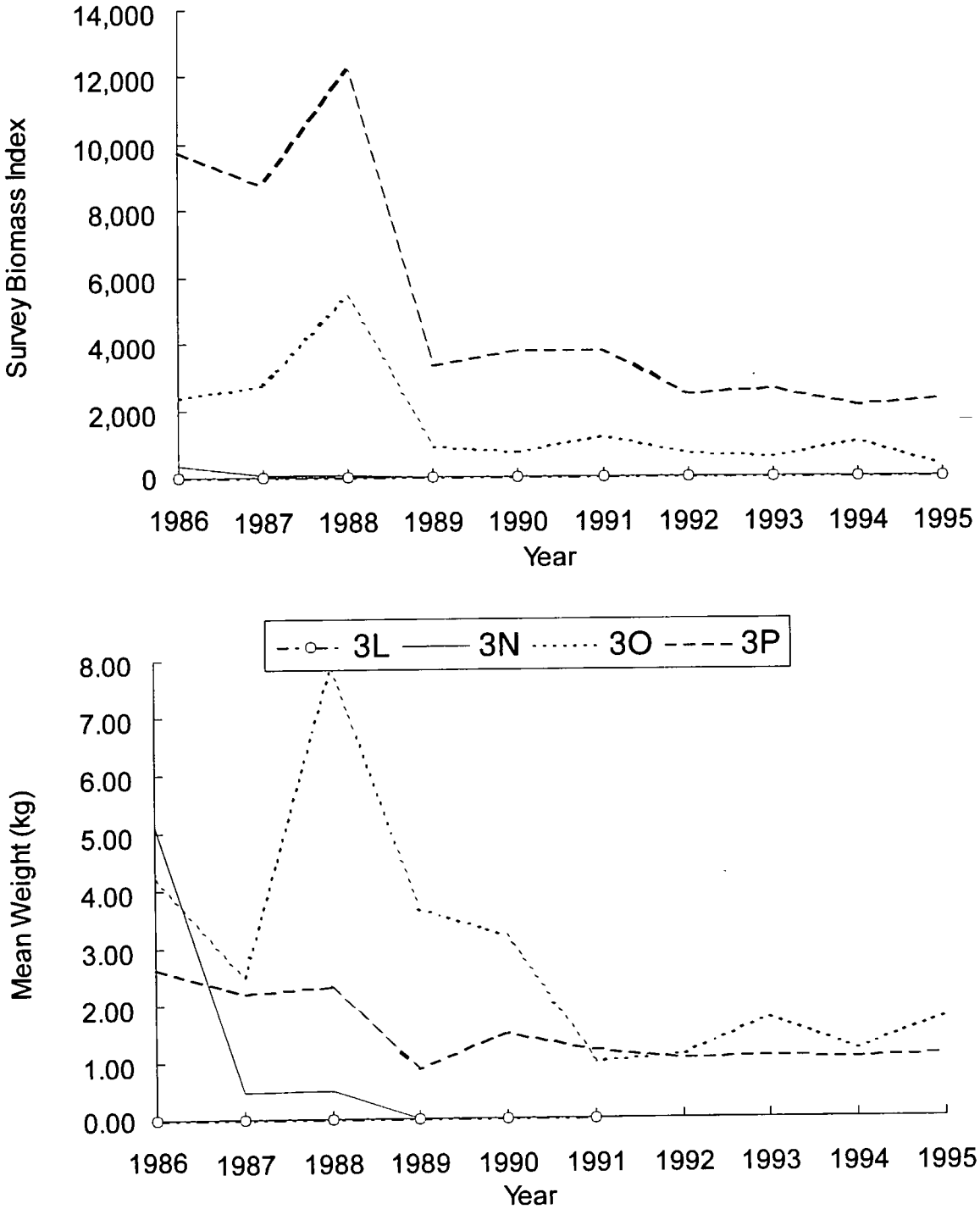

Figure 16 - Survey biomass index and mean weight per tow for white hake in NAFO Divisions 3L, 3N, 3O and 3P, 1986 to 1995.

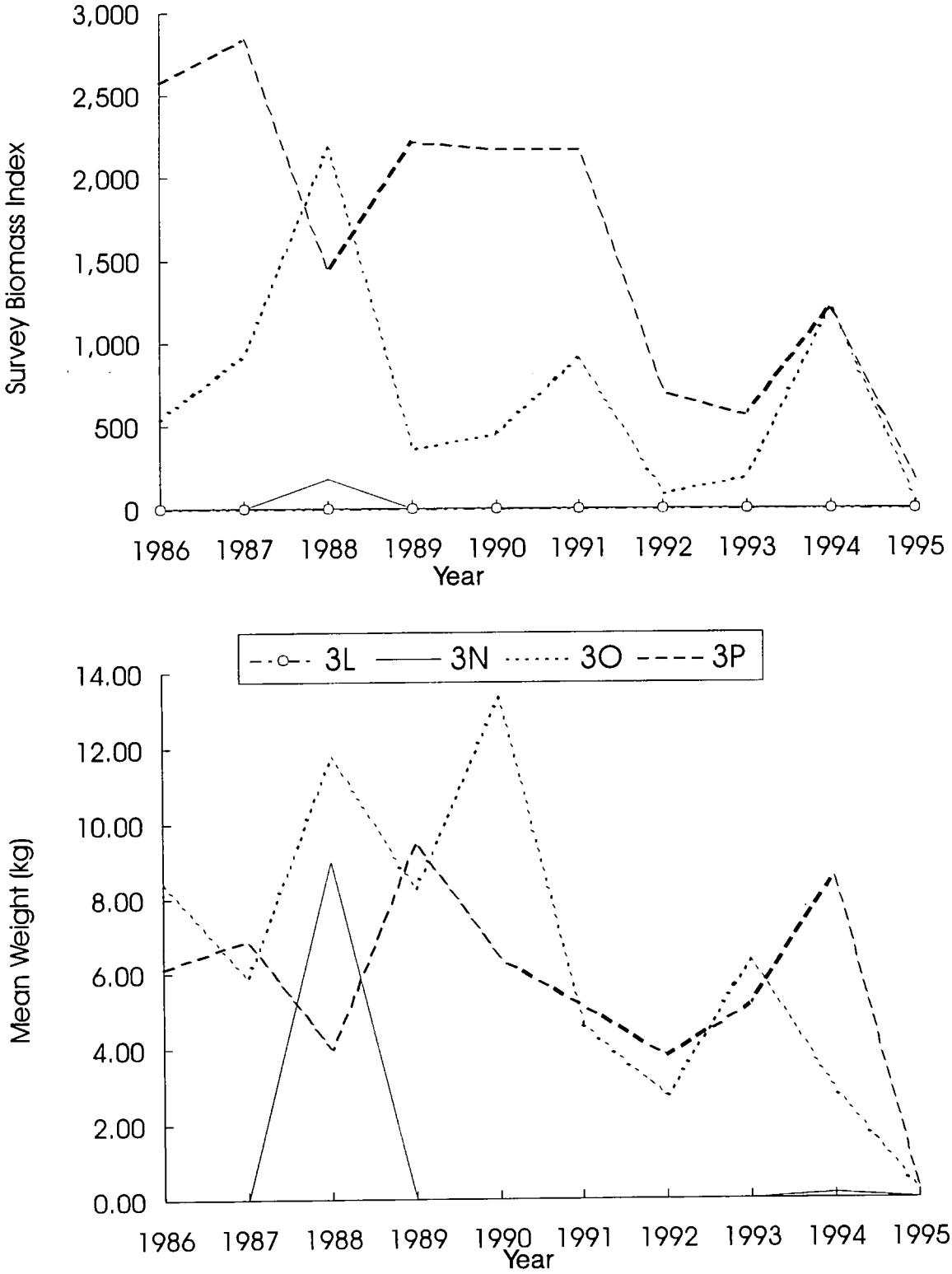

Figure 17 - Survey biomass index and mean weight per tow for monkfish in NAFO Divisions 3L, 3N, 3O and 3P, 1986 to 1995.

White Hake

	NAFO Division							
Year	**2J**	**3K**	**3L**	**3N**	**3O**	**3Pn**	**3Ps**	**Cdn. TAC**
87	0	0	7	8	78	85	648	
88	0	0	30	3	87	38	325	
89	1	0	13	3	90	19	335	
90	0	0	7	15	42	12	504	
91	0	0	41	1	213	43	1102	
92	0	0	26	5	458	39	955	
93	0	0	0	1	320	106	594	
94	0	0	0	0	6	281	169	
95	0	0	2	0	112	57	305	

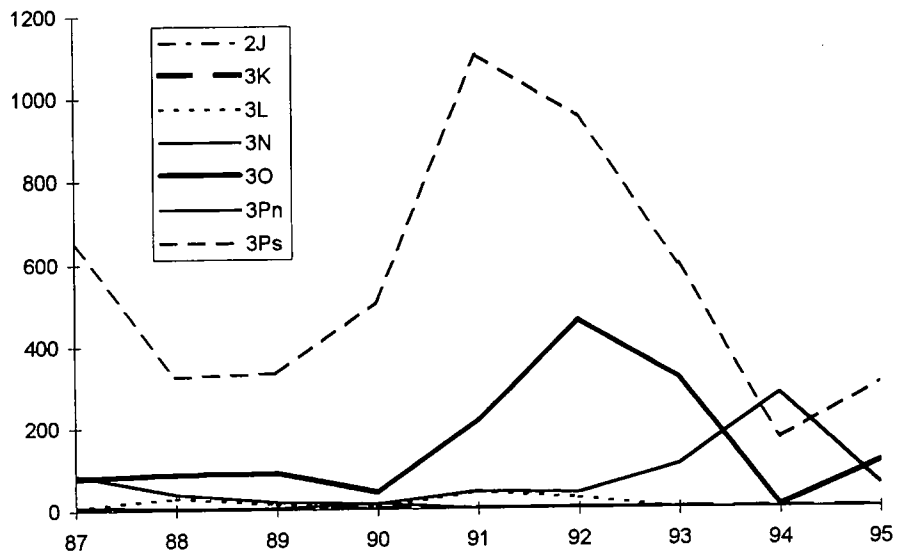

Figure 18 - Landings of white hake by NAFO Div., 1987-1995.

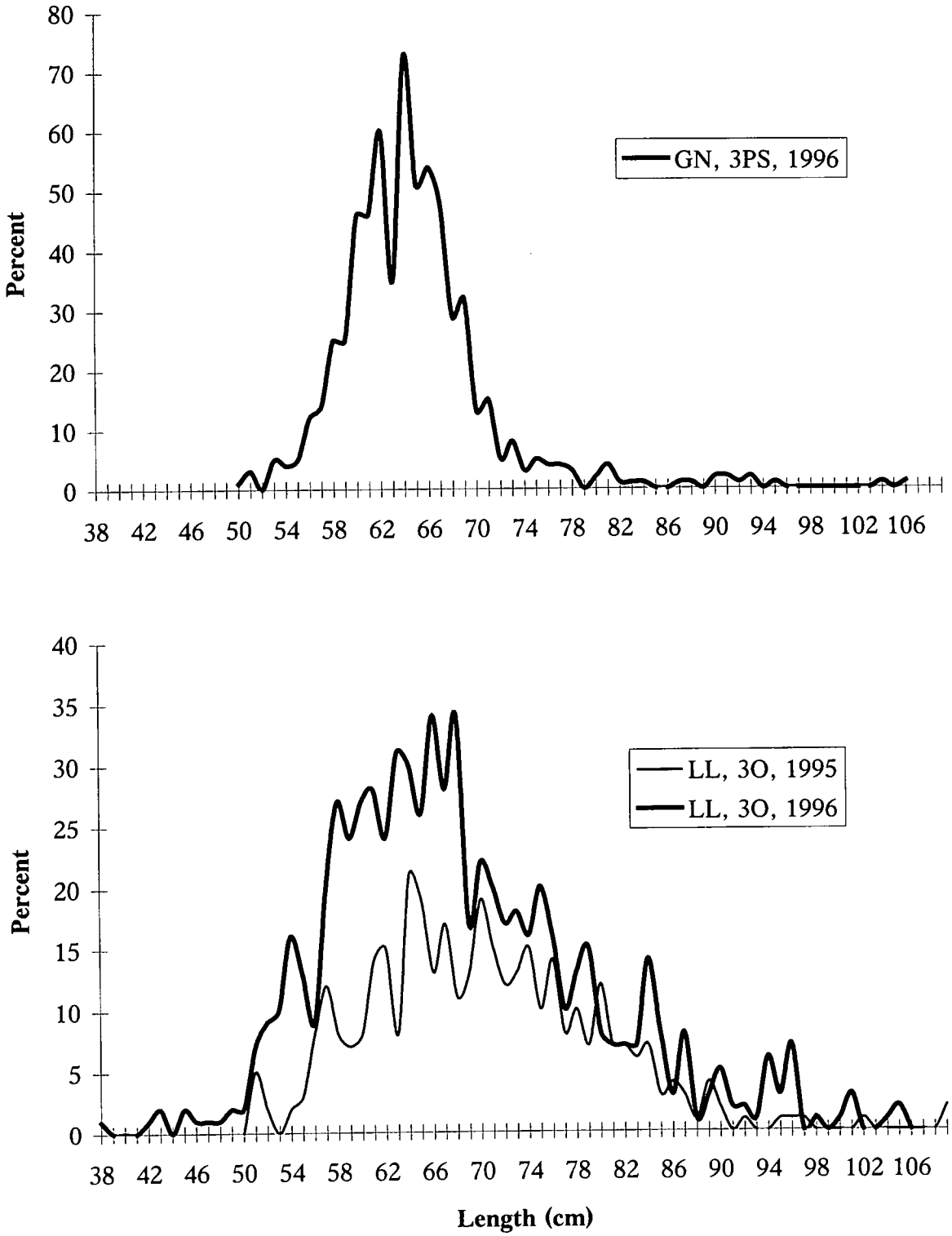

Figure 19 - Commercial length frequencies of white hake from longline (LL) and gillnet (GN) gears, 1995-96.

Monkfish

	NAFO Division							
Year	2H	3K	3L	3N	3O	3Pn	3Ps	Cdn. TAC
87	0	0	25	0	1	1	7	
88	0	0	1	0	0	0	5	
89	0	0	0	0	0	0	1	
90	0	0	0	0	3	0	0	
91	0	0	2	2	136	1	45	
92	0	0	4	0	244	1	86	
93	0	0	0	4	425	5	48	
94	3	0	0	0	441	3	383	
95	0	0	6	0	100	1	59	200 t

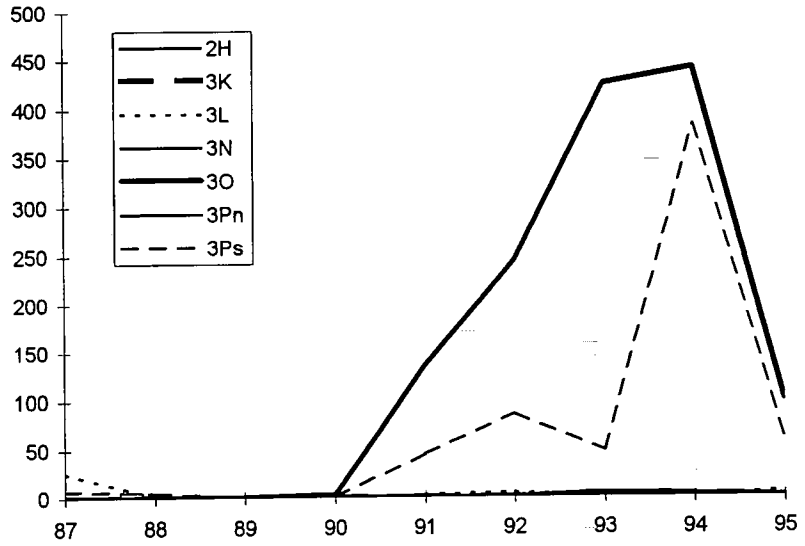

Figure 20 - Landings of monkfish by NAFO Div., 1987-1995.

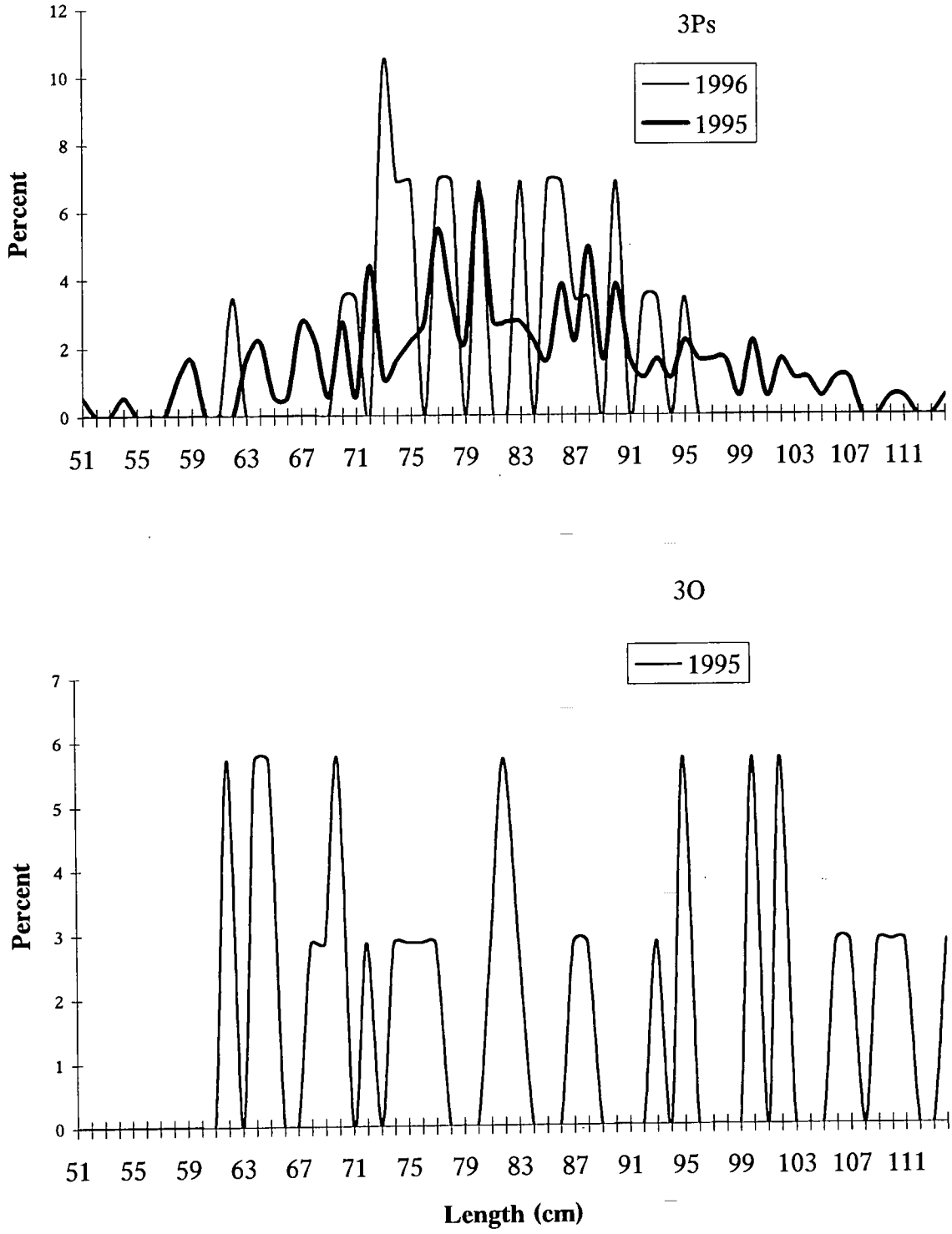

Figure 21 - Commercial length frequencies for monkfish, 1995-96

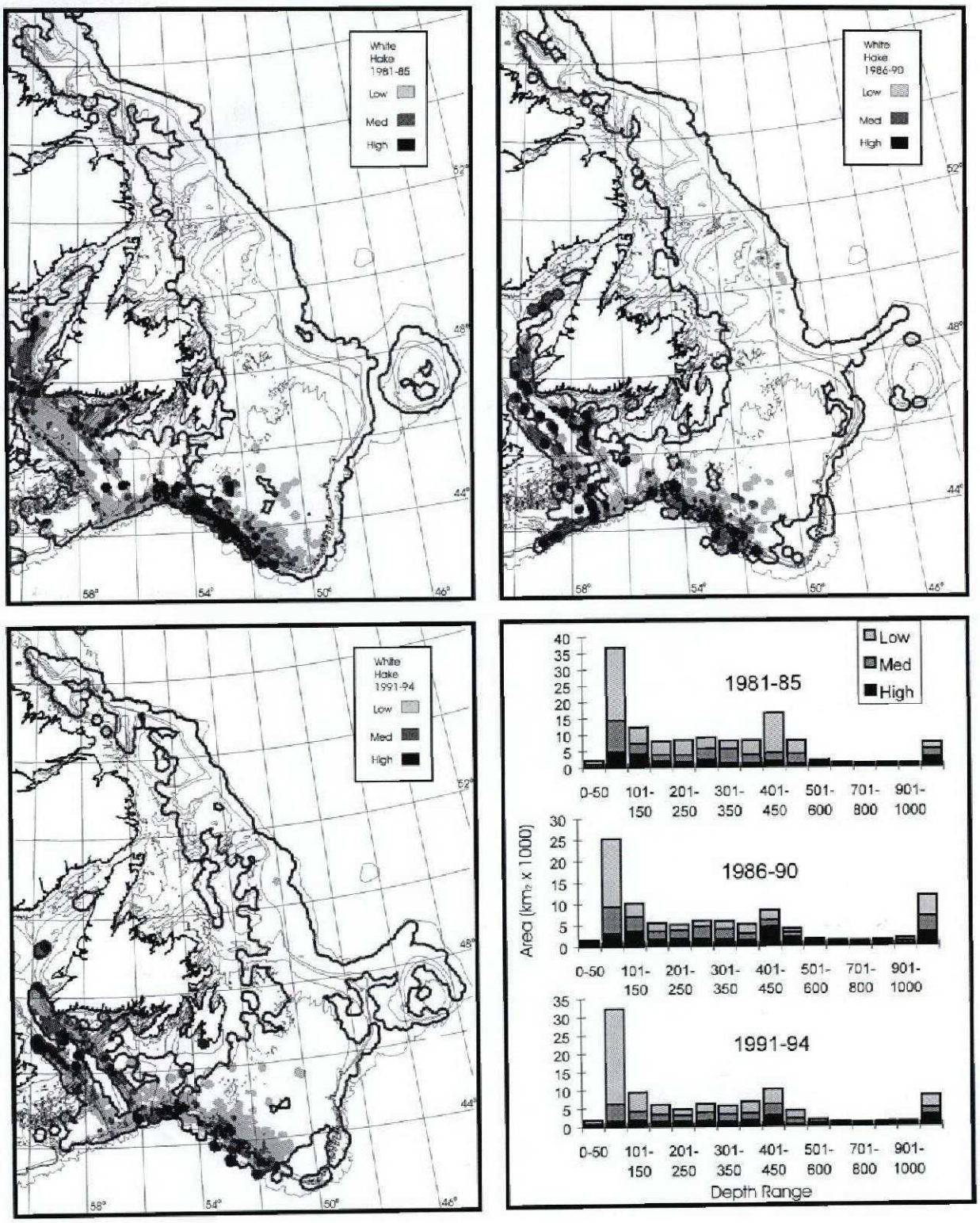

Figure 22 - White hake distribution from commercial fisheries, 1981 to 1994 where high = > 25.0, med =5.0 - 24.9 and low = <4.9 kg. per hour. The thick outline represents surveyed area.

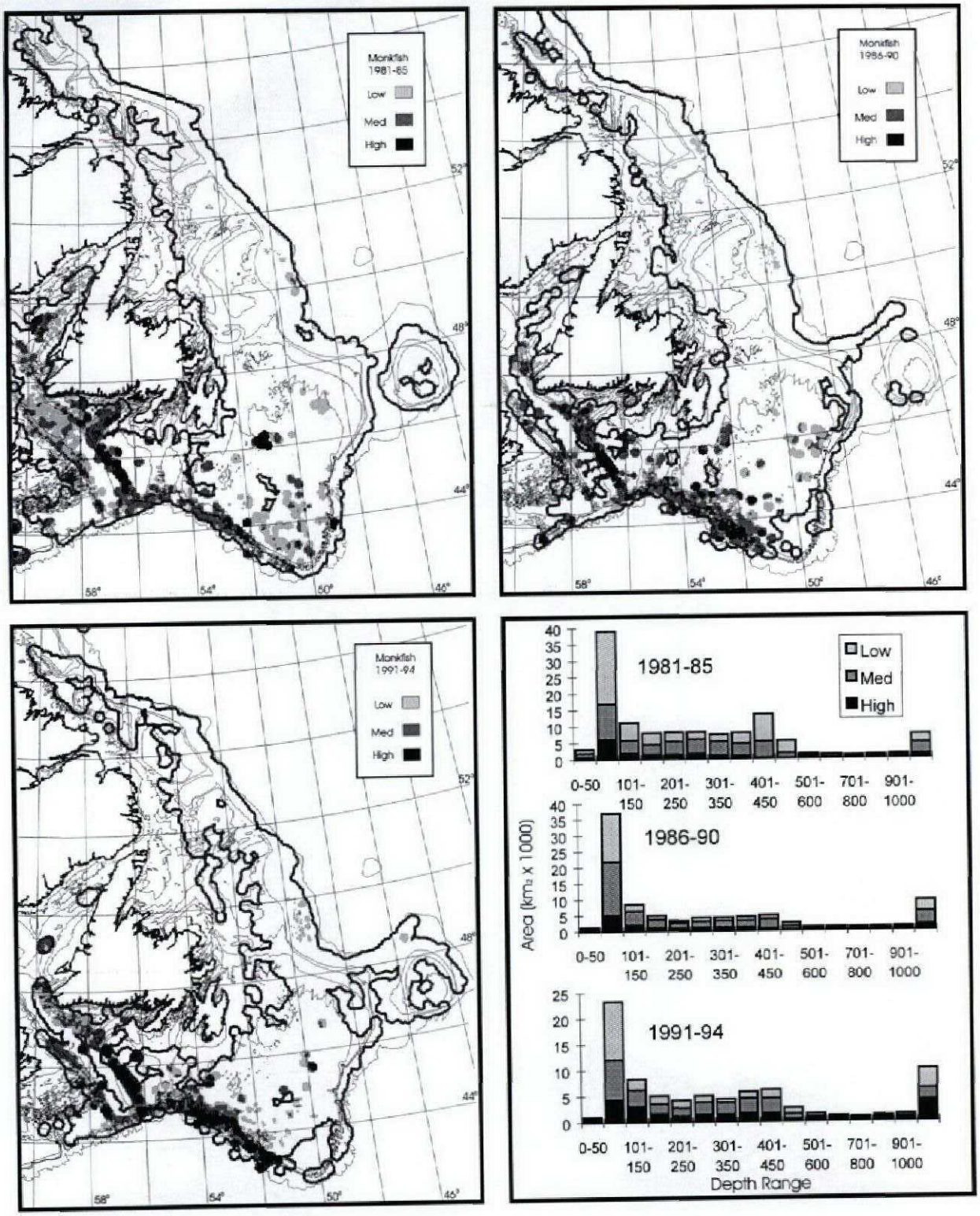

Figure 23 - Monkfish distribution from commercial fisheries, 1981 to 1994 where high = > 5.0, med = 1.0 - 4.9 and low = <0.9 kg. per hour. The thick outline represents surveyed area.

Blackback

	NAFO Division						
Year	2J	3K	3L	3N	3Pn	3Ps	Cdn. TAC
87	0	1603	604	0	4	219	
88	0	350	235	0	1	107	
89	0	250	136	0	2	88	
90	0	214	154	0	3	83	
91	0	438	378	0	30	92	
92	5	224	324	0	54	98	
93	0	183	364	0	18	275	
94	0	144	821	0	1	602	
95	0	134	663	0	0	240	

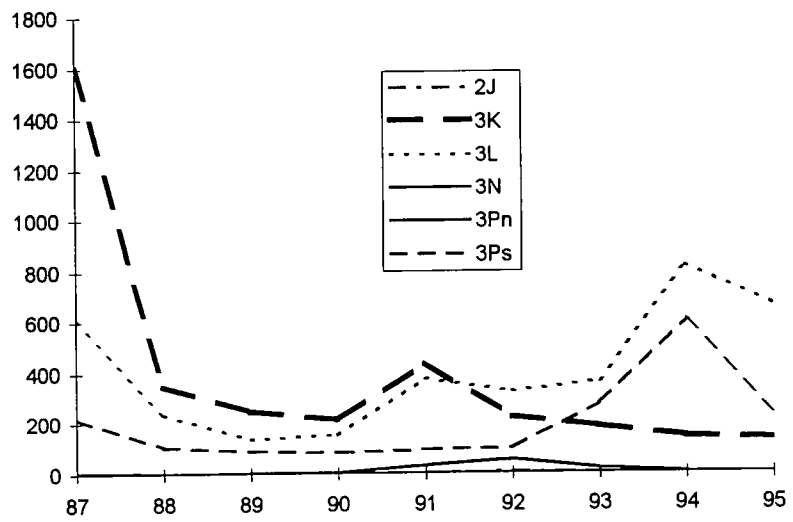

Figure 24 - Landings of monkfish by NAFO Div., 1987-1995.

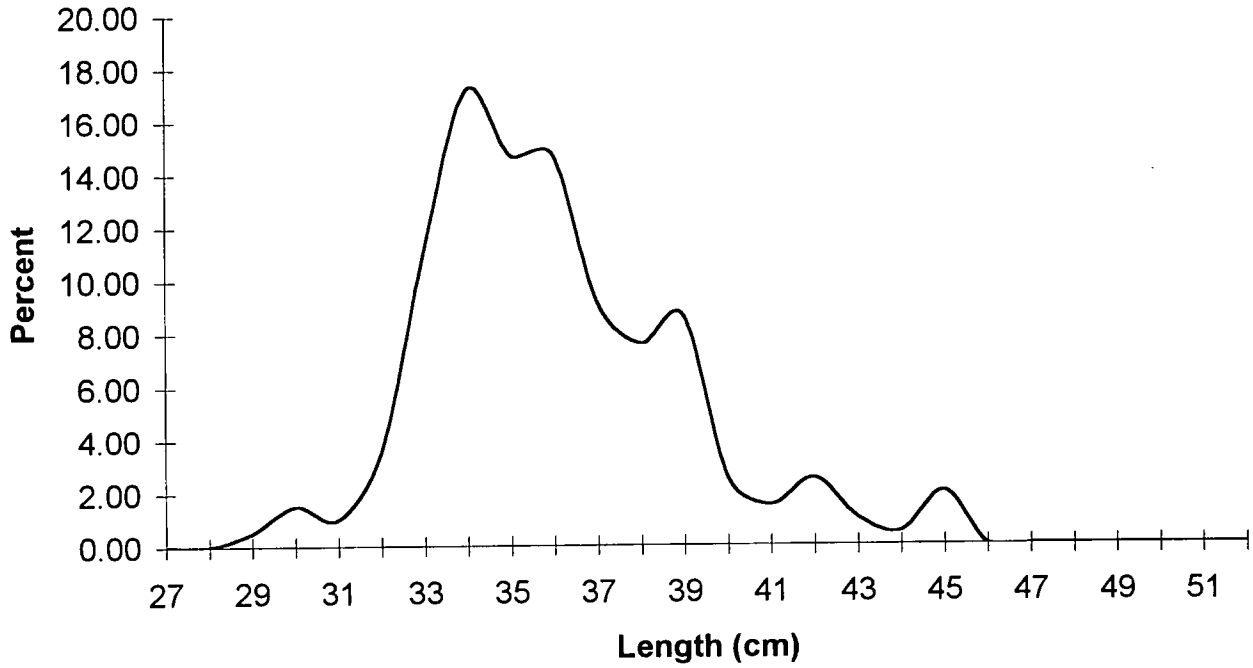

Figure 25 - Commercial length frequencies for blackback flounder, 1996.