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Depth-distribution of Deepwater Species in Flemish Pass

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Abstract

The depth distribution of the main deep sea fish species in Divisions 3LMN of the NAFO Regulatory Area is analysed using data from a longline survey carried out between 708 and 3 028 m depths in 1996. The results indicate that the most commercially important deep-sea species, Greenland halibut and roughhead grenadier, were only distributed up to 2 000 m depth. Below this depth another deep-sea species, the armed grenadier, replaced Greenland halibut and roughhead grenadier. The species which showed the widest depth distribution were blue antimora, smalleyed rabbitfish and skates (700 m to about 3 000 m). Two species, the roughhead grenadier and the blue antimora, made up more than 60% of the catch in weight. Depth was the factor which most influenced the distribution of the species, affecting both yield and mean length of the catch. Mean length of the catch increased with depth in the majority of species. The yield of all species combined increased with depth between 700 and 1 500 m, where it reached a mean yield of 536 kg per 1 430 hooks. Below this depth the yield diminished.

Key words: Deep distribution, deepwater fishery, Flemish Pass, Greenland halibut, roughhead grenadier

Introduction

The first records of the Greenland halibut, *Reinhardtius hippoglossoides*, fishery in the Arctic region of the Northwest Atlantic appeared in the early 1800s, although the commercial exploitation of this important fishery began in the 1960s when the exploratory fishing of the former Soviet Union discovered important concentrations of Greenland halibut inhabiting slope areas of the Northwest Atlantic (Bowering and Nedreaas, 2000). In this period, catches increased sharply from low levels to reach a peak of 36 000 tons in 1969, and ranged between 20 000 and 39 000 tons until 1990 (Anon., 2004).

In 1990, a deep water fishery targeting Greenland halibut was developed in the NAFO Regulatory Area (NRA[1]) (Junquera *el al*., MS 1992) and catches increased rapidly ranging between 47 000 and 63 000 tons during 1990–94 (Bowering and Nedreaas, 2000). The Fisheries Commission of NAFO introduced quota restrictions for this resource in 1995 and catches declined to around 20 000 tons in the period 1995–99. Catches increased again in 2000 to approximately 30 000 tons and have been kept at this level since.

This new deep water fleet began operating in the northern area of the Flemish Pass, but has gradually extended the area of activities toward the south, and now operates in practically the whole of the slope of the Regulatory Area between 800 and 1 800 m depth (de Cárdenas *et al*., MS 1996; Gónzalez *et al*., MS 2004).

From 1990 to February 1995 most of the vessels involved in this fishery had a scientific observer on board to obtain biological samples in order to monitor this new deep water fishery. The observer data showed that the main species of commercial interest in the trawl catch up to 1 800 m depth were Greenland halibut, roughhead grenadier (*Macrourus berglax*), skates (*Raja* spp.) and American plaice (*Hippoglossoides platessoides*).

At 1 800 m, the depth limit of the fleet, Greenland halibut and roughhead grenadier still appeared in the catch, although they were mainly immature specimens. Little data were available from surveys below 1 500 m depth, and information regarding depth distribution of species or the location of spawners was limited (Anon., 2004). A lack of data from greater depths had hindered the assessment of these stocks during the past years.

[1] Defined by NAFO as "*the part of the NAFO Convention Area which lies beyond the areas in which Coastal States exercise YKHULHVMXLVGLFWLRQ*

The aim of this study was to determine the depth distribution of Greenland halibut and the main accompanying species in the fishery, and to analyze the trend of yield and mean length with respect to depth. The objective was not only to study the depth-distribution of each species but also to investigate the influence of different baits in the catch of the survey and the length-weight relationships of the different species.

Material and Methods

The survey was carried out aboard the Norwegian longliner "*Skarheim*", a vessel of 246 tons gross registered tonnage and 1 000 horse power, between 16 April and 5 May 1996. In the survey a total of 64 hauls were performed in the Div. 3L, 3M and 3N of the NAFO Regulatory Area between latitudes of 43º and 48ºN, at depths ranging from 708 to 3 028 m (Fig. 1). Hauls were performed following transects with a depth interval of 300 m.

The gear used was an automatically baited longline equipped with 1 430 hooks (#4 Mustad) baited with squid (*Loligo* spp.). Squid was used since it was thought that this bait would remain on the hook in better condition for a long time at great depth. The longlines remained in the

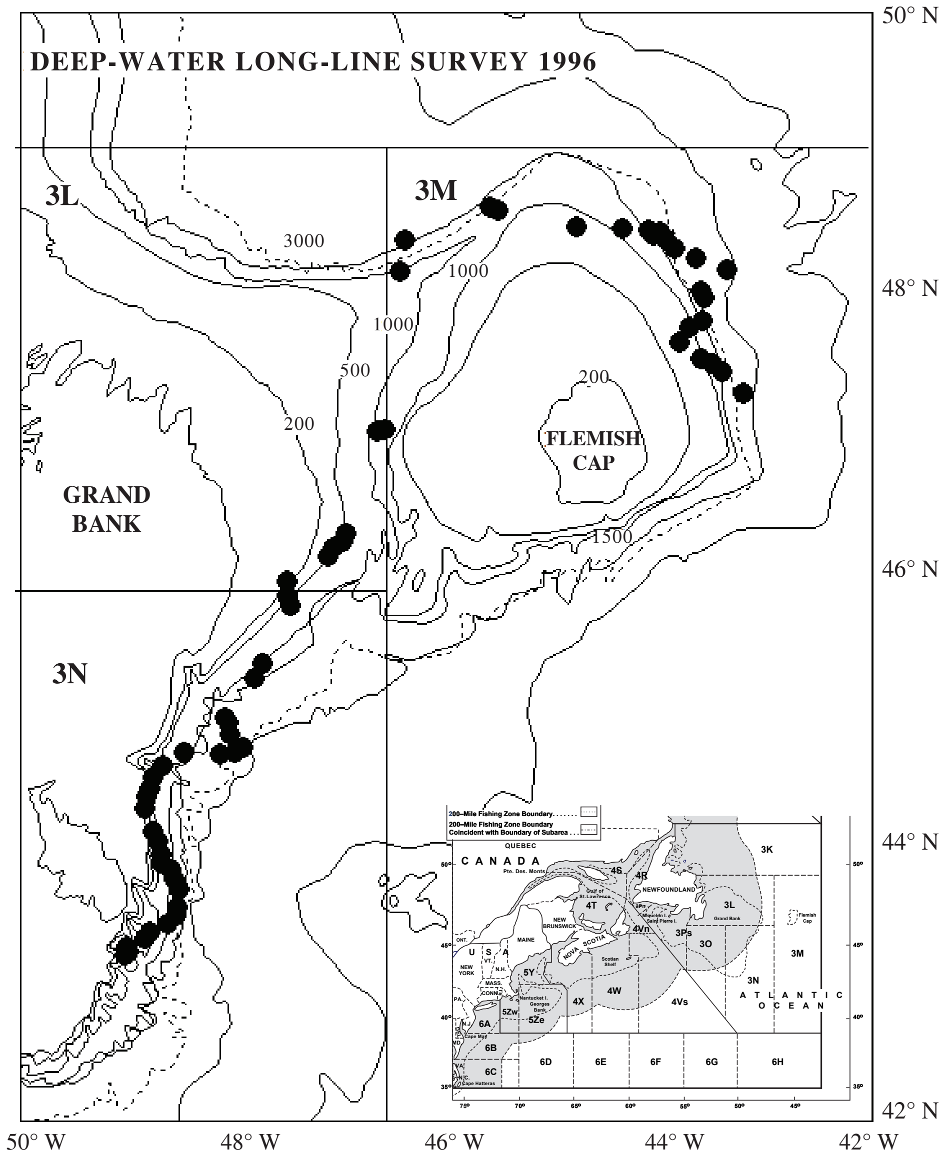

Fig. 1. Area surveyed and location of hauls.

water for a mean of 6 hours and 42 min, although this time varied between 2 hr and 33 min and 15 hr and 17 min.

In each of the hauls the catch was separated by species. The skates were identified by species but when this was not possible they were included in the 'skate spp.' category. Total length to the lower cm was measured and the sex identified for each individual. A length stratified subsample was taken to carry out biological sampling of the main species, for which weight (g) and gonad weight (g) were measured. The total length and total weight relationship were determined by fitting the data to a power relationship in the form of: $W = aL^b$ for sexes combined, where W is the weight (g), L is the total length (cm), and a and b the coefficients to be estimated.

Cluster analysis was used with the aim of categorizing hauls into homogeneous groups that accounted for differences in depth, NAFO Division, latitude and duration of haul. The yields per haul of the seven main species of the catch, excluding skates which were not taken into account as they constituted a heterogeneous group made up of at least four different species, were used to carry out the cluster analysis. The hierarchical cluster procedure was carried out using Euclidean metric distances between stations as a dissimilarity index (Sokal and Rohlf, 1981) and the aggregation algorithm applied was the Unweighted Pair-group Average Method (Sneath and Sokal, 1973). This method was also used to obtain the association between the seven species considering the 60 valid stations as variables.

The log transformed yields, expressed in kg per 1 430 hooks, and mean lengths were compared by means of non parametric Kruskal Wallis tests, because the distributions did not fulfill the normality condition (verified through the Kolmogorov-Smirnov test) nor homogeneity of variance (verified through the Cochran C and Bartlett – Box F tests) necessary to the application of a parametric test such as ANOVA.

The effect of the different baits on the catch was studied from two hauls (one in the 700–1 000 m depth range and other in the 1 000–1 300 m range) in which the number of hooks was doubled; the first 1 430 hooks were baited with squid and the other 1 430 with mackerel (*Scomber* spp.). The mean lengths of catches and yields were compared by means of Kruskal Wallis tests.

The duration of the haul could not be kept constant due mainly to two reasons. The main factor affecting haul duration was the time spent searching for the marker buoy (in some cases this time was considerably longer due to fog). The second, less important factor was the depth of the station, with the shallowest hauls being slightly shorter in duration.

Results

The 64 hauls carried out were distributed throughout NAFO Div. 3L, 3M and 3N (Fig. 1). Four of these hauls were lost when the rope connecting the longline to the surface broke (Table 1). Hauls in Div. 3L were not made beyond 1 360 m depth since in this Division work was

TABLE 1. Distribution of hauls by strata and Divisions in the NAFO Regulatory Area.

	No. of hauls				
Depth Strata	Div. 3L	Div. 3M	Div. 3N	Total	Lost
700–999	3	3	5	11	
1 000–1 299	5	4	3	12	
1 300–1 599	1	3	4	8	
1 600–1 899		2	6	8	
1 900–2 199		1	2	3	
2 200–2 499		3	4	7	2
2 500–2 799		3	2	5	
2 800–3 100		5	5	10	2
Total	**9**	**24**	**31**	**64**	**4**
Lost		4		4	

only carried out in the Flemish Pass, which is the area between the Flemish Cap and the Grand Banks with a maximum depth of 1 360 m.

The catch in weight and the length-weight relationship of the main species caught in the survey are presented in Table 2. Two species, roughhead grenadier and blue antimora (*Antimora rostrata*), made up more than 60% of the catch in weight, and roughhead grenadier alone was more than 33% of the total catch in weight even though this species was only caught at less than 2 000 m. With regard to Divisions, the catch percentage in Div. 3M was similar to the overall average of 60% given above, but the percentage of different species caught was much different in Div. 3L and 3N. In Div. 3L roughhead grenadier made up 70% of the catch, blackdogfish (*Centroscyllium fabricii*) was more common in comparison to the other Divisions 3M and 3N, and blue antimora, smalleyed rabbitfish (Hydrolagus affinis) and skates appeared much less frequently. In Div. 3N the percentage of blue antimora was the highest (39%) and the presence of roughhead grenadier dropped to 20%. The percentage of Greenland halibut in the catches was around 5% in all Divisions.

When studying the association between hauls, the cluster analysis showed that the stations are best grouped by depth. The NAFO Division, the duration of the haul and latitude appeared mixed in the different clusters (Fig. 2). Two clearly differentiated clusters appeared, the first group (1) presented a sub-group in which all stations of less than 800 m depths (1A) were concentrated, and all stations of more than 2 000 m depth, with the exception of one, were clustered in another sub-group (1B). The second group can also be separated into two sub-groups, one including stations of depths between 800 and 1 150 m (2A), and the other (2B) containing stations between the depths of 1 150 m and 2 000 m (with an apparent discontinuity at around 1 500 m). In the first group (1), the level of mixture of stations was less than in the second group, since only one station was found to be out of place (the station of 1 831 m was found in the >2 000 m group).

The total mean catch per haul increased with depth between 700 and 1 500 m, where it reached a mean yield of 536 kg per 1 430 hooks. Below this depth the yield diminished (Fig. 3).

The catches in stations at depths of less than 800 m showed very poor yields and were clearly dominated by Greenland halibut, followed in importance by the skates (Fig. 4). The yield at stations between 800 and 1 150 m increased greatly compared with the group at less than 800 m, and roughhead grenadier dominated the catches. The stations at depths between 1 150 and 1 500 m presented mean yields about double those of the group between 800 and 1 150 m. The catch in these stations appeared to be dominated by roughhead grenadier and blue antimora, whereas Greenland halibut made up 11% of the catch (Fig. 4). Between 1 500 and 2 000 m depth, the yields were still high and catches were dominated by blue antimora followed by smalleyed rabbitfish. At stations greater than 2 000 m depth, yields declined by around 50% (2 000–2 500 m) and 65 % (>2 500 m) with respect to the group between 1 500 and 2 000. At 2 000 m depth, Greenland halibut and roughhead grenadier were no longer in the catch and were replaced by the armed grenadier (*Nematonurus armatus*). This species became dominant in catches below the 2 000 m depth (Fig. 4).

TABLE 2. Catch composition of each species in weight and (*a*) and (*b*) parameters of the length-weight relationships, expressed as $W = a\ L^b$.

		% Catch				Length weight relationship			
Scientific name	Common name	All	Div. 3M	Div. 3N	Div. 3L	*a*	*b*	R^2	No.
Macrourus berglax	Roughhead grenadier	33.9	33.3	20.6	69.7	0.00135	3.3412	97.0%	274
Antimora rostrata	Blue antimora	27.9	24.4	39.2	9.0	0.00139	3.4534	95.8%	255
Hydrolagus affinis	Smalleyed rabbitfish	12.2	15.5	12.1	2.9	0.00297	3.1492	95.3%	205
Raja spp.	Skates	6.2	3.6	10.7	2.5	0.01111	2.9471	90.3%	230
Nematonurus armatus	Armed grenadier	8.4	11.2	8.5	0.0	0.00245	3.1514	91.0%	300
Reinhardtius hippoglossoides	Greenland halibut	5.2	5.5	4.7	5.5	0.00116	3.5120	98.1%	181
Centroscyllium fabricii	Black dogfish	4.8	5.0	3.2	8.2	0.00335	3.1106	99.0%	175
Anarhichas denticulatus	Wolfish	0.7	1.0	0.2	1.3	0.01963	2.8590	97.5%	28
Others		0.7	0.6	0.8	0.8				
Total		1.00	1.00	1.00	1.00				

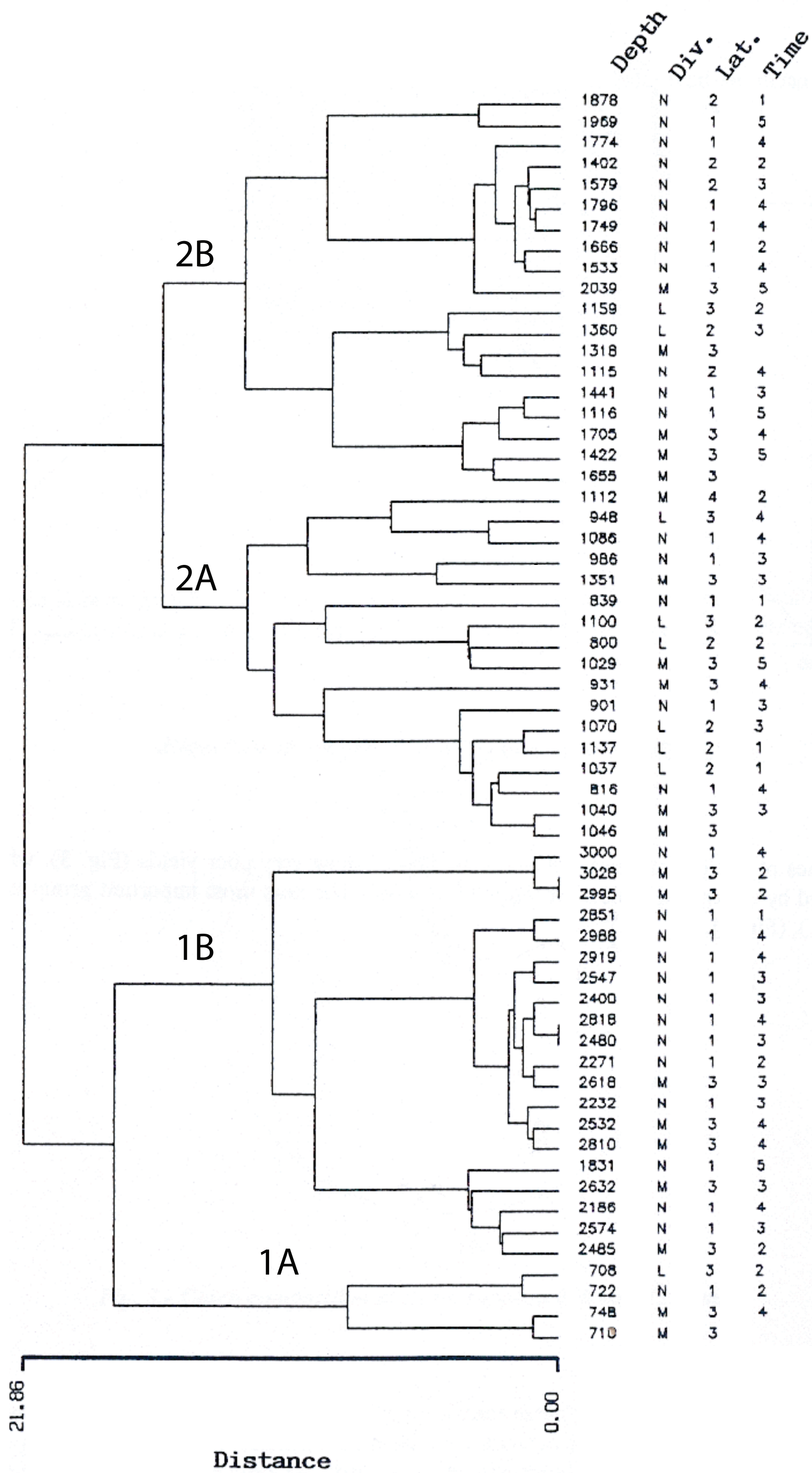

Fig. 2. Average linkage dendogram of the stations using Euclidean Distance. To analyze the infuence of different parameters on the yields of species, 5 categories were established for duration (<199 min, 200–299, 300–399, 400–499 and >500 min), 24 classes for depth (every 100 m between 700 and 3 000 m), 4 classes for latitude (one every 100 miles North between 43°30' and 48°30'N) and 3 classes for statistical Division (3L, 3M and 3N).

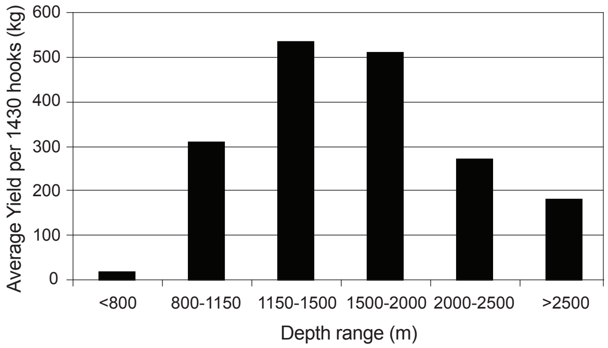

Fig. 3. Average total yields (kg) per 1 430 hooks haul with respect to depth.

Blue antimora, smalleyed rabbitfish and skates presented the widest depth distributions, whereas black dogfsh, Greenland halibut, roughhead grenadier, thorny skate (*Raja radiata*), smooth skate (*Malacoraja senta*), Spinytail (*Bathyraja spinicauda*) and armed grenadier showed more limited depth distributions (Fig. 5). Within the species showing the greatest depth range, blue antimora appeared in all depths (from 700 m to 3 000 m), whereas the skate species (700–2 800 m) and smalleyed rabbitfish (1 000–2 800 m) showed a somewhat more restricted depth distribution. With regard to species with a narrower depth-range, Greenland halibut and roughhead grenadier appeared from 700 m to 2 000 m,

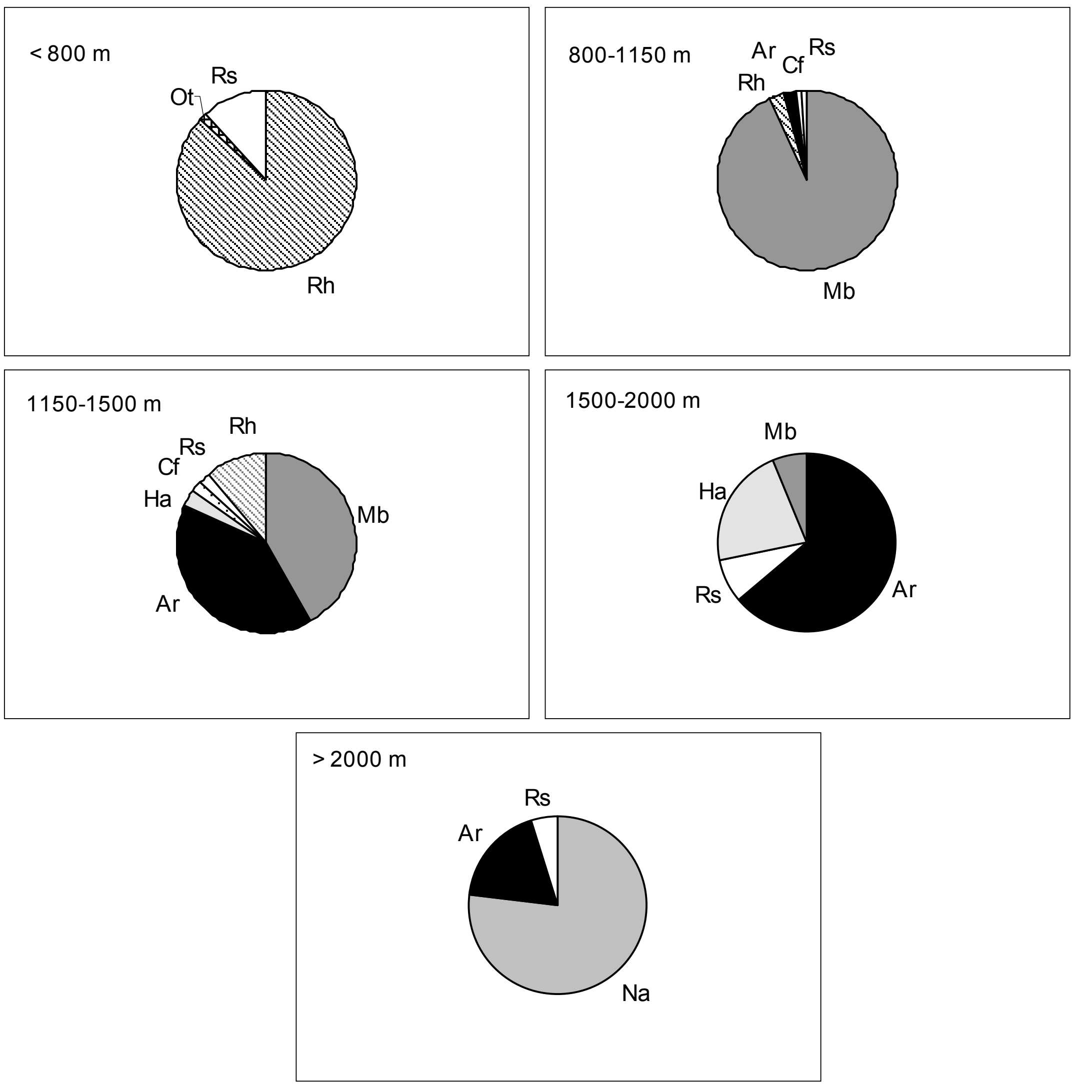

Fig. 4. Catch composition as percentage at different depths: at depth less than 800 m, between 800 and 1 150 m, between 1 150 and 1 500 m, between 1 500 and 2 000 m, and at depth over 2 000 m Rh: Greenland halibut; Mb: roughhead grenadier; Rs: skates; Ar: blue antimora; Cf: black dogfsh; Na: armed grenadier; Ha: smalleyed rabbitfsh; Ot: others.

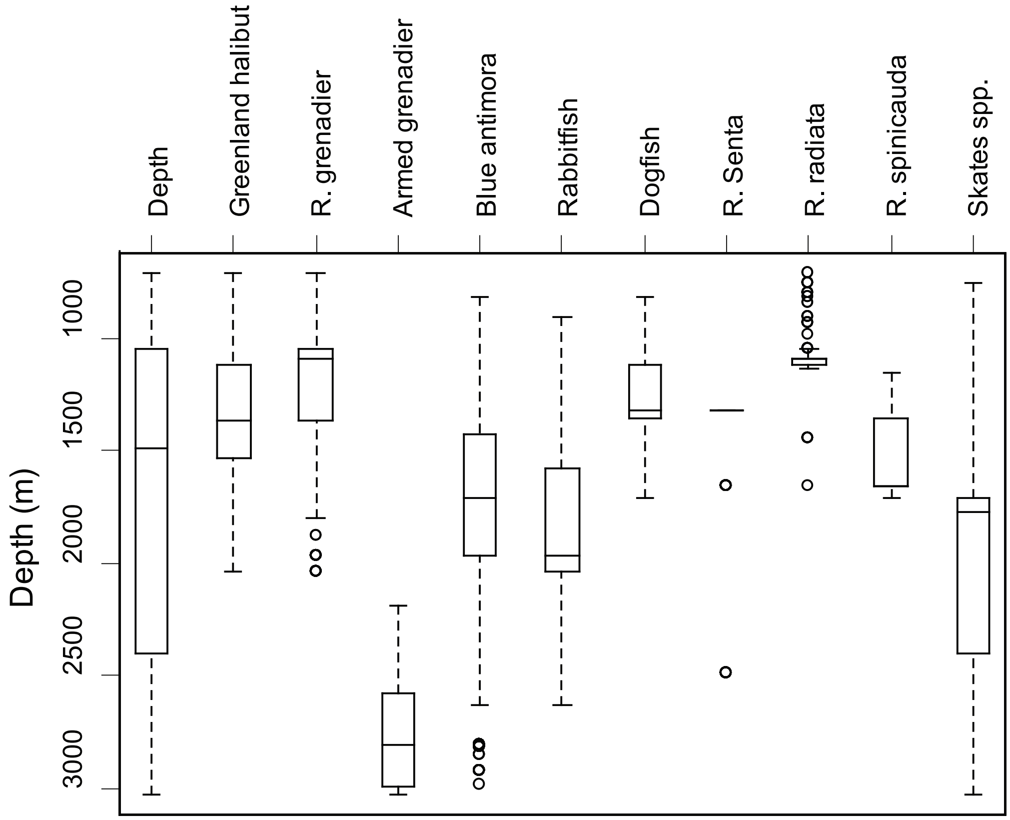

Fig. 5. Box and Whisker plot of depth distribution of different species caught in the deep water longline survey in NAFO Div. 3LMN.

while armed grenadier occurred only below 2 000 m (2 000–3 000 m).

Accordingly, the cluster analysis with respect to species showed that the stronger association was between Greenland halibut and roughhead grenadier, and this group was found near that of the species of limited depth distribution such as Northern wolffish (*Anarhichas denticulatus*) and the black dogfish. At somewhat greater distance was found the group made up of smalleyed rabbitfish and blue antimora which belonged to the group of widest depth-distribution. The armed grenadier, which had a narrow and deepest depth-distribution, was clearly separated from the rest of the species (Fig. 6).

Kruskal Wallis non parametric tests used to compare yield by depth, duration of haul, latitude and NAFO Division showed that depth significantly influences the yields of all species, with the exception of the skate species (P = 0.06), but the latitude, duration of the haul and NAFO Division (comparing depths <1 360 m) were found to have no significant effect on the yields of any of the species (Table 3).

The results of the Kruskal Wallis non parametric tests of mean length with respect to depth, duration of haul, latitude and NAFO Division indicated that both depth and duration had a significant effect on the mean length of the catch of all species, whereas latitude and NAFO Division (comparing depths <1 360 m) did not (Table 3).

The yields of Greenland halibut increased between 700 and 1 600 m and then decreased, declining greatly at a depth range of 1 900–2 200 m. No Greenland halibut were caught at depths over 2 000 m. Mean lengths increased between 700 and 1 600 m, and then stabilized at around 78 cm (Fig. 7). The mean length of the catch in the survey was 66.47 cm and the percentage of females was 91.8%. The yields of roughhead grenadier rose between 700 and 1 300 m where they reached a maximum. The yield then began to decrease slightly down to the depth range of 1 900–2 200 m and were no longer in the catch at around

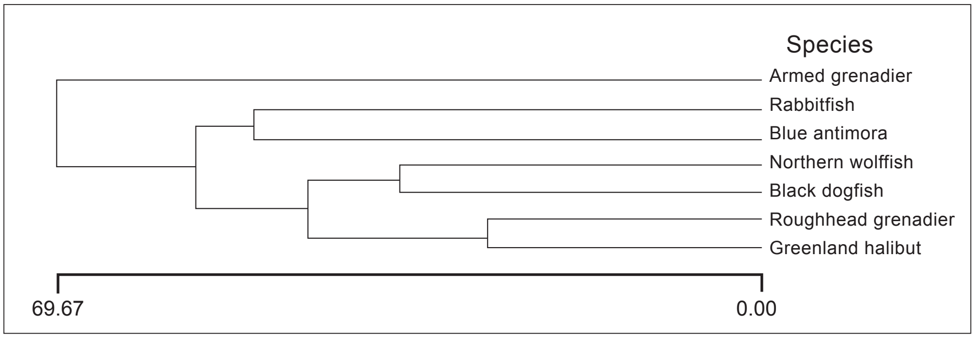

Fig. 6. Average linkage dendogram with respect to species using Euclidean Distance.

TABLE 3. Kruskal Wallis test comparing the yields and mean length with respect to depth, latitude, NAFO Division and duration of the haul. For latitude and NAFO Division analysis only hauls of depths <1 360 m were considered. (* denotes statistical significance differences, *P* <0.05; NS = no significant differences).

	Yield				Mean Length			
Species	Depth (m)	Latitude	Time	NAFO Divisions	Depth (m)	Latitude	Time	NAFO Divisions
Greenland halibut	*	NS	NS	NS	*	NS	*	NS
Roundnose grenadier	*	NS	NS	NS	*	NS	*	NS
Blue antimora	*	NS	NS	NS	*	NS	*	NS
Armed grenadier	*	NS	NS	NS	*	NS	*	NS
Rabbitfish	*	NS	NS	NS	*	NS	*	NS
Black dogfish	*	NS	NS	NS	*	NS	*	NS
Skates	NS	NS	NS	NS	*	NS	*	NS

2 000 m. Mean lengths presented an increasing trend with depth and the mean length of the catch was 54.39 cm, 71.4% of them being females.

The blue antimora was the species which showed the widest depth-distribution, from 800 m to approximately 3 000 m. Its yield increased with depth between 700 and 1 900 m and decreased continuously thereafter. Mean length of catches increased between 700 and 1 600 m before becoming stable at around 50 cm.

The armed grenadier appeared in the catches for the first time in the depth range 1 600–1 900 m at around 1 800 m, but only few specimens were present at that depth. The species was abundant in all hauls of more than 2 200 m and its yield increased with depth below 2 200 m. Contrary to what was observed in most other species, mean length of the catch presented a slight decreasing trend with depth (Fig. 7). The mean length of the catch was 50.25 cm.

Thorny skate, smooth skate and spinytail were distributed between 700 and 1 600 m. The skate species appeared at between 700 and 3 000 m depth, with a maximum yield around the depth range 1 600–1 900 m. Neither the mean length nor the yield followed a clear pattern; this could be due to different species being grouped in this class. The smalleyed rabbitfish began to appear at 1 000–1 300 m depth range and its yield increased with depth up to the range of 1 900–2 200 m. Beyond this depth range the yield fell drastically and the species was no longer present in the catch at 2 800 m depth. Mean lengths did not present a clear trend with depth (mean length of 109.62 cm).

The duration of the haul also produced significant differences in mean lengths of the catches of all species (Table 3). The mean length showed an increasing trend as the duration of the haul increased. This trend was very clear in species such as blue antimora and armed grenadier, and less clear although still present in Greenland halibut, roughhead grenadier and smalleyed rabbitfish. In the case of black dogfish no such a trend was observed.

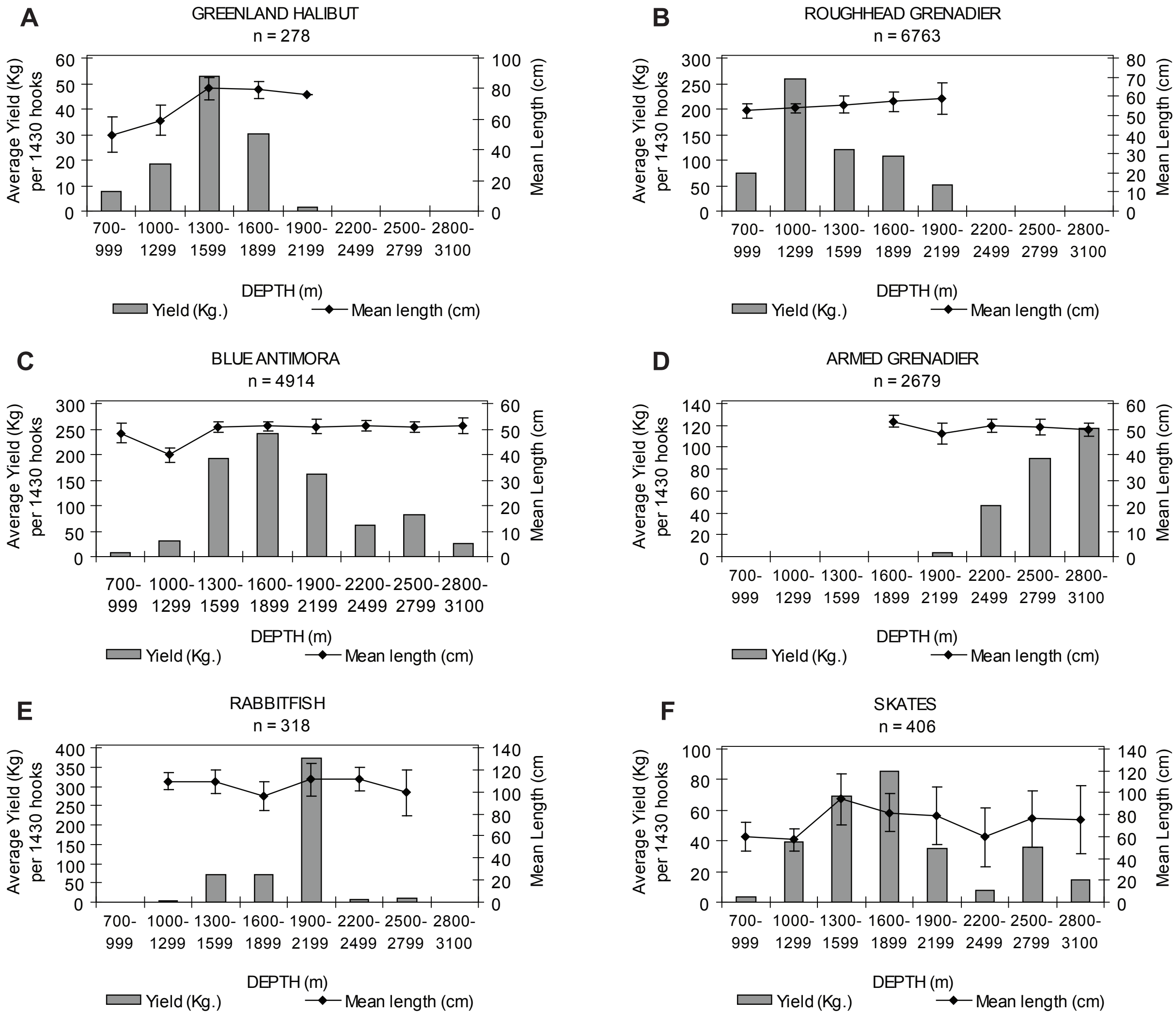

Fig. 7. Evolution of mean length and yield (kg per 1 430 hooks) by depth for the different species: (**A**) Greenland halibut, (**B**) Roughhead grenadier, (**C**) Blue antimora, (**D**) Armed grenadier, (**E**) Smalleyed rabbitfish and (**F**) skates.

The only two species which were caught in sufficient numbers to be able to study the effect of different baits in the catch were roughhead grenadier and blue antimora. The mean length in the catch of both species increased significantly with the use of mackerel as bait. This increase in mean length coincided with a decrease in the yields of both species, although this decrease was not significant according to the Kruskal Wallis test (Table 4).

Discussion

Our results demonstrated that depth was the factor which most influenced the distribution of the species, affecting both yields and mean lengths of the catch. This was also observed in the literature for other species (Gage and Tyler, 1991; Morales-Nin *et al*., 2003). In particular, the increase in mean length by depth, i.e. movement to greater depths as they grow, in the NAFO area has been extensively reported for Greenland halibut (Templeman, 1973; Bowering and Chumakov, 1989; Jorgensen, 1997; Bowering and Nedreaas, 2000) and for roughhead grenadier (Atkinson and Power, MS 1987; Savvatimsky, 1989; Bowering *et al*., MS 1995; Murua 2003; Murua *et al*. 2006).

The duration of the haul was shown to have an influence on mean length but not on yields. The duration of the hauls were not kept constant, which in turn may have affected the results of the survey, especially those regarding mean length distribution by depth. However, the influence of depth on the duration of the haul was

TABLE 4. The effect of using different bait in the long-line (squid *vs* mackerel) on mean lengths and yields of catches of blue antimora and roughhead grenadier. (*denotes statistical significance differences, P <0.05).

	Blue antimora		Roughhead grenadier	
Bait	Mean length (cm)	Yield (kg)	Mean length (cm)	Yield (kg)
Squid	39.82 *	23	54.34 *	268
Mackerel	43.02 *	14	61.79 *	171

minimal and did not mask the result of the increase in mean length due to depth.

The depth distribution of the main commercial species, Greenland halibut and roughhead grenadier, in this survey extended from 700 (minimum depth surveyed) to 2 000 m. Other surveys carried out in the NAFO area, covering only up to 1 500 m in depth, showed that Greenland halibut and roughhead grenadier are distributed between 200 and 1 500 m (Bowering and Brodie, 1995; Bowering and Nedreaas, 2000 for Greenland halibut; Murua *et al*., 2006 for roughhead grenadier). The combined results of all of these studies would indicate that the depth range of these two species is 200 to 2 000 m. The commercial fleet is fishing down to 2 000 m (Vargas *et al*., MS 2004; Gónzalez *et al*., MS 2004) and, therefore, we can consider that the commercial feet is currently capable of fshing up to the depth distribution limit of Greenland halibut and roughhead grenadier.

The cluster analysis showed a drastic change in the catch composition at around 2 000 m depth. This isobath marks the disappearance of species such as Greenland halibut and roughhead grenadier, and the appearance of armed grenadier, a species which never co-occurred in the catch with the other two species. In the NAFO Regulatory Area, a pronounced halocline appears at around 2 000 m depth which separates a more saline, less oxygenated and colder North Atlantic Deep Water mass from a more superfcial water mass (Labrador Sea Water) (Clarke, 1984; Stein and Wegner, 1990). The deepest water possibly forms the habitat of the armed grenadier and its appearance marks the presence of this water mass. Greenland halibut and roughhead grenadier, on the other hand, would inhabit the less saline, warmer and more oxygenated water, and their disappearance, would mark the limit of this Labrador Sea Water mass. Other species, such as blue antimora, do not seem to be affected by this boundary.

At less than 800 m, catches appear to be dominated by Greenland halibut, which makes up 87% of the catch. Nevertheless, the total yield per haul at these depths was minimal, and consequently, the catch of Greenland halibut in absolute numbers was small. The highest Greenland halibut yields for longline were taken at depths between 1 300 and 1 600 m, and within this range the highest overall yields also occurred. The yields of Greenland halibut for trawl at those depths are lower (de Cárdenas *et al*., MS 1993) and are highest at depths between 500 and 1 200 m for the Canadian fshery (Bowering and Brodie, 1995) and between 900 and 1 400 m for the Spanish fshery (Junquera *et al*., MS 2000). This may be due to a combination of the increase in mean length with depth and the different exploitation pattern by trawl and longline. There are certainly differences in mean length by depth; in fact, mean length increased with depth as has been reported for other deep-water species (Murua, 2003), the "bigger deeper" distribution (Merrett *et al*., 1991; Gordon and Bergstad, 1992). Also there are differences in the exploitation pattern of both gears used in the commercial fshery targeting Greenland halibut. In effect, trawl is around 80 times more effcient than longline in the catch of specimens with lengths of between 42 and 47 cm and longline is more effcient than trawl for specimens greater than 60 cm, being ten times more effcient for specimens greater than 80 cm (Jorgensen and Boje, MS 1992). Jorgensen (1995) concluded that the catchability of trawl for Greenland halibut bigger than 50 cm decreases markedly.

The overall catch composition obtained in our longline survey contrasts with that of the Spanish trawl feet in this area. Whereas in the commercial feet the dominant species in the catch was Greenland halibut, which made up approximately 65% of the catch (Gónzalez *et al*., MS 2004), in our survey the main species were roughhead grenadier and blue antimora, which together made up more than 60% of catches. As explained above, this could be related to the different depth range investigated and to differences in selectivity for roughhead grenadier and Greenland halibut of trawl and long-line.

Other species such as roundnose grenadier (*Coryphaenoides rupestris*), American plaice and witch flounder (*Glyptocephalus cynoglossus*), relatively important in the trawl by-catch (Duran *et al.*, MS 1996), have not been caught in this survey. This could be probably because the mouths of these species are not big enough to take the baited hooks.

With regard to the length weight relationships available in the literature for roughhead grenadier, this study showed the highest coefficient of allometry (b parameter of the length-weight relationship) in comparison with other studies carried out in the same area (Savvatimsky, 1984; 1989; Murua, 2003). In other words, this survey found the heaviest fish for a given length, while the study of Murua (2003) showed fish with the least weight for the same length. In the case of Greenland halibut, again this study showed the higher coefficient of allometry compared to other studies (Dwyer *et al*., MS 2004). This variability could be explained by the depth range covered by different surveys as well as by the different number of large fishes sampled in different surveys due to different selectivity of gears (trawl *vs* longline).

It would appear that there are some differences in the mean length of catches depending on the bait of the longline, since fishing with mackerel caused a slight increase in mean length of the catch of both blue antimora and roughhead grenadier. This could be explained by the differences in the width of the cross-section of the bait cut by the automatic baiting machine. In our case, the widths of two bait species used differed slightly; and consequently, the volume of resulting sections was slightly different. The bait cross sections of mackerel were more voluminous, thus the expected catch would be composed of individuals with a mouth large enough to take the prey.

We found that at around 1 500 m, where the greatest yields are found, most of the catch (82%) was composed of blue antimora and roughhead grenadier of 47 cm and 55 cm mean length, respectively (Fig. 7). Blue antimora is of practically no commercial interest. For roughhead grenadier only fish of greater than 50 cm are commercially important. The increase in the mean length of the catch of roughhead grenadier should be of great interest to the commercial fishery, which could obtain this size of roughhead grenadier by fishing with longline at depth around 1 500 m.

The mean length of the catch of Greenland halibut in the survey was 66.47 cm. This length is much greater than that found in the trawl survey, which has been around 45 cm in recent years (Vargas *et al*., MS 2004; Gónzalez *et al*., MS 2004; Vaskov *et al*., MS 2004). The Greenland halibut catch was made up of more than 90% females, which implies that the use of this gear will produce a catch composed almost entirely of females. If we take into account that females mature at around 65 cm (Junquera and Saborido Rey, MS 1995), it is clear that this gear is more selective than trawl in catching adult Greenland halibut. Also, this gear, as a survey gear, would be more capable of detecting changes in abundance of the spawning stock due to its selectivity for bigger Greenland halibut individuals. However, in the case of long-line the estimation of the swept area is much more difficult than in the trawl, making difficult its use as a standard survey for estimating abundance of the spawning stock (Kimura and Zenger, 1997)

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