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Distribution of Greenland Halibut and By-catch Species that Overlap the 200-mile Limit Spatially and in Relation to Depth – Effect of Depth Restrictions in the Fishery. Distribution of the Fishable Biomass of the Main Commercial Species of Fish in Relation to Depth

by

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Abstract

It is thought that measures currently in operation in the NAFO Regulatory Area are not adequate for the protection of the juvenile fish. The largest fishery in the NRA and thus the one of greatest concern is that directing for Greenland halibut. As well, the need to reduce by-catch of any species in the Greenland halibut and other fisheries has been noted. Because of the range of depths currently fished, the Greenland halibut fishery not only focuses on the juvenile component of the population but also takes significant by-catch. This paper is a compendium of 12 papers presented recently to Scientific Council. Information on the distribution of Greenland halibut including distribution of undersized (below 35 cm, the Canadian minimum landing size) and mature and immature components of the population based on both survey and commercial information is presented. The paper also elaborates on the distribution of other commercial species that occur in the NRA, those that may be taken as by-catch in the directed Greenland halibut or other NRA fisheries, including those that overlap the Southeast Shoal.

Introduction

Establishment of an Exclusive Economic Zone or EEZ obligates interested parties in addressing issues of extended rights of ownership and management responsibilities of fish resources, as detailed in the Convention of the Law of the Sea (Anon 1982). When stocks straddle international zones, the Convention suggests that states exploiting the resource should seek to agree upon measures necessary to ensure the conservation of those resources. For NAFO (Northwest Atlantic Fisheries Organization), part of its responsibilities of ensuring sustainable fisheries is the formulation and implementation of conservation measures for the purpose of maintaining viability of stocks for which they are responsible. Since 1977, when Canada established its 200 mile limit (formally referred to the EEZ) NAFO responsibilities have focused on stocks that straddle that border.

STACTIC (the Standing Committee on International Control) a Committee of NAFO has indicated that in part, the measures currently in operation in the NAFO Regulatory Area (NRA) were felt to be inadequate for the protection of the juvenile fish. Scientific Council also noted the need to reduce exploitation of juvenile fish. The largest fishery in the NRA and thus the one of greatest concern is that directing for Greenland halibut (*Reinhardtius hippoglossoides*). As well, the Joint Scientific Council/Fisheries Commission WG on Implementation of the Precautionary Approach recommended that for the three stocks considered in their report, Div. 3LNO yellowtail flounder (*Limanda ferruginea*), Div. 3NO cod (*Gadus morhua*), and 3LNO American plaice (*Hippoglossoides plattesoides*), steps be taken to minimize the catch of juveniles. They also indicated the need to reduce by-catch of any species in the Greenland halibut and other fisheries to the lowest possible level.

Because of the range of depths currently fished, the Greenland halibut fishery in the NRA not only focuses on the juvenile component of the population but also takes significant by-catch. Yellowtail flounder, cod, American plaice and thorny skate, among other species have been regularly recorded from the Greenland halibut (and other fisheries) in the NRA. Cod and American plaice are restricted species (under moratorium) in Canadian waters and the NRA given their current low abundance.

The Fisheries Commission of NAFO reiterated the request for scientific advice on management in 2002 (FC Doc. 00/20) as follows:

a) Evaluate the distribution of the fishable biomass of the main commercial species of fish in relation to depth (in 100 m intervals). Separate values should be provided for a) for fish above and below the length of 50% maturity and b) for fish above and below the current minimum landing size.
b) Evaluate the likely future medium-term development for Greenland halibut in 2+3KLMNO (and 2 other species) under the following assumed constraint:
   Closure of targeted Greenland halibut fishery in depths less than 200, 500 and 800 meters or any other depths considered appropriate. These cases, which will have to make a reasonable assumption on the redirection of effort so removed onto the remaining depth strata, should be compared with evaluation of current fishing practices.

While the proposal for a depth restriction was aimed at protecting juvenile Greenland halibut, it was thought that reductions in by-catch of other groundfish species, including yellowtail flounder, cod and American plaice could also be realized by constraining the Greenland halibut effort to deep water. In addition, a Canadian proposal for a closure of the Southeast (SE) Shoal to directed fishing for Greenland halibut, thorny skate (*Raja radiata*), roundnose grenadier (*Coryphaenoides rupestris*) and roughead grenadier (*Macrourus berglax)* and yellowtail flounder was also presented to NAFO.

The above proposed measures are aimed at promoting conservation of the resources straddling the 200 mile limit. While the Precautionary Approach indicates that even when there is doubt, fisheries managers should err on the side of caution, wherever possible, it is clearly more appropriate to base conservation related decisions on sufficient supporting information. With this in mind, the purpose of this paper is to amalgamate available information on the juvenile fish, by-catch and effect on the fishery issues raised by the Fisheries Commission. Information on the distribution of Greenland halibut including distribution of undersized and mature vs. immature components of the population is presented. Expected affects on the fishery are examined. The paper elaborates on the distribution of thirteen other commercial species that occur in or adjacent to the NRA, those that may be taken as by-catch in the directed Greenland halibut or other NRA fisheries, including those that overlap the Southeast Shoal.

METHODS

This paper represents a compendium of 12 papers tabled at the June 2001 meeting and one from September 2000 Using information contained in those documents based on both research survey and commercial fisheries data, Scientific Council was able to evaluate the distribution of the fishable biomass of the main commercial species of fish in relation to depth. Size of Greenland halibut was also evaluated with respect to depth: a) fish above and below the length of 50% maturity and b) for fish above and below the current minimum landing size.

RESULTS

Distribution of the fishable biomass of the main commercial species of fish in relation to depth – Research Surveys (FC Request 9)

The following information was taken from documents containing information based on research survey data to evaluate the above request (Bowering, 2001, Junquera et *al*. 2000, Junquera et *al*. 2001, Kulka, 2001, Kulka and Miri, 2001, Morgan et *al*. 2001, Saborido and Vázquez, 2001, Vinnichenko et *al*. 2001).

1) Greenland Halibut in Relation to Depth

Canadian survey data (1995-1999) in Divisions 3L-3O combined showed that 92% of total Greenland halibut biomass was concentrated at depths greater than 250 m, 60% in greater than 700 m and 49% in greater than 1000 m. These percentages represent minimum estimates of fishable biomass at depth given that the mature portion of the population, largely not captured by the survey gear are concentrated at the deepest part of the distribution. The highest catch rates were observed within the ranges of depths peaking at 200-500 m and 700-900 m. The biomass captured by the Canadian surveys largely (97%) comprised the juvenile portion of the population.

Russian surveys in Divisions 3LM (Flemish Pass) were conducted at greater than 732 m. In 1996, they showed a a higher index of total abundance and biomass of Greenland halibut in 731-1280 m in 1996 (Fig. 2, upper panel). Biomass and particularly abundance were lower at the shallowest depth in 2000 perhaps reflecting fewer small fish than in 1996.

2) Greenland Halibut a) above and below length of 50% maturity and b) above and below current minimum landing size in relation to depth (Junquera et al. 2000, Kulka 2001, Bowering 2001, Morgan et al. 2001).

a) Canadian and Spanish trawl survey data show that almost all (99% for Canadian surveys, 97% for Spanish (Table 2), of the SSB of Greenland halibut (> 70 cm) was distributed at depths greater than 800m. (Sect. 1 points out that the Canadian surveys largely represent the immature component of the population due to the catchability of the survey gear). The proportion of mature fish in the catches increased with depth attaining highest proportions beyond 1000 m.

b) Greenland halibut increase in size with depth. Based on Canadian surveys in NAFO Divisions 3L-3O, the proportion by number of Greenland halibut less than 30 cm was fairly constant down to about 300 m then declined with increasing depth (Fig. 3). There was another significant drop between 600 and 700 m to very low levels. At depths exceeding 700 m, only 4% of fish by number (~2% by weight) were less than 30 cm. At depths exceeding 1000 m, fish less than 30 cm are largely absent. This approximately corresponds with the depth zone where mature fish begin to appear in the survey catches. Corresponding to the shallower peak in the biomass between 200-500 m (Fig. 2), about 69% of the fish were less than 30 cm. At 700-900 m, the deeper mode 8% of the fish were less than 30 cm.

Data from the Canadian surveys also showed that biomass of Greenland halibut below minimum landing size, < 30 cm has been relatively stable from the late 1970's until about 1992. By 1997, the biomass of small fish had increased to more than double the pre-1992 level due to above average recruitment. More recently, due to growth, the proportion of >30 cm fish has started to increase. Biomass of mainly mature Greenland halibut (>70 cm) has declined from an index of 50,000 t in the early 1980's to near zero by 1991 and has remained low since.

3) Other species: biomass in relation to depth, above and below length of 50% maturity and above and below current minimum landing size in relation to depth.

A variety of species are taken as by-catch in the Greenland halibut fishery and in other directed fisheries in the NRA. Based on Canadian survey data for Divisions 3L-3O, 99% of yellowtail biomass and 85% of thorny skate was distributed in less than 150 m. No yellowtail were recorded in depths greater than 100 m. Thorny skate although distributed primarily at depths less than 150 m was also found at low concentrations as deep as 1,100 m. The two wolfish species were distributed similarly over a wide range of depths (51-700 m) with biomass peaking at 300 m. They were most densely aggregated in the deep channels on the banks as well as along the shelf edge. Striped wolfish varied from spotted in that a shallow mode was observed at 101-150 m (on the southern Grand Bank). Redfish was widely distributed by depth (101 to about 1400 m) with greatest biomass in the 251-500 m range. It has a complex and variable inter-annual distribution. Witch flounder occurred commonly over all depths surveyed. A mode at 51-150 m (63% of the biomass) corresponded to a concentration of witch along the southwest slope of the Grand Bank. Although witch was considerably denser at depths between 601 and 900 m, the biomass was relatively small in that area. Roughead and roundnose grenadier, in addition to

Greenland halibut were observed to be predominantly distributed along the slope or in the deeper parts of the channels. For the grenadiers, the density distributions were uni-modal with 70% of the biomass for roughead and 90% for roundnose at depths exceeding 1000 m. A Russian survey in Divisions 3LM indicated a similar pattern of distribution of the two grenadier species by depth. Similarly, Spanish spring surveys in Divisions 3NO indicated very little biomass of roughead grenadier (less than 2%) at depths less than 731 m.

Some differences among Division for the various species were also observed. For American plaice in the spring, 70% of biomass was observed at depths less than 274 m in Div. 3L (Fig. 4). In Div. 3N and 3O, it was most abundant at depths less than 92 m (83% in 3N, 72% in 3O). In the fall, depths out to 1463 m were sampled. It was also found to be most abundant at depths less than 274 m (69%) but a significant portion of the biomass, 7% was found at 732-914 m, mainly from Div. 3L.

Spanish survey data from NAFO Div. 3M for two periods, 1988-1994 and 1995-2000 shows that cod and American plaice overlap only marginally with Greenland halibut. Less than 6% of American plaice and less than 2% of cod are found at depths exceeding 367 m whereas Greenland halibut exceeds 83% at those depths.

In NAFO Divisions 3LMNO, based on Canadian survey data, a ratio of percent of catch for species that co-occur with Greenland halibut to percent catch of Greenland halibut at depth scaled to a range of 0 (no overlap) to 1 (most overlap) was used to illustrate overlap of each species with Greenland halibut. Assuming that the survey data would reflect species composition in the commercial catches, the effect of fishing in depths restricted greater than 700 m (light bars) effectively reduces proportion of by-catch of some species while increasing others. For species that occur in the NRA, yellowtail flounder, cod, and striped wolfish would be virtually eliminated from the catches. Redfish, witch and spotted wolfish by-catch would be reduced. American plaice would remain about the same. Skate by-catch would increase slightly and by-catch of grenadiers would increase substantially.

Distribution of the fishable biomass of the main commercial species of fish in relation to depth

Part B – Commercial catches (FC Request 9)

The following information was taken from documents containing information based on commercial fisheries data to evaluate the above request (Junquera et *al*., 2000, Alpoim and Avila de Melo, 2001, Del Rio and Junquera, 2001, Igashov, 2001, Savvatimsky and Gorchinsky, 2001). These data, collected prior to discarding represent catch figures.

1) Species in Relation to Depth

a) Greenland halibut

For the Portuguese fleet, Greenland halibut is the main species in the catches beyond 500m in Divisions 3L and 3M, with proportion of total catch > 80% (Alpoim, and Avila de Melo. 2001). In Division 3N, Greenland halibut increased with depth, averaging 52% at > 800m. In Div. 3O it comprised 84% of the catch, but this Division accounts for only 4% of the Greenland halibut catch for all Divisions. (Fig. 8)

For the Russian Greenland halibut fishery conducted in Divisions 3LN, from 500 to 800 m, the relative amount of Greenland halibut in the catch increased rapidly to 80% and in depths of 1200-1300 m, Greenland halibut accounted for 90% of the catch (Savvatimsky and Gorchinsky. 2001). No differences were noted between Divisions with respect to distribution of catch by depth (Fig. 9).

The catches by Division and depth of the Spanish fishery collected by the Spanish scientific observers (Junquera et al. 2000) showed that more than 90% of the Greenland halibut catches were taken at depths beyond 700 meters in Divisions 3L and 3M. In the Divisions 3N and 3O the catches were much smaller and only 1% of them came from depths shallower than 700 meters (Fig 11).

Based on the Canadian fishery for Greenland halibut (2GHJ3KLNO) longlines and gillnets have a higher selectivity for the larger Greenland halibut than otter trawls (Kulka 2001). Average size in the catch was observed to increase with depth from about 35 cm to 52 cm at 1200+ m for otter trawls and 45 cm to 67 cm for gillnets. Percent of the catch < 70 cm for for all gears was close to 100% at depths shallower than 700 m decreasing to 96% for otter trawls and 65% for gillnets at 1200 m.

b) American plaice

By-catch rates of American plaice in the 2000 Russian fishery recorded as t per hour by 100 m depth intervals shows relatively low numbers at all depths fished exceeding 0.05 t only a the shallowest depths fished. In Divisions 3LM, where fishing was restricted to depths > 600 m, catch rates diminished with depth to near zero at 1100 m. In Div. 3N, maximum catch rate occurred at 100 m but increased again at 800-1000m. Catch rates in Div. 3O fluctuated across all depths fished (Table 3, Fig. 7).

For the Portuguese fishery in < 200m in Div. 3N, American plaice was the most abundant species in the summer and fall catches (49%) and was the second most important species at 200-499m (11%). Through winter and spring, American plaice was the main by-catch in the Greenland halibut fishery > 800m in Div. 3N, averaging 19% of the catch (taken mostly before July). In Div. 3O at < 200m, American plaice comprised 22% of the catch (Fig. 8). For each one of these divisions the associated effort in shallower waters less than 200m represents less than 5% of the total observed effort in 1999 and 2000 (Alpoim and Avila de Melo, 2001).

Based on data collected by Spanish scientific observers (1991-2000), the highest percentage of American plaice in the catches were recorded in NAFO Div. 3N and usually diminished with depth. In Divisions 3LM, the proportion of American plaice was low at depths > 800 m except in 1995. In Divisions 3NO, the proportion of American plaice at depths > 800 m was unusually high in three years (1991, 1995, 1999) coinciding with the lowest catches of Greenland halibut recorded by the observers. The CPUE of American plaice has been found to decrease with depth in all Divisions (Fig 12).

c) Grenadiers (Savvatimsky and Gorchinsky 2001)

For the Russian Greenland halibut fishery conducted in Divisions 3LN, grenadiers were the major by-catch. At < 500 m, Greenland halibut accounted for less than 10% of the total catch (Fig. 9).

d) Redfish

In the Portuguese catches for depths from 200-500 m, redfish comprised the largest proportion in Div. 3M. In Div. 3N redfish was most abundant from 200-800 m depth; 60% of the catch in 200-499 m and 65% in 500-799 m. The proportion of observed effort in 1999 and 2000 deployed between 200m and 799m in Div. 3N was less than 4%. In Div. 3O, redfish comprised 85-89% at depths between 200 m and 799 m (and is still the most abundant species in the catches taken from depths less than 200 m) (Fig. 8, Alpoim and Avila de Melo. 2001).

In the Spanish fleet, the highest proportions of redfish in the catches were recorded in NAFO Div. 3O and there, the highest catches correspond to depths between 400 m and 600 m (Fig. 11, Junquera et al. 2000).

e) Skates

In the Portuguese fishery, skates were taken in Div. 3N (all depths except 500-799m) and Div. 3O for depths less than 200 m, with an average proportion of 10% regardless depth (Alpoim and Avila de Melo. 2001).

Information on catch rates (reflecting density) of skates by depth based on data collected by observers from the Spanish skate fishery in 1997 and 2000 shows different patterns between years (Table 4). These data show that the fishery is constrained mainly to depths less than the 200 meters and that the best yields are obtained in the strata located to depths smaller than 100 meters (Del Rio and Junquera, 2001).

f) Cod

Highest proportions of cod in the Portuguese catch are recorded in Div 3N at depths less than 200m (6%). In Div. 3O, 5% of cod is taken as by-catch of the redfish fishery occurring between 200m and 499m. (Fig.8 Alpoim and Avila de Melo, 2001). In Div 3N for the Spanish fleet at depths in < 400m, cod comprised 4% of the catches (Fig.11, Junquera et al. 2000).

g) Yellowtail flounder

In Div 3N for the Portuguese fleet at depths less than 200 m, yellowtail flounder comprised 24% of the catches. Most of these yellowtail flounder catches were taken after June. In Div 3O at less than 200m, the percent of yellowtail was 8%. (Fig. 8, Alpoim and Avila de Melo, 2001). In the Spanish fleet, yellowtail flounder comprised 14% of the catch in Division 3N and more than 95% of this species it was captured to depths smaller than 200 meters. (Fig. 11 Junquera et al. 2000).

1) Species in relation to depth above the length of 50% maturity and b) for fish above and below the current minimum landing size.

a) Greenland halibut

Greenland halibut lengths > 60 cm are scarce in the Portuguese catch regardless the year, month, Division or depth interval. No higher frequencies of lengths of Greenland halibut smaller than 30 cm can be allocated to a particular division and/or depth interval. (Fig. 10, Alpoim and Avila de Melo, 2001).

Length composition data from the Russian (Igashov 2001) and Spanish (Junquera et al. 2000) directed fisheries for Greenland halibut in 1998-2000 shows that only a very small proportion, 1.6% of Greenland halibut was less than 30 cm. These fisheries were reported to have taken place at depths largely exceeding 700 m.

Percentages of mature fish (actual numbers of mature fish sampled in brackets) by depth and Division in the Spanish Greenland halibut commercial catches are illustrated in Table 5 (Junquera et al. 2000).

b) Other species

For other species (with exception cod) fish under minimum size comprised a small proportion in the observed Portuguese catches. Average length of American plaice in Div 3L Russian by-catches are presented in Table 6 (Gorchinsky, 2001). There are no obvious differences with depth between 700 and 1100 m.

In the Spanish catches, the percentage of American Plaice larger than 25 centimetres (minimum landing size) and the proportion of the SSB over the total catches are presented in Figure 12 (Junquera et al. 2000).

SUMMARY

Information presented is based on Canadian, Spanish, Portuguese and Russian research surveys and the various fisheries in the NRA. The fishery data are catch figures collected prior to discarding.

Greenland halibut biomass at depth

a) Surveys

Canadian survey data showed that 60% of total Greenland halibut biomass was distributed at depths greater than 700 m. (represents a minimum estimates of fishable biomass at depth since the mature portion of the population, largely not captured by the survey gear are concentrated at the deepest part of the distribution). The highest catch rates were observed within the ranges of depths peaking at 200-500 m and 700-900 m (the biomass captured by the Canadian surveys largely [97%] comprised the juvenile portion of the population). Russian surveys were restricted to depths greater than 732 m and thus provided little information in regard to the 700 m question.

b) Fishery

For the Portuguese fleet, in 3LM, Greenland halibut amounts to > 80% of the total catch, beyond 500m, 52% in 3N > 800m and 84% of the catch in 3O (the latter accounts for only 4% of the Greenland halibut catch for all Divisions). At < 500 m, Greenland halibut accounted for less than 10% of the total catch in the Russian fisheries. For the directed Russian fishery in Divisions 3LN at 500-800 m, Greenland halibut increased rapidly to 80% of the catch and at 1200-1300 m, it accounted for 90%. For the Spanish fishery, more than 90% of the Greenland halibut catches were taken at depths beyond 700 meters in Divisions 3LM. In the Divisions 3NO the catches were much smaller and 1% of them came from depths < 700 m.

Greenland halibut Size/Maturity at depth

a) Surveys

Greenland halibut increase in size with depth. Based on Canadian surveys in NAFO Divisions 3L-3O proportion of Greenland halibut less than 30 cm was fairly constant down to about 300 m then declined with increasing depth. There was significant drop between 600 and 700 m. At depths exceeding 700 m, only 4% of fish by number (~2% by weight) were less than 30 cm and at depths exceeding 1000 m, are largely absent. This approximately corresponds with the depth zone where mature fish begin to appear in the survey catches. Proportion of undersized fish declined with depth. At the shallower peak in the biomass, between 200-500 m (as defined from Canadian survey data), 69% of the fish were less than 30 cm. At 700-900 m 8% of the fish were less than 30 cm. Canadian and Spanish trawl survey data show that almost all (99% for Canadian surveys, 97% for Spanish of the SSB of Greenland halibut (> 70 cm, as proxy for mature fish) was distributed at depths greater than 800m. The proportion of mature fish in the catches increased with depth attaining highest proportions beyond 1000 m.

b) Fishery

Greenland halibut > 60 cm are scarce in the Portuguese catch regardless the year, month, Division or depth interval. No higher frequencies of lengths of Greenland halibut smaller than 30 cm can be allocated to a particular division and/or depth interval. Length composition data from the Russian and Spanish directed fisheries for Greenland halibut in 1998-2000 shows that 1.6% of Greenland halibut was less than 30 cm (these fisheries were reported to have taken place at depths largely exceeding 700 m). Percentages of mature fish by depth and Division in the Spanish Greenland halibut commercial catches generally increase with depth.

Based on the Canadian fishery for Greenland halibut (2GHJ3KLNO) longlines and gillnets have a higher selectivity for the larger Greenland halibut than otter trawls. Average size in the catch was observed to increase with depth from about 35 cm to 52 cm at 1200+ m for otter trawls and 45 cm to 67 cm for gillnets. Percent of the catch < 70 cm for for all gears was close to 100% at depths shallower than 700 m decreasing to 96% for otter trawls and 65% for gillnets at 1200 m.

By-catch

a) Survey

Assuming that the survey data would reflect species composition in the commercial catches, the effect of fishing in depths restricted greater than 700 m effectively eliminates yellowtail flounder, cod, and striped wolfish by-catch. Redfish, witch and spotted wolfish by-catch would be reduced. American plaice would remain about the same. Skate by-catch would increase slightly and by-catch of grenadiers would increase substantially.

b) Fishery

Plaice

By-catch rates of American plaice in the 2000 Russian fishery shows relatively low numbers at all depths fished exceeding 0.05 t/hr only a the shallowest depths fished. In Div. 3N, maximum catch rate occurred at 100 m but increased again at 800-1000m. For the Portuguese fishery, the by-catch of American plaice was observed to vary seasonally in Div. 3N: summer and fall, it was most abundant in < 200 m; winter and spring, it was the main by-catch at > 800m. For the Spanish fishery, CPUE of American plaice decreased with depth. The highest percentage of American plaice were recorded in Div. 3N, usually diminishing with depth. The proportion of American plaice in 3LM was low at depths > 800 m. The proportion of American plaice at depths > 800 m was unusually high in three years (1991, 1995, 1999) in 3NO. Information from all of the fisheries indicates that fishing restricted to greater than about 1000 m would largely eliminate American plaice by-catch.

Yellowtail flounder

At depths less than 200 m in 3N, yellowtail flounder comprised 24% of the catches. In Div 3O at less than 200m, the percent of yellowtail was 8% based on Portuguese catch records. For the Spanish fleet, yellowtail flounder comprised 14% of the catch in Division 3N and > 95% from depths < 200 meters.

Cod

For Portuguese catches, highest proportions of cod are recorded in Div 3N at < 200m (6%). In Div. 3O, 5% of cod is taken as by-catch of the redfish fishery occurring between 200m and 499m. In Div 3N for the Spanish fleet cod comprised 4% of the catches at depths < 400m.

Skates

In the Portuguese fishery, skates were taken in Div. 3N (all depths except 500-799m) and Div. 3O for depths less than 200 m, with an average proportion of 10% regardless depth. The Spanish skate fishery in 1997 and 2000 shows different patterns between years. The fishery is constrained mainly to depths less than the 200 m and the best yields are obtained at depths < 100 meters.

Redfish

For Portuguese catches at depths from 200-500 m, redfish comprised the largest proportion in Div. 3M. In Div. 3N redfish was most abundant from 200-800 m depth; 60% of the catch in 200-499 m and 65% in 500-799 m. In Div. 3O, redfish comprised 85-89% at depths between 200 m and 799 m. For Spanish catches, the highest proportions of redfish in the catches were recorded in 3O between 400-600 m.

Grenadiers

For the Russian Greenland halibut fishery restricted to deep waters in Divisions 3LN, grenadiers were the major by-catch.

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Table 1. Density (kg per tow) and relative total biomass of Greenland halibut in Divisions 3L-3O based on Canadian fall survey data (after Kulka, 2001).

Depth (m)	# Sets	Area (km^2)	% of Area	Mean Kg per tow	Biomass (t)	% of Biomass	Cumulat. Biomass
0-50	21	3,770	1.3%	0.0	0	0.00%	0.0%
51-100	525	117,666	43.2%	0.4	1,813	1.97%	2.0%
101-150	198	33,605	55.1%	0.5	777	0.84%	2.8%
151-200	119	28,746	65.3%	1.4	1,772	1.92%	4.7%
201-250	96	12,063	69.6%	5.7	2,943	3.20%	7.9%
251-300	51	9,943	73.2%	13.0	5,536	6.01%	13.9%
301-350	61	7,442	75.8%	14.3	4,567	4.96%	18.9%
351-400	24	4,237	77.3%	15.6	2,834	3.08%	22.0%
401-450	37	2,814	78.3%	27.2	3,278	3.56%	25.5%
451-500	34	2,555	79.2%	11.2	1,225	1.33%	26.9%
501-600	40	3,991	80.6%	14.6	2,495	2.71%	29.6%
601-700	48	3,629	81.9%	20.5	3,176	3.45%	33.0%
701-800	19	3,734	83.3%	42.2	6,741	7.32%	40.4%
801-900	33	3,806	84.6%	35.4	5,761	6.26%	46.6%
900-1000	30	4,137	86.1%	24.8	4,386	4.76%	51.4%
1001-2000	110	39,171	100.0%	26.7	44,777	48.63%	100.0%
	1446	**281,309**		**15.85**	**92,081**		

Table 2. Proportion of Greenland halibut Spawning Stock Biomass at depth by year from the Spanish survey in Div. 3NO, 1996-1999 (after Junquera, 2000).

				Percentages of SSB by depth strata (m.)								
Year	**Biomass**	**SSB**	**%**	**0-99**	**100-199**	**200-299**	**300-399**	**400-599**	**600-799**	**800-999**	**1000-1199**	**1200-1600**
1996	34246	8124	24	0	0	0	0	0	4	74	22	n.s
1997	71000	21731	31	0	0	0	0	0	0	9	90	n.s
1998	147864	33657	23	2	2	0	0	0	3	35	28	29
1999	121043	31664	26	0	0	0	0	0	5	16	42	36

Table 3. Russian by-catch of American plaice (t/h) by depth range, January – July 2000 (after Savvatimsky and Gorchinsky, 2001).

Division	Month	Depth, m														Aver.	No. of tows
		0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300		
3L	Jan									0.009	0.007	0.004	0.003	0.002		0.006	65
3L	Feb							0.004	0.024	0.018	0.004	0.002	0.004	0.001	0.001	0.011	183
3L	Mar								0.018	0.018	0.011	0.022	0.015	0.001	0.001	0.008	318
3L	Apr								0.012	0.016	0.026	0.034				0.009	197
3L	May							0.054	0.040	0.046	0.017	0.016	0.002			0.016	241
3L	**TOTAL**							**0.047**	**0.025**	**0.025**	**0.017**	**0.021**	**0.007**	**0.001**	**0.001**	**0.011**	**1004**
3M	Jan											0.002	0.001			0.002	5
3M	Feb								0.008		0.012		0.001			0.005	7
3M	Mar							0.010	0.055	0.092						0.063	11
3M	May							0.139		0.021	0.019	0.010	0.001			0.028	42
3M	**TOTAL**							**0.084**	**0.039**	**0.052**	**0.019**	**0.006**	**0.001**			**0.029**	**65**
3N	Mar									0.025	0.016	0.017				0.020	36
3N	May	0.009					0.002	0.002	0.001	0.001	0.004					0.007	23
3N	Jun	0.084			0.004	0.009	0.001	0.015	0.014							0.050	182
3N	Jul	0.048														0.048	22
3N	**TOTAL**	**0.071**			**0.004**	**0.009**	**0.001**	**0.009**	**0.008**	**0.023**	**0.015**	**0.017**				**0.042**	**263**
3O	Mar					0.075				0.046						0.068	12
3O	May	0.032	0.010		0.034	0.053										0.030	19
3O	Jun	0.063	0.069	0.041	0.104	0.090	0.024	0.031	0.051							0.060	181
3O	Jul	0.039	0.034			0.006	0.016									0.016	66
3O	**TOTAL**	**0.053**	**0.062**	**0.041**	**0.069**	**0.053**	**0.022**	**0.031**	**0.051**	**0.046**						**0.048**	**278**

Table 4. CPUE (kg/h) by month in the skate fishery in the Div. 3N Spanish fishery, 1997 and 2000 (after Del Rio and Junquera, 2001).

1997						
DEPTH (meters)	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
0- 50	-	355,7	576,2	-	-	527,3
51- 100	-	508,5	582,1	-	-	541,9
101- 150	-	3,3	-	-	-	6,7
151- 200	-	22,3	1,9	-	-	15,4
201-250	-	-	-	-	-	-
TOTAL	-	457,4	573,9	-	-	519,1
2000						
DEPTH (meters)	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
0- 50	1079,3	592,4	-	640,2	937,5	801,9
51- 100	768,9	729,9	897,1	663,8	275,3	686,9
101- 150	-	-	-	13,9	11,4	10,9
151- 200	-	485,9	-	-	-	489,1
201-250	-	234,7	-	-	-	663,5
TOTAL	995,9	626,3	897,1	628,4	298,8	690,6

Table 5. Percentages of mature fish (actual numbers of mature fish sampled in brackets) by depth and Division in the Spanish Greenland halibut commercial catches (after Junquera et al. 2000).

Div. 3L				
Depth (m.)	1991	1997	1998	1999
600 - 799	14 (19038)	8 (15840)	10 (11114)	23 (1711)
800 - 999	28 (195368)	14 (54419)	10 (32694)	19 (9769)
1000 - 1199	37 (419875)	15 (70637)	10 (11119)	19 (65674)
1200 +	50 (58894)	-	40 (1616)	21 (36779)
Total of the year	33 (693175)	13 (140896)	12 (56538)	20 (113933)
Div. 3M				
Depth (m.)	1991	1997	1998	1999
600 - 799	-	-	17 (3732)	17 (9056)
800 - 999	-	21 (11436)	31 (7579)	29 (11204)
1000 - 1199	46 (524050)	19 (34090)	17 (3733)	26 (39000)
1200 +	56 (266474)	19 (34090)	34 (2013)	33 (87729)
Total of the year	49 (790524)	20 (79616)	17 (17055)	29 (146989)
Div. 3N				
Depth (m.)	1991	1997	1998	1999
400 - 599	-	-	0	-
600 - 799	-	5 (445)	8 (2649)	5 (627)
800 - 999	-	14 (54394)	8 (11046)	25 (6482)
1000 - 1199	-	12 (7164)	9 (2517)	24 (4336)
1200 +	-	13 (8167)	12 (771)	5 (670)
Total of the year	-	14 (70169)	9 (16982)	21 (12115)

Table 6. Russian fishery: Average length (cm) of American plaice in Div. 3L by 100m depth range in January-May 2000 (after Gorchinsky, 2001).

Month	Males							Females							F/M sex ratio
	Depth, m					Av. L	No. sp.	Depth, m					Av. L	No. sp.	
	700	800	900	1000	1100			700	800	900	1000	1100			
Jan			31.5			31.5	11			34.4			34.4	50	4.5
Feb	30.8	36.3	31.8	31.9	31.0	32.6	44	35.5	37.2	34.8	36.9	36.1	35.9	591	13.4
Mar	34.7	31.3				33.0	28	36.4	36.7	35.6			36.5	311	11.1
Apr		33.4	31.3			33.3	47		36.0	34.7	34.4		35.5	256	5.4
May		41.5	33.1			34.0	20		36.3	37.0			36.8	253	12.7

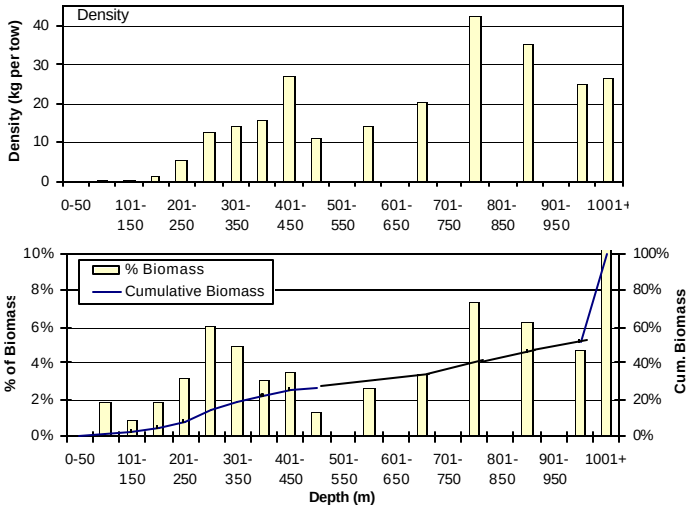

Figure 1. Density (kg per tow) and relative biomass of Greenland halibut in Divisions 3L-3O (after Kulka, 2001).

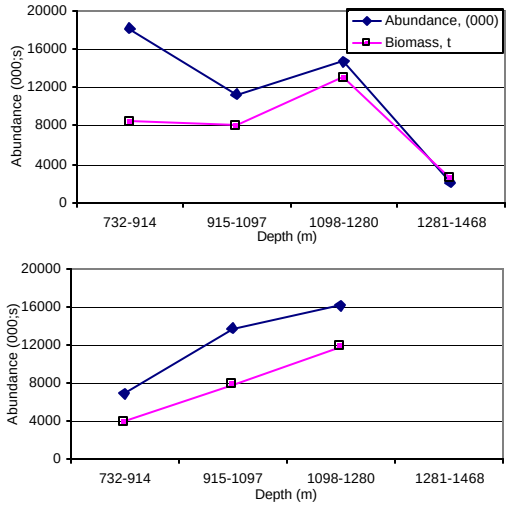

Figure 2. Index of total abundance and biomass at depth for Greenland halibut in Divisions 3LM from Russian surveys (after Vinnichenko et *al*. 2001). Upper panel is 1996, lower panel is 2000. The depth range 1281-1468 m was not sampled in 2000.

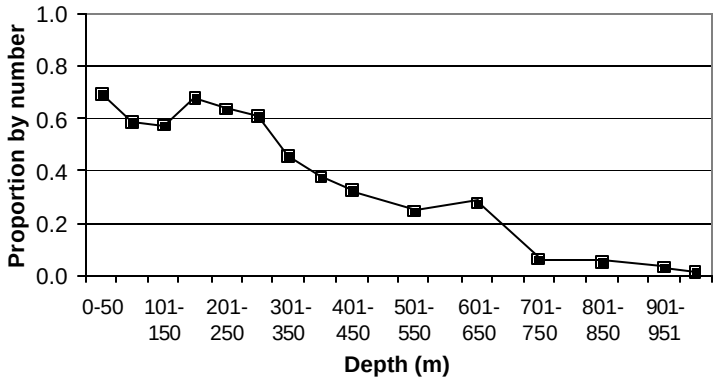

Figure 3. Proportion of Greenland halibut (by number) less than 30 cm at depth in NAFO Divisions 3L-3O based on Canadian trawl survey data (after Kulka, 2001).

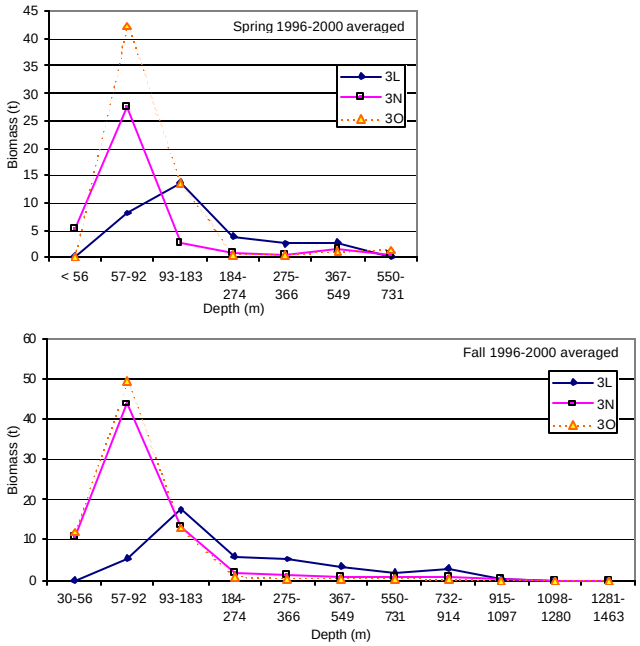

Figure 4. American plaice biomass at depth in Divisions 3L, 3N and 3O from Canadian spring and fall surveys, 1996-2000 (after Morgan et *al*. 2001).

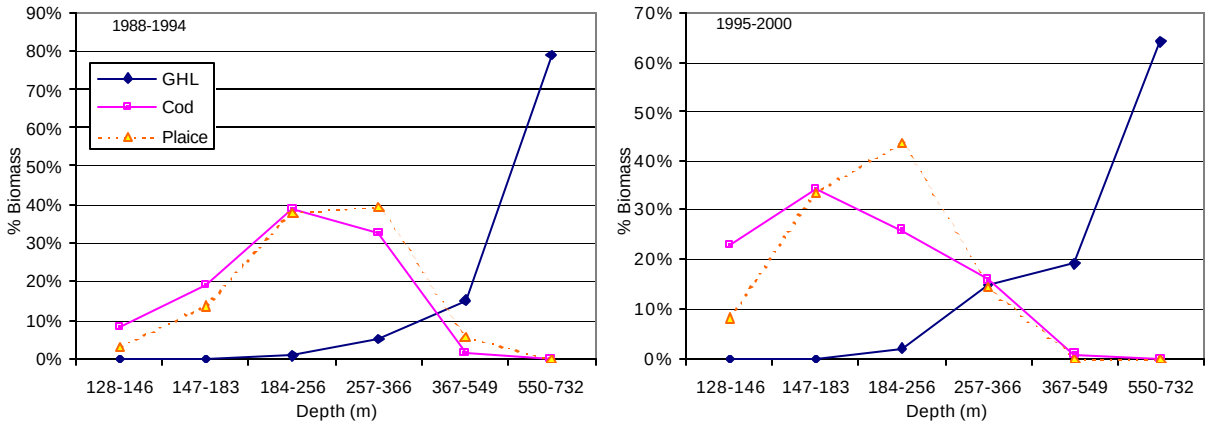

Figure 5. American plaice, cod and Greenland halibut biomass at depth in NAFO Division 3M from Spanish surveys, 1988-1994 and 1995-2000 (after Saborido and Vázquez, 2001).

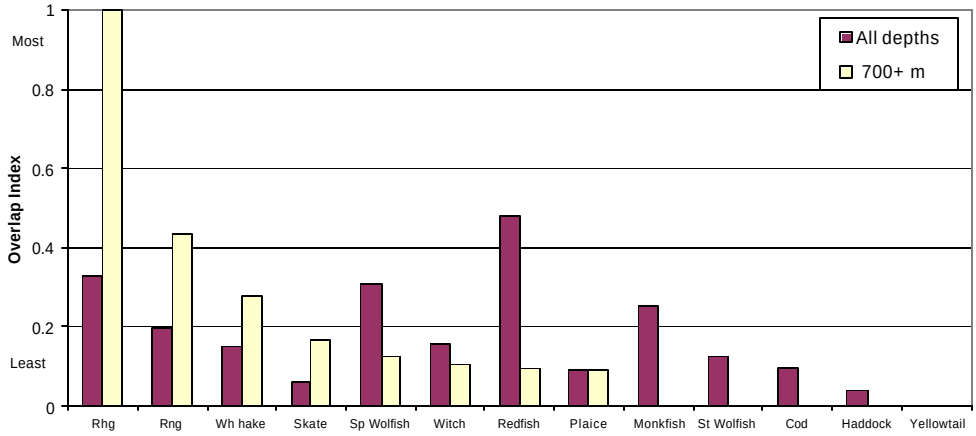

Figure 6. Degree of overlap of selected by-catch species across all depths vs. depths greater than 700 m. Species are placed in order of their depth distribution for areas greater than 700 m (after Kulka, 2001).

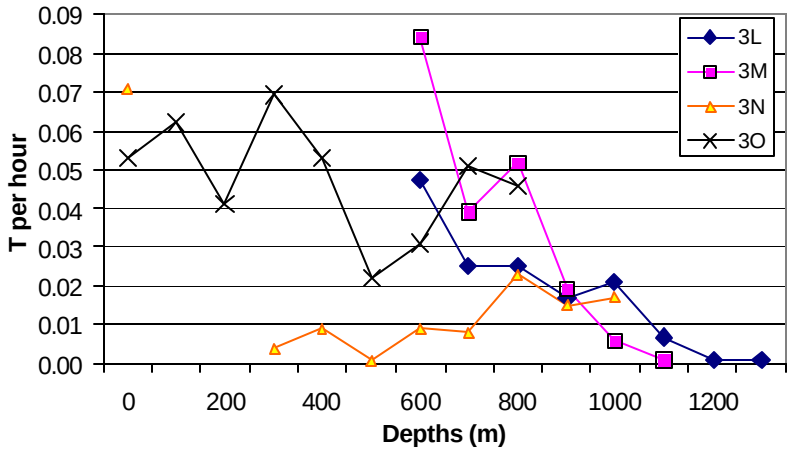

Figure 7. Russian catch rates of American plaice by NAFO Division in 2000 (after Gorchinsky, 2001, WP 01/25).

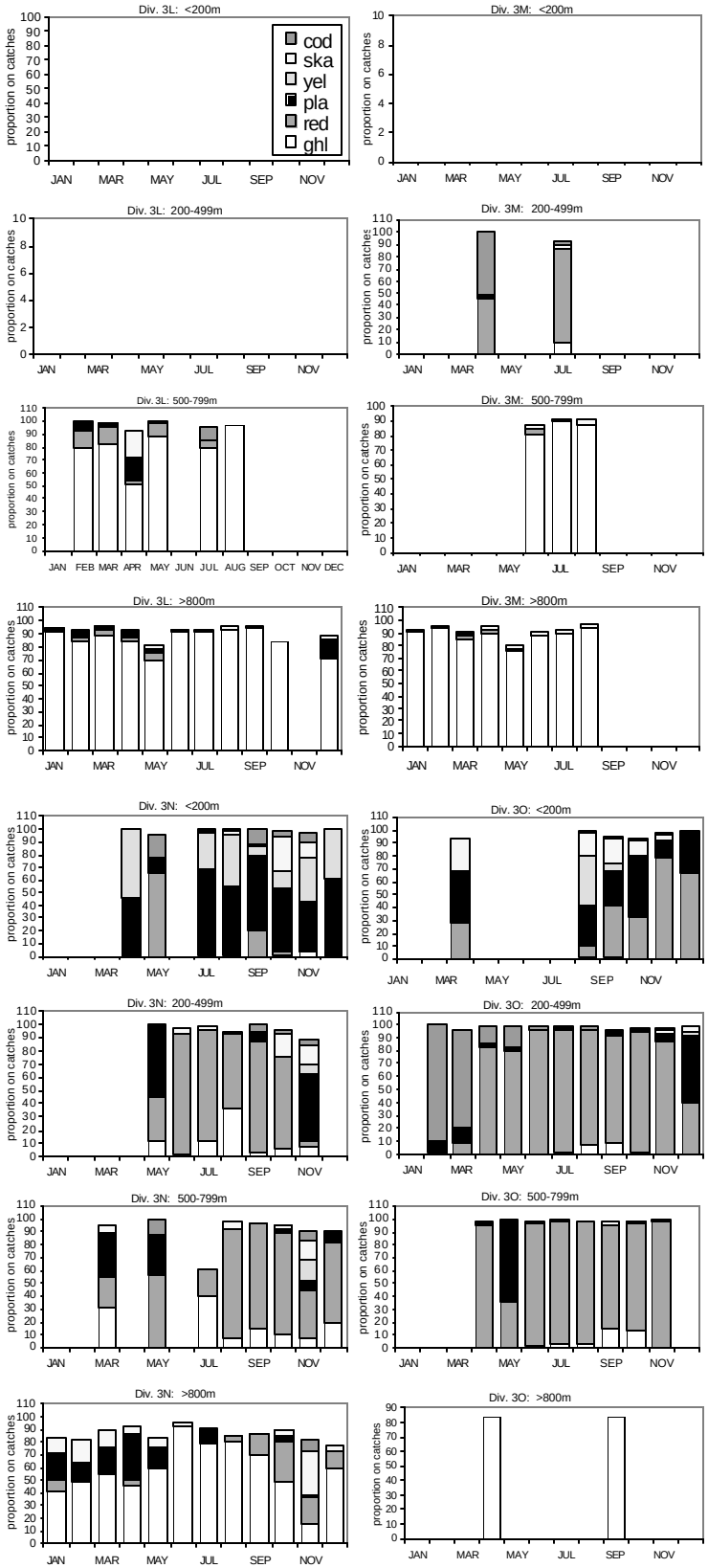

Figure 8. Relative catch composition of the Portuguese fishery as reported by scientific observers, 1999-2000 (after Alpoim and Avila de Melo, 2001).

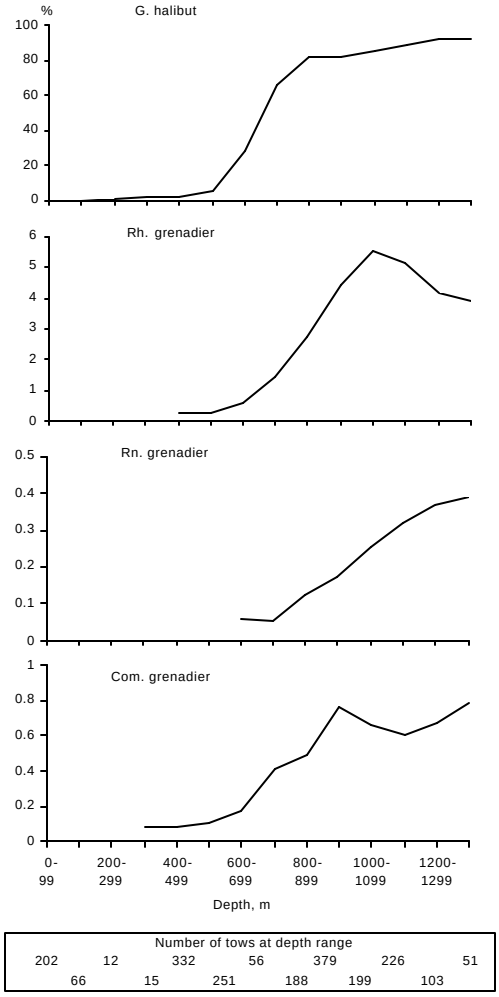

Figure 9. Some groundfishes by-catches (%) by depths in Russian Greenland halibut fishery in Divisions 3LMN, 2000 (smoothed curves) (after Savvatimsky and Gorchinsky, 2001).

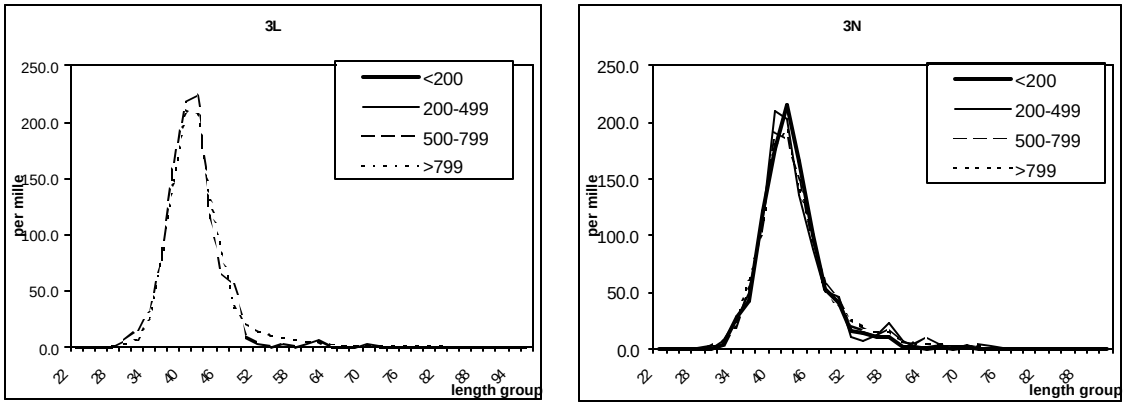

Figure 10. Portuguese length frequencies For NAFO Divisions 3L and 3N, Greenland halibut 2000 by depth interval (m) (after Alpoim and Avila de Melo, 2001).

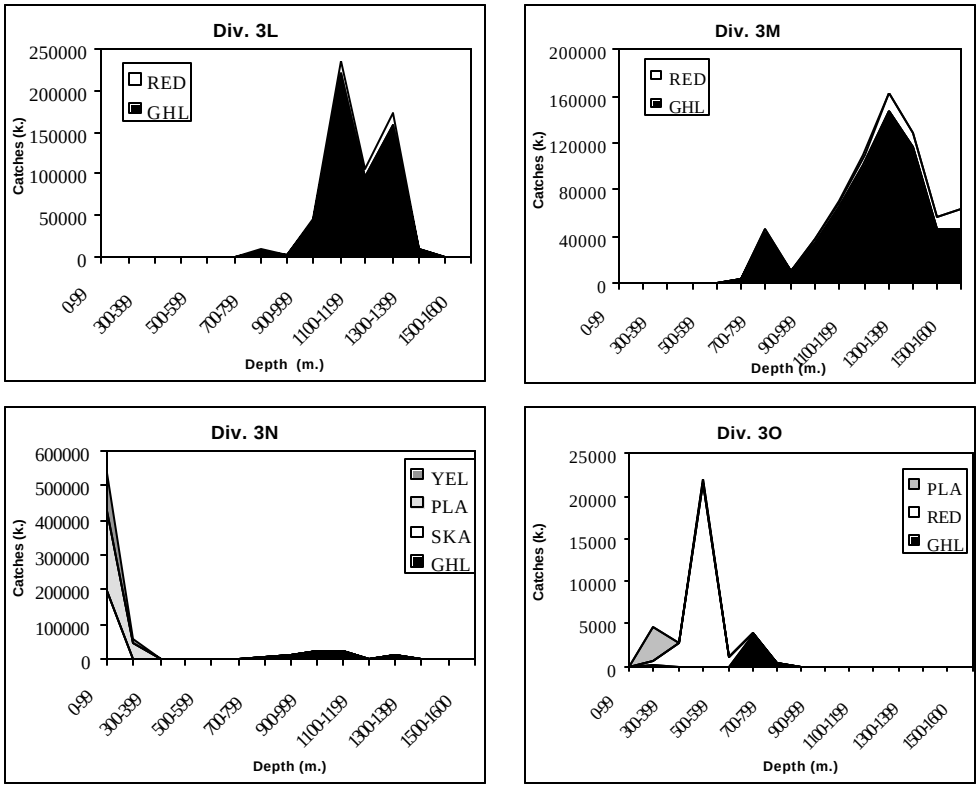

Figure 11. Depth distribution of the catches as recorded by the scientific observers on board the Spanish fleet in 1999. GHL = Greenland halibut; RED = redfish; PLA = American Plaice; YEL =yellowtail flounder (after Junquera et al. 2000).

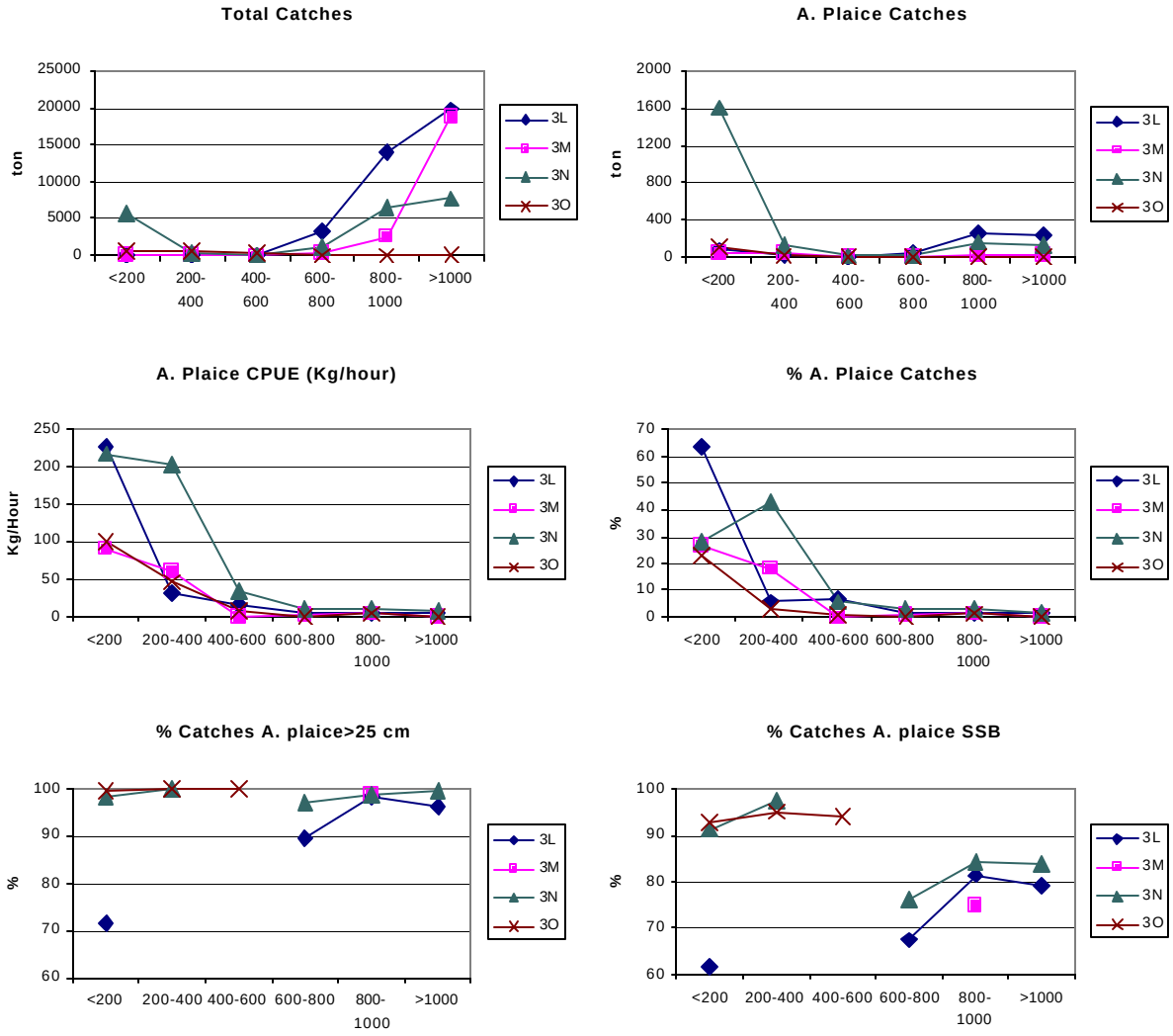

Figure 12. Depth distribution of the Total catches and American Plaice Catches by Division collected by the Spanish scientific observers in the period 1991-2000. Percentage in catches of individuals large than 25cm and the percentage of SSB in the catches (after González et al., 2001, WP 01/15)