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Notes of the Structures and Changes in the Ichthyofauna off West Greenland

by

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Abstract

Several studies analysing fish communities emphasize the management implications of delimitations between demersal fish assemblages. Provisional informations about the structures and changes in the ichthyofauna inhabiting the continental shelf and slope off West Greenland (0-600m depth, south of 67° north latitude) are given.

Regarding the quantitative species composition, the ichthyofauna is mainly composed of a few species belonging to the Boreal Fauna as none of the Arctic species contributes more than 1% to the overall catch in numbers. Comparing the 0-200m and 401-600m depth zones, the abundance and biomass estimates of the latter are clearly lower. Individual size increases with decreasing latitude and an indication of the principle 'deeper-bigger' is found. The decreasing trend in species diversity with decreasing latitude is apparent and the 401-600m depth zone shows relatively high values. During the past 9 years, aggregate abundance and biomass estimates have undergone dramatic changes in coherence with fundamental shifts in species dominance. Apart from the increase for the elasmobranch species starry skate (Raja radiata), the remaining dominant species cod (Gadus morhua), long rough dab (Hippoglossoides platessoides), golden redfish (Sebastes marinus), wolf-fish (Anarhichas lupus) and spotted wolf-fish (Anarhichas minor) display enormous changes and decrease in abundance and biomass indices. These results coincide with changes in temperature and fishing effort and are interpreted as symptoms of ecosystem stress.

Introduction

The exploitation of fish stocks is generally based on catches comprising a variety of species. Multispecies models are developed to consider this fact but require the knowledge of the community structures in the whole ecosystem. On this account, several qualitative and quantitative analyses are published using catch data both from commercial fisheries or surveys to identify persitent spatial boundaries of species assemblages (Murawski et al., 1983; Williams and Hatcher, 1983; Rätz, 1984; Gabriel, 1989; Gomes et al., 1989).

The ichthyofauna of West Greenland waters has been significantly affected by fishing during the past 70 years. For cod the history of exploitation is documented since the recolonization of Greenland in 1721 (Hovgard, 1990). Starting from 1917, cod catches increased to 60,000-100,000 tonnes annually in the 1930'ies taken primarily by a hook and line fishery. After the war, the pertubations due to an intensive fishing came up to the high level of 300,000 tonnes. During the last two decades (1970-90), the annual catch collapsed to approximately 60,000 tons. Apart from the cod, redfish and shrimp fishery, the remaining species are taken more or less as by-catches.

For the period 1982-90, this paper represents the spatial distribution patterns of the total abundance, biomass, mean individual weight and diversity of the ichthyofauna off West Greenland (NAFO Subdiv. 1B-1F) at 0-600m depth as derived from an annual groundfish survey. Additionally, the trends in total abundance and biomass estimates and assessments for the most common species Anarhichas lupus L., Anarhichas minor O., Gadus morhua L., Hippoglossoides platessoides F., Raja radiata D., Sebastes marinus L. and Sebastes mentella T. are described.

Materials and Methods

Fpr the period 1982-90, the analyses are based on data derived from an annual groundfish survey established by the Federal Republic of Germany. The stratified-random survey covers the shelf area and continental slope off West Greenland (NAFO Subdiv. 1B-1F) outside the 3-mile zone to the 600m isobath. Due to favourable weather and ice conditions and to avoid spawning concentrations, the autumn is chosen for the survey time. Figure 1 shows the area of investigation and the geographic stratification. The 4 geographic strata are subdivided to 3 depth strata covering the 0-200m, 201-400m and 401-600m zones, respectively. Thus, this stratification scheme produces 12 strata. Table 1 specifies the names of the strata, strata boundaries, depth zones and strata areas. The standard gear used is the 140-feet bottom trawl rigged with a heavy ground gear and equipped with a small mesh liner inside the cod end. Usually, the towing time amounts to 30 minutes and 4.5 knots are aimed as towing speed. In the case of any net damage of the trawl netting or hangup before 15 minutes towing time, the haul is rejected from the evaluation. In 1987 and 1988, some hauls are not exluded although their towing time is intentionally reduced to 10 minutes due to extreme traces of the echo sounder.

The hauls are randomly distributed following a stratified system. The numbers of valid hauls per stratum are listed in Table 2. During 1982-90, 1,071 successful sets are conducted. The main feature of Table 2 is the high number of tows allocated in the shallow strata 1.1, 2.1, 3.1 and 4.1 (0-200m). The strata 1.2, 2.2, 3.2 and 4.2 (201-400m) are distinguished by significantly lower numbers of hauls, especially the southern strata 3.2 and 4.2 characterized by extremely rough trawling grounds. The remaining strata 2.3, 3.3 and 4.3 (401-600m) are covered inadequately with hauls apart from the northern stratum 1.3. In general, the haul distribution is fairly consistent over the total time series. Informations about the survey design and gear parameters are given by the Working Group on Cod Stocks off East Greenland (Anon., 1991), by Messtorff and Cornus (1985) and by Rätz (1991).

Catches are identified to species or taxonomic units, counted and weighted. Stratified abundance and biomass estimates are calculated using the "swept area" method (Saville, 1977) and a coefficient of catchability taken to 1.0 for all species. Consequently, the estimates are merely an index of abundance and biomass. The respective confidence intervals are given at the 95% level of significance. Strata including less than 5 hauls are excluded from the calculation of the stratified mean abundance and biomass. This is the cause of the differences between the calculated values and the abundance and biomass indices given in the report of the Working Group on Cod Stocks off East Greenland (Anon., 1991) and by Messtorff and Cornus (1989).

Species diversity indices for each haul are computed using the formula of Shannon and Weaver (1963) :

$$H' = - \sum_{i=1}^{s} p_i \log p_i$$

where p_i is the proportion of the i^{th} species in the sample and s is the number of species in the sample (Pielou, 1966).

Results

A total of 69 species or taxonomic units belonging to 26 families (Tab. 3) and comprising a total number of 879,805 individuals are collected. The majority of species (60) is rare in numbers contributing less than <1% to the total catch (Fig. 2).

Patterns of Abundance, Biomass, Mean Individual Weight and Diversity

The spatial distribution patterns of the overall mean abundance, biomass, mean individual weight and species diversity are illustrated in Figure 3. The lowest mean abundance values are calculated for the very deep strata (401-600m), varying among 3.6 and 12.2 thousand individuals/nm². The mean abundance values of the strata covering the 0-200m and 201-400m depth zones are considerably higher and vary among 14 and 57.9 thousand individuals/nm². The highest density values are calculated for stratum 2.1 (0-200m) and 4.2 (201-400m) amounting to 55.1 and 57.9 thousand individuals/nm², respectively.

The spatial distribution pattern of the overall mean biomass is very similar to the mean abundance (Fig. 3). The deepest strata again are characterized by very low values. The mean fish biomass varies among 3.9 and 7.1 tonnes/nm². The mean biomass of the northern stratum 1 varies among the same low level over all depth zones. The remaining strata covering the 0-200m and 201-400m depth zones show maximal values for stratum 2.1 and 4.2 in correspondence with the distribution pattern of the mean abundance. Repectively, these values amount to 38.1 and 50.4 tonnes/nm². The pattern reveals a decrease in biomass with increasing depth for all strata apart from the southern stratum 4.

The strata 1-4 covering the 0-200m and 201-400m depth zones display an increase in mean individual weight with decreasing latitude (Fig. 3). The highest mean individual weight is observed in the southern stratum 4.1 (1.186 kg), whereas the minimum mean weight amounting to 0.255 kg is determined for the northern stratum 1.1. The values of the deeper region (401-600m) vary among 0.482 kg and 1.171 kg and indicate an increasing trend with increasing depth from the 201-400m to the 401-600m depth zone.

In contrast to the trend in mean individual weight, the calculated species diversity decreases with decreasing latitude (Fig. 3). The species composition of the northern stratum 1.1 (0-200m) shows the highest diversity. Apart from this northern area, the mean diversity values of the very deep strata (401-600m) are clearly higher compared to the species diversity of the shallow strata (0-200m) and point to an increasing trend with increasing depth.

Trends in Fish Abundance and Biomass Estimates (Stratified)

The aggregate fish abundance and biomass values splitted into the most common species are illustrated in Figure 4 and 5. During the 1982-90 period, both the total abundance and biomass have undergone dramatic changes. The first 3 years are characterized by a decrease in abundance from 352 millions in 1982 to the minimum value of 188 millions in 1984. The period 1985-87 displays an enourmous increase in abundance by 590% to 1,296 millions while subsequently, the total fish abundance decreases strongly to 243 millions in 1990. This trend is mainly affected by the changes in abundance of the cod stock (Fig. 4). The significantly higher contribution of the non-specifeid species (others) to the total fish abundance during 1986-90 is evident.

The outstanding predominance of the cod in the ecosystem of greenland waters is even more pronounced regarding the trend in aggregate fish biomass (Fig. 5). The estimated total fish biomass decreases from 266 thousand tonnes in 1982 to 77 thousand tonnes in 1984. The period 1985-87 is characterized by a huge increase in biomass to 672 thousand tonnes. Thereafter, a strong decline to the minimum value of 55 thousand tonnes in 1990 is observed. The proportion of non-specified species (others) is of a minor importance. The contribution of the remaining species presented in Figure 5 decreases over the total time series.

For wolf-fish (Anarhichas lupus) the trends in stratified abundance and biomass estimates as well as the respective confidence intervals in per cent are shown in Figure 6. During the period 1982-84, the survey results reveal a major decline both in abundance and biomass from 23 millions to 11 millions and 26 thousand to 7 thousand tonnes, respectively. No significant changes in abundance are determined for the following time till 1990 while the biomass continues to decrease by 4 thousand tonnes indicating an increasing number of small specimens. The confidence intervals of the abundance and biomass estimates vary among 21 and 36%.

Courses in abundance and biomass estimates for the spotted wolf-fish (Anarhichas minor) are illustrated in Figure 7. The abundance values are low and vary among 1.5 millions in 1982 and 0.6 million in 1990. The overall decreasing trend in biomass from 8 thousand tonnes in 1982 to 2.2 thousand tonnes in 1990 is more pronounced although the values increase during 1986-88. The repective confidence intervals range from 26 to 59%.

In 1987, both abundance and biomass estimates of the predominating cod (Gadus morhua) reach their peak amounting to 764 millions and 620 thousand tonnes, respectively (Fig. 8). The 1982-84 period is characterized by a decrease in abundance and biomass. The following 3 years show an enormous increase in abundance by 4,477% and biomass by 2,323%. During 1988-90, the abundance and biomass values decline strongly to 35 millions and 34 thousand tonnes, respectively. The 95% confidence intervals vary over a wide range (26-73%).

The long rough dab (Hippoglossoides platessoides) is the second predominating species. During the period 1982-87, the trends in abundance and biomass estimates show two pronounced peaks in 1983 and 1986 (Fig. 9). For this time, the abundance and biomass values vary among 57-115 millions and 8-22 tousand tonnes, respectively. The estimates of the last 3 years 1988-90 are significantly lower amounting to 29-39 millions and 3-5 tousand tonnes. The variability of the confidence intervals (25-54%) is similar to the values of the spotted wolf-fish.

The starry skate (Raja radiata) is the only elasmobranch taken into consideration (Fig. 10). The results of the stratified calculations indicate an extreme increase in abundance and biomass for the period 1988-89. During the last year, the abundance and biomass estimates decrease from 200 millions to 14 millions and from 4 thousand tonnes to 2.3 thousand tonnes, respectively. The values determined previously are distinctly lower. The confidence intervals of the abundance and biomass estimates range from 24 to 88%.

For golden redfish (Sebastes marinus) trends in abundance and biomass as well as the confidence intervals are illustrated in Figure 11. Both trends are negative over the total time series. During 1982-83, a major decline in abundance and biomass is apparent from 136 millions to 33 millions and from 56 thousand tonnes to 14 thousand tonnes, respectively. From 1984 to 1989, the estimates in abundance and biomass vary among 15 millions and 60 millions and among 4 thousand tonnes and 20 thousand tonnes, respectively. A second major drop is observed for the last year 1990 when the abundance and biomass values amount to 6 millions and 2.5 thousand tonnes, respectively. The vast confidence intervals (30-110%) reflect a low precision of the estimates.

The beaked redfish (Sebastes mentella) lacks a definite trend in abundance and biomass (Fig. 12). During 1982-90, the calculated biomass varies among 700 tonnes and 3.8 thousand tonnes exept for 1987, when suddenly a remarkable increase to 10.5 thousand tonnes is determined. This peak is much more pronounced in the 1987 abundance estimate (152 millions) pointing to the occurrence of small individuals in an enormous number. As already mentioned for the golden redfish, a low precision is achieved in abundance and biomass estimates (34-117% confidence intervals).

Discussion

The ecological approach taken here is to start an examination of the fish community in the continental shelf and slope area outside the 3-mile zone off West Greenland (south of 67° north latitude). 69 taxa belonging to 26 families are recorded presenting elements of the Arctic and Boreal Fauna. Regarding the quantitative species composition, the great majority of the species are rare and the latter component predominates as none of the Artic species contributes more than 1% to the overall catch in numbers. Similar results are documented for the fish fauna around Elephant Island characterized by negligible abundance and biomass of High Antarctic species (Tiedtke and Kock, 1989). Accordingly, most of the near bottom temperatures at the fishing stations off West Greenland are relatively high (Rätz, 1989) pointing to the great influence of the heat input from the Irminger Current (Stein und Buch, 1989).

Community studies on marine demersal fish fauna based on trawl cathces are subject to several methological problems. Boundaries between species assemblages are not clearly defined and hinge on a subjective assessment in spite of the variety of multivariate methods applied. Additionally, the abundance values as derived from catches show a high variability (Taylor, 1953.). Usually, the calculated 95% confidence intervals accounted between 30 and 50% of the stratified means and exceed even 100%. The selectivity of the trawl used may result in misinterpretation of the quantitative species composition and in substantial restrictions concerning comparative investigations in case of different sampling gears. Nevertheless, the identification of fish assemblages as natural compartments in ecosystems has multispecies management implications (Gomes et al., 1989; Muraski et al., 1983).

Comparing the 0-200m and 401-600m depth zones, the spatial distribution patterns of abundance and biomass reveal a decrease with increasing depth. The same trends in abundance estimates are reported by Haedrich et al. (1980), Merrett and Marshall (1980), Pearcy et al. (1982) and Rätz (1984) for the continental slope of the northwestern Atlantic, the upwelling areas off northwest Africa, the continental slope of the northeastern Pacific and waters west of British Isles, respectively. On the contrary, the patterns of biomass in these areas differ.

The increase in mean individual weight with decreasing latitude is evident for the depth zones 0-400m. The indication of an increase in individual size with increasing depth is in conformity with the findings for the waters west of British Isles (Rätz, 1984) and the northwestern Atlantic (Haedrich and Rowe, 1977), whereas the principle 'deeper-bigger' is not observed regarding the upwelling areas off northwest Africa (Merrett and Marshall, 1980) and the continental slope of the northeastern Pacific (Pearcy et al., 1982).

A good agreement is apparent between the relatively high species diversity at the 400-600m depth zone and the fish communities of the continental slopes of the northwestern Atlantic (Haedrich et al., 1980), the northeastern Pacific (Pearcy et al., 1982) and the waters west of British Isles (Rätz, 1984). These areas show maximum values at the depth zones ranging from 600-800m. The decreasing trend in mean diversity with decreasing latitude is remarkable. The calculated diversity values seem to be comparable to those observed by Tiedtke and Kock (1989) for the fish fauna around Elephant Island and by Hubold (1991) for East Greenland and the North Sea, whereas the species diversity of the communities found in the high Artic Weddel Sea (Schwarzbach, 1988), the Ross Sea and the Prydz Bay (Hubold, 1991) are substantially higher.

During the past 9 years, the aggregate abundance and biomass indices display dramatic changes in coherence with major shifts in species dominance. Both trends show minimum values in 1984 when extremely cold anomalies are observed (Stein and Buch, 1984). The following increase in total abundance and biomass in 1985-87 coincides with a warming off West Greenland (Stein, 1986 and 1987). During 1988-90, the strong decline in abundance and biomass estimates happens concurrently with a decrease in temperature (Stein, 1991). The coincidence of variations in temperature with the courses in total abundance and biomass indices underlines the importance of the environmental conditions for the changes in the ecosystem being located at the northern-most limit of distribution concerning the main ichthyofaunistic elements. Similar trends in aggregate abundance and biomass are determined for the fish community inhabiting the shelf area and continental slope off East Greenland (Rätz, 1990). The cod (Gadus morhua) is the predominating species off West Greenland, whereas the quantitative species composition off the ichthyofauna off East Greenland is mainly composed of golden redfish (Sebastes marinus) and beaked redfish (Sebastes mentella).

The most striking changes in abundance and biomass indices have been noted for the predominating cod (Gadus morhua). The high values observed during 1987-89 reach historical levels. Hansen (1949) already describes the periodical occurrence of cod in Greenland waters and Hovgard and Messtorff (1987) suggest a main recruitment from Icelandic waters by a larval drift. The collapse in abundance and biomass determined in 1988-90 is partly due to an emigration and to an increased fishing effort (Anon., 1991). During the period 1985-90, the trends in abundance and biomass estimates for the second predominating long rough dab (Hippoglossoides platessoides) are very similar to the cod. A short-term increase has been followed by a dramatic decline. Apart from the starry skate (Raja radiata), the species wolf-fish (Anarhichas lupus), spotted wolf-fish (Anarhichas minor) and golden redfish (Sebastes marinus) show remarkable losses too. The generally decreasing trend in abundance and biomass estimates for the main species and the increase for the starry skate in recent years are symptoms of ecosystem stress as observed for the northwest Atlantic continental slope by Gabriel (1989). On the contrary, there is a lack in definite trend in the estimates for the beaked redfish (Sebastes mentella). The enormous increase in abundance and biomass observed in 1987 points to an 0-group drift originating from East Greenland waters.

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Table 1 Specification of the strata.

64°15'N - 67°00'N 50°00'W - 57°00'W
Stratum 1.1 depth 1-200m, area 6,805 nm^2
Stratum 1.2 depth 201-400m, area 1,881 nm^2
Stratum 1.3 depth 401-600m, area 1,191 nm^2

62°30'N - 64°15'N 50°00'W - 55°00'W
Stratum 2.1 depth 1-200m, area 2,350 nm^2
Stratum 2.2 depth 201-400m, area 1,018 nm^2
Stratum 2.3 depth 401-600m, area 259 nm^2

60°45'N - 62°30'N 48°00'W - 53°00'W
Stratum 3.1 depth 1-200m, area 1,938 nm^2
Stratum 3.2 depth 201-400m, area 742 nm^2
Stratum 3.3 depth 401-600m, area 57 nm^2

59°00'N - 60°45'N 44°00'W - 50°00'W
Stratum 4.1 depth 1-200m, area 2,568 nm^2
Stratum 4.2 depth 201-400m, area 971 nm^2
Stratum 4.3 depth 401-600m, area 353 nm^2

Table 2 Number of valid hauls per stratum, 1982-90

Stratum Year	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3
1982	20	11	4	16	7	2	9	6	0	13	2	0
1983	26	11	4	25	11	0	17	5	0	18	4	0
1984	25	13	13	26	8	2	18	6	1	21	4	1
1985	10	8	3	26	10	1	17	5	0	21	4	0
1986	27	9	7	21	9	3	16	7	1	18	3	0
1987	25	11	8	21	4	1	18	3	0	21	3	2
1988	34	21	9	28	5	1	18	5	2	18	2	1
1989	26	14	5	30	9	1	8	3	0	25	3	0
1990	19	7	7	23	8	0	16	3	0	21	6	1

Table 3 List of taxa and rank species importance as illustrated in Figure 3.

Taxa	Families	Rank species importance
Myxine glutinosa Linnaeus, 1758	Myxinidae	23
Centroscyllium fabricii (Reinhardt, 1825)	Squalidae	33
Centroscymnus crepidater (Bocage & Capello, 1864)	"	57
Etmopterus spinax (Linnaeus, 1758)	"	30
Somniosus microcephalus (Bloch & Schneider, 1801)	"	50
Squalus acanthias Linnaeus, 1758	"	63
Bathraja spinicauda (Jensen, 1914)	Rajidae	54
Raja radiata Donovan, 1808	"	8
Raja batis Linnaeus, 1758	"	60
Raja clavata Linnaeus, 1785	"	62
Raja fyllae Lütken, 1888	"	38
Raja lintea Fries, 1839	"	49
Raja species	"	42
Alepocephalus bairdii Goode & Bean, 1879	Alepocephalidae	61
Maurolicus muelleri (Gmelin,, 1788)	Sternoptychidae	65
Malacosteus niger Ayres, 1848	Malacosteidae	66
Argentina silus (Ascanius, 1775)	Argentinidae	48
Mallotus villosus (Müller, 1776)	Osmeridae	9
Species	Myctophidae	45
Species	Paralepididae	47
Synaphobranchus kaupi Johnson, 1862	Synaphobranchidae	36
Notachanthus chemnitzii Bloch, 1788	Notachanthidae	51
Coryphaenoides rupestris Gunnerus, 1765	Macrouridae	12
Macrourus berlax Lacepede, 1801	"	25
Boreogadus saida (Lepechin, 1774)	Gadidae	32
Gadus morhua Linnaeus, 1758	"	1
Gadus ogac	"	27
Melanogrammus aeglefinus (Linnaeus, 1758)	"	26
Micromesistius poutassou (Risso, 1826)	"	28
Pollachius virens (Linnaeus, 1758)	"	64
Brosme brosme (Ascanius, 1772)	"	39
Gaidropsarus vulgaris (Cloquet, 1824)	"	40
Molva dipterygia (Pennant, 1784)	"	43
Onogadus argentatus (Reinhardt, 1837)	"	44
Onogadus ensis (Reinhardt, 1837)	"	56
Rhinonemus cimbrius (Linnaeus, 1758)	"	68
Phycis blennoides (Brünnich, 1768)	"	58
Antimora rostrata Günter, 1878	Moridae	67
Lepidion eques (Günther, 1887)	"	53
Species	Ammodytidae	6
Anarhichas denticulatus Kröyer, 1845	Anarhichadidae	22
Anarhichas lupus Linnaeus, 1758	"	7
Anarhichas minor Olafsen, 1772	"	17
Leptoclinus maculatus (Fries, 1837)	Lumpenidae	21
Eumesogrammus praecisus	"	55
Gymnelus viridis (Fabricius, 1780)	Zoarcidae	41
Lycodes species	"	14
Sebastes marinus (Linnaeus, 1758)	Scorpaenidae	3
Sebastes mentella Travin, 1951	"	4
Sebastes viviparus Kroyer, 1845	"	69
Sebastes species	"	5
Artediellus species	Cottidae	13
Icelus bicornis (Reinhardt, 1840)	"	29
Myoxocephalus scorpioides (Fabricius, 1780)	"	19
Triglops murrayi Günther, 1888	"	20
Triglops pingeli Reinhardt, 1831	"	59
Triglops species	"	11
Cottunculus species	Psychrolutidae	18
Agonus cataphractus (Linnaeus, 1758)	Agonidae	31
Leptagonus decagonus(Schneider, 1801)	"	24
Cyclopterus lumpus Linnaeus, 1758	Cyclopteridae	35
Eumicrotremus spinosus (Fabricius, 1776)	"	15
Careproctus species	Liparididae	34
Liparis species	"	37
Paraliparis species	"	52
Hippoglossus hippoglossus (Linnaeus,1758)	Pleuronectidae	16
Hippoglossoides platessoides (Fabricius, 1780)	"	2
Glyptocephalus cynoglossus (Linnaeus, 1758)	"	46
Reinhardtius hippoglossoides (Walbaum, 1792)	"	10

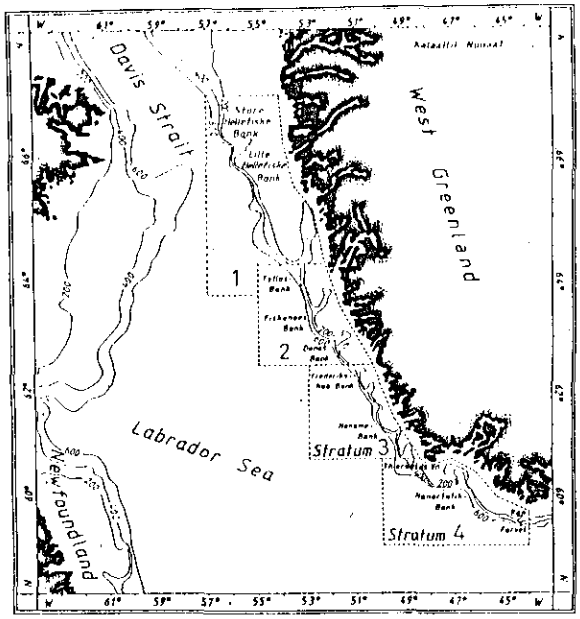

Figure 1 Area of investigation and stratification scheme as specified in Table 1.

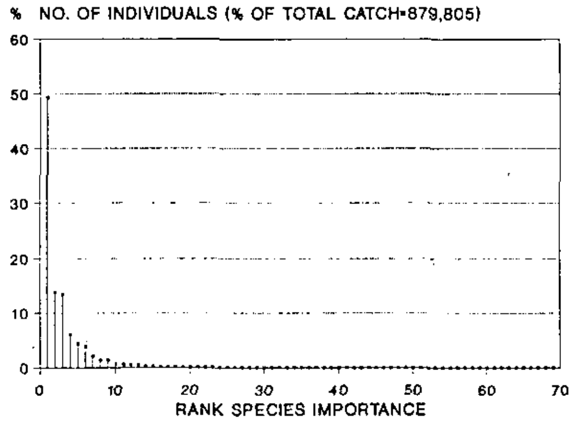

Figure 2 Rank species importance in per cent of total catch in numbers. Species are listed in Table 3.

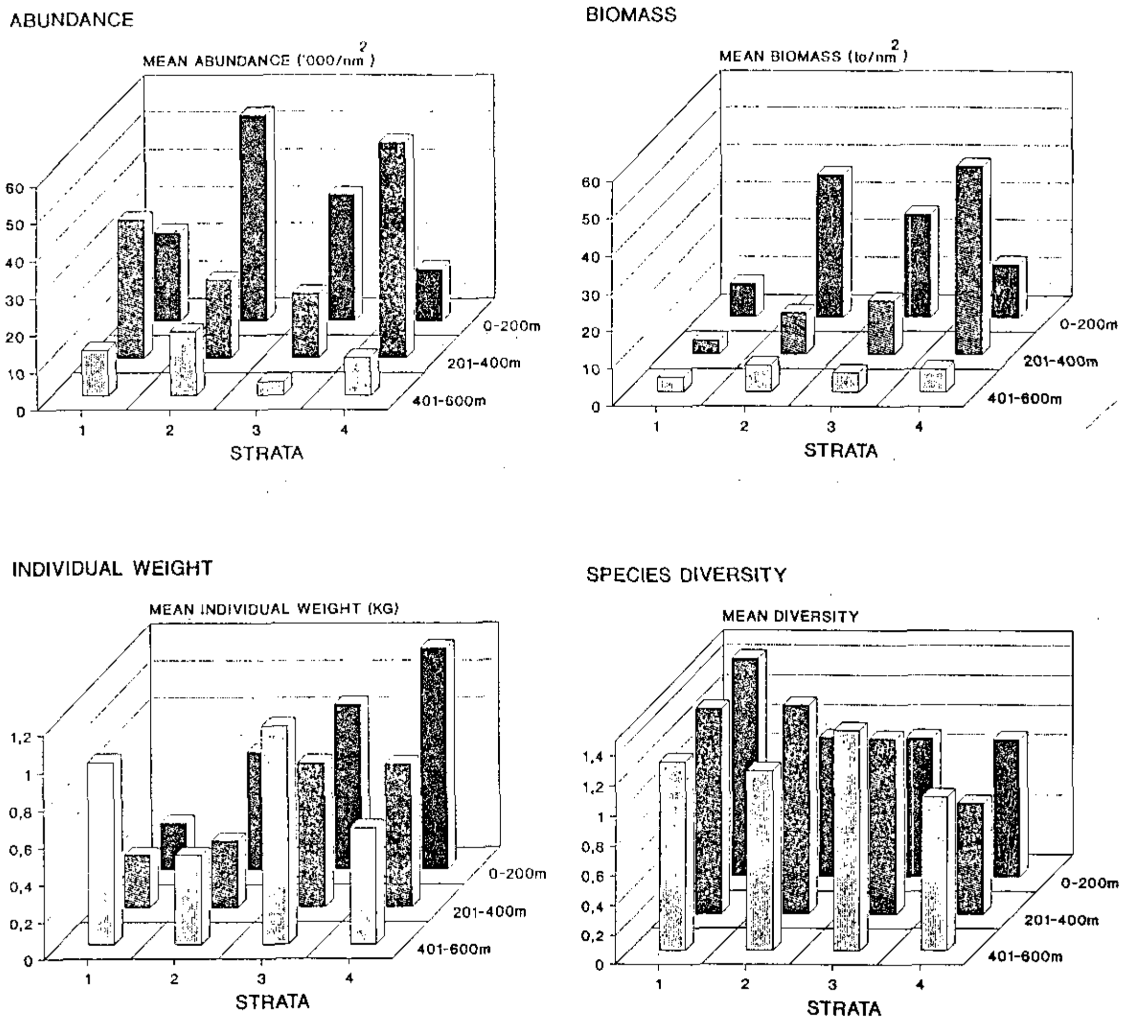

Figure 3 Spatial distribution pattern of the overall mean abundance (n/nm2), biomass (to/nm2), individual weigth (kg) and species diversity.

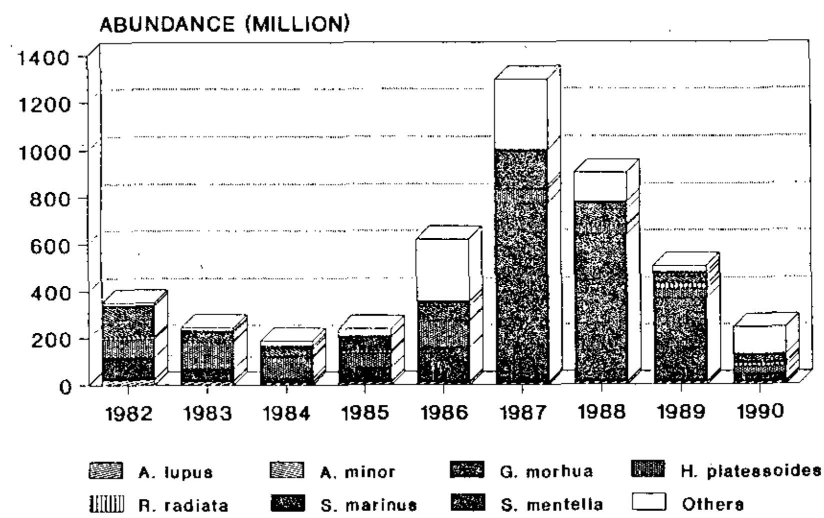

Figure 4 Aggregate fish abundance estimates (stratified) of NAFO Subdiv. 1B-1F, 1982-90.

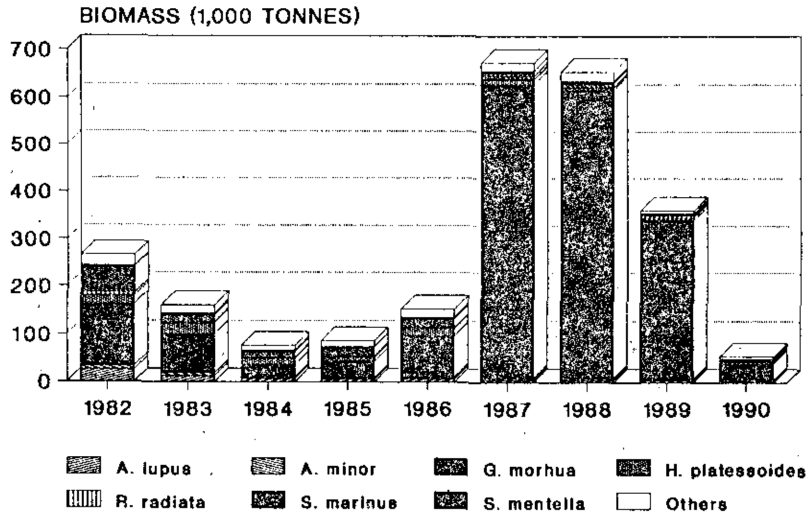

Figure 5 Aggregate fish biomass estimates (stratified) of NAFO Subdiv. 1B-1F, 1982-90.

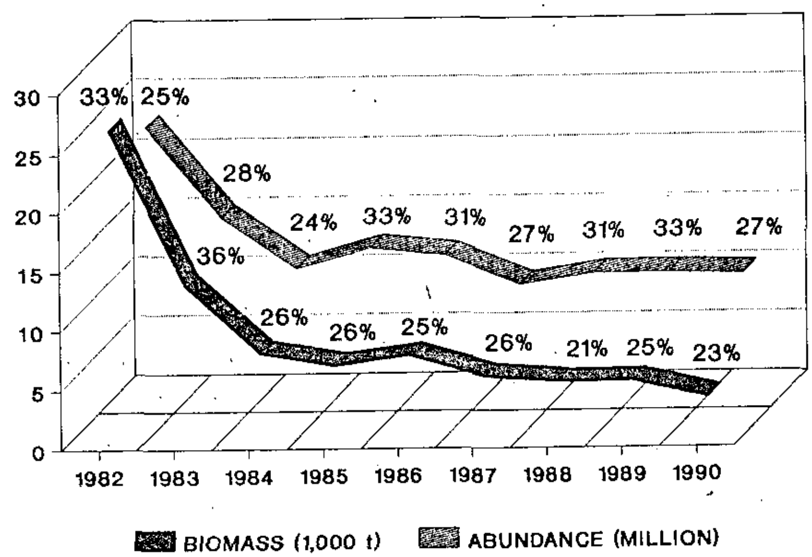

Figure 6 Stratified abundance and biomass estimates of wolf-fish (Anarhichas lupus) and respective confidence intervals in per cent, 1982-90.

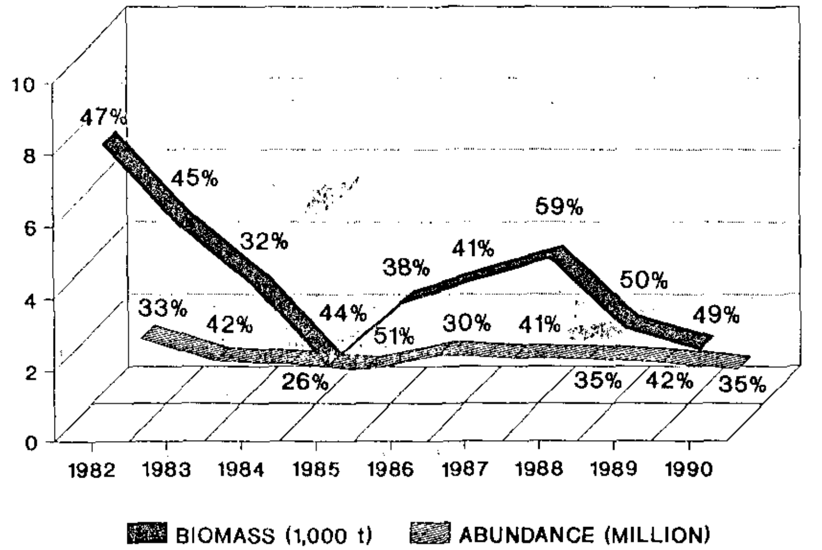

Figure 7 Stratified abundance and biomass estimates of spotted wolf-fish (Anarhichas minor) and respective confidence intervals in per cent, 1982-90.

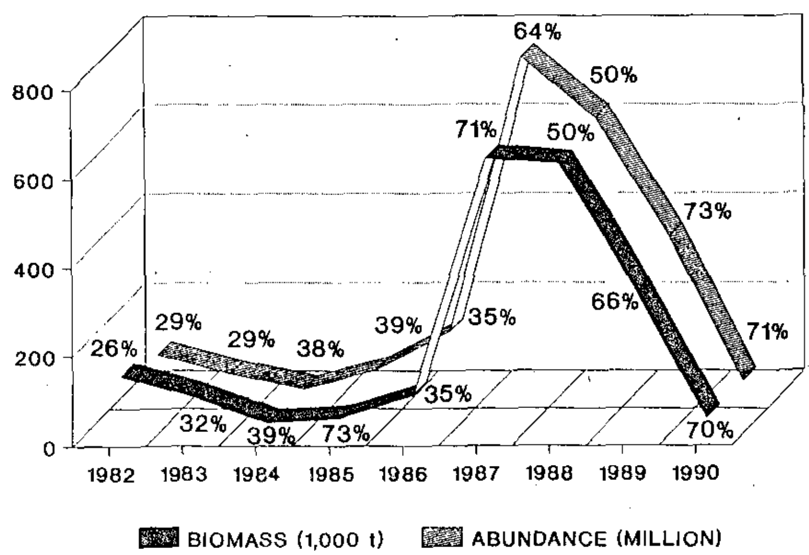

Figure 8 Stratified abundance and biomass estimates of cod (Gadus morhua) and respective confidence intervals in per cent, 1982-90.

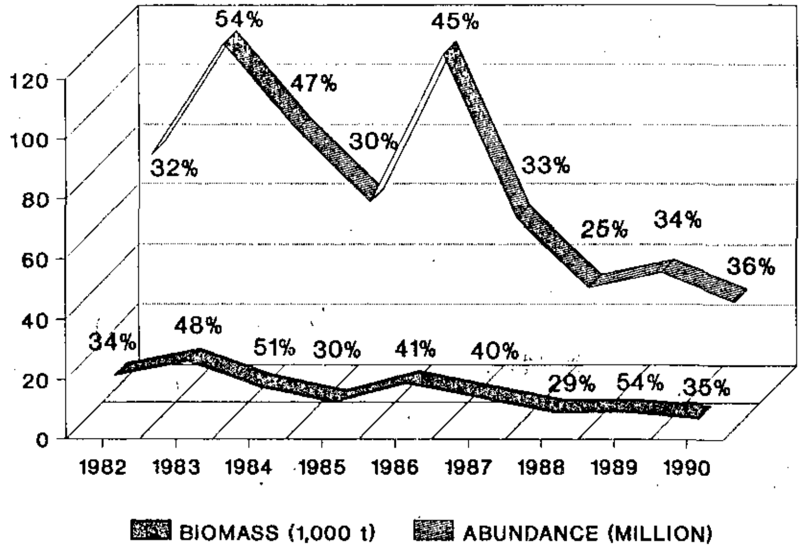

Figure 9 Stratified abundance and biomass estimates of long rough dab (Hippoglossoides platessoides) and respective confidence intervals in per cent, 1982-90.

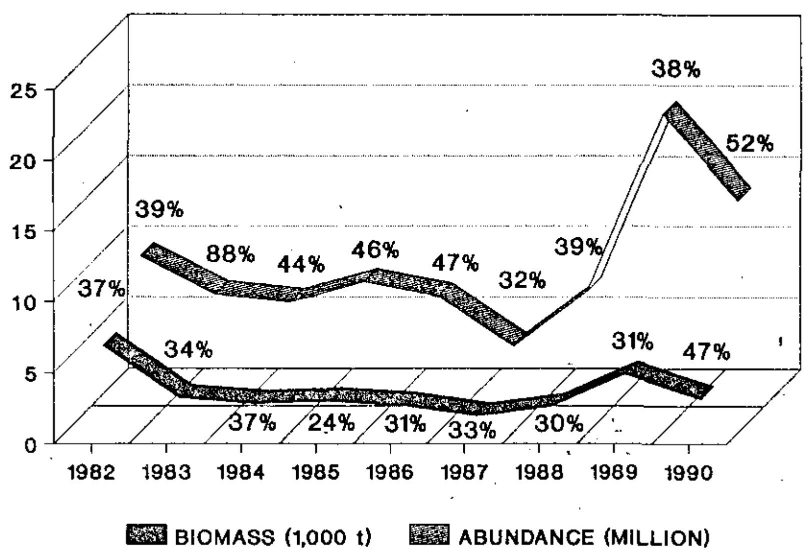

Figure 10 Stratified abundance and biomass estimates of starry skate (Raja radiata) and respective confidence intervals in per cent, 1982-90.

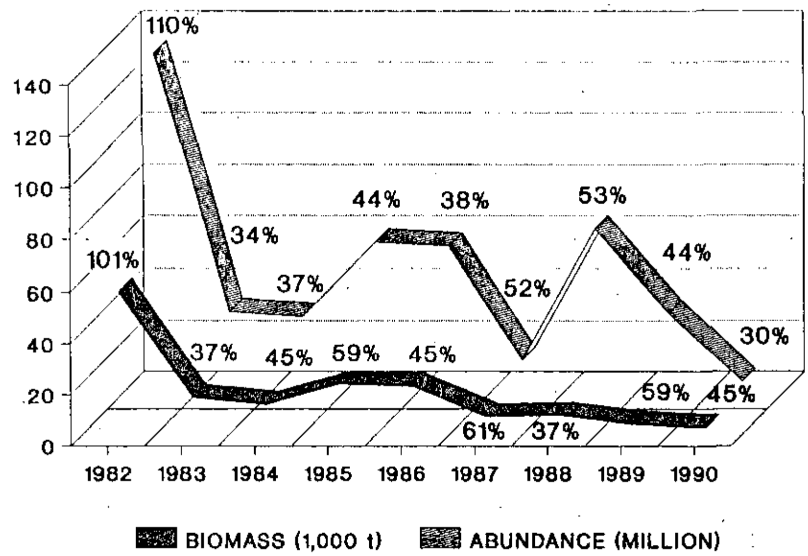

Figure 11 Stratified abundance and biomass estimates of golden redfish (Sebastes marinus) and respective confidence intervals in per cent, 1982-90.

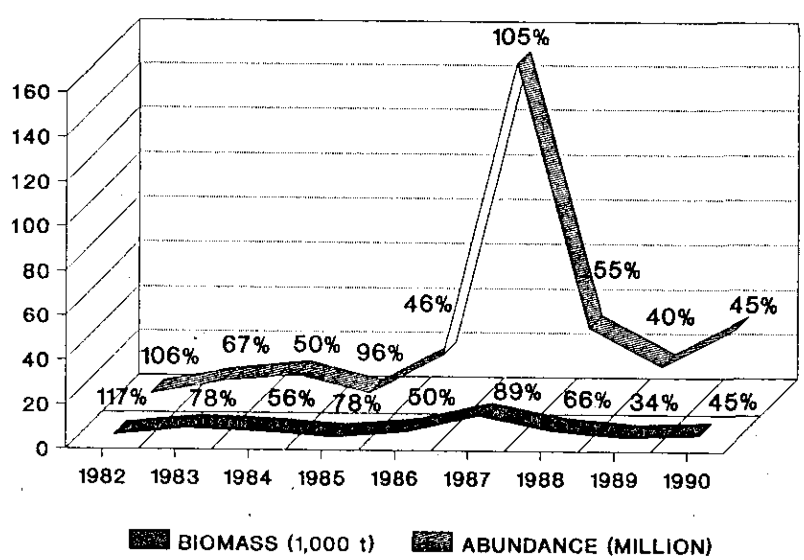

Figure 12 Stratified abundance and biomass estimates of beaked redfish (Sebastes mentella) and respective confidence intervals in per cent, 1982-90.