Northwest Atlantic Fisheries Organization

Serial No. N1374 NAFO SCR Doc. 87/74

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1987

A Review of the Natural History, Fisheries and Management of Greenland Halibut (Reinhardtius hippoglossoides) in the Eastern Norwegian and Barents Sea

by

Olav Rune Godø

Directorate of Fisheries, Institute of Marine Research
P. O. Box 1870, N-5011 Bergen-Nordnes, Norway

and

Tore Haug

Department of Marine Biology, Tromsø Museum, University of Tromsø
P. O. Box 2550, N-9001, Tromsø, Norway

INTRODUCTION

The Greenland halibut, Reinhardtius hippoglossoides, a flatfish of the family Pleuronectidae, is usually regarded as a boreal-Arctic form (Fedorov 1971). The species is distributed in both the Pacific and Atlantic Oceans. Electrophoretic results suggest a genetic divergence between these regions at the subspecies rather than the stock level (Fairbairn 1981).

In the Atlantic Ocean the species is found off the North American and Greenland coasts, in the Iceland/Faroes area and in the eastern Norwegian and Barents Sea (Andriyashev 1954). The management in the northeast Atlantic is based upon the assumption that there are two different stocks of Greenland halibut; the Iceland/-Faroes stock and the stock off Norway and in the Barents Sea. Since tagging experiments have documented considerable migration from Iceland to the west coast of North Norway, thus indicating some mixing (Sigurðsson 1981), the two units must be considred as management units rather than stock units.

Prior to the middle 1960s Greenland halibut in the eastern Norwegian/Barents Sea was only moderately exploited, almost exclusively by longlines. In the late 1960s and early 1970s the increased use of bottom trawls in the fisheries led to catches which far exceeded the long term yield, and the stock was substantially reduced (Anon.1978 a).

Note: Authorship equal

In the following we present a review of the existing knowledge on the distribution and life history of Greenland halibut in the eastern Norwegian Sea /Barents Sea and the development of the fisheries and management.

DISTRIBUTION

Total area

The Greenland halibut is a eurytopic species, adapted to life in a wide range of hydrologic parameters; it is found from a depth of 20 m to 1200 m at temperatures between 1.5^0C to 10.0^0C (see Fedorov 1971). In the eastern Norwegian Sea (Fig.1), it is distributed along the continental slope from the Norwegian coast to the Spitzbergen Islands, and, in lower numbers, along the coast of Norway as far south as Bergen (Andriayshev 1954, Hognestad 1969). In the Barents Sea it is widely distributed in low numbers eastwards to the Kanin Peninsula and the southwestern coast of Novaja Zemlja in the south, and northwards to the coast of Spitzbergen (Milinsky 1944).

Differential distribution by life history stage

Godø & Haug (1967a) have documented a clear size dependent geographic and depth distribution of the species: Higher proportions of small fish are found north of 76^0 than south of this latitude, and large fish are most abundant in the deeper areas. The northern areas, particularly the coastal areas west and north of Spitzbergen serve as nursery grounds for the species while the mature stock is distributed further south, both along the continental slope where spawning areas are also located (Hognestad 1961, 1969, Haug & Gulliksen 1982) and in the Barents Sea (Milinsky 1944). Adult specimens seem more stenothermal than juveniles, avoiding surface layers and shallower depths and generally prefering depths between 200 and 800 m; during reproduction their depth distribution is even more limited (600-900 m) (Fedorov 1971).

REPRODUCTION

Maturity

Male Greenland halibut reach sexual maturity at younger ages and smaller sizes than females. In their 1971-1984 studies of the Norwegian-Barents Sea stock, Kovtsova & Nizovtsev (1985) found 50% maturation for males and females to occur at ages of 4-5 and 9-10 years respectively (Fig.2); corresponding lengths were approximately 40 and 60 cm (Fig.3). These observations indicate that the species in this region matured at younger ages and smaller sizes during the last 15 years than during the 1940s (Milinsky 1944) and 1960s (Sorokin 1967). This change in the age

and size at maturity is most probably related to the pronounced increase in growth rates observed in late 1970s. Corresponding in time to these changes in age at maturity and growth were observations of reduced abundance of the population because of intense exploitation (Kovtsova & Nizovtsev 1985). Such density-dependency in population parameters has also been observed in a number of other flatfish species, e.g., the Atlantic halibut, Hippoglossus hippoglossus (Haug & Tjemsland 1986, Jakupsstovu & Haug 1987).

Gonads

In studying mature females from the Norwegian-Barents Sea, ranging in total length from 51 to 81 cm, Sorokin (1967) observed absolute fecundities varying between c. 7000 and 140 000 eggs. This is in good agreement with observations made in the western Atlantic by Bowering (1980) who also found Greenland halibut fecundity to be highly correlated with length and, to a lesser extent, with age.

Soviet investigators studying oogenesis and the sexual cycle of prespawning Greenland halibut from the Nowegian/Barents Sea have observed two groups of oocytes containing yolk: transparent mature oocytes 3.8 - 4.2 mm in diameter, and nontransparent white oocytes, 0.6 - 1.2 mm in size and in the phase of initial yolk accumulation; the latter oocytes are not spawned in the same year as the larger oocytes, but are released during spawning in the following year (Sorokin 1967, Fedorov 1968, 1971).

Investigations of male gonads have shown that spermatogenesis in the Greenland halibut population of the Barents Sea varies: in one group studied, spermatogenesis was the same in all fish, while in another group it was not (Sorokin & Grigoryev 1968). From these findings the authors assumed that spawning is simultaneous for some fish but for others, it may be protracted or fish may spawn at two different time periods.

Spawning

From the microscope analysis of gonads, Fedorov (1971) has suggested that Greenland halibut are potentially capable of intermittent spawning. This is consistent with the fact that ripe spawners have been observed in spawning areas of the continental slope practically year-round. The comparatively stable thermal regime of the spawning grounds and favourable feeding conditions probably contribute to the ability of Greenland halibut to spawn year-round (Sorokin 1967, Fedorov 1971). This apparent year-round spawning has caused some question as to the main spawning period of the species. Milinsky (1944) has suggested spawning in April-July, with a probable peak of activity in May/June. This was also

the conclusion of Hognestad (1969), based on the sizes of the 0-group fish observed in August-September, and of Breiby & Eliassen (1984) who observed females with running roe in June and July. Contradicting this are findings from Soviet investigations carried out in spawning areas which point towards bulk spawning during the period October-January; this period corresponds to the time of maximum intensification of the Norwegian Atlantic Current which plays a decisive role in the formation of continental slope temperature conditions favouring Greenland halibut spawning (Fedorov 1971). The discrepancy among observations of the spawning season clearly calls for further investigations of the reproductive processes of the Norwegian/Barents Sea stock of Greenland halibut.

The main spawning grounds of Greenland halibut in the Norwegian-Barents Sea (see fig.1) are located at depths of 600-900 m along the continental slope between 70^0N and 75^0N, with a particularly large accumulation of spawners being located between $71^0$30'N and $73^0$30'N (Hognestad 1969, Nizovtsev 1969). Observation of Greenland halibut females with running roe at 66^0N indicate that spawing may take place further south along the continental slope further south as well (Breiby & Eliassen 1984).

PRE-ADULT PHASES

Embryonic

No observations of Greenland halibut eggs in pelagic waters of the Norwegian/Barents Sea have been documented. Results from ichthyoplankton surveys in Davis Strait (Smidt 1969), Denmark Strait (Magnusson 1977), and the Bering Sea (Bulatov 1983) suggest that the eggs have a bathypelagic vertical distribution. The eggs are very large (3.8 - 4.3 mm in diameter) and characterized by a reddish-brown egg membrane. No detailed description of the stages of development of the Greenland halibut eggs appears to have been published. However Magnusson (1977) separated eggs captured bathypelagically in the Denmark Strait into three different developmental classes.

Larvae/Postlarvae

In the eastern Norwegian and Barents Sea, standard international 0-group fish surveys have been performed annually in July/August since 1965. Pelagic 0-group of Greenland halibut have mostly been found in the areas between Bear and Hopen Islands and Spitzbergen and in coastal waters to the west and north of Spitzbergen (Hognestad 1969, Anon. 1970, 1972, 1973, 1974, 1975, 1976, 1977a, 1978b, 1979, 1980, 1981, 1983, 1984a). These were all postlarvae, well past the yolk-sac stage, and their sizes ranged between 20

and 80 mm with the bulk of specimens being c. 40-50 mm (see Fig. 4). Yolk-sac larvae of Greenland halibut (10 -15 mm) have so far been found only in areas off western Greenland at 600 - 1000 m depths (Smidt 1969). The reason for the lack of smaller sized larvae in the Norwegian/Barents Sea area is certainly that ichthyoplankton surveys have not been carried out in the deep layers where Greenland halibut is supposed to spawn (Hognestad 1969).

Most probably, the eggs and larvae are carried northwards from the spawning areas along the continental slope between 66^0N and 75^0N to Spitzbergen coastal waters by the Spitzbergen Atlantic Current (see Helland-Hansen & Nansen 1909). The unusually long larval period of the species probably accounts for the long period of drift required for the larvae to reach the nursery area. The movement of the left eye in pelagic Greenland halibut larvae starts at a length of 30-35 mm, and metamorphosis is complete at a larvae length of c. 60 mm (Hognestad 1969). At 35-40 mm, the larvae are still transparent - often with their intestines filled with red-coloured food, and the maximum size in pelagic waters seems to be c. 80 mm (Hognestad loc. cit.). Consequently, metamorphosis is completed well before the larvae settle to the bottom. The pigmentation of larvae from Spitzbergen waters is identical to that described by the very thorough observations made in West Greenland waters (see review by Jensen 1935). The latter author also presents gives some excellent plate drawings of Greenland halibut in various stages of larval and juvenile development.

Temperatures in the pelagic layers of the nursery area around Spitzbergen during the period of July-September when Greenland halibut larvae have been observed, usually ranges within $2-5^0$C (Anon. 1984, Normann & Pettersen 1984, Normann 1986).

Immatures

Greenland halibut found in bottom waters of Spitzbergen coastal areas, are small (10-50 cm), ranging in age from 1-6 years (Fig. 5) (Hognestad 1961, Haug & Gulliksen 1982). Since the youngest age groups (0-4 years) are not numerous in other parts of the Barensts Sea or along the Norwegian coast (Andriyashev 1954, Hognestad 1969), it has been concluded that the Spitzbergen coastal areas most probably serves as the main nursery area for the eastern Norwegian Sea and Barents Sea stock. The occurrence in some years of pelagic postlarvae in the Bear Island-Hopen area may point towards a possible recruitment from these sites in certain years (Godø & Haug 1987b). I-group Greenland halibut have also been caught further north along the east coast of Spitsbergen at times (unpubl. data).

The bottom temperatures in Spitzbergen coastal areas varies from

year to year (Normann & Pettersen 1984, Normann 1986). During the summer months, when most research surveys in the nersery areas are made, juveniles are mainly found in temperatures varying from 0^0C to 3.2^0C, in a few cases they have been found in temperatures below 0^0C (Hognestad 1969, Godø & Haug 1987a).

Haug & Gulliksen (1982) give some data on the growth and food of immature Greenland halibut in Spitzbergen coastal waters. Growth was observed to be approximately linear in age classes 1 through 6, with an average yearly length increment of 7.77 cm. Their diet (as observed in August) was dominated by polar cod (Boreogadus saida) and prawns (Pandalus boralis) which respectively were found in 62.1% and 18.4% of the stomachs examined.

Most juvenile Greenland halibut appear appear to spend their first 3-4 years of life in Spitzbergen waters; thereafter they start southward migrations toward areas occupied by the adult stock (Haug & Gulliksen 1982). Norwegian tagging experiments performed in Spitzbergen coastal waters (78^0-79^0N) have produced recaptures along the continental slope as far south as southwest of Bear Island at about latitude 73^0N (Godø & Haug 1987a). Furthermore, Soviet tagging experiments (Sorokin 1967) in the areas southwest of Bear Island have shown long distance easterly migration penetrating far into the Barents Sea as well as south- and southwestwards towards the areas off the west coast of North Norway; no long-distance northward migrations to the areas west of Spitzbergen have been observed.

ADULT PHASE

Distribution and migrations

According to Godø & Haug (1987a), the Greenland halibut population in the Norwegian/Barents Sea is characterized by large proportions of small fish north of 76^0N, while south of this latitude, large fish dominate. This indicates that the main distribution of the adult stock is south of 76^0N, along the continental slope as well as in parts of the Barents Sea (Fig. 1).

Based on the seasonal distribution of catches of Greenland halibut, Milinsky (1944) hypothesized seasonal migrations of the species. He suggested that sexually mature fish migrate to the south-western regions of the Barents Sea in winter (including the continental slope area) where spawning occurs. After spawning the adult fish were believed to gradually migrate to the more easterly regions of the Barents Sea. This adult migration pattern has been supported by tagging experiments (Sorokin 1967). The latter author also demonstrated northward and southward movements of adult fish along the continental slope as well as towards the coast of Norway.

As previously mentioned, tagging experiments have demonstrated migrations of Greenland halibut from Icelandic waters to the Norwegian coast and the Barents Sea (Sigurðsson 1981). These migrations indicate long distance migrations and the potential crossing of deep sea basins. No recaptures have thus far been reported from Icelandic waters of fish tagged in Norwegian slope areas (Anon. 1978a).

Sex ratio and size/age distribution

The sex ratios observed from catches of adult fish have indicated that males far outnumber females (number of males vs. number of females: 2.18-?2.39; Nizovtsev 1969, Kovtsova & Nizovtsev 1985).

In their comprehensive study of the presumably adult population of the Norwegian/Barents Sea Greenland halibut during the period 1971-1984, Kovtsova & Nizovtsev (1985) observed a size range of 30 to 105 cm with the bulk of individuals between 45-60 cm (Fig.6). This is consistent with other observations in these areas (Nizovtsev 1969, Lahn-Johannessen 1972, Krzykawski 1975). According to Nizovtsev (1969), the assortment of Greenland halibut in the catches is not constant throughout the October-January period (which he claims to be the main spawning period): The females tended to be largest in the middle of the period, while no seasonal variation was observed in length distribution of the males (Fig.7).

The age range of fish caught in the areas of presumed adult distribution has been oberved to be 5-15 years (Milinsky 1944, Nizovtsev 1969, Lahn-Johannessen 1972, Krzykawski 1975, Kovtsova & Nizovtsev 1985). For pooled sexes, the age groups 7-10 years were most frequently taken. Treating the sexes separately, however, Kovtsova & Nizovtsev (1985) found that most of the males were 7 or 8 years old, while females of ages 10-13 years were most abundant (Fig.8).

The findings of Nizovtsev (1969) and Kovtsova & Nizovtsev 1985) that females in the adult population are less abundant in numbers than males, is certainly a result of females maturing at a larger size and older age than males (see Figs 2 and 3). This higher age at maturity for the females would have exposed them to higher natural and fishing mortality as immatures compared to the males.

Growth

According to Kovtsova & Nizovtsev (1985), as discussed previously, an increase in the growth rate of Greenland halibut has taken place in the Norwegian/Barents Sea during the second half of the 1970s due to a decline in abundance of the stock from intense exploitation in the late 1960s and early 1970s. Their growth data are illustrateded in Figs 9 and 10. Such density-dependency in

growth parameters is also observed in the Atlantic halibut (Haug & Tjemsland 1986). Female growth slightly exceeded male growth from about age 8-9 (Figs 9 and 10), which is the average age at which females attain sexual maturity (see Fig.2). This is consistent with previous observations of the Norwegian/Barents Sea stock of Greenland halibut by Krzykawski (1975). Such differences in growth rates between the sexes have also been observed in a number of other flatfish species. It is probably attributable to the positive relationship between fecundity and body size which favours rapid growth in female fish after the onset of maturity (Roff 1982).

Feeding

Data on feeding of adult specimens of the Norwegian-Barents Sea stock of Greenland halibut is not very substantial, although some stomach analysis were carried out on fish caught during spawning (October-January) in 1964-1967 (Nizovtsev 1969): The results suggested that male specimens fed less energetically than females; however, very little was found in the stomachs, which might suggest reduced food intake during spawning. The food composition was in agreement with the belief that this species feeds mainly in pelagic waters (see Smidt 1969). The diet was comprised mainly of cephalopods (41.7%) and fish (32.0%). The latter group was quite variable with blue whiting, Micromeistitius poutassou, and herring, Clupea harengus, as the most frequent components.

FISHERIES AND MANAGEMENT

Total catch

The first official recorded catch of Greenland halibut in the northeast Atlantic (about 1000 tons) is found in the Norwegian fisheries statistics of 1942. Originally the species was taken as a by-catch in fisheries operating in deeper waters off the North Norwegian coast. After the Second World War a directed fishery with bottom long line developed (Lahn-Johannessen 1972), and catches gradually increased to about 11000 tons in 1963 (Fig. 11). Until that time the fishery was almost exclusively a Norwegain activity. There is some uncertainty about the accuracy of catch statsistics from the 1960s because Greenland halibut were partially categorized as "Various Pleuronectiformes" in the ICES Bulletin Statistique (Lahn-Johannessen 1972). There was a tremendous increase in the total catches from 1964 to 1970 (Fig. 11). This expansion period was followed by a sudden drop during the next four years. After that some variation has occurred, but the catches have generally shown a downward trend until they leveled out during the 1980-ies.

Catch by area

The location of the main fishing grounds by ICES subareas (Fig.

12) are the western part towards the Norwegian coast in subarea I (eastern Barents Sea), along the continental slope of the Norwegian Sea between 67°N and 73°30'N in subarea IIa, and along the continental slope, mainly in the southern part, in subarea IIb (the Svalbard area). Most variation in catches occurs in area IIb. The peak in the total catches around 1970 (Fig.11) was the result of a tremendous increase in catches in this area (Fig. 12). Catches were the highest in area IIa prior to 1969, but decreased significantly after 1970. A similar, but not so pronounced, trend occurred at the end of the 1970s with another peak in IIb catches in 1976 followed by a decline after 1977.

Catches in area IIb are mainly young Greenland halibut, while those in IIa and I are older individuals of the same population (Fig. 13). This agrees with the observations of differential distribution of young and adult fish and migrations of juveniles from nursery areas in subarea IIb to subarea IIa with increasing age (Godø & Haug 1987a). Migrations also occur from area II to area I (Sorokin 1967). The area I fishery probably also mainly takes fish that have migrated from area II. A plausible conclusion is that the prevailing lower level of the fisheries in area I and IIa, since the beginning of the 1970s, is a result of the increased exploitation of young fish in area IIb starting in the late 1960s.

Catch by nation and gear

In the Norwegian and Barents Sea (ICES subareas I, IIa and IIb) the Greenland halibut resource has mainly been exploited by fishing vessels from Norway, the USSR, the DDR, the FRG, the UK and Poland. The latter three countries had a considerable share of the catches until the late 1970s. These nations, however, along with some others, now take only small quantities of Greenland halibut.

Until 1964 the fishery was almost exclusively carried out by Norwegian fishermen using bottom long lines (Fig. 14); this fishery traditionally has been mainly carried out during April-May and August-September in areas IIa and I (Lahn-Johannessen 1972). During the 1970s a gill net fishery was developed by Norwegian fishermen in certain of the areas where the long line fishery also operated (fisherman P.O. Benjaminsen, Vesterålen, Norway, pers. comm.).

A trawl fishery was developed during the late 1960s by a number of nations (Fig. 14). This is a year round fishery, but the directed trawl fishery is conducted mainly in autumn. Since 1969 trawls have been the dominate fishing gear and the USSR has taken the largest catch of Greenland halibut with this gear. The largest trawl catches were taken in 1970-1971. The development of a trawl

fishery resulted in a completely new exploitation strategy for Greenland halibut. The long line fishery, to a large extent, exploits the adult population. The trawl fishery expanded the fishing area and catches to a great extent are made up of smaller/younger individuals as a result of fishing in subarea IIb (Fig. 13). The rapid growth of the trawl fishery in the main nursery area and areas occupied by young fish appears to have caused a decline in catches of adult fish by the traditional long line fishery without any increase in total nominal catches.

Effort and catch per unit effort

The timeseries on fishing effort and catch per unit effort (CPUE) given in Fig. 15 are based on data from the USSR trawl fishery, which from 1973 is combined with Norwegian trawl data. The effort is adjusted to total annual catches. The variations in total effort follows to a great extent the variations in total catches (Fig. 11). The CPUE, however, showed an almost continuous downward trend until 1978. After that an upward trend has prevailed.

Mortality, predation and recruitment

Total mortality for age 5 and older fish is, under today's fishing pressure, dominated by fishing mortality. The ICES working group uses 0.15 as an estimate of natural mortality. The fishing mortality has fluctuated according to variations in fishing effort (see Figs 15 and 16). Natural mortality of the commercial exploited age groups results from predation and senecence.

Predators of the Norwegian/Barents Sea stock of Greenland halibut are unknown. In other parts of the Atlantic, Greenland halibut is known to be a common prey of Greenland shark, Somniosus microcephalus, white whale, Delphinapterus leucas, and narwhale, Monodon monoceros (Smidt 1969).

Predation and mortality on younger age groups are believed to be much higher than for adults. However, information on mortality of young fish is scarce. Godø & Haug (1987b) have discussed the possibility of predation by cod on age 0-2 year Greenland halibut, which may influence recruitment to the commercially exploited stock. Although indications of this were found, contradictions in the data prevent firm conclusions. In other areas pelagic juveniles are frequently eaten by cod and salmon, Salmo salar, while the youngest stages are preyed upon by cod and older Greenland halibut (Smidt 1969).

Annual 0-group surveys are conducted in the Barents Sea/Svalbard area, which provide indices of abundance for all important commercial fish species. The validity of the recruitment index for year classes of Greenland halibut is dubious, however (Godø & Haug 1987b). The ICES working group uses input Fs for age 3-5 fish in VPA (Virtual population analysis) to produce numbers of 3 year

olds close to the average over the last 10 years (Anon. 1984b). The use of this average recruitment is probably far from reality (Godø & Haug 1987b). The lack of reliable recruitment data for age 3 fish is an obstacle to the prognosis of catches. The groundfish surveys in the Svalbard area since 1981, which may provide improved estimates of recruitment, will be evaluated by the ICES working group in the near future (Anon. 1987).

Stock assessment and long term yield

Based on the concerns over the decline in catches of Greenland halibut in the early 1970s and the implementation of a 200 nautical mile fishery jurisdiction, the 1976 ICES Statutory Meeting adopted a resolution to form a working group on Greenland halibut for the northeastern Atlantic (ICES region I). This working group met for the first time in 1977 (C.Res. 1976/2:11). In the period 1977-84 VPA's were run by this working group. The 1985 and 1986 VPA have not been completed because data is not yet available.

As seen from Fig. 16, the biomass from VPA for both the total stock and spawning stock decreased up to the end of the 1970s, after which an upward trend has prevailed. The CPUE showed a sharp decrease since 1965 (Fig.15) which indicates that the stock abundance was already decreasing from the beginning of exploitation by the trawl fishery. Because the exploitation before 1964 was very low, the reason for the sharp decrease in CPUE up to 1972 is believed to be caused by the expanding trawl fishery. Studies of abundance of juveniles and young fish have also indicated low recruitment during this period (Godø and Haug, 1987b), which may have in part caused the sharp decrease in catches. The possibility that observed increases in growth rates and lower ages at maturity are a result of reduced abundance has already been discussed (see p.4). The larger catches obtained from the accumulated stock around 1970 can not be considered as a long term yield. The productivity of the stock has, however, increased considerably as a result of the increased exploitation. According to the ICES working group (Anon. 1977b) the surplus production (the difference between changes in biomass and catch) in the period 1965-71 was about 20000 tons, while it nearly doubled between 1972 and 1976. Under certain assumptions they found it reasonable to believe that the stock size had been reduced to about half of its maximum level by the mid-1970s. The indications that the stock size increased after 1978 is probably the result of increased recruitment during the 1970s (Godø and Haug, 1987b).

The ICES working group has discussed management options for the stock (Anon. 1984b). Under the present exploitation pattern, the maximum sustainable yield (MSY) is estimated to about 27000 tons. The fishing mortality (ages 7-11) during a considerable part of the period from 1970-1983 was around 0.5 (Fig. 16). In 1983 it was

0.27, which compares to an F of 0.20 at MSY. Thus, the stock was more or less overexploited during most of the 1970s.

The ICES working group did not consider the influence of an optimized fishing pattern on MSY, i.e., increasing the mean age at capture. According to growth studies (Figs 9 and 10) and with reasonable low natuaral mortality on adult fish, it is plausible that an increased mean age at capture would have a considerable positive effect on the long term yield.

Management

Geographically the Greenland halibut stock is distributed in the Norwegian and USSR 200 nautical mile economic zones as well as the Svalbard zone. The great bulk of the catches in subareas I and IIa are taken within the Norwegian economic zone and the IIb catches come from the Svalbard fish protection zone. Norway is responsible for the conservation of the natural resources in this latter zone. The jurisdiction over these economic zones was internationally recognized in 1977, and was one of the reasons for the initiation of the ICES working group that year. Prior to 1977 Greenland halibut was subjected to unregulated fishing. Management since 1978 has been based on recommended total allowable catch (TAC) by ICES. Norway and the USSR conduct annual negotiations concerning the allocation to country of the total agreed quotas of Greenland halibut together with other commercial species. As the Greenland halibut trawl fishery is economically most profitable when carried out together with the exploitation of other species, especially cod, haddock and redfish, some of the countries fishing for Greenland halibut have ceased fishing because their quotas for cod and haddock have been reduced to a minimum (see p. 12).

There were substantial differences in actual catches of Greenland halibut and those recommended by ICES in 1978-1979 (Table 1). This was the result of over estimation of the stock size during the first VPA runs, probably due to the pattern of the CPUE curve (see Fig. 15; indication of a strong stock size decrease appeared when the 1977 and 1978 results were available in 1978 and 1979). After 1979 total catches have more closely followed the recommendations. However, there was considerable over-fishing in 1982-1984. No regulations have, until now, been put into effect by either Norway or the USSR to keep catches within agreed limits.

ACKNOWLEDGEMENTS

Sincere thanks are due to Aa. Svendsen and M.S. Nilsen for technical assistance, and to dr. R. Bakkala who criticized the manuscript and corrected the English.

REFERENCES

Andriyashev, A.P. 1954. Fishes of the northern seas of the U.S.S.R.Transl. from Russian, Israel program for Scientific Translations, Jerusalem 1964. 617 pp.

Anon. 1970. Report to the 0-group fish survey in the Barents Sea and adjacent waters in August-September 1969. Annls biol., Copenh., 26: 287-300.

Anon. 1972. Preliminary report of joint Soviet-Norwegian 0-group fish survey in the Barents Sea and adjacent waters in August and September 1970. Annls biol., Copenh., 27: 216-222.

Anon. 1973. Report of the international 0-group fish survey in the Barents Sea and adjacent waters in August-September 1971. Annls biol., Copenh., 28: 239-246.

Anon. 1974. Preliminary report of the international 0-group fish survey in the Barents Sea and adjacent water in August-September 1972. Annls biol., Copenh., 29: 205-210.

Anon. 1975. Preliminary report on the international 0-group fish survey in the Baretns Sea and adjacent waters in August-September 1973. Annls biol., Copenh., 30: 234-240.

Anon. 1976. Preliminary report on the international 0-group fish survey in the Barents Sea and adjacent waters in August-September 1974. Annls biol., Copenh., 31: 202-210.

Anon. 1977a. Report on the international 0-group fish survey in the Barents Sea and adjacent waters in August-September 1975. Annls biol., Copenh., 32: 199-205.

Anon. 1977b. Report of the working group on Greenland halibut in Region I. Charlottenlund, 7-11 March 1977. ICES CM 1977/F:4: 20 pp. (Mimeo).

Anon. 1978a. Ressursoversikt for 1978. Fisken Hav., 1978. Særnr.2: 1-97.

Anon. 1978b. Report on the international 0-group fish survey in the Barents Sea and adjacent waters in August-September 1976. Annls biol., Copenh., 33: 213-219.

Anon. 1978c. Report of the working group on Greenland halibut in Region I. Charlottenlund, 27 February - 3 March 1978. ICES CM 1978/G:4: 20 pp. (Mimeo).

Anon. 1979. Report to the international 0-group fish survey in the Barents Sea and adjacent waters in August/September 1977. Annls biol., Copenh., 34: 251-257.

Anon. 1980. Report to the international 0-group fish survey in the Barents Sea and adjacent waters in August/September 1978. Annls biol., Copenh., 35: 273-280.

Anon. 1981. Report on the international 0-group fish survey in the Barents Sea and adjacent waters in August/September 1979. Annl biol., Copenh., 36: 219-226.

Anon. 1983. Preliminary report on the international 0-group fish survey in the Barents Sea and adjacent waters in August/ September 1980. Annls biol., Copenh., 37: 259-266.

Anon. 1984a. Report of the international 0-group fish survey in the Barents Sea and adjacent waters in August/September 1981. Annls biol., Copenh., 38: 228-236.

Anon. 1984b. Report of the working group on redfish and Greenland halibut in Region I. Copenhagen 22 - 27 February 1984. ICES CM 1984/Assess.:6: 89 pp. (Mimeo).

Anon. 1987. Report of the Arctic fisheries working group. Copenhagen, 22-30 September 1986. ICES CM 1987/Assess.: In press.

Bowering, W.R. 1980. Fecundity of Greenland halibut, Reinhardtius hippoglossoides (Walbaum), from southern Labrador and southeastern Gulf of St. Lawrence.J. Northw. Atl. Fish. Sci. 1:39-43.

Breiby, A. & Eliassen, J.-E. 1984. Forsøksfiske etter isgalt og blåkveite i 1984. Inst. Fiskerifag, Univ. Tromsø, Ser. B: Ressursbiol. 1984(2): 1-25.

Bulatov, D.A. 1983. Distribution of eggs and larvae of Greenland halibut (Reinhardtius hippoglossoides (Pleuronectidae), in the Eastern Bering Sea. J.Ichthyol. 23(1): 157-159.

Fairbairn, D.J. 1981. Biochemical genetic analysis of population differentiation in Greenland halibut (Reinhardtius hippoglossoides) from the northwest Atlantic, Gulf of St. Lawrence, and Bering sea. Can.J.Fish.Aquat.Sci. 38: 669-677.

Fedorov, K.Y. 1968. Oogenesis and the sexual cycle of the Greenland halibut. Tr. Polyarm. n.-i. inst. morsk. rybn. khoz. okeanogr. 23: 425-451.

Fedorov, K.Y. 1971. Zoogeographic characteristics of the Greenland halibut (Reinhardtius hippoglossoides (Walbaum)). J. Ichthyol. 11(6): 971-976.

Godø, O.R. & Haug, T. 1987a. Migration and recruitment to the commercial stock of Greenland halibut, Reinhardtius hippoglossiodes (Walbaum), in the Svalbard area. Fisk Dir.Skr.Ser.HavUnders. 18: 311-328.

Godø, O.R. & Haug, T. 1987b. A preliminary report on the Recruitment variation in Greenland halibut (Reinhardtius hippoglossoides Walbaum) in the Svalbard area. This Meeting.

Haug, T. & Gulliksen, B. 1982. Size, age, occurrence, growth, and food of Greenland halibut, Reinhardtius hippoglossoides (Walbaum) in coastal waters of western Spitzbergen. Sarsia 68: 293-297.

Haug, T. & Tjemsland, J. 1986. Changes in size- and age-distributions and age at sexual maturity in Atlantic halibut, Hippoglossus hippoglossus, caught in North Norwegian waters. Fish.Res. 4: 145-155.

Helland-Hansen, B. & Nansen, F. 1909. The Norwegian Sea: Its physical oceanography based upon the Norwegian researches 1900-1904. FiskDir. Skr. Ser. HavUnderss. 2(2): 1-360.

Hognestad, P.T. 1961. Contributions to the fish fauna of Spitzbegen. I. The fish fauna of Isfjorden. Acta Borealia, A. Scientia 18: 1-36.

Hognestad, P.T. 1969. Notes on Greenland halibut, Reinhardtius hippoglossoides (Walbaum), in the eastern Norwegian Sea. FiskDir.Skr.Ser. HavUnders. 15(3): 139-144.

Jakupsstovu, S.H.i & Haug, T. 1987. Growth, sexual maturation, and spawning season of Atlantic halibut, Hippoglossus hippoglossus, in Faroe waters. Fish.Res. 5: In press.

Jensen, A.S. 1935. The Greenland halibut (Reinhardtius hippoglossoides (Walb.)). its development and migrations. K.danske vidensk.Selsk.Skr., Naturv.math.Afd., 9 Række 6(4): 1-32.

Kovtsova, M.V. & Nizovtsev, G.P. 1985. Pecularities of growth and maturation of Greenland halibut of the Norwegian - Barents Sea stock in 1971-1984. ICES CM 1985/G:7 (Sess.S): 17 pp. (Mimeo).

Krzykawski, S. 1975. Age and growth rate of the Greenland halibut, Reinhardtius hippoglossoides (Walbaum) from the Northern Atlantic. ICES CM 1975/F:24: 15 pp. (Mimeo).

Lahn-Johannessen, J. 1972. Recent development of the fisheries of Greenland halibut (Reinhardtius hippoglossoides, Walbaum) in northeast Atlantic waters. ICES CM 1972/F:39: 8 pp. (Mimeo).

Magnusson, J.V. 1977. Notes on the eggs and larvae of Greenland halibut at Iceland. ICES CM 1977 F:47: 6 pp. (Mimeo).

Milinsky, G.I. 1944. On the biology and fisheries of Reinhardtius hippoglossoides (Walbaum) of the Barents Sea. Tr. Polyarn., n.-i. inst. morsk. rybn. khoz. Okeanogr. 8: 375-387.

Nizovtsev, G. 1969. Soviet investigations on Greenland halibut in the Barents Sea, 1964-1967. Annls biol., Copenh., 25: 239-242.

Normann, U. 1986. Hydrografiske observasjoner (havmiljødata) fra Svalbard i 1984 og 1985. Tromura-Tromsø Museums Rapportserie, Naturvitenskap 53: 129 pp.

Normann, U. & Pettersen, F. 1984. Hydrografiske observasjoner (havmiljødata) fra Svalbard 1979-1983. Tromura-Tromsø Museums Rapportserie, Naturvitenskap 40: 168 pp.

Roff, D.A. 1982. Reproductive strategies in flatfish: A first synthesis.Can.J.Fish.Aquat.Sci. 39: 1686-1698.

Sigurðsson, A. 1981. Migrations of Greenland halibut Reinhardtius hippoglossoides (Walb.) from Iceland to Norway. Rit Fiskideildar 6(1): 3-6.

Smidt, E.L.B. 1969. The Greenland halibut, Reinhardtius hippoglossoides (Walb.), biology and exploitation in Greenland waters. Meddr.Danm.Fisk.- og Havunders., N.S. 6(4): 79-148.

Sorokin, V.P. 1967. Some features of biology of Greenland halibut Reinhardtius hippoglossoides (Walbaum) in the Barents Sea. Materialy sessii ucenogo sovita PINRO 8: 44-67.

Sorokin, V.P. & Grigoryev, G.V. 1968. Spermatogenesis and sexual cycle in Greenland halibut of the Barents Sea population. Tr. Polyarn. n.-i. inst. morsk. rybn. khoz. Okeanogr. 23:413-423.

Table 1. The Norwegian and Barents Sea Greenland halibut stock: Comparison between ICES recommendations and recorded total catches during the years 1978-1986.

Year:	78	79	80	81	82	83	84	85	86
ICES recommendation (1000 tons)	40	25	14	12	12	17	17	20	20
Catch (1000 tons)	24.6	17.3	13.3	15.0	16.7	22.2	21.9	19.7	
Difference	15.4	7.7	0.7	-2.0	-4.7	-5.2	-4.9	0.3	

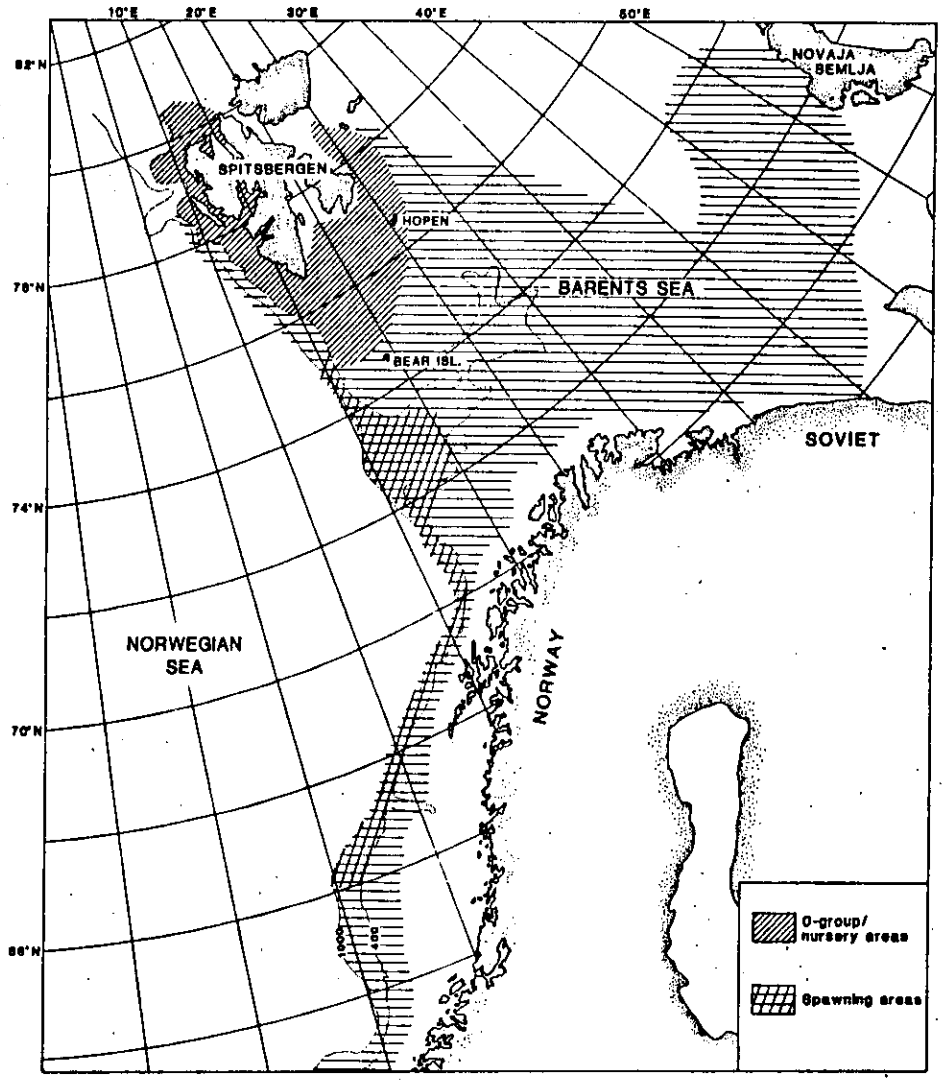

Fig. 1. The distribution (all hatched areas) of Greenland halibut in the eastern Norwegian and Barents Seas. The main area of 0-group observation / nursery areas, and the area of spawning are indicated by extra hatching. The dotted lines are the 400 and 1000 m depth lines along the slope of the continental shelf.

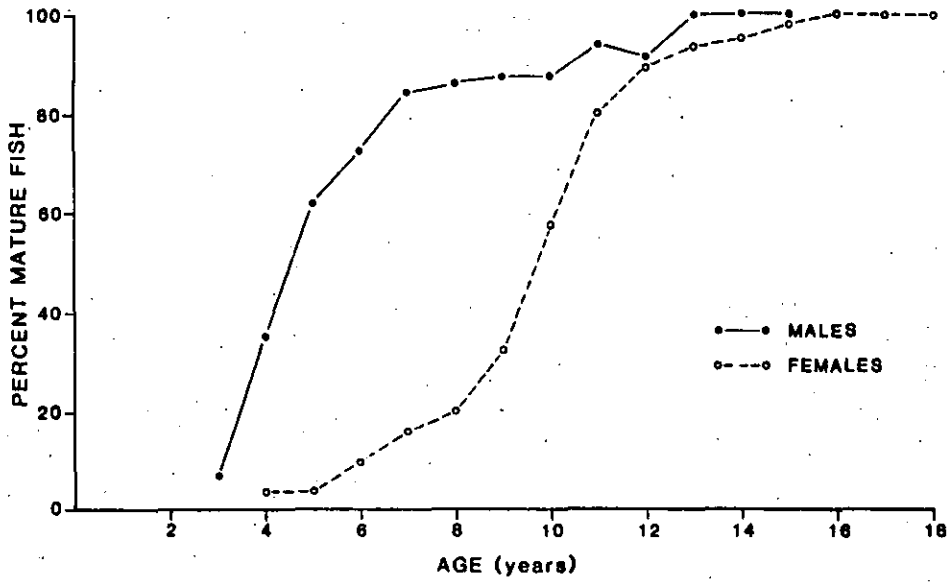

Fig. 2. Percentage of mature males and females by age in the Norwegian / Barents Sea stock of Greenland halibut. The curves are based on data collected in 1971-1984 and originally presented by Kovtsova & Nizovtsev (1985).

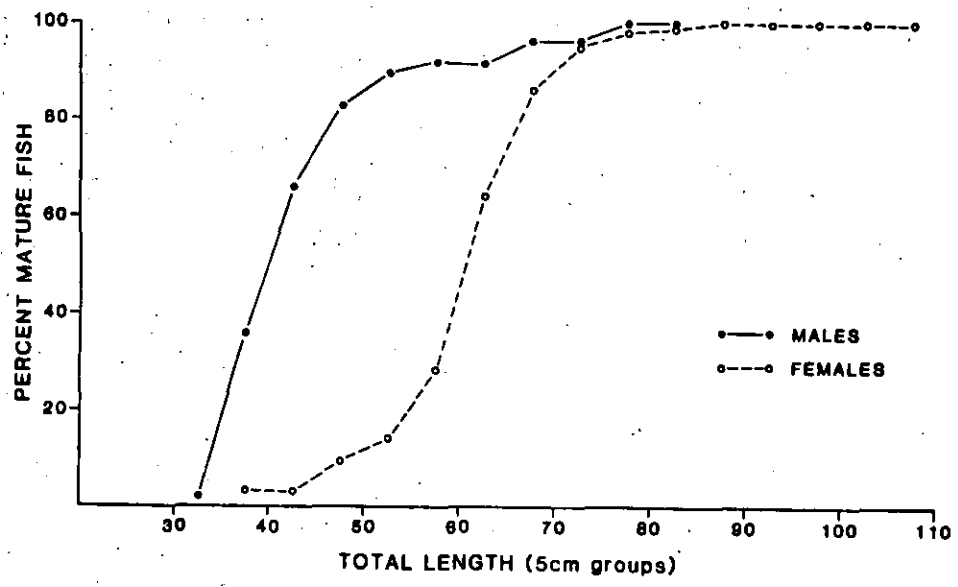

Fig. 3. Percentage of mature males and females by length in the Norwegian / Barents Sea stock of Greenland halibut. The curves are based on data collected in 1971-1984, and originally presented by Kovtsova & Nizovtsev (1985).

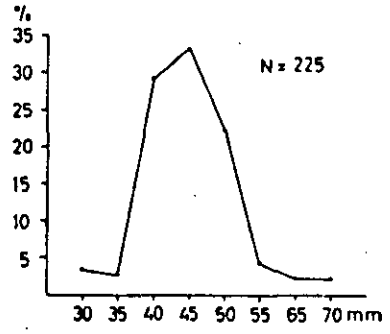

Fig. 4. Length distribution of 0-group Greenland halibut fry taken in the Spitzbergen area in August-September 1968. (From Hognestad 1969).

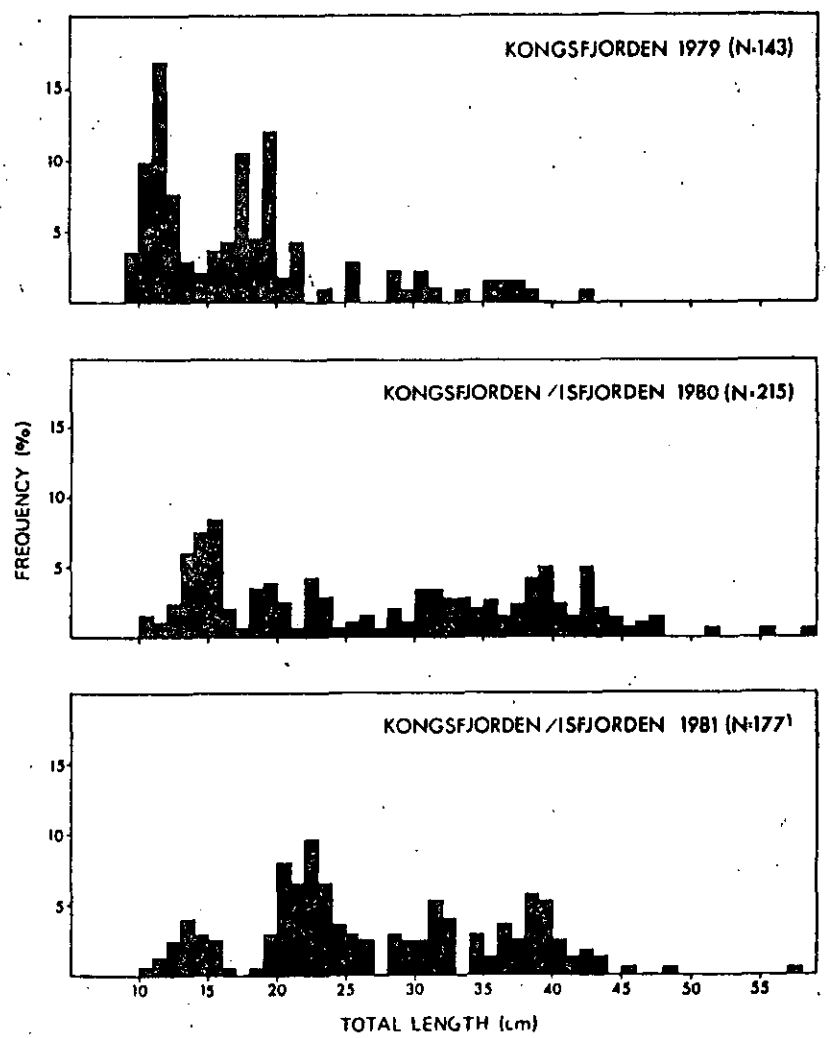

Fig. 5. Length-frequency histograms of Greenland halibut caught in July-August in the Spitzbergen nursery areas in 1979-1981. The length distribution of each year class for the 1981-data is indicated in the bottom panel of the figure. (From Haug & Gulliksen 1982).

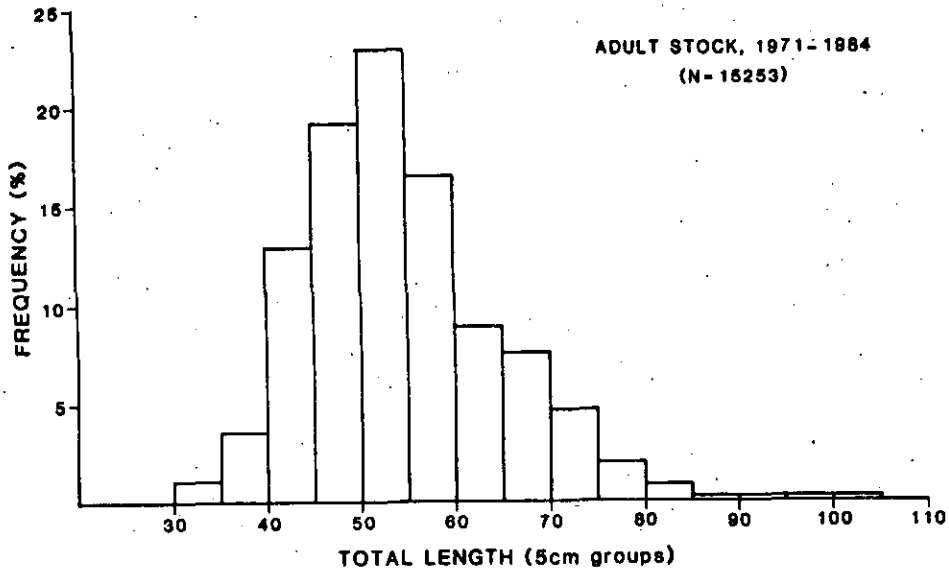

Fig. 6. Size distribution of Greenland halibut caught in the Norwegian / Barents Sea area during the years 1971-1984. Data are from Kovtsova & Nizovtsev (1985).

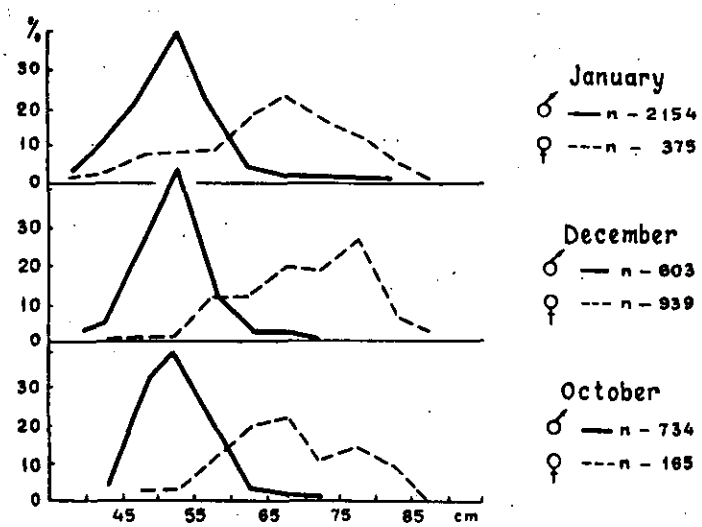

Fig. 7. The length distributions of male and female Greenland halibut caught in the Norwegian / Barents Sea spawning area in 1967. (From Nizovtsev 1967).

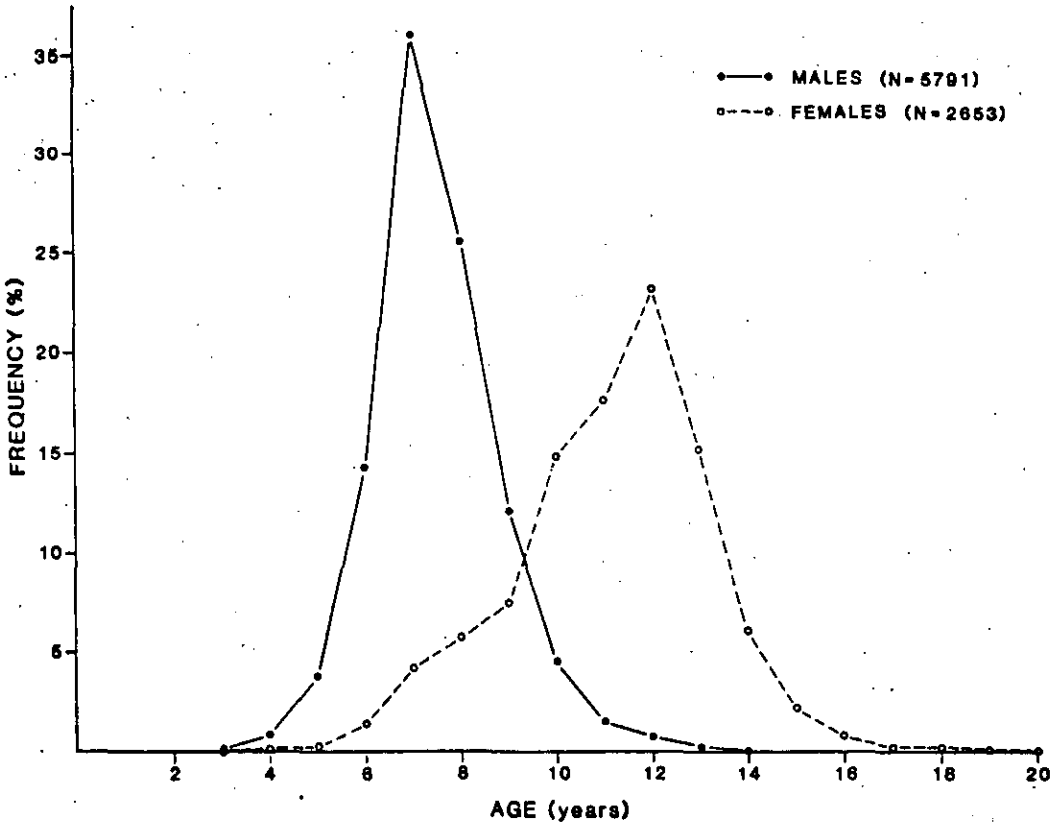

Fig. 8. The age distribution of male and female Greenland halibut caught in the Norwegian / Barents Sea area during the years 1971-1984. Data are from Kovtsova & Nizovtsev (1985).

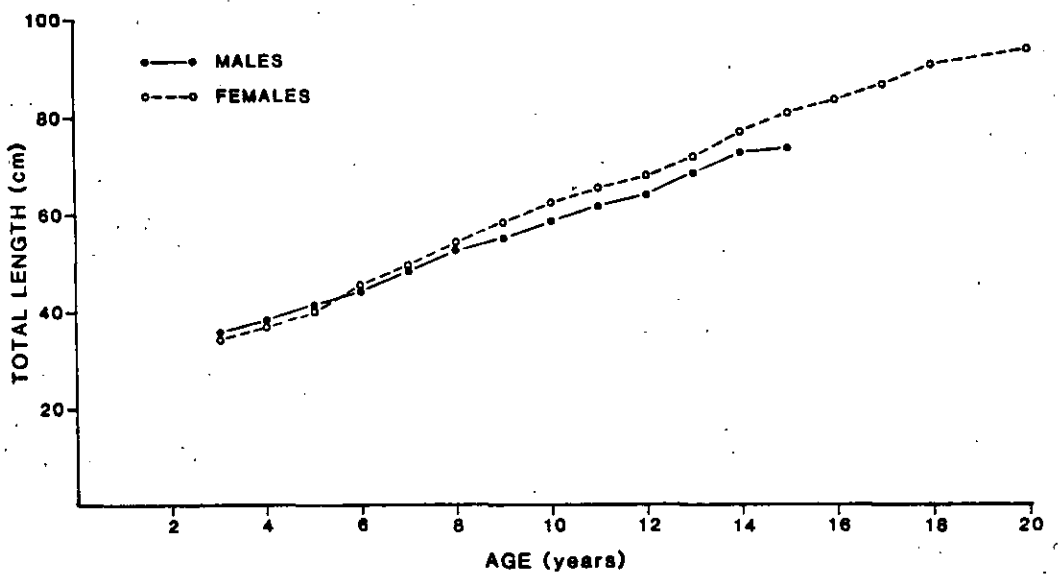

Fig. 9. Growth in length of male and female Greenland halibut caught in the Norwegian / Barents Sea in 1971-1984. Data are from Kovtsova & Nizovtsev (1985).

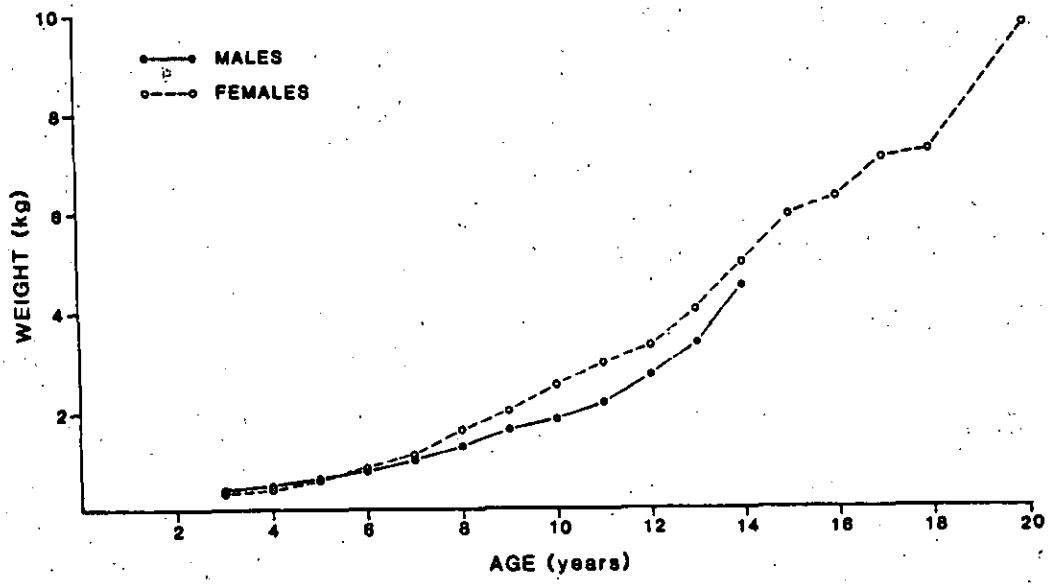

Fig.10. Growth in weight of male and female Greenland halibut caught in the Norwegian / Barents Sea in 1971-1984. Data are from Kovtsova & Nizovtsev (1985).

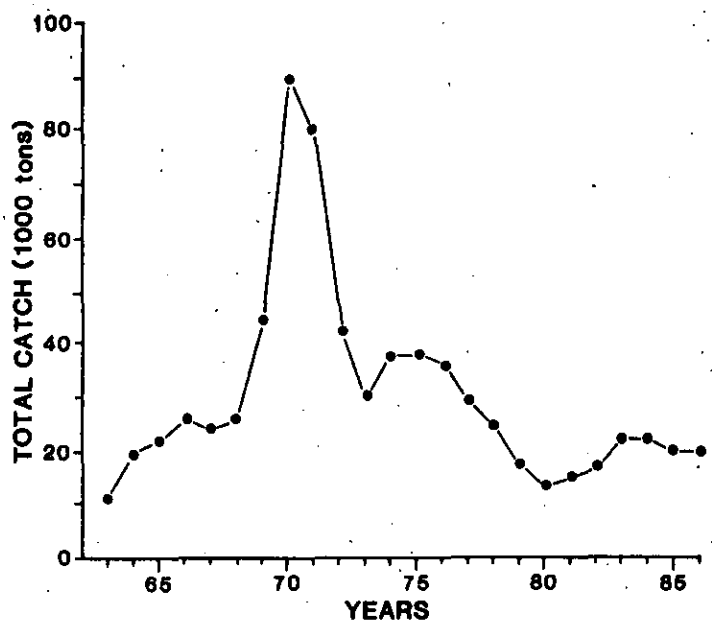

Fig. 11. Total catches of Greenland halibut from the Norwegian and Barents Sea stock during 1962-1986. Data are from Lahn-Johannessen (1972), Anon. (1977, 1987).

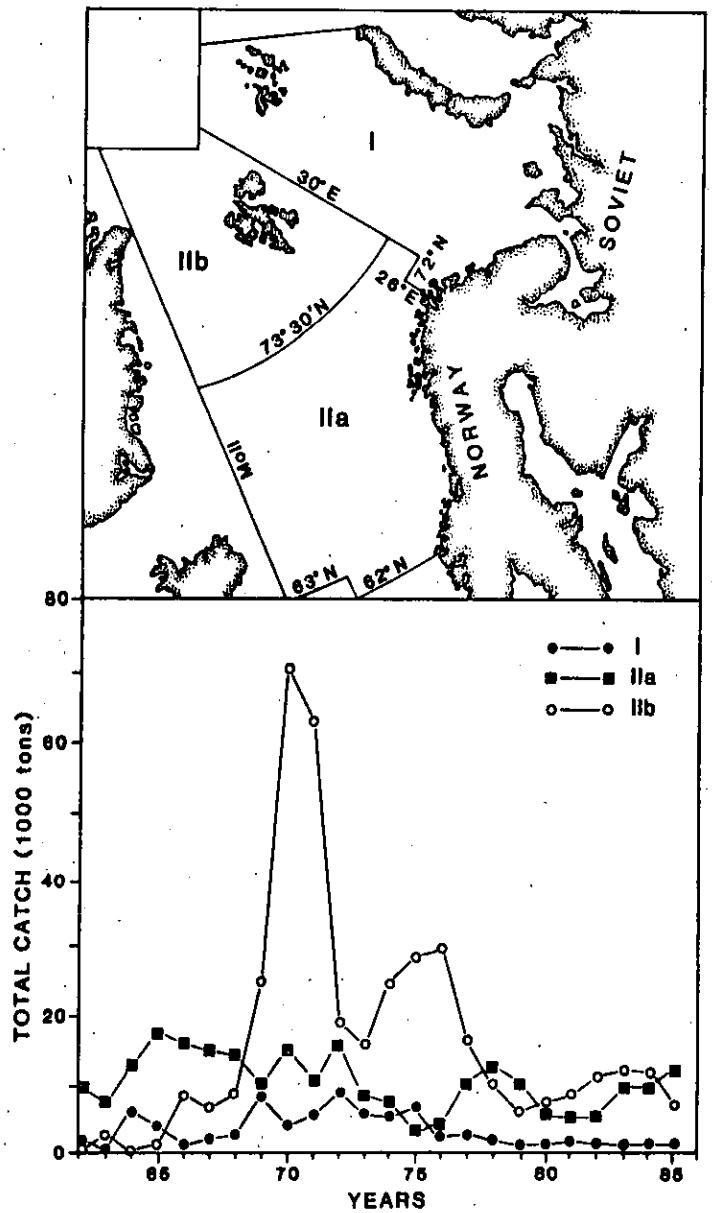

Fig. 12. The ICES subareas I, IIa, and IIb in the Norwegian and Barents Sea, and the catches of Greenland halibut by subareas during the period 1962-1985.

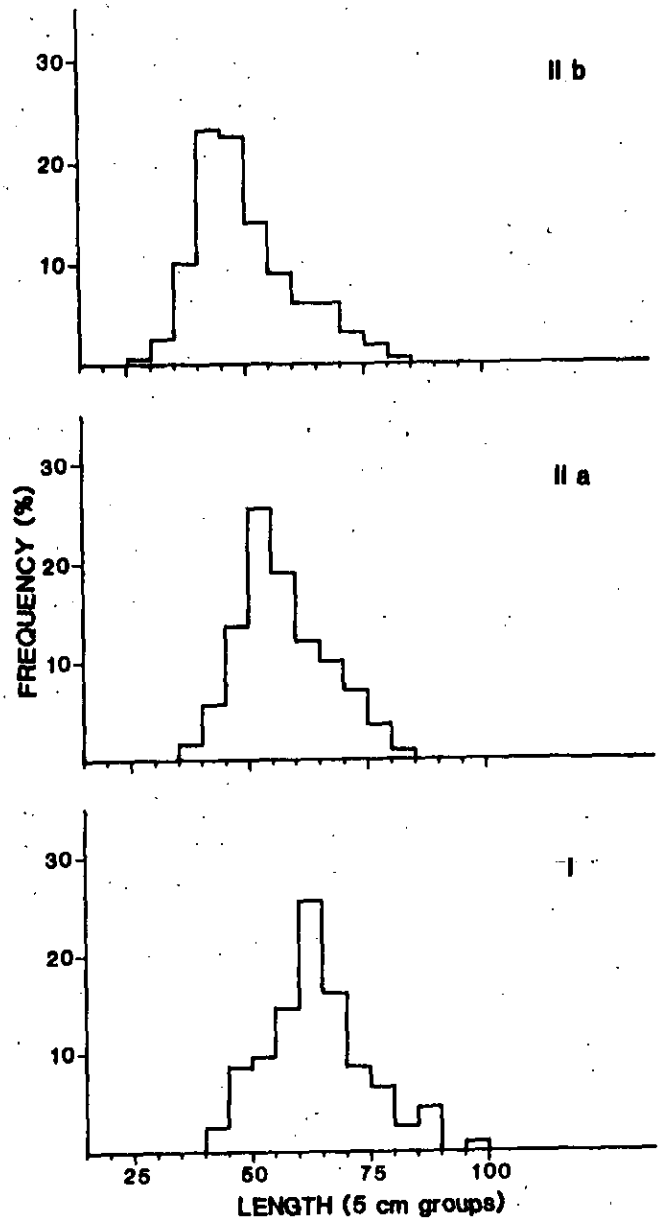

Fig. 13. Length distributions of Greenland halibut taken by USSR trawlers in ICES subareas I, IIa, and IIb in 1983 as reported to the ICES working group.

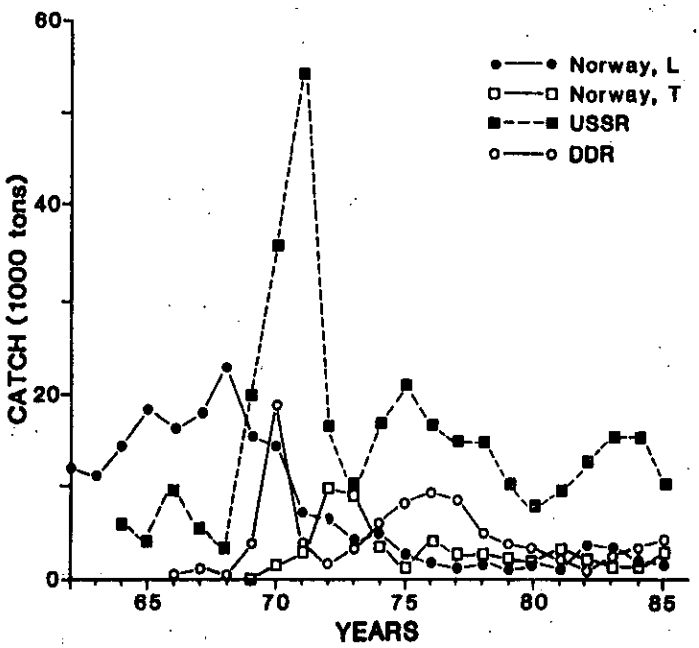

Fig. 14. Catches of Greenland halibut from the Norwegian and Barents Sea stock by major fishing nations and by fishing gear for the Norwegian fishery.

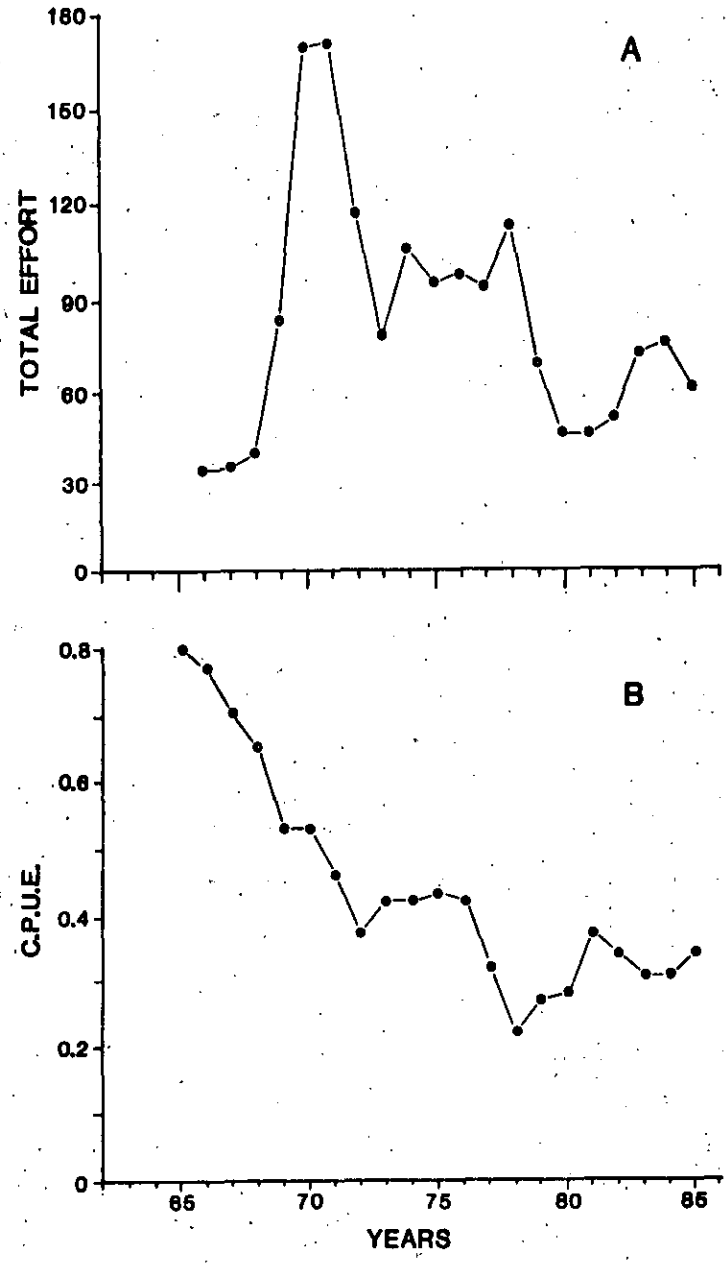

Fig. 15. Time series (1965-1985) of fishing effort (A), and catch per unit effort (CPUE) (B) in the Norwegian and Barents Sea Greenland halibut fishery. Data were obtained from the ICES working group on Greenland halibut (Anon. 1987).

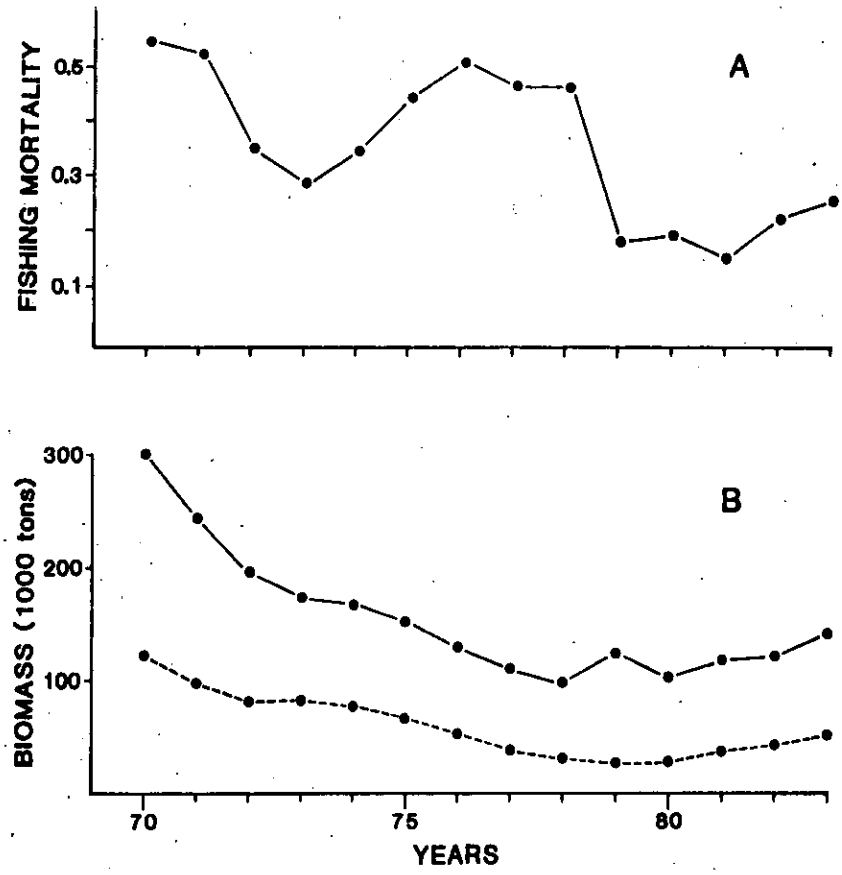

Fig. 16. Variation in fishing mortality (A), and total stock biomass (solid line) and spawning stock biomass (stipled line) (B) for age 7-11 year Greenland halibut in ICES subareas I, IIa and IIb. (From Anon. 1984).