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Preliminary Report on Recruitment Variation in Greenland Halibut (Reinhardtius Hippoglossoides Walb.) in the Svalbard Area

by

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ABSTRACT

The main nursery area for Greenland halibut is found off the Spitzbergen west coast. A decrease in the abundance of small Greenland halibut (<25 cm) was found on these grounds during the mid-1980s. Further, there was inconsistency in the relationship between abundance indices for 0-group fish and indices for I- and II-group fish.

In this paper possible relationships between the variation in recruitment of Greenland halibut and recruitment and abundance of cod and the commercial catch of shrimp are studied. Competition, predation and mortality caused by shrimp fishery by-catch are discussed as possible sources which might influence recruitment. The data so far are inconsistent and inconclusive. However, the material from the 80-ies, which include survey data, is interesting. This report must thus be considered a rewiev of the available data on Greenland halibut recruitment and a background for further analyses when more data are available.

SPECIAL SESSION ON DEEPWATER FISHES

INTRODUCTION

The main nursery area for Greenland halibut, Reinhardtius hippoglossoides (Walbaum) is found off the Spitzbergen west coast (Godø and Haug, 1987). In their migration and recruitment studies, Godø and Haug (ioc. cit.) found a severe decrease in the abundance of small Greenland halibut (<25 cm) on these grounds during the mid-1980s. Further, there was inconsistency in the relationship between abundance indices for 0-group fish and indices for I- and II-group fish.

Long term fluctuations in the abundance of Greenland halibut are known to occur in the Svalbard area. During extensive trawl surveys carried out in

1876-78 (Collett, 1880) and 1908 (Hofsten, 1919) the species was not found in Spitzbergen coastal waters. It was also classified as rare off the Spitzbergen west coast in the period 1923-32 (Iversen, 1934). During later trawl surveys, juvenile Greenland halibut were commonly found at depths of 150-350 m in the fjords and coastal areas off Spitzbergen (Hognestad, 1961, Haug and Gulliksen, 1982, Godø and Haug, 1987). Thus survey data indicate an increase in abundance during the 20th century. Long term fluctuations in abundance of Greenland halibut have also been observed in Greenlandic waters. These fluctuations have been found to form an inverse relationship with variations in abundance of cod (Gadus morhua L.) (Smidt, 1969).

The Svalbard area during the 1980s has been characterized by an rapidly increasing cod stock (Godø and Nedreaas, 1986) and a tremendous increase in the shrimp catch. Competition between cod and Greenland halibut at the 0-group stage is possible, or cod of age 1 or older may prey on small Greenland halibut. The shrimp fishery off Spitzbergen is to a great extent carried out in important nursery grounds for Greenland halibut and substantial quantities of juveniles are caught. The purpose of this paper is to study possible relationships between the variation in recruitment of Greenland halibut, and recruitment and abundance of cod, and the commercial catch of shrimps.

MATERIAL AND METHODS

0-group

Abundance of 0-group fish in the Barents Sea Svalbard area has been measured yearly in August since 1965 by a pelagic trawl survey (ANON, 1986). Survey methods are presented by Randa (1984). Indices of abundance for both 0-group Greenland halibut and cod are available since 1970 (ANON, 1986).

I-, II- and III-group

Abundance indices at age 1 and 2 for the 1979-85 year classes of cod and Greenland halibut are available from stratified random trawl surveys carried out by the Institute of Marine Research, Bergen in September - October 1981-86. The main objectives of these surveys are to provide data for the management and monitoring of demersal fish stocks in the Svalbard area (Randa and Smedstad, 1982, 1983; Godø et al. 1984; Godø, 1985; Godø and Nedreaas, 1986). The gear used was a Campelen 1800 mesh shrimp trawl with rubber bobbins, a cod end mesh size of 35 mm, and sweep wires of 80 m. A standard haul consisted of the trawl being towed for three nautical miles at a speed of three knots.

The stratified random trawl survey comprised 22 strata north of 76°N (the northern area) and 23 strata south of this latitude (the southern area). Hauls were made at the following depth intervals: 0-100 m, 100-200 m, 200-300 m, 300-400 m and greater than 400 m. The catch data were used to calculate abundance indices which were defined as the stratified mean catch in number

per haul:

$$\bar{X}_{st} = (1/A) \sum_{i=1}^{k} a_i \quad \bar{x}_i$$

where $\bar{X}_{st}$ = stratified mean catch per haul, A = total area of all strata, a_i = area of stratum i, $\bar{x}_i$ = sample mean catch in stratum i, and k = number of strata. The presented values represent swept area indices $I = \bar{X}_{st} \cdot A \cdot 10^{-3}/SA$, where SA is the area swept by the trawl. Methodology is more fully described by Randa and Smedstad (1982, 1983).

For each haul the total number of Greenland halibut was recorded. Total lengths were measured for all, or, in cases of large catches, for random samples consisting of at least 100 fish.

The Greenland halibut indices are separated in age groups based on length frequency distributions (cm groups) in the catches. Haug and Gulliksen (1982) found very little overlap between the length distributions of age groups 1 and 2 as well as between age groups 2 and 3.

Virtual population analyses (VPA) are conducted by ICES Working Groups. Abundance estimates of 3 year old cod are obtained from these analyses (ANON, 1987). As a relative estimate of variation of 3 year old Greenland halibut abundance, is used catch per unit effort data (ANON, 1984). Corresponding data are available for the 1969-1980 year classes.

Shrimp fishery

There is no commercial interest in age 1-3 Greenland halibut by this fishery, and they are discarded when caught. The commercial shrimp trawl has a mesh size 35 mm and catches significant quantities of small Greenland halibut. The annual shrimp catch in area IIb is therefore assumed to reflect the variation in fishing effort on young Greenland halibut (age 1-3). These data are taken from ICES Bull. Stat., the 1985-86 figures are provisional.

RESULTS

In Table 1 and 2 the various recruitment measurements for Greenland halibut and cod is presented. Fig. 1 shows the Barents Sea - Svalbard area where both cod and Greenland halibut are distributed. Area references I, IIa and IIb in Fig. 1 and Table 2 indicate ICES sub-areas for which the data are valid.

0-group recruitment

The indices for 0-group fish indicate an inverse relationship between strong and weak year classes of Greenland halibut and cod in most years during the period 1970-86 (Fig. 2a). A scatter diagram of the indices (Fig. 2b), indicate

that the possibility of having a strong year class of both species in the same year is small. However, the 1984-86 year classes represent a period when year classes are strong for both species. There is an over all tendency for an increase in recruitment of Greenland halibut during the period of investigation.

Age 1 and 2 recruitment

The period after 1980 is of particular interest as explained in the introduction. For this period survey abundance data are available for young Greenland halibut and cod. There is correspondence in the variation of year class strength between age 1 and 2 year for both species (Figs 4a; 4b). However, while indices for age 2 Greenland halibut were higher than for age 1 fish prior to 1982, they were lower from 1982 onwards. No inverse relationship between the abundance of corresponding year classes of the two species is indicated. There is also no correspondance in variation of the indices between the 0-group (Fig. 2) and I/II-group stages of Greenland halibut.

The relative change in numbers of Greenland halibut from the 0-group stage to I-group stage and from age 1-group to the 2-group stage can be obtained by dividing the index from the 0-group survey with the index at age 1 (0/I) and likewise the index at age 1 by the index at age 2 (I/II). The variations in this relationship for 0-group and I-group fish of the 1980-85 year classes (Table 2 and Fig. 5a) indicates that the strong 1981 and 1985 year classes were very much reduced during their first year of life compared to year classes of average size. This was also seen for the very strong 1984 year class in the northern area (Table 2), but an unusual high recruitment of age 1 fish from the southern area resulted in moderate mortality index. The relationship between the I-group and II-group fish gives a minimum mortality index for the 1981 year class but it was considerably higher for the 1982-84 year classes suggesting increased mortality between ages I and II during the 1983 to 1986 period.

Figure 5b and Table 2 show the variation in abundance indices for age 1 and 2 year cod and shrimp catches. Both the indices and catches show minimum values in 1981 and 1982 and an increasing trend between 1981 and 1985. Shrimp catches declined in 1986 based on provisional data.

Age 3 recruitment

Recruitment indices of Greenland halibut at age 3 years are presented for the year classes 1969-80 in Fig. 3. These indices are shown to vary in roughly the same way as the indices for 0-group fish (Fig. 2), indicating high and low recruitment levels during the same periods. When plotted against each other (Fig. 3b), however, there is no indication of a strong relationship between abundance of Greenland halibut at the 0- and III-group stage (simple linear regression, $r=0.66$).

It appears from a comparison of indices of abundance of cod and Greenland

halibut at age 3 (Fig. 3b), that there is a tendency of an inverse relationship between cod and Greenland halibut recruitment, as also observed at the 0-group stage. When the figures are plotted against each other (Fig. 3c), it appears that strong year classes of Greenland halibut are occurring only at weak year classes of cod.

DISCUSSION

Limitations of the data

The results presented in this paper are weakened by the fact that corresponding measurements of recruitment and abundance do not refer to the same geographic area. Concerning the 0-group indices for cod and Greenland halibut, they are based on data from the same survey which covers the whole Barents Sea - Svalbard area but are not specified for the two areas independently. While the main nursery area for Greenland halibut is in the Svalbard area, in most years off the Spitzbergen west coast (Godø and Haug, 1987), young cod are distributed over the whole Barents Sea - Svalbard area (Fig. 1). Randa (1984) analysed abundance indices for 0-group cod and found that there is not always correspondence in indices of year class strength between the Barents Sea and Svalbard area. An example is the 1979 year class which was relatively much stronger in the Svalbard area than in the Barents Sea. Furthermore, all cod year classes do not recruite equally well to all of the Svalbard area (Godø and Nedreaas, 1986). This adds complexity to the comparison of recruitment of the two species as well as to the analyses of possible predation of cod on Greenland halibut abundance.

The recruitment relationship between Greenland halibut and cod

The tendency for an inverse relationship between abundance of cod and Greenland halibut at the 0-group stage was found over a relative short period. The year classes 1984-86 do not fit the hypothesis of an inverse recruitment relationship.

CPUE of age 3 Greenland halibut are used instead of age 3 abundance from VPA because the VPA has been run under the assumption of an average recruitment at age 3 (ANON, 1984). An inverse relationship between abundance of age 3 cod and CPUE of Greenland halibut was observed during the 1970s. Abundance data at age 3 for the 1984-86 year classes are, however, not available. This information will probably be available from the 1987 working group reports. If the rich 1984-86 year classes of Greenland halibut were decimated by high mortality, then the inverse relationship between abundance of cod and Greenland halibut may continue into the 1980s. Comparing the 0-group indices of abundance with indices at age I and II in 1981-86, shows no correspondance. If the surveys are assumed to reflect the true abundance of the various age groups, especially high mortality is indicated for rich year classes during the 1980s, and the 0-group index cannot be considered a reliable index for recruitment to the commercial stock.

Cod predation and by-catch in the shrimp fishery

In Greenland waters an inverse recruitment relationship between cod and Greenland halibut was indicated by Smidt (1969). He based his hypothesis on the observation that cod predate on larval and young Greenland halibut.

The cod in the Svalbard area usually represents 15-30% of the total stock of northeast Arctic cod (Garrod, 1967). For strong year classes about 200 million individuals might occupy the Svalbard area at age 3 years. The mean recruitment for age 3 Greenland halibut from VPA is estimated to be 32.8 million (ANON, 1984). Thus there exists the possibility that cod could reduce the abundance of Greenland halibut through predation. A stomach sampling program has been carried out by the Institute of Marine Research, Bergen, during the 1985-86 bottom trawl surveys (Mehl, 1986). Only occasionally have Greenland halibut been found in the cod stomachs. The frequency has been so low that the incidence has not been reported (Mehl, pers. comm.). However, it is possible that systematic predation is taking place in periods of the year other than those sampled. Cod in the Svalbard area have a distinct seasonal migration from shallow to deep water in late autumn and vice versa in late spring (Trout, 1957). The highest densities of cod during the young fish surveys are in the 0-100 m depth zone, and 82% were recorded at depths shallower than 200 m in 1985 (Godø and Nedreaas, 1986). Only insignificant quantities of Greenland halibut were recorded in the 0-200 m depth zone. There are thus two plausible reasons for the scarcity of 0-group and other young age groups of Greenland halibut in stomach contents of cod. Firstly, the stomach sampling was carried out before the 0-group Greenland halibut settled to the bottom (Godø and Haug, 1987). Secondly, the stomach sampling was from a season when geographic overlap of the two species was at its minimum.

As previously mentioned, high mortality was observed between age 0 and age 1 for the strong 1981, 1984 (northern area) and 1985 year classes of Greenland halibut. This mortality occurred when average or strong year classes of cod (the 1979, 1982 and 1983 year classes) were 2-3 years old. It is not unreasonable to assume that these juveniles were exposed to predation during the period they were settling to the bottom by the rich year classes of young cod.

The high recruitment of the 1984 year class at age 1 to the southern Svalbard area may be a result of recruitment from the area east of Spitzbergen. This area is known to be a nursery area (unpubl. data), but it is not covered either by the 0-group or groundfish surveys. Juveniles from this area may migrate (or be carried by currents) to the southern area which may have caused the high recruitment at age 2 for the 1982-83 year classes and at age 1 for the 1984 year class.

The increased cod stock size in 1982 and later years may also have contributed to the increased Greenland halibut mortality between ages 1 and 2 for the 1982-84 year classes. If the extreme mortality for the 1982 year class

reflects reality, cod predation cannot be the only explanation, since the 1982 year class of cod would only be slightly larger than the Greenland halibut at this age.

The possible influence of the shrimp fishery on Greenland halibut abundance is very difficult to evaluate from the present data. A yearly stratified random trawl survey for shrimps is conducted in the Svalbard area by the Institute of Marine Research, Bergen. The survey reports also present by-catch data on Greenland halibut. If by-catches of Greenland halibut in strata where the mean shrimp catch exceeds 100 kg/hour are assumed to be representative of commercial catches, the by-catch in 1984 in the fishery would be 1.1 individuals/kg shrimp (Hylen et al., 1984). According to the length distribution of Greenland halibut in the demersal fish survey, about 27% were age 1 and 2 years, i.e., about 0.3 individuals/kg shrimp. If the mean catch of 1 and 2 year old Greenland halibut is assumed to be 0.3 specimens per kg of shrimp, the by-catch in 1984 would be about 18 million 1 to 2 year old fish. Compared to a mean recruitment level of 32.8 million, the effect of the by-catch problem can not be excluded as a significant cause of mortality of young Greenland halibut.

CONCLUSIONS

The 1980s represent a very interesting period concerning Greenland halibut - cod interactions, and the possible influence of commercial shrimp fishing on recruitment of Greenland halibut through by-catch of juveniles. The data analysed in this report are inconsistent and inconclusive as to the influence of competition and predation by cod and by-catch in the shrimp fishery on the recruitment of Greenland halibut. These studies will therefore be continued when data for the year classes up to 1986 are more complete both from VPA and surveys. Cod stomach content analyses from different periods of the year should also be a part of these studies.

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Table 1. Recruitment indices of Greenland halibut (GH) and cod at the 0-group and III-group stages.

	VPA AGE III		0-GROUP	
Year class	GH	Cod	GH	Cod
1969	9		-	93
1970	13	1818	1.0	606
1971	10	525	1.0	157
1972	232	622	8.0	140
1973	10	614	3.2	648
1974	667	348	13.4	51
1975	652	641	21.1	343
1976	1275	205	15.6	43
1977	1391	148	9.0	173
1978	14756	177	34.4	106
1979	941	158	22.5	94
1980	4361	168	12.0	49
1981			38.0	65
1982			17.0	114
1983			15.8	386
1984			40.4	486
1985			36.0	742
1986			55.0	434

Table 2. Recruitment indices at age 1 and 2 years for the northern and southern part of area IIb, and indices of mortality from age 0 to 1 (0/I) and from age 1 to 2 (I/II)

Year class	North I	North II	South I	South II	Total I	Total II	0/I (x100)	I/II
79		1200		232		1432		
80	364	900	60	120	424	1020	2.83	0.42
81	153	1900	210	218	363	2118	10.45	0.17
82	5631	891	190	1632	7151	2523	0.24	2.83
83	2486	863	733	2282	3219	3145	0.49	1.02
84	90	174	1352	858	1442	1031	2.77	1.40
85	72		169		241		14.93	

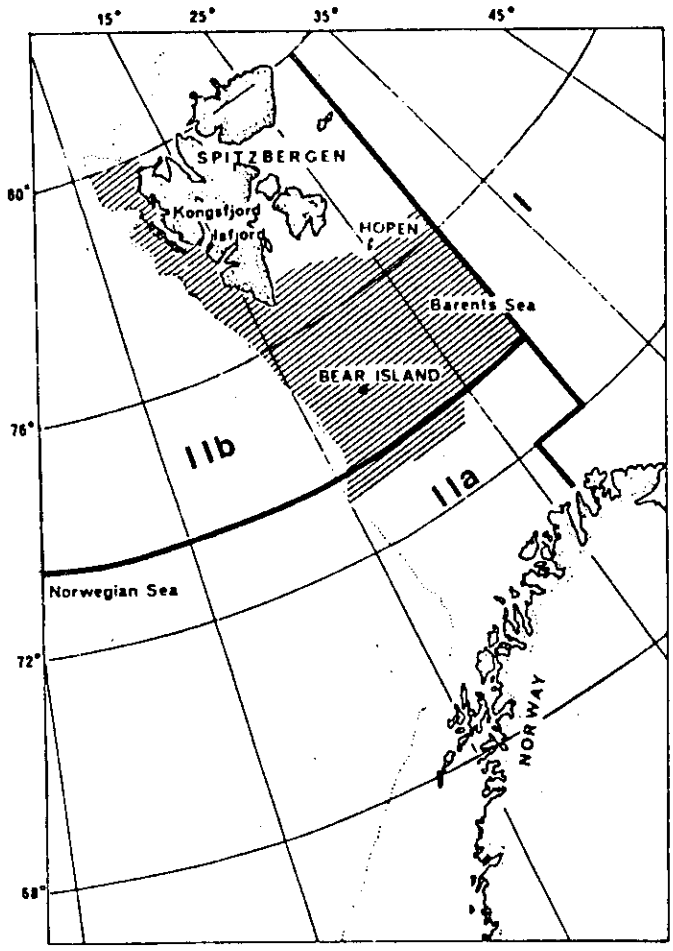


Fig. 1. The Barents Sea and the Svalbard area. The ICES area division (I, IIa, IIb) and the bottom trawl survey area (hatched) are shown.

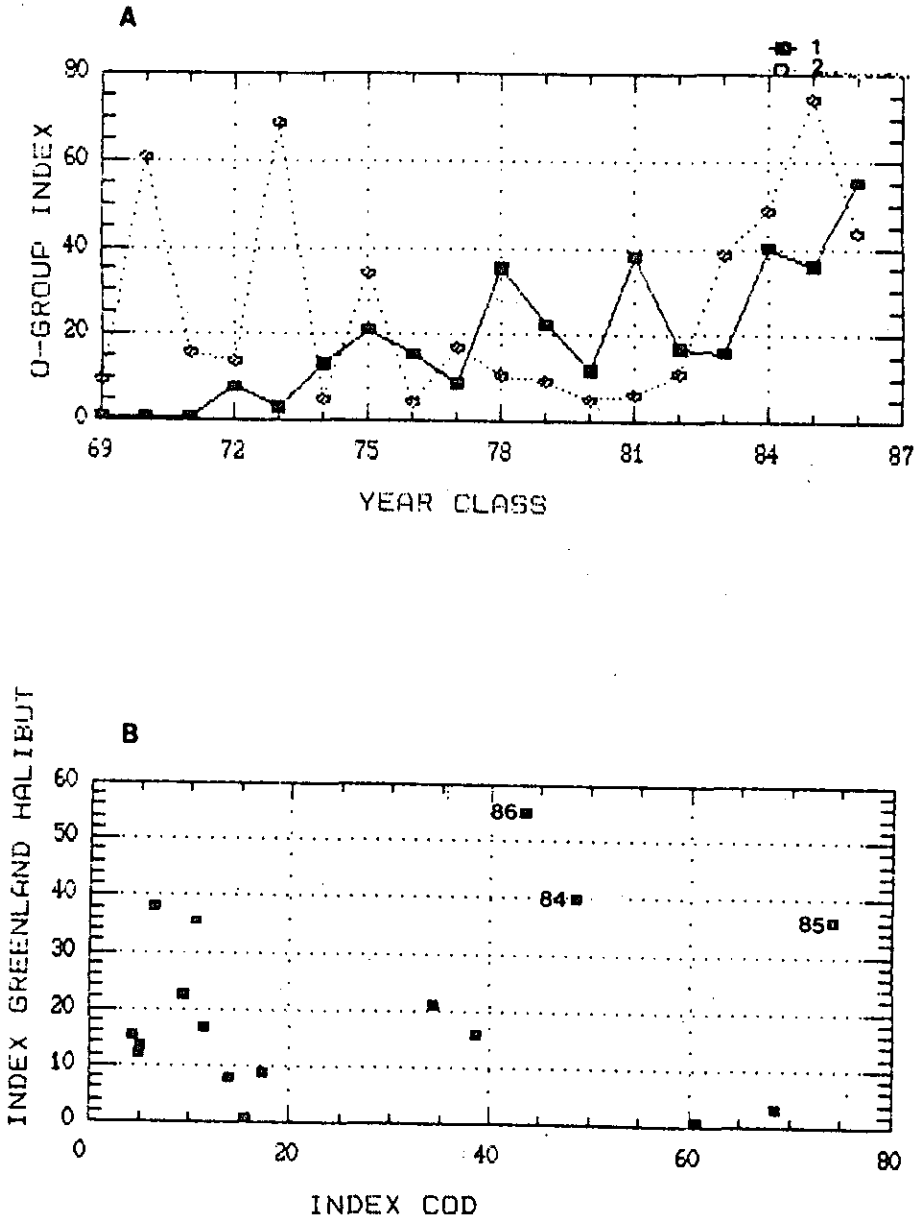


Fig. 2. The variation of the 0-group indices of Greenland halibut [1] and cod ($\times 10^{-1}$) [2] in the Barents Sea - Svalbard area during the period 1969-85. A. Variation by year. B. Cod index against Greenland halibut index (Year classes 1984, 1985, 1986 indicated).

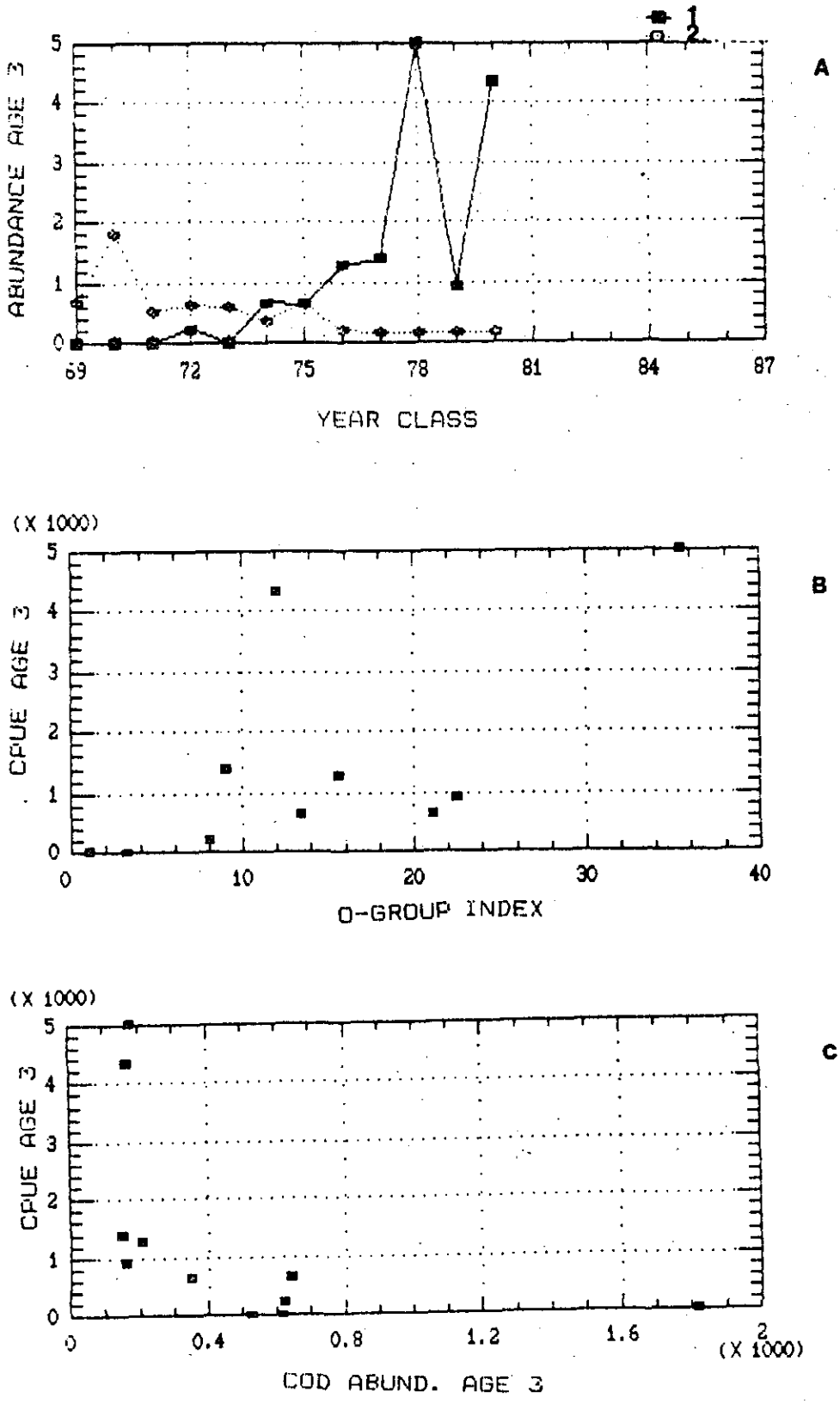
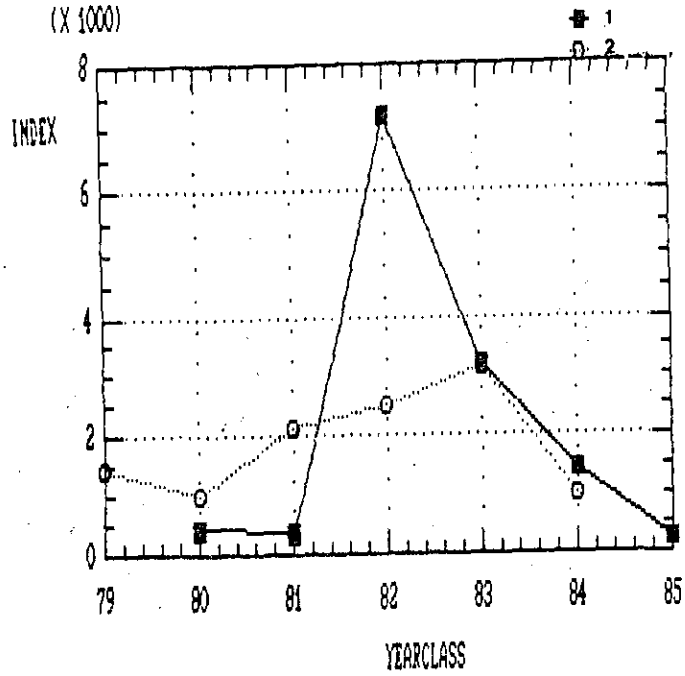
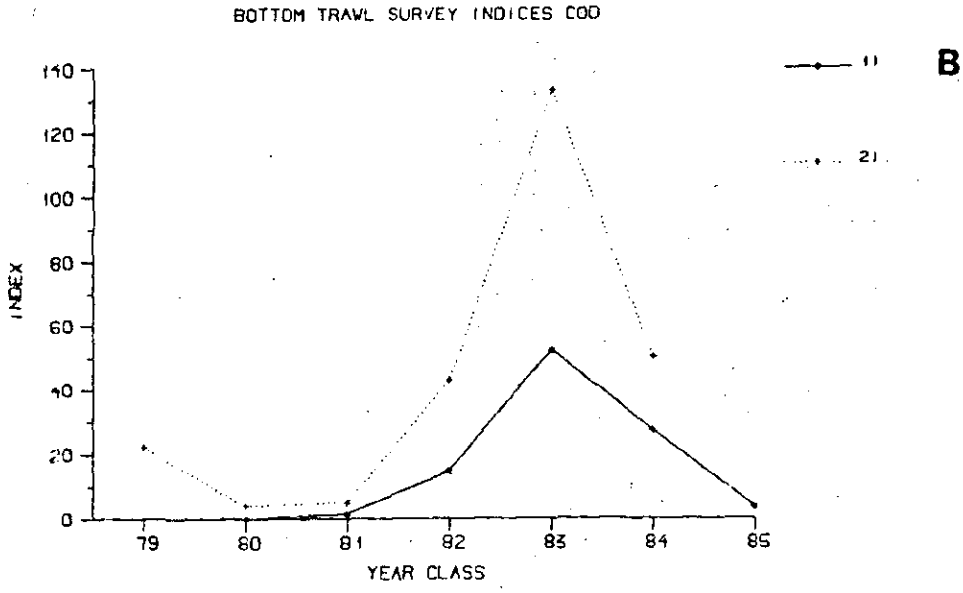


Fig. 3. The variation of CPUE of Greenland halibut age 3 years [1] compared to the abundance of cod age 3 years [2]. A. Variation by year. B. CPUE age 3 years against 0-group index Greenland halibut. C. Cod against Greenland halibut, age 3 recruitment.

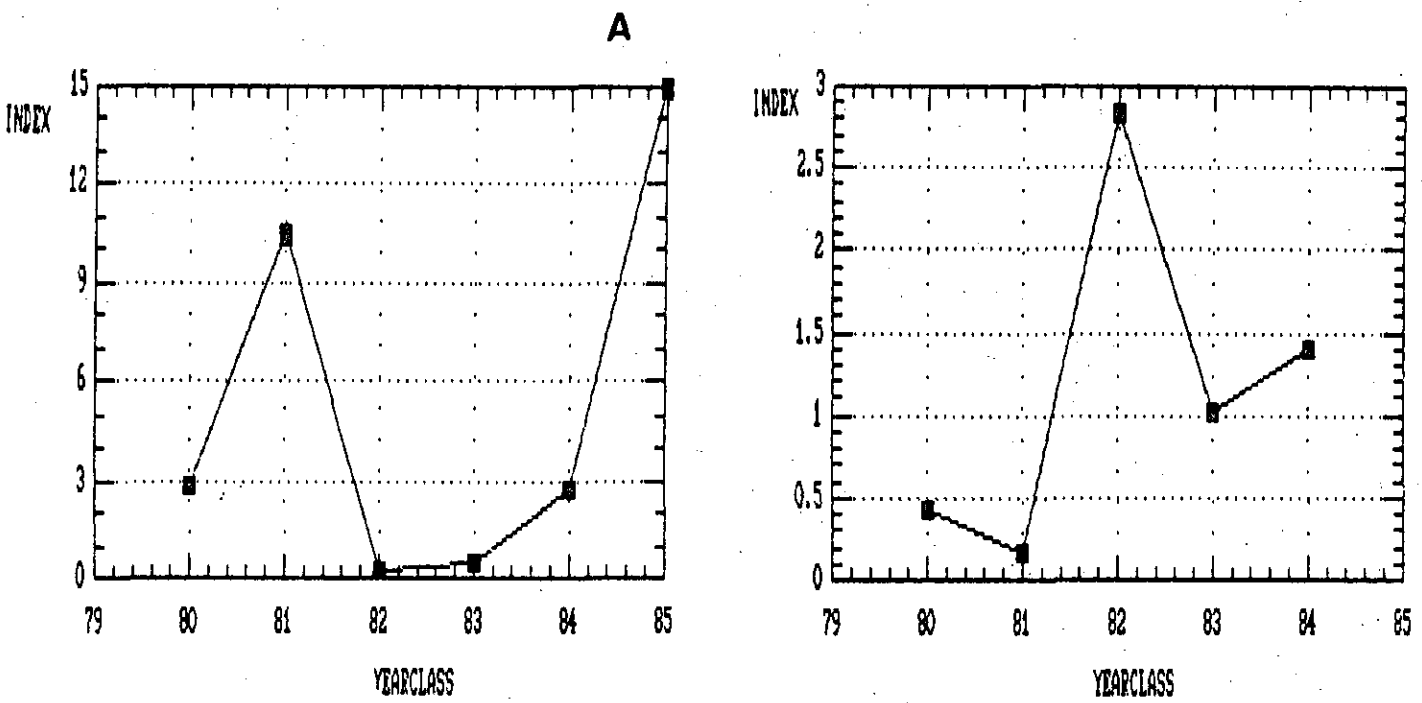


A



B

Fig. 4. Variation in Greenland halibut (A) and cod indices (B) at age 1 [1] and 2 [2] years in the Svalbard bottom trawl survey.



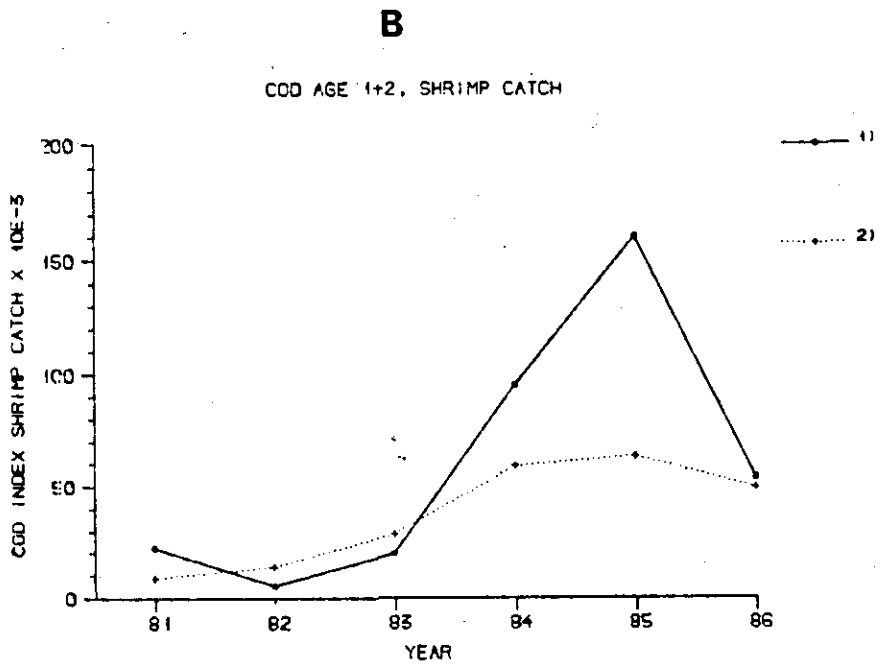


Fig. 5. Variation in the relation between 0- and I-group (0/I) and I- and II-group (I/II) Greenland halibut for the year classes 1980-85 (A). The indices of abundance of 1+2 year old cod and the shrimp catches (1000 tons) in the Svalbard area in the period 1980-85 (B).