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Development of a bottom trawl survey off East Greenland from 1980 to 1984

Summarized

by

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Abstract

The development of a bottom trawl survey over a time period of 5 years is described in relation to survey design, strategy, evaluation and possible application in fish stock assessments. Value is set on considerations of general problems in connection with special problems of the East Greenland region. Sources of improvements are displayed describing experiences in planning, conducting and evaluating such a survey.
Theoretical application of survey results in fish stock assessment is regarded and future aspects are given.

1. Survey design and strategy

1.1 Introduction

Many years assessment of fish stocks based on results of a mathematical model which is called 'Virtual Population Analysis' or 'VPA'. Since validity of the results is related to the detailed knowledge of the fishery (sometimes even more than one) changes in the fishery have great influence on the assessment.

In the case of the cod stock off East Greenland additional difficulties as migration and area of distribution have to be surmounted. The behaviour of fishing vessels (mainly trawlers) to directed fishery on cod is in doubt during the last years. Sometimes cod is taken only as by-catch in redfish fishery and other times there is no directed fishery at all. Therefore no reliable cpue can be

expected. Catch informations are believed to be inaccurate.

In this situation the ICES 'Working Group on Cod Stocks off East Greenland' decided to use bottom trawl survey results as basis for stock assessment. Such surveys were conducted by the Federal Republic of Germany since 1980. So the working group could use the results of two consecutive surveys first time during it's meeting in march 1982.

1.2 Target species

Survey design and strategy compiled for more than one species mostly consists of compromises because different species rarely show the same behaviour. Area of distribution, spawning time and migration patterns do not fit in one survey design or strategy. Various bottom trawl surveys off East Greenland before 1980 in different seasons confirmed this assumption.

Although cod and redfish are of great value in the fishery the first was chosen as target species alone, so that survey design and strategy can get the best fit to the behaviour of cod. Another reason was the pelagic living of a substantial part of redfish stocks, which cannot be represented in a bottom trawl survey.
1980 such survey was started and repeated annually.

1.3 Biological background

From various pilot surveys before 1980 the seasonal distribution of cod was known. Spawning mainly starts in spring and decrease during summer. No spawning concentrations were found in autumn when cod seems to be distributed most evenly. Also commercial catch rates are then at lowest level compared to the other seasons. Migration starts from early winter until spawning season when fish immigrate from West Greenland waters or other fish start their emigration to Icelandic waters. Sometimes pre-recruit cod emigrate from East Greenland to southern West Greenland. Intensity of migration is very variable while density distribution in autumn is surprisingly constant (CORNUS, 1984) as can be deduced from the series of surveys. Further informations on migration in Greenland and Islandic waters and its problems are compiled in the working group's report (ANON., 1981).

1.4 Timing

Depending on the choice of mathematical methods to evaluate survey data, timing of surveys helps very much to overcome statistical problems. Using arithmetic means and 'swept-area' method it can be clearly seen, that conduction of a survey in season with most even distribution of target species is the best choice. This is the case for cod in autumn what is additionally indicated by low number of fishing vessels and low cpue, that means less commercial interest caused by the absence of profitable concentrations. Therefore, autumn seems to be the best season to expect minimum variance between hauls.

Fortunately the covering of the survey area by ice is statistically smallest during autumn; from 1982 onwards there were practically no ice problems.

1.5 Stratification

The area of cod distribution off East Greenland is covered by 36 ICES statistical rectangles (figure 1). The area of each is measured and the sum of all results in 17 377 nautical square miles (table 1). The statistical rectangles serve as basic elements of various types of stratification as on depth zones , density, temperature, bottom type etc.

The first stratification (1980-survey) basing on subjective experience and knowledge of the fishery consists of 11 strata. As the distribution of sets per stratum was only weighed by area the whole survey area was covered evenly by hauls. A restratification could therefore be done without big problems. Effects of various stratifications were compared and besides others a stratification based on depth intervals was used. The depth intervals are

0 - 200 m
200 - 400 m
400 - 600 m
600 - 800 m

It turns out that the latter delivered better results in terms of confidence limits than the 11-strata model. It was applicated to the surveys from 1980 to 1982 assuming cod distribution with depth coincides nearly with its density distribution which is the best item to stratify on.

During the preparation and organisation of the 1983 survey it was aimed to stratify on density distribution based on mean density of statistical rectangles. To compare density values they have to be normalized because they are a function of abundance. On this reason density values of one survey were normalized by abundance, i.e. the number of all animals caught, to get a distribution of relative density which is then comparable to others. So mean relative density was calculated for each statistical rectangle based on 3 surveys and 360 hauls in total (Fig. 2) and 1984 stratum boundaries were determined using on objective method of DALENIUS and HODGES (1959). Such a stratification is only valid for one survey because its results influence the stratification of the following survey.

A remarkable stability of density distribution comes out of the calculations. This result again encouraged the use of stratification on that item (CORNUS, 1984).

Each new survey contributes to the distribution of mean relative density. Although the distribution seems to be very stable an unormal year may stop this or even a normal year may change the strata boundaries.

1.5.1 Number of strata

To determine the number of strata developed to a critical point in survey design and strategy. Theoretically, a finer stratification, that means a greater number of strata, produces better results in terms of confidence limits if the number of hauls per stratum becomes not to low. To avoid artificial high variation between hauls caused by low number of sets, at least round about 30 hauls should be set in a stratum (theory of small number sampling, COCHRAN,1972). Only if it is very shure that variation between hauls is reasonable small in a stratum the number of hauls can be reduced on benefit to other strata. Because the number of hauls during a survey is a limited factor the number of strata had to be determined in a way that the above proposition is hold. Time schedule of East Greenland surveys allows about 100 to 160 hauls at all, the realistic number depending mainly on days with bad weather. So a five strata design based on distribution of mean relative density seems to be a good compromise. In table 2 the number of hauls per stratum in all surveys are compiled. The 1982 survey was time restricted as well as the 1984 survey. This was only a quick look one because the normally used research vessel FFS "Walther Herwig" was in this time not able to fish on technical reasons. FFS "Anton Dohrn" had to take both parts, East and West-Greenland survey, with emphasize on the latter one and time missing to conduct the first one accurately.

1.5.2 Number of hauls per stratum

The distribution of number of hauls on strata was calculated by means of weighing of stratum area and mean relativ density per stratum:

$$N_s = N_T \frac{F_S \, D_S}{\sum_S F_S \, D_S}$$

N_S number of hauls per stratum s

N_T total number of hauls

F_S area of stratum s

D_S mean relative density of stratum s

F_T total survey area

The distribution of hauls for the 1980 survey was done weighing on stratum area alone:

$$N_S = N_T \frac{F_S}{F_T}$$

Weighing only by area has the advantage to cover the total area evenly in a statistical sense; naturally the hauls were distributed in a stratum at random. The problems arising when restratification is wished are not so evident. On the other hand there is a disadvantage to get not an optimal

distribution in relation to resulting confidence limits. The described advantage and disadvantage change to opposite applicating a weight combined of area and density.

Basicly, only a very strong intensification of effort, i.e. increasing number of hauls, results in reasonable improvement of confidence limits (YATES, 1965). In a few cases appropriate stratification and weight may generate improvements of the same order.

On the other hand, the total number of hauls has to be in suitable order in relation to the survey area. An example showing the negative effect is the 1984 survey which bad confidence limits are mainly caused by the low number of total hauls. Table 2 shows the effect of reduced total number of hauls in terms of represented area per haul.

1.6 Restrictions by environment

Special problems arise from bottom topography, bottom covering, ice and strong currents along the shelf edge off East Greenland. Well known to the fisherman are the trawlable banks and ridges. But a substantial part of the shelf edge, mainly in the southern area, consists of canyons, where trawl fishery is practically not possible. On the other hand great areas are covered with silicate sponges which are a big handicap filling the net rapidly and totally. Ice may be a sudden barrier or covers a region which should be trawled. Strong currents (up to 2 knots) along the shelf edge complicate navigation during trawling and demand permanent corrections.

1.7 The gear

A 140 feet bottom trawl was chosen since the commercial fishery used the same gear with good experience. Although there are bigger gears in use the one in choice is better to handle on East Greenland trawling grounds.

The horizontal net opening at 4.5 knots trawled is 22 m. The gear was measured by FFS "Walther Herwig" during a special cruise to the Rockall Plateau. A detailed description and first results are given by KROEGER and KOCK (1982).

Problems arise using "swept-area" method to estimate biomass since only a mean horizontal opening at a certain trawl velocity could be determined during a haul and time of effective trawling is not known precisely.

2. Evaluation of Survey Data

2.1 Data Base

The source of basic informations of all surveys are standard hauls of 30 minutes duration trawled with 4.5 knots velocity. Haul positions were determined randomly within a stratum. Each haul got a stratum index for abundance estimate purpose.

A haul broken after less than 10 minutes was defined to be invalid, the same was true for 30 minutes hauls with net teared up.

Number as well as weight per 30 minutes trawling for each species were recorded. Length frequencies, sex and maturity determinations, individual weights and otoliths or shell sampling were taken always of main species and for others depending on time available. Age-length-keys, maturity ogives and mean weight and mean length at age were compiled and evaluated.

2.2 Restrictions on validity

A maine purpose of a survey is to get on estimation of stock abundance and stock biomass. The results of a survey as described before however, are estimations of abundance and biomass in the trawlable area. During the survey in autumn prerecruit cod live in coastal waters or are in pelagic state. On the other hand adult cod can stay in not trawlable areas of deep rugged canyons. Sometimes certain age groups may behave in away which make them less available to the gear, so parts of the stock cannot be represented in bottom trawl survey results.

It has to be emphasized that survey indices or deduced parameters are related to the above mentioned restrictions. This is even more valid when survey results are used for stock assessments !

2.3 Number per hour and density

The number of fish per hour trawled is a function of abundance of that species within the survey area and can serve as an abundance index. It is also a function of trawl velocity, horizontal and vertical net opening as well as catchability. Since all parameters are variable from haul to haul, even haul duration, the use of N/h may therefore generate additional variations computing mean values. It is better to normalize the number caught by the actual area swept of the trawled net on ground which is also a function of haul duration, trawl velocity and horizontal net opening. If N denotes the number caught, the normalized index I then reads

$$I = C\frac{N}{T\,V\,B}$$

with C - catchability factor
T - actual haul duration
V - actual trawl velocity
B - horizontal net opening.

The product $T\,V\,B$ is equal to the actual area swept and as C is dimensionless the dimension of the calculated index I is accurately a dimension of density.

2.4 Estimation of abundance and biomass

Availability of density makes it easy to extrapolate abundance to an area. Whereas an index is only an indirect or relative measure of abundance extrapolation gives an estimation of the size of stock abundance keeping in mind the restrictions described in section 2.2. Using indicies, other

informations on size of abundance were necessary.

Normalized indices (density) were calculated for every valid haul. Mean density and standard deviation were computed for each stratum and abundance extrapolated to stratum area. By means of evaluation of stratified random sampling (COCHRAN, 1972) abundance was calculated for the whole survey area and confidence limits determined at 95% level of significance.

The same procedure was done in terms of density of weight and resulted in an estimation of biomass. Since the surveys were designed on density of abundance (of number of fish) the evaluation of biomass mainly is not as good as that of abundance in terms of confidence limits because a high abundance may not be correlated with high weight when there are young and small fish. A comparison of the estimated biomass can be done with the product of age composition and mean weight at age.

Commercial interest may be more on biomass values but abundance and age composition are basic parameters for stock assessments and have first priority.

2.5 Note on catchability

A very critical point in estimating stock size and age composition of a species is the catchability of the gear. Basicly two effects influence the catchability.

First, technical design as wrigging, meshsize, material etc. are responsible whether a gear does it's function, independant of fish species and their own behaviour. A bad construction may dam water infront of the net and reduce the flow. Suitable trawl velocity stabilize the gear, less velocity may let collapse the net timewise when it hits an obstacle.

Second, behaviour of fish may influence catchability, dependant on species. Some try to escape upward , others sideward and again others try to escape increasing their velocity. Behaviour is also a function of seasons.

In the case of cod it is fortunately known that it dives to the bottom trying to escape what indicates that vertical net opening may not be an influencing factor (MAIN and SANGSTER, 1981, 1982). Although this is only observed in European waters it is assumed cod behave the same way off Greenland. In spite of that the catchability factor of the gear in use off East Greenland is unknown.

The value of 1 on the other hand was used in the calculations because it prevents an overestimation of abundance.

It can be concluded that 'swept-area' method is adequate in case of the species cod.

2.6 Results

The summarized standard parameters of the surveys are:

gear	140' bottom trawl

horizontal net opening	22 m
catchability coefficient	1.0
trawling speed	4.5 kn
haul duration	30 minutes
total survey area	17377 nm²

Table 3 exposes the results of all surveys from 1980 to 1984
The 'Working Group on Cod Stocks off East Greenland' interpretated the results in relation to the state of the cod stock in it's reports (ANON., 1981, 1982, 1983, 1984, 1985).

2.6.1 Improvements

No improvement was expected for the 1981 survey because of time restriction. Also it was not known whether the distribution pattern of cod changed from 1980 to 1981 or not. The very bad confidence limits of the 1982 survey are mainly caused by one haul twenty times bigger than the mean in this stratum which had the greatest weight of area and mean relative density. Additionally there was lowest abundance off all surveys and only 80 hauls.

The best improvement could be noticed after changing the stratification type in 1983 which reduced confidence limits to the lowest on record. On technical reasons the 1984 survey had to be conducted with another ship and in shortened time and consequently the number of hauls was reduced. This survey cannot be regarded as a normal one.

Naturally, sampling of data refined on experience and this is not seen on a first sight but may be evident on other items as stock composition, growth calculation etc.

2.6.2 Deficiencies

There are two species of deficiencies in bottom trawl surveys, those which are removable and those of methodical nature.

Beginning with the latter the extrapolation of abundance from mean density to an area proposes an evenly distributed fish stock, which rarely can be found in nature. Timing can only reduce the effect of concentrations to a minimum . One example of that effect is mentioned in the section before. Additionally the even but still random distribution of hauls is only possible in a very few cases, when environmental factors are favourable. Another uncertain proposion is presuming all fish above the swept area within the vertical net opening are caught ! For some species that may be nearly true, but for many others not !

The other type of deficiencies is in principle removeable, mainly obstacled by technical difficulties. Timing may be difficult by ship's operation schedule or in one year another vessel has to be taken, influencing comparability of survey results. In relation to determining swept area sometimes only measurements of relative velocity of the ship is possible although real velocity over ground is necessary, or the exact time span of net fishing on ground cannot be measured.

The estimated abundance based on survey results is dependant on all above mentioned parameters !

2.6.3 Conclusions on further improvements

It is believed that increasing of the total number of hauls make bottom trawl survey results more secure with respect to biological parameters or even decrease confidence limits. To enlarge survey time by one or two weeks is a point of organisation. Survey experience shows that a mean of about 5 hauls per day is realistic; this would be a profit of about 35 hauls per week. In case of East Greenland survey a total number of 150 hauls is possible planning total survey time on 7 weeks including transfer to and from survey area as well as a short interruption on logistic reasons.

Survey results become more valid when experience in design and strategy and knowledge of basic biological parameters increase with the growing of a time series. Therefore important survey parameters should not be changed. One of those is the vessel which should be the same in a time series because it is the most evident source of variability. It is very difficult to get factors of comparison of fishing power.

Changeable is the set of area elements serving for strata generation. Now they are .5° in latitude times 1° in longitude and equal to ICES statistical rectangles. It is aimed to reduce these basic area bits to a quarter of a statistical rectangle in order to increase knowledge on density distribution. Refined stratification produces better accuracy. Only quite a lot of hauls as a sum of all surveys enable such a procedure. An improvement which can be achieved financially is the purchase of a 'Doppler-log'. Direct velocity over ground then is possible to measure.

Gear technical problems may be enlightened by starting another special cruise on gear measurements based on the first one in 1981 (KROEGER and KOCK, 1982), perhaps combined with research on behaviour of cod infront of the net. A special problem in shelf region off East Greenland is the covering of large areas by silicate sponges,(Ceodia gigas).In principle those areas are trawlable, but the net is then very quickly filled up with sponges. Fishermen use tricks on wrigging and design to minimize filling up. Until now however, it was refused to use such a tuned gear as it has surely another catchability and it is yet not known how to regard this effect.

From theoretical point of view an improvement may be possible distributing hauls to strata by means of refined weight. Referring to chaapter 1.5.2 the weight is a combination of stratum area and stratum density with same weight against each other. It should be proved whether an unbalanced weight generates better confidence areas.

It should be noticed that given frame of time and possible effort restricts improvement in confidence area to a certain but still not known limit.

3. Reliability of survey results

Only informations independant of survey results are appropriate to be criterion

on reliability of survey results. Those are informations from the fishery or results of other surveys. Off East Greenland there is an annually 0-Group survey in summer conducted by Island (VILHJALMSON and MAGNUSSON, 1981, 1982, 1983), which can serve as information on the estimation of size of 0-group yearclass. Target of this survey are the cod from age 0 to 2 and so the methods which may not represent the rest of the stock whereas the autumn survey methods just cannot represent the young age fish. Results of the 0-group survey are usefull one or two years later when these age groups become available to the gear. But meanwhile environmental circumstances may have reduced the size of the concerning yearclasses rapidly as the life story of the 1982 year class told.

Informations from fishery although independant from surveys are biased by migration behaviour of cod in Greenland waters. So trends in fishery and reports on nominal catch may not show trends of the size of cod stocks off East Greenland alone but also effects of migration from West Greenland waters into East Greenland area which may counterbalance decreasing trends of size in East Greenland. Between surveys in autumn of two consecutive years migration and most of the fishery takes place in spring of the year of the following survey and a substantial if not the larger part of the catch off East Greenland proceed from West Greenland. Informations on catch of pure East Greenland stock are not yet available but a joint research program of Denmark and the Federal Republic of Germany on characterization of otoliths from East and West Greenland is sharted in 1984 and hopefully helps to solve the problem of distinguishing. In case of West Greenland cod stock immigration is of reasonable low order and considerations on reliability of surveys using data from fishery are possible (CORNUS et al., 1985).

Statements on the reliability of survey results of the East Greenland part are only possible if the puzzle of parts which consists of size of stocks, catches, migration between West and East Greenland and emigration to island fits together.

4. Survey results and stock assessment

It is stressed out that following considerations are valid to the meaning of a fish stock with restrictions described in section 2.2

4.1 Available informations

A basic data set necessary for assessment of fish stocks can be drawn from fishery and surveys.

Market samples and norminal catch allow for calculation of numbers caught during a year split up be yearclasses.
Total stock size, spawning stock size, age compossitiosn, mean weight and maturity at age are results of consecutive surveys respectively.

4.2 Theoretical considerations

From a data set as described in section 4.1 total mortality of recorded yearclasses can be calculated. It is then possible to determine fishery

mortality (per recorded yearclass) directly. Using the common assumption of 0.2 for natural mortality a factor of combined effects of immigration, emigration and recruitment is available for each recorded yearclass, too.

Let S_i total stock in year i
S_{i-1} total stock in year i-1
C_i total number caught in year i
K_i total number of emigrants, immigrants and recruits in year i
z_i coefficient of total mortality
f_i coefficient of fishing mortality
m_i coefficient of natural mortality
k_i coefficient of combined effect of emigration, immigration and recruitment

and $m_i = 0.2$ as conventional assumption then following equations are valid

$$(1)\quad S_i = S_{i-1} e^{-z_i}$$

$$(2)\quad C_i = S_{i-1} \frac{f_i}{z_i} (1-e^{-z_i})$$

$$(3)\quad K_i = S_{i-1} \frac{1_i}{z_i} (1-e^{-z_i})$$

$$(4)\quad z_i = f_i+m_i+k_i$$

Known parameters are S_i, S_{i-1} from surveys, C_i from fishery and m_i as assumption. Requested parameters are z_i, f_i, k_i and K_i .

z_i can be extracted from equation (1):

$$(5)\quad z_i = -\ln(\frac{S_i}{S_{i-1}})$$

Subsequently f_i can be determined from (2):

$$(6)\quad f_i = \frac{C_i\, z_i}{S_{i-1}(1-e^{-z_i})}$$

and k_i from equation (4):

$$(7)\quad k_i = z_i-f_i-m_i$$

Finally K_i is directly calculated by equation (3). The procedure fails only when S_{i-1} or S_i equal 0. Adding an age group index j to all parameters equation (1) to (7) are also valid for any age group j.

Let e_i, i_i and r_i coefficients of emigration, immigration and recruitment respectively then k_i is displayable as

$$(8) \quad k_i = e_i - i_i - r_i$$

From informations of tagging experiments or programs like that mentioned in chapter 3 for certain age groups e_i or both parameters may be estimated and an imagination of recruitment is easily got. On the other hand, if there is a stock where definitively no migration occurs determination of natural mortality is possible for full recruited year classes existing accurate catch records.

In assessments based on 'VPA'-method the only information is the total number caught broken down on age groups. No information is available on stock composition and trends within; catch composition may not reflect such changes because other influences as different gears or new vessels change the catch composition itself. Stock size in 'VPA' method is a function of catch and therefore a function of changes in a stock whereas stock sizes from results of consecutive surveys are estimated independently of fishery in terms of absolute size. Concerning stocks which are reasonable affected by migration it is very difficult to consider migration aspect using 'VPA'.

4.3 Note on practical application

Since surveys normally were not conducted on a 1. of January stock size of survey results has to be fitted to that date in conventional pattern for catch projections and management options. This has to be done with respect to catches, migration and partial recruitment during the time between survey and beginning or end of the year.

A wide range of age groups of cod is affected by migration and recruitment in the East Greenland area. To give catch projections and management options needs more knowledge on those features. Surveys are very helpful in this context.

A detailed description of practical application of survey results is given in the series of reports of the 'Working Group on Cod Stocks off East Greenland' (ANON., 1981, 1982, 1983, 1984).

5. Future aspects

To handle confidence limits in connection with 'VPA' is very difficult and this problem is somewhat ignored in assessments. The adventage to have confidence limits with survey results raises (new) problems in relation to significance of differences of stock sizes in consecutive years and a

fertile ground for investigations is found.

Encouraged by the reasonable success of surveys off East Greenland a similar surveys series was started in 1982 off West Greenland (MESSTORFF and CORNUS, 1984). Specialities of that region have to be experienced and a stratification on density is in preparation. Only a combination of assessments of East and West Greenland cod stocks may proceed the success enlightening the problems of migration around Greenland. Timing should be organized that all data necessary are available for both assessments. All bits and pieces of assessment elements may then be fitted together to an assessment of cod stocks off whole Greenland.

A step further would be to include results of assessments of Icelandic cod stocks because Icelandic waters are sources of larvae spending to Greenlandic waters and receive grown up fish from it.

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Table 1 Trawlable area in nm²

	stat.rect.	0-200m	200-400m	400-600m	600-800m	total
1	48 A1	217	208	51	39	515
2	49 A1	466	313	76	17	872
3	49 A2	-	28	9	11	48
4	50 A1	343	234	65	-	642
5	50 A2	69	97	39	17	222
6	51 A2	105	225	151	27	508
7	52 A2	208	547	55	7	817
8	52 A3	1	21	13	14	49
9	53 A2	43	444	284	26	797
10	53 A3	31	142	175	50	398
11	54 A3	79	236	93	18	426
12	55 A3	194	456	53	7	710
13	55 B0	-	196	119	15	330
14	55 B1	-	43	22	20	85
15	55 B2	-	5	7	10	22
16	56 B0	57	593	114	33	797
17	56 B1	-	797	-	-	797
18	56 B2	-	666	17	14	697
19	56 B3	-	188	15	11	214
20	57 B2	30	225	378	98	731
21	57 B3	2	572	148	16	738
22	57 B4	-	205	61	30	296
23	58 B3	17	137	569	45	768
24	58 B4	22	323	323	35	703
25	58 B5	-	22	50	89	161
26	59 B4	-	754	-	-	754
27	59 B5	-	728	18	8	754
28	59 B6	25	323	60	79	487
29	59 B7	-	40	33	27	100
30	59 B8	-	13	46	63	122
31	59 B9	-	30	97	47	174
32	59 C0	-	4	9	12	25
33	60 B7	-	709	18	5	732
34	60 B8	-	562	164	15	741
35	60 B9	-	254	487	-	741
36	60 C0	-	388	16	-	404
		1909	10728	3835	905	17377

Table 2

Stratum No.	Stratum Area nm²	No. of Hauls	Mean No. of Fish per nm²	Standard Deviation	Coefficient of variation	Mean Area per Haul nm²
FMS 'Karlsburg' 1980. Stratification item: depth						
1	1 909	20	187	51	0.27	95
2	10 728	65	34	7	0.21	165
3	3 035	16	3	1	0.33	190
4	905	5	0	-	-	181
Total	17 377	106	42	7	0.17	164
FFS 'Walther Herwig' 1981. Stratification item: depth						
1	1 909	10	195	72	0.37	191
2	10 728	38	59	11	0.19	282
3	3 035	14	14	8	0.57	216
4	905	1	0	-	-	905
Total	17 377	63	61	11	0.18	276
FFS 'Walther Herwig' 1982. Stratification item: depth						
1	1 909	7	56	10	0.18	272
2	10 728	54	20	8	0.40	199
3	3 035	17	5	1	0.2	179
4	905	2	0	-	-	458
Total	17 377	80	19	5	0.26	217
FFS 'Walther Herwig' 1983. Stratification item: density						
1	3 237	6	17	11	0.65	540
2	3 286	41	10	2	0.20	80
3	7 766	48	19	5	0.26	162
4	1 931	10	24	10	0.42	193
5	1 157	17	70	16	0.23	69
Total	17 377	122	21	3	0.14	142
FFS 'Anton Dohrn' 1984. Stratification item: density						
1	2 570	3	39	5	0.13	857
2	3 885	9	3	2	0.67	432
3	8 236	16	18	9	0.50	515
4	1 527	2	18	18	1.00	763
5	1 157	6	54	31	0.57	193
Total	17 377	36	20	5	0.25	483

Table 3 Survey results 1980 to 1984

Biomass in tonnes

Stock size in order of 10^3

Year	Season	Ship	Biomass	Stocksize
1980	Oct/Nov	FMS 'Karlsburg'	62 944 ± 32.8%	15 425 ± 33.9%
1981	Nov/Dec	FFS 'Walther Herwig'	88 336 ± 43.4%	19 448 ± 35.3%
1982	Sep/Oct	FFS 'Walther Herwig'	19 782 ± 35.0%	6 106 ± 52.5%
1983	Sep/Oct	FFS 'Walther Herwig'	26 980 ± 37.9%	6 730 ± 33.1%
1984	Oct	FFS 'Anton Dohrn'	21 151 ± 41.7%	6 488 ± 51.2%

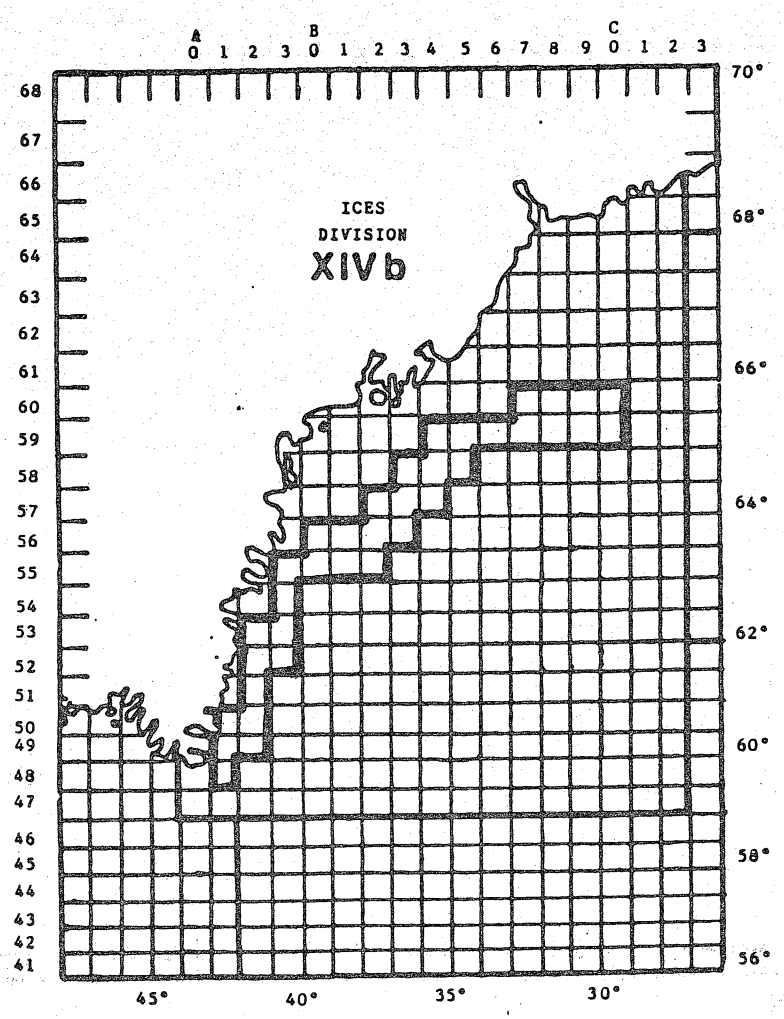

Fig. 1

Trawlable area

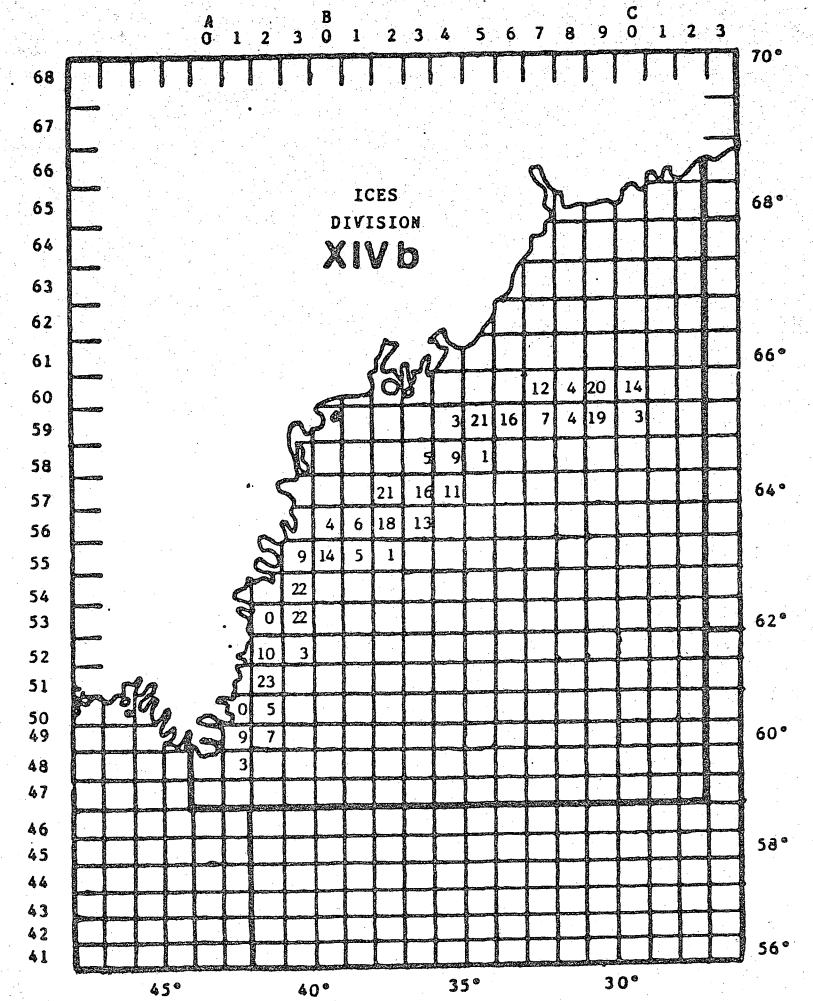

Fig. 2

No. of hauls per statistical rectangle from 1980 - 1983

Total 360