RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2707
(B.g.7)

ICNAF Res.Doc.72/1

ANNUAL MEETING - JUNE 1972

Report of Mid-Term Meeting of Assessment Subcommittee
24-29 January 1972

The mid-term meeting was held at FAO, Rome, Italy from 24-29 January 1972. Twenty-two scientists from 11 member countries attended, together with guest scientists from FAO and the Institute of High Seas Fisheries, Rostock, and the Executive Secretary and Assistant Executive Secretary. Groundfish and herring working groups were organized to facilitate completion of tasks. A completed report on herring assessment was submitted to STACRES, and, in turn to the Commission for its special meeting on herring (see also 1972 Special Meeting Proceedings No. 1).

The complexity and amount of assessment work has increased greatly in recent years. The present report is the result of comprehensive research over the year by many scientists at their home laboratories, and intense work during the meeting.

The work of the Subcommittee was greatly facilitated by the accommodations provided by FAO.

TABLE OF CONTENTS

I. Chairman's Synopsis

Cod

The assessments this year again indicate that the major cod stocks are probably being fished at a higher intensity than that which would produce the long-term maximum yield. This is particularly so for the northern stocks, which provide most of the catch. The southern stocks are being fished very near the level of maximum sustainable yield. Recent catch and estimated sustainable yield for 1972 and the long-term maximum sustainable yield are summarized below.

It is again stressed that regulation of catches, in order to achieve population levels which provide the maximum production, should be instituted now when cutbacks would be minimal. Setting quotas for 1973 at the 1970 catch level would in most cases be a suitable conservation measure.

Stock	Catch[a] 1970	Sustainable Catch[a] 1972	Maximum
Subarea 1	115	100	300
Subarea 2 and Div. 3K-L	504	520	800
Div. 3Ps	71	60	60
Div. 4T-Vn	74	100	100
Div. 4X (offshore)	9	5	15
Subarea 5	35	30	35
Total	808	815	1,210
Div. 3M	18	Currently overexploited	
Div. 3N-O	104	No assessment	
Div. 4R-S	100	" "	
Div. 4Vs-W	59	" "	
Total	281		

[a] in thousands of metric tons

Haddock

Research vessel surveys in 1971 indicate continued low levels of population and poor year-class production for all the stocks. The 1972 quotas are too high to provide for any increase in stock abundance; more likely it will continue to decline. A total ban on haddock fishing is the only measure which might permit an increase in stock abundance. Even then, a long period, certainly more than five years, will be required to rebuild stocks to levels which would provide again a good harvest.

Herring

An intensive assessment effort was required to meet the requirements of the Commission for the special meeting on herring. A special report was prepared and circulated as an appendix to the STACRES meeting proceedings (see 1972 Special Meeting Proceedings No. 1). It is also included herein.

A summary of recommended quotas for 1972 to achieve the objective of maintaining or increasing stock abundance is given below, compared with 1971 catches and possible long-term maximum yields for the three southernmost stocks. Even though the quotas require a rather drastic decrease in catch, they are more likely to be too large than too small to achieve the objectives.

Summary of maximum yields and allowable yields in 1972

	Maximum sustainable yield	1972 Quota		
		To maintain 1971 stock size	To increase stock size in 1972	To achieve optimum yield per recruit
Georges Bank (Div.5Z, Subarea 6)				
Long-term average recruitment	300,000	-	-	-
Recent average recruitment	130,000	95,000	70,000	70,000
Recruitment reduced 25%	-	70,000	50,000	-
Gulf of Maine (Div.5Y, 4Xb)				
Average recruitment	>50,000[1]	0[2]	-	28,000
Nova Scotia (Div. 4Xa, 4W)				
Average recruitment	100,000	60,000	-	?

[1] If all taken as juveniles. Harvesting as adults would increase sustainable yield
[2] Adult fishery

Yellowtail flounder (Subarea 5)

The revised assessment confirms the conclusions of last year regarding the desired quotas for 1972. Providing the quota is not exceeded in 1971-72, assessment of current status and estimated recruitment for 1973 indicates the quotas should remain the same in 1973, i.e., 10,000 tons west of 69° and 16,000 tons east of 69°.

American plaice (Subarea 3)

The current assessment confirms last year's advice that the two stocks (Div. 3L and Div. 3N) are being fished near the maximum level, and that increased fishing mortality will not provide a long-term increase in catch. Thus, catches should not exceed the 1970 level (40,000 tons in Div. 3L; 20,000 tons in Div. 3N).

Red and silver hake (Subareas 5-6)

Assessment of the status of these stocks are not yet complete. The preliminary analysis indicates that some increase in catch over the 1970 level may be possible in 1973 because of increased recruitment.

Scallops (Subarea 5)

The abundance of scallops over Georges Bank remains low, and it has been demonstrated that the fishery is concentrating more on the small, newly recruited age-groups. Yield per recruit is drastically reduced compared to that achieved by delaying capture for about 3 years. It is apparent that the size of first capture should be increased, and overall fishing intensity reduced to permit an increase in population density.

General

The case of herring has demonstrated again the drastic and difficult measures that are required to restore productivity of heavily overfished stocks. The total fishing effort in the ICNAF area may already be close to that which can be supported, in the long run, by the total available biomass. Fishing effort will probably increase if left unregulated, and the unregulated stocks will be subject to increasing fishing intensity. It is problematical that thorough assessment of the status of these stocks can be completed before over-exploitation takes place.

If it is desired to maximize the productivity of the resource, which would provide, in turn, near maximum economic returns, some limitation of the total effort (or catch), or at least some limitation of the rate of increase of total effort will be required.

II. Cod

1. Subarea 1

Nominal catch in 1970 was approximately 115,000 tons, and provisional figures for some countries indicate that the 1971 nominal catch may be about equal to the 1970 catch. Information on fishing effort and catch-per-unit-effort for 1971 is not yet available.

Total numbers landed per age-group in 1970 are estimated as follows, based on German and Danish samples from otter trawlers' catch:

Age-Group	Year-Class		Nos. x 10^{-3} landed
IV	1966		2,644
V	1965		9,788
VI	1964		7,283
VII	1963		14,243
VIII	1962		4,360
IX +	1961 -		4,132
		Total	42,450

Estimated mean weight per fish landed in 1970 was 2.71 kg round fresh weight. There was some difference in age-composition between fish caught from Div. 1A-1D and 1E-1F. In Div. 1A-1D age-group V (year-class 1965) predominated in catches, whereas age-group VII (year-class 1963) was by far the most important in Div. 1E-1F. Cod in Div. 1E-1F seemed to grow slowly in 1970, and even more slowly in 1971, so that the observed difference in age-composition was not reflected in any great difference in mean weight of fish in the two stocks mentioned. German data for 1970 gave mean weight in Div. 1A-1D as 2.43 kg and 3.17 kg in Div. 1E-1F, whereas for 1971 they were 3.22 kg and 3.14 kg in Div. 1A-1D and 1E-1F, respectively.

In last year's report (Redbook 1971, Part I, p. 34) it was estimated that the 1970 catch corresponded to an F value of 0.30. However, landings per age-group as given above show that numbers of fish landed of age-groups VI and older correspond to an F value of about 0.6. Landings of younger age-groups in 1971 were less than predicted in last year's assessment. Evidently, trawlers, the landings of which make up 70% of total landings, have concentrated on schools of older fish in the southern part of the subarea.

This change in fishing practice combined with the most recent change in growth-rate in the southern divisions makes assessment of future catches very difficult. It seems necessary to develop assessment separately for Div. 1A-1D and 1E-1F respectively, but neither data nor time allowed this at the present meeting. It is, however, evident that fishing in 1970 and probably also in 1971 has been relatively more intensive on older fish than presumed at last year's meeting.

The prospect for recruitment in 1972-74 is not very good. In Div. 1E-1F there are no signs of a good, incoming year-class. In Div. 1A-1D the 1968 year-class seems relatively promising although not comparable to the good 1965 year-class. The apparent more northerly distribution of the young fish and trawlers concentration in the southern part of the subarea may, however, provide for increased yield-per-recruit from the 1968 year-class than would have been the case by fishing more intensively on the young fish as was done in the beginning of the 1960's. Also, the 1965 year-class has a northern distribution and must be expected to be the most important in the 1972 fishery in Div. 1A-1F. It is expected gradually to move southward to Div. 1E-1F as the fish become mature.

In summary, the abundance of the cod stock at West Greenland is low at present, and with the present prospects for recruitment it is likely that at a favourable level of fishing (i.e., F = 0.6 which has been proposed as a desirable upper limit), the annual catch 1972-75 will not approach the 300,000 tons previously estimated to be about the long-term maximum sustainable yield for this stock. Owing to recent changes in the structure of the fishery, we have not been able to estimate the exact level of fishing mortality over the whole of the subarea in 1970, but it appears that despite the low catch level the fishing mortality on some age-groups has not fallen far below the value F = 0.6. This situation will be re-analyzed in more detail but it is clear that, at present, if the stock improves relative to other areas, even despite its low absolute level, fishing mortality could quickly rise to an undesirably high level. The best available estimates of catches associated with constant level of fishing mortality in 1971 and 1972 are given in the table below.

1968	1969	1970	1971	1972
382 (0.80)	230 (0.60)	115 (0.60)	115 (0.60)	100 (0.60)

2. Subareas 2 and 3

Subarea 2

The total catch of cod has fallen from 412,000 tons in 1969 to 217,000 tons in 1970. The underlying trend is shown most clearly by the review of the fishery in Div. 2J presented at the last Annual Meeting (Res.Doc.71/10). Attention was drawn to the increase in catch from 39,000 tons in 1959 to a peak of 361,000 tons in 1969. Catches in Div. 2J fell sharply to 199,000 tons in 1970. Estimates based on Polish and USSR fishery statistics indicate a decline in stock abundance since 1968: in 1969 the decline in catch per unit effort was presumably offset by increased fishing to give a small increase in total catch in that year, but the fall in catch in 1970 is rather greater than the apparent decline in stock abundance, pointing to a slight reduction in fishing in that year. Estimates of catch in 1972 are not yet complete but it is evident that the decline in stock abundance has continued.

The change in total catch has been accompanied by a reduction in the relative abundance of older age-groups. A major part of this change is related to fluctuations in year-class strength. The 5-6-year-olds from the 1963 year-class which provided the peak catches in 1968/69 have now been replaced in importance by the much weaker 1964 and 1965 year-classes. However, USSR young cod surveys show improved recruitment will come from the 1966, 1967 and 1968 year-classes (see table below) which will start to enter commercial catches in 1972. There is, therefore, a prospect of improvement in abundance of this stock, provided, of course, that fishing intensity does not increase at a proportionate rate.

Mean number of 3-year-old cod per hour trawling (USSR Labrador young cod survey).

Year-class	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Number	21	11	20	15	36	8	15	27	32	40

The trend of increasing fishing effort up to 1969 is evident in the most recent assessment of fishing mortality (F) in this part of the stock. Using a value of natural mortality M = 0.2 which has been verified by some recent studies, virtual population analysis gives an estimate of F = 0.69 on fully recruited age-groups in 1968. It may be expected from the changes in catch and catch-per-unit effort that F increased further in 1969 but probably fell in 1970. The situation in 1971 is not yet known.

Div. 3K-L

The catches in Div. 2J described above represent only a part of a single stock complex also fished off northern Newfoundland, and a full evaluation of the fishery situation for the stock as a whole must await completion of similar analyses of the cod in Div. 3K and 3L. Catches in both these divisions have also declined from 424,000 tons in 1968 to 287,000 tons in 1970.

The available information indicates that at the peak in 1968 fishing effort in Div. 2J, 3K, 3L was at or slightly beyond the level giving maximum yield per recruit. Changes in fishing mortality since that time are not yet known.

3. Div. 3Ps

Landings from the Div. 3Ps cod stock increased from 60,000 tons in 1959 to 84,000 tons in 1961, varied between 47,000 tons and 52,000 tons in the 1962-65 period, then increased again ranging from 61,000 tons to 74,000 tons between 1966 and 1970.

Population numbers declined from 254 million fish aged 3 and older in 1959 to 145 million in 1963 as a result of recruitment of the fairly poor 1956-60 year-classes. Population numbers increased progressively to 263 million in 1967 reflecting recruitment of good 1961-64 year-classes.

Fishing mortality varied between 0.30 and 0.54 during the 1958-68 period. Landings in 1969 and 1970 were similar to those in 1967-68 and abundance may have increased somewhat due to the recruitment of the good 1961-64 year-classes. Even so, fishing mortality in 1969 and 1970 probably was similar to that in 1967-68, i.e., 0.45-0.50. Maximum yield-per-recruit is obtained at F = 0.30 for this stock. Thus, F was greater than that giving maximum yield-per-recruit in the 1959-68 period and probably also in 1969-70. An increase in fishing effort probably will not result in a long-term increase in yield per recruit, and in fact, a decrease in effort of perhaps about one-third will result in improved catch-per-unit effort and yield per recruit.

4. Div. 4T-Vn

Landings from this stock declined from a high of 110,000 tons in 1956 to 41,000 tons in 1967, but have since increased, particularly in 1970, to over 64,000 tons. In the last decade the bulk of landings have come from the summer fishery in Div. 4T prosecuted mainly by Canada. However, the 1970 increase in landings came mainly from the winter Div. 4Vn fishery reflecting increased interest in this fishery, particularly by Spain, but also by Portugal and France. Otter trawls were the most important gear in the 1960-70 period, tkaing 57-77% of landings. However, the importance of line catches substantially declined, while that of gill net catches increased.

Abundance of the stock increased from 1960 to 1963, reflecting recruitment of good 1955-57 year-classes. Subsequent declidning abundance resulted from recruitment of poorer 1958-63 year-classes, whereas increasing abundance from 1967 reflected recruitment of strong 1964 and 1965 year-classes to the trawl fishery.

Changes in fishing mortality F, in the period 1960-70 resulted from changes in the intensity of the fishery and were also affected by an increased growth rate which resulted in progressively earlier recruitment to the trawl fishery. The age of 100% recruitment was 7 years in 1960-62 but had decreased to 5 years in 1966-68. Increasing F on younger age-groups resulted from this decrease in age of full recruitment to the fishery. Declining F on 7-10-year-olds from 0.60 to 0.25 in 1965-68 reflected reduced effort by trawl and line fisheries, whereas increasing F on 11-14-year-olds from about 0.30 in 1960 to 0.70 in 1968 reflected the increasing importance of the gill net fishery which concentrates on older fish.

Thus, the increase in trawl landings from the winter Div. 4Vn fishery in 1970 probably increased mortality only to about F = 0.30 on 7-10-year-olds as stock abundance also increased. This is still lower than the F on these age-groups in 1960-66 of 0.35-0.60.

Because of indications of density-dependent changes in recruitment and production in the 1949-65 period and continuing large changes in growth rate and in the nature of the fishery, we cannot at this time estimate the value of F which will result in optimum yield from the stock. However, current F values on the bulk of the stock are lower than those of the early 1906's which apparently did not have a deleterious effect on stock production. Thus, a moderate increase in fishing effort to a level of 0.40-0.45 may provide for a sustainable increase in future production. This is somewhat above the level of F giving the maximum yield-per-recruit in adjacent cod stocks.

5. Div. 4X

The fishery on the offshore cod stock on Browns and LaHave Banks of Div. 4X (the stock is believed to be independent from the inshore stocks around southwestern Nova Scotia and in the Bay of Fundy) expanded rapidly from 1963 with the introduction of otter trawling and landings reached 17,623 tons in 1969. However, abundance declined markedly in the latter part of this period, and declined a further 23% in 1970. Landings declined 50% to about 8,600 tons in 1970. Research vessel surveys, which show a very similar trend of declidning abundance to that shown by commercial catch effort statistics, indicate that pre-recruit year-classes are not strong and thus stock abundance is unlikely to improve in the next few years.

Maximum yield-per-recruit from this stock is obtained at F = 0.35 whereas F in the 1965-70 period is estimated to be about 0.70. The yield-per-recruit model predicts that an increase in long-term yield of 10-15% would accrue from a 50% reduction in fishing effort. At current very low stock abundance and with predicted poor recruitment, a reduction in F of this magnitude implies very low catches - probably somewhat less than 5,000 tons.

The present extremely low stock abundance may reduce the probability of good recruitment and this is a more important reason for severely limiting removals from this stock.

6. Subarea 5

The cod landings for 1971 from Subarea 5 are not fully known; however, it is expected that they will be about the same as the 35,000 tons landed in 1970. Peak catches of 42,000-57,000 tons occurred in the period 1965-69. The 1970-71 landings fall within the 30,000-40,000 tons maximum sustained yield level, as judged from the analysis reported in ICNAF Res.Doc. 71/125. This analysis was a preliminary study of yield and yield per recruit, based on long-term catch and effort statistics. Abundance indices have been obtained from US research survey cruises since 1963, and the 1971 data indicate no significant change in population size between 1970 and 1971. This fishery appears to be fully exploited at this time.

III. Haddock

1. Subarea 3

An estimate of young haddock in Subarea 3 (Shestov, PINRO, USSR) indicated that in 1969, 1970 and 1971 the abundance of 1+, 2+ and 3+ year-old fish was at a low level. Thus in 1972 and 1973 there will be low recruitment to the adult stock and abundance will remain at the present very low level.

For the whole Newfoundland area (Grand Newfoundland Bank, Green Bank and St. Pierre Bank) the average catch of 1+, 2+ and 3+ year-old fish per hour of trawling by USSR research vessels was as follows:

Year	1966	1967	1968	1969	1970	1971
No. of fish/hour	30	120	188	26	19	19

The low incidental catches of haddock in fisheries for other species in the area amount to an intensive fishery on the haddock itself. Recruitment is highly variable due to natural causes. It is less certain to what extent the present low level of the stock is caused by the fishery itself, but the probability of good recruitment is most certainly reduced at the present low population level.

2. Div. 4V-W

Landings of 9,500 tons from this stock in 1970 generated a high mortality of F = 1.12 (estimated from research vessel surveys). Analysis of most recent survey data indicates that F in 1971 was 1.31, implying that landings in 1971 were similar to 1970 (i.e., about 9,000 tons). With the imposition of a 4,000-ton catch quota in Div. 4W in 1972, landings from the total stock are likely to be about 6,000 tons in that year.

Research vessel surveys in 1971 confirm that the year-classes of 1967-69 are poor and give a first estimate of the 1970 year-class strength. This year-class appears to be of comparable abundance to those of 1967-69, indicating that recruitment to the fishery will not improve before 1975 at the earliest. (First significant contribution of a year-class to the fishery is at age 4).

Historical catch data indicates that the Div. 4V-W haddock fishery might maintain a substained annual catch of 20,000-25,000 tons with normal recruitment. An assessment presented at the 1970 Annual Meeting indicated that the average annual yield of 28,000 tons in the 1958-64 period was obtained at an average F of about 0.5, which is the value giving maximum sustainable yield. Stock size at that time was on the order of 78,000 tons.

In 1972 the quota of 6,000 tons has been set for a stock estimated to be 10,000 tons, which is relatively low compared to former times. It is expected that the quota, if caught, will reduce F from its 1971 level of 1.3 to 0.7 in 1972. With continuing poor recruitment and resulting further stock decline, a quota maintained at that level in 1973 will generate an F considerably higher than the value F = 0.5 giving the maximum yield per recruit. More important, this will not allow any significant increase in abundance to occur, and thus, will further reduce the probability of good recruitment.

Thus, regulations should be considered for 1973 which will further reduce removals from the stock.

Possible ways of doing this are:

1. Reductions in quota in Div. 4W. Under present exemption regulations, the by-catch under complete closure would be about 2,000 tons.
2. Closure of Div. 4V to haddock fishing, thus extending regulations over the major distributional range of the stock.
3. Closure of the spawning area in Div. 4W during the spawning season (March-May), thus reducing by-catches.

The Assessment Subcommittee recommends

that the effects of measures 2 and 3 on fisheries for other species be re-assessed at the 1972 Annual Meeting and those Member Countries who have fisheries which would be affected by such regulations are particularly urged to provide relevant data.

3. Div. 4X

The 18,000-ton quota in Div. 4X haddock was apparently not quite reached in 1971; preliminary statistics indicate landings of 15,600 tons.

Stock abundance, as indicated by USA commercial fleet landings-per-day of 2.6 tons, continued to decline, reaching the lowest level observed in the 1956-71 period. USA survey cruise abundance estimates (Table 1) confirm the decline in abundance in recent years. The "young of the year index" (Table 2), derived from USA fall surveys, indicates that the 1971 year-class is comparable in strength to that of 1969, both of which are only slightly stronger than the extremely poor year-classes of 1964-68 and 1970. Thus, a significant improvement in recruitment and hence stock abundance cannot be expected prior to 1976 at the earliest.

Survey cruise data confirm that F in the 1963-70 period was about 0.60, the value used in earlier assessments.

This high F will probably be reduced to some extent by the imposition of a 9,000-ton quota in 1972. However, with continued poor recruitment, stock abundance will likely continue to decline. At such low levels of adult stock abundance the probability of good recruitment is almost certainly reduced. Thus, the Commission should give consideration to reduction of the catch to the lowest practicable level in order to achieve some recovery of the stock to former levels. Under present exemption regulations, the by-catch under complete closure is estimated to be about 6,000 tons.

Table 1. Average numbers of fish caught per tow on *Albatross IV* surveys in Div. 4X.

Year	Season	Numbers per tow	
		Total	Age 4+
1963	summer	104	31
	autumn	193	34
1964	winter	181	45
	summer	147	37
	autumn	44	13
1965	winter	100	22
	summer	86	19
	autumn	55	13
1966	winter	59	9
	autumn	39	14
1967	autumn	37	30
1968	spring	28	25
	autumn	21	14
1969	spring	28	15
	summer	17	9
	autumn	23	5
1970	spring	29	18
	autumn	14	6
1971	spring	23	14
	autumn	25	

Table 2. Browns Bank haddock young-of-year survey cruise index.

Year-class	Index
1962	6.03
1963	37.16
1964	1.10
1965	1.51
1966	1.32
1967	1.10
1968	1.51
1969	3.31
1970	1.03
1971	3.19

4. Subarea 5

The reported catch in 1971 was 9,549 tons compared to the quota of 12,000 tons. Thus, only 80% of the quota was reached.

The age-composition of USA landings in 1971 substantiates the prediction of low recruitment for every year-class since 1963. The 1962 and 1963 year-classes accounted for 54% of the number of fish landed by the USA in the first half of 1971.

In 1970 these two year-classes contributed 65% of the entire year's catch. The preliminary estimate of average age was 6.6 years.

Table 3. 1971 age-composition, January-June.

Age	2	3	4	5	6	7	8	9+	Total
No./thousand	163	56	13	72	69	87	317	223	1,000
No./days fished	189	65	15	84	80	101	370	259	1,163

The index of abundance calculated from the US commercial fishery dropped from 2.1 in 1970 to 1.6 in 1971. The index varied between 5 and 6 in the 1962 to 1966 period.

The 1971 groundfish survey cruise indicates no significant change in the population from 1968 through 1971, although the numbers and pounds per tow did decline somewhat between 1970 and 1971. Very few young of year haddock were caught on the 1971 survey cruise and the young of year abundance index for 1971 was 1.38 compared to 1.00 in 1970 and 12.6 in 1963.

The estimates of available population and recruitment are given in Table 2. The 1972 quota of 6,000 tons may arrest the decline but would allow only a modest improvement of stock size under the most favourable of assumptions. Significant recovery of stock size considering current low population and recruitment levels will occur only with a cessation of fishing. Even then, incidental catches would probably amount to 3,000-4,000 tons.

Table 4. Estimates of available population and recruitment for Subarea 5 haddock (in millions of fish).

	1935-1960	1968	1969	1970	1971	1972	1973
Available population (age 2+) including recruits	145	52	27	21	21	22	29
Removals:							
Total	63	33	15	9	7	4	?
Fishing	41	28	12	6	5	3[1]	
Natural	22	5	3	3	2	1	
Recruits (age 2)	54	16	8	9	9	8	11

[1] Under regulation, 2 kg per fish

IV. Herring

1. Stock identity, relative size and inter-relationships

(a) Adult stage

Evidence presented to the Subcommittee at this meeting increased our knowledge and understanding of the stock structure and inter-relationships of herring in the ICNAF area. Figure 1 summarizes the present state of knowledge for the stocks and indicates stock boundaries and seasonal movements of the adults of individual stocks.

The Gulf of St. Lawrence stock complex, occurring in Div. 4RST and 3P, migrates seasonally between the southwestern Gulf of St. Lawrence, where it is fished in the summer, to southwest Newfoundland, where it is fished in autumn and winter. The available evidence indicates that a small but not significant proportion of the stock may move into Div. 4Vn. The Banquereau stock in Div. 4Vs and 4Wa (Chedabucto Bay), fished mainly in the winter both offshore and inshore, does not move northward into the Gulf nor southward into the main part of Div. 4W.

Of particular importance are the stocks to the south and west of the 4V-4W boundary (see double lines in Fig. 1). It is now established beyond reasonable doubt that each of the three areas A, B and C, in Fig. 1 (which correspond to the areas for which proposals on catch limitation were discussed at the 1971 Annual Meeting) contain the spawning grounds of a distinct, major stock (i.e., the Nova Scotia stock, the Gulf of Maine stock, and the Georges Bank stock, respectively), which can be treated separately for fishery management purposes. Moreover, seasonal movements of the adults of these stocks are largely within their respective areas. USSR data presented at the meeting confirmed that herring fished in Div. 4W are the over-wintering members of the stock spawning in the autumn off southwest Nova Scotia and that this stock is distinct from the Banquereau stock.

The Georges Bank stock (C in Fig. 1) moves from Div. 5Ze to the southwest (Div. 5Zw and Subarea 6) after spawning. It is possible that part of the adult stock spawning in the Western Gulf of Maine (Div. 5Y) moves south and to the west, joining the adults of the Georges Bank stock, but USSR serological and US biochemical data suggested that the proportion of Div. 5Y herring in Div. 5Z must be very small (less than 10%). It was agreed that USSR and USA would exchange material for further analysis.

"Local" spawning grounds, in addition to the major groups dealt with above, are known to occur in each of the areas A, B and C, but there is no evidence that the potential of any of these is large in relation to the potential of the major groups.

(b) Juvenile stage

The position for the juvenile stages of these three major stocks is not as clear. Three major juvenile stocks should be involved and the simplest assumption is that the post larval and juvenile stages of each stock are also confined to their respective adult areas. There is evidence that this is so for the Nova Scotia stock. The majority of the late larval stages of this stock occur in the eastern portion of the Bay of Fundy and this area contained large mumbers of larvae during several winter surveys in the 1960's. Differences in vertebral counts of the juveniles on the Nova Scotia side an d the New Brunswick side of the Bay of Fundy were found. This and other evidence suggests that the Nova Scotia spawning stock does not contribute progeny to the New Brunswick juvenile fishery. This further suggests that the juveniles caught on the New Brunswick (Div.4Xb) side of the Bay of Fundy and along the coastal Gulf of Maine (Div.5Y) are derived from and contribute to, other than the Nova Scotia stocks. The relationship between the juveniles from the Gulf of Maine coast, New Brunswick coast, and from Georges Bank needs further resolution.

(c) Larval surveys

At the 1971 ICNAF Annual Meeting it was agreed to mount a joint survey of larvae herring in the Georges Bank-Gulf of Maine areas to delimit the major spawning grounds in these areas, to obtain relative estimates of spawning stock size and to obtain information about larval drift and dispersal. Offshore cruises were made sequentially on a standardized grid pattern, and using standardized gear and methods, during the period 5 September to 17 December 1971 by the following research vessels:

Cryos (France)
Delaware II (USA)
Viandra (USSR)
Walther Herwig (Federal Republic of Germany)
Albatross IV (USA).

During the period 9 September to 8 November four alongshore cruises in the Gulf of Maine were made, using the same standard procedures, from Massachusetts Bay to Machias Bay on board the small US research vessel *Rorqual*. An alongshore cruise in the Bay of Fundy and southwest Nova Scotia was also made in October by the Canadian research vessel *Prince* but different gear and sampling procedures were used. Preliminary reports were available for most of these cruises at the Mid-term Assessment Meeting. Certain preliminary analyses and conclusions from these surveys follow.

Qualitative results: The significant sites of larval production detected in the survey were as follows.

Georges Bank: Spawning is concentrated on the northern edge; significant numbers of larvae were first detected during the second half of September and small larvae were found until the middle of November. Drift and dispersal is in a southwesterly direction in the clockwise gyre. An additional spawning site apparently occurs in the western part of the Bank just east of the channel. Spawning occurs here later than on the northern edge. Very few larvae were found outside the 100-m isobath. By December, larvae were widely dispersed over the Bank.

Nantucket Shoals: Larvae were detected in significant numbers in this area (west of the Great South Channel) first in early November. Dispersal is apparently southwestward but may also be in part northeastward across the channel on to Georges Bank. This area has been included with Georges Bank when making quantitative estimates.

Nova Scotia: The Trinity Ledge-Lurcher Shoal area was readily detectable in the surveys with larvae in significant numbers obtained in the second half of September. These larvae were larger than those taken on Georges Bank at the same time. Major drift is northward along the eastern side of the Bay of Fundy.

Southwestern Gulf of Maine: The first concentration of larvae detected in this area was off Cape Elizabeth, Maine, during the latter part of September. Dispersal of this group of larvae was mainly shoreward into Saco Bay and perhaps Casco Bay. Concentrations of larvae in the Jeffreys Ledge-Stellwagen Bank areas were detected about the middle of October with dispersal shoreward. Virtually no larvae were found on the oceanic side of Jeffreys Ledge.

Eastern Sector of the Maine Coast: A group of larvae, centered off Frenchman's Bay, was found in the first half of September. This larval group persisted into early November with dispersal inshore and southwestward along the coast. The origin of these larvae is unknown but they may result from spawning on Grand Manan Bank.

Quantitative estimates: In order to compare the relative importance of the different spawning stocks, it is necessary to get a relative measurement of the size of spawning stocks. This could be done by estimating the absolute numbers of very small larvae in the same area several times, thus being able to draw a production curve and calculate the overall larval production in that area. However, length frequency data are not yet available for all surveys.

The Georges Bank area was surveyed five times; the results of three cruises are at hand at the moment. The coastal Gulf of Maine area was sampled four times; all data are available. Coverage of the spawning area southwest of Nova Scotia was incomplete in time and area. Depending on the handling of the gear (the upper 40 m were sampled more extensively than the deeper water), it was necessary to make the assumption that most larvae were located in the depth range 0-40 m and that the number of larvae in the deeper part of the water column was negligible. From the results of inshore stations with a depth of 40 m, the mean volume of water filtered in the 0-40-m water column was calculated using the standard sampling method. From this the number of larvae per m^2 referring to the water depth of 40 m were estimated. By calculating the size of the surveyed area and taking the mean of number of larvae $1/m^2$, the following estimates of the total number of larvae were obtained:

Total numbers (billions) of larvae for time and area

1971	Georges Bank	Gulf of Maine
9 September-16 September		36
22 September-1 October		75
21 September-3 October	560	
9 October-25 October	1,270	
13 October-25 October		225
27 October-8 November		54
4 November-12 November	1,240	

It seems reasonable to take the ratio of the highest estimates of larval numbers which occurred during the season as a very rough measure for the relative size of spawning stocks. In the Gulf of Maine a distinct peak in the total amount of larvae was found in the second half of October (225 billion), while the maximum amount found on Georges Bank was about 1,300 billion. These data suggest that the spawning population on Georges Bank may have been almost six times as large as the population spawning in the coastal waters of the Gulf of Maine.

2. Fishery trends

Tables 5-8 list the herring catches by country and area for each of the years 1968 to 1971. The grouping of ICNAF statistical subdivisions at the head of each table are based on the stock delineation shown in Fig. 1 and facilitate the combination of catches by stocks. The grouping of subdivisions to provide catch data for individual stocks are indicated at the bottom of the tables. These tables represent a more refined and accurate breakdown of catches, in some cases, and include up-to-date information on catches by non-member countries. Comprehensive non-member catch data for the period 1966-71 were presented by Dr Ranke of the Sea Fisheries Institute, Rostock.

A summary of catches (all countries combined) for the period 1961-71 is given in Table 9 by ICNAF subdivisions and in Table 10 by stocks. The total Northwest Atlantic herring catch in 1971 was 720,000 tons, 143,000 tons less than the 1970 catch, and 246,000 tons less than the 961,000 tons reported in the peak year of 1969. The catch in 1971 from the Georges Bank stock (261,000 tons) was slightly greater than that for 1970 (247,000 tons). The catch from the Gulf of Maine stock declined by 25% (89,000 → 67,000 tons), that of the Nova Scotia stock by about 47% (148,000 → 77,000 tons), that of the Banqureau stock by 13% (63,000 → 55,000 tons) and that of the Gulf of St. Lawrence stock by 20% (316,000 → 260,000 tons).

The catches from the Nova Scotia, Gulf of Maine, and Georges Bank stocks are shown in Fig. 2. For the Gulf of Maine stock and the Nova Scotia stock the total catches of juveniles are now available for the first time and Fig. 3 shows total catch (adults + juveniles) and the catch of juveniles for each, over the period 1963-71; for the Gulf of Maine stock the juvenile catch is subdivided into its New Brunswick (Div. 4Xb) and Gulf of Maine (Div. 5Y) components. These data show that the great increase in total catch in the fisheries on these stocks during the mid-1960's was made up largely to increases in the catches of adults, particularly from the Nova Scotia stock. Catches of juveniles from the Nova Scotia stock have remained relatively constant; those of the Gulf of Maine stock have declined steadily since 1968 from more than 100,000 tons to 21,000 tons. The rate of decline of the catch of juveniles was more rapid than that of the total catch. From 1970 to 1971 the Div. 5Y catch of juveniles declined only slightly (11,000 tons-9,000 tons); in the same period the catch of juveniles in Div. 4Xb declined from 30,000 to 12,000 tons (Table 9). A significant proportion of the decline in Div. 4Xb resulted from the application in 1971 of measures restricting the catching of yearling herring (less than 12 cm) in the New Brunswick purse seine fishery in autumn and winter.

3. Herring assessment

(a) Div. 5Y herring assessment

Fishing and abundance changes: The traditional US herring fishery in Div. 5Y has changed greatly in recent years (Table 9). The juvenile catch (fish 1-3 years old) is less than one-sixth of that in the period from the late 1940's through the early 1960's. The decrease in abundance of recent year-classes is indicated by the decline in total catch of juveniles and also by other indices of abundance. Figure 4 presents the total catch of stop seines and weirs, and an adjusted index of abundance computed from the catch per effort of selected fishermen from the western Maine juvenile fishery. Stop seine fishermen with catches for 5 years or more (63 fishermen) were used in determining the index of abundance. An analysis of variance procedure was used for estimating relative catches per fisherman (population density) for each year which were then standardized against 1951. All indices of abundance indicate drastic declines, i.e., up to an order of 90% of the peak year-classes of the 1950's. The last large year-class occurred in 1961. The estimated juvenile catch of 9,000 tons in 1971 was the lowest catch since 1938, and may be contrasted with the average annual catch of 64,000 tons during the 1950's. The similar slope of the total catch of stop seines and weirs and the adjusted index of abundance indicates a fixed fishing intensity on the average.

Table 5. Herring landings ('000 tons) by country and area (stock) in 1968. (Juveniles in parentheses)

Country	Subarea 3	Div. 4RST	Div. 4Vn	Div. 4Vs	Div. 4Wa	Div. 4Wb	Div. 4Xa	Div. 4Xb	Div. 5Y	Div. 5Z	Subarea 6	Total
Can (M)	15	103.2	Ø	-	1	-	143(13)	84(75)	22	14	-	382
Can (N)	130	16	1	-	-	-	-	-	-	-	-	147
Germany	-	-	3	7	-	-	-	-	-	71	Ø	81
Iceland	-	-	-	-	-	-	-	-	-	Ø	-	Ø
Poland	Ø	-	-	-	-	Ø	Ø	-	-	64	12	76
Romania	-	-	-	-	-	-	-	-	-	2	-	2
USSR	-	-	-	1	-	2	Ø	-	-	127	16	146
USA	-	-	-	-	-	-	-	-	41(29)	1	Ø	42
Non-member (GDR)	-	-	-	8	-	-	-	-	-	59	1	69
Non-member (Others)	Ø	-	-	-	-	-	-	-	-	7	-	7
Total	145	120	4	16	1	2	143(13)	84(75)	63(29)	345	29	952
	Gulf of St.Lawrence		Banquereau Stock			Nova Scotia		Gulf of Maine		Georges Bank		

4Wa = Chedabucto Bay area

4Wb = Div. 4W offshore

4Xa = Southwest Nova Scotia and offshore Div. 4X

4Xb = New Brunswick side of Bay of Fundy

Table 6. Herring landings ('000 tons) by country and area (stock) in 1969. (Juveniles in parentheses)

Country	Subarea 3	Div. 4RST	Div. 4Vn	Div. 4Vs	Div. 4Wa	Div. 4Wb	Div. 4Xa	Div. 4Xb	Div. 5Y	Div. 5Z	Subarea 6	Total
Can (M)	-	143	Ø	-	28	-	93(11)	47(43)	10	1	-	322
Can (N)	146	15	2	-	Ø	-	-	-	-	-	-	163
Germany	-	-	9	13	-	Ø	1	-	11	62	-	96
Iceland	-	-	-	-	-	-	-	-	-	13	-	13
Norway	-	-	-	...	-	...	-	-	...	1	-	1
Poland	-	-	-	5	-	-	Ø	-	-	32	13	50
Romania	-	-	-	-	-	-	-	-	-	Ø	-	Ø
USSR	-	-	-	53	-	12	Ø	-	-	101	38	204
USA	-	-	-	-	-	-	-	-	29(23)	2	2	33
Non-member (GDR)	-	-	...	36	-	1	Ø	-	5	41	1	84
Total	146	158	11	107	28	13	95(11)	47(43)	55(23)	253	53	966
	Gulf of St. Lawrence		Banquereau Stock			Nova Scotia		Gulf of Maine		Georges Bank		

4Wa = Chedabucto Bay area

4Wb = Div. 4W offshore

4Xa = Div. 4X offshore and Nova Scotia inshore

4Xb = Bay of Fundy (New Brunswick coast)

Table 7. Herring landings ('000 tons) by country and area (stock) in 1970. (Juveniles in parentheses)

Country	Subarea 3	Div. 4RST	Div. 4Vn	Div. 4Vs	Div. 4Wa	Div. 4Wb	Div. 4Xa	Div. 4Xb	Div. 5Y	Div. 5Z	Subarea 6	Total
Can (M)	-	161	2	-	29	-	88(12)	33(30)	18	Ø	-	331
Can (N)	135	20	3	-	Ø	-	-	-	-	-	-	158
Germany	-	-	2	3	-	Ø	-	-	6	82	-	94
Japan	-	-	-	-	-	-	-	-	-	1	-	1
Poland	-	-	Ø	1	-	Ø	-	-	Ø	55	16	72
Romania	-	-	-	-	-	-	-	-	-	1	-	1
USSR	-	-	-	13	-	59	Ø	-	-	39	22	134
USA	-	-	-	-	-	-	-	-	29(11)	1	1	31
Non-member (GDR)	-	-	-	10	-	Ø	-	-	3	27	1	41
Total	135	181	7	27	29	60	88(12)	33(30)	56(11)	207	40	863
	Gulf of St.Lawrence		Banquereau Stock			Nova Scotia		Gulf of Maine		Georges Bank		

4Wa = Chedabucto Bay area

4Wb = Div. 4W offshore

4Xa = Div. 4X offshore and Nova Scotia inshore

4Xb = Bay of Fundy (New Brunswick coast)

B 3

Table 8. Herring landings ('000 tons) by country and area (stock) in 1971 (preliminary data). (Juveniles in parentheses)

	Subarea 3	Div. 4RST	Div. 4Vn	Div. 4Vs	Div. 4Wa	Div. 4Wb	Div. 4Xa	Div. 4Xb	Div. 5Y	Div. 5Z	Subarea 6	Total
Can (M)	-	138	2	-	49	-	48(10)	13(12)	13	12	-	275
Can (N)	110	12	2	-	1	-	-	-	-	-	-	125
Germany	-	-	-	-	-	-	-	-	5	55	Ø	60
Japan	Ø	-	-	-	-	-	1	-	-	2	Ø	3
Poland	-	-	-	Ø	-	Ø	-	-	-	75	11	86
Romania	-	-	-	-	-	-	-	-	-	1	-	1
USSR	-	-	-	...	-	28	-	-	-	67	17	112
USA	-	-	-	-	-	-	-	-	34(9)	5	...	39
Non-member (GDR)	-	-	-	...	-	1	-	-	2	14	2	19
Total	110	150	4	Ø	49	29	49(10)	13(12)	54(9)	231	30	720
	Gulf of St.Lawrence		Banquereau Stock			Nova Scotia		Gulf of Maine		Georges Bank		

4Wa = Chedabucto Bay area

4Wb = 4W offshore

4Xa = 4X offshore and Nova Scotia inshore

4Xb = Bay of Fundy (New Brunswick coast)

Table 9. Herring landings ('000 tons) by area (stock), 1961-71. (Juveniles in parentheses where known)

Year	Subarea 3	Div. 4RST	Div. 4Vn	Div. 4Vs	Div. 4Wa	Div. 4Wb	Div. 4Xa	Div. 4Xb	Div. 5Y	Div. 5Z	Subarea 6	Total
1961	4	20	—	—	3	—	58	—	26(23)	68	-	179
1962	5	36	—	—	12	—	68	—	70(69)	151	-	342
1963	6	42	1	-	2	3	30(5)	36(32)	68(67)	97	-	285
1964	4	44	Ø	-	2	1	49(12)	45(40)	28(20)	131	-	304
1965	8	49	Ø	-	1	6	77(12)	49(44)	34(31)	41	-	265
1966	23	43	Ø	-	1	2	130(8)	61(55)	28(24)	137	6	431
1967	78	69	Ø	Ø	1	1	141(13)	56(50)	43(19)	216	4	598
1968	145	120	4	16	1	2	143(13)	84(75)	62(29)	345	29	951
1969	146	158	11	107	28	13	95(11)	47(43)	55(23)	253	53	966
1970	135	181	7	27	29	60	88(12)	33(30)	56(11)	207	40	863
1971[1]	110	150	4	1	50	29	48(10)	13(12)	54(9)	231	30	720
	Gulf of St.Lawrence		Banquereau Stock			Nova Scotia		Gulf of Maine		Georges Bank		

[1] Preliminary

Table 10. Herring landings ('000 tons) by stock, 1961-71. (Juveniles in parentheses)

Year	Subarea 3 + Div. 4RST	Div. 4V + 4Wa	Div. 4Wb + 4Xa	Div. 5Y + 4Xb	Div. 5Z + Subarea 6	Total
1961	24	(3)	--- 84(23+) ---		68	179
1962	41	(3)	--- 147(69+) ---		151	342
1963	48	3	33(5)	104(99)	97	285
1964	48	2	50(12)	73(60)	131	304
1965	57	1	83(12)	83(75)	41	265
1966	66	1	132(8)	89(79)	143	431
1967	147	1	142(13)	88(69)	220	598
1968	265	21	145(13)	146(104)	374	951
1969	304	146	108(11)	102(66)	306	966
1970	316	63	148(12)	89(42)	247	863
1971[1]	260	55	77(10)	67(21)	261	720

[1] Preliminary

An adult fishery of sizable proportions has developed in the western portion of the Gulf of Maine, beginning in 1967. This adult fishery has concentrated on Jeffrey's Ledge, Stellwagen Bank and adjacent areas (Fig. 5) while the US juvenile fishery, as it has existed historically, is limited to the Maine coastline. The age-composition of herring in the adult fishery, as estimated from US samples, has reflected a decline in the abundance of recent year-classes. The 1961 and older year-classes have supported this fishery since its development. In 1967 and 1968 only 28% of the fish caught were of ages 7 and older, whereas in 1970 and 1971 the herring of age 7 and older made up 61% of the total catch.

The juveniles occurring inshore probably provide the major source of recruitment to the Div. 5Y adult population, and it is shown in Table 9 and Fig. 4 that the 1963-68 year-classes are relatively very low in abundance.

It is possible that the juvenile herring found on the west side of the Bay of Fundy in Div. 4X are also part of the Gulf of Maine stock complex. Canadian biologists have made preliminary estimates of that portion of the Div. 4X catch caught on the New Brunswick side of the Bay of Fundy since 1963. The weir catch consists mainly of 2-year-old fish and has declined drastically from 1968. The 1971 weir catch of 9,500 tons is only about one-fourth of what it was in 1968.

It may be expected, therefore, that by the end of 1972 when the year-classes 1960-62 will have probably passed through the fishery, the adult stock will decline even without a fishery.

<u>Estimate of mortality:</u> Estimates of juvenile fishing mortality were obtained by comparing juvenile catches with the mean stock sizes which were estimated from the adult catches. The number of adults caught are shown in Table 11. A minimum estimate of mean stock size at age 2 was obtained following Pope's cohort analysis assuming year-classes 1962-65 are still being fished, year-classes 1960 and 1961 are not still being fished and assuming an F of 0.6 in the terminal year of catches. Dividing the catch of age 2 herring by this mean stock size provides an estimate of fishing mortality. Table 12 gives six different sets of estimates of fishing mortality under different assumptions of parentage of juvenile populations. The catch of age 2 herring is combined over Western and Central Maine; all of Maine; and Maine and New Brunswick combined. The estimates of F range from 0.4 to 9.9 and are highest for the 1960 year-class if one assumes that the New Brunswick juveniles recruit to the adult Div. 5Y fishery. Even allowing for some emigration of juveniles to Georges Bank the average of estimates of F are still of the order of 1.1.

Table 11. Numbers of herring in '000's caught in the Div. 5Y adult fishery.

Year	Year-class 1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	Total
1967	682	656	16,242	27,743	15,540	6,113	687	-	-	-	-	67,663
1968	-	6,636	13,806	26,740	29,783	29,820	19,963	23,800	-	-	-	150,548
1969	-	924	19,607	20,469	40,872	47,795	20,420	6,844	13,548	-	-	170,479
1970	-	981	20,394	30,255	20,323	31,227	33,619	13,135	15,550	13,226	4,600	183,310
1971[1]	-	-	11,026	16,342	16,212	20,556	34,579	21,639	19,200	7,750	1,391	148,695
Total	682	9,197	81,075	121,549	122,730	135,511	109,268	65,418	48,298	20,976	5,991	720,695

[1] Only U.S. and Canadian estimated landings

Table 12. Estimates of juvenile fishing mortality assuming different segments of juveniles recruit to the Div. 5Y adult fishery (catch and stock size in '000s)

	Year-class					
	1960	1961	1962	1963	1964	1965
Estimated mean stock size at age 2						
assuming M = .2	351,000	422,700	417,200	404,200	348,600	168,700
assuming M = .3	729,513	789,574	719,125	642,275	522,102	226,600
Age 2 catch from Western and Central Maine	1,841,100	684,800	379,800	626,400	217,500	191,800
$\hat{F}$ - assuming M = .2	5.25	1.62	0.91	1.55	0.62	1.14
assuming M = .3	2.52	0.87	0.53	0.98	0.42	0.85
Age 2 catch from all of Maine	2,341,200	891,700	421,700	1,001,100	321,300	304,800
$\hat{F}$ - assuming M = .2	6.67	2.11	1.01	2.48	0.92	1.81
assuming M = .3	3.21	1.13	0.59	1.56	0.62	1.34
Age 2 catch from Maine and New Brunswick	3,477,600	1,370,700	918,800	2,326,200	731,800	1,033,900
$\hat{F}$ - assuming M = .2	9.91	3.24	2.20	5.76	2.10	6.13
assuming M = .3	4.77	1.74	1.28	3.62	1.40	4.56

Other estimates indicate also that mortality occurring in the Maine herring fishery is large. Catch curves of age 2 herring by week, adjusted for moon phase, were examined for mortality (Table 13). The original estimates were made for varying amounts of time but the estimates of Z in Table 13 are for a 10-week period in all cases. These estimates are large even assuming that the fishery lasted only 10 weeks. The juvenile herring along the Maine coast are generally taken during June and July but there is some evidence that the decline in catch during the hot summer months is not entirely due to fishing mortality but, to some degree, to the movement of the herring to deeper waters or eastward along the Maine coast. Catch curves in this situation over-estimate the total mortality rates.

Despite obvious uncertainties about the reliability of the data, all mortality estimates are large; the exploitation rate (E) is probably well over 0.65.

Estimates of adult stock sizes: In order to obtain a rough estimate of the relation of stock size to harvest in the adult fishery, the following approximations were made:

1) Juvenile populations were estimated by applying the catch equation separately to the juvenile catch in Div. 5Y and in Div. 5Y plus the west side of the Bay of Fundy assuming conservative estimates of F of 0.6 with an M of 0.2.
2) A natural mortality M = 0.2 was applied over the years to the numbers remaining after the juvenile fishery, to arrive at an adult stock three years later.

The results of these computations are presented in Table 14.

Table 13. Estimates of total mortality rates from catch curve of the Maine juvenile fishery.

Year	Total Mortality Rate	
	Western Maine	Central Maine
1953	1.50	0.83
1954	1.48	1.18
1955	1.54	1.31
1956	1.74	1.23
1957	2.51	1.16
1958	1.20	0.90
1959	1.99	1.18
1960	1.45	0.78
1961	1.32	0.76
1962	1.59	0.79
1963	1.71	0.93
1964	0.75	0.93
1965	1.04	1.05
1966	0.64	0.91
1967	0.78	0.79

Table 14. Population size and removals from the Gulf of Maine herring stock (numbers in millions).

	Based on 5Y juvenile catches				
Period	Juvenile fishing mortality rate	Juvenile catch	Juvenile stock size at beginning of year[1]	Adult stock size at beginning of year[2]	Adult harvest[3]
1947-1963	0.6	2,000	4,850	1,450	100
1964-1969	0.6	700	1,700	500	165
1970-1971	0.6	250	600	175	165
	Based on 5Y plus the west side of the Bay of Fundy juvenile catches				
Period	Juvenile fishing mortality rate	Juvenile catch	Juvenile stock size at beginning of year[1]	Adult stock size at beginning of year[2]	Adult harvest[3]
1961-1962	0.6	3,000	7,275	2,200	100
1964-1969	0.6	1,700	4,125	1,250	165
1970	0.6	825	2,000	600	165
1971	0.6	450	1,100	325	165

[1] $N_i = \frac{C_i Z_j}{F_j(1-\exp[-Z_j])}$, where $Z_j = F_j + 0.2$, $F_j = 0.2$ or 0.6, and i = period

[2] $N_{i+3} = N_i \exp[-(F_j + 3M)]$

[3] Average of 1967-1968 for the adult harvest of 100
Average of 1969-1970 for the adult harvest of 165

Catch quotas. From the late 1940's through the early 1960's the annual Maine sardine catch was of the order of magnitude of 65,000 tons - approximately 2 billion fish. In the period from 1964 to 1969, about 25,000 tons were taken each year - approximately 700 million fish. In 1970 and 1971 an average of 10,000 tons were taken - approximately 250 million fish. The weir fishery on the west side of the Bay of Fundy took approximately 1 billion fish (mostly 2-year-olds) annually in 1964-69, 530 million fish in 1970 and 220 million in 1971. The average estimated adult catch in Div. 5Y was approximately 100 million fish per year in 1967 and 1968 and 165 million per year in 1970-71 (Table 14). An adult harvest of this magnitude under current low levels of recruitment (as judged from the juvenile fishery) is approaching the exploitation levels that occur on Georges Bank.

There is little evidence to indicate whether the juvenile fish of both the coast of Maine and Div. 4Xb are related to the Div. 5Y adult stock or whether only the Maine coast fish recruit to the adult Div. 5Y fishery. The former implies an adult stock size in 1971 of 325 million fish and the latter a stock size of 175 million (Table 14) if one uses an F of 0.6 in the juvenile fishery. Yield-per-recruit considerations suggest that an upper limit to the fishing mortality of 0.5 would be desirable. The estimates of adult stock sizes of 175 and 325 million fish would imply catches of 15,000 and 28,000 tons respectively to achieve a fishing mortality of 0.5. Since the larval survey results suggest that the estimate of adult stock size in 1971 may be nearer the higher figure, the catch of 28,000 tons may be the more accurate.

However, because of poor recruitment the adult stock will decrease in the immediate future, regardless of the volume of catches. Though the relation of adult stock to subsequent recruitment is unknown, a further decline in the already small adult stock would appear to reduce the probability of getting a good new year-class. It seems therefore desirable to slow this decline in abundance of adults as far as possible, and to reduce the catches as far below 28,000 tons as the Commission finds practicable.

We must also call to the attention of the Commission that a high escapement of juveniles through the juvenile fisheries woudl accelerate the recovery of adult stock abundance. The decision between limiting juveniles and adults is one that the Commission must consider.

(b) Div. 5Z-Subarea 6 herring assessment

Since 1961 the Georges Bank herring fishery has been supported largely by the 1960 and 1961 year-classes. These very strong year-classes provided 58% of the catch by number from 1964 to 1966 and 24% of the catch from 1967 to 1969. Estimates of age-composition are based on weighted averages of the available national data. The 1960 year-class finally passed through the fishery in 1971 and the catch of the 1961 year-class was insignificant. There have been no year-classes as strong as those of 1960-61 during the period since the 1961 year-class entered the fishery, a period in which the international herring fishing fleet working in that area grew to a very large size. The overall stock size declined during this period by from 75 to 95% as recruitment failed to replace the losses (Tables 15 and 18).

In 1970 and 1971 because the large 1960 and 1961 year-classes did not contribute significantly to the landings, the herring fishery began to take more substantive quantities of fish of the younger age-groups soon after recruitment. In 1967 and 1968, age 3- and 4-year-old herring accounted for approximately 8% of the total catch in number. In 1970 and 1971 the frequency had increased to 49%.

Estimates of stock size and fishing mortality from 1967 to 1971 are given in Table 15. For the years 1967-70 these estimates were derived by virtual population analysis, assuming $M = 0.2$. Such estimates for the year 1971 are not possible, and the fishing mortality in 1971 was estimated by assuming that the increase over 1970 was in the same ratio as that observed from 1969-70.

There is evidence that the natural mortality may be greater than 0.2, especially among the older fish. However, among the younger fish, which now make up the bulk of the stock, the probable upper limit to the natural mortality is 0.4. Using this value in the virtual population analysis would increase the estimate of stock size, and decrease the estimated value of the current fishing mortality, but not to any significant extent. The advice on catch quotas (see page 30) would therefore not be affected. In other words, the conclusion that present fishing mortality is too high is not changed.

Table 15. Div. 5Z stock size (million of fish).

Year	Age 9+	9	8	7	6	5	4	3	Number	Total Weight ('000s tons)
1967	16[1]	27[1]	130[1]	1,107[1]	1,291[1]	910[1]	1,370[1]	765[1]	5,616	1,232
1968	12[1]	66[1]	562[1]	849[1]	649[1]	1,053[1]	922[1]	1,178[1]	5,291	1,163
1969	39[1]	183[1]	311[1]	323[1]	563[1]	708[1]	972[1]	1,153[1]	4,252	898
1970	50[2]	66[2]	77[2]	184[2]	303[2]	584[2]	898[2]	900[1]	3,062	614
1971	47[2]	16[2]	66[2]	136[2]	231[2]	388[2]	622[2]	760[1]	2,266	448
1972	13[2]	14[2]	62[2]	124[2]	143[2]	132[2]	348[2]	760[3]	1,596	305

Catch (million of fish)

Year	Age 9+	9	8	7	6	5	4	3	Number	Total Weight ('000s tons)
1967	10	11	49	379	251	108	61	7	876	219
1968	7	22	337	433	233	336	72	52	1,492	373
1969	26	123	213	211	312	310	236	51	1,483	343
1970	18	30	53	95	125	275	459	128	1,183	250
1971	20	13	47	98	164	266	253	307	1,168	243

Fishing mortality

Year	Age 9	8	7	6	5	4	3	Average[4]
1967	0.61	0.54	0.47	0.24	0.14	0.05	<0.01	0.21
1968	0.45	1.05	0.81	0.50	0.43	0.09	0.05	0.45
1969	1.70	1.35	1.23	0.92	0.65	0.31	0.05	0.58
1970	0.68	1.33	0.83	0.60	0.73	0.64	0.17	0.55
1971[5]	1.33	1.33	0.58	0.42	0.80	1.34	0.58	0.85

[1] Calculated from $CZ/_{F(1-e^{-z})}$

[2] Calculated from $N_{i+1} = N_i e^{-Z_i}$

[3] Assumed same as in 1971

[4] The average $\hat{F}$ is weighed over year-classes by the stock size in number

[5] Fishing mortality for 1971 was estimated by assuming the same proportional change in 1971 over 1970 as occurred in 1970 over that of 1969

Table 16. Nova Scotia (Div. 4Xa-4Wb) stock. Age distribution.

Year	Age (year) 3	4	5	6	7	8	9	10+
Canadian Data								
1965	184	931	326	127	16	3	-	-
1966	743	96	254	26	1	-	-	-
1967	339	415	298	255	128	10	-	-
1968	91	42	83	12	11	3	1	-
1969	1,063	80	261	166	168	56	9	-
1970	98	1,021	600	473	319	159	33	3
1971	93	248	487	167	205	74	18	12
USSR Data								
1970	2	10	26	19	24	11	5	2
1971	41	12	20	9	8	5	2	2

Table 17. Nova Scotia (Div. 4Xa-4Wb) stock. Numbers and percentages for two age-groups (less than 6 years and greater than 5 years).

Year	Numbers		%		Mean %	
	<6	>5	<6	>5	<6	>5
Canadian Data						
1965	1,441	146	90	10	-	-
1966	1,093	27	90+	10	-	-
1967	1,052	393	70	30	53	47
1968	377	678	36	64		
1969	1,404	399	72	28		
1970	1,711	987	63	37	66	34
1971	828	476	64	36		
USSR Data						
1970	73	26	74	26	56	42
1971	38	61	38	62		

Table 18. Results of estimates of the spawning stock of herring population on major spawning grounds on the northern Georges Bank, 1964-1971.

Year	Spawning area km^2	Eggs 10^{-6}kg	Spawning population 10^{-6}kg
1964	38.8	427.8	1,180
1965	24.3	299.5	530
1966	19.1	76.5	150
1967	-	-	-
1968	5.7	46.1	130
1969	4.0	25.7	60
1970	1.9	6.9	12
1971	1.9	5.2	11

B 12

The spawning stock in 1971 was equal to 11,000 tons, thus remaining at the level of 1970.

Herring catch per day of the Polish steam trawlers in the period 1967-1970.

Year	Tons/day (m.t.)
1967	11.5
1968	10.5
1969	5.5
1970	6.4

The estimation of recruitment of 3- and 4-year-olds in 1972 is rather critical to the estimation of production and yield in that year. Two-year-old abundance in 1971 is almost impossible to establish, hence the recruitment of this year-class in 1972 cannot be specified. The effect of different assumptions about this on yields in 1972 are specified.

Age 3 fish have not been completely recruited to the fishery in the past. It is not expected to be so in 1972; however, the relative catch of age 3 fish in 1971 probably increased significantly over that in previous years. Because of the scarcity of older fish in 1972, the 3-year-old contribution is expected to be relatively even greater.

Thus, in spite of some data which shows an increase in catch per effort of 3-year-olds in 1971, this cannot be accepted as clear evidence that the 1968 year-class is above average.

Fishing effort in the Georges Bank herring stock (Div. 5Z and Subarea 6) continued to increase through 1971 as indicated below:

Total international effort and catch of the Georges Bank stock

Year	Catch ('000 tons)	Effort ('000 days)
1967	218.6	31.3
1968	373.4	103.3
1969	342.7	107.1
1970	251.7	125.3
1971	256.0	169.2

Effort data for 1971 were calculated assuming catchability did not increase in 1971 and that effort must have increased in inverse proportion to the decrease in stock size in order to maintain a catch of 261,000 tons. The stock size during the 1967-71 period was estimated to have declined from 5,616 million to 2,266 million fish. A stock size in 1972 of 1,596 million fish has been projected (Table 15). The decline from 1964 (when the maximum stock size of 6,605 million fish existed) to the level of 1972 given in Table 15 has been to a level of 24% of that of 1964.

It may be noted that on the one hand there are much higher estimates of the total decline in the stock since 1964 (by between 75% and 99%, see Tables 15 and 18) and on the other hand, there was no decrease in catch per unit of effort of some fleets between 1970 and 1971. The figure of the total decline in stock up to 1972 given in Table 15 is probably reasonable.

Table 15 shows the calculated stock size in 1972 with recruitment (age 3 fish) assumed to be the same as in 1971. With the estimated reduction in stock size in 1972, only with very large recruitment is it possible to return to the level of stock size of 1971 by 1973. Figure 6 shows the stock size at the begin ning of 1973 that would result from various levels of fishing mortality and recruitment in 1972. The fishing mortality used was the average value over age-groups 3-9 weighted by age-group abundance in numbers. It is important to note that values of F estimated in this way are not directly comparable to those usually used with yield-per-recruit curves, because all fish of age-group 3 are not fully recruited. Weighted average fishing mortality of ages 5-9 (the fully recruited age-groups until 1970-71) has been greater than that of ages 3-4. If it is assumed, therefore, that at present age 3 and 4 herring are not fully recruited, an F of 0.5 over ages 5-9 is comparable to an F of 0.3 on ages 3-9 (Fig. 7). Since an F of 0.5 is the maximum that should be allowed on the Georges Bank herring stock to obtain maximal yield-per-recruit, an F of 0.3 on ages 3-9 should be the upper limit under presently estimated recruitment rates of ages 3 and 4. From Fig. 6 it may be determined that this indicates a catch of 70,000 tons in 1972, assuming recruitment of age 3 fish to be at the same level as in 1971. This catch would provide for a slight increase in stock size from 305,000 to 330,000 tons in 1973, regaining 17% of the expected loss in stock size from 1971 to 1972.

This reduction in catch must be made to stop the very sharp decline in stock size that is now taking place. An F of 0.3 is a reduction of 63% in F and implies a reduction of 71% in total catch from 1971. The estimated stock levels are shown in Fig. 6 for 1969 to 1972 under various assumptions for fishing rate in 1972.

To merely arrest the decline in the size of the stock with no provision for any stock increase, an F of 0.44 could be placed on the stock (assuming steady recruitment) which would yield a catch of 95,000 tons in 1972. Such a procedure is not advisable since it does not allow for any rebuilding of the stock and will cause a further decline in stock size if poorer recruitment appears in 1972 and 1973 than in 1971. The catch quota would then have to be revised downward. Even a delay of one year of the implementation of this new low level of catch would mean the stock could be reduced to such a low level that it would require even more severe restrictions to rebuild the stock to the level that existed in 1971.

At a low level of stock the probability of achieving good recruitment must be diminished. Therefore, to reduce the probability of successive years of poor recruitment by increasing the stock, an F of 0.2 is recommended which would restrict the catch of 50,000 tons and would, in all likelihood, permit the stock to regain 31% of the reduction in 1971 and bring back the stock to a size of 350,000 tons.

Since the current low stock levels mean the fishery depends greatly on annual recruitment, future determination of allowable yields depends almost entirely on early estimates of recruitment. An overestimate of recruitment by as little as 25% could cause a further significant decline in stock size. Figure 6 shows the effect of recruitment reduced by 25% in 1972 over that of 1971. Under these circumstances, a regulated F of 0.44 would mean a stock decrease of 25,000 tons through 1972.

A 25% reduction in recruitment from the 1971 level requires an F equal to 0.3 to maintain the 1972 stock level, and this corresponds to 70,000 tons catch in 1972. An increase in stock size from the 1972 level can only be safely obtained by achieving an F of 0.2 which corresponds to a catch of 50,000 tons in 1972.

While estimates of recruitment can be too low or too high, under present circumstances, in which the proportion of 3- or 4-year-old fish taken by the fishery is increasing, overestimates of recruitment are more probable than underestimates. Further, if the Commission acts on an assessment of lower incoming recruitment than is actually the case, the subsequent stock will be greater than expected, and later catches can be increased. Provided the readjustment of quotas is done quickly this procedure will involve no loss, or even some increase in the catch taken from the initially underestimated year-classes. The Commission should, therefore, act on conservative estimates of the strength of incoming year-classes.

(c) Div. 4X herring assessment

Three different Canadian fisheries occur on herring stocks in Div. 4Xa and 4Wb. The Nova Scotia weir fishery along southeastern shore of Bay of Fundy takes mainly juveniles. An inshore gillnet fishery extends along the Atlantic coast of Nova Scotia and also in the Bay of Fundy. Up to 1971 most of this gillnet catch was taken outside the Bay of Fundy and came from a "local" coastal stock. The purse-seine fishery off southwestern Nova Scotia exploits pre-spawning and spawning herring of the major 4Xa-4Wb stock. All of these fisheries occur from early summer to autumn.

Catches from both the weir and gillnet fisheries have fluctuated very little over the past 10 years, each taking about 10,000 tons annually. Catches from the purse-seine fishery increased rapidly in the mid-1960's, reached apeak of about 120,000 tons in 1967 and 1968, and declined to about 30,000-40,000 tons in 1971. In 1969 an offshore fishery, mainly by USSR, developed on over-wintering concentrations of this stock in Div. 4Wb and a catch of 60,000 tons was reported in 1970. Because of this offshore fishery the total catch of adults from this major stock increased by about 40,000 tons in 1970. Catches of adults from both the Canadian inshore fishery in Div. 4Wa and the offshore fishery in Div. 4Wb declined substantially in 1971.

Both the quality and quantity of data, on which accurate assessment should be based, are much less than are available for the Gulf of Maine and Georges Bank stocks. Canadian purse-seine catches per boat-night had declined by about 45% between 1966 and 1971, but these data were not adjusted for changes in efficiency. It is thought that efficiency may have increased over the same period by a factor of about 2. This would indicate a decline in stock abundance to about 30% of the pre-1966 level.

Age-compositions for the period 1965-71 indicate that no great change has occurred in the relative proportions of the older and younger members of the adult stock. Table 16 gives the numbers at each age for the 3rd quarter (Canadian data); for 1970 and 1971 these refer to the spawning area only, but for earlier years they refer to a larger area including other parts of Div. 4X. Table 17 gives, for the same data of Table 16, the numbers and the percentages in two groups - six years and above, and five years and below, for each year. Mean percentages for each of the periods 1965-68 and 1969-71 are also given. This separation divides the whole period at the time of peak catches in the Canadian fishery. The proportion of younger fish (less than 6 years) increased from 54% to 66% between the two periods. USSR data for 1970 and 1971 are also shown in Table 16, and compare reasonably with the Canadian data.

Recruitment to the Nova Scotia stock varies from year to year but this variability in year-class size is not as great as it is for the Georges Bank stock. The very good year-class of 1966 still contributes substantially to the fishery and is followed by the reasonably sized 1967 year-class. Although historical data is scanty there is no indication of long periods over which recruitment is very low, as is known for the Georges Bank stock and also for the Gulf of St. Lawrence stock. Moreover, there has been no decline in the Nova Scotia juvenile (weir) fishery as there has been on the New Brunswick side of the Bay of Fundy and in the Gulf of Maine.

In recent years total effort in the Canadian purse-seine fishery has declined because of the diversion of boats to other herring fisheries as catch rates fell off from initial high levels. This was certainly true of the 1971 fishery.

While it is not possible to make a full assessment for this stock the conclusion is that the current status of the Div. 4Xa-4Wb stock is not very far from that giving maximum yield. This would mean that there should certainly be no increase in the fishing mortality rate in 1972.

Based on observed decline in catch since 1966, a catch in 1972, which is the same in 1971, would probably lead to an increase in fishing mortality (assuming no change in recruitment in 1972) and a decline in stock size. It is believed that this would not lead to a critical situation over a period of one year but because of uncertainties of recruitment prospects it would be advisable to fix the quota level somewhat below that of the 1971 catch.

The 1971 adult catch was 67,000 tons and a quota of 60,000-65,000 tons is suggested as that which probably would prevent a stock decline. In doing this, allowance is made for the possibility that provisional Canadian statistics for the 1971 catch of Div. 4Xa-4Wb stock underestimate the catch by 5,000-10,000 tons, but that approximately this amount of "local" inshore stocks are caught in the Nova Scotia Atlantic coast gillnet fishery.

If an annual catch of some 70,000-80,000 tons represents approximately the average maximum sustained yield for this stock then it implies that the Nova Scotia stock is rather less than one-third the size of the Georges Bank stock. This is not inconsistent with estimates of the relative size of the area available to larval and post-larval stages of these two stocks.

As in Div. 5Y a fishery on juveniles exists. Therefore, consideration of limitations of adult fisheries must include the possible effects of the juvenile fisheries on adult abundance and yield.

(d) Advice to Commission on catch levels

At the 1971 meeting the scientists were asked three questions regarding the herring stocks: (a) what is the level of the maximum sustainable yield? (b) what is the current level of the sustainable yield? (c) what should the catches be to initiate a program of rebuilding the stocks?

Because of the uncertainties surrounding certain aspects of herring biology, such as the relation between stock and recruitment, and the large apparently random fluctuation in year-class strength, the concepts of maximum sustainable yield, and sustainable yield, which have proved very useful in considering management of seals or whales, are less useful for advice on herring. Fluctuations in year-class strength mean for example that when a good year-class enters the fishery the stock will increase in the short term almost irrespective of the amount of fishing. Conversely, the stock will decrease when good year-classes leave the fishery, even if fishing is very light, but the decrease could be catastrophic if catches are too high.

The Subcommittee has therefore attempted to answer the questions in a slightly different form:

(a) What are the average annual catches possible if the stock is maintained at the level giving good recruitment?
(b) What values of fishing mortality would be desirable, at an average long-term level, to give a high yield per recruit while maintaining a spawning stock large enough to provide a reasonable expectation of good recruitment? What would be the catch quotas necessary in 1972, and later years, to maintain such values of fishing mortality?
(c) What would be the changes in spawning stock size following the adoption of the quotas in (b), and what lower quotas would be necessary to restore the stock at different rates?

One explicit estimate has been made by Anthony (ICNAF Spec. Asst. Contrib. No. 72/23, also ICNAF Res. Doc. 72/24) of the possible maximum sustainable yield, based on the surplus production model, giving figures of a little over 300,000 tons. This may be rather high, since the analysis may be distorted by the presence of the very strong 1960 and 1961 year-classes.

Another estimate of the potential yield assuming year-classes of the average strength of the 1962 and later years, was equal to 130,000 tons. Provided that the spawning stock is maintained, year-classes of the 1960 or 1961 strength should occur occasionally, and depending on their frequency, the yield would be greater. Perhaps a realistic estimate of the potential average long-term yield is around 250,000 tons.

The first estimate of the optimum fishing mortality can be obtained from the yield-per-recruit curve. Given the slow post-recruit growth, and relatively high natural mortality, this curve has no maximum, but has a flat top (Fig. 8). It seems undesirable to increase the effort beyond the left hand shoulder of the curve, where any increase in yield per recruit will be very small compared with the increase in fishing required to catch it. While the limiting position must be somewhat arbitrary, it is suggested that it would at least be at a level of effort no higher than that at which the marginal yield per recruit is one-tenth of the marginal yield of the unexploited stock. That is, the point when the net addition to the total catch achieved by an additional vessel is only one-tenth of the yield taken by the first vessel operating in the fishery.

Calculated on this basis, for the Georges Bank stock, the limiting value of the fishing mortality is 0.57 for a constant natural mortality, M, of 0.44 and F of 0.45 for M = 0.35. The Subcommittee therefore concluded that there would be no biological justification for a fishing mortality in excess of approximately 0.5. If a fishing mortality of 0.5 were to be generated in 1972, the catch would be about 70,000 tons, which is an upper limit to the 1972 quota.

This calculation, based on yield per recruit, makes no allowance for the effect of the size of the adult stock on subsequent recruitment. The nature of this effect is not known, and it is clear that natural factors are critical in determining whether a good year-class will occur in any particular year. However, if the spawning stock is too low, a good year-class cannot be produced, even when environmental factors are favorable. It is likely that the present very low spawning stock on Georges Bank is considerably smaller than that required to give a high probability of a good year-class occurring when environmental conditions are favourable. A catch of 70,000 tons in 1972 would just maintain the 1971 stock size, though precise calculations are difficult because of uncertainties about the strengths of the year-classes recruiting to the fishery in 1970 and 1971. It is possible that the occurrence of 3- and 4-year-old fish in the catches in 1970 and 1971 gives a fair representation of their relative frequency in the stock. If they do, the recent year-classes are of average strength or higher and a catch of 70,000 tons in 1972 would leave the stock unchanged or at best a little greater. It is more likely, however, that the catch data overestimate their relative strengths, due to a recent increase in the proportion of a year-class recruiting to the fishery at ages 3 and 4, in which case they are no better than average, and the catches in 1972 would have to be no higher than 50,000 tons to ensure that the stocks were not further depleted.

4. Research requirements

(a) Stock identity

Although considerable progress has been made in the solution of problems relating to stock identity, much remains to be done if the herring stocks of the Northwest Atlantic are to be managed in a way that realizes their maximum potential.

Much would be gained from a well-planned large-scale tagging program in Div. 4X and 4W and in Subareas 5 and 6, if as successful as the Canadian tagging program on the Gulf of St. Lawrence stock. Such a program should deal with both adult and juvenile stages. A program of this kind could only be undertaken if it received special support from all countries interested in the Northwest Atlantic herring fisheries. The Subcommittee recommends

> that a small group of experts under Mr Iles (Canada) plan a detailed program to be presented at the 1972 Annual Meeting.

The results of the 1971 *ad hoc* larval survey program were promising, and it is recommended that the program be continued and intensified in 1972 and plans made for a long-term project. Attention should also be directed to post-larval stages. It is suggested that Dr Schnack (Fed. Rep. Germany) and a scientist from Northeast Fisheries Center (USA) plan for coordinating the 1972-73 surveys. Proposals for their continuation in future years and full analysis of data should be put forward at the 1972 Annual Meeting, and it is recommended that a working group be established for this purpose to meet just prior to the 1972 Annual Meeting.

(b) Sampling and statistics

The quality of fishery statistics and biological sampling data, needed for effective management, depends on the complexity of the measures to be applied. The recommendations in this report represent only the first step toward rational management. Developments and refinements in management procedures will be possible only if parallel improvements are made in the collection and reporting of statistical and biological data. Immediate needs are: (1) accurate catch data for each of the subdivisions listed in Tables 5-9; (2) catches, on a monthly basis, expressed in numbers by age-groups in a standard format for the Assessment Subcommittee; (3) extensive coverage of various maturation stages in all fisheries to determine the degree of recruitment of the various age-groups to the fisheries on spawning stocks.

(c) Juvenile surveys

A fundamental problem inherent in the management of herring fisheries is the great variability in year-class size and our present inability to estimate the relative abundance of year-classes prior to their full recruitment to the adult stocks. Emphasis should be placed on the immediate development of methods to measure year-class abundance for individual stocks at as early a life-history stage as possible.

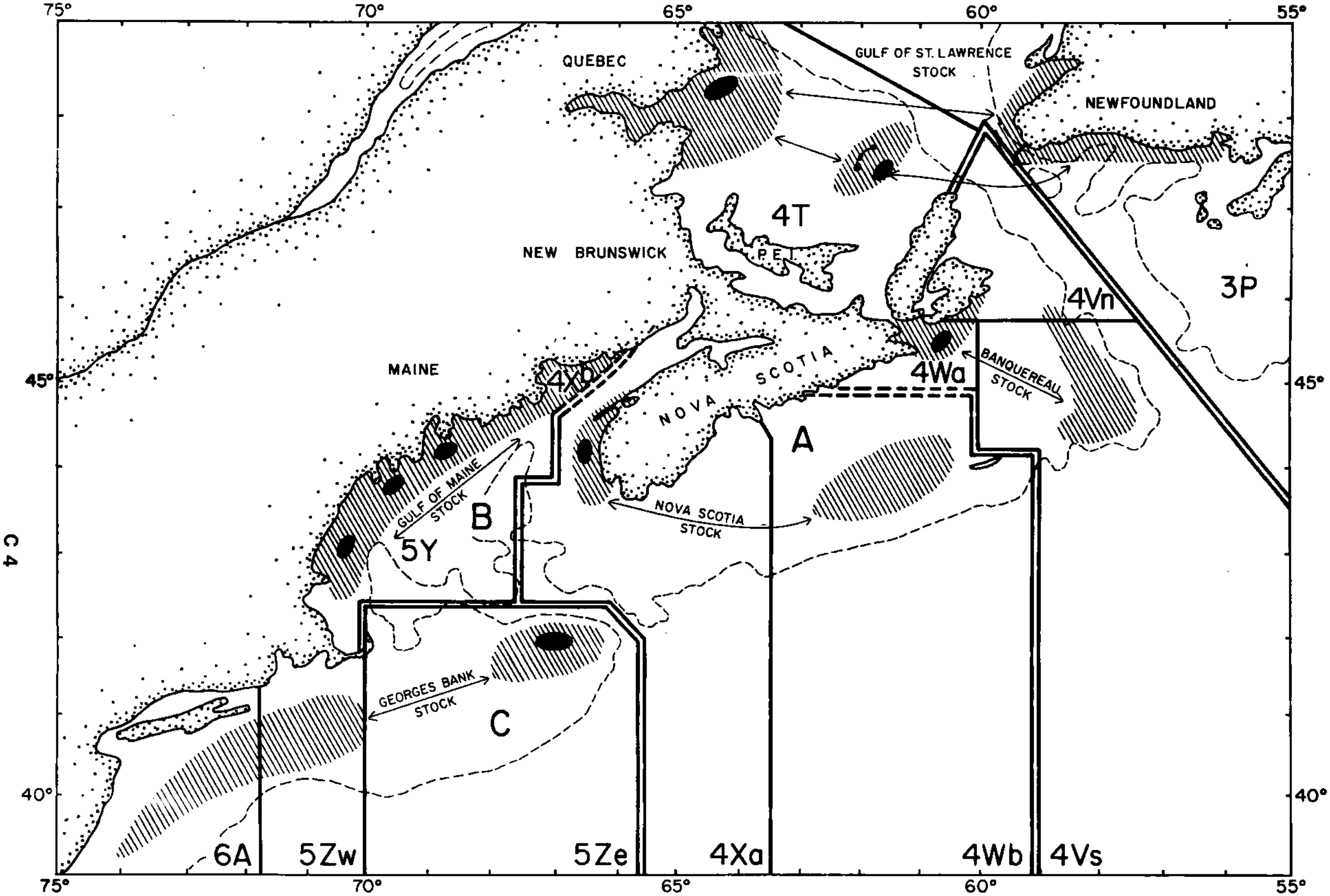

Fig. 1. Herring stock structure in the ICNAF Area (double lines indicate stock boundaries and the solid black areas indicate the general spawning grounds).

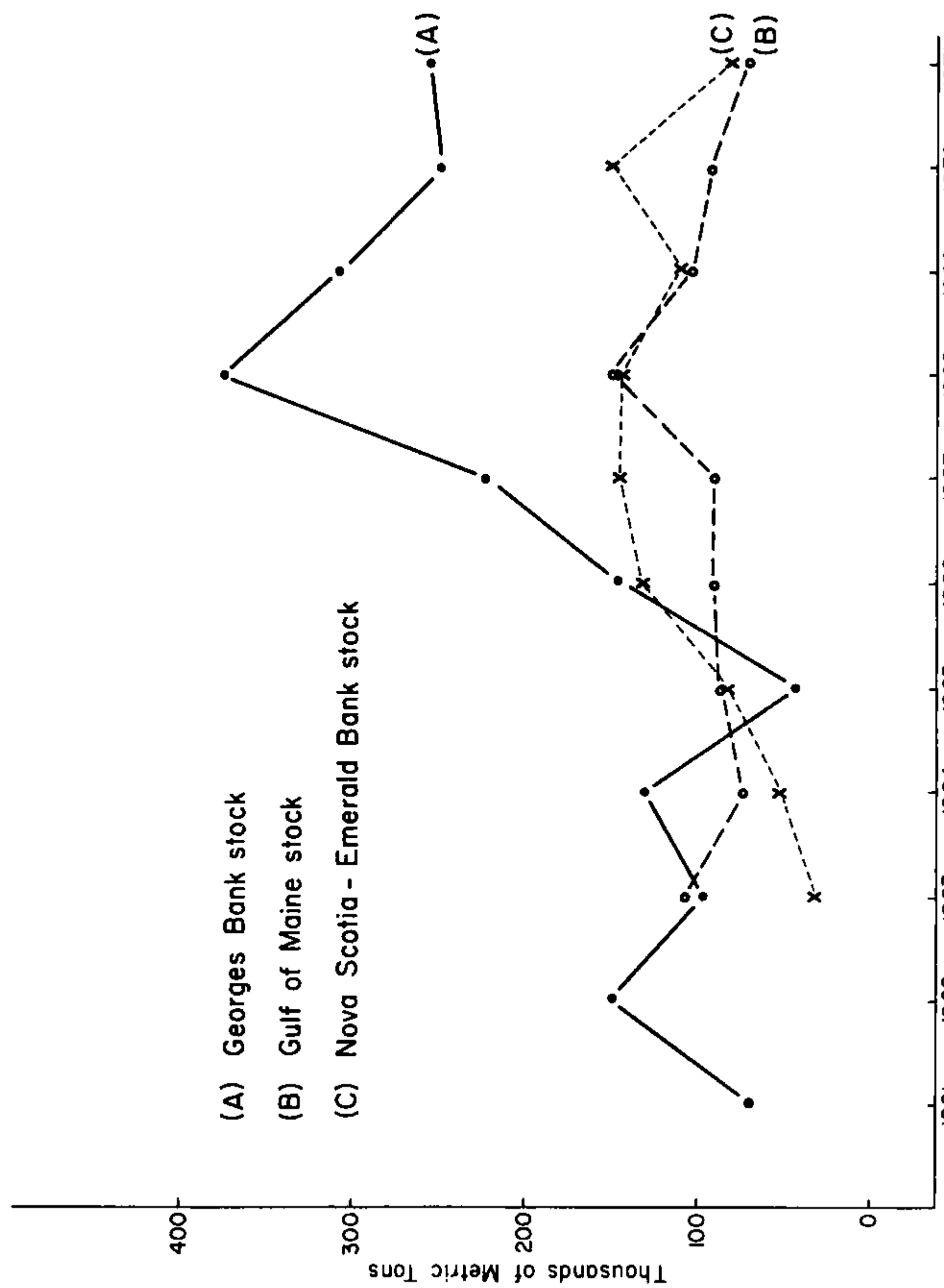

Fig. 2. Herring landings by stocks, 1961-71.

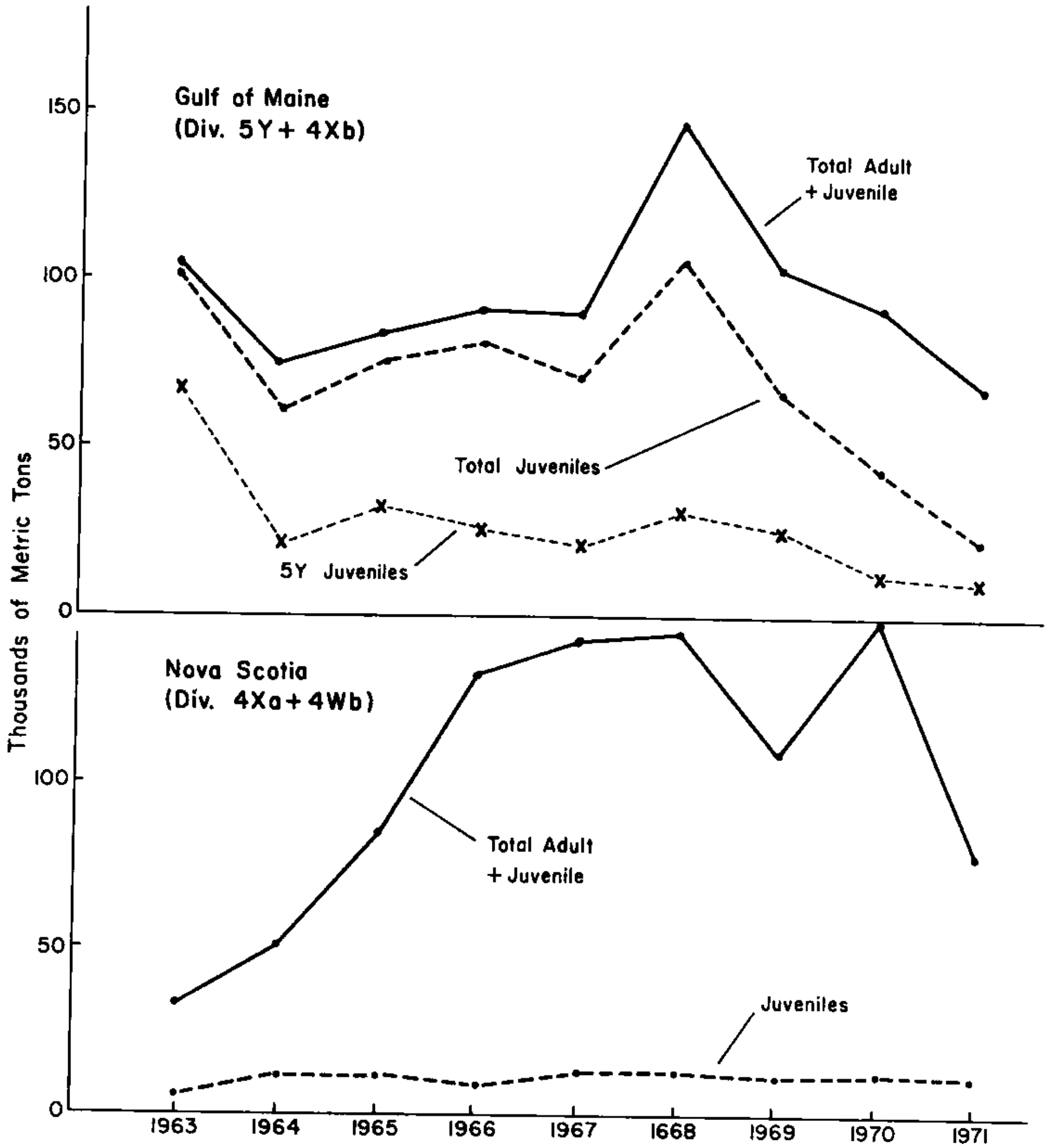

Fig. 3. Gulf of Maine and Nova Scotia stocks showing the juvenile catches relative to the total catches.

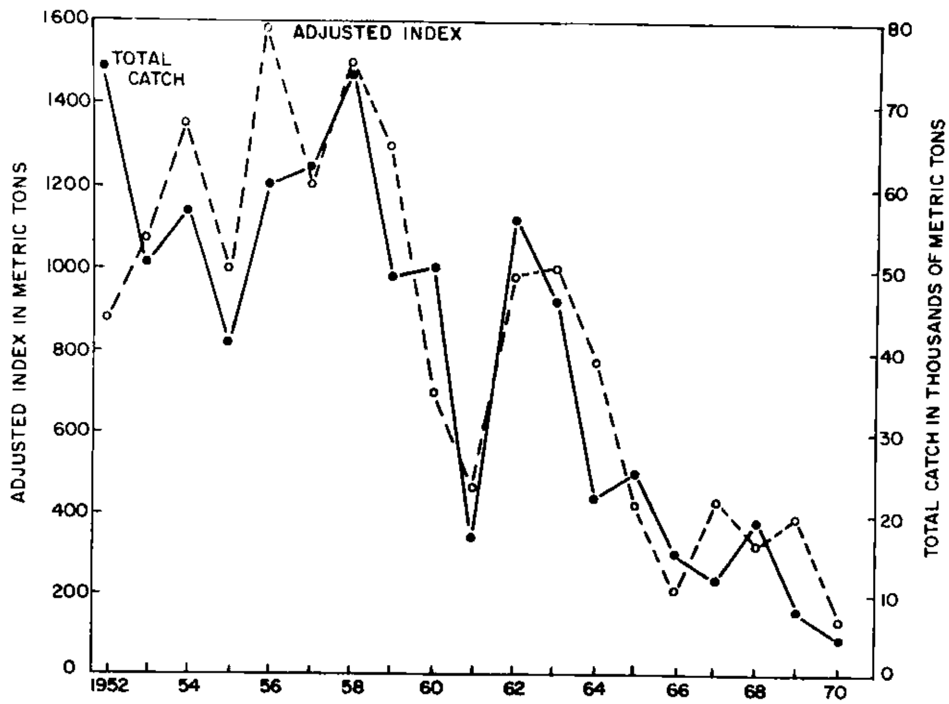

Fig. 4. Abundance indices Div. 5Y herring, total catch by stop seines and weirs, and an adjusted catch per man index.

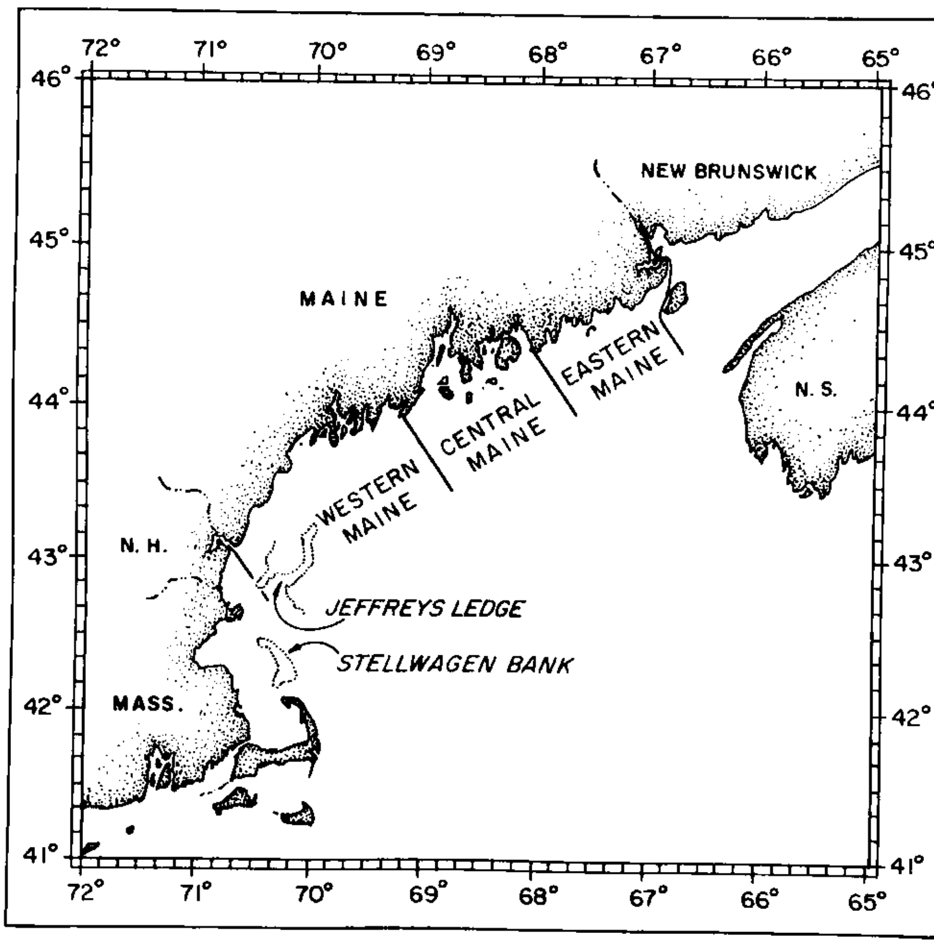

Fig. 5. Map of Gulf of Maine giving place names referred to in the Div. 5Y herring stock assessment.

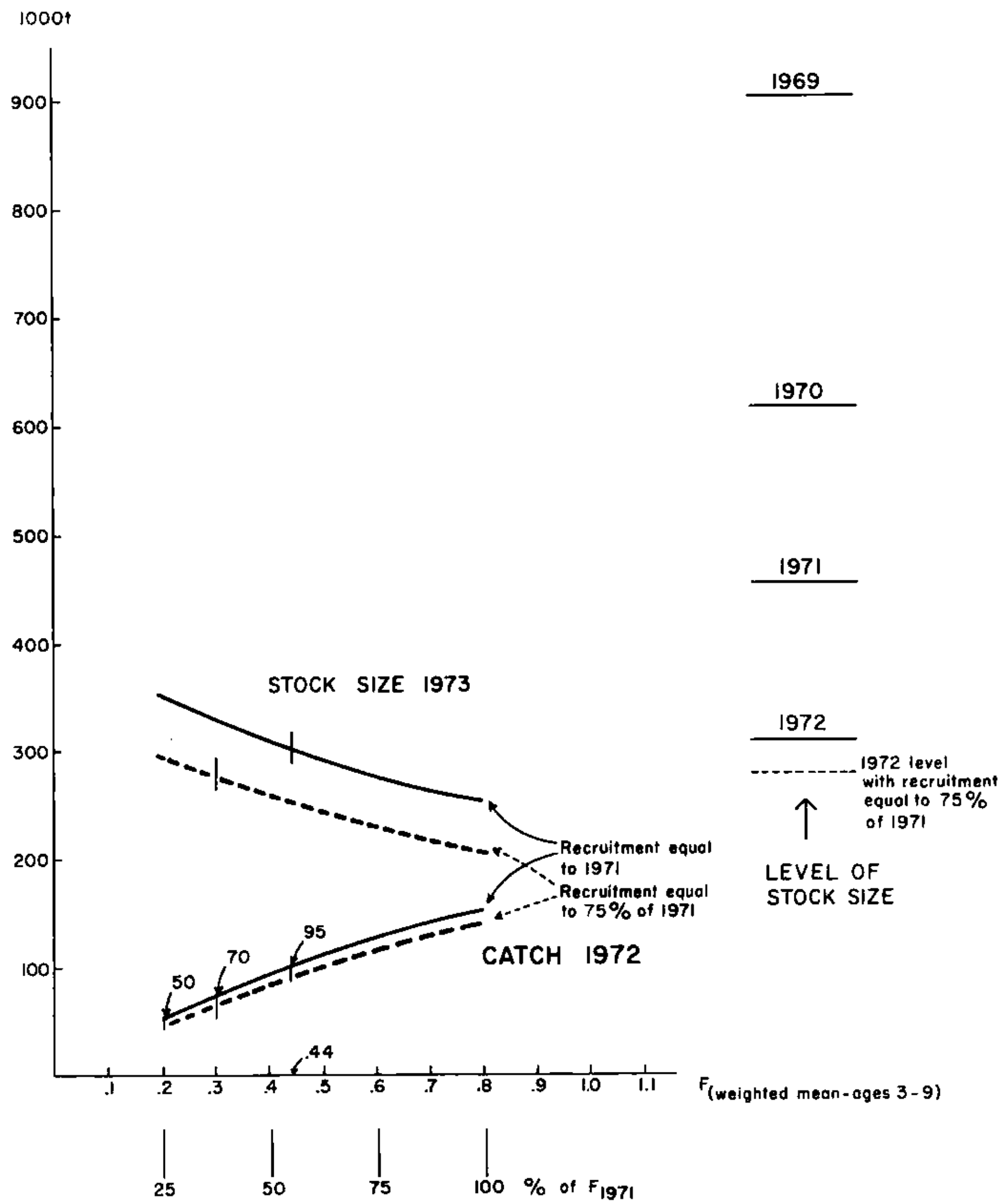

Fig. 6. Georges Bank herring stock sizes in 1973 by levels of catch and fishing mortality in 1972.

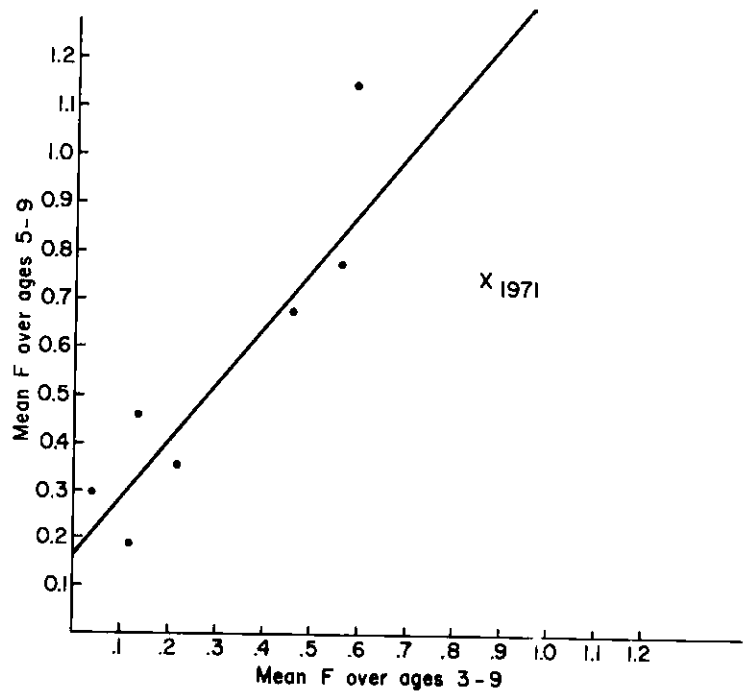
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Mean F over ages 5-9
X 1971
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2
Mean F over ages 3-9

Fig. 7.

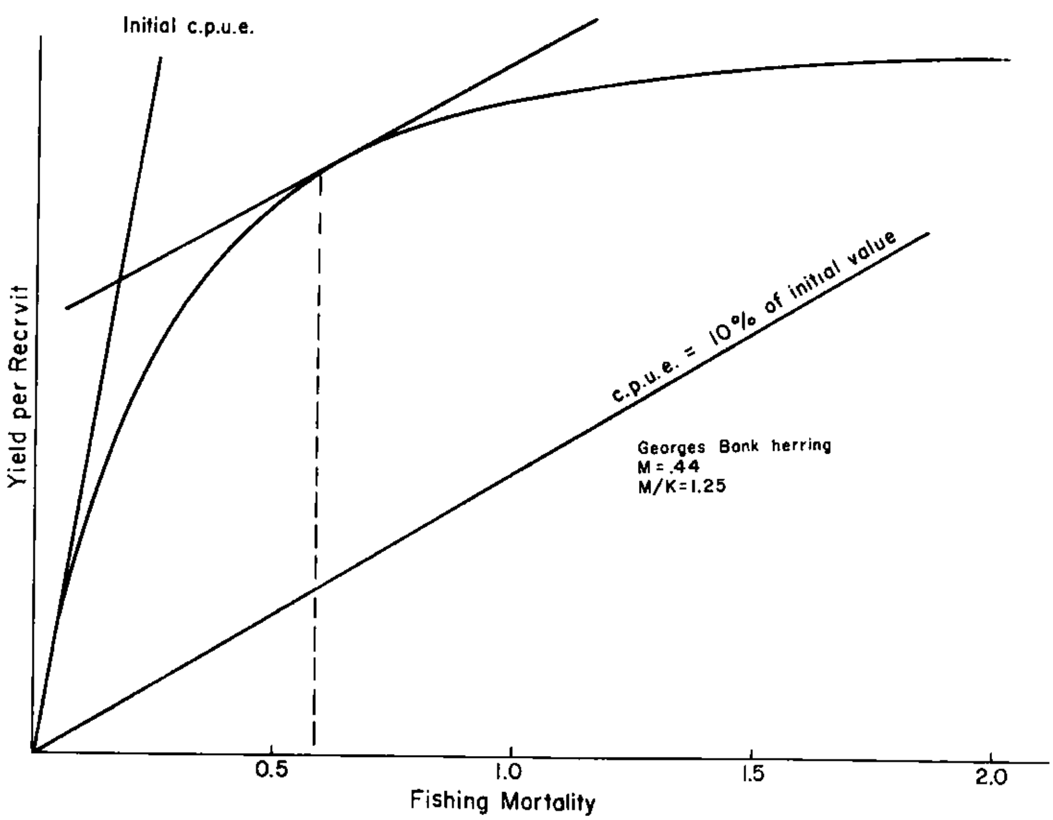
Initial c.p.u.e.
c.p.u.e. = 10% of initial value
Georges Bank herring
M = .44
M/K = 1.25
Yield per Recrvit
0.5
1.0
1.5
2.0
Fishing Mortality

Fig. 8.

V. Other Groundfish

1. Yellowtail flounder, Subarea 5

The assessment of these stocks has been updated with data obtained from 1971 research survey cruises and preliminary 1971 catch statistics. Predictions through 1973 of the changes in stock status, considering the implications of the quota regulations, have been made.

Area West of 69°, Cape Cod-Southern New England

Cape Cod. The catch of the Cape Cod stock in 1971 was 2,000 tons, up 400 tons from 1970. This stock should be capable of supporting this level of harvest in 1973.

Southern New England. The southern New England stock abundance continued to decline in 1971. The catch per day of the US commercial vessels decreased from 3.5 tons to 3.0 tons. The landings per day (catch excluding discard of small fish) declined from 2.6 tons to 2.0 tons. US survey cruise abundance indices declined by 50% (Table 19). Total catch statistics for 1971 are not available but the catch is expected to exceed somewhat the 13,000-ton quota. With the current low population level as estimated from survey cruises, this level of catch would not have reduced F to the desired 0.8 level.

The pre-recruit index from the 1971 survey cruise continued to be low (Table 20). This substantiates last year's conclusion of the Assessment Subcommittee, based on predicted population size from survey cruise data, that a catch of 8,000 tons is necessary in 1972 to reduce F to the required level.

Length frequencies in US survey cruise catches in 1971 indicated a further decrease in fish 4 years of age and older, which are now at a very low level. This is also shown in the age-composition of the US commercial landings (Table 21).

Table 19. Yellowtail flounder abundance indices from US survey cruises.

Year	Southern New England		Georges Bank	
	Numbers per tow	Weight[1] per two	Numbers per tow	Weight[1] per tow
1963	50.6	32.1	30.1	22.0
1964	60.8	41.9	22.5	23.4
1965	38.7	28.0	15.0	15.7
1966	50.2	20.8	14.8	6.7
1967	57.7	31.0	18.6	13.0
1968	40.2	22.1	25.6	18.1
1969	54.7	31.7	23.1	15.9
1970	49.5	30.1	16.0	11.6
1971	33.9	21.0	15.3	11.1

[1] Weight in pounds

Table 20. Indices of pre-recruit (I+) yellowtail flounder abundance southern New England populations (west of 69°).

Year	Numbers per tow
1963	16.3
1964	18.5
1965	11.7
1966	34.4
1967	19.9
1968	9.0
1969	7.0
1970	8.3
1971	7.7

Table 21. Age-composition of the US landings[1], January-September 1971.

Age	2	3	4	5	6	7	8+
Nos. in '000s	4,057	23,492	54,105	27,967	6,755	1,755	252

[1] not including fish discarded

Recent analysis of age-composition of yellowtail flounder in catches of the US survey cruises from 1963-1969 provided an estimate of total mortality, $Z = 1.25$. This substantiates earlier findings based on analysis of commercial catch-effort data of a high fishing mortality rate (natural mortality, $M = 0.2$).

Quota values. The 1971 quota of 13,000 tons was based on assuming a catch of 2,000 tons from the Cape Cod stock and 11,000 tons from the southern New England stock. If the catch quota for 1971 has not been gresatly exceeded, and if the 1972 southern New England catch does not exceed 8,000 tons, then the 1973 catch in that area can be held at the 8,000-ton level based on predicted population size. This level should not be exceeded as long as recruitment continues at the current low levels. If the catch of the Cape Cod stock is included, then the quota can be set at 10,000 tonsfor the area west of 69°.

Area East of 69°, Georges Bank

Preliminary catch statistics indicate that the 1971 quota of 16,000 tons will be somewhat exceeded. Catch per day in the US fishery declined from 3.4 tons in 1970 to 2.7 tons in 1971. Landings per day declined from 2.5 tons to 2.1 tons. The greater decline in catch per day may be more due to changes in fishing practices, e.g. larger mesh and market conditions, than a decline in the population of smaller fish.

Survey cruise abundance indices remained the same in 1971 as in 1970 (Table 19). The length frequencies of survey catches have remained about the same in the period 1963-1971. Pre-recruit (I+) numbers are less in 1971 than in 1970 but the relationship of this index to the future populations on Georges Bank is not yet established. The age-composition of the US commercial landings indicates a reasonable proportion of older fish (Table 22).

Table 22. Age-composition of the US landings[1], January-September 1971.

Age	2	3	4	5	6	7	8+
Nos. in '000s	10,048	68,792	56,322	21,236	8,464	2,320	2,069

[1] not including discards

A total mortality rate of 1.0 was estimated from the age-composition of 1963-1959 US survey cruise catch data. This gives an F of 0.8 with natural mortality, M = 0.2. This is lower than the F = 1.0 used in the 1971 assessment obtained from commercial catch-effort data and thus indicates that the 16,000-ton quota is probably going to be effective in regulating F to a desired 0.8 level.

Although the pre-recruit index declined in 1971, the high variability of the index since 1963 means that the observed decline is not of significant magnitude to recommend a reduced quota for 1973.

Subarea 6

The preliminary US catch statistics for Subarea 6 indicate an increase in 1971 over 1970 (5,000 tons vs 3,300 tons). Most of this increase occurred in the area along the 71°40' Subarea 5-Subarea 6 border. Although the relationship between the stocks in the middle Atlantic and in southern New England has not been clearly defined, when the stock situation is as critical as it is in the latter area, such an increase is cause for concern. If there is a significant intermixing of the fish in these two areas then increasing fishing in Subarea 6 could temper the desired effect of the quota in southern New England.

2. American plaice - Div. 3L and Div. 3N

Tagging and growth characteristics indicate that for assessment purposes the American plaice resource of Grand Bank should be divided into two separate stocks, one in Div. 3L, the other in Div. 3N.

The fishery in Div. 3L is almost entirely Canadian, landings increased from 15,000 tons in the late 1950's to 25,000 tons in 1965 and then to over 50,000 tons in 1969, declining to 40,000 tons in 1970. Increasing landings were accompanied by increasing fishing mortality rates, F increasing from 0.08 in 1955 to about 0.35 for males and 0.25 for females in 1967. Abundance declined by over half in the 1956-1969 period. With declining abundance and increased landings, F in 1968-70 was almost certainly greater than in 1967, which was close to that giving maximum yield per recruit. Only a very small increase in yield per recruit would result from increased F. As abundance is probably still declining, maintaining F at current levels implies landings in the immediate future of 35,000-40,000 tons per year.

The Div. 3N stock yielded about 5,000 tons annually in 1954-1963. The yield in more recent years is less certain because of increased participation in the fishery by the countries (USSR, Poland) which until 1970 have included American plaice in landings of unspecified flounders. Canadian landings increased to 30,000 tons in 1966 and then declined to about 10,000 tons in 1968-1970. Total landings probably followed a similar pattern, declining to 21,000 tons in 1970. Mortality increased with increasing landings to about F = 0.35 in 1966-1967. Declining landings in 1968-1970 were accompanied by declining stock abundance, and thus F may not have changed greatly since 1967, which is close to the value giving maximum yield per recruit. Thus, although the status of this stock is less precisely determined than that of Div. 3L because of uncertainty about yields in recent years, it does appear that only small increases in long-term yield per recruit would occur from increased effort. As abundance is declining, landings probably should not exceed 20,000 tons (the 1970 level of catch) in the immediate future to prevent a precipitous decline in stock abundance.

3. Silver hake - Subareas 4, 5 and 6

Stock identification

USSR research studies based primarily on otolith structure and the relationship of otolith weight to length of fish, but with some supporting biochemical evidence, have delineated several separate silver hake stocks in the Northwest Atlantic. These stocks inhabit the Sable Island area (Div. 4W), the Browns Bank area (Div. 4X), Georges Bank and adjacent areas (Div. 5Ze, 5Y), and the southern New England-middle Atlantic region (Div. 5Zw, Subarea 6). The area off southern New England (Div. 5Zw) appears to be a region of overlap between the middle Atlantic and Georges Bank populations, with the former moving into that area in the summer. Observations of migration patterns, abundance indices from survey cruises, age structure of commercial and research catches indicate the inshore Gulf of Maine area (Div. 5Y) may be a separate stock also.

Div. 4W

USSR surveys and commercial catch-effort statistics in Div. 4W indicate an increasing population from 1969 to 1971. The fishery during this period consisted primarily of 3- and 4-year-old fish of the 1966, 1967, 1968 and 1969 year-classes. The 1971 catch increased over that of 1970. The percentage age-composition of the USSR commercial catch is given in the following table for 1970, and on the average, for 1963-1970:

	Age									Average Age
	1	2	3	4	5	6	7	8	9	
1970	7.0	11.6	35.9	33.1	10.1	1.4	0.5	0.3	0.1	3.36
Average for 1963-1970	1.7	6.4	30.9	41.3	16.1	3.0	0.5	0.1	+	3.75

Div. 5Z

Silver hake catches increased in 1971 and USSR age-composition data indicates that the fishery is dependent primarily on 3- and 4-year-olds. The 1968 year-class is of moderate strength and provided for 36% of the catch. The percentage age-composition of the USSR commercial catch is given in the following table for 1971 and for the averages of the percentages for 1962-1971:

	Age											Average Age
	1	2	3	4	5	6	7	8	9	10	11	
1971	0.1	4.9	36.6	27.6	17.7	6.9	2.5	2.2	1.3	0.1	0.1	4.12
Average for 1962-1971	2.6	8.5	37.3	34.6	11.7	2.9	1.5	0.6	0.3	+	+	3.54

Age-composition estimates based on US research survey cruise data for 1968-1971 indicated decreasing numbers of fish 5 years and older since 1968. The 1971 autumn survey cruise catch of numbers of 0+ fish was the largest recorded since 1963, by a factor of about two. The mean weight per tow for all sizes of fish in the survey cruise remained at the same level in 1971 compared to 1970, but would be expected to increase in 1972 and 1973 from the growth in biomass of the 1971 year-class.

Div. 5Y

The 1971 catch (preliminary statistics) in Div. 5Y continued to drop, being 7,000 tons contrasted with 11,000 tons in 1970. The US commercial fishery abundance index also declined. Mean weight per tow in the 1971 US autumn survey cruise remained the same as that in 1970. It was greater than the low of 1967 and 1968 but still less than half of the average value for 1964-1966. Abundance indices of young-of-year fish based on autumn survey cruise length frequencies exceeded the previous highest value (1963) in the 1963-1971 series by a factor of almost two. However, the years 1964 through 1968 were characterized by extremely low recruitment. Age-compositions of catch were determined for the 1968-1970 US autumn survey data. In 1968 4- and 5-year-old fish predominated but by 1970 fish of these ages were non-existent in the sample. Age-compositions of the US landings were determined only for the years 1966 and 1967 but in these years 4- and 5-year-old fish were abundant in the catch and a fairly significant number (11%) were even older. A preliminary production curve has been calculated based on abundance indices derived from the US commercial fishery catch-effort data. There appears to be a reasonable fit giving a maximum sustained yield of 35,000 tons. This is close to the long-term average catch in this fishery over its 30-year history.

Subarea 6

The fishery in the middle Atlantic in 1971 did not have the increase in catch that was indicated for Georges Bank and Subarea 4. Age-composition of the USSR catches show this fishery to be supported by fish 3 and 4 years of age. Survey cruise abundance indices for 1971 are up over 1970 and similar to the 1967 and 1968 levels. Pre-recruit numbers are also greater than in 1970, but are not exceptionally high when compared with the entire series of values since 1963.

Research needs

There is an urgent need for improved assessment of silver hake, particularly in the Subarea 5 area where a closed area and season exist. The combination of the expiration of this regulation in 1973 and the indications of a strong 1971 year-class necessitates that emphasis be given to assessment of populations in this area before the May 1972 meeting. There is still a problem of stock identification and further study is required. Sufficient information is not presently available for the Assessment Subcommittee to provide proper advice to the Commissioners for management of silver hake. The following list outlines studies the USA and USSR have agreed to complete during the next year, and if possible, by the Annual Meeting next May.

USA

1. Provide otoliths to USSR from Div. 5Y for stock identification studies
2. Estimate growth curves from available age-length data
3. Provide age-composition of the US catches as current as possible and as far back into the history of the fishery as possible
4. Provide current estimates of abundance from US-USSR survey cruises by size-groups. Using Soviet age-length key, provide estimate of survey cruise age-composition for US cruises prior to joint surveys
5. Provide yield and yield per recruit models using both US and USSR growth data; this study should simulate varying conditions in the fishery depending on different assumptions of mortality rates
6. Provide virtual population model estimate of year-class size and mortality.

USSR

1. Provide background data and research document on stock structure studies using otoliths
2. Provide growth curve and age-length key from survey cruise data (see point 4 US)
3. Provide age-composition of the USSR fishery catches as current as possible and as far back into the history as possible
4. Provide data on age-composition of US-USSR joint survey cruises
5. Provide a document with background data for USSR estimate of silver hake mortality rates

4. Red hake - Subareas 5 and 6

A US fishery for red hake has existed for a long period, but the catch was rather small except in the late 1950's when the catch rose to about 40,000 tons. An intensive USSR fishery began in 1965. Total catches for all countries are tabulated below for recent years.

Year	1965	1966	1967	1968	1969	1970
Catch (tons x 10^{-3})	84	114	58	20	55	12

USSR studies indicate two principal stocks exist. The first inhabits the southeast Georges Bank area (Div. 5Ze) and the second the waters southwest of Cape Cod (Div. 5Zw, Subarea 6). During the winter the stocks may be relatively discrete, occupying the area deeper than 100 m. During the summer the fish make extensive inshore migrations and may well be intermixed in some areas. The relative abundance of the stocks has been estimated from trawl surveys which have been conducted by the US since 1963, and by the USSR jointly with the US since 1967. The pounds per tow in the area of the southern stock component decreased significantly from 1963 to 1967, increased in 1968-1969, but decreased somewhat in 1970-1971 (see Table 23).

Table 23. Pounds per tow of red hake in *Albatross IV* surveys in Div. 5Zw and Subarea 6.

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971
Div. 5Zw	18	10	12	6	6	10	11	9	9
Subarea 6	-	-	-	-	0.3	2	1	.4	.8
Comb.	-	-	-	-	3	6	6	5	5

In the northern stock, the trends in abundance were much the same (Table 24).

Table 24. Pounds per tow of red hake in *Albatross IV* surveys in Div. 5Ze.

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971
Catch	15	5	3	2	1	2	3	1	3

The USSR used commercial fishery and survey data to estimate total mortality rates from age 7 onward for the 1965-1970 period (Table 25).

Table 25. Estimate of Z for red hake.

	Age											
	1		2		3		4		5		Average 3-5	
	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.
Div. 5Ze	-	-	-	-	.62	.71	1.34	0.82	1.71	1.29	1.40	1.0
Div. 5Zw-Subarea 6	-	.22	-	.64	.59	.79	1.21	.94	2.0	1.57	1.27	1.09

The estimated mortality for age 1 fish in the survey catch, Z = 0.22, is assumed mostly due to natural mortality. However, because the commercial catches contain significant numbers of 2-year-olds (up to 35% of total, averaging about 15% at age 2) the coefficients for age 2 onward contain increasing proportions of fishing mortality. The age-composition of commercial catch show full recruitment to the fishery between age 3 and 4. If ages 4 and 5 are fully recruited, and equally vulnerable, the increased Z of 0.6 may reflect an increase in natural mortality. Thus, the upper limit of natural mortality rate is between 0.2 for age 1 fish and 0.8 for age 5 fish. Total mortality on fully recruited fish (ages 4 and 5) is about 1.5.

The USSR has also estimated stock size which is given below, together with catch (tons x 10^{-3}):

Table 26. Biomass estimates of red hake, based on the commercial catch and on survey cruise catches ( ).

		1965	1966	1967	1968	1969	1970	1971
Div. 5Ze	stock	125	91	62	12	11 (13)	11 (8)	(10)
	catch	55	40	27	5	5	2	
Div. 5Zw-Subarea 6	stock	69	174	72	36	117 (87)	104 (54)	(54)
	catch	30	74	31	15	50	10	

It does appear that in some years the fishery removals were a significant part of the stock.

The fishery has become more dependent on annual recruits. Thus, any regulations or quotas will have to be based on predictions of recruitment, which the USSR analysis has shown can be done from the trawl survey data.

It is not possible at the present time to establish the effects of different rates of fishing. The total stock in 1970 was estimated to be at most 115,000 tons. Good recruitment from the 1971 year-class is expected in 1973-1974. If fishing intensity in 1971-1972 does not increase substantially, the harvestable surplus in 1973 may be in the 50,000-70,000-ton range.

5. Scallops, Subarea 5

Scallop landings reached a peak of 15,000 tons of meats (130,000 tons whole weight) in 1962 following recruitment to the fishery of the abundant 1955 year-class in 1959. They declined to 6,000 tons of meats by 1965 and landings have remained near that level since, being about 5,500 tons of meats (46,000 tons whole weight) in 1970. However, catch-per-effort has been in almost continuous decline from 1961, the 1971 level being only 1/5 that of 1961.

In 1970 a dense concentration of 3-ring scallops was located by the commercial fleet in a limited area (274 km^2) on the northern edge of Georges Bank. This concentration was heavily fished in 1970 and 1971, and has now largely been fished out. Another area of predominantly small scallops has been located on the east side of the Bank and is currently being exploited by part of the fleet.

Research vessel surveys in July 1970 and 1971 indicated that total mortality, Z, of scallops $\geq$ 50 mm in the northern edge concentration was 1.06 in the period between surveys. As natural mortality, M, has been estimated at 0.10-0.20, most of this total mortality probably resulted directly or indirectly from fishing. Scallops as small as 70 mm shell height were landed by the fleet in 1970 and direct fishing mortality was undoubtedly high for scallops larger than 70 mm. However, at least half of the population present in 1970 was smaller than 70 mm, and yet Z for 50-70 mm scallops was about 0.90, indicating that mortality incidental to fishing was large. Underwater observations have confirmed substantial damaging effects of the offshore dredge on those scallops which, though in its path, are not retained.

The fishery on the scallop stocks has thus developed in an unsatisfactory pattern. As the stock decreased, the fleet has exploited smaller and smaller scallops. Also the very patchy settlement of scallops has encouraged the concentration of the fleet on each new settlement, leading to a rapid reduction in abundance, while the animals are still very small. Since they grow rapidly, with a low natural mortality, the benefit from allowing the small animals to grow, either by a general reduction of mortality, or more specific protection, would be considerable.

Taking F = 0.90, M = 0.15, the constant parameter yield-per-recruit model indicates that, by increasing cull size, yield-per-recruit and catch-per-effort could be increased by up to 30% in the long term. Reducing F by half to 0.45 would result in only a small increase in yield, but catch-per-effort would more than double. As this substantially increased population would contain a larger proportion of old scallops, concentrations of small, just recruiting scallops may prove less attractive to fishermen, essentially raising cull size. This larger population may also enhance the possibilities of good recruitment. It appears that some combination of reduced fishing mortality and increased cull size would be desirable.

However, peculiarities of the fishery and the gear require that somewhat different regulatory measures from those currently in force for some groundfish stocks be adopted to ensure that the full potential of the stock is realized. The poor selective properties of the offshore dredge and the high incidental mortality caused by it make it difficult to assess the efficacy of increasing ring size in order to increase effective cull size. Ideally, a new, less destructive and more selective, gear should be introduced to the fishery, thus allowing cull size to be effectively regulated and the substantial loss in yield due to incidental fishing mortality to be reduced. If this is not done, other measures which prevent the fishing of young scallops should be adopted. This would not only control the size at first capture, but result in more effective control of F when combined with catch quotas. As the fishermen can choose to a large extent the size of scallops fished by selecting certain grounds, F could differ widely, depending on their decisions, under a catch quota without ancillary measures.

VI. Other Matters

1. Joint ICES/ICNAF North Atlantic Cod Working Group

This Group will be convened by Mr Garrod (UK) to meet in Copenhagen, 8-14 March. Its terms of reference were defined at the ICES Meeting in Helsinki as follows:

"To summarize existing assessments concerning cod stocks in the North East Arctic, Icelandic and East Greenland waters, as well as the West Greenland, Labrador and Newfoundland stocks, and to examine in general terms the effects of possible regulatory measures, with particular emphasis on the interaction between fisheries on different stocks."

The Committee indicated that cod fisheries in Subareas 4 and 5 should be included in the review if possible, and it is recognized that at some stage it may be desirable to include also some stocks in the Northeast Atlantic which are at present excluded.

The initial objectives of the Group will be to summarize:

i) the recent history, current status and immediate future prospects in these resources
ii) trends in the fishing effort deployed on cod resources, its geographical distribution, and its distribution among different vessel categories.

This will provide the essential basis for a discussion of the effects of possible regulatory measures and for an Atlantic-wide review of the problems and degree of urgency for the regulation of cod stocks. It has also been agreed that a final analysis and report on those aspects dealing with interactions between fisheries may require the development of appropriate computer techniques and more detailed studies at a later date.

2. Groundfish surveys

Groundfish survey operations in 1971 and proposed surveys for 1972 were reviewed briefly, and there was further evaluation of accuracy achieved in survey estimates of stock abundance and age-length composition. Progress and strategy in development of a coordinated ICNAF groundfish survey program were discussed. Dr Grosslein (USA), Chairman of the *ad hoc* Working Group on Coordinated Groundfish Surveys, led the discussions.

Review of survey operations in 1971 and plans for 1972

In addition to the continuing series of groundfish surveys in Subareas 3-6 conducted by Canada, USA and USSR, the results of which were used in assessment of several species, there were brief reports on other survey operations in the ICNAF Area. Dr Noskov (USSR) reported on a June 1971 survey from Hudson Canyon to LaHave Bank with the USSR research vessel *Argus* (see ICNAF Spec.Asst. Contrib.No.72/29, also ICNAF Res.Doc.72/29). Distribution and abundance of all fish species were recorded for the 103 hauls in this survey, and hydrographic observations and plankton samples were also taken. Mr Letaconnoux (France) reported that the French completed two groundfish surveys in Div. 4V and 3P on the R/V *Cryos* in July and November 1971. Dr Messtorff (Fed. Rep. Germany) noted that the Federal Republic of Germany conducted a 1-week groundfish survey in Subarea 2 in November and also in Subarea 1 in December, aboard the R/V *Walther Herwig*. In September, the Polish research vessel *Wieczno* made a series of test hauls for groundfish on the southern Grand Bank, as noted by Mr Day. Finally, Mr Horsted (Denmark) indicated that several new bottom trawling locations had been located off West Greenland which probably could be added to the series of stations now being monitored by the Danish research vessel *Adolf Jensen*.

About the same level of survey activity is planned in 1972 as for 1971 in each of the subareas except for the addition of a survey by the UK next autumn. The R/V *Cirolana* is scheduled to conduct a 17-day groundfish survey in Subarea 1 or Subarea 2 which will be coordinated with survey operations on the *Walther Herwig*. A detailed list of proposed surveys by member countries will be prepared by Dr Grosslein (USA) in the next few months and the information will be available as a document at the next annual meeting.

Accuracy of survey results

An intensive groundfish survey was carried out on Faroe Bank in June 1971 aboard the UK R/V *Cirolana* to test survey sampling procedures and particularly to evaluate the level of accuracy obtained in estimates of stock abundance and age-length compositions. Trawling was done at 32 stations with replicate hauls at each station. Mr Garrod noted that very high consistency was achieved among replicate hauls and that general levels of accuracy were very satisfactory. Coefficients of variation for abundance estimates of principal species were only 5-10%, and the accuracy of age-length compositions compared very favourably with that achieved in market sampling.

Dr Grosslein (USA) reported on some preliminary biomass estimates derived from the 1970 and 1971 surveys in Subarea 4 by Canada, USA and USSR. Minimum estimates of total biomass of each species were provided by Dr Halliday (Canada) for the Canadian surveys in 1970 and 1971, and these were compared with data from the US and USSR surveys on the Scotian Shelf in 1970. These estimates were made simply by expanding mean catch per haul figures according to estimated area swept by an average haul and assuming 100% trawl efficiency (i.e., catchability coefficient = 1). Although significant differences in fishing power were apparent for the trawls used, nevertheless relative abundance estimates were fairly consistent among the trawls and among subdivisions of Subarea 4 for species such as cod, haddock, flounders and skates. Furthermore, comparisons of 1970 and 1971 abundance estimates of cod, haddock and flounders from the Canadian series were very consistent among the various subdivisions. Estimates for species such as silver hake, redfish and squid were much more variable as would be expected because of schooling behaviour, vertical distribution and diurnal movements, etc.

Biomass estimates for cod and haddock which were derived from the 1970 Canadian and US surveys in Subarea 4, were compared with estimates of total stock size calculated from the ratio of landings to current annual fishing mortality rates on fully recruited age-groups, i.e., landings divided by $E(1-e^{-Z})$ which would give a minimum estimate of total stock size. The two estimates were quite comparable for cod and haddock in Div. 4X, and for haddock in Div. 4VW, allowing for the likelihood that catchability coefficients are <1. Although these are only first approximations they contribute to the growing evidence that surveys can provide biomass estimates of sufficient precision for assessment. Further evaluation of these and other survey data is in progress and will be presented at the 1972 annual meeting when the Working Group on Coordinated Groundfish Surveys will be re-convened (tentatively, 23 May).

Development of coordinated survey plan

Discussion centered around our readiness to implement coordinated surveys throughout the entire ICNAF Area, and on the problems of data processing and difficulties of field operations in Subareas 1 and 2. There was general agreement that we should proceed with development of a coordinated survey plan but there were significant questions about the feasibility of conducting surveys in Subareas 1 and 2 which are patterned after the on-going surveys in Subareas 4-6. Movements of fish and ice in Subareas 1 and 2 may preclude use of fixed-boundary sampling strata, and may require reconnaissance surveys in advance of the trawling phase, thereby increasing vessel requirements for the northern area. It would appear that these questions can only be answered by further trial surveys in Subareas 1 and 2 and therefore priority should be given to such operations as soon as vessel time is available. Since we already have a fairly good basis for estimating the manpower and vessel requirements for field operations, implementing these trials will depend primarily on available resources and priorities. In any case, it would seem desirable to continue efforts to formulate a specific survey plan for these areas to be implemented by 1973. Evaluation of fixed-boundary sampling areas in Subarea 3 is now in progress, and there appears to be no obstacle to their use in that area.

Data processing is another key element in the development of a successful survey program and discussion involved the desirability of standard data formats for reporting ICNAF survey results and a centralized data processing unit at ICNAF headquarters. The large volume of data acquired on groundfish surveys requires machine processing if results are to be made available in time for current assessment needs. There are some obvious advantages and savings in a centralized data processing unit since a number of countries do not have such facilities. Mr Day noted that ICNAF has recently acquired a new statistical assistant to aid with data processing but at least one more professional (biologist with good ADP background) would be necessary to organize and run such a unit. It was noted that if such a unit were required in the near future, prompt action was necessary so that the Commission would have sufficient time to provide for the necessary resources. No firm consensus was reached on this point. However, Dr Grosslein (USA) will investigate the probable volume of data processing involved and the feasibility and costs of such a unit and report to the Working Group in May.

Scientists involved with surveys were urged to submit documents to the next annual meeting, evaluating their surveys according to the various aspects outlined in the 1971 reports of the Working Group. Dr Grosslein (USA) will correspond with appropriate ICNAF scientists and endeavour to have a tentative coordinated survey plan for the entire ICNAF area for review and discussion at the 1972 annual meeting.

VII. List of Participants

Canada

HALLIDAY, R.G.
Research Scientist
Biological Station
Fisheries Research Board of Canada
St. Andrews, New Brunswick

ILES, T.D. (Chairman, Herring Group)
Coordinator, Atlantic Herring Program
Biological Station
Fisheries Research Board of Canada
St. Andrews, New Brunswick

SMITH, G.F.M.
Scientific Adviser
Department of Environment
Sir Charles Tupper Building
Ottawa, Ontario

Denmark

HORSTED, Sv.Aa.
Grønlands Fiskeriundersøgelser
Jaegersborg Allé 1B
DK 2920 Charlottenlund

France

LETACONNOUX, R.
Directeur adjoint
Institut des Pêches maritimes
B.P. 1049
44 Nantes

Germany, Federal Republic

MESSTORFF, J.
Fishery Biologist
Bundesforschungsanstalt für Fischerei
Institut für Seefischerei
Bremerhaven

SCHNACK, D.
Institut für Meereskunde
Niemannsweg 11
23 Kiel 1

SCHUMACHER, A.
Institut für Seefischerei
Palmaille 9
2 Hamburg 40

Japan

MIMURA, K.
First Secretary
Embassy of Japan
Via Virginio Orsini 18
00192 Rome, Italy

NAGASAKI, F.
Chief Biologist
Far-Seas Fisheries Research Laboratory
Japanese Fisheries Agency
Kasumigaseki
Tokyo

Norway

HYLEN, A.
Havforsker
Institute of Marine Research
Nordnesparken 2
5011 Nordnes-Bergen

Poland

DRAGANIK, B.
Sea Fisheries Institute
Al. Zjednoczenia 1
Gdynia

Portugal

MONTEIRO, R.
Director
Instituto de Biologia Maritima
Cais do Sodré
Lisbon 2

United Kingdom

GARROD, D.J.
Senior Scientific Officer
Fisheries Laboratory
Lowestoft, Suffolk
England

PARRISH, B.B.
Deputy Director
Marine Laboratory
P.O. Box 101, Torry
Aberdeen AB9 8DB, Scotland

United States of America

ANTHONY, V.C.
Fishery Research Biologist
Biological Laboratory
Boothbay Harbor, Maine 04538

BROWN, B.E.
Fisheries Biologist (Research)
Northeast Fisheries Center
National Marine Fisheries Service
Woods Hole, Massachusetts 02543

GROSSLEIN, M.D.
Northeast Fisheries Center
National Marine Fisheries Service
Woods Hole, Massachusetts 02543

HENNEMUTH, R.C. (Chairman, Subcommittee)
Deputy Director
Northeast Fisheries Center
National Marine Fisheries Service
Woods Hole, Massachusetts 02543

RIDGWAY, G.J.
Assistant Laboratory Director
Biological Laboratory
Boothbay Harbor, Maine 04538

Union of Soviet
Socialist Republics

BOGDANOV, A.S.
Director
All-Union Research Institute of Marine
Fisheries and Oceanography (VNIRO)
17 V. Krasnoselskaya
Moscow, B-140

NIKOLAEV, V.M.
Chief of Division
Central Research Institute on Fisheries
Information and Technical-Economic
Investigation
Dubininskaya 29
CNIITEIRH
Moscow

NOSKOV, A.
Laboratory Chief
Atlantic Research Institute of Marine
Fisheries and Oceanography (AtlantNIRO)
5 Dmitry Donskoy Street
Kaliningrad

Food and Agriculture Organization

BOEREMA, L.K.
Acting Chief, Fish Stock Evaluation Branch
Fishery Resources Division
Department of Fisheries
Food and Agriculture Organization
00100 Rome, Italy

GULLAND, J.A.
Chief, Fishery Statistics and Economic
Data Branch
Fishery Economics and Institutions Division
Department of Fisheries
Food and Agriculture Organization
00100 Rome, Italy

International Commission for the
Northwest Atlantic Fisheries

DAY, L.R.
Executive Secretary
International Commission for the
Northwest Atlantic Fisheries
Bedford Institute
P.O. Box 638
Dartmouth, Nova Scotia, Canada

HODDER, V.M.
Assistant Executive Secretary
International Commission for the
Northwest Atlantic Fisheries
Bedford Institute
P.O. Box 638
Dartmouth, Nova Scotia, Canada

Guest Observer

RANKE, W.
Institut für Hochseefischerei
Rostock-Marienehe
German Democratic Republic