# International Commission for the Northwest Atlantic Fisheries

Serial No. 3499
(B.g.26)

ICNAF Summ.Doc. 75/19

## ANNUAL MEETING - JUNE 1975

## Report of the Herring Working Group, April 1975

### Contents

## REPORT OF THE HERRING WORKING GROUP, APRIL 1975

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### 1. Introduction

The Herring Working Group met during 8-11 April 1975 at the Northeast Fisheries Center, Woods Hole, USA with representatives from Canada, Federal Republic of Germany, German Democratic Republic, Poland, USSR, UK, and USA. The main task of the Group was to prepare assessments and recommend TACs to the Commission for the Chedabucto Bay-Cape Breton (Subdiv. 4Vn-Div.4W(a)), Nova Scotia (Div. 4XW(b)), Gulf of Maine (Div. 5Y), and Georges Bank (Div. 5Z + Stat. Area 6) herring stocks. In addition, the Group gave consideration to the status and results of larval and juvenile surveys. Possible stock interactions based on recent tag recoveries and the influence of temperature on the interaction of recruitment mechanisms for herring was also discussed. The following research documents were considered during the course of discussion: larval and juvenile surveys (Res.Docs. 75/33, 47, 49, 50, 66, 67, 71); assessments (Res.Docs. 75/17, 33, 36, 37, 38, 39, 56). In addition, over twenty working papers were discussed and incorporated into the results presented below.

### 2. Fishery Trends

Table 1 lists the provisional herring catches by country and area for 1974. The total 1974 catch was 430,000 tons, 45% of the peak 1969 catch of 965,000 tons, and 89% of the 1973 catch of 485,000 tons. Catches from the Gulf of St. Lawrence-Newfoundland stocks (Subarea 3 and Div. 4RST) declined from 85,000 tons in 1973 to 61,000 tons in 1974, mainly due to continuing poor recruitment and anomalous ice conditions in the winter fishery along the south coast of Newfoundland. Catches from the Div. 4VW(a) stocks increased from 31,000 tons in 1973 to 44,000 tons in 1974, reflecting the appearance of the 1972 year-class and favourable ice conditions in the Div. 4W(a) winter fishery. The TAC for this stock complex was 45,000 tons in 1974.

The total catch in Div. 4X and 4W(b) (south of 44°52'N) increased slightly from 134,000 tons in 1973 to 142,000 tons in 1974. The catch from Grand Manan Banks decreased from 25,000 tons in 1973 to 1,000 tons in 1974.

Catches in the Gulf of Maine (Div. 5Y) were 37,000 tons in 1974 compared with 32,000 tons in 1973 and 62,000 tons in 1972. In the Georges Bank fishery (Div. 5Z + Stat. Area 6), the 1974 catch of 146,000 tons was about 72% of the 1973 level.

In all areas under quota regulation in 1974, the 1970 year-class made up the major proportion of the catches.

### 3. Surveys

#### (a) Larval surveys

Results of the 1974-75 larval herring surveys in the Georges Bank-Gulf of Maine area were reviewed. Herring spawning in September was indicated in nearshore regions of the northern and eastern parts of the Gulf of Maine from larval catches by *Cryos* (Res.Doc. 75/71) and the *Duchess II* (Res.Doc. 75/49). Spawning on Georges Bank and Nantucket Shoals had just begun by the middle of October (as indicated by small catches of larvae by *Wieczno*) and then increased substantially in the latter half of October as shown by *Prognoz* catches (Res.Doc. 75/66). As in previous years, peak spawning appeared to be later on Nantucket Shoals than on the northeast part of Georges Bank, but spawning in both areas in 1974 appeared to start later than in 1973. Results of the November (*Anton Dohrn*) and December and February (*Albatross IV*) cruises in Div. 5Z indicated a geographic distribution of larvae similar to that of previous years, and abundance was of the same order of magnitude as in 1973 (Res.Docs. 75/49, 67). The production of larvae was considerably higher in both 1973 and 1974 than it was in 1971 and 1972, presumably reflecting the increase in spawning stock from recruitment of the 1970 year-class.

A special study of the vertical distribution of recently-hatched herring larvae was conducted by the USA at a single site in 80 m of water on northeastern Georges Bank. The study indicated a concentration of larvae in the 30-50-m layer and some evidence of diurnal movement (Res.Doc. 75/50). Diurnal movements of larger larvae is implied by the fact that neuston hauls in the December and February cruises caught higher numbers of large larvae than did the Bongo hauls at corresponding stations (Res.Doc. 75/49).

The Working Group discussed the general value of the coordinated larval herring program and agreed that ICNAF should continue monitoring the production and survival of herring larvae from the spawning populations in Div. 4X and Subarea 5, at least for several more years. Such a time series is necessary for a meaningful evaluation of the stock/recruitment relationship for these stocks. However, it was suggested that additional larval survey coverage be attempted in March or April to improve knowledge of the over-winter survival of

larvae and improve the likelihood for a useful 1-group index of year-class strength. The larval sampling done concurrently with the spring bottom trawl surveys (such as on *Walther Herwig*) should be continued, and, in addition, special larval surveys with large Bongos or midwater trawls should be considered. Also, it was noted that investigations directed toward identification of the mortality mechanisms (e.g. prey-predator studies) should be encouraged in conjunction with the monitoring surveys to provide insight necessary for evaluation of stock/recruitment models.

(b) Spring trawl surveys for pelagic species

The Working Group reviewed the results of the coordinated bottom trawl surveys which have been conducted each spring (March-April) since 1973 in parts of Subarea 5, Stat. Area 6, and Div. 4X. Mean numbers per haul of herring at each age were calculated for all spring surveys from 1973-75, and also the 1972 *Albatross IV* spring survey, and these are documented in Table 2. Attention was focused on the catches of ages 2-4, in an attempt to estimate the relative strength of the 1971, 1972 and 1973 year-classes in relation to the 1969 and 1970 year-classes. Primary emphasis was given to the *Walther Herwig* surveys in Div. 5Z and Stat. Area 6, since these were considered to represent the best available measure of pre-recruit year-classes because: (1) these surveys covered a substantial portion of the usual geographic range of juvenile herring, (2) large numbers of herring were caught, and (3) there was a comparable time series of three years of data. Sampling by the *Walther Herwig* in Div. 4X was considered too sparse to provide a reliable measure of year-class abundance there. The *Albatross IV* series covers the entire area from Cape Hatteras to Nova Scotia (including Gulf of Maine), but there is less confidence in the *Albatross IV* data because the catches of herring are very small. Nevertheless, the *Albatross IV* data on relative strength of recent year-classes is consistent with that from the *Walther Herwig*, and results for both vessels in all divisions are given in Table 3 to facilitate comparison of year-classes.

In Div. 5Z-Stat. Area 6, both the *Walther Herwig* and *Albatross IV* surveys showed the 1971 and 1972 year-classes to be very weak relative to the 1970 year-class, based on catches of ages 3 and 4 herring, and both surveys suggest that the 1973 year-class was even weaker than the 1971 year-class as indicated by catches of 2-year-old fish (Table 3). The strength of the 1969 year-class, as indicated by Div. 5Z-Stat. Area 6 catches of 4-year-old herring, appears to be similar to that of the 1971 year-class based on *Walther Herwig* data, and about one-third the strength of the 1970 year-class based on *Albatross IV* data. Comparisons of the relative sizes of the 1969-1972 year-classes are summarized in Table 4 in terms of the ratios of catches of each year-class at a given age to the catches of the 1970 or 1971 year-classes at the corresponding age. With the exception of the *Albatross IV* data for the 1969 year-class, both series of surveys in Div. 5Z-Stat. Area 6 show the 1970 year-class index to be at least 20 times as large as the indices for the other year-classes. Similarly, the *Albatross IV* indices for Div. 4X and 5Y show the 1971-1973 year-classes as smaller than the 1970 year-class, although the differential is not as great as in Div. 5Z-Stat. Area 6. On the basis of these data the Working Group considered that the best estimate was to equate the strength of the 1971 and 1972 year-classes to that of the 1969 year-class.

The validity of the index for the 1973 year-class is still open to considerable question because of uncertainty regarding availability of 2-year-old herring to bottom trawls and their distribution by time and area. The problem is complicated by the fact that there appears to have been very few 2-year-olds in Div. 5Z-Stat. Area 6 since 1973, whereas they have been found consistently in Div. 4X during winter and spring surveys by *Albatross IV* since 1964. In the coordinated surveys since 1973, both the *Walther Herwig* and *Albatross IV* caught many more 2-year-olds in Div. 4X than in Div. 5Z-Stat. Area 6 (Table 2). It was suggested that there may have been a shift in distribution of 2-year-olds which might be related to the apparent warming of the waters in the region. In any case, the Working Group concluded that until there is a better understanding of the availability of 2-year-olds, it will not be possible to develop a firm prediction of year-class strength at that age.

With respect to future surveys, the Working Group noted that the available time series was still too short to provide an adequate evaluation of the potential of spring surveys for pre-recruit estimates. Results to date are sufficiently encouraging that the Group felt that spring series should be continued and even expanded to include the Gulf of Maine with greater sampling by high-opening bottom trawls. However, it was noted that more complete analysis of the existing data was desirable, using transformed data to achieve more efficient statistical estimates. Also, it was noted that to avoid wasting ship time careful evaluation of age-specific distribution patterns was needed to improve the design and analysis of future surveys.

The proposed schedule of surveys for both larval and juvenile herring in autumn 1975 and spring 1976 is given in the Report of the Biological Surveys Subcommittee (Summ.Doc. 75/17).

4. Biological Information

(a) Recruitment mechanisms

There was considerable discussion of the recruitment studies on herring and mackerel in the Gulf of Lawrence (Res.Doc. 75/33). Stock/recruitment relationships were derived for both herring and mackerel populations, based on planktonic eggs and larvae and virtual population estimates of spawning stock size. For both species a dome-shaped stock/recruitment curve was indicated, with a rapidly declining right-hand limb beyond optimum stock sizes and a declining left-hand limb at low stock sizes.

With respect to herring, it was found that the catch of larvae was related to the spawning stock biomass and to temperature. The recruitment of age 2+ herring is related to both total pelagic biomass and the number of larvae. The total pelagic biomass seems to control the degree of density dependence. Although these results were determined in the Gulf of St. Lawrence, the general form of the relationships may be applicable to other herring stocks. Much additional research will be required to confirm assumptions regarding controlling mechanisms, as well as the predictive capability of the models. However, the results to date suggest that we may be on the verge of gaining significant new insight into the stock/recruitment mechanisms of herring and mackerel, including both biotic and abiotic interactions involving the two species.

(b) Tagging results

Canada reported tagging 35,931 herring along both sides of the Bay of Fundy in the summer of 1974 using yellow external tags (Res.Doc. 75/38). While the majority of recoveries (total of 1,127) showed movement within the Bay of Fundy area between New Brunswick and Nova Scotia, some recaptures were made south of Cape Cod (off Rhode Island) and as far east as Chedabucto Bay. These results suggest some degree of interaction of Div. 4X herring with those in Div. 4W(a) and Subarea 5. The consequence of such interaction to assessments and TAC recommendations was considered and, while results were judged preliminary, a combined Div. 4XW assessment was completed (see Section 6). Canada indicated a continuing tagging program with planned releases in Div. 4W(a) and Subdiv. 4Vn in the winter of 1975/76 and advises that new information on the relationship of the DIv. 4W(a) and Subdiv. 4Vn fisheries could be available for consideration at the June 1976 Annual Meeting. Member Countries are advised of possible tag recoveries in Subareas 4 and 5 and requested to send tags to: Biological Station, St. Andrews, New Brunswick, Canada E0G 2X0.

(c) Growth studies

Analysis of mean weights at age indicates a significant increase in mean weight beginning with the 1967 year-class in the Div. 5Y juvenile fishery and in the Div. 5Z-Stat. Area 6 fishery. An increase in mean weight-at-age from previous years for all year-classes was thus required in the Subarea 4 and Div. 5Z-Stat. Area 6 assessments. This was not required for the DIv. 5Y adult fishery assessment as previous mean weights were apparently too high.

USSR research on growth rates of Subarea 4 herring (Res.Doc. 75/56) indicates a lower value of K in the von Bertalanffy growth equation when compared to that of Georges Bank herring (0.24 vs. 0.43).

(d) Spawning times

Results of the investigation of spawning periods for Georges Bank herring (Res.Doc. 75/37) provided estimates of the onset of spawning in 1972-74. Onset of spawning was defined as the date when catch per tow of herring in maturity stages VI and VII reached a sustained maximum. Probable onsets of spawning in 1972, 1973, and 1974 were 24-26 September, 24 September, and 2 October, respectively. Variability in the time of spawning may be attributed in part to changes in the temperature of water masses in Georges Bank. It is anticipated that the above dates will be incorporated into the analysis of larval surveys.

5. Effect of Juvenile Fisheries on Herring Yields

Although the stock relationship between herring exploited in juvenile fisheries and those in adult fisheries is not clear, the Herring Working Group was concerned about the potential of excessive mortality being placed on the herring resources from both the juvenile and adult fisheries. This has not yet been fully evaluated for all the Canadian fisheries, but the very preliminary assessment given below illustrates the importance of the juvenile fisheries to the overall conservation of the herring resources. Catches from the Nova Scotia herring fishery i n Div. 4W(b) and 4X were not included in the analysis because the data for this area were available only since 1965. The catches of juvenile herring from both Maine (Div. 5Y) and New Brunswick (Div. 4X) were available since the mid-50's and were combined with catches of herring from the Jeffreys Ledge (Div. 5Y) and the Georges Bank fisheries (Div. 5Z-Stat. Area 6) (Table 5).

Beginning with data in 1973, a cohort analysis was applied to each year-class with starting F's of 0.4, 0.6, 0.8, and 1.1. In 1971 and 1972 average F's over ages 4-9 were generally in excess of 0.7 and averaged 0.95. Since the values were increasing, a starting figure of 1.1 was used in 1973 for ages 6 and older. For year-classes 1968 and 1969 the log catches were extrapolated and a range of F's applied in the last year. The resulting fishing mortalities are shown in Table 6, and the stock sizes in Table 7. Fishing mortality rates were averaged over year-classes by age for two periods of 1956 to 1973, and 1961 to 1973. The latter period covers the period of the Div. 5Z-Stat. Area 6 fishery. These rates are given in Table 8 for ages 1 to 9 with the total catches and average annual catches for each age. The fishing mortalities for the entire period from 1955 to 1973 are 0.09, 0.72, and 0.41 for ages 1-3, respectively, and for the period of 1961 to 1973 are 0.09, 0.47, and 0.28 for ages 1-3, respectively.

The mortality rate on age 2 herring declined substantially during the 1960's from the middle 1950's, but still accounted for an average catch of 45,000 tons annually during 1961-75. These fish, if caught at age 5, would have produced a catch averaging 176,000 tons per year (assuming the mean weight given in Table 8 and M = 0.2). This is equivalent to 94% of the catch in tons taken from the Georges Bank stock over the period of 1961-73 or approximately a doubling of the catch.

More important than increasing the catch over that period is the long-term effect of the juvenile fisheries on the size of the stock. Beginning with the stock in 1961, three sets of fishing mortalities were applied to the stocks for each year until 1972. One set was the average F's for each age as given in Table 8 as calculated from 1956-73. The second set was the same as the first, except an F of 0.25 was placed on age 2 and 3 herring. The third set is the same as Set 1, except F was zero on age 1 and age 2 herring and reduced to 0.13 for age 3. The F of 0.13 is that placed on age 3 herring by the adult fishery. This last set, therefore, assumes that no juvenile fishery exists. Recruitment was assumed at age 1 of 12,029 million in 1961, 7,862 million in 1962, etc., the calculated year-class size at age 1 (Table 6 - 0.119, 0.263, etc.) was 0.286. Each annual mean F was taken proportional to 0.286 and raised by multiplying by 0.72 which is the F at age 2 given in Table 8. This gave the F at 100% used for each year (Table 9). Percentage coefficients applied to F for each age were determined by setting 0.72 equal to 1.0 and taking the percentage each F is of 0.72 for each age. The results of the three sets of mortalities is given in Table 9 and Fig. 1. With Set 1 (a rough simulation of the present situation), the stock declines to 216,000 tons by 1972 and gives a catch of 113,000 tons in that year. With F reduced on age 2 and 3 herring, the stock size is 506,000 tons by 1972 with a catch of 223,000 tons in that year. With no fishing mortality on ages 1 and 2 herring and the portion of F on age 3 fish from the juvenile fishery reduced to zero, the stock size by 1972 is 938,000 tons providing a catch of 372,000 tons in that year. The stock declined after 1968 due to reduction in recruitment (Fig. 1), but the reduction of F on the young fish maintained a stock size of 300,000-400,000 tons. Over the period of 1961 to 1972 the average annual catch would have been: Set 1 - base situation - 199,000 tons; Set 2 - ages 2 and 3, F = 0.25 - 289,000 tons; and Set 3 - no juvenile fishery - 375,000 tons.

The catches from the juvenile fisheries (Div. 4W(b) and 5Y), however, have declined from the mid-1950's (Fig. 2) so that the average juvenile catch for 1970-73 (including all age fish) was only 44,000 tons. The Div. 5Y juvenile fishery is also catching a greater percentage of older fish. In 1974, 50% of the "juvenile" catch by weight consisted of fish age 3 and older.

6. Assessments

(a) Div. 4V-4W(a) herring

Catch statistics and catch composition. The total catch in Div. 4VW(a) in 1974 was 44,000 tons (45,000-ton TAC), up 43% from 1973. The Canadian catch during the 1974/75 season (November to January) was limited by quota restrictions to 43,552 tons.

The removals at age from Subdiv. 4Vn and Div. 4W(a) for the Canadian fishery in 1974/75 are given in Table 10.

The 1970 year-class again sustained the fisheries in both areas, comprising 51% and 52% in Subdiv. 4Vn and Div. 4W(a), respectively. The 1972 year-class made a strong appearance in Div. 4W(a), comprising 24% of the 1974/75 catch.

Catch per unit effort. The annual weighted mean CPUE values for Subdiv. 4Vn and Div. 4W(a) were 76.4 and 146.5 tons, respectively, and indicate the radical difference in the trends for CPUE in the two areas (Fig. 3). In Subdiv. 4Vn the CPUE has decreased by 34% in the last three years, while for the same period in Div. 4W(a) it has increased by almost 97%.

Management considerations. Recoveries from the 1973/74 tagging studies in Div. 4X suggest that different stocks are being exploited in Div. 4W(a) and Subdiv. 4Vn (see Section 4). No tag recoveries were made in November and December 1974 when the majority of the Subdiv. 4Vn fishery occurs in the Sydney Bight area. In January the fishery is traditionally concentrated in Div. 4W(a) with only a relatively small fishery occurring in Subdiv. 4Vn near the boundary of Div. 4W(a) and Subdiv. 4Vn. All of the recoveries (43) were made in January, most being taken in the Chedabucto Bay area (40) and the few returns reported from Subdiv. 4Vn were taken off Gabarus Bay near the boundary line between these two areas.

These facts would suggest that the Subdiv. 4Vn fishery should be regulated separately from the Div. 4W(a) stock and, in view of the continuing decline in CPUE, a decrease in the catch level from the 1974/75 catch of 16,000 tons should be considered for Div. 4V.

The tagging results indicate a strong relationship between herring from the two fisheries of Div. 4W(a) and Div. 4XW(b). Furthermore, although Div. 4W(a) fish are autumn spawners, Canadian larval surveys in 1974 in October-November in Div. 4VW found no larval concentrations; this indicates no spawning grounds on the eastern Scotian Shelf which would support a fishery of this size. Considering the lack of data upon which the original management units were determined and the information now available, it is advised that the Div. 4W(a) fishery be assessed as part of the Div. 4XW(b) stock.

The number of tag returns and geographic location of these returns suggest that the Subdiv. 4Vn fishery may exploit two different groups of fish, one in Sydney Bight and another off Gabarus Bay which is related to the Div. 4W(a) fishery. Additional tagging studies are planned by Canada for 1975/76 and should clarify the relationships involved.

This adjustment in the management unit would leave Div. 4V to be managed separately from Div. 4W(a). In view of the declining CPUE (Fig. 3) in Subdiv. 4Vn, a decrease in the catch level should be considered. No analytical assessment is available on this fishery; the average catch for the last three seasons has been about 16,000 tons and a reduction to about 11,000 tons would seem appropriate for 1976.

(b) Assessment for Div. 4W(a) and 4XW(b) combined

Catch statistics and catch composition. The total catch in 1974 for the Div. 4XW fishery was 173,000 tons. The 1970 year-class comprised 67% of the catch.

The catch composition from 1969-75 for Div. 4W(a) is given in Table 11. These removal figures are from the Canadian fishery during the years 1969-73; in 1974 the USSR catches were included as being part of the Div. 4XW stock. Catches in earlier years from Subdiv. 4Vs were assumed to be from another stock, possibly the same as that of the Subdiv. 4Vn fishery. The 1975 removal figures are the January-June 1975 Canadian allocation which was completely taken in January.

Year-class size and estimates of F. The starting F's used in cohort analysis (Table 12) were the same as those derived for the assessment of the Div. 4XW(b) stock (see below). The catch in numbers at age used in the analysis are the combined Div. 4W(a) and 4XW(b) removals. The starting F for the 1970 year-class, however, was adjusted from 0.39 to 0.24 to get a year-class size at age 1 of 2.0 x 1966 year-class. It was assumed that M = 0.2. The calculated fishing mortalities and year-class sizes at age from cohort analysis are given in Tables 13 and 14.

Catch predictions for 1975 and 1976. The two fisheries occur at different times of the year. Thus, it would not be appropriate to use the same mean weights in the predictions for the two fisheries. The mean weights (kg) used for both portions of the fishery are given below:

| Age | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Div. 4W(a) | .036 | .087 | .141 | .178 | .234 | .270 | .292 | .325 | .336 |
| Div. 4XW(b) | .031 | .114 | .179 | .230 | .286 | .299 | .334 | .360 | .386 |

Catch predictions are given in Table 15. Since the Div. 4W(a) fishery occurs in the early part of the year and the Div. 4XW(b) fishery in the summer and autumn, the projection was run for essentially 6-month intervals. The natural mortality was divided equally between the two 6-month periods (0.1 for each). The 1974 catch in numbers at age in the Div. 4W(a) fishery were then run against the derived combined population size for 1974 to determine the fishing mortality exerted on the combined stock in the first part of the year. The 1974 catch in numbers at age in Div. 4XW(b) were then run against the population size remaining after the 1974 Div. 4W(a) fishery to determine the fishing mortalities for the rest of 1974 on this combined stock. This procedure was repeated for the first part of 1975 since the Canadian quota allocation for January-June 1975 in Div. 4W(a) was taken in January and catch in numbers at age was available. However, this was not possible for Div. 4XW(b) for 1975 since the 1975 fishery in that area had not yet begun. Thus, for the 1975 Div. 4XW(b) portion of the combined fishery, the values of F predicted in the 1975 assessment of Div. 4XW(b) (see below) were initially used. These values, however, resulted in a catch higher than the TAC set for that area in 1975, and all these F values had to be reduced by 15% to keep the catch within the TAC for 1975 (90,000 tons, plus an estimated 15,000 tons by inshore fixed gear not under quota regulation).

For the 1976 prediction for the Div. 4W(a) fishery, the 1975 F values for ages 2-5 were used and those on the older age-groups set at 0.10. The F values for the Div. 4XW(b) portion were set at the levels used in the 1974 assessment of Div. 4XW(b) fishery (maximum yield per recruit values: *Redbook* 1974, p. 109).

The sizes of the 1973 and 1974 year-classes were set at $750 \times 10^6$. In 1974 conventional year-class sizes were agreed upon for new year-classes for which no data were available which was based on the size of the moderate and poor year-classes. This resulted in a conventional size for Div. 4XW(b) of about $400 \times 10^6$. Combining Div. 4XW(b) and Div. 4W(a) resulted in an average increase of 88% in the size of year-classes 1965, 1967, 1968, and 1969 and approximately that increase was applied to the $400 \times 10^6$ to obtain $750 \times 10^6$.

Accepting the assumptions as to the size of year-classes, the prediction indicates a reduction in the catches from 1975 to 1976 of about 4,000 tons in Div. 4W(a) and 16,000 tons in Div. 4XW(b) and a reduction in biomass of 47% between 1974 and 1976. This total reduction in catch in the combined areas is very similar to the prediction resulting from the assessment of Div. 4XW(b) alone (see below).

At the Annual Meeting in 1974, the 1975 TAC for Div. 4VW(a) was partitioned to allow regulation to be based on a fishing season commencing 1 July 1975. As a consequence, a January-June 1975 TAC was placed on Div. 4VW(a) of 30,000 tons. The 1975 TAC for Div. 4XW(b) was set at 90,000 tons. Thus, the TAC for the combined Div. 4XW(b) and 4W(a) area in 1975 will allow a catch of 120,000 tons (plus an estimated inshore catch of 15,000 tons in Div. 4XW(b), for a total catch of 135,000 tons). The analysis indicates that a total catch for 1976 from the combined areas of 115,000 tons can be taken, a reduction of 20,000 tons from that of

1975. Removing the estimated inshore catch for 1976 (11,000 tons) results in a 1976 TAC of 104,000 tons.

(c) Div. 4XW(b) assessment (Southwest Nova Scotia)

Catch statistics and catch composition. The total catch of herring in Div. 4XW(b) by Canada, Federal Republic of Germany, Japan, Poland, and USSR was 142,000 tons, about 6% more than taken in 1973. The catch by country is given in Table 16; the Canadian catches are partitioned by gear, and the catches made in New Brunswick (Div. 4X(b) are excluded from the assessment due to unresolved stock inter-relationships between Div. 4X(b) and 4X(a).

The 1974 catch composition is given in Table 17. The 1970 year-class again supported the Div. 4XW(b) adult fishery. Although large numbers of the 1972 year-class were taken, this was mainly by the New Brunswick juvenile fisheries.

Year-class size and estimates of F. The calculated estimates of F and resultant stock sizes at age from cohort analysis are given in Tables 18 and 19. It was assumed that M = 0.2. The derivation of starting F's for 1974 are given below.

The main F at age 2 for 1964-71 of 0.20 was used as the F for the 1972 year-class at age 2; as a result, the size of the 1972 year-class is estimated to have been $1.2 \times 10^9$ at age 1 about 0.5 x 1966 year-class. This estimated size is justified on the basis that the 1972 year-class has contributed substantially more to the catches in the various Div. 4XW(b) fisheries than did the acknowledged weak year-classes of 1971, 1969, or 1968 (Table 20). Catches of the 1972 year-class in the New Brunswick and Nova Scotia weir and purse seine fisheries at age 2 were substantially greater than catches of the 1968, 1969, or 1971 year-classes (Table 20). The 1972 year-class also appeared to be relatively strong in the 1975 Div. 4W(a) fishery (26% of catch).

The 1974 commercial catch data continue to indicate that the 1971 year-class is a poor one. Consequently, it was again assumed to be $5.0 \times 10^8$ individuals at age 1, the estimated strength of the 1969 year-class, and the 1974 F set at 0.10 to conform with this estimate in the cohort analysis.

The 1970 year-class contributed the major portion of the 1974 catch. Log records indicated a relatively high CPUE, comparable to that of the 1973 fishery. The 1973 assumption that the 1970 year-class was 2.0 x 1966 year-class at age 1, that is, $4.8 \times 10^9$ individuals, was again assumed, resulting in an F for 1974 of 0.39.

The size of the 1969 year-class was assumed to be $5.0 \times 10^8$, one of the poorest on record, and resulted in an F of 0.40 for 1974.

Catch curves were calculated for the 1966, 1967, and 1968 year-classes and catches for 1975 and 1976 were extrapolated from the curves for each year-class. These extrapolated catches were then used in cohort analysis with an F of 1.0 to estimate the F for 1974. The resultant F's in 1974 for the 1966, 1967, and 1968 year-classes were 0.97, 1.18, and 0.38, respectively.

The 1974 F values for the 1964 and 1965 year-classes were arbitrarily set at 1.0. This estimate appeared to be a reasonable value of F for older age-groups.

Catch predictions for 1975 and 1976. Catch predictions are given in Table 21.

The conventional size of year-classes entering the Div. 4XW(b) fishery at age 3 was discussed at the 1974 Annual Meeting (*Redbook* 1974, p. 109) and agreed to be set at $300 \times 10^6$, the level of the poorer year-classes. From the cohort analysis (Table 21), the sizes of these year-classes (1968, 1969, 1972) were about $400 \times 10^6$ at age 2. Thus, for both 1975 and 1976 recruitment at age 2 was assumed to be $400 \times 10^6$. The F values for 1975 were set in the same proportions as in 1974, but had to be increased slightly to arrive at the 1975 Div. 4XW(b) TAC of 90,000 tons (plus estimated inshore gear catches of 16,000 tons). Since the 1970 year-class has been supporting this fishery, the F on this year-class was increased the most, from 0.39 in 1974 to 0.55 in 1975.

The values for F in 1976 were set as 0.50 for age 5 and older, 0.25 at age 4, 0.13 at age 3, and 0.03 at age 2, as used in the 1974 assessment. These values are the same as those used in 1974 and are based on maximum yield per recruit (*Redbook* 1974, p. 107).

The mean weights used in previous predictions appeared inappropriate for 1975 and 1976, since recent data indicate an increase in weight at age. Therefore, a regression of weight at age was calculated for the 1970 year-class for ages 1-4. The mean weight at age for ages 4, 5, and 6 were then calculated from the regression and used in the prediction analysis. Mean weights for ages 2, 3, and 7-10 were not changed from those used in 1974. Mean weights used are as follows:

| Age | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Weight (kg) | .031 | .114 | .179 | .230 | .286 | .299 | .334 | .360 | .386 |

The prediction indicates a decline in stock size of 25% from the beginning of 1975 to 1977, and a reduction in the catches in 1976 of about 25,000 tons, from 106,000 to 81,000 tons.

Since the inshore catches (estimated for 1975 at 15,000 tons and not under quota regulations) were included in the assessment, these estimated catches have to be removed from the predicted catch before the TAC is set. With the reduction in stock size predicted, the inshore catches should also decrease (probably to 11,000 tons in 1976); since the total predicted catch in 1976 is 81,000 tons, removing the estimated 11,000 tons for inshore catches results in a TAC for 1976 of 70,000 tons, a 20,000-ton reduction from 1975.

Only by raising the fishing mortalities on all age-groups substantially above optimum levels in 1976 could the TAC remain at 90,000 tons. It must be stressed, however, that if the 1972 year-class is not as strong as assumed, the stock size could be severely reduced even with the recommended reduction in the 1976 TAC.

If neither the 1973 or 1974 year-class is stronger than assumed ($400 \times 10^6$), and optimum F levels are maintained on all age-groups, an even greater reduction in catch will be required for 1977.

(d) Div. 5Y assessment

Catch statistics. The catch of the adult herring fishery in Div. 5Y (Jeffreys Ledge area) increased in 1974 to 18,000 tons from 16,859 tons in 1973 (Table 22). Catches declined for the German Democratic Republic and Canada and increased for USA. The 1970 year-class provided 10,631 tons (60%) of the adult fishery catch. The catch of the Div. 5Y juvenile fishery also increased slightly, from 16,400 tons in 1973 to 19,142 tons in 1974. Age 3 and older herring made up 9,582 tons (50% of the total) from the 1974 juvenile fishery.

Estimation of recruitment and fishing mortality

Ages 7 and older. Cohort anlyses were applied to the catches with starting F's in 1974 of 0.4, 0.6, and 0.8. The resulting F's were averaged over ages 4-9 for each year and plotted against years. The average F increased from 0.06 in 1967 to 0.91, 0.91, and 0.72 in 1971, 1972, and 1973, respectively. A value of 0.8, therefore, was chosen as the most representative F in 1974 for year-classes 1962-1967.

Ages 5 and 6 (1968 and 1969 year-classes). The catch data for the 1968 and 1969 year-classes were extrapolated ahead in time by fitting a regression of the natural log of the catches on years. This procedure produced estimates of catches for the 1968 year-class in 1975 and for the 1969 year-class in years 1975-78. Cohort analyses were applied again to the data with a range of starting F's of 0.6 to 1.1 which produced F's in 1974 varying from 0.74 to 0.96. The true F probably lies between these two values and a starting F of 0.8 was chosen in 1975 which gave an F in 1974 of 0.844. The estimated F's in 1974 of the 1969 year-class varied from 0.364 to 0.400 for a range of starting F's in 1978 of 0.6 to 1.1. Again, a starting F of 0.8 was chosen which gave an F of 0.382 in 1974.

Age 4 (1970 year-class). The catch of this year-class increased from 2,500 tons in 1973 to 10,600 tons in 1974. Quantitative estimates of the strength of this year-class could not be resolved and it was assumed, as in prior assessments, to be twice as large as the 1966 year-class at age 3. This procedure gave a 1970 year-class size of 533 million in 1973 and, with a catch of only 18.6 million fish, gave an F of 0.039 in 1973, a year-class size of 420 million and an F of 0.180 in 1974.

Age 3 (1971 year-class). Juvenile surveys are not yet available for Div. 5Y, except for *Albatross IV* bottom fish surveys. The catches of herring are small and the stratified numbers per tow (not log transformed) are difficult to interpret (see Section 3(b)). There were no herring of the 1971 year-class caught as age 2 herring in the Div. 5Y survey, but catches at age 3 suggest that the 1971 year-class is very poor. In spite of the decrease in abundance of year-classes 1968 and older in 1974 in the adult fishery, the catch of this 1971 year-class in 1974 in the adult fishery was only 15 million herring, a catch even less than the 1969 year-class at age 3. In the Div. 5Y juvenile fishery, the catch of the 1971 year-class was the smallest ever at age 1 and second smallest at age 2 (Table 23). The size of the 1971 year-class recruiting in 1974 was assumed to be equal to the poorest observed in the fishery (1969 year-class at age 3 of 64 million fish). An assumed year-class size of 64 million and a catch of 15 million fish gave an F in 1974 of 0.30 for the 1971 year-class.

Recruitment in 1975 (1972 year-class) and 1976 (1973 year-class). Stratified numbers per tow of the 1972 year-class at age 2 from the *Albatross IV* spring survey in Div. 5Y suggest that this year-class is even poorer than the 1971 year-class. The catch of the 1972 year-class at age 1 in the juvenile fishery was 10.6 million fish (Table 23) which was more than the age 1 catch from the 1967, 1968, 1969, and 1971 year-classes, but fewer than from all other year-classes since 1946. The catch at age 2 of the 1972 year-class in 1974 was only 175 million herring in the Div. 5Y juvenile fishery, only slightly more than that from the 1971 year-class (155 million). The abundance of this year-class is, therefore, assumed to be equal to the very poor 1969 year-class at age 3 of 64 million fish.

The catch of the 1973 year-class at age 1 in the Div. 5Y juvenile fishery was 30.5 million fish, a catch three times that of the 1972 year-class catch at age 1. Survey data from Div. 5Y are not yet available for

the 1973 year-class but 1975 *Albatross IV* surveys in Div. 5Z suggest that this year-class is very small. The abundance of this year-class is known with even less certainty than for the 1972 year-class and was incorporated into the analysis at two levels: (1) 64 million fish which is equal to the poor year-class of 1969, 1971, and 1972 at age 3: (2) 150 million fish - the conventional year-class size assumed in the previous assessment (*Redbook* 1974, p. 110).

Estimate of stock size. Catches and estimates of F are given in Table 24 for 1967-74. Stock size is shown to the beginning of 1975. The stock size at the beginning of 1976 was calculated by assuming that the TAC of 15,000 tons (16,000 minus 1,000 tons that will not be taken by the Federal Republic of Germany and the German Democratic Republic) will be taken in the adult fishery in 1975. Selection coefficients applied to fishing mortalities were calculated by age from years 1972 and 1973. These were 0.171, 0.475, 0.708, 0.871 for ages 3-6 and 1.0 for ages 7 and older. Mean weights were those used in previous assessments: 0.155, 0.180, 0.220, 0.240, 0.275, 0.300, and 0.320 kg for ages 3-9, and 0.340 kg for fish older than age 9. This procedure gave an F at 100% in 1975 of 0.33, a catch of 15,000 tons and a stock size (age 4 and older) in 1976 of 63,600 tons, a decrease in stock from 76,400 tons in 1975.

Recommended TAC level for 1976. The projected stock sizes in 1977 resulting from catches in 1976 are given in Table 25 and Fig. 4. At the June 1974 Annual Meeting, the Commission (1974 Meeting Proceedings No. 20, Appendix II, p. 240) agreed that the Div. 5Y catch in 1976 must maintain the adult stock (age 4 and older) at a minimum of 60,000 tons. It was also agreed that this level of catch for 1976 will not be increased above that for 1975 (25,000 tons, when this constraint was agreed to in June 1974 but changed to 16,000 tons in November 1974), unless the adult stock size at the end of 1975 has reached a level (110,000 tons) which will provide the maximum sustainable yield by the end of 1976. Assessment results indicate this level will not be reached in 1975. To maintain the other constraint of a minimum stock size of 60,000 tons, a catch in 1976 of 9,000-21,000 tons may be taken, depending on the size of the 1973 year-class (Table 25). A TAC of 21,000 tons would merely keep the size of the resulting stock at the already low level without any safeguard for over-estimating the 1973 year-class. A TAC of 9,000 tons would also keep the size of the stock on the low level of 60,000 tons if recruitment of the 1973 year-class is at the lower level, but would reduce the probability that the stock size at the end of 1976 will be further reduced by over-estimating the size of the 1973 year-class. If the size of the 1973 year-class is larger than anticipated, the resulting stock size in 1977 will only increase to a level of 65,000-75,000 tons which is still low compared to previous years.

In view of the present state of the stock, the Working Group recommends that the Commission set the TAC as close to 9,000 tons as possible. Only by accepting such a TAC level can any increase in the stock size be anticipated in accord with the management objectives of the Commission to increase the stock size.

(e) Div. 5Z and Stat. Area 6 (Georges Bank stock)

Catch statistics. The catch of 146,000 tons in 1974 for this stock was the lowest since 1966 and represents a reduction from catches of 174,000 tons and 199,000 tons in 1972 and 1973, respectively, when TACs of 150,000 tons were also in effect (Table 26). In 1974, however, the German Democratic Republic joined the Commission and since then its catches have been included in the TAC. The 1970 year-class accounted for 82% of the 1974 catch by numbers and 81.4% by weight.

Indices of abundance. The catch per unit of effort of the German Democratic Republic factory trawlers and side trawlers decreased slightly in 1974 from 1973 (German Democratic Republic Research Report, Summ. Doc. 75/29), while the catch per unit of effort of B-18 trawlers of Poland in September and October increased from 30.7 to 38.7 tons per day from 1973 to 1974 (Polish Research Report, Summ.Doc. 75/28). The US bottom trawl surveys suggest a strong decline in abundance from 1973 to 1975. The stratified numbers per tow from the US spring surveys in Southern New England were 7.24, 2.09, and 0.04 for 1973, 1974, and 1975, respectively. There seems to be no doubt that the abundance of the Georges Bank stock is declining, but the Working Group could not agree on an abundance index that would give the rate of decline which could be used for assessment purposes.

Estimation of recruitment and fishing mortality. Fishing mortality on different ages in 1974 were estimated as follows:

Age 5 and older. Fishing mortalities for the older age-groups were estimated using cohort analysis. In order to minimize the bias introduced by the starting value of F, catches from the 1967 and 1968 year-classes were extrapolated up to age 10 by using the catch curve method. Starting the cohort analysis on these year-classes with F = 0.8 produced an F for herring at age 6 in 1974 of 0.72 and for 7-year-old herring of 0.63. Starting with an F of 1.2, the corresponding values were 0.74 and 0.66, respectively.

The year-classes prior to 1970 contributed only 13% to the catch in 1974 and they are expected to contribute even less in 1975 and 1976. Therefore, for the catch prediction, a uniform starting F of 0.7 in 1974 was accepted for herring of age 5 and older.

Age 4 (1970 year-class). No new information on the abundance of this year-class in relation to the 1966 year-class was available at this meeting, other than the catch data. The sum of the catches in

1973 and 1974, however, suggest that this year-class is at least 150% of the 1966 year-class at age 3. It was assumed that this year-class was 200% of the 1966 year-class at age 3, as was done in previous assessments (*Redbook* 1974, p. 112), and, using the catch in numbers in 1973 and 1974, fishing mortality for 1974 was estimated as 0.5 (Table 27).

Age 3 (1971 year-class). The size of the 1971 year-class recruiting in 1974 at age 3 to the fishery was assumed to be equal to the poorest observed in the fishery (1969 year-class at age 3 equals 550 x $10^6$ herring). This assumption was based on juvenile surveys and the catch of this year-class in juvenile fisheries. Using the catch in numbers in 1974 from this year-class, fishing mortality for 3-year-old herring in 1974 was estimated as 0.084 (Table 27).

Recruitment levels of the 1972 and 1973 year-class. The juvenile herring surveys of 1973, 1974, and 1975 and the US bottom fish survey for 1972 were examined to determine the abundance of the 1972 and 1973 year-classes. These data and their reliability are explained in Section 3(b). Table 4 indicates that the 1972 year-class is very weak relative to the 1970 year-class and that the 1973 year-class is even poorer than the 1971 year-class. The Working Group could not agree, however, that the surveys provide accurate estimates of age 2 herring abundance.

The catch of age 2 herring in 1974 from the Div. 5Z-Stat. Area 6 fishery was 2 million as compared with age 2 catches of 13, 13, 28, and 10 million for year-classes 1968-1971, respectively. The abundance, therefore, of the 1972 year-class was assumed to be equal to the 1969 and 1971 year-class abundance at age 3 (550 million).

Catch information for the 1973 year-class exists only in the juvenile fisheries of Div. 4X(b) and Div. 5Y. In Div. 4X(b) 46.7 million herring were taken at age 1 (Table 17) in 1974 - the lowest catch of age 1 fish since the 1961 year-class, except for the 1971 and 1972 year-classes. Catches of this year-class in Div. 5Y at age 1 (Table 23) were 30.5 million which was greater than all other recent year-classes, except the 1970 year-class. In summary, this year-class may be poor but considerable uncertainty remains as to its size.

The TAC level for 1976

Assumptions. The assessment of the Div. 5Z-Stat. Area 6 herring stock to set a TAC for 1976 was made with the following assumptions:

1) The 1975 TAC of 150,000 tons will be fully taken.
2) The size of the 1970 year-class at age 3 is equal to 200% of the 1966 year-class as estimated in the previous assessment (*Redbook* 1974, p. 44).
3) The sizes of the 1971 and the 1972 year-classes at age 3 are equal to the poorest year-class observed in the fishery, i.e., the 1969 year-class as estimated in the previous assessment (*Redbook* 1974, p. 44).
4) The size of the 1973 year-class is equal to 800 million fish at age 3 or approximately one-half the size of the 1966 year-class and 25% below the 1964-69 average. The size of this year-class was chosen at a conventional level, as the information on the abundance of this year-class is very limited. This level of recruitment (800 million) may be conservative over a long period, but it may be equal to or an over-estimate of present levels of recruitment. Therefore, an alternative assessment was worked out assuming recruitment of the 1973 year-class at age 3 is equal to the size of the two preceding year-classes (i.e., 550 million fish) in order to demonstrate the consequences to the size of the stock in 1977 of over-estimating the size of the 1973 year-class.

Results. The results of the assessments are described in Fig. 5 and Table 28. The two constraints (Report of the Fourth Special Commission Meeting, Proceedings No. 7, Appendix II, p. 93) provided by the Commission specify that an adult stock of at least 225,000 tons be maintained to the beginning of 1977 and that the present TAC of 150,000 tons can only be increased if the adult stock size at the end of 1975 will reach a size that will provide the maximum sustainable yield by the end of 1976 (i.e., at least 500,000 tons). This level cannot be reached by the end of 1975 and the TAC for 1976 cannot, therefore, be advised to exceed 150,000 tons. Under the two assumptions on recruitment of the 1973 year-class, a catch in 1976 of 150,000 tons would leave an adult stock size at the beginning of 1977 of 176,000 tons or 137,000 tons. This resulting stock size is far below the level imposed by the Commission as minimum. In order to prevent a decline of the stock size below the level of 225,000 tons by the end of 1976, the TAC in 1976 should not exceed 100,000 tons. On the basis of the lower assumption as to the recruitment of the 1973 year-class in 1976, the corresponding TAC for 1976 would be 60,000 tons.

A TAC of 100,000 tons in 1976 implies a fishing mortality of 0.7 on fully recruited year-classes in that year. This level of F is equal to that of 1974 and below the level to be expected for 1975 if the TAC in 1975 is fully taken (F = 0.8).

On the lower assumption of recruitment, a TAC of 60,000 tons in 1976 would imply a fishing mortality

of 0.38 in that year which is slightly higher than the level of $F_{0.1}$ from yield per recruit consideration (Fig. 6). A TAC of 100,000 tons would merely keep the size of the resulting stock at the already low level without any safeguard for over-estimating the 1973 year-class. A TAC of 60,000 tons would also keep the size of the stock on the low level of 225,000 tons if recruitment of the 1973 year-class is at the lower level, but would reduce the probability that the stock size at the end of 1976 will be further reduced by over-estimating the size of the 1973 year-class. If the size of the 1973 year-class is larger than anticipated, the resulting stock size in 1977 will again increase to a level of 250,000-300,000 tons which is still low compared to previous years.

In view of the present state of the stock, the Working Group recommends that the Commission set the TAC as close to 60,000 tons as possible. Only by accepting such a TAC level can any increase in the stock size be anticipated in accord with the management objectives of the Commission to increase the stock size. If evidence appears suggesting a high abundance of the 1973 year-class, a TAC of 100,000 tons could be recommended which would maintain the stock restraint size of 225,000 tons.

7. Future Research

(a) ICNAF should continue monitoring the production and survival of herring larvae in Div. 4X and Subarea 5 to complete the time series needed for proper evaluation and analysis. Additional larval survey coverage is also needed in March or April.

(b) ICNAF should continue the spring juvenile herring surveys in Div. 5Z and expand the survey area to include the Gulf of Maine with high-opening bottom trawls.

(c) In view of the successful tagging studies conducted by Canada in 1973 and 1974, the Working Group felt that additional tagging studies should be conducted in Subareas 4 and 5.

(d) Because of recent changes in growth, sampling to provide mean weight data should be continued.

Table 1. Provisional herring catches (tons) by country and stock area, 1974.

| Country | Nfld-Gulf of St. Lawrence SA 3 | Nfld-Gulf of St. Lawrence 4RST | Banquereau-Chedebucto Bay 4VW(a)[1] | Nova Scotia-Bay of Fundy 4XW(b)[2] <23 cm | Nova Scotia-Bay of Fundy 4XW(b)[2] >23 cm | Gulf of Maine 5Y | Georges Bank 5Z+6 | 1974 Total | 1973 Total |
|---|---|---|---|---|---|---|---|---|---|
| Bulgaria | - | - | - | - | - | - | 1773 | 1773 | 1758 |
| Canada (MQ) | - | 28750 | 38554[3] | 41365[4] | 79150[4] | 4045 | 217 | 192081 | 170258 |
| Canada (N) | 18300 | 13635 | 1825 | - | - | - | - | 33760 | 54449 |
| France (M) | - | - | - | - | - | 100 | 1935 | 2035 | 2794 |
| Fed.Rep. Germany | - | - | 638 | - | 187 | 2384 | 21933 | 25142 | 33846 |
| German Dem.Rep. | - | - | - | - | - | 1008 | 31530 | 32538 | 58612 |
| Japan | - | - | 8 | - | 1011 | - | 2433 | 3452 | 2777 |
| Poland | - | - | - | - | 98 | 103 | 39312 | 39513 | 50307 |
| Romania | - | - | - | - | - | - | 2009 | 2009 | 297 |
| USSR | - | - | 2955 | - | 20102 | - | 41710 | 64767 | 83524 |
| USA | - | - | - | - | - | 29376[5] | 3312 | 32688 | 26293 |
| Total 1974 | 18300 | 42385 | 43980 | 41365 | 100548 | 37016 | 146164 | 429758 | - |
| Total 1973 | 17162 | 68104 | 30592 | 36907 | 97424 | 32391 | 202335 | - | 484915 |

[1] Div. 4W(a) is that part of 4W north of 42°52'N.
[2] Div. 4W(b) is that part of 4W south of 42°52'N.
[3] Catches in Div. 4V and 4W(a) were 10,791 and 27,793 tons respectively.
[4] Includes approximately 30,700 tons of juveniles and 3,225 tons of adults taken on New Brunswick side of the Bay of Fundy.
[5] Includes a total of 19,143 tons of herring taken in Div. 5Y juvenile fishery.

Table 2 . Stratified numbers per tow of herring at age, and % age composition for 1972-75 spring research cruises.[1]

| Vessel | Year | Ages 2 No/tow | 2 % | 3 No/tow | 3 % | 4 No/tow | 4 % | 5 No/tow | 5 % | 6+ No/tow | 6+ % | Total No/tow | Total % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Div. 4X | | | | | | | | | | | | | |
| *Albatross IV* | 1972 | 5.58 | 98.94 | 0.06 | 1.06 | 0 | 0 | 0 | 0 | 0 | 0 | 5.64 | 100 |
| *Walther Herwig* | 1973 | 514.45 | 97.00 | 15.27 | 2.90 | 0.29 | <0.100 | 0.14 | <0.10 | 0.07 | <0.10 | 530.22 | 100 |
| *Albatross IV* | 1973 | 1.34 | 26.22 | 2.09 | 40.90 | 1.19 | 23.29 | 0.44 | 8.61 | 0.05 | 1.00 | 5.11 | 100 |
| *Walther Herwig* | 1974 | 11.02 | 3.78 | 147.97 | 50.79 | 131.60 | 45.17 | 0.64 | 0.02 | 0.55 | 0.01 | 291.36 | 100 |
| *Albatross IV* | 1974 | 1.76 | 78.92 | 0.17 | 7.62 | 0.28 | 12.55 | - | - | 0.02 | 0.09 | 2.23 | 100 |
| *Walther Herwig* | 1975 | 69.38 | 63.29 | 24.32 | 22.19 | 15.91 | 14.92 | - | - | - | - | 109.61 | 100 |
| *Albatross IV* | 1975 | | | | | | | | | | | | |
| Div. 5Y | | | | | | | | | | | | | |
| *Albatross IV* | 1972 | 1.18 | 80.82 | 0 | 0 | 0.22 | 15.07 | 0.06 | 4.11 | 0 | 0 | 1.46 | 100 |
| " | 1973 | - | - | 0.34 | 3.72 | 3.08 | 33.70 | 3.86 | 42.23 | 1.86 | 20.35 | 9.14 | 100 |
| " | 1974 | 0.02 | 3.03 | 0.15 | 22.72 | 0.48 | 72.73 | - | - | 0.01 | 1.52 | 0.66 | 100 |
| " | 1975 | | | | | | | | | | | | |
| Div. 5Z | | | | | | | | | | | | | |
| *Albatross IV* | 1972 | 6.74 | 55.93 | 2.09 | 17.34 | 3.05 | 25.31 | 0.17 | 1.42 | 0 | 0 | 12.05 | 100 |
| *Walther Herwig* | 1973 | 3.23 | 0.10 | 2211.94 | 98.00 | 35.26 | 1.60 | 4.92 | 0.20 | 1.77 | <0.10 | 2257.30 | 100 |
| *Albatross IV* | 1973 | 0.35 | 3.02 | 7.44 | 64.25 | 3.19 | 27.55 | 0.25 | 2.16 | 0.35 | 3.02 | 11.58 | 100 |
| *Walther Herwig* | 1974 | - | - | 94.40 | 1.89 | 4845.30 | 97.52 | 23.81 | 0.50 | 4.98 | 0.10 | 4968.50 | 100 |
| *Albatross IV* | 1974 | - | - | 0.03 | 0.31 | 8.57 | 89.83 | 0.61 | 6.39 | 0.31 | 3.45 | 9.54 | 100 |
| *Khronometer* | 1974 | - | - | 48.77 | 3.03 | 1444.28 | 89.85 | 57.79 | 3.60 | 56.61 | 3.52 | 1607.45 | 100 |
| *Walther Herwig* | 1975 | 0.45 | - | 20.93 | 3.28 | 22.80 | 3.57 | 561.32 | 87.83 | 33.61 | 5.26 | 639.11 | 100 |
| *Albatross IV* | 1975 | 0.01 | 2.63 | 0.01 | 2.63 | 0.13 | 34.21 | 0.23 | 60.53 | - | - | 0.38 | 100 |
| *Wieczno* | 1975 | - | - | 0.08 | 1.87 | 3.03 | 70.80 | 0.50 | 11.68 | 0.67 | 15.65 | 4.28 | 100 |
| *Ernst Haeckel* | 1975 | 0.06 | 0.02 | 1.84 | 0.73 | 151.05 | 60.25 | 50.61 | 20.19 | 47.13 | 18.80 | 250.69 | 100 |

[1] The *Albatross IV* catch per haul indices for herring in 1972 were increased by a factor of 2.75 to account for the estimated fishing power differential for this species between the #36 trawl (used in 1972) and the #41 trawl (used in 1973 and subsequent spring surveys). This factor is based on unpublished US data on trawl comparison experiments.

Table 3. Stratified mean numbers/haul of 2-4-year-old herring in 1973-75 spring surveys.

| Year-class | *Walther Herwig* Div. 4X Age groups 2 | 3 | 4 | *Walther Herwig* Div. 5Z-SA 6 Age groups 2 | 3 | 4 | *Albatross IV* Div. 4X Age groups 2 | 3 | 4 | *Albatross IV* Div. 5Z-SA 6 Age groups 2 | 3 | 4 | Year-class | *Albatross IV* Div. 5Y Age groups 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | - | - | 0.3 | - | - | 35 | - | 0.06 | 1.19 | - | 2.09 | 3.19 | 1969 | - | 0 | 3.08 |
| 1970 | - | 15 | 132.0 | - | 2212 | 4845 | 5.58 | 2.09 | 0.28 | 6.74 | 7.44 | 8.57 | 1970 | 1.18 | 0.34 | 0.48 |
| 1971 | 514 | 148 | 16.0 | 3.0 | 94 | 23 | 1.34 | 0.17 | - | 0.35 | 0.03 | 0.13[1] | 1971 | 0 | 0.15 | - |
| 1972 | 11 | 24 | - | - | 21 | - | 1.76 | - | - | 0 | 0.01[1] | - | 1972 | 0.02 | - | - |
| 1973 | 69 | - | - | 0.4 | - | - | - | - | - | 0.01[1] | - | - | 1973 | - | - | - |

[1] Preliminary estimates based only on southern part of Div. 5Z which was the only part of survey completed by *Albatross IV* at time of meeting.

Table 4. Ratios of abundance indices of year-classes to the 1970 or 1971 year-class, in terms of catch per haul at ages 2-4, for surveys by *W. Herwig* and *Albatross IV* in Div. 5Z-Stat. Area 6 and for *Albatross IV* in Div. 5Y.

| Year-class | *Albatross IV* Div. 4X Age groups 2 | 3 | 4 | *Walther Herwig* Div. 5Z + SA 6 Age groups 2 | 3 | 4 | *Albatross IV* Div. 5Z + SA 6 Age groups 2 | 3 | 4 | *Albatross IV* Div. 5Y Age groups 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | - | 0.029 | 4.250 | - | - | 0.007 | - | 0.281 | 0.372 | - | - | 6.417 |
| 1970 | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 1971 | 0.240 | 0.081 | - | 1.000 | 0.042 | 0.005 | 0.052 | 0.004 | 0.015 | - | 0.441 | - |
| 1972 | 0.315 | - | - | - | 0.010 | - | - | 0.001 | - | 0.017 | - | - |
| 1973 | - | - | - | 0.133 | - | - | 0.001 | - | - | - | - | - |

Table 5. Total herring catch from Div. 4X(b), 5Y, 5Z and SA 6 (millions of fish).

| | Year-class | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
| 1956 | 286.5 | 1813.5 | 757.2 | | | | | | | | |
| 1957 | | 276.7 | 2931.8 | 421.8 | | | | | | | |
| 1958 | | 1.1 | 416.4 | 2034.4 | 423.5 | | | | | | |
| 1959 | | | | 420.0 | 1575.1 | 466.3 | | | | | |
| 1960 | | | | | 200.4 | 3436.9 | 161.0 | | | | |
| 1961 | 7.0 | 13.8 | 64.1 | 171.8 | 47.8 | 125.6 | 756.9 | 310.2 | | | |
| 1962 | 9.7 | 18.3 | 140.4 | 299.1 | 99.5 | 74.4 | 100.6 | 2617.8 | 74.3 | | |
| 1963 | | | 5.9 | 14.7 | 67.6 | 145.6 | 66.1 | 825.1 | 1804.4 | 309.3 | |
| 1964 | | | | | 34.9 | 97.5 | 129.4 | 253.2 | 421.4 | 1152.0 | 461.7 |
| 1965 | | | | | | 12.8 | 25.8 | 113.9 | 89.9 | 137.6 | 2533.4 |
| 1966 | | | | | 2.0 | 13.8 | 65.5 | 283.1 | 228.5 | 97.4 | 787.9 |
| 1967 | | | | 0.2 | 10.5 | 11.4 | 50.1 | 388.5 | 271.7 | 145.2 | 230.3 |
| 1968 | | | | | 2.0 | 9.0 | 25.0 | 355.7 | 463.9 | 266.6 | 411.7 |
| 1969 | | | | | | 1.7 | 26.2 | 121.2 | 213.7 | 221.6 | 310.1 |
| 1970 | | | | | | | 2.7 | 31.5 | 58.1 | 77.3 | 123.8 |
| 1971 | | | | | | | | 3.2 | 29.1 | 25.5 | 67.9 |
| 1972 | | | | | | | | | 0.8 | 22.3 | 30.7 |
| 1973 | | | | | | | | | | 0.2 | 5.4 |
| | 303.2 | 2122.9 | 4315.8 | 3362.0 | 2463.3 | 4395.0 | 1409.3 | 6303.4 | 3655.8 | 2455.0 | 4962.9 |

| | Year-class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | Total |
| 1956 | | | | | | | | | | 2856.7 |
| 1957 | | | | | | | | | | 3630.3 |
| 1958 | | | | | | | | | | 2875.4 |
| 1959 | | | | | | | | | | 2461.4 |
| 1960 | | | | | | | | | | 3798.3 |
| 1961 | | | | | | | | | | 1497.2 |
| 1962 | | | | | | | | | | 4434.1 |
| 1963 | | | | | | | | | | 3238.7 |
| 1964 | | | | | | | | | | 2550.1 |
| 1965 | 287.1 | | | | | | | | | 3200.5 |
| 1966 | 1200.7 | 168.4 | | | | | | | | 2847.3 |
| 1967 | 260.0 | 919.9 | 805.3 | | | | | | | 3093.1 |
| 1968 | 135.6 | 403.5 | 3182.7 | 164.2 | | | | | | 5419.9 |
| 1969 | 298.6 | 244.1 | 613.1 | 817.8 | 166.5 | | | | | 3034.6 |
| 1970 | 156.1 | 302.9 | 506.8 | 207.1 | 1022.2 | 639.6 | | | | 3128.1 |
| 1971 | 133.7 | 216.4 | 331.1 | 327.1 | 417.6 | 479.3 | 271.4 | | | 2302.3 |
| 1972 | 55.4 | 129.4 | 203.7 | 259.0 | 160.9 | 65.2 | 1016.7 | 9.1 | | 1953.2 |
| 1973 | 5.3 | 19.6 | 37.1 | 47.2 | 76.2 | 293.9 | 1333.5 | 460.0 | 37.6 | 2316.0 |
| | 2532.5 | 2404.2 | 5679.8 | 1822.4 | 1843.4 | 1478.0 | 2621.6 | 469.1 | 37.6 | 54637.2 |

Table 6. Estimates of fishing mortality rates for herring from combined areas of Div. 4X(b), 5Y, 5Z and SA 6.

| Year | Year-class 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | Mean F[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | .163 | | | | | | | | | | | | | | | | |
| 1957 | 1.690 | .123 | | | | | | | | | | | | | | | |
| 1958 | 1.466 | 1.401 | .137 | | | | | | | | | | | | | | |
| 1959 | .000 | 1.472 | 1.075 | .085 | | | | | | | | | | | | | |
| 1960 | .000 | .000 | .362 | 1.531 | .069 | | | | | | | | | | | | |
| 1961 | .300 | .377 | .136 | .181 | .518 | .029 | | | | | | | | | | | .119 |
| 1962 | 2.619 | 2.831 | .461 | .155 | .118 | .534 | .000 | | | | | | | | | | .263 |
| 1963 | 1.100 | 3.114 | .662 | .506 | .106 | .220 | .372 | .072 | | | | | | | | | .243 |
| 1964 | | .002 | .871 | .770 | .308 | .097 | .138 | .415 | .061 | | | | | | | | .164 |
| 1965 | | .002 | .000 | .208 | .092 | .058 | .039 | .075 | .548 | .072 | | | | | | | .237 |
| 1966 | | .003 | .111 | .362 | .355 | .198 | .133 | .073 | .326 | .473 | .042 | | | | | | .220 |
| 1967 | | 1.100 | 1.350 | .576 | .506 | .454 | .231 | .149 | .148 | .175 | .333 | .107 | | | | | .194 |
| 1968 | | | 1.100 | 1.356 | .513 | 1.014 | .770 | .443 | .427 | .130 | .238 | .775 | .060 | | | | .491 |
| 1969 | | | | 1.100 | 1.831 | 1.301 | 1.047 | .827 | .669 | .465 | .272 | .325 | .470 | .066 | | | .376 |
| 1970 | | | | | 1.100 | 1.843 | .955 | .795 | .625 | .474 | .469 | .489 | .206 | .709 | .331 | | .479 |
| 1971 | | | | | | 1.100 | 3.014 | .673 | .867 | .994 | .734 | .697 | .579 | .722 | .443 | .040 | .272 |
| 1972 | | | | | | | 1.100 | 4.090 | 1.409 | 1.594 | 1.522 | 1.383 | 1.382 | .691 | .098 | .206 | .375 |
| 1973 | | | | | | | | 1.100 | 1.100 | 1.100 | 1.100 | 1.100 | 1.100 | .853 | .820 | .454 | |

[1] Weighted average over all age groups.

Table 7. Estimates of stock size for herring from combined areas of Div. 4X(b), 5Y, 5Z and SA 6. (millions of fish)

| Year | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | Age 4 & Older | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 5550 | | | | | | | | | | | | | | | | | 5550 |
| 1957 | 3862 | 4021 | | | | | | | | | | | | | | | | 7883 |
| 1958 | 584 | 2912 | 3632 | | | | | | | | | | | | | | | 7128 |
| 1959 | 110 | 587 | 2592 | 6281 | | | | | | | | | | | | | 110 | 9570 |
| 1960 | 110 | 110 | 724 | 4722 | 2679 | | | | | | | | | | | | 220 | 8345 |
| 1961 | 267 | 599 | 413 | 836 | 2048 | 12029 | | | | | | | | | | | 1327 | 16240 |
| 1962 | 161 | 336 | 295 | 572 | 999 | 9569 | 7862 | | | | | | | | | | 1430 | 19860 |
| 1963 | 10 | 16 | 152 | 401 | 727 | 4595 | 6375 | 4876 | | | | | | | | | 1306 | 17152 |
| 1964 | | 1 | 66 | 198 | 537 | 3020 | 3599 | 3714 | 8533 | | | | | | | | 3822 | 19688 |
| 1965 | | 1 | 22 | 75 | 322 | 2244 | 2567 | 2007 | 6569 | 4577 | | | | | | | 5231 | 18384 |
| 1966 | | 0 | 21 | 50 | 241 | 1735 | 2021 | 1519 | 3111 | 3489 | 4540 | | | | | | 5587 | 16727 |
| 1967 | | 0 | 15 | 29 | 138 | 1165 | 1449 | 1156 | 1839 | 1780 | 3565 | 8737 | | | | | 5791 | 19873 |
| 1968 | | | 3 | 13 | 68 | 606 | 942 | 816 | 1298 | 1223 | 2092 | 6427 | 3095 | | | | 4969 | 16583 |
| 1969 | | | | 3 | 33 | 180 | 357 | 429 | 694 | 880 | 1350 | 2424 | 2387 | 2865 | | | 3926 | 11602 |
| 1970 | | | | | 4 | 40 | 103 | 154 | 291 | 452 | 886 | 1434 | 1221 | 2196 | 2492 | | 3364 | 9273 |
| 1971 | | | | | | 5 | 32 | 57 | 127 | 233 | 454 | 720 | 813 | 885 | 1465 | 7634 | 2441 | 12425 |
| 1972 | | | | | | | 1 | 24 | 44 | 70 | 178 | 293 | 373 | 352 | 770 | 6006 | 1335 | |
| 1973 | | | | | | | | | 9 | 9 | 32 | 60 | 77 | 144 | 572 | 4002 | 903 | |

Table 8. Catch of herring by age from Div. 4X(b), 5Y, 5Z and SA 6 combined.

| | | Period 1956-1973 | | | | | | Period 1961-1973 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total catch | | Average catch | | Mean F | F averaged over year-classes | Total catch | | Average catch | | Mean F | F averaged over year classes |
| Age | Mean Weight (kg) | (Millions of fish) | (1000 tons) | (Millions of fish) | (1000 tons) | | | (Millions of fish) | (1000 tons) | (Millions of fish) | (1000 tons) | | |
| 1 | .012 | 5934.42 | 71.2 | 329.69 | 4.0 | .091 | 55 - 70 | 3704.62 | 44.5 | 284.97 | 3.4 | .085 | 61 - 70 |
| 2 | .031 | 30754.98 | 953.4 | 1708.61 | 53.0 | .72 | 55 - 70 | 18963.78 | 587.9 | 1458.75 | 45.2 | .47 | 61 - 70 |
| 3 | .118 | 7298.28 | 861.2 | 405.46 | 47.8 | .41 | 55 - 70 | 5698.28 | 672.4 | 438.33 | 51.7 | .28 | 61 - 70 |
| 4 | .180 | 2528.64 | 455.2 | 158.04 | 28.4 | .27 | 56 - 69 | 2527.54 | 455.0 | 194.43 | 35.0 | .36 | 61 - 69 |
| 5 | .220 | 2713.35 | 596.9 | 180.89 | 39.8 | .48 | 56 - 68 | 2713.35 | 596.9 | 180.89 | 39.8 | .57 | 61 - 68 |
| 6 | .240 | 2309.02 | 554.2 | 164.93 | 39.6 | .57 | 57 - 66 | 2309.02 | 554.2 | 164.93 | 39.6 | .66 | 61 - 66 |
| 7 | .275 | 1780.09 | 489.5 | 136.93 | 37.7 | .74 | 57 - 65 | 1780.09 | 489.5 | 136.93 | 37.7 | .95 | 61 - 65 |
| 8 | .300 | 884.65 | 265.4 | 68.05 | 20.4 | .77 | 57 - 64 | 884.65 | 265.4 | 68.05 | 20.4 | 1.08 | 61 - 64 |
| 9 | .340 | 288.96 | 98.3 | 24.08 | 8.2 | .79 | 57 - 63 | 288.96 | 98.2 | 24.08 | 8.2 | 1.01 | 61 - 63 |
| 10 | .340 | 133.98 | 45.6 | 19.14 | 6.5 | | | 133.98 | 45.6 | 19.14 | 6.5 | | |
| 11 | .340 | 10.80 | 3.7 | 1.54 | .5 | | | 10.80 | 3.7 | 1.54 | .5 | | |

TABLE 9. Stock size and catches for herring from Div. 4X(b), 5Y, 5Z and SA 6 for 3 sets of mortalities.

| | | | SET 1 | | SET 2 | | SET 3 | |
|---|---|---|---|---|---|---|---|---|
| | | | Mortality as calculated from data | | F reduced for age 2 and 3 to 0.25 | | F=0 for age 1 and 2 F=0.13 for age 3 | |
| Year | F 100% | Number of Recruits (Millions) | Stock age 4 and older (000 t) | Catch age 3 and older (000 t) | Stock age 4 and older (000 t) | Catch age 3 and older (000 t) | Stock age 4 and older (000 t) | Catch age 3 and older (000 t) |
| 1961 | .30 | 12029 | 284 | 48 | 284 | 43 | 284 | 39 |
| 62 | .66 | 7862 | 331 | 130 | 337 | 124 | 343 | 112 |
| 63 | .61 | 4876 | 348 | 199 | 401 | 216 | 446 | 187 |
| 64 | .41 | 8533 | 665 | 139 | 1018 | 172 | 1379 | 190 |
| 65 | .60 | 4577 | 853 | 233 | 1355 | 320 | 1896 | 403 |
| 66 | .55 | 4540 | 831 | 270 | 1306 | 381 | 1830 | 477 |
| 67 | .49 | 8737 | 906 | 230 | 1445 | 342 | 2035 | 454 |
| 68 | 1.24 | 3095 | 834 | 466 | 1330 | 689 | 1877 | 912 |
| 69 | .95 | 2865 | 509 | 253 | 824 | 406 | 1192 | 524 |
| 70 | 1.21 | 2492 | 421 | 210 | 838 | 364 | 1391 | 541 |
| 71 | .68 | 7634 | 268 | 93 | 591 | 182 | 1057 | 293 |
| 72 | .94 | 2617 | 216 | 113 | 506 | 223 | 938 | 372 |

TABLE 10. Numbers of herring at age (x $10^{-6}$) taken in the Canadian 1974-75 Div. 4VW(a) fishery.

| | | Age-group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ | Total |
| 1974 | 4Vn | 0.1 | 4.2 | 3.7 | 29.4 | 5.9 | 2.4 | 2.0 | 1.8 | 2.1 | 4.6 | 56.2 |
| | 4W(a) | - | 0.1 | 1.3 | 11.8 | 1.1 | 0.4 | 0.3 | 0.4 | 0.4 | 0.6 | 16.4 |
| 1975 | 4Vn | - | - | 1.8 | 1.1 | 8.6 | 1.4 | 0.3 | 0.6 | 0.9 | 3.1 | 17.8 |
| | 4W(a) | - | 1.9 | 39.8 | 15.4 | 74.0 | 7.4 | 2.2 | 1.5 | 2.0 | 5.3 | 149.5 |

Table 11. Removals (x $10^{-6}$) in the Div. 4W(a) herring fishery, 1969-75.

| | | Age-group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1969 | | | 4.0 | 49.0 | 70.3 | 35.5 | 31.9 | 7.1 | 1.9 | 0.7 | 0.0 |
| 1970 | | | 47.8 | 145.4 | 273.4 | 75.3 | 87.5 | 36.6 | 20.8 | 9.7 | 0.4 |
| 1971 | | 1.3 | 149.3 | 150.3 | 68.3 | 51.1 | 36.8 | 44.8 | 25.9 | 9.7 | 5.0 |
| 1972 | | 2.6 | 0.5 | 20.2 | 35.0 | 70.2 | 13.3 | 8.3 | 10.7 | 4.2 | 4.7 |
| 1973 | | | 14.9 | 39.9 | 23.8 | 7.2 | 3.6 | 1.4 | 0.9 | 8.4 | 0.2 |
| 1974 | Can. | | 2.6 | 9.7 | 118.2 | 15.5 | 3.4 | 2.3 | 1.8 | 1.6 | 1.4 |
| | USSR | | | 0.3 | 8.9 | 4.1 | 0.9 | 0.5 | 0.3 | 0.4 | 0.4 |
| | Total | | 2.6 | 10.0 | 127.1 | 19.6 | 4.3 | 2.8 | 2.1 | 2.0 | 1.7 |
| 1975 | | | 1.9 | 39.8 | 15.4 | 74.0 | 7.4 | 2.2 | 1.5 | 2.0 | 1.9 |

Table 12. Removals at age and starting estimates of F for the combined Div. 4XW(b) and 4W(a) fishery.

| | Removals (x $10^{-6}$) by year-class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
| 1 | - | - | 1 | 4 | 14 | - | - | 6 | 10 | - |
| 2 | 211 | 46 | 43 | 746 | 70 | 132 | 160 | 649 | 35 | 170 |
| 3 | 270 | 69 | 79 | 374 | 160 | 213 | 56 | 650 | 37 | - |
| 4 | 238 | 64 | 122 | 462 | 114 | 120 | 106 | 599 | - | - |
| 5 | 268 | 151 | 238 | 131 | 127 | 29 | 55 | - | - | - |
| 6 | 103 | 177 | 79 | 71 | 22 | 13 | - | - | - | - |
| 7 | 130 | 98 | 51 | 74 | 6 | - | - | - | - | - |
| 8 | 470 | 51 | 14 | 34 | - | - | - | - | - | - |
| 9 | 273 | 12 | 5 | - | - | - | - | - | - | - |
| 10 | 6 | 3 | - | - | - | - | - | - | - | - |
| F's to start | 1.00 | 1.00 | 1.00 | 0.38 | 1.18 | 0.97 | 0.40 | 0.24 | 0.102 | 0.20 |

Table 13. Estimates of fishing mortality for the combined Div. 4XW(b)-4W(a) fishery at age from cohort analysis, assuming M = 0.2.

| | Year-class | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| 1 | .00 | .00 | .00 | .00 | .02 | .00 | .00 | .00 | .02 | .00 | |
| 2 | .05 | .03 | .04 | .30 | .10 | .22 | .26 | .12 | .07 | .20 | |
| 3 | .08 | .06 | .09 | .25 | .35 | .66 | .14 | .17 | .10 | - | |
| 4 | .09 | .08 | .20 | .54 | .44 | 1.03 | .42 | .24 | - | - | |
| 5 | .14 | .27 | .74 | .29 | 1.44 | .77 | .40 | - | - | - | |
| 6 | .07 | .58 | .59 | .25 | 1.14 | .97 | - | - | - | - | |
| 7 | .12 | .76 | 1.02 | .45 | 1.18 | - | - | - | - | - | |
| 8 | .86 | 1.28 | .91 | .38 | - | - | - | - | - | - | |
| 9 | 3.56 | 1.39 | 1.00 | - | - | - | - | - | - | - | |
| 10 | 1.00 | 1.00 | - | - | - | - | - | - | - | - | |

Table 14. Calculated stock size (x $10^{-6}$) for the combined Div. 4XW(b)-4W(a) fishery at age from cohort analysis.

| | Year-class | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| 1 | 6300 | 1885 | 1550 | 3844 | 1013 | 905 | 930 | 7576 | 685 | 1261 | |
| 2 | 5157 | 1542 | 1268 | 3143 | 817 | 740 | 760 | 6197 | 552 | 1031 | |
| 3 | 4031 | 1221 | 999 | 1898 | 605 | 487 | 478 | 4486 | 420 | | |
| 4 | 3056 | 937 | 747 | 1216 | 351 | 206 | 340 | 3085 | | | |
| 5 | 2287 | 709 | 501 | 577 | 184 | 60 | 183 | | | | |
| 6 | 1630 | 444 | 195 | 354 | 36 | 23 | | | | | |
| 7 | 1241 | 203 | 88 | 226 | 9 | | | | | | |
| 8 | 899 | 78 | 26 | 118 | | | | | | | |
| 9 | 311 | 18 | 9 | | | | | | | | |
| 10 | 7 | 4 | | | | | | | | | |

Table 15. Catch predictions for 1975 and 1976 for the Div. 4XW(b)-4W(a) fishery with associated population numbers and estimates of F.

| 1974 | | | | Catch | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Population | F | | Nos.(x $10^{-6}$) | | Wt('000 mt) | | Residual population | | Catch |
| Age | (x $10^{-8}$) | 4Wa | 4XWb | 4Wa | 4XWb | 4Wa | 4XWb | 4Wa (x $10^{-6}$) | 4XWb | (000t) |
| 2 | 1031 | .01 | .22 | 2.6 | 167.5 | 0.4 | 5.4 | 923.6 | 670.7 | 20.8 |
| 3 | 420 | .03 | .09 | 10.0 | 27.4 | 1.0 | 3.5 | 368.8 | 305.0 | 34.8 |
| 4 | 3085 | .05 | .21 | 127.1 | 472.2 | 20.2 | 85.8 | 2655.3 | 1947.5 | 348.6 |
| 5 | 183 | .12 | .29 | 19.6 | 35.0 | 3.5 | 8.1 | 146.9 | 99.4 | 22.9 |
| 6 | 23 | .22 | .79 | 4.3 | 8.7 | 1.0 | 2.5 | 16.7 | 6.9 | 2.0 |
| 7 | 9 | .42 | .88 | 2.9 | 3.0 | 0.8 | 0.9 | 5.4 | 2.0 | 0.6 |
| 8 | 118 | .02 | .02 | 2.1 | 1.3 | 0.7 | 0.7 | 104.7 | 92.8 | 31.0 |
| 9 | 9 | .27 | .58 | 2.0 | 2.6 | 0.7 | 0.9 | 6.2 | 3.2 | 1.2 |
| 10 | 4 | .61 | 1.44 | 1.8 | 1.4 | 0.6 | 0.5 | 1.9 | 0.4 | 0.2 |
| Totals | 4882 | | | 172.3 | 719.2 | 28.9 | 108.3 | 4229.5 | 3127.9 | 462.1 |
| 1975 | | | | | | | | | | |
| 2 | 750.0 | .02 | .18 | 8.3 | 103.2 | 0.5 | 3.2 | 665.2 | 502.7 | 15.6 |
| 3 | 670.7 | .08 | .18 | 43.7 | 87.7 | 4.3 | 10.0 | 560.2 | 423.4 | 48.3 |
| 4 | 305.0 | .07 | .09 | 17.0 | 21.2 | 2.8 | 3.8 | 257.3 | 212.8 | 38.1 |
| 5 | 1947.5 | .09 | .47 | 80.3 | 323.9 | 16.0 | 74.5 | 904.4 | 511.4 | 117.6 |
| 6 | 99.4 | .09 | .36 | 8.1 | 23.8 | 1.9 | 6.8 | 82.2 | 51.9 | 14.8 |
| 7 | 6.9 | .43 | .94 | 2.2 | 2.3 | 0.6 | 0.7 | 3.9 | 1.4 | 0.4 |
| 8 | 2.0 | 2.11 | 1.05 | 1.7 | 0.3 | 0.5 | 0.1 | 0.2 | 0.1 | 0.0 |
| 9 | 92.8 | .04 | .34 | 2.8 | 22.2 | 1.1 | 8.0 | 80.7 | 52.0 | 18.7 |
| 10 | 3.2 | .94 | .89 | 1.8 | 0.5 | 0.6 | 0.2 | 1.1 | 0.4 | 0.2 |
| Totals | 3877.5 | | | 165.9 | 585.1 | 28.4 | 107.3 | 2555.2 | 1756.1 | 253.7 |
| 1976 | | | | | | | | | | |
| 2 | 750.0 | .02 | .03 | 13.9 | 19.4 | 0.5 | 0.6 | 665.2 | 584.1 | 50.8 |
| 3 | 502.7 | .08 | .13 | 36.8 | 49.1 | 3.2 | 5.6 | 419.9 | 333.6 | 47.0 |
| 4 | 423.4 | .07 | .25 | 27.0 | 75.4 | 3.8 | 13.5 | 357.2 | 251.7 | 44.8 |
| 5 | 212.8 | .09 | .50 | 17.4 | 66.1 | 3.1 | 15.2 | 176.0 | 96.6 | 22.6 |
| 6 | 511.4 | .10 | .50 | 46.8 | 157.3 | 10.9 | 45.0 | 418.7 | 229.8 | 62.0 |
| 7 | 51.9 | .10 | .50 | 4.8 | 16.1 | 1.3 | 4.8 | 42.5 | 23.3 | 6.8 |
| 8 | 1.4 | .10 | .50 | 0.1 | 0.4 | 0.0 | 0.1 | 1.1 | 0.6 | 0.2 |
| 9 | 0.1 | .10 | .50 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.3 | 0.1 |
| 10 | 52.0 | .10 | .50 | 4.8 | 16.1 | 1.6 | 6.2 | 42.5 | 23.4 | 7.9 |
| Totals | 2505.7 | | | 151.4 | 399.9 | 24.4 | 91.0 | 2123.7 | 1543.4 | 242.2 |

Table 16. Preliminary monthly catches (m.t.) in the 1974 Div. 4XW(b) herring fishery.

| | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NS Purse Seine | - | - | - | - | 770 | 15313 | 35766 | 23950 | 2201 | - | - | - | 78000 |
| NS Weirs | - | - | - | - | 917 | 602 | 451 | 424 | 161 | 5 | - | - | 2560 |
| NS Gill Nets | - | - | - | 16 | 68 | 1060 | 680 | 985 | 838 | 13 | 1 | - | 3661 |
| NS Miscellaneous | - | - | - | - | - | - | - | - | - | - | - | - | 3119 |
| NS Totals | - | - | - | 16 | 1755 | 16975 | 36897 | 25359 | 3200 | 18 | 1 | - | 87340 |
| NB Purse Seine | 2355 | 794 | 267 | 868 | - | - | 165 | - | 295 | 1718 | 1825 | 1287 | 9574 |
| NB Weirs | 31 | - | - | 37 | 1257 | 1875 | 6101 | 7621 | 4668 | 2299 | 470 | 41 | 24400 |
| NB Totals | 2386 | 794 | 267 | 905 | 1257 | 1875 | 6266 | 7621 | 4963 | 4017 | 2295 | 1328 | 35529 |
| CANADA Total | 2386 | 794 | 267 | 921 | 3012 | 18850 | 43163 | 32980 | 8163 | 4035 | 2296 | 1328 | 121314 |
| USSR Total | - | - | 163 | 550 | 3156 | 15143 | 1090 | - | - | - | - | - | 20102 |
| 4XW(b) TOTAL[1] | 2386 | 794 | 430 | 1471 | 6168 | 33993 | 44253 | 32980 | 8163 | 4035 | 2296 | 1328 | 141416 |

[1] Excludes 1,296 tons for Poland, FRG and Japan.

Table 17. Removals (thousands) of herring at age by the 1974 Div. 4XW(b) Canadian Bay of Fundy fishery. The totals may differ slightly from the table values due to rounding off to thousands.

| | Age-group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
| NB Weirs | 38080 | 627393 | 49788 | 18495 | 598 | 119 | 10 | 13 | 56 | 8 | 12 | 734572 |
| NB Purse Seine | 8637 | 512977 | 23581 | 903 | 107 | - | - | - | - | - | - | 546205 |
| NB Totals | 46717 | 1140370 | 73369 | 19398 | 705 | 119 | 10 | 13 | 56 | 8 | 12 | 1280777 |
| NS Weirs | 4 | 31518 | 1661 | 8351 | 485 | 85 | 21 | 25 | 35 | 15 | | 42199 |
| NS Gill Nets | - | - | 93 | 37153 | 4331 | 1170 | 690 | 284 | 375 | 64 | 502 | 44663 |
| NS Purse Seine | - | 131003 | 25168 | 339065 | 20086 | 4917 | 1815 | 490 | 1136 | 363 | 563 | 615000 |
| NS Miscellaneous | - | 961 | 169 | 2221 | 128 | 32 | 12 | 3 | 7 | 2 | 3 | 3538 |
| NS Totals | 4 | 1303852 | 100460 | 386790 | 25030 | 6204 | 2538 | 802 | 1553 | 444 | 1068 | 615006 |
| CANADA Total | 46721 | 1303852 | 100460 | 406188 | 25735 | 6323 | 2548 | 815 | 1609 | 452 | 1080 | 1895783 |
| USSR Total | - | - | 279 | 85419 | 10006 | 2461 | 478 | 492 | 1027 | 902 | 1771 | 102835 |
| TOTAL 4XW(b)Catch[1] | 46721 | 1303852 | 100739 | 491607 | 35741 | 8784 | 3026 | 1307 | 2636 | 1354 | 2851 | 1998618 |

[1] Excluding 1,296 tons for Poland, FRG and Japan.

Table 18. Estimates of fishing mortality of Div. 4X(a) - 4W(b) herring fishery at age from cohort analysis, assuming M = 0.2.

| Age | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .00 | .00 | .00 | .04 | .00 | .00 | .00 | .02 | .00 |
| 2 | .05 | .06 | .55 | .24 | .27 | .03 | .20 | .06 | .20 |
| 3 | .10 | .14 | .50 | .08 | .33 | .13 | .30 | .102 | |
| 4 | .12 | .13 | .61 | .37 | 1.03 | .49 | .39 | | |
| 5 | .34 | .75 | .58 | 1.10 | .82 | .40 | | | |
| 6 | .47 | .43 | 1.17 | 1.48 | .97 | | | | |
| 7 | .57 | 1.08 | 1.44 | 1.18 | | | | | |
| 8 | 1.24 | 1.29 | .38 | | | | | | |
| 9 | 2.00 | 1.00 | | | | | | | |
| 10 | 1.00 | | | | | | | | |

Table 19. Calculated stock size (X $10^{-6}$) at age for Div. 4X(a)-4W(b) herring fishery.

| Age | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1303 | 1056 | 2375 | 432 | 482 | 499 | 4806 | 500 | 1241 |
| 2 | 1066 | 864 | 1940 | 341 | 395 | 408 | 3931 | 402 | 1016 |
| 3 | 832 | 668 | 914 | 220 | 248 | 324 | 2612 | 311 | |
| 4 | 619 | 476 | 454 | 167 | 146 | 233 | 1603 | | |
| 5 | 449 | 342 | 201 | 95 | 45 | 116 | | | |
| 6 | 263 | 133 | 92 | 26 | 15 | | | | |
| 7 | 134 | 71 | 23 | 5 | | | | | |
| 8 | 62 | 20 | 5 | | | | | | |
| 9 | 15 | 4 | | | | | | | |
| 10 | 2 | | | | | | | | |

Table 20. Numbers (X $10^{-6}$) of 2 year old herring taken by the various Canadian fisheries in Div. 4XW(b).

| | YEAR CLASS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
| NB Purse seine | 1578.0 | 236.9 | 491.1 | 227.0 | - * | 85.1 | 513.0 |
| NB Weirs | 694.5 | 350.7 | 321.9 | 165.0 | 615.0 | 197.7 | 627.4 |
| NS Purse seine | 678.6 | 26.1 | 41.5 | 4.6 | 232.3 | 2.1 | 131.0 |
| NS Weirs | 117.6 | 39.4 | 41.8 | 6.5 | 107.2 | 18.4 | 31.5 |
| TOTALS | 3018.7 | 653.1 | 887.3 | 403.1 | 954.7 | 303.3 | 1302.9 |

* Canadian domestic minimum size regulation eliminated the NB purse seine fishery in 1970, but was not effective since then.

Table 21. Catch Predictions for 1975 and 1976 for 4Xa - 4Wb stock with associated population numbers (X $10^{-6}$), weights ('000 mt), and estimates of F.

| Age | | Population ($10^{-6}$) | F | Catch ($10^{-6}$) | Catch (000 tons) | Residual Population ($10^{-6}$) | Population ($10^{-6}$) |
|---|---|---|---|---|---|---|---|
| 1974 | 2 | 1,016 | 0.20 | 167.7 | 5.2 | 681.0 | 21.1 |
| | 3 | 311 | 0.10 | 27.2 | 3.1 | 229.9 | 26.2 |
| | 4 | 1,603 | 0.39 | 472.1 | 84.5 | 888.6 | 159.1 |
| | 5 | 116 | 0.40 | 34.8 | 8.0 | 63.7 | 14.7 |
| | 6 | 15 | 0.97 | 8.7 | 2.5 | 4.7 | 1.3 |
| | 7 | 5 | 1.18 | 3.3 | 1.0 | 1.3 | 0.4 |
| | 8 | 5 | 0.38 | 1.5 | 0.5 | 2.8 | 0.9 |
| | 9 | 4 | 1.00 | 2.2 | 0.8 | 1.2 | 0.4 |
| | 10 | 2 | 1.00 | 1.0 | 0.4 | 0.6 | 0.2 |
| | | 3,077 | | 718.5 | 106.0 | 1,873.8 | 224.3 |
| 1975 | 2 | 400.0 | 0.21 | 67.7 | 2.1 | 265.5 | 8.2 |
| | 3 | 681.0 | 0.21 | 117.5 | 13.4 | 452.0 | 51.5 |
| | 4 | 229.9 | 0.11 | 21.9 | 3.9 | 168.6 | 30.2 |
| | 5 | 888.6 | 0.55 | 343.9 | 79.1 | 419.7 | 96.5 |
| | 6 | 63.7 | 0.42 | 19.9 | 5.7 | 34.2 | 9.8 |
| | 7 | 4.7 | 1.11 | 3.0 | 0.9 | 1.3 | 0.4 |
| | 8 | 1.3 | 1.24 | 0.9 | 0.3 | 0.3 | 0.1 |
| | 9 | 2.8 | 0.40 | 0.8 | 0.3 | 1.5 | 0.5 |
| | 10 | 1.2 | 1.05 | 0.8 | 0.3 | 0.3 | 0.1 |
| | | 2,273.2 | | 567.4 | 105.9 | 1,343.4 | 197.3 |
| 1976 | 2 | 400.0 | 0.03 | 9.7 | 0.3 | 317.8 | 9.9 |
| | 3 | 265.5 | 0.13 | 29.8 | 3.4 | 190.8 | 21.8 |
| | 4 | 452.0 | 0.25 | 91.1 | 16.3 | 288.2 | 51.6 |
| | 5 | 168.6 | 0.50 | 60.4 | 13.9 | 83.7 | 19.3 |
| | 6 | 419.7 | 0.50 | 151.0 | 43.2 | 208.4 | 59.6 |
| | 7 | 34.2 | 0.50 | 12.4 | 3.7 | 17.0 | 5.1 |
| | 8 | 1.3 | 0.50 | 0.6 | 0.2 | 0.6 | 0.2 |
| | 9 | 0.3 | 0.50 | 0.0 | 0.0 | 0.1 | 0.0 |
| | 10 | 1.5 | 0.50 | 0.5 | 0.2 | 0.8 | 0.3 |
| | | 1,743.1 | | 355.5 | 81.2 | 1,107.4 | 167.8 |

Table 22. Catch of herring in ICNAF Division 5Y (national allocation in brackets).

| Year | USA Juvenile fishery | USA Adult fishery | USA Total Catch | Canada | Germany FR | German DR | USSR | Poland | Japan | Bulgaria | 5Y Total | Total without juvenile fishery |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 28,577 | 2,581 | 31,158 | 5,226 | | | | | | | 36,384 | 7,807 |
| 1968 | 31,073 | 10,403 | 41,476 | 21,497 | | | | | | | 62,973 | 31,900 |
| 1969 | 23,853 | 4,834 | 28,687 | 10,106 | 10,446 | 7,020 | | | | | 56,259 | 32,406 |
| 1970 | 15,617 | 13,564 | 29,181 | 17,912 | 6,079 | 2,580 | | 43 | 9 | | 55,804 | 40,187 |
| 1971 | 12,408 | 19,077 | 31,491 | 15,518 | 1,723 | 2,257 | | | | | 50,983 | 38,575 |
| 1972 | 19,498 | 18,698 (21,000) | 38,196 | 11,638 (6,000) | 2,930 (2,500) | 9,296 | 256 (others = 500) | 100 | | | 62,416 | 42,918 (30,000) |
| 1973 | 16,400 | 5,201 (19,750) | 21,601 | 5,040 (4,000) | 876 (1,000) | 5,284 | 69 (others = 250) | 11 | | 378 | 33,259 | 16,859 (25,000) |
| 1974 | 19,142 | 10,233 (16,750) | 29,376 | 4,045 (6,000) | 2,384 (1,000) | 1,008 (1,000) | (others = 250) | 103 | | | 36,916 | 17,773 (25,000) |
| 1975 | | (10,750) | | (4,200) | ( 500) | ( 500) | (others = 50) | | | | | (16,000) |

Table 23(a). Maine herring catch (millions of fish)

| Year | AGE 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 85.77 | 1,446.91 | 200.37 | | | | | | | 1,733.05 |
| 1961 | 229.20 | 386.97 | 39.51 | | | | | | | 655.68 |
| 1962 | 51.94 | 2,238.35 | 37.51 | | | | | | | 2,327.80 |
| 1963 | 73.68 | 771.76 | 497.91 | | | | | | | 1,343.35 |
| 1964 | 97.93 | 474.88 | 32.30 | 22.70 | 0.98 | | | | | 628.79 |
| 1965 | 40.93 | 932.85 | 57.81 | 2.41 | 4.19 | | | | | 1,038.19 |
| 1966 | 20.99 | 291.65 | 208.52 | 2.23 | 10.06 | 1.25 | 0.36 | 0.18 | | 535.24 |
| 1967 | 21.47 | 268.07 | 122.08 | 33.74 | 17.73 | 3.48 | | | 1.81 | 468.38 |
| 1968 | 7.76 | 877.34 | 151.58 | 5.58 | 2.03 | | 0.13 | | | 1,044.41 |
| 1969 | 5.65 | 216.58 | 249.01 | 11.45 | 0.64 | 0.48 | 0.32 | 0.16 | 0.16 | 484.45 |
| 1970 | 1.94 | 183.09 | 45.24 | 17.16 | 8.42 | 3.44 | 1.65 | 1.57 | 0.47 | 262.95 |
| 1971 | 108.98 | 61.89 | 17.69 | 20.98 | 7.75 | 1.61 | 0.48 | 0.44 | 0.26 | 220.06 |
| 1972 | 0.18 | 338.87 | 7.05 | 3.08 | 1.22 | 1.36 | 0.88 | | | 352.64 |
| 1973 | 10.59 | 154.91 | 72.42 | 1.12 | .77 | .38 | .49 | .17 | .19 | 241.46 |
| 1974 | 30.45 | 174.91 | 52.59 | 20.84 | 1.16 | 0.31 | .04 | | | 280.30 |

Table 23(b). Maine herring catch (metric tons)

| Year | AGE 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 950 | 37,864 | 20,534 | | | | | | | 59,348 |
| 1961 | 2,703 | 14,575 | 6,853 | | | | | | | 24,131 |
| 1962 | 624 | 64,520 | 4,232 | | | | | | | 69,376 |
| 1963 | 736 | 17,928 | 48,232 | | | | | | | 66,895 |
| 1964 | 1,210 | 16,645 | 4,023 | 4,155 | 263 | | | | | 26,295 |
| 1965 | 449 | 24,676 | 5,872 | 353 | 738 | | | | | 32,088 |
| 1966 | 174 | 6,330 | 18,452 | 275 | 648 | 199 | 75 | 25 | | 26,178 |
| 1967 | 225 | 6,635 | 14,575 | 5,819 | 113 | 698 | --- | --- | 424 | 28,490 |
| 1968 | 80 | 21,037 | 7,932 | 744 | 376 | --- | 36 | --- | --- | 30,205 |
| 1969 | 72 | 6,702 | 15,909 | 883 | 72 | 95 | 72 | 24 | 24 | 23,852 |
| 1970 | 294 | 6,258 | 4,422 | 2,672 | 531 | 726 | 294 | 265 | 118 | 15,581 |
| 1971 | 1,909 | 2,838 | 1,731 | 3,388 | 1,793 | 409 | 127 | 126 | 86 | 12,407 |
| 1972 | 3 | 17,360 | 833 | 492 | 242 | 318 | 264 | | | 19,513 |
| 1973 | 164 | 8,100 | 7,456 | 193 | 164 | 80 | 121 | 55 | 65 | 16,400 |
| 1974 | 486 | 9,074 | 5,489 | 3,779 | 230 | 75 | 9 | | | 19,143 |

Table 24. Herring catches from Div. 5Y adult fishery by age group, 1967-74.

| Year | Stock size (millions) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9+ | Age 3 and older Number ($10^6$) | Age 3 and older Weight (000t) | Age 4 and older Number ($10^6$) | Age 4 and older Weight (000t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 257 | 199 | 179 | 169 | 164 | 93 | 19 | 9 | - | 832 | 192 | 633 | 147 |
| 1968 | 326 | 228 | 163 | 144 | 132 | 122 | 69 | 15 | 7 | 880 | 190 | 652 | 145 |
| 1969 | 181 | 267 | 171 | 117 | 91 | 81 | 75 | 40 | 13 | 855 | 196 | 588 | 149 |
| 1970 | 138 | 147 | 183 | 134 | 87 | 55 | 43 | 42 | 28 | 719 | 163 | 572 | 130 |
| 1971 | 78 | 110 | 112 | 126 | 94 | 47 | 21 | 14 | 16 | 540 | 115 | 430 | 95 |
| 1972 | 674 | 64 | 69 | 71 | 73 | 44 | 15 | 3 | 3 | 342 | 80 | 278 | 60 |
| 1973 | 80 | 533 | 37 | 23 | 23 | 22 | 11 | 4 | 2 | 655 | 147 | 122 | 30 |
| 1974 | - | 64[1] | 420 | 25 | 10 | 7 | 6 | 3 | 2 | 537 | 95 | 473 | 85 |
| 1975[2] | - | 64[1] | 39 | 287 | 14 | 3 | 3 | 2 | 2 | 414 | 86 | 350 | 76 |

| Year | Catch in numbers (000's) by age group 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9+ | Total Number (000s) | Total Weight (tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 21 | 317 | 2953 | 7410 | 13366 | 8197 | 565 | 343 | 493 | 33665 | 7807 |
| 1968 | 564 | 17734 | 17467 | 29458 | 29280 | 27974 | 18387 | 3166 | 4372 | 148402 | 31900 |
| 1969 | 1722 | 39044 | 6192 | 9850 | 22476 | 26618 | 21124 | 11028 | 4289 | 142343 | 32406 |
| 1970 | 3419 | 9327 | 26370 | 18350 | 26835 | 26943 | 23344 | 27993 | 16440 | 179021 | 40187 |
| 1971 | 634 | 23129 | 22676 | 33979 | 36750 | 26335 | 16011 | 11020 | 10588 | 181122 | 38575 |
| 1972 | 21243 | 16992 | 37487 | 39758 | 42449 | 27493 | 9347 | 1434 | 2072 | 199375 | 42646 |
| 1973 | 2226 | 18594 | 5701 | 10437 | 13182 | 13645 | 7293 | 2116 | 653 | 73847 | 16200 |
| 1974 | 3979 | 14950 | 62821 | 7224 | 5094 | 3568 | 2991 | 1436 | 1149 | 103212 | 17774 |

| Year | Fishing mortality 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean F[3] (age 3 and older) |
|---|---|---|---|---|---|---|---|---|---|
| 1967 | - | .002 | .018 | .050 | .094 | .102 | .034 | .045 | .046 |
| 1968 | .002 | .089 | .126 | .254 | .280 | .290 | .346 | .267 | .202 |
| 1969 | .011 | .175 | .041 | .097 | .314 | .443 | .372 | .361 | .204 |
| 1970 | .028 | .073 | .172 | .163 | .411 | .770 | .900 | 1.266 | .325 |
| 1971 | .009 | .263 | .252 | .349 | .562 | .928 | 1.766 | 1.775 | .481 |
| 1972 | .035 | .348 | .890 | .933 | .998 | 1.146 | 1.084 | .773 | .853 |
| 1973 | .030 | .039 | .187 | .672 | .979 | 1.114 | 1.187 | .784 | .162 |
| 1974 | - | .300 | .180 | .382 | .844 | .800 | .800 | .800 | .234 |

[1] Recruitment assumed equal to 1969 year-class at age 3.

[2] Stock size calculated from $N_{i+1} = N_{ie}^{-Zi}$.

[3] Average F's weighted over year-class by stock size in number.

Table 25. Resultant stock sizes (age 4 and older) in 1977 as a function of catches (age 3 and older) for the Div. 5Y adult herring fishery assuming that the 1970 year-class at age 3 is 200% of the 1966 year-class at age, the 1972 year-class equals the 1971 and 1969 year-classes at age 3 (63.5 millions) and for two assumptions on the size of the 1973 year-class at age 3.

| Stock size at start of 1975 (age 4 and older) million | 000 tons | Total catch in 1975 (000 tons) | Stock size at start of 1975 (age 4 and older) million | 000 tons | $F_{100\%}$ in 1976 | Catch in 1976 (000 tons) | Stock size in 1977 (age 4 and older) (000 tons) |
|---|---|---|---|---|---|---|---|
| | | | | | 1973 year-class = 63.5 million | | |
| | | | | | .2 | 8.9 | 59.8 |
| | | | | | .4 | 16.5 | 52.0 |
| | | | | | .6 | 23.1 | 45.3 |
| | | | | | .8 | 28.7 | 39.7 |
| 350 | 76 | 15 | 276.3 | 63.6 | | | |
| | | | | | 1973 year-class = 150 million | | |
| | | | | | .2 | 9.3 | 72.1 |
| | | | | | .4 | 17.4 | 63.9 |
| | | | | | .5 | 21.0 | 60.0 |
| | | | | | .6 | 24.3 | 56.8 |
| | | | | | .8 | 30.3 | 50.8 |

Table 26. Catch of herring (tons) in Div. 5Z and SA 6, with national allocations in parentheses.

| Year | USA | Canada | Germany FR | German DR | USSR | Poland | Japan | Bulgaria | France | Iceland | Norway | Romania | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | | | | | | | | | | | | | | |
| 1961 | 105 | | | | 67,550 | | | | | | | | | 67,655 |
| 1962 | 101 | | | | 151,864 | 277 | | | | | | | | 152,242 |
| 1963 | 322 | | | | 97,646 | | | | | | | | | 97,968 |
| 1964 | 489 | | | | 130,914 | 35 | | | | | | | | 131,438 |
| 1965 | 1,191 | | | | 38,262 | 1,447 | | | | | | 1,982 | | 42,882 |
| 1966 | 4,308 | | | 1,133 | 120,113 | 14,473 | | | | | | 2,677 | | 142,704 |
| 1967 | 1,211 | 1,306 | 28,171 | 22,159 | 126,759 | 37,677 | 40 | | | | | 1,420 | | 218,743 |
| 1968 | 758 | 13,674 | 71,086 | 67,719 | 143,097 | 75,080 | 171 | | | 292 | | 1,656 | 65 | 373,598 |
| 1969 | 3,678 | 945 | 61,990 | 44,624 | 138,673 | 45,021 | 583 | 812 | | 12,786 | 1,224 | 337 | 85 | 310,758 |
| 1970 | 2,011 | 7 | 82,498 | 28,063 | 61,579 | 70,691 | 1,412 | 348 | | | | 685 | | 247,294 |
| 1971 | 3,822 | 12,863 | 54,744 | 18,447 | 81,258 | 88,325 | 2,466 | 4,551 | | | | 898 | | 267,374 |
| 1972 | 2,782 (4,000) | 53 (5,800) | 27,703 (31,600) | 40,016 | 48,072 (48,200) | 49,392 (49,400) | 1,161 (1,200) | 2,355 | 500 | | | 2,156 (600) | (8,200) | 174,190 (150,000) |
| 1973 | 4,627 (5,250) | 5,082 (5,050) | 31,502 (31,600) | 53,326 | 52,340 (48,200) | 49,275 (49,400) | 1,249 (1,200) | 1,380 | 1,180 | | | 297 (1,300) | (8,000) | 200,258 (150,000) |
| 1974 | 3,312 (6,955) | 217 (2,980) | 21,933 (23,900) | 31,530 (31,440) | 41,710 (41,725) | 39,312 (39,000) | 2,433 | 1,773 | 1,935 | | | 2,009 | (4,000) | 146,164 (150,000) |
| 1975 | (8,400) | (3,000) | (23,750) | (31,150) | (41,400) | (38,400) | | | | | | | (4,200) | |

Table 27. Stock size and catch (millions) and fishing mortality for Georges Bank herring stock (Div. 5Z+SA 6), 1965-1974.

| Year | Numbers (millions) by age group | | | | | | | | Age 3 and older | | Age 4 and older | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock | 2 | 3 | 4 | 5 | 6 | 7 | 8 | >8 | Number | Weight | Number | Weight |
| 1965 | 2241 | 1576 | 2335 | 2409 | 355 | 77 | 46 | | 6798 | 1352 | 5222 | 1101 |
| 1966 | 1490 | 1834 | 1281 | 1880 | 1879 | 268 | 51 | 51 | 7244 | 1468 | 5410 | 1187 |
| 1967 | 1758 | 1220 | 1490 | 1017 | 1378 | 1285 | 160 | 44 | 6594 | 1603 | 5374 | 1391 |
| 1968 | 1863 | 1438 | 993 | 1165 | 735 | 902 | 709 | 138 | 6080 | 1514 | 4642 | 1263 |
| 1969 | 1172 | 1523 | 1130 | 748 | 650 | 391 | 347 | 276 | 5065 | 1171 | 3542 | 912 |
| 1970 | 835 | 959 | 1206 | 735 | 361 | 281 | 149 | 111 | 3802 | 801 | 2843 | 647 |
| 1971 | 771 | 672 | 672 | 580 | 357 | 185 | 146 | 76 | 2688 | 555 | 2016 | 452 |
| 1972 | 3942 | 619 | 250 | 301 | 217 | 133 | 58 | 73 | 1651 | 403 | 1032 | 289 |
| 1973 | 682 | 3202 | 476 | 105 | 53 | 35 | 18 | 6 | 3895 | 541 | 693 | 118 |
| 1974 | | 550[1] | 1693 | 149 | 28 | 13 | 8 | 4 | 2445 | 480 | 1895 | 386 |
| 1975[2] | | 550[1] | 414 | 841 | 60 | 11 | 5 | 5 | 1886 | 389 | 1336 | 298 |

| | | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Catch | | | | | | | | | Number | Weight |
| 1964 | 16.5 | 150.8 | 230.5 | 128.4 | 97.5 | 34.9 | | | 658.6 | 131.0 |
| 1965 | 0.4 | 10.3 | 34.9 | 103.0 | 25.5 | 12.7 | 9.3 | | 200.3 | 40.6 |
| 1966 | 0.3 | 12.8 | 34.6 | 178.0 | 280.1 | 65.1 | 13.6 | 2.0 | 587.1 | 142.7 |
| 1967 | 1.8 | 6.9 | 60.6 | 108.0 | 250.7 | 379.2 | 49.4 | 21.3 | 877.9 | 218.6 |
| 1968 | 2.5 | 52.1 | 72.0 | 336.0 | 233.4 | 432.9 | 336.6 | 28.4 | 1493.9 | 373.4 |
| 1969 | | 45.5 | 210.8 | 277.1 | 278.1 | 188.5 | 190.5 | 133.3 | 1323.8 | 306.0 |
| 1970 | 12.6 | 125.4 | 450.5 | 270.3 | 122.3 | 92.9 | 51.6 | 47.3 | 1172.9 | 247.0 |
| 1971 | 12.9 | 332.5 | 275.5 | 284.6 | 175.8 | 103.9 | 50.4 | 35.7 | 1271.3 | 262.5 |
| 1972 | 28.0 | 35.0 | 110.0 | 214.0 | 158.0 | 100.0 | 45.0 | 50.0 | 712.0 | 174.0 |
| 1973 | 10.0 | 1026.0 | 266.0 | 64.0 | 33.0 | 23.0 | 12.0 | 8.0 | 1432.0 | 199.0 |
| 1974 | 1.9 | 39.9 | 608.9 | 68.6 | 12.9 | 6.1 | 3.5 | 2.1 | 743.9 | 146.2 |

| | | | | Fishing mortality | | | | | Mean F[3] (Age 3+) |
|---|---|---|---|---|---|---|---|---|---|
| 1964 | 0.009 | 0.057 | 0.08 | 0.28 | 0.77 | 0.52 | | | 0.19 |
| 1965 | <0.001 | 0.007 | 0.02 | 0.05 | 0.08 | 0.20 | 0.25 | | 0.05 |
| 1966 | <0.001 | 0.008 | 0.03 | 0.11 | 0.18 | 0.31 | 0.35 | (0.7) | 0.10 |
| 1967 | 0.001 | 0.006 | 0.05 | 0.12 | 0.22 | 0.39 | 0.42 | (0.7) | 0.16 |
| 1968 | 0.002 | 0.041 | 0.08 | 0.38 | 0.43 | 0.76 | 0.74 | (0.7) | 0.36 |
| 1969 | 0.000 | 0.034 | 0.23 | 0.53 | 0.64 | 0.76 | 0.94 | (0.7) | 0.37 |
| 1970 | 0.017 | 0.156 | 0.53 | 0.52 | 0.47 | 0.46 | 0.48 | (0.7) | 0.42 |
| 1971 | 0.019 | 0.791 | 0.60 | 0.78 | 0.79 | 0.97 | 0.48 | (0.7) | 0.78 |
| 1972 | 0.008 | 0.065 | 0.67 | 1.54 | 1.63 | 1.78 | 1.98 | (0.7) | 0.87 |
| 1973 | 0.016 | 0.437 | 0.96 | 1.12 | 1.18 | 1.32 | 1.27 | (0.7) | 0.54 |
| 1974 | | 0.083 | 0.50 | 0.70 | 0.70 | 0.70 | 0.70 | (0.7) | 0.42 |

[1] Recrutiment at age 3 assumed as in the previous assessment (*Redbook* 1974, p. 112).

[2] Stock size calculated from $N_{i+1} = N_{ie}^{-zi}$.

[3] Average F's weighted over year-classes by stock size in number.

Table 28. Georges Bank herring stock (Div. 5Z and Statistical Area 6) 1977 stock size as a function of 1976 catch for two assumed levels of the 1973 year-class and for a range of fishing mortalities in 1976.

| Stock size at start of 1975 (age 4 and older) | | Total catch in 1975 | Stock size at start of 1976 (age 4 and older) | | $F_{100\%}$ in 1976 | Catch in 1976 | Stock size at start of 1977 (age 4 and older) |
|---|---|---|---|---|---|---|---|
| ($10^6$) | (000t) | (000t) | ($10^6$) | (000t) | | (000t) | (000t) |
| | | | | | 1973 year-class = 550 million | | |
| | | | | | .20 | 34 | 254 |
| | | | | | .38 | 60 | 225 |
| | | | | | .60 | 87 | 200 |
| | | | | | .70 | 96 | 188 |
| | | | | | 1.00 | 125 | 161 |
| | | | | | 1.26 | 142 | 142 |
| | | | | | 1.35 | 150 | 137 |
| 1337 | 298 | 150 | 948 | 217 | | | |
| | | | | | 1973 year-class = 800 million | | |
| | | | | | .20 | 35 | 293 |
| | | | | | .38 | 61 | 265 |
| | | | | | .60 | 89 | 236 |
| | | | | | .70 | 100 | 225 |
| | | | | | 1.00 | 129 | 196 |
| | | | | | 1.26 | 150 | 176 |
| | | | | | 1.35 | 156 | 170 |

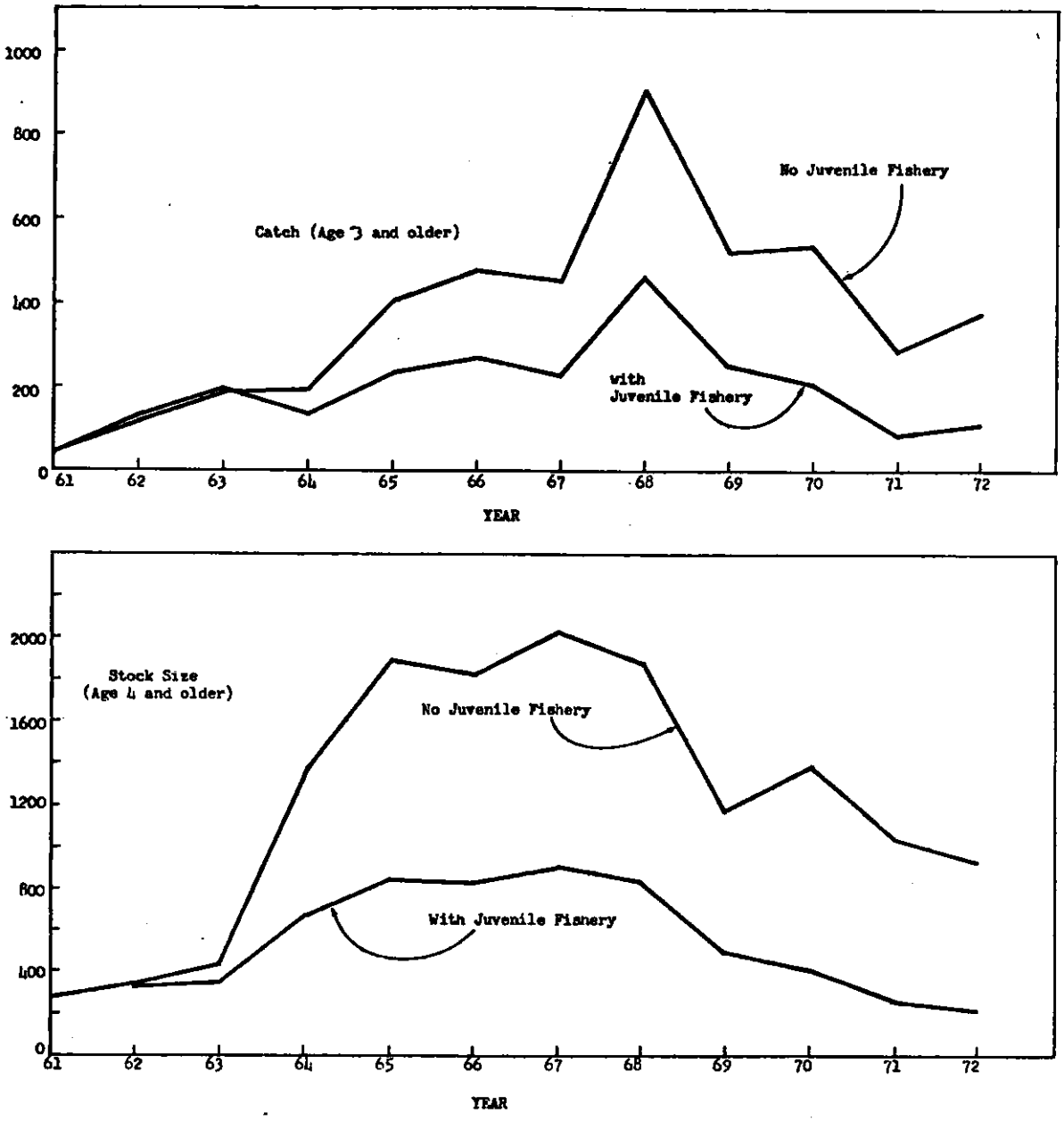


Fig. 1. Catch and stock size for herring in Div. 4X(b), Subarea 5 and Stat. Area 6 combined with and without a juvenile fishery.

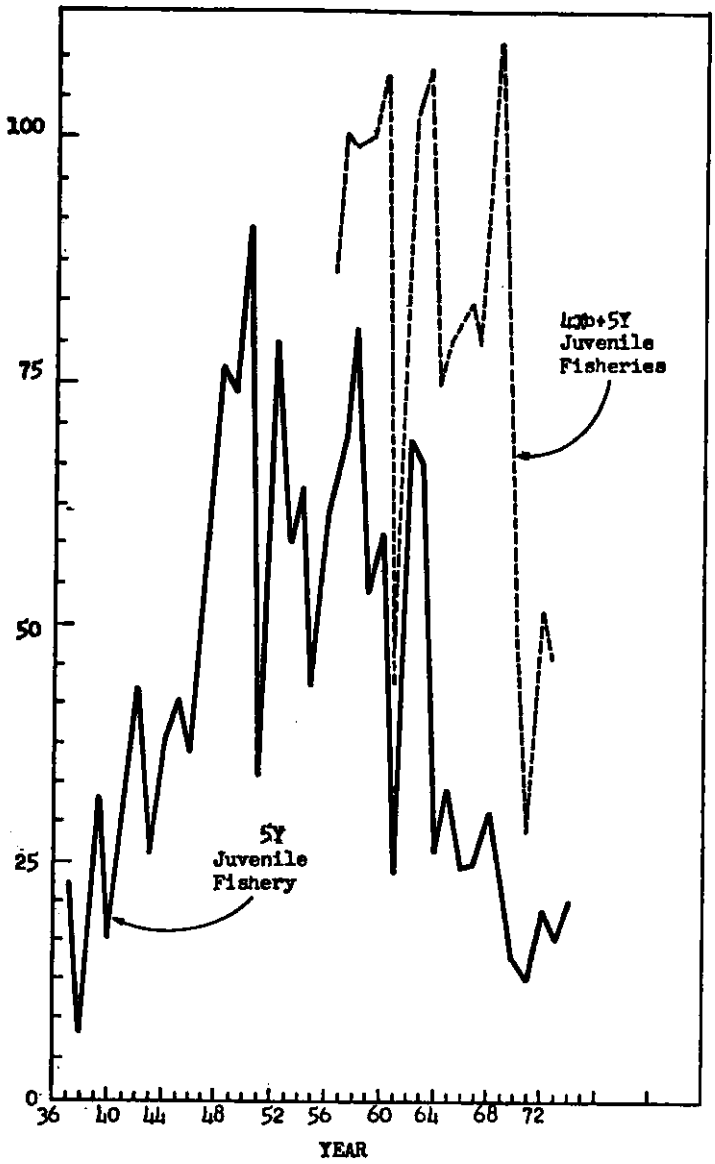


Fig. 2. Catches of herring from juvenile fisheries in Div. 4X(b) and 5Y.

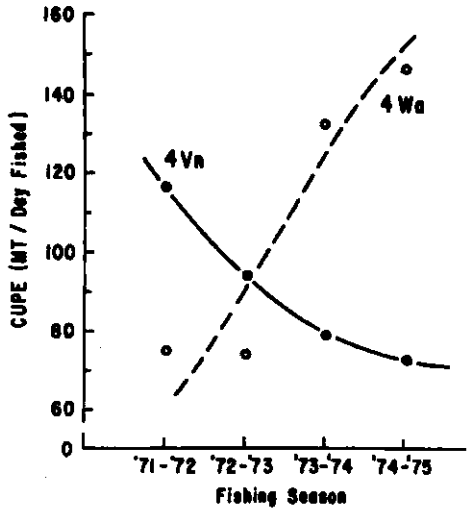


Fig. 3. Mean yearly Canadian catch per unit effort values for Subdiv. 4Vn and Div. 4W(a) fisheries for the seasons 1971-72 to 1974-75.

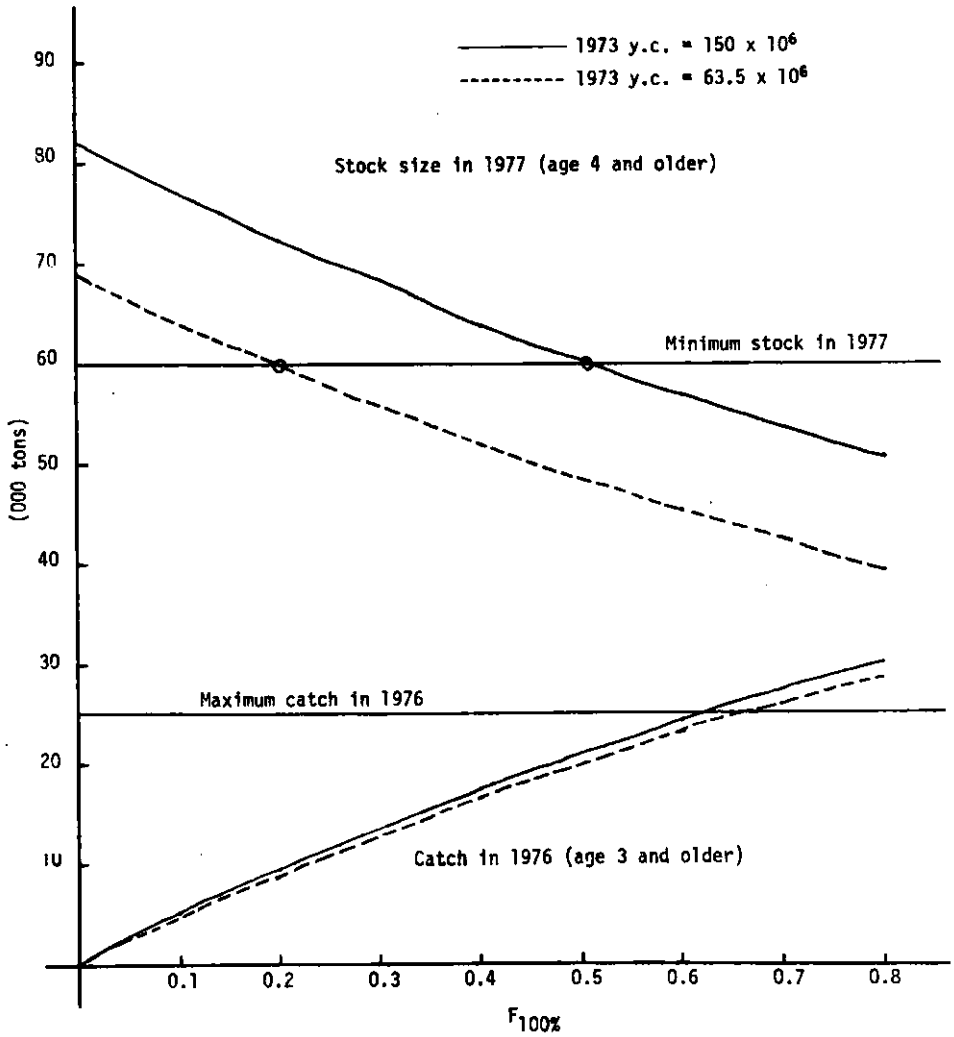


Fig. 4. Predicted Herring catches in 1976 and resulting stock size in 1977 for the Div. 5Y adult fishery for two levels of recruitment.

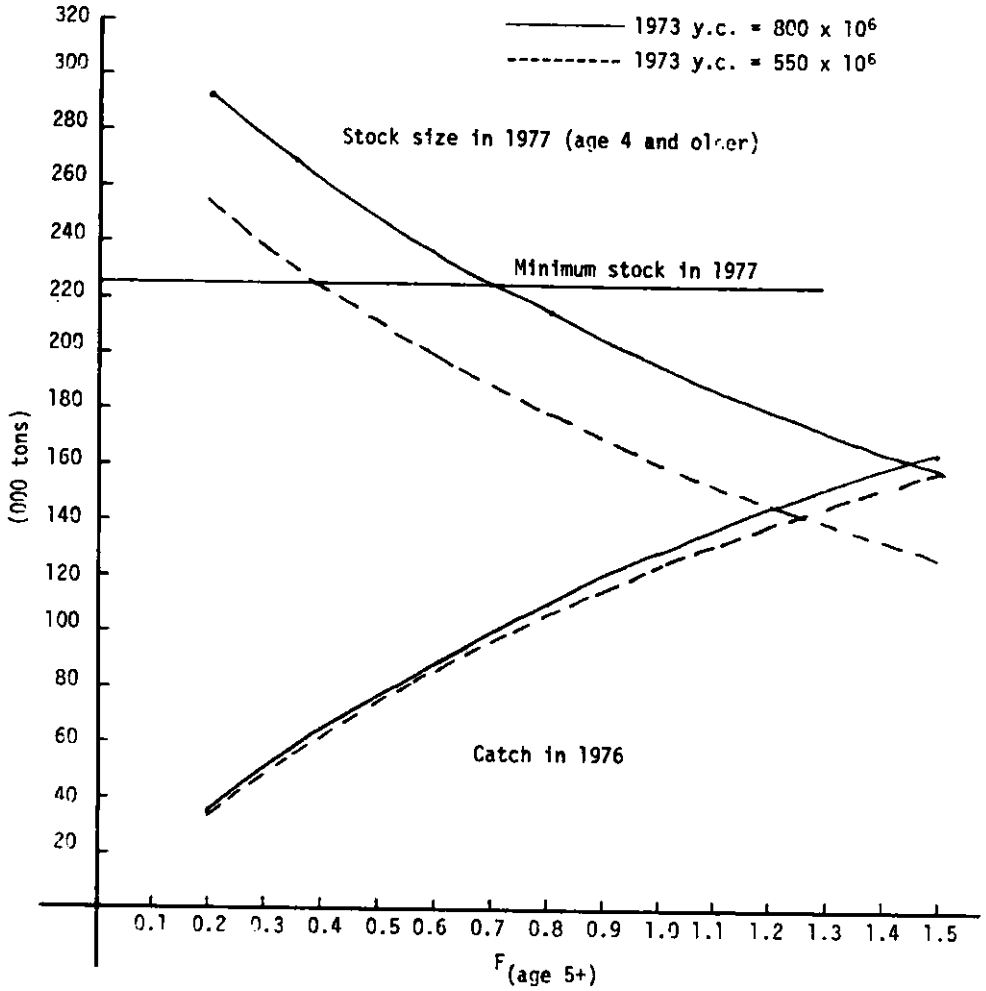


Fig. 5. Predicted herring catches in 1976 and resulting stock sizes in 1977 for the Div. 5Z + Stat. Area 6 fishery for two levels of recruitment.

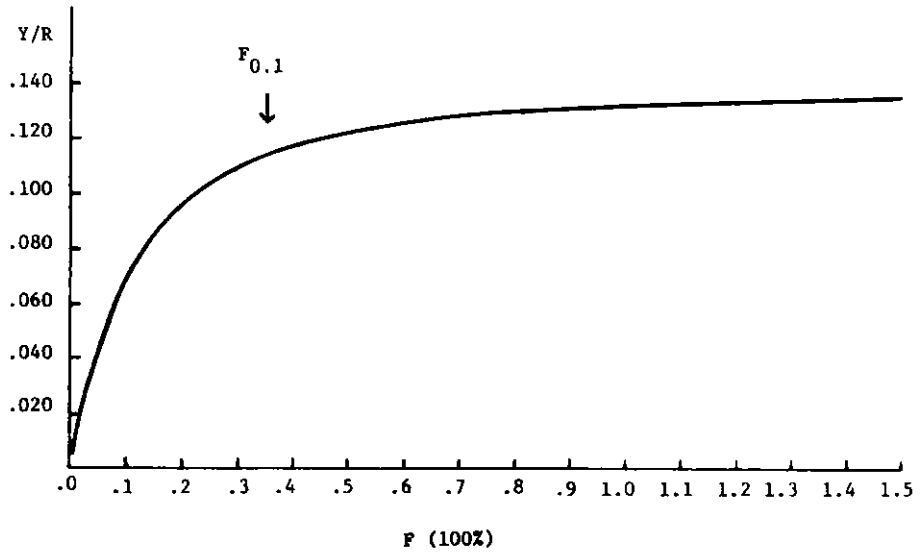


Fig. 6. Herring in Div. 5Z and Stat. Area 6: yield per recruit curve based on parameters used in the assessment.