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# Assessment of the Eastern Scotian Shelf (4VW) Haddock Stock

by

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## INTRODUCTION

The Scotian Shelf haddock stocks are divided into two groups: the ICNAF Divison 4VW and 4X stocks (McCracken 1963). Between 1960 and 1975, the eastern Scotian Shelf haddock stock (4VW), was exploited primarily by the Canadian, Spanish, and Soviet fleets. Prior to 1965, this stock was fished at levels from 13,000 tons to 34,000 tons averaging 27,000 tons. In 1965 the total fleet reported a large haddock catch of 55,000 tons which was twice that of the pre 1965 average of 27,000 tons (Fig. 1). Canadian catches accounted for 8,700 t of this total, while the USSR caught 43,000 t. After this, the fishery decreased to yearly levels from one-half to one-eighth of those prior to 1965. This decrease continued until 1977 when the catches began an upswing under stringently low TACs.

The Canadian domestic fishery for 4VW haddock was exploited by large trawlers (TC 4 and 5), long-lines, traps, and hand-lines. Those fisheries conducted by the USA, USSR, and Spain, used trawlers ranging in size from TC 4 to 7. Spain used primarily pair trawlers while the USA and USSR employed both side and stern trawlers.

Peak catches by Canada occurred in 4W during late winter and early spring (Figure 2). Both the USSR and Spanish fleets fished during the summer and early fall in 4W and 4VW respectively.

Most foreign catches of haddock were a by-catch to some other species. The USSR haddock catch was almost exclusively a by-catch of the small mesh silver hake fishery with the possible exception of the 1964 to 1966 fisheries. Spanish vessels caught haddock as a by-catch in their cod fishery. The Spanish cod fishery persisted until 1975, while the USSR continues to fish for silver hake today, although within a rather restricted area.

For the years 1963 - 1966, the USSR concentrated its fishery on Middle Ground and the southern tips of Banquereau and Sable Island Banks (Clay 1979). Both Scott (1979) and Hare (1977) indicate that the latter area is one which has a high concentration of haddock.

## POSSIBLE IMPACT OF SMALL MESH FISHERIES ON 4VW HADDOCK

Halliday (1971) suggests that the selectivity of the 40 mm nets used in the Soviet silver hake fishery would be similar to that used on Canadian research vessels (32 mm). Data reported to ICNAF suggest that 67% of the 1965 USSR haddock catch was obtained in a directed silver hake fishery. Also, the catch of haddock for the directed silver hake fishery was reported to be 41% of the silver hake catch by weight. Such data suggests that these two fisheries were being conducted simultaneously.

The USSR fishing patterns reported by Clay (1979) indicate that the USSR fished the same areas from 1963 - 1965, yet the by-catch in 1963 and 1964 was well below the 1965 level (3 - 7% compared to 41%). Therefore, it is highly unlikely that the USSR would have equipped its vessels with 114 mm nets in order to direct a fishery toward haddock for only one year. The most plausible scenario would be that the USSR small meshed fishery was capitalizing on the large 1962 and 1963 year-classes of haddock (Table 1).

Further adjustment to reported catches for the USSR were calculated from data collected during the 1977 and 1978 Observer Programs. Comparison of reported by-catch of haddock in the 1977 USSR silver hake fishery (0.1%) to that actually observed (1.0%) demonstrates that the USSR could have under reported its catch by 111 tons (Waldron 1978). Similar results were observed in 1978 where it was estimated that the USSR may have under reported its haddock catch by at least 246 tons (Table 2) (Waldron 1979). These quantities, although small in relation to the total 4VW haddock catch, are nonetheless important since they represent predominantly 1 and 2 year-old haddock (Table 3).

These adjustments are likely to be underestimates of the actual events since the current silver hake fishery has been restricted to an area south of Sable Island. Experiments to evaluate the placement of this line were conducted in both 1977 and 1978. Both the USSR and Cuba suggested the studies would benefit directly by not only removing restriction on where the vessels could fish but also elminating the 1% by-catch regulation for cod and haddock. The results may have been biased with fleet commanders attempting to minimize the amount of by-catch, yet they do demonstrate that by-catches of haddock in a directed silver hake fishery on the Shelf, ranging from between 1.1 and 3.7%, were higher than those observed in areas near the slopes which ranged from .5 to 2% (Waldron 1979). These observations would increase again the total haddock catch in small-meshed fisheries from those estimated.

## RESEARCH VESSEL SURVEYS

Random stratified surveys of the Scotian Shelf have been conducted since 1970 during July and August. The estimated 4VW haddock biomass has varied from a low of 9,000 tons to a high of 69,500 tons. Generally there has been an increasing trend since 1974, with 1978 and 1979 estimates being 69,500 tons and 69,400 tons respectively (Fig. 3). The decrease in numbers reported for 1979 is primarily due to the conspicuous absence of the 1978 year-class (Table 4).

The 1979 survey also suggests that the 1979 year-class is the largest in the history of these surveys. Although there are subsequent cruises in 1979, the data are not yet available to corroborate these observations.

## EFFORT STANDARDIZATION

The most consistent effort series was that of Maritime-based TC 4 vessels. Directed CPUE and total catch of OTB 1 and 2 from February to June were obtained from ICNAF statistics. Catch per unit of effort for tonnage classes 3 to 5 were standardized to 1966 (Table 5). These indices were weighted to the total OTB catches for that year. The final effort index was obtained by dividing the total catch of all fisheries by the weighted CPUE index.

In some years the Maritimes-based vessels caught less than 30% of the reported catch, both Spain and the USSR reported most catches of haddock as by-catches of either a directed cod or silver hake fishery. In recent years, the offshore catch of haddock has decreased by all gears. The percentage removed by OTB and long-lines has remained fairly consistent, except during the period 1974-1977 when long-lines increased their take. The effort series is affected both by the low percentage of total removals and the fact that the CPUE index is based on only part of the population supporting the fishery i.e. older age groups (see below). Thus it is not likely that this effort series will reflect total effective effort in the fishery.

## REMOVALS AT AGE

Historically, there have been three major fishing fleets operating in the 4VW haddock fishery. The Spanish and Canadian fisheries were required by regulations to utilize 114 mm gear until 1974 and 130 mm through to present, while it is speculated that the USSR utilized 40 mm gear (Halliday, 1971). Removals at age for all countries except the USSR were calculated from Canadian commercial age length keys (Table 6).

The high catches of haddock by the USSR in 1965 were unsampled. The only USSR samples reported to ICNAF were from 1966 and consisted of three age, and 14 length frequency, samples. USSR removals for 1960, 1965, 1967, 1969, and 1970-76 were calculated from Canadian research

vessel cruises which used mesh sizes of approximately 35 mm. The years 1961-64 were extrapolated from the 1960 Canadian research vessel cruise, while 1968 used the average of the 1967 and 1969 research cruises. Removals at age for 1977 and 1978 were obtained from Canadian sampling onboard USSR vessels.

Comparison of 1977 Canadian research and observed estimates of Soviet removals at age showed similar results, estimates of both indicating full recruitment at age 2 (Table 7). Age 0 fish caught by the Canadian research vessel were not observed in USSR vessel catches. This should not necessarily be interpreted as implying that the USSR did not catch 0 group fish but, rather, it could represent sampling variation. In order to avoid bias in population estimates, age 0 fish are not included in the cohort analysis. The removals at age matrix used in the cohort analysis (Table 8) is the summation of USSR removals (Table 3) and other countries' removals (Table 6).

## STOCK ASSESSMENT

Partial recruitment - An initial partial recruitment vector was derived from a relationship between commercial fishery removals-at-age and research vessel estimates of population numbers-at-age in 1979. Research vessel numbers at ages 1, 2 and 3 for 1979 were adjusted to compensate for partial recruitment to the survey gear relative to age 4 (Tables 9a to 9b). The resultant numbers-at-age were divided into the commercial numbers-at-age and plotted against age in order to obtain the initial partial recruitment (Table 10). Full recruitment occurred at age 6 and partial recruitments for earlier ages were read from the curve. These were used during the initial runs of the cohorts. A partial recruitment of 0.040 .050 .178 .550 .673 1.0 1.0 1.0 1.0 1.0 1.0 for ages 1-11 was finally utilized as this gives a high correlation ($r = 0.97$) between numbers at age 1 from the cohort and numbers at age 1+2 in research vessel surveys.

Fishing Mortalities - Starting F's were calculated for each year from average Z values after full recruitment. The cohort began with a terminal F of 0.2 derived from an earlier assessment and M of 0.2. Effort calculated from the weighting of commercial CPUE did not give any statistically signifcant relationships with F. With the above partial recruitment and terminal F's, cohort runs were made to find the final F which gave the greatest GM correlation between estimates of age 3+ numbers from the cohort and research vessel surveys (Fig. 4). The best r(0.95) was obtained with an F of 0.1 (Table 11).

Recruitment - The geometric relationship between age 1, as calculated from the cohort analysis, and age 1 + 2 from research surveys gave an $r = 0.97$ (Fig. 5). The 1962-64 year-classes were the largest in the time period studied (Table 11). However, the assumptions involved in determining removals at age will have resulted in some smoothing over adjacent year-classes. From analogy with haddock stocks to the southwest of 4VW, it is likely that it was the 1963 year-class which was extraordinarily large. The 1962 year-class

was probably also above average strength, but neither it nor the 1964 year-class are likely to have been quite as strong in relation to the 1963 year-class as shown here. The 1965 to 1973 year-classes were extremely poor. However, the 1974-77 year-classes, which are responsible for the recent increase in population abundance are comparable in size to those of 1959-61.

For projection purposes the 1979 year-class size at age 1 was assumed to be equal in size to the geometric mean of age 1 numbers over the years 1970-78 i.e. 13.7 million fish.

## YIELD PER RECRUIT

Using mean weights at length obtained from research vessel cruises, with length at age in commercial catch sampling data, and using partial recruitments as derived for 1979, a Thompson-Bell yield analysis was run. This gave a maximum yield per recruit at age 1 of 0.630 kg at a fishing mortality of 0.60. $F_{0.1}$ was 0.31 and gave a yield per recruit of 0.585 kg. (Table 12).

## PROJECTION

The projected catch in 1980 at $F_{0.1}$ is 15,000 tons.

| Year | Population Age 1+ | | Catch | |
|---|---|---|---|---|
| | Numbers ($x10^{-6}$) | Biomass (tons) | Numbers ($x10^{-6}$) | Weight (tons) |
| 1979 | 99.8 | 93,000 | 2.3 | 3,000 |
| 1980 | 93.2 | 103,000 | 9.9 | 15,000 |

The marked improvement in the status of this stock is a result of the improved recruitment from the 1974 to 1977 year-classes. The sizes of these year-classes are comparable to the average year-class size in the late 1950's and early 1960's when the catch averaged about 27,000 tons.

It is clear from research vessel surveys that the 1978 year-class is poor. The 1979 year-class may be strong but a further year's data is required to establish this with any degree of confidence. The overall situation encourages the view that the stock is recovering and, within a few years, could be providing annual yields comparable to those produced in the 1950's.

## References

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1979. Preliminary results of a joint International Observer Prog. to evaluate the Silver hake small mesh gear line in ICNAF Division 4VWX. ICNAF Res. Doc. No. 5343, 79/11/17.

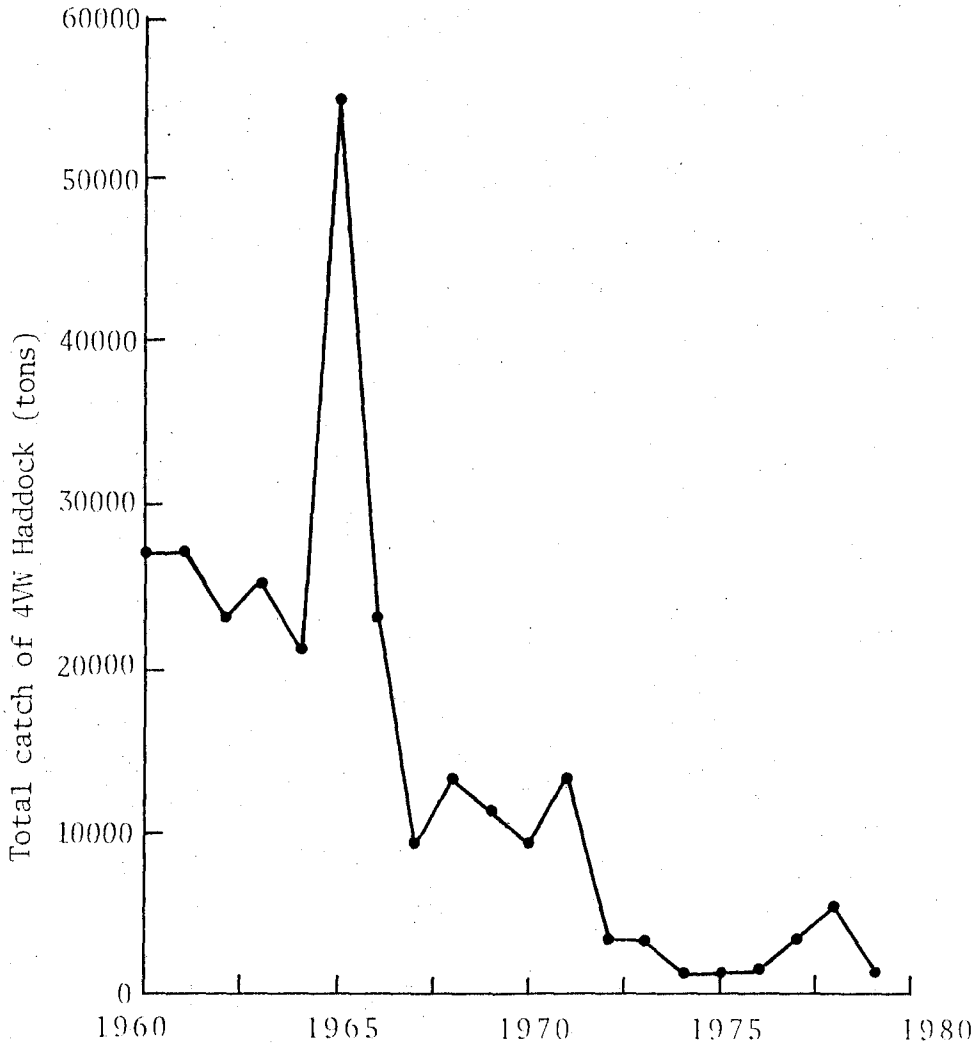


Figure 1. Plot of nominal catches of Div 4VW Haddock (tons). Nominal catches for 1978 and 1979 are preliminary.

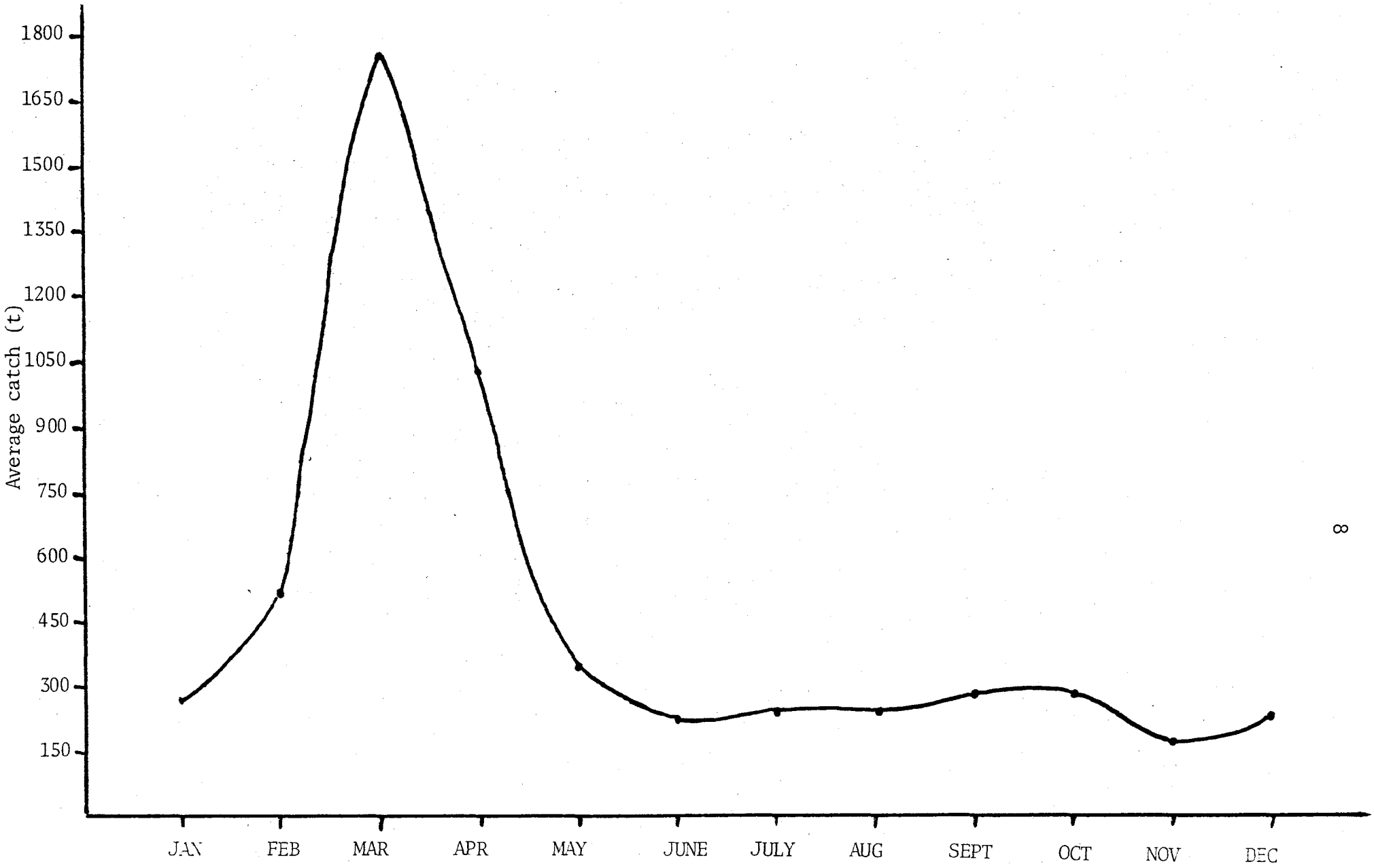


Fig:2 Average Monthly Catch of 4VW Haddock (1969-78) by Canada.

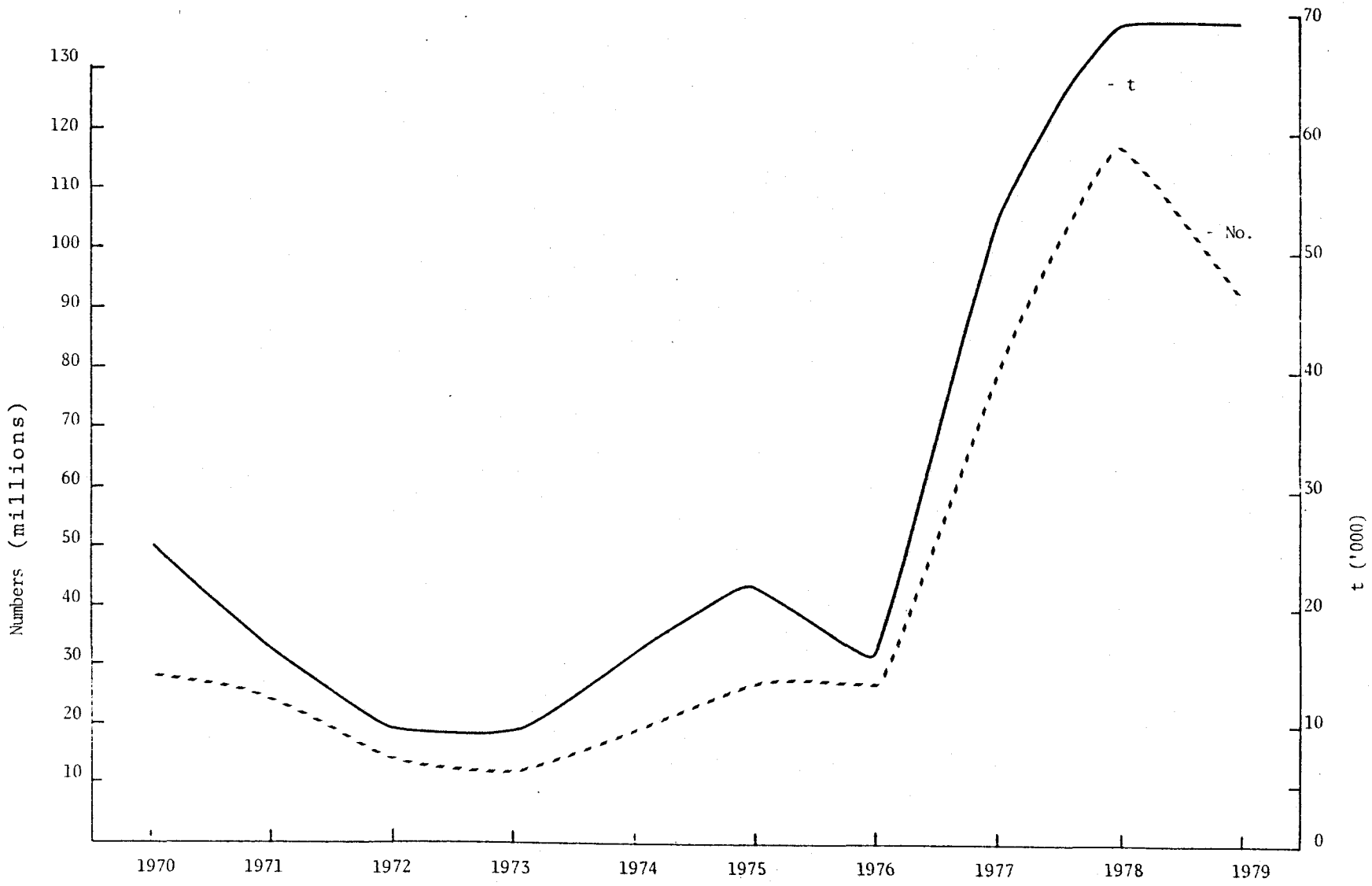


Figure 3. Research vessel estimate numbers and biomass (t) for 4VW Haddock.

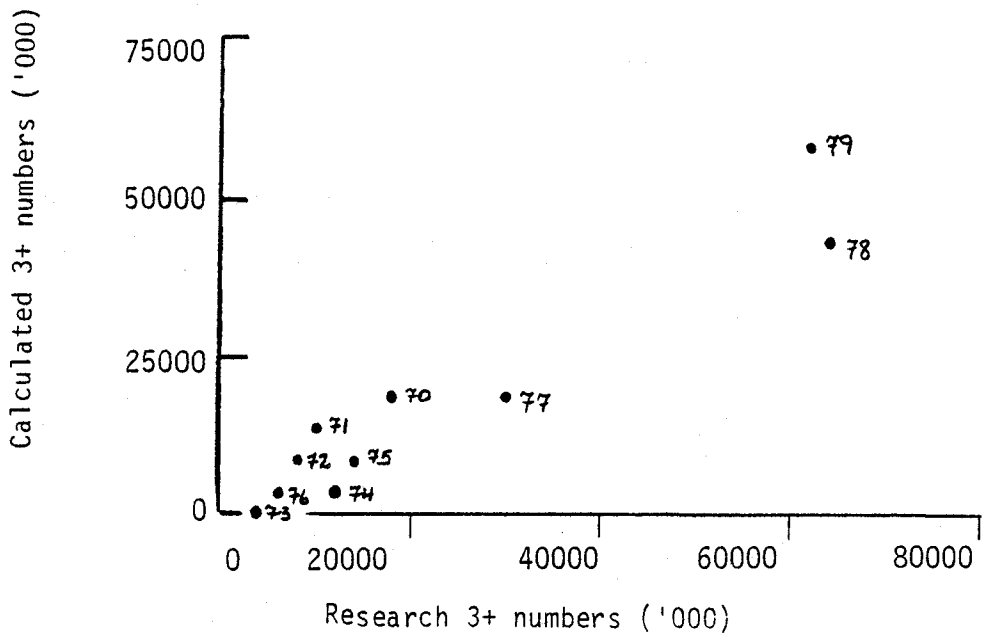


Figure 4. Calculated 3+ numbers ('000) against Research vessel 3+ numbers ('000) for the 4VW Haddock Stock. (r = 0.95)

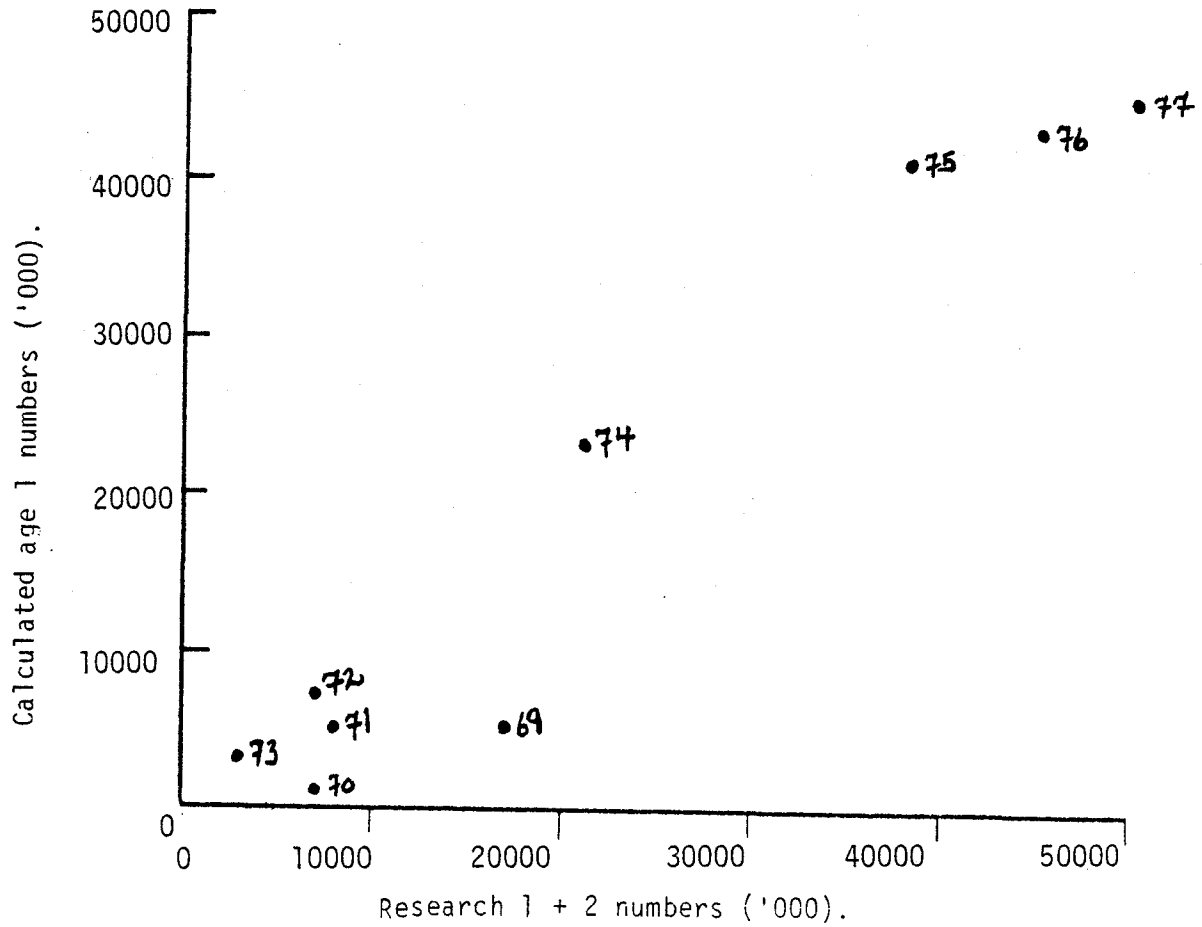


Figure 5. Calculated age 1 numbers ('000) against Research 1 + 2 numbers ('000) for the 4VW Haddock stock. (r = 0.97)

TABLE 1 USSR DIRECTED S. HAKE FISHERY (4VW) AND ASSOCIATED BYCATCHES (mt)

| YEAR / MONTH | 1960 | | | 1961 | | | 1962 | | | 1963 | | | 1964 | | | 1965 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod |
| January | | | | | | | | | | 7884 | 9 | 683 | 160 | 16 | 103 | | | |
| February | | | | | | | | | | 4101 | | 4 | 180 | 7 | 255 | | | |
| March | | | | | | | | | | 5860 | | 1630 | 1207 | 177 | 706 | 18 | | |
| April | | | | | | | 837 | 102 | 256 | 6763 | | 1182 | 3 | - | 3 | | | |
| May | | | | | | | | | | 38839 | 294 | 1256 | 29009 | 99 | 479 | 15577 | 148 | 507 |
| June | | | | | | | 1 | | 1 | 23946 | 434 | 1292 | 678 | 10 | 293 | 511 | 74 | 80 |
| July | | | | | | | | | | 2 | | | 13235 | 429 | 1317 | 14227 | 10997 | 593 |
| August | | | | | | | | | | 13040 | 246 | 619 | 19531 | 3618 | 3809 | 2848 | 2558 | 1030 |
| September | | | | | | | | | | 12564 | 493 | 891 | | | | | | |
| October | | | | | | | | | | 1750 | 1655 | 1021 | 1 | | | 27 | | |
| November | | | | | | | 4595 | 306 | - | 2403 | 602 | 858 | 67 | | 3 | | | |
| December | | | | | | | 4678 | 232 | - | 2764 | - | 165 | 23 | | | 650 | 165 | |
| Total Rpt Dir (other) | | | | | | | 9273 | 640 | 257 | 119936 | 3733 | 9601 | 64094 | 4256 | 6968 | 33858 | 13942 | 2107 |
| Total Reported | | | | | 151 | 113 | 8825 | 2567 | 2383 | 116388 | 3301 | 9505 | 62905 | 4391 | 7133 | 49644 | 42876 | 7856 |
| Yearly Ratio | | | | | | | 1.000 | 0.073 | 0.029 | 1.000 | .032 | .082 | 1.000 | 0.068 | 0.111 | 1.000 | 0.412 | 0.062 |

[2] Clay, 1979

| YEAR / MONTH | 1966 | | | 1967 | | | 1968 | | | 1969 | | | 1970 | | | 1971 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod |
| January | | | | | | | | | | 459 | 26 | 33 | | | | 3 | | |
| February | | | | | | | | | | 860 | 5 | 43 | 41 | | | 3246 | 26 | 51 |
| March | | | | | | | | | | 1363 | 76 | 44 | 4326 | 38 | 155 | 30817 | | |
| April | | | | | | | | | | 9079 | 7 | 108 | 16546 | | 605 | 19364 | 66 | 299 |
| May | | | | 58 | 12 | | 626 | 67 | 222 | 5035 | 5 | 55 | 17820 | 52 | 446 | 6746 | 68 | 423 |
| June | | | | 1746 | 13 | 917 | | | | | | | 17473 | 122 | 166 | 9186 | 64 | 1096 |
| July | | | | 20 | | | | | | 5235 | 51 | 399 | 34601 | 177 | 673 | 22118 | 18 | 435 |
| August | | | | 10 | | | | | | 12299 | 15 | 221 | 43165 | 99 | 58 | 21101 | 8 | 261 |
| September | | | | | | | | | | 6992 | 45 | 1254 | 18787 | 137 | 115 | 8174 | 21 | 174 |
| October | | | | | | | 972 | | 389 | 1631 | - | 401 | 6129 | 45 | 142 | 1357 | 6 | 52 |
| November | | | | | | | | | | 1747 | 5 | 61 | 4115 | | 43 | 581 | 2 | 88 |
| December | | | | | | | | | | | | | 1010 | | 110 | | | |
| Total Rpt Dir. | | | | 1834 | 25 | 917 | 1598 | 67 | 611 | 44700 | 235 | 2619 | 164013 | 670 | 2513 | 122413 | 279 | 2909 |
| USSR Total Reported | 3900 | 10501 | 6016 | 1834 | 554 | 1077 | 3385 | 254 | 4865 | 44769 | 235 | 2783 | 164013 | 670 | 2521 | 122445 | 475 | 4586 |
| Ratio | | | | 1.00 | .014 | .500 | 1.000 | .042 | 0.382 | 1.000 | .005 | .059 | 1.000 | .001 | .015 | 1.000 | .002 | .024 |

TABLE 1. USSR DIRECTED SILVER HAKE FISHERY (4VW) AND ASSOCIATED BYCATCHES (mt)

| YEAR / MONTH | 1972 | | | 1973 | | | 1974 | | | 1975 | | | 1976 | | | 1977 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod | S.Hake | Haddock | Cod |
| January | | | | | | | 1039 | - | - | 2381 | - | 108 | 982 | 11 | 75 | | | |
| February | | | | 104 | - | - | | | | 83 | - | - | 1146 | - | 88 | | | |
| March | 7166 | 28 | 247 | 11264 | 37 | 42 | 6963 | - | 40 | 2565 | 1 | 63 | 14644 | 1 | 177 | 37 | | |
| April | 11445 | - | 39 | 69254 | - | 52 | 8562 | 3 | 249 | 12501 | 4 | 245 | 9579 | - | 137 | 4040 | 6 | 10 |
| May | 19675 | - | 494 | 71540 | 20 | 290 | 11967 | 22 | 1128 | 12120 | 9 | 517 | 4952 | - | 360 | 3721 | 2 | 12 |
| June | 16336 | - | 796 | 40103 | 17 | 1079 | 12617 | 15 | 470 | 5978 | 3 | 445 | | | | 1820 | 2 | |
| July | 24043 | 35 | 971 | 38789 | - | 464 | 10114 | 6 | 311 | 23789 | 27 | 166 | 12719 | - | 62 | 8723 | | 17 |
| August | 14610 | 38 | 339 | 13116 | 2 | 321 | 9883 | 29 | 347 | 18260 | 8 | 146 | 6088 | 6 | - | 14 | | |
| September | 11481 | 1 | 136 | 8314 | - | 126 | 2072 | - | - | 17621 | - | 113 | 5058 | - | 19 | 695 | | |
| October | 3213 | - | 156 | 5394 | - | 171 | 3628 | 1 | 47 | | | | 6533 | - | 4 | 112 | | |
| November | | | | 1060 | - | 4 | 4699 | - | 140 | | | | 3480 | - | 12 | 183 | 1 | |
| December | | | | 7945 | - | 15 | 9637 | 15 | 97 | | | | 4873 | - | 38 | | | |
| Total | 107969 | 102 | 3178 | 266883 | 76 | 2564 | 81181 | 91 | 2829 | 95298 | 52 | 1833 | 70054 | 18 | 972 | 20145 | 10 | 39 |
| USSR Total Reported | 108657 | 106 | 4646 | 268511 | 76 | 2918 | 87497 | 132 | 3099 | 96853 | 52 | 3042 | 74823 | 24 | 1018 | 27351 | 14 | 97 |
| Ratio | 1.000 | .001 | .029 | 1.000 | .0003 | .010 | 1.000 | .002 | .035 | 1.000 | .001 | .031 | 1.000 | .0003 | .014 | 1.000 | .0005 | .0020 |

Table 2. Adjusted USSR haddock catches (t) in ICNAF division 4VW based upon observed data in 1977 and 1978.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Year | Directed Catch of S.Hake by USSR (4VW) | Reported Catch of Haddock in Directed S.Hake Fishery by USSR | Reported Total Catch of Haddock by USSR | Estimated USSR Haddock Catch in Directed S.Hake Fishery | Difference Between Reported and Estimated | Adjusted Haddock Catch for USSR [1] |
| | | | | | (4-2) | (3+5) |
| 1971 | 122413 | 279 | 475 | 918 | 639 | 1114 |
| 1972 | 107969 | 102 | 106 | 810 | 708 | 814 |
| 1973 | 268511 | 76 | 76 | 2014 | 1938 | 2014 |
| 1974 | 81181 | 91 | 132 | 609 | 518 | 650 |
| 1975 | 95298 | 52 | 52 | 715 | 663 | 715 |
| 1976 | 70054 | 18 | 24 | 525 | 507 | 531 |
| 1977 | 20145 | 10 | 14 | 121 | 111 | 125 |
| 1978 | 41915 [2] | - | 131 | 377 | - | 377 |
| 1979 | 44444.3[3] | - | 148 | 400 | - | 400 |

[1] Adjusted Haddock Catch = [Total Reported Haddock - Haddock Catch in S.Hake] + Estimated Haddock Catch.

[2] Report of directed fisheries not available from ICNAF to date. Estimated from Observer Programme.

[3] Reported to Canada and entered into the FLASH system.

Table 3. Removals ('000) at age for USSR commercial catches of 4VW Haddock.

| Age | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 67 | 1133 | 1456 | 1937 | 45318 | 1869 | 123 | 42 | 47 | 231 | 179 | 453 | 290 | 26 | 318 | 348 | 36 | 105 | 1 |
| 2 | 0 | 16 | 271 | 348 | 463 | 40548 | 2089 | 80 | 41 | 63 | 84 | 409 | 95 | 1016 | 216 | 36 | 238 | 60 | 178 | 154 |
| 3 | 0 | 190 | 3229 | 4151 | 5522 | 31075 | 9735 | 172 | 72 | 95 | 155 | 133 | 271 | 272 | 293 | 132 | 40 | 51 | 150 | 167 |
| 4 | 0 | 136 | 2308 | 2967 | 3947 | 8527 | 4102 | 234 | 69 | 63 | 119 | 177 | 169 | 252 | 51 | 118 | 98 | 24 | 69 | 174 |
| 5 | 0 | 34 | 580 | 745 | 991 | 2076 | 1597 | 227 | 55 | 35 | 54 | 68 | 158 | 105 | 54 | 29 | 103 | 7 | 21 | 49 |
| 6 | 0 | 10 | 175 | 225 | 299 | 2562 | 548 | 68 | 35 | 54 | 39 | 36 | 86 | 209 | 27 | 52 | 22 | 11 | 34 | 6 |
| 7 | 0 | 3 | 49 | 63 | 83 | 854 | 120 | 20 | 18 | 34 | 51 | 16 | 46 | 35 | 19 | 14 | 25 | 2 | 6 | 5 |
| 8 | 0 | 5 | 80 | 103 | 137 | 105 | 0 | 45 | 11 | 7 | 14 | 26 | 26 | 53 | 6 | 6 | 5 | 1 | 2 | 2 |
| 9 | 0 | 1 | 12 | 15 | 20 | 210 | 0 | 12 | 6 | 10 | 7 | 1 | 15 | 17 | 5 | 3 | 2 | 1 | 3 | 1 |
| 10 | 0 | 1 | 10 | 13 | 17 | 39 | 0 | 15 | 4 | 2 | 0 | 0 | 7 | 19 | 2 | 3 | 2 | 0 | 0 | 0 |
| 11 | 0 | 5 | 93 | 119 | 159 | 53 | 0 | 10 | 2 | 1 | 2 | 0 | 0 | 0 | 3 | 0 | 2 | 1 | 3 | 0 |

Table 4. Haddock numbers-at-age ('000) from research vessel surveys in 4VW.

| Age | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 273 | 161 | 40 | 0 | 594 | 192 | 780 | 645 | 0 | 3874 |
| 1 | 7100 | 4489 | 3435 | 1508 | 944 | 12025 | 8547 | 15666 | 25779 | 229 |
| 2 | 2640 | 9451 | 2321 | 4978 | 5587 | 1700 | 9400 | 29656 | 28842 | 23780 |
| 3 | 4788 | 3117 | 3378 | 1490 | 7556 | 4991 | 1322 | 23396 | 38613 | 25874 |
| 4 | 5325 | 4104 | 1524 | 1401 | 1369 | 4463 | 2569 | 3176 | 21592 | 26879 |
| 5 | 2548 | 1633 | 1271 | 514 | 1409 | 1170 | 2465 | 950 | 1372 | 7538 |
| 6 | 1632 | 925 | 955 | 1023 | 702 | 2135 | 542 | 1879 | 1234 | 969 |
| 7 | 1817 | 426 | 392 | 214 | 523 | 557 | 592 | 531 | 323 | 752 |
| 8 | 924 | 663 | 186 | 251 | 208 | 226 | 151 | 306 | 39 | 256 |
| 9 | 388 | 30 | 111 | 81 | 118 | 117 | 41 | 0 | 0 | 0 |
| 10 | 86 | 0 | 49 | 119 | 86 | 134 | 40 | 179 | 29 | 98 |
| 11 | 98 | 0 | 0 | 0 | 101 | 0 | 41 | 23 | 36 | 47 |

Table 5. Adjusted CPUE index for OTB TC 3-5 for the 4VW haddock stock (CPUE directed) adjusted to 1966.

| YEAR | TC3 | | TC4 | | TC5 | | TOTAL OTB CATCH | WTD CPUE INDEX | GRAND TOTAL CATCH | EFFORT INDEX (HRS) |
|---|---|---|---|---|---|---|---|---|---|---|
| | CPUE | MT | CPUE | MT | CPUE | MT | | | | |
| 1960 | 0.6051 | 767 | 1.2213 | 10259 | | | 11301 | 1.1497 | 27795 | 24175 |
| 1961 | 2.220 | 1704 | 1.4773 | 14017 | | | 16108 | 1.5204 | 27196 | 17887 |
| 1962 | 1.2864 | 737 | 0.9398 | 10003 | | | 10792 | 0.9589 | 24822 | 25885 |
| 1963 | 1.4687 | 598 | 1.1358 | 6245 | | | 7070 | 1.1275 | 25507 | 22622 |
| 1964 | 0.6300 | 246 | 0.9925 | 5826 | | | 6094 | 0.9743 | 22778 | 23378 |
| 1965 | 1.000 | 299 | 1.5821 | 3710 | | 251 | 4274 | 1.3733 | 55070 | 40100 |
| 1966 | 1.000 | 357 | 1.000 | 7283 | 1.000 | 358 | 8000 | 0.9997 | 23421 | 23428 |
| 1967 | 1.2330 | 42 | 1.3174 | 4649 | 1.2607 | 779 | 5475 | 1.3075 | 10747 | 8219 |
| 1968 | | 8 | 0.8685 | 4584 | 0.6365 | 1666 | 6261 | 0.8052 | 13377 | 16613 |
| 1969 | | | 0.7633 | 3431 | 0.6289 | 3367 | 6798 | 0.6967 | 11169 | 16031 |
| 1970 | 1.2424 | 120 | 0.4823 | 2083 | 0.4820 | 1398 | 3601 | 0.5075 | 9820 | 19350 |
| 1971 | 0.4372 | 97 | 0.6541 | 3592 | 0.5696 | 690 | 4379 | 0.6360 | 13672 | 21497 |
| 1972 | 0.3957 | 25 | 0.4688 | 678 | 0.3301 | 978 | 1681 | 0.3870 | 4821 | 12457 |
| 1973 | | | 0.4264 | 1253 | 0.3502 | 981 | 2235 | 0.3928 | 6373 | 16225 |
| 1974 | 1.8456 | 60 | 0.1841 | 153 | 0.2531 | 68 | 281 | 0.5583 | 2913 | 5218 |
| 1975 | 0.3293 | 19 | 0.4225 | 176 | 0.3987 | 161 | 354 | 0.4091 | 2583 | 6314 |
| 1976 | 0.2214 | 4 | 0.6135 | 139 | 0.1793 | 92 | 235 | 0.4368 | 2034 | 4657 |
| 1977 | 0.5202 | 3 | 0.4245 | 166 | 0.3586 | 297 | 438 | 0.4076 | 3380 | 8292 |
| 1978 | 1.9037 | 28 | 1.5705 | 827 | 0.8090 | 1343 | 2198 | 1.1095 | 6222 | 5608 |

Table 6. Removals at age ('000) for 4VW Haddock (excluding USSR Data)

| Age | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 16 | 2 | 168 | 102 | 0 | 0 | 1 | 21 | 5 | 32 | 0 | 0 | 246 | 67 | 4 | 18 |
| 3 | 125 | 43 | 213 | 30 | 185 | 343 | 899 | 578 | 253 | 289 | 288 | 453 | 176 | 167 | 331 | 187 | 84 | 781 | 415 | 295 |
| 4 | 2848 | 2939 | 977 | 1483 | 485 | 1227 | 4097 | 1532 | 1255 | 1020 | 950 | 1313 | 336 | 798 | 107 | 454 | 97 | 339 | 1363 | 879 |
| 5 | 5106 | 6289 | 5004 | 1327 | 2894 | 1100 | 2342 | 1943 | 1965 | 1525 | 832 | 1822 | 461 | 533 | 215 | 189 | 150 | 423 | 278 | 465 |
| 6 | 2556 | 3492 | 4159 | 3443 | 1091 | 1753 | 678 | 853 | 1730 | 1434 | 849 | 799 | 343 | 351 | 173 | 88 | 118 | 190 | 465 | 92 |
| 7 | 1986 | 1103 | 1257 | 1712 | 1718 | 539 | 1168 | 335 | 549 | 699 | 717 | 631 | 179 | 205 | 52 | 35 | 97 | 64 | 137 | 73 |
| 8 | 1754 | 868 | 572 | 448 | 939 | 633 | 306 | 463 | 267 | 208 | 224 | 792 | 98 | 74 | 21 | 17 | 22 | 37 | 40 | 4 |
| 9 | 411 | 701 | 227 | 111 | 237 | 287 | 212 | 162 | 294 | 97 | 46 | 193 | 86 | 31 | 2 | 3 | 4 | 11 | 16 | 2 |
| 10 | 172 | 179 | 146 | 30 | 50 | 55 | 68 | 131 | 86 | 86 | 22 | 26 | 4 | 56 | 6 | 0 | 6 | 7 | 6 | 1 |
| 11 | 178 | 57 | 35 | 11 | 31 | 37 | 9 | 42 | 53 | 28 | 8 | 14 | 11 | 1 | 5 | 1 | 5 | 5 | 2 | 1 |

Table 7. Removals at age ('000) for USSR catches in 1977 estimated by using observed samples and Canadian research.

| | Canadian Research | | USSR Sampled | |
|---|---|---|---|---|
| Age | No. | % | No. | % |
| 0 | 1 | 0.51 | 0 | - |
| 1 | 36 | 18.46 | 34 | 19.54 |
| 2 | 60 | 30.77 | 68 | 39.08 |
| 3 | 51 | 26.15 | 54 | 31.03 |
| 4 | 24 | 12.31 | 6 | 3.45 |
| 5 | 7 | 3.59 | 8 | 4.60 |
| 6 | 11 | 5.64 | 3 | 1.72 |
| 7 | 2 | 1.03 | 1 | 0.57 |
| 8 | 1 | 0.51 | | |
| 9 | 1 | 0.51 | | |
| 10 | 0 | - | | |
| 11 | 1 | 0.51 | | |
| 11+ | - | - | | |
| TOTALS | 195 | 100.00 | 174 | 100.00 |

Table 8. Removals at age ('000) for the 4VW Haddock Stock.

| AGE | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 67 | 1133 | 1456 | 1937 | 45318 | 1869 | 123 | 42 | 47 | 231 | 179 | 453 | 290 | 26 | 318 | 348 | 36 | 105 | 1 |
| 2 | 0 | 16 | 271 | 348 | 479 | 40550 | 2257 | 182 | 41 | 63 | 85 | 430 | 100 | 1048 | 216 | 36 | 484 | 127 | 182 | 172 |
| 3 | 125 | 233 | 3442 | 4181 | 5707 | 31418 | 10634 | 750 | 325 | 384 | 443 | 586 | 447 | 439 | 624 | 319 | 124 | 832 | 565 | 462 |
| 4 | 2848 | 3075 | 3285 | 4450 | 4432 | 9754 | 8199 | 1766 | 1324 | 1083 | 1069 | 1490 | 505 | 1050 | 158 | 572 | 195 | 363 | 1432 | 1053 |
| 5 | 5106 | 6323 | 5584 | 2072 | 3885 | 3176 | 3939 | 2170 | 2020 | 1560 | 886 | 1890 | 619 | 638 | 269 | 218 | 253 | 430 | 299 | 514 |
| 6 | 2556 | 3502 | 4334 | 3668 | 1390 | 4315 | 1226 | 921 | 1765 | 1488 | 888 | 835 | 429 | 560 | 200 | 140 | 140 | 201 | 499 | 98 |
| 7 | 1986 | 1106 | 1306 | 1775 | 1801 | 1393 | 1288 | 355 | 567 | 733 | 768 | 647 | 225 | 240 | 71 | 49 | 122 | 66 | 143 | 78 |
| 8 | 1754 | 873 | 652 | 551 | 1076 | 738 | 306 | 508 | 278 | 215 | 238 | 818 | 124 | 127 | 27 | 23 | 27 | 38 | 42 | 6 |
| 9 | 411 | 702 | 239 | 126 | 257 | 497 | 212 | 174 | 300 | 107 | 53 | 194 | 101 | 48 | 7 | 6 | 6 | 12 | 19 | 3 |
| 10 | 172 | 180 | 156 | 43 | 67 | 94 | 68 | 146 | 90 | 88 | 22 | 26 | 11 | 75 | 8 | 3 | 8 | 7 | 6 | 1 |
| 11 | 178 | 62 | 128 | 130 | 190 | 90 | 9 | 52 | 55 | 29 | 10 | 14 | 11 | 1 | 8 | 1 | 7 | 6 | 5 | 1 |

Table 9a . Adjustment of survey estimates numbers at age ('000) at M = 0.2 for ages 1 to 3 to compensate for partial recruitment relative to age 4.

| Survey Year | YEAR CLASS | | | |
|---|---|---|---|---|
| | 1978 | 1977 | 1976 | 1975 |
| 1979 | 407 | 33364 | 23912 | 26879 |
| 1978 | | 45834 | 40466 | |
| 1977 | | | 27854 | |
| Average | 407 | 39599 | 30744 | 26879 |
| Ratio to Age 4 | 0.015 | 1.473 | 1.144 | 1.000 |

Table 9b. 1979 research survey numbers at age ('000) prior and after adjustment to compensate for partial recruitment at age 4.

| AGE | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Original #'s | 229 | 23780 | 25874 | 26879 |
| Adjusted #'s | 407 | 39599 | 30744 | 26879 |

Table 10. Initial and Final Partial recruitments and mean weights at age.

| AGE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Par. Rec. | .040 | .069 | .178 | .386 | .673 | 1 | 1 | 1 | 1 | 1 | 1 |
| Final Par. Rec. | .040 | .050 | .178 | .550 | .673 | 1 | 1 | 1 | 1 | 1 | 1 |
| Mean wt. at age (kg) | .103 | .590 | .820 | 1.220 | 1.690 | 2.150 | 2.660 | 3.020 | 3.630 | 3.900 | 3.61 |

Table 11. Population numbers ('000) and fishing mortalities at M = 0.2

*POPULATION NUMBERS*

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 46602 | 31190 | 46904 | 86108 | 95065 | 66807 | 11285 | 10104 | 7582 | 4812 | 5561 | 2934 | 6128 | 7085 | 4832 | 24630 | 41010 | 43375 |
| 2 | 20329 | 38155 | 25476 | 37376 | 69182 | 76080 | 13692 | 7548 | 8161 | 6170 | 3897 | 4344 | 2240 | 4608 | 5538 | 3932 | 19878 | 33261 |
| 3 | 29501 | 16644 | 31224 | 20612 | 30286 | 56208 | 25598 | 9167 | 6015 | 6645 | 4994 | 3114 | 3168 | 1744 | 2824 | 4339 | 3187 | 15837 |
| 4 | 27313 | 24040 | 13416 | 22450 | 13093 | 19632 | 17591 | 11336 | 6827 | 4631 | 5093 | 3688 | 2019 | 2189 | 1030 | 1748 | 3264 | 2497 |
| 5 | 14615 | 19785 | 16900 | 8012 | 14354 | 6709 | 7248 | 6983 | 7683 | 4391 | 2811 | 3202 | 1671 | 1196 | 842 | 701 | 913 | 2496 |
| 6 | 6265 | 7346 | 10477 | 8784 | 4684 | 8237 | 2619 | 2370 | 3754 | 4463 | 2184 | 1500 | 912 | 808 | 402 | 446 | 376 | 519 |
| 7 | 4876 | 2817 | 2845 | 4656 | 3873 | 2578 | 2839 | 1035 | 1107 | 1477 | 2307 | 985 | 473 | 358 | 155 | 148 | 239 | 181 |
| 8 | 3733 | 2195 | 1306 | 1148 | 2206 | 1541 | 850 | 1159 | 526 | 393 | 546 | 1194 | 221 | 183 | 76 | 63 | 77 | 85 |
| 9 | 1151 | 1469 | 1007 | 479 | 441 | 833 | 594 | 419 | 489 | 179 | 127 | 231 | 238 | 68 | 35 | 38 | 31 | 39 |
| 10 | 358 | 570 | 568 | 608 | 278 | 129 | 232 | 294 | 186 | 129 | 50 | 56 | 14 | 103 | 13 | 22 | 26 | 20 |
| 11 | 418 | 138 | 304 | 323 | 459 | 167 | 20 | 128 | 109 | 71 | 26 | 21 | 23 | 1 | 17 | 3 | 16 | 14 |
| | 155161 | 144348 | 150426 | 190557 | 233922 | 238921 | 82568 | 50545 | 42440 | 33360 | 27597 | 21270 | 17106 | 18344 | 15764 | 36070 | 69015 | 98323 |

| | 1978 | 1979 |
|---|---|---|
| 1 | 46586 | 276 |
| 2 | 35480 | 38046 |
| 3 | 27117 | 28884 |
| 4 | 12213 | 21690 |
| 5 | 1716 | 8704 |
| 6 | 1654 | 1134 |
| 7 | 243 | 903 |
| 8 | 89 | 69 |
| 9 | 35 | 35 |
| 10 | 21 | 12 |
| 11 | 10 | 12 |
| | 125164 | 99765 |

*FISHING MORTALITY*

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.002 | 0.027 | 0.019 | 0.023 | 1.385 | 0.202 | 0.014 | 0.006 | 0.011 | 0.047 | 0.070 | 0.085 | 0.046 | 0.006 | 0.014 | 0.009 | 0.001 | 0.002 |
| 2 | 0.000 | 0.000 | 0.012 | 0.010 | 0.008 | 0.889 | 0.201 | 0.027 | 0.006 | 0.011 | 0.024 | 0.116 | 0.051 | 0.290 | 0.044 | 0.010 | 0.027 | 0.004 | 0.006 |
| 3 | 0.005 | 0.016 | 0.130 | 0.254 | 0.234 | 0.962 | 0.615 | 0.095 | 0.062 | 0.066 | 0.103 | 0.233 | 0.170 | 0.326 | 0.280 | 0.085 | 0.044 | 0.060 | 0.023 |
| 4 | 0.122 | 0.152 | 0.316 | 0.247 | 0.469 | 0.796 | 0.724 | 0.189 | 0.241 | 0.299 | 0.264 | 0.591 | 0.324 | 0.755 | 0.186 | 0.449 | 0.058 | 0.175 | 0.139 |
| 5 | 0.488 | 0.436 | 0.454 | 0.337 | 0.355 | 0.741 | 0.918 | 0.421 | 0.343 | 0.499 | 0.428 | 1.056 | 0.526 | 0.890 | 0.435 | 0.421 | 0.366 | 0.211 | 0.214 |
| 6 | 0.599 | 0.748 | 0.611 | 0.619 | 0.397 | 0.865 | 0.728 | 0.561 | 0.733 | 0.460 | 0.597 | 0.955 | 0.734 | 1.451 | 0.798 | 0.426 | 0.530 | 0.559 | 0.406 |
| 7 | 0.598 | 0.569 | 0.708 | 0.547 | 0.721 | 0.909 | 0.696 | 0.476 | 0.835 | 0.795 | 0.459 | 1.296 | 0.747 | 1.348 | 0.705 | 0.455 | 0.833 | 0.514 | 1.052 |
| 8 | 0.733 | 0.579 | 0.803 | 0.756 | 0.774 | 0.753 | 0.507 | 0.662 | 0.876 | 0.927 | 0.658 | 1.415 | 0.970 | 1.451 | 0.497 | 0.519 | 0.490 | 0.682 | 0.739 |
| 9 | 0.502 | 0.751 | 0.304 | 0.344 | 1.032 | 1.078 | 0.502 | 0.614 | 1.132 | 1.076 | 0.615 | 2.611 | 0.635 | 1.492 | 0.249 | 0.192 | 0.245 | 0.421 | 0.910 |
| 10 | 0.756 | 0.429 | 0.362 | 0.081 | 0.310 | 1.645 | 0.391 | 0.794 | 0.768 | 1.399 | 0.665 | 0.712 | 2.070 | 1.630 | 1.208 | 0.160 | 0.423 | 0.502 | 0.385 |
| 11 | 0.626 | 0.675 | 0.616 | 0.578 | 0.601 | 0.882 | 0.659 | 0.584 | 0.797 | 0.597 | 0.543 | 1.266 | 0.754 | 1.388 | 0.749 | 0.439 | 0.669 | 0.647 | 0.823 |
| | 0.136 | 0.156 | 0.184 | 0.130 | 0.120 | 1.033 | 0.543 | 0.187 | 0.228 | 0.244 | 0.227 | 0.567 | 0.242 | 0.389 | 0.135 | 0.059 | 0.030 | 0.026 | 0.032 |

| | 1979 |
|---|---|
| 1 | 0.004 |
| 2 | 0.005 |
| 3 | 0.018 |
| 4 | 0.055 |
| 5 | 0.067 |
| 6 | 0.100 |
| 7 | 0.100 |
| 8 | 0.100 |
| 9 | 0.100 |
| 10 | 0.100 |
| 11 | 0.100 |
| | 0.027 |

Table 12. Yield per recruit for the 4VW Haddock (M = 0.20, partial recruitment and wt. at age as in Table 10).

| | FISHING MORTALITY | CATCH (NUMBER) | YIELD (KG) | AVG. WEIGHT (KG) | YIELD PER UNIT EFFORT |
|---|---|---|---|---|---|
| | 0.050 | 0.08383 | 0.198 | 2.246 | 1.000 |
| | 0.100 | 0.15550 | 0.337 | 2.154 | 0.849 |
| | 0.150 | 0.20990 | 0.434 | 2.066 | 0.728 |
| | 0.200 | 0.25240 | 0.501 | 1.984 | 0.631 |
| | 0.250 | 0.28679 | 0.547 | 1.907 | 0.551 |
| | 0.300 | 0.31506 | 0.578 | 1.836 | 0.486 |
| F0.1--- | 0.313 | 0.32169 | 0.585 | 1.818 | 0.471 |
| | 0.350 | 0.33869 | 0.600 | 1.770 | 0.432 |
| | 0.400 | 0.35874 | 0.613 | 1.710 | 0.386 |
| | 0.450 | 0.37601 | 0.622 | 1.654 | 0.348 |
| | 0.500 | 0.39107 | 0.627 | 1.603 | 0.316 |
| | 0.550 | 0.40438 | 0.629 | 1.556 | 0.288 |
| FMAX--- | 0.596 | 0.41525 | 0.630 | 1.517 | 0.266 |
| | 0.600 | 0.41626 | 0.630 | 1.513 | 0.264 |
| | 0.650 | 0.42698 | 0.629 | 1.473 | 0.244 |
| | 0.700 | 0.43672 | 0.627 | 1.436 | 0.226 |
| | 0.750 | 0.44565 | 0.625 | 1.403 | 0.210 |
| | 0.800 | 0.45388 | 0.622 | 1.371 | 0.196 |
| | 0.850 | 0.46152 | 0.619 | 1.342 | 0.184 |
| | 0.900 | 0.46864 | 0.616 | 1.315 | 0.173 |
| | 0.950 | 0.47531 | 0.613 | 1.290 | 0.163 |
| | 1.000 | 0.48159 | 0.610 | 1.266 | 0.154 |