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# AN ASSESSMENT OF THE 4X HADDOCK STOCK FOR THE 1962-80 PERIOD

by

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## Abstract

Recent reported landings of 4X Haddock (26-28,000 mt) have been considerably in excess of the long term average (10-20,000 mt). The catches are thought to be even higher on account of high discarding and misreporting which is suspected to have occurred.

The seasonal pattern of exploitation by fleet components has also changed. The offshore fleet, which prior to 1977 was operational year round, now only fishes in the early spring and late fall, on account of their management plan. The inshore fleet is presently reporting the dominant amount of the catch. This shift in fleet dominance is causing problems in obtaining adequate sampling coverage of the catch.

Both the U.S. and Canadian bottom trawl surveys indicate dramatic increases in stock size during the 1974-78 period. However whereas the Canadian survey shows continuing increases to 1980, the U.S. surveys shows either a leveling off or slight decrease in stock abundance.

Two forms of sequential population analysis were used to describe stock dynamics during the 1962-80 period. Both used the Canadian survey series only in tuning the analysis. The first employed the Survivor Method of Rivard (1980) while the second employed procedures previously in use. Both methods derived a 1980 fully recruited fishing mortality of 0.3 which is slightly above $F_{0.1}$ (0.284). However, the calculated sizes of the 1974 and 1977 year-classes were significantly different between the two methods. The more conservative estimates were chosen for both of these year-classes.

Projections to 1982 were carried assuming a 1981 catch of 28,000 mt and $F_{0.1}$ exploitation for 1982. Age one recruitment for 1980 was set at $100 \times 10^6$ and $40 \times 10^6$ for 1981-82. The 1982 projected catch was determined to be $32 \times 10^3$ mt.

## Résumé

Les récents rapports de débarquements d'aiglefin de 4X (26-28 000 tm) sont de beaucoup supérieurs à la moyenne à long terme (10-20 000 tm). On croit que les prises sont même beaucoup plus élévées, à cause des grandes quantités rejetées à la mer et des faux rapports qu'on est en droit de supposer.

Le déploiement saisonnier des composants de la flottile a également changé. La flottille de grande pêche qui, avant 1977, pêchait à l'année longue, ne pêche maintenant qu'au début du printemps et à la fin de l'automne, pour se conformer aux plan de gestion. La flottile côtière est à l'heure actuelle celle qui rapporte la majeure portion des prises. Ce changement dans la répartition des prises rend difficile un échantillonnage adéquat des prises.

Les relevés par chalut de fond, tant américains que canadiens, indiquent des augmentations dramatiques des effectifs du stock pendant la période 1974-78. Cependant, alors que les relevés canadiens indiquent des augmentations continues jusqu'en 1980, les relevés américains montrent soit un plateau, soit une légère diminution.

Deux formes d'analyse de population séquentielle ont été utilisées pour décrire la dynamique du stock pendant la période 1962-80. Pour l'ajustement précis des deux formes, seule la série des relevés canadiens a été utilisée. La première forme d'analyse est fondée sur la méthode des survivants de Rivard (1980), tandis que la seconde utilise les méthodes traditionnelles. Les deux méthodes donnent une mortalité par pêche au plein recrutement de 0,3 en 1980, légèrement supérieure à $F_{0,1}$ (0,284). Cependant, elles donnent des résultats significativement différents dans le calcul des effectifs des classes d'âge de 1974 et 1977. Nous avons choisi les estimations les plus conservatrices de ces deux classes d'âge.

Des prédictions jusqu'en 1982 on été effectuées, en supposant des prises de 28 000 tm en 1981 et une exploitation à $F_{0,1}$ en 1982. Le recrutement d'âge 1 en 1980 a été fixé à $100 \times 10^6$ et à $40 \times 10^6$ en 1981-82. Les prises prévues en 1982 sont de $32 \times 10^3$ tm.

## INTRODUCTION

Biological assessment of this stock has been carried out since the mid 1960's. Sequential Population Analysis (SPA) was first employed by Halliday in 1974 to determine the population structure and exploitation rates in the current year. Since 1977, the U.S. and Canadian groundfish bottom trawl survey data have been extensively used to tune the SPA. Much of this tuning has necessarily depended on subjective decisions by the assessment biologist. Rivard (1980) has recently introduced a technique referred to as the Survivor Method to make the tuning of the SPA with the research survey data a more objective process.

This document presents an analysis of the 4X haddock stock structure during the 1962-80 period based on both the Survivor Method and the older procedures used to tune an SPA. Yield projections were made to 1982 using the $F_{0.1}$ exploitation rate for 1982.

## TRENDS IN REPORTED LANDINGS AND RECENT MANAGEMENT HISTORY

From the early 1930's to the early 1960's, reported landings of the NAFO Division 4X haddock stock fluctuated between 10-20,000 mt annually (Figure 1). These landings were split equally between Canada and the U.S. During this period, the major part of Canada's catches was landed by longliners while the U.S. landings were almost wholly reported by otter trawlers. In 1963, the USSR first entered the fishery, reporting a catch of 400 mt (Table 1). Their involvement in the fishery increased until 1966, when they reported catches of 10,065 mt. However, subsequent to this, they did not undertake directed fishing on 4X haddock. During the same period, the Canadian otter trawl fleet expanded rapidly, with a particularly large increase in the number of vessels in the tonnage class 4 category (Figure 2). As well, tonnage class 5 vessels entered the Canadian fishery (Table 4 ) for the first time in 1966.

The increased effort in the fishery resulted in peak reported total landings from the stock of 37,116 mt in 1966. Catches remained close to or above 30,000 mt until 1969. The high exploitation rates generated during the late 1960's provoked dramatic declines in stock abundance which in turn resulted in the establishment of a TAC and restricted fishing area regulations in 1970.

In both 1970 and 1971, the TAC was set at 18,000 mt. No bottom trawling was allowed on Brown's Bank during March-May. In the following two years, the TAC was reduced to 9,000 mt with similar area restrictions. In 1974, 4X was closed to directed fishing on haddock altogether and managed through by-catch regulations. Limitations on total haddock landed per fishing trip were continued in 1975 in an attempt to control exploitation rates. These have continued in varying forms to the present. Since 1976 the offshore fleet allocation has been divided into sub-annual quotas in an effort to regulate fishing pressure throughout the year. By 1975 and 1976, discards were becoming an increasingly important problem. In 1977 and 1978, the TACs were overrun by considerable margins (Table 1) despite all the regulations.

Belzile (1978) estimated that in the springs of 1977 and 1978, the offshore fleet encountered large by-catches of haddock, particularly while fishing for pollock, and discarded approximately 10% of the total catch. No reports on discard patterns in 1979 and 1980 are available.

Since 1975, misreporting of haddock by species (particularly by the inshore fleet) and by area (particularly by the offshore fleet) has become increasingly evident. No data exist which can provide estimates on the level of these catches.

The trends in the fishery since 1975 suggest that the fishermen have had a difficult time staying within the established TACs, particularly in 1977 and 1978. Consequently the catches shown in Table 1 are most likely conservative, although by how much is impossible to determine.

As well, since 1979, the offshore fleet allocation has continually declined while that for the inshore fleet has slightly increased (Table 2). As can be seen from Figure 3 and 4, this has led to an overall change in the exploitation strategy of the fishery. The smaller vessels of the inshore fleet, which cannot fish in the early spring and late fall, due to weather restrictions, are replacing the larger offshore vessels during the summer months. The offshore vessels, which are almost exclusively TC 4 and 5 otter trawlers, are now fishing in the early spring and late fall, whereas previously some summer fishing had occurred. As will be seen below, this has implications on the interpretation of the commercial catch rate data.

## COMMERCIAL CATCH-AT-AGE COMPOSITION

Previous analyses (Halliday and McCracken, 1970; McCracken, 1956, 1960) have indicated that catches reported from Unit Area 4Xs are likely from the NAFO Division 5Y haddock stock. These landings were therefore excluded from the present assessment.

The age composition of landings from the NAFO Division 4X haddock stock were constructed for the 1962-80 period. It has been observed (Hennemuth et al., 1964) that Unit Area 4Xr haddock landings have a substantially different size and age composition from those reported from 4Xmnopq. Consequently, sampling data from these two areas were applied separately to the respective catches in construction of the removals at age table.

Canadian commercial samples were applied to Canadian landings whenever possible. Generally, otter trawl samples were applied to landings reported by otter trawlers, danish seiners and shrimp trawlers. Longline samples were applied to combined longline and gillnet landings.

USA landings compositions for 1962-64 were taken from Schultz and Halliday (MS 1969) while from 1965 to the present, Canadian samples were applied to USA landings. This should not introduce major errors since landings from both countries have been similar in age composition (Hennemuth et al., 1964) and USA landings have been only a small proportion of total reported catch during the 1965-80 period.

No commercial samples for the 1962-76 period are available for the USSR and Spanish landings. The age composition of these catches was assumed to be the same as that of Canada.

On Tables 3 and 4 are indicated the number of samples that have been taken by gear category and tonnage class. Although the coverage by gear has been good, the small vessels have consistently been undersampled. This problem is becoming more acute since the smaller vessels are now reporting the predominant proportion of the catch.

It is impossible to state at this time whether or not the catch composition for the small vessels differs from that for the large vessels. The present assessment has assumed them to be the same.

The generated removals-at-age are given in Table 5 and the percent age composition, by numbers and weight, are given in Table 6. These numbers do not include any correction for discarding as the age structure of the discarded and misreported catches is not well known. During the early 1960's, the 1959 and 1960 year-classes supported the fishery. In the subsequent years of high exploitation rates, the 1962 and very large 1963 year-classes supported the fishery. The latter remained an important component of the landings until 1972. During the mid 1970's, when the stock appeared to be recovering, the 1969 and 1971 year-classes contributed significantly to the landings. Since 1977, the 1974 and 1975 year-classes have become increasingly important to the fishery. In 1980 they contributed 28 and 33% by weight respectively to the landings.

The weights-at-age derived from the commercial samples are given in Table 7.

These are derived solely from Canadian sampling information.

## STOCK ABUNDANCE TRENDS

### A. Commercial Statistics

In previous assessments, the Canadian T.C. 4 otter trawl catch rates have been used as indicators of trends in abundance. The equivalent series for the U.S. fleet is only useful up to 1977. Now, due to the changing seasonal pattern in exploitation by the various fleet components, it seems that the Canadian series may be suspect. Two alternate series of catch rates for the Canadian T.C. 3 vessels - one for side and one for stern trawlers - were then developed. The means of the July-October catch rates for each year by vessel type are given in Table 8 and illustrated in Figure 5. Although there is considerable variation in the data, there is a general trend of increasing stock abundance over the 1972-80 period.

However, due to the changing nature of the fishery and the extensive regulation present, it was felt that these trends can only be considered in the most general way and could not be used to assist in tuning of the sequential population analysis.

B. U.S. Fall Bottom Trawl Survey Data

The NMFS at Woods Hole has been running a standardized bottom survey on the east coast since 1963. The strata sampled in NAFO Division 4X (31-34, 41 and 42) are illustrated in Figure 6a. The stratified mean catch-at-age in numbers per tow for other strata are presented in Table 9. As was discussed in O'Boyle (1980), strata 41 and 42 were not sampled by the survey during 1963, 1964, 1976, 1978, 1979 and also 1980, although significant amounts of haddock have been caught in these two strata in other years. The catches-at-age were thus recalculated with strata 41 and 42 removed for the whole time series (Table 10).

C. Canadian Summer Bottom Trawl Survey Data

MFD at St. Andrew's has been conducting a standardized bottom trawl survey every July-August since 1970. The stratified mean catch-at-age in numbers per tow for this data set are given in Table 11.

A ranking of the catch rates by strata is given in Table 12. It is evident from this that, during July-August, haddock concentrate primarily on Brown's Bank and secondarily in the Roseway Bank area. The highest concentrations in the last two years of the survey were actually observed just in the mouth of the Bay of Fundy. This stratum 90, is not sampled by the U.S. survey. It will be interesting to see if stratum 90 is an important area of capture during the 1981 survey.

A preliminary analysis of the variation in the survey data was undertaken in an attempt to see how precise the survey is. The contribution of each stratum to the overall stratified mean catch rate and the variance was determined as per White et al., (1981). The results of this analysis are given in Table 13. It can be readily seen that in general few strata determine the overall catch rates as used in the assessment. In one year, 1977, one tow in stratum 76 heavily influenced the overall survey results. These data warrant considerable further study. For the present assessment, the observed catch rates were taken as indicative of abundance trends in the stock.

D. Comparison of Abundance Trends from the Canadian and U.S. Research Surveys

The mean stratified catch per tow in numbers and weight for each survey were treated with a three year median smooth procedure. The results of this smooth are given in Table 8 and illustrated in Figure 7. In the latter, the original or "rough" data are shown for comparison.

Since 1970, both surveys show very similar trends. The main difference between the two data sets is that whereas the Canadian survey indicates an increase in stock size in 1980, the U.S. survey indicates a stabilization in the numbers per tow and a decrease in the weight per tow. Both surveys do, however, indicate that the catch rates in numbers are presently 3-4 times those obtained in 1970 while the catch rates in weight are now 2-3 times those obtained in 1970.

## SEQUENTIAL POPULATION ANALYSIS

Two procedures were followed to obtain estimates of the population structure and exploitation rates in 1980. The first involved applying the Survivor Method of Rivard (1980) to the catch-at-age and survey data to obtain estimates of the stock size for ages 2-9. These data were then input into a cohort analysis to obtain a stock structure for the 1962-80 period.

The second method involved utilizing the survey information in cohort analysis as has been done previously i.e. linearity between cohort analysis results and survey data taken as the criterion for good fit.

### A. Determination of the Terminal Fishing Mortalities for 1980 - the Survivor Method

A complete description of the Survivor Method is given in Rivard (1980) so it will not be repeated here. However as the procedure has never before been used in a standard assessment, the details of its application will be discussed.

When a preliminary survivor run was carried out on the U.S. survey data, the predicted population sizes were found to have very large coefficients of variation (400-500%). The reason for this is not apparent. Preliminary survivor runs on the Canadian data exhibited coefficients of variation which were considerably less (30-80%). Therefore, for this assessment, only the Canadian survey data as provided in Table 11 was utilized.

The first step in the method was examination of the data in Table 11 to determine what ages were most likely linearly related to population numbers-at-age. Data for ages 10-13+ were dropped as it was felt that the low numbers being sampled would lead to the generation of spurious relationships.

The second step was to determine the optimum size of the calibration block. The standard deviation of the overall residual was used as the optimizing criterion, along with the CV-at-age and the total number of residuals (Table 14). To determine the block size, the procedure was run with a small calibration block and then this was systematically increased both in number of years and ages. Each run provided the estimated survivors for the succeeding run. From these runs, two things were determined. First, the survivor estimates were most accurate for a data set with ages 3-8 only. Second, a calibration block with a final year and age of 1979 and 7 respectively gave the lowest standard deviation of the residuals.

The pattern of K over age was also examined. When K was allowed to level off at 8, the oldest age in the analysis, there was some evidence to suggest that K first decreased to a minimum around age 6 and then increased up to age 9. From preliminary cohort runs, the partial recruitment patterns in the commercial fishery could not be determined as being dome-shaped. This was taken as evidence that K most likely does level off in the older age groups, here chosen to be age 6.

Next, a run of survivor was made, using a calibration block with a final year and age being 1979 and 7 respectively and K leveling off at age 6 (Table 15). The mid-year population estimates-at-age from the survivor run were plotted against the research survey estimates to examine inconsistencies in the data set (Figure 8). Fits for ages 4-8 were very good but not so good for age 3.

Fishing mortalities for ages 3-8 for 1980 were then calculated by inputting the survivor estimates and catches-at-age into a Newton-Raphson interative solution to the Baranov catch equation. The fact that the survivor estimates are end of the year values was taken into account.

One final survivor run was made using the same final year and age for a calibration block but including data for ages 2 and 9. The calculated age 2 survivor estimate and hence fishing mortality was used in later analysis, although its estimate was not as reliable as those for ages 3-8.

Finally, the generated pattern of fishing mortality-at-age was examined for determination of the partial recruitment-at-age. The age 6 estimate of 0.72 was extremely high as was the CV-at-age (84%). The value was felt high as the survivor procedure fit the other points for that particular year-class reasonably well. Thus it appears likely that either the catch-at-age or the survey data for age 6 in 1980 is bad. Full recruitment was taken to be at age 6 and asymptotic thereafter. The fully recruited F was taken at 0.315, the fishing mortality on age 7. The partial recruitments for ages 2-5 was determined by dividing the survivor-derived fishing mortalities by 0.315.

## B. Determination of the Terminal Fishing Mortalities for Age 12 in all Years

In the two cohort runs to be described below, the fishing mortalities for age 12 were determined by the iteration method. Initial F's of 0.3 were input and the fishing mortalities for ages 5-8 averaged and reentered at age 12. This iteration was continued until the F at age 12 changed less than 0.001 per iteration. Normally 4-5 iterations were required.

Whenever changes were made to the 1980 F's-at-age, the F's at age 12 were reiterated.

## C. Cohort Analysis with Survivor Derived F's for 1980-Option 1

Table 16 presents the results of a cohort analysis run using a 1980 $F_R$ of 0.315 and the survivor-derived partial recruitment pattern for age 2-9. The partial recruitments for age 10-12 were taken as 1 while the PR for age 1 was arbitrarily chosen as 0.0003.

The plots in Figures 9 and 10 were used to determine how well the cohort analysis predicted population estimates fit the estimates derived from the research data. For Figure 9, the research numbers-at-age were multiplied by the survivor-derived K's-at-age to obtain absolute estimates

of population size, which could be directly compared to the cohort analysis results.

Figure 10 shows the three standard relationships that were also examined, these being:

1. Summation of age 3 to 8 numbers from the cohort analysis versus the summation of ages 3 to 8 research survey catch rates.
2. Age 2 + 3 from the CA versus age 2 + 3 (standardized to 1970-80 mean) from the research survey data for each year-class.
3. Age 3+ population biomass from the cohort analysis versus the Canadian Otter Trawler T.C. 4 catch rate.

In all these relationships the CA numbers were adjusted to obtain mid-year estimates for comparison with the research survey data.

The relationships indicated that the fit was quite good but could be improved if the partial recruitment on ages 3 and 4 was raised.

## D. Cohort Analysis using Standard Procedures Option 2

It was decided to see if the standard procedures employed previously would give the same or a different answer to that derived by the Survivor Method.

First, a set of relationships was chosen on which to tune the CA, these being:

1. Age 2 + 3 CA vs age 2 + 3 from survey data for each year-class. Here, the standardized (to 1970-80 mean) survey estimates were averaged rather than just sumed as was done above.
2. Age 2-5 from CA vs age 2-5 from survey data. Here the smoothed (by median) survey data was used. This series is illustrated in Figure 11. As well, the CA estimates were converted to mid-year values.
3. Age 6+ from CA vs age 6+ from survey data. As with the above relationship, the survey data were smoothed (Figure 11) and the CA estimates converted to mid-year values before the data were examined.
4. 3+ Population Biomass from CA vs Canadian OT 4 catch rates. Again, the CA estimates were converted to mid-year values.

Next, a preliminary partial recruitment pattern for 1980 was estimated by determining, from catch curves, full recruitment to be at age 6, a low partial recruitment of 0.0003 at age 1 and a linear progression in PR between ages 1 and 6. Recruitment was assumed to be asymptotic after age 6.

Then a series of cohort analyses were run with varying $F_R$'s for 1980 of 0.2-0.5, in increments of 0.05. The resulting correlation coefficients for the four relationships are given in Table 17. It is evident from this that the relationships are relatively insensitive to variations in the terminal fishing mortality. A fishing mortality of 0.3 does optimize two of the first three relationships, albeit marginally, and was thus chosen as the run which best represents stock status with this procedure.

Minor adjustments were also made to the 1980 PR to allow optimization of the year-class strength estimates.

The results are given in Table 18 and Figure 12.

## F. Final Cohort Analysis

Table 19 presents an overview of the year-class sizes-at-age one as determined by this and previous assessments. The present assessment's age one estimates are remarkably similar to those determined in previous years. However, between the two options presented above, the sizes of the 1974 and 1977 year-classes are significantly different.

Previous estimates of the 1974 year-class at age one have been closer to 50 x $10^6$ than the 70 x $10^6$ as determined by Option 2. Thus the age one estimates for this year-class were taken from the Option 1 calculations.

The Survivor Method predicted the size of the 1977 year-class at age one to be 93 x $10^6$, compared to 76 x $10^6$ for the standard procedure. The survivor estimate was based on only one survey data point while the second estimate was based on two. For this reason, the latter value for the 1977 year-class at age one was chosen.

The final cohort analysis run is given in Table 20. The pattern in production (Rivard, 1980) over the 1962-80 period for this cohort analysis is provided in Figure 13. It can be immediately seen that much of the more recent production is due to growth by incoming large year-classes during the 1973-80 period. Indeed, the present analysis suggests production due to growth has never been higher.

# YIELD PROJECTIONS TO 1982

## A. Yield Per Recruit Model

The three input parameters to the yield per recruit model are weight-at-age, partial recruitment and natural mortality. Both the first two are known to have undergone considerable changes over the time period covered by the present analysis. Discussion here will be restricted to the changes observed in the partial recruitment pattern.

Figure 14 illustrates the partial recruitment patterns determined for three year intervals from the final cohort analysis run. The age at full recruitment has varied between 4 and 7 with it presently being estimated at age 6 (Figure 15). When one compares the pattern in change of age at

50% recruitment (Figure 16) to the pattern in change in population biomass and production (Figure 17), one finds a possible direct relationship - the larger the population, the older the fish recruits to the fishery. It is encouraging to see then that the presently determined age of full recruitment, age 6, is quite old and near the upmost extreme, age 7, exhibited for the 1962-80 period.

These variations in the partial recruitment cause considerable variation in the calculated $F_{0.1}$. Using mean weights-at-age for the 1962-80 period, $F_{0.1}$ values were calculated for a period when the stock size was high (1962-64), when it was low (1971-73) and at its present size. The results are given in Table 21. The $F_{0.1}$ values vary between 0.256 and 0.313 which could be considered limits to its variation due to changes in the partial recruitment.

For the present assessment, mean weights-at-age for the 1978-80 period were used in the calculation of the $F_{0.1}$. When this is done, the $F_{0.1}$ is determined to be 0.284, a considerable drop from the 0.304 determined with different weights-at-age. According to this calculation, which is taken to be more indicative of recent events, the current exploitation rate of 0.3 is above $F_{0.1}$.

B. Catch Projections to 1982

Using the 1980 stock status as outlined in Table 22, projections to 1982 were carried out, assuming a 1981 catch at the TAC level of 28,000 mt and fishing at $F_{0.1}$ (0.284) in 1982.

The size of the 1979 year-class at age one was, from both the U.S. and Canadian surveys, shown to be 3.2 times the 1970-80 average. This provided an estimate of 150 x $10^6$ in 1980. As this estimate is based on a small number of observations and as the estimated size of the year-class rivals the extremely large 1963 year-class, it was decided to discount the year-class estimate by an arbitrary amount. A figure of 100 x $10^6$ was used which is about equal to the size of the second largest year-class in the data series--that of 1962.

Age one recruitment for 1981 and 1982 was taken to be 40 x $10^6$, similar to value used by O'Boyle (1980) and approximately average for recent recruitment values.

The results of the projection are presented in Table 23. It is seen that the 1982 TAC could be set at 32 x $10^3$ mt. There is some evidence to suggest that the estimates of both the 1977 and 1979 year-classes are conservative in the present analysis. If this is the case, then the 1982 yield could be in excess of 32 x $10^3$ mt fishing at $F_{0.1}$. Nevertheless, given the degree of uncertainity in the estimates, the more conservative figures presented here appear more appropriate.

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Table 1. Reported nominal catches (mt round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country.

| YEAR | CANADA (Ma) | CANADA (Nfld) | USA | USSR | SPAIN | JAPAN | OTHER | TOTAL | QUOTA |
|---|---|---|---|---|---|---|---|---|---|
| 1962 | 10118 | | 5761 | | | | | 15879 | |
| 1963 | 14385 | | 6397 | 400 | | | 28 | 21210 | |
| 1964 | 24468 | 12 | 7612 | 1108 | | | 40 | 33240 | |
| 1965 | 20562 | | 2455 | 2582 | | | | 25599 | |
| 1966 | 25492 | 23 | 1393 | 10065 | 143 | | | 37116 | |
| 1967 | 29098 | 46 | 2937 | 199 | 78 | | | 32358 | |
| 1968 | 27277 | | 2858 | 335 | 116 | | 36 | 30622 | |
| 1969 | 27419 | | 1707 | | 478 | | 19 | 29623 | |
| 1970 | 15561 | | 1639 | 2 | 370 | 12 | | 17584 | 18000 |
| 1971 | 16064 | | 656 | 97 | 347 | 1 | | 17165 | 18000 |
| 1972 | 12394 | | 411 | 10 | 470 | | 1 | 13286 | 9000 |
| 1973 | 12580 | | 268 | 14 | 134 | 6 | | 13002 | 9000 |
| 1974 | 12434 | | 662 | 35 | 97 | | | 13228 | 0 |
| 1975 | 16509 | | 2109 | 39 | 7 | | 2 | 18666 | 15000 |
| 1976 | 16338 | | 972 | | 95 | | 5 | 17410 | 15000 |
| 1977 | 19537 | | 1649 | 2 | | | 12 | 21200 | 15000 |
| 1978 | 25356 | 114 | 1134 | 2 | | 16 | 11 | 26633 | 21500 |
| 1979 | 24260 | 268 | 69 | 3 | | 15 | | 24615 | 26000 |
| *1980 | 28177 | 75 | 256 | | | 34 | | 28542 | 28000 |

* Provisional 25/4/81

Table 2. Recent Canadian fishery allocations and the respective reported catch in metric tons for 4X haddock. (unit areas M-R)

| Year | Vessel Size | Allocation | Reported Catch | % of Allocation |
|---|---|---|---|---|
| 1975 | all vessels | 12,500 | 16,509[1] | 132 |
| 1976 | all vessels | 13,300 | 16,338[1] | 123 |
| 1977 | all vessels | 13,400 | 19,537[1] | 146 |
| 1978 | all vessels | 21,500* | 25,356[1] | 118 |
| 1979 | > 125 ft. | 8,500 | 8,687[2] | 102 |
| | < 125 ft. | 17,500* | 15,515[2] | 89 |
| 1980 | > 125 ft. | 5,500 | 7,518[2] | 137 |
| | < 125 ft. | 22,500 | 20,659[2] | 92 |
| 1981 | > 125 ft. | 4,600 | 3,336[3] | 73 |
| | < 125 ft. | 20,600 | 4,050[3] | 20 |

* Closed Fisheries

[1] Maritimes and Quebec

[2] Maritimes

[3] 15 April 1981 Atlantic Quota Report

Table 3. Reported nominal catches (mt round) of haddock from NAFO Division 4X (all unit areas combined) for Canadian (Maritimes and Quebec) fishery by gear type.

( ) - number of samples taken by MFD.

| YEAR | OTTER TRAWL SIDE & STERN | LONGLINE | MISCELLANEOUS GEARS | TOTAL |
|---|---|---|---|---|
| 1962 | 7813(2) | 3724(1) | - | 11537 |
| 1963 | 12063(6) | 4700(9) | - | 16763 |
| 1964 | 20532(8) | 5799(10) | - | 26331 |
| 1965 | 18048(14) | 4692(2) | - | 22740 |
| 1966 | 25800(12) | 3720(3) | - | 29520 |
| 1967 | 28696(37) | 3108 | 162 | 31966 |
| 1968 | 25515(42) | 2997 | 325 | 28837 |
| 1969 | 24333(52) | 3302 | 439 | 28074 |
| 1970 | 11750(23) | 3907 | 355 | 16012 |
| 1971 | 12152(20) | 3940(3) | 312 | 16404 |
| 1972 | 7639(22) | 4048(7) | 883(1) | 12570 |
| 1973 | 6123(16) | 5853(9) | 704 | 12680 |
| 1974 | 5688(9) | 6211(10) | 535(1) | 12434 |
| 1975 | 10567(43) | 4944(8) | 548(1) | 16059 |
| 1976 | 10505(35) | 4642(6) | 1191(2) | 16338 |
| 1977 | 14464(70) | 4032(8) | 1097 | 19593 |
| 1978 | 17437(49) | 6052(10) | 1966(4) | 25455 |
| 1979 | 18776(35) | 4347(12) | 1430(2) | 24553 |
| 1980 | 20685(34) | 5338(17) | 2543(4) | 28566 |

Table 4. Reported nominal catches (mt round) of haddock from NAFO Division 4X (all unit areas combined) for Canadian otter trawl fishery by by tonnage class.

( ) - number of samples taken by MFD.

| YEAR | VESSEL SIZE (TONS) | | | | | TOTAL |
|---|---|---|---|---|---|---|
| | 0-50 | 51-150 | 151-500 | 500+ | NK | |
| TONNAGE CLASS | 1&2 | 3 | 4 | 5 | | |
| 1962 | 5224(1) | 1973 | 432(1) | - | 184 | 7813 |
| 1963 | 5926 | 3230(3) | 2863(3) | - | 44 | 12063 |
| 1964 | 3118 | 3964(3) | 13450(5) | - | - | 20532 |
| 1965 | 4605 | 4182(2) | 9261(12) | - | - | 18048 |
| 1966 | 8872 | 9094 | 7648(12) | 186 | - | 25800 |
| 1967 | 7479(2) | 7983(1) | 11085(31) | 2149(3) | - | 28696 |
| 1968 | 4753(1) | 6938(5) | 10552(34) | 3272(2) | - | 25515 |
| 1969 | 2619 | 4144(6) | 9791(36) | 7779(10) | - | 24333 |
| 1970 | 2050 | 3165(1) | 3703(20) | 2832(2) | - | 11750 |
| 1971 | 1715 | 2714(2) | 4773(12) | 2950(5) | - | 12152 |
| 1972 | 1196 | 1688(2) | 2811(17) | 1944(3) | - | 7639 |
| 1973 | 919(2) | 971 | 2569(11) | 1664(3) | - | 6123 |
| 1974 | 2165(2) | 1895(2) | 1072(5) | 556 | - | 5688 |
| 1975 | 2742(2) | 3419(10) | 2413(19) | 1993(9) | - | 10567 |
| 1976 | 1778(1) | 2598(1) | 3029(22) | 3100(11) | - | 10505 |
| 1977 | 2672(2) | 3543(4) | 3627(33) | 4622(31) | - | 14464 |
| 1978 | 4424 | 4923(1) | 4045(35) | 4045(13) | - | 17437 |
| 1979 | 4684 | 5455(2) | 4317(21) | 4320(12) | - | 18776 |
| 1980 | 6781(6) | 6431(4) | 3537(13) | 3936(11) | - | 20685 |

Table 5. Catch at age (numbers x $10^{-3}$) of haddock from 4Xm-r (excludes discards)

| AGE | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - | - | - | - | - | 41 | 150 | 1 | 37 | 18 | 2 | - | - | 12 |
| 2 | 139 | 713 | 155 | 70 | 219 | 22 | 665 | 10 | 1055 | 788 | 22 | 3077 | 694 | 2175 | 1296 | 1285 | 75 | 81 | 168 |
| 3 | 4524 | 2013 | 1272 | 3038 | 18341 | 515 | 297 | 2016 | 724 | 1617 | 3434 | 113 | 4653 | 4568 | 1644 | 3126 | 3354 | 1158 | 2692 |
| 4 | 1415 | 7185 | 4286 | 1981 | 9796 | 20380 | 1164 | 1968 | 1502 | 788 | 1841 | 2247 | 309 | 5164 | 4261 | 2019 | 7014 | 6709 | 3283 |
| 5 | 1778 | 3087 | 9337 | 3153 | 3167 | 9148 | 17448 | 1621 | 379 | 1422 | 509 | 1067 | 1779 | 485 | 3682 | 3193 | 2094 | 3881 | 5321 |
| 6 | 1708 | 1649 | 3018 | 5409 | 2149 | 1039 | 4684 | 11243 | 524 | 404 | 645 | 527 | 509 | 1103 | 434 | 2881 | 2832 | 1070 | 3457 |
| 7 | 1648 | 1415 | 1492 | 1973 | 3747 | 735 | 713 | 3220 | 4536 | 69 | 90 | 600 | 189 | 247 | 807 | 360 | 1040 | 1244 | 578 |
| 8 | 973 | 593 | 1370 | 1000 | 840 | 1052 | 518 | 455 | 1863 | 3316 | 57 | 322 | 269 | 172 | 154 | 389 | 137 | 263 | 526 |
| 9 | 645 | 473 | 612 | 745 | 409 | 187 | 672 | 249 | 133 | 1020 | 1166 | 259 | 186 | 62 | 71 | 107 | 107 | 57 | 173 |
| 10 | 232 | 152 | 416 | 288 | 424 | 102 | 190 | 194 | 96 | 163 | 512 | 614 | 269 | 32 | 95 | 72 | 26 | 68 | 36 |
| 11 | 205 | 113 | 297 | 203 | 88 | 90 | 131 | 172 | 175 | 181 | 26 | 55 | 552 | 165 | 39 | 23 | 9 | 11 | 24 |
| 12 | 64 | 59 | 168 | 114 | 62 | 23 | 65 | 94 | 27 | 146 | 193 | 13 | 24 | 229 | 103 | 8 | 6 | - | 9 |
| 13+ | 100 | 43 | 36 | 113 | 84 | 81 | 89 | 69 | 37 | 105 | 92 | 6 | 4 | 11 | 157 | 87 | 48 | 18 | 16 |
| Total | 13431 | 17500 | 22459 | 18087 | 39326 | 33374 | 26636 | 21311 | 11051 | 10019 | 8628 | 9050 | 9438 | 14450 | 12761 | 13552 | 16742 | 14560 | 16295 |
| Estimated Landings | 18949 | 22806 | 32172 | 25910 | 39116 | 33494 | 31903 | 28435 | 16414 | 16235 | 13054 | 12095 | 13030 | 17318 | 18651 | 20557 | 26812 | 24678 | 28677 |
| Reported Landings | 15879 | 21210 | 33240 | 25599 | 37116 | 32358 | 30622 | 29623 | 17584 | 17165 | 13286 | 13003 | 13228 | 18666 | 17410 | 21200 | 26633 | 24615 | 28542 |

Table 6. Composition of commercial catch for 4X haddock fishery

| AGE | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. PER CENT BY NUMBER | | | | | | | | | | | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 1.66 | 0.01 | 0.26 | 0.14 | 0.01 | 0.00 | 0.00 | 0.07 |
| 2 | 1.03 | 4.07 | 0.69 | 0.39 | 0.56 | 0.07 | 2.50 | 0.05 | 9.55 | 7.78 | 0.25 | 34.00 | 7.35 | 15.05 | 10.16 | 9.48 | 0.45 | 0.56 | 1.03 |
| 3 | 33.68 | 11.50 | 5.66 | 16.80 | 46.64 | 1.54 | 1.12 | 9.46 | 6.55 | 16.14 | 39.80 | 1.25 | 49.30 | 31.61 | 12.88 | 23.07 | 20.03 | 7.95 | 16.52 |
| 4 | 10.54 | 41.06 | 19.08 | 10.95 | 24.91 | 61.07 | 4.37 | 9.23 | 13.59 | 7.87 | 21.34 | 24.83 | 3.27 | 35.74 | 33.39 | 14.90 | 41.89 | 46.08 | 20.15 |
| 5 | 13.24 | 17.64 | 41.57 | 17.43 | 8.05 | 27.41 | 65.51 | 7.61 | 3.43 | 14.20 | 5.90 | 11.79 | 18.85 | 3.36 | 28.85 | 23.56 | 12.51 | 26.66 | 32.65 |
| 6 | 12.72 | 9.42 | 13.44 | 29.91 | 5.46 | 3.11 | 17.59 | 52.76 | 4.74 | 4.03 | 7.48 | 5.82 | 5.39 | 7.63 | 3.40 | 21.26 | 16.92 | 7.35 | 21.22 |
| 7 | 12.27 | 8.09 | 6.64 | 10.91 | 9.53 | 2.20 | 2.68 | 15.11 | 41.05 | 0.69 | 1.04 | 6.63 | 2.00 | 1.71 | 6.32 | 2.66 | 6.21 | 8.54 | 3.55 |
| 8 | 7.24 | 3.39 | 6.10 | 5.53 | 2.14 | 3.15 | 1.94 | 2.14 | 16.86 | 33.10 | 0.66 | 3.56 | 2.85 | 1.19 | 1.21 | 2.87 | 0.82 | 1.81 | 3.23 |
| 9 | 4.80 | 2.73 | 2.72 | 4.12 | 1.04 | 0.56 | 2.52 | 1.17 | 1.20 | 10.18 | 13.51 | 2.86 | 1.97 | 0.43 | 0.56 | 0.79 | 0.64 | 0.39 | 1.06 |
| 10 | 1.73 | 0.87 | 1.85 | 1.59 | 1.08 | 0.31 | 0.71 | 0.91 | 0.87 | 1.63 | 5.93 | 6.78 | 2.85 | 0.22 | 0.74 | 0.53 | 0.16 | 0.47 | 0.22 |
| 11 | 1.53 | 0.65 | 1.32 | 1.12 | 0.22 | 0.27 | 0.49 | 0.81 | 1.58 | 1.81 | 0.30 | 0.61 | 5.85 | 1.14 | 0.31 | 0.17 | 0.05 | 0.08 | 0.15 |
| 12 | 0.48 | 0.34 | 0.75 | 0.63 | 0.16 | 0.07 | 0.24 | 0.44 | 0.24 | 1.46 | 2.24 | 0.14 | 0.25 | 1.58 | 0.81 | 0.06 | 0.04 | 0.00 | 0.06 |
| 13+ | 0.74 | 0.25 | 0.16 | 0.62 | 0.21 | 0.24 | 0.33 | 0.32 | 0.33 | 1.05 | 1.07 | 0.07 | 0.04 | 0.08 | 1.23 | 0.64 | 0.29 | 0.12 | 0.10 |
| B. PER CENT BY WEIGHT | | | | | | | | | | | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.33 | 0.00 | 0.05 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2 | 0.41 | 1.56 | 0.24 | 0.10 | 0.17 | 0.02 | 0.77 | 0.02 | 3.66 | 2.43 | 0.08 | 12.97 | 2.45 | 6.53 | 3.61 | 2.88 | 0.13 | 0.17 | 0.32 |
| 3 | 17.91 | 6.89 | 2.97 | 7.62 | 31.42 | 0.95 | 0.58 | 5.32 | 3.97 | 9.56 | 23.68 | 0.70 | 29.28 | 21.63 | 7.14 | 10.80 | 10.83 | 4.10 | 8.41 |
| 4 | 8.59 | 33.08 | 13.32 | 7.65 | 21.29 | 51.72 | 3.28 | 6.09 | 9.61 | 6.07 | 19.04 | 23.22 | 2.61 | 35.78 | 27.19 | 11.98 | 34.85 | 36.07 | 15.06 |
| 5 | 13.14 | 19.63 | 37.73 | 14.60 | 9.96 | 28.68 | 60.16 | 6.56 | 2.68 | 12.26 | 6.24 | 15.88 | 23.21 | 4.34 | 31.59 | 26.72 | 14.46 | 28.95 | 32.54 |
| 6 | 14.42 | 12.29 | 15.95 | 32.57 | 8.24 | 4.50 | 19.09 | 53.38 | 4.57 | 3.73 | 8.65 | 8.71 | 8.99 | 14.33 | 4.89 | 30.83 | 24.57 | 10.23 | 28.30 |
| 7 | 19.13 | 11.48 | 9.04 | 14.85 | 17.24 | 3.95 | 3.80 | 18.12 | 45.60 | 0.74 | 1.31 | 10.91 | 3.63 | 4.06 | 12.76 | 5.15 | 10.46 | 14.25 | 5.77 |
| 8 | 10.89 | 6.11 | 8.69 | 8.49 | 4.68 | 6.44 | 3.33 | 3.20 | 22.13 | 39.83 | 0.92 | 6.12 | 5.37 | 2.98 | 2.89 | 6.24 | 1.73 | 3.52 | 6.07 |
| 9 | 6.47 | 4.72 | 4.76 | 5.61 | 2.61 | 1.32 | 4.84 | 2.15 | 1.86 | 14.45 | 20.54 | 5.35 | 4.00 | 1.15 | 1.37 | 1.86 | 1.51 | 0.93 | 2.23 |
| 10 | 2.94 | 1.47 | 3.10 | 2.92 | 2.71 | 0.82 | 1.50 | 1.71 | 1.65 | 2.66 | 10.98 | 13.71 | 6.09 | 0.64 | 1.94 | 1.32 | 0.41 | 1.15 | 0.52 |
| 11 | 3.09 | 1.34 | 2.23 | 1.96 | 0.62 | 0.73 | 1.23 | 1.63 | 2.99 | 3.62 | 0.60 | 1.50 | 13.56 | 3.33 | 0.86 | 0.41 | 0.14 | 0.22 | 0.35 |
| 12 | 0.91 | 0.83 | 1.57 | 1.19 | 0.41 | 0.20 | 0.59 | 1.09 | 0.47 | 2.70 | 5.47 | 0.37 | 0.70 | 4.89 | 2.21 | 0.15 | 0.08 | 0.00 | 0.15 |
| 13+ | 2.11 | 0.61 | 0.40 | 1.44 | 0.64 | 0.68 | 0.82 | 0.74 | 0.81 | 1.94 | 2.33 | 0.21 | 0.12 | 0.28 | 3.54 | 1.65 | 0.83 | 0.42 | 0.27 |

Table 7. Mean weights at age (kg) for 4X haddock stock derived from commercial statistics

| AGE | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | (0.29) | .56 | .27 | .18 | .23 | .23 | .28 | (.29) | (0.29) | 0.23 |
| 2 | .56 | .50 | .50 | .36 | .31 | .32 | .37 | .56 | .57 | .50 | .45 | .51 | .46 | .52 | .52 | .46 | .44 | 0.51 | 0.54 |
| 3 | .75 | .78 | .75 | .65 | .67 | .62 | .62 | .75 | .90 | .96 | .90 | .75 | .82 | .82 | .81 | .71 | .87 | 0.87 | 0.90 |
| 4 | 1.15 | 1.05 | 1.00 | 1.00 | .85 | .85 | .9 | .88 | 1.05 | 1.25 | 1.35 | 1.25 | 1.10 | 1.20 | 1.19 | 1.22 | 1.33 | 1.33 | 1.32 |
| 5 | 1.40 | 1.45 | 1.30 | 1.20 | 1.23 | 1.05 | 1.10 | 1.15 | 1.16 | 1.40 | 1.60 | 1.80 | 1.70 | 1.55 | 1.60 | 1.72 | 1.85 | 1.84 | 1.75 |
| 6 | 1.60 | 1.70 | 1.70 | 1.56 | 1.50 | 1.45 | 1.30 | 1.35 | 1.43 | 1.50 | 1.75 | 2.00 | 2.30 | 2.25 | 2.10 | 2.20 | 2.33 | 2.36 | 2.35 |
| 7 | 2.20 | 1.85 | 1.95 | 1.95 | 1.80 | 1.80 | 1.70 | 1.60 | 1.65 | 1.75 | 1.90 | 2.20 | 2.50 | 2.85 | 2.95 | 2.94 | 2.67 | 2.83 | 2.86 |
| 8 | 2.12 | 2.35 | 2.04 | 2.20 | 2.18 | 2.05 | 2.05 | 2.00 | 1.95 | 1.95 | 2.10 | 2.30 | 2.60 | 3.00 | 3.50 | 3.30 | 3.39 | 3.30 | 3.31 |
| 9 | 1.90 | 2.25 | 2.50 | 2.30 | 2.50 | 2.36 | 2.30 | 2.45 | 2.30 | 2.30 | 2.30 | 2.50 | 2.80 | 3.20 | 3.60 | 3.57 | 3.77 | 4.03 | 3.69 |
| 10 | 2.40 | 2.20 | 2.40 | 2.63 | 2.50 | 2.70 | 2.52 | 2.50 | 2.82 | 2.65 | 2.80 | 2.70 | 2.95 | 3.80 | 3.80 | 3.77 | 4.17 | 4.15 | 4.13 |
| 11 | 2.86 | 2.70 | 2.42 | 2.50 | 2.75 | 2.70 | 3.00 | 2.70 | 2.80 | 3.25 | 3.00 | 3.30 | 3.20 | 3.50 | 4.10 | 3.69 | 4.03 | 4.96 | 4.17 |
| 12 | 2.70 | 3.20 | 3.00 | 2.70 | 2.60 | 2.89 | 2.90 | 3.30 | 2.85 | 3.00 | 3.70 | 3.40 | 3.80 | 3.70 | 4.00 | 3.94 | 3.62 | 6.00 | 4.78 |
| 13+ | 3.99 | 3.25 | 3.61 | 3.30 | 3.00 | 2.80 | 2.95 | 3.06 | 3.60 | 3.00 | 3.20 | 4.20 | 3.90 | 4.40 | 4.20 | 3.91 | 4.63 | 5.68 | 4.83 |

Weights in parenthesis are estimates, based on 1972-1978 data.

Table 8. Indices of abundance for the 4X haddock stock

| | RESEARCH SURVEYS | | | | COMMERCIAL STATISTICS | | | |
|---|---|---|---|---|---|---|---|---|
| | Canadian Summer Strata 70-91,95 (smoothed over 3 years) | | U.S. Fall Strata 31-34 (smoothed over 3 years) | | Canadian Otter Trawlers (mt/hr) (>50% of catch) Tonnage Class 3 | | Tonnage Class 4 | U.S. Otter Trawlers Tonnage Class 4 |
| Year | num/tow | kg/tow | num/tow | kg/tow | side | stern | side & stern | (mt/hr) |
| 1963 | | | 191.92 | 67.91 | | | | 0.271 |
| 1964 | | | 52.07 | 31.82 | | | | 0.313 |
| 1965 | | | 52.07 | 31.82 | | | | 0.271 |
| 1966 | | | 52.07 | 34.91 | | | | 0.196 |
| 1967 | | | 51.63 | 34.91 | | | | 0.225 |
| 1968 | | | 30.92 | 28.53 | | | 0.285 | 0.188 |
| 1969 | | | 23.74 | 17.66 | | | 0.204 | 0.142 |
| 1970 | 21.385 | 22.95 | 23.74 | 17.66 | 0.079 | 0.058 | 0.170 | 0.133 |
| 1971 | 21.385 | 22.95 | 39.01 | 24.1 | 0.114 | 0.085 | 0.170 | 0.104 |
| 1972 | 25.484 | 13.24 | 39.01 | 24.1 | - | 0.214 | 0.168 | 0.138 |
| 1973 | 30.21 | 13.24 | 25.48 | 20.74 | 0.200 | 0.124 | 0.149 | 0.104 |
| 1974 | 30.21 | 21.29 | 24.78 | 20.74 | 0.542 | 0.192 | 0.165 | - |
| 1975 | 24.409 | 22.21 | 24.78 | 20.74 | 0.215 | 0.253 | 0.243 | 0.242 |
| 1976 | 24.409 | 22.21 | 38.69 | 21.94 | - | 0.323 | 0.310 | 0.217 |
| 1977 | 27.746 | 26.46 | 54.18 | 53.59 | 0.255 | 0.391 | 0.286 | 0.321 |
| 1978 | 37.581 | 41.98 | 86.30 | 53.59 | 0.500 | 0.470 | 0.386 | (1) |
| 1979 | 37.581 | 41.98 | 87.99 | 53.59 | 0.226 | 0.306 | 0.488 | (1) |
| 1980 | 61.679 | 57.01 | 87.99 | 33.47 | 0.276 | 0.388 | 0.420 | (1) |

[1] Not calculated due to 10% trip limitation on U.S. vessels

Table 9. Stratified mean catch (in numbers) per standard tow of haddock caught during U.S. Fall Bottom Trawl Survey (Strata 31-42)

| AGE | 1963* | 1964* | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976* | 1977 | 1978* | 1979* | 1980* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 79.39 | 0.21 | 0.44 | 0.70 | 0.08 | 2.05 | 10.22 | 0.10 | 12.59 | 8.19 | 1.82 | 4.10 | 9.58 | 11.71 | 12.06 | 6.08 | 25.24 | 55.57 |
| 1 | 48.68 | 14.21 | 6.07 | 1.18 | 3.37 | 0.91 | 4.13 | 4.31 | 0.02 | 20.59 | 8.89 | 1.79 | 6.93 | 13.66 | 8.98 | 9.85 | 12.05 | 42.83 |
| 2 | 15.67 | 10.96 | 26.10 | 1.51 | 1.25 | 2.64 | 0.77 | 2.14 | 5.76 | 0.18 | 12.31 | 5.26 | 3.42 | 4.43 | 18.13 | 11.93 | 28.85 | 8.73 |
| 3 | 14.03 | 3.58 | 9.87 | 22.31 | 2.44 | 1.09 | 2.16 | 0.67 | 1.60 | 4.31 | 0.16 | 5.39 | 4.51 | 1.92 | 9.63 | 14.45 | 8.47 | 5.52 |
| 4 | 19.62 | 4.62 | 3.55 | 7.42 | 22.09 | 0.37 | 0.31 | 1.27 | 0.67 | 1.26 | 3.48 | 0.14 | 5.38 | 2.38 | 2.44 | 5.61 | 8.38 | 2.37 |
| 5 | 7.64 | 7.37 | 3.18 | 2.23 | 4.04 | 8.41 | 0.08 | 0.20 | 0.98 | 0.32 | 0.83 | 1.54 | 0 | 3.66 | 3.49 | 2.43 | 2.84 | 1.95 |
| 6 | 3.29 | 2.18 | 4.13 | 1.57 | 0.92 | 2.97 | 2.91 | 0.71 | 0.19 | 0.54 | 0.11 | 0.47 | 0.74 | 0 | 3.82 | 3.14 | 1.52 | 0.47 |
| 7 | 1.52 | 0.63 | 1.25 | 2.28 | 0.83 | 0.33 | 1.22 | 2.43 | 0.11 | 0.14 | 0.35 | 0.05 | 0.29 | 0.58 | 0.19 | 0.43 | 0.60 | 0.19 |
| 8 | 1.21 | 0.75 | 0.30 | 0.84 | 0.40 | 0.42 | 0.13 | 0.81 | 2.51 | 0.07 | 0.12 | 0.28 | 0.18 | 0.02 | 0.12 | 0 | 0.04 | 0.35 |
| 9 | 0.33 | 0.34 | 0.40 | 0.55 | 0.14 | 0.52 | 0.33 | 0.25 | 0.83 | 1.17 | 0.24 | 0.03 | 0.07 | 0 | 0.14 | 0.12 | 0 | 0.11 |
| 10 | 0.42 | 0 | 0 | 0 | 0 | 0 | 0.19 | 0.15 | 0.19 | 0.22 | 0.83 | 0.04 | 0.02 | 0.02 | 0 | 0.07 | 0 | 0 |
| 11 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0.05 | 0.14 | 0.23 | 0.04 | 0.08 | 1.09 | 0.05 | . 0 | 0.05 | 0 | 0 | 0 |
| 12 | 0.08 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 | 0 | 0.08 | 0 | 0.18 | 0.03 | 0.25 | 0.02 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0 | 0.01 | 0 | 0 | 0.07 | 0.03 | 0.02 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.12 | 0.01 | 0 | 0.04 | 0.05 | 0 | 0 |
| TOTAL | 191.92 | 44.85 | 55.29 | 40.61 | 35.56 | 19.71 | 22.50 | 13.26 | 25.69 | 37.12 | 29.24 | 20.47 | 31.28 | 38.66 | 59.14 | 54.18 | 87.99 | 118.09 |
| Ages 2+ | 63.86 | 30.43 | 48.78 | 38.71 | 32.11 | 16.75 | 8.15 | 8.83 | 13.07 | 8.34 | 18.51 | 14.59 | 14.77 | 13.29 | 38.09 | 38.23 | 50.70 | 19.69 |
| Ages 5+ | 14.54 | 11.27 | 9.26 | 7.47 | 6.33 | 12.65 | 4.91 | 4.75 | 5.04 | 2.59 | 2.55 | 3.80 | 1.46 | 4.56 | 7.89 | 6.24 | 5.00 | 3.07 |
| Total Kg/tow | 67.91 | 31.43 | 30.59 | 33.49 | 27.11 | 19.10 | 12.79 | 14.53 | 17.05 | 17.10 | 18.94 | 17.21 | 18.29 | 21.94 | 48.73 | 53.59 | 55.55 | 33.47 |

* Strata 41 and 42 not sampled.

Table 10. Stratified mean catch (in numbers) per standard tow of haddock caught during U.S. Fall Bottom Trawl Survey (Strata 31-34)

| AGE | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 79.39 | 0.21 | 1.53 | 1.12 | 0.13 | 3.55 | 10.27 | 0.13 | 20.46 | 7.74 | 1.12 | 3.70 | 7.10 | 11.71 | 12.55 | 6.08 | 25.24 | 55.57 |
| 1 | 48.68 | 14.21 | 2.46 | 1.83 | 6.29 | 1.72 | 4.66 | 4.88 | 0.06 | 34.03 | 3.85 | 2.77 | 4.42 | 13.66 | 16.16 | 9.85 | 12.05 | 42.83 |
| 2 | 15.67 | 10.96 | 24.99 | 2.88 | 2.44 | 4.60 | 0.52 | 2.51 | 8.61 | 0.12 | 16.12 | 6.72 | 2.91 | 4.43 | 29.46 | 11.93 | 28.85 | 8.73 |
| 3 | 14.03 | 3.58 | 10.67 | 39.85 | 3.89 | 1.62 | 2.17 | 0.41 | 2.30 | 5.32 | 0.16 | 7.54 | 1.96 | 1.92 | 13.33 | 14.45 | 8.47 | 5.52 |
| 4 | 19.62 | 4.62 | 3.67 | 12.82 | 31.64 | 0.49 | 0.32 | 1.16 | 0.31 | 1.54 | 1.95 | _ | 5.07 | 2.38 | 3.99 | 5.61 | 8.38 | 2.37 |
| 5 | 7.64 | 7.37 | 2.95 | 4.08 | 4.57 | 12.83 | 0.04 | 0.25 | 1.07 | 0.18 | 0.35 | 0.87 | _ | 3.66 | 4.27 | 2.43 | 2.84 | 1.95 |
| 6 | 3.29 | 2.18 | 3.99 | 2.30 | 0.98 | 4.13 | 3.09 | 0.81 | 0.16 | 0.60 | 0.16 | 0.36 | 0.35 | _ | 6.02 | 3.14 | 1.52 | 0.47 |
| 7 | 1.52 | 0.63 | 1.24 | 3.80 | 1.07 | 0.53 | 1.42 | 3.09 | 0.11 | 0.17 | 0.16 | 0.13 | 0.23 | 0.58 | 0.14 | 0.43 | 0.60 | 0.19 |
| 8 | 1.21 | 0.75 | 0.19 | 1.55 | 0.47 | 0.73 | 0.17 | 1.29 | 3.70 | 0.14 | 0.08 | 0.14 | 0.14 | 0.02 | 0.09 | _ | 0.04 | 0.35 |
| 9 | 0.33 | 0.34 | 0.37 | 0.90 | 0.17 | 0.71 | 0.62 | 0.34 | 1.54 | 1.83 | 0.30 | 0.07 | 0.12 | _ | 0.10 | 0.12 | _ | 0.11 |
| 10 | 0.42 | _ | _ | _ | _ | _ | 0.36 | 0.34 | 0.28 | 0.36 | 1.07 | 0.07 | _ | 0.02 | _ | 0.07 | _ | _ |
| 11 | 0.05 | _ | _ | _ | _ | _ | 0.10 | 0.16 | 0.41 | _ | 0.12 | 2.02 | 0.03 | _ | 0.09 | _ | _ | _ |
| 12 | 0.08 | _ | _ | _ | _ | _ | _ | 0.06 | _ | 0.20 | _ | 0.27 | 0.05 | 0.25 | _ | _ | _ | _ |
| 13 | _ | _ | _ | _ | _ | _ | _ | 0.05 | _ | _ | _ | _ | 0.04 | 0.03 | _ | _ | _ | _ |
| 14 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 0.12 | _ | _ | 0.10 | 0.05 | _ | _ |
| TOTAL | 191.92 | 44.85 | 52.07 | 71.15 | 51.63 | 30.92 | 23.74 | 15.48 | 39.01 | 52.22 | 25.44 | 24.78 | 22.42 | 38.66 | 86.30 | 54.18 | 87.99 | 118.09 |
| AGES 2+ | 63.86 | 30.43 | 48.07 | 68.18 | 45.23 | 25.64 | 8.81 | 10.47 | 18.49 | 10.46 | 20.47 | 18.31 | 10.90 | 13.29 | 57.59 | 38.23 | 50.70 | 19.69 |
| AGES 5+ | 14.54 | 11.27 | 8.74 | 12.63 | 7.26 | 18.93 | 5.80 | 6.39 | 7.27 | 3.48 | 2.24 | 4.05 | 0.96 | 4.56 | 10.81 | 6.24 | 5.00 | 3.07 |
| TOTAL kg/tow | 67.91 | 31.43 | 31.82 | 58.65 | 34.91 | 28.53 | 14.59 | 17.66 | 24.10 | 24.45 | 17.27 | 20.74 | 13.86 | 21.94 | 75.29 | 53.59 | 55.55 | 33.47 |

Table 11. Stratified mean catch (in numbers) per standard tow of haddock caught during Canadian Summer Bottom Trawl Survey (strata 70-91, 95).

| Age | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | - | - | - | - | - | - | - | 0.007 | - | 0.352 | 0.024 |
| 1 | 4.872 | 0.099 | 4.404 | 4.976 | 8.153 | 5.518 | 4.617 | 5.278 | 5.391 | 1.636 | 18.511 |
| 2 | 3.921 | 9.263 | 0.195 | 19.053 | 17.942 | 3.466 | 5.272 | 20.246 | 4.660 | 11.528 | 6.028 |
| 3 | 1.148 | 3.933 | 2.732 | 0.479 | 21.220 | 4.383 | 3.394 | 13.077 | 9.544 | 6.605 | 13.179 |
| 4 | 2.167 | 1.729 | 1.160 | 2.466 | 0.768 | 6.013 | 3.405 | 3.868 | 2.870 | 7.919 | 6.841 |
| 5 | 0.881 | 2.489 | 0.761 | 1.131 | 3.578 | 0.394 | 6.175 | 5.557 | 1.400 | 4.009 | 10.472 |
| 6 | 1.982 | 1.131 | 0.825 | 0.423 | 0.775 | 1.417 | 0.467 | 3.456 | 2.615 | 1.605 | 3.527 |
| 7 | 5.073 | 1.746 | 0.543 | 0.569 | 0.438 | 0.510 | 0.553 | 0.466 | 0.988 | 2.524 | 1.298 |
| 8 | 0.704 | 4.424 | 0.808 | 0.429 | 0.505 | 0.287 | 0.101 | 0.558 | 0.025 | 0.949 | 1.056 |
| 9 | 0.293 | 0.504 | 1.106 | 0.287 | 0.268 | 0.136 | 0.026 | 0.121 | - | 0.208 | 0.510 |
| 10 | 0.258 | 0.078 | 0.037 | 0.371 | 0.202 | 0.043 | 0.033 | 0.095 | - | 0.026 | 0.202 |
| 11 | 0.069 | 0.035 | 0.005 | 0.018 | 0.287 | 0.246 | 0.008 | 0.008 | 0.035 | - | 0.031 |
| 12 | 0.017 | 0.053 | 0.004 | 0.008 | - | 0.153 | 0.284 | 0.216 | 0.130 | 0.099 | - |
| NK | - | - | 0.066 | - | - | - | 0.074 | 0.007 | 0.088 | 0.121 | - |
| TOTAL | 21.385 | 25.484 | 12.646 | 30.210 | 54.136 | 22.566 | 24.409 | 52.960 | 27.746 | 37.581 | 61.679 |
| 2+ | 16.513 | 25.385 | 8.242 | 25.234 | 45.983 | 17.048 | 19.792 | 47.675 | 22.355 | 35.593 | 43.144 |
| 5+ | 9.277 | 10.460 | 4.155 | 3.236 | 6.053 | 3.186 | 7.721 | 10.484 | 5.281 | 9.541 | 17.096 |
| TOTAL kg/tow | 22.95 | 27.50 | 13.24 | 12.77 | 39.46 | 21.29 | 22.21 | 90.45 | 26.46 | 41.98 | 57.01 |

Table 12. Strata ranking of haddock catches (numbers per tow) from Canadian Summer Bottom Trawl Survey

1 - highest catch rate; 2 - second highest catch rate . . . . . 5 - fifth highest catch rate.

O - Strata equivalent sampled by U.S. Fall Bottom Trawl Survey

| STRATA | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | | | | | | | | 2 | | | |
| 71 | | | | | | | | | | | |
| 72 | | | | | | 4 | | | | | 2 |
| 73 | 2 | | 2 | 4 | | | 2 | 3 | | 5 | |
| 74 | 5 | | 4 | | 4 | 2 | 4 | | 2 | 2 | |
| 75 | 3 | 4 | | 5 | 3 | | 1 | | 4 | | 5 |
| 76 | | 2 | | | 5 | 3 | | | | | |
| 77 | | 5 | 5 | | | | 5 | | | | |
| 78 | | | | | | | | | | | |
| 79 | | | | | | | | | | | |
| 80 | 1 | 1 | 1 | 2 | 2 | 1 | | 1 | 1 | 3 | 3 |
| 81 | 4 | | 3 | 1 | 1 | | | | 3 | 4 | 4 |
| 82 | | | | | | | | | | | |
| 83 | | | | | | | | | | | |
| 84 | | | | | | | | | | | |
| 85 | | | | | | | | | | | |
| 90 | | 3 | | 3 | | 5 | 3 | 5 | 5 | 1 | 1 |
| 91 | | | | | | | | 4 | | | |
| 92 | | | | | | | | | | | |
| 93 | | | | | | | | | | | |
| 94 | | | | | | | | | | | |
| 95 | | | | | | | | | | | |

Table 13. Analysis of variation present in Canadian Summer Bottom Trawl Survey

| Year | Strata Contributing Most to Survey Estimate | % Contribution to Abundance Estimate | % Contribution to Overall Variance | No. Sets |
|---|---|---|---|---|
| 1970 | 81 | 26.7 | 30.1 | 5 |
| | 85 | 18.6 | 54.0 | 2 |
| | | 45.3 | 84.1 | 7 |
| 1971 | 76 | 23.69 | 50.9 | 2 |
| | 80 | 31.47 | 25.5 | 4 |
| | | 55.16 | 76.4 | 6 |
| 1972 | 80 | 26.09 | 45.98 | 4 |
| | 81 | 23.72 | 38.31 | 4 |
| | | 49.81 | 84.29 | 8 |
| 1973 | 81 | 56.27 | 84.31 | 4 |
| 1974 | 81 | 40.87 | 61.35 | 4 |
| | 90 | 15.41 | 22.08 | 2 |
| | | 56.28 | 83.43 | 6 |
| 1975 | 72 | 13.74 | 39.00 | 2 |
| | 76 | 17.73 | >1 | 6 |
| | 80 | 26.15 | 14.57 | 3 |
| | 81 | 16.84 | 38.15 | 4 |
| | | 74.46 | 91.72 | 15 |
| 1976 | 77 | 19.20 | 34.87 | 2 |
| | 81 | 24.64 | 7.77 | 4 |
| | 90 | 15.22 | 11.43 | 3 |
| | | 59.06 | 54.07 | 9 |
| 1977 | 76 | 45.75 | 84.66 | 4 (one tow primarily) |
| 1978 | 80 | 24.34 | 35.97 | 3 |
| | 81 | 31.35 | 62.48 | 4 |
| | | 55.69 | 98.45 | 7 |
| 1979 | 81 | 21.22 | 71.63 | 4 |
| | 90 | 30.32 | 6.57 | 2 |
| | | 51.54 | 78.20 | 6 |
| 1980 | 72 | 25.93 | 43.85 | 2 |
| | 81 | 25.93 | 41.42 | 3 |
| | | 51.86 | 85.27 | 5 |

Table 14. Summary of survivor output parameters in analysis of Canadian Summer Bottom Trawl Survey Data

| Ages in Data Set | Calibration Block Final Year | Calibration Block Oldest Age | Age of Full Recruitment | K Age 6 | Residuals $\bar{X}$ | Residuals 50 | Range (%) of CV's for Last Year for ages 3-8 | No. Outliers | Estimated Survivors (Weighted) 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-9 | 1974 | 5 | 5 | 13775 | 0.454 | 0.722 | 99-220 | 3 | 63765 | 23548 | 27664 | 5496 | 6888 | 5532 |
| 2-9 | 1975 | 6 | 5 | 3226 | 0.239 | 0.552 | 65-142 | 2 | 50827 | 16192 | 17676 | 2712 | 2127 | 2474 |
| 2-9 | 1976 | 6 | 6 | 5207 | 0.302 | 0.596 | 63-139 | 3 | 53829 | 18084 | 21189 | 3220 | 2156 | 3460 |
| 2-9 | 1977 | 6 | 6 | 4694 | 0.274 | 0.590 | 58-136 | 3 | 48267 | 16025 | 18875 | 2716 | 1882 | 3091 |
| 2-9 | 1978 | 6 | 6 | 5018 | 0.294 | 0.586 | 58-122 | 3 | 51683 | 17500 | 21383 | 3378 | 2324 | 3502 |
| 2-9 | 1979 | 6 | 6 | 4531 | 0.280 | 0.576 | 54-114 | 3 | 50907 | 17271 | 20778 | 3306 | 2147 | 3293 |
| 3-9 | 1979 | 6 | 6 | 2829 | 0.211 | 0.508 | 50-86 | 1 | 49549 | 19390 | 16848 | 3130 | 1611 | 2184 |
| 3-9 | 1979 | 7 | 6 | 1909 | 0.142 | 0.486 | 49-86 | 3 | 47169 | 18259 | 15430 | 2610 | 1179 | 1420 |
| 3-9 | 1979 | 8 | 6 | 1789 | 0.128 | 0.485 | 50-89 | 3 | 46840 | 18112 | 15248 | 2514 | 1110 | 1305 |
| 3-9 | 1980 | 6 | 6 | 2533 | 0.189 | 0.501 | 47-60 | 2 | 48548 | 18826 | 16061 | 2881 | 1421 | 1942 |
| 3-8 | 1979 | 7 | 6 | 2257 | 0.116 | 0.361 | 49-84 | 2 | 48009 | 18985 | 16314 | 2925 | 1403 | 1750* |
| 3-8 | 1979 | 8 | 8 | 2663 | 0.151 | 0.392 | 52-84 | 2 | 52545 | 20713 | 18429 | 3480 | 1803 | 2534 |

* Run chosen to determine $F_R$ in 1980

Table 15. Results of survivor method including analysis of variance.

INTEGRATED CATCH 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 3957 | 6596 | 12085 | 3130 | 22560 | 21761 | 9705 | 22334 | 17923 | 4625 | 1416 |
| 4 | 5188 | 2553 | 3828 | 7346 | 2367 | 14010 | 13822 | 6277 | 13602 | 10038 | 1726 |
| 5 | 1416 | 2924 | 1509 | 1834 | 4201 | 1574 | 7495 | 7963 | 3274 | 6270 | 2798 |
| 6 | 445 | 804 | 1475 | 765 | 800 | 2149 | 873 | 3180 | 3797 | 1270 | 1818 |
| 7 | 6442 | 106 | 441 | 645 | 310 | 318 | 900 | 357 | 869 | 1298 | 304 |
| 8 | 980 | 1744 | 30 | 169 | 141 | 90 | 81 | 205 | 72 | 138 | 277 |

FINAL ITERATION (1)

INTEGRATED SURVIVORS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1078 | 550 | 1718 | 9 | 4690 | 5254 | 3451 | 5888 | 26892 | 25623 | 53936 |
| 4 | 1498 | 883 | 450 | 1407 | 7 | 3839 | 4302 | 2825 | 4821 | 22018 | 20978 |
| 5 | 1307 | 1226 | 723 | 369 | 1152 | 6 | 3143 | 3522 | 2313 | 3947 | 18026 |
| 6 | 3344 | 1070 | 1004 | 592 | 302 | 943 | 5 | 2574 | 2884 | 1894 | 3232 |
| 7 | 7376 | 2738 | 876 | 822 | 485 | 247 | 772 | 4 | 2107 | 2361 | 1551 |
| 8 | 609 | 6039 | 2241 | 717 | 673 | 397 | 202 | 632 | 3 | 1725 | 1933 |

POPULATION NUMBERS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 5035 | 7146 | 13803 | 3139 | 27249 | 27015 | 13156 | 28222 | 44815 | 30249 | 55351 |
| 4 | 6686 | 3436 | 4278 | 8753 | 2374 | 17849 | 18124 | 9103 | 18423 | 32055 | 22705 |
| 5 | 2723 | 4151 | 2232 | 2203 | 5353 | 1580 | 10638 | 11485 | 5587 | 10217 | 20825 |
| 6 | 3789 | 1874 | 2479 | 1357 | 1102 | 3092 | 878 | 5754 | 6681 | 3164 | 5049 |
| 7 | 13818 | 2844 | 1317 | 1467 | 794 | 565 | 1672 | 361 | 2976 | 3659 | 1854 |
| 8 | 1589 | 7782 | 2271 | 887 | 815 | 487 | 283 | 837 | 75 | 1863 | 2210 |

ESTIMATED SURVIVORS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 288 | 3304 | 0 | 0 | 22161 | 0 | 1850 | 16186 | 13444 | 17127 | 48809 |
| 4 | 1123 | 1541 | 174 | 692 | 183 | 3274 | 0 | 3930 | 0 | 14089 | 21150 |
| 5 | 418 | 1715 | 219 | 528 | 2466 | 0 | 4135 | 3116 | 190 | 2964 | 21746 |
| 6 | 2443 | 1061 | 235 | 115 | 576 | 637 | 110 | 2802 | 1277 | 1743 | 5559 |
| 7 | 3710 | 2841 | 581 | 474 | 503 | 617 | 258 | 515 | 1009 | 3259 | 2376 |
| 8 | 551 | 7458 | 1623 | 723 | 903 | 504 | 133 | 955 | 0 | 1813 | 1906 |

ESTIMATED VARIANCE OF SURVIVORS

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 980295 | 11505907 | 5551807 | 170665 | 334937467 | 14289463 | 12782460 | 283090180 | 224950629 | 160727351 | 911220467 |
| 4 | 3976078 | 2531204 | 1139339 | 5149004 | 499413 | 30613960 | 9816832 | 18898522 | 15521600 | 176291418 | 187345848 |
| 5 | 478069 | 3815829 | 356704 | 787888 | 7885328 | 95616 | 23486213 | 19020410 | 1800997 | 22031637 | 214066314 |
| 6 | 2801417 | 912212 | 485376 | 127600 | 428325 | 1431892 | 155526 | 8517615 | 4876564 | 2740554 | 18845759 |
| 7 | 26134527 | 3095804 | 299423 | 328783 | 194820 | 264135 | 310553 | 220524 | 991286 | 6469394 | 2552420 |
| 8 | 750841 | 29650563 | 989066 | 278816 | 386354 | 124786 | 15454 | 471706 | 947 | 1364379 | 1689392 |

WEIGHTED SURVIVORS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 12 | 4 | 0 | 0 | 34 | 0 | 100 | 344 | 4041 | 9218 | 48809 |
| 4 | 34 | 24 | 2 | 21 | 0 | 55 | 0 | 144 | 0 | 5404 | 9766 |
| 5 | 86 | 55 | 24 | 9 | 48 | 0 | 91 | 139 | 73 | 809 | 6869 |
| 6 | 516 | 115 | 59 | 36 | 18 | 68 | 1 | 170 | 223 | 441 | 1772 |
| 7 | 1972 | 543 | 192 | 176 | 102 | 32 | 127 | 2 | 525 | 428 | 645 |
| 8 | 551 | 3494 | 970 | 256 | 285 | 160 | 118 | 309 | 0 | 686 | 960 |

RMS=0.3458871348

Table 15. continued

ESTIMATED SURVIVORS FOR AGE 8 (WEIGHTED)

| YEAR | SURVIVORS | VARIANCE | STANDARD ERROR | C.V.(%) |
|---|---|---|---|---|
| 1970 | 551 | 750841 | 867 | 157.15 |
| 1971 | 5466 | 13890870 | 3727 | 68.19 |
| 1972 | 2029 | 591354 | 769 | 37.90 |
| 1973 | 650 | 98870 | 314 | 48.40 |
| 1974 | 609 | 121897 | 349 | 57.34 |
| 1975 | 359 | 39679 | 199 | 55.53 |
| 1976 | 183 | 13687 | 117 | 63.80 |
| 1977 | 573 | 152915 | 391 | 68.28 |
| 1978 | 3 | 921 | 30 | 967.11 |
| 1979 | 1561 | 516167 | 718 | 46.02 |
| 1980 | 1750 | 850349 | 922 | 52.69 |

ESTIMATED SURVIVORS FOR 1980 (WEIGHTED)

| AGE | SURVIVORS | VARIANCE | STANDARD ERROR | C.V.(%) |
|---|---|---|---|---|
| 3 | 48809 | 911220467 | 30186 | 61.85 |
| 4 | 18985 | 86509395 | 9301 | 48.99 |
| 5 | 16314 | 67616474 | 8223 | 50.40 |
| 6 | 2925 | 6009240 | 2451 | 83.82 |
| 7 | 1403 | 692967 | 832 | 59.32 |
| 8 | 1750 | 850349 | 922 | 52.69 |

FINAL ESTIMATION FOR K

| AGE | K | LN(K) | VAR(LN(K) | STANDARD ERROR | D.F |
|---|---|---|---|---|---|
| 3 | 4200.46 | 8.1914 | 0.3031 | 0.1741 | 1 |
| 4 | 3669.19 | 8.1465 | 0.1225 | 0.1107 | 1 |
| 5 | 2562.19 | 7.7841 | 0.1291 | 0.1136 | 1 |
| 6 | 2257.19 | 7.5905 | 0.2627 | 0.1146 | 19 |
| 7 | 2257.19 | 7.5905 | 0.2627 | 0.1146 | 19 |
| 8 | 2257.19 | 7.5905 | 0.2627 | 0.1146 | 19 |

RESIDUALS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | -0.0433 | 0.8381 | -0.1847 | -0.4447 | 1.1851 | -0.3835 | 0.0803 | 0.6659 | -0.1114 | -0.0864 | 0.0001 |
| 4 | 0.1733 | 0.6132 | -0.0052 | 0.0331 | 0.1713 | 0.2119 | -0.3720 | 0.4441 | -0.5593 | -0.0982 | 0.1003 |
| 5 | -0.1875 | 0.4294 | -0.1350 | 0.2744 | 0.5381 | -0.4480 | 0.3969 | 0.2149 | -0.4431 | 0.0053 | 0.2534 |
| 6 | 0.1662 | 0.3093 | -0.2862 | -0.3517 | 0.4624 | 0.0339 | 0.1824 | 0.3043 | -0.1239 | 0.1355 | 0.4553 |
| 7 | -0.1879 | 0.3264 | -0.0721 | -0.1328 | 0.2187 | 0.7111 | -0.2923 | 1.0695 | -0.2885 | 0.4429 | 0.4573 |
| 8 | 0.0003 | 0.2493 | -0.2194 | 0.0882 | 0.3361 | 0.2849 | -0.2170 | 0.4090 | -0.2892 | 0.1393 | 0.0758 |

MEAN OF RESIDUALS=0.1157565314
STANDARD DEVIATION OF RESIDUALS=0.3616113332

OUTLIERS OF RESIDUALS 5/ 5/81

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.07 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 15. continued

ANALYSIS OF VARIANCE

| SOURCE | | B | STAND ERROR OF B |
|---|---|---|---|
| CONSTANT | | 0.114 | |
| AGE | 4 | -0.089 | 0.118 |
| | 5 | -0.066 | 0.126 |
| | 6 | -0.002 | 0.135 |
| | 7 | 0.136 | 0.145 |
| | 8 | 0.026 | 0.145 |
| YEAR | 1971 | 0.391 | 0.160 |
| | 1972 | -0.292 | 0.161 |
| | 1973 | -0.259 | 0.165 |
| | 1974 | 0.249 | 0.169 |
| | 1975 | -0.178 | 0.174 |
| | 1976 | -0.315 | 0.180 |
| | 1977 | 0.257 | 0.187 |
| | 1978 | -0.588 | 0.194 |
| | 1979 | -0.185 | 0.184 |
| | 1980 | 0.005 | 0.174 |
| YRCLASS | 1963 | -0.360 | 0.254 |
| | 1964 | -0.109 | 0.227 |
| | 1965 | -0.063 | 0.208 |
| | 1966 | -0.029 | 0.193 |
| | 1967 | -0.002 | 0.176 |
| | 1968 | 0.297 | 0.185 |
| | 1969 | 0.064 | 0.184 |
| | 1970 | 0.065 | 0.183 |
| | 1971 | 0.337 | 0.181 |
| | 1972 | 0.028 | 0.176 |
| | 1973 | 0.190 | 0.187 |
| | 1974 | 0.195 | 0.201 |
| | 1975 | 0.208 | 0.219 |

SUMMARY OF ANALYSIS OF VARIANCE

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| CONSTANT | 0.8578 | 1 | | |
| AGE | 0.28291 | 5 | 0.0566 | 0.752 |
| YEAR | 4.46136 | 10 | 0.4461 | 5.929 |
| YRCLASS | 0.89580 | 14 | 0.0640 | 0.850 |
| RESIDUALS | 2.85930 | 36 | 0.0794 | |
| TOTAL | 9.35715 | 66 | | |

Table 16. Cohort analysis results for option 1 (recruitment as determined by survivor method).

POPULATION NUMBERS

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24977 | 91674 | 201143 | 16783 | 10116 | 17407 | 8071 | 14727 | 25405 | 6467 | 48456 | 46805 | 25873 | 50577 | 78201 | 50793 | 92695 |
| 2 | 36913 | 20450 | 75057 | 164682 | 13741 | 8282 | 14251 | 6608 | 12057 | 20800 | 5294 | 39635 | 38185 | 21182 | 41376 | 64009 | 41584 |
| 3 | 60485 | 30096 | 16098 | 61311 | 134767 | 11052 | 6761 | 11066 | 5401 | 8917 | 16316 | 4315 | 29666 | 30635 | 15375 | 32703 | 51244 |
| 4 | 19235 | 45427 | 22819 | 12029 | 47448 | 93742 | 8582 | 5267 | 7236 | 3767 | 5838 | 10251 | 3430 | 20079 | 20949 | 11100 | 23946 |
| 5 | 11654 | 14468 | 30691 | 14805 | 8056 | 29983 | 58309 | 5973 | 2531 | 4565 | 2371 | 3114 | 6360 | 2529 | 11766 | 13296 | 7261 |
| 6 | 9657 | 7933 | 9052 | 16679 | 9268 | 3730 | 16271 | 31952 | 3424 | 1730 | 2451 | 1481 | 1584 | 3597 | 1632 | 6302 | 7996 |
| 7 | 4703 | 6361 | 5003 | 4681 | 8762 | 5644 | 2114 | 9083 | 15987 | 2329 | 1050 | 1423 | 736 | 836 | 1947 | 943 | 2553 |
| 8 | 3207 | 2359 | 3928 | 2746 | 2047 | 3783 | 3955 | 1085 | 4523 | 8985 | 1844 | 779 | 622 | 431 | 461 | 864 | 446 |
| 9 | 1959 | 1745 | 1395 | 1976 | 1343 | 916 | 2145 | 2770 | 477 | 2018 | 4356 | 1459 | 346 | 266 | 197 | 238 | 355 |
| 10 | 1104 | 1021 | 996 | 588 | 944 | 730 | 581 | 1148 | 2042 | 270 | 729 | 2511 | 960 | 115 | 162 | 97 | 98 |
| 11 | 526 | 694 | 698 | 439 | 221 | 389 | 505 | 303 | 765 | 1585 | 74 | 133 | 1500 | 542 | 65 | 47 | 15 |
| 12 | 217 | 245 | 466 | 303 | 176 | 101 | 237 | 295 | 93 | 468 | 1134 | 37 | 60 | 729 | 295 | 18 | 17 |
| | 174637 | 222473 | 367346 | 297021 | 236888 | 175759 | 121784 | 90279 | 79941 | 61900 | 89914 | 111942 | 109322 | 131519 | 172425 | 180410 | 228211 |

| | 1979 | 1980 |
|---|---|---|
| 1 | 45389 | 132406 |
| 2 | 75892 | 37162 |
| 3 | 33978 | 62062 |
| 4 | 38920 | 26771 |
| 5 | 13259 | 25794 |
| 6 | 4050 | 7344 |
| 7 | 3984 | 2348 |
| 8 | 1149 | 2137 |
| 9 | 242 | 703 |
| 10 | 194 | 146 |
| 11 | 57 | 97 |
| 12 | 4 | 37 |
| | 217119 | 297007 |

FISHING MORTALITY 3/ 5/81

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.004 | 0.039 | 0.002 | 0.000 | 0.018 | 0.003 | 0.053 | 0.002 | 0.102 | 0.043 | 0.005 | 0.090 | 0.020 | 0.120 | 0.035 | 0.022 | 0.002 | 0.001 | 0.005 |
| 3 | 0.086 | 0.077 | 0.091 | 0.056 | 0.163 | 0.053 | 0.050 | 0.225 | 0.160 | 0.224 | 0.265 | 0.029 | 0.190 | 0.180 | 0.126 | 0.112 | 0.075 | 0.038 | 0.049 |
| 4 | 0.085 | 0.192 | 0.233 | 0.201 | 0.259 | 0.275 | 0.162 | 0.533 | 0.261 | 0.263 | 0.429 | 0.277 | 0.105 | 0.334 | 0.255 | 0.224 | 0.391 | 0.211 | 0.145 |
| 5 | 0.185 | 0.269 | 0.410 | 0.268 | 0.570 | 0.411 | 0.402 | 0.357 | 0.181 | 0.422 | 0.271 | 0.476 | 0.370 | 0.238 | 0.424 | 0.308 | 0.384 | 0.391 | 0.257 |
| 6 | 0.217 | 0.261 | 0.460 | 0.444 | 0.296 | 0.368 | 0.383 | 0.492 | 0.185 | 0.299 | 0.344 | 0.500 | 0.439 | 0.414 | 0.348 | 0.704 | 0.497 | 0.345 | 0.720 |
| 7 | 0.490 | 0.282 | 0.400 | 0.627 | 0.640 | 0.155 | 0.467 | 0.497 | 0.376 | 0.033 | 0.099 | 0.627 | 0.334 | 0.395 | 0.613 | 0.548 | 0.598 | 0.423 | 0.315 |
| 8 | 0.408 | 0.325 | 0.487 | 0.515 | 0.604 | 0.367 | 0.156 | 0.622 | 0.607 | 0.524 | 0.035 | 0.611 | 0.649 | 0.581 | 0.461 | 0.688 | 0.414 | 0.292 | 0.315 |
| 9 | 0.452 | 0.361 | 0.663 | 0.539 | 0.410 | 0.256 | 0.425 | 0.105 | 0.368 | 0.818 | 0.351 | 0.218 | 0.901 | 0.298 | 0.507 | 0.686 | 0.404 | 0.302 | 0.315 |
| 10 | 0.264 | 0.180 | 0.619 | 0.779 | 0.686 | 0.168 | 0.449 | 0.207 | 0.053 | 1.099 | 1.497 | 0.315 | 0.371 | 0.367 | 1.047 | 1.698 | 0.347 | 0.489 | 0.315 |
| 11 | 0.564 | 0.198 | 0.635 | 0.715 | 0.580 | 0.295 | 0.338 | 0.985 | 0.292 | 0.135 | 0.494 | 0.608 | 0.522 | 0.410 | 1.080 | 0.791 | 1.145 | 0.241 | 0.315 |
| 12 | 0.392 | 0.307 | 0.502 | 0.531 | 0.487 | 0.286 | 0.358 | 0.429 | 0.384 | 0.419 | 0.207 | 0.489 | 0.581 | 0.422 | 0.482 | 0.657 | 0.478 | 0.341 | 0.315 |
| | 0.094 | 0.096 | 0.081 | 0.080 | 0.211 | 0.244 | 0.289 | 0.325 | 0.180 | 0.217 | 0.127 | 0.103 | 0.109 | 0.138 | 0.094 | 0.098 | 0.096 | 0.085 | 0.070 |

NUMBER OF ITERATIONS : 4

Table 17. Summary of correlation coefficients obtained with various terminal F's in 1980* for Option 2.

| F | 2 To 5 SPA vs 2 To 5 Research | 6+ SPA vs 6+ Research | 2+3 SPA vs 2+3 Research | 3+ SPA Biomass vs Commercial CPUE |
|---|---|---|---|---|
| 0.2 | 0.68 | 0.84 | 0.85 | 0.94 |
| 0.25 | 0.65 | 0.88 | 0.85 | 0.94 |
| 0.3 | 0.62 | 0.89 | 0.85 | 0.93 |
| 0.315 | 0.61 | 0.89 | 0.84 | 0.93 |
| 0.325 | 0.6 | 0.89 | 0.84 | 0.92 |
| 0.35 | 0.58 | 0.88 | 0.84 | 0.91 |
| 0.4 | 0.55 | 0.87 | 0.84 | 0.88 |
| 0.5 | 0.47 | 0.83 | 0.8 | 0.78 |

* Partial recruitment for all runs was:

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7+ |
|---|---|---|---|---|---|---|---|
| PR | .001 | 0.2 | 0.4 | 0.6 | 0.8 | 1 | 1 |

Table 18. Final cohort analysis results for option 2 (standard assessment procedure)

POPULATION NUMBERS

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24977 | 91675 | 201160 | 16796 | 10118 | 17410 | 8072 | 14741 | 25436 | 6504 | 48605 | 47176 | 26207 | 70419 | 81785 |
| 2 | 36919 | 20450 | 75057 | 164696 | 13752 | 8284 | 14254 | 6609 | 12069 | 20825 | 5325 | 39757 | 38488 | 21455 | 57621 |
| 3 | 60485 | 30101 | 16098 | 61311 | 134778 | 11061 | 6762 | 11068 | 5402 | 8926 | 16337 | 4340 | 29766 | 30884 | 15598 |
| 4 | 19235 | 45428 | 22823 | 12029 | 47449 | 93751 | 8590 | 5268 | 7238 | 3768 | 5845 | 10268 | 3451 | 20160 | 21152 |
| 5 | 11655 | 14468 | 30692 | 14808 | 8056 | 29984 | 58317 | 5980 | 2532 | 4567 | 2372 | 3120 | 6374 | 2546 | 11833 |
| 6 | 9657 | 7933 | 9052 | 16680 | 9271 | 3730 | 16271 | 31958 | 3429 | 1730 | 2452 | 1481 | 1589 | 3609 | 1646 |
| 7 | 4703 | 6361 | 5003 | 4681 | 8762 | 5646 | 2114 | 9083 | 15992 | 2333 | 1051 | 1424 | 736 | 840 | 1957 |
| 8 | 3207 | 2359 | 3928 | 2746 | 2047 | 3783 | 3957 | 1085 | 4523 | 8989 | 1848 | 779 | 623 | 431 | 464 |
| 9 | 1959 | 1745 | 1395 | 1976 | 1343 | 916 | 2146 | 2771 | 477 | 2018 | 4359 | 1461 | 346 | 267 | 198 |
| 10 | 1104 | 1021 | 996 | 588 | 944 | 730 | 581 | 1149 | 2044 | 270 | 729 | 2514 | 962 | 115 | 162 |
| 11 | 526 | 694 | 698 | 439 | 221 | 389 | 505 | 303 | 765 | 1586 | 74 | 134 | 1502 | 544 | 65 |
| 12 | 217 | 245 | 466 | 303 | 176 | 101 | 237 | 295 | 93 | 468 | 1135 | 37 | 60 | 731 | 296 |
| 1+ | 174644 | 222480 | 367368 | 297053 | 236916 | 175785 | 121806 | 90311 | 79999 | 61984 | 90132 | 112491 | 110105 | 152002 | 192778 |

| | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|
| 1 | 41959 | 76120 | 45299 | 44140 |
| 2 | 66944 | 34352 | 62322 | 37088 |
| 3 | 46003 | 53646 | 28057 | 50952 |
| 4 | 11283 | 34836 | 40887 | 21923 |
| 5 | 13462 | 7411 | 22174 | 27405 |
| 6 | 6357 | 8133 | 4173 | 14643 |
| 7 | 955 | 2598 | 4096 | 2448 |
| 8 | 872 | 456 | 1186 | 2228 |
| 9 | 241 | 362 | 249 | 733 |
| 10 | 98 | 100 | 199 | 152 |
| 11 | 47 | 15 | 59 | 102 |
| 12 | 18 | 18 | 4 | 38 |
| 1+ | 188239 | 218046 | 208705 | 201852 |

FISHING MORTALITY

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2 | 0.004 | 0.039 | 0.002 | 0.000 | 0.018 | 0.003 | 0.053 | 0.002 | 0.102 | 0.043 | 0.005 | 0.089 | 0.020 | 0.119 | 0.025 | 0.021 |
| 3 | 0.086 | 0.077 | 0.091 | 0.056 | 0.163 | 0.053 | 0.050 | 0.225 | 0.160 | 0.223 | 0.264 | 0.029 | 0.190 | 0.178 | 0.124 | 0.078 |
| 4 | 0.085 | 0.192 | 0.233 | 0.201 | 0.259 | 0.275 | 0.162 | 0.533 | 0.261 | 0.263 | 0.428 | 0.277 | 0.104 | 0.333 | 0.252 | 0.220 |
| 5 | 0.185 | 0.269 | 0.410 | 0.268 | 0.570 | 0.411 | 0.401 | 0.356 | 0.181 | 0.422 | 0.271 | 0.475 | 0.369 | 0.236 | 0.421 | 0.304 |
| 6 | 0.217 | 0.261 | 0.460 | 0.444 | 0.296 | 0.368 | 0.383 | 0.492 | 0.185 | 0.298 | 0.343 | 0.500 | 0.437 | 0.412 | 0.345 | 0.695 |
| 7 | 0.490 | 0.282 | 0.400 | 0.627 | 0.640 | 0.155 | 0.466 | 0.497 | 0.376 | 0.033 | 0.099 | 0.627 | 0.334 | 0.393 | 0.609 | 0.539 |
| 8 | 0.408 | 0.325 | 0.487 | 0.515 | 0.604 | 0.367 | 0.156 | 0.622 | 0.607 | 0.524 | 0.035 | 0.610 | 0.648 | 0.581 | 0.456 | 0.680 |
| 9 | 0.452 | 0.361 | 0.663 | 0.539 | 0.410 | 0.256 | 0.425 | 0.105 | 0.368 | 0.818 | 0.350 | 0.218 | 0.900 | 0.297 | 0.506 | 0.675 |
| 10 | 0.264 | 0.180 | 0.619 | 0.779 | 0.686 | 0.168 | 0.449 | 0.207 | 0.053 | 1.099 | 1.497 | 0.315 | 0.370 | 0.366 | 1.041 | 1.691 |
| 11 | 0.564 | 0.198 | 0.635 | 0.715 | 0.580 | 0.295 | 0.338 | 0.985 | 0.291 | 0.135 | 0.494 | 0.607 | 0.521 | 0.408 | 1.073 | 0.781 |
| 12 | 0.392 | 0.307 | 0.502 | 0.531 | 0.487 | 0.286 | 0.357 | 0.429 | 0.384 | 0.418 | 0.207 | 0.489 | 0.580 | 0.421 | 0.479 | 0.647 |
| 1+ | 0.094 | 0.096 | 0.081 | 0.080 | 0.211 | 0.244 | 0.289 | 0.325 | 0.180 | 0.217 | 0.127 | 0.102 | 0.109 | 0.119 | 0.084 | 0.093 |

| | 1978 | 1979 | 1980 |
|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 |
| 2 | 0.002 | 0.001 | 0.005 |
| 3 | 0.072 | 0.047 | 0.060 |
| 4 | 0.252 | 0.200 | 0.180 |
| 5 | 0.374 | 0.215 | 0.240 |
| 6 | 0.486 | 0.333 | 0.300 |
| 7 | 0.584 | 0.409 | 0.300 |
| 8 | 0.404 | 0.281 | 0.300 |
| 9 | 0.396 | 0.291 | 0.300 |
| 10 | 0.337 | 0.473 | 0.300 |
| 11 | 1.125 | 0.232 | 0.300 |
| 12 | 0.467 | 0.329 | 0.300 |
| 1+ | 0.098 | 0.086 | 0.099 |

NUMBER OF ITERATIONS : 4

Table 19. Comparison of numbers ( x $10^{-3}$) at age 1 generated by CAFSAC Assessments since 1976.

| ASSESSMENT | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | $F_R$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O'BOYLE unpublished assessment #1 1977 | 30810 | 7007 | 60391 | 49293 | 28861 | 33393 | - | - | - | - | - | 0.28 |
| O'BOYLE unpublished assessment #2 1977 | 20810 | 7007 | 60231 | 35308 | 14606 | 26889 | 44755 | - | - | - | - | 0.33 |
| Res. Doc. 78/19 | 33077 | 10775 | 75014 | 56364 | 34737 | 43539 | 83036 | 29423 | - | - | - | 0.3 |
| Res. Doc. 80/2 | 26436 | 7169 | 50301 | 53352 | 28948 | 56167 | 73480 | 41293 | 50339 | - | - | 0.325 |
| Present Doc. | | | | | | | | | | | | |
| Opt. 1 | 25405 | 6467 | 48456 | 46805 | 25873 | 50577 | 78201 | 50793 | 92695 | 45389 | - | 0.315 |
| Opt. 2 | 25436 | 6504 | 48605 | 47176 | 26207 | 70419 | 81785 | 41959 | 76120 | 45299 | - | 0.300 |
| FINAL | 25436 | 6504 | 48605 | 47176 | 26207 | 50577 | 81785 | 41959 | 76120 | 45299 | 100000 | 0.300 |

Table 20. Final cohort analysis for present assessment.

POPULATION NUMBERS

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24977 | 91675 | 201156 | 16796 | 10118 | 17410 | 8072 | 14741 | 25436 | 6504 | 48605 | 47176 | 26207 | 50577 | 81785 |
| 2 | 36919 | 20450 | 75057 | 164692 | 13751 | 8284 | 14254 | 6609 | 12069 | 20825 | 5325 | 39757 | 38488 | 21155 | 41376 |
| 3 | 60487 | 30101 | 16098 | 61311 | 134775 | 11060 | 6762 | 11068 | 5402 | 8926 | 16337 | 4340 | 29766 | 30884 | 15598 |
| 4 | 19235 | 45429 | 22823 | 12029 | 47448 | 93749 | 8589 | 5268 | 7238 | 3768 | 5845 | 10268 | 3451 | 20160 | 21152 |
| 5 | 11655 | 14468 | 30693 | 14808 | 8056 | 29984 | 58315 | 5979 | 2532 | 4567 | 2372 | 3120 | 6374 | 2546 | 11033 |
| 6 | 9658 | 7933 | 9052 | 16681 | 9271 | 3730 | 16271 | 31956 | 3429 | 1730 | 2452 | 1481 | 1589 | 3609 | 1646 |
| 7 | 4703 | 6362 | 5003 | 4681 | 8763 | 5646 | 2114 | 9083 | 15991 | 2333 | 1051 | 1424 | 736 | 840 | 1957 |
| 8 | 3207 | 2359 | 3929 | 2746 | 2047 | 3784 | 3957 | 1085 | 4523 | 8988 | 1848 | 779 | 623 | 431 | 464 |
| 9 | 1959 | 1745 | 1395 | 1977 | 1344 | 916 | 2146 | 2771 | 477 | 2018 | 4358 | 1461 | 346 | 267 | 198 |
| 10 | 1104 | 1020 | 996 | 589 | 944 | 730 | 581 | 1149 | 2044 | 270 | 729 | 2313 | 962 | 115 | 162 |
| 11 | 526 | 694 | 698 | 439 | 221 | 390 | 505 | 303 | 765 | 1586 | 74 | 134 | 1502 | 344 | 65 |
| 12 | 216 | 245 | 466 | 303 | 176 | 102 | 237 | 295 | 93 | 468 | 1135 | 37 | 60 | 730 | 296 |
| 1+ | 174647 | 222482 | 367366 | 297051 | 236914 | 175783 | 121804 | 90310 | 79998 | 61983 | 90131 | 112490 | 110104 | 132160 | 176533 |
| 2+ | 149670 | 130808 | 166210 | 280255 | 226797 | 158373 | 113732 | 75569 | 54562 | 55479 | 41526 | 65315 | 83898 | 81583 | 94748 |
| 3+ | 112751 | 110358 | 91153 | 115563 | 213045 | 150090 | 99478 | 68960 | 42493 | 34654 | 36201 | 25557 | 49409 | 60127 | 53372 |
| 4+ | 52264 | 80257 | 75056 | 54252 | 78270 | 139029 | 92716 | 57891 | 37091 | 25728 | 19864 | 21217 | 15643 | 29243 | 37774 |

| | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|
| 1 | 41959 | 76120 | 45299 | 44140 |
| 2 | 66944 | 34352 | 62322 | 37088 |
| 3 | 32703 | 53646 | 28057 | 50952 |
| 4 | 11283 | 23946 | 40887 | 21923 |
| 5 | 13462 | 7411 | 13259 | 27405 |
| 6 | 6357 | 8133 | 4173 | 7344 |
| 7 | 955 | 2598 | 4096 | 2448 |
| 8 | 872 | 456 | 1186 | 2228 |
| 9 | 241 | 362 | 249 | 733 |
| 10 | 98 | 100 | 199 | 152 |
| 11 | 47 | 15 | 59 | 102 |
| 12 | 18 | 18 | 4 | 38 |
| 1+ | 174939 | 227157 | 199790 | 194553 |
| 2+ | 132979 | 131036 | 154491 | 150413 |
| 3+ | 66035 | 96685 | 92169 | 113325 |
| 4+ | 33332 | 43036 | 64112 | 62374 |

FISHING MORTALITY

| | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2 | 0.004 | 0.039 | 0.002 | 0.000 | 0.018 | 0.003 | 0.053 | 0.002 | 0.102 | 0.043 | 0.005 | 0.089 | 0.020 | 0.119 | 0.035 | 0.021 |
| 3 | 0.086 | 0.077 | 0.091 | 0.056 | 0.163 | 0.053 | 0.050 | 0.225 | 0.160 | 0.223 | 0.264 | 0.029 | 0.190 | 0.178 | 0.124 | 0.112 |
| 4 | 0.085 | 0.192 | 0.233 | 0.201 | 0.259 | 0.275 | 0.162 | 0.333 | 0.261 | 0.263 | 0.428 | 0.277 | 0.104 | 0.333 | 0.252 | 0.220 |
| 5 | 0.185 | 0.269 | 0.410 | 0.268 | 0.570 | 0.411 | 0.401 | 0.356 | 0.181 | 0.422 | 0.271 | 0.475 | 0.369 | 0.236 | 0.421 | 0.304 |
| 6 | 0.217 | 0.261 | 0.460 | 0.444 | 0.296 | 0.368 | 0.383 | 0.492 | 0.185 | 0.298 | 0.343 | 0.500 | 0.437 | 0.412 | 0.345 | 0.695 |
| 7 | 0.490 | 0.282 | 0.400 | 0.627 | 0.640 | 0.155 | 0.467 | 0.497 | 0.376 | 0.033 | 0.099 | 0.627 | 0.334 | 0.393 | 0.609 | 0.539 |
| 8 | 0.408 | 0.325 | 0.487 | 0.515 | 0.604 | 0.367 | 0.156 | 0.622 | 0.607 | 0.524 | 0.035 | 0.610 | 0.648 | 0.581 | 0.456 | 0.680 |
| 9 | 0.452 | 0.361 | 0.663 | 0.539 | 0.410 | 0.256 | 0.425 | 0.105 | 0.368 | 0.818 | 0.351 | 0.218 | 0.900 | 0.297 | 0.506 | 0.675 |
| 10 | 0.264 | 0.180 | 0.619 | 0.778 | 0.686 | 0.168 | 0.449 | 0.206 | 0.053 | 1.099 | 1.497 | 0.315 | 0.370 | 0.366 | 1.041 | 1.691 |
| 11 | 0.564 | 0.198 | 0.636 | 0.715 | 0.579 | 0.295 | 0.338 | 0.985 | 0.291 | 0.135 | 0.494 | 0.607 | 0.521 | 0.408 | 1.073 | 0.780 |
| 12 | 0.392 | 0.307 | 0.502 | 0.531 | 0.487 | 0.286 | 0.337 | 0.429 | 0.364 | 0.418 | 0.207 | 0.489 | 0.580 | 0.421 | 0.479 | 0.647 |
| 6+ | 0.340 | 0.278 | 0.478 | 0.502 | 0.483 | 0.271 | 0.359 | 0.469 | 0.364 | 0.440 | 0.235 | 0.424 | 0.486 | 0.416 | 0.512 | 0.687 |

| | 1978 | 1979 | 1980 |
|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 |
| 2 | 0.002 | 0.001 | 0.005 |
| 3 | 0.072 | 0.047 | 0.060 |
| 4 | 0.391 | 0.200 | 0.180 |
| 5 | 0.374 | 0.391 | 0.240 |
| 6 | 0.486 | 0.333 | 0.720 |
| 7 | 0.584 | 0.409 | 0.300 |
| 8 | 0.404 | 0.281 | 0.300 |
| 9 | 0.396 | 0.281 | 0.300 |
| 10 | 0.337 | 0.473 | 0.300 |
| 11 | 1.125 | 0.232 | 0.300 |
| 12 | 0.467 | 0.329 | 0.300 |
| 6+ | 0.501 | 0.359 | 0.536 |

Table 21. Comparison of partial recruitment, weight (kg) at age and yield per recruit estimates for 4X haddock at differing stock sizes.

| Age | Weight (kg) at age Mean of 1962-1980 Commercial Sample Data | Partial Recruitment at High Stock Size (1962-64) | Partial Recruitment at Low Stock Size (1971-73) | 1980 Partial Recruitment |
|---|---|---|---|---|
| 1 | 0.287 | 0.001 | 0.003 | 0.0003 |
| 2 | 0.472 | 0.050 | 0.103 | 0.017 |
| 3 | 0.784 | 0.230 | 0.614 | 0.20 |
| 4 | 1.119 | 0.470 | 1 | 0.60 |
| 5 | 1.466 | 0.700 | 1 | 0.80 |
| 6 | 1.828 | 0.900 | 1 | 1 |
| 7 | 2.209 | 1 | 1 | 1 |
| 8 | 2.510 | 1 | 1 | 1 |
| 9 | 2.769 | 1 | 1 | 1 |
| 10 | 3.013 | 1 | 1 | 1 |
| 11 | 3.244 | 1 | 1 | 1 |
| 12 | 3.478 | 1 | 1 | 1 |
| $F_{0.1}$ | | 0.313 | 0.256 | 0.304 |
| $F_{MAX}$ | | 0.721 | 0.519 | 0.734 |
| Yield (kg) at $F_{0.1}$ | | 0.510 | 0.495 | 0.515 |

Table 22. Yield per recruitment calculations and 1980 population parameters used in the catch projection.

| AGE | MEAN (1978-80) WEIGHT AT AGE kg. | 1980 CATCH AT AGE NUMBER X $10^{-3}$ | 1980 POPULATION AT AGE NUMBER X $10^{-3}$ | PARTIAL RECRUITMENT |
|---|---|---|---|---|
| 1 | 0.269 | 12 | 100000 | 0.0003 |
| 2 | 0.489 | 168 | 37088 | 0.0167 |
| 3 | 0.878 | 2692 | 50952 | 0.2 |
| 4 | 1.325 | 3283 | 21924 | 0.6 |
| 5 | 1.816 | 5321 | 27405 | 0.8 |
| 6 | 2.345 | 3457 | 7344 | 1 |
| 7 | 2.797 | 578 | 2449 | 1 |
| 8 | 3.332 | 526 | 2229 | 1 |
| 9 | 3.829 | 173 | 733 | 1 |
| 10 | 4.151 | 36 | 153 | 1 |
| 11 | 4.386 | 24 | 102 | 1 |
| 12 | 4.798 | 9 | 39 | 1 |

| | |
|---|---|
| $F_{0.1}$ | 0.284 |
| $F_{max}$ | 0.595 |
| Yield at $F_{0.1}$, kg. | 0.639 |
| M | 0.2 |

Table 23. Catch projection at $F_{0.1}$ to 1982 under the 1980 conditions as outlined in Table 22. A value of 40 x $10^6$ was taken for age 1 recruitment for 1981 and 1982.

| Year | 1+ Population Number $x10^{-6}$ | Mean 1+ Population Biomass, mt $x10^{-3}$ | 1+ Catch Biomass, mt $x10^{-3}$ | 1+ Surplus Production, mt $x10^{-3}$ |
|---|---|---|---|---|
| 1980 | 250 | 171 | 29 | 56 |
| 1981 | 230 | 185 | 28 | 41 |
| 1982 | 214 | 196 | 32 | 38 |

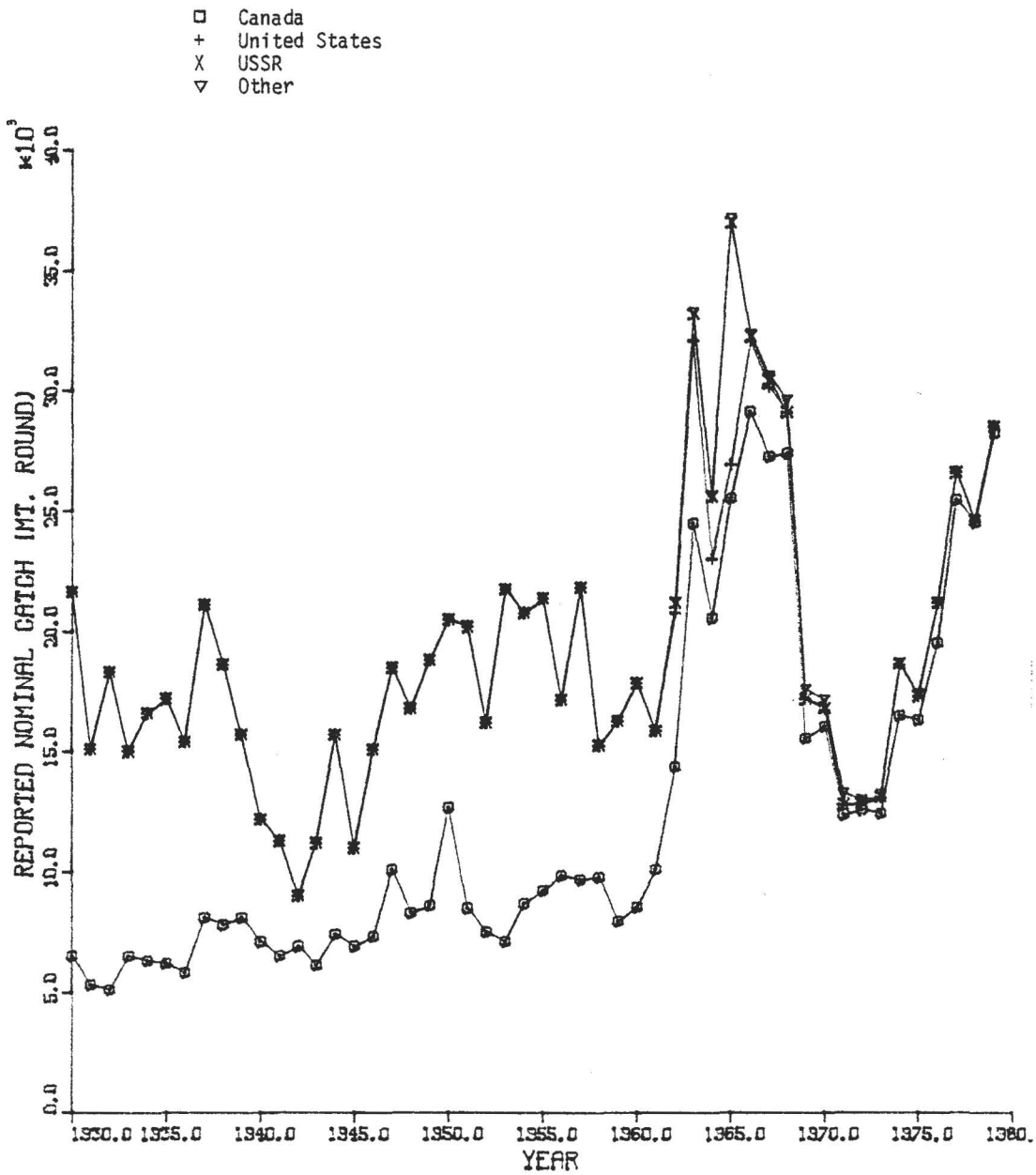



Figure 1. Reported nominal catches (mt round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country.

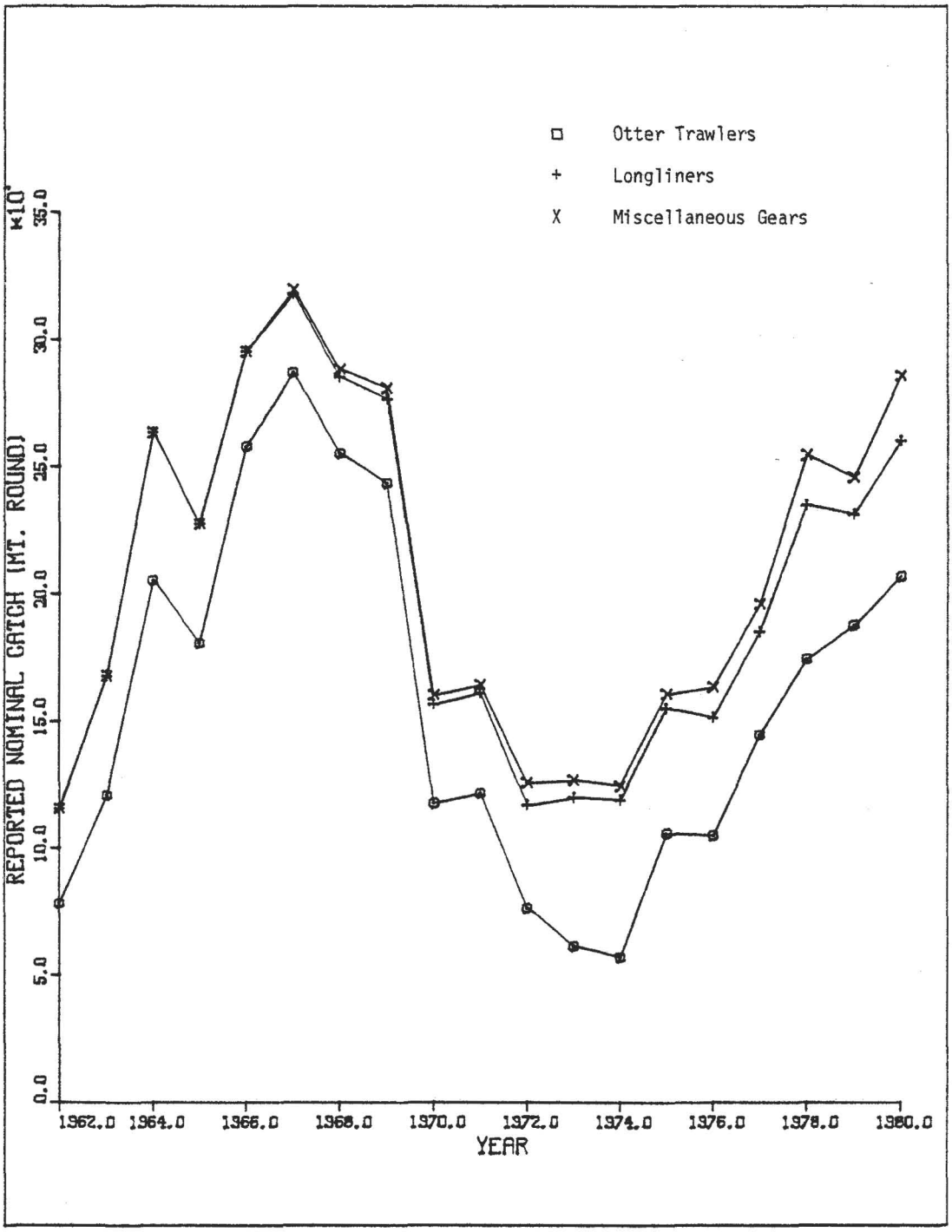



Figure 2. Reported nominal catch (mt x $10^{-3}$) of 4X haddock by Canadian fishery

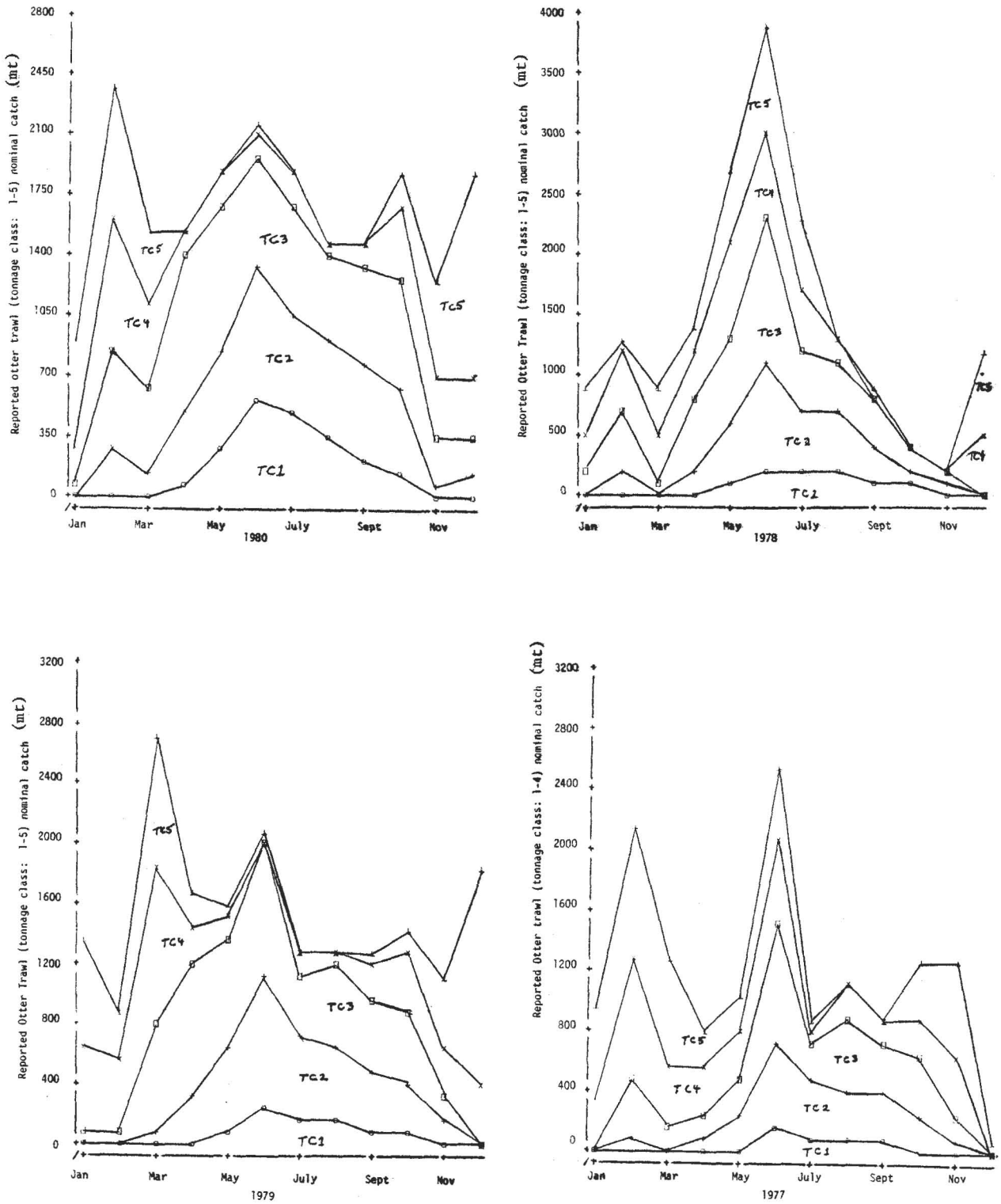



Figure 3. Distribution of landings by Canadian otter trawlers by month for the years 1977-1980

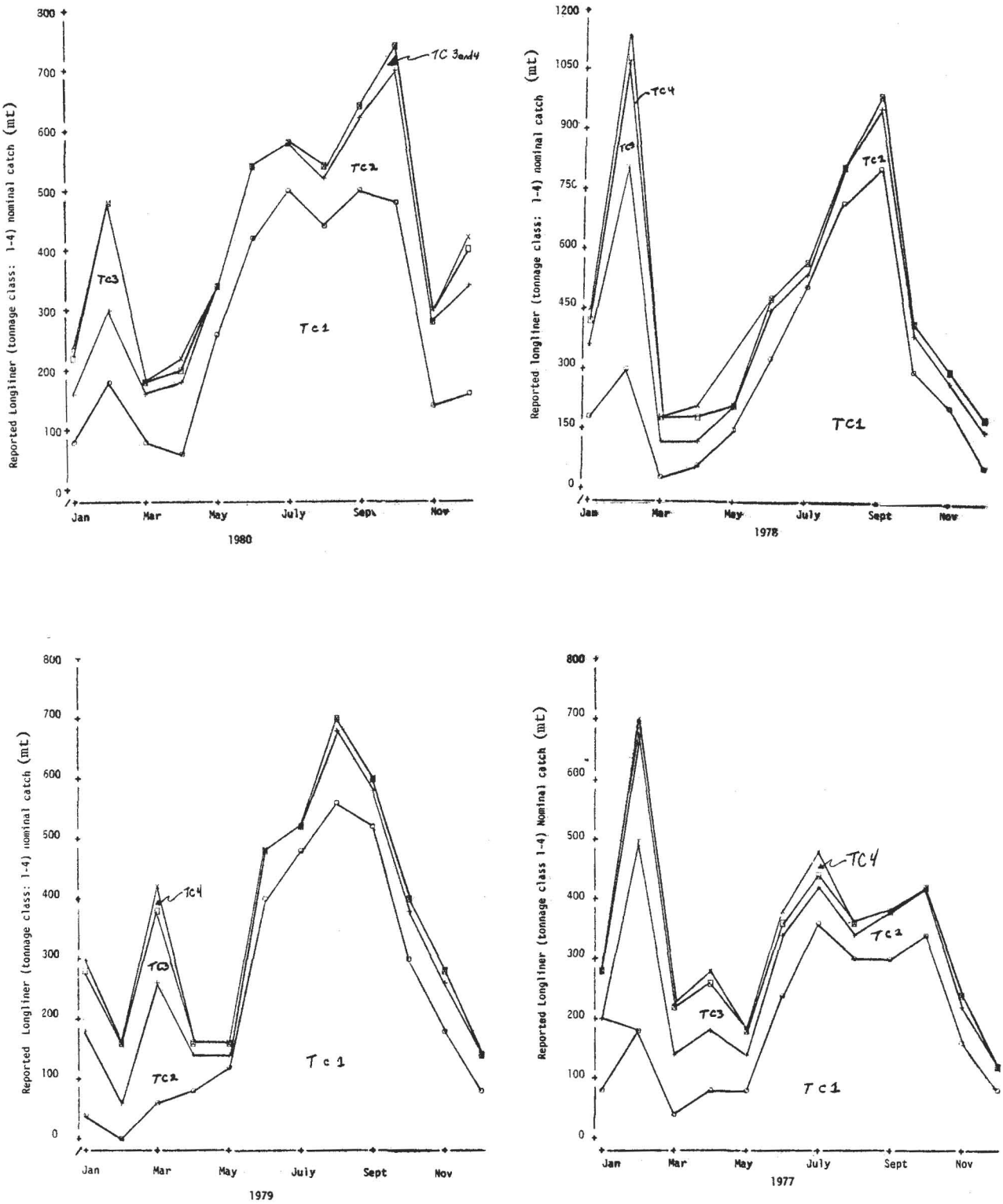



Figure 4. Distribution of landings by Canadian longliners by month for the years 1977-1980

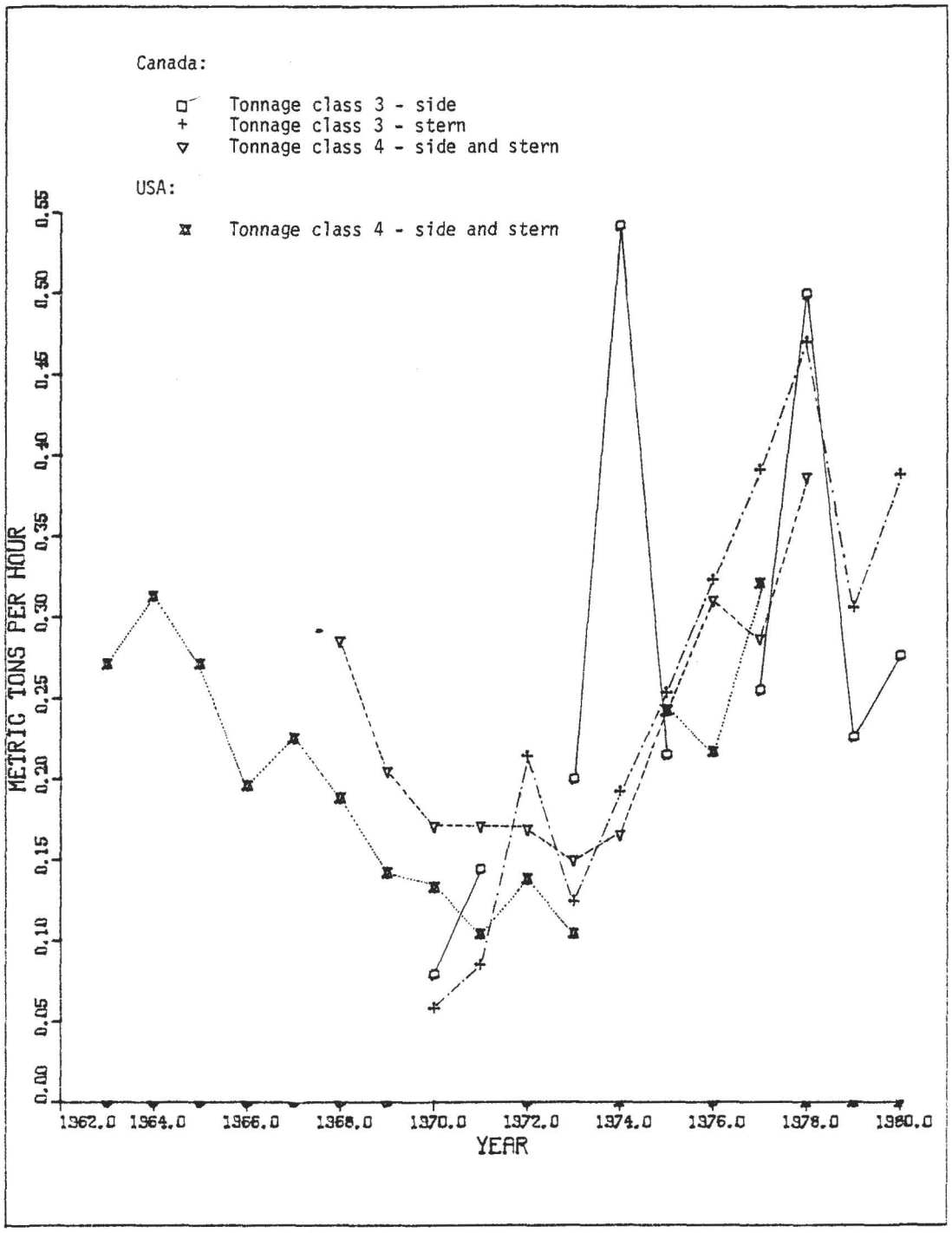
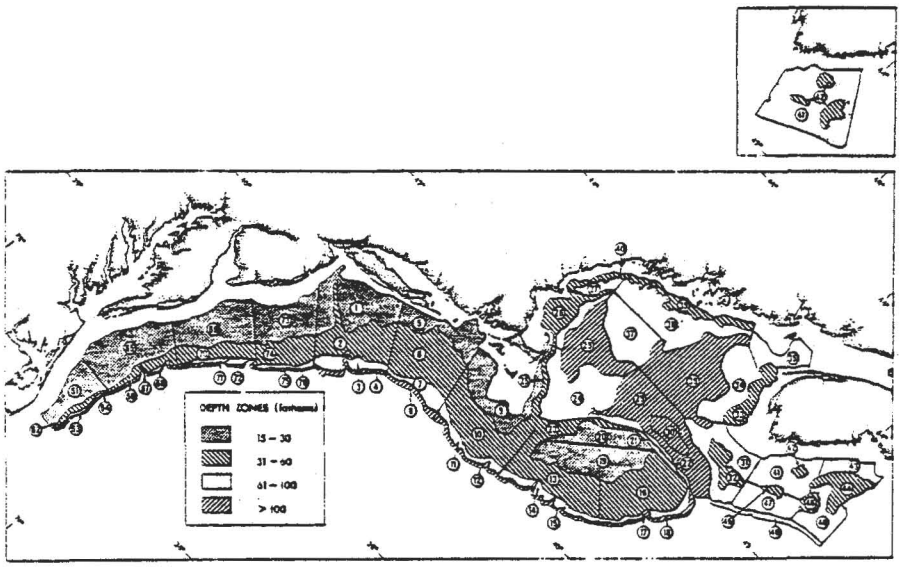



Figure 5. Trends in commercial catch rates observed in Canadian and U.S. otter trawl fisheries since 1963. (Gaps indicate unobserved periods)

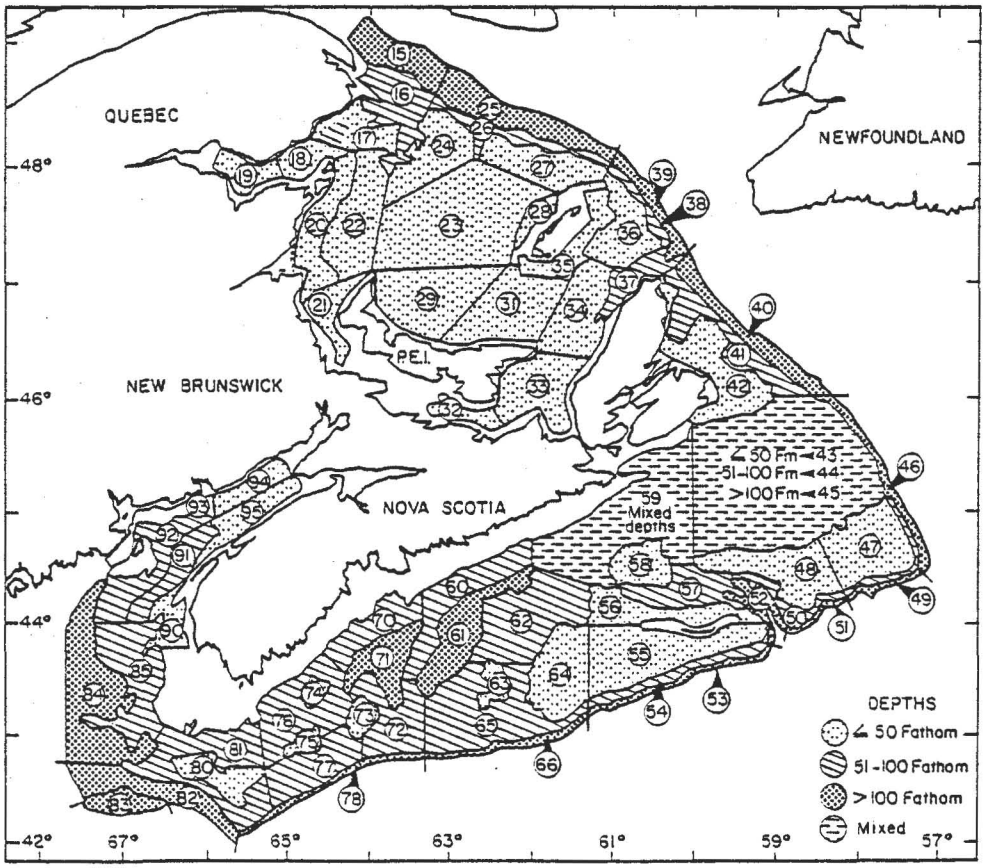
Figure 6. Stratification schemes used during U.S. fall (A) and Canadian (B) bottom trawl surveys

(A)




Sampling strata used in spring and fall USA groundfish surveys. Strata 41, 42 (outset) used until 1970 when switched to strata 41-49 , corresponding to Canadian strata.

(B)



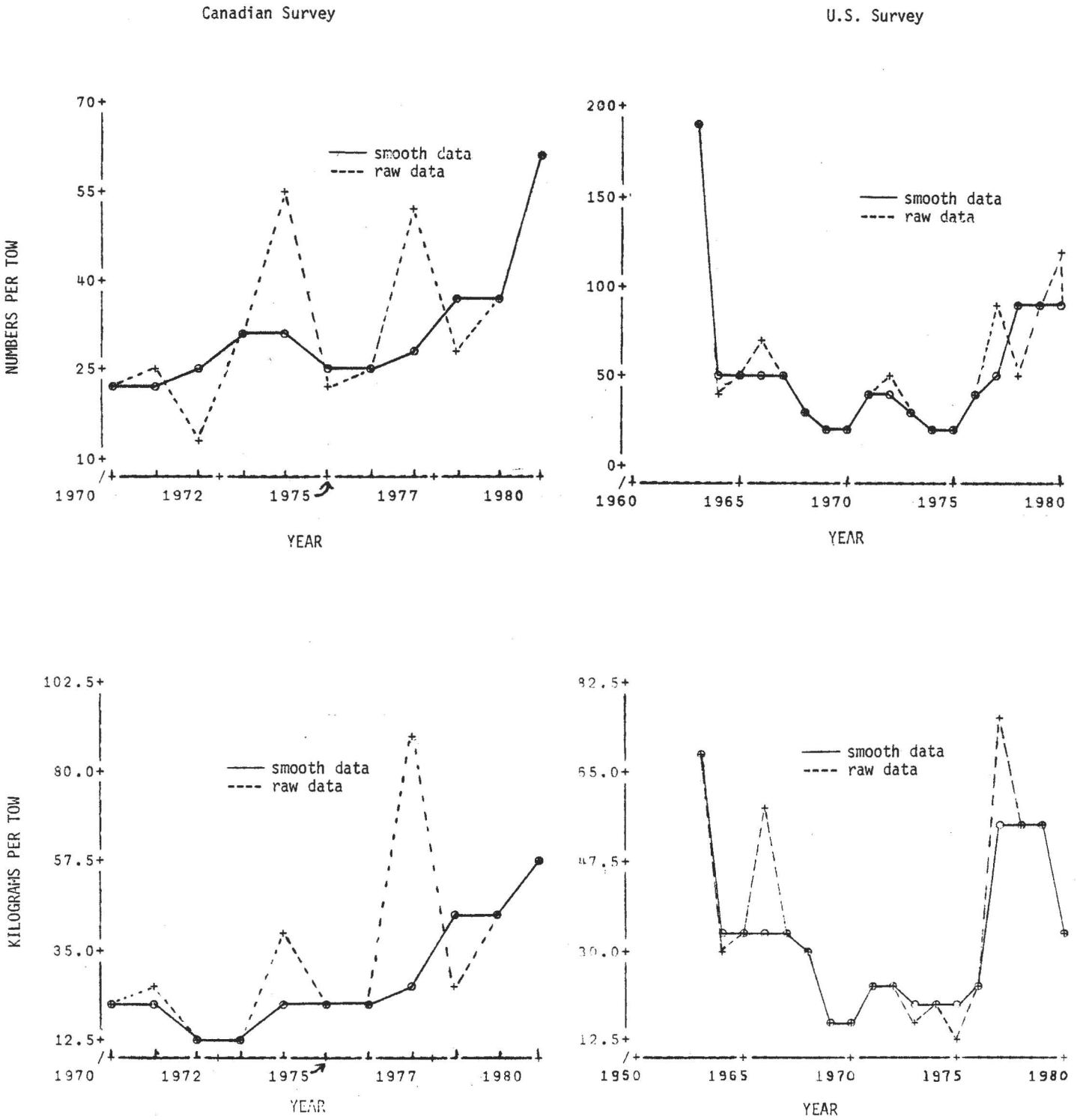
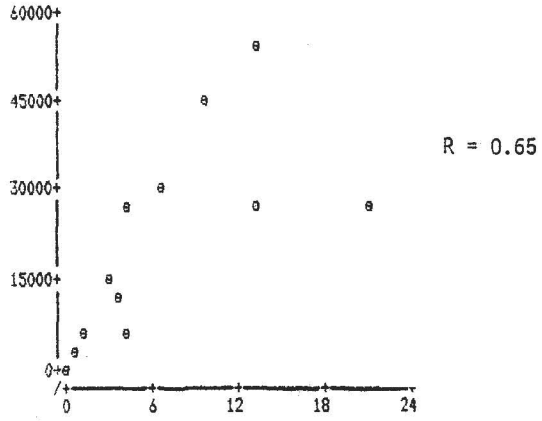


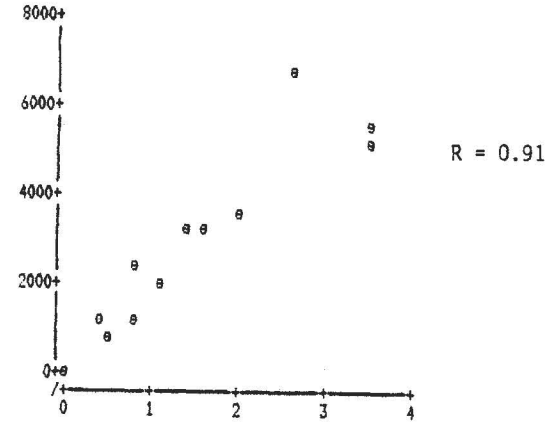

Figure 7. Trends in abundance of 4X haddock stock as determined by Canadian and U.S. bottom trawl surveys. Smoothing done by 3 year median.

AGE 3



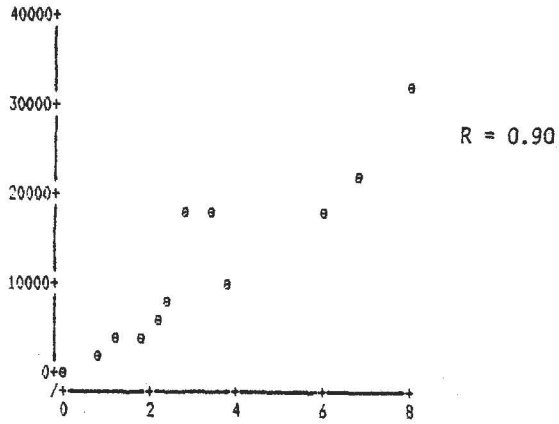

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 5035 | 7146 | 13803 | 3139 | 27249 | 27015 | 13156 | 28222 | 44815 | 30249 | 55351 |
| RES : | 1.15 | 3.93 | 2.73 | 0.48 | 21.22 | 4.38 | 3.39 | 13.08 | 9.54 | 6.60 | 13.18 |

AGE 6



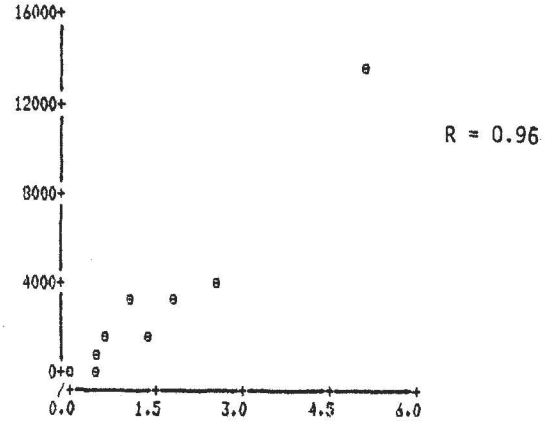

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 3789 | 1874 | 2479 | 1357 | 1102 | 3092 | 878 | 5754 | 6681 | 3164 | 5049 |
| RES : | 1.98 | 1.13 | 0.83 | 0.42 | 0.77 | 1.42 | 0.47 | 3.46 | 2.61 | 1.60 | 3.53 |

AGE 4



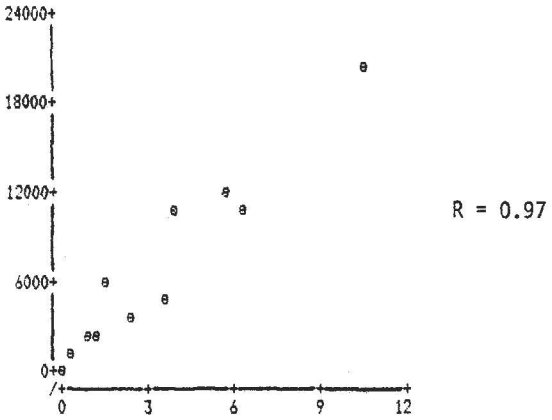

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 6686 | 3436 | 4278 | 8753 | 2374 | 17849 | 18124 | 9103 | 18423 | 32055 | 22705 |
| RES : | 2.17 | 1.73 | 1.16 | 2.47 | 0.77 | 6.01 | 3.40 | 3.87 | 2.87 | 7.92 | 6.84 |

AGE 7



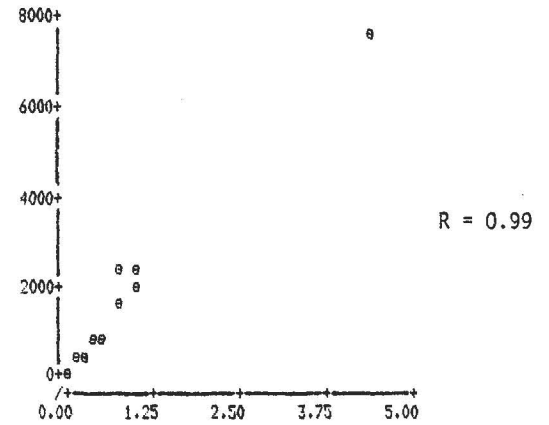

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 13818 | 2844 | 1317 | 1467 | 794 | 565 | 1672 | 361 | 2976 | 3659 | 1854 |
| RES : | 5.07 | 1.75 | 0.54 | 0.57 | 0.44 | 0.51 | 0.55 | 0.47 | 0.99 | 2.52 | 1.30 |

AGE 5




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 2723 | 4151 | 2232 | 2203 | 5353 | 1580 | 10638 | 11485 | 5587 | 10217 | 20825 |
| RES : | 0.88 | 2.49 | 0.76 | 1.13 | 3.58 | 0.39 | 6.17 | 5.56 | 1.40 | 4.01 | 10.47 |

AGE 8

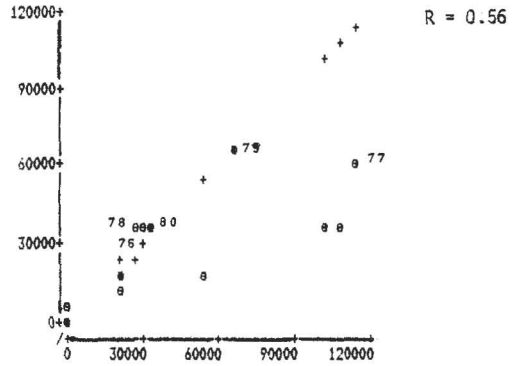



| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 1589 | 7782 | 2271 | 887 | 815 | 487 | 283 | 837 | 75 | 1863 | 2210 |
| RES : | 0.70 | 4.42 | 0.81 | 0.43 | 0.50 | 0.29 | 0.10 | 0.56 | 0.02 | 0.95 | 1.06 |

Figure 8. Survivor midyear population numbers versus Canadian research survey numbers per tow at age. (Num is Y axis and Res is X axis).

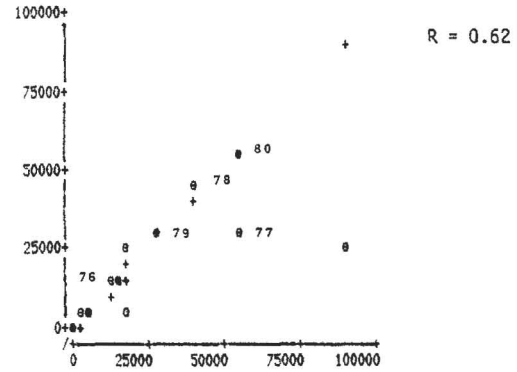
A, PLOTS AT AGE

AGE 2



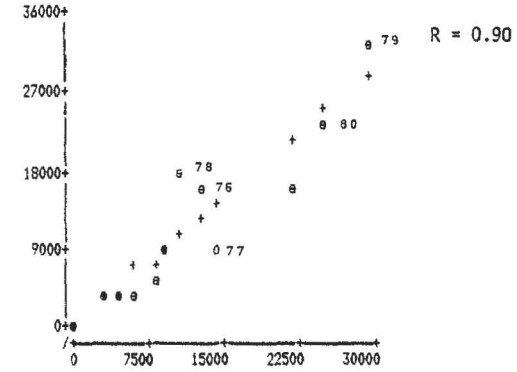

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 10408 | 18467 | 4788 | 34411 | 34271 | 18124 | 36870 | 57390 | 37653 | 68746 | 33600 |
| RES | 22257 | 52579 | 110710 | 81491 | 101843 | 19674 | 29925 | 114971 | 26452 | 65436 | 34217 |

AGE 3



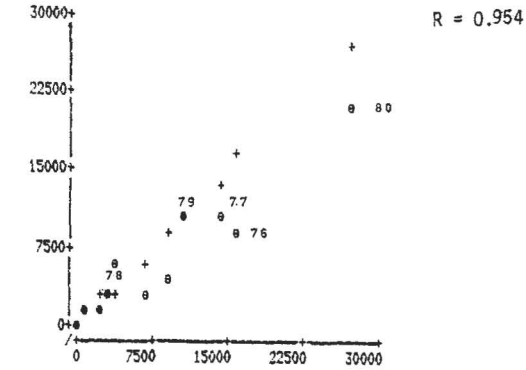

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 4535 | 7269 | 13050 | 3856 | 24561 | 25486 | 13121 | 28098 | 44800 | 30232 | 54939 |
| RES | 4822 | 16519 | 11475 | 2012 | 89123 | 18409 | 14255 | 54923 | 40085 | 27741 | 55352 |

AGE 4



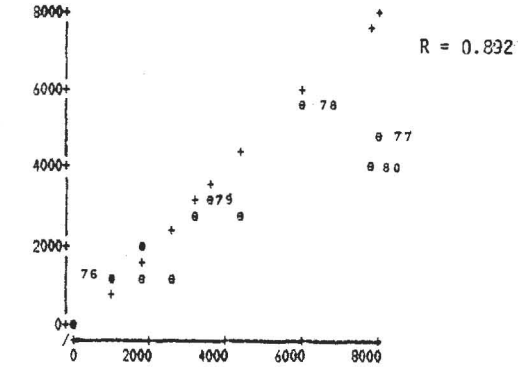

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 5799 | 3016 | 4334 | 8151 | 2957 | 15554 | 16833 | 9045 | 18079 | 31908 | 22641 |
| RES | 7951 | 6344 | 4256 | 9048 | 2818 | 22060 | 12492 | 14191 | 10530 | 29053 | 25098 |

AGE 5



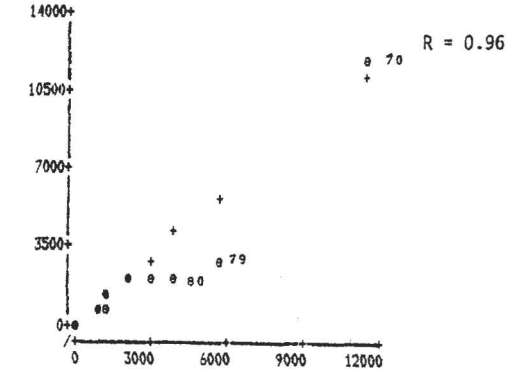

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 2105 | 3399 | 1891 | 2263 | 4848 | 2048 | 8752 | 10423 | 5500 | 10012 | 20704 |
| RES | 2257 | 6377 | 1950 | 2898 | 9166 | 1010 | 15819 | 14236 | 3587 | 10270 | 26827 |

AGE 6



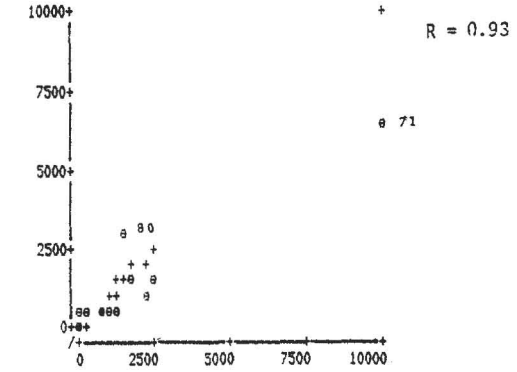

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 2841 | 1362 | 1891 | 1065 | 1170 | 2688 | 1256 | 4149 | 5759 | 8122 | 4801 |
| RES | 4473 | 2553 | 1862 | 955 | 1749 | 3198 | 1054 | 7799 | 5901 | 3622 | 7959 |

AGE 7



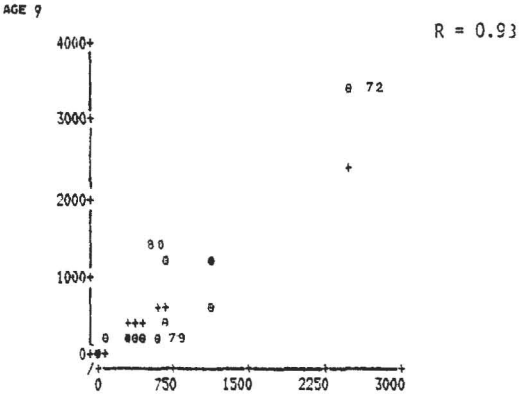

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 12151 | 2077 | 908 | 968 | 570 | 630 | 1333 | 664 | 1758 | 2965 | 1835 |
| RES | 11448 | 3940 | 1226 | 1284 | 989 | 1151 | 1248 | 1052 | 2230 | 5696 | 2930 |

AGE 8




| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 3104 | 6393 | 1644 | 533 | 419 | 299 | 337 | 573 | 334 | 908 | 1670 |
| RES | 1589 | 9984 | 1824 | 969 | 1140 | 648 | 228 | 1260 | 57 | 2142 | 2383 |

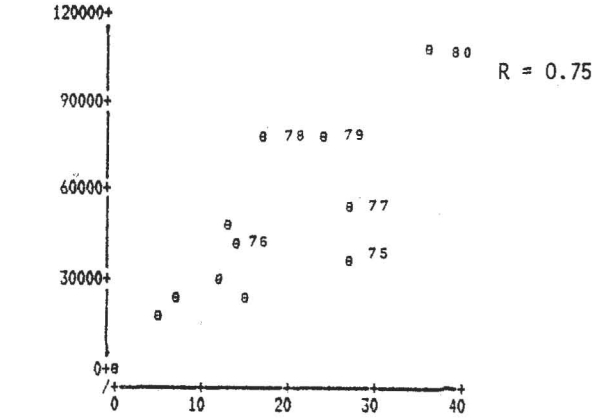
AGE 9




| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 364 | 1266 | 3349 | 1192 | 210 | 210 | 142 | 158 | 267 | 190 | 549 |
| RES | 662 | 1138 | 2496 | 648 | 605 | 307 | 59 | 274 | 357 | 470 | 1151 |

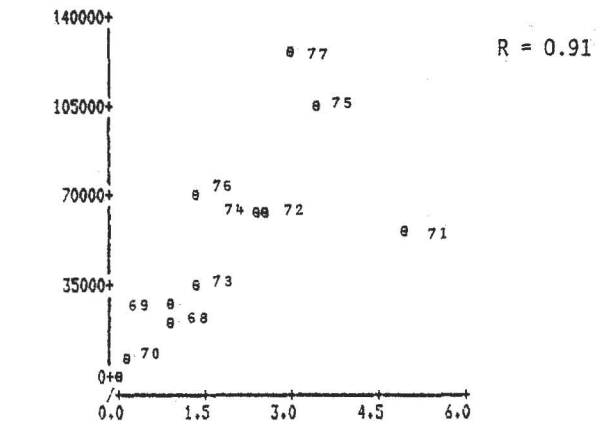
Figure 9. Comparison of survivor predicted and cohort analysis predicted population sizes at age for Option 1 (Num is Y axis and Res is X axis).

AGES 3 TO 8 SPA VS AGES 3 TO 8 RESEARCH



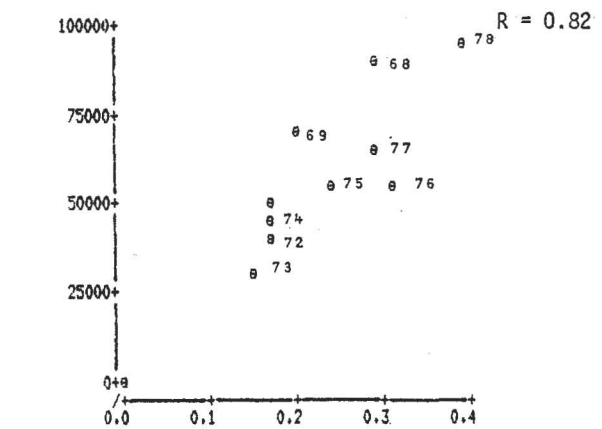

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| NUM : | 30535 | 23516 | 23717 | 16837 | 34526 | 46705 | 41633 | 32951 | 76231 | 79147 | 106591 |
| RES : | 11.95 | 15.45 | 6.83 | 5.50 | 27.28 | 13.00 | 14.09 | 26.98 | 17.44 | 23.61 | 36.37 |

AGES 2 + 3 SPA VS AGES 2 + 3 RESEARCH




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Y,C, : | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
| NUM : | 17677 | 31517 | 8644 | 58972 | 59757 | 31245 | 64967 | 102189 | 67885 | 123684 |
| RES : | 0.97 | 1.38 | 0.09 | 4.99 | 2.55 | 0.84 | 2.38 | 3.51 | 1.42 | 3.07 |

3+ POP BIOMASS VS COMMERCIAL CATCH RATE, MT/HR

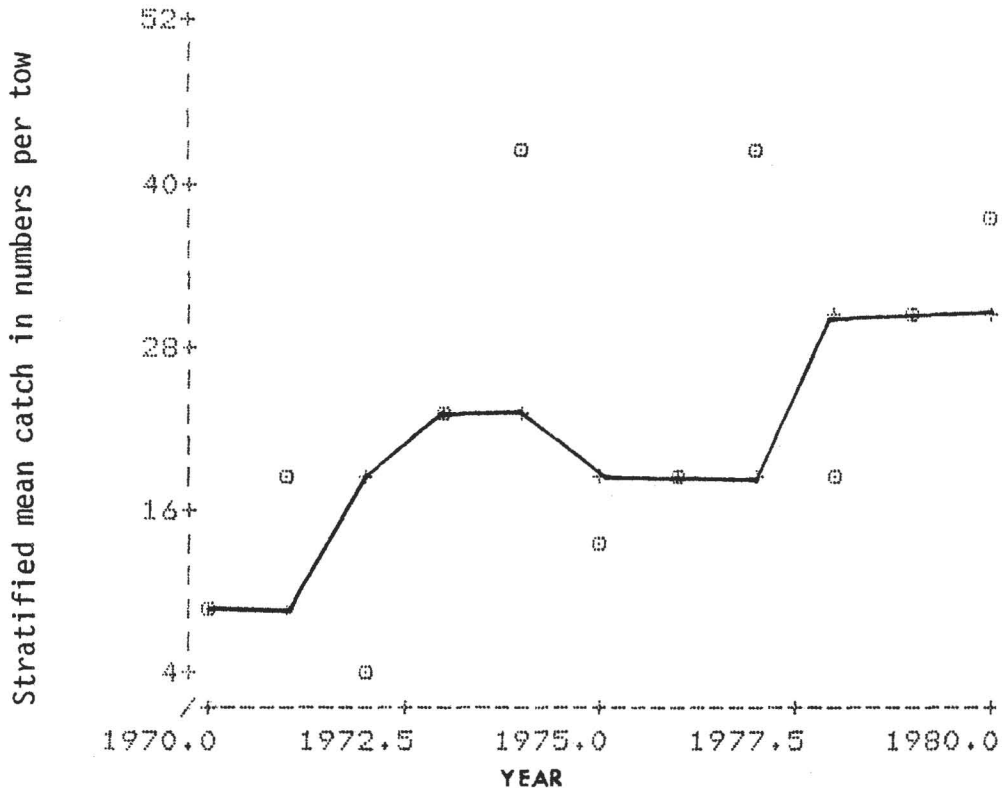



| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR : | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
| NUM : | 90306 | 67796 | 50593 | 42388 | 41399 | 31313 | 43163 | 55883 | 54281 | 62766 | 93778 |
| COM : | 0.28 | 0.20 | 0.17 | 0.17 | 0.17 | 0.15 | 0.16 | 0.24 | 0.31 | 0.28 | 0.39 |

Figure 10. Standard relationships examined to adjust cohort analysis (Option 1). (Num is Y axis and Res and Com are X axis).

Figure 11. Comparison of rough and smoothed (by median) 2-5 and 6+ research numbers per tow (Canadian survey only)

A. Ages 2-5




B. Age 6+

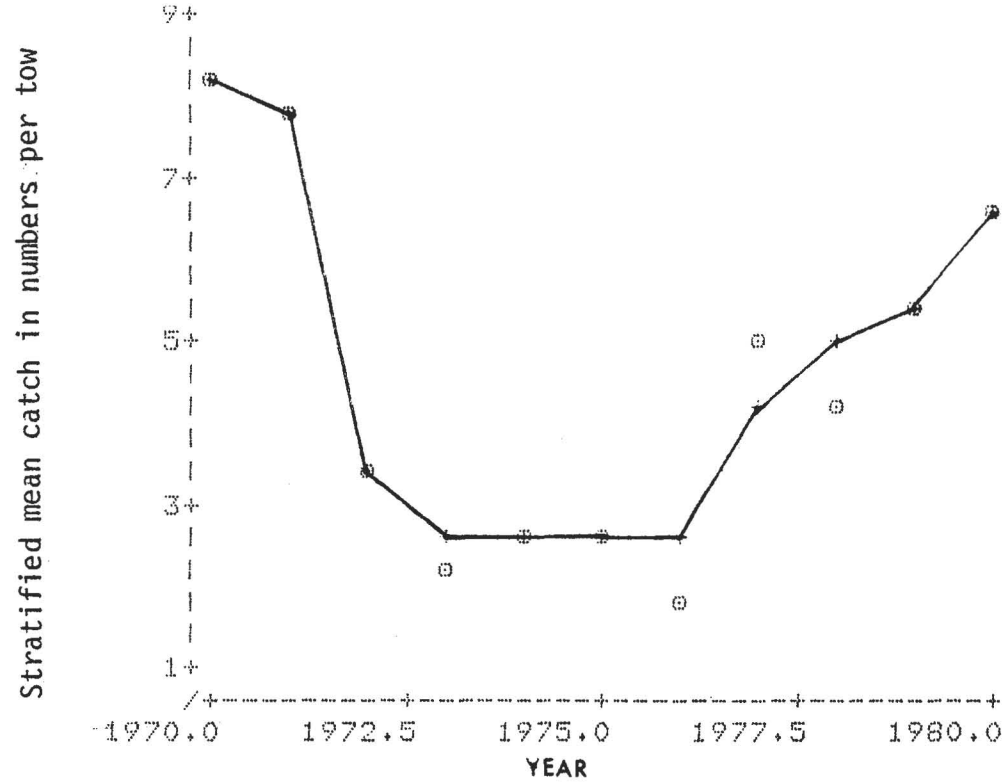
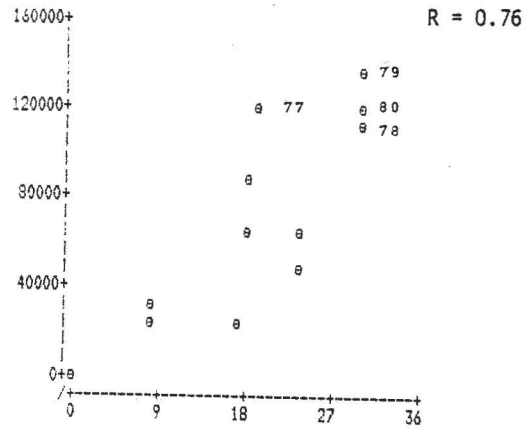


Figure 12. Standard relationships used in generating cohort analysis for option 2 (standard assessment procedure). (Num is Y axis and Res is X axis).

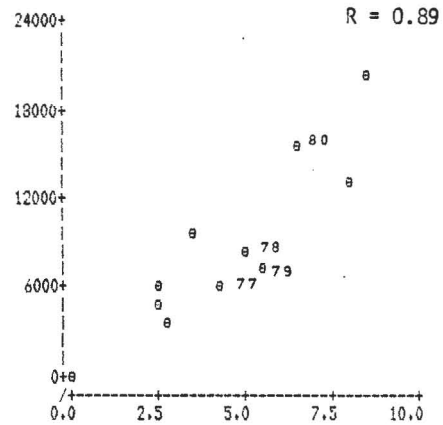
1981 4X HADDOCK ASSESSMENT NO. 2

AGES 2 TO 5 SPA VS AGES 2 TO 5 RESEARCH



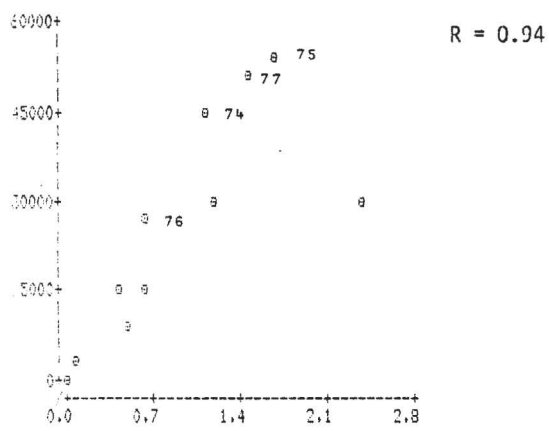

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 22861 | 32184 | 24117 | 48836 | 67035 | 61775 | 90750 | 119997 | 111744 | 133157 | 118809 |
| RES | 8.12 | 3.12 | 17.41 | 23.13 | 23.13 | 18.25 | 18.25 | 18.47 | 30.06 | 30.06 | 30.06 |

AGES 6 PLUS SPA VS AGES 6 PLUS RESEARCH



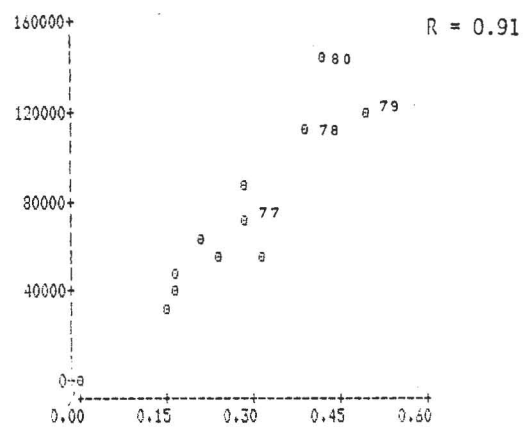

| YEAR | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 20949 | 12955 | 9136 | 5846 | 4221 | 4883 | 3438 | 5702 | 8399 | 7636 | 16010 |
| RES | 8.40 | 7.97 | 3.46 | 2.47 | 2.47 | 2.47 | 2.79 | 4.13 | 4.93 | 5.53 | 6.62 |

AGE 2 + 3 SPA VS AGE 2 + 3 RESEARCH




| YEAR | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 8848 | 15779 | 4347 | 29587 | 30129 | 15848 | 45877 | 53514 | 27981 | 50636 |
| RES | 0.46 | 0.66 | 0.04 | 2.35 | 1.22 | 0.40 | 1.11 | 1.67 | 0.66 | 1.44 |

3+ POP BIOMASS VS COMMERCIAL CATCH RATE, MT/HR




| YEAR | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUM | 90324 | 67817 | 50614 | 42417 | 41445 | 31377 | 43307 | 56232 | 54837 | 71977 | 109634 | 120941 | 144499 |
| COM | 0.28 | 0.20 | 0.17 | 0.17 | 0.17 | 0.15 | 0.16 | 0.24 | 0.31 | 0.29 | 0.39 | 0.49 | 0.42 |

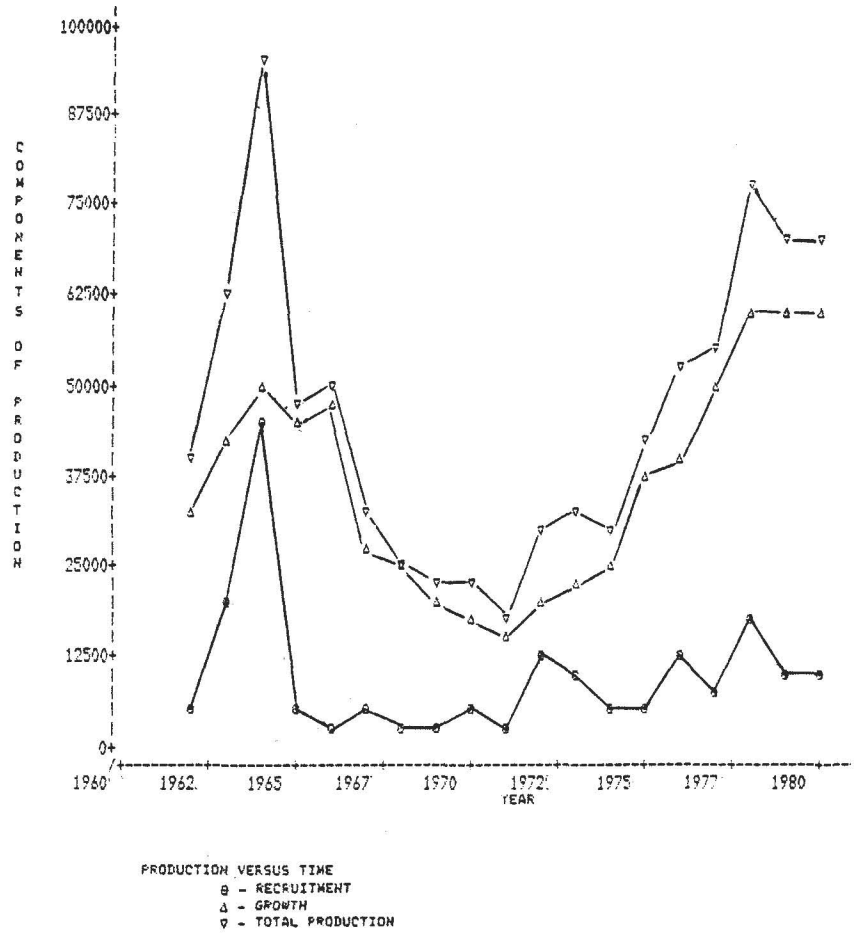



Figure 13. Variations in components of stock production (mt) during the 1962-80 period.

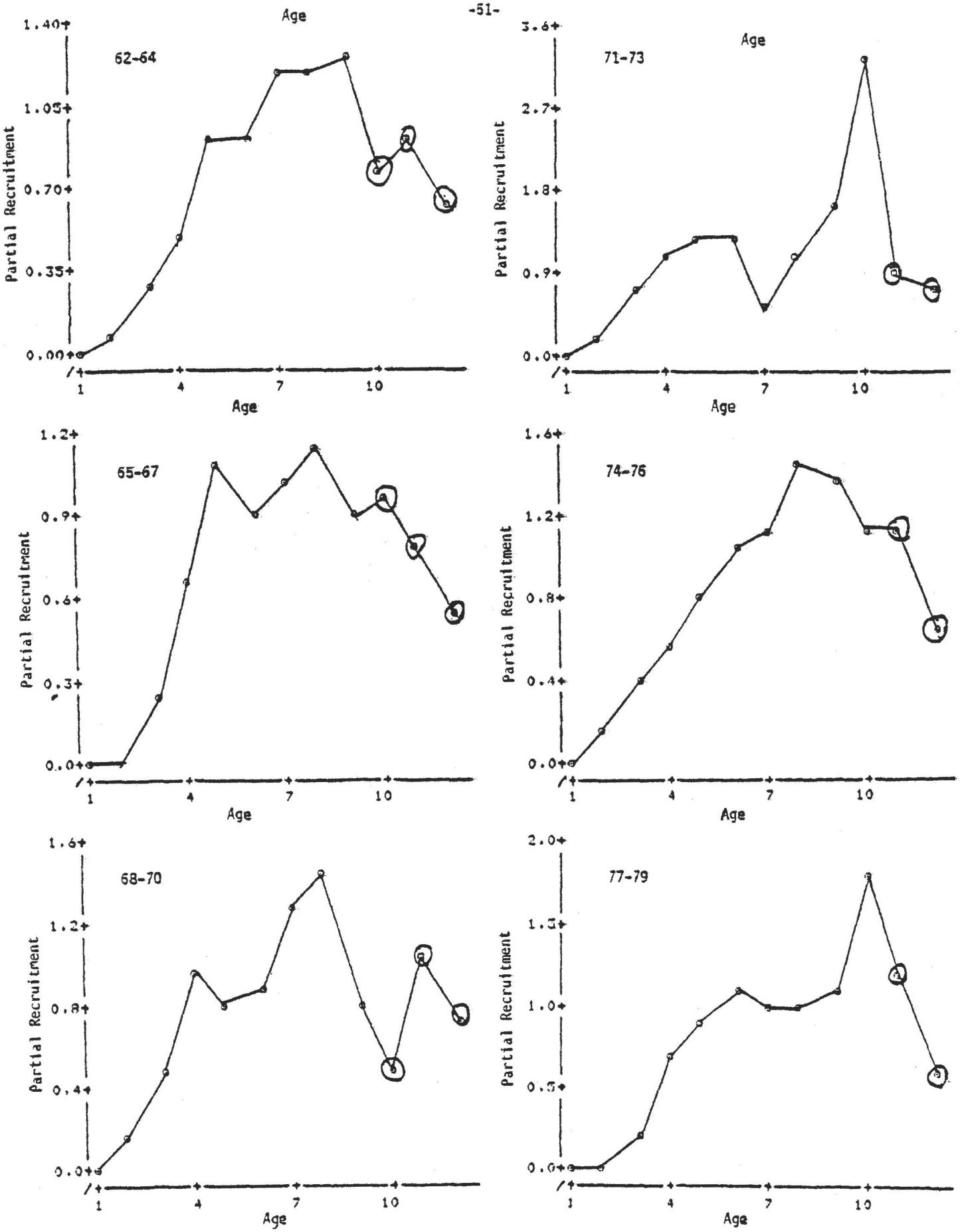



Figure 14. Change in partial recruitment at age during 1962-79 period. The circled points were dropped from the analysis.

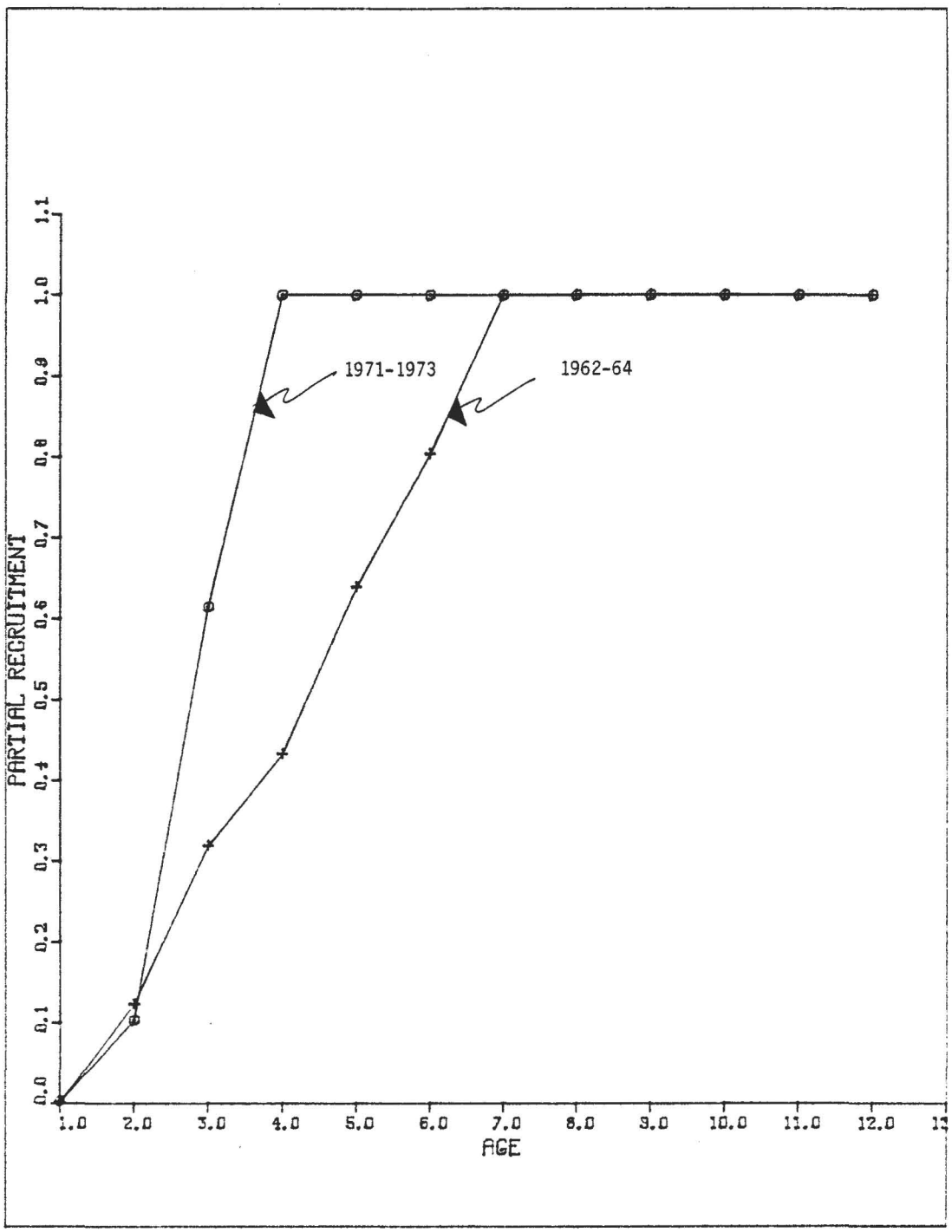



Figure 15. Observed extremes in the partial recruitment pattern for 4X haddock since 1962, as derived from the final cohort analysis.

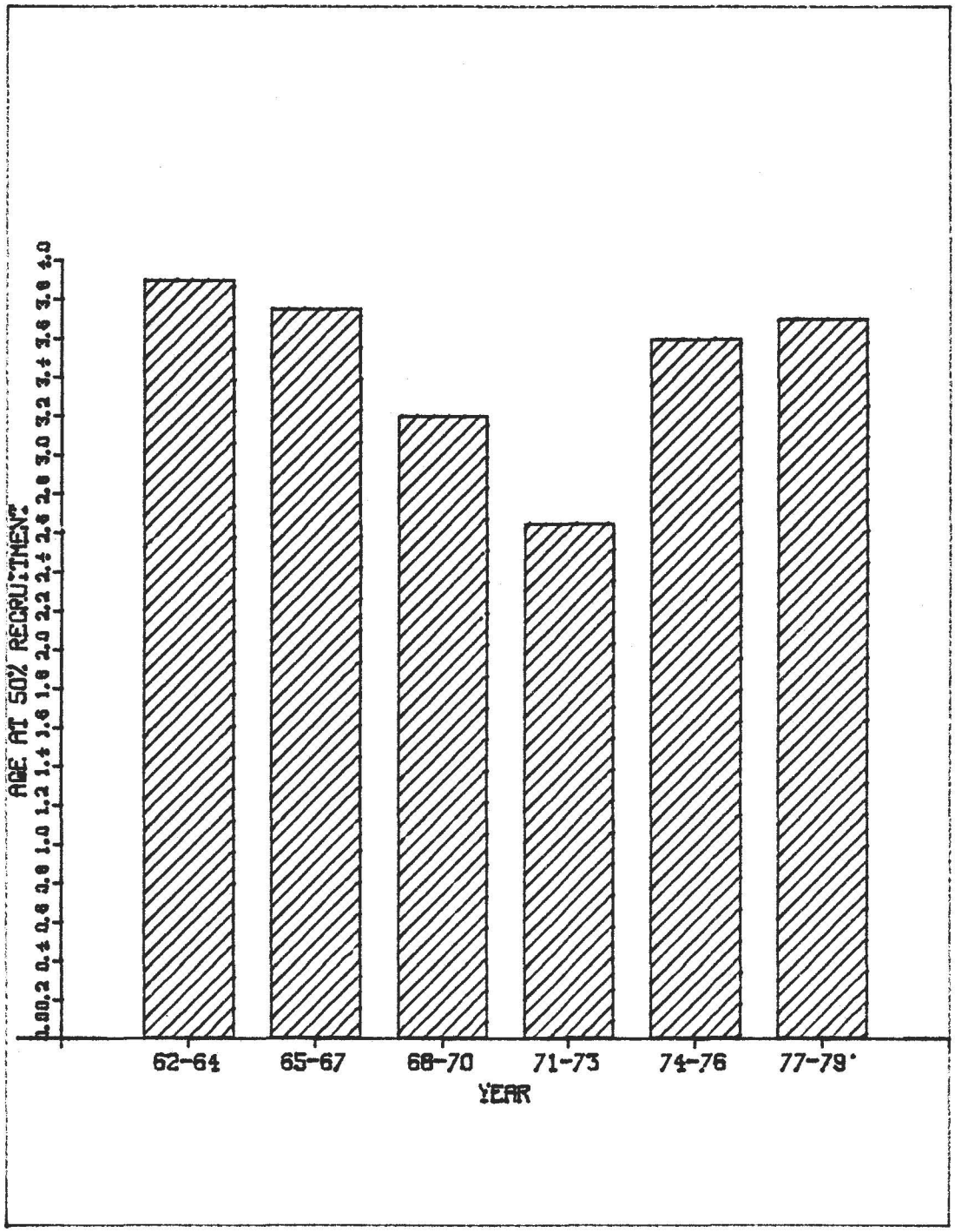



Figure 16. Observed pattern in the age of 50% recruitment to the fishery since 1962 as derived from final cohort analysis.

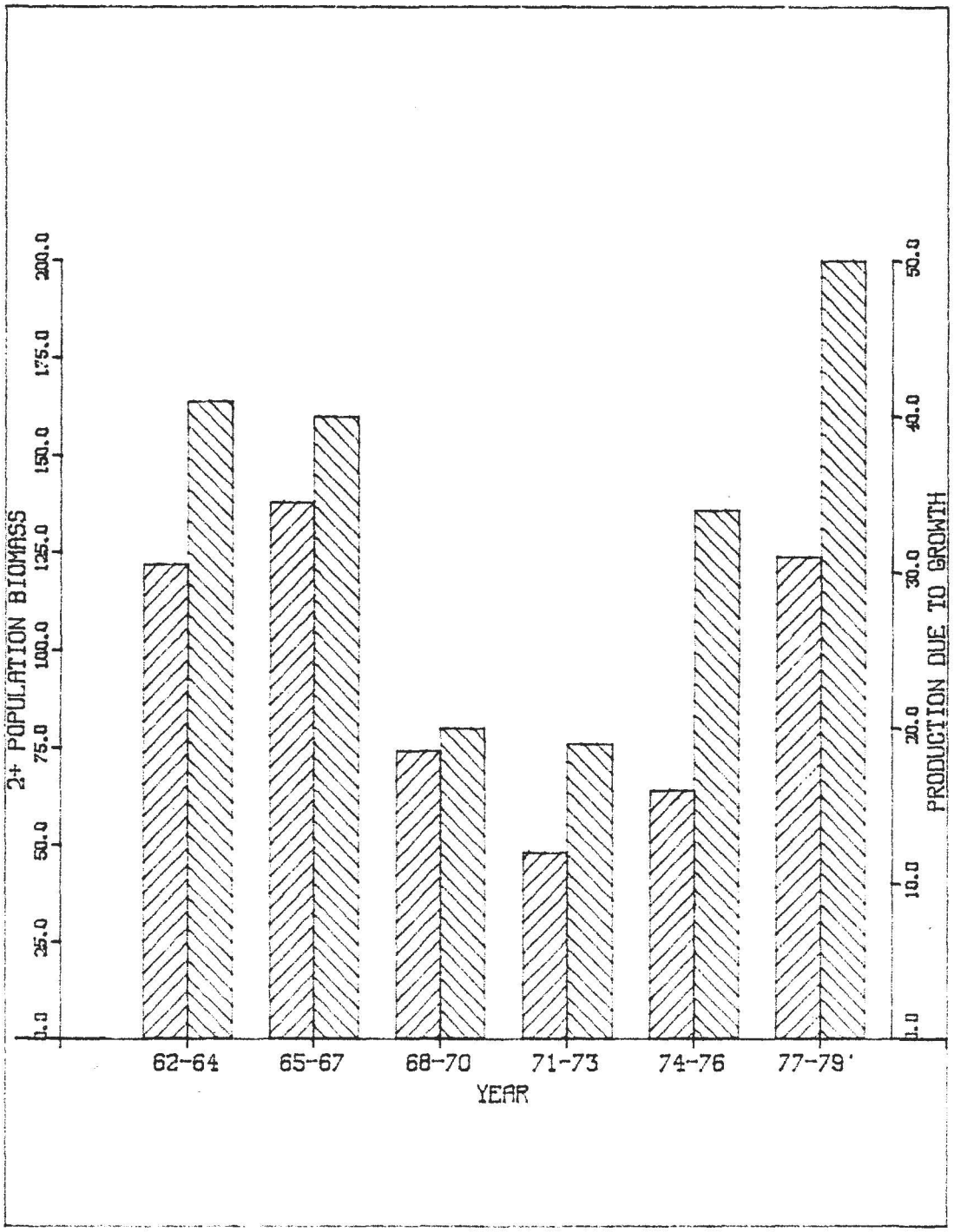



Figure 17. Observed patterns in 2+ population biomass and total production (growth component only) since 1962, as derived from final cohort analysis. (Bar on left is biomass and bar on right is production).