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An evaluation of the 4X haddock population characteristics during 1962-82 with yield projected to 1984.

by

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Abstract

Prior to 1960, nominal catches of Division 4X haddock fluctuated between 10,000 and 20,000 t annually. During the mid to late 1960s, heavy exploitation resulted in catches in excess of 30,000 t. Declining stock biomass prompted the introduction of TAC regulation in 1970. Nominal catches subsequently increased from a recent low of 13,000 t in 1973 to 31,000 t in 1981, but declined to 24,000 t in 1982. The catch for 1982 was dominated by the 1975 and 1979 year classes. It was similar to the catch percent age composition as projected by the 1982 assessment. Canadian summer groundfish survey abundance estimates indicate that while the number of age 2 to 5 haddock has steadily increased since 1976, that of ages 6+ reached a peak in 1979-80 and has declined thereafter. Survey recruitment indices show that the 1979, 1980, and possibly 1981 year classes are well above the long term average. The present assessment involved both the survivor method and cohort analysis in the determination of the 1982 fishing mortalities. The partial recruitment pattern was similar to that calculated in 1981 while the fully recruited F, although chosen at 0.3, could be as high as 0.42 which is suggested by the Survivor analysis. A new $F_{0.1}$ value of 0.25 was calculated using 16 rather than 12 age groups which previously has been the case. Using the derived partial recruitments and the 1982 weights-at-age, yield projections to 1984 were made, assuming $F_{0.1}$ catch in 1984. The estimated 1984 yield was 32,000 t.

Résumé

Les prises nominales d'aiglefin de la div. 4X avant 1960 ont fluctué entre 10 000 et 20 000 t annuellement. Du milieu à la fin des années 60, une exploitation intensive a donné des prises de plus de 30 000 t. Un déclin de la biomasse du stock a nécessité l'introduction d'une réglementation par TPA en 1970. Les prises nominales augmentèrent par la suite, passant d'un creux de 13 000 t en 1973 à 31 000 t en 1981, mais elles déclinèrent de nouveau à 24 000 t en 1982. Les classes d'âge de 1975 et 1979 ont dominé les prises de 1982. C'est la même structure d'âge qui avait été prédite lors de l'évaluation de 1982. Les estimations d'abondance découlant du relevé estival des poissons de fond mené par les Canadiens indiquent que si le nombre d'aiglefins d'âges 2 à 5 a augmenté régulièrement depuis 1976, celui des âges 6+ a atteint un sommet en 1979-80 et a diminué par la suite. Les indices de recrutement découlant du relevé indiquent que les classes d'âge de 1979, 1980 et, possiblement, 1981 sont bien au-dessus de la moyenne à long terme. La présente évaluation est fondée a la fois sur la méthode des survivants et l'analyse des cohortes pour déterminer les mortalités par pêche en 1982. Le recrutement partiel avait les mêmes caractéristiques qu'en 1981, alors que F de plein recrutement, bien que fixé à 0,3, pouvait être aussi élevé que 0,42, comme le porte à croire l'analyse des survivants. On a calculé une nouvelle valeur de 0,25 à $F_{0.1}$, utilisant 16, plutôt que 12 groupes, d'âge comme ce fut le cas précédemment. En se fondant sur les recrutement partiels dérivés et les poids à un âge donné en 1982, on a fait des projections de rendement pour 1984, en supposant des prises au niveau de $F_{0.1}$ en 1984. Le rendement a été estimé à 32 000 t en 1984.

Introduction

Biological evaluations of the 4X haddock stock have been conducted since the mid-1960s. Prior to 1974, these involved examination of trends in commercial catch rates and/or survey abundance indices. Halliday (1974) conducted the first Cohort Analysis (Pope, 1972) to be used in these assessments and this approach has been continued to the present. In addition, O'Boyle (1981a) employed Survivor Analysis (Doubleday, 1981a) in an attempt to make the choice of terminal fishing mortality a more objective process. The analyses conducted since 1981 have shown that in general the Cohort Analysis has led to lower estimated terminal fishing mortalities than those derived from the Survivor Analysis.

The present evaluation again uses the Survivor and Cohort Analyses to determine terminal fishing mortality, with the Canadian summer bottom trawl survey data being the main source of stock trend information. The stock sizes for 1962 to 1982 are determined and yield projected, under $F_{0.1}$ conditions, to 1984.

Trends in Reported Landings

Annual Trends

Prior to 1960, catches of haddock from Division 4X (Figure 1) fluctuated between 10-20,000 t annually. These landings were split equally between Canada and the USA. In 1963, the USSR entered the fishery for the first time and reported landings of 400 t. This increased to 10,065 t by 1966. As well the Canadian offshore fleet catch expanded rapidly. During the 1970s, foreign catch, including that of the US, declined leaving Canada almost the sole exploiter of the stock (Table 1). High exploitation rates in the late 1960s caused sharp declines in abundance and provoked the establishment of quotas and closed spawning areas in 1970 in an attempt to curb fishing effort.

The stock showed signs of recovery in the mid-late 1970s. Since 1973, when 12,958 t were landed, the annual catch has steadily increased with over 30,000 t reported landed in 1981 (Table 1). Reports from the field indicate that the actual catch during the 1977-80 period was higher than that reported. Low quotas caused substantial discarding, dumping, and misreporting by species and division. During this period the inshore fleet overran and the offshore fleet underran its allocation (Table 2) In 1982, landings (24,015 t) fell short of the TAC (32,000 t) by a substantial margin for the first time in 10 years.

Canadian Fishery by Gear Type, Tonnage Class, and Unit Area

During the 1970s, the landings of the tonnage class 1-3 otter trawlers increased dramatically. Longliner catches have also increased but not to the same extent (Table 3 and Figures 2 and 3). Landings by other gear and size categories have remained relatively stable.

The largest change in the fishery has been from a predominantly tonnage class 4 and 5 vessel fishery in the 1960s - early 1970s to a tonnage class 1-3 vessel fishery from the mid-1970s to the present (Figure 3). This has caused a change in both the seasonal exploitation pattern and the area of fishing. Regarding the season, O'Boyle et al., (1983) showed that the smaller, inshore otter trawlers restrict their activity to the February-November period whereas the larger offshore vessels have increasingly resticted their activity to the beginning and end months of the year. Regarding area, the inshore otter trawlers fish first on Browns Bank and then move into the Bay of Fundy during the summer months (Figure 4). The offshore vessels, on the other hand, have always restricted their fishing to Browns Bank and its environs. Thus with the change in fleet catch composition, the spatial and temporal distribution pattern of exploitation has changed.

Age Composition of the Commercial Catch

Sampling Intensity

Since 1970, sampling coverage by gear type has been good (Table 3). However, prior to 1981 coverage within gear type by tonnage class has been strongly biased toward the larger vessels. This is particularly evident when one examines the mean weight landed per commercial sample (Table 4) for the six main fishing fleets. In 1981, a shift in sampling intensity towards the smaller vessels was undertaken to rectify this problem and as a consequence sampling coverage since 1981 has been much more equitable. The 1982 sampling coverage by gear type, season, and unit area was very good with only tonnage class 4-5 trawler catches being undersampled (Table 5).

Examination of length-weight and length-at-age relationships by season and unit area

An analysis was conducted on the combined 1970-81 research survey data and 1981-82 port sampling information to examine seasonal changes in condition factor. Multiple regression analysis was used to fit the model:

$$(1) \quad W = A \cdot L^B \cdot T^C$$

or

$$(2)\quad \mathrm{Log}_{10}\, W = \mathrm{Log}_{10}\, A + B\, \mathrm{Log}_{10}\, L + C\, \mathrm{Log}_{10}\, T$$

where:

W is the weight in grams
L is the length in centimetres
T is the Julian date of the year
A, B, and C are equation constants

The model was fit for inshore (4Xq,r) and offshore areas (4Xm,n,o,p) separately due to lack of coverage of inshore vessel data offshore and offshore vessel data inshore. Using the partial F test, the C coefficient was found to be significant at the 5% level; however the increase in fit was only slight. Nevertheless it was felt warranted to include the C coefficient in determination of the length-weight relationship on a seasonal basis. Consequently the C term was calculated for the mid day of the quarter in question and the Log_{10} A term adjusted appropriately (Table 6). These eight length-weight relationships, four for inshore and four for offshore, were used when constructing the catch-at-age matrix.

It was observed that, with regard to the survey data, haddock found in inshore areas are longer-at-age than those found offshore (Figures 5A-D). This pattern was not clearly visible in the commercial data (Figures 5E-I), although there was a general tendency for age 2-6 fish to be longer at age inshore than offshore.

The reasons for these results needs to be further investigated. They could result from differential migration, exploitation or from the existence of different stocks. Work is presently underway to examine each of these effects.

Construction of the Catch-at-age Matrix

Construction of the catch-at-age prior to 1978 is discussed by O'Boyle (1981a). A key point is that no adjustment has been made for the USSR catches in the mid-1960s. The length frequency of the landings by this country was assumed to be the same as that for Canada. This is believed not to be the case, and efforts are presently underway to rectify the analysis. However, this should be kept in mind when analysing the present data set for recruitment studies.

The 1978-79 catch-at-age was reconstructed as per O'Boyle (1981a). The 1980-81 catch-at-age was reconstructed using gear (otter trawler, longliner, and miscellaneous gear), area (mnopu and qr), and quarter for stratification (unit area "u" is "unit area unknown").

In 1982, tonnage class was added to the stratification scheme (Table 5) and seasonally adjusted length-weight relationships (Table

6) were used in converting sample numbers to catch numbers. For 1978-82, only Canadian sampling was used as no foreign sampling data was available. No correction for discarding has been applied.

The Catch-at-age Matrix

The numbers landed-at-age for 1962-1982 are presented along with the weights-at-age calculated for commercial landings in Tables 7 and 8. Ages 4 to 7 haddock have over the years contributed the majority of numbers and biomass to the landings (Tables 9 and 10). In almost all years, catches of fish older than 12 years have represented a very small fraction of the total catch.

A comparison of the 1982 projected catch-at-age from O'Boyle and White (1982) with the observed 1982 catch-at-age (Figure 6 and Table 11) shows that the actual catch age composition was well predicted. The only discrepancy is the lower than predicted catch of the 1979 year class. Also, the absolute numbers caught was lower than those predicted.

Stock Abundance Trends

Groundfish Bottom Trawl Surveys

Canada and the US have conducted standardized groundfish surveys (Doubleday, 1981b) in NAFO Division 4X since 1970 and 1963 respectively. Initially Canada only ran summer surveys, but in 1979 a fall survey was added and the following year a spring survey series was initiated. The US has conducted autumn surveys since 1963 and spring surveys since 1968. Summer surveys have also been conducted since 1963 but the series is not complete.

The Canadian surveys have habitually sampled all of 4X (strata 70-95 of Figure 7a). On the other hand, recent coverage by the US surveys has been restricted to Browns Bank (strata 31-34 of Figure 7b). Consequently, although indicative of trends in abundance, the US data were felt not complete enough to use in tuning of the Sequential Population Analysis. The Canadian summer survey data, due to its completeness in sampling time and space, were used for this purpose.

In 1982, the A.T. Cameron, the Canadian summer survey vessel was replaced by the Lady Hammond. Comparison studies of the fishing efficiency of both vessels have been underway since 1979 but the final results are still forthcoming. Nevertheless, preliminary results (Koeller and Smith, 1983) indicate that, for haddock, the Lady Hammond's catch rates by numbers are 20% higher than those for the A.T Cameron. For this reason, the Lady Hammond figures in this analysis were divided by 1.2 to make the 1982 data comparable with the long time series available from the A.T. Cameron.

The longer US time series shows that stock size was high in 1963-67, declined during 1967-76, and subsequently rose to an asymptote in 1979-82. Present stock levels appear to be about 60% higher than those observed in the mid-1960s (Table 12).

The Canadian summer survey time series (Table 13) exhibits the same rapid rise in stock abundance during 1976-80 as was observed in the US data set (Figure 8). Most of the recent increase in abundance has occurred in the inshore areas, particularly stratum 90, at the mouth of the Bay of Fundy (Table 14).

An examination of the changes in the age structure of the population shows that whereas the relative abundance of the partially recruited age groups (age 2 to 5) has steadily increased since 1977 (Figure 9), the abundance of the fully recruited age groups (age 6+) increased during 1976-79 and have fallen off since then (Figure 10).

Recent recruitment fluctuations partially explain these trends. These were examined through the calculation of recruitment indices for the Canadian summer and U.S. fall surveys using the normalization method of O'Boyle (1981b). For each survey, two indices were developed. Indices for the Canadian survey were developed using ages 1 + 2 and 2 + 3 of each cohort while the US recruitment indices used ages 0 + 1 and 1 + 2 of each cohort (Table 15).

The US recruitment indices show exceptionally large 1962 and 1963 year classes. The 1971 year class is strong in this survey but only average in the Canadian survey (Figure 11). The year classes between 1972 and 1977 are not exceptional but above those seen during 1964-70. The 1978 year class represents a recent low in recruitment but still larger in size than those seen in the 1964-70 period. The 1979 year class is shown to be exceptionally strong in both surveys, as is the 1980 year class. Initial indications from the Canadian survey of the 1981 year class are that it is similar in size to the 1979 and 1980 year classes. The US survey results do not agree with this and show this year class to be weaker than the 1978 year class. Thus it is too early to predict with any degree of confidence the size of this year class.

It is interesting to examine seasonal trends in the strengths of these year classes to get some idea as when year class size is finally established. First, it is clear that the July survey only sporadically picks up the age 0 individuals (Table 16) and that the autumn survey is the first time that young of the year are caught in any number. It is uncertain, however whether or not year class size is fixed by this time. The 1980 year class was seen to be exceptionally large in the autumn survey but had become substantially reduced by

March 1981 and further reduced by the following summer. It now appears smaller than the 1979 or 1981 year classes in the second summer of life. From this it is apparent that the age 1 + 2 recruitment indices should be superior to the age 0 + 1 index in estimating year class size.

Commercial Catch Rates

Previous attempts to use the commercial catch rate data available for 4X haddock have not met with success (O'Boyle, 1981a; O'Boyle and White, 1982). There are a number of reasons for this. First, until recently, the full data set has not been conducive to large scale analysis. Second, misreporting, dumping, and discarding in the late 1970s has led to strong biases in the catch rate series. Finally, the fleets have undergone many changes, both in area, time of year fished and gear used over the time period of the available data set (1968-present). Without quantification of these changes, it is risky to consider the efficiency now in any way comparable to that observed in the early 1970s.

Thus, for the purposes of tuning the SPA, it was felt not valuable at this time to use the commercial catch rate data. However it was felt of benefit to examine the series to both prepare for its future use and get an impression of what the fishermen see in stock biomass trends.

O'Boyle and White (1982) developed two catch rate series - one for the tonnage class 1-3 otter trawlers fishing in unit areas 4Xq-r in August-September and the other for tonnage class 4-5 otter trawlers fishing in unit area 4Xn in January-March. Both series used tons per trip as indicative of abundance.

These series were reworked in this analysis. The first set of changes was to express catch rates as tons per fishing hour and for the tonnage class 4-5 vessels include unit areas 4Xm-p and u in the calculations (Table 17).

The second set of calculations used the Multiplicative Model of Gavaris (1980) in an attempt to adjust for seasonal, areal, and vessel type and size effects on the catch rates. Essentially the Multiplicative Model is a large Analysis of Covariance with season, unit area, and vessel type and tonnage class as covariates. Unfortunately the model assumes linearity between the dependent and each independant variable which with vessel tonnage class is probably not the case. Nevertheless the analysis represents an important first step in the consideration of these confounding factors.

The analysis of the unit area 4Xq-r (inshore) data was conducted separately from the 4Xm-p, u (offshore)data. This was due to the lack of tonnage class 4-5 vessel activity in the former area.

The "inshore" analysis used 1968, tonnage class 2, January-March and stern otter trawler type as a standard. The fit of the model to the data was barely significant (r^2 of 0.23). The most significant difference in catch rates was observed between side and stern otter trawlers. Season and year were significant while tonnage class was not.

The "offshore" analysis used 1968, tonnage class 5, January-March and stern otter trawler type as a standard. Again the model fit was poor (r^2 of 0.31) with vessel type and season explaining most of the variance.

These two models were used to calculate two catch rate series - one for unit area 4Xqr using stern otter trawlers of tonnage class 3 operating during July-September and the other for unit area 4Xm-p, u using stern otter trawlers of tonnage class 5 operating during July-September.

The two series for each of the nonstandardized and standardized catch rates (Table 17) are illustrated in Figure 12. Standardization dramatically changes the view of the resource, particularly the trend in recent years. It also makes more comparable the catch rates series for the inshore and offshore area. According to the nonstandardized series, abundance inshore started to decline in 1977; offshore, declines were abrupt in 1981. The standardized series show decreases in fishable biomass since 1978. Biomass in 1982 is comparable to that observed in the late 1960s.

Sequential Population Analysis

Survivor Analysis

O'Boyle (1981a) used Survivor Analysis (Doubleday, 1981a) for the first time in the 4X haddock stock evaluation. The method has the advantage of statistically fitting the survey data to the population numbers derived from an SPA and is thus objective. Its main weaknesses are: 1) it assumes the data are normally distributed and 2) there is a linear trend between survey catch rate and stock biomass. The latter means that one cannot use those age groups which are not well sampled by the survey. O'Boyle (1981a) thus restricted his analysis to the age 3 to 8 individuals. As a consequence, the method cannot generate 0+ population numbers but does provide a terminal fully recruited fishing mortality (F_t) which can be used in a Cohort Analysis.

Because the Survivor method is a relatively new procedure which requires certain assumptions, the Sequential Population Analysis procedure (O'Boyle, 1981b) has continued to be used. In the 1981 evaluation, both approaches provide an F_t of approximately 0.3. In the 1982 evaluation (O'Boyle and White, 1982), the Survivor Analysis provided an F_t of about 0.46 while the Cohort Analysis provided an F_t of 0.4. The latter was chosen because it presented population trends more in line with those calculated by O'Boyle (1981a).

The Survivor Analysis on the 1970-82 data set was carried out for ages 3 to 8. The calibration block was set for ages 3 to 7, years 1970 to 1982, with the calibration constant, K, asymptotic after age 5. Natural mortality, M, was set at 0.2. Fishing mortalities for 1982 were calculated by inputting the survivor estimates and catch statistics for 1982 into a Newton-Raphson iterative solution of the Baranov catch equation. Adjustment of the survivor estimates from the end to the beginning of the year were made in this calculation.

The results of the Survivor Analysis (Table 18a and b) provided a weighted (by population numbers) terminal fishing mortality, F_t, for ages 6 to 8 of 0.417. The unweighted value was 0.46. However, as in previous years, the coefficients of variation on this analysis were quite high, ranging from 42 to 60 percent.

Cohort Analysis

The determination of the 1982 partial recruitment vector and fully recruited fishing mortality closely followed the procedure outlined by O'Boyle (1981b). A modification was however made to the Cohort Analysis (Pope, 1972) to improve the calculation of the age 13+ population numbers. In previous assessments (O'Boyle, 1981a; O'Boyle and White, 1982), the age 13+ catch-at-age has simply been dropped from the analysis. Here, the age 12 and 13+ numbers were calculated using the "fishing incomplete" equation of Pope (1972). However only the age 12 numbers were used to commence the analysis. During the various runs to be mentioned below, these values, once the analysis commenced, were updated through an iteration process with the arithmetic mean of the age 6 to 9 fishing mortalities serving as input F at age 12 and 13+ for the next run. The convergence criterion was $F_i - F_{i+1} < 0.001$.

Choice of the 1982 partial recruitment pattern and fully recruited fishing mortality was made through close examination of the following relationships:

1. Age 6+ SPA population numbers ($x10^{-3}$) vs age 6+ numbers per tow from Canadian summer research survey.

2. Age 2 to 5 SPA population numbers ($x10^{-3}$) vs age 2 to 5 numbers per tow from Canadian summer research survey.

3. Age 1 SPA population numbers ($x10^{-3}$) vs age 1+2 recruitment index from Canadian summer research survey.

4. Age 2+3 SPA population numbers ($x10^{-3}$) by cohort vs age 2+3 recruitment index from Canadian summer research survey.

The partial recruitment pattern was established before choice of the 1982 fully recruited fishing mortality (F_t). First, the pattern as calculated for 1981 by O'Boyle and White (1982) was multiplied by the F_t estimated by the Survivor Analysis. Full recruitment in previous assessments has been shown to occur at age 6 and be asymptotic thereafter. Small adjustments were made to the age 1 to 5 partial recruitment values to maximize the r^2 of relationships 2, 3, and 4. The resultant vector was not dissimilar to that provided by O'Boyle and White (1982) and almost identical to that given by O'Boyle (1981a) (Table 19).

The fully recruited F_t for 1982 was calculated using the following criteria:

1. Maximization of the r^2 of relationships 1, 2, 3, and 4 examining the plots closely for the identification of outliers.

2. Assuming an intercept of zero and thus seeking those relationships which regress lines closest to the origin. Again plots were closely examined to identify data points which could be spurious.

3. Choice of a 1982 F_t which gave a 1981 F_t which is consistent with 1981 F_t provided by O'Boyle and White (1982).

In general, the discrimination power of the various criteria was low for the range of F_t values chosen. The results for relationship 2 (Table 20) suggest that, from an r^2 point of view, an F_t of 0.46 would be appropriate. From an intercept point of view, a value closes to 0.25 is likely. This relationship had two outliers - those for 1974 and 1977. Removal of these points from the analysis would narrow the choice of F_t to the range of 0.25 to 0.35.

The first relationship's results (Table 21) suggest that F_t should be around 0.4. The intercept never passed through the origin, the value of A changing only slightly over the range of F_t values tested.

The results for relationship 3 (Table 22) suggest an F_t of 0.35 to maximize the r^2 and 0.25 to pass the intercept through the origin.

The last relationship's analysis (Table 23) provided an F_t in 1982 of 0.50 and 0.375 for the r^2 and intercept criteria respectively.

The summary of this analysis is that two relationships, 2 and 3, suggest an average F_t of 0.3 (middle of range 0.25-0.35) while the remaining two suggest a value around 0.425 (average of 0.4, 0.5, and 0.375). The latter value is very close to that generated by the Survivor Analyis. Thus the choice in essence reduces to a decision for F_t in 1982 between 0.3 and 0.42.

The last criterion to examine, that of consistency with the 1982 assessment, was used to discriminate between these two options. In the Cohort Analysis using an F_t of 0.3, the average 1981 F_t (weighted by population numbers) for ages 6 to 9 was 0.43. The comparable value for the analysis with an F_t of 0.4 was 0.52. The 1981 F_t chosen in the 1982 assessment was 0.4 (O'Boyle and White, 1982) which suggests that the 1982 F_t for this analysis should be closer to 0.3 than 0.4.

Final Cohort Analysis

The Survivor Analysis suggested an F_t of 0.42 whereas the Cohort Analysis suggested a value of 0.3. Both procedures have inherent problems. The first suffers from high variance while the second requires much subjective decision making. The most persuasive piece of information in the analysis is that an F_t of 0.3 would be consistent with the decision for F_t made in 1982. What is worrisome about this is that the analysis as presented by O'Boyle and White (1982) might be too optimistic. It is still too early to tell whether or not this is the case.

The Cohort Analysis using an F_t of 0.3 and the partial recruitment pattern as given in Table 19 is presented in Table 24. The associated plots are provided in Figure 13. An examination of the age 1 estimates for the stock assessments over the last three years shows that the various evaluations have been fairly consistant (Table 25). There has been, however, a general increase in size estimates of the 1977 to 1978 year classes between this (F_t of 0.3) and the evaluation by O'Boyle and White (1982). It is important to point out here that the value for the 1980 year class (93,681 x 10^{-3}) was predicted from the relationship between age 1+2 population numbers (x10^{-3}) by cohort and age 1+2 survey recruitment index. The same relationship predicts a large 1981 year class (85,110 x 10^{-3}). However, because there is still not enough data to definitively fix the size of this year class, the geometric mean of the age 1 estimates for 1962 to 1980 was used as representative of the size of the 1981 year class.

Table 25 also presents the age 1 population size estimates assuming an F_t of 0.4. The view of the resource is much more pessimistic than that with F_t = 0.3. Also, an F_t of 0.4 suggests that the F_t value in the current year had been underestimated in the last three years as shown by the decreasing population numbers estimated by each successive assessment.

Yield-per-recruit Analysis and Catch Projections

Yield-per-recruit

In previous evaluations, the maximum age chosen for the yield per-recruit analysis has been 12 years. Closer examination of the available commercial sample data and discussions with other colleagues has indicated that the maximum age that a haddock can attain is in the order of 16 years.

The partial recruitment vector was that as derived above in the Cohort Analysis.

The weight-at-age (kg) was obtained through converting the 1982 commercial weight-at-age (Table 8) to length using the offshore, quarter 2 length-weight relationship (Table 6) and then fitting a Von Bertalanaffy growth equation to this data. This equation was used to calculate a 20 year vector of lengths which was then converted back to weight using the same length-weight relationship as used above (Table 26). M was taken as 0.2.

The $F_{0.1}$ with 16 ages was 0.248, compared to 0.3 for 12 ages, which is a decrease by 21%. The yield per recruit, on the other hand, changed from 0.605 to 0.596 which is only a 2% decrease. The F_{MAX} and yield-per-recruit at F_{MAX} changed 5% and 1% respectively.

Catch Projections

Projections were only carried out for the Cohort Analysis with F_t of 0.3, although it is realized that this may represent an overly optimistic resource picture. The Cohort Analysis run with F_t of 0.4 produces a 1982 population about 75% the size of that produced by the F_t = 0.3 run. Thus under equivalent catch projection conditions, yield in this case can be expected to be 75% of that presented here.

The catch projection was run to 1984 using the starting conditions as given in Table 27. Three assumptions were considered for 1983 - 32,000 t caught (the TAC); $F_{0.1}$ caught; 25,000 t caught (projected). The 1984 exploitation was at $F_{0.1}$.

The results (Table 28) show that, regardless of the 1983 assumption, 1984 yield can be expected to be near the present TAC of 32,000 t. This conclusion is of course contingent on F_t being 0.3.

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

YEAR	CANADA (MQ)	CANADA (Nfld)	USA	USSR	SPAIN	OTHER	TOTAL	TAC
1970	15560	-	1639	2	370	12	17583	18000
1971	16067	-	656	97	347	1	17168	18000
1972	12391	-	411	10	470	1	13283	9000
1973	12536	-	268	14	134	6	12958	9000
1974	12243	-	662	35	97	-	13037	0
1975	15991	-	2109	39	7	2	18148	15000
1976	16294	-	972	-	95	5	17366	15000
1977	19561	-	1649	2	-	12	21224	15000
1978	25300	114	1135	2	-	27	26578	21500
1979	24287	268	69	3	-	15	24642	26000
1980	28215	75	256	-	-	34	28580	28000
1981	30156	113	342	-	-	16	30627	27850
1982	23216	28	767	-	-	4	24015	32000

Table 2. Recent Canadian fishery allocations and the respective reported catch of 4X haddock (t). (All information from Atlantic Quota Reports.)

YEAR	VESSEL SIZE	ALLOCATION	REPORTED CATCH	% OF ALLOCATION
1975	all vessels	12500	15970	128
1976	all vessels	13300	15715	118
1977	all vessels	13400	20220	151
1978	all vessels	21500	25518	119
1979	> 125 ft.	8500	6471	76
	< 125 ft.	17500	17949	103
1980	> 125 ft.	5500	5095	93
	< 125 ft.	22500	23585	105
1981	> 125 ft.	5500	5319	97
	< 125 ft.	22350	23881	107
1982	< 65 ft.	23850	21077	88
	65-100 ft.	1100	691	63
	> 100 ft.	7050	2829	40

Table 3. Nominal catch (t round) of haddock from unit areas 4X m-r and u (unknown) landed in the Maritimes and reported by tonnage class and gear type. The number in brackets represents the number of commercial samples taken by MFD.

	TONNAGE CLASS						
	1-3			4-5			
YEAR	OT	LL	MISC	OT	LL	MISC	TOTAL
1970	4894(5)	2754	1295	6500(22)	113	3	15559
1971	4289(6)	3019(3)	954	7712(17)	93	0	16067
1972	2741(3)	3904(7)	933(1)	4750(20)	63	0	12391
1973	1822(6)	5714(9)	701	4228(14)	70	0	12535
1974	3949(5)	6106(10)	509(1)	1623(5)	56	0	12243
1975	6091(18)	4917(8)	548(1)	4409(28)	26	0	15991
1976	4348(4)	4591(6)	1159(2)	6144(33)	46	6	16294
1977	6185(6)	3918(8)	960	8345(64)	117	35	19560
1978	9213(1)	5957(10)	1947(4)	8093(48)	92	0	25302
1979	9870(2)	4292(12)	1435(2)	8634(33)	56	0	24287
1980	12655(10)	5635(17)	2403(4)	7440(24)	82	0	28215
1981	14599(42)	6925(26)	1915(7)	6647(7)	70	0	30156
1982	11495(49)	6708(20)	1888(14)	3091(10)	32	0	23214

Table 4. The mean weight (t) per commercial sample as per Table 3.

	TONNAGE CLASS					
	1-3			4-5		
YEAR	OT	LL	MISC	OT	LL	MISC
1970	979	-	-	295	-	-
1971	715	1006	-	454	-	-
1972	914	558	933	238	-	-
1973	304	635	-	302	-	-
1974	790	611	509	325	-	-
1975	338	615	548	157	-	-
1976	1087	765	580	186	-	-
1977	1031	490	-	130	-	-
1978	9213	596	487	169	-	-
1979	4935	358	718	262	-	-
1980	1266	331	601	310	-	-
1981	348	266	274	950	-	-
1982	235	335	135	309	-	-

Table 5. Summary of commercial sampling for the 4X haddock fishery in 1982 - tons landed (no. of samples).

	Otter Trawler Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC 1-3	TC 4-5
1	1412(7)	1781(7)	46(1)	-
2	2162(15)	378	1915(2)	-
3	1141(5)	219(1)	3472(8)	8
4	643(3)	705(1)	704(5)	1
Total	5358(30)	3083(9)	6137(16)	9

	Longliner Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC-1-3	TC 4-5
1	1975(3)	29	37	-
2	1011(2)	-	97(1)	-
3	2065(6)	-	88	-
4	1379(8)	3	57	-
Total	6430(19)	32	279(1)	-

	Miscellaneous Gear Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC 1-3	TC 4-5
1	71	-	1	-
2	432(2)	-	29	-
3	1062(9)	-	32	-
4	253(3)	-	9	-
Total	1818(14)	-	71	-

Table 6. Seasonal adjustment in weight (gm) at length (cm) for inshore (4Xq,r) and offshore (4Xm,n,o,p) components based on combined (1970-81) research survey data and 1981-82 port sample data.

Fishery	Quarter	Log a	b	c	Log a (adjusted)	n
Inshore (q,r)	1	-2.04376	3.03027	1.2378×10^{-4}	-2.03782	7754
	2	"	"	"	-2.02742	
	3	"	"	"	-2.01529	
	4	"	"	"	-2.00403	
Offshore (m,n,o,p)	1	-2.11667	3.07669	2.8047×10^{-5}	-2.11532	30091
	2	"	"	"	-2.11297	
	3	"	"	"	-2.11022	
	4	"	"	"	-2.10767	

Table 7. Landings at age (numbers in 000's) of haddock caught in unit areas 4Xm-4Xr, excluding discards.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1992
1	0	0	0	0	0	0	0	0	0	0	41	150	1	37	18	2	0	0	18	2	0
2	139	713	155	70	219	22	665	10	1055	788	22	3077	694	2175	1296	1285	75	81	155	1143	493
3	4524	2013	1272	3038	18341	515	297	2016	724	1617	3434	113	4653	4568	1644	3126	3354	1158	2305	2176	3652
4	1415	7185	4286	1981	9796	20380	1164	1968	1502	788	1841	2247	309	5164	4261	2019	7014	6709	2997	6177	2269
5	1778	3087	9337	3153	3167	9148	17448	1621	379	1422	509	1067	1779	485	3682	3193	2094	3881	5430	4180	4406
6	1708	1649	3018	5409	2149	1039	4684	11243	524	404	645	527	509	1103	434	2881	2832	1070	3538	3190	1675
7	1648	1415	1492	1973	3747	735	713	3220	4536	69	90	600	189	247	807	360	1040	1244	505	1169	1419
8	973	593	1370	1000	840	1052	518	455	1863	3316	57	322	269	172	154	389	137	763	625	373	341
9	643	478	612	745	409	187	672	249	133	1020	1166	259	186	62	71	107	107	57	170	327	180
10	232	152	416	288	424	102	190	194	96	163	512	614	269	32	95	72	26	68	33	97	93
11	203	113	297	203	88	90	131	172	175	181	26	55	552	165	39	23	9	11	22	14	46
12	64	59	168	114	62	23	65	94	27	146	193	13	24	229	103	8	6	0	4	22	18
13	100	43	36	113	84	81	89	69	37	105	92	6	4	11	157	87	48	18	16	11	10

Table 8. Mean weights at age (kg) of haddock caught in unit areas 4Xm-4Xr.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.27	0.18	0.23	0.23	0.28	0.29	0.29	0.15	0.23	0.22
2	0.56	0.50	0.50	0.36	0.31	0.32	0.37	0.56	0.57	0.50	0.45	0.51	0.46	0.52	0.52	0.46	0.44	0.51	0.52	0.59	0.49
3	0.75	0.78	0.75	0.65	0.67	0.62	0.62	0.75	0.90	0.96	0.90	0.75	0.82	0.82	0.81	0.71	0.87	0.87	0.88	0.88	0.90
4	1.15	1.05	1.00	1.00	0.85	0.85	0.90	0.88	1.05	1.25	1.35	1.25	1.10	1.20	1.19	1.22	1.33	1.33	1.33	1.26	1.29
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	1.78	1.72	1.67
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	2.36	2.22	2.14
7	2.20	1.85	1.75	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	2.70	2.83	2.90	2.65	2.58
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	3.28	3.15	2.96
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	3.82	3.65	3.48
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	3.45	3.80	3.77	4.17	4.15	4.34	3.70	4.04
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	4.21	4.51	3.96
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	4.84	4.83	4.13
13	3.99	3.25	3.61	3.30	3.00	2.80	2.95	3.06	3.60	3.00	3.30	4.20	3.90	4.40	4.20	3.91	4.63	5.68	4.97	4.72	4.62

Table 9. Percent composition (by weight) of haddock caught in unit areas 4Xm-4Xr, excluding discards.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.4	1.6	0.2	0.1	0.2	0.0	0.8	0.0	3.7	2.4	0.1	13.0	2.5	6.5	3.6	2.9	0.1	0.2	0.3	2.2	1.0
3	17.9	6.9	3.0	7.6	31.4	1.0	0.6	5.3	4.0	9.6	23.7	0.7	29.3	21.6	7.1	10.8	10.8	4.1	7.1	6.2	14.0
4	3.6	33.1	13.3	7.6	21.3	51.7	3.3	6.1	9.6	6.1	19.1	23.2	2.6	35.8	27.2	17.0	34.9	36.1	13.7	23.4	13.1
5	13.1	19.6	37.7	14.6	10.0	28.7	60.2	6.6	2.7	12.3	6.2	15.9	23.2	4.3	31.6	26.7	14.5	29.0	33.8	23.4	31.3
6	14.4	12.3	15.9	32.6	8.2	4.5	19.1	53.4	4.6	3.7	8.7	8.7	9.0	14.3	4.9	30.8	24.6	10.2	29.2	23.1	15.3
7	19.1	11.5	9.0	14.8	17.2	3.9	3.8	18.1	45.6	0.7	1.3	10.9	3.6	4.1	12.8	5.1	10.5	14.3	5.1	10.1	15.6
8	10.9	6.1	8.7	8.5	4.7	6.4	3.3	3.2	22.1	39.8	0.9	6.1	5.4	3.0	2.9	6.2	1.7	3.5	7.2	3.8	4.3
9	6.5	4.7	4.8	6.6	2.6	1.3	4.8	2.1	1.9	14.5	20.6	5.4	4.0	1.1	1.4	1.9	1.5	0.9	2.3	3.9	2.7
10	2.9	1.5	3.1	2.9	2.7	0.8	1.5	1.7	1.6	2.7	11.0	13.7	6.1	0.6	1.9	1.3	0.4	1.1	0.5	1.2	1.6
11	3.1	1.3	2.2	2.0	0.6	0.7	1.2	1.6	3.0	3.6	0.6	1.5	13.6	3.3	0.9	0.4	0.1	0.2	0.3	0.2	0.8
12	2.9	0.8	1.6	1.2	0.4	0.2	0.6	1.1	0.5	2.7	5.5	0.4	0.7	4.9	2.2	0.2	0.1	0.0	0.1	0.3	0.3
13	2.1	0.6	0.4	1.4	0.6	0.7	0.3	0.7	0.3	1.9	2.3	0.2	0.1	0.3	3.5	1.7	0.8	0.4	0.3	0.2	0.2

Table 10. Percent composition (by numbers) of haddock caught in unit areas 4Xm-4Xr, excluding discards.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.7	0.0	0.3	0.1	0.0	0.0	0.0	0.1	0.0	0.0
2	1.0	4.1	0.7	0.4	0.6	0.1	2.5	0.0	9.5	7.9	0.3	34.0	7.4	15.1	10.2	9.5	0.4	0.6	1.0	6.1	3.4
3	33.7	11.5	5.7	16.8	46.6	1.5	1.1	9.5	6.6	16.1	39.8	1.2	49.3	31.6	12.9	23.1	20.0	8.0	14.6	11.5	24.8
4	10.5	41.1	19.1	11.0	24.9	61.1	4.4	9.2	13.6	7.9	21.3	24.8	3.3	35.7	33.4	14.9	41.9	46.1	18.9	32.7	16.1
5	13.2	17.6	41.6	17.4	8.1	27.4	65.5	7.6	3.4	14.2	5.9	11.8	18.8	3.4	28.9	23.6	12.5	26.7	34.3	22.1	30.0
6	12.7	9.4	13.4	29.9	5.5	3.1	17.6	52.8	4.7	4.0	7.5	5.8	5.4	7.6	3.4	21.3	16.9	7.3	22.4	16.9	11.4
7	12.3	8.1	6.6	10.9	9.5	2.2	2.7	15.1	41.0	0.7	1.0	6.6	2.0	1.7	6.3	2.7	6.2	8.5	3.2	6.2	9.6
8	7.2	3.4	6.1	5.5	2.1	3.2	1.9	2.1	16.9	33.1	0.7	3.6	2.9	1.2	1.2	2.9	0.8	1.8	4.0	2.0	2.3
9	4.8	2.7	2.7	4.1	1.0	0.6	2.5	1.2	1.2	10.2	13.5	2.9	2.0	0.4	0.6	0.8	0.6	0.4	1.1	1.7	1.2
10	1.7	0.9	1.9	1.6	1.1	0.3	0.7	0.9	0.9	1.6	5.9	6.8	2.9	0.2	0.7	0.5	0.2	0.5	0.2	0.5	0.6
11	1.5	0.6	1.3	1.1	0.2	0.3	0.5	0.8	1.6	1.8	0.3	0.6	5.8	1.1	0.3	0.2	0.1	0.1	0.1	0.1	0.3
12	0.3	0.3	0.7	0.6	0.2	0.1	0.2	0.4	0.2	1.5	2.2	0.1	0.3	1.6	0.8	0.1	0.0	0.0	0.0	0.1	0.1
13	0.7	0.2	0.2	0.6	0.2	0.2	0.3	0.3	0.3	1.0	1.1	0.1	0.0	0.1	1.2	0.6	0.3	0.1	0.1	0.1	0.1

Table 11. Comparison of 1982 catch-at-age as projected by O'Boyle and White (1982) and as observed in the fishery.

	OBSERVED		O'BOYLE & WHITE	
AGE	Number (10^{-3})	% Composition	Number (10^{-3})	% Composition
1	0	0	1	0
2	493	3.4	1002	4.9
3	3652	24.8	6101	29.8
4	2369	16.1	2785	13.6
5	4406	30.0	5775	28.2
6	1675	11.4	2150	10.5
7	1418	9.6	1641	8.0
8	341	2.3	601	2.9
9	180	1.2	192	0.9
10	93	0.6	168	0.8
11	46	0.3	50	0.2
12	18	0.1	7	0
13+	10	0.1	-	-
Number (10^{-3})	14701	99.9	20473	99.8
Catch (t)	23216		32000	
Avg. wt(kg)	1.579		1.563	

Table 12. Stratified mean catch (in numbers) per standard tow of haddock caught during U.S. Fall Bottom Trawl Survey (Strata 31-34) (--- no data).

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981*	1982
0	79.39	0.21	1.53	1.14	0.13	3.55	10.27	0.13	20.46	7.74	1.12	3.70	7.10	11.74	12.55	6.08	25.24	55.57	6.31	---
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	47.82	---
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	0.21	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	0.042	-	-	-	-	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	44.89	52.07	71.15	51.63	30.92	23.74	15.48	39.01	52.22	25.49	24.78	22.42	38.69	86.30	54.18	87.99	118.09	96.06	59.7
AGES 2+	63.86	30.47	48.07	68.18	45.23	25.64	8.81	10.47	18.49	10.46	20.52	18.31	10.90	13.29	57.59	38.23	50.70	19.69	41.93	---
AGES 5+	14.54	11.31	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	56.57	25.1

* Ageing data unavailable at this time.

Table 13. Stratified mean catch (in numbers) per standard tow of haddock caught during Canadian summer bottom trawl survey (strata 70-91, 95) 1970-81 - A. T. Cameron; 1982 - Lady Hammond; includes Lady Hammond correction in 1982.

AGE	1970	1971	1972	1973	1974[4]	1975	1976	1977[3]	1978	1979	1980	1981	1982[2]
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.352	0.024	0.510	0.117
1	4.872	0.099	4.404	4.976	8.153	5.518	4.617	5.278	5.391	1.636	18.511	11.740[1]	10.842
2	3.921	9.263	0.195	19.053	17.942	3.466	5.272	20.246	4.660	11.528	6.028	23.780	23.833
3	1.148	3.933	2.732	0.479	21.220	4.383	3.394	13.077	9.544	6.605	13.179	5.860	10.667
4	2.167	1.729	1.160	2.466	0.768	6.013	3.405	3.868	2.870	7.919	6.841	7.320	3.883
5	0.881	2.489	0.761	1.131	3.578	0.394	6.175	5.557	1.400	4.009	10.472	2.770	5.542
6	1.982	1.131	0.825	0.423	0.775	1.417	0.467	3.456	2.615	1.605	3.527	3.040	2.108
7	5.073	1.746	0.543	0.569	0.438	0.510	0.553	0.466	0.988	2.524	1.298	1.030	2.083
8	0.704	4.424	0.808	0.429	0.505	0.287	0.101	0.558	0.025	0.949	1.056	0.210	0.275
9	0.293	0.504	1.106	0.287	0.268	0.136	0.026	0.121	0.158	0.208	0.510	0.370	0.158
10	0.258	0.078	0.037	0.371	0.202	0.043	0.033	0.095	0.000	0.026	0.202	0.240	0.042
11	0.069	0.035	0.005	0.018	0.287	0.246	0.008	0.008	0.035	0.000	0.031	0.120	0.025
12+	0.017	0.053	0.070	0.008	0.000	0.153	0.358	0.223	0.318	0.099	0.000	0.040	0.000
NK	0.000	0.000	0.066	0.000	0.000	0.000	0.074	0.007	0.088	0.121	0.000	0.010	0.100
TOTAL	21.39	25.48	12.71	30.21	54.14	22.57	24.48	52.97	27.99	37.58	61.68	57.04	59.68
2+	16.51	25.39	8.31	25.23	45.98	17.05	19.87	47.68	22.60	35.59	43.14	44.79	48.72
5+	9.28	10.46	4.22	3.24	6.05	3.19	7.80	10.48	5.53	9.54	17.10	7.83	10.33
TOTAL Kg/tow	22.95	27.5	13.24	12.77	39.46	21.29	22.21	47.77	26.46	41.98	57.1	44.68	39.96

[1] set 66 (stratum 90) was changed to equal the numbers per tow in the next lowest set. This was done for age 1 fish only. Leaving set 66 as it was gives an estimate of 30.86 for age 1 and a total of 76.16.

[2] adjusted for differences in Lady Hammond and A.C. Cameron selectivity.

[3] set 42 (stratum 76) was excluded.

[4] set 13 (stratum 90) was excluded.

Table 14. 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. 1970-1981 - A.T. Cameron; 1982 - Lady Hammond.

STRATA	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
70	-	-	-	-	-	-	-	2	-	-	-	-	-
71	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	4	-	-	-	-	2	2	3
73	2	-	2	4	-	-	2	3	-	5	-	-	4
74	5	-	4	-	4	2	4	-	2	2	-	4	5
75	3	4	-	5	3	-	1	-	4	-	5	-	-
76	-	2	-	-	5	3	-	-	-	-	-	-	-
77	-	5	5	-	-	-	5	-	-	-	-	5	-
78	-	-	-	-	-	-	-	-	-	-	-	-	-
79	-	-	-	-	-	-	-	-	-	-	-	-	-
80	1	1	1	2	2	1	-	1	1	3	3	3	-
81	4	-	3	1	1	-	-	-	3	4	4	-	2
82	-	-	-	-	-	-	-	-	-	-	-	-	-
83	-	-	-	-	-	-	-	-	-	-	-	-	-
84	-	-	-	-	-	-	-	-	-	-	-	-	-
85	-	-	-	-	-	-	-	-	-	-	-	-	-
90	-	3	-	3	-	5	3	5	5	1	1	1	1
91	-	-	-	-	-	-	-	-	4	-	-	-	-
92	-	-	-	-	-	-	-	-	-	-	-	-	-
93	-	-	-	-	-	-	-	-	-	-	-	-	-
94	-	-	-	-	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 15. Recruitment Indices for the 4X haddock stock (--- no data).

Year Class	Based on Canadian Summer Survey Ages 1 + 2	2 + 3	Based on U.S. Fall Survey Ages 0 + 1	1 + 2
1962	---	---	---	2.493
1963	---	---	3.455	1.803
1964	---	---	0.106	0.241
1965	---	---	0.129	0.194
1966	---	---	0.294	0.479
1967	---	---	0.074	0.095
1968	---	0.437	0.316	0.311
1969	0.772	0.588	0.569	0.620
1970	0.016	0.041	0.007	0.008
1971	1.163	2.264	2.108	2.160
1972	1.158	1.078	0.436	0.486
1973	0.767	0.380	0.152	0.255
1974	0.647	1.113	0.312	0.396
1975	1.231	1.527	0.806	2.001
1976	0.602	0.649	1.075	1.237
1977	0.910	1.393	0.851	1.818
1978	0.386	0.658	0.704	0.914
1979	2.435	1.757	2.635	3.435[1]
1980	1.925	2.077[2]	3.940	3.835[1]
1981	1.638[1]	---	0.459[3]	---

[1] Based on age one catch/tow only.

[2] Based on age two catch/tow only.

[3] Based on age zero catch/tow only.

Table 16. Catch rates (numbers per tow weighted by stratum area) for age 0-12+ haddock caught in Canadian groundfish survey (1 - Lady Hammond; 2 - A.T. Cameron) in 1979 to 1982. M - March; J-July; O-N - October- November. Only strata 70-85 are included (--- no data available) (-- incomplete survey).

AGE	1979 M[1]	1979 J[2]	1979 O-N[1]	1980 M[1]	1980 J[2]	1980 O-N[1]	1981 M[1,3]	1981 J[2]	1981 O[1,3]-N	1982 M[1]	1982 J[1]	1982 O-N[1]
0	--	0.40	13.27	0.0	0.03	112.80	0.0	0.57	11.30	---	0.17	---
1	--	1.58	6.61	7.08	20.19	21.15	44.50	13.05	13.13	---	14.16	---
2	--	7.00	20.77	2.62	3.41	5.99	18.45	3.68	12.01	---	21.04	---
3	--	3.27	6.18	19.92	9.41	10.96	6.79	1.71	7.57	---	7.11	---
4	--	6.61	8.33	7.30	6.74	5.34	16.87	6.99	21.40	---	3.23	---
5	--	4.15	3.84	8.07	11.13	5.42	7.77	2.87	7.89	---	6.32	---
6	--	1.73	1.23	6.30	3.77	3.13	5.52	3.30	7.37	---	2.60	---
7	--	2.75	1.77	2.38	1.46	0.76	3.85	1.12	3.70	---	2.60	---
8	--	1.00	0.37	2.96	1.16	0.80	0.98	0.24	0.77	---	0.32	---
9	--	0.23	0.14	1.41	2.53	0.21	0.40	0.40	1.50	---	0.21	---
10	--	0.0	0.06	0.09	0.23	0.02	0.34	0.26	0.92	---	0.07	---
11	--	0.0	0.0	0.26	0.03	0.02	0.05	0.13	0.33	---	0.04	---
12+	--	0.11	0.09	0.12	0.0	0.06	0.04	0.04	0.06	---	0.0	---
4+	--	16.58	15.83	28.89	27.05	15.76	35.82	15.35	43.94	---	15.39	---
5+	--	9.97	7.50	21.59	20.31	10.42	18.95	8.36	22.54	---	12.16	---
TOTAL	--	28.83	62.66	58.51	60.09	166.66	105.56	34.36	87.95	---	57.87	---

[3] excludes strata 83 and 84.

Table 17. Research and commercial abundance indices for the 4X haddock stock (--- no data).

Year Sampled	Canadian Summer Strata 70-91, 95 Age 2-5 No/tow	Canadian Summer Strata 70-91, 95 Age 6+ No/tow	Commercial Catch Rates (t/hr) OTB2 TC2-3 May-Aug. 4Xq-r	OTB2 TC4-5 Jan-March 4Xm-p, u	OTB2 TC3[1] July-Sept. 4Xq-r	OTB2 TC5[1] July-Sept. 4Xm-p, u
1968	---	---	0.453	0.443	0.258	0.386
1969	---	---	0.231	0.534	0.277	0.354
1970	8.117	8.396	0.201	0.232	0.137	0.306
1971	17.414	7.971	0.098	0.261	0.149	0.266
1972	4.848	3.462	0.114	0.243	0.193	0.240
1973	23.129	2.105	0.091	0.265	0.144	0.259
1974	43.508	2.475	0.185	0.301	0.233	0.283
1975	14.256	2.792	0.199	0.342	0.270	0.364
1976	18.246	1.620	0.163	0.459	0.240	0.380
1977	42.748	4.934	0.274	0.413	0.370	0.487
1978	18.474	4.127	0.247	0.447	0.413	0.651
1979	30.061	5.532	0.242	0.653	0.346	0.610
1980	36.520	6.624	0.208	0.679	0.320	0.550
1981	39.730	5.060	0.218	0.777	0.307	0.529
1982	43.925	4.791	0.190	0.523	0.266	0.395

[1] derived through multiplicative model

Table 18a. 4X haddock population numbers, survivors, variance of survivors and weighted survivors estimated using Survivor. The calibration block was 1970-1982; age 3-7 and K=6.

POPULATION NUMBERS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	4648	6972	13109	3136	25954	25716	11228	27194	33762	19334	35054	20346	42994
4	6138	3119	4136	8185	2372	16789	17061	7524	17581	23006	13905	24768	14594
5	2376	3702	1972	2086	4888	1578	9771	10614	4295	9528	13363	8105	15523
6	3096	1590	2112	1145	1006	2711	877	5043	5968	2106	4447	7085	4039
7	11470	2277	1085	1166	620	487	1361	360	2394	3075	1023	1561	3753
8	1273	5860	1807	696	568	345	219	581	74	1387	1685	443	613

ESTIMATED SURVIVORS 1/ 5/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	51	2491	0	0	17776	0	530	6922	2885	4998	19302	12545	37163
4	755	1247	0	272	53	2251	0	2276	0	4080	7912	11227	11755
5	299	1378	116	375	1983	0	3300	2275	0	219	9161	1553	10833
6	1903	752	10	0	364	250	0	1859	474	705	1561	1542	3095
7	2020	2259	400	294	357	447	73	360	679	2328	1203	615	3168
8	-265	5657	1294	548	698	387	92	727	0	1427	1430	166	345

ESTIMATED VARIANCE OF SURVIVORS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	486816	5713854	2757037	34752	166330538	7096173	4255052	63169051	50194934	35864309	213009772
4	2133768	1358374	611429	2763220	268010	16429024	5268216	6798331	3742770	42509680	47326471
5	261121	2084202	194832	430344	4306959	52225	12928149	10388931	659396	5407073	55038570
6	1228061	399887	212775	55936	187766	627700	68178	3733876	2137745	805309	3888870
7	11573527	1370959	132598	145600	86275	116971	137526	97658	435985	2864935	757679
8	332506	13130584	438002	123472	171095	55261	6844	208892	419	604208	748138

	1981	1982
3	62827190	393691657
4	80836015	43176631
5	5744936	43492326
6	4310002	3940960
7	477101	3705011
8	29586	64473

WEIGHTED SURVIVORS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	2	3	0	0	25	0	3	6	102	292	2262	5110	37163
4	19	17	0	7	0	32	0	9	0	170	351	3467	6967
5	52	36	11	5	32	0	59	85	0	2	295	567	6218
6	405	86	2	0	12	27	0	115	86	23	22	635	1647
7	1073	431	137	106	75	23	37	2	356	315	42	70	1517
8	265	2650	772	202	222	126	82	238	0	543	740	147	292

RMS=0.2415763437

Table 18b. Estimated survivors for age 8 and 1982 and estimation of k and residuals from Survivor. The calibration block was 1970-1982; age 3-7 and K=6. In insert, F's (1982) for age 3-8 were calculated from Survivor using Newton.

ESTIMATED SURVIVORS FOR AGE 3 (WEIGHTED)

YEAR	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(o/o)
1970	265	332506	577	217.74
1971	3724	6151493	2480	66.61
1972	1608	261315	511	31.80
1973	477	45515	213	44.71
1974	386	54463	233	60.43
1975	230	18022	134	58.34
1976	125	6093	78	62.50
1977	340	68454	262	76.85
1978	2	409	20	1274.92
1979	1129	230113	480	42.47
1980	1226	387525	623	50.77
1981	223	26137	162	72.50
1982	392	54551	234	59.53

ESTIMATED SURVIVORS FOR 1982 (WEIGHTED)

AGE	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(o/o)
3	37163	393691657	19842	53.39
4	12077	25590270	5059	41.89
5	11947	24963861	4996	41.82
6	2857	2097208	1448	50.69
7	2720	1774501	1332	48.97
8	392	54551	234	59.58

FINAL ESTIMATION FOR K

AGE	K	LN(K)	VAR(LN(K))	STANDARD ERROR	D.F
3	3579.69	8.0734	0.2193	0.1299	0
4	3250.57	8.0265	0.1201	0.0961	0
5	2289.98	7.6750	0.1226	0.0971	0
6	1807.32	7.3887	0.2218	0.0924	25
7	1807.32	7.3887	0.2218	0.0924	25
8	1807.32	7.3887	0.2218	0.0924	25

INSERT

		A	B
AGE	3	49415	0.3849
	4	17358	0.1627
	5	19431	0.2963
	6	5324	0.4226
	7	4877	0.3839
	8	851	0.5757
YEAR	1970	2317	1.9690
	1971	8172	0.5859
	1972	2026	0.0315
	1973	935	0.4730
	1974	766	0.4850
	1975	469	0.5125
	1976	320	0.7421
	1977	840	0.7032
	1978	145	4.3148
	1979	1669	0.1904
	1980	2183	0.3763
	1981	573	0.2117
	1982	851	0.5757

RESIDUALS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	¯0.1231	0.7028	¯0.2930	¯0.6037	1.0739	¯0.4941	0.0789	0.5431	0.0119	0.2012	0.2970	0.0305	0.0000
4	0.1377	0.5890	¯0.0924	¯0.0209	0.0512	0.1520	¯0.4327	0.5134	¯0.6337	0.1124	0.4695	¯0.0401	¯0.0247
5	¯0.1637	0.4316	¯0.1236	0.2165	0.5167	¯0.5590	0.3697	0.1814	¯0.2924	¯0.0371	0.5847	¯0.2451	¯0.0828
6	0.1457	0.2511	¯0.3480	¯0.4036	0.3309	¯0.0569	¯0.0380	0.2139	¯0.2333	0.3204	0.3602	¯0.2543	0.0629
7	¯0.2240	0.3265	¯0.1005	¯0.1253	0.2439	0.6379	¯0.3085	0.8510	¯0.2932	0.3944	0.8300	0.1760	0.1237
8	¯0.0001	0.3107	¯0.2131	0.1072	0.4742	0.4088	¯0.1327	0.5507	¯0.4968	0.2122	0.1247	¯0.1537	¯0.0892

MEAN OF RESIDUALS=0.09011697582

STANDARD DEVIATION OF RESIDUALS=0.3554507023

OUTLIERS OF RESIDUALS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	0.00	0.00	0.00	0.00	1.07	0.00	0.00	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	¯0.63	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	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	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.83	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	0.00	0.00

Table 19. Comparison of partial recruitment vectors used for 1982 with those determined in the last two assessments.

AGE	PR 1980 (O'Boyle, 1981a)	PR 1981 (O'Boyle and White, 1982)	PR 1982 (This assessment)
1	0.003	0.00006	0.0002
2	0.017	0.04	0.021
3	0.200	0.3	0.180
4	0.600	0.6	0.541
5	0.800	1	0.770
6+	1	1	1

Table 20. Age 2-5 SPA population numbers (x 10^{-3}) vs age 2-5 numbers per tow from the Canadian research summer survey. A and B are the intercept and the slope respectively of the linear regression of the SPA estimate on the research data.

YEAR	Age 2-5 Research no/tow	Terminal Fishing Mortality							
		0.2	0.3	0.35	0.40	0.46	0.50	0.55	0.60
1970	8.12	22585	22554	22545	22538	22532	22529	22525	22522
1971	17.41	32024	31881	31840	31810	31782	31767	31752	31739
1972	4.85	24213	23879	23784	23713	23648	23614	23578	23548
1973	23.13	48849	48115	47906	47750	47608	47532	47453	47388
1974	43.51	66248	64892	64506	64217	63954	63814	63668	63547
1975	14.26	61483	59209	58562	58077	57636	57402	57158	56955
1976	18.25	78054	74412	73374	72598	71892	71517	71125	70801
1977	42.75	102497	93334	90725	88772	86996	86051	85067	84250
1978	18.47	100477	87116	83310	80462	77870	76492	75056	73864
1979	30.06	135288	107569	99666	93749	88359	85491	82499	80014
1980	36.52	129906	97174	87833	80836	74457	71060	67515	64567
1981	39.73	209290	144074	125437	111459	98695	91889	84774	78846
1982	43.93	268656	179007	153388	134172	116623	107262	97474	89315
A		-495	13425	17397	20377	23100	24553	26074	27381
B		3770	2518	2160	1892	1647	1517	1380	1267
r^2		0.512	0.575	0.599	0.617	0.626	0.625	0.616	0.598

Table 21. Age 6+ SPA population numbers (x 10^{-3}) vs age 6+ numbers per tow from the Canadian rsearch summer survey. A and B are the intercept and the slope respectively of the linear regression of the SPA estimate on the research data.

YEAR	Age 6+ Research no/tow	Terminal Fishing Mortality							
		0.2	0.3	0.35	0.40	0.46	0.50	0.55	0.60
1970	8.40	19634	19610	19603	19597	19593	19590	19587	19584
1971	7.97	11944	11923	11916	11912	11908	11905	11902	11900
1972	3.46	8513	8491	8485	8480	8476	8473	8470	8468
1973	2.10	5647	5628	5623	5619	5615	5613	5610	5609
1974	2.47	3984	3959	3952	3946	3941	3938	3936	3933
1975	2.79	4760	4685	4664	4648	4633	4626	4617	4611
1976	1.62	3674	3509	3462	3427	3395	3378	3360	3345
1977	4.93	5727	5373	5272	5195	5126	5089	5051	5019
1978	4.13	8080	7432	7247	7108	6981	6914	6844	6785
1979	5.53	7654	6583	6277	6048	5838	5727	5611	5514
1980	6.62	10255	8488	7980	7599	7250	7064	6870	6708
1981	5.06	16542	12187	10942	10005	9148	8690	8211	7811
1982	4.79	18780	12473	10668	9312	8072	7410	6716	6137
A		1387	819	656	535	422	363	300	248
B		1789	1665	1629	1602	1578	1565	1551	1539
r^2		0.484	0.621	0.639	0.640	0.63	0.621	0.608	0.595

Table 22. Age 1 SPA population numbers (x 10^{-3}) vs age 1+2 recruitment index from the Canadian research summer survey. A and B are the intercept and the slope respectively of the linear regression of the SPA estimate on the Canadian research data.

Year Class	Age 1+2 Index	Terminal Fishing Mortality							
		0.2	0.3	0.35	0.40	0.46	0.50	0.55	0.60
1969	0.772	25612	25452	25406	25372	25341	25324	25307	25292
1970	0.016	6902	6605	6520	6457	6399	6369	6337	6310
1971	1.163	48616	47994	47817	47684	47564	47500	47433	47377
1972	1.158	46145	45115	44821	44602	44402	44296	44186	44094
1973	0.767	27011	25379	24915	24567	24250	24082	23907	23762
1974	0.647	53921	51390	50669	50130	49639	49378	49106	48881
1975	1.231	72294	63675	61221	59385	57714	56826	55901	55133
1976	0.602	45950	37615	35242	33466	31850	30991	30096	29353
1977	0.910	91956	68601	61941	56954	52409	49990	47466	45368
1978	0.386	50155	35501	31319	28185	25325	23802	22211	20887
1979	2.435	171460	115809	99911	87988	77104	71299	65231	60175
1980	1.925	158507	105780	90715	79416	69099	63597	57845	53058
A		-2467	7605	10487	12651	14630	15687	16793	17717
B		18939	44758	37848	32665	27933	25408	22768	20568
r^2		0.798	0.843	0.846	0.836	0.803	0.771	0.722	0.666

Table 23. Age 2+3 SPA population numbers (x 10^{-3}) vs age 2+3 recruitment index from the Canadian research survey. A and B are the intercept and the slope respectively of the linear regression of the SPA estimate on the Canadian research data.

Year Class	Age 2+3 Index	Terminal Fishing Mortality							
		0.20	0.30	0.35	0.40	0.46	0.50	0.55	0.60
1968	0.44	8677	8658	8653	8649	8646	8644	8642	8640
1969	0.59	15818	15709	15678	15655	15634	15623	15611	15602
1970	0.04	4607	4407	4350	4307	4268	4247	4226	4208
1971	2.26	29457	29036	28917	28827	28746	28702	28657	28620
1972	1.08	29322	28627	28429	28281	28146	28074	28000	27938
1973	0.38	16323	15222	14908	14673	14460	14346	14228	14129
1974	1.11	34639	32932	32446	32083	31752	31576	31393	31241
1975	1.53	46984	41175	39521	38284	37157	36559	35935	35417
1976	0.65	30612	24996	23397	22201	21112	20533	19930	19429
1977	1.39	61313	45577	41089	37729	34666	33036	31335	29921
1978	0.66	33131	23256	20436	18322	16394	15366	14293	13399
1979	1.76	113821	76327	65615	57580	50245	46333	42243	38835
A		-7389	-1943	-387	780	1846	2415	3010	3506
B		49530	35159	31055	27978	25771	23674	22110	20808
r^2		0.750	0.867	0.909	0.939	0.959	0.962	0.956	0.942

Table 24. Results of cohort analysis with terminal F of 0.3 .

POPULATION NUMBERS

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	24999	91671	201084	16187	10080	17402	8068	14529	25452	6605	47994	45115	25379	51390	63675	37615	68601	35501	115809	93681	32367
2	32514	20467	75054	164634	13252	8252	14247	6605	11896	20838	5408	39257	36801	20778	42041	52117	30795	56165	29066	94800	76700
3	59759	26494	16112	61309	134727	10652	6737	11063	5399	8785	16348	4408	29357	29502	15043	33248	41507	25145	45911	23657	76582
4	19259	44833	19870	12041	47446	93710	8255	5247	7234	3765	5729	10277	3506	19825	20021	10829	24392	30948	19539	35503	17400
5	11763	14488	30205	12390	8065	29982	58282	5706	2515	4563	2370	3025	6381	2591	11559	12536	7039	13624	19268	13285	23478
6	9574	8022	9068	16281	7291	3738	16270	31930	3205	1716	2449	1479	1511	3615	1683	6132	7375	3868	7643	10862	7095
7	4728	6293	5076	4694	8436	4025	2120	9082	15969	2150	1039	1422	734	777	1961	985	2414	3475	2199	3056	6006
8	3150	2380	3872	2806	2058	3516	2630	1091	4522	8970	1697	770	621	430	412	876	481	1035	1720	1343	1444
9	1906	1699	1412	1930	1392	925	1927	1685	481	2017	4344	1338	339	265	197	198	365	270	609	843	762
10	1058	977	958	602	906	770	588	970	1154	274	728	2501	861	109	161	97	66	202	169	345	394
11	539	657	662	408	232	358	538	309	618	858	77	133	1492	462	60	46	14	30	104	109	195
12	208	256	435	273	150	111	212	322	98	348	539	39	59	722	229	14	17	3	15	65	76
13	324	186	93	271	204	389	290	235	134	250	257	18	10	35	349	153	134	61	59	33	42
	169781	218422	363902	293825	234241	173830	120164	88775	78676	61138	88979	109782	107053	130501	157392	154846	183198	170329	242111	278241	242943

FISHING MORTALITY   18/10/83

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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	0.000	0.000
2	0.005	0.039	0.002	0.000	0.018	0.003	0.053	0.002	0.103	0.043	0.005	0.091	0.021	0.123	0.035	0.028	0.003	0.002	0.006	0.013	0.007
3	0.087	0.088	0.091	0.056	0.163	0.055	0.050	0.225	0.160	0.227	0.264	0.029	0.193	0.188	0.129	0.110	0.094	0.052	0.057	0.107	0.054
4	0.085	0.195	0.272	0.201	0.259	0.275	0.169	0.535	0.261	0.263	0.439	0.277	0.102	0.339	0.268	0.231	0.392	0.274	0.186	0.214	0.162
5	0.183	0.269	0.418	0.330	0.569	0.411	0.402	0.377	0.182	0.422	0.271	0.494	0.368	0.232	0.434	0.331	0.399	0.378	0.373	0.427	0.231
6	0.220	0.258	0.459	0.458	0.394	0.367	0.383	0.493	0.199	0.301	0.344	0.500	0.466	0.411	0.336	0.732	0.552	0.365	0.717	0.392	0.300
7	0.487	0.286	0.393	0.625	0.675	0.225	0.465	0.497	0.377	0.036	0.101	0.628	0.335	0.433	0.606	0.517	0.647	0.503	0.293	0.549	0.300
8	0.418	0.322	0.496	0.501	0.600	0.401	0.245	0.618	0.607	0.525	0.038	0.621	0.651	0.583	0.532	0.675	0.378	0.330	0.514	0.366	0.300
9	0.468	0.373	0.652	0.556	0.393	0.253	0.487	0.178	0.364	0.819	0.352	0.241	0.933	0.299	0.509	0.907	0.392	0.266	0.369	0.560	0.300
10	0.277	0.189	0.654	0.752	0.728	0.158	0.442	0.250	0.096	1.073	1.500	0.317	0.423	0.392	1.056	1.727	0.577	0.465	0.243	0.372	0.300
11	0.545	0.211	0.685	0.798	0.542	0.325	0.314	0.953	0.375	0.265	0.470	0.610	0.526	0.502	1.253	0.808	1.225	0.517	0.267	0.154	0.300
12	0.412	0.292	0.548	0.608	0.598	0.259	0.410	0.386	0.361	0.613	0.498	0.451	0.586	0.427	0.676	0.957	0.498	0.391	0.354	0.462	0.300
13	0.412	0.292	0.548	0.608	0.598	0.259	0.410	0.386	0.361	0.613	0.498	0.451	0.595	0.427	0.676	0.957	0.498	0.391	0.354	0.462	0.300
	0.098	0.098	0.083	0.082	0.215	0.247	0.294	0.332	0.184	0.223	0.130	0.105	0.112	0.140	0.105	0.115	0.121	0.110	0.087	0.083	0.081

Table 25. 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	1981	1982	F_t
O'Boyle unpublished assessment #1 1977	30810	7007	60391	49293	28861	33393	-	-	-	-	-	-	-	0.28
O'Boyle unpublished assessment #2 1978	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
Res. Doc. 81/24	25436	6504	48605	47176	26207	50577	81785	41959	76120	45299	100000	-	-	0.300
Res. Doc. 82/53	25524	6146	47857	46326	24960	54146	62978	38975	61878	31820	97036	91945	-	0.400
Present Document	25452	6605	47994	45115	25379	51390	63675	37615	68601	35501	115809	93681	32367	0.300
Present Document	25372	6457	47684	44602	24567	50130	59385	33466	56954	28185	87988	75471	30736	0.400

*(O'Boyle, 1978)
**(O'Boyle, 1980)

Table 26. Weight-at-age (kg) and partial recruitment vectors used in yield-per-recruit calculations.

Age	Weight	PR
1	0.220	0.0002
2	0.498	0.021
3	0.862	0.180
4	1.283	0.541
5	1.729	0.770
6	2.177	1.000
7	2.611	1.000
8	3.018	1.000
9	3.392	1.000
10	3.730	1.000
11	4.032	1.000
12	4.298	1.000
13	4.531	1.000
14	4.734	1.000
15	4.909	1.000
16	5.060	1.000
17	5.189	1.000
18	5.300	1.000
19	5.394	1.000
20	5.475	1.000

Table 27. 1982 population characteristics used in catch projections.

AGE	Population No. (000's)	Catch No. (000's)	Weight-at-age[1] (kg)	Partial Recruitment
1	32367	0	0.22	0.0002
2	76700	493	0.49	0.021
3	76582	3652	0.90	0.180
4	17400	2369	1.29	0.541
5	23478	4406	1.67	0.770
6	7095	1675	2.14	1
7	6006	1418	2.58	1
8	1444	341	2.96	1
9	762	180	3.48	1
10	394	93	4.04	1
11	195	46	3.96	1
12	76	18	4.13	1
13+	42	10	4.62	1

[1] As observed in 1982 fishery.

Table 28. Catch projections with varying assumptions concerning the catch in 1983 and fishing at $F_{0.1}$ = 0.25 in 1982. A value of 32,367 x 10^3 (geometric mean of 1962-1980) was taken for age one recruitment in 1982-84.

Assumption Concenring 1983 Catch	Year	Fully Recruited Fishing Mortality	1+ Mean Population Biomass, t(10^{-3})	1+ Fishable Population Biomass, t(10^{-3})	1+ Catch Biomass, t(10^{-3})
32,000 t	1982	0.3	183.8	96.0	23.5
in 1983	1983	0.31	196.2	128.5	32.0
(TAC)	1984	0.25	193.6	150.4	31.0
$F_{0.1}$	1982	0.3	183.8	96.0	23.5
in 1983	1983	0.25	199.0	128.5	26.6
	1984	0.25	198.5	155.7	32.1
25,000 t	1982	0.3	183.8	96.0	23.5
in 1983	1983	0.23	199.8	128.5	25.0
	1984	0.25	200.0	157.3	32.4

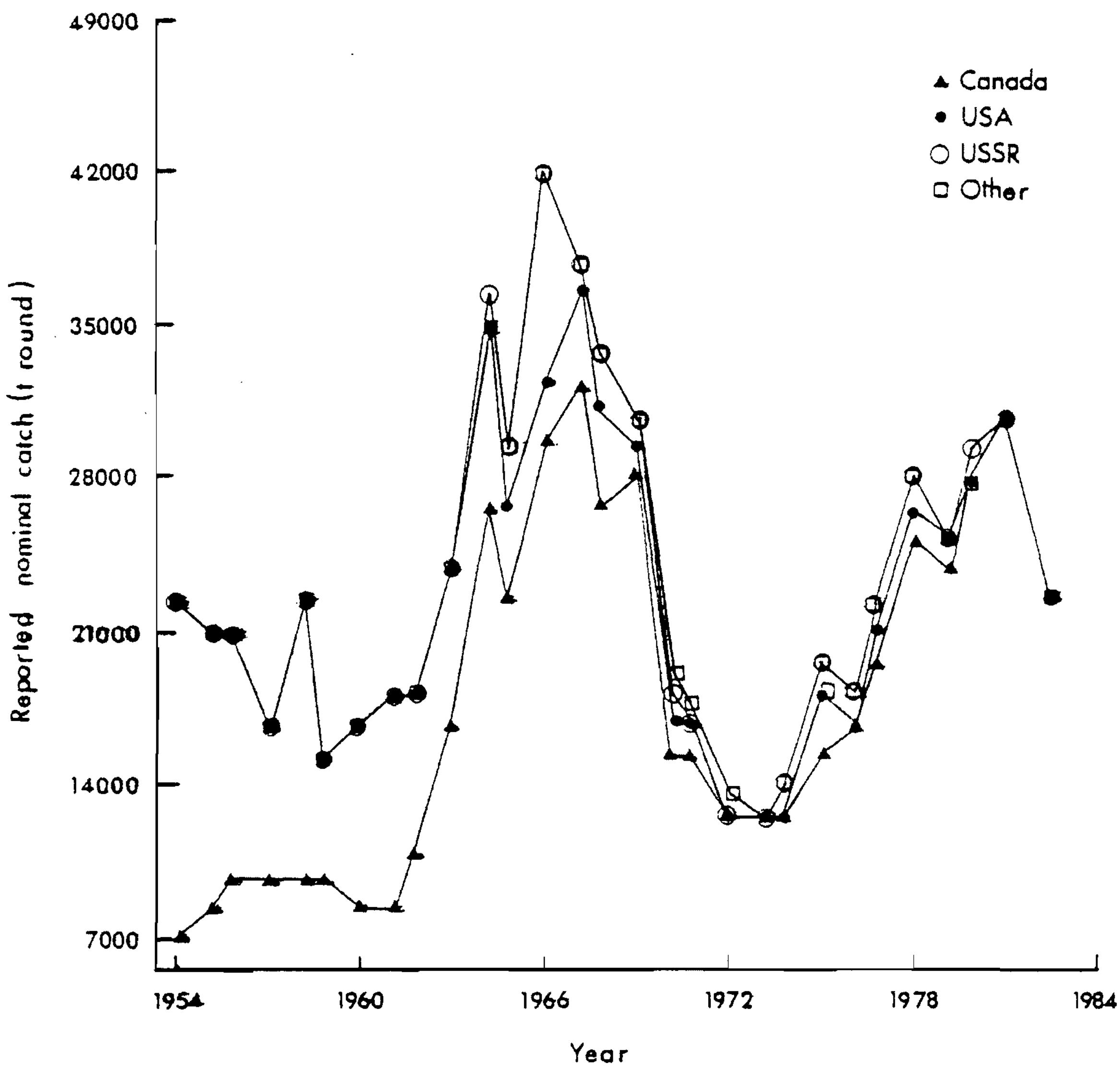


Figure 1. Cumulative reported nominal catches (t round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country.

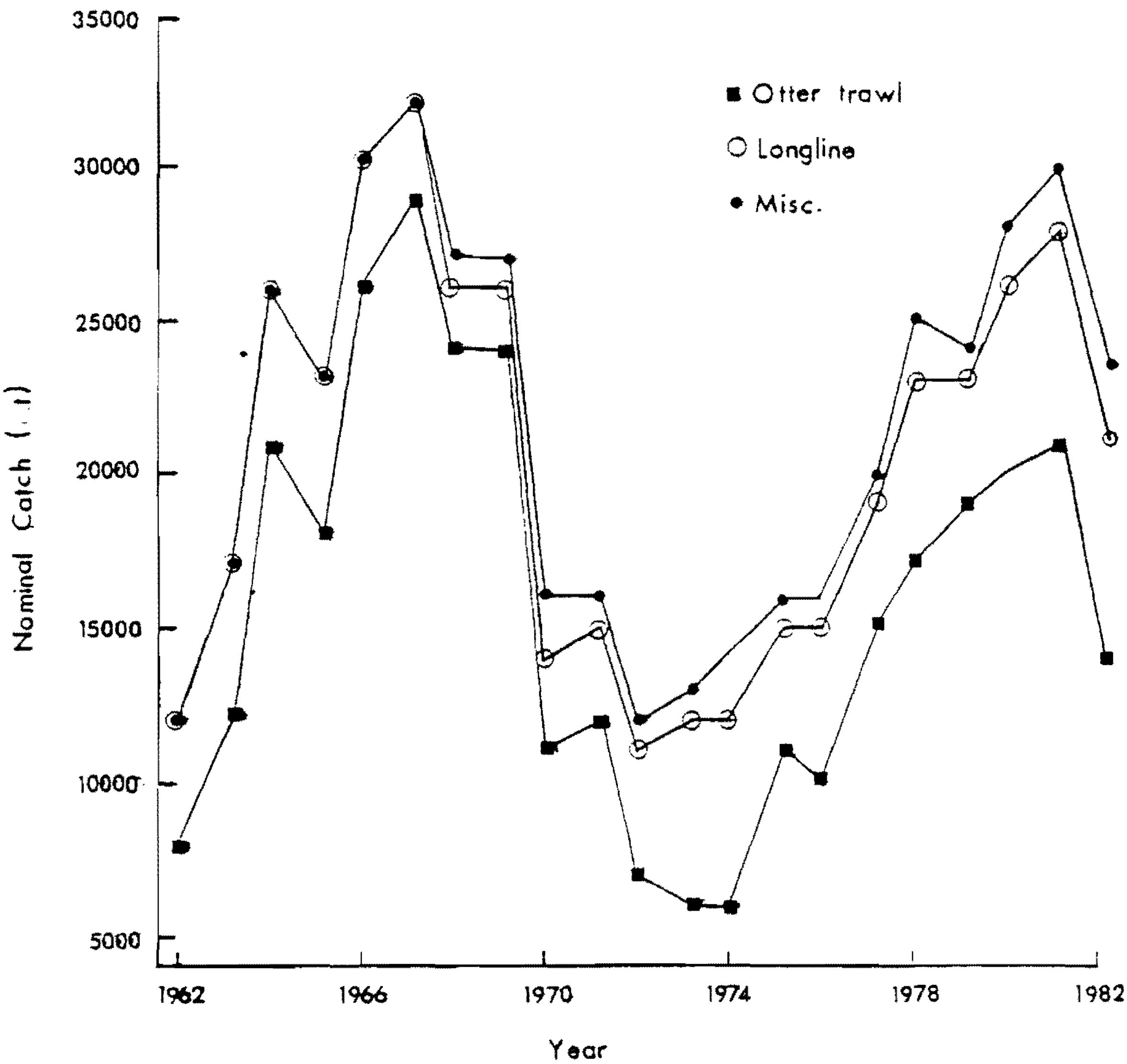


Figure 2. Cumulative nominal catch (t) of haddock from unit areas 4Xm-r for Canadian (MQ) fishing fleets during 1962-1982.

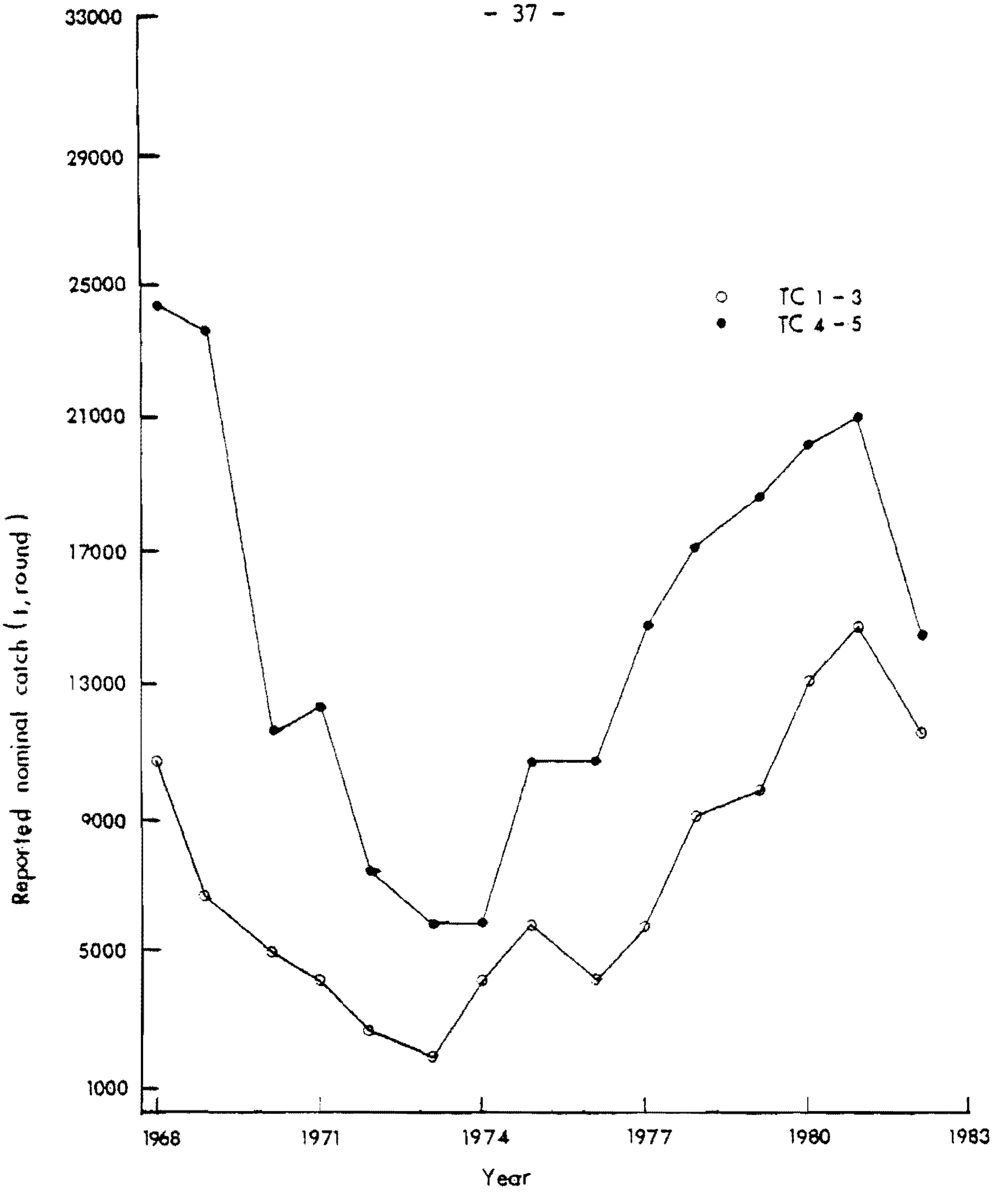


Figure 3. Cumulative reported nominal catch (t round) of haddock from unit areas 4Xm-r for the Canadian (MQ) otter trawl fishery by tonnage class.

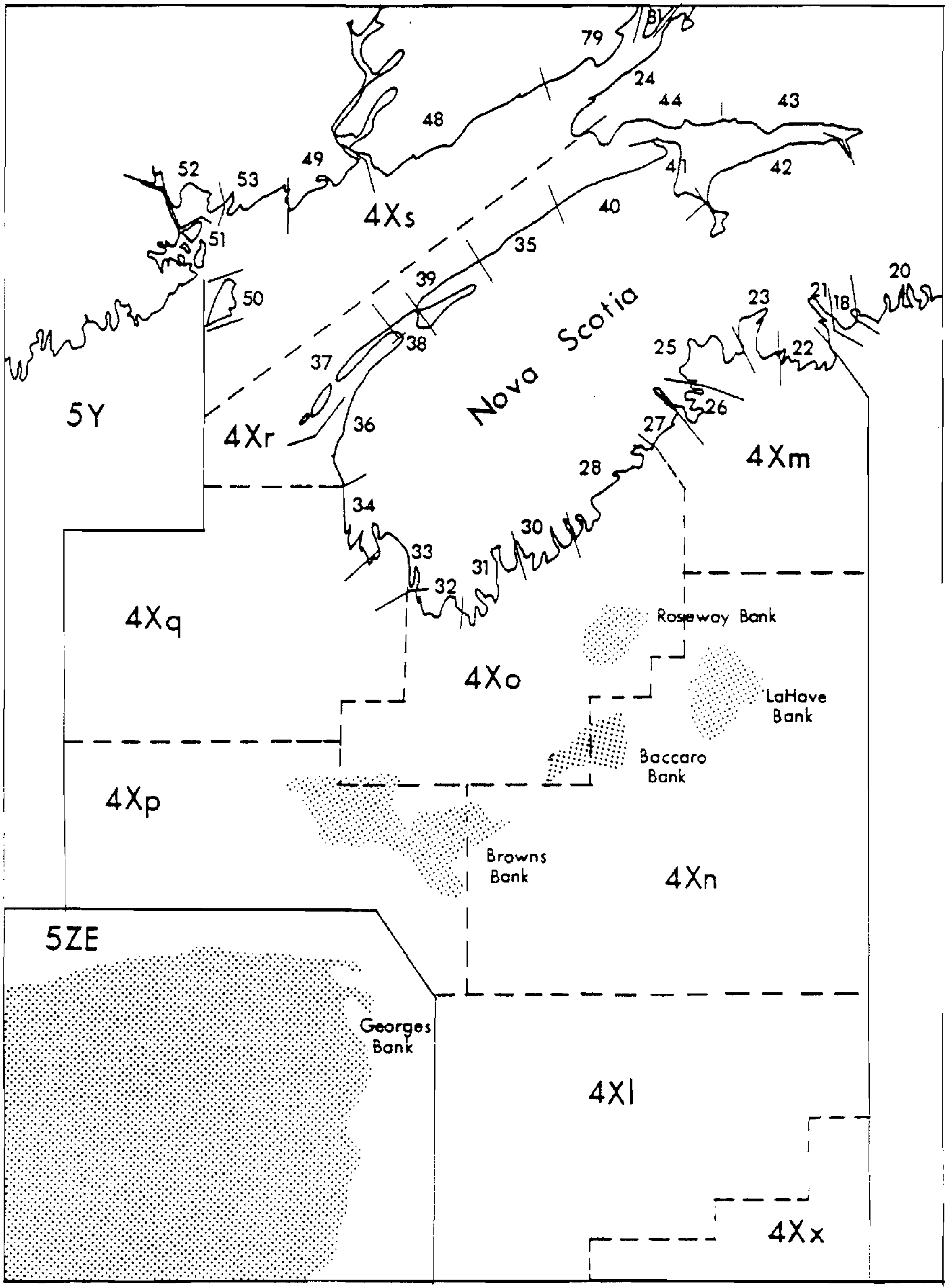
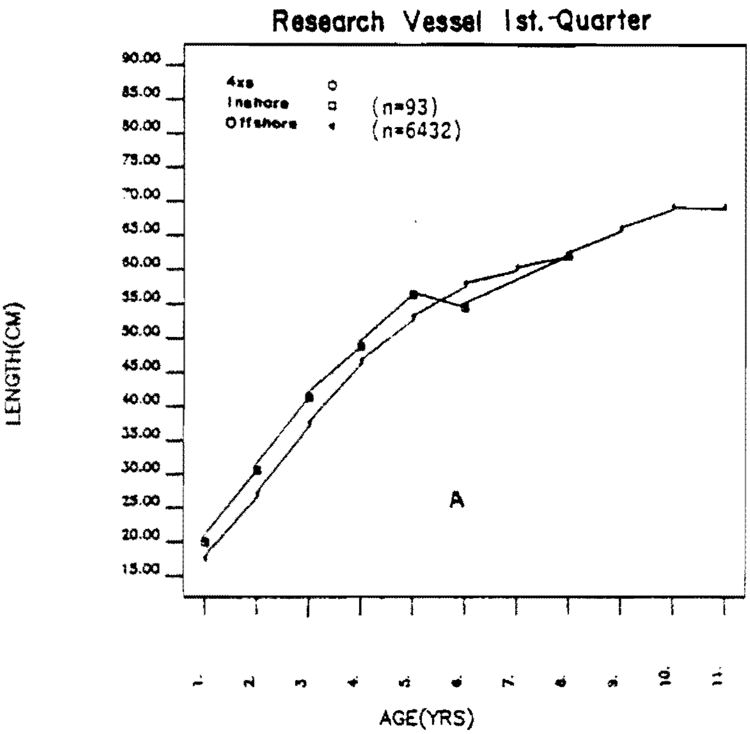


Figure 4. Canadian fisheries statistical unit areas in NAFO Division 4X.



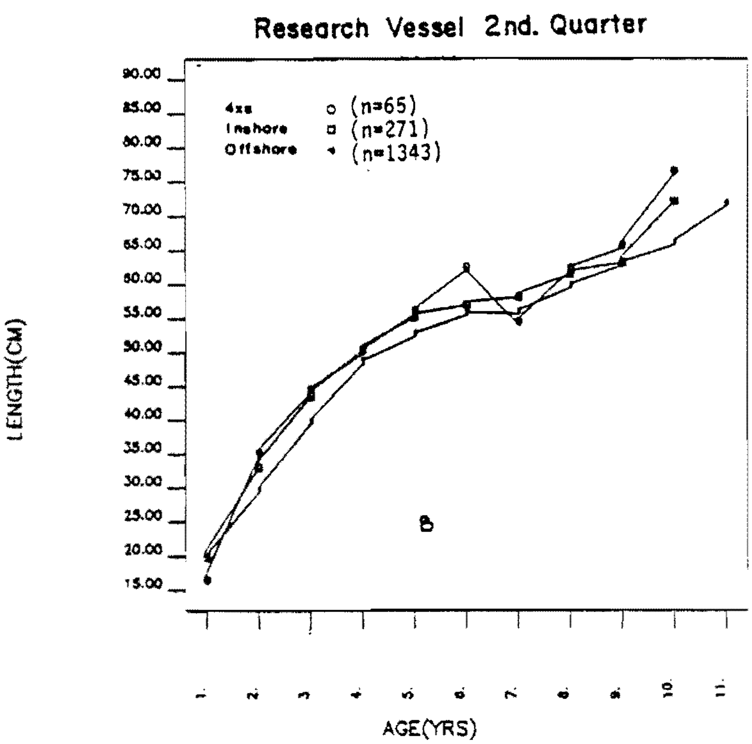
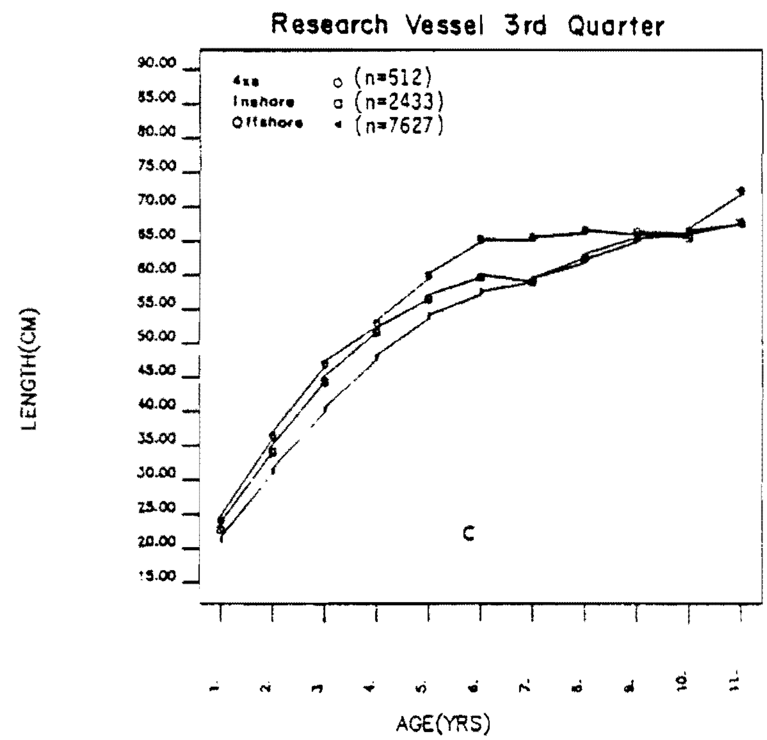


Figure 5. Length-at-age for 4Xqr (inshore), 4Xmnop (offshore), and 4Xs haddock from 1970 - 1981 RV survey data (A-D) and from 1970 - 1981 commercial sample data (E-I). Gears quarters and sample size are indicated in figures.



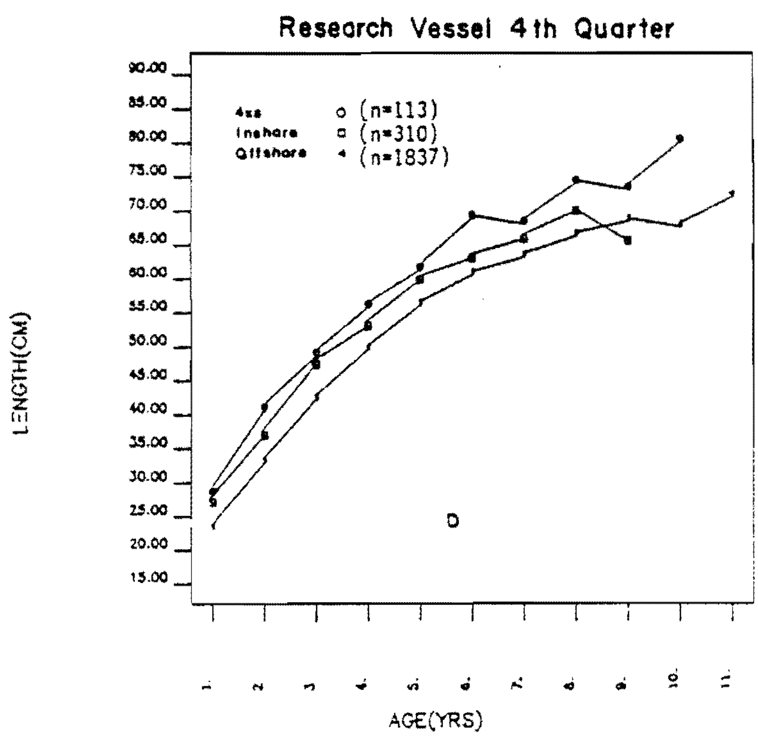
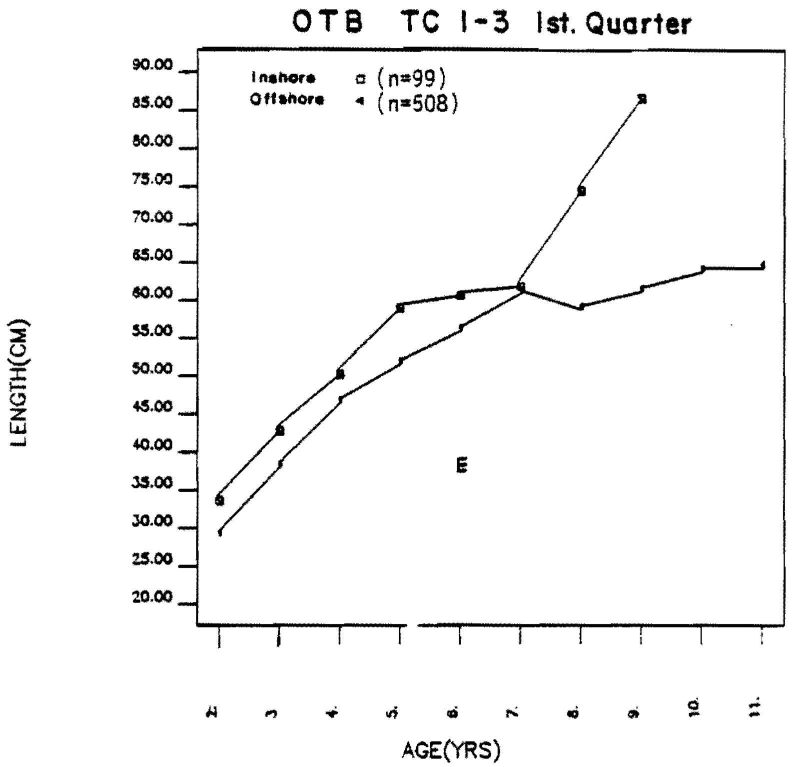
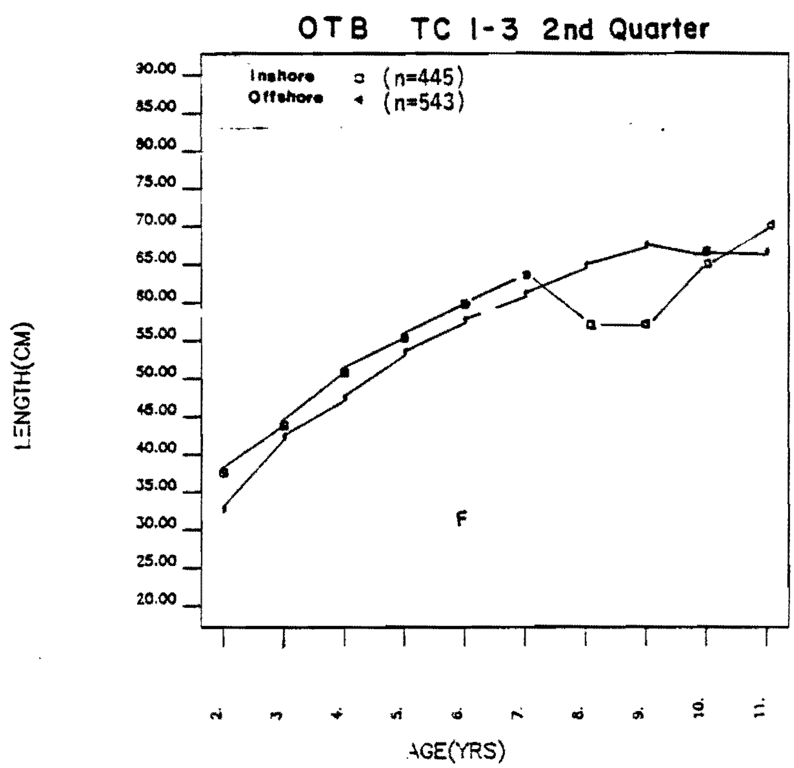


Figure 5 (cont'd)





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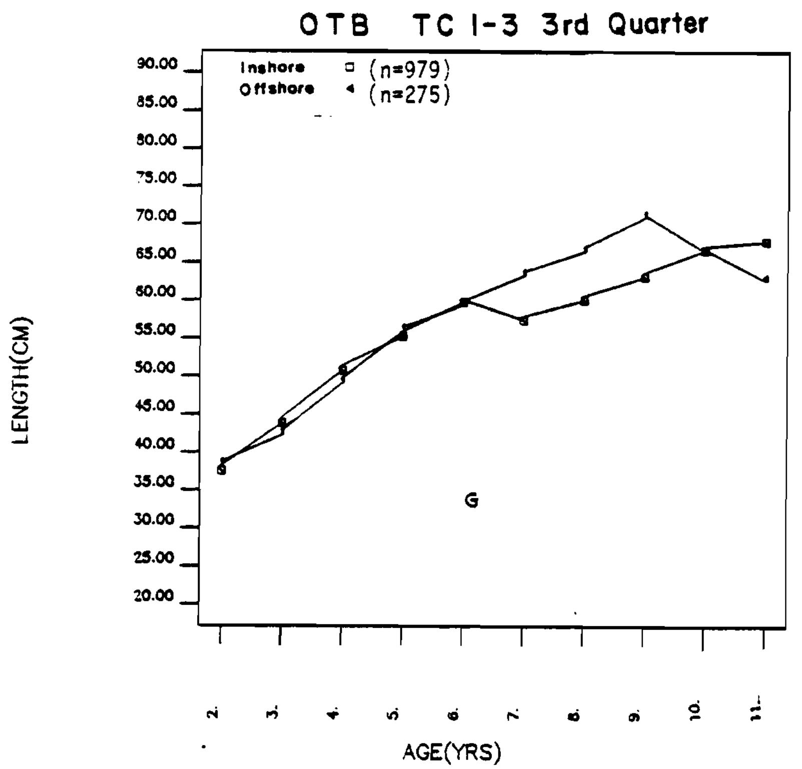

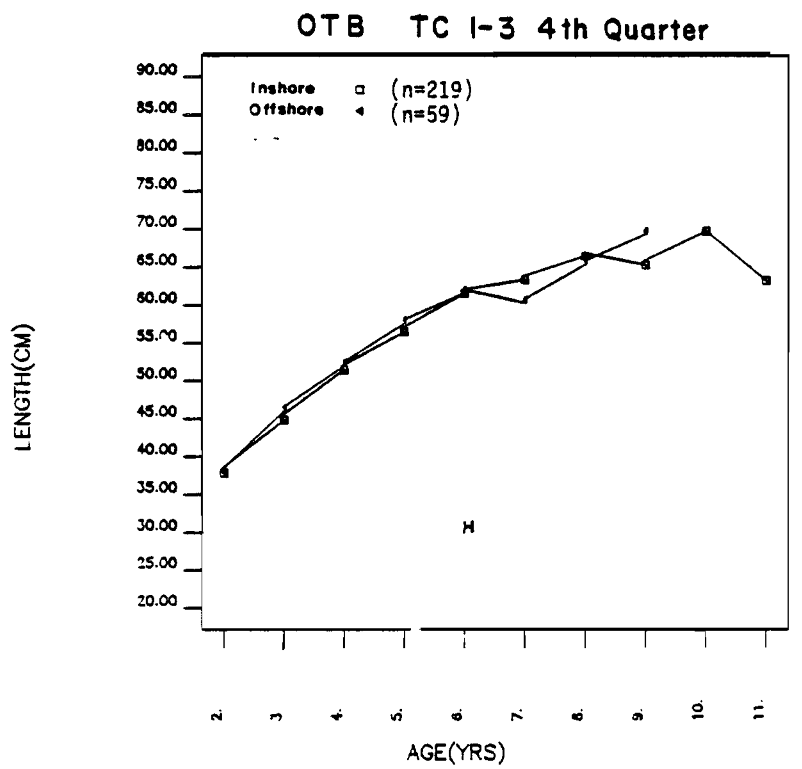

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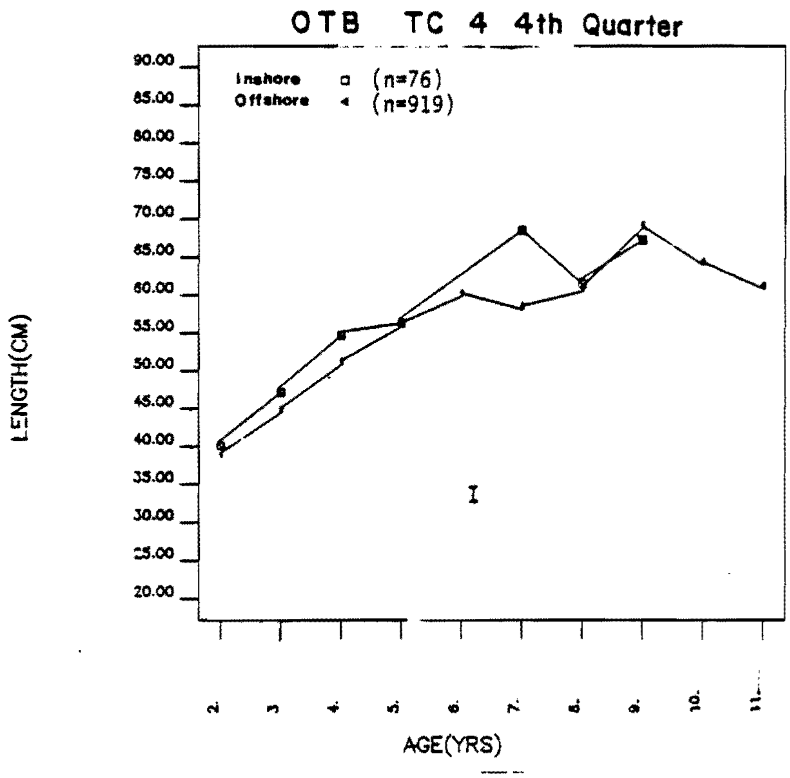

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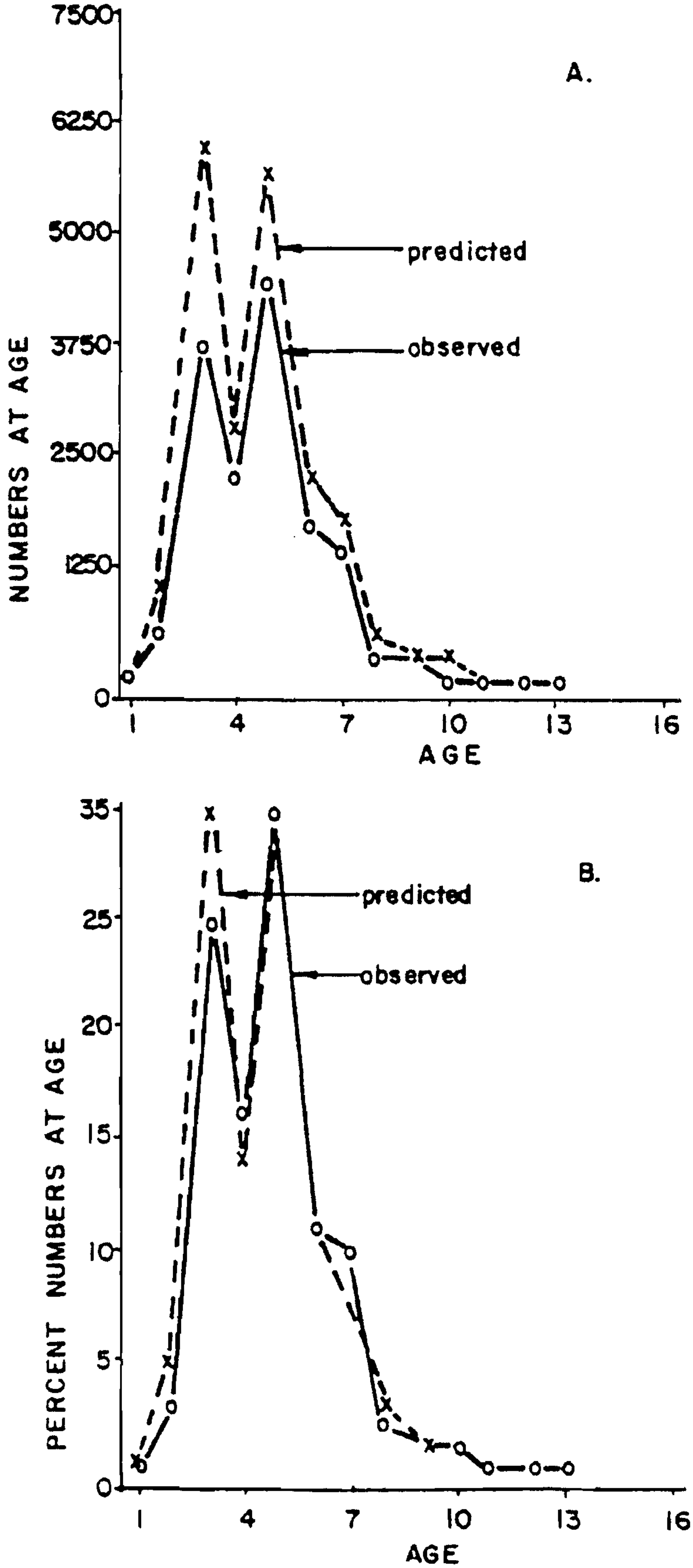

Figure 6. Comparison of the projected 1982 catch-at-age from the 1982 4X haddock assessment (O'Boyle and White, 1982) and the observed 1982 catch-at-age.
a. numbers (10^{-3}) at-age vs age
b. percent of total numbers-at-age vs age.

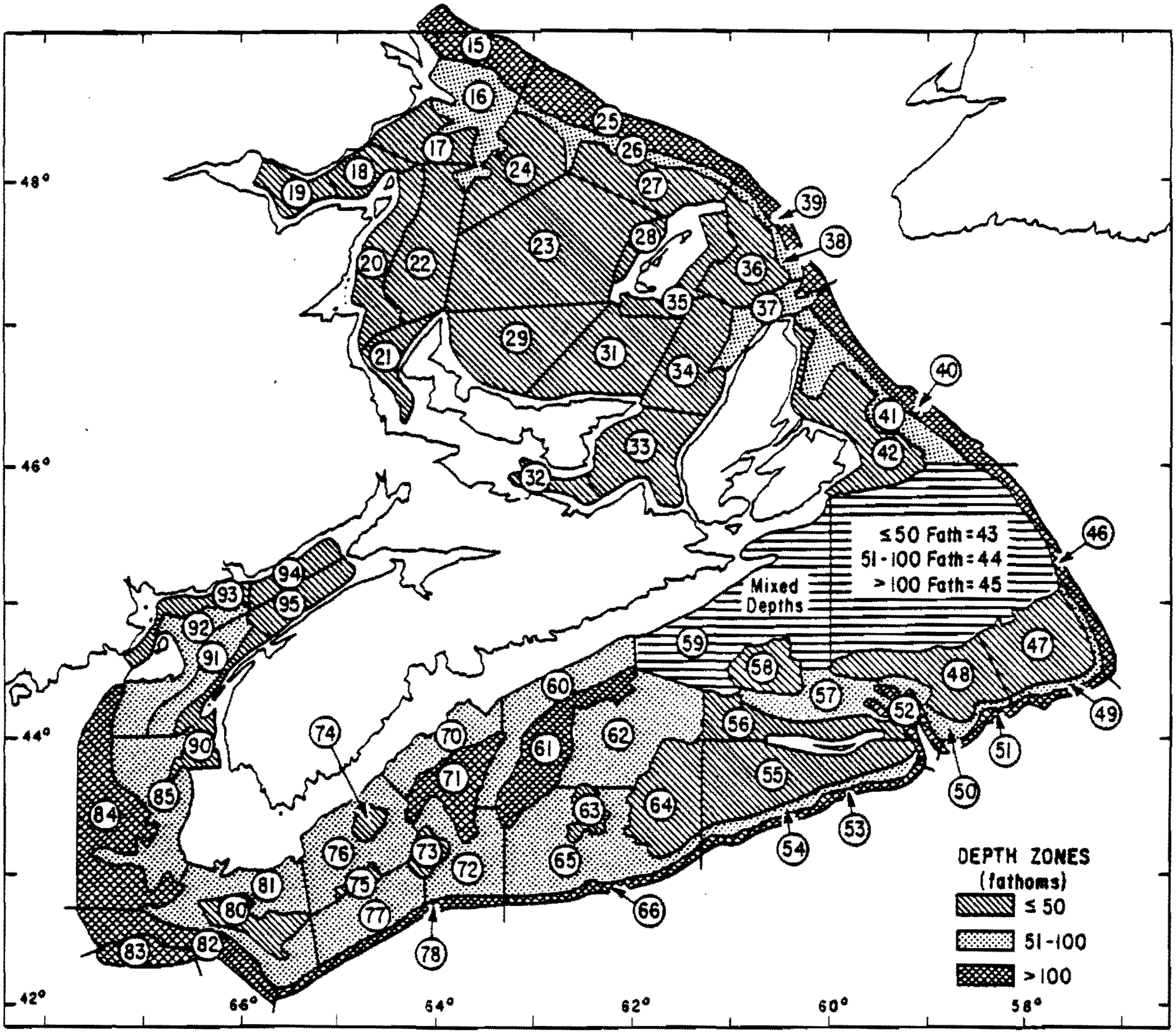

Figure 7a. Stratification scheme used for the Canadian bottom-trawl surveys.

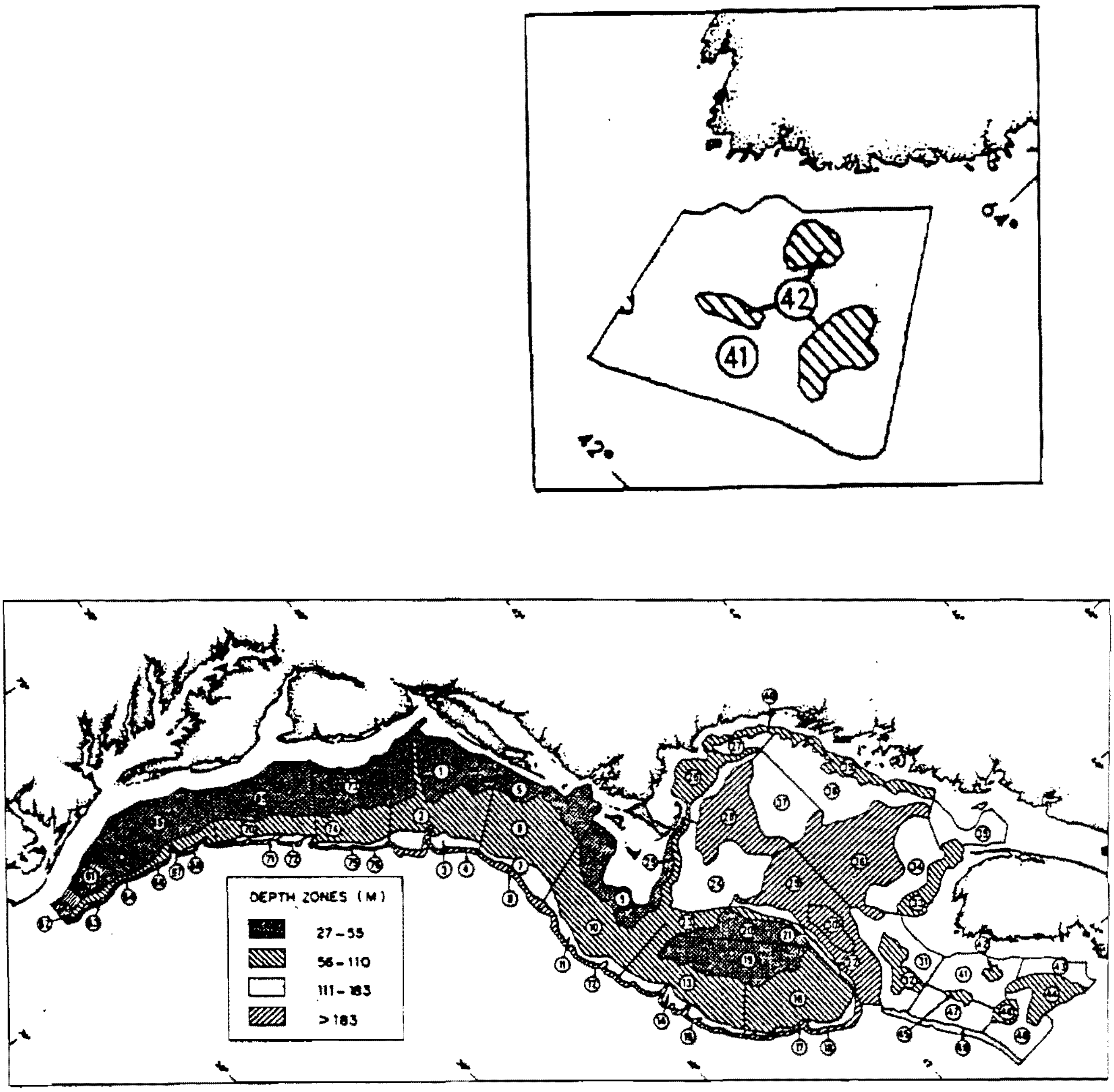

Figure 7b.. Stratification used for the U.S. bottom trawl surveys. The stratification illustrated in the outset had been used prior to 1970.

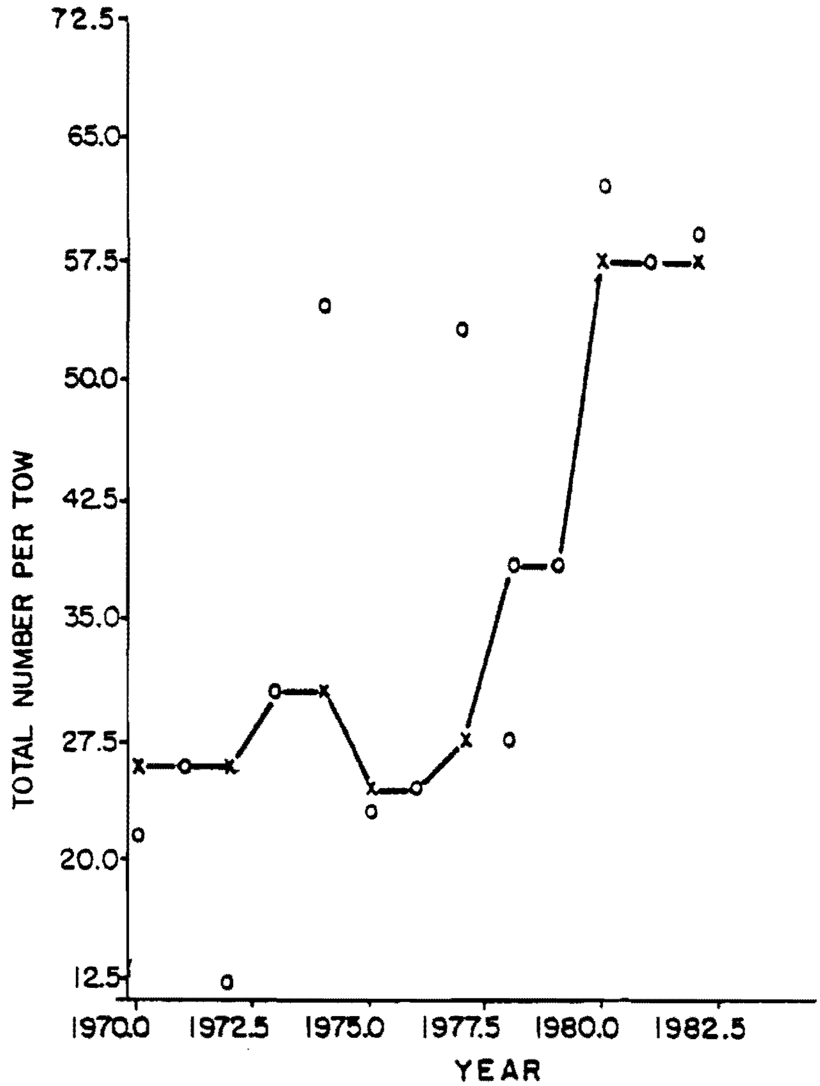

Figure 8. Research abundance indices (age 0+) for 4X haddock stock. Canadian summer survey strata 70-91 and 95. Solid line is based on median smoothed data.

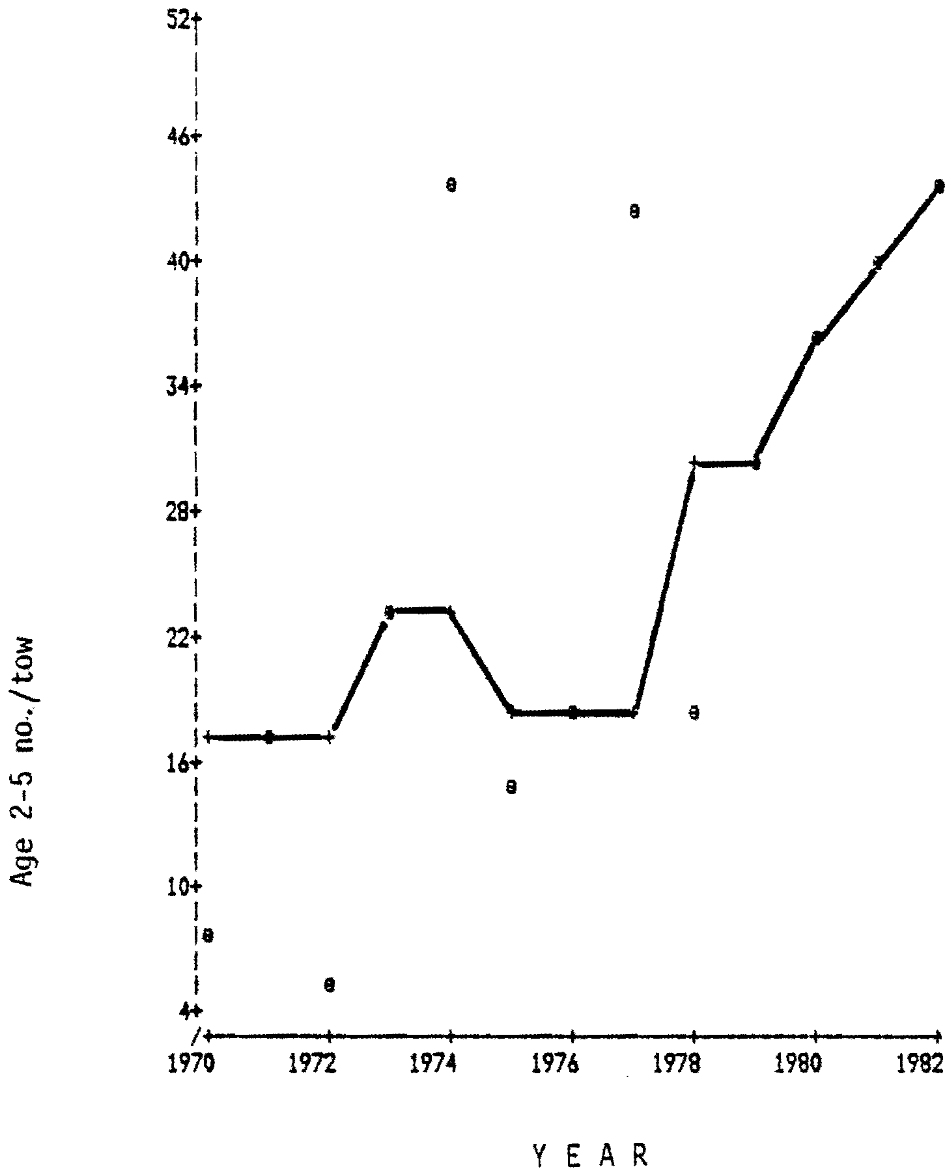

Figure 9. Research abundance indices (age 2-5 no./tow) for 4X haddock stock. Canadian summer survey strats 70-91,95. Solid line is based on median smoothed data.

Figure 10. Research abundance indices (age 6+ no./tow) for 4X haddock stock. Canadian summer survey strats 70-91,95. Solid line is based on median smoothed data.

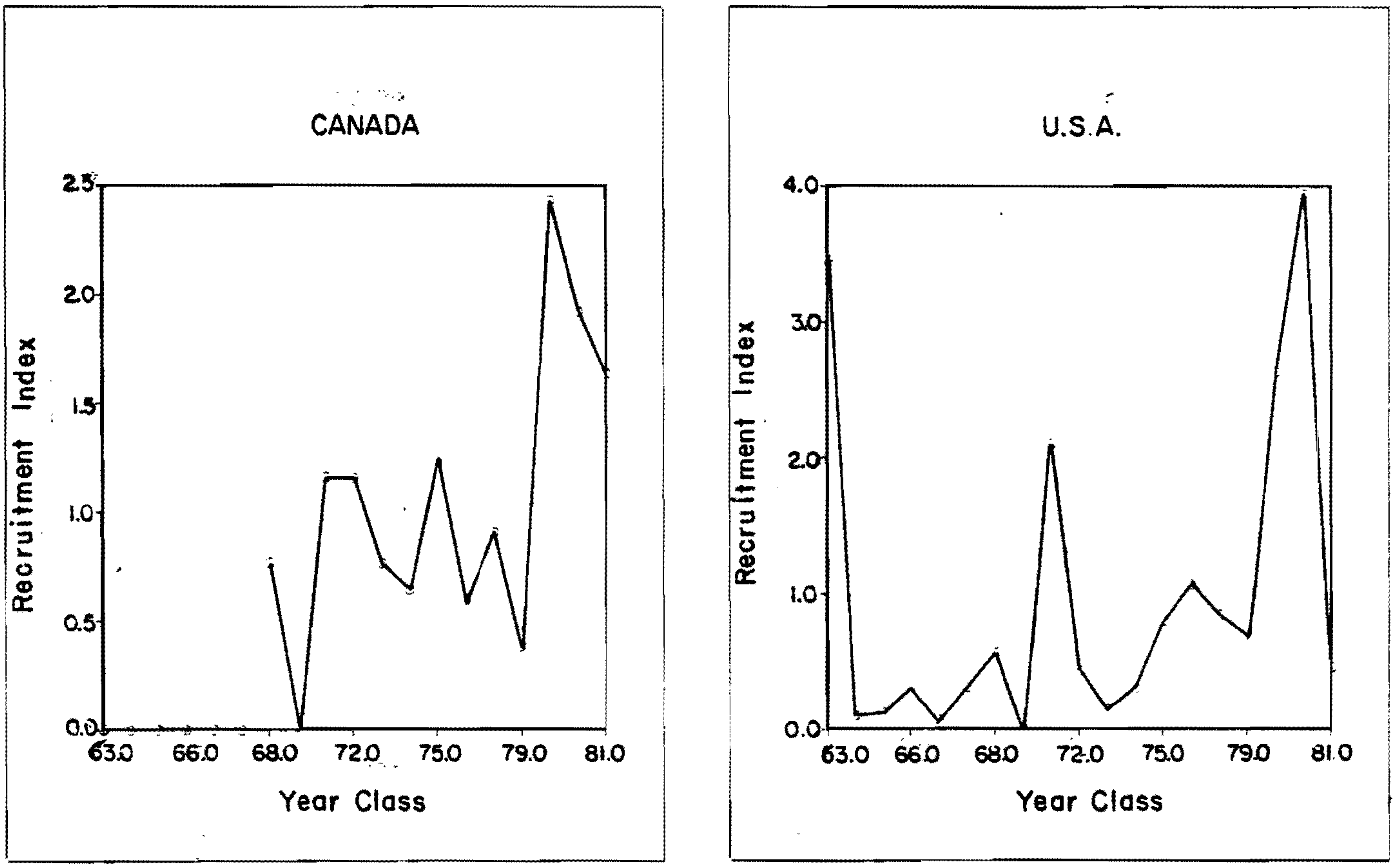

Figure 11. Recruitment indices for the 4X haddock stock (catch/tow) as determined by the Canadian summer (ages 1+2) and U.S. fall (ages 0+1) bottom trawl surveys.

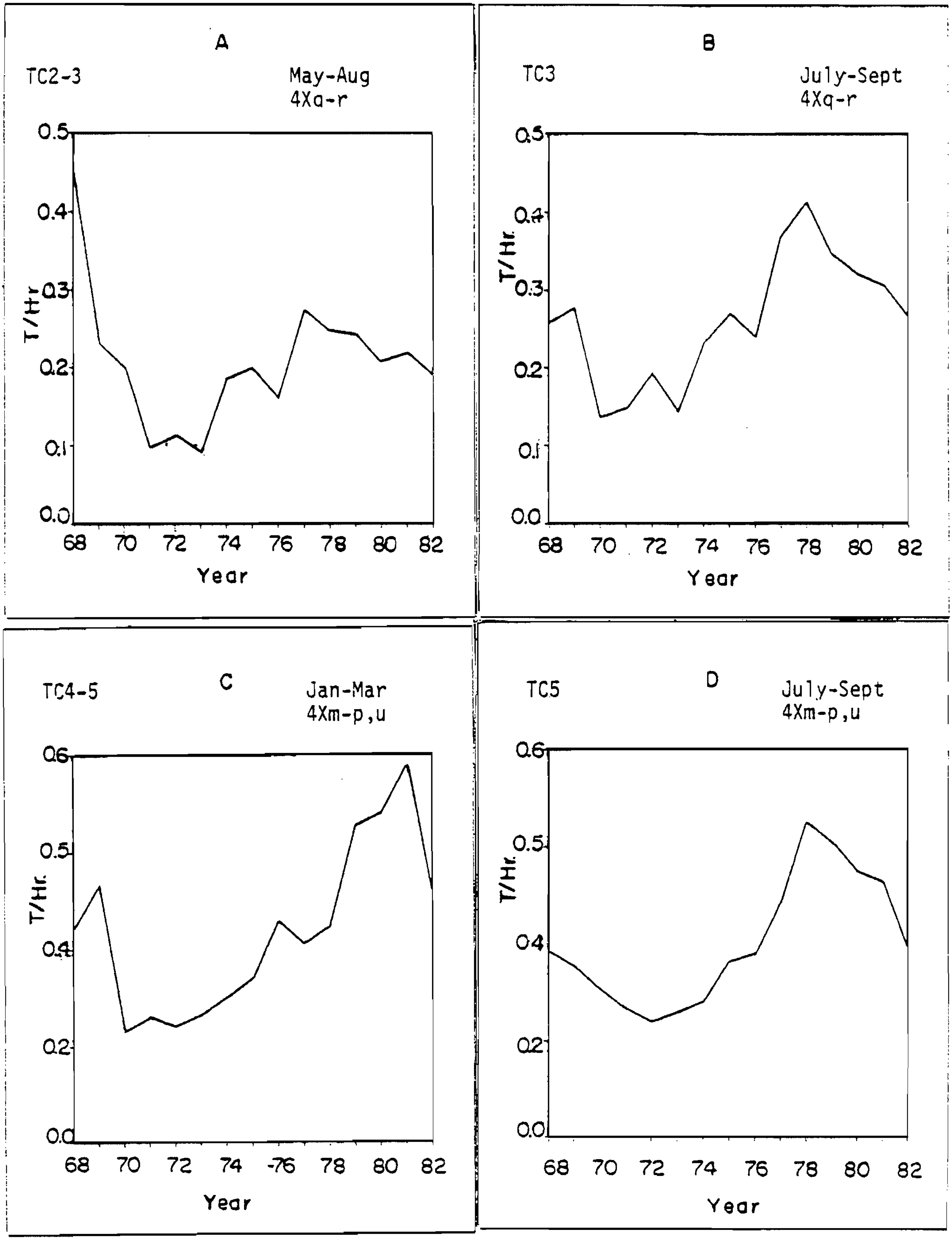

Figure 12. Trends in commercial catch rates by otter trawl in the 4X haddock fishery. A+B were calculated for the landing statistics while C+D were standardized using the multiplicative model of Gavaris (1980).

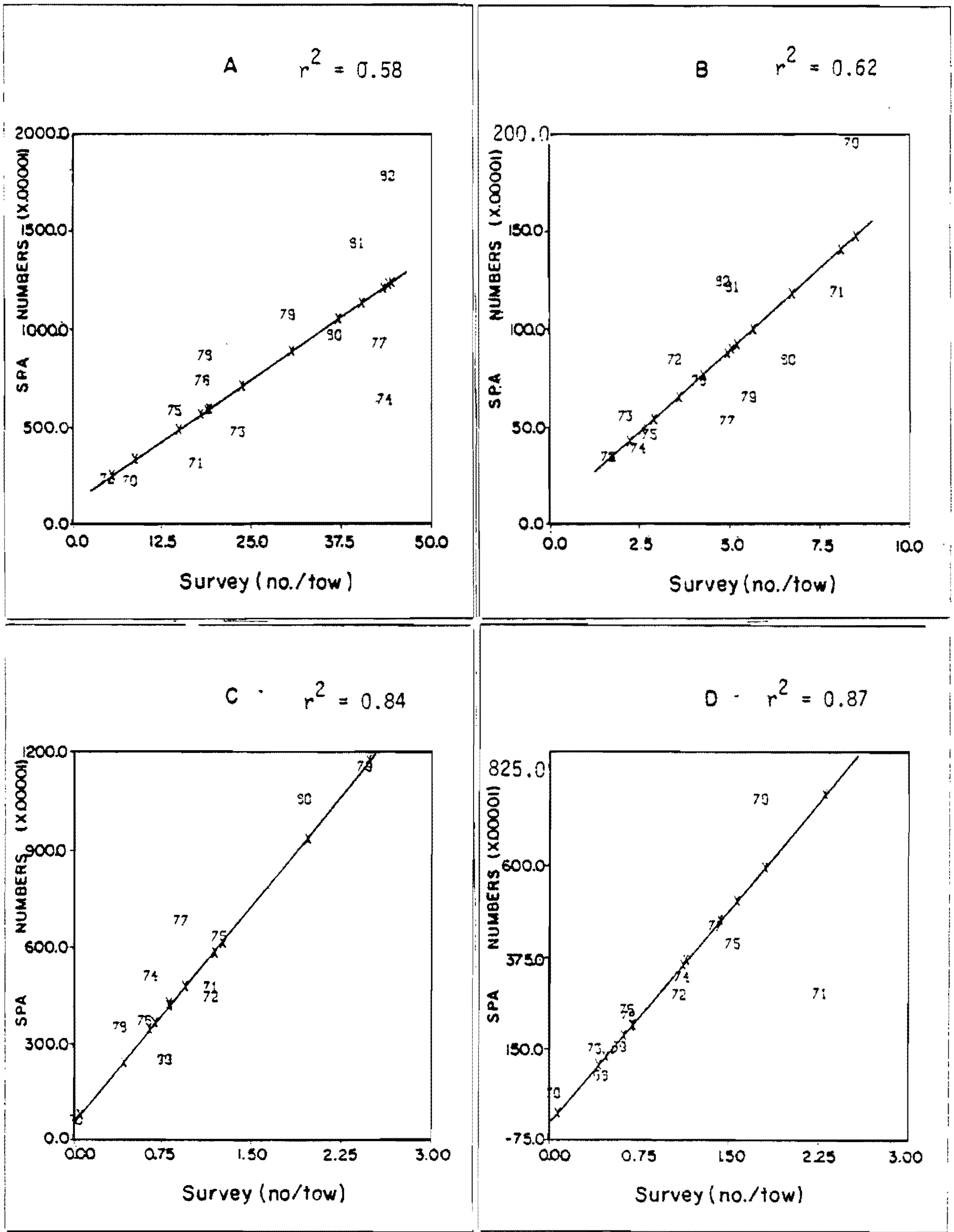

Figure 13. The relationship between the SPA results at F_t = 0.3 and the survey indices of abundance for a) ages 2-5, b) ages 6+, c) age 1 SPA vs age 1+2 survey and d) ages 2+3. The number represents the observed value in that year and the X represents the predicted.